Prichard Creek Assessment and Restoration Strategy

SUBMITTED TO
Trout Unlimited
1777 N. Kent St. Suite 100
Arlington, VA 22209

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PREPARED BY

Inter-Fluve, Inc.
501 Portway Ave., Suite 101
Hood River, OR 97031

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1. Introduction

1.1 PROJECT OVERVIEW AND BACKGROUND

The Prichard Creek Assessment and Restoration Strategy consists of an existing conditions assessment of aquatic habitat and watershed processes along approximately 10 miles of Prichard Creek and a framework of proposed restoration actions for each reach evaluated in the assessment. Prichard Creek is a tributary of the North Fork Coeur d'Alene River, located in northern Idaho on the border with Montana (Figure 1). The creek flows west through the Bitterroot Mountains, past the town of Murray, to where it joins the North Fork Coeur d'Alene River at the unincorporated community of Prichard. The focus of this project is on that portion of the valley bottom owned by Idaho Forest Group (IFG) (approximately 10 miles of stream), a private lumber company.

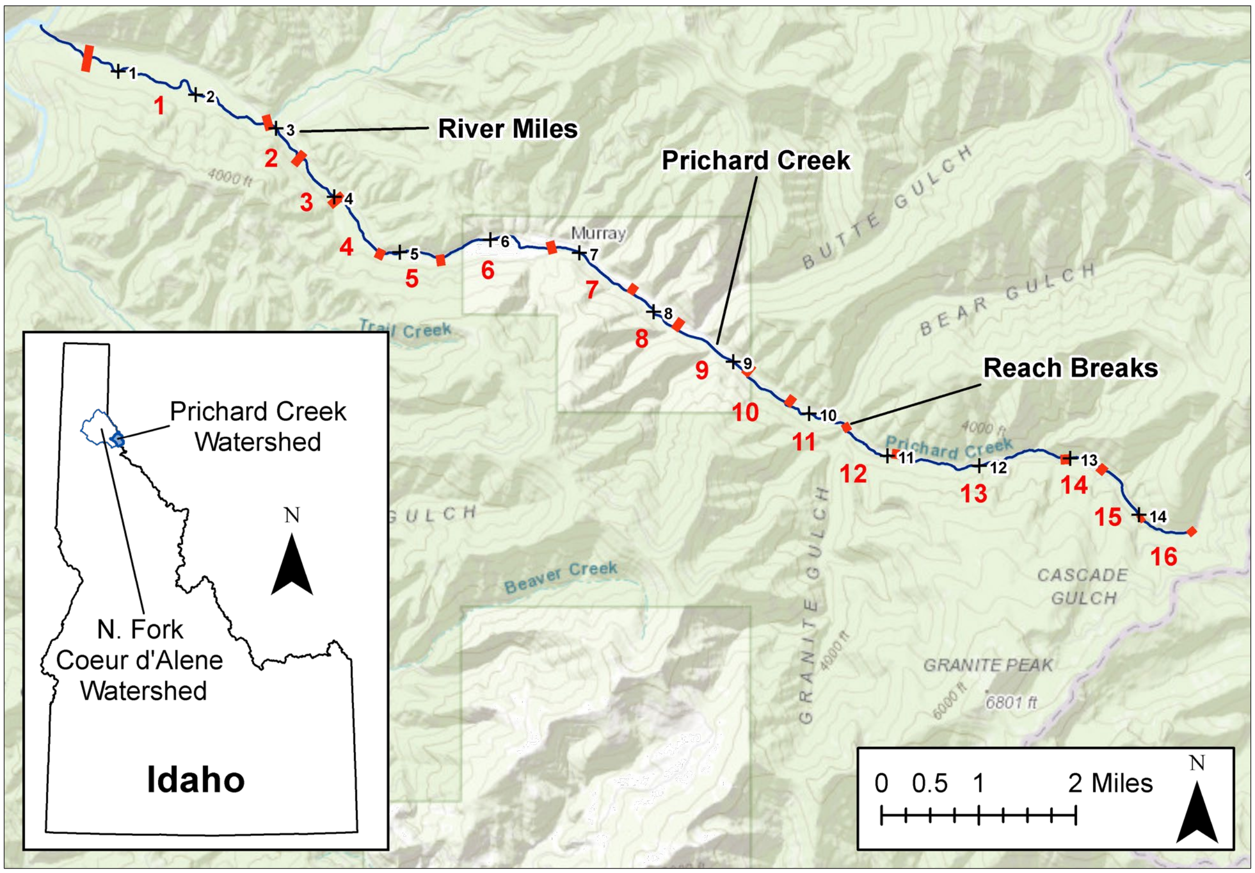

Figure 1. Overview map of the study area showing the Prichard Creek watershed whose eastern edge follows the Idaho / Montana border and the town of Murray, ID at the center of the study area. Reach breaks used for this project are shown in red; river miles in black.

This project is being led by Trout Unlimited, with significant support provided by IFG and the Idaho Department of Environmental Quality (DEQ). Prichard Creek was identified as a high priority for restoration as it is a source of cold water and is heavily used by Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*).

Conducting the assessment involved collecting field data of the area and combining it with existing available information on Prichard Creek. This report does not attempt to re-create the work accomplished in existing documents but summarizes that material and relies upon it to provide context for the field observations. New data collection and analysis performed as part of this effort include a geomorphic assessment of the valley bottom owned by IFG, a habitat assessment and characterization of landforms and human impacts. The assessment will be used as a basis upon which restoration actions and restoration strategy are developed.

The development of the restoration strategy involved the use of field surveys, inventories, and analyses performed in the reach assessment as the technical basis for identifying and prioritizing restoration actions along Prichard Creek. The intent is to provide a direct linkage between the technical analyses, identified limiting factors, and the actions that are moved forward towards implementation. The restoration strategy includes reach-scale concepts and alternatives that depict options for implementing the strategy. Lastly, a ranking matrix was developed that compares different variables (e.g., impact of the alternative on limiting factors, risks, costs) between alternatives.

2. Reach Assessment

The reach assessment provides a technical foundation and baseline for understanding existing conditions of Prichard Creek and for identifying appropriate restoration strategies to improve aquatic habitat conditions. Conditions for this assessment were evaluated at the watershed and reach scales. The aim of this assessment is to identify restoration actions that address factors limiting the productivity of native salmonids, and to ensure that the identified actions fit within the appropriate geomorphic context of the river system. An emphasis is placed on understanding the underlying biological and physical processes at work and how human impacts have affected these processes and the habitat they support.

The reach assessment includes the following components:

- Study area characterization: Summary evaluation of valley and basin-scale factors influencing aquatic habitat and stream geomorphic processes.
- Reach-scale characterization: Analysis of habitat and geomorphic conditions at the reach and sub-reach scales.
- Reach-Based Ecosystem Indicators (REI) analysis – Comparison of habitat conditions to established functional thresholds.

2.1 ASSESSMENT AREA CHARACTERIZATION

2.1.1 Geology

Prichard Creek flows through the town of Murray in Shoshone County in the panhandle of northern Idaho. Murray lies within the Coeur d’Alene Mountains; a rugged and deeply dissected range which is part of the Bitterroot Mountain Range east of the northern Rocky Mountains physiographic province (Idaho Department of Environmental Quality, 2001). The geology of the area is primarily a

Precambrian metasedimentary Coeur d'Alene Belt Series (Hobbs et al., 1965). This series of thick, conformable, fine-grained clastic rocks can be broken into six formations. From oldest to youngest, these formations are the Prichard Formation, the Burke Formation, the Revett Quartzite, the St. Regis Formation, the Wallace Formation, and the Striped Peak Formation. Each of these formations is primarily composed of interbedded, laminated argillites and fine-grained quartzites. Rocks of the Prichard Formation underlie much of Prichard Creek, but the creek also cuts through the Burke Formation and Wallace Formation near the junction with the North Fork Coeur d'Alene River (Figure 2). The Prichard Formation has been subdivided into two lithologic units; the upper and lower part. The lower part is around 9,000 feet thick while the upper part is about 2,000 feet thick. The lower part is about 75% dark grey slate and 25% light brown, fine-grained quartzite (Hosterman, 1956). Inter-bedding is regular, usually about 5 inches thick, and many layers contain pyrite. The upper part of the Prichard Formation represents the transition zone between the overlying Burke Formation and contains quartzite and slate in a 2 to 1 ratio (Hosterman, 1956). The Burke Formation is exposed primarily along the East Fork Eagle Creek to the junction with Prichard Creek and is composed of thin-bedded, greenish-grey, fine-grained quartzite and carbonaceous mudstone (Jennings, 2018). The thickness of this unit is typically around 2,000 feet. A small portion of the Wallace Formation is also exposed at Eagle Creek and along Prichard Creek near Perry Gulch. The Wallace Formation is composed of blueish-grey calcareous shales interbedded with iron-bearing limestone and dark grey quartzite (Hosterman, 1956). It is identified by extensive folding and shearing parallel to bedding planes and is more fractured than the other units (Jennings, 2018).

The belt series in this area is cut by small monzonite intrusions related to the Cretaceous Idaho batholith, although, igneous rocks only make up a small portion of the bedrock (Hobbs et al., 1965). The dominant structural features in this district are steep-angled normal and reverse faults and folding; the result of which is bedded rocks tilted at an angle of 45° or more. The largest structure in the Murray area is the Trout Creek anticline which extends through Prichard Creek north to Trout Creek and south to the Thompson Pass fault. The axis trends in a north to northeast direction. Parallel and west of the Trout Creek anticline is the Eagle Creek syncline which is about 5 miles long and also trends north to northeast. The limbs of the Eagle Creek syncline are essentially parallel at about 20°- 30° (Hobbs et al., 1965). The fault and fold zones throughout the district have centralized veins of mineralized deposits rich in zinc and silver (Hobbs and Fryklund, 1968). The Thompson Pass fault is a right lateral strike-slip fault which defines the Prichard Creek drainage and is associated with the Lewis and Clark Fault Zone; the dominant structural feature south of Murray (Jennings, 2018). The entire Coeur d'Alene range is rich in gold deposits, specifically in the alluvium found in the modern river traces which have since been mined extensively. In addition to gold, there were also large deposits of lead, silver, and zinc found in the area (Hobbs et al., 1965).

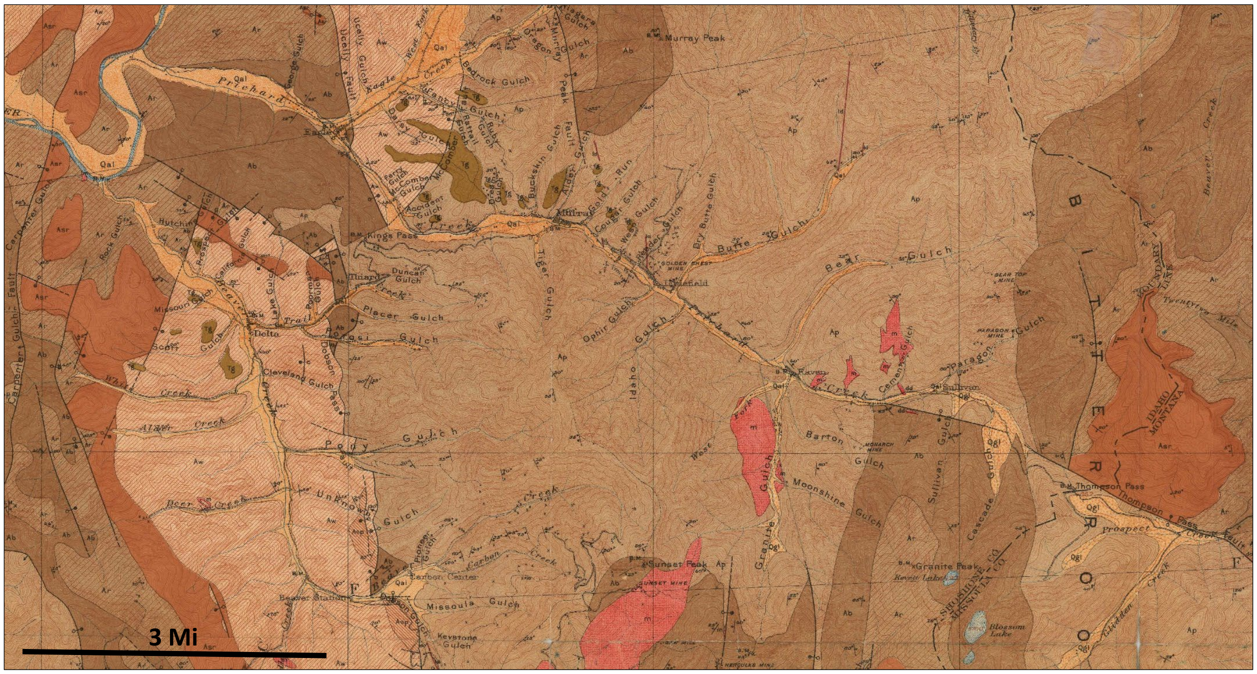

Figure 2. Geology of Prichard Creek (center) with the surrounding Coeur d'Alene district geology. Formations shown include Prichard slate (Ap, light brown) which makes up the majority of the watershed, monzonite and syenite (m, bright pink) which outcrops in a few places in the upper watershed, Burke Formation (Ab, dark brown), and alluvium (Qal, light orange) in the channel of Prichard Creek.

2.1.2 Historical Human Disturbance

Mining

Shoshone County, in which Murray is located, is often referred to as the Silver Valley because of the immense amount of silver, gold, and zinc that has previously been mined out of the area. Prichard Creek's namesake is AJ Prichard, a miner who first discovered placer gold in Prichard Creek in 1879. This sparked the Coeur d'Alene district mining gold rush which has been referred to as "The Last Great Gold Rush of the Lower 48" (Jennings, 2018). Gold mining in the region boomed in the late 1800's but had another revival in the Great Depression era. Dredge mining, with the use of a bucket dredge to mine river and floodplain alluvium in Prichard Creek, lasted from 1917-1926; the result of which is roughly five miles of dredge deposits. These dredge spoil piles consist of fines mixed with and overlaid by gravels, cobbles, and boulders. These coarse deposits cause a significant volume of Prichard Creek to flow subsurface in the low-flow summer months (Bureau of Land Management, 2012). Production records show that approximately 440,000 ounces of gold were mined between 1884 and 1951 (Jennings, 2018).

In addition to the dredging operations, a number of hard rock mines producing lead, zinc, and silver ore are located in the Prichard watershed (USGS, 2004: USFS, 1998). A number of ore concentration mills were located near the creek (Figure 3).

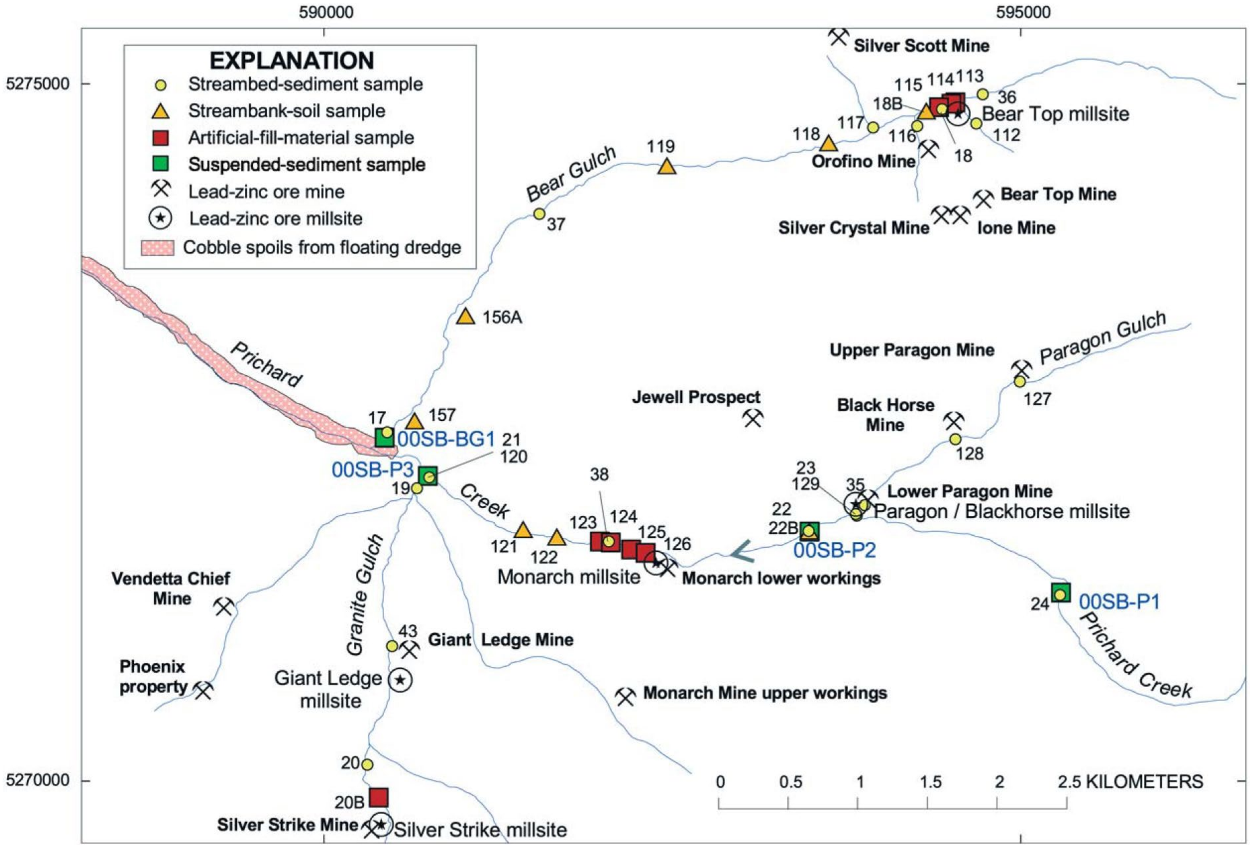

Figure 3. Locations of mines and mill sites in the Prichard area (source: USGS, 2004).

There are two principal mines in the Murray area near Prichard Creek; the first of which is Monarch Mill which is located adjacent to Prichard Creek 4.5 miles east of Murray. The mine began producing lead and zinc ores from the Burke Formation in 1905 and ceased operation in 1923 (Hosterman, 1956). Waste from this site consisted of jig tailings high in cadmium, lead, and zinc which were shown to be leaching into Prichard Creek (Idaho Department of Environmental Quality Closure Report, 2013). For this reason, the tailings containing around 13,000 cubic yards of contaminated material were removed by IDEQ to a Forest Service repository in 2005. The second principal mine in the area is the Paragon Mine located 3 miles downstream of the headwaters of Prichard Creek in Paragon Gulch 6 miles east of Murray. The Paragon Mine began producing lead, zinc, and silver ore from the Upper Prichard Formation in 1890 and intermittent production continued through the 1930's (Johnson, 1999). The mine was then abandoned in 1953 (Hosterman, 1956). The tailing deposits were originally located at the confluence of Paragon Creek and Prichard Creek but were removed by the Forest Service in 2003.

Development

Prichard Creek basin land ownership is a mixture of BLM, US Forest Service, and private ownership (Idaho Department of Environmental Quality, 2013). Historic logging and development (roads, houses, railroads) have contributed to the loss of riparian shade within the entire Coeur d'Alene watershed, contributing to increasing water temperatures and loss of fish habitat provided by large wood inputs and log jams. The US Forest Service once said in regards to the historical timber harvest and log drives down rivers of the North Fork Coeur d'Alene watershed that, "the related riparian cleaning, including removal of any timber that might catch transported logs, channel straightening, and the extreme nature of dam operations have altered the functions and processes of streams and riparian areas to an extent that it is difficult to see any recovery even today" (Watershed Characterization, USFS, 1998). Furthermore, in 2012, the Bureau of Land Management proposed channel restoration of Prichard Creek due to bank erosion causing increased sedimentation downstream (Environmental Assessment, BLM, 2012).

Modern Anthropogenic Features

Following the closure of many of the mines in the Murray area, it has become a much smaller town with a population of about 35 people and 2 local businesses still open. The area is now used mostly for recreation. The most significant legacy impacts of the dredge operation are through Reaches 4, 5, and 6 (see field maps in Appendix A for Reaches 4 – 6). These dredge deposits are remnants of the gold rush mining in the 1920's and 30's, which left mounds of fines overlain by gravel, cobble and boulder throughout the floodplain. The sorting of the floodplain deposits (alluvium) into fine and coarse fractions as part of the mining process causes Prichard Creek to flow subsurface in the low-flow months (i.e., when the infiltration rate of the sorted substrates is greater than the surface rate of discharge).

Other anthropogenic features include the town of Murray and its residential homes, some of which are built along the banks of the channel and across former floodplain. Thompson Pass Road runs the length of Prichard Creek through Murray, often intersecting the floodplain and confining the river. The Yellowstone pipeline is buried adjacent to the highway, increasing the confinement from the road. Similarly, remnants of an old railroad grade runs the length of Prichard Creek through Reach 1, confining the river and limiting the extent of restoration along the banks.

2.1.3 Climate

Murray, Idaho lies at an elevation of about 2,700 feet. The average annual low is 20°F, and the average annual high is 79°F. The average annual precipitation (falling as rain) is approximately 38 inches, and the average annual snowfall is 80 inches (PRISM, 2021). Typically, the highest precipitation occurs in November and December and the lowest in July and August. Shoshone County, Idaho receives the most precipitation in January (Figure 4), primarily as snow (PRISM, 2021). The fall and winter months produce the most precipitation while the summer months are extremely dry. For 2019 and 2020, nearby Kellogg, Idaho received an average of about 70 inches of precipitation throughout the year with about 30% of that precipitation falling as rain and 70% falling as snow (PRISM, 2021).

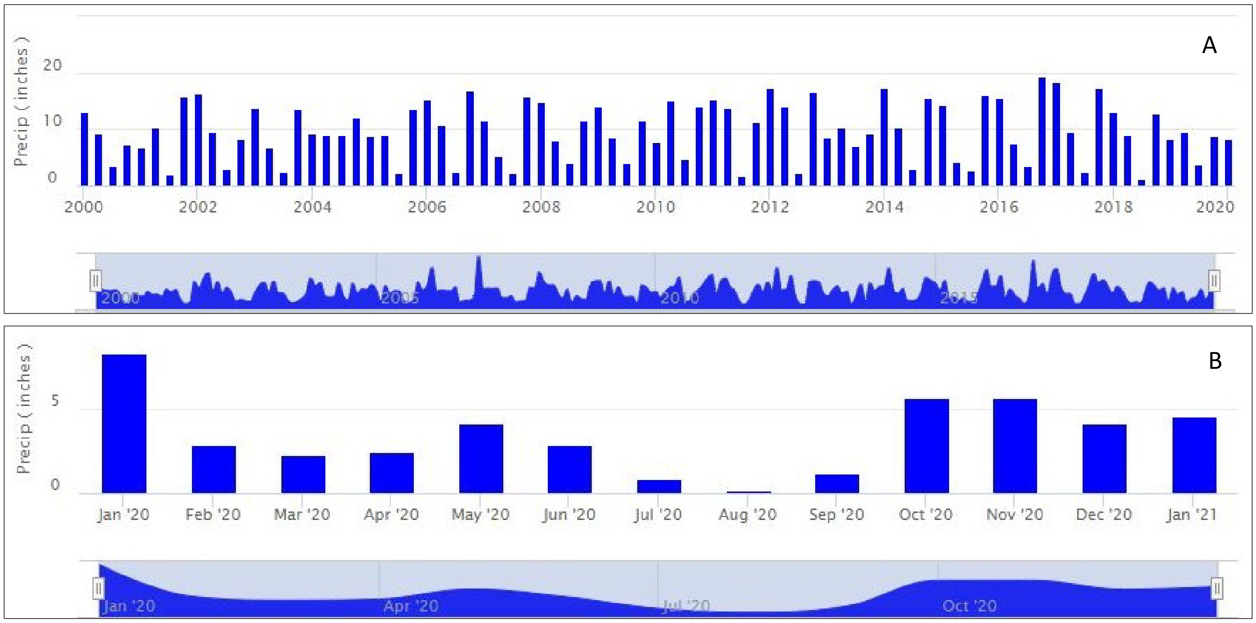

Figure 4. (A) Monthly precipitation for Shoshone County, Idaho from 2000 – 2020 and (B) 2020 from PRISM climate data.

Though much of North America's forests are accustomed to wildfires, the hot, dry summers combined with climate change and human-driven changes to the landscape have worsened the summer wildfire season in much of the west, Shoshone County included. Major wildfires to note are the South Bobtail fire of 2015 which encompassed much of the Eagle Creek watershed at a total burn area of 9,791 acres, and the recent Character Complex fire in July 2021 near the town of Prichard with a burn area of 12,367 acres (Idaho Fish and Wildlife Information System). The loss of vegetation and the resulting decrease in cohesion of soil-mantled hillslopes caused by large wildfires increases the risk of mass wasting events including debris flows. Shoshone County has experienced a few large debris flow events, most notably, two rain-on-snow events which caused sudden runoff and massive debris flows in January 1997 and March 2017 (State of Idaho, 2018). Logging in the area can have similar effects to wildfires in terms of increased erosion, sedimentation, and impacts to riverine ecosystems. Studies in northern Idaho have shown that timber harvest likely changes the hydrologic regime of nearby rivers by causing higher discharges at shorter recurrence intervals and increasing scour of the riverbed and banks, which has adverse effects on the mortality of salmonoid species (Tonina et al., 2008). The combined effect of hot, dry summers with increasing wildfire potential, wet winters with a high likelihood for debris flows from rain-on-snow events, and human influence of logging and development all adversely affect the hydrology and riverine ecology of Prichard Creek.

2.1.4 Hydrology

Prichard Creek is a third order, cold-water tributary of the North Fork Coeur d'Alene River, and drains a watershed of approximately 98 square miles. Average basin elevation is approximately 4300 feet (maximum elevation approximately 6800 feet). The basin trends from east to west, with several major tributaries entering from the north, including Eagle Creek, the largest tributary, which accounts for nearly half (~45%, 45 square miles) of the area of the Prichard Creek watershed (Figure

5). These tributaries generally flow from south-facing slopes which have higher discharges and colder water from snow runoff.

The hydrologic regime is snowmelt driven, with annual flows increasing to a late April or May runoff peak, followed by a return to baseflow in August (Figure 6 - Figure 8). During the winter months, flows are generally elevated above base flows in response to seasonal storms, periods of snowmelt, and rain-on-snow events. Anecdotally, these rain-on-snow events have accounted for and are capable of producing major floods, such as that which occurred during 2008[1].

A stream gauge operated for a short period of time (1998 – 2002) on Prichard Creek (USGS 12411935), so flow data is limited for the project area. Gauge data is available for the North Fork Coeur d’Alene River upstream (USGS 12411000) and downstream (USGS 12413000, 894 square mile drainage area) of the Prichard Creek confluence. USGS 12411000 (NF Coeur D Alene R Ab Shoshone Ck Nr Prichard Id) has recorded data from October 1, 1950, through to the present and has a 334 square mile drainage area. USGS 12413000 (NF Coeur D Alene River at Enaville Id) began recording data in 1911, but there is a large data gap between 1917 and 1940. USGS 12413000 drains an 895 square mile contributing drainage area. Both of these gauges cover substantially larger drainage areas compared to Prichard Creek, but daily average flows for the overlapping period of record on each gauge correlate well (correlation coefficient for USGS 12411000 equal to 0.95 and 12413000 equal to 0.94).

[1] Conversations with Forest Working Group during June fieldwork.

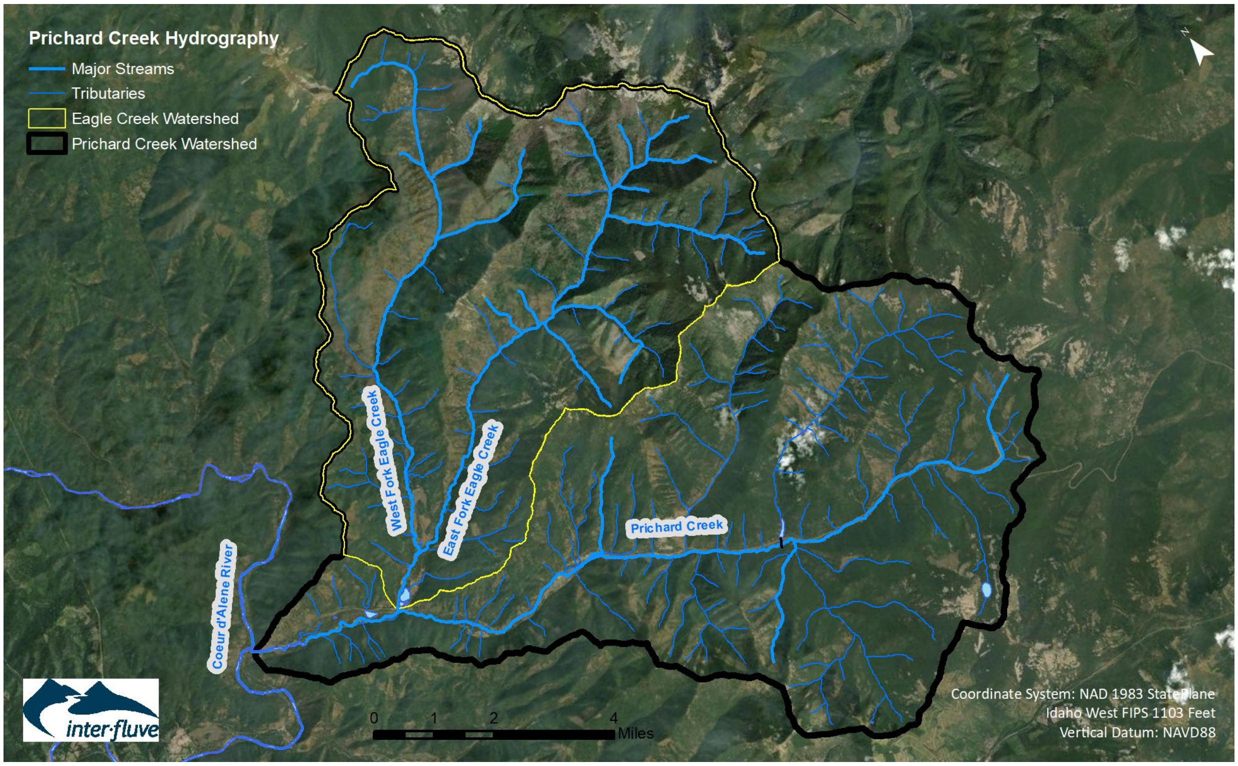

Figure 5. Hydrography of Prichard Creek showing the Prichard Creek watershed (black) which contains the Eagle Creek watershed (yellow) and flows west to the Coeur d'Alene River.

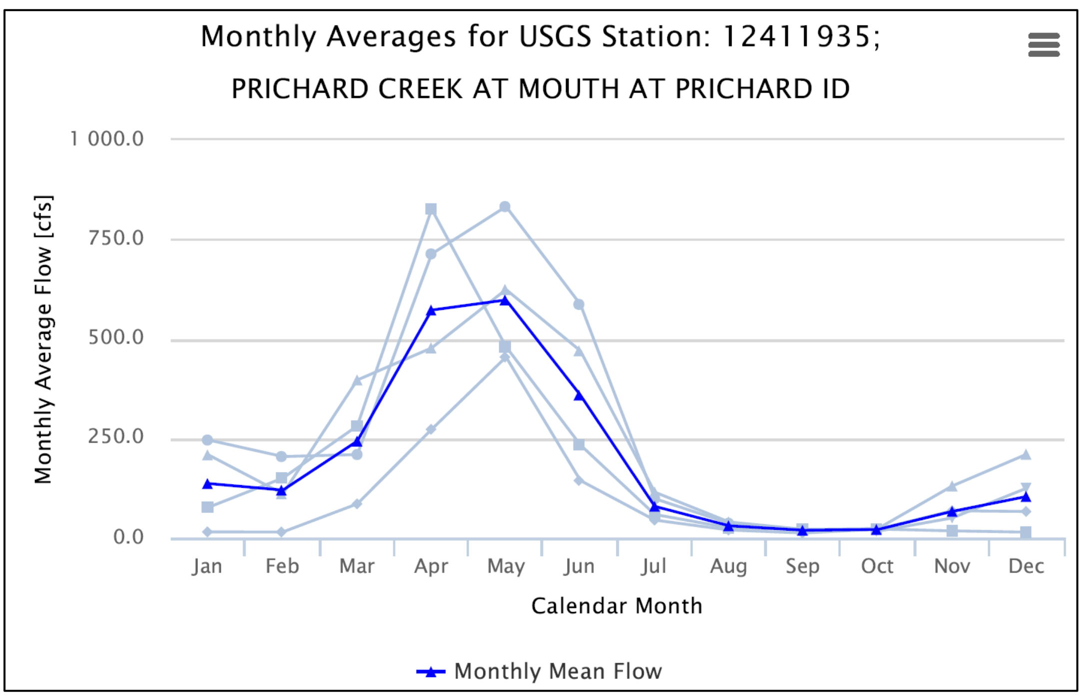

Figure 6. Monthly average flows from the period of record (1998-2002) for the Prichard Creek gauge (USGS 12411935). Individual years are shown in light blue and the monthly mean flow for the entire period of record in dark blue.

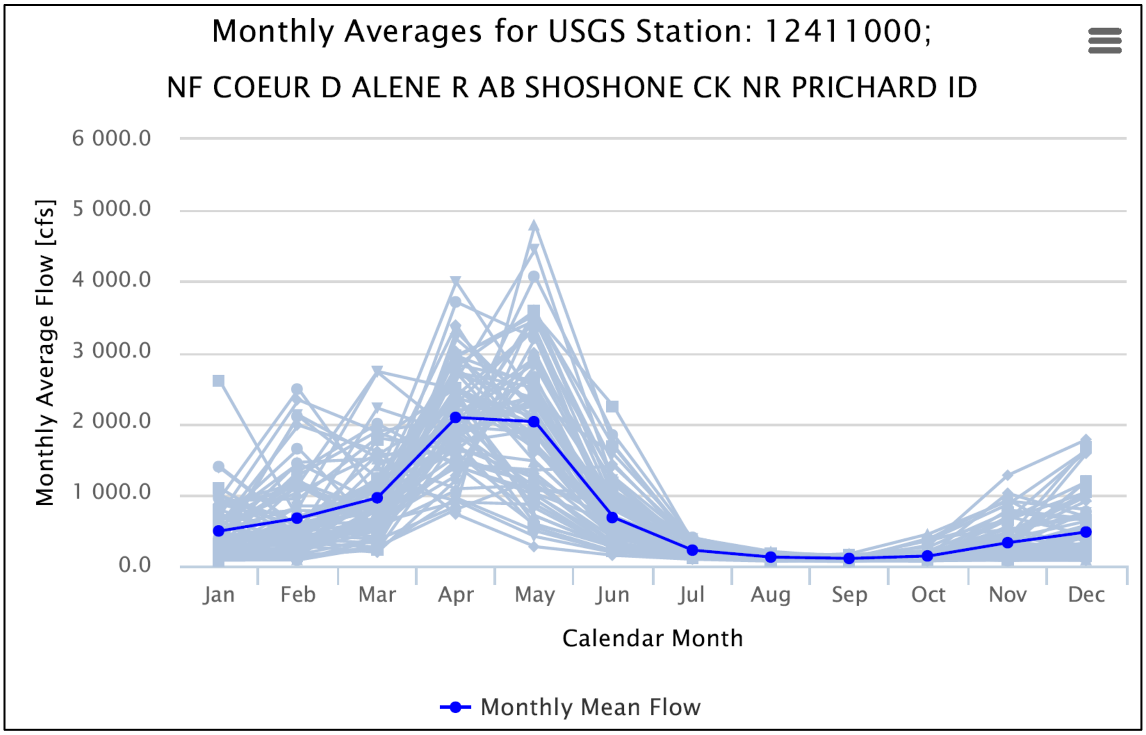

Figure 7. Monthly average flows for the period of record for USGS 12411000. Individual years are shown in light blue and the monthly mean flow for the entire period of record in dark blue.

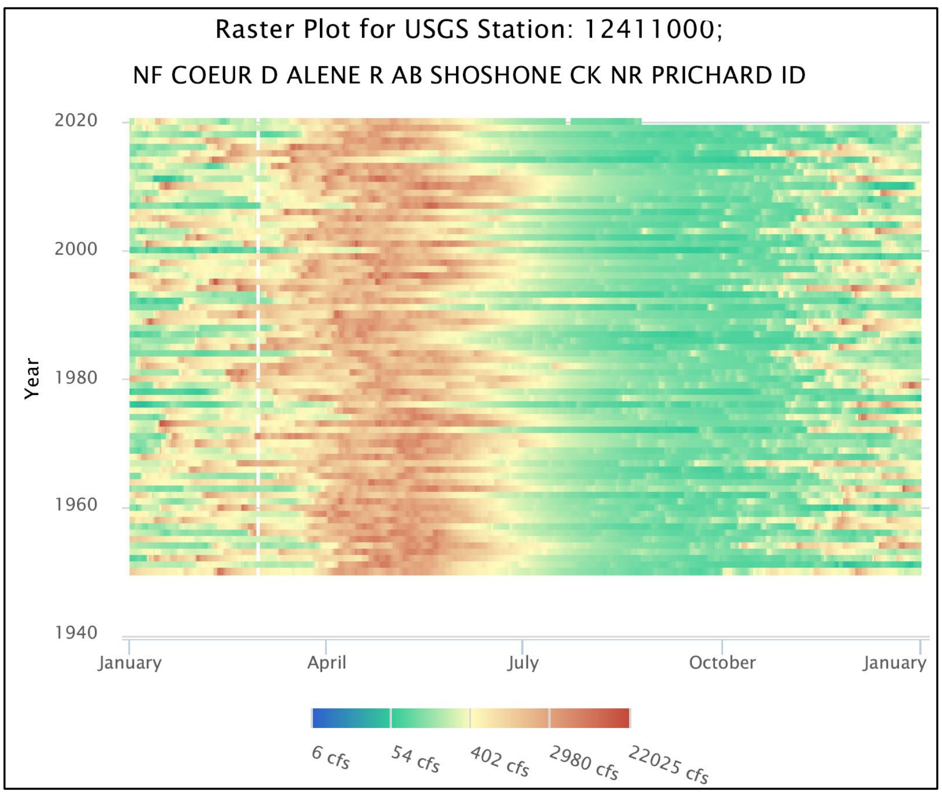

Figure 8. Raster plot for daily flow data over the period of record for USGS 12411000. The plot highlights the seasonality of flows captured by the gauge, showing annual runoff peaks and winter storm stream response.

Peak Flows

Annual peak flow events for USGS 12411000 are shown in Figure 9. Particularly high magnitude floods occurred in January of 1974 (22,000 cfs) and February of 1996 (17,000 cfs), with the 1974 flood being the flood of record. The majority of the annual peak flow events occurred in April and May, but as with the two floods mentioned above, several of the annual peaks occurred during the winter months. While these records are for the North Fork Coeur d'Alene River, they provide some insight into the frequency and timing of floods on Prichard Creek.

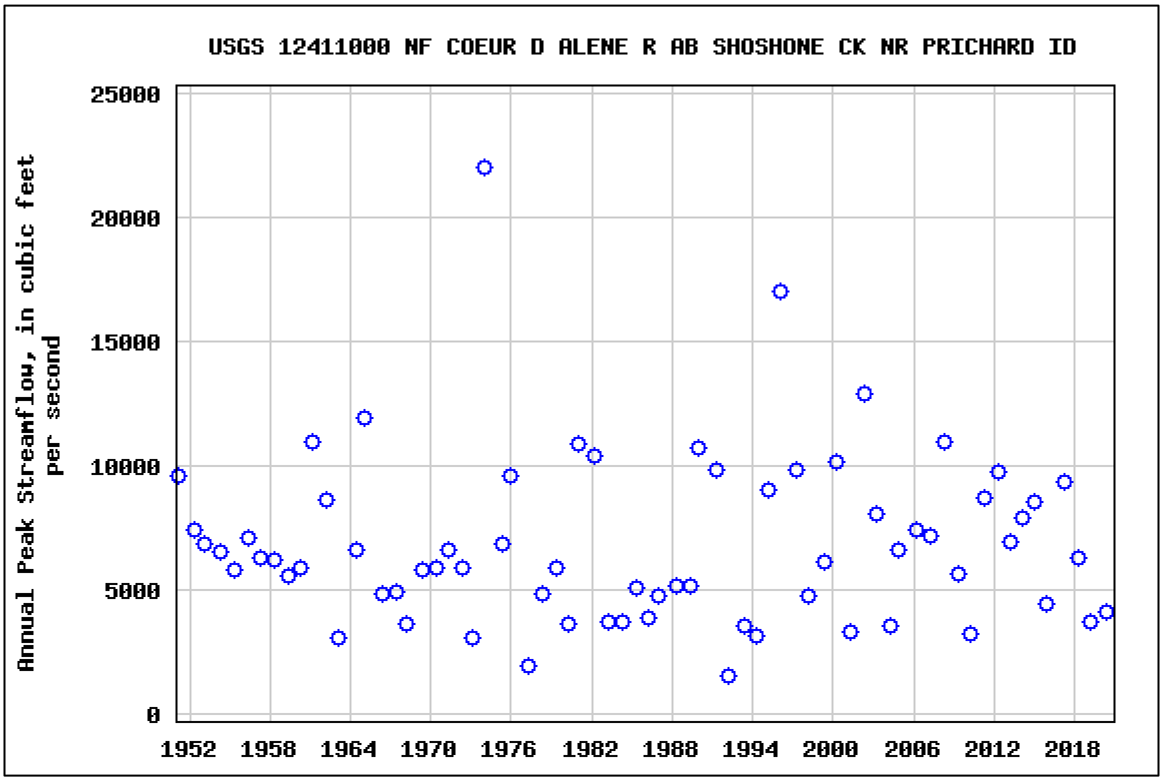

Figure 9. Annual peak flow events from USGS 12411000.

Due to the lack of gauge data for Prichard Creek, peak flow rates for the project area were determined using the USGS StreamStats online application (USGS, 2016). Select return period peak flow rates are shown in Table 1 for Prichard Creek and the two North Fork Coeur d'Alene River gauges discussed above. For ungauged sites, StreamStats relies on regional regression equations to define peak flow rates and relied on those defined in Wood et al. (2016) for this application. A pour point at the mouth of Prichard Creek was used in the StreamStats tool. The return period peak flow rates for Prichard Creek have high error estimates (i.e., average standard error estimates range between 60% and 80%), and will need to be refined as part of the design process. They likely underestimate flow rates by muting the flood peaks and flashiness associated with storm response.

Table 1. Select return period peak flow rates for the Prichard Creek watershed and gauges on the North Fork Coeur d'Alene River (USGS, 2016).

	USGS 12411000	**USGS 12413000[1]**	**Prichard Creek**
Return Period (years)	Q (cfs)	Q (cfs)	Q (cfs)
2	6,040	15,800	1,370
5	9,280	25,000	2,020
10	11,600	31,800	2,410
25	14,700	41,300	2,940
50	17,100	48,900	3,340
100	19,600	56,900	3,840
200	22,300	65,500	4,250
500	25,900	77,700	4,800

1. Values reported in USGS (2016) differ from those in FEMA, 2008 for USGS 12413000.

Water Level Monitoring

In order to better understand the impact of the bucket dredge on Prichard Creek hydrology, water level loggers were implemented in various locations in Reaches 4, 5, 6, and 11. The loggers (HOBO U20 or U20L) were installed in September of 2021 and data was collected in August of 2022, providing nearly a year of data, spanning seasonal high and low flows. Monitoring locations were chosen to provide WSE information in both the down- and across-valley directions (Figure 10). Results are discussed in the reach descriptions (Section 3) below.

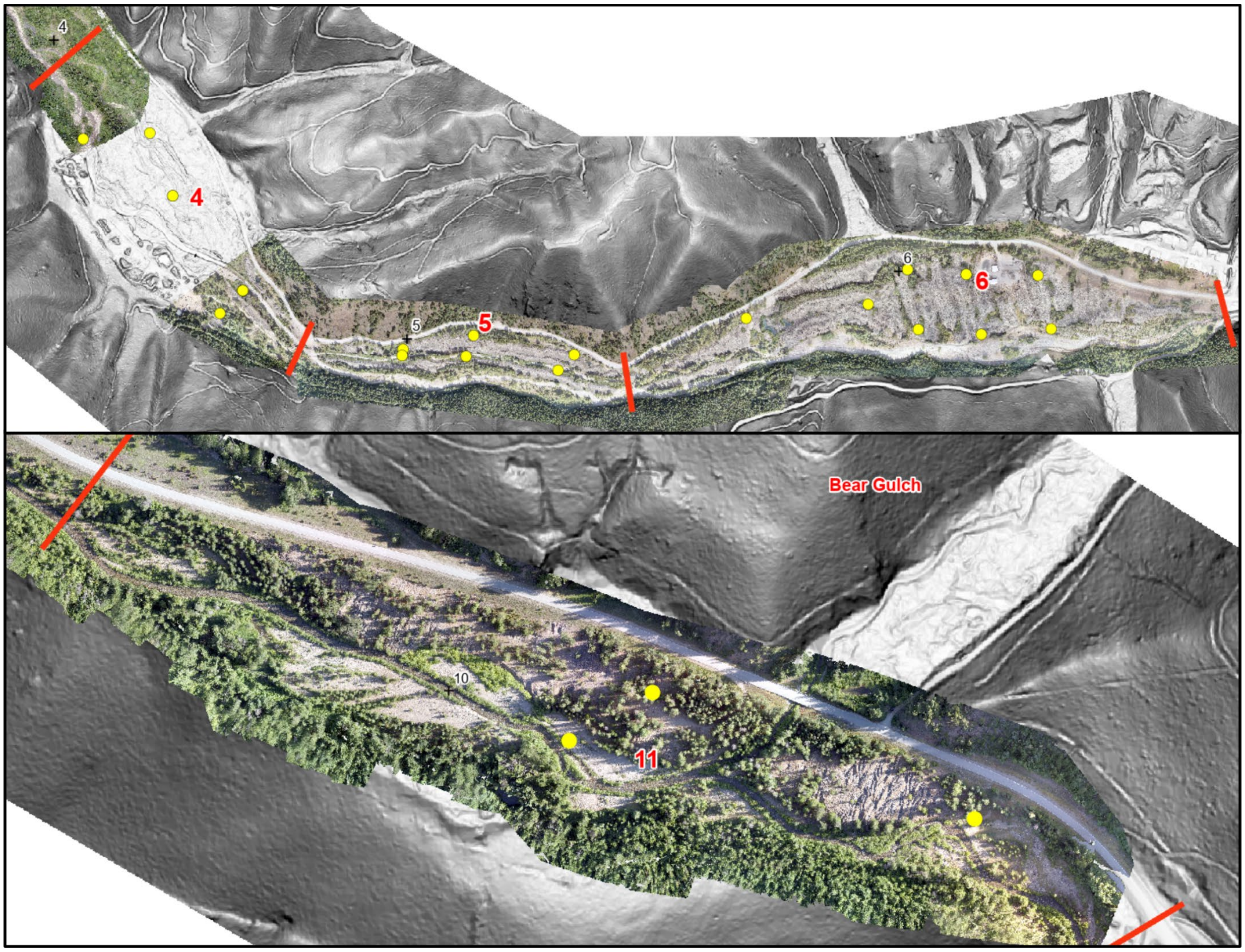

Figure 10. Water level logger locations (yellow dots) in Reaches 4, 5, and 6 (top) and Reach 11 (bottom). Reach breaks and numbers are shown in red. River miles are labeled and shown as black plus signs.

2.1.5 Geomorphology

Valley Geomorphology

The present geomorphology of the Coeur d'Alene district is the result of continued uplift which led to the heavy dissection of a mature landscape. The Coeur d'Alene Mountains are characterized by steep, tall mountains approximately 7000 feet and deeply dissected intermontane valleys dropping to approximately 2,000 feet (Idaho Department of Environmental Quality, 2001). The maximum and minimum elevations in the Prichard Creek watershed are approximately 6814 feet and 2400 feet, respectively (elevations reference the North American Vertical Datum of 1988; USGS topographic quadrangles for Prichard, ID and Burke, ID, MT, 2020). There was a principal period of aggradation caused by the Columbia River basalt flow damming of the Coeur d'Alene River in the middle Tertiary (Hobbs et al., 1965). The Cordilleran continental ice sheet did not extend far enough south to impact the Bitterroot Mountains during the last glacial maxima, however, alpine glaciers of the Pleistocene contributed to the cutting of cirques in the higher ridges above ~5,000 feet and deposition of moraine gravels in the lower valleys (Dort, 1962). Where the continental ice sheet did extend, the Purcell Trench ice lobe created an ice dam of the Clark River to the north at Lake Pend Oreille. This created Glacial Lake Missoula and, when the ice dam failed as a glacial lake outburst flood, the flood waters and resulting debris flows created many smaller lakes to the south including Lake Coeur d'Alene (Dort, 1962).

In the upper watershed, bedrock exposure on steep hillslopes increases soil creep and mass wasting events, especially in areas with mines or development, as evidenced by landslide scarps across the study region. Soil cover on hillslopes varies greatly; exposed bedrock is common on steep slopes, but colluvial talus slopes of mixed rock fragments and fines can be up to 33 feet thick (National Research Council, 2005). There is evidence of soil loading from mass wasting in the upper tributary channels to Prichard Creek which likely accounts for some of the increased sediment supply in the downstream reaches. Wildfire is another important catalyst of geomorphic work in the Coeur d'Alene District, as fire changes the cohesion of the soil, loosening soil that was previously held to steep slopes by vegetation and allowing for more downslope movement and mass wasting. Fallen trees also move downslope after wildfires causing episodic loading of wood and sediment in the upper tributaries which then move downstream as debris flows at high rainfall events. Overall landscape steepness exhibits a large control on valley width and confinement as the upper reaches of the Prichard Creek watershed are steep and confined while the lower reaches are low slope and unconfined. The disturbance regime also transitions from the upper Prichard watershed to the lower watershed area in that the upper watershed is dominated by mass wasting, debris flows, and intermittent wildfire, as well as freeze-thaw cyclic processes and tree throw. In contrast, the lower watershed areas are dominated mostly by intermittent flooding events.

Floodplain and Channel Geomorphology

Prichard Creek and many of the other streams in the Coeur d'Alene Mountains have cut steep-sided, narrow channels which dissect the range. Prichard Creek is about 15 miles long with its headwaters reaching towards the Idaho-Montana border. Prichard Creek follows the trace of the Thompson Pass fault (Jennings, 2018). The headwaters are steep at a slope of about 0.075 (ft/ft) where the stream is well confined and characterized by Prichard Formation gravel- to cobble-sized sediment and steep channel banks and valley sides with heavy vegetation. Downstream, however, Prichard Creek becomes much less confined with an active, connected floodplain and less vegetation directly on the banks of the channel. The stream bed is lined with silt, sand, gravel and cobble. The confluence of Eagle Creek increases the sediment supply and alters Prichard Creek to a multi-thread stream form with side channels, vegetated islands, and active channel deposits in various configurations (e.g., point bars, lateral bars, flood deposits).

Stream power is defined as the rate of energy dissipation per unit downstream length and is proportional to stream discharge, bed slope, and inverse channel width. Specific stream power, or stream power per unit width of channel, was estimated for three different event types: channel forming stream power calculated using the two-year return flow discharge and the existing channel width; the inundation stream power using the 100-year return flow discharge and the existing valley width; and, the historic inundation stream power using the 100-year return flow discharge and the historic valley width (Figure 11). As width is a primary control on where streams can dissipate energy (by spreading out flows into the floodplain, confinement ratios were also calculated for each reach. For this assessment, confinement ratio was simply calculated as the ratio of valley width to channel width.

Referring to Figure 11, the diversion of the channel forming (blue) and inundation stream power (green dashed) from the historic inundation (green) is in part due to the added channel and floodplain confinement from human development and mining deposits. The main impact of this increased confinement from human development in the central reaches of Prichard Creek is that the function of these transitional reaches between the upper and lower watershed is greatly decreased. This transition zone typically functions as a geomorphically complex energy dissipation zone which protects the lower reaches from increased flooding with the supply of fast water and increased sediment from the upper mountainous reaches. The central reaches would have historically had more access to the floodplain, allowing for wider streams with slower flow and the development of riffles and pools which increase roughness and decrease the overall energy of the flow. The increased confinement of these reaches makes them narrower, straighter, faster, and higher energy than historically, which allows for increased transport of sediment, evidenced by higher stream power (and the divergence from the historic stream power). This sediment then deposits in the lower, less confined reaches. As the flow slows down and spreads out in the lower reaches, more sediment drops out and chokes the stream, creating a braided flow pattern and increasing the impact of flooding. The trend in historic inundation stream power follows a more predictable pattern of high in the upper reaches which tend to be steep and confined with a steady decrease as the channel becomes wider and less steep.

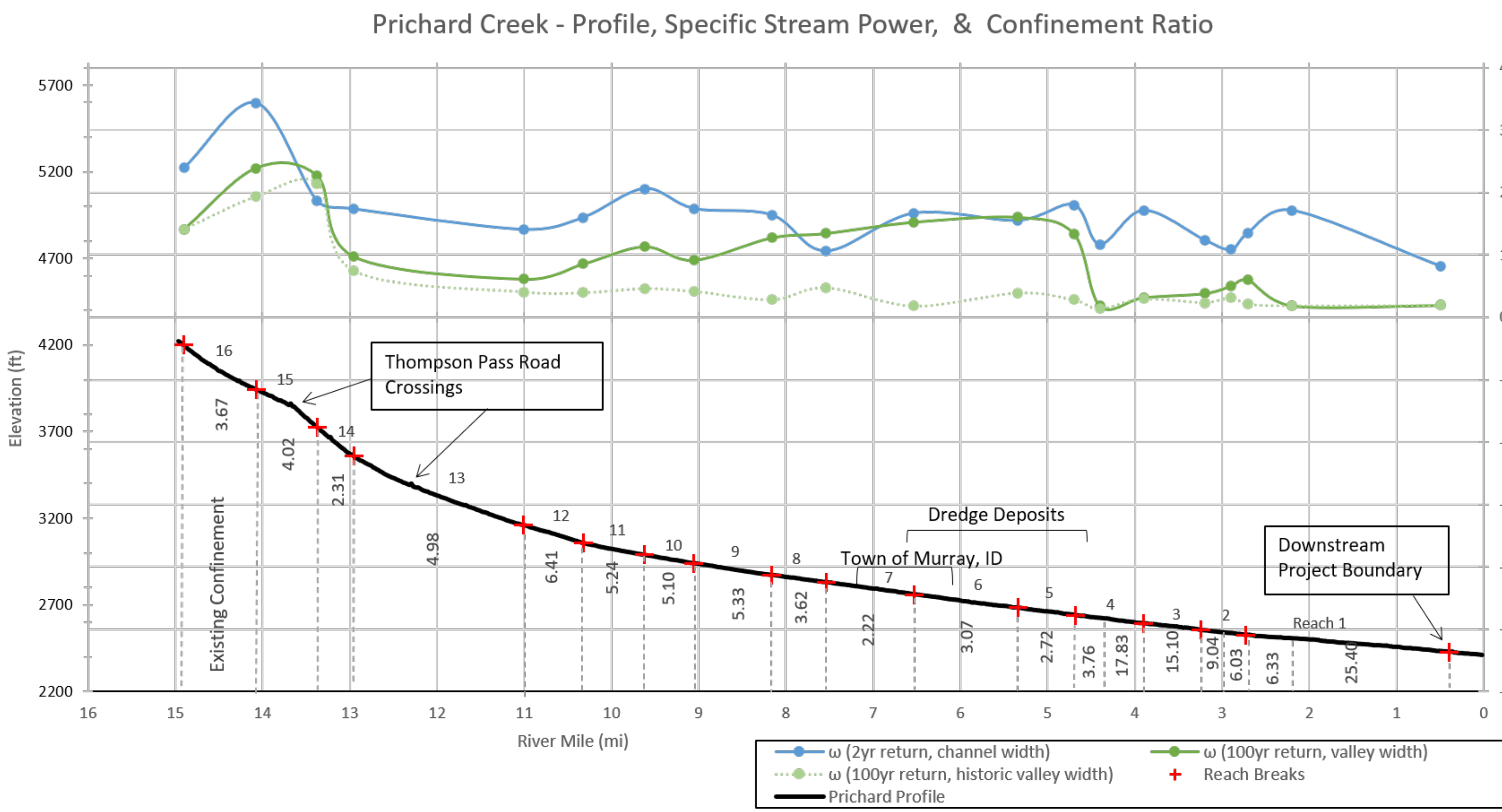

Figure 11. Prichard Creek profile from river mile (RM) 14.9 to 0.6 mi upstream of the confluence with the North Fork Coeur d'Alene (indicated as the downstream project boundary). Confinement ratio for reach each shown below the profile and separated by dashed lines. Reach breaks indicated with red crosses and labelled above the profile. Stream power plotted in green and blue above the profile and calculated for each reach.

2.1.6 Salmonid Use and Status

Fish species known to occur in Prichard Creek include Westslope Cutthroat trout (WCT; *Oncorhynchus clarkii lewisi*), rainbow trout, brook trout, longnose dace, and various sculpin species. WCT are native to Prichard Creek and are a BLM sensitive species (Figure 16). Brook and rainbow trout are both introduced species. Other aquatic species known to occur in the greater North Fork Coeur d'Alene (NFCDA) watershed also include mountain whitefish, Chinook salmon, torrent sculpin, and Pacific giant salamander. Lower Prichard Creek, from the mouth to the confluence with Eagle Creek at RM 2.7, is also designated as Bull trout critical habitat, though no bull trout have been observed in lower Prichard Creek and are thought to be extirpated from the NFCDA subbasin (IDEQ, 2013; BLM, 2012).

Of particular interest for this effort are WCT, which is the most widely distributed subspecies of cutthroat trout and are distributed primarily throughout the northern Idaho and western Montana (IDFG, 2013). In Idaho, WCT populations and distribution have declined compared to historical conditions, though WCT are estimated to still occupy 80% of their historical Idahoan range (IDFG, 2013). Overall, declines in population and abundance of WCT are likely a result of many factors, including the combined effects of habitat degradation and fragmentation, blocked migration corridors, degraded water quality or quantity, angler harvest and poaching, entrainment into diversion canals and dams, non-native fish species interactions, and other factors. Climate change may also play an important role in restricting distribution of Westslope cutthroat trout populations in the future (IDFG, 2013).

WCT can follow three life history forms, including lacustrine-adfluvial, which migrates between lakes and rivers, fluvial-adfluvial, which migrates between mainstem rivers and tributaries, and fluvial (resident), which spend entire lives in small headwater streams (IDFG, 2013). Though all three life history forms may occur in a single basin, the headwaters and upper reaches of large river basins like the Coeur d'Alene are typically dominated by resident and fluvial forms (IDFG, 2013).

Figure 12. Westslope cutthroat trout in Idaho (NF Clearwater watershed).

WCT utilize streams with cold, clean water and an abundance of pools with cover from large wood, vegetation, and boulders. As with other salmonids, the presence of excessive fine sediments can affect egg and juvenile WCT survival. Adult WCT typically first spawn at age 4 or 5. Spawning occurs between March and July, typically in small tributaries at water temperatures around 8-10°C (IDFG, 2013). Liknes (1984, in IDFG, 2013) found that sexually maturing adfluvial fish move into the vicinity of tributaries in fall and winter where they remain until they begin to migrate upstream to spawning areas in spring. A 2004 movement and migration study of pit-tagged fish by IDFG observed fish moving into spawning grounds quickly, following by rapid spawning and downstream migrations back to the main river. This study found that changes in water temperatures appeared to trigger WCT movement into spawning areas. Following spawning, WCT in the Coeur d'Alene watershed tend to stay in one subbasin for the entire summer, fall, and winter seasons, and after spawning WCT will return to the same area they utilized the previous year (IDFG, 2008).

Adult WCT sampling in Prichard Creek indicates a preference for holding in deep pools (1 – 3 meters) with slow water velocities and large wood or boulder cover available (IDFG, 2008). Water velocities during spawning vary but have been reported between 0.3 ft/sec and 3 ft/s and are assumed to be ideal between 1 – 2 ft/sec (Hickman and Raleigh, 1982).

Post-emergent fry prefer shallower water and slower velocities than larger juveniles. Fry typically utilize velocities of less than 1 ft/sec, but less than 0.25 ft/sec are preferred (Hickman and Raleigh, 1982). As WCT grow, they select deeper, faster water. Juvenile cutthroat in Idaho have been found in water velocities between 0.32 ft/sec and 1.64 ft/sec (Hickman and Raleigh, 1982). Juvenile cutthroat trout in streams are often found in water depths of 1.5 to 2.5 ft and close to cover. Larger WCT (15 cm or greater) are more frequently found in water depths of at least 0.5 to 1.5 ft (Hickman and Raleigh 1982). Cover in the form of aquatic vegetation, large wood, and interstitial spaces between rocks is critical for fry and older WCT.

After emergence, fry remain in natal reaches between 1 and 3 years prior to downstream migrations to larger rivers or lakes (for the adfluvial/lacustrine life histories) (IDFG, 2013). During summer months when flows are low, water temperatures often exceed WCT thermal tolerances. Coldwater refugia habitat is important for survival of WCT, with fish utilizing deep pools, off-channel habitats where groundwater inputs are present, or and where cover is available (IDFG, 2008; IDFG, 2013). Smaller fish, and those are still rearing in natal reaches, may utilize interstitial spaces between cobbles and gravels, where there may be cooler water from hyporheic exchange. Almost all fish during a 2004 summer survey were located in pools and runs with maximum depths between 1 – 3 meters and associated with some form of cover. The cover was usually large substrate or large organic debris. Extreme cold during the winter is also a factor in Prichard Creek and the North Fork Coeur d'Alene River. Contradicting what has been found in other basins, older/larger WCT in the NF Coeur d'Alene basin migrate downstream to larger rivers during winter (IDFG 2008), with a majority of radio-tagged fish moving to areas where there were wider floodplains during the winter. These overwintering areas also tended to have wider stream channels, greater depths, less cover and smaller substrate sizes. General observations indicate these fish used deep pools and areas with slower water velocities on the NFCDA during the winter (IDFG, 2008, Ed Lider USFS, pers. comm. 2021).

Limiting factors (IDFG, 2008) identified for WCT in the NF Coeur d'Alene watershed include:

- Degraded/loss of cold water refugia
- Degraded/loss of overwinter habitat for larger adult fish
- Degraded/loss of adult summer rearing habitat

2.1.7 Aquatic Habitat Conditions

Habitat conditions in Prichard Creek and other watersheds throughout Idaho have been impacted by historical and on-going land and water management activities. Activities that could decrease the quality or quantity of aquatic habitat include construction of dams and other diversion structures, timber harvest and forestry management, livestock grazing, intensive agriculture, road construction and maintenance, mining, and urban/rural landscape development (IDFG 2013). IDFG assessed stream habitat in Prichard Creek in 2004. Prichard Creek subbasin was dominated by riffle and pool habitat. Pool and run habitats were shallow, with maximum depths of 76% of the units measured less than 3.5 feet (IDFG, 2008).

Figure 13. Shallow riffle habitats with little stream bank cover or instream habitat complexity are common throughout Prichard Creek.

Aquatic habitat conditions observed during field surveys in 2020 were similar: simplified, shallow channel habitat units with limited cover and shade. Reach 1 offers some of the most dynamic channel habitat and floodplain off-channel habitats within the study area, with large log jams and associated complex pool/depositional features that offer high-quality rearing and refugia habitat for adult and juvenile salmonids. Fish sampling by the Idaho BURP program has recorded relatively large WCT (>300 mm) in lower Prichard Creek (BURP, 2018).

Mainstem channel habitat in reaches 2 and 3 is largely a single-thread channel with a few large wood jams and associated deeper pools located on the outside of meander bends and limited off-channel habitats. Reach 4 represents an actively mined segment of Prichard Creek that flows through an active main channel along the south side of the valley. The channel bed through this reach is featureless plane bed, with smaller gravel and cobble sizes as compared to Reach 1. Mobile bars are frequent. Much of the mobilized sediment through this reach has transported through and deposited between RM 4.0 and RM 4.2. Between reaches 4 and 6 there is very little quality fish habitat available. Mining activity is present in reach 4, while the historical mining operations in reaches 5 and 6 have altered the channel and floodplain conditions dramatically. During dry summers, the channel loses water and flows subsurface in reaches 5 and 6, sometimes not reemerging until downstream of RM 5.3. Little to no large wood or other cover habitat is present in these reaches.

From Reach 7 upstream, the channel is more naturally confined with smaller pockets of floodplain or off-channel habitats. Prichard Creek Road confines the channel and floodplain even further in some locations. A small number of large wood jams are present, generally located on the outside of meander bends. Instream aquatic habitat in Prichard Creek in these reaches is highly simplified, with limited rearing and refugia habitat. Channel slope starts to increase in reach 11 compared to downstream reaches. Fish habitat in reaches 12 – 16 is largely consistent with other forested headwater systems, with relatively steep plane bed riffle transitioning to step pools in the upper reach. The valley is increasingly confined in upper Prichard Creek, and large boulders and frequent small pools form the majority of the habitat in these reaches. Large wood inputs are frequent and provide overhead cover, but fallen trees often span the channel above the wetted perimeter.

Water Temperature

Water temperatures throughout the year are a key factor in fish use and movement to or from habitats. Water temperature monitoring at the mouth of Prichard Creek between 1998 – 2004 found water temperatures remained below 16°C throughout the year. Even so, only a few (n = 4) fish were found in Prichard Creek during survey efforts and Prichard Creek was not frequently utilized by fish in the summer, despite much cooler water temperatures than those found in the adjacent NF Coeur d'Alene River (reaching 25°C; IDFG, 2008). Fish sampling by the Idaho BURP program has recorded more numbers of WCT in lower Prichard Creek, including relatively large WCT (>300 mm; BURP, 2018).

WCT appear to avoid water temperatures 22°C or greater, seeking out cold-water refugia in deep pools (greater than 2 m deep preferred) with cover or in side channels where water temperatures were lower, possibly from increased groundwater inputs. Degraded and lost cold-water refugia is primarily impacting larger WCT (greater than 300 mm in length). Several differences in habitat use and behavior of the smaller fish help explain these differences. Younger, smaller WCT remain in tributary habitats for up to 3 years where water temperatures are generally cooler, and smaller fish that have moved out of their natal habitats can migrate back into the smaller headwater tributaries (that are too small for larger fish to utilize adequately). The larger tributaries that could support bigger fish looking for cold-water refugia tend to be dominated by riffle habitat, shallow water, and have limited cover. Smaller fish also can move into interstitial spaces in the substate where they are protected and may possibly access waters cooled by subsurface hyporheic interaction (IDFG, 2008).

Equally important to WCT survival in Prichard Creek and the greater NF Coeur d'Alene is availability of suitable overwintering habitat. Water temperatures in Prichard Creek can drop below 0°C in January with ice cover (IDFG, 2008). Smaller fish are typically found utilizing voids in the substrate, while larger fish (200-300 mm or greater) have been found to utilize slow, deep pools in lower, larger river systems in the winter. The presence of floodplain may be a key factor in winter habitat selection for many WCT in larger river systems in Idaho (IDFG, 2008).

Climate Change Impacts on WCT

Climate change may also be a key factor affecting habitat availability and WCT distribution in the NF Coeur d'Alene watershed. According to NorWeST stream temperature mapping (Isaak et al. 2017), Prichard Creek may see an increase of around 2°C by 2080 during the summer. Even with the increase, water temperatures are predicted to remain relatively cool and remain below 16°C in mainstem Prichard Creek within the study area (Isaak et al., 2017). In the upper reaches, predicted 2080 water temperatures are between 12 – 14 °C, indicating the potential for Prichard Creek to continue to provide cold water refugia.

Water Quality

Prichard Creek is located within the Coeur d'Alene Mining District, one of the world's largest producers of silver and one of the Nation's largest historical producers of lead and zinc. Because of historical activities associated with the mining and milling of silver-lead-zinc ores, these streams have been significantly impacted, both physically and chemically. Historical and on-going mining practices in Prichard Creek have resulted in increased concentrations of minerals/metals in the substrate and water column. Compared to a nearby reference site, the USGS (2004) found streambed sediment in the vicinity of the mines and mill sites had elevated lead and zinc contents that were 20 to 100 times background values. Mercury and arsenic concentrations were also elevated near the mine/mill sites compared to the reference conditions. These concentrations generally decreased moving downstream from the mine/mill sites. Maximum enrichments of mining-related elements in streambed sediment in Prichard Creek generally occur upstream from Murray except for arsenic, which peaks from Murray to Eagle (Figure 14). Lead, zinc, and mercury contents peak in Prichard Creek just below the Monarch mill site and decrease sharply to the vicinity of the town of Murray, then move gradually downstream.

Further assessment of sediment and surface water contamination in 2021 (Alta Science & Engineering, Inc.) found levels of cadmium, lead, and zinc exceed water quality standards in Prichard Creek surface water. Arsenic concentrations did not exceed water quality standards but was elevated relative to background conditions. Sediment samples exceed EPA standards for arsenic and lead within the watershed, and show elevated levels of cadmium, mercury, silver and zinc. Compared to earlier assessments (USGS 2004), recent composite sediment samples do show some improvements in metals concentrations for arsenic, barium, and chromium. Lead and zinc concentrations are increased over previous samples in the middle of the study area, though these increases are not statistically significant.

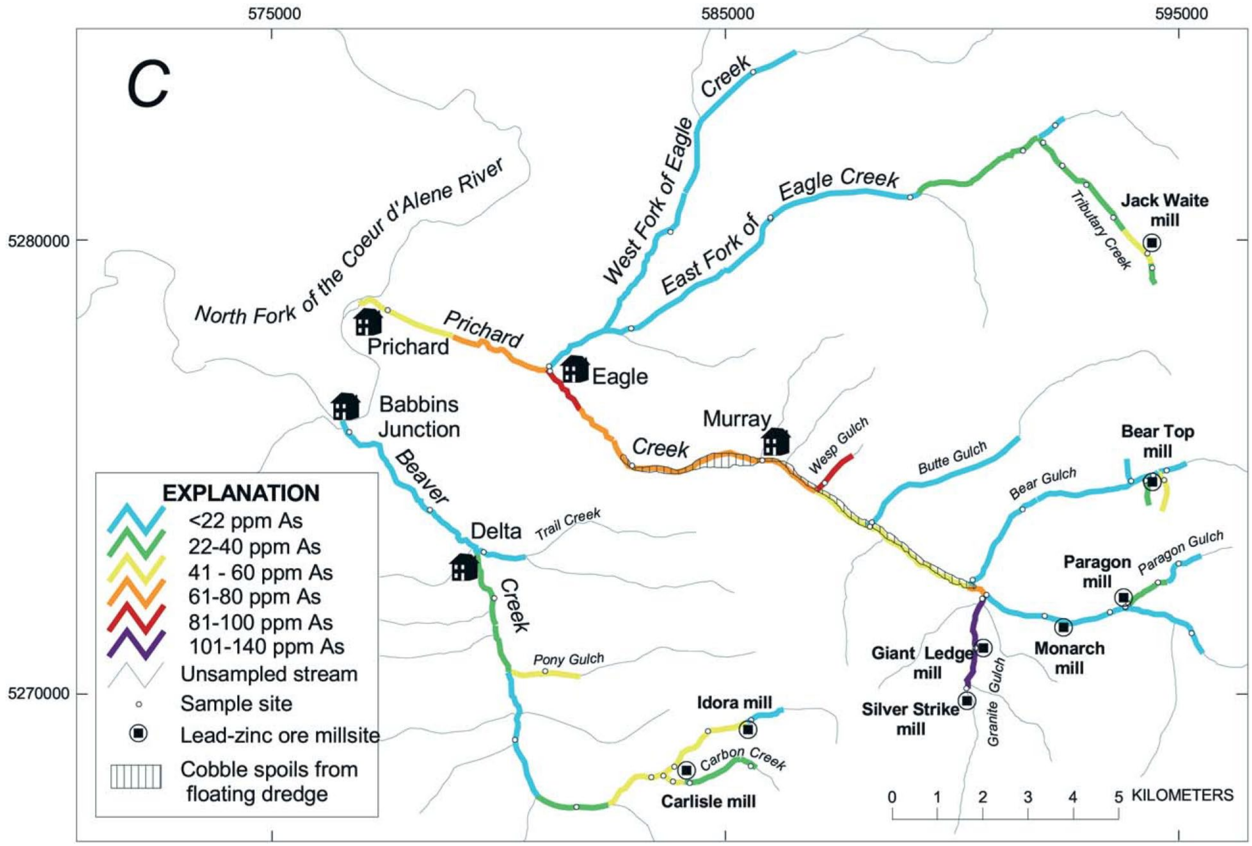

Figure 14. Arsenic concentrations peak on Prichard Creek between Murray and the Eagle Creek Confluence (from USGS, 2004).

Elevated levels of metal contaminants in Prichard Creek may reduce potential for high-quality habitat in these reaches. Woodward et al. (1997) found cutthroat trout avoided water with relatively low concentrations of cadmium, copper, lead, and zinc (2004 and 2021 samples show significantly higher levels in Prichard Creek).

2.1.8 Aquatic Organism Passage

Aquatic Organism Passage (AOP) was assessed in the field, along the mainstem of Prichard Creek. Crossings evaluated as part of this assessment include Eagle Creek, Tiger Gulch, Butte Gulch, Bear Gulch, and Prichard Creek at RM 12.3 (Thompson Pass Road). The crossing at Eagle Creek is a bridge with natural substrates in the channel. Butte Gulch, Bear Gulch, and RM 12.3 (Figure 15) are all bridges or box culverts with either open bottoms or have streambed substrates that form a natural channel. The hydraulic characteristics of these crossings were not quantitatively assessed, but it is assumed that it is unimpeded at low to moderate flows. Higher magnitude flood flows may prevent a velocity barrier to passage.

Tiger Gulch appears to supply a substantial amount of sediment to Prichard Creek but was dry at the time of the field visit. The crossing is a corrugated metal pipe under Kings Pass Road and likely presents a passage barrier at times of flow. Fish use of the tributary is uncertain, but this crossing may warrant further investigation if this tributary is determined to be important for fish.

In the project area, the primary AOP barrier is that the creek flows subsurface from RM 4.4 to RM 6.7 (approximately) for portions of the year (Figure 15). Based on our observations and conversations with locals, the creek through this stretch can go from flowing to dry in the span of a day. This behavior is a direct result of the dredging that occurred in the past, as the dredge effectively turns over the floodplain. Fine sediments that would have slowed subsurface flow flush downstream, leaving an overly coarse and sorted substrate through which water can easily infiltrate. As part of this project, TU and IFG have installed a network of monitoring wells that will provide seasonal and spatiotemporal information on groundwater levels. This information will be used to determine potential restoration strategies.

Figure 15. Crossings on Butte Gulch (top left) and RM 12.3 (top right). The show a downstream view of Prichard Creek, taken near RM 4.7, of water flowing in late June (lower left) and dry in November (lower right).

2.1.9 Reach-Based Ecosystem Indicators (REI)

The Reach-based Ecosystem Indicators (REI) provides a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These indicators, along with other scientific evaluations, describe the current quality of stream biophysical conditions and can help inform restoration targets and actions. The specific subset of reach-scale REI indicators used in this assessment are adaptations from previous efforts including the NMFS matrix of pathways and indicators (NMFS, 1996) and the USFWS (1998). With a few exceptions, the REI are based on the USBR's latest adaptations and use of these indicators (USBR, 2012). Watershed-scale indicators were not evaluated for Prichard Creek.

Per the request of Trout Unlimited, Bank Stability was added to the REI, focusing on the presence of active erosion deemed to be caused by anthropogenic actions and mass wasting of the bank. Actively eroding banks determined to be part of natural processes and covered by woody vegetation were not considered in the evaluation. Instead, banks were flagged as at risk if more than 10% of the channel length per reach was actively eroding, lacking woody vegetative cover, and the result of anthropogenic actions. Banks rated as unacceptable exhibited mass wasting and are likely contributing excess sediment to the creek.

The REI evaluation for Prichard Creek was conducted using field data and observations, previous studies, and desktop analyses for the study area, and is provided in Appendix B. Specific indicators were selected due to their applicability to salmonid habitat evaluation and availability of field or desktop-driven data availability (e.g., LiDAR or high-resolution ortho-imagery available for assessment). Functional ratings include **Adequate**, **At-Risk**, or **Unacceptable**. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches.

General trends in the reach-scale metrics show some of the poorest riparian and channel conditions are present in the middle reaches of the Prichard Creek assessment area. Reach 6 is the most impacted reach with seven **Unacceptable** ratings, the most of all the reaches. Reaches 5 and 9 both had five **Unacceptable** ratings. The legacy of historical and ongoing human disturbances – including timber harvests, development for residential or agricultural uses, and mining or dredging activities – have contributed to the ecosystem impacts in these reaches. Reaches 1 through 3 offer some of the least impacted habitat to varying degrees; Reaches 1 and 3 had the most **Adequate** ratings (6) with no **Unacceptable** ratings. Reaches 12 through 16 in the upper watershed were not assigned ratings for several indicators.

The ratings relating to salmonid habitat ranged from **Adequate** to **Unacceptable** across the study area. All reaches besides Reach 1 received **Adequate** ratings for the Dominant Substrate/Fine Sediment indicators since there were primarily gravel and cobble substrates and limited sands or fine material that can be detrimental to egg incubation and juvenile rearing. Reach 1 was given an **At-Risk** rating due to a greater percentage of sands and other fine substrates.

Large wood ratings were highly variable among the reaches, and were based on the number of large wood jams present in the reach. Reaches 1, 3, 8, and 12 were assigned **Adequate** ratings for large wood. Pool frequency was primarily rated **Unacceptable** in the assessment area, with Reaches 3, 7 and 12 the only **Adequate** ratings. Large, deep pools with cover were often associated with large wood jams. Pool frequency was given an **At-Risk** rating for Reaches 1 and 8 due to low quality of the pools (low residual depths and minimal/no large wood cover or habitat). Reaches 13 – 16 were not assigned ratings for Large Wood or Pools due to a lack of low-elevation, high quality orthoimagery from which these metrics could be tallied. Off-channel habitat in the assessment area is more available in the lower reaches than the upper watershed. The Off-channel Habitat indicator was rated as **Unacceptable** for Reaches 5 – 9 and 12 – 16 due to either the complete lack or very infrequent occurrence of connected alcoves and side channels or floodplains. Reaches 1 and 4 received **Adequate** ratings for this indicator.

Reaches 1 – 3 received **Adequate** ratings for the Habitat Access Pathway- Main Channel Accessibility indicator. The main channel of Prichard Creek flows subsurface through Reaches 4 – 6 during low flows, limiting salmonid movement and migration through the assessment area and into the upper reaches. Reaches 5 through 16 were assigned **Unacceptable** ratings for Main Channel Accessibility, due to the subsurface flow conditions downstream, with Reach 4 receiving an **At-Risk** rating for the portion of the channel within the reach going subsurface.

Indicators of Riparian vegetation condition – Structure & Canopy Cover and Human Disturbance – were rated more favorably in the lower and upper portions of the watershed than the middle reaches. In particular, Reaches 5 and 6 were rated **Unacceptable** for both indicators. Riparian vegetation size and density increases in the upper reaches (primarily Reaches 12 – 16). Reaches 4 through 10 received **Unacceptable** or **At-Risk** ratings in the Human Disturbance indicator due to residences or other developed areas within the riparian zones. In many of the middle and upper reaches (Reach 4, 7, 8, 9, 10, 13, and 15), Prichard Creek Road or Thompson Pass Road runs immediately adjacent to the channel and limits the presence of high-quality riparian vegetation. Reaches 1 – 3, 11, 12, 14, and 16 received ratings of **Adequate** for this indicator due to minimal roads and development located within the riparian zone of these reaches.

Channel dynamics for Reach 1 is satisfactory; Reach 1 received Adequate ratings for both indicators: Floodplain Connectivity and Bank Stability. Most of the assessment areas (Reaches 2 – 13 and Reach 15) were assigned an **At-Risk** rating for the Floodplain Connectivity indicator, with the loss of well-inundated floodplains due in part to human disturbances. However, few reaches had actively eroding banks that were associated with anthropogenic actions; only Reaches 4, 6 and 7 were assigned **Unacceptable** ratings, and Reach 11 was rated **At-Risk**. All other reaches were rated **Adequate**, indicating bank erosion or presence of vertical banks is associated with natural channel migration processes. Reaches 13 – 16 were not assigned ratings for the Bank Stability indicator but were assumed to be in **Adequate** condition.

For the study area as a whole, **Unacceptable** was the most common rating (47), followed by **Adequate** (42) and **At-Risk** ratings (40). A summary of all reach ratings is presented in Table 2 below.

Table 2. Summary ratings for the Prichard Creek reach assessment study area. Ratings are color-coded, with green shading for Adequate condition, yellow for At Risk condition, and red for Unacceptable condition.

Path-way	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16
Habitat Quality	*Substrate*	*Dominant Substrate / Fine Sediment*	At Risk	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	No Rating	No Rating	No Rating
	LWM	*Jams per mile*	Adequate	Unacceptable	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	Adequate	Unacceptable	Unacceptable	At Risk	Adequate	No Rating	No Rating	No Rating	No Rating
	Pools	*Pool Freq. & Quality; Large Pools*	At Risk	Unacceptable	Adequate	Unacceptable	Unacceptable	Unacceptable	Adequate	At Risk	Unacceptable	Unacceptable	Unacceptable	Adequate	No Rating	No Rating	No Rating	No Rating
	Off-Channel Habitat	*Connectivity with Main Channel*	Adequate	At Risk	At Risk	Adequate	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Riparian Vegetation	*Condition*	*Structure & Canopy Cover*	At Risk	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk
		Disturbance (Human)	Adequate	Adequate	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	At Risk	At Risk	At Risk	Adequate	Adequate	At Risk	Adequate	At Risk	Adequate
Channel Dynamics	*Floodplain Connectivity*		Adequate	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate	At Risk	Adequate
	Bank Stability		Adequate	Adequate	Adequate	Unacceptable	Adequate	Unacceptable	Unacceptable	Adequate	Adequate	Adequate	At Risk	Adequate	No Rating	No Rating	No Rating	No Rating
Habitat Access	*Physical Barriers*	*Main Channel Barriers*	Adequate	Adequate	Adequate	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable

2.2 REACH-SCALE CONDITIONS

The following sections outline the assessment results for each reach. In some instances, shorter reaches, with characteristics similar to adjacent reaches have been grouped together.

2.2.1 Reach 1 (RM 0.4 - 2.7)

Reach 1 is the downstream-most reach within the study area just above the confluence with the North Fork Coeur d'Alene and just below the confluence with Eagle Creek. It is characterized as a broad alluvial valley with distributary flow and many side channels, alcoves, and pools (Figure 16).

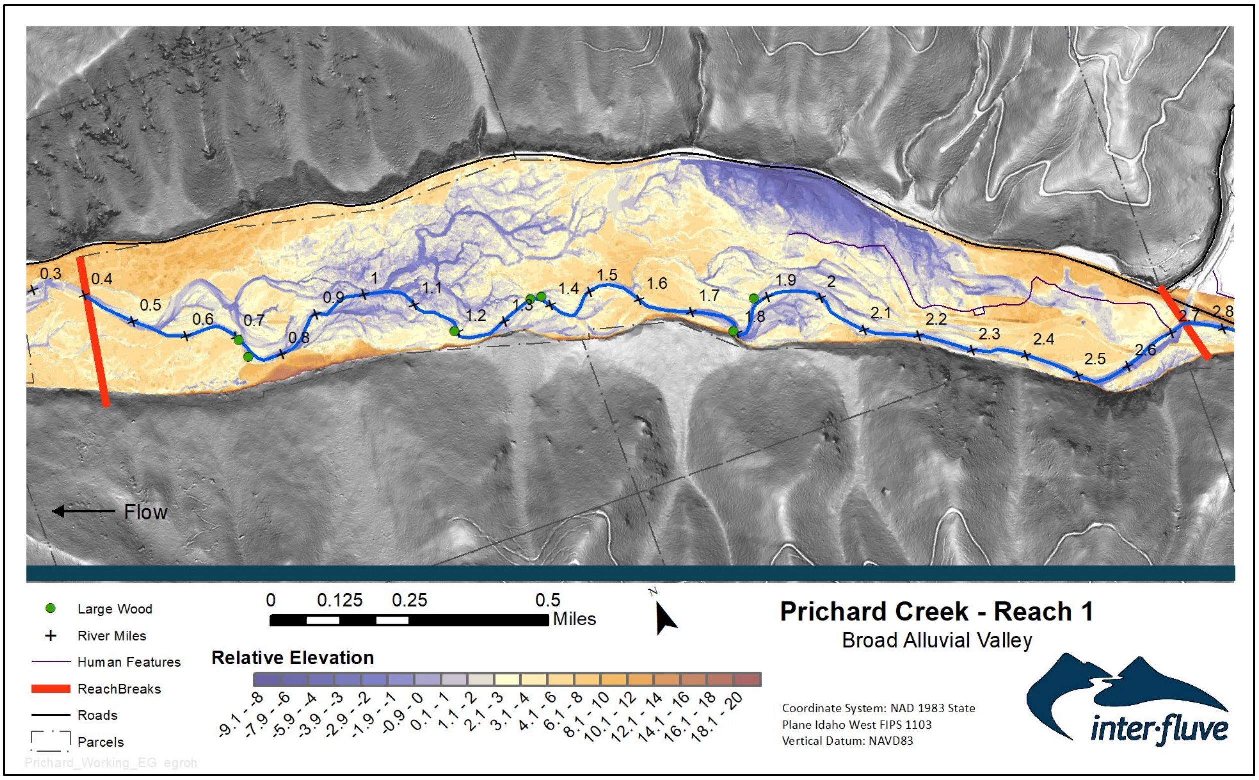

Figure 16. Overview map of Reach 1.

Geomorphology

Reach 1 has a reach-averaged slope of 0.008 and is 12,300 ft long, following the river centerline. The increased sediment supply from Eagle Creek just upstream creates the shift in Prichard Creek from a moderately confined channel to a multi-threaded stream with a broad alluvial floodplain. The lack of confinement also allows for an active floodplain with >10 connected side channels with a combined length >7,500 ft and deep pools with ample shade along these side channels. There are seven distinct large wood jams along the mainstem channel, in addition to numerous smaller accumulations, and approximately 3% of the riparian zone (defined as the area within 100 feet of the main channel for this assessment) is covered with shade trees (trees 100 ft or taller).

Based on geomorphic features and level of confinement, Reach 1 can be broken into two segments; the downstream segment from RM 0.4 to 2.2 and the upstream segment from RM 2.2 to 2.7. The upstream segment is confined by human features to the north which has pushed the channel against the valley walls to the south, cutting off access to much of the floodplain. The confinement ratio (defined as the ratio of channel width to valley width) for the existing channel in the upstream section (RM 2.1 to 2.7) is 6.3; whereas the confinement ratio for the downstream section (RM 0.4 to 2.1) is 25.4. The change in confinement is reflected in the channel pattern, with an active floodplain and braided channel morphology in the downstream section, and a single-thread channel with little available floodplain area in the upstream.

Specific stream power, or the rate of energy dissipation against the riverbed per unit of channel width, through Reach 1 is generally very low (~20 W/m^2) at the one-hundred-year return period peak flow, reflecting the substantial width available for the river to spread across. However, the confinement caused by the remnant infrastructure in the upper end of the reach causes the specific stream power to spike (~60 W/m^2) through that segment (RM 2.1 to 2.7). This has the effect of turning what would otherwise function as a response reach, into a transport reach. Near RM 2.1, the remnant infrastructure is no longer present, allowing flood flows to spread into the floodplain. This causes a decrease in stream power (from ~60 to 20 W/m^2), and thus a reduction in the rivers' ability to transport sediment. As a result, this portion of the channel is severely aggraded. This has encouraged flows to find relic channels and alternate, down valley pathways through the Reach 1 floodplain. As the river adjusts to the deposition, it has moved laterally, recruiting the trees seen in the large jams present in the lower floodplain.

Human Alterations and Erosion

Reach 1 is one of the few reaches within Prichard Creek that has very little human alteration. There is a small gravel road, indicated in purple above, that runs along Prichard Creek and Thompson Pass Rd, indicated in black above, that runs along the northern edge of the floodplain. Legacy infrastructure, in the form of a railroad grade, is present in the floodplain between RM 2.1 and 2.6. The floodplain between the elevated features and the existing highway has also been cleared and potentially used for log sorting in the past. Increased sedimentation at the mouth of Prichard Creek has been observed and is attributed to eroding banks further upstream (BLM, Environmental Assessment, 2012).

Biological Considerations

Reach 1 offers some of the most dynamic channel habitat and floodplain off-channel habitats within the study area. In addition, there are some significant log jams and associated complex pool/depositional features that offer high-quality rearing and refugia habitat for adult and juvenile salmonids. Lower Prichard Creek is a dynamic channel that actively responds to flood events. The aerial photo record over the past 60 years suggests multiple transitions from braided to a multi-thread planform, with a larger main channel present periodically. The current channel from RM 0.4 to 2.7 consists of a main low flow channel roughly 30-40 feet in width traversing a larger active channel between 200-300 feet in width. This larger channel contains the main low flow channel and both wet and dry multi-thread channels, all of which have homogenous, plane bed profiles over cobble and gravel substrates (Figure 17**Error! Reference source not found.**).

Figure 17. Prichard Creek at RM 1.2. Plane bed channel segments like this one offer little or no fish habitat, and the small, mobile bed material sizes offer limited stable attachment sites for macroinvertebrates.

Islands of vegetation exist, but the majority of these are shown to be ephemeral in the photo record. A number of riffles are present in this reach but appear to be highly mobile gravel lobes that may or may not provide stable spawning habitat for cutthroat trout and other species.

Large wood plays a significant role in in-stream habitat formation in lower Prichard Creek. There are approximately 600 pieces of large wood (greater than 10" in diameter and 10 feet in length) from RM 0.4 to the Eagle Creek confluence. These wood accumulations take the form of racked bank accumulations, channel spanning jams, mid channel jams and apex bar jams (Figure 18). Throughout the reach, side channels and backwater areas with large wood accumulations provide quality juvenile fish rearing habitat. In the downstream half of the reach, side channels have limited wood present. These relatively open backwater areas provide no overhead cover, are shallow and are exposed to full sun.

Large wood protruding from banks and accumulated along bank margins provide some cover for fish, but these jams vary in associated pool habitat. There are a select number of large log jams at meander bends that offer complex bed forms, overhead cover, and deep pool habitat.

Figure 18. Large wood accumulations in lower Prichard consist mainly of a) channel spanning jams that cause channel departures or multi-threading, b) mid channel structures that guide the main channel, c) racked bank accumulations, and d) apex bar jams or racked wood at the head of vegetated islands.

In addition to the large wood accumulations, Reach 1 is also influenced by the presence of beaver. Both active and abandoned beaver dams are present in the many inundated side channels, and beavers have built a large complex of ponds along the highway (visible in the REM near RM 2). These ponds occupy a relic Prichard Creek channel and are likely fed by local hillslope drainage and tributary inputs.

Recommended Actions

Overall, Reach 1 is functioning at a fairly productive level, though it lacks deep pools and cover, and legacy human works are encroaching on the floodplain. A primary component of the strategy for Reach 1 is to leave the high functioning aspects undisturbed (e.g., existing wood accumulations, beaver dams and ponds, large standing trees). Recommended actions include:

- Adding large wood structure to scour deep pools and sort the substantial sediment load being delivered to the reach. Existing accumulations of large wood serve as excellent analogs and demonstrate the effectiveness that wood structures could have on the reach.
- Adding cover to side channels and existing pools. In the mainstem, this could be accomplished with wood structures. In the side channels, low-tech approaches (*sensu*

Wheaton et al., 2019), including structures made of small wood and beaver dam analogs, and falling select trees could be effective.

- Removing the legacy railroad grades and human features present in the upper portion of the reach.

2.2.2 Reaches 2 - 4 (RM 2.7 – 3.7)

Reaches 2 through 4 are characterized as moderately confined with a few side channels and large wood jams as well as human alteration (Figure 19). There is a parcel of private land containing a cabin on the banks of the creek in Reach 3. Reach 4 contains the Four Square mine, through which the river avulsed in 2011 or 2012. For portions of the year, Prichard Creek flows subsurface from above Reach 4 to approximately RM 4.3, presenting a significant passage barrier.

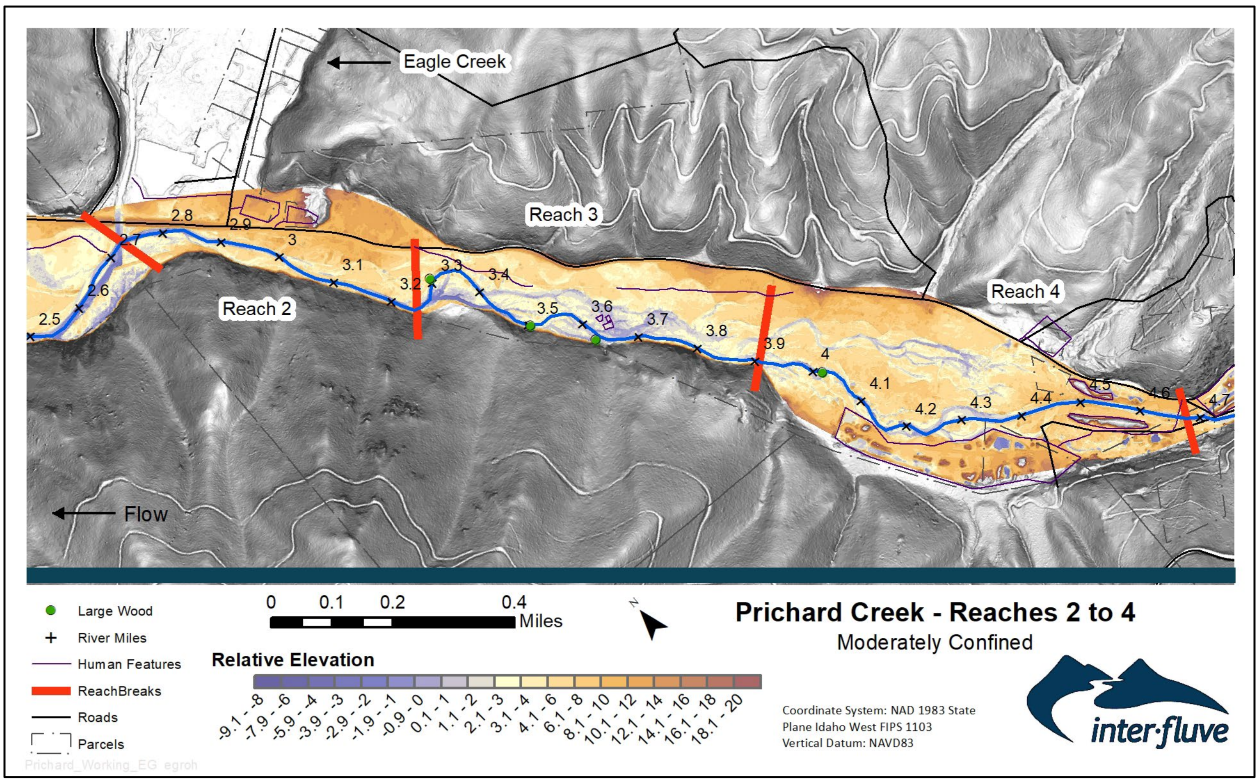

Figure 19. Overview map for Reaches 2-4.

Geomorphology

The total length along the centerline of Prichard Creek within these reaches is 10,300 ft, and the reach-averaged slope for each reach is around 0.01 ft/ft. Through these reaches, the valley narrows, moderately confining the channel: in Reach 2 by Thompson Pass Road; in Reach 3 by the adjacent hillslopes; and, in Reach 4 by mining deposits and buildings. There are a total of 5 side channels with a combined length of 4,300 ft, and the percentage of the riparian area covered in shade trees ranges from less than 2% in Reach 4 to nearly 8% in Reach 2. There are 4 large wood jams along the mainstem channel in this section of reaches. A geomorphic feature to note is the relic channel within Reach 4 due to the main channel avulsion in the south end of the floodplain. The relic channel area offers a well-established floodplain with side channels, pools, large wood jams, ample shade trees and alcoves.

The confinement ratio through reaches 2, 3, and 4 generally decreases in the downstream direction (~18 in Reach 4 and 6 at the bottom of reach 2) as the valley narrows and the channel approaches the Eagle Creek Crossing. The available floodplain appears generally active in Reaches 3 and 4. Beaver dams, both active and abandoned, are prevalent in both reaches. Mining related infrastructure and dredge spoils confine the upper end of Reach 4.

Following the trend of increasing confinement in the downstream direction, estimated specific stream power also generally increases in the downstream direction. For the 100-year return period peak flow, stream power increases from approximately 18 W/m^2 at the top end of reach to 50 W/m^2 at the downstream end of Reach 2. These values are elevated relative to estimated historical conditions of less than 10 W/m^2. Specific stream power estimates for the two-year return period peak flow more closely follow the variations in channel width (as opposed to valley width) and show more variability.

In response to the trends in confinement and stream power, Prichard Creek transitions from a response reach (i.e., adjusting its geometry in response to the sediment supply) to a transport reach (i.e., passing the incoming sediment load through with limited ability to adjust its geometry). The difference between historical and contemporary specific stream power suggests that floodplain encroachments may be influencing channel dynamics.

Human Alterations and Erosion

Reach 2 is confined by Thompson Pass Rd which also has a bridge where it passes over the confluence with Eagle Creek. There are a few gravel roads that cross the floodplain as well as houses along the banks of the channel. A berm has been constructed near RM 3.3, presumably to protect the road. The main human alteration in this group of reaches is the Four Square mine (Figure 20) and the dredge spoils in Reach 4. Vegetation clearing associated with the mining operation likely contributed to the channel avulsion experienced in 2011 or 2012.

Figure 20. Prichard Creek though the Four Square Mine is braided and lacks a vegetated riparian zone.

Water Level Monitoring

To understand the impact of the dredging on surface water flows, water surface elevations (WSE) were monitored in five wells through the reach (Figure 21). Table 3 displays select descriptive statistics for the wells in Reach 4; Figure 22 and Figure 23 show elevations relative to topographic cross sections and profiles. WSE slopes in the down-valley direction approximately match the overall valley slope of 0.013 ft/ft. In the upper portion of reach four, the water surface maintains a similar average elevation on both sides of the valley, with a mean elevation of 2631.0 and 2631.2 at wells 5 and 6, respectively. Moving down the reach, the ground water remains higher on the right side of the valley, with well two having a mean elevation 4.1 feet above that of well four. The WSE in wells four and six, on the river left side of the valley, are on average closer to the surface than wells two and five, which are located on the river right side of the valley. The former Prichard creek alignment is a few feet higher than the current main channel, and is flanked by a mostly intact floodplain. Tributary and hillslope runoff and a fluvially-sorted soil structure likely help maintain higher WSE on that side of the valley. These monitoring results suggest that water is close to the surface (i.e., within a foot) through Reach 4.

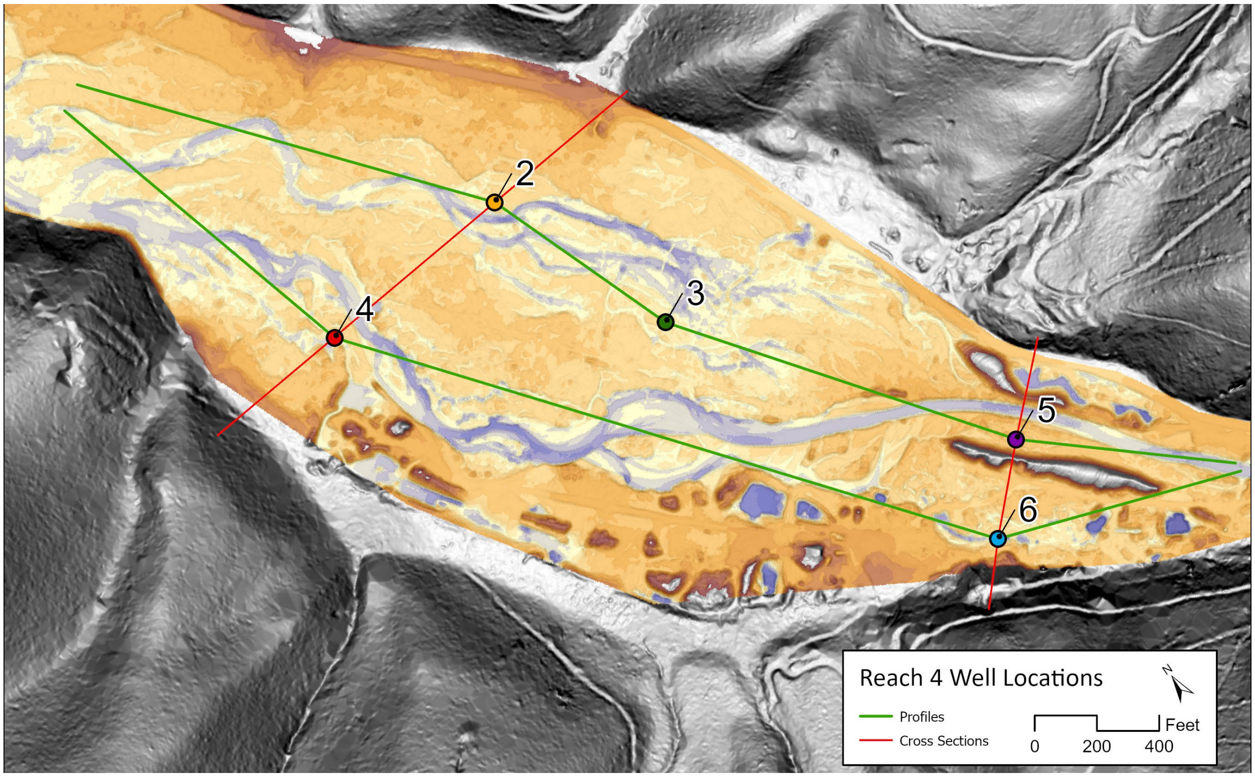

Figure 21. Reach 4 well locations, numbers, and the cross sections and profiles used to compare elevations.

Table 3. WSE for wells located in Reach 4. Low WSE refers to the 5th percentile WSE between August 15 and October 20.

Well	Low WSE (ft)	Mean WSE (ft)	Max WSE (ft)	Range (ft)
Well 2	2603.0	2606.2	2608.7	5.7
Well 3	2614.7	2616.5	2618.5	3.9
Well 4	2601.1	2602.1	2603.4	2.4
Well 5	2629.1	2631.0	2633.5	5.0
Well 6	2630.1	2631.2	2631.9	1.8

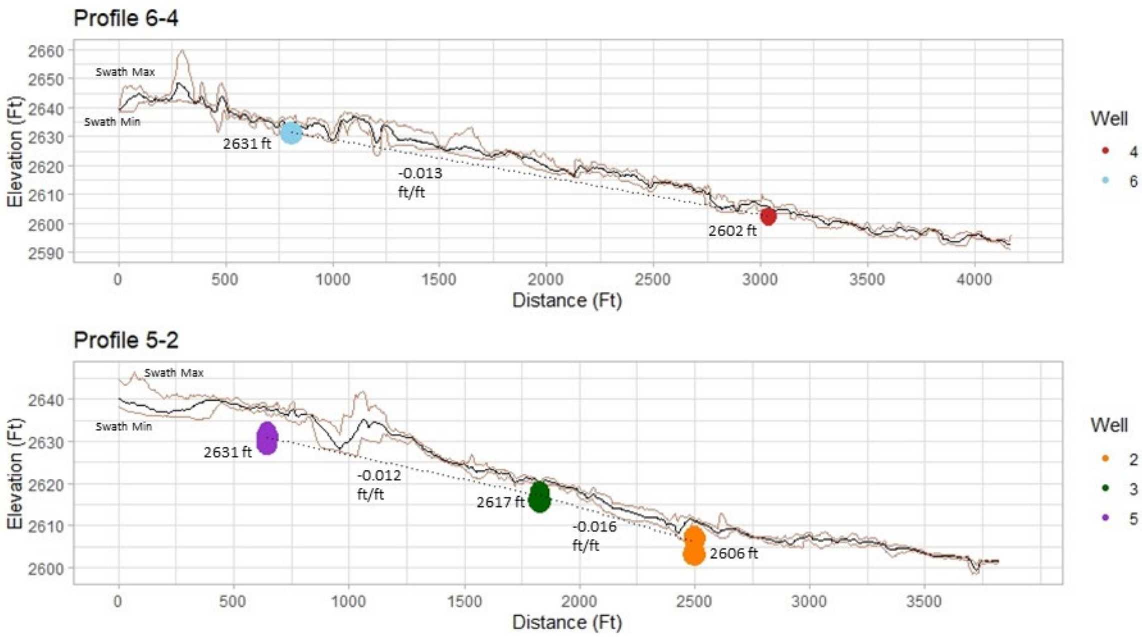

Figure 22. WSE profiles showing the data of profiles depicted in Figure 21. Colored dots show the range of elevations for that well. The most frequently occurring elevation is labeled. The slope of the water surface is labeled. Topography is from LiDAR and brown lines represent a 50 m swath to show local variability.

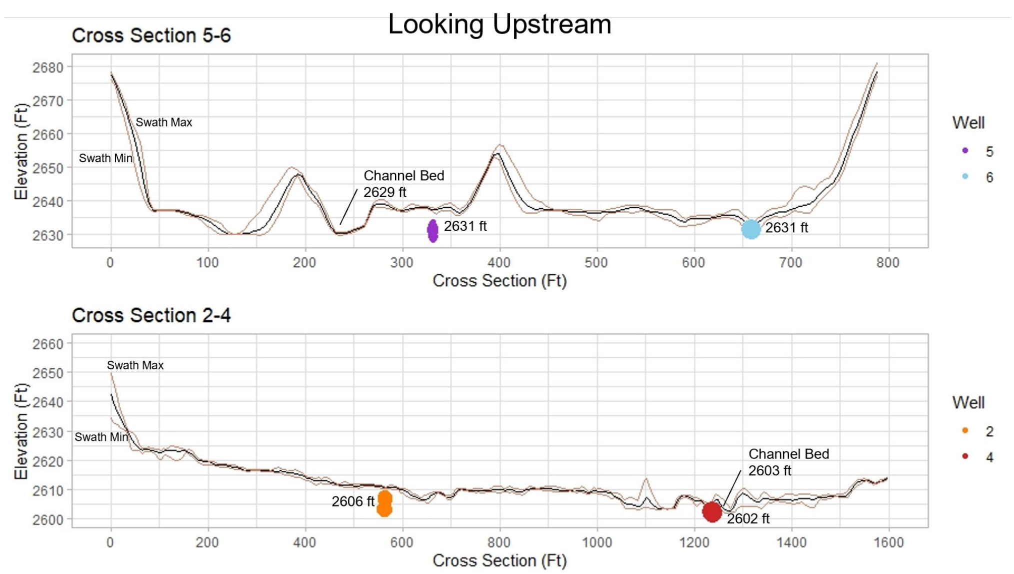

Figure 23. Cross sections showing how WSE vary across the floodplain for paired wells. Topography is from LiDAR and brown lines represent a 50 m swath to show local variability.

Biological Considerations

From RM 2.9 to RM 3.4 (Reach 2), Prichard Creek Road runs immediately adjacent to the channel on river-right, disconnecting the Eagle Creek alluvial fan and Prichard Creek's river-right floodplain. Moving upstream into Reach 3, the road runs closer to the valley toe and away from the river channel and floodplain. The upstream end of Reach 3 is where the most recent avulsion channel returns flow to the pre-flood Prichard Creek and is also the downstream end of the active mining area in Reach 4. The channel runs along the river left side of the floodplain for a significant portion of this reach. The southern hillslope and abundant riparian trees, such as spruce, fir, willow and alders, provide significant shade to Prichard Creek. Mainstem channel habitat in reaches 2 and 3 is largely a single-thread channel with a few large wood jams and associated deeper pools located on the outside of meander bends. Cover habitat within the mainstem is limited. The main channel upstream of the Eagle Creek confluence (RM 2.9 – RM 3.6) consists of long, cobble-bed riffles and runs, and large wood accumulations are infrequent. Channel dimensions may be impacted here by construction fill and mining. Banks consist of generally unsorted sand (50%) and gravel and cobble (50%). Bank heights vary from 3-4 feet, with a consistent lower limit of woody vegetation approximately 2 ft off of mean depth.

From 3.2 to 4.0, beaver activity has created split flow conditions in this segment (Figure 24), and large wood accumulations have diverted flow into wooded floodplain areas, either through existing relic channels or in newly created side channels varying in width from 5-20 feet. Juvenile fish were observed in the side channels.

Figure 24. Beaver ponds in Reach 3 (left) is driving the development of new channels through the river right floodplain (right).

Larger relic channels wind through the river right floodplain. A primary, or recently active side channel is present from RM 3.45 to 3.6 and has a bed elevation roughly 1.5-2.5 feet above the current main channel bed (Figure 25). This side channel had been partially dredged in recent years, and did have active flow at the time of survey. However, mean flow depth was low, approximately 2-3 inches. Other relic channels were present at higher elevations and can be seen in LiDAR imagery, including excavated drainage ditches between RM 3.5 and 4.0. Mobile gravels and recent bank erosion were observed in all of the relic side channels. Vegetation in the river-right floodplain is dominated by spruce (<6" DBH) and alder thickets, as well as sparse grass, forb, and sedge growth.

Reach 4 represents an actively mined segment of Prichard Creek and extends downstream of the private driveway bridge at RM 4.77. Prichard Creek currently flows through an active main channel along the south side of the valley in Reach 4. The channel historically ran through the north central floodplain area. This relic channel area is at roughly the same elevation as the active base flow channel, and still holds water, particularly in ponded areas between beaver dams. The creek flows subsurface for portions of the year above RM 4.3, presenting a substantial AOP barrier. The lack of pools identified in this area may be a particular stressor on fish as holding and rearing habitats are not available during the times of year that Prichard flows subsurface.

Banks along the main channel are 2.5-3.5 feet in height, composed largely of mining spoils, gravel, and sand. The channel bed through this reach is featureless and plane bed, with smaller gravel and cobble sizes, compared to Reach 1. Mobile bars are frequent. Much of the mobilized sediment through this reach has transported through and deposited between RM 4.0 and RM 4.2. The valley is confined at RM 3.8, likely resulting in backwater at RM 4.0 and precipitating sediment deposition. Multiple smaller channels flow through bar deposits in this segment.

Figure 25. Photo looking downstream in the prominent side channel in Reach 3. Dredged material used to create a berm is visible on the right side of the photo (right bank).

Recommended Actions

Recommended actions for Reaches 2-4 reflect the process dynamics discussed above, with more opportunities in Reach 4 where a wider valley configuration contributes to lower stream energy. Field observations and the REI suggest that Reach 3 is functioning well, but Reach 2 lacks pools and large wood. Reach 4 contains a number of impairments, related to the mining operation and subsurface flow. Therefore, recommended actions include:

- Addressing the AOP barrier and lack of in-channel and floodplain habitats in the upstream portion of Reach 4;
- Using large wood structures to sort sediments and scour holding and rearing habitats in the perennially wetted portion of Reach 4; and,
- Allowing the beaver and channel space to evolve through Reach 3.

2.2.3 Reach 5 - 6 (RM 3.7 – 6.5)

Reaches 5 and 6 are characterized by dredge mining deposits, visible as lateral ridges and troughs on the north side of the river in Figure 26. These dredge deposits not only confine the river and occupy the floodplain but also change the hydrology of Prichard Creek, causing surface flows to go subsurface through the turned-over floodplain sediments.

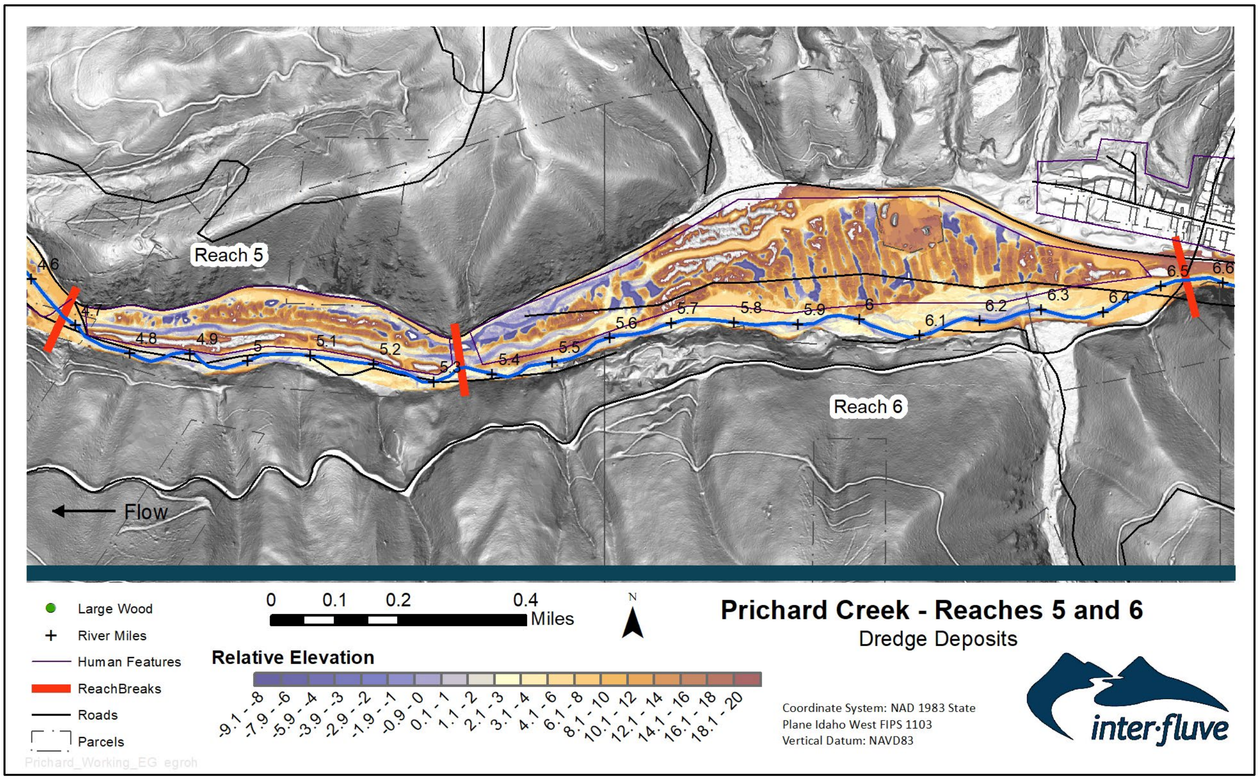

Figure 26. Overview map of Reaches 5 and 6.

Geomorphology

Reaches 5 and 6 both have a reach-averaged slope of about 0.01 and a combined length along the river centerline of 9,800 ft. Due to the confinement of the dredge deposits on the north banks of Prichard Creek and the valley walls on the south side, there is very little existing side channel or floodplain habitat. The dredge mining process effectively flips the floodplain over, placing the coarser cobble- and boulder-sized sediments on top of the finer grains. This reverse-sorting increases the hydraulic conductivity of the floodplain, facilitating subsurface flow during periods of the year when the hydraulic conductivity is greater than the rate of surface flow to the reach. Although several smaller tributaries enter Reach 6 from the north and south, alluvial fans are not visible in the terrain. Anecdotal evidence suggests that the fans were also mined, hydraulically, and likely explains their absence from the landscape. Finally, the project team was informed by local residents that the current creek alignment was mined again in the 1990s.

During periods of surface flow, the channel occupies a fairly straight, down-valley alignment through a portion of the valley where the alluvium was too shallow for dredge mining. The channel is trapezoidal and inset into recent, longitudinally-oriented flood deposits. Little vegetation is present on the banks or in the overbank areas. Less than 2% of the riparian is covered in shade trees and there are no large wood structures on the mainstem channel.

As a result of the dredging, the channel is artificially confined along the south valley toe. The existing confinement ratio for Reach 5 is 2.72 and for Reach 6 is 3.07. In contrast, the historical confinement ratio for Reach 5 is 11.11 and for Reach 6 is 25.38. This change in confinement has altered the distribution of stream energy through this reach, transforming what would have lower energy, depositional reaches, into highly efficient transport reaches.

For the 100-year return period peak flow, stream power generally increases in the downstream direction (~150 W/m^2 in Reach 6 to ~160 W/m^2 in Reach 5), matching the trend in confinement. This is substantial departure from historical conditions, which estimated using the valley width, may have been less than 10 W/m^2. This is likely an artificially low value because the alluvial fans would have narrowed the valley. Estimated specific stream power for the two-year return period peak flow (160-180 W/m^2) is similar to the 100-year, reflecting the lack of floodplain available for energy distribution.

Historically, Reach 6, and to a lesser extent Reach 5, would have stored sediment and dissipated flood energy across the relatively wide valley. The extensive mining in the reaches has altered the hydrology and turned a response reach into an efficient transport channel. Sediment delivered to Prichard from upstream and the tributaries is routed through the reach, inundating the downstream reaches.

Human Alterations and Erosion

This section of Prichard Creek has undergone the most drastic alterations due to the land clearing, channelization dredge mining and other forms of mining discussed above. In addition, hard rock mines are present on the hillslopes above Reaches 5 and 6, as well as in Reaches 5 and 6. The hillslopes have been and continue to be logged contributing to fine sediment delivery. The Town of Murry is located at the upstream end of Reach 6 and Thompson Pass Road runs the length of the northern edge of the floodplain. The Yellowstone Pipeline follows the road alignment through Reaches 5 and 6.

Water Level Monitoring

Water level loggers were installed in various locations throughout Reaches 5 and 6 to better understand how water levels vary down and across the floodplain, and throughout the year. Figure 27 and Figure 28 show the monitoring locations; Table 4 reports select descriptive statistics for each of the water level loggers.

WSE in Reaches 5 and 6 generally follow the valley slope of 0.013 ft/ft. However, the profile plots in Figure 29 and Figure 30 show a reduction in water surface slope toward the downstream end of the reach. Reaches 5 and 6 each end in locations where valley width is reduced by proximity to hillslopes and bedrock. Presumably, the bedrock is in close proximity to the channel and is forcing groundwater up, though not high enough to wet the active channel.

Through Reach 5, WSE appears to be higher on the river right side of the valley (Figure 31). At the downstream end of the reach, both sides of the valley have nearly the same average WSE. However, wells 7 and 8 are only 60 feet apart and may not fully capture WSE variation at that point in the valley. All of the wells in Reach 5 have significantly more variation than the wells in reaches 4 and 6 and have maximum WSE that are above the channel elevation (at an equal position down the valley). However, the mean WSE at all wells are below the channel elevation.

Through Reach 6, the WSE are generally within a foot or two across the width of the valley and track together (Figure 32). This suggests that the subsurface sediments are of a consistent texture or have similar level of variability across the valley. Unlike Reach 5, all of the recorded elevations in Reach 6 remain below the elevation of the channel (at a similar position down the valley). Through Reaches 5 and 6, the 5th percentile WSE (i.e., the low WSE) are approximately 12-14 feet below the active channel bottom in Reach 5 and 12-13 feet in Reach 6. These results support observations that the reach is losing (i.e., surface flows infiltrate from the active channel into the substrate) and will go dry when the discharge in the channel is less than the infiltration rate of the dredge spoils.

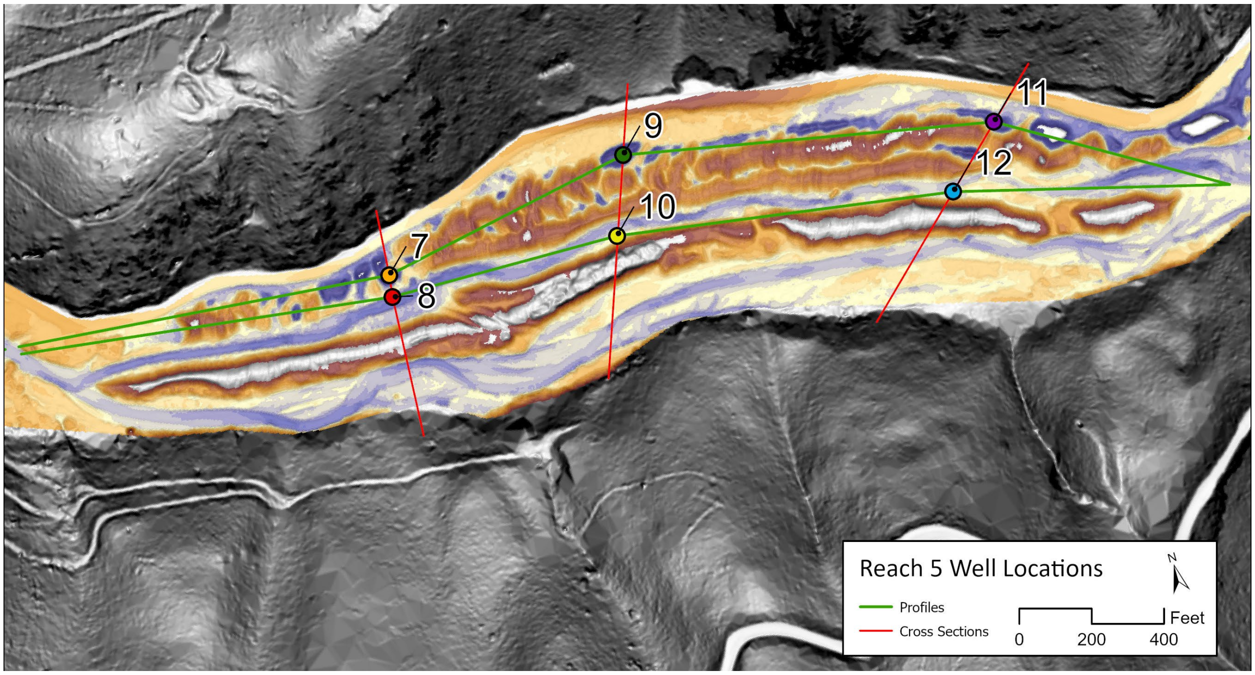

Figure 27. Reach 5 well locations, numbers, and the cross sections and profiles used to compare elevations.

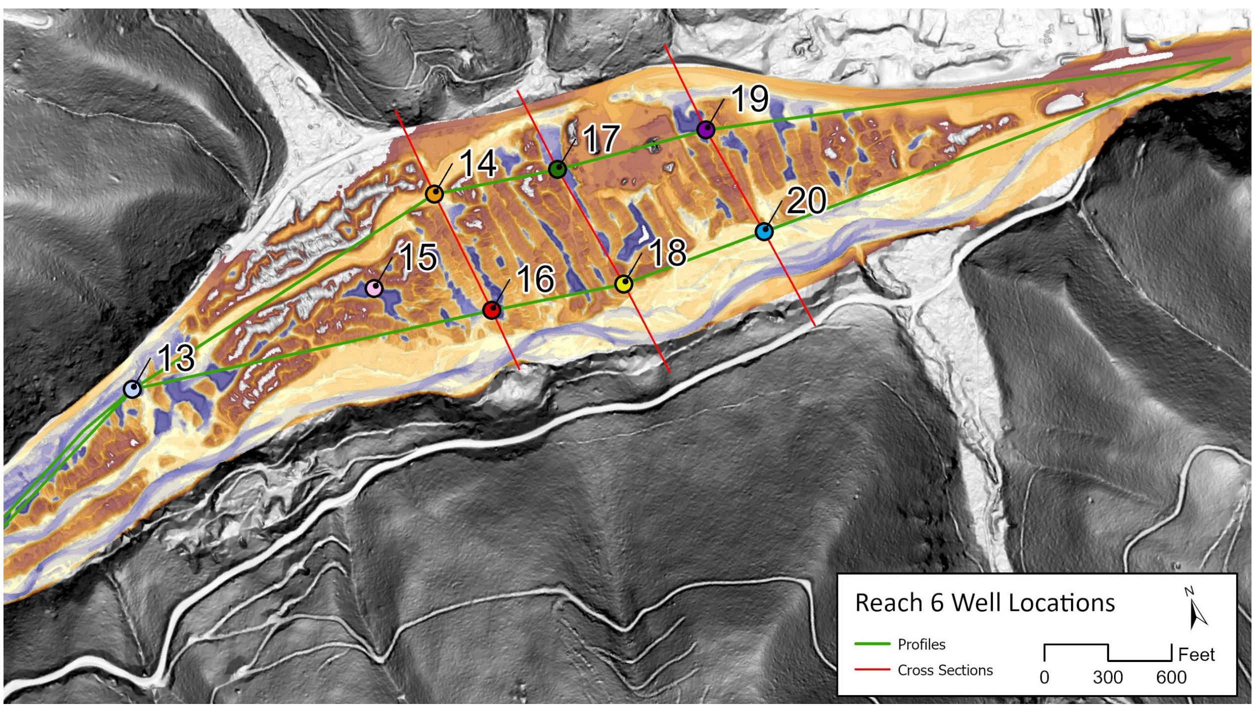

Figure 28. Reach 6 well locations, numbers, and the cross sections and profiles used to compare elevations.

Table 4. WSE statistics for wells located in Reaches 5 and 6. Low WSE refers to the 5th percentile WSE between August 15 and October 20.

Well	Low WSE (ft)*	Mean WSE (ft)	Max WSE (ft)	Range (ft)
Well 7	2644.7	2651.7	2659.0	14.4
Well 8	2644.1	2651.6	2656.0	11.9
Well 9	2652.7	2658.1	2665.5	12.9
Well 10	2650.3	2657.0	2664.2	14.0
Well 11	2664.8	2670.6	2675.6	10.8
Well 12	2660.8	2667.0	2675.6	14.6
Well 13	2694.7	2696.0	2698.9	4.2
Well 14	2709.2	2710.2	2714.5	5.5
Well 15	2704.2	2705.9	2709.9	5.8
Well 16	2707.4	2711.4	2715.5	8.1
Well 17	2716.9	2718.1	2719.9	3.1
Well 18	2718.4	2719.0	2720.3	1.9
Well 19	2727.3	2728.0	2731.0	3.8
Well 20	2728.9	2730.0	2733.2	4.3

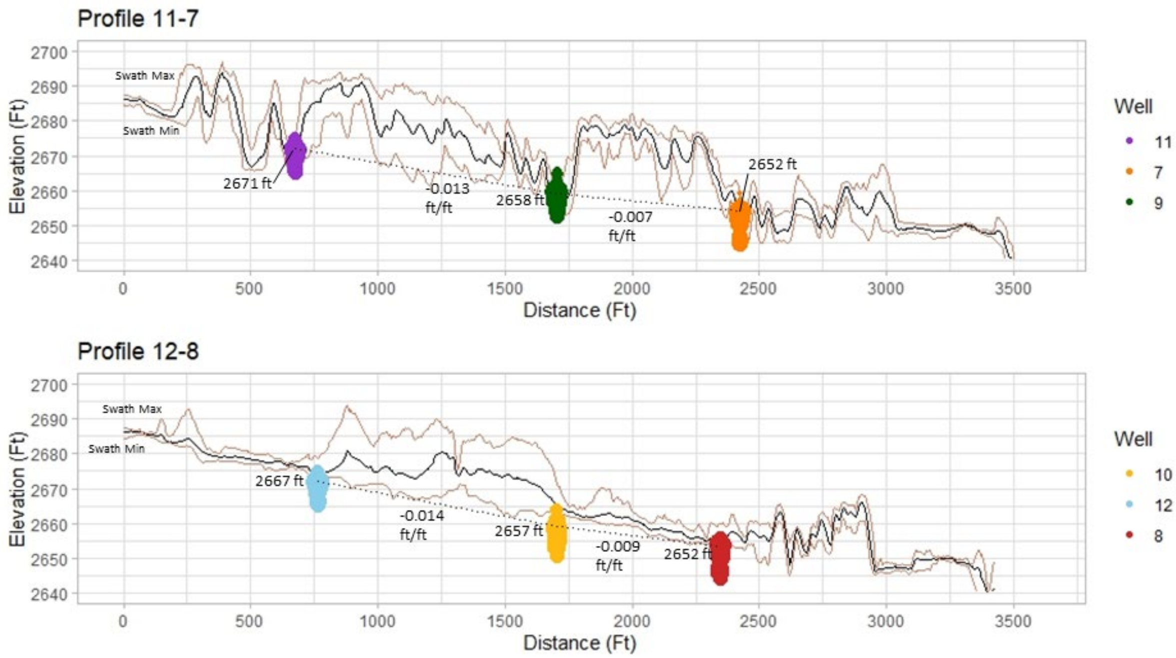

Figure 29. WSE profiles for Reach 5 showing the data of profiles depicted in Figure 27. Colored dots show the range of elevations for that well. The most frequently occurring elevation is labeled. The slope of the water surface is labeled. Topography is from LiDAR and brown lines represent a 50 m swath to show local variability.

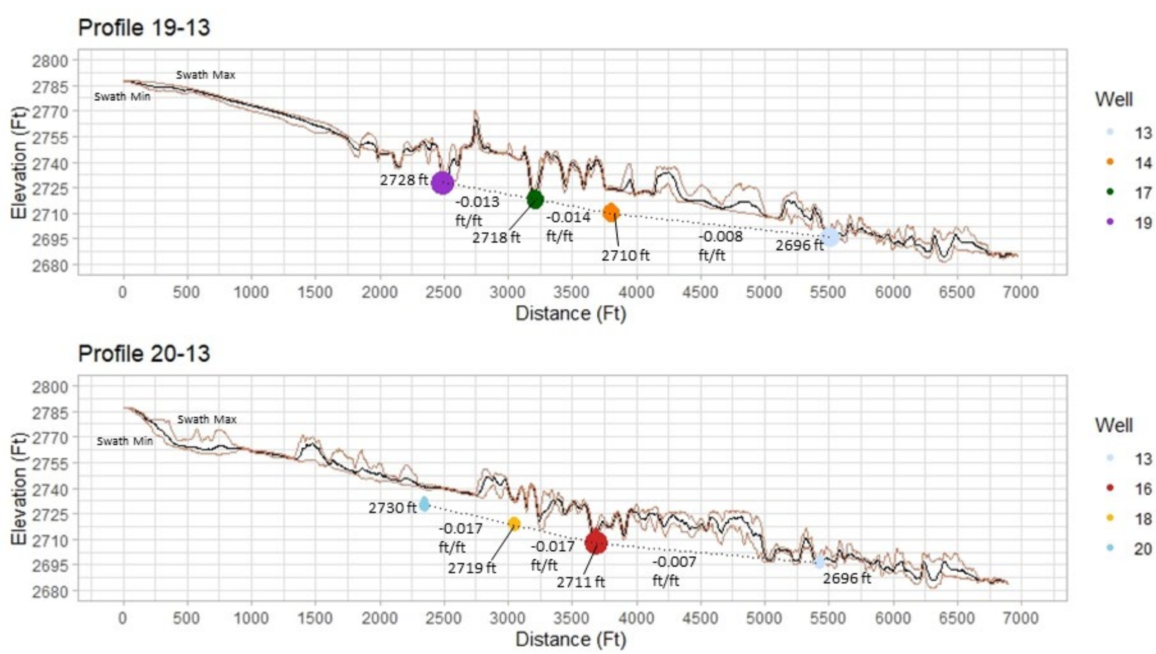

Figure 30. WSE profiles for Reach 6 showing the data of profiles depicted in Figure 28. Colored dots show the range of elevations for that well. The most frequently occurring elevation is labeled. The slope of the water surface is labeled. Topography is from LiDAR and brown lines represent a 50 m swath to show local variability.

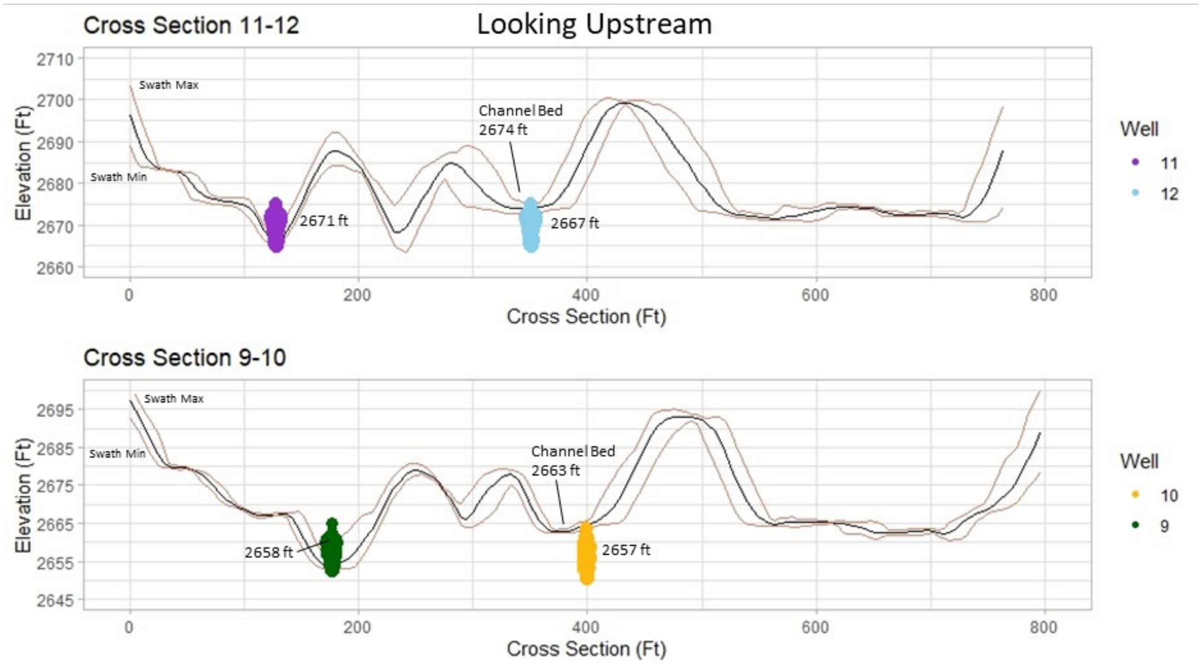

Figure 31. Cross sections showing how water level elevations vary across the floodplain for paired wells in Reach 5. Topography is from LiDAR, and the brown lines represent a 50 m swath to show local variability.

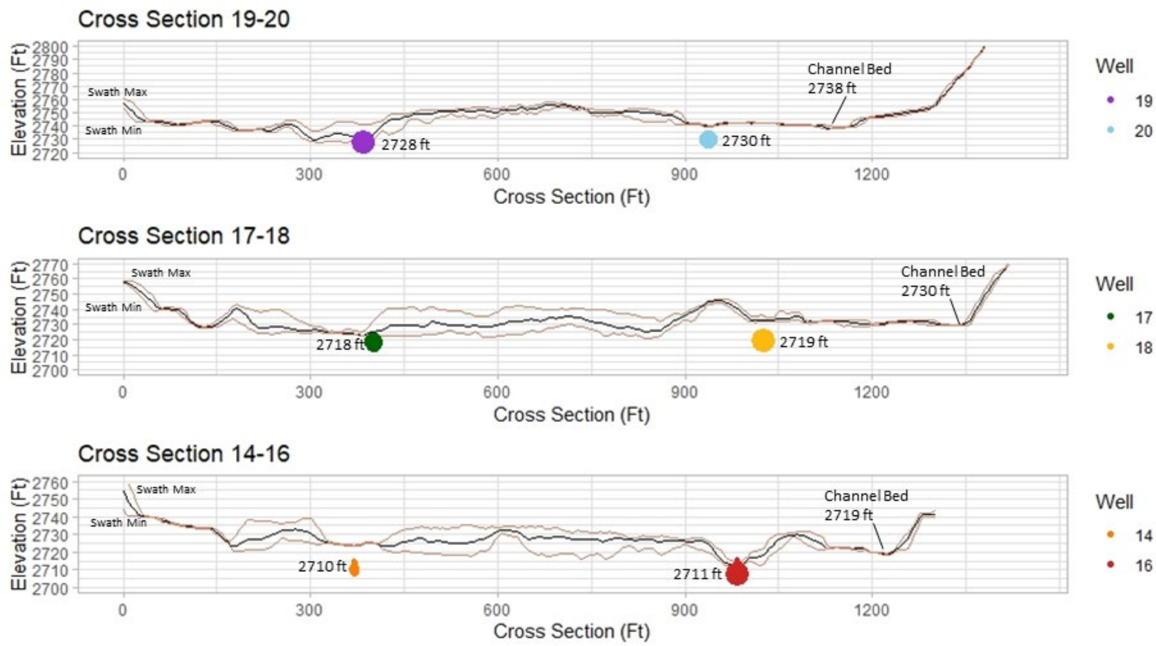

Figure 32. Cross sections showing how water level elevations vary across the floodplain for paired wells in Reach 6. Topography is from LiDAR and brown lines represent a 50 m swath to show local variability.

Biological Considerations

In Reaches 5 and 6 there is limited quality fish habitat available. Channel banks in this reach vary from 2 to 4 feet in height, and the bed consists of plane bed cobble and gravel. Deep pool habitat was observed between RM 5.5 and 5.7, where the channel abuts the bedrock valley wall. Upstream of RM

5.8, the channel is shallow with mean water depths at the time of survey between 3-6 inches. Pools are infrequent and shallow. During lower flow periods (e.g., dry summers, winter), the channel loses water and flows to the subsurface, which at times does not resurface until downstream of RM 4.3. Little to no large wood or other cover habitat is present in these reaches. Roughly 80 percent of the floodplain in this reach is occupied by mining dredge spoil piles, most laid down in a north-south direction, dissecting the floodplain.

Dredge spoil piles remain unvegetated in these floodplains (Figure 33) and very little riparian vegetation is present that could provide shading or cover habitat for fish in this reach. Low active floodplain surfaces consist of gravel and sand, and remain largely unvegetated. Ponded areas and pools that are present in these floodplains, fed by groundwater or precipitation, are isolated from the main channel and therefore provide no fish riverine habitat.

Figure 33. Prichard Creek is confined between unvegetated dredge spoils and the southern valley toe. View is looking upstream.

Recommended Actions

Recommended actions for Reaches 5 and 6 largely depend on whether or not the floodplain can be reconstructed to address the subsurface flow conditions. Though there may be options to work within the existing alignment of Prichard Creek, restoring the valley to act as a response reach, dissipating flood energy and storing/sorting sediment, would have larger-scale impacts and help to reduce the responsiveness of the downstream reaches. The level to which surface flows and floodplain reconstruction can be accomplished will determine the extent to which other actions can be completed (e.g., wood loading, revegetation, habitat creation).

2.2.4 Reach 7 - 10 (RM 6.5 – 9.6)

Reaches 7 through 10 are located just upstream of the dredge deposits and are heavily influenced by a substantially narrower valley width (Figure 34). Thompson Pass Road and the Yellowstone Pipeline roughly bisect the valley through these reaches.

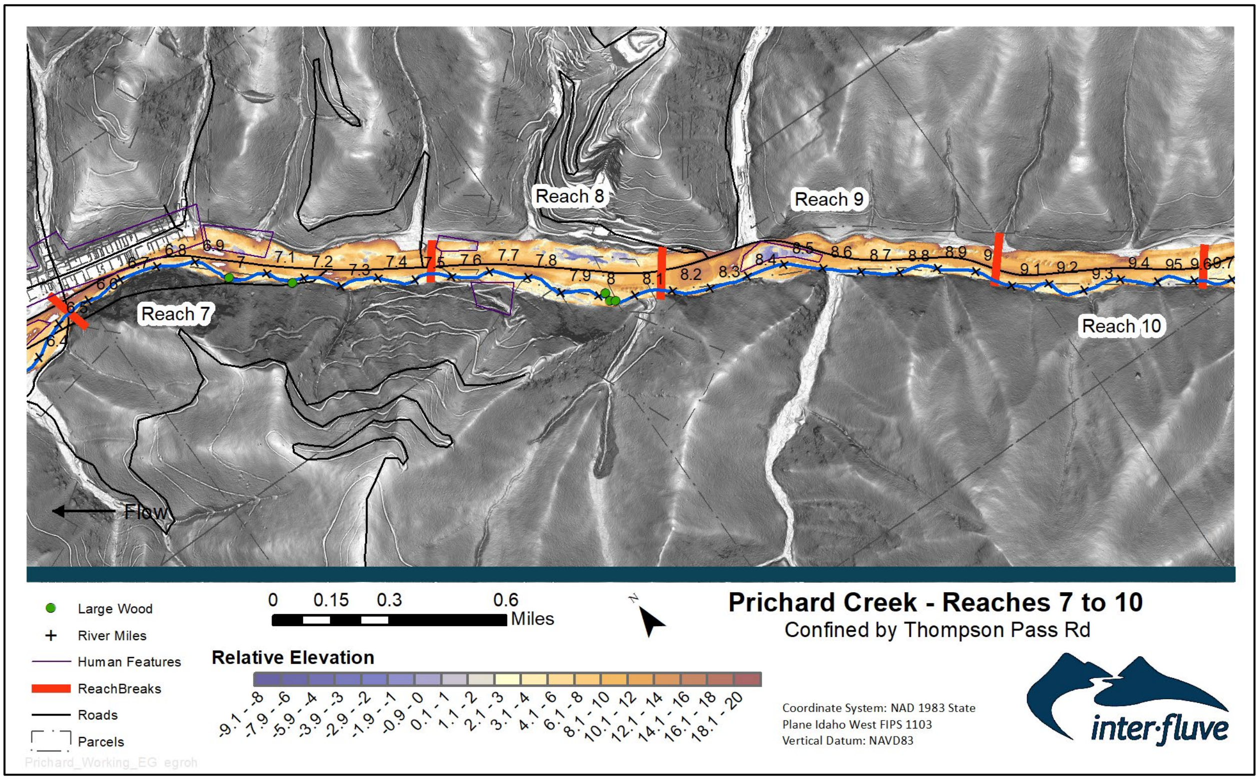

Figure 34. Overview map of Reaches 7 to 10.

Geomorphology

The total combined length along the centerline of this group of reaches is 16,300 ft. The slope of the channel increases with proximity Thompson Pass - Reaches 7 and 8 are 0.012 ft/ft; slope in Reaches 9 and 10 is 0.016 ft/ft. Reaches 7 through 10 are highly confined as Thompson Pass Rd intersects the floodplain on the north side of the river and allows for very little channel migration or side channel and floodplain development (e.g., Figure 35). Additionally, the Yellowstone Pipeline follows the highway alignment, buried adjacent to the road embankment. Despite this, there are a few connected side channels within this group of reaches with a total combined length along the centerline of 1,400 ft. A narrow riparian zone is mostly present along the channel and shade tree cover ranges from 2% to 5%. There are approximately 5 wood jams present on the mainstem. Wetland ponds were constructed in the overbank area of Reach 9, near the Butte Gulch confluence and presents an opportunity to reconnect floodplain as the road transitions to the opposite (north) valley toe.

Figure 35. Nadir UAV photo showing Prichard Creek confined by the highway and opposite valley toe.

Owing to the increase in slope and valley confinement, confinement ratios are low (ranging from 2 to 5) through Reaches 7-10. Compounding the valley confinement, the position of the road and pipeline further confine the channel, disconnecting roughly half of the available floodplain. Historical confinement ratios range from approximately 6 to 13. These reaches would have historically been moderately confined, moderately sloping reaches at the transition between the lower watershed and upper watershed which are typically important for the natural development of energy dissipating geomorphic features. While there is still evidence of these features in this section of reaches, the increased confinement has straightened the channel which encourages the stream to favor erosion over deposition and removes the floodplain as a potential area for deposition and energy dissipation during high flows.

Stream power for the 2-year return period peak flow is similar to that of the 100-year, at approximately 150 W/m^2. Historical stream power would have potentially been order-of-magnitude less than current, ranging from 8-15 W/m^2. Again, these values show that the energy exerted by the stream on the banks and bed of the river is higher for both channel forming and high flows compared to historic conditions due to the increased confinement by Thompson Pass Road. While geomorphic features such as riffles and pools are still evident, they are more often formed by large boulders or wood in the stream from deposition during high flow events. Whereas, historically, they may have been formed from a variety of sediment types through variations in flow conditions and would have created more energy dissipation of the flow.

Human Alterations and Erosion

The high channel confinement in this section of reaches is due to the construction of Thompson Pass Rd and the Yellowstone Pipeline through the middle of the floodplain, as well as human development features on the western side of Reach 7. Cut banks are present throughout, mostly on the outside of bends located adjacent to the road embankment. Topographic features captured in the LiDAR also show that the valley bottom has been mined, including operation of the dredge, though the highway obscures the extent of mining.

Biological Considerations

Reaches 7 – 10 upstream of Murray to the Bear Creek confluence are naturally confined to a floodplain less than 1,000 feet wide. Construction of the current Prichard Creek Road dissected the floodplain to widths less than 300 feet in most places. Spoil piles are intermittent along this segment and confine the channel even further. A small number of large wood jams are present in reaches 7 and 8, located primarily on the outside of meander bends. Instream aquatic habitat in Prichard Creek in these reaches is highly simplified, with limited rearing and refugia habitat. In the upper portion of Reach 10, some small off-channel features are present to provide fish habitat but have little riparian vegetation along the banks or cover habitat for fish. Under historical conditions with much decreased stream power, beaver may have been present, adding substantial complexity to the valley bottom.

Recommended Actions

Recommended actions for Reach 7-10 include creating holding habitats in the existing channel, which could be accomplished through the application of large wood and boulders. Channel confinement reduces through Reach 9 at the location of the wetland ponds, and this area could be targeted for increased channel-floodplain complexity. Mitigation requirements may be present on the ponds and will need to be determined prior to implementing any restoration actions. The road and pipeline limit opportunities and potential impacts to these features resulting from restoration actions will need to be thoroughly evaluated. Realignment of the road and pipeline were deemed infeasible and not considered as potential actions for this effort.

2.2.5 Reach 11 - 12 (RM 9.6 – 11.0)

Reaches 11 and 12 contain the Bear Creek and West Fork Prichard Creek confluences. The reach is characterized as moderately confined, moderately sloping, and represent the transition to the headwaters (Figure 36).

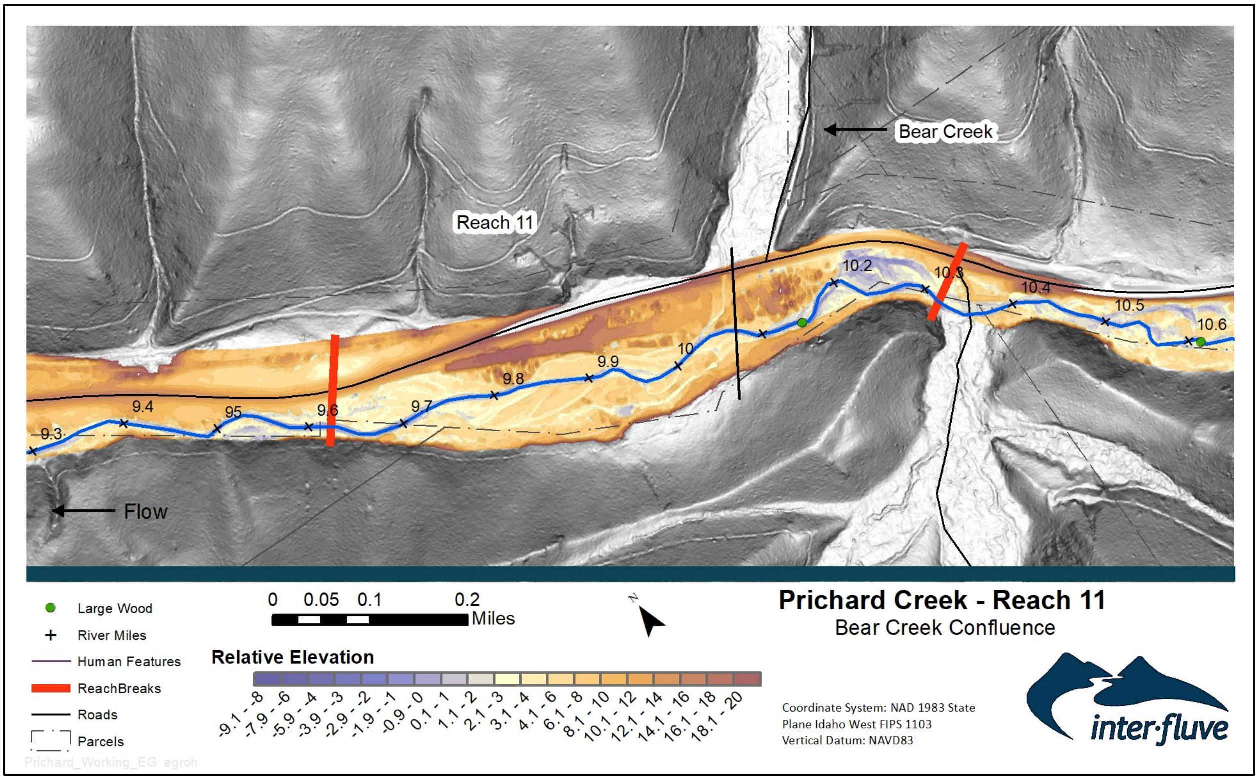

Figure 36. Overview map of Reach 11.

Geomorphology

Reaches 11 and 12 are moderately confined with more space for channel migration and side channel and floodplain habitat development than the reaches immediately below them (i.e., 7-10). The reach-averaged slope is 0.02 ft/ft. It has a reach length of 7,300 ft and connected side channels with a combined length greater than 800 ft. There are 5 large wood accumulations and the percentage of the riparian zone covered with shade trees is approximately 5.5%. Multiple channels have formed in locations and were all flowing at the time of observation. Extensive bare gravel deposits are visible in the aerial and suggest a substantial amount of the bedload is transported to the reach (Figure 37). In addition to the tributaries, the Monarch mill site upstream in Reach 13 and may be a substantial source of bedload-sized (e.g., gravel, cobble) sediments.

Figure 37. Upstream, oblique aerial view of bedload storage and multiple flow path development in Reach 12.

The channel is moderately confined with contemporary confinement ratios for both reaches are approximately 5, roughly half the estimated historical values that range from 11-12. The valley bottom widens through these reaches, relative to upstream and downstream, allowing more room for this section to meander slightly and access the floodplain. The two-year return period peak flow stream power for Reaches 11 and 12 ranges from 140-160 W/m^2; 100-year return period peak flow values are roughly half the two-year, as flow spreads across the valley bottom. Historically, 100-year peak flow stream power is estimated to range from 10-30 W/m^2. This again shows that the modern channel is slightly more confined than historically, but still has some access to the floodplain.

Human Alterations and Erosion

Reaches 11 and 12 are mostly free from development and active human disturbance. However, Reach 11 was dredge mined, and spoils remain in the floodplain in the reach. An abandoned road grade, possibly a former highway alignment, reduces floodplain width in Reach 11. Through Reach 12, Thompson Pass Highway is positioned along the north valley toe, but dirt roads are present throughout the floodplain. Some of the highest concentrations of lead, zinc, and mercury are located in these reaches, presumably sourced from Giant Ledge and Silver Strike mills in Granite Gulch and the Monarch mill located upstream.

Biological Considerations

Though much of Reaches 11 and 12 show a multi-thread channel pattern, the dominant flow path is aligned almost directly down valley. The side channels likely offer high flow refuge, but most lack roughness (e.g., wood) and vegetation and may be quickly overwhelmed at high flows. Bed complexity is limited and mostly related to boulders and larger clasts that have organized into steps and rapids (Figure 38). One large wood jam is located in the upper portion of this reach. Riparian vegetation is relatively sparse in this reach however, offering limited shade (shade trees cover approximately 1% of the riparian in Reach 11 and 10% in Reach 12) and bank cover habitat for fish.

Figure 38. While mostly plane bed, larger clasts have organized into steps through reaches 11 and 12.

Recommended Actions

Recommended actions for Reaches 11 and 12 are focused on removing impediments to floodplain connection and adding large wood to scour pools, sort sediments, and force floodplain connection. Reach 11 contains dredge spoil and an old road grade that if removed, could provide a substantial increase in floodplain width and increase opportunities to add complexity at the Bear Gulch confluence. Decommissioning of the dirt roads in Reach 12 would offer similar benefits. Large wood loading and pool creation would help drive lateral channel processes, sort sediments, and create holding and rearing habitats.

2.2.6 Reaches 13 - 16 (RM 11.0 – 14.6)

Reaches 13 through 16 are the upper, headwater reaches of the Prichard Creek (Figure 39). These reaches have moderate to high confinement, are steep, and well vegetated. Reach 13 is owned by a private landowner and was not assessed as part of this project.

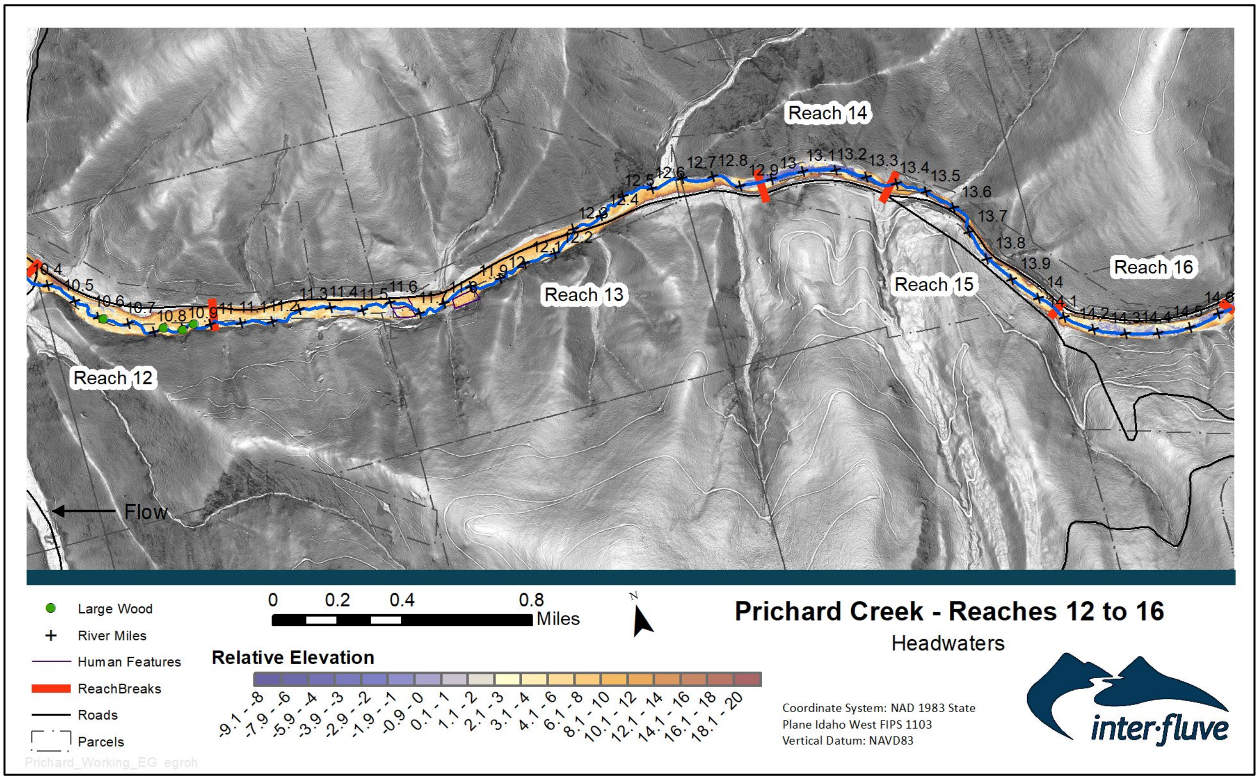

Figure 39. Overview map for Reaches 12-16.

Geomorphology

In the headwater reaches, Prichard Creek narrows and steepens; the reach-averaged slope in this group ranges from 0.03 to 0.075. The total combined length along the centerline is 8900 ft. As Prichard Creek here becomes a narrow mountain stream, there is little room for side channels or floodplain development. However, Reach 13 has two connected side channels with a combined length of 950 ft. Reaches 14 - 16 are well forested, with challenging access, and show much complexity in the REM. With the exception of where the highway crosses the creek in Reach 15 (RM 13.6), the road primarily sits above the valley bottom, on the valley wall, as it climbs toward Thompson Pass. We assume that these reaches are in relatively good shape, but impacts from the highway construction and recent logging operations may be present.

Confinement ratios are generally small, ranging from approximately 2 to 5. Again, with the road being situated on the valley slope, there is not much change in confinement between contemporary and historical conditions. Upper watershed reaches of mountain streams are typically steep, narrowly confined by valley sides, transport dominated, and subject to intermittent debris flows, and Prichard Creek exhibits these behaviors through Reaches 13-16.

Owing to the limited valley width, specific stream power does not vary much between the two-year and 100-year return period peak flow rates (approximately 200 W/m^2 and 150 $W'm^2$, respectively). The similarity in stream power values is a common trait in transport reaches (such as these) and illustrates that little storage occurs in these reaches. Debris flows commonly sweep sediment and wood from the hillslopes, and these headwater reaches then convey the material through the main channel to storage reaches. The little storage that does occur is typically associated with steps (log or boulder supported), in slackwater deposits (in the downstream lee of boulders and debris), and in the overbank areas.

Human Alterations and Erosion

There is little human development in Reaches 13-16, except for Thompson Pass Rd which runs the length of Prichard Creek, crossing in a few locations. Evidence of past logging on the adjacent hillslopes is present. The Monarch mill is located in Reach 13.

Biological Considerations

Fish habitat in Reaches 13 – 16 is largely consistent with other forested headwater systems, with relatively steep plane bed riffle transitioning to step pools in the upper reach. The valley is increasingly confined in upper Prichard Creek, and the channel flows through mostly colluvial substrates, with low bank heights and frequently inundated narrow floodplain areas. Large boulders and frequent small pools form the majority of the habitat in these reaches (e.g., Figure 40). Large wood inputs are frequent and provide overhead cover, but fallen trees often span the channel above the wetted perimeter. Wood-forced morphologies, localized sections of channel where alluvium is stored on the upstream side of fallen trees, are present in Reaches 14-16. These areas create short sections where the reduced gradient creates sediment storage and response reach characteristics (e.g., lateral complexity, downwelling). Canopy cover is near 100% upstream of RM 12.0.

Figure 40. Step-pool channel in the upper reaches of Prichard Creek.

Recommended Actions

Recommended actions are primarily strategic in nature, assuming that the channel is already functioning at a relatively high level. Opportunities to purchase and rehabilitate Reach 13 should be considered. From the aerial imagery, Reach 13 would need treatment to build (or influence the creation of) viable habitats and floodplain as much of the reach consists of bare gravel bars and is braided in planform. Additionally, the Monarch Mill may require environmental cleanup and/or remediation. For Reaches 14-16, logging operations should try to preserve a riparian buffer, keeping the creek cool and shaded.

3. Restoration Strategy

The following sections describe the restoration strategy framework, specific reach-scale restoration strategies developed for Prichard Creek, alternatives, and concept-level cost estimates for each alternative.

3.1 RESTORATION STRATEGY FRAMEWORK

The Prichard Creek restoration strategy assumes that an ecosystem approach is required to fully address Westslope Cutthroat trout (WCT) needs. Inherent in this is an understanding of the controls and process drivers that affect aquatic habitat conditions that trout and other salmonids rely on. These controls and processes, and their relationships to fish and habitat, are displayed conceptually in Figure 41. The condition of habitat necessary to support trout migration, spawning, rearing, and holding in Prichard Creek were identified, as well as the impaired process drivers that contribute to degradation. Through this lens, restoration and preservation actions were recommended.

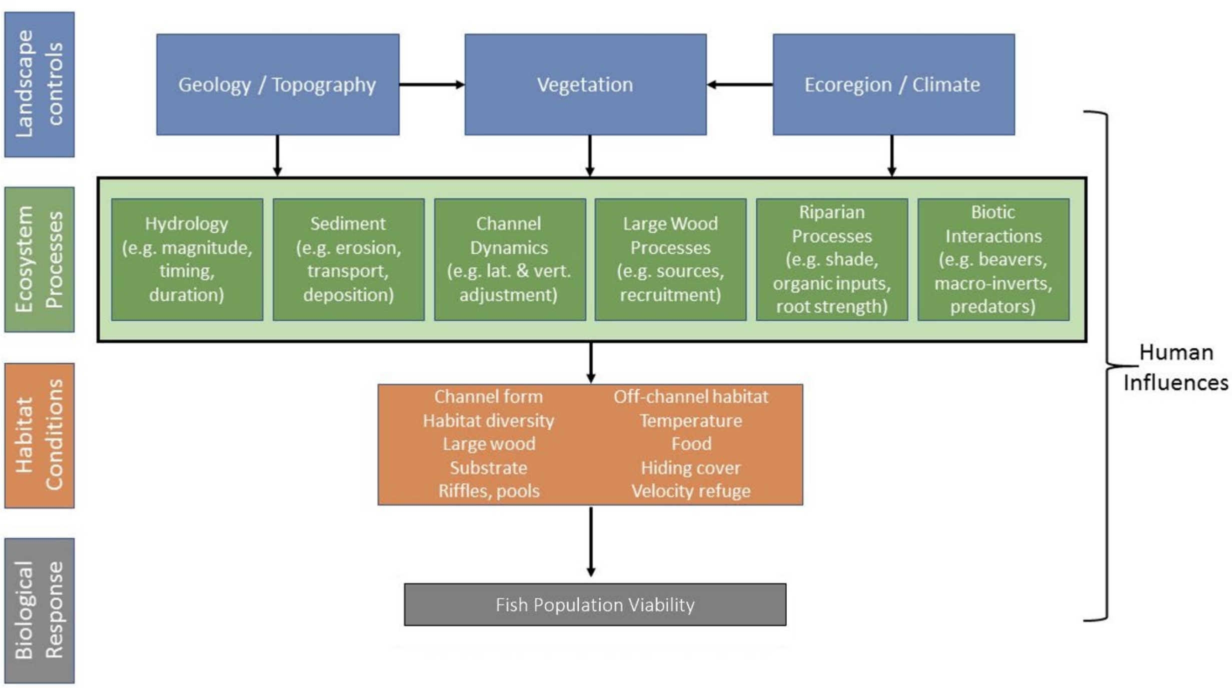

Figure 41. Linkages among landscape controls, ecosystem processes, habitat conditions, and biological response (adapted from Beechie and Bolton 1999, Beechie et al. 2010).

This restoration strategy incorporates concepts and methods from well-established approaches for developing watershed- and reach-scale restoration strategies. In particular, we have incorporated principles from the River Styles Framework (Brierley & Fryirs 2005), Beechie et al. (2008), Roni et al. (2002, 2008, 2013), and Montgomery (1999) with respect to how to assess reach-scale conditions and identify and prioritize restoration treatments. Our overall approach also closely follows a process-based philosophy (e.g., Beechie and Bolton 1999, Beechie et al. 2010), which prioritizes actions that address scale-appropriate key drivers of watershed process impairments that focus on root causes of problems rather than symptom or form-based approaches. This is not to say that site-scale habitat enhancement or creation actions are not identified, as oftentimes this is the only reasonable alternative in a highly altered and developed area. However, the focus is on first targeting the most important process-impairments to address root causes.

3.2 RESTORATION STRATEGY OVERVIEW

Inherent to the restoration strategy is the link between fish habitat and ecosystem processes that create the habitat. Limiting factors identified for WCT in Prichard Creek include degraded or loss of 1) coldwater refugia habitat, 2) overwintering habitat, and 3) summer rearing habitat. Table 5 below describes the relationships between these WCT limiting factors and the related ecosystem processes, the restoration action types that can help achieve the target conditions, and the potential biological response to these actions for the Prichard Creek project area as a whole. The Reach-Scale Restoration Strategies described below identify potential restoration alternatives that address, where possible, these limiting factors based on site-specific considerations. More detailed descriptions of the restoration action types referenced in Table 5 are included in Section 3.2.1.

Table 5. Prichard Creek project area limiting factors for Westslope cutthroat trout and the related ecosystem conditions under existing and potential future target conditions. Action types, and the anticipated response from WCT as a result of those action types, is also described.

Fish Limiting Factor	Related Ecosystem Condition		Action Types to Achieve Target Conditions	Anticipated Effect on Fish Limiting Factor(s)
	Existing Prichard Creek Condition [REI/Reach Assessment]	**Target Condition [REI – Adequate Rating]**		
Degraded/Loss of coldwater refugia	**Habitat Access** Portions of the main Prichard Creek channel flow subsurface during baseflows as a result of dredge mining in the channel and floodplains of those reaches. Fish passage up- and downstream is limited during those periods.	No human-caused barriers are present in the mainstem that limit upstream or downstream migration at any flow.	• Remove impediments and reconstruct floodplains • Riparian vegetation	Increasing access to upstream portions of Prichard Creek or floodplains with hyporheic exchange during the warmest months (at baseflows) may allow for more fish to access coldwater refugia in lower floodplains or upstream headwaters/tributaries
Degraded/loss of overwinter habitat for larger fish Degraded/loss of summer rearing habitat for larger fish Degraded/loss of coldwater refugia	**Habitat Quality** Substrate quality is primarily adequate throughout the assessment area. Large wood, pools, and side channel/off-channel areas are very limited, especially in Reaches 4 - 10.	Gravels or small cobbles make up >50% of the bed materials in spawning areas. ≤12% of substrates <6 mm in spawning gravel. Assuming at least 10 pieces of large wood/jam, reach has 3 or greater jams/mile. Pool frequency is between 2 – 5 per mile (depending on average wetted width of the channel), and pools are deep with good fish cover. Contains side or off-channel refugia.	• Remove impediments and reconstruct floodplains • Riparian vegetation • Enhance Aquatic Habitat • Improve floodplain / off-channel habitat connectivity • Large wood placement	Increasing the depth of pools and large wood cover habitat available in Prichard Cr will improve both overwinter and summer rearing habitat. Deeper pools may have increased hyporheic inputs supporting cooler summer water temperatures and warmer winter water temperatures that benefit WCT. Increased quantity or access to off-channel floodplains (wetlands) and side channels may increase area of suitable refugia habitat in Prichard Creek.

Fish Limiting Factor	Related Ecosystem Condition		Action Types to Achieve Target Conditions	Anticipated Effect on Fish Limiting Factor(s)
	Existing Prichard Creek Condition [REI/Reach Assessment]	**Target Condition [REI – Adequate Rating]**		
	Riparian Condition Historical timber harvest and human land uses in riparian areas and floodplains have limited the extent and size of riparian trees. Recovery of riparian vegetation is occurring, but in reaches where mining dredge piles remain, little vegetation regrowth has occurred.	Large trees are present throughout most of the riparian buffer zone (defined as a 100ft buffer along each bank) based on GIS analyses and drone aerial imagery assessment data. <20% disturbance in the 200-foot riparian buffer zone (e.g., agriculture and grazing, residential, roads, etc.) based on visual estimate from GIS.	• Riparian Restoration • Improve floodplain / off-channel habitat connectivity • Remove impediments and reconstruct floodplains	Increase extent of native riparian vegetation to drive long-term large wood recruitment to the channel, improve channel shading and increase prey/food inputs for rearing WCT.
	Channel Dynamics Channel entrenchment & floodplain disconnection throughout exaggerated by levees, roads, riprap, and bridges. Large section of the channel with no lateral migration occurring due to human built features or historical human land uses (e.g., dredge mining).	Floodplain areas are hydrologically linked to main channel within the context of the local process domain; overbank flows occur and maintain wetland functions, and riparian vegetation. Naturally confined channels are considered adequate. Erosion of actively eroding, vertical banks is associated with natural channel migration processes and/or deposition of large wood. Actively eroding banks are vegetated with woody riparian plants.	• Improve floodplain / off-channel habitat connectivity • Remove impediments and reconstruct floodplains • Large wood placement	Increase creation and maintenance of off-channel features, including wetlands or seasonal/perennial side channels

3.2.1 Restoration Action Types

Five restoration action types appropriate for the aquatic species and geomorphic processes of the Prichard Creek assessment area were developed for application in individual project areas within each reach. Action types are developed at a broad scale and are often achieved through the use of numerous project elements. For example, the action type "off-channel habitat" can be achieved in various ways ranging from removing a barrier to hydraulic connectivity in the floodplain to allow passive reconnection of off-channel features to excavating the full extent of a side channel through a floodplain. The specific project opportunities identified at the reach-scale, on the other hand, are site-specific and have unique characteristics (i.e., type of large wood jam), depending on the particular habitat conditions, land uses, geomorphic context of the site, and existing infrastructure limitations. In addition to certain types of restoration actions, several strategic actions have been identified where property acquisition or other management could open up additional or more expansive restoration opportunities.

We use the term 'restoration' as a broad catch-all when we refer to recommended actions; however, we acknowledge that many of the actions are not restoration in the true sense of the word, and would be more appropriately labeled as "enhancement," "improvement," or "creation." True restoration actions are those that address root causes of impairments and that aim to return the system close to its naturally functioning state. This is often not achievable due to past changes to the underlying processes or to process impairments that are unlikely to change due to infrastructure and/or land management policies. An example of a true restoration project would be one that fully removes a levee, returns the channel to its historical form, and replants the valley floor to restore natural floodplain inundation patterns. Enhancement measures are those that improve or rehabilitate habitat to the extent possible given existing impaired processes and anthropogenic constraints. Installation of a bank buried large wood jam at an existing pool to provide cover is an example of habitat enhancement. Creation projects are those that create new habitat that is currently lacking or that will not be created on its own in a reasonable timeframe given existing trends and process impairments. Excavating an inset floodplain along an otherwise entrenched channel is an example of a creation project.

In total, five general action types are recommended for the Prichard Creek assessment area that emulate existing processes, landforms, and features that are already found in Prichard Creek. The action types intend to increase the rate of these natural processes or density of the features to improve fish habitat and channel conditions. The five action types are described in more detail below.

1. Riparian Revegetation

Riparian restoration projects are located in areas where native riparian vegetation communities have been impacted such that riparian function and connection with the stream are compromised. In Prichard Creek, riparian vegetation has been cleared for resource extraction and access (roads and bridges) and overwhelmed by high sediment loads. Restoration actions are focused on restoring native riparian buffer vegetation communities in order to reestablish natural stream stability, stream shading, nutrient exchange, and large wood recruitment. Even though it is not always explicitly stated in the other actions, riparian restoration is also a recommended component of actions that result in ground disturbance.

Examples:

- Replanting a riparian buffer area with native vegetation; and,
- Planting native vegetation in areas disturbed by decommissioning, removing, or upgrading existing human infrastructure.

2. Remove Impediments and Reconstruct Floodplains

This action includes identifying the human-caused ecosystem modifications that are currently impeding natural channel processes and/or habitat complexity and determining how best to address those impacts. For example, a remnant levee feature in the river-right floodplain of Reach 1 will improve hydrologic connectivity between the mainstem and off-channel or floodplain areas. The addition of large wood along the toe of the Prichard Creek Road prism can improve localized habitat with additional cover while limiting any risk to infrastructure that may result from increased water on the floodplains.

Examples:

- Removing remnant push-up levees or berms disconnecting the floodplain from the mainstem;
- Regrading dredge spoil piles to recreate floodplain habitats and increase surface water flow in main channel; and,
- Strategic parcel acquisition or conservation easement actions.

3. Enhance Aquatic Habitat

This action includes the creation of complex channel habitat features such as deep pools and riffle/boulder features in order to increase existing channel habitat complexity for WCT. Portions of the Prichard Creek channel within the assessment area are very long, simplified plane-bed runs that have little flow diversity or complexity features (such as large wood). Aquatic habitat improvement actions include excavation of pool features (combined with large wood placements, see #5, below) or installation of large boulders to provide small mid-channel eddies and heterogeneous flow paths. Aquatic habitat enhancement actions may also include realignment of the mainstem Prichard Creek channel where sufficient floodplain widths exist. These projects are generally considered enhancement measures, as they do not fully restore the root cause of the problem (e.g., channel entrenchment due to leveeing, bank hardening, and bridges).

Examples:

- Excavating a pool feature on an existing lateral bend in the channel, with large wood placements on the bank and into the pool for cover and complexity (see Action #5 below, and example in Figure 42); and,
- Placement of large boulders to increase habitat complexity and ballast/catch large wood from upstream.

Figure 42. Example of pool excavation with wood loading to create holding and rearing habitat from the Middle Fork John Day River, OR.

4. Improve Floodplain and Off-Channel Habitat Connectivity

Floodplain and off-channel habitat connectivity improvement actions are aimed at increasing the variety of habitat types within a reach. This type of action is designed in areas where evidence of historical channel features is present on the landscape or where off-channel habitat features would be most likely to persist on the current landscape. These actions identify and take advantage of existing conditions such as locations of large boulders, channel planform and geometry, gradient and stream energy, available valley width and maturity of vegetation.

Project examples:

- Excavating an inset floodplain along an entrenched channel to improve system function to support aquatic habit diversity;
- Excavating side channel through floodplain (e.g., Figure 43); and,
- Excavating a short pilot inlet channel through high ground to increase inundation of existing low floodplain surfaces or high flow side channels.

Figure 43. Example of constructed side channel habitat on the Twisp River, WA.

5. Large Wood Placement

This action includes placement of habitat structures such as large wood and log jams order to improve existing local habitat features or influence physical channel dynamics to increase geomorphic complexity such that habitat conditions are improved locally and overall, in a reach. A majority of the Prichard Creek assessment area is lacking in quality mainstem large wood, pool, and off channel habitat. Large wood placements may be aimed at biological factors, such as increasing cover and complexity to the existing pool habitats or creating shear zones and velocity refugia for juvenile WCT. Large wood placements may also serve a geomorphic function, aiming to increase complexity of flow hydraulics and encourage natural lateral and vertical migration in the channel. The expectation is that the channel will respond to (i.e., pool scour, sediment accumulation) and organize (i.e., jam accumulations or steps) the added material into highly functional habitat units that benefit WCT and other aquatic species.

Large wood placements are identified for areas where they will naturally be maintained and organized by stream hydrology and geomorphology. For the Prichard Creek assessment area, this action type includes a range of various sized large wood channel loading and jam installations. These actions identify and take advantage of existing conditions such as locations of large boulders, channel planform and geometry, gradient and stream energy, available valley width, and maturity of vegetation.

Project examples:

- Installing large wood jams in a location that will promote split-flow (e.g., Figure 44, top) or floodplain activation, sediment accumulation, and pool scour such that habitat complexity and system connectivity is improved;
- Installing a large wood, bank-buried log jam to maintain pool scour, provide cover, and to increase quantity of available high velocity refugia for rearing;
- Installing an apex jam to instigate and maintain floodplain connectivity and side channels;
- Pushing/tipping bank trees into the channel to mimic natural erosional recruitment processes and increase habitat complexity; and,
- Installing wood structures meant to maintain pool habitat while protecting infrastructure from exposure to channel migration hazards (e.g., Figure 44, bottom).

Figure 44. Example of a flow-splitting apex jam constructed on the Entiat River in central Washington State (top). Bottom photo shows wood bank revetment meant to protect the road from bank erosion while providing covered pool habitat.

3.3 REACH-SCALE RESTORATION STRATEGIES

The following sections outline the framework used to develop the restoration strategies and the strategies for each reach, including a description of reach-specific ecological conditions and trajectory, recovery potential, recommended restoration action types and potential project alternatives within each reach. The ecological function rating (Low, Moderate, and High) of each reach is characterized by the ratings that resulted from the REI (Appendix B). The trajectory (decline, same, improve) is determined by evaluation of the modern geomorphic trends, related existing habitat conditions, and continued limitations such as infrastructure and land. The recovery potential (Low, Moderate, and High) is based on the ability of the site to recover functioning habitat and processes with restoration actions. To do so, the potential for the REI indicator ratings to improve via restoration actions is considered. The recovery potential rating considers known limitations to recovery that are unlikely to be eliminated as part of implementation of this restoration strategy, such as the presence of private property, roads or utility corridors. Project action types were identified that are believed to best achieve target conditions and to address key factors limiting Westslope cutthroat and bull trout populations and improve their habitat conditions in Prichard Creek. These projects represent an initial first step in this process, and it is expected that projects will be modified once project-specific surveys, analysis, and stakeholder coordination are performed as part of design.

Note that some of the reaches have alternatives while others do not. Many of the recommended actions could be implemented in an *a la carte* manner, and those instances are noted in the text. Where considerations and treatments are similar, adjacent reaches have been grouped together to reduce repetition.

Each section below describes the strategy for the reach (or reaches), provides a summary table, and a copy of the concept map. The maps are also included in Appendix C .

3.3.1 Reach 1 Restoration Strategy

Reach 1 covers the largely unconfined (confinement ratios range from 6 to 25) alluvial valley at the most downstream end of the project area. Through much of the reach, the active channel has aggraded with sediment providing little complexity. The floodplain, though logged in the recent past, is highly complex, with side channels and beaver dams. The exception to this is towards the upstream end of the reach where the legacy impacts from past logging operations (e.g., raised berms, railroad grades, and hardened surfaces) have confined the channel against the valley wall.

The recommended restoration actions broadly include the removal of the legacy berms and reconnection of the floodplain near the upstream end; large wood loading in the active channel to sort sediments, mute flood response, and create complex habitat; and, the implementation of low-tech actions to further add complexity and cover to the vast network of side channels.

Alternatives for the reach (Table 6 and Figure 45) are divided based on floodplain connection (Alternative 1) versus active channel wood loading (Alternative 2), though could either be combined (for a much larger project) or implemented in an *a la carte* manner, as funds become available. Large portions of Alternative 2 (active channel wood loading) are included in the Phase 1 project scheduled for construction in the summer of 2023.

Key considerations for project design and implementation include evaluation of potential impacts to Prichard Creek Road and the Keystone Pipeline (which runs adjacent to the road). Furthermore, the existing floodplain is quite complex, and the potential to damage those high-quality floodplain habitats should also be considered.

Table 6. Restoration Strategy overview for Reach 1.

Overall ecological function	**High**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Six of the nine REI metrics are at adequate condition and three are at risk, with no unacceptable ratings. Instream habitat complexity and connectivity with off-channel habitats/floodplains is limited, with few deep pools with cover and limited shade or large wood recruitment potential from riparian vegetation. Fine sediment and a highly dynamic channel in this reach may limit successful spawning or rearing activities of salmonids.
Trajectory if no action taken	**Same - Improve**
	The riparian forest in the reach is in the process of passively maturing. Over time, quantity and quality of available large wood will increase and shade cover will increase. If clearing or thinning occurs, or large wood is cleared from the channel, conditions could remain the same or decline.
Recovery potential	**Moderate – High**
	Limited infrastructure is within the riparian/floodplain of this reach, and there is potential to increase channel and floodplain connectivity and function. Enhanced habitat complexity potential is present via increased scour pools and added large wood as well as reconnection of off -channel habitats in upper portion of reach via levee removal.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions (multiple habitat and geomorphic attributes), where possible, for the metrics identified in Table 1 above. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian Revegetation** **Remove Impediments and Reconnect Floodplain** **Improve Floodplain and Off-Channel Habitat Connectivity** **Large Wood Placement**
	Actions include enhancement of channel complexity and improving the connectivity of floodplain and off-channel habitats to the mainstem.
Alternatives	**Alternatives 1 and 2**
	Alternative 1 – Large wood structure placement throughout main channel in Reach 1, to provide cover habitat, encourage creation or maintain presence of deeper pools, and promote natural lateral channel migration processes. Revegetation of gravel bars and riparian areas to improve long-term channel shading and wood recruitment. *Alternative 2 – Large wood structure placement throughout main channel and in secondary/tertiary channels of the mainstem, to provide cover habitat and refugia, encourage formation of deep pools, and promote natural lateral channel migration processes. Revegetation of gravel bars and riparian areas to improve long-term channel shading and wood recruitment. Low-tech habitat complexity and large wood actions, such as Beaver Dam Analogues or Post-Assisted Log Structures in the floodplain wetlands. Remove levee feature on upper river right floodplain and create side channel pilot inlet features to increase hydrologic connectivity of low floodplain wetland surfaces. Large wood placed along the toe of the valley (Prichard Creek Rd) slope to protect infrastructure.*

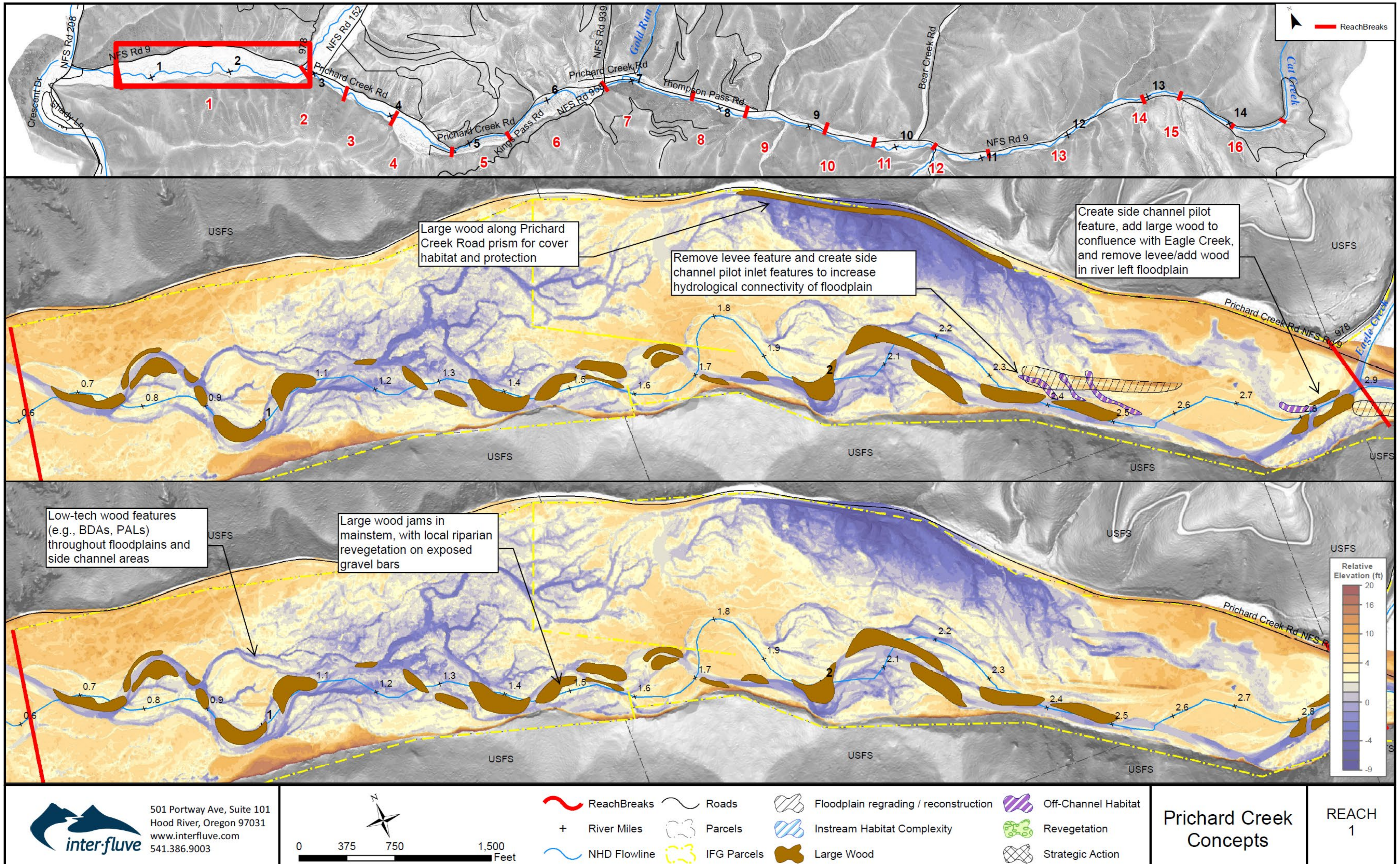

Figure 45. Reach 1 concepts.

3.3.2 Reaches 2 - 3 Restoration Strategy

Through Reach 2, Prichard Creek follows a straightened alignment along the southwestern valley toe. Through Reach 3, Prichard again flows along the valley toe, however beaver activity in the reach is driving the development of wetlands and side channels. At the lower end of Reach 3 it looks like a flood protection berm was created from dredged channel material. Reach 3 also contains a private parcel, not owned by the Idaho Forest Group (IFG), that roughly bisects the reach.

The recommended restoration actions generally include wood loading and the creation or reactivation of side channels in Reach 2. A strategic action is proposed to purchase the private parcel as it covers one of the more complex and ecologically valuable sections of the floodplain. A cabin has been constructed on the banks of the river and is likely to be frequently inundated by flood flows.

One alternative is proposed for the reaches (summarized in Table 7 and Figure 46), and similar to Reach 1, many of the actions could be implemented in an *a la carte* manner, depending on resources. However, the side channels would need to be coupled with wood placements at the entrances and throughout.

Key considerations for project design and implementation include evaluation of potential flooding and channel migration impacts to Prichard Creek Road and the private parcel. Additionally, the alignment of the Yellowstone Pipeline through these reaches will need to be determined and evaluated for potential project impacts.

Table 7. Restoration Strategy overview for Reaches 2-3.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. In Reach 2, three of the nine REI metrics are at risk and two are unacceptable. In Reach 3, three of the metrics are at risk (no unacceptable ratings). The main channel has been straightened and pushed up against the river left valley toe in Reaches 2 and 3. Floodplain disconnection is particularly evident in the downstream half of Reach 2 where Prichard Creek Road bisects the river right floodplain and runs immediately adjacent to the channel, limiting natural lateral migration potential.
Trajectory if no action taken	**Same**
	The riparian forest is in the process of passively maturing. Over time, quantity and quality of available large wood will increase and shade cover will increase. However, the relatively straight and incised nature of the main channel limits the potential to reconnect floodplain surfaces or create complex aquatic habitats without more intentional actions taken. Continued land uses – residential and transportation corridors, for example – limit recovery potential.
Recovery potential	**Moderate**
	Added instream and floodplain/off-channel habitat complexity from large wood placement, instream habitat creation, and reconnection of off-channel habitats occurs where appropriate and riparian vegetation is permitted to mature, then high potential for improved quantity and quality of habitat, increased floodplain connectivity, and side channel development/maintenance. However, full recovery is limited by the presence of Prichard Creek Road and other land uses surrounding the town of Eagle.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian revegetation** **Enhance Aquatic Habitat** **Improve Floodplain and Off-Channel Habitat Connectivity** **Remove Impediments and Reconnect Floodplain** **Large Wood Placement**
	Actions include enhancement of aquatic habitat with large wood and increase the amount of side channel and off-channel habitat. Full recovery potential is limited by private property in Reach 3 floodplain; strategic actions to acquire parcel would allow for more complete ecosystem recovery.
Alternatives	**Alternative 1**
	Alternative 1 – Actions in this alternative include large wood loading throughout the main channel to improve fish habitat complexity and cover. Select floodplain grading to increase frequency of inundation and create side channels or floodplain wetland features in portions of both Reaches 2 and 3. Acquisition of a privately-owned parcel in the middle of Reach 3 is a strategic action that would allow more room for the channel and off-channel features.

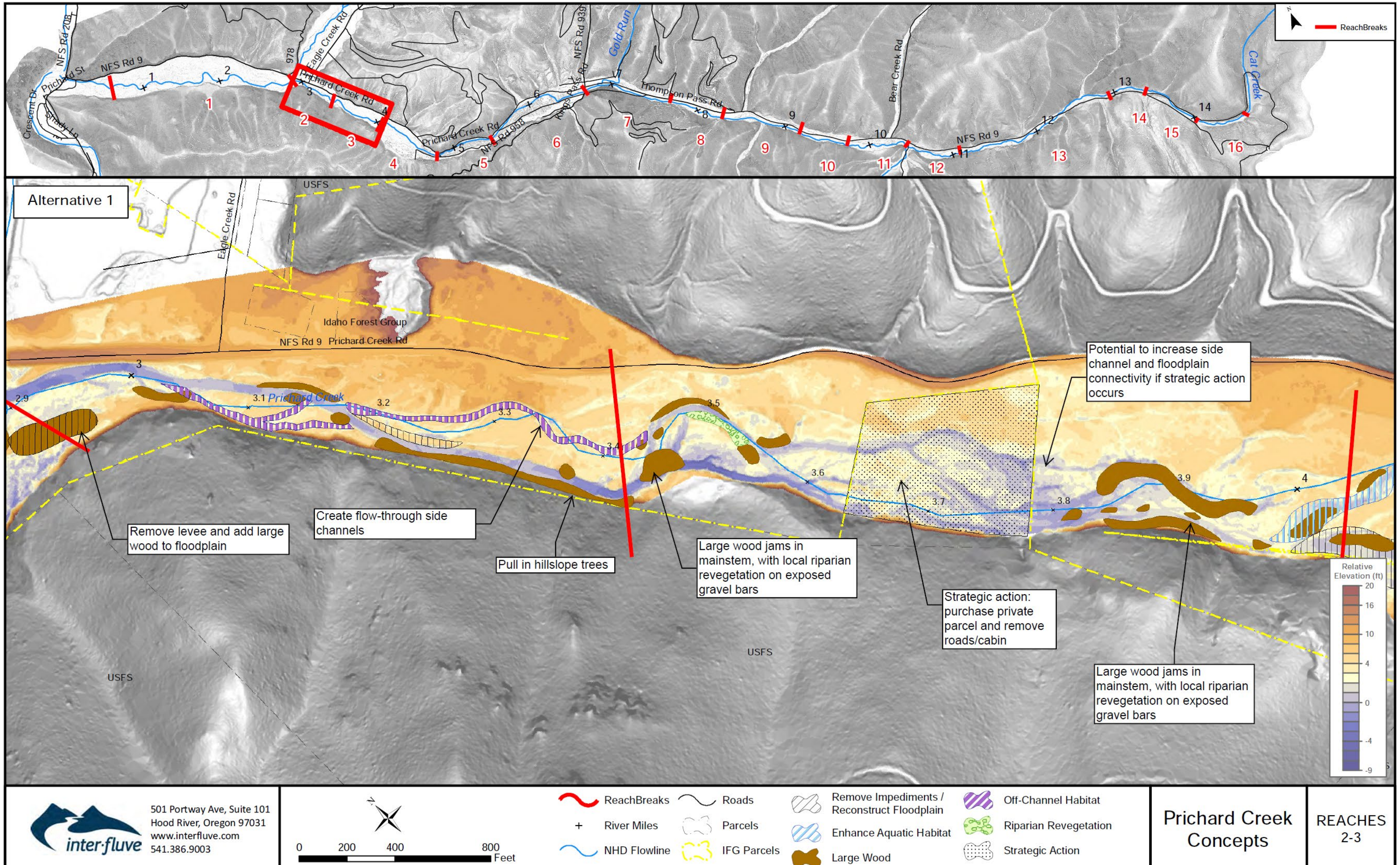

Figure 46. Reaches 2 and 3 concepts

3.3.3 Reach 4 Restoration Strategy

Reach 4 sits in a relatively wide alluvial valley and has mixed public and private land ownership, including a private parcel not owned by the IFG. During flooding that occurred in 2008, Prichard avulsed into the current alignment, following an easier down-valley path through land that was cleared for mining. The riparian zone through much of the pre-2008 alignment was very complex, containing many beaver ponds, however a wildfire moved through that area 2022. Much of the riparian and channel through Reach 4 is heavily impacted by the mining operation in the reach. Flows are subsurface through the upper half of the reach during low flow periods of the year but resurface near RM 4.3. Prior to the 2022 wildfire, the pre-2008 alignment appeared to hold water throughout the year (likely hillslope runoff and intercepted hyporheic flow).

The recommended restoration actions range from moving the active channel back into the pre-2008 alignment to wood loading that avoids the existing mining operation. Alternatives for the reach (summarized in Table 8 and Figure 47) are divided based on work occurring on the mining parcel. Alternative 1 assumes that work will not occur on the mining parcel and focuses on adding channel complexity with large wood placements. The wood proposed for the lower end of the reach is thought to be at a critical location for holding habitat because fish may be able to retreat to that location as flows infiltrate into the substrates upstream of here. These features have been incorporated into the Phase 1 project, constructed in the summer of 2023. For Alternative 1, it is assumed that the dredge piles near the upper end of the reach will remain.

Alternative 2 proposes a fairly dramatic shift of the river back into the pre-2008 alignment and removal of a large portion of the dredge spoils. Depending on the materials contained in the dredge spoils, it may be possible to dispose of that material onsite by filling in portions of the current channel. Even though the riparian corridor burned in 2022, this alternative would take advantage of an intact hyporheic zone. For Alternative 2 to become viable, it may be necessary to purchase the mining parcel, which is a recommended strategic action for the reach. Additional design is required to determine whether pieces of the alternative could be constructed independent of the whole.

Key considerations for project design and implementation center around the fate of the mining parcel. Alternative 2 is a costly project but would likely result in substantial ecological uplift for the reach.

Table 8. Restoration Strategy overview for Reach 4.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. In Reach 4, there are three at risk and three unacceptable ratings. Impairments include a lack of deep pools (≥ 3-ft deep), lack of large wood, riparian vegetation structure and cover, and floodplain/off-channel connection with the main channel. Historical and on-going mining activities in Reach 4 have straightened and incised the main channel, disconnecting extensive off-channel side channels and historical floodplain surfaces in the river right floodplain. Portions of the upper reach flow subsurface during baseflows.
Trajectory if no action taken	**Same - decline**
	The riparian forest is in the process of passively maturing. Over time, quantity and quality of available large wood will increase and shade cover will increase. However, the modified nature of the main channel limits the potential to reconnect floodplain surfaces or create complex aquatic habitats without more intentional actions taken. Continued land uses – residential and mining – will limit recovery potential.
Recovery potential	**Moderate – High**
	Added instream and floodplain/off-channel habitat complexity from large wood placement, instream habitat enhancement, and reconnection of off-channel habitats occurs where appropriate and riparian vegetation is permitted to mature, then high potential for improved quantity and quality of habitat, increased floodplain connectivity, and side channel development/maintenance.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian Revegetation** **Enhance Aquatic Habitat** **Improve Floodplain and Off-Channel Habitat Connectivity** **Large Wood Placement**
	Actions include enhance aquatic habitat and increase fish habitat complexity via large wood loading. Realign main channel or create side channel or off-channel features in river-right floodplain swale features.
Alternatives	**Alternatives 1 and 2**
	Alternative 1 – Mainstem remains in current alignment; large wood loading in mainstem throughout reach. Create river-right side channel inlet to reconnect swale feature to mainstem. Low-tech habitat complexity and large wood actions, such as Beaver Dam Analogues or Post-Assisted Log Structures in the river-right floodplain. *Alternative 2 – Realign mainstem channel and regrade floodplain wetlands/re-connect off-channel features adjacent to realigned channel. Large wood loading and revegetation throughout reach.*

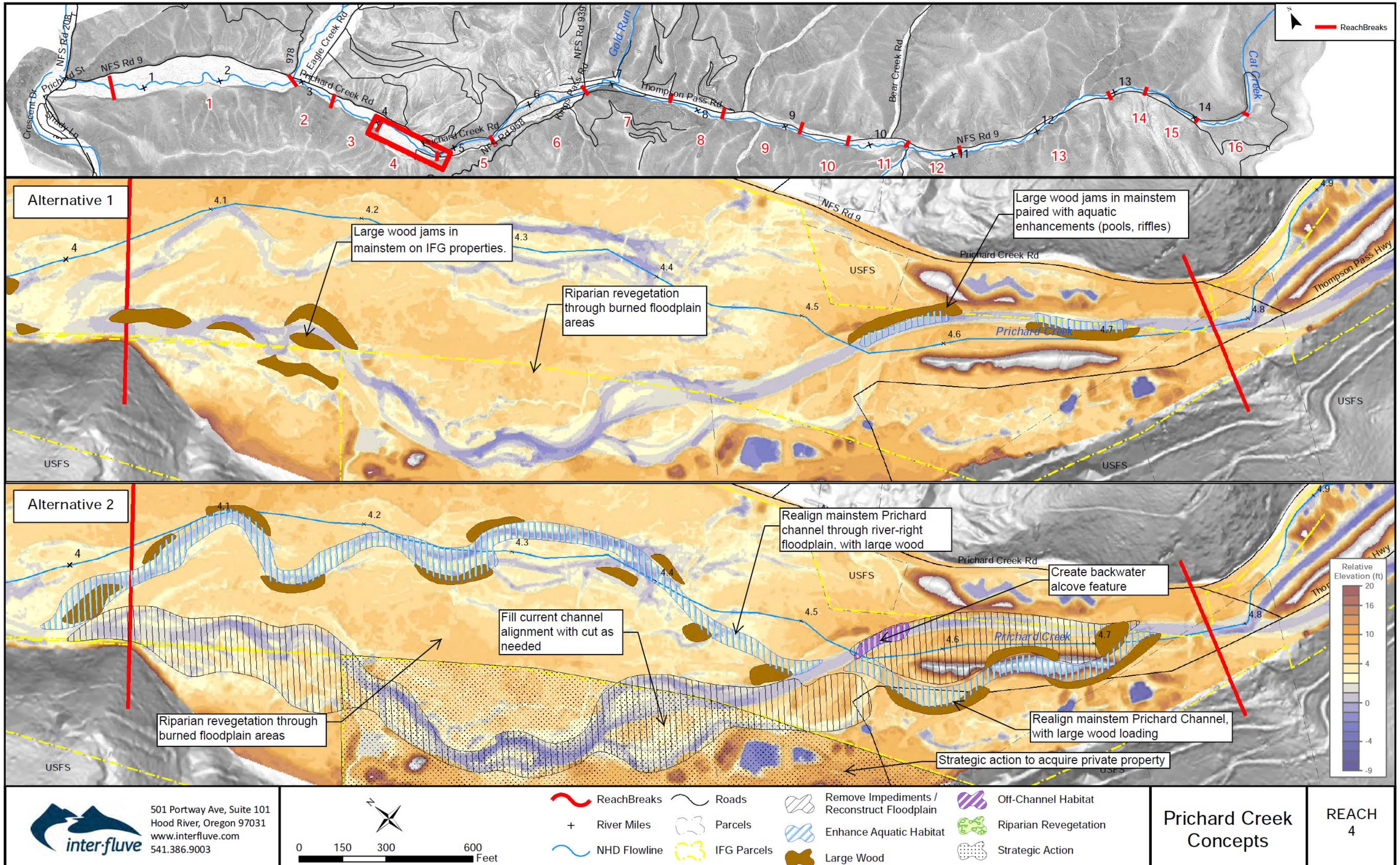

Figure 47. Reach 4 concepts.

3.3.4 Reaches 5 - 6 Restoration Strategy

Reaches 5 and 6 sit in relatively wide alluvial valleys separated by bedrock pinch where the valley width is limited by bedrock. Reach 6 has several smaller tributaries that enter from the adjacent hillslopes and has accumulated much alluvium, resulting in a relatively wide valley. The tributary alluvial fans are no longer present in the topography along the valley margins, likely the result of past hydraulic mining. Despite the relatively large amount of width, the stream is confined between the valley toe and dredge spoils. The stream does not have the energy to erode the dredge material, so those remain a barrier to lateral channel processes, including sediment storage and riparian vegetation growth. The confinement has produced a channel that is quite efficient at transporting water and sediment through the reach juxtaposed into a valley that likely would have resembled something more akin to Reach 1 prior to human disturbance.

Much of the valley bottom is devoid of vegetation through Reaches 5 and 6, though trees are present, presumably in places where the roots can access water. Groundwater elevations vary throughout the year, resulting in surface flows through the wetter portions of the year. Elevations drop during the drier portions of the year, ranging from 8 to 11 feet below the active channel elevation. A series of test pits were dug during March of 2023 to determine substrate characteristics of the dredge piles and to collect fine sediment samples that could be tested for contaminates. Few fine sediments were observed in the pits (e.g., Figure 48), with the majority of the material visually estimated to range between gravel and boulder size classes.

Figure 48. Example test pit photos taken in Reach 6.

The valley bottom through Reaches 5 and 6 is predominantly owned by the IFG. The USFS owns a small parcel in Reach 5, and Shoshone County has a DOT yard in Reach 6.

The recommended restoration actions developed herein were developed with guidance from the project partners to only examine options that restore perennial surface flows to the reaches and place the reaches on trajectories to where they can address the identified limiting factors (improve access to and quality of coldwater refugia, increase the quantity and quality of overwinter habitat for adult fish, and improve the access to and quality of summer rearing habitat). Key to addressing each of these limiting factors is a reconstruction of a functional floodplain that can store and sort sediment, slow the downstream transport of water and nutrients, and provide the conditions necessary to grow riparian vegetation.

Alternative 1 involves a complete floodplain reconstruction that extends from the Prichard Creek Road right-of-way to the opposite valley toe. This would involve redistributing, and likely sorting, the dredge piles across the valley, and grading an active channel corridor. Figure 49 illustrates an example of what a reconstructed channel and floodplain might look like. The floodplain and active channel corridor would be reconstructed at an elevation closer to the groundwater (i.e., ~8 feet lower than the current active channel). Material will need to be exported from the site, through options may exist to store much of it in the reach (e.g., use the excess material to rebuild the alluvial fans of the tributaries). In addition to the grading, an ample quantity of large wood would be used to provide roughness across the active channel and floodplain. This wood is key in sorting sediments and using the energy of the river to rebuild a functional floodplain. This option would also require a substantial revegetation effort and relocating the County DOT yard to another location.

Alternative 2 is similar to Alternative 1, where a floodplain and active channel corridor would be reconstructed at an elevation closer to the groundwater, however the width of the project area would be much reduced to an approximately 400-foot-wide corridor. The 400-foot width was determined by examining the widths of reaches of Prichard Creek that exhibit the conditions desired for Reaches 5 and 6. Figure 50 illustrates what this might look like for a section of Reach 6 located near the county yard. The corridor would consist of a reconstructed floodplain and active channel corridor; each loaded with ample large wood. A substantial revegetation effort would be required to provide surface roughness, erosion resistance, and to jumpstart riparian vegetation growth.

Alternative 3 assumes a similar corridor width to Alternative 2 (i.e., approximately 400 feet), but reduces the excavated depth to roughly half of that assumed in Alternatives 1 and 2 (i.e., 4 feet instead of 8). As with the other alternatives, the corridor would require ample wood and a substantial revegetation effort. The recommended actions for alternative are summarized in Table 9 and Figure 51 and Figure 52.

Key considerations for project design and implementation center around the resources available to implement the projects. Alternative 1, the full width reconstruction depends on moving the County DOT yard and the ability to waste material within the reach or close by. Alternative 3 stems from previous experiences where groundwater elevations were observed to rebound post-project. It is thought that if a similar response was observed here, it would reduce the amount of excavation required. Alternative 3 also depends on recovering enough fine sediments from the dredge spoils to be recovered and used to seal up the bed. The feasibility of this approach will need to be investigated through additional design and assessment work.

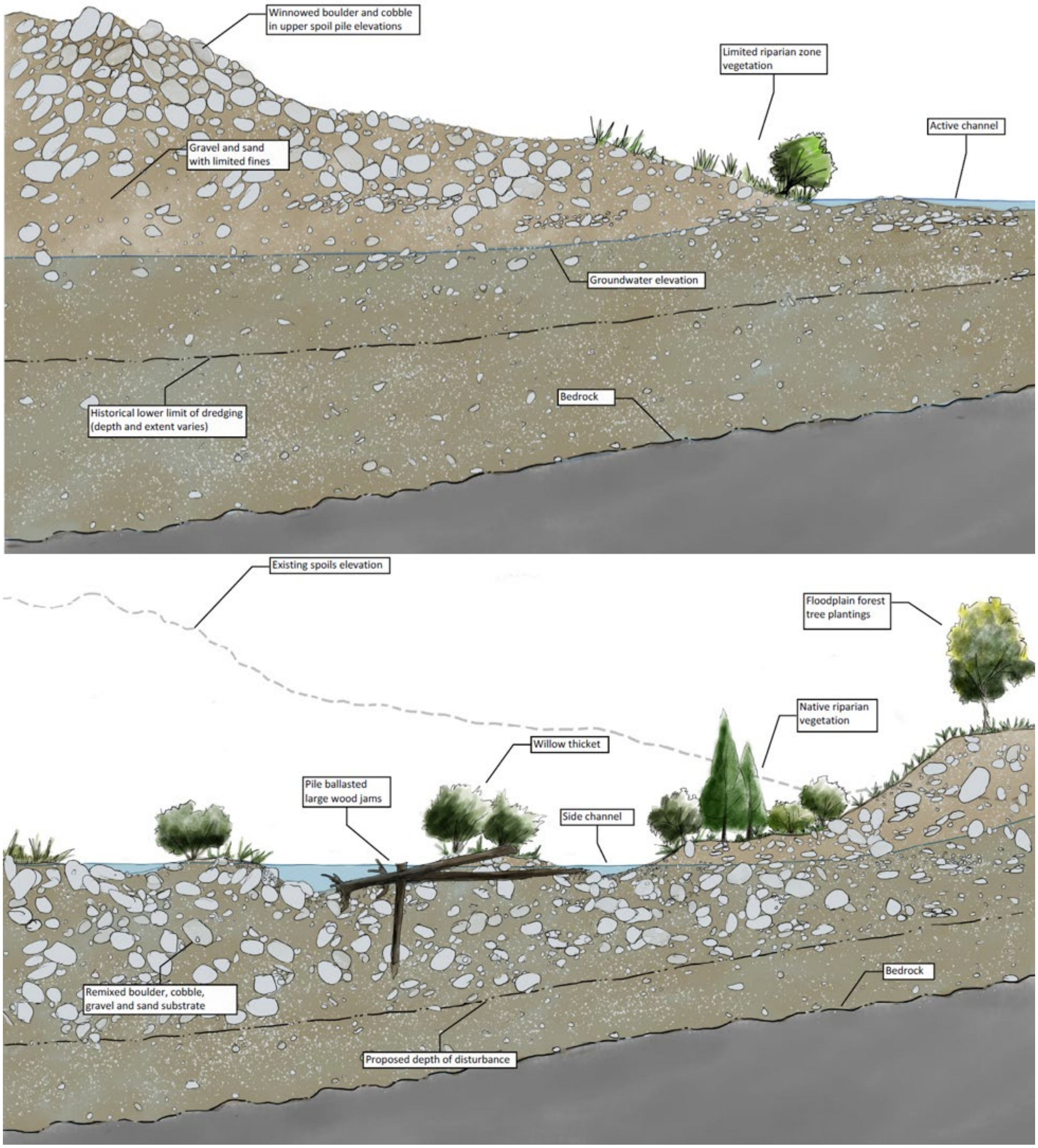

Figure 49. Illustrated cross sections showing a concept of existing conditions (top) and a proposed conditions example of a reconstructed floodplain and channel (bottom).

Figure 50. Illustration of proposed treatments and benefits of Alternative 2 for a section of Reach 6.

Table 9. Restoration strategy overview for Reaches 5 and 6.

Overall ecological function	**Low**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Reaches 5 and 6 have the most unacceptable ratings of all the reaches (five in Reach 5 and seven in Reach 6). The primary source of impairment is seasonal loss of surface flow to the subsurface that creates a barrier to fish movement. Additionally, the reaches lack large wood and pools, are disconnected from their floodplains, lack off-channel habitat features, are susceptible to episodic sediment loading, and contain little riparian vegetation.
Trajectory if no action taken	**Same**
	Ecologic function is expected to remain relatively the same under existing conditions. The Creek is unlikely to be able to naturally recover from historical dredging activity in the floodplain and channel which left large piles of dredge materials in the floodplains and deeply incised and straightened the channel in both reaches. The dredge piles are armored by boulder sized clasts and Prichard lacks the stream power to move those larger clasts. Without the ability to re-sort the dredged material, the river will not be able to rebuild a functional floodplain. Instead, it will continue to be inundated by episodic delivery of sediment.
Recovery potential	**Moderate**
	Reaches 5 and 6 benefit from being mostly owned by one landowner that would like to see a restored river. While the reaches have a long way to go, regrading a well-connected floodplain and adding large wood to help reduce the responsiveness of the reach to episodic sediment loading should initiate recovery. Recovery potential is moderate in the near term, but trends toward high over longer time scales, with ecologically-mindful land management. Reach 5 is situated an unconfined valley and as a result, presents the highest opportunity for ecological uplift.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities. Reach 6 sits in a relatively wide alluvial valley that is not confined by the valley. In this manner, it is analogous to Reach 1 which provides a longer-term analog for target conditions.
Action Types	**Channel-Floodplain Reconstruction** **Riparian Revegetation** **Enhance Aquatic Habitat** **Improve Floodplain and Off-Channel Habitat Connectivity** **Large Wood Placement**
	Actions recommended for Reaches 5 and 6 start with sorting the dredge sediments and excavating a channel corridor at an elevation closer to the measured groundwater elevations. Large wood should be used to scour pool habitats and sort sediments, initiating the formation of an anastomosing channel pattern. Revegetation in the riparian zone will further speed recovery.
Alternatives	**Alternatives 1, 2, and 3**
	Alternative 1 – Full valley excavation, sorting, regrade; would require relocating the County DOT lot or repositioning it to have less impact on available width; preliminary grading suggests an excess of material, some of which may need to be hauled offsite; no

	impacts to the road or utilities; dredge material will need to be sorted and it is unclear if enough fines are present to fill void spaces in the subsurface *Alternative 2 – Partial valley excavation, sorting, regrade; accommodates County DOT lot and leaves opportunities to leave excess dredge material in certain locations around the site; dredge material will need to be sorted and it is unclear if enough fines are present to fill void spaces in the subsurface* *Alternative 3 – Partial valley regrade; intent is to provide more width for the river to spread out and seal up the bed over time; requires less excavation; excess dredge spoils could be stored onsite; uncertainty persists regarding the fundamental issue of subsurface flow in near term; time require to seal up the bed depends on flow sequences and sediment supply making it very challenging to predict*

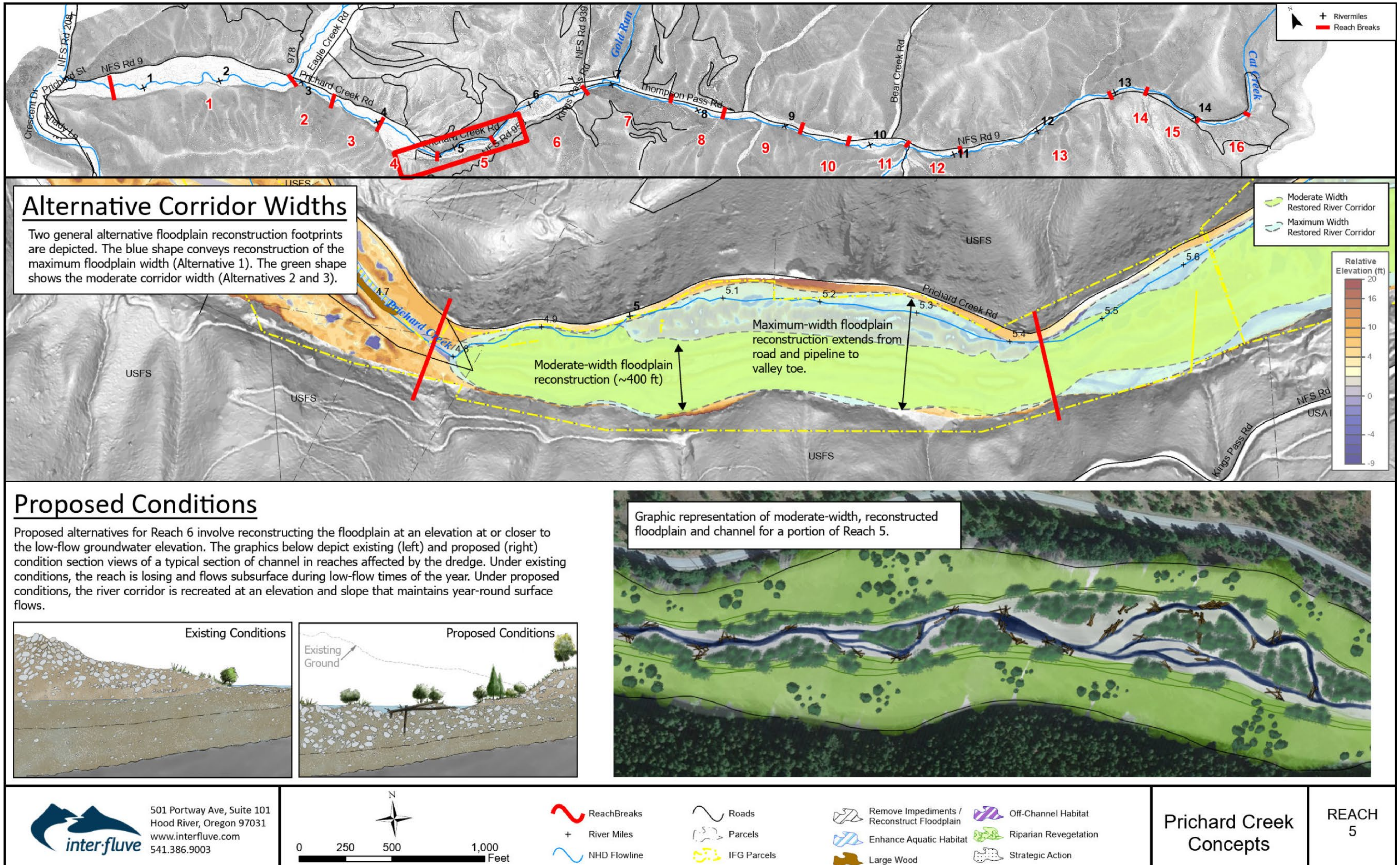

Figure 51. Reach 5 concepts.

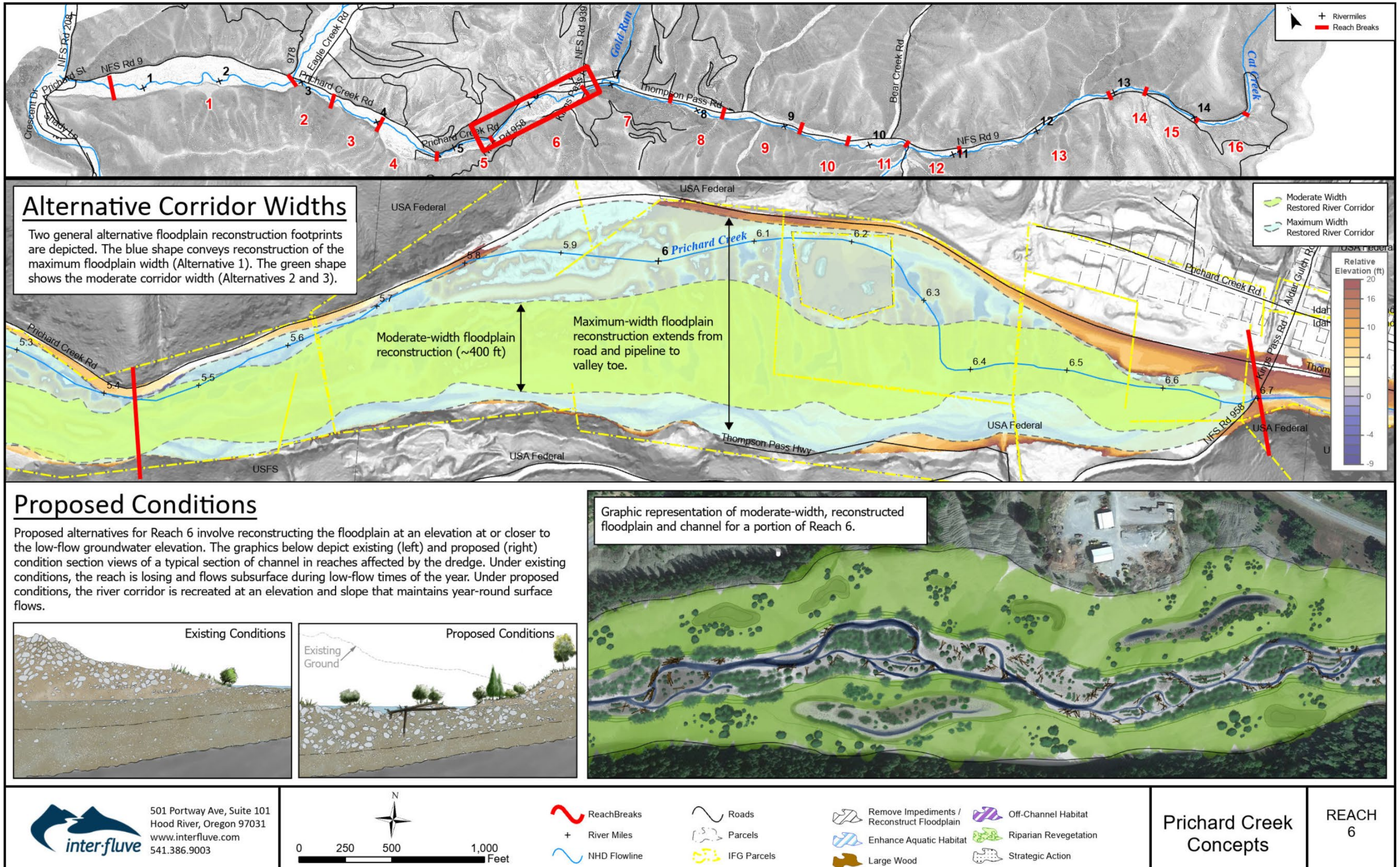

Figure 52. Reach 6 concepts.

3.3.5 Reaches 7 - 8 Restoration Strategy

Through Reaches 7 and 8, Prichard is well confined (confinement ratios ranging from 1-3) between the road, Yellowstone Pipeline, and the valley. The lack of width is a substantial constraint on the uplift potential for these reaches. Land ownership is a mix of private and public with most of the river corridor owned by IFG.

The recommended restoration actions are focused on the creation of holding habitat as the reaches are important migration corridors for Westslope Cutthroat trout. This primarily involves the placement of large wood and boulder clusters, though limited opportunities to reconnect pockets of floodplain exist in Reach 8.

One alternative is proposed for the reaches (summarized in Table 10 and Figure 53), and many of the actions could be implemented in an *a la carte* manner, depending on resources. The side channels proposed in Reach 8 would require accompanying wood placements to drive the flow splits.

Key considerations for project design and implementation include evaluation of potential impacts to Prichard Creek Road and the Yellowstone Pipeline. Bank disturbing work may not be possible in locations where the pipeline is close to the channel unless it can be completed in a manner that has no impact on the pipeline. Work on federal land may require a more involved permitting process.

Table 10. Restoration strategy overview for Reaches 7-8.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Both reaches have a majority of unacceptable or at-risk ratings. Impairments are associated with a lack of large wood and deep pools, limited side channel or off channel refugia; and human disturbance, especially in the riparian zone.
Trajectory if no action taken	**Same**
	Although these reaches are naturally somewhat confined, human land uses – particularly Thompson Pass Rd – have further artificially confined the channel and disconnected the already limited floodplain and off-channel habitats of these reaches. Ecologic function is expected to remain relatively the same under existing conditions due to the straightened, simplified nature of the channel and limited large wood inputs that might encourage natural lateral migration processes. The Thompson Pass Rd prism and buried utility pipeline adjacent to the road limits full recovery through these reaches.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Enhance Aquatic Habitat** **Large Wood Placement** **Riparian Revegetation** **Improve Floodplain and Off-Channel Habitat Connectivity**
	Actions include enhance aquatic habitat through deep pool creation, boulder roughness features, and large wood loading.
Alternatives	**Alternative 1**
	Alternative 1 – Large wood loading in the mainstem for cover habitat. Creation of deep pools and boulder roughness features to enhance aquatic habitat complexity.

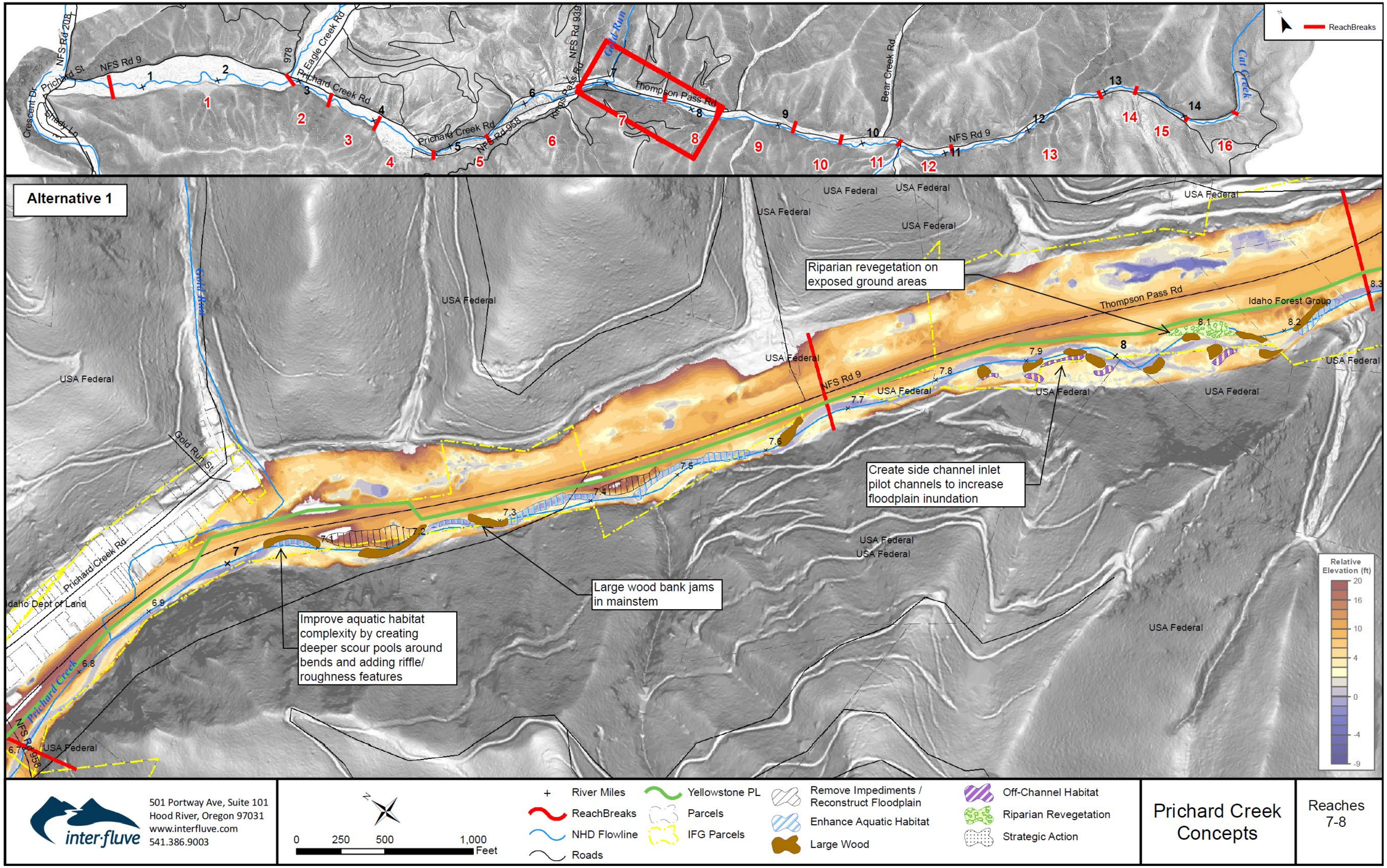

Figure 53. Concepts for Reaches 7 and 8.

3.3.6 Reaches 9 - 10 Restoration Strategy

Similar to Reaches 7 and 8, Reaches 9 and 10 are confined (confinement ratios ranging from 1-3) between the road, Yellowstone Pipeline, and the valley toe. While the lack of width is, again, a constraint on the uplift potential for these reaches small pockets of floodplain could provide localized habitat improvements. Land ownership is a mix of private and public with most of the river corridor owned by IFG.

The recommended restoration actions are focused on the creation of holding habitat as the reaches are important migration corridors for Westslope Cutthroat trout. This primarily involves the placement of large wood and boulder clusters. The downstream end of Reach 9, at the confluence with Butte Gulch, a relatively large pocket of floodplain presents an opportunity to reconnect floodplain though it would involve removing the ponds.

Two alternatives are proposed for the reaches (summarized in Table 11 and Figure 54) that center around the reconfiguration of the downstream end of Reach 9. Alternative 1 converts the ponds to flow-through side channel and wetland habitat. Alternative 2 creates frequently inundated floodplain and wetland habitat. Both alternatives would create substantial complexity around the confluence. The remaining proposed treatments are the same between alternatives and could be implemented in an *a al carte* manner.

Key considerations for project design and implementation include evaluation of potential impacts to Prichard Creek Road and the Yellowstone Pipeline. Just downstream of the ponds, the pipeline traverses from the road to an alignment that is close to the right bank of Prichard Creek. While wood is incorporated into the alternatives to protect the pipeline from any channel migration that may result from the proposed work, additional design is needed to ensure that the actions can be implemented without impacts to the pipeline.

Table 11. Restoration strategy overview for Reaches 9-10.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Both reaches have unacceptable or at-risk ratings for a majority of the REI metrics. Impairments are associated with a lack of large wood and deep pools, limited side channel or off channel refugia; and human disturbance, especially in the riparian zone. Key limiting factors for this reach include limited deep pools for holding adults during spawning up- or downstream migrations.
Trajectory if no action taken	**Same**
	Although these reaches are naturally more confined than other reaches in the assessment area, human land uses – particularly Thompson Pass Rd – have further artificially confined the channel and disconnected the already limited floodplain and off-channel habitats of these reaches. Ecologic function is expected to remain relatively the same under existing conditions due to the straightened, simplified nature of the channel and limited large wood inputs that might encourage natural lateral migration processes. The Thompson Pass Rd prism and buried utility pipeline adjacent to the road limits full recovery through these reaches.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian Revegetation** **Enhance Aquatic Habitat** **Improve Floodplain and Off-Channel Habitat Connectivity** **Large Wood Placement**
	Actions include enhance aquatic habitat through deep pool creation, boulder roughness features, and large wood loading. An off-channel created pond feature in Reach 9 may be modified to increase the hydrologic connectivity with the mainstem.
Alternatives	**Alternatives 1 and 2**
	Alternative 1 – Perennial side channel through current pond feature in river-right floodplain just upstream of the tributary confluence. Large wood loading along the side channel and in the main stem for cover habitat. Creation of deep pools and boulder roughness features to enhance aquatic habitat complexity. No impacts to Yellowstone Pipeline. *Alternative 2 – Regrade and revegetate current pond feature to function as frequently inundated floodplain habitat. Large wood loading in the mainstem for cover habitat. Creation of deep pools and boulder roughness features to enhance aquatic habitat complexity. No impacts to Yellowstone Pipeline.*

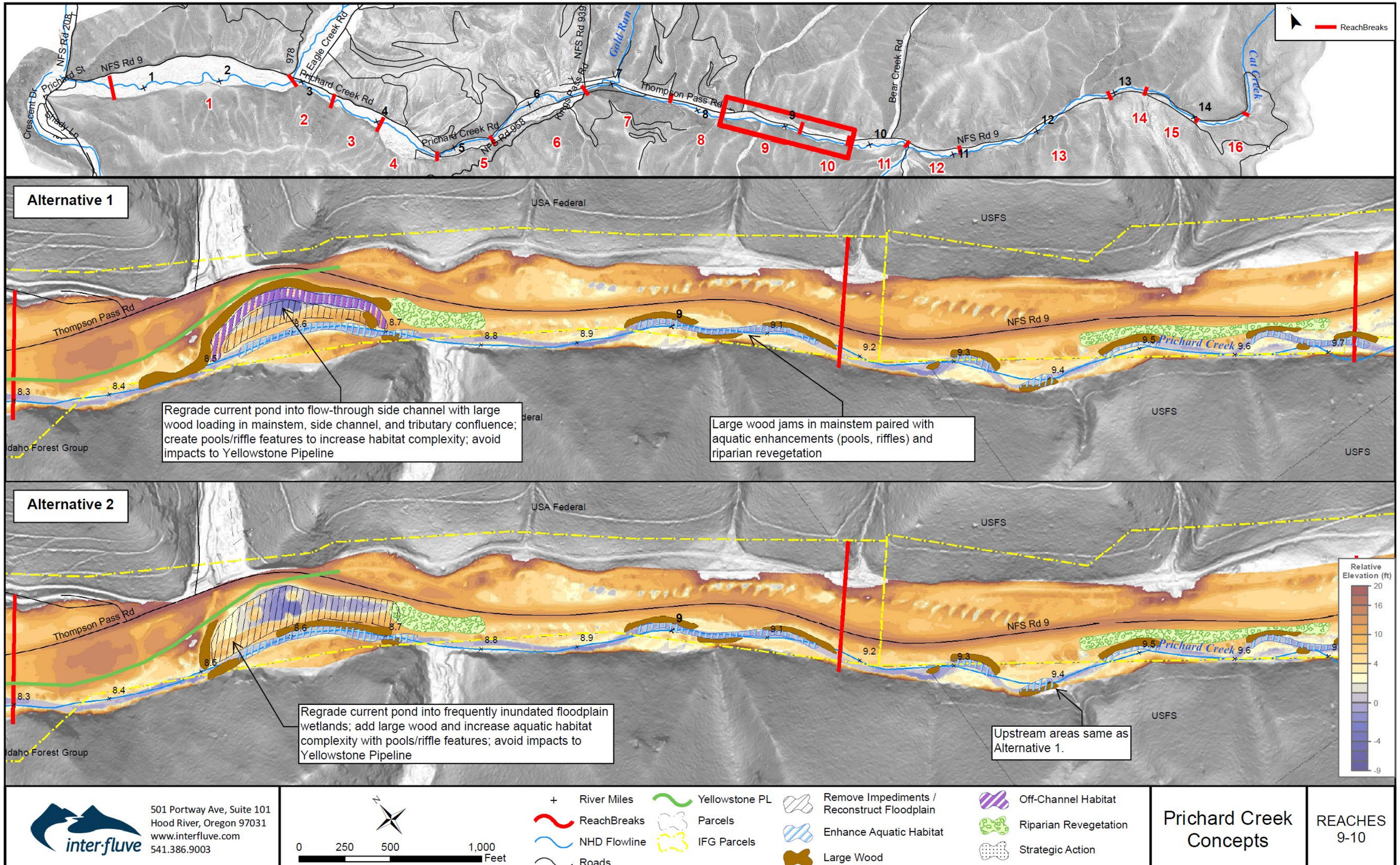

Figure 54. Concepts for Reaches 9 and 10.

3.3.7 Reach 11 Restoration Strategy

Reach 11 contains the Bear Creek and Granite Gulch confluences, and the most upstream extents of bucket dredge operation. Confinement is much reduced compared to downstream reaches (confinement ratios near 6). The river and floodplain sit well below the road elevation, opening opportunities for more impactful treatments that affect the entire floodplain. The majority of the valley bottom is owned by IFG.

The recommended restoration actions are focused on restoring depositional characteristics to the valley by adding large wood, removing dredge spoils, revegetating bartops, and creating multiple channels. This includes adding complexity to the Bear Creek confluence and the lower portion of Bear Creek.

Two alternatives are proposed for the reach (summarized in Table 12 and Figure 55) that differ based on whether or not the dredge spoils are removed from the floodplain. Alternative 1 assumes that the spoils remain in place and proposed to create habitat complexity via wood placements, side channel enhancement, and revegetation. Alternative 2 uses many of the same treatments but adds in removal of the dredge spoils. There are options to scale the alternatives down (i.e., reduce the intensity of treatment) if resources are limited.

Key considerations for project design and implementation stem from the high levels of lead and arsenic sampled in the reach. While the source is thought to be from lead-zinc ore mill sites in Granite Gulch, the presence of the contaminants in the dredge piles is uncertain. A third option, consisting of a valley reset and restoration to Stage 0, was considered but high sediment loads and contaminants present substantial challenges to the longevity and ecological uplift of this option. Additional information and design would need to occur before understanding if this approach is viable.

Table 12. Restoration strategy overview for Reach 11.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Three of 9 REI metrics are rated as unacceptable, and four as at risk. Impairments are associated with a lack of large wood and deep pools, limited side channel or off channel refugia; and riparian canopy disturbance.
Trajectory if no action taken	**Same**
	The history of channel and floodplain dredging in the reach has impacted the Creek's natural ability to inundate and reconnect with historical floodplain or off-channel habitats. Limited large riparian tree regrowth has occurred since disturbance activities. Therefore, ecologic function is expected to remain relatively the same under existing conditions.
Recovery potential	**High - Moderate**
	Large wood loading is expected to instigate a trajectory (channel response) that will enhance channel and floodplain function. Reconnection of off-channel and side channel habitats through previously dredged floodplain areas and riparian vegetation is permitted to mature, then high potential for improved quantity and quality of habitat, increased floodplain connectivity, and side channel development/maintenance.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian Revegetation** **Remove Impediments and Reconnect Floodplain** **Enhance Aquatic Habitat** **Improve Floodplain and Off-Channel Habitat Connectivity** **Large Wood Placement**
	Actions include enhance aquatic habitat and remove dredge mining spoil piles in historical floodplain areas to increase available channel freedom space. increase channel habitat complexity via large wood and pool creation. Create side channels and low floodplain/wetland surfaces that are inundated frequently. Enhance aquatic habitat in Bear Creek fan and confluence with large wood.
Alternatives	**Alternatives 1 and 2**
	Alternative 1 – Floodplain regrading upstream of Bear Creek confluence in river right floodplain. Add large wood structures throughout mainstem and Bear Creek below the Thompson Pass Road crossing to increase cover and complexity of aquatic habitat and encourage lateral migration and floodplain connectivity. Potentially realign Bear Creek channel through the fan. Create side channels through lower floodplain surfaces and encourage flow into side channels with large wood features. *Alternative 2 – Floodplain regrading in upstream and downstream river right floodplains. Add large wood structures throughout mainstem and Bear Creek below the Thompson Pass Road crossing to increase cover and complexity of aquatic habitat and encourage lateral migration and floodplain connectivity. Potentially realign Bear Creek channel through the fan. Create side channels through lower floodplain surfaces and encourage flow into side channels with large wood features.*

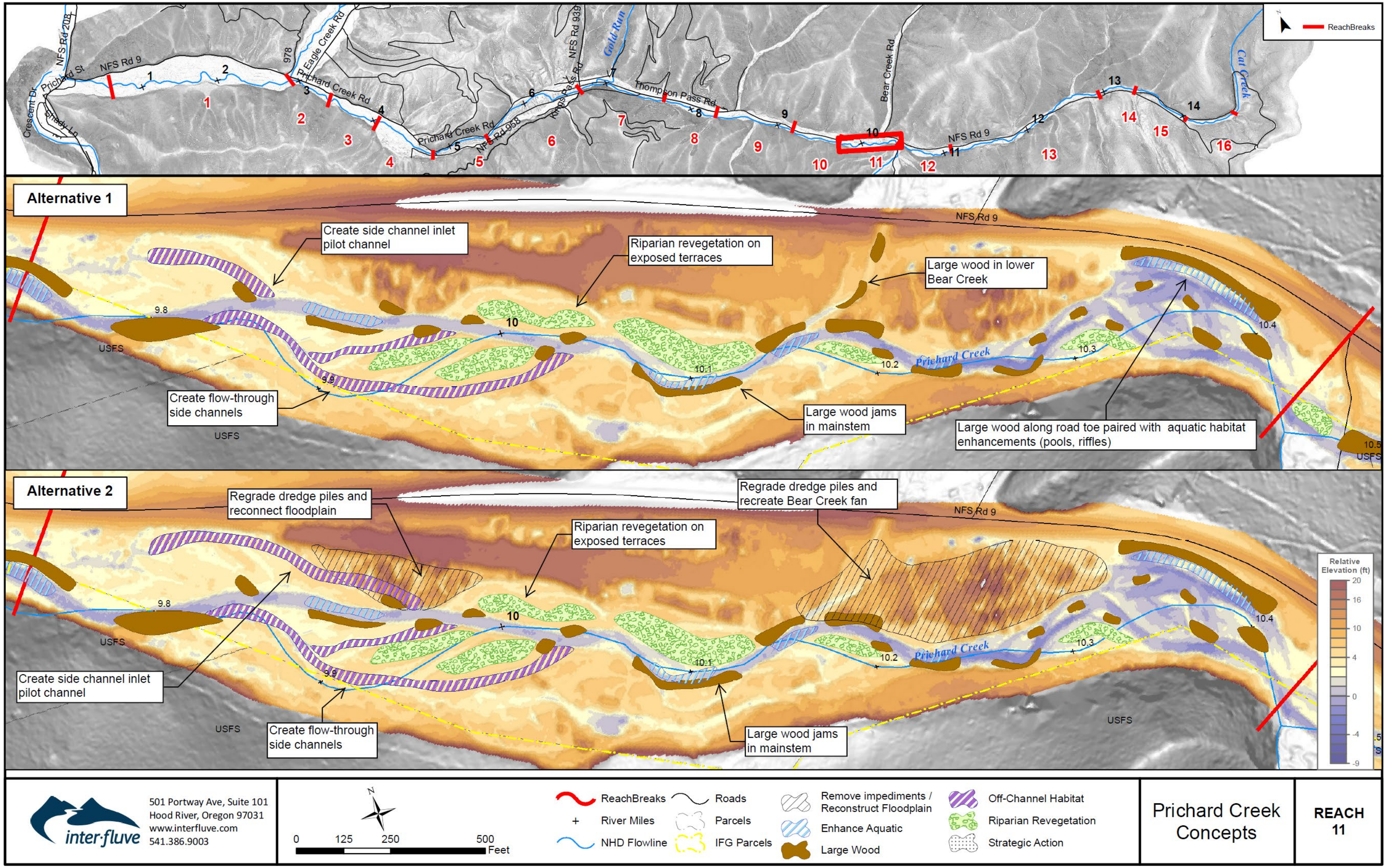

Figure 55. Reach 11 concepts

3.3.8 Reach 12 Restoration Strategy

Reach 12 extends from the Granite Gulch confluence upstream approximately half of a mile to the end of IFG property. The valley bottom has federal and private land ownership. The reach is partially confined (confinement ratios near 6) but contains adequate width to improve the floodplain. The river and floodplain sit well below the road elevation, opening opportunities for more impactful treatments that affect the entire valley bottom.

The recommended restoration actions are focused on restoring depositional characteristics to the valley by adding large wood, revegetating bartops, and creating multiple channels. A mining operation, located upstream, appears to be the source of a substantial sediment load that is inundating the reach.

One alternative is proposed for the reach (summarized in Table 13 and Figure 56) with treatments focused on using wood to store and sort the sediment loads coming from upstream. The proposed treatments can be implemented in an *a la carte* manner. There are options to scale the alternatives down (i.e., reduce the intensity of treatment) if resources are limited.

Key considerations for project design and implementation are based around the mixed land ownership of the valley bottom. Additionally, there is a ford-style crossing at the Granite Gulch confluence that was assumed to remain unaffected by any restoration actions in the reach.

Table 13. Restoration strategy overview for Reach 12.

Overall ecological function	**Moderate**
	Rating is based on the reach assessment evaluations of habitat, geomorphology, hydrology, hydraulics, and vegetation. Two of 9 REI metrics are rated as unacceptable, and two as at risk. Impairments are associated with a lack of floodplain connectivity and off-channel habitat, and riparian canopy disturbance.
Trajectory if no action taken	**Same**
	The history of channel and floodplain dredging in the reach has impacted the Creek's natural ability to inundate and reconnect with historical floodplain or off-channel habitats. Limited large riparian tree regrowth has occurred since disturbance activities. Therefore, ecologic function is expected to remain relatively the same under existing conditions.
Recovery potential	**High - Moderate**
	Large wood loading is expected to instigate channel response that will enhance off-channel and floodplain connection as well as improve in-channel aquatic habitat condition. With revegetation of riparian vegetation that is permitted to mature, there may be high potential for improved quantity and quality of habitat, increased floodplain connectivity, and side channel development/maintenance.
Restoration objectives	**Target conditions in Table 1**
	Bring existing conditions to target conditions for the habitat and geomorphic metrics identified in Table 1 above. These targets apply to multiple habitat and geomorphic attributes. To the extent possible at this stage of planning, the targets are presented as measurable quantities.
Action Types	**Riparian Revegetation** **Large Wood**
	Actions include enhance aquatic habitat and remove dredge mining spoil piles in historical floodplain areas to increase available channel freedom space. increase channel habitat complexity via large wood and pool creation. Create side channels and low floodplain/wetland surfaces that are inundated frequently. Enhance aquatic habitat in Bear Creek fan and confluence with large wood.
Alternatives	**Alternative 1**
	Alternative 1 – Add large wood structures throughout mainstem to increase cover and complexity of aquatic habitat, and encourage lateral migration and floodplain connectivity. Revegetate riparian zones to encourage channel shading, nutrient and prey input to the channel, and provide sources for long-term large wood recruitment.

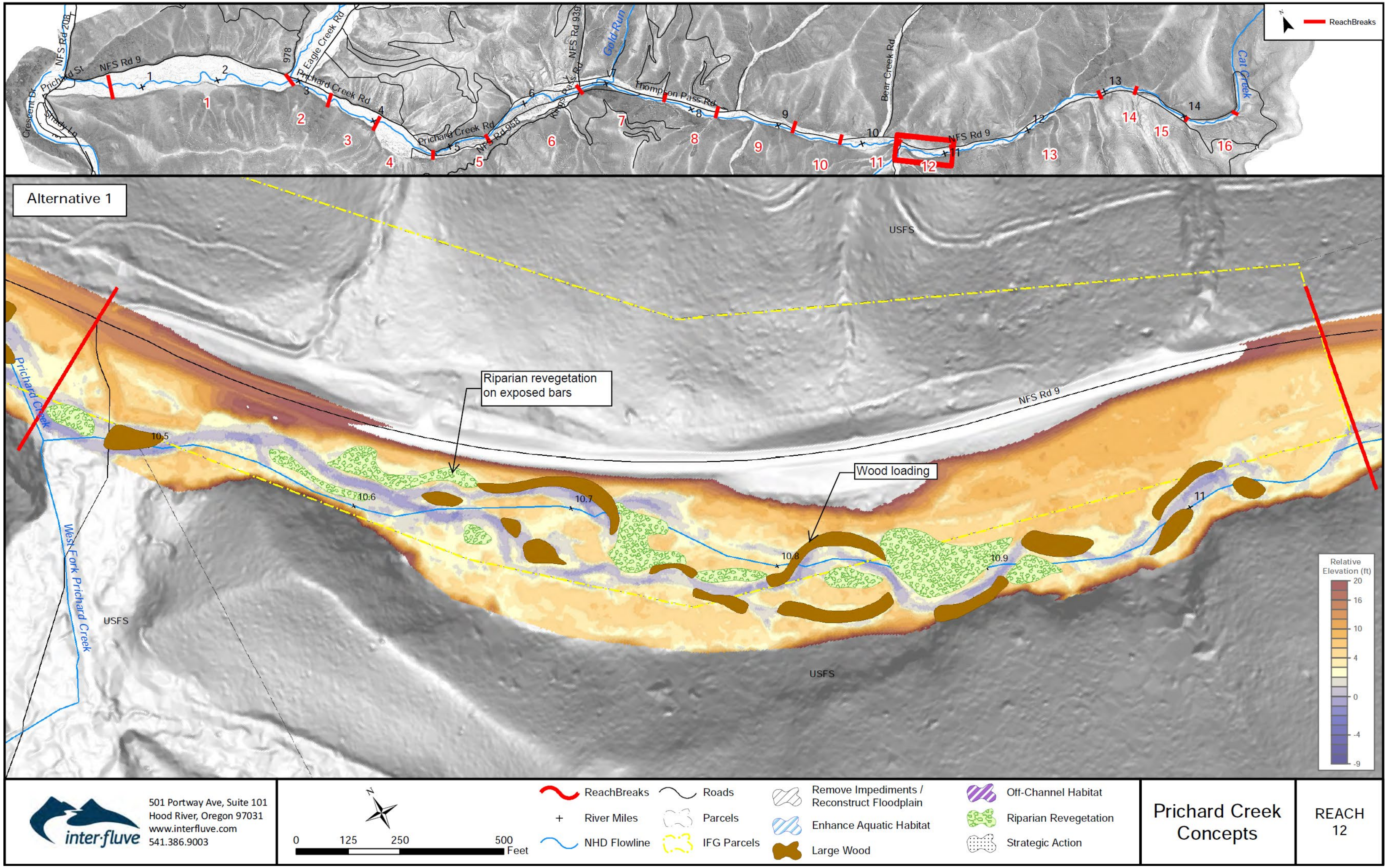

Figure 56. Reach 12 concepts.

3.4 CONCEPT LEVEL COST ESTIMATES

Concept level cost estimates for each of the Prichard Creek concept designs were estimated using a number of references including published guidance and unit costs from similar projects. Quantities estimates and associated costs were developed for various habitat items such as large wood and side channel excavation where feasible, and other construction costs, such as mobilization and temporary erosion control measures were estimated based on percentages of the direct construction costs.

In order to determine log quantities, large wood volume was estimated based on the density of wood applied for the Phase 1 projects multiplied by the length of stream to be treated. Wood quantities are conveyed as volumes rather than log counts as this mitigates some of the uncertainty in available large wood material size in the early stages of design. An equivalent number of logs is provided in the cost estimates for reference, assuming an average log (with an attached rootwad) dimension of 16-inch diameter at breast height (DBH). It is important to note that the log quantities are highly sensitive to the size of the large wood material, and it is anticipated that relatively large logs (i.e., larger than the average size used to develop the cost estimates) would be used in some capacity in these projects. The cost estimates assume that all large wood material will need to be purchased and delivered to the project sites, except for tipped trees which will be salvaged on site.

Excavation volumes were estimated from the LiDAR and area of the associated polygon. In all cases, the costs assume that excavated material can be placed on site and that material import would not be required. Other habitat elements, such as riparian revegetation, were estimated based on high level, conservative assumptions of materials quantities and unit costs from similar projects.

Construction costs such as mobilization, site clearing and access, and erosion and sediment control were estimated based on assumed percentages of the direct costs described above. Mobilization costs were estimated at 10% of the direct costs, per guidance from WSDOT (2023). As the projects progress, more details will be developed that can allow for a refined estimate of these items.

There is a great deal of uncertainty of unit costs and quantities at the current concept design phase. Given this high degree of uncertainty, the estimated costs should be expected to have an accuracy range between -30% and +50%, per Association for Advancement of Cost Engineering (AACE) guidelines (AACE, 2016). Table 14 shows an overview of estimated costs for each reach and alternative. Table 15 through Table 22 provide a breakdown of costs for each reach and alternative.

Table 14. Overview of estimated concept level construction costs for Prichard Creek.

Estimated Costs			
	Low Estimate (cost-30%)	Estimated Cost	Cost plus 50% Contingency
Reach 1			
Alt1	$ 430,000	$ 613,000	$ 920,000
Alt2	$ 1,148,000	$ 1,639,000	$ 2,460,000
Reaches 2-3			
Alt1	$ 614,000	$ 876,000	$ 1,320,000
Reach 4			
Alt1	$ 469,000	$ 669,000	$ 1,010,000
Alt2	$ 1,431,000	$ 2,043,000	$ 3,070,000
Reach 5-6			
Alt1	$ 15,026,000	$ 21,465,500	$ 32,200,000
Alt2	$ 10,234,000	$ 14,619,700	$ 21,930,000
Alt3	$ 7,468,000	$ 10,667,700	$ 16,010,000
Reach 7-8			
Alt1	$ 558,000	$ 797,000	$ 1,200,000
Reach 9-10			
Alt1	$ 497,000	$ 710,000	$ 1,070,000
Alt2	$ 507,000	$ 723,000	$ 1,090,000
Reach 11			
Alt1	$ 531,000	$ 757,800	$ 1,140,000
Alt2	$ 869,000	$ 1,240,600	$ 1,870,000
Reach 12			
Alt1	$ 365,000	$ 520,200	$ 790,000

Table 15. Cost estimates for Reach 1.

	Prichard Creek Reach 1							
	Quantity			Unit Cost		Cost		
	Alt 1	Alt 2	Unit	Alt 1	Alt 2	Alt 1	Alt 2	Notes
Miscellaneous								
Mobilization/Demobilization	1	1	LS	$ 60,000	$ 140,000	$ 60,000	$ 140,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	1	LS	$ 50,000	$ 120,000	$ 50,000	$ 120,000	Direct Costs.
		Subtotal (rounded up to nearest hundred)				**$ 110,000**	**$ 260,000**	
Staging and Access								
Staging Areas and Temporary Access	1	1	LS	$ 10,000	$ 10,000	$ 10,000	$ 10,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
		Subtotal (rounded up to nearest hundred)				**$ 10,000**	**$ 10,000**	
Habiat Construction								
Large Wood Structure - Mainstem Wood	20,000	107,000	CF	$ 12	$ 12	$ 240,000	$ 1,284,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*357*	*1,911*	*EA*	*Per-Log Project Cost*		*$ 672*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 16" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	5	50	EA	$ 800	$ 800	$ 4,000	$ 40,000	Includes tipping large trees on site using excavator or winch truck
		Subtotal (rounded up to nearest hundred)				**$ 244,000**	**$ 1,324,000**	
Earthwork								
Side Channel Construction	8,000	0	CY	$ 15	$ 15	$ 120,000	$ -	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Berm Removal	19,000	0	CY	$ 6	$ 6	$ 114,000	$ -	Includes cut to adjacent floodplain elevation and local disposal of material. Assumes minimal hauling.
		Subtotal (rounded up to nearest hundred)				**$ 234,000**	**$ -**	
Revegetation								
Site Decomissioning Seeding	1	3	AC	$ 3,000	$ 3,000	$ 3,000	$ 9,000	Seeding access routes and staging areas.
Habitat Revegetation	1	3	AC	$ 12,000	$ 12,000	$ 12,000	$ 36,000	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
		Subtotal (rounded up to nearest hundred)				**$ 15,000**	**$ 45,000**	
					Sub-Total	**$ 613,000**	**$ 1,639,000**	
					Contingencies (50%)	$ 306,500	$ 819,500	
Project Totals (Rounded Up to the Nearest $10,000)						**$ 920,000**	**$ 2,460,000**	

Abbreviations

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

Notes:

1. Costs do not include design fees and construction observation.

Table 16. Cost estimates for Reaches 2-3.

	Prichard Creek Reaches 2-3				
	Quantity Alt 1	Unit	Unit Cost	Cost Alt 1	Notes
Miscellaneous					
Mobilization/Demobilization	1	LS	$ 80,000	$ 80,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	LS	$ 60,000	$ 60,000	Direct Costs.
	Subtotal (rounded up to nearest hundred)			**$ 140,000**	
Staging and Access					
Staging Areas and Temporary Access	1	LS	$ 15,000	$ 15,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
	Subtotal (rounded up to nearest hundred)			**$ 15,000**	
Habiat Construction					
Large Wood Structure - Mainstem Wood	44,000	CF	$ 12	$ 528,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*786*	*EA*	*Per-Log Project Cost*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 18" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	20	EA	$ 800	$ 16,000	Includes tipping large trees on site using excavator or winch truck
	Subtotal (rounded up to nearest hundred)			**$ 544,000**	
Earthwork					
Side Channel Construction	8,000	CY	$ 15	$ 120,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Berm Removal	5,000	CY	$ 6	$ 30,000	Includes cut to adjacent floodplain elevation and local disposal of material.
	Subtotal (rounded up to nearest hundred)			**$ 150,000**	
Revegetation					
Site Decomissioning Seeding	1	AC	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	2	AC	$ 12,000	$ 24,000	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
	Subtotal (rounded up to nearest hundred)			**$ 27,000**	
			Sub-Total	**$ 876,000**	
			Contingencies (50%)	$ 438,000	
Project Totals (Rounded Up to the Nearest $10,000)				**$ 1,320,000**	

Abbreviations

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

Notes:

1. Costs do not include the Strategic Action of acquiring the property in Reach 3.
2. Costs do not include design fees and construction observation.

Table 17. Cost estimates for Reach 4.

	Prichard Creek Reach 4							
	Quantity			Unit Cost		Cost		
	Alt 1	Alt 2	Unit	Alt 1	Alt 2	Alt 1	Alt 2	Notes
Miscellaneous								
Mobilization/Demobilization	1	1	LS	$ 60,000	$ 200,000	$ 60,000	$ 60,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	1	LS	$ 50,000	$ 160,000	$ 50,000	$ 50,000	Direct Costs.
Subtotal (rounded up to nearest hundred)						**$ 110,000**	**$ 110,000**	
Staging and Access								
Staging Areas and Temporary Access	1	1	LS	$ 11,000	$ 11,000	$ 11,000	$ 11,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
Subtotal (rounded up to nearest hundred)						**$ 11,000**	**$ 11,000**	
Habitat Construction								
Large Wood Structure - Mainstem Wood	19,000	45,000	CF	$ 12	$ 12	$ 228,000	$ 540,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*339*	*804*	*EA*	*Per-Log Project Cost*		*$ 672*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 16" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	10	10	EA	$ 800	$ 800	$ 8,000	$ 8,000	Includes tipping large trees on site using excavator or winch truck
Subtotal (rounded up to nearest hundred)						**$ 236,000**	**$ 548,000**	
Earthwork								
Instream Habitat Complexity	1,000	78,200	CY	$ 15	$ 15	$ 15,000	$ 1,173,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Floodplain Reconstruction	19,000	25,000	CY	$ 6	$ 6	$ 114,000	$ 150,000	required.
Subtotal (rounded up to nearest hundred)						**$ 129,000**	**$ 1,323,000**	
Revegetation								
Site Decomissioning Seeding	1	1	AC	$ 3,000	$ 3,000	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	15	4	AC	$ 12,000	$ 12,000	$ 180,000	$ 48,000	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
Subtotal (rounded up to nearest hundred)						**$ 183,000**	**$ 51,000**	
Sub-Total						**$ 669,000**	**$ 2,043,000**	
Contingencies (50%)						$ 334,500	$ 1,021,500	
Project Totals (Rounded Up to the Nearest $10,000)						**$ 1,010,000**	**$ 3,070,000**	

Abbreviations

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

Notes:

1. Costs do not include the Strategic Action of acquiring the property in Reach 4.
2. Costs do not include design fees and construction observation.

Table 18. Cost estimates for Reaches 5-6.

	Prichard Creek Reaches 5-6										
	Quantity				**Unit Cost**			**Cost**			
	Alt 1	**Alt 2**	**Alt 3**	**Unit**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 1**	**Alt 2**	**Alt 3**	**Notes**
Miscellaneous											
Mobilization/Demobilization	1	1	1	LS	$ 1,790,000	$ 1,220,000	$ 890,000	$ 1,790,000	$ 1,220,000	$ 890,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	1	1	LS	$ 1,790,000	$ 1,220,000	$ 890,000	$ 1,790,000	$ 1,220,000	$ 890,000	Direct Costs.
							Subtotal (rounded up to nearest hundred)	**$ 3,580,000**	**$ 2,440,000**	**$ 1,780,000**	
Staging and Access											
Staging Areas and Temporary Access	1	1	1	LS	$ 351,000	$ 239,000	$ 175,000	$ 351,000	$ 239,000	$ 175,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
							Subtotal (rounded up to nearest hundred)	**$ 351,000**	**$ 239,000**	**$ 175,000**	
Habitat Construction											
Large Wood Structure - Mainstem Wood	220,000	220,000	220,000	CF	$ 12	$ 12	$ 12	$ 2,640,000	$ 2,640,000	$ 2,640,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*3,929*	*3,929*	*3,929*	*EA*			*Per-Log Project Cost*	*$ 672*	*$ 672*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 16" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	0	0	0	EA	$ 800	$ 800	$ 800	$ -	$ -	$ -	Includes tipping large trees on site using excavator or winch truck
							Subtotal (rounded up to nearest hundred)	**$ 2,640,000**	**$ 2,640,000**	**$ 2,640,000**	
Earthwork											
Instream Habitat Complexity	118,000	118,000	118,000	CY	$ 15	$ 15	$ 15	$ 1,770,000	$ 1,770,000	$ 1,770,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Floodplain Reconstruction	1,883,100	1,076,000	538,000	CY	$ 6	$ 6	$ 6	$ 11,298,600	$ 6,456,000	$ 3,228,000	Includes general cut, grading, and shaping of the floodplain. Assumes material can be placed onsite and no import will be required.
							Subtotal (rounded up to nearest hundred)	**$ 13,068,600**	**$ 8,226,000**	**$ 4,998,000**	
Revegetation											
Site Decomissioning Seeding	1	1	1	AC	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	152	89	89	AC	$ 12,000	$ 12,000	$ 12,000	$ 1,822,807	$ 1,071,604	$ 1,071,604	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
							Subtotal (rounded up to nearest hundred)	**$ 1,825,900**	**$ 1,074,700**	**$ 1,074,700**	
							Sub-Total	**$ 21,465,500**	**$ 14,619,700**	**$ 10,667,700**	
							Contingencies (50%)	$ 10,732,750	$ 7,309,850	$ 5,333,850	
							Project Totals (Rounded Up to the Nearest $10,000)	**$ 32,200,000**	**$ 21,930,000**	**$ 16,010,000**	

<u>Abbreviations</u>

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

<u>Notes:</u>

1. Costs do not include design fees and construction observation.

Table 19. Cost estimates for Reaches 7-8.

	Prichard Creek Reaches 7-8				
	Quantity Alt 1	Unit	Unit Cost	Cost Alt 1	Notes
Miscellaneous					
Mobilization/Demobilization	1	LS	$ 10,000	$ 10,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	LS	$ 60,000	$ 60,000	Direct Costs.
	Subtotal (rounded up to nearest hundred)			**$ 70,000**	
Staging and Access					
Staging Areas and Temporary Access	1	LS	$ 15,000	$ 15,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
	Subtotal (rounded up to nearest hundred)			**$ 15,000**	
Habiat Construction					
Large Wood Structure - Mainstem Wood	35,000	CF	$ 12	$ 420,000	Includes purchase, delivery, stockpiling, and installation of large wood material.
Equivalent Log Quantity	*625*	*EA*	*Per-Log Project Cost*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 18" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	0	EA	$ 800	$ -	Includes tipping large trees on site using excavator or winch truck
	Subtotal (rounded up to nearest hundred)			**$ 420,000**	
Earthwork					
Instream Habitat Complexity	5,000	CY	$ 15	$ 75,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Berm Removal	19,000	CY	$ 10	$ 190,000	Includes cut to adjacent floodplain elevation and local disposal of material.
	Subtotal (rounded up to nearest hundred)			**$ 265,000**	
Revegetation					
Site Decomissioning Seeding	1	AC	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	2	AC	$ 12,000	$ 24,000	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
	Subtotal (rounded up to nearest hundred)			**$ 27,000**	
			Sub-Total	**$ 797,000**	
			Contingencies (50%)	$ 398,500	
			Project Totals (Rounded Up to the Nearest $10,000)	**$ 1,200,000**	

Abbreviations

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

Notes:

1. Costs do not include design fees and construction observation.

Table 20. Cost estimates for Reaches 9-10.

	Prichard Creek Reaches 9-10							
	Quantity			Unit Cost		Cost		
	Alt 1	Alt 2	Unit	Alt 1	Alt 2	Alt 1	Alt 2	Notes
Miscellaneous								
Mobilization/Demobilization	1	1	LS	$ 60,000	$ 50,000	$ 60,000	$ 50,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	1	LS	$ 50,000	$ 30,000	$ 50,000	$ 30,000	Direct Costs.
					Subtotal (rounded up to nearest hundred)	**$ 110,000**	**$ 80,000**	
Staging and Access								
Staging Areas and Temporary Access	1	1	LS	$ 12,000	$ 13,000	$ 12,000	$ 13,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
					Subtotal (rounded up to nearest hundred)	**$ 12,000**	**$ 13,000**	
Habiat Construction								
Large Wood Structure - Mainstem Wood	37,000	37,000	CF	$ 12	$ 12	$ 444,000	$ 444,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*661*	*661*	*EA*		*Per-Log Project Cost*	*$ 672*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 18" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	0	0	EA	$ 1,000	$ 1,000	$ -	$ -	Includes tipping large trees on site using excavator or winch truck
					Subtotal (rounded up to nearest hundred)	**$ 444,000**	**$ 444,000**	
Earthwork								
Instream Habitat Complexity	3,000	3,000	CY	$ 15	$ 15	$ 45,000	$ 45,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Floodplain Reconstruction	6,000	7,000	CY	$ 6	$ 6	$ 36,000	$ 42,000	Includes general cut, grading, and shaping of the floodplain. Assumes material can be placed onsite and no import will be required.
					Subtotal (rounded up to nearest hundred)	**$ 81,000**	**$ 87,000**	
Revegetation								
Site Decomissioning Seeding	1	1	AC	$ 3,000	$ 3,000	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	5	8	AC	$ 12,000	$ 12,000	$ 60,000	$ 96,000	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
					Subtotal (rounded up to nearest hundred)	**$ 63,000**	**$ 99,000**	
					Sub-Total	**$ 710,000**	**$ 723,000**	
					Contingencies (50%)	$ 355,000	$ 361,500	
					Project Totals (Rounded Up to the Nearest $10,000)	**$ 1,070,000**	**$ 1,090,000**	

Abbreviations
LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet
Notes:
1. Costs do not include design fees and construction observation.

Table 21. Cost estimates for Reach 11.

	Prichard Creek Reach 11							
	Quantity			**Unit Cost**		**Cost**		
	Alt 1	**Alt 2**	**Unit**	**Alt 1**	**Alt 2**	**Alt 1**	**Alt 2**	**Notes**
					Miscellaneous			
Mobilization/Demobilization	1	1	LS	$ 70,000	$ 110,000	$ 70,000	$ 110,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	1	LS	$ 60,000	$ 90,000	$ 60,000	$ 90,000	Direct Costs.
		Subtotal (rounded up to nearest hundred)				**$ 130,000**	**$ 200,000**	
					Staging and Access			
Staging Areas and Temporary Access	1	1	LS	$ 13,000	$ 21,000	$ 13,000	$ 21,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
		Subtotal (rounded up to nearest hundred)				**$ 13,000**	**$ 21,000**	
					Habiat Construction			
Large Wood Structure - Mainstem Wood	41,000	41,000	CF	$ 12	$ 12	$ 492,000	$ 492,000	Includes purchase, delivery, stockpiling, and installation of large wood material
Equivalent Log Quantity	*732*	*732*	*EA*		*Per-Log Project Cost*	*$ 672*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 18" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	10	10	EA	$ 1,000	$ 1,000	$ 10,000	$ 10,000	Includes tipping large trees on site using excavator or winch truck
		Subtotal (rounded up to nearest hundred)				**$ 502,000**	**$ 502,000**	
					Earthwork			
Instream Habitat Complexity	6,000	8,000	CY	$ 15	$ 15	$ 90,000	$ 120,000	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Floodplain Reconstruction	0	54,000	CY	$ 6	$ 6	$ -	$ 324,000	Includes general cut, grading, and shaping of the floodplain. Assumes material can be placed onsite and no import will be required.
		Subtotal (rounded up to nearest hundred)				**$ 90,000**	**$ 444,000**	
					Revegetation			
Site Decomissioning Seeding	1	1	AC	$ 3,000	$ 3,000	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	2	6	AC	$ 12,000	$ 12,000	$ 19,760	$ 70,570	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
		Subtotal (rounded up to nearest hundred)				**$ 22,800**	**$ 73,600**	
					Sub-Total	**$ 757,800**	**$ 1,240,600**	
					Contingencies (50%)	$ 378,900	$ 620,300	
	Project Totals (Rounded Up to the Nearest $10,000)					**$ 1,140,000**	**$ 1,870,000**	

Abbreviations

LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet

Notes:

1. Costs do not include design fees and construction observation.

Table 22. Cost estimates for Reach 12.

	Prichard Creek Reach 12				
	Quantity Alt 1	**Unit**	**Unit Cost**	**Cost Alt 1**	**Notes**
Miscellaneous					
Mobilization/Demobilization	1	LS	$ 50,000	$ 50,000	Includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site. Estimated as approximately 10% of Direct Costs.
Temporary Erosion and Sediment Control	1	LS	$ 40,000	$ 40,000	Direct Costs.
Subtotal (rounded up to nearest hundred)				**$ 90,000**	
Staging and Access					
Staging Areas and Temporary Access	1	LS	$ 9,000	$ 9,000	Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate. Estimated as approximately 2% of Direct Costs.
Subtotal (rounded up to nearest hundred)				**$ 9,000**	
Habiat Construction					
Large Wood Structure - Mainstem Wood	32,000	CF	$ 12	$ 384,000	Includes purchase, delivery, stockpiling, and installation of large wood material.
Equivalent Log Quantity	*571*	*EA*	*Per-Log Project*	*$ 672*	*The Equivalent log quantities assume an average log dimension of a 18" dbh, 40-foot long rootwad log. The actual log quantities may vary substantially based on the size and shape of the large wood material available.*
Tipped Whole Tree	10	EA	$ 1,000	$ 10,000	Includes tipping large trees on site using excavator or winch truck
Subtotal (rounded up to nearest hundred)				**$ 394,000**	
Earthwork					
Instream Habitat Complexity	0	CY	$ 15	$ -	Excavation of native material and shaping of channel features. Assumes material can be placed onsite and no import will be required.
Berm Removal	0	CY	$ 6	$ -	Includes cut to adjacent floodplain elevation and local disposal of material.
Subtotal (rounded up to nearest hundred)				**$ -**	
Revegetation					
Site Decomissioning Seeding	1	AC	$ 3,000	$ 3,000	Seeding access routes and staging areas.
Habitat Revegetation	2	AC	$ 12,000	$ 24,128	Includes a mix of stakes, potted plants, and seeding. Includes Plant Establishment and Plant Replacement.
Subtotal (rounded up to nearest hundred)				**$ 27,200**	
Sub-Total				**$ 520,200**	
Contingencies (50%)				$ 260,100	
Project Totals (Rounded Up to the Nearest $10,000)				**$ 790,000**	

Abbreviations
LS= Lump Sum, AC = Acre, CY= Cubic Yards, EA= Each, CF = Cubic Feet
Notes:
1. Costs do not include design fees and construction observation.

3.5 ALTERNATIVES EVALUATION MATRIX

An alternatives prioritization and ranking matrix was developed in collaboration with Trout Unlimited and stakeholders. This matrix is intended to help provide a qualitative ranking for project alternatives based on the degree of impact that each of the proposed alternatives has on the project goals and objectives. A description of the matrix is presented below, and the full matrix is provided as Table 23. The tool is intended to be flexible as new information, funding opportunities, and/or projects become available.

The matrix provides a qualitative rating (e.g., high, medium, low) of each alternative for reach limiting factors, ecological benefit, feasibility, cost, and risk for each proposed reach alternative. As the ratings for each alternative are ordinal data, they were summarized by count (e.g., number of high ratings, number of medium ratings). Alternative rankings were initially determined using the counts, prioritizing the biological benefit, goals and objectives, and feasibility ratings over the cost and risk ratings. In order to make the rankings more determinate, numerical values of 1, 3, and 5 to were assigned to the low, medium, and high (respectively) ratings. The numerical values were then multiplied by the counts and then summed to more explicitly define a ranked order for the alternatives.

Cost/benefit analyses for each sub-area alternative projects were also created by comparing the estimated benefits of each alternative relative to the projected cost range. The alternative numerical ratings were binned based on the interquartile range to assign each alternative an ordinal (e.g., high, medium, or low) rating. Costs were binned into ordinal categories based on professional experience. As many of the costs and benefits associated with each alternative have considerable uncertainty, the cost-benefit rating provided is simply a visual relation of the ordinal cost and benefit ratings.

Preliminary rankings show that Alternatives 1 and 2 in Reaches 5-6 received the highest ranking (tied for first) of all project area alternatives, largely due to the substantial ecological and biological benefit of the Alternatives. Reach 1 Alternative 2, Reach 5-6 Alternative 3, Reach 4 Alternative 2, and Reach 12 Alternative 1a all received the next-highest rankings, due to combined high biological value of the treatments and low cost or risks for implementation. Restoration alternatives that were limited to adding habitat features to the existing channel, such as Reach 11 Alternative 1, Reach 12 Alternative 1b, and Reaches 2-3 Alternative 1b received the lowest rankings, largely due to the limited ecological uplift that would result. The "Time to Benefit" category was ranked by evaluating the proposed alternative's anticipated time to achieve uplift to fish habitat limiting factors. Additional benefits, such as riparian revegetation, are anticipated to take longer to achieve.

Table 23. Prichard Creek restoration alternatives ranking matrix.

ACTIONS		LIMITING FACTORS			ECOLOGICAL PATHWAYS				FEAS-IBILITY	COST	RISK			
	Alternative Description	Improve access/quality of coldwater refugia	Increase quantity/quality of overwinter habitat for large fish	Improve access/quality of summer rearing habitat	Habitat Quality	Riparian Vegetation Condition	Channel Dynamics	Habitat Accessibility	Longevity/Resilience	Implementation Costs*	Time to Benefit	Ecological Risk	Potential for maintenance needs	Risk to Infrastructure
	Weighting factor for column													
Reach 1														
-	Baseline Conditions (Do Nothing Alternative)	Low	N/A	N/A	N/A	Low	N/A	N/A	N/A	N/A	High	Med	N/A	Low
1	Remove impediments to surface connection	Med	Med	Med	High	Low	Low	N/A	Med	Low	Med	N/A	Med	High
2	Create hard points (large wood) in the channel to sort sediment and create habitat	High	High	High	High	Med	High	N/A	High	Med	Low	Med	Low	Low
Reaches 2-3														
-	Baseline Conditions (Do Nothing Alternative)	N/A	Low	N/A	Low	Low	N/A	N/A	N/A	N/A	Low	Med	N/A	Med
1	Habitat Improvements													
1a	*Alt 1 with Strategic Action and Aggressive Treatment Plan*	Med	Med	Med	Med	Med	Low	N/A	Med	Med	Med	Low	Med	Med
1b	*Alt 1 wth Select treatment plan that does not include strategic action*	Low	Low	Low	Med	Low	N/A	N/A	Med	Med	Low	Low	Low	Low
Reach 4														
-	Baseline Conditions (Do Nothing Alternative)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	High	N/A	Low
1	Large wood and habitat improvements	Low	Med	Low	Med	Low	Med	N/A	Med	Med	Med	Med	Low	Low
2	Channel realignment with strategic action and large wood habitat improvements	Med	High	Med	High	Med	High	Low	High	High	Low	Med	Low	Low
Reaches 5-6														
-	Baseline Conditions (Do Nothing Alternative)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	High	N/A	Low
1	Max width/max depth	High	High	High	High	High	Med	High	High	High	Low	Low	Low	Low
2	Mod width/max depth	High	High	High	High	High	Med	High	High	High	Low	Low	Low	Low
3	Mod width/mod depth	Med	High	High	High	Med	Med	High	High	High	Low	Med	Med	Low
Reaches 7-8														
-	Baseline Conditions (Do Nothing Alternative)	Low	N/A	N/A	Low	Low	N/A	N/A	N/A	N/A	High	Low	N/A	Med
1	Habitat and floodplain improvements to existing channel	Low	Low	Med	Med	Low	Low	N/A	Med	Med	Low	Low	Low	Med
Reaches 9-10														
-	Baseline Conditions (Do Nothing Alternative)	Low	N/A	N/A	Low	Low	N/A	N/A	N/A	N/A	High	Low	N/A	Med
1	Create perennial side channel and add habitat improvments throughout reach	Med	Med	Low	Med	Med	Low	N/A	Med	Med	Low	Low	Med	Med
2	Create low floodplain feature with habitat improvements throughout reach	Med	Low	Low	Med	Med	Low	N/A	High	Med	Low	Low	Low	Low
Reach 11														
-	Baseline Conditions (Do Nothing Alternative)	Low	Low	Low	Low	Low	Low	N/A	N/A	N/A	High	Med	N/A	N/A
1	Habitat and floodplain improvements to existing channel	Low	Low	Med	Med	Low	Low	N/A	Med	Med	Low	Low	N/A	Low
2	Removal of dredged material, floodplain reconnection and habitat improvements	Med	Med	High	High	Med	Med	N/A	High	Med	Med	Low	N/A	Low
Reach 12														
-	Baseline Conditions (Do Nothing Alternative)	Low	N/A	N/A	Low	Low	N/A	N/A	N/A	N/A	High	Low	N/A	N/A
1	Habitat Improvements													
1a	*Alt 1 with Aggressive Treatment Plan*	Med	High	Med	High	High	Med	N/A	High	Low	Low	Med	N/A	Low
1b	*Alt 1 wth Select treatment plan*	Low	Med	Low	Med	Med	Low	N/A	Med	Low	Med	Med	N/A	Low

ACTIONS		COUNTS & RANKING								COST BENEFIT		
	Alternative Description	Biological Benefit + Feasibility			Cost & Risk			Sum Counts	Ranking	Implementaiton Cost	Benefit	Cost/Benefit Ratio
	Weighting factor for column	*5*	*3*	*1*	*5*	*3*	*1*					
		# High	# Med	# Low	# Low	# Med	# High					
Reach 1												
-	Baseline Conditions (Do Nothing Alternative)	0	0	2	5	3	1	11	20	N/A	Low	N/A/Low
1	Remove impediments to surface connection	5	12	2	5	6	1	31	14	Low	Med	Low/Med
2	Create hard points (large wood) in the channel to sort sediment and create habitat	30	3	0	15	6	0	54	3	Med	High	Med/High
Reaches 2-3												
-	Baseline Conditions (Do Nothing Alternative)	0	0	3	5	6	0	14	17	N/A	Med	N/A/Med
1	Habitat Improvements											
1a	*Alt 1 with Strategic Action and Aggressive Treatment Plan*	0	18	1	5	12	0	36	9	Med	Med	Med/Med
1b	*Alt 1 wth Select treatment plan that does not include strategic action*	0	6	4	20	3	0	33	13	Med	Med	Med/Med
Reach 4												
-	Baseline Conditions (Do Nothing Alternative)	0	0	0	5	0	1	6	23	N/A	Low	N/A/Low
1	Large wood and habitat improvements	0	12	3	10	9	0	34	11	Med	Med	Med/Med
2	Channel realignment with strategic action and large wood habitat improvements	20	9	1	15	3	1	49	5	High	High	High/High
Reaches 5-6												
-	Baseline Conditions (Do Nothing Alternative)	0	0	0	5	0	1	6	23	N/A	Low	N/A/Low
1	Max width/max depth	35	3	0	20	0	1	59	1	High	High	High/High
2	Mod width/max depth	35	3	0	20	0	1	59	1	High	High	High/High
3	Mod width/mod depth	25	9	0	10	6	1	51	4	High	High	High/High
Reaches 7-8												
-	Baseline Conditions (Do Nothing Alternative)	0	0	3	5	3	1	12	18	N/A	Med	N/A/Med
1	Habitat and floodplain improvements to existing channel	0	9	4	15	6	0	34	11	Med	Med	Med/Med
Reaches 9-10												
-	Baseline Conditions (Do Nothing Alternative)	0	0	3	5	3	1	12	18	N/A	Med	N/A/Med
1	Create perennial side channel and add habitat improvments throughout reach	0	15	2	10	9	0	36	9	Med	Med	Med/Med
2	Create low floodplain feature with habitat improvements throughout reach	5	9	3	20	3	0	40	8	Med	Med	Med/Med
Reach 11												
-	Baseline Conditions (Do Nothing Alternative)	0	0	6	0	3	1	10	21	N/A	Low	N/A/Low
1	Habitat and floodplain improvements to existing channel	0	9	4	15	3	0	31	14	Med	Med	Med/Med
2	Removal of dredged material, floodplain reconnection and habitat improvements	15	12	0	10	6	0	43	7	Med	Med	Med/Med
Reach 12												
-	Baseline Conditions (Do Nothing Alternative)	0	0	3	5	0	1	9	22	N/A	Low	N/A/Low
1	Habitat Improvements											
1a	*Alt 1 with Aggressive Treatment Plan*	20	9	0	15	3	0	47	6	Low	High	Low/High
1b	*Alt 1 wth Select treatment plan*	0	12	3	10	6	0	31	14	Low	Med	Low/Med

*Implementation costs: "Low" = <$750,000; "Med" = $750,000 - $2 million; "High" = > $2 million based on Estimated Costs table including 50% contingency.

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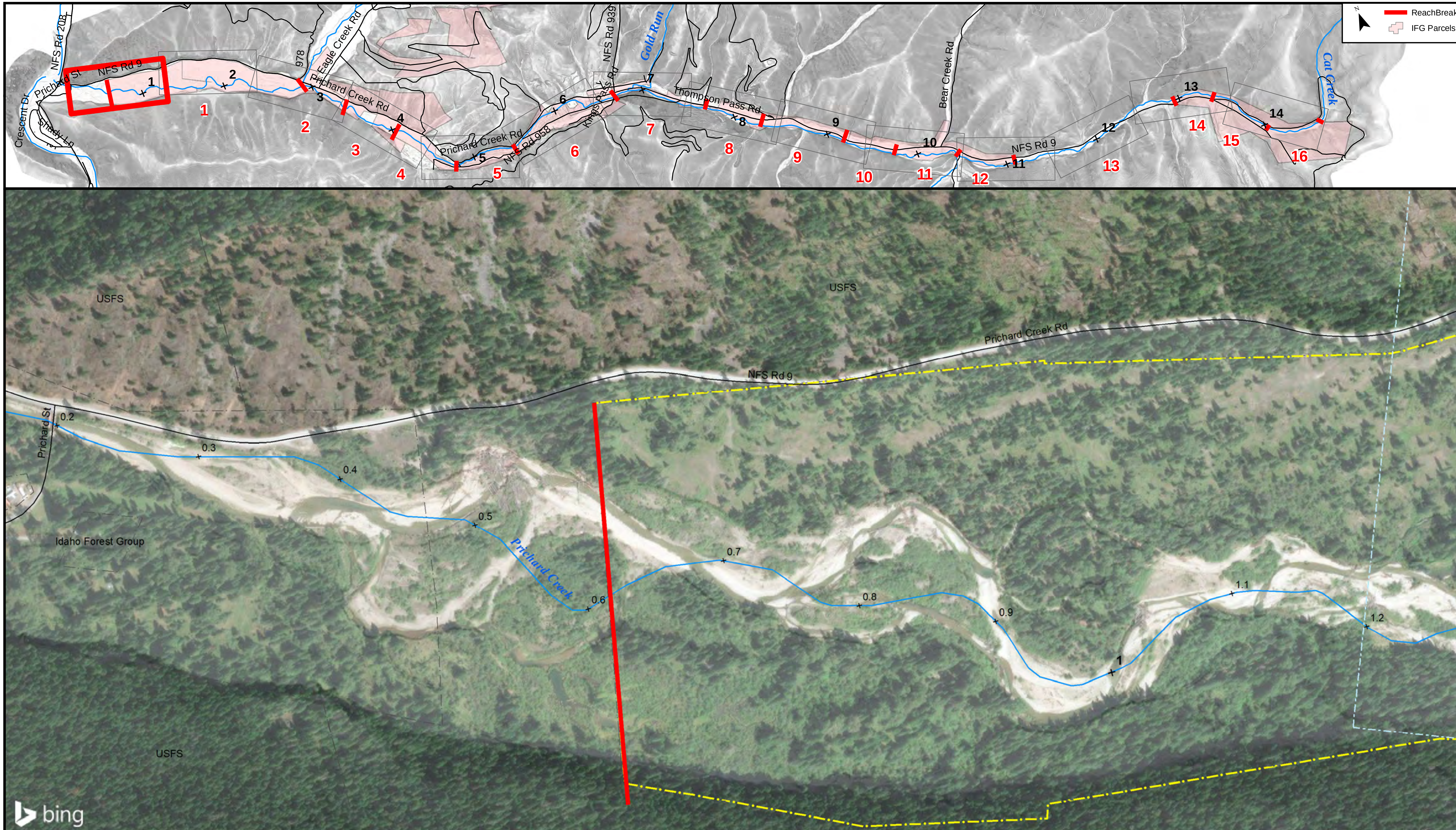
Appendix A – Field Assessment Maps



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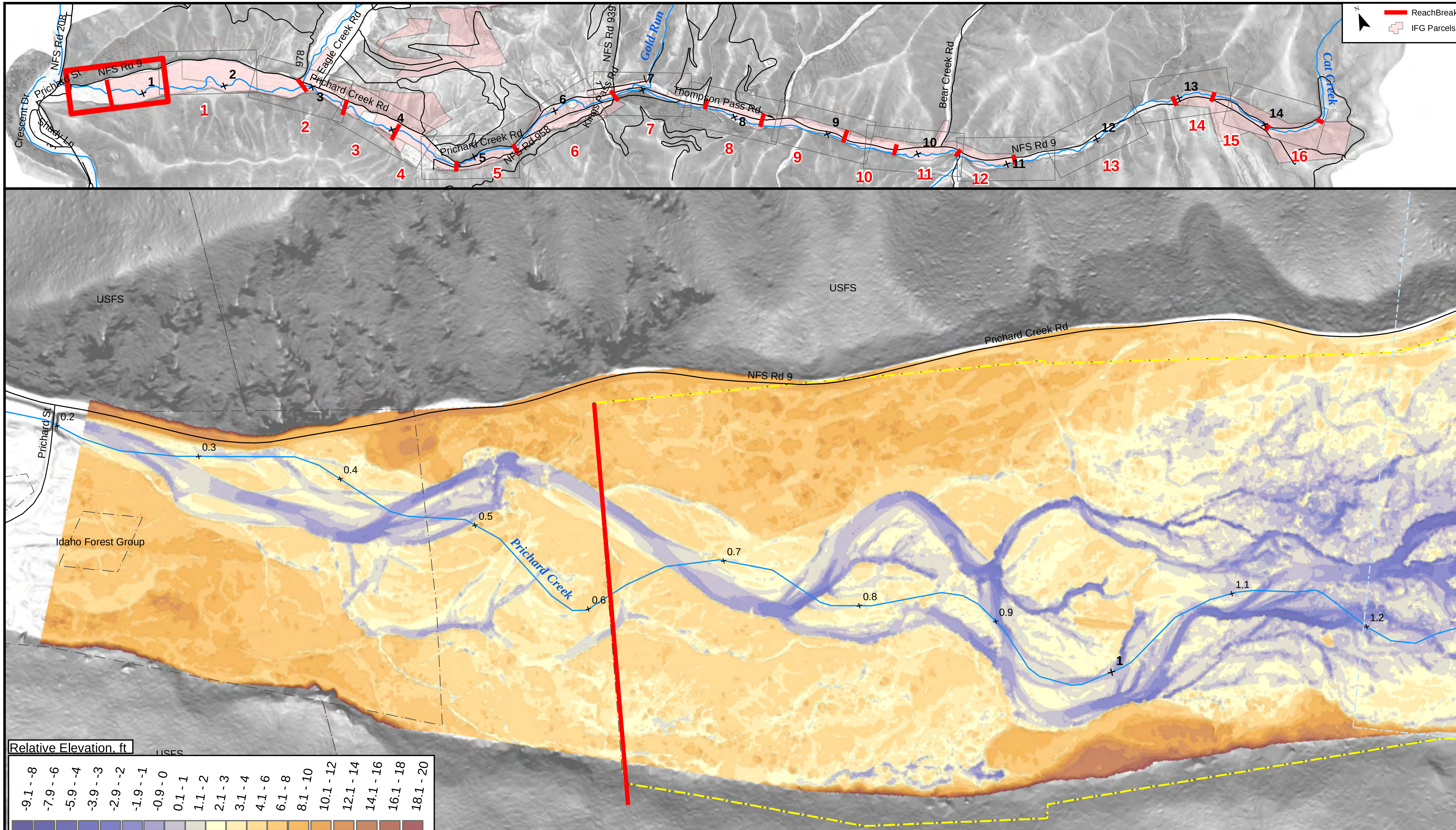
0 250 500 1,000 Feet

ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 1



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NHD Flowline

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 1

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ReachBreaks
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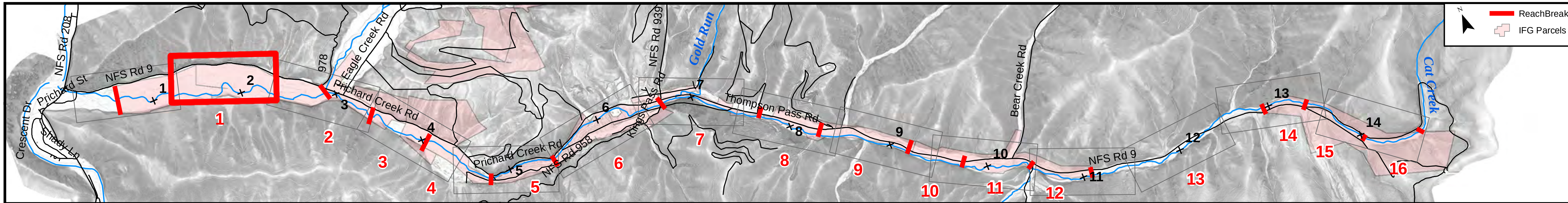
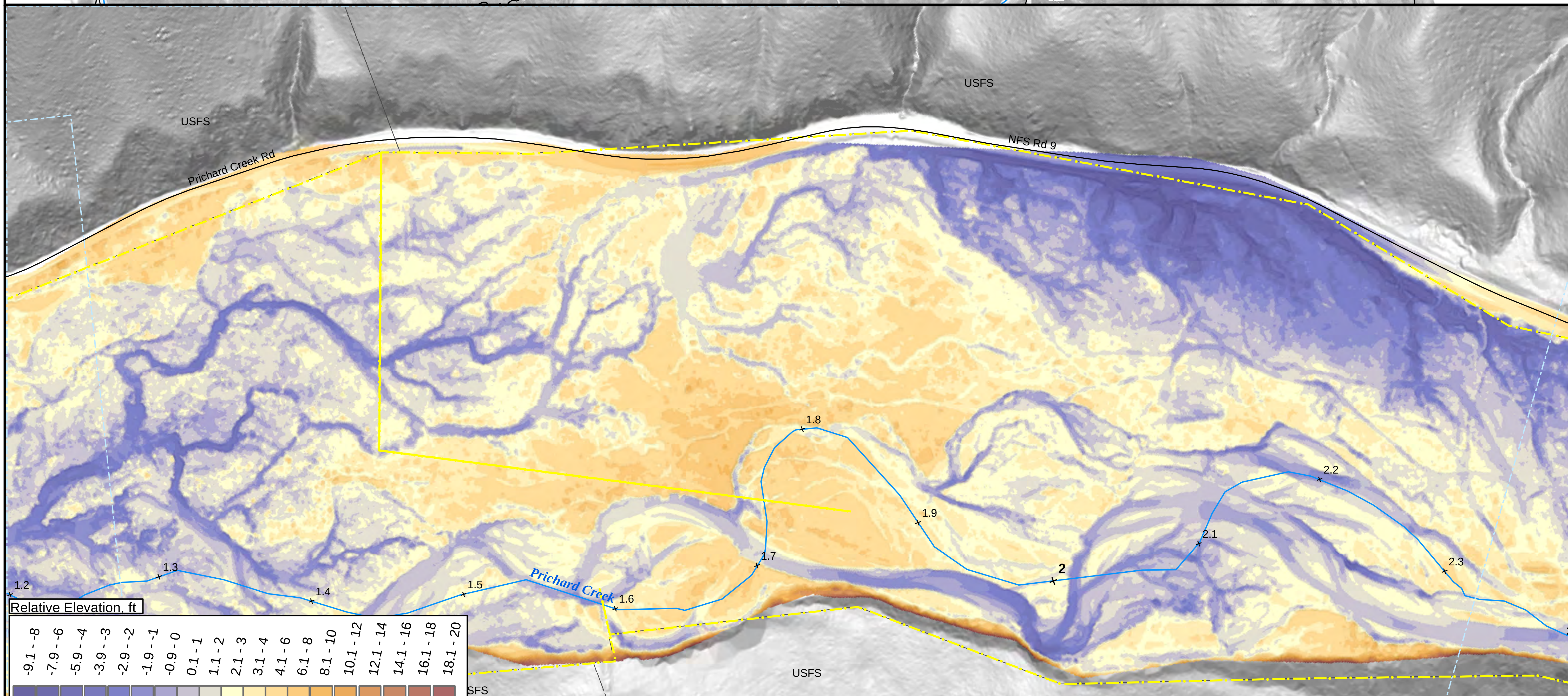
Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 2





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Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
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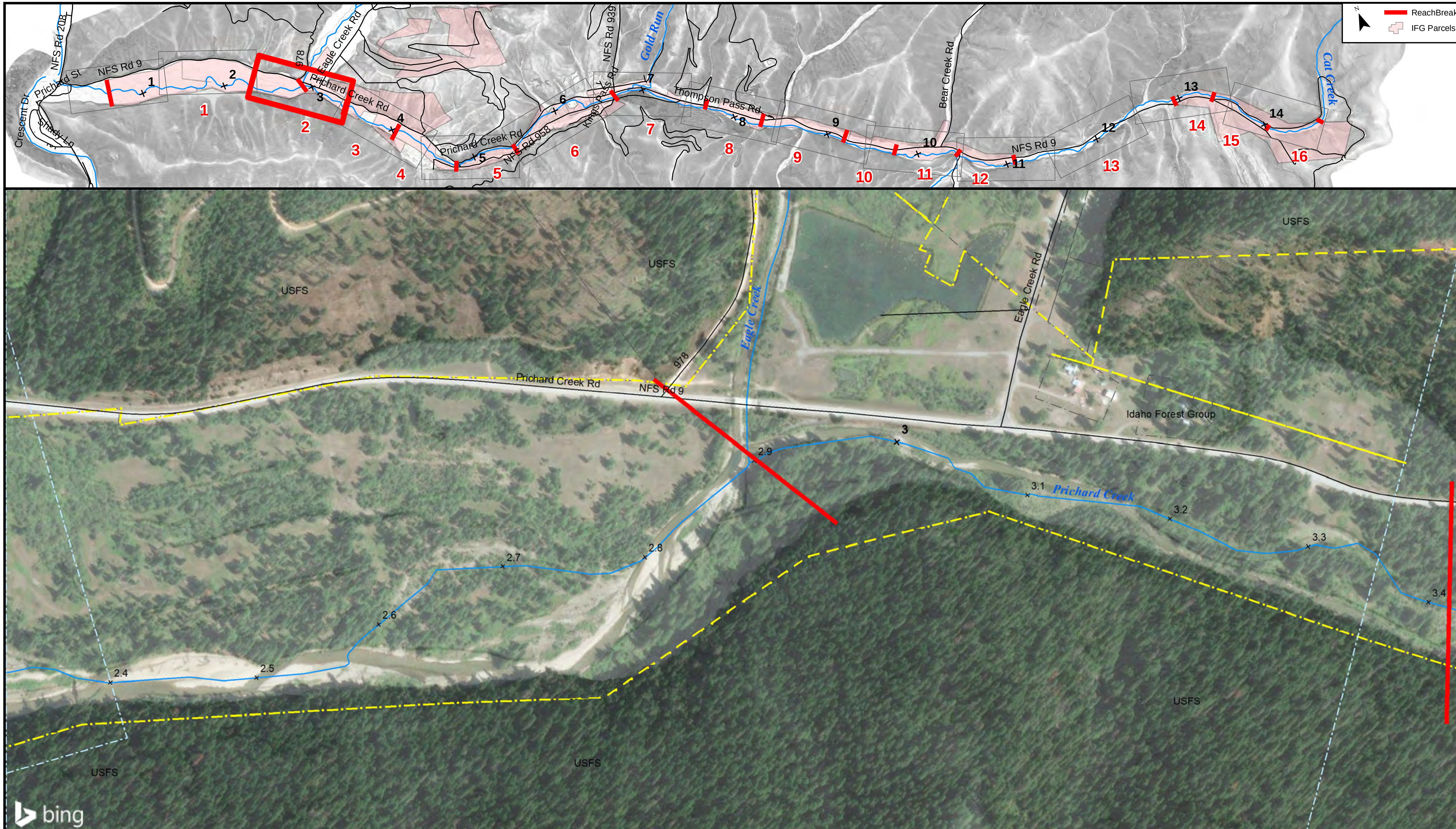

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Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
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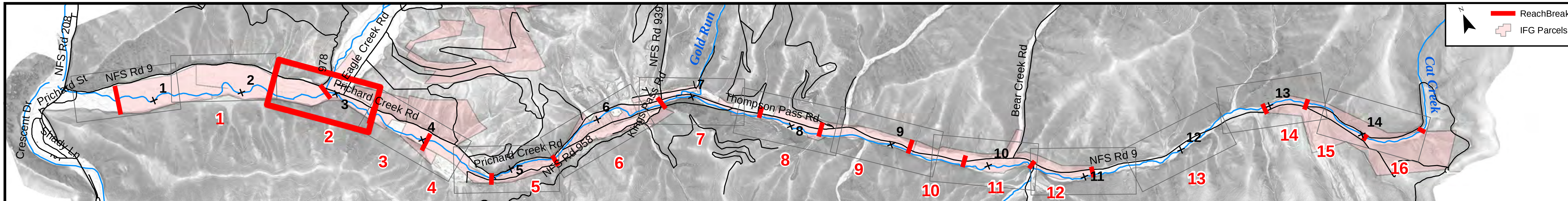

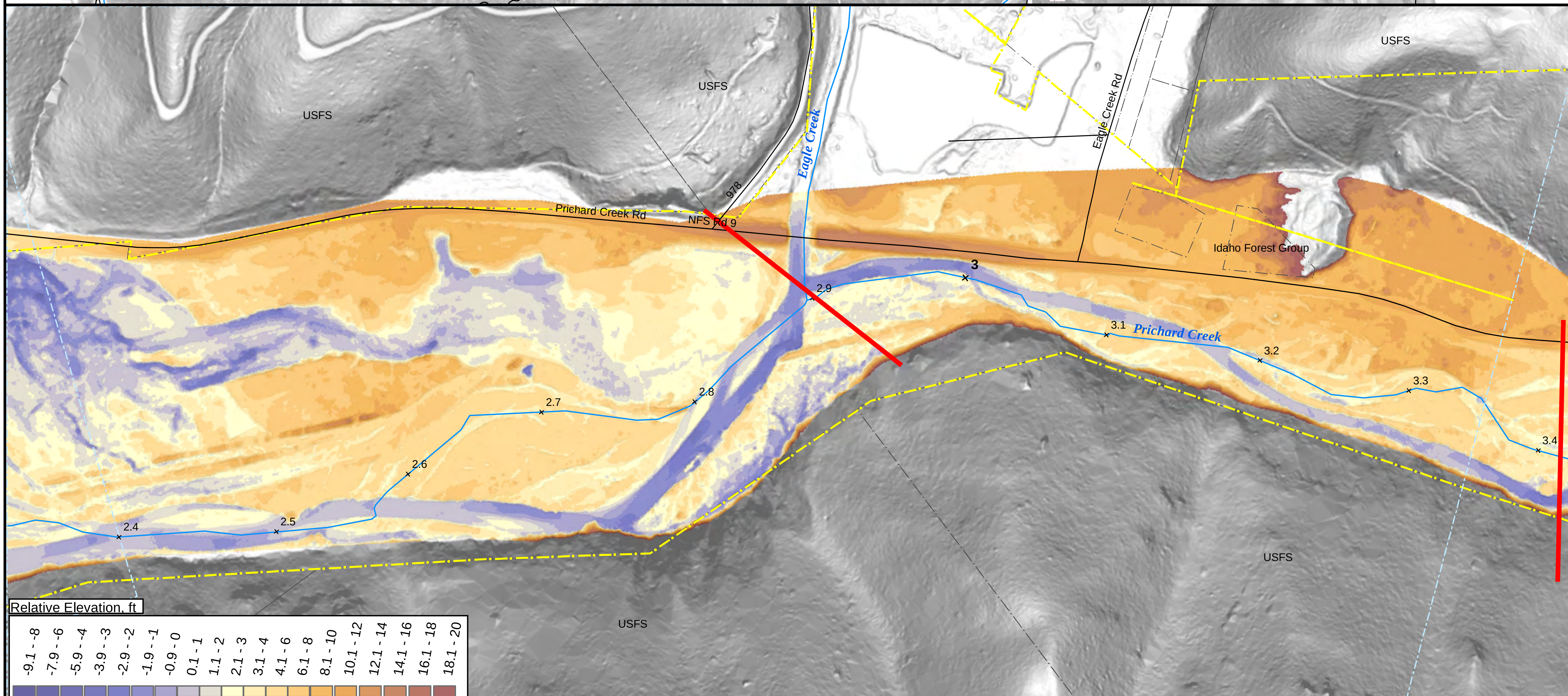

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Parcels

Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
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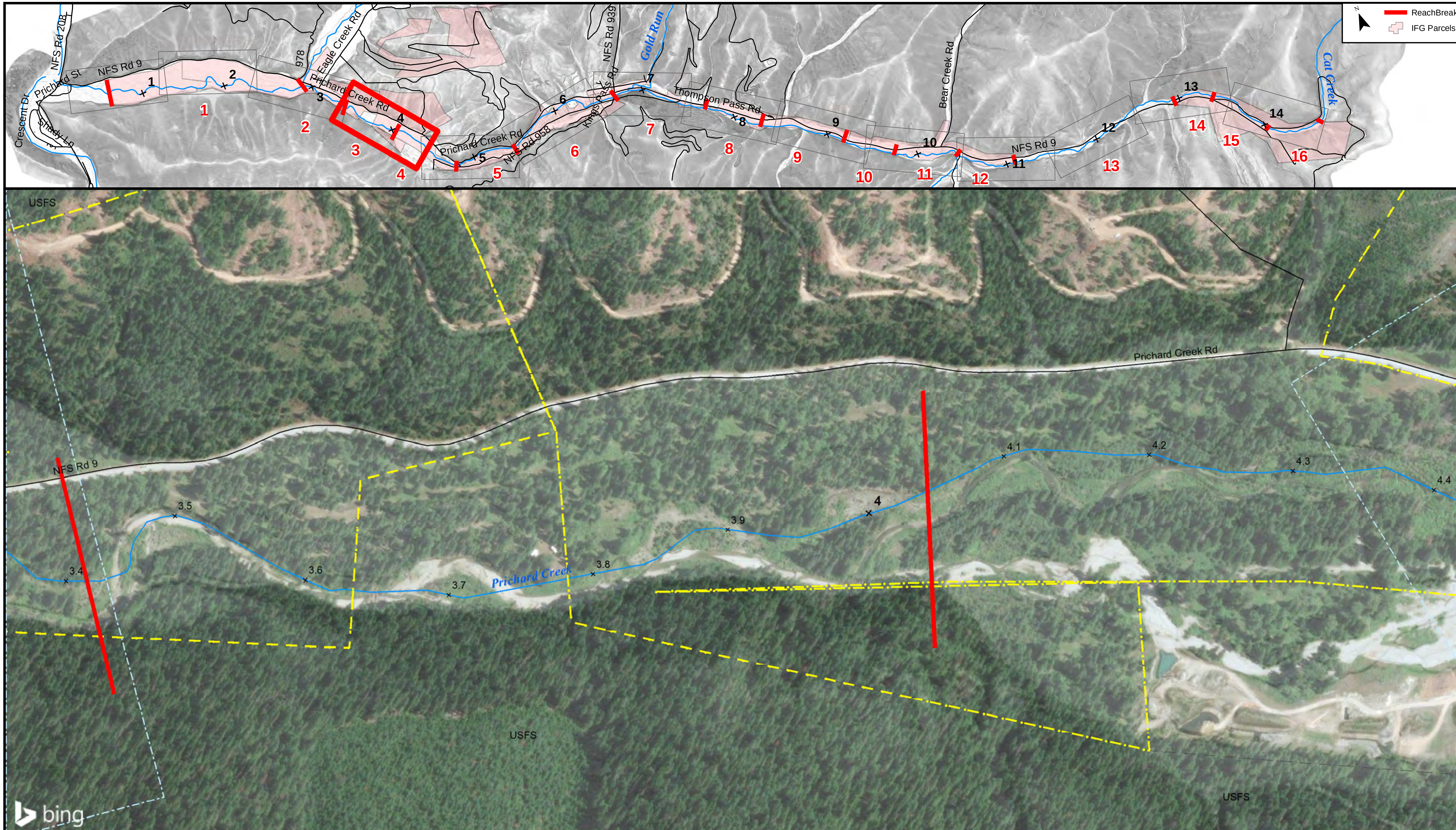

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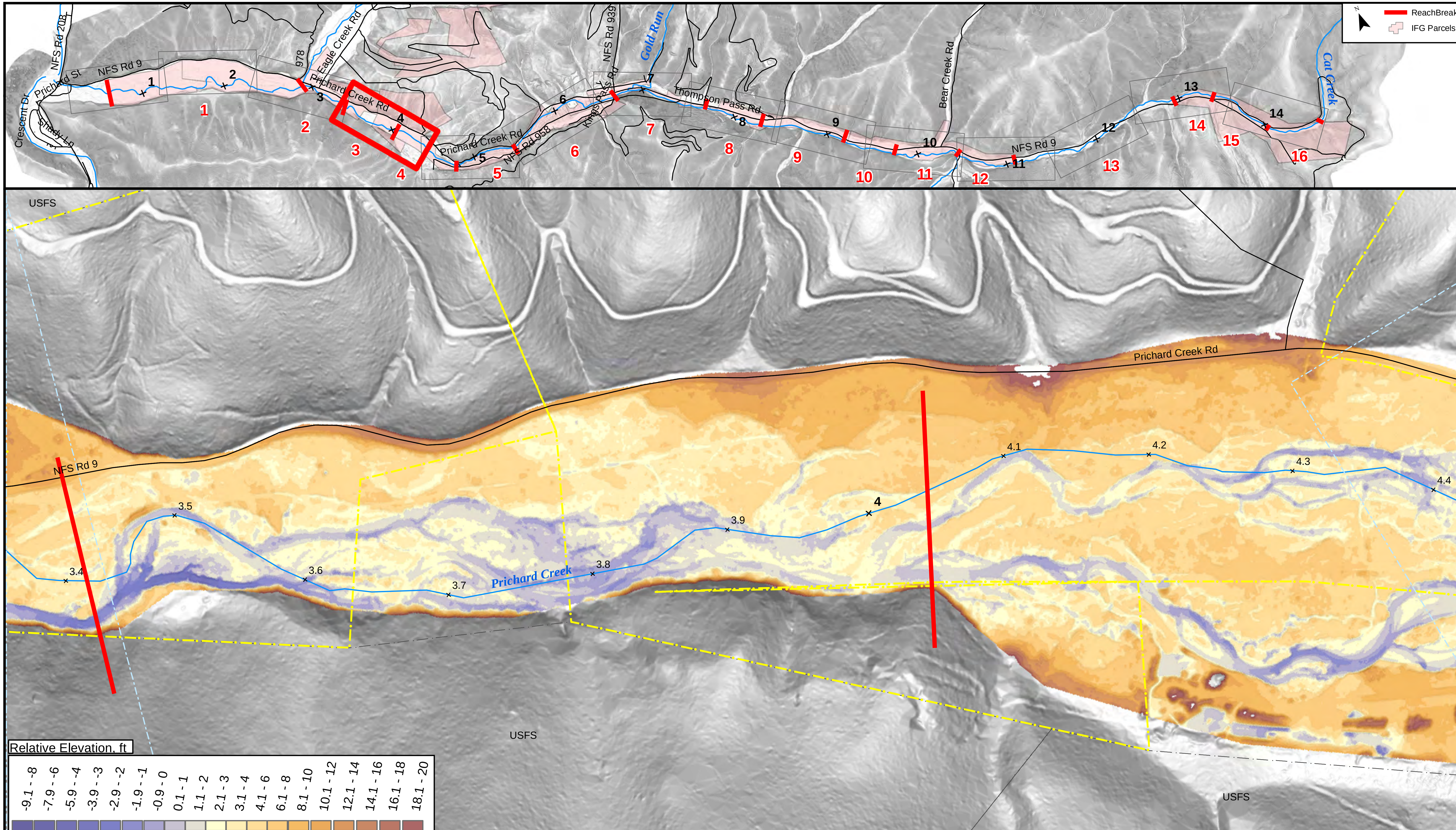
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
4



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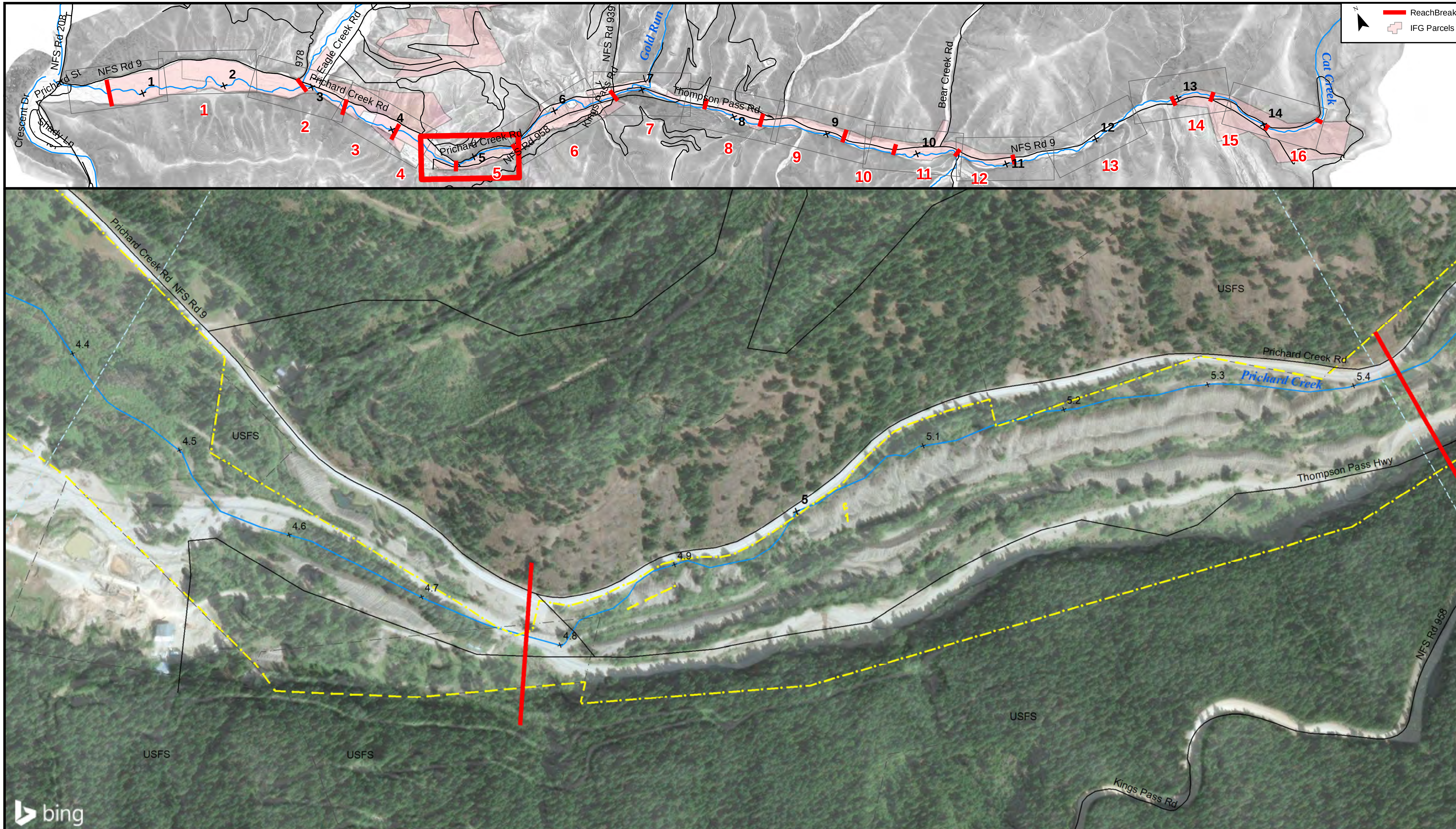
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 4



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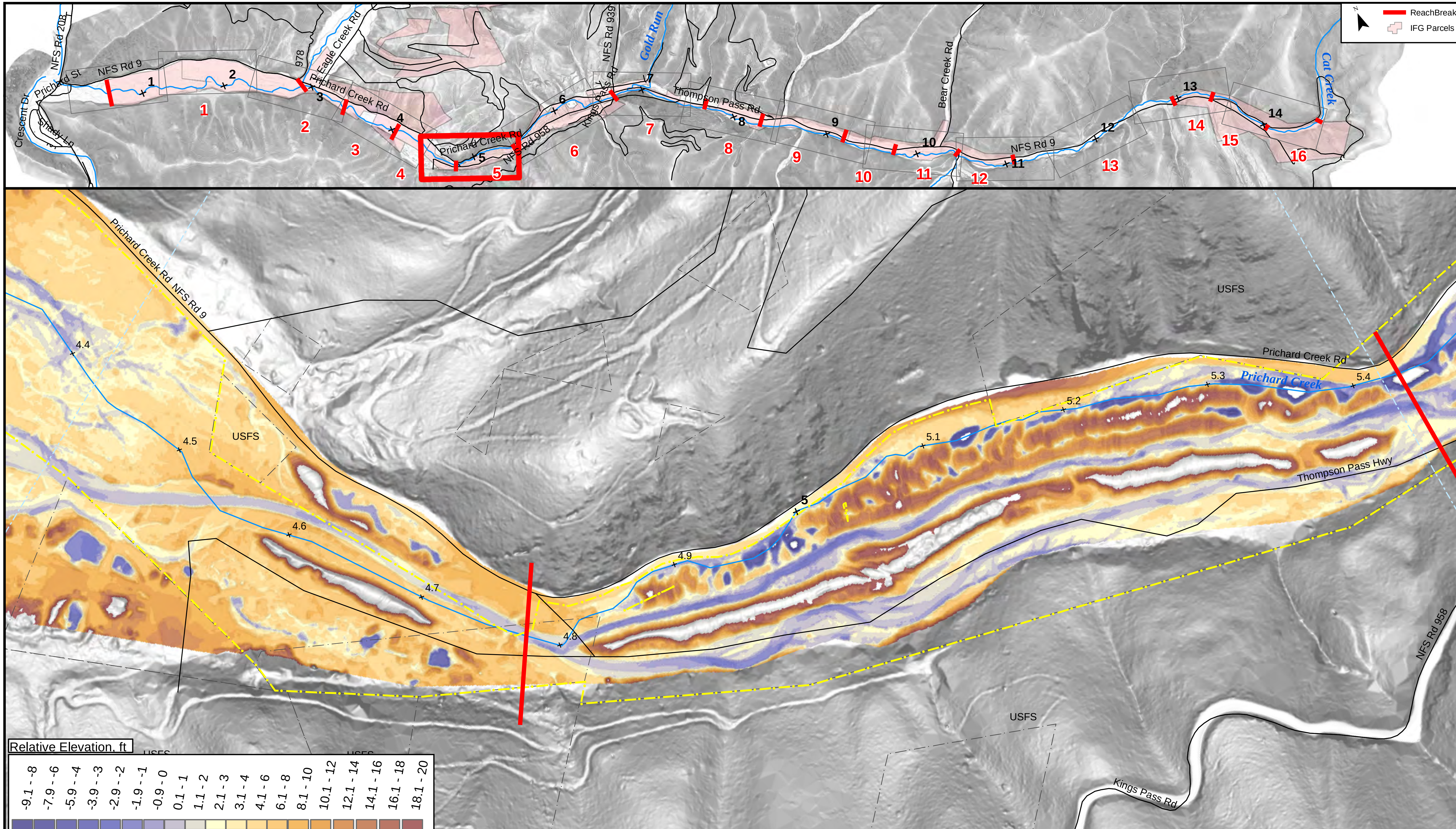
- Roads
- Match Line
- IFG Parcels
- Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 5



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River Miles
NHD Flowline
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Match Line
IFG Parcels
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Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 5

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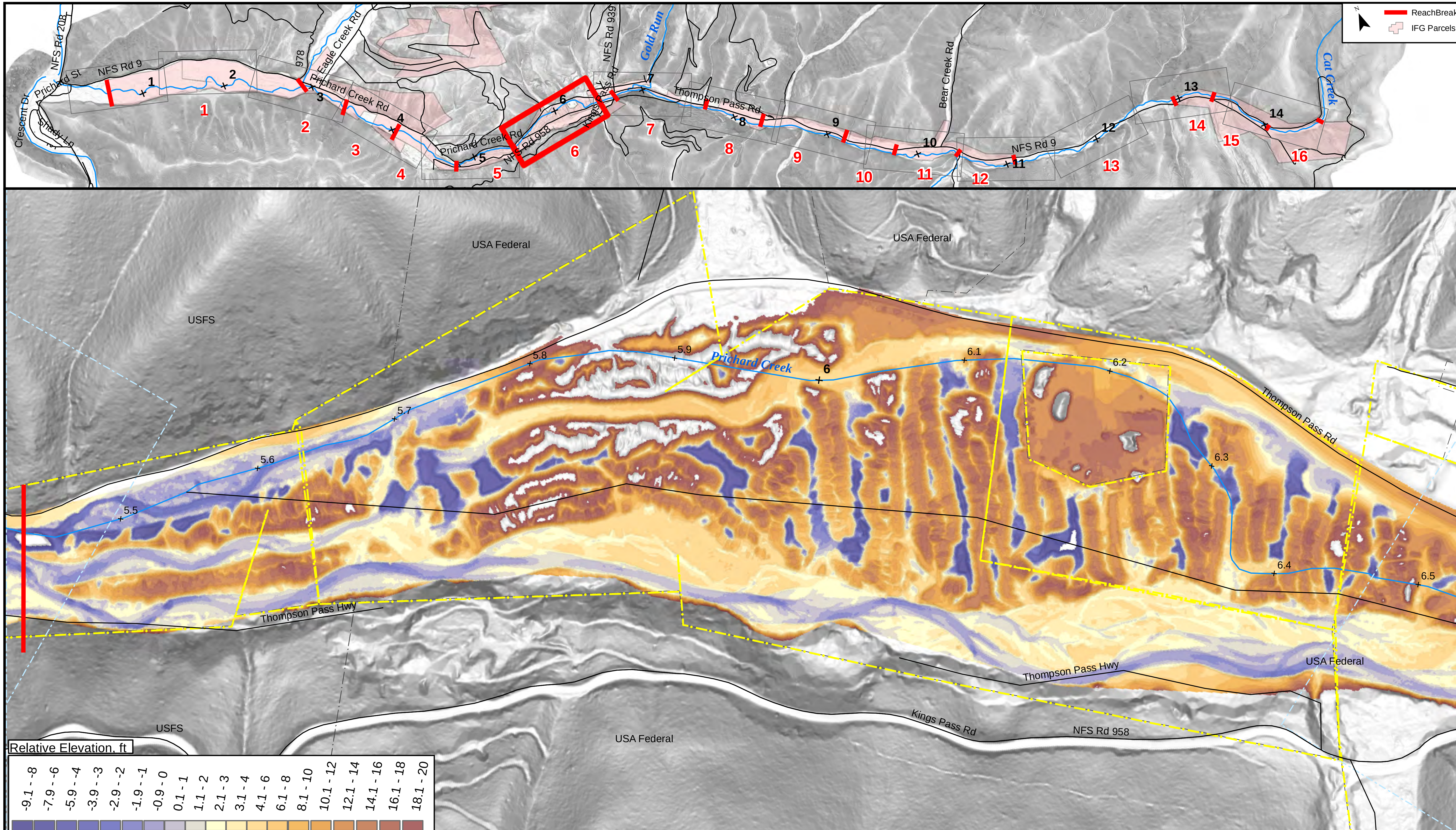
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 6



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ReachBreaks — Roads — IFG Parcels
River Miles — Match Line — Parcels
NHD Flowline

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 6

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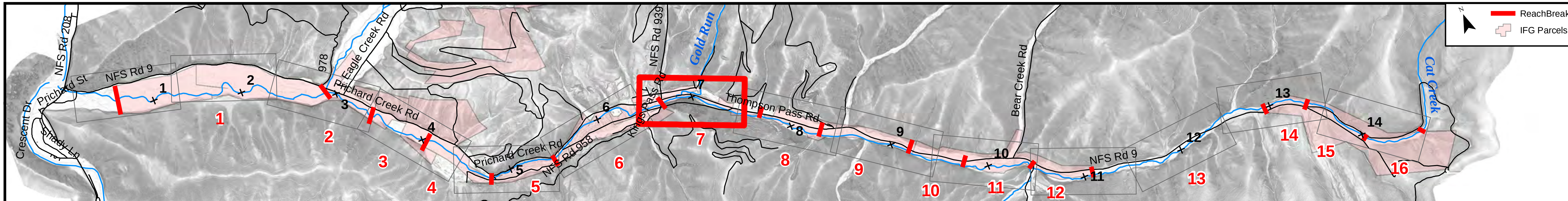
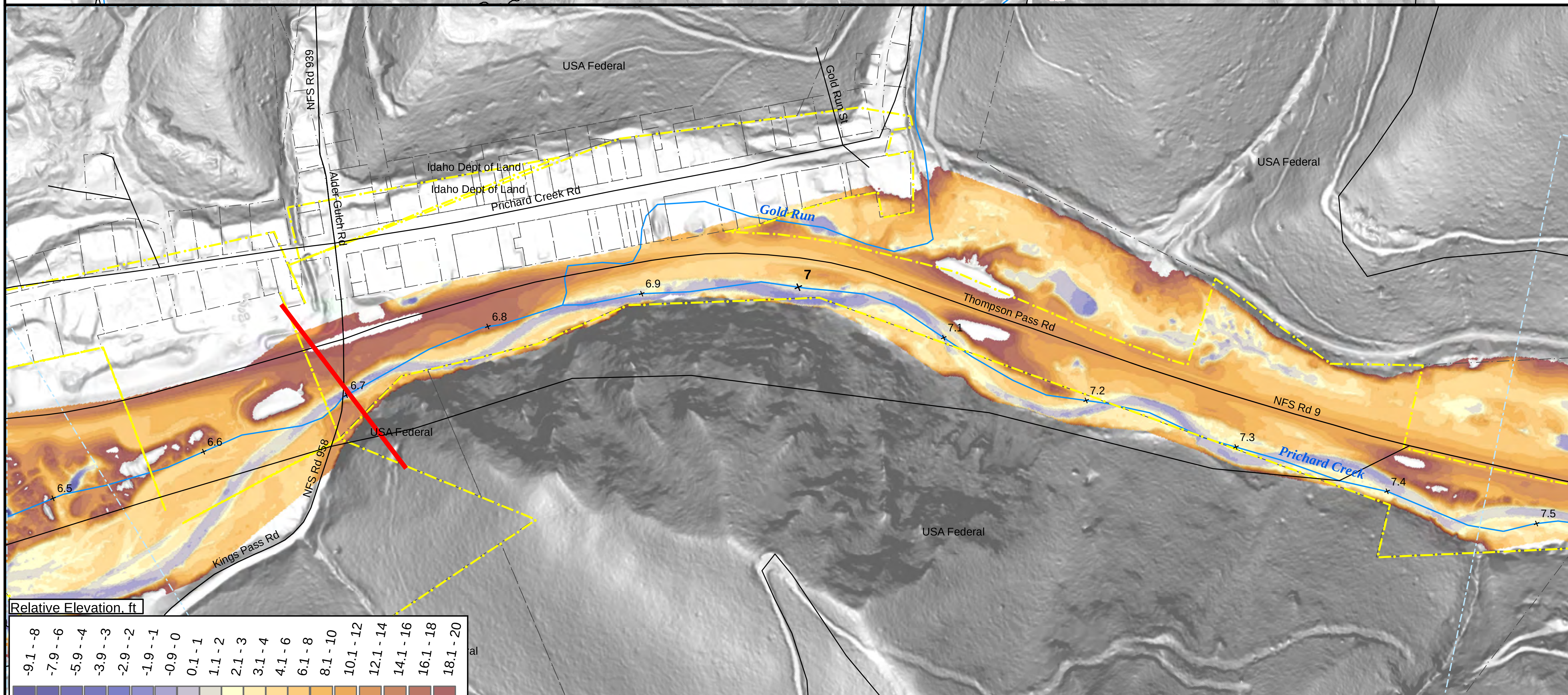
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 7





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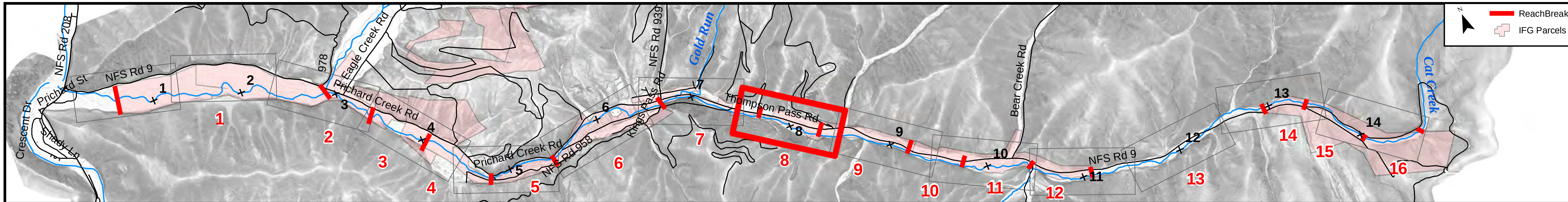
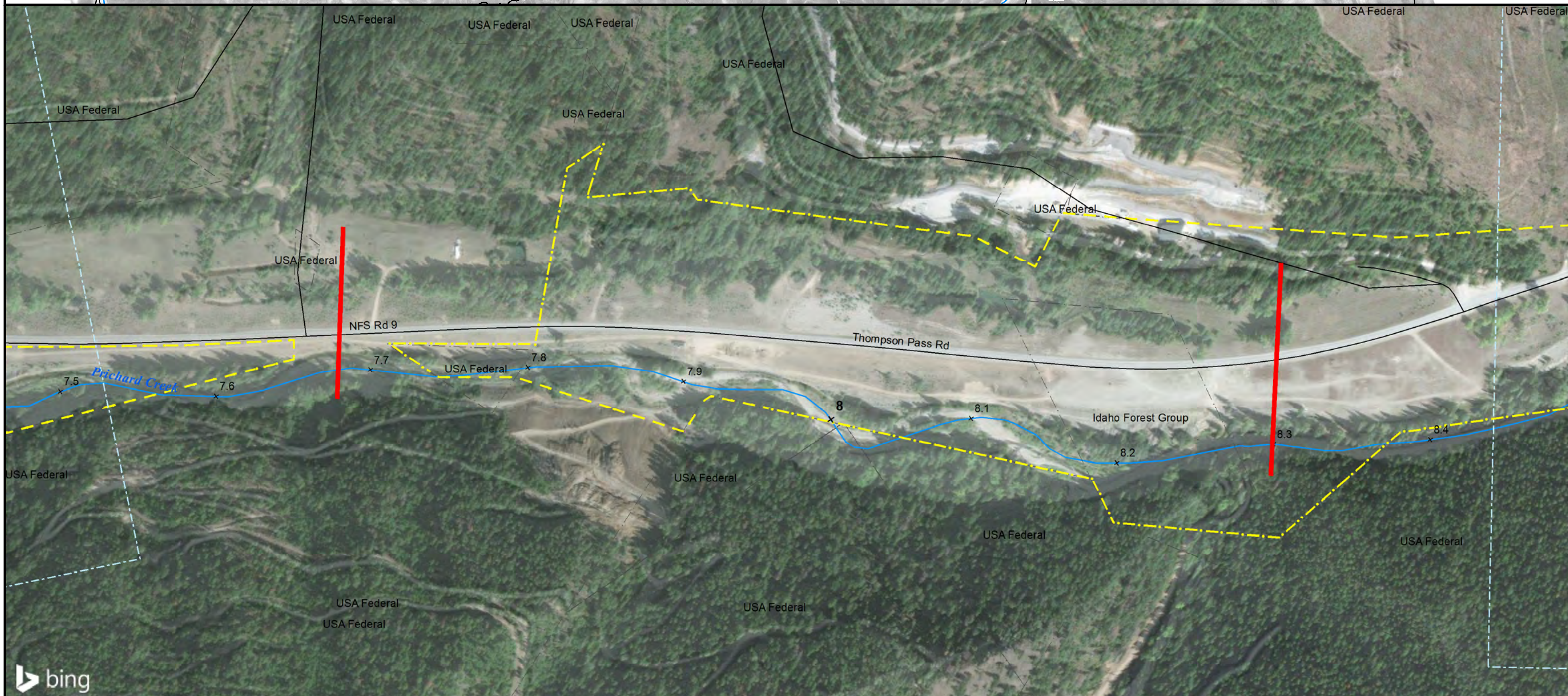
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 7





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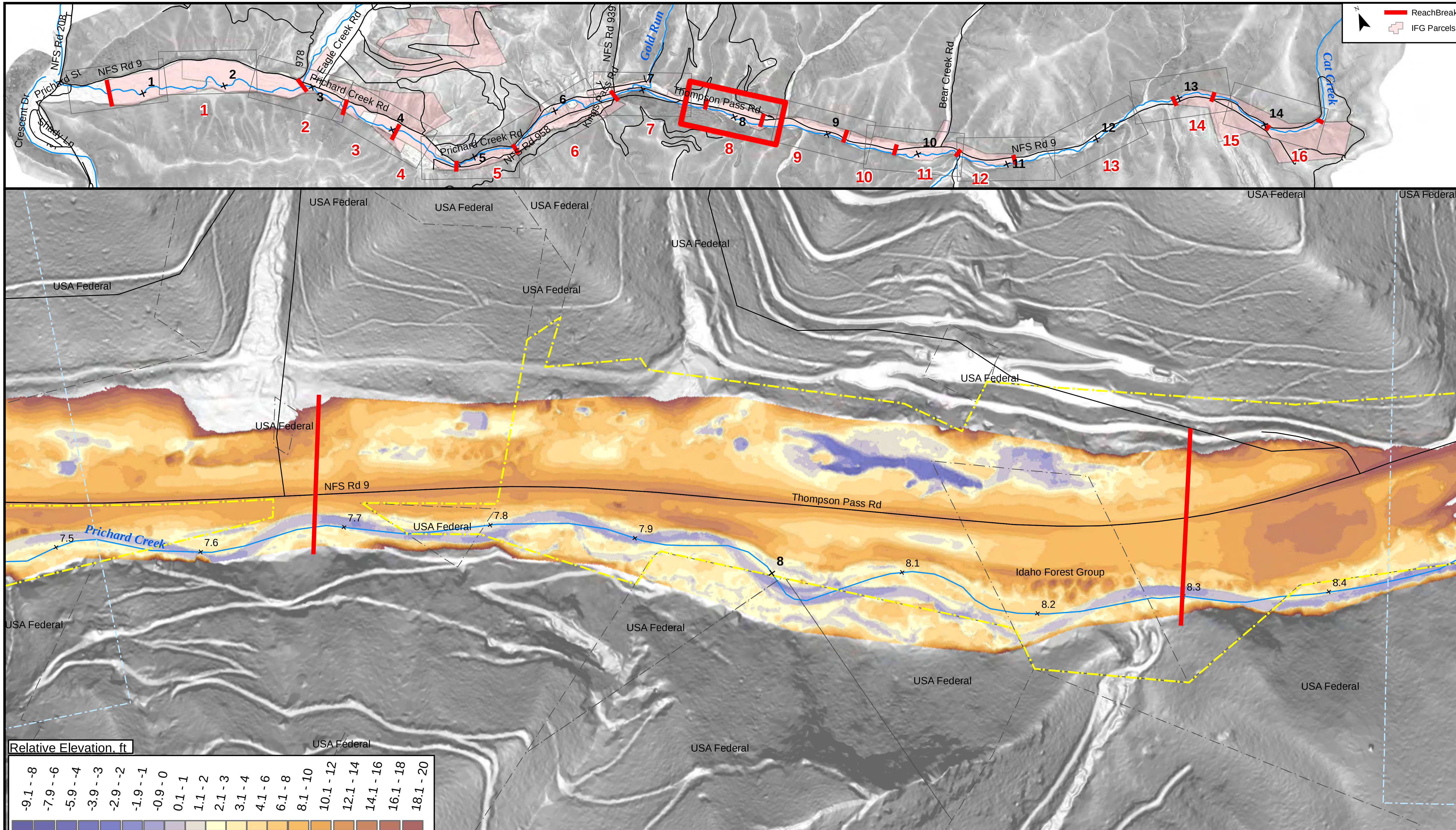
ReachBreaks
River Miles
NHD Flowline
Roads
Match Line
IFG Parcels
Parcels

Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
8



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ReachBreaks	Roads	IFG Parcels
River Miles	Match Line	Parcels
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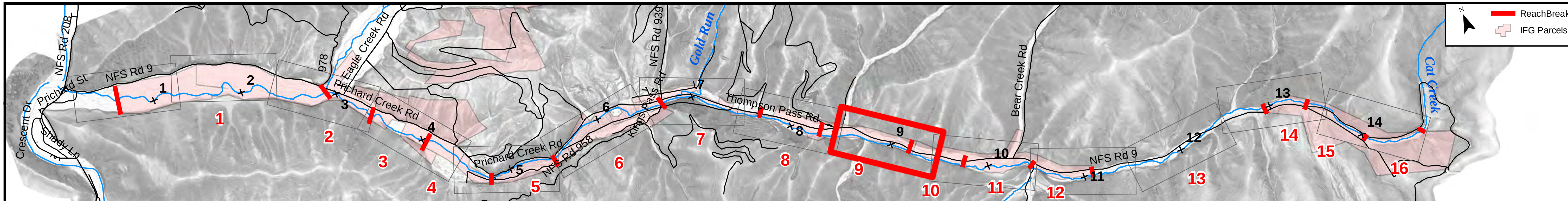
Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 8



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ReachBreaks
River Miles
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Roads
Match Line
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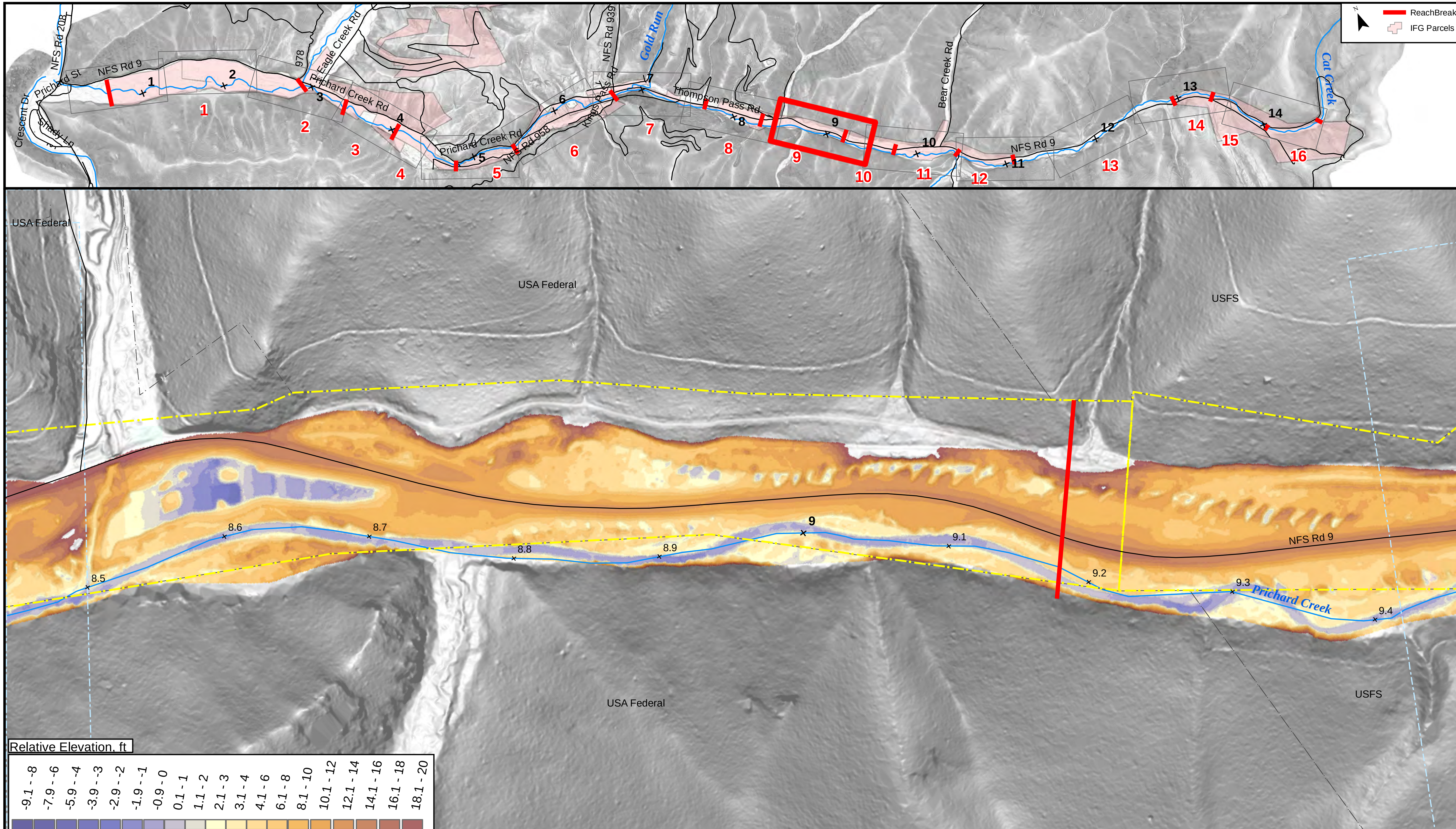
Parcels

Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
9



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ReachBreaks — Roads — IFG Parcels
River Miles — Match Line — Parcels
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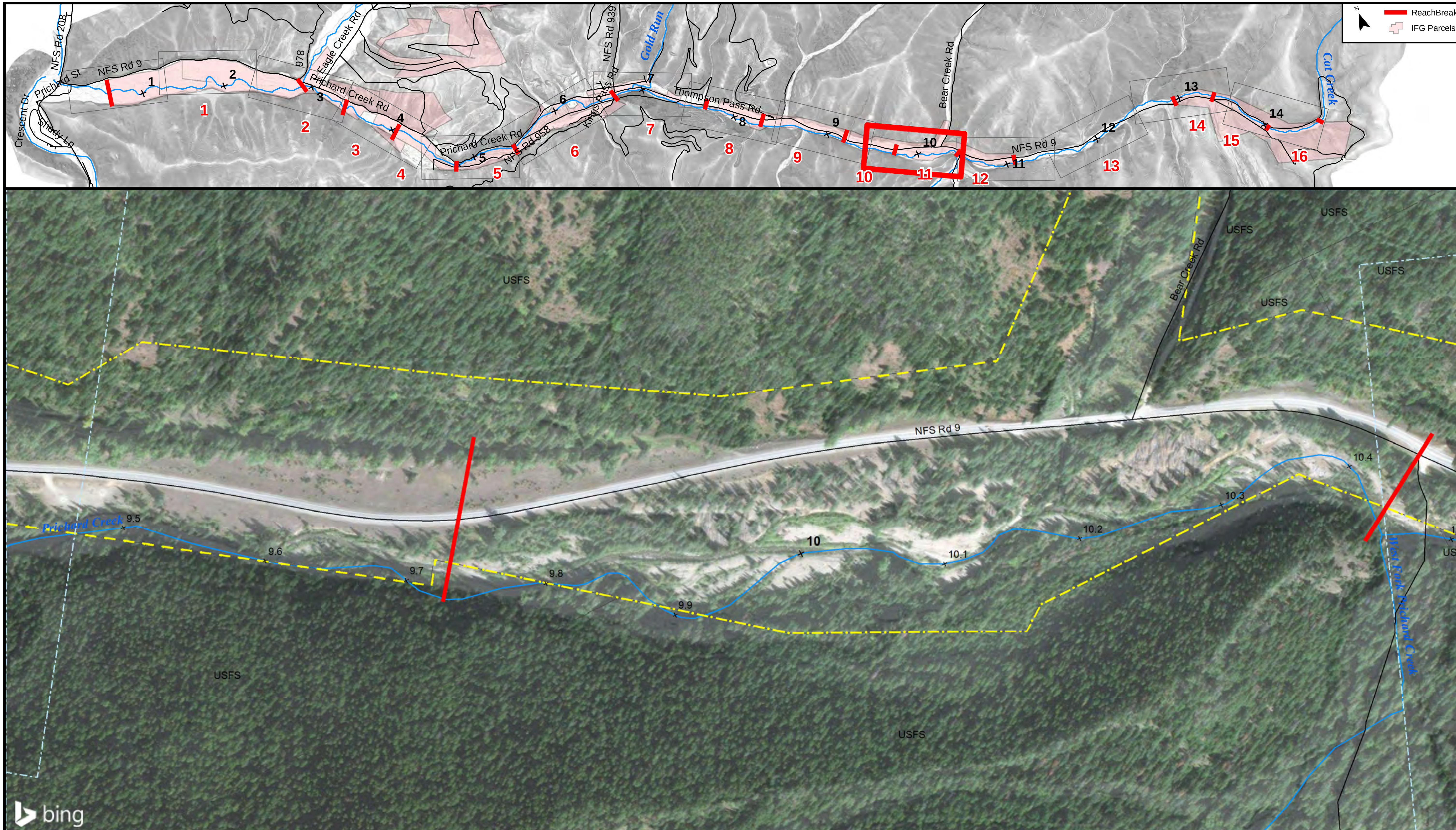
Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 9



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ReachBreaks
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Prichard Creek Field Maps

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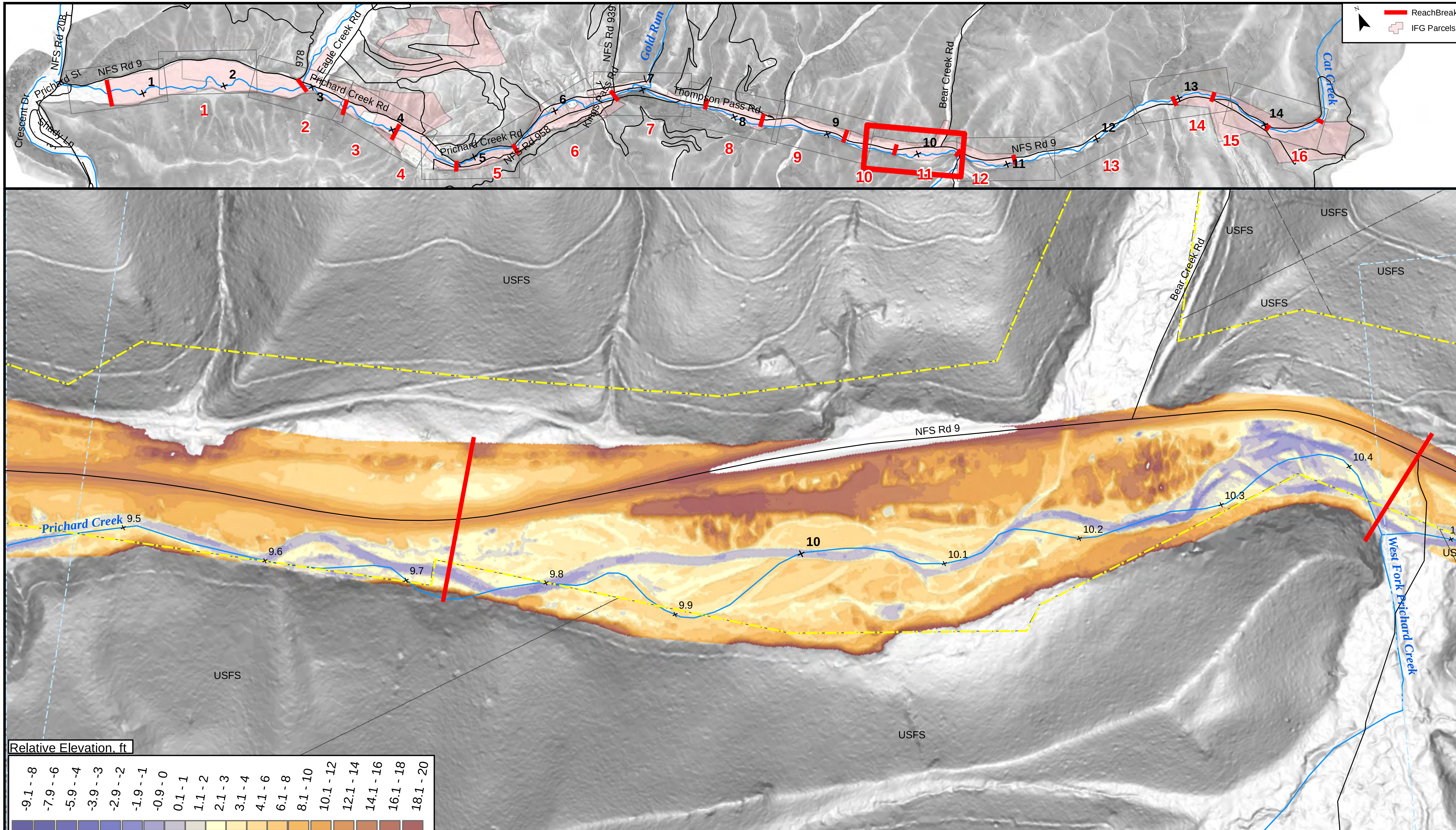
MAP 10



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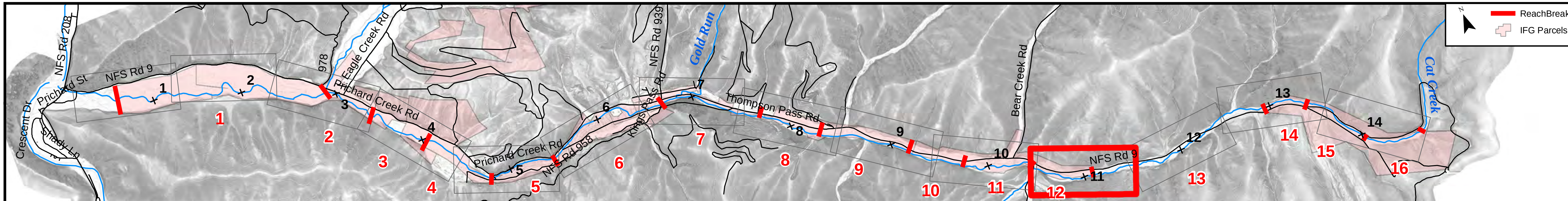
ReachBreaks	Roads	IFG Parcels
River Miles	Match Line	Parcels
NHD Flowline		

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 10



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ReachBreaks
River Miles
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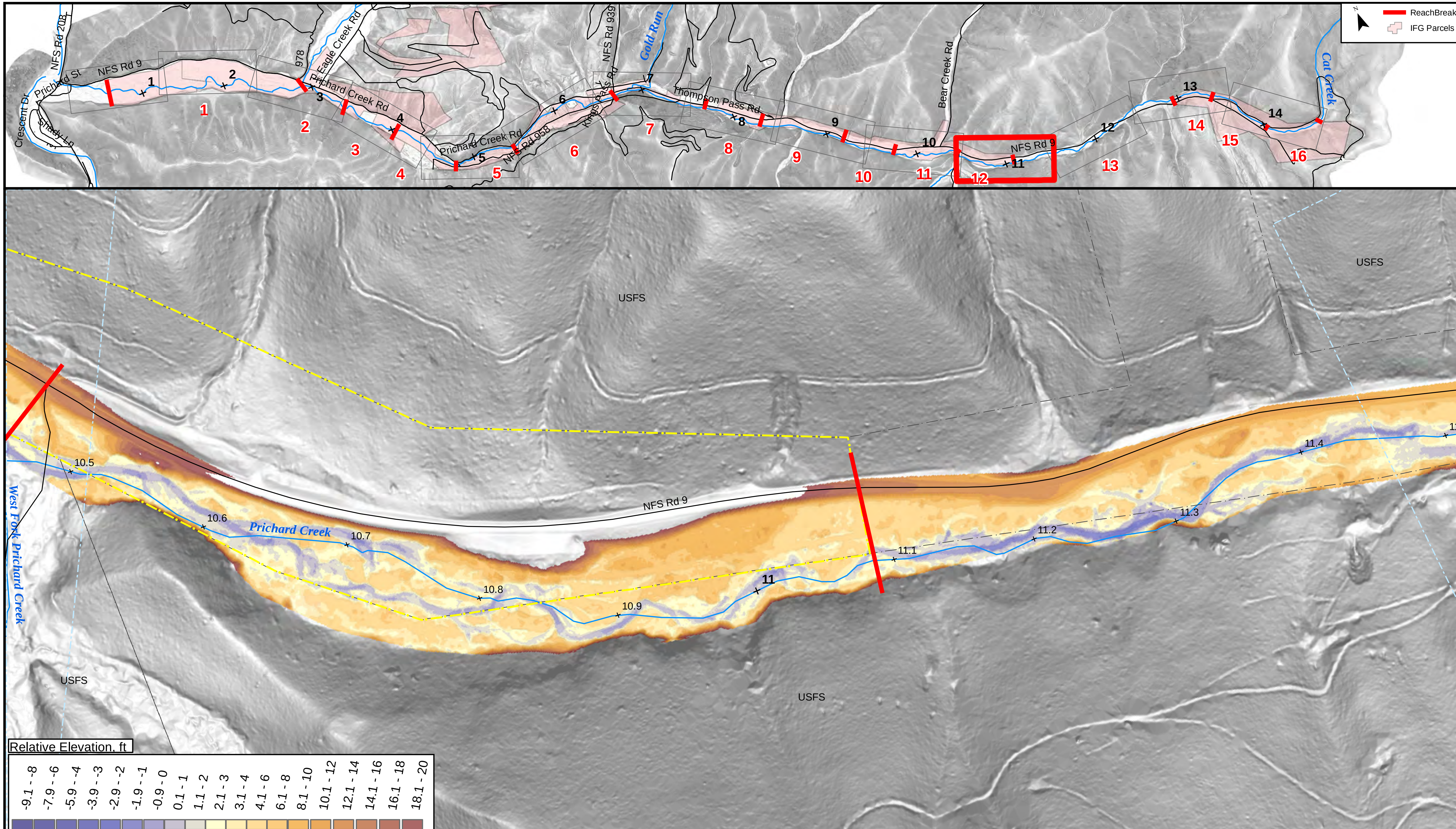
Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
11



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ReachBreaks
River Miles
NHD Flowline
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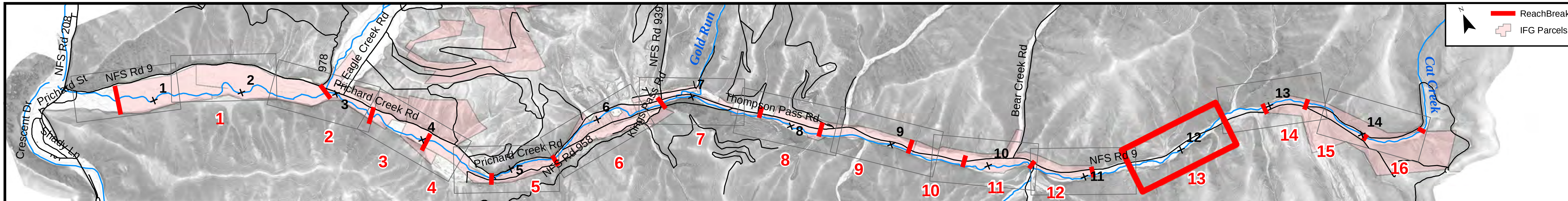
IFG Parcels
Parcels

Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 11



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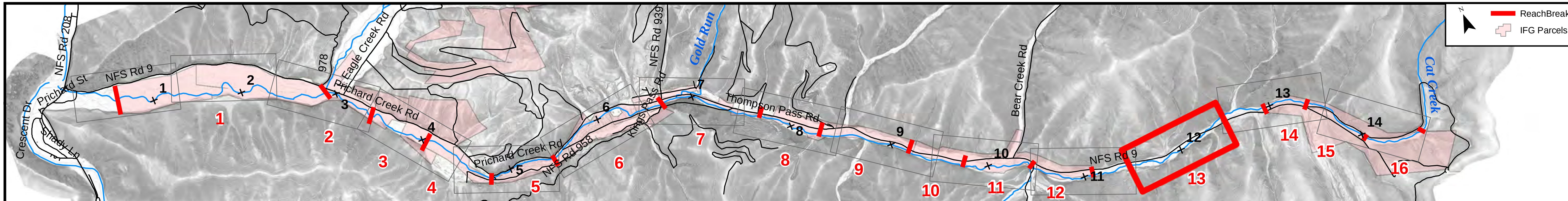
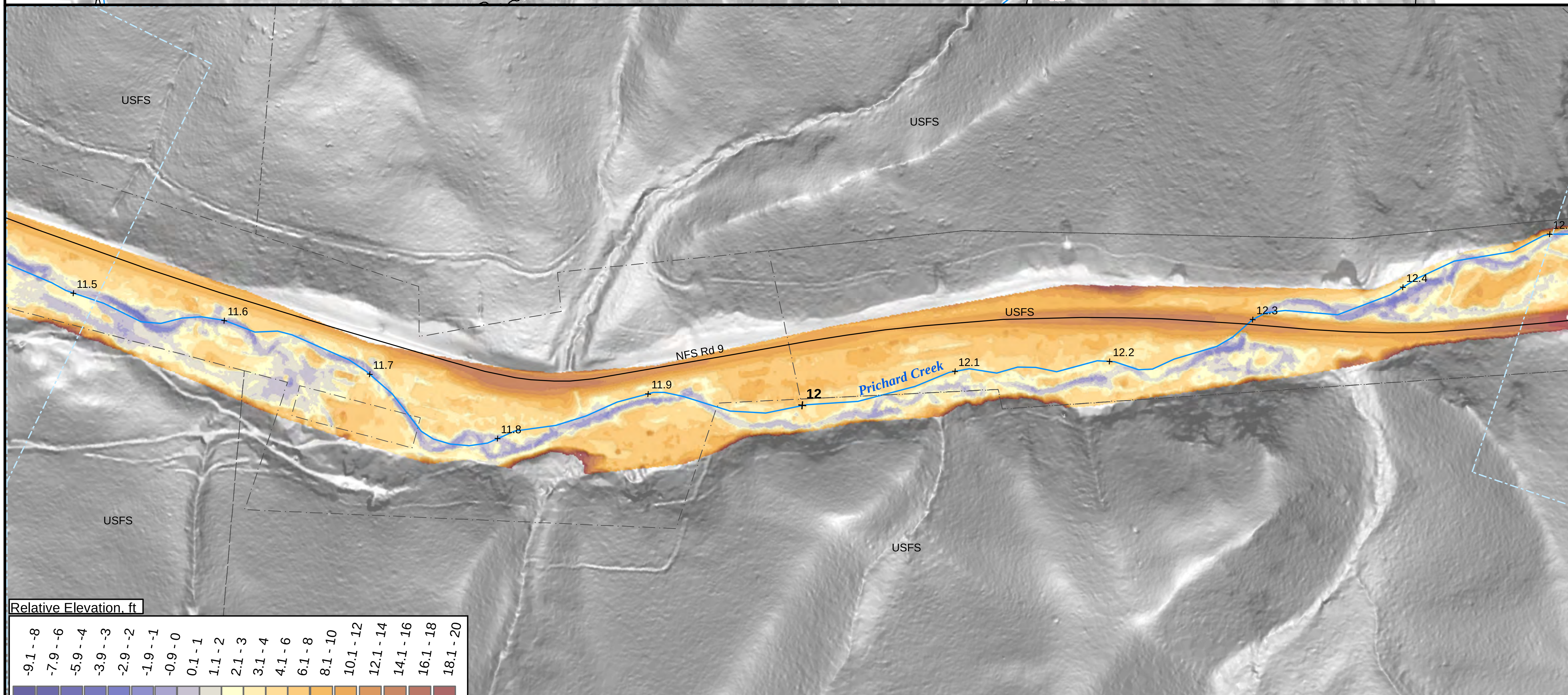
MAP 12





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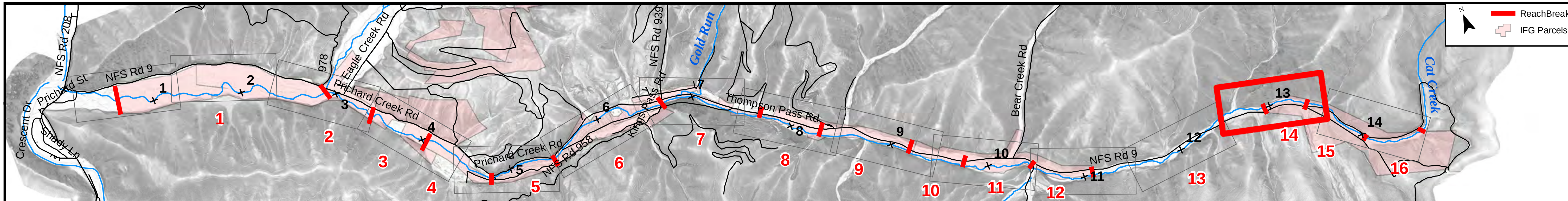
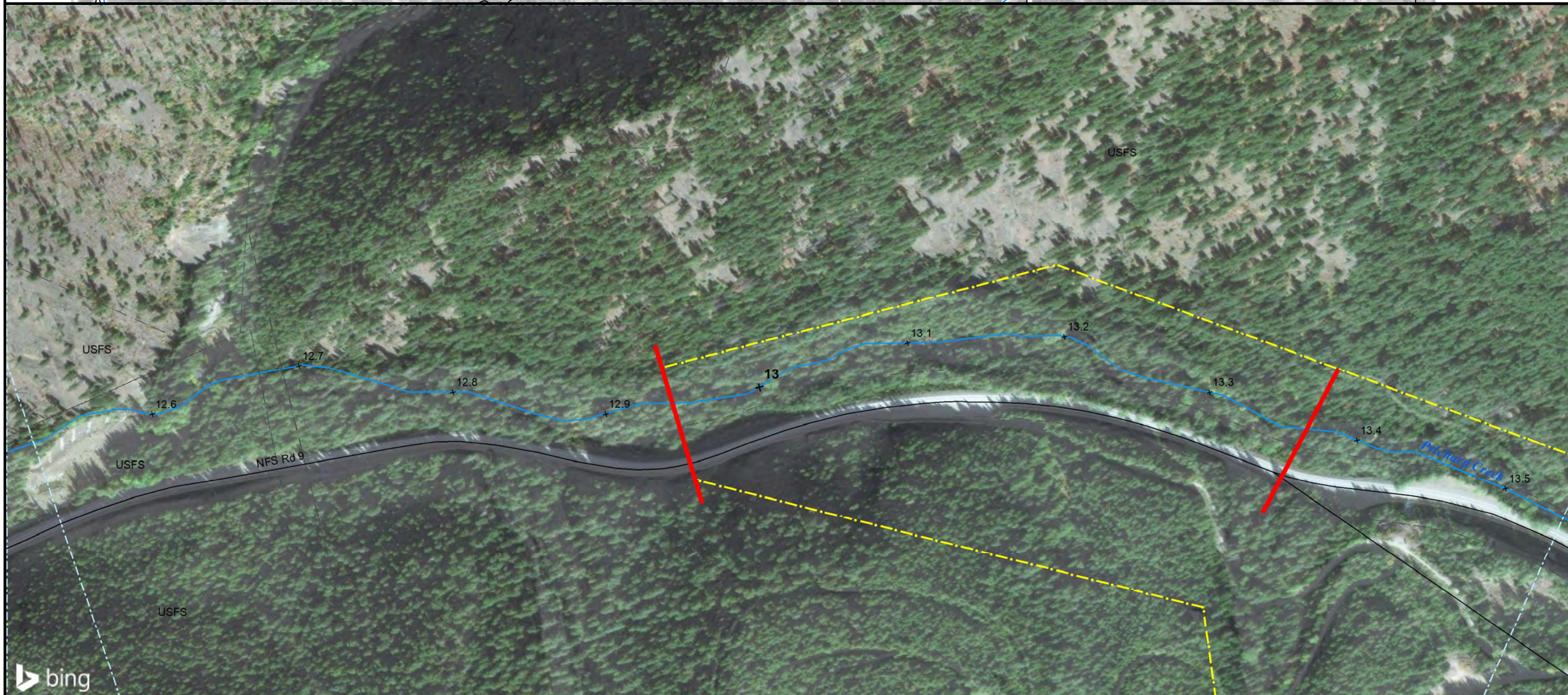
Prichard Creek
Field Maps
6/21/2021 - 6/25/2021

MAP
12





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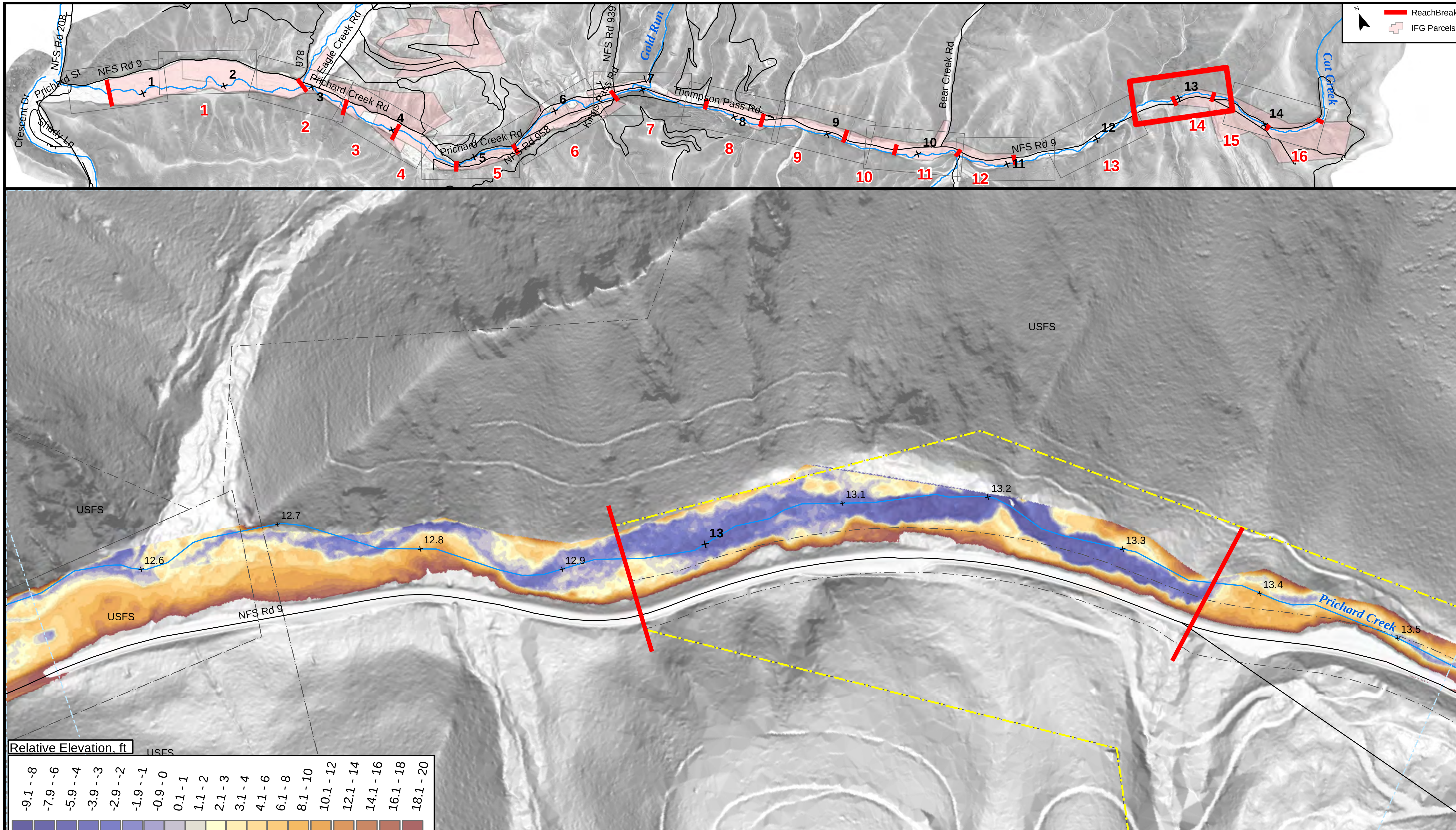
Prichard Creek Field Maps

6/21/2021 - 6/25/2021

MAP 13



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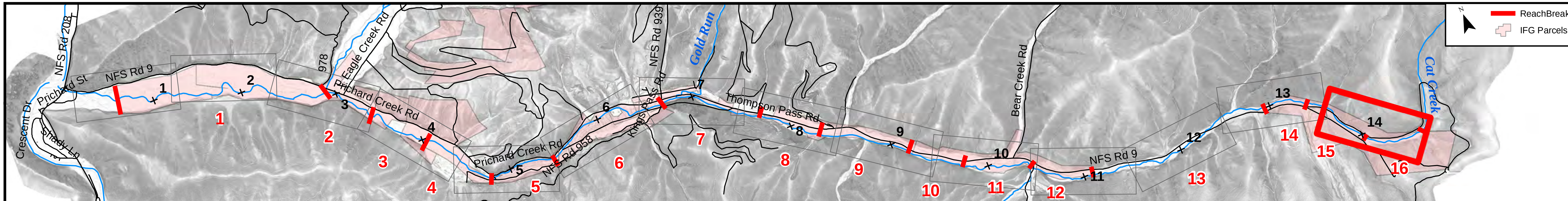
6/21/2021 - 6/25/2021

MAP 13



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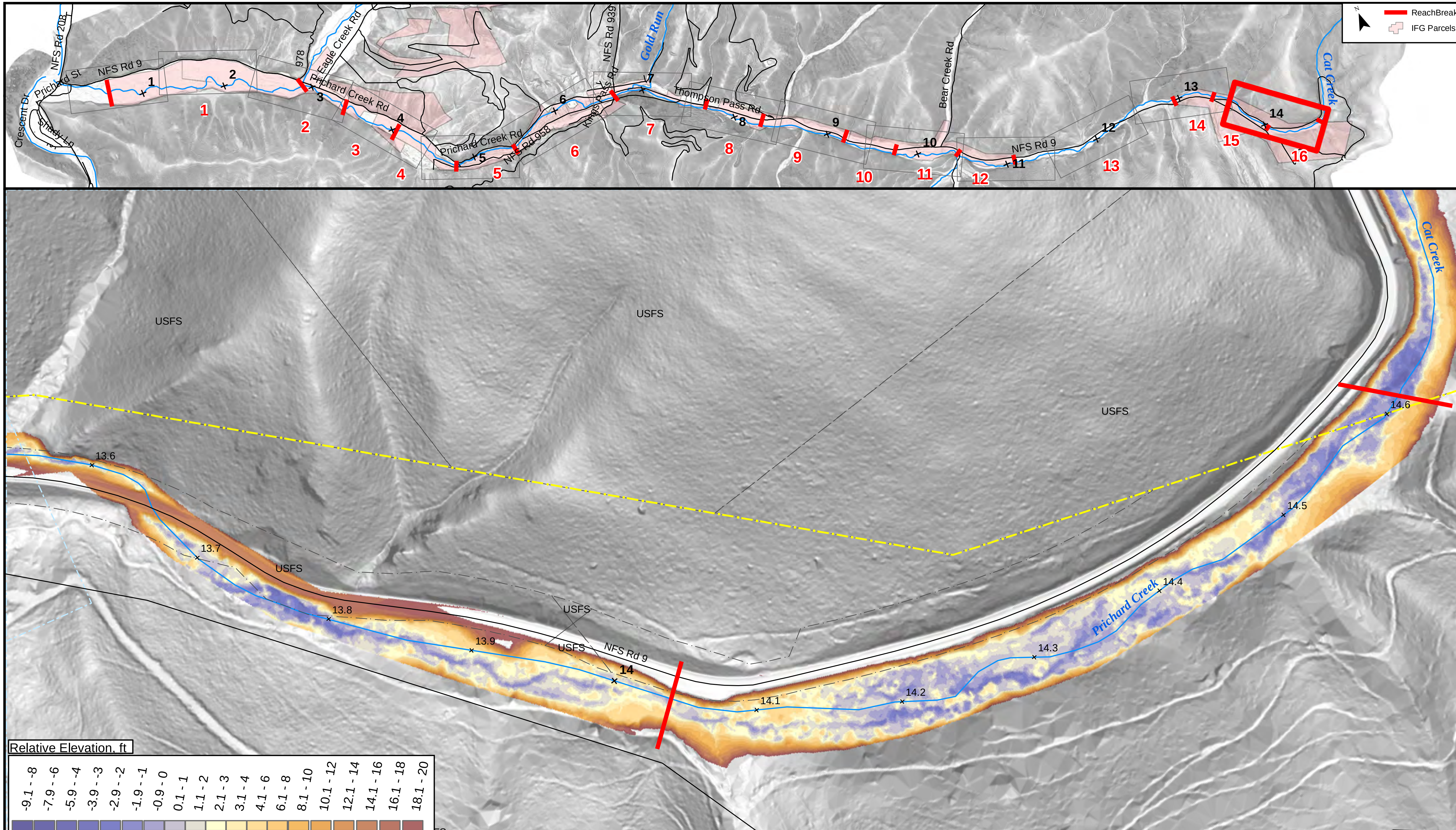
MAP
14



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MAP 14

Appendix B – Reach-based Ecosystem Indicators (REI)

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1 Introduction

1.1 BACKGROUND

The Reach-based Ecosystem Indicators (REI) provides a consistent means of evaluating biological and physical conditions of a watershed in relation to regional standards and known habitat requirements for aquatic biota. These indicators, along with other scientific evaluations, describe the current quality of stream biophysical conditions and can help inform restoration targets and actions. The specific subset of reach-scale REI indicators used in this assessment are adaptations from previous efforts including the NMFS matrix of pathways and indicators (NMFS 1996) and the USFWS (1998). With a few exceptions, the REI are based on the USBR's latest adaptations and use of these indicators (USBR 2012). Watershed-scale indicators were not evaluated for Prichard Creek.

The REI evaluation for Prichard Creek was conducted using field data and observations, previous studies, and desktop analyses for the study area. Specific indicators were selected due to their applicability to salmonid habitat evaluation and availability of field or desktop-driven data availability (e.g., LiDAR or high-resolution ortho-imagery available for assessment). Functional ratings include **Adequate**, **At Risk**, or **Unacceptable**. The REI analysis helps to summarize habitat impairments and to distill the impairments down to a consistent value that can be compared among reaches.

1.2 SUMMARY OF RESULTS

General trends in the reach-scale metrics show some of the poorest riparian and channel conditions are present in the middle reaches of the Prichard Creek assessment area. Reach 6 is the most impacted reach with seven **Unacceptable** ratings, the most of all the reaches. Reach 5 has six **Unacceptable** ratings, and Reach 9 has five **Unacceptable** ratings. The legacy of historical and ongoing human disturbances – including timber harvests, development for residential or agricultural uses, and mining or dredging activities – have contributed to the ecosystem impacts in these reaches. Reaches 1 through 3 offer some of the least impacted habitat to varying degrees; Reaches 1 and 3 had the most **Adequate** ratings (6) with no **Unacceptable** ratings. Reaches 12 through 16 in the upper watershed were not assigned ratings for several indicators.

The ratings relating to salmonid habitat ranged from Adequate to Unacceptable across the study area. All reaches besides Reach 1 received **Adequate** ratings for the Dominant Substrate/Fine Sediment indicators since there were primarily gravel and cobble substrates and limited sands or fine material that can be detrimental to egg incubation and juvenile rearing. Reach 1 was given at **At Risk** rating due to a greater percentage of sands and other fine substrates.

Large wood ratings were highly variable among the reaches, and was primarily tied to the number of large wood jams present in the reach. Reaches 1, 3, 8, and 12 were assigned Adequate ratings for large wood. Pool frequency was primarily rated **Unacceptable** in the assessment area, with Reaches 3, 7 and 12 the only **Adequate** ratings. Large, deep pools with cover were often associated with large wood jams. Pool frequency was given an **At Risk** rating for Reaches 1 and 8 due to low quality of the pools (low

residual depths and minimal/no large wood cover or habitat). Reaches 13 – 16 were not assigned ratings for Large Wood or Pools due to a lack of low-elevation, high quality orthoimagery from which these metrics could be tallied. Off-channel habitat in the assessment area is more available in the lower reaches than the upper watershed. The Off-channel Habitat indicator was rated as **Unacceptable** for Reaches 5 – 9 and 12 – 16 due to either the complete lack or very infrequent occurrence of connected alcoves and side channels or floodplains. Reaches 1 and 4 received **Adequate** ratings for this indicator.
REI ratings for salmonid habitat quantity/quality generally reflect known WCT limiting factors in Prichard Creek and the greater North Fork Coeur D'Alene watershed. IDFG 2008 identified several limiting factors for WCT in the NF Coeur d'Alene watershed, including degraded or loss of cold water refugia during summer rearing, degraded or loss of overwinter habitat (e.g., large, deep pools in downstream reaches) for larger fish, and degraded or loss of adult summer rearing habitat (e.g., large, deep pools and off-channel areas). The Unacceptable or At Risk ratings for large wood, pool habitat, and off-channel habitat/floodplain connectivity in most reaches correspond to the types of habitat preferred by WCT during summer rearing and overwintering.

Reaches 1 – 3 received **Adequate** ratings for the Habitat Access Pathway- Main Channel Accessibility indicator. The main channel of Prichard Creek flows subsurface through Reaches 4 – 6 during low flows, limiting salmonid movement and migration through the assessment area and into the upper reaches. Reaches 5 through 16 were assigned **Unacceptable** ratings for Main Channel Accessibility, due to the subsurface flow conditions downstream, with Reach 4 receiving an **At Risk** rating for the portion of the channel within the reach going subsurface.

Indicators of Riparian vegetation condition – Structure & Canopy Cover and Human Disturbance – were rated more favorably in the lower and upper portions of the watershed than the middle reaches. In particular, Reaches 5 and 6 were rated **Unacceptable** for both indicators. Riparian vegetation size and density increases in the upper reaches (primarily Reaches 12 – 16). Reaches 4 through 10 received **Unacceptable** or **At Risk** ratings in the Human Disturbance indicator due to residences or other developed areas within the riparian zones. In many of the middle and upper reaches (Reach 4, 7, 8, 9, 10, 13, and 15), Prichard Creek Road or Thompson Pass Road runs immediately adjacent to the channel and limits the presence of high-quality riparian vegetation. Reaches 1 – 3, 11, 12, 14, and 16 received ratings of **Adequate** for this indicator due to minimal roads and development located within the riparian zone of these reaches.

Channel dynamics for Reach 1 is satisfactory. Reach 1 received **Adequate** ratings for both indicators: Floodplain Connectivity and Bank Stability. Most of the assessment area (Reaches 2 – 13 and Reach 15) were assigned an **At Risk** rating for the Floodplain Connectivity indicator, with the loss of well-inundated floodplains due in part to human disturbances. However, few reaches had actively eroding banks that were associated with anthropogenic actions; only Reaches 4, 6 and 7 were assigned **Unacceptable** ratings, and Reach 11 was rated **At Risk**. All other reaches were rated **Adequate**, indicating bank erosion or presence of vertical banks is associated with natural channel migration processes. Reaches 13 – 16 were not assigned ratings for the Bank Stability indicator, but were assumed to be in **Adequate** condition.

For the study area as a whole, **Unacceptable** was the most common rating (47), followed by **Adequate** (42) and **At Risk** ratings (40). A summary of all reach ratings is presented in Table 1.

Table 1. Summary ratings for the Prichard Creek reach assessment study area. Ratings are color-coded, with green shading for Adequate condition, yellow for At Risk condition, and red for Unacceptable condition.

Path-way	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16
Habitat Quality	*Substrate*	*Dominant Substrate / Fine Sediment*	At Risk	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	No Rating	No Rating	No Rating
	LWM	*Jams per mile*	Adequate	Unacceptable	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	Adequate	Unacceptable	Unacceptable	At Risk	Adequate	No Rating	No Rating	No Rating	No Rating
	Pools	*Pool Freq. & Quality; Large Pools*	At Risk	Unacceptable	Adequate	Unacceptable	Unacceptable	Unacceptable	Adequate	At Risk	Unacceptable	Unacceptable	Unacceptable	Adequate	No Rating	No Rating	No Rating	No Rating
	Off-Channel Habitat	*Connectivity with Main Channel*	Adequate	At Risk	At Risk	Adequate	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
Riparian Vegetation	*Condition*	*Structure & Canopy Cover*	At Risk	At Risk	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	At Risk	Unacceptable	At Risk	At Risk	At Risk	Unacceptable	At Risk
		Disturbance (Human)	Adequate	Adequate	Adequate	At Risk	Unacceptable	Unacceptable	At Risk	At Risk	At Risk	At Risk	Adequate	Adequate	At Risk	Adequate	At Risk	Adequate
Channel Dynamics	*Floodplain Connectivity*		Adequate	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	At Risk	Adequate	At Risk	Adequate
	Bank Stability		Adequate	Adequate	Adequate	Unacceptable	Adequate	Unacceptable	Unacceptable	Adequate	Adequate	Adequate	At Risk	Adequate	No Rating	No Rating	No Rating	No Rating
Habitat Access	*Physical Barriers*	*Main Channel Barriers*	Adequate	Adequate	Adequate	At Risk	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable

2 Reach Metrics & Indicators

This section describes the conditions for Adequate, At Risk, and Unacceptable ratings for each indicator.

Pathway	General Indicators	Specific Indicators	Adequate Condition	At Risk Condition	Unacceptable Risk Condition
Habitat Quality	Substrate	Dominant Substrate/Fine Sediment	Gravels or small cobbles make up >50% of the bed materials in spawning areas. ≤12% of substrates <6 mm in spawning gravel.	Gravels or small cobbles make up 30-50% of the bed materials in spawning areas. 12-20% of substrates <6 mm in spawning gravel.	Gravels or small cobbles make up <30% of the bed materials in spawning areas. >20% of substrates <6 mm in spawning gravel.
	LWM	Pieces per Mile at Bankfull	Assuming at least 10 pieces of LW/jam, reach has 3 or greater jams/mile. Based on Fox and Bolton (2007) metrics for Eastern Washington, at least 32 pieces/mile of large wood, and USFS criteria of >20 pieces/mile. In addition to the jams / mile metric, an adequate rating also indicates there are sources of woody material available for both long- and short-term recruitment within the reach as determined by aerial imagery.	Reach has between 1 and 3 jams / mile. Potential sources for long-term woody material recruitment, as determined by aerial imagery, are limited within the reach riparian zone.	Reach has less than 1 jam / mile. Potential source of woody material for short- and/or long-term recruitment are very limited, or do not exist, in the reach riparian zone.
	Pools	Pool Frequency and Quality; presence of large pools.	High quality pool frequency: Number of high quality (deep, with cover) pools/mile for a given wetted width (based on NMFS total pool frequency divided by 2). Average wetted width (estimate): 35 – 40 ft 5 pools/mi 40 - 65 ft 4 pools/mi 65 - 100 ft 2 pools/mi To be considered adequate, the Prichard reach metric meets these targets for pool frequency, indicating there is adequate high-quality pool habitat in the reach: large pools >1 m (3 ft) deep with good fish cover (as determined by aerial drone imagery in GIS).	Pool frequency meets the values for the "adequate" rating, but aerial imagery or field observations indicate pools have inadequate cover/temperature and/or there has been a moderate reduction of pool volume by fine sediment.	Pool frequency does not meet the pools/mile metric given in the "adequate" rating.
	Off-Channel Habitat and Refugia	Connectivity with Main Channel	Reach has side channels and/or groundwater fed tributaries. Aquatic refugia such as backwaters, alcoves, large boulder eddies exist within the channel. Well-vegetated floodplains with healthy riparian community are inundated on a 1-2-year recurrence frequency. No man-made barriers along the mainstem that prevent access to off-channel areas.	Reach provides some aquatic off-channel and refugia features but access varies or is at risk of disconnection due to human impacts or man-made barriers. Floodplains along the off-channel habitat are well-vegetated with inundation recurrence of 2-5-years.	Reach provides no or only minimal off-channel or in-channel refugia. Floodplains are disconnected by processes of incision and/or human structures (levee, bridges, etc.) and riparian vegetation has been altered.
Riparian Vegetation	Condition	Structure & Canopy Cover	More than 25% of the riparian buffer zone (defined as a 100ft buffer along each bank) has large trees (>100 ft tall) present based on GIS analyses and drone aerial imagery assessment data.	5-25% of the riparian buffer zone (defined as a 100ft buffer along each bank) has large trees (>100 ft tall) present based on GIS analyses and drone aerial imagery assessment data.	0-5% of the riparian buffer zone (defined as a 100ft buffer along each bank) has large trees (>100 ft tall) present based on GIS analyses and drone aerial imagery assessment data.
		Disturbance (Human)	<20% disturbance in the 200-foot riparian buffer zone (e.g., agriculture and grazing, residential, roads, etc.) based on visual estimate from GIS.	20-50% disturbance in the 200-foot riparian buffer zone (e.g., agriculture and grazing, residential, roads, etc.) based on visual estimate from GIS.	>50% disturbance in the 200-foot riparian buffer zone (e.g., agriculture and grazing, residential, roads, etc.) based on visual estimate from GIS.

Channel	Dynamics	Floodplain Connectivity	Floodplain areas are hydrologically linked to main channel within the context of the local process domain; overbank flows occur and maintain wetland functions, and riparian vegetation. Naturally confined channels are considered adequate.	Reduced linkage of floodplains and riparian areas to main channel in reaches with historically strong connectivity; overbank flows are reduced relative to historic frequency, as evidenced by moderate degradation of floodplain soil accumulations and riparian vegetation/succession.	Severe reduction in hydrologic connectivity between off-channel, floodplain, and riparian areas relative to historical connectivity; riparian vegetation/succession is altered significantly.
		Bank Stability	Erosion of actively eroding, vertical banks is associated with natural channel migration processes and/or deposition of large wood. Actively eroding banks are vegetated with woody riparian plants.	More than 10% of the reach contains actively eroding, vertical banks that lack woody vegetation, or mass wasting of the banks was observed in the reach. Observed erosion is likely the result of past or ongoing anthropogenic actions.	Mass wasting is observed on actively eroding, vertical or undercut banks that lack woody vegetation cover. Observed erosion is likely the result of past or ongoing anthropogenic actions.
Habitat Access	Physical Barriers	Main Channel Barriers	No man-made barriers present in the mainstem that limit upstream or downstream migration at any flow.	Man-made barriers are present in the mainstem that have the potential to prevent or inhibit upstream or downstream migration at a subset of flows.	Man-made barriers present in the mainstem that prevent upstream or downstream migration at multiple or all flows.

3 REI Ratings

This section discusses the results for each indicator, rated at the reach-scale for Reaches 1 – 16.

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16
Habitat Quality	**Substrate**	*Dominant Substrate / Fine Sediment*	At Risk Suitable spawning size substrates (gravel / cobbles); fine sediment exceeds criteria	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	Adequate	*No Substrate Rating*	*No Substrate Rating*	*No Substrate Rating*
	Large Wood	*Jams per Mile*	Adequate 3 jams/mi Wood Recruitment potential high	Unacceptable 0 jams/mi Wood recruitment potential high	Adequate 4.5 jams/mi Wood recruitment potential moderate	At Risk 1.3 jams/mi Wood recruitment potential low	Unacceptable 0 jams/mi Wood recruitment potential low	Unacceptable 0 jams/mi Wood recruitment potential moderate	At Risk 2 jams/mi Wood recruitment potential low	Adequate 4.8 jams/mi Wood recruitment potential low	Unacceptable 0 jams/mi Wood recruitment potential low	Unacceptable 0 jams/mi Wood recruitment potential moderate	At Risk 1.4 jams/mi Wood recruitment potential low	Adequate 5.9 jams/mi Wood recruitment potential moderate	*No Jams Rating* *Wood recruitment potential moderate*	*No Jams Rating* *Wood recruitment potential moderate*	*No Jams Rating* *Wood recruitment potential low*	*No Jams Rating* *Wood recruitment potential moderate*
	Pools	*Pool Frequency and Quality; presence of large pools.*	At Risk Avg channel width ~ 62 ft Number of pools meets criteria; pools lack cover	Unacceptable Est. channel width ~ 57 ft Number of pools does not meet criteria; pools lack cover	Adequate Avg channel width ~ 41 ft Number of pools meets criteria; pools have cover	Unacceptable Est. channel width ~ 52 ft Number of pools does not meet criteria; pools lack cover	Unacceptable Est. channel width ~ 53 ft Number of pools does not meet criteria; pools lack cover	Unacceptable Est. channel width ~ 45 ft Number of pools does not meet criteria; pools lack cover	Adequate Avg channel width ~ 65 ft Number of pools meets criteria; most pools have cover	At Risk Avg channel width ~ 39 ft Number of pools meets criteria; some pools lack cover	Unacceptable Est. channel width ~ 43 ft Number of pools does not meet criteria; pools lack cover	Unacceptable Est. channel width ~ 40 ft Number of pools does not meet criteria; pools lack cover	Unacceptable Est. channel width ~ 59 ft Number of pools does not meet criteria; pools lack cover	Adequate Avg channel width ~ 51 ft Number of pools meets criteria; pools have cover	*No Pools Rating*	*No Pools Rating*	*No Pools Rating*	*No Pools Rating*

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16
	Off-Channel Habitat and Refugia	*Connectivity with Main Channel*	Adequate Reach has several long side channels; off-channel and floodplain habitats well connected	At Risk Off-channel habitat available, some may be disconnected	At Risk Off-channel habitat available, some may be disconnected	Adequate Reach has several long side channels; off-channel and floodplain habitats well connected	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach has very little connected off-channel habitats	Unacceptable Reach has very little connected off-channel habitats	At Risk Off-channel habitat available, some may be disconnected	At Risk Off-channel habitat available, some may be disconnected	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach has very little connected off-channel habitats	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach does not have connected off-channel habitats	Unacceptable Reach does not have connected off-channel habitats
Riparian Vegetation	**Condition**	*Structure & Canopy Cover*	At Risk Some large trees present within riparian zone	At Risk Some large trees present within riparian zone	At Risk Some large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	At Risk Some large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	At Risk Some large trees present within riparian zone	At Risk Some large trees present within riparian zone	At Risk Some large trees present within riparian zone	Unacceptable Very few large trees present within riparian zone	At Risk Some large trees present within riparian zone
		Disturbance (Human)	Adequate Approx. 2% disturbance present in riparian zone	Adequate Approx. 5% disturbance present in riparian zone	Adequate Approx. 5% disturbance present in riparian zone	At Risk Approx. 30% disturbance present in riparian zone	Unacceptable Approx. 80% disturbance present in riparian zone	Unacceptable Approx. 60% disturbance present in riparian zone	At Risk Approx. 50% disturbance present in riparian zone	At Risk Approx. 50% disturbance present in riparian zone	At Risk Approx. 40% disturbance present in riparian zone	At Risk Approx. 25% disturbance present in riparian zone	Adequate Approx. 0% disturbance present in riparian zone	Adequate Approx. 5% disturbance present in riparian zone	At Risk Approx. 20% disturbance present in riparian zone	Adequate Approx. 10% disturbance present in riparian zone	At Risk Approx. 20% disturbance present in riparian zone	Adequate Approx. 5% disturbance present in riparian zone
Channel	**Dynamics**	*Floodplain Connectivity*	Adequate Naturally unconfined; floodplains are connected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally partially confined; some reduced linkage of floodplains	At Risk Naturally partially confined; some reduced linkage of floodplains	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally confined; available floodplain is disconnected	At Risk Naturally partially confined; some reduced linkage of floodplains	At Risk Naturally partially confined; some reduced linkage of floodplains	At Risk Naturally partially confined; some reduced linkage of floodplains	Adequate Naturally confined; floodplains are connected	At Risk Naturally confined; available floodplain is disconnected	Adequate Naturally confined; floodplains are connected

Pathway	General Indicators	Specific Indicators	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7	Reach 8	Reach 9	Reach 10	Reach 11	Reach 12	Reach 13	Reach 14	Reach 15	Reach 16
		Bank Stability	Adequate 13% of reach has vertical / undercut banks that are actively eroding, but only 3% lack woody riparian vegetation. No mass wasting observed.	Adequate No observation of vertical or undercut banks actively eroding and no mass wasting observed.	Adequate 7% of reach has vertical / undercut banks that are actively eroding, but only 4% lack woody riparian vegetation. No mass wasting observed.	Unacceptable 20% of reach has vertical / undercut banks that are actively eroding, and all 20% lack woody riparian vegetation. Mass wasting observed.	Adequate No observation of vertical or undercut banks actively eroding and no mass wasting observed.	Unacceptable 15% of reach has vertical / undercut banks that are actively eroding, and 13% lacks woody riparian vegetation. Mass wasting observed.	Unacceptable 15% of reach has vertical / undercut banks that are actively eroding, and all 15% lack woody riparian vegetation. Mass wasting observed.	Adequate 5% of reach has vertical / undercut banks that are actively eroding, and all 5% lack woody riparian vegetation. No mass wasting observed.	Adequate 1% of reach has vertical / undercut banks that are actively eroding, and all 1% lack woody riparian vegetation. No mass wasting observed	Adequate No observation of vertical or undercut banks actively eroding and no mass wasting observed.	At Risk While only 4% of reach has vertical / undercut banks that are actively eroding, all 4% lack woody riparian vegetation and mass wasting is observed.	Adequate 6% of reach has vertical / undercut banks that are actively eroding, and all 6% lack woody riparian vegetation. No mass wasting observed.	*Banks Not Observed*	*Banks not observed but assumed to be in adequate condition*	*Banks not observed but assumed to be in adequate condition*	*Banks not observed but assumed to be in adequate condition*
Habitat Access	**Physical Barriers**	*Main Channel Accessibility*	Adequate No barriers	Adequate No barriers	Adequate No barriers	At Risk Upstream portion of reach flows sub-surface during baseflows	Unacceptable Seasonal barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream	Unacceptable Seasonal sub-surface flow barrier downstream

4 References

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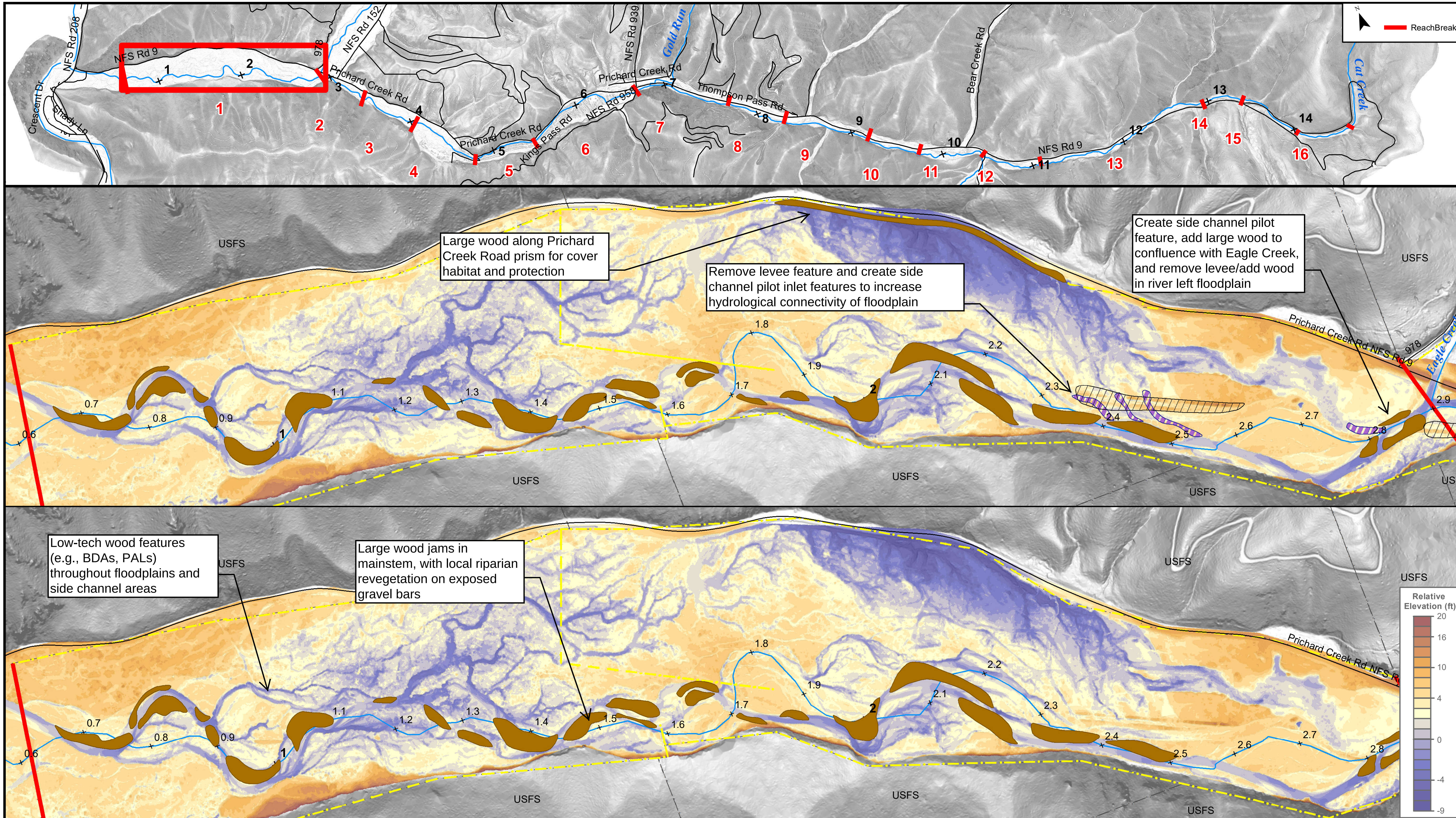
Appendix C – Concept Mapbook



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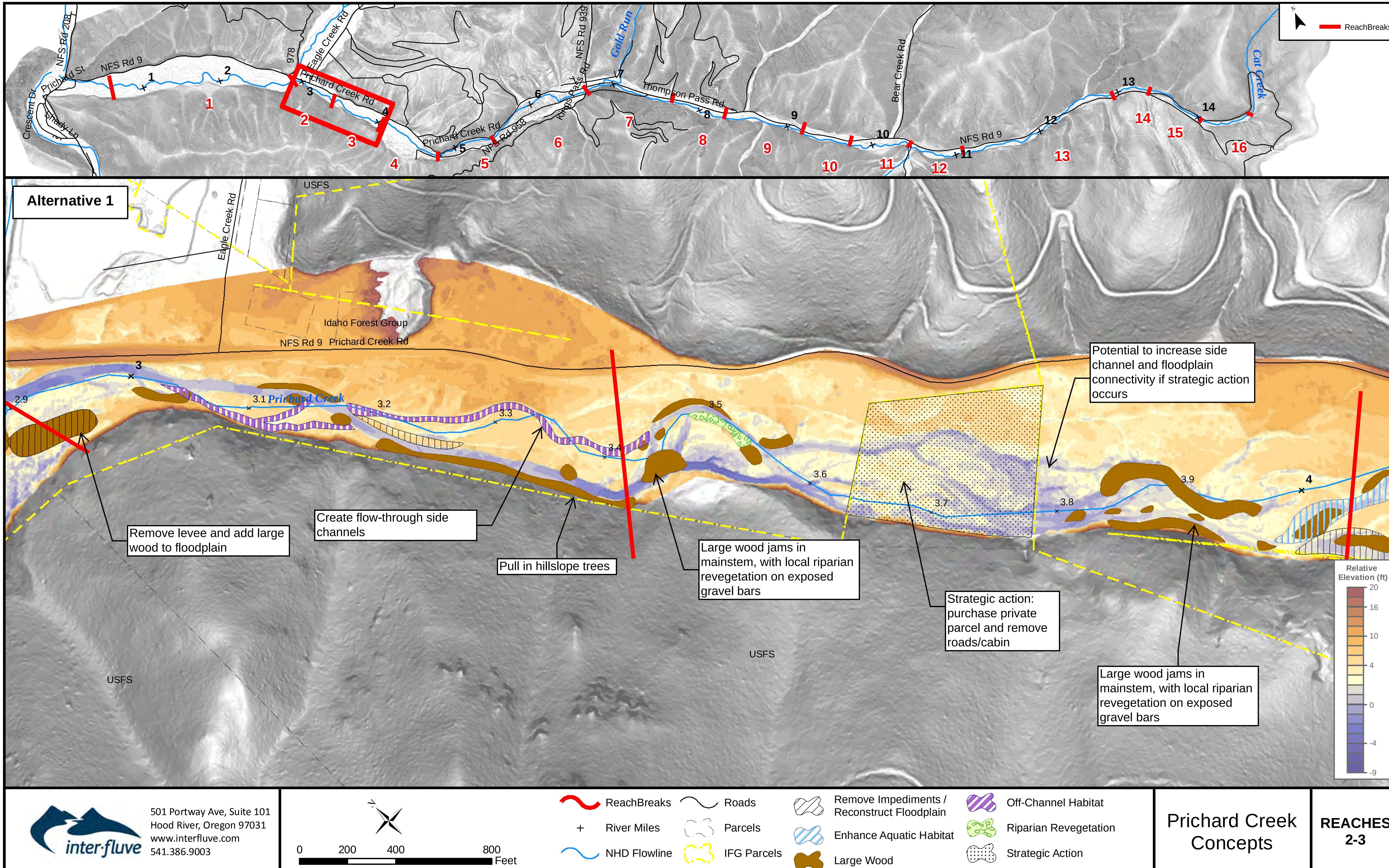
ReachBreaks
River Miles
NHD Flowline
Roads
Parcels
IFG Parcels
Floodplain regrading / reconstruction
Instream Habitat Complexity
Large Wood
Off-Channel Habitat
Revegetation
Strategic Action

Prichard Creek Concepts

REACH 1



ReachBreaks
NFS Rd 208
Prichard St
NFS Rd 9
Crescent Dr
Shady Ln
Eagle Creek Rd
978
Prichard Creek Rd
NFS Rd 958
NFS Rd 939
Kings Pass Rd
Gold Run
Thompson Pass Rd
Bear Creek Rd
Cat Creek
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
Alternative 1
USFS
Idaho Forest Group
NFS Rd 9
Prichard Creek Rd
Prichard Creek
2.9
3
3.1
3.2
3.3
3.4
3.5
3.6
3.7
3.8
3.9
4
Potential to increase side channel and floodplain connectivity if strategic action occurs
Remove levee and add large wood to floodplain
Create flow-through side channels
Pull in hillslope trees
Large wood jams in mainstem, with local riparian revegetation on exposed gravel bars
Strategic action: purchase private parcel and remove roads/cabin
Large wood jams in mainstem, with local riparian revegetation on exposed gravel bars
Relative Elevation (ft)
20
16
10
4
0
-4
-9
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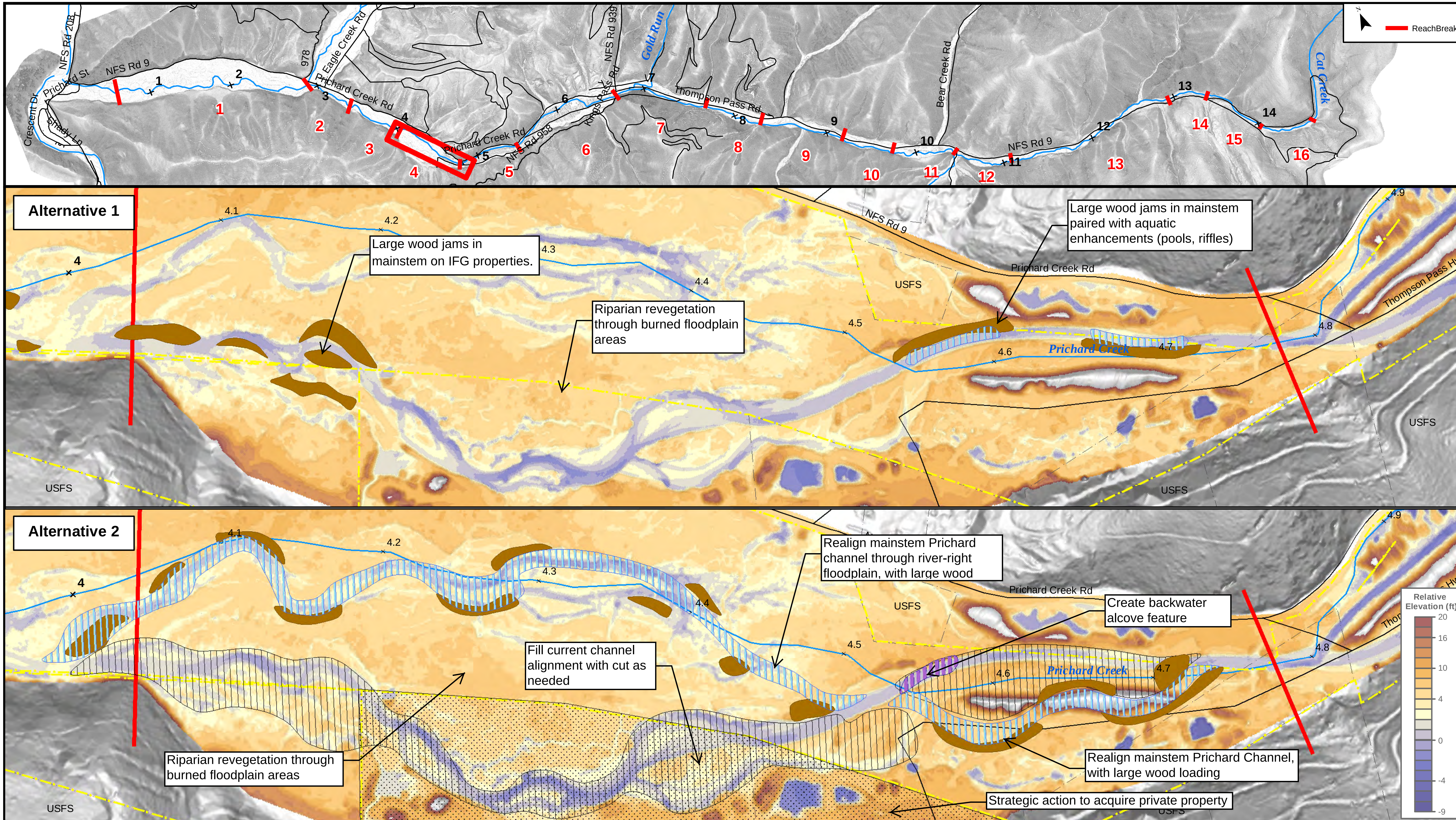
River Miles
NHD Flowline
Roads
Parcels
IFG Parcels
Remove Impediments / Reconstruct Floodplain
Enhance Aquatic Habitat
Large Wood
Off-Channel Habitat
Riparian Revegetation
Strategic Action
Prichard Creek Concepts
REACHES 2-3



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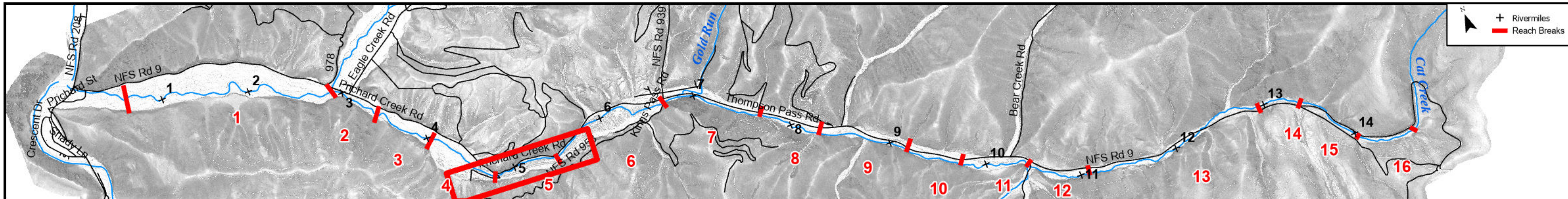
- Roads
- Parcels
- IFG Parcels
- Remove Impediments / Reconstruct Floodplain
- Enhance Aquatic Habitat
- Large Wood
- Off-Channel Habitat
- Riparian Revegetation
- Strategic Action

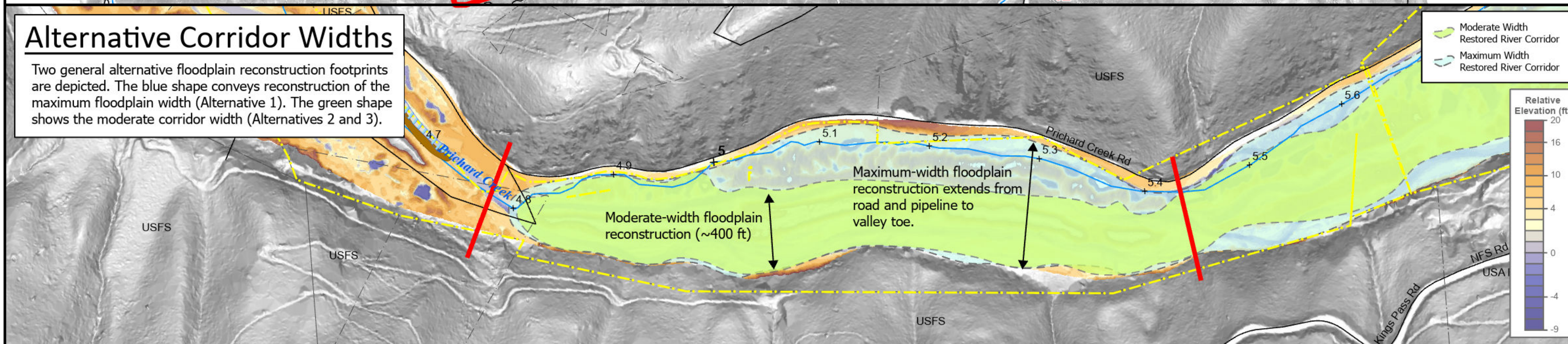
Prichard Creek Concepts

REACH 4



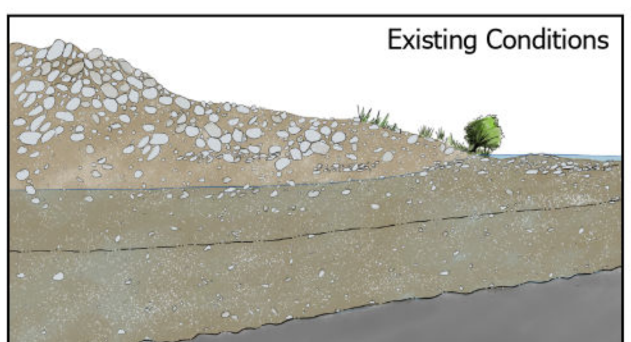
Alternative Corridor Widths

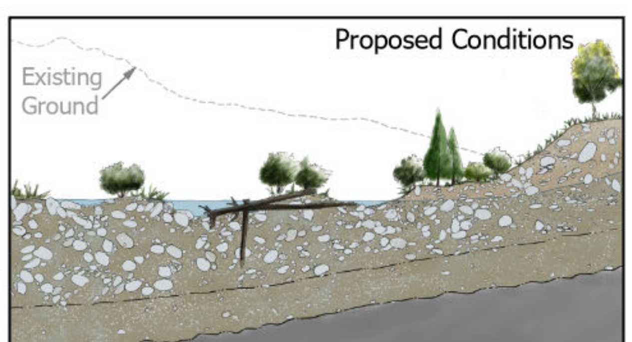
Two general alternative floodplain reconstruction footprints are depicted. The blue shape conveys reconstruction of the maximum floodplain width (Alternative 1). The green shape shows the moderate corridor width (Alternatives 2 and 3).

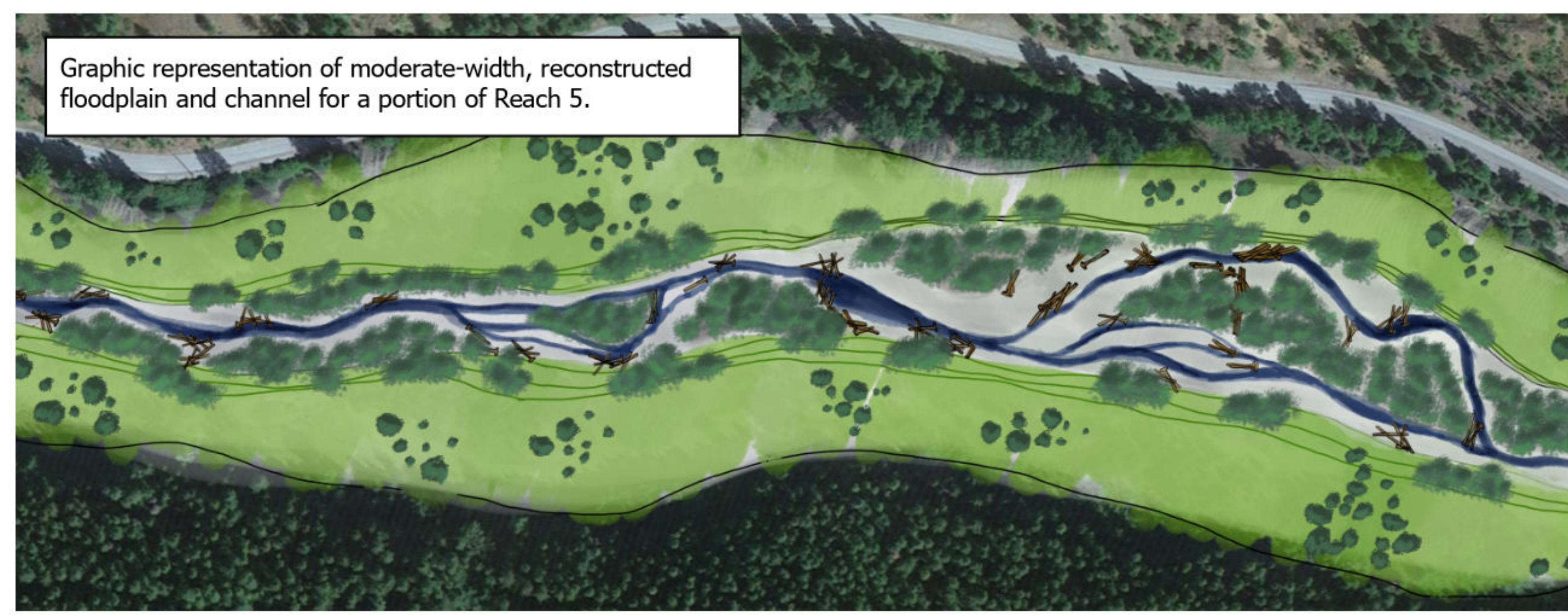


Proposed Conditions

Proposed alternatives for Reach 6 involve reconstructing the floodplain at an elevation at or closer to the low-flow groundwater elevation. The graphics below depict existing (left) and proposed (right) condition section views of a typical section of channel in reaches affected by the dredge. Under existing conditions, the reach is losing and flows subsurface during low-flow times of the year. Under proposed conditions, the river corridor is recreated at an elevation and slope that maintains year-round surface flows.







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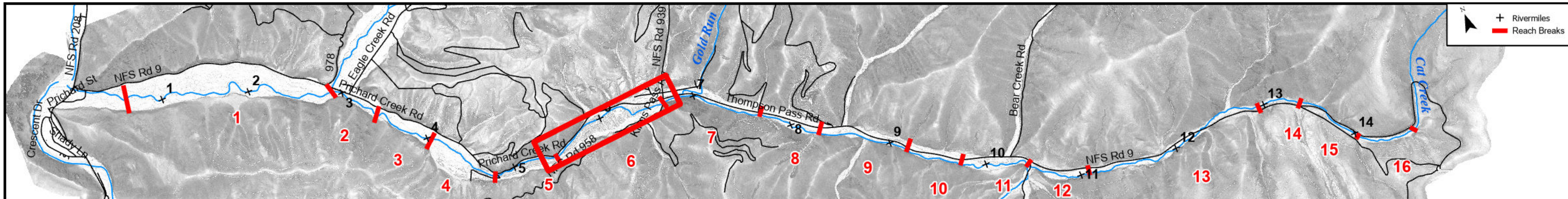
ReachBreaks	Roads	Remove Impediments / Reconstruct Floodplain	Off-Channel Habitat
River Miles	Parcels	Enhance Aquatic Habitat	Riparian Revegetation
NHD Flowline	IFG Parcels	Large Wood	Strategic Action

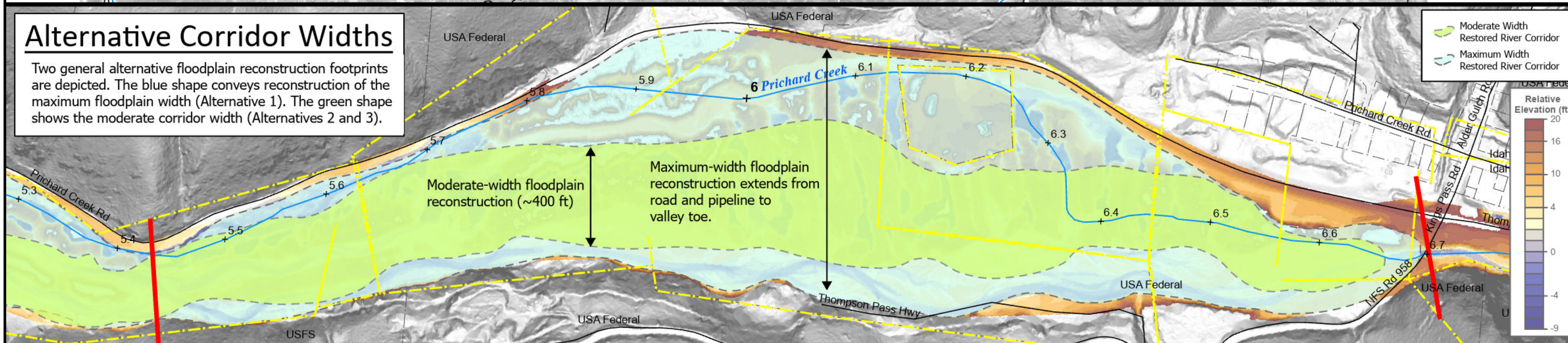
Prichard Creek Concepts

REACH 5



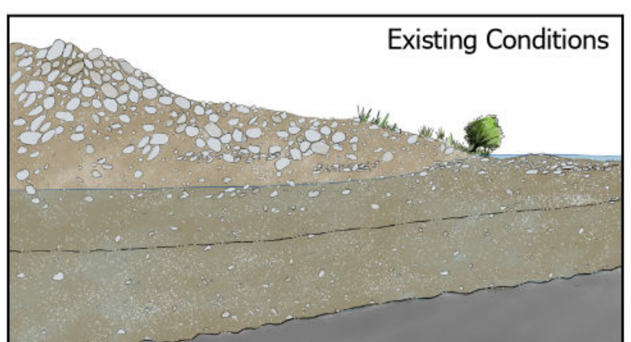
Alternative Corridor Widths

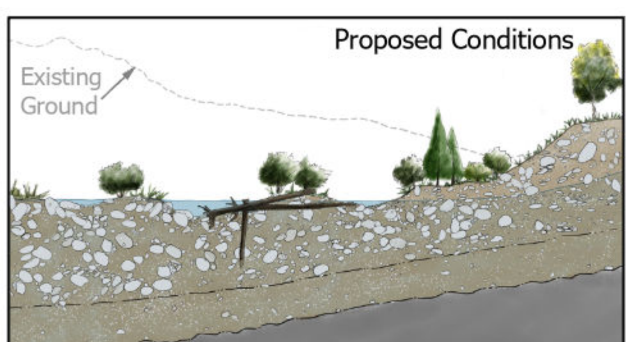
Two general alternative floodplain reconstruction footprints are depicted. The blue shape conveys reconstruction of the maximum floodplain width (Alternative 1). The green shape shows the moderate corridor width (Alternatives 2 and 3).



Proposed Conditions

Proposed alternatives for Reach 6 involve reconstructing the floodplain at an elevation at or closer to the low-flow groundwater elevation. The graphics below depict existing (left) and proposed (right) condition section views of a typical section of channel in reaches affected by the dredge. Under existing conditions, the reach is losing and flows subsurface during low-flow times of the year. Under proposed conditions, the river corridor is recreated at an elevation and slope that maintains year-round surface flows.





Graphic representation of moderate-width, reconstructed floodplain and channel for a portion of Reach 6.

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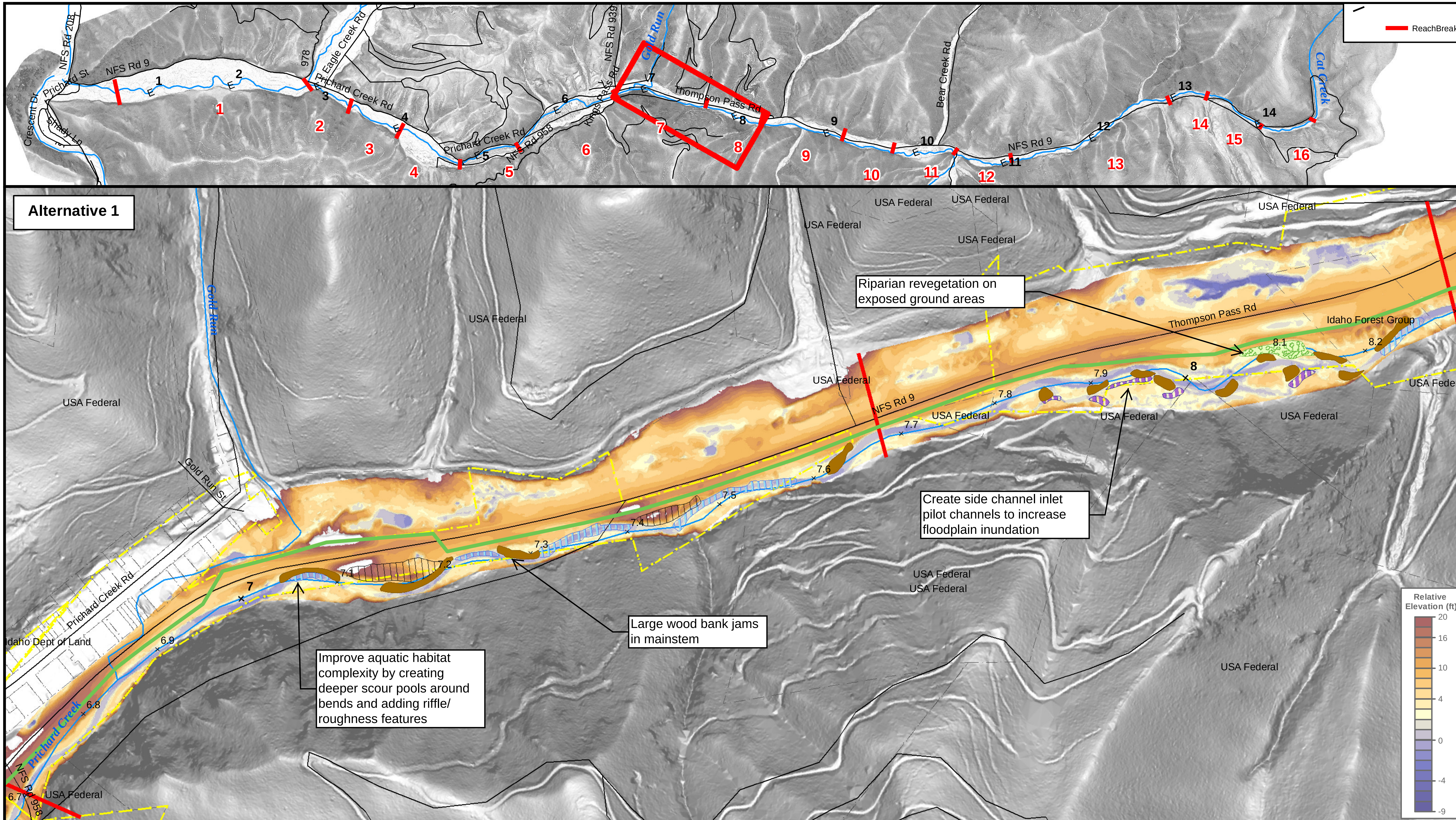
N
0 250 500 1,000 Feet

ReachBreaks
River Miles
NHD Flowline
Roads
Parcels
IFG Parcels
Remove Impediments / Reconstruct Floodplain
Enhance Aquatic Habitat
Large Wood
Off-Channel Habitat
Riparian Revegetation
Strategic Action

Prichard Creek Concepts

REACH 6



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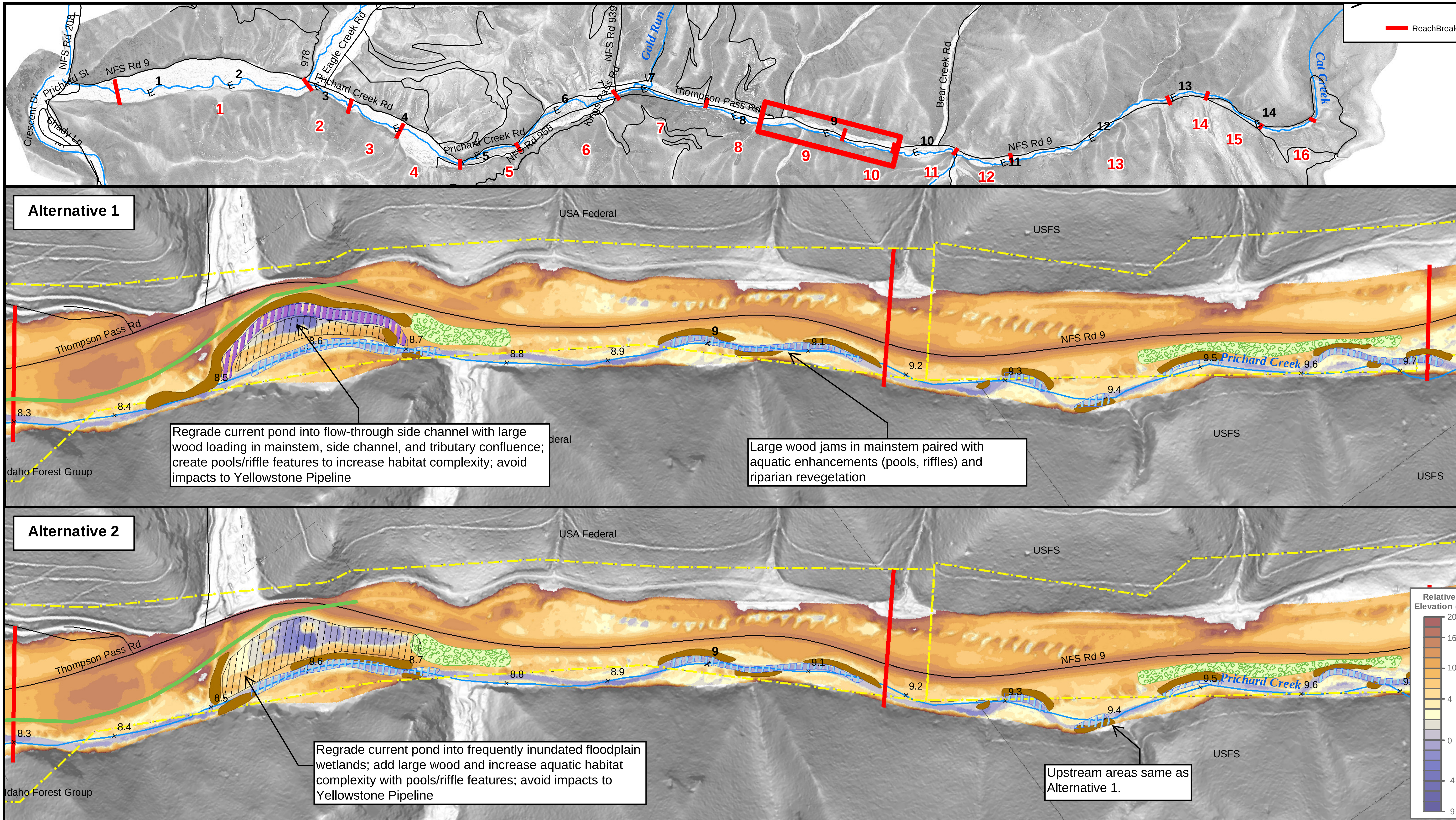
0 250 500 1,000 Feet

Legend	
E	River Miles
	ReachBreaks
	NHD Flowline
	Roads
	Yellowstone PL
	Parcels
	IFG Parcels
	Remove Impediments / Reconstruct Floodplain
	Enhance Aquatic Habitat
	Large Wood
	Off-Channel Habitat
	Riparian Revegetation
	Strategic Action

Prichard Creek Concepts

Reaches 7-8



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0 250 500 1,000 Feet

E	River Miles
	ReachBreaks
	NHD Flowline
	Roads
	Yellowstone PL
	Parcels
	IFG Parcels
	Remove Impediments / Reconstruct Floodplain
	Enhance Aquatic Habitat
	Large Wood
	Off-Channel Habitat
	Riparian Revegetation
	Strategic Action

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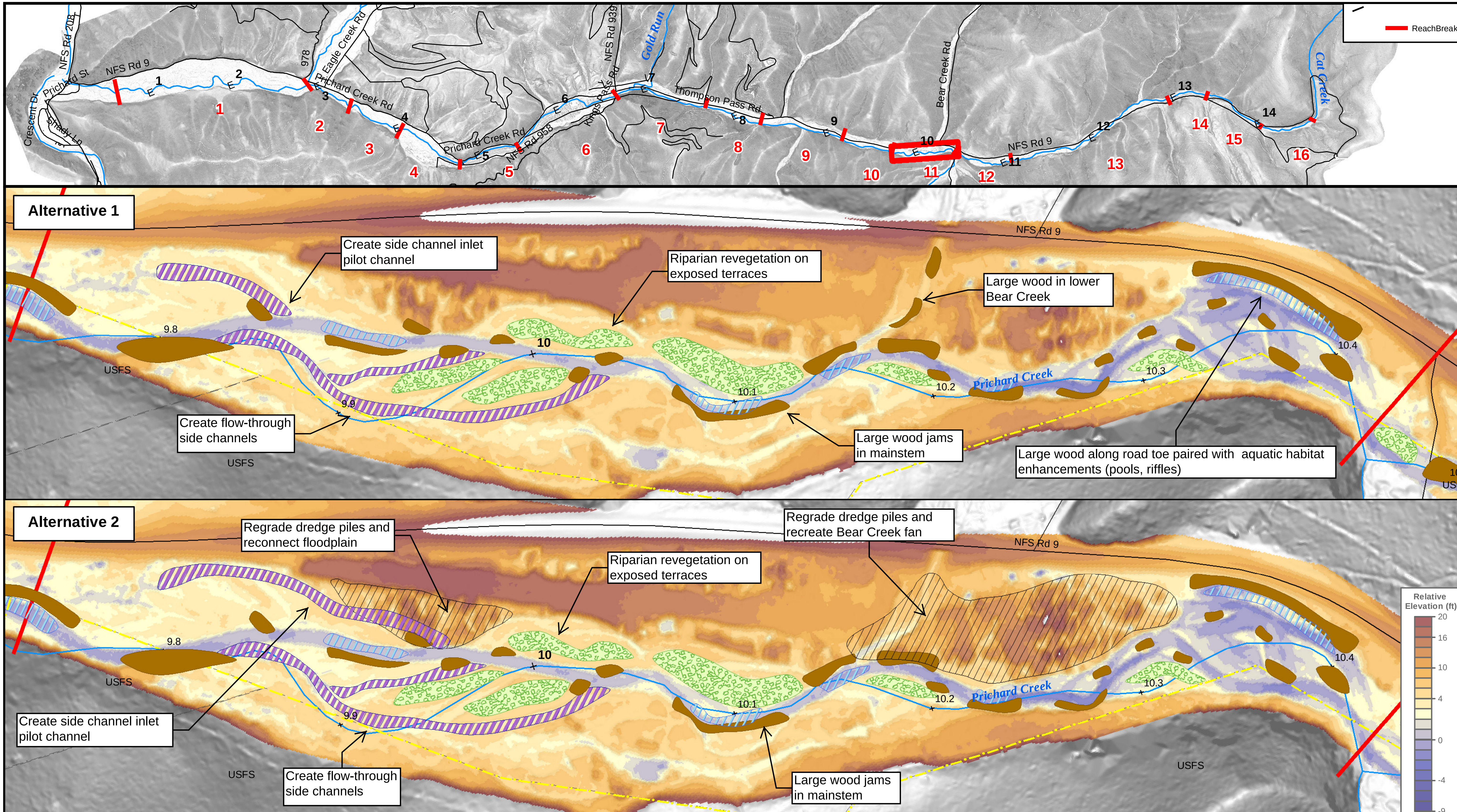
REACHES 9-10



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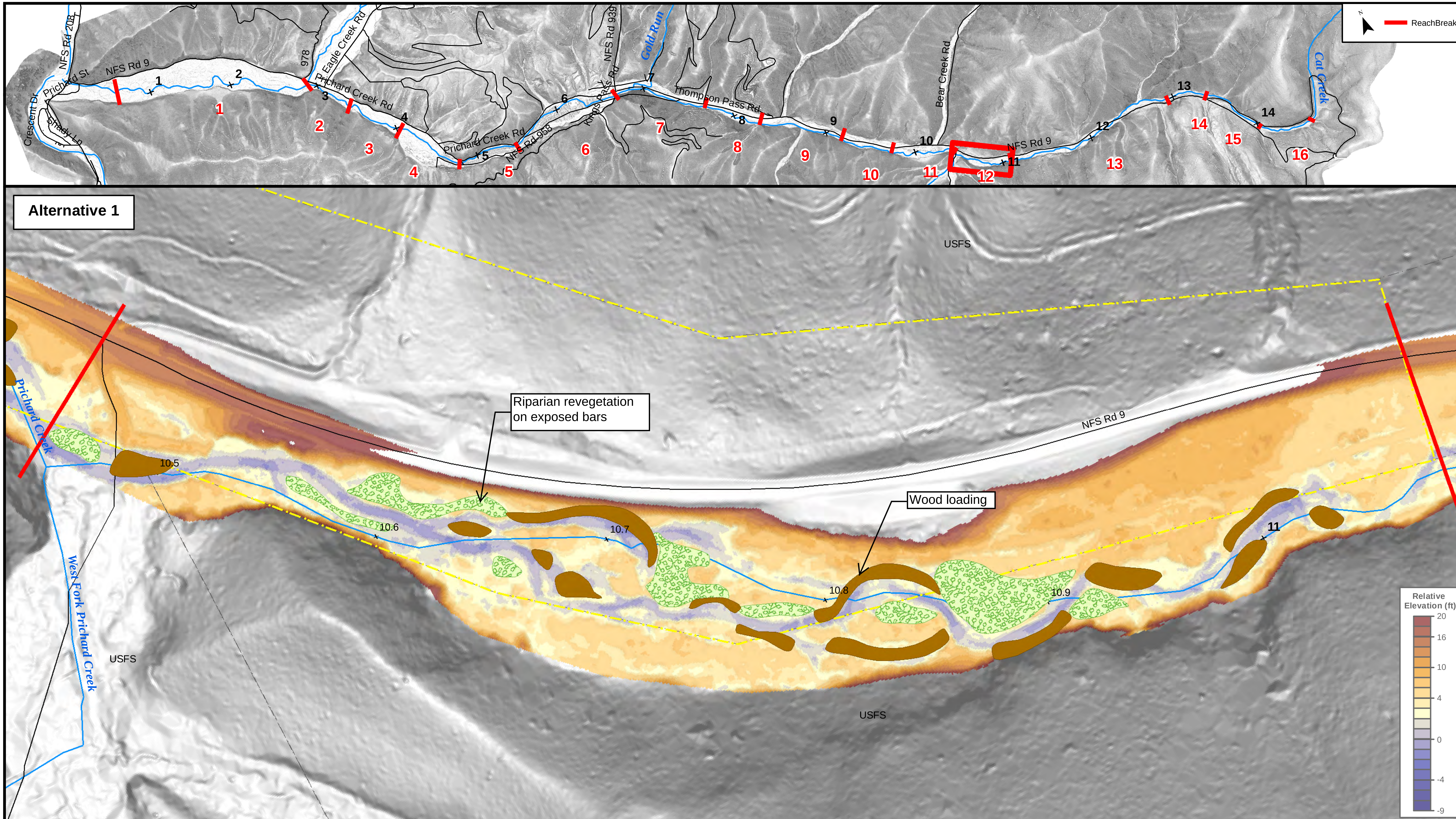
0 125 250 500 Feet

ReachBreaks
Roads
Remove impediments / Reconstruct Floodplain
Off-Channel Habitat
E River Miles
Parcels
Enhance Aquatic
Riparian Revegetation
NHD Flowline
IFG Parcels
Large Wood
Strategic Action

Prichard Creek Concepts

REACH 11



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N

0 125 250 500 Feet

ReachBreaks
River Miles
NHD Flowline
Roads
Parcels
IFG Parcels
Remove Impediments / Reconstruct Floodplain
Enhance Aquatic Habitat
Large Wood
Off-Channel Habitat
Riparian Revegetation
Strategic Action

Prichard Creek Concepts

REACH 12