Upper Methow River – Fawn Creek & Weeman Habitat Restoration

Concept Design Report

SUBMITTED TO
Yakama Nation Fisheries

JANUARY 27, 2017

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SUBMITTED TO
Yakama Nation Fisheries
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1. Project background

The Fawn Creek project area is located between Methow River Mile (RM) 62.5 and 64 on both private property and land owned by Washington Department of Fish and Wildlife (Figure 1). The Weeman project area is located between RM 60.6 and 61.8 mainly on private property with Washington Department of Transportation ownership along State Route 20 (Figure 2). These projects are being considered to address priority ecological concerns for ESA listed species in Upper Methow, including spring Chinook (*Oncorhynchus tshawytscha),* steelhead (*Oncorhynchus mykiss*), and bull trout (*Salvelinus confluentus*). These projects have been developed in accordance with the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007), the Revised Biological Strategy (RTT 2014), and Upper Methow Reach Assessment (Inter-Fluve Inc 2015).

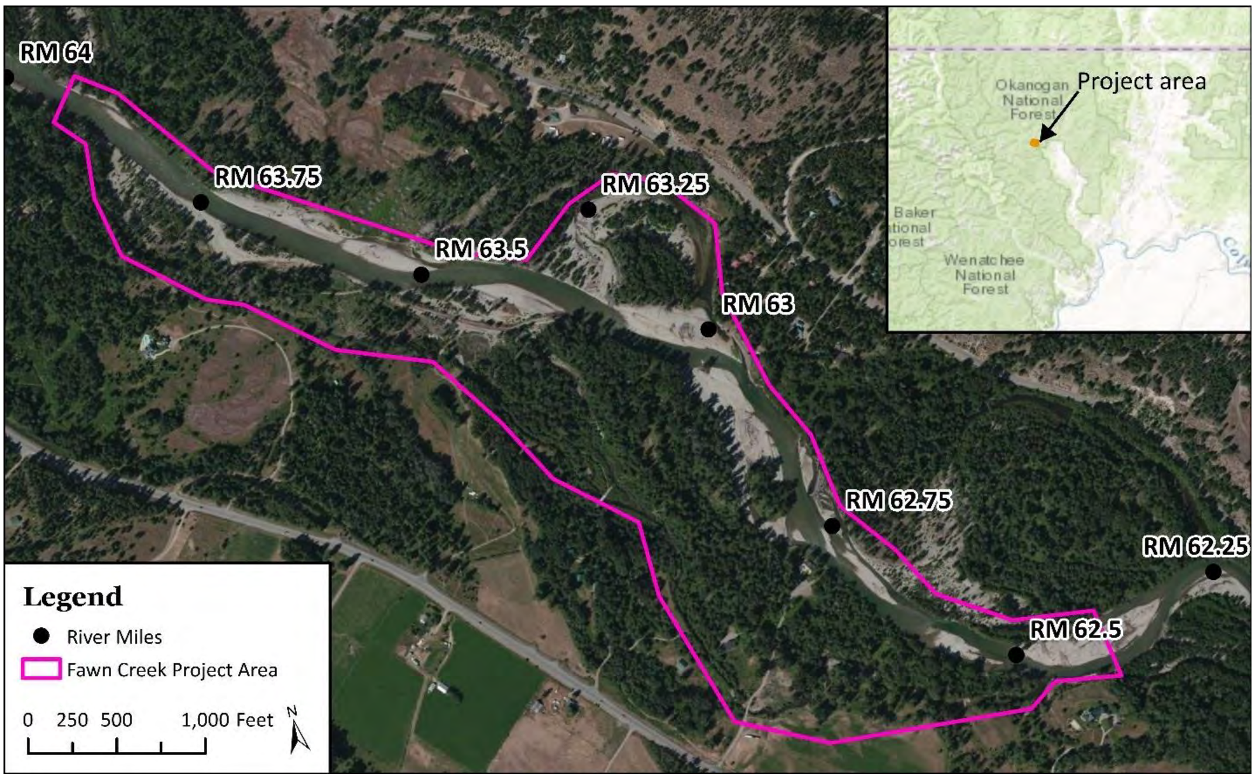


Figure 1. Overview of the Fawn Creek project area.

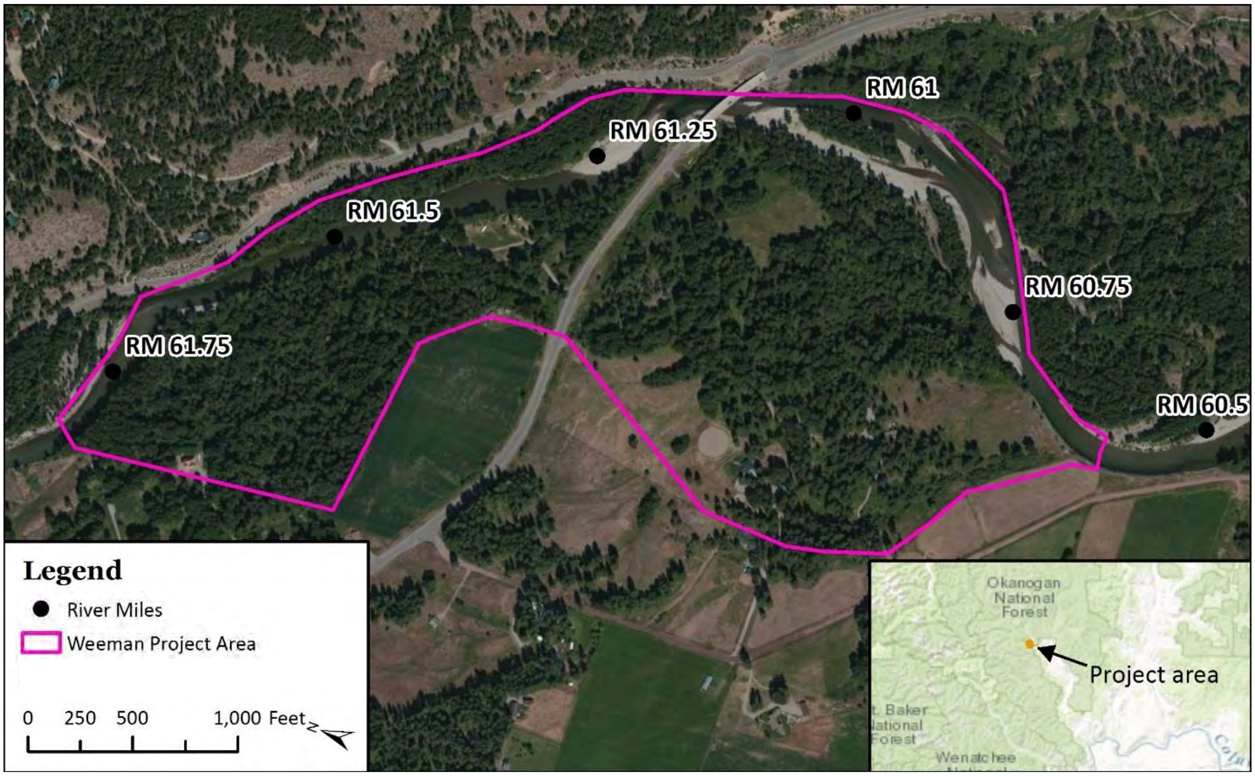


Figure 2. Overview of the Weeman project area.

Several watershed-scale studies have been conducted on the Methow River to identify and prioritize restoration opportunities. These assessments include the Methow Sub-basin Geomorphic Assessment (USBR 2008) and the Yakama Nation's Upper Methow Reach Assessment (Inter-Fluve Inc 2015). The Geomorphic Assessment provides a watershed and valley-scale context for primary controls on bio-physical processes to prioritize reaches for restoration. The Reach Assessment describes habitat conditions at the reach-scale and proposes restoration projects at distinct locations to address ecological concerns for salmon and steelhead. The findings of these studies along with regional salmon recovery objectives will guide the design of these projects.

1.1 REGIONAL GOALS AND OBJECTIVES

1.1.1 Regional Habitat Objectives and Priorities

Regional objectives for salmonid habitat protection and restoration in the Upper Columbia Region have been evaluated in the document *A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region* (2014) by the Upper Columbia Salmon Recovery Board (UCSRB) Regional Technical Team (RTT). This Biological Strategy is an appendix to the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007) that recommends region-wide biological considerations and approaches to salmonid habitat restoration and protection actions. The RTT guides the development and evaluation of salmonid recovery projects within the Upper Columbia Region.

The species of concern addressed in the Biological Strategy are those listed for federal protection under the ESA including spring Chinook salmon, steelhead, and bull trout. The Upper Methow Assessment Unit is a major spawning and rearing area for these species.

The Biological Strategy has identified several assessment units within the major watersheds of the Upper Columbia River. The Fawn Creek project area (RM 62.5 - 64) and Weeman project area (RM 60.6-61.8) fall within the Upper Methow Assessment Unit (RM 61 - 75), which has been characterized as a Tier 1 priority habitat for protection and the highest priority habitat for restoration compared to other assessment units within the Methow Basin based on existing conditions and future habitat potential.

The RTT has prioritized a list of restoration actions to address key ecological concerns impeding salmon recovery goals for the Upper Methow Assessment Unit. Ecological concerns and prioritized restoration actions relevant to the project areas include:

1. **Decreased water quantity**: Improve natural water storage by allowing off-channel connection, floodplain function, and beaver recolonization. Increase stream flow through irrigation practice improvements and water leases/purchases.
2. **Channel structure and form** (Bed and channel form): Remove levees, undersized bridges, bank armoring, and other human features.
3. **Peripheral and transitional habitat** (Side channel and wetland habitat conditions): Reconnect disconnected side channels and increase wood complexity therein.
4. **Channel structure and form** (Instream structural complexity): Install large wood to provide habitat benefit and intermediate-term channel form and function benefit. Improve LWD recruitment.
5. **Riparian Condition:** Improve riparian conditions in areas currently impaired by residential development or past logging practices.
6. **Food** (Altered primary production)
7. **Sediment conditions** (Increased sediment quantity): Restore sediment and LWD recruitment rates in riparian and upland areas.
8. **Species interactions** (Introduced competitors and predators): Reduce or eliminate brook trout in floodplain ponds and channels.
9. **Habitat quantity, anthropogenic barriers**

1.1.2 Upper Methow Reach Assessment and Restoration Strategy

The Upper Methow Reach Assessment and Restoration Strategy was conducted in 2014-2015 to evaluate aquatic habitat conditions and geomorphic processes, and identify habitat restoration strategies (Inter-Fluve Inc 2015). Restoration strategies were developed by comparing existing aquatic habitat conditions to target conditions obtained from reference areas and regional habitat thresholds. General restoration strategies included protection of quality habitat, restoration of riparian communities, reconnection of habitat, placement of structural habitat elements, and construction of off-channel habitat features. The Fawn Creek Project area represents the greatest restoration opportunity in the Upper Methow reach (Inter-fluve Inc 2015). The following restoration activities were recommended for the Fawn Creek project area:

- Reconnect existing side channel complex on river right (RM 62.45 – 64.0),
- Reconnect oxbow wetland habitat (RM 63.0),
- Enhance existing backwater habitat at outlet using large wood and pool excavation if an upstream connection is not feasible (RM 62.5),
- Install main channel log jams to enhance local complexity and cover (entire project area),
- Restore riparian conditions where there has been clearing.

The following restoration activities were recommended for the Weeman project area (note that the Reach Assessment did not include the Methow River downstream of Weeman bridge.

- Reconnect groundwater-fed wall-based alcove channel on river right (RM 61.75) and river left (RM 61.7),
- Place channel margin jams on right bank upstream of bridge (RM 61.25),
- Install main channel and margin wood jams to improve habitat and geomorphic conditions (entire project area),
- Riparian reforestation (entire project area).

1.2 PROJECT GOALS AND OBJECTIVES

Project goals and objectives were developed for consistency with the aforementioned guiding documents. Goals of these projects are to 1) improve in-stream and off channel habitat for juvenile steelhead, spring Chinook, and bull trout, 2) increase floodplain connectivity, and 3) promote natural geomorphic and habitat forming processes. Project objectives developed to meet these goals include:

- Reconnect and enhance existing side channel habitat,
- Protect intact floodplain and plant native species,
- Install large wood in the main channel and side channel,
- Design habitat structures that provide diverse juvenile rearing habitat for target species at a range of flow conditions.

This report describes existing site conditions and concept level restoration design elements for both the Fawn Creek and Weeman project areas.

2. Site Conditions and Baseline Analyses

2.1 SITE SURVEY AND DATA COLLECTION

2.1.1 Topographic Survey

Topographic and bathymetric data were collected for the project areas in July 2016 using rtk GPS and total station survey equipment, while previously collected survey for the Weeman project area was also used. These data were collected to support hydraulic modeling and concept development. Data collection focused on the main channel, active floodplain surfaces, disconnected side channels, and additional cross sections in upland areas to check LiDAR data. Existing LiDAR (collected July 1, 2015) was used for floodplain areas where restoration treatments are not likely to occur (Quantum Spatial 2015). Control points for the survey were established in the floodplain and upland area on river right using rebar and wooden stakes.

Static data were collected at the rtkGPS base unit to adjust our survey data using the National Geodetic Survey's (NGS) Online Positioning User Service (OPUS, http://www.ngs.noaa.gov/OPUS/). These data were based on the Washington State Plane North coordinate system with the North American Vertical Datum of 1988.

LiDAR data collected in 2015 was then compared to our survey data. The median difference between LiDAR and survey data was approximately 0.2 feet, with minimum and maximum differences between the two datasets of -15.7 and 16.1 feet, respectively. A majority of the point differences were within ±1.5 feet, with very few outliers having differences greater than ±5 feet.

The largest outliers tended to be located on the edge of the Methow River channel where recent bank erosion might explain the difference since the LiDAR flight. Discrepancies closer to several feet tended to be located within densely vegetated floodplain surfaces. The smallest discrepancies between the 2015 LiDAR and surveyed points typically occurred in open areas where vegetation was unlikely to interfere.

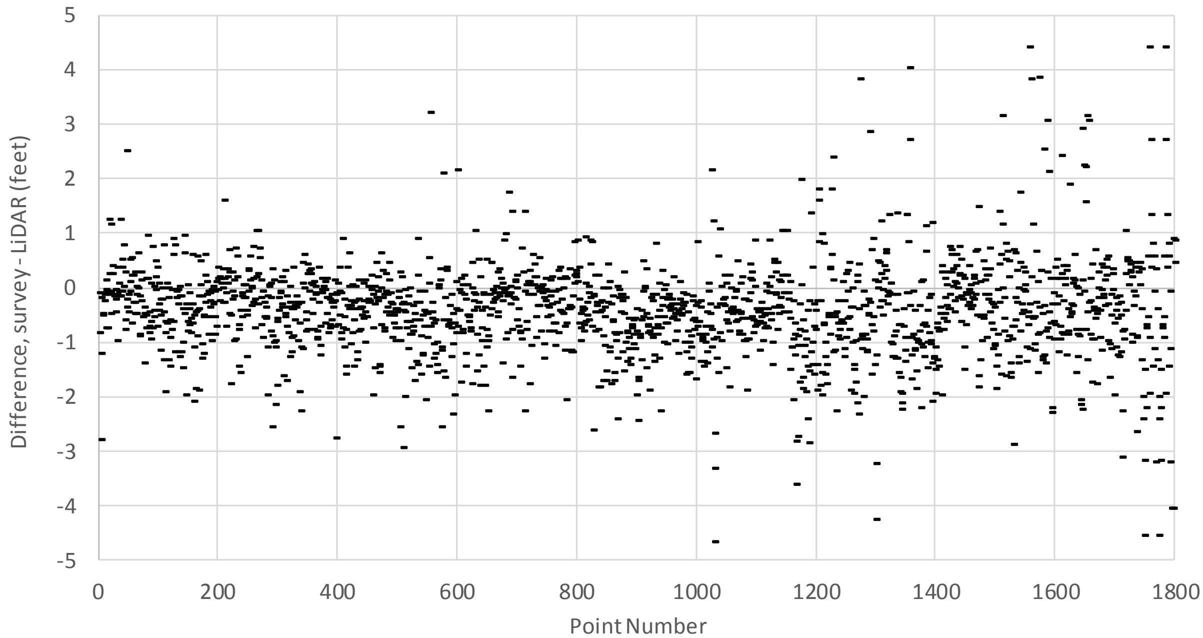


Figure 3. Comparison of survey points collected by Inter-Fluve using rtkGPS and TotalStation in August 2016 to LiDAR collected in 2015 by Quantum Spatial.

2.1.2 Hydrologic investigation

Groundwater and surface water dynamics at the Fawn Creek project site are being investigated using HOBO U-20 and U-22 pressure data loggers installed at several locations throughout the site (Figure 4). An atmospheric pressure sensor is maintained by Yakama Nation at the Fender Mill project area downstream near RM 60.5 and is used to correct the data for barometric pressure. The Hobo data loggers were installed on August 31, 2016 and were set to collect pressure and temperature every 15 minutes. On October 27, 2016 the data were downloaded and the loggers where reinstalled. Water surface elevation was calculated using the surveyed sensor elevation and pressure readings calibrated with the atmospheric pressure data. The water surface elevation (WSE) and temperature for each of the loggers, along with stream discharge from the upstream USGS gage (Methow River above Goat Creek #12447383), are shown in Figure 5 and Figure 6.

The water surface elevation data for the period of record shows limited variability corresponding to the minor change in river discharge. Although all locations show some water surface elevation correlation with river discharge, the two main channel locations show the most direct correlation, while the side channel and upper pond locations have a more muted response to changes in discharge. The data logger water surface elevation data were used to help validate the project site hydraulic model at low flows, see Section 2.6.

The temperature data for the period of record show typical diurnal fluctuations and a seasonal cooling trend from the later summer into the fall. Along with the cooling trend the magnitude of diurnal fluctuations decreases, especially from early October on. The seasonal cooling trend is related to both lower air temperatures and also increases in river discharge caused by fall rain events in the watershed. In general, all 4 locations track together and have relatively similar daily high and low temperatures. One notable exception is the higher temperatures in the Upper Off Channel Pond in early September. Given the surface water isolation of the pond in the late summer and high daytime air temperatures, these higher water temperatures are not unexpected. The Side Channel water temperature tracks with the main channel temperatures through September indicating a good groundwater connection with the main channel. In October, the side channel temperature is greater than the main channel and lags behind the main channel – a reflection of the side channel temperature being buffered by the thermal capacity of the ground between the main and side channels.

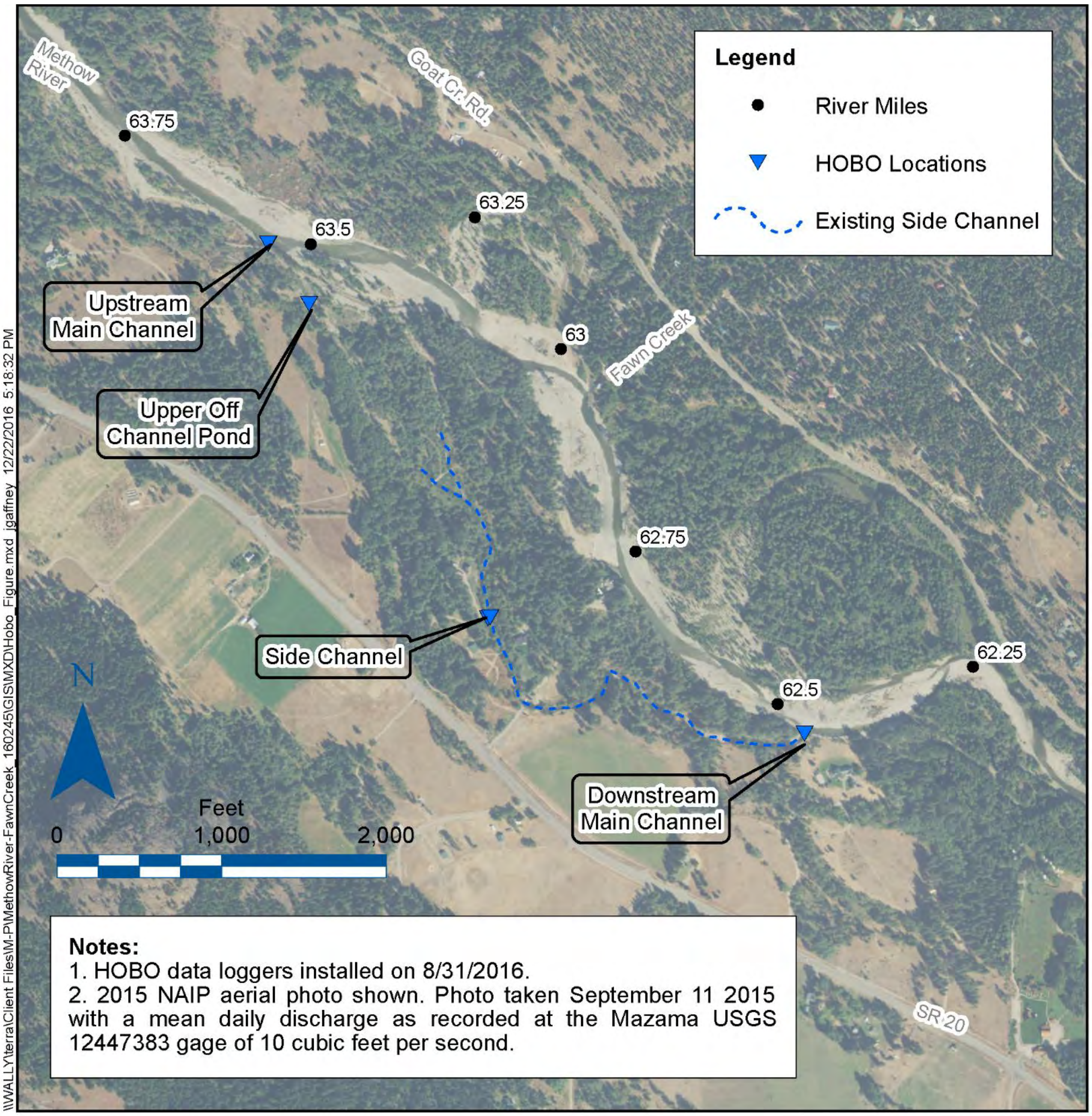


Figure 4. Location of water monitoring stations. Atmospheric pressure sensor is located at RM 60.5 and is maintained by Yakama Nation.

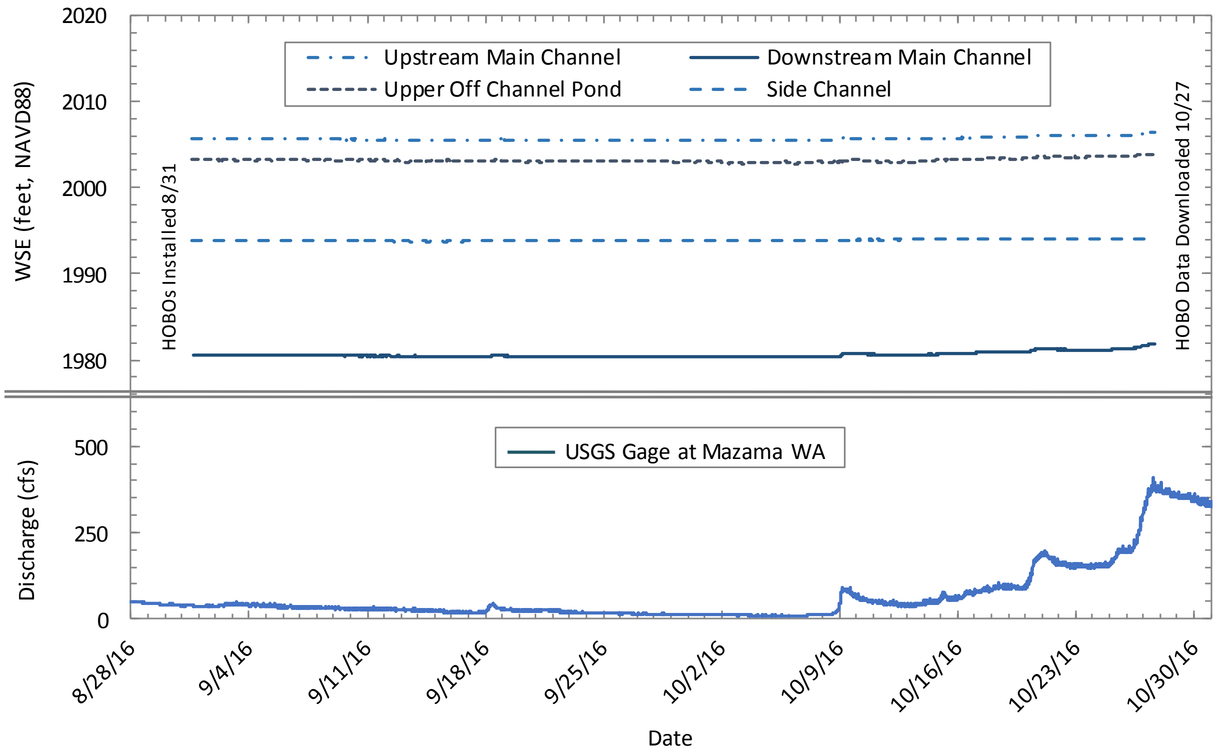


Figure 5. HOBO water surface elevation data and river gage discharge in cubic feet per second (cfs)

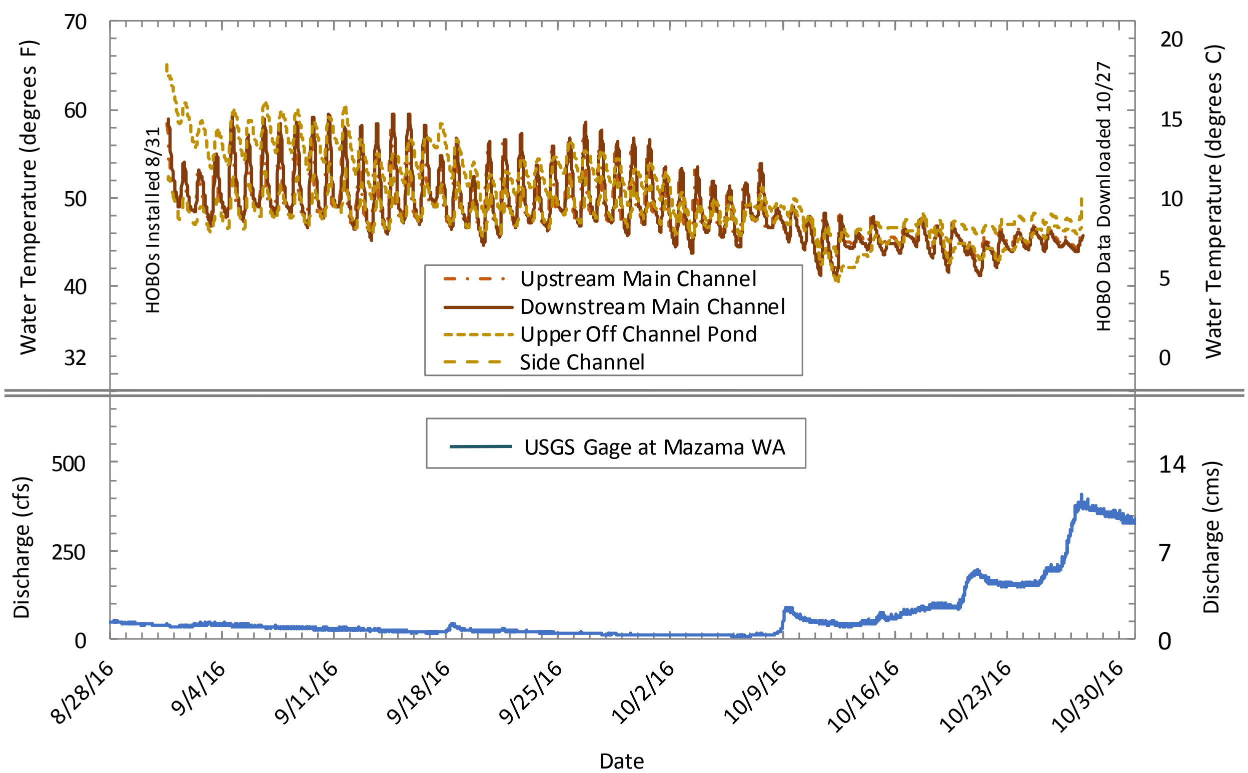


Figure 6. HOBO temperature data and river gage discharge in cubic feet per second (cfs) and cubic meters per second (cms).

2.2 GEOMORPHIC SETTING AND HISTORICAL TRENDS

2.2.1 Geomorphic setting

A comprehensive review of the geology and geomorphology of the Fawn Creek and Weeman project areas can be found in the Upper Methow Reach Assessment (Inter-Fluve Inc 2015) and the Methow Subbasin Geomorphic Assessment (USBR 2008). The following is a summary of the key elements.

In general, both project areas are located within a wide, U-shaped valley most recently carved by Quaternary glaciation. Steep, resistant valley walls framing the modern Methow Valley are primarily composed of extrusive volcanics that are approximately 90 million years old. Lateral mobility of the channel within the Methow Valley is limited by the presence of large alluvial fans at valley wall toes and tributary mouths.

Current channel and valley form was created through consecutive glaciation cycles, the last of which occurred as recently as 9,500 years ago (USBR 2008). The modern valley floor is characterized by a thick layer of glacial outwash deposits, resulting from increased flow and sediment supply regimes during early Holocene glacial retreat. The depth of outwash deposits ranges from 200 to 1,000 feet in this section of the Methow Valley (Konrad 2006). The Methow River naturally incised into these deposits during the late Pleistocene and Holocene. As glaciers retreated, water and sediment inputs were reduced and the channel incised into valley fill. This left behind abandoned alluvial terraces above the present channel, which historically would have been active floodplains.

The Methow Valley is home to a thriving population of beavers that continue to influence geomorphic process. Beaver dams exist in many of the oxbows, side channels and tributaries within the project reach. Beaver activity is generally viewed to be complimentary to fish habitat with many desirable geomorphic impacts. However, beaver dams can also change flow paths and floodplain inundation patterns. Therefore, the potential for beaver activity to alter a project’s function over time was considered when evaluating alternatives.

Fawn Creek

At the project site, the mouths of Little Boulder Creek and Fawn Creek contain alluvial fans that impinge on the ability of the channel to migrate laterally. Smaller talus and debris fan deposits exist elsewhere along the margin of the valley floor, but do not directly impact lateral migration or sediment supply at the project site. A series of large levees from RM 63.7 to 63.25 confine the channel on river-right and disconnect side-channels located behind them.

The channel at the Fawn Creek project site is less sinuous (1.1) than upstream reaches, featuring elongated side-channel and mid-channel bars. Local substrate is primarily composed of coarse gravels and cobbles. Channel gradient is approximately 0.5% (Inter-Fluve Inc 2015). The upstream section, from approximately RM 64.0 to 63.0, is straight and largely composed of plane-bed riffles and glides, with occasional pools associated with log jams. Bank-attached and side-channel bars dominate this section. An avulsion near RM 63.0 further straightened this portion of the project site. From RM 63.0 to 62.5, the channel is more sinuous, complex, and features mid-channel bars in addition to those in side channels or attached to the bank. Fawn Creek represents the only significant tributary input to the main channel within the project reach, though Little Boulder

Creek's contribution to subsurface flow likely influences the upstream end of the project reach (Inter-Fluve Inc 2015).

Weeman

Within the Weeman project area, the channel and modern alluvial surfaces consist of a narrow active floodplain on river left, confined by three small alluvial fans and glacial terraces. River right contains a broad active floodplain, disconnected floodplain surfaces, and a high floodplain surface. Floodplain surfaces on river right are partially disconnected as a result of levees and riprapped banks near RM 61.75 and 61.35. The construction of Highway 20 and Weeman Bridge constricted the floodplain migration zone at the crossing by approximately 1,000 feet, to the current width of the channel (115 feet). Today the channel remains laterally constricted between bridge abutments and high, riprapped banks (approximately 15+ feet high) constructed of large, angular boulders. Upstream from Weeman Bridge, the channel is partially constricted on the east side of the valley (between RM 61.1 to 61.7) by glacial outwash terraces and alluvial debris fans flanking the valley walls. Bank hardening by the Goat Creek Road embankment increases the stability of the terrace banks, further confining the channel within the project area on river left. The result of this unnatural confinement may be instigating incision processes such as bed scour during high-energy flow periods, decreasing the frequency of floodplain inundation. However, pulses of incoming bedload inputs from upstream appear to partially off-set bed incision enough to support the floodplain surfaces on river right and develop elongated channel bars that become visible during low-flow periods.

At the Weeman project site, the channel also has a lower sinuosity (1.01) compared to upstream portions of the Methow River. The relatively straight, single-thread channel consists of extended riffle and glide habitat units, with a single, deep pool present where Weeman Bridge crosses the channel. Local substrate is primarily composed of coarse gravels and cobbles, with accumulated fine sediments on the floodplain surfaces transported during high flow events. There is little to no large wood remaining in the channel within the Weeman project area, though there is potential for recruitment of large trees (50+ ft tall) from the floodplain surfaces. There are no significant tributaries or off-channel habitat units within the Weeman project area.

2.2.2 Historical land use and constructed features – Fawn Creek

The Fawn Creek project area was historically used for agriculture and mining. Early settlers filed water right claims for their homesteads in the late 1800's and early 1900's, and managed several diversions (overflow inlet, middle inlet, and lower inlet) that diverted water from the Methow River into the Sloan-Wickert Slough. This slough and the associated Kumm-Hollaway and McKinney Mountain ditches were the primary source of water for nearby irrigators (Whittaker 2003)[1]. Water and flood control efforts have been going on since the early 1900's and have included the use of riprap, levees, check dams, ditches, and culverts which have all had an impact on channel morphology and fish habitat in the area (Figure 7).

[1] *The Whittaker (2003) document is a historical account of the McKinney Mountain regional irrigation system compiled by Lee Whittaker, a citizen-scientists and resident of the Methow Valley.*

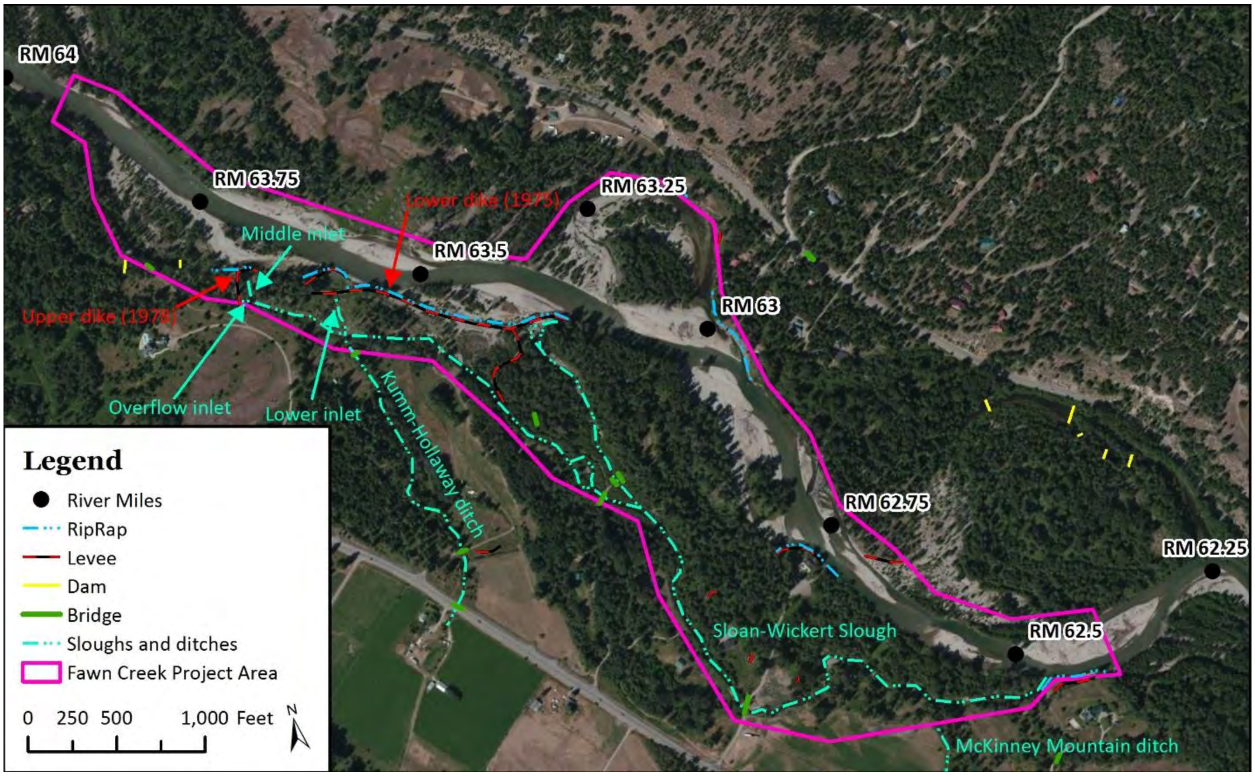


Figure 7. Built and natural features within the project area vicinity (Inter-fluve Inc 2015). Aerial image is from 2016 courtesy of Microsoft Bing.

A series of historical aerial photos is presented below in Figure 8 through Figure 12. The earliest photos from 1945 (Figure 8) are not early enough to show conditions prior to human disturbance: agricultural and residential uses in the project area are present at this time. The irrigation inlets (overflow, middle, and lower inlets) were active at this time and diverted Methow flows into the Sloan-Wickert Slough. The lower inlet was the primary inlet, and had a wing dam and diversion gate made of logs and planks to control water flow into the slough (Whittaker 2003).

The main channel widened considerably between 1945 and 1948 (Figure 8). Channel widening and bar expansion is visible from RM 63.75 to 63.5 and resulted from the large 1948 flood. The main channel also migrated to the north and disconnected from the lower inlet during baseflow. The middle inlet became the primary diversion into the Sloan-Wickert Slough following the 1948 flood (Whittaker 2003).

Further avulsions are evident within the active channel between 1954 and 1964, including a minor cutoff near RM 63.5 (Figure 9). This suggests that the channel was free to laterally migrate within the historical floodplain. Land-use changes in 1954 and 1964 were minor, as the bulk of clearing and land development had already occurred by this time.

The middle inlet was seasonally diked to prevent flooding in the 1950's-1960's. Heavy equipment was used in the Methow River channel and slough to remove the dike and clean the Sloan-Wickert Slough after spring runoff (Whittaker 2003).

Floods in the 1970's cause damage to roadways and pasture land, prompting landowners and the state to pursue levee construction. Flooding in 1970 caused a large log jam to form which diverted the Methow into the Sloan-Wickert Slough, causing erosion and soil loss. A large double flood in 1972 caused dike failure at the middle inlet, and flood waters washed out portions of the nearly complete North Cascades Pass highway. A major avulsion near RM 62.5 occurred by 1974 which stranded the previous main channel as an abandoned oxbow (Figure 10). Smaller avulsions within the active channel had also occurred between RM 64 and 63.25.

In 1975 and 1978, two levee projects were undertaken by the state and private landowners to control flood damage. The lower levee was constructed in 1975 from 800 CY of heavy loose riprap. The upper levee was constructed in 1978 from 143 CY of dike fill and 91 CY of riprap after the lower levee was deemed in danger of being bypassed at the middle inlet upstream. Two 24" culverts were installed in the upper levee to provide year-round connectivity to the Methow River. These culverts proved to be inadequately sized and resulted in reduced flows in the slough. Further flooding prompted repairs to both levees in 1983 and 1987 (Whittaker 2003). These levees had a large impact on geomorphology of the project area, which had previously been highly dynamic.

Another major avulsion occurred between 1998 and 2003 near the lower levee at RM 63.25 (Figure 10). The avulsion and associated downcutting propagated upstream to RM 63.75, cutting off a side channel immediately downstream near RM 63.7. The primary changes between 2006 and 2016 have been continued vegetation growth and a slight increase in main channel sinuosity, as small meanders formed in the sections straightened by prior avulsions. The levee system is currently used as a community biking and hiking path.

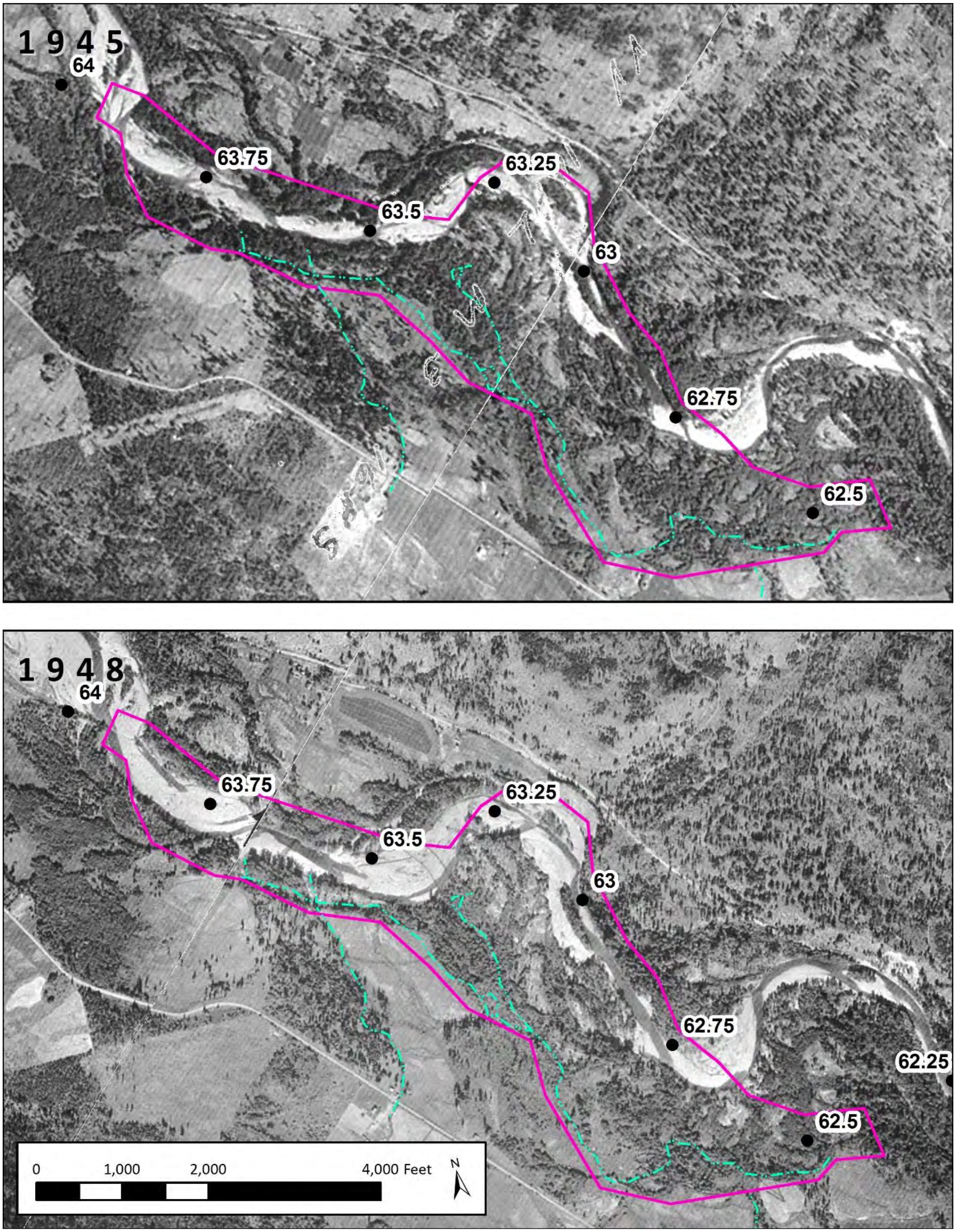


Figure 8. Aerial imagery from 1945 and 1948 of the Fawn Creek project area. Sloan-Wickert Slough and ditches shown in cyan. Images courtesy of USGS Earth Explorer.

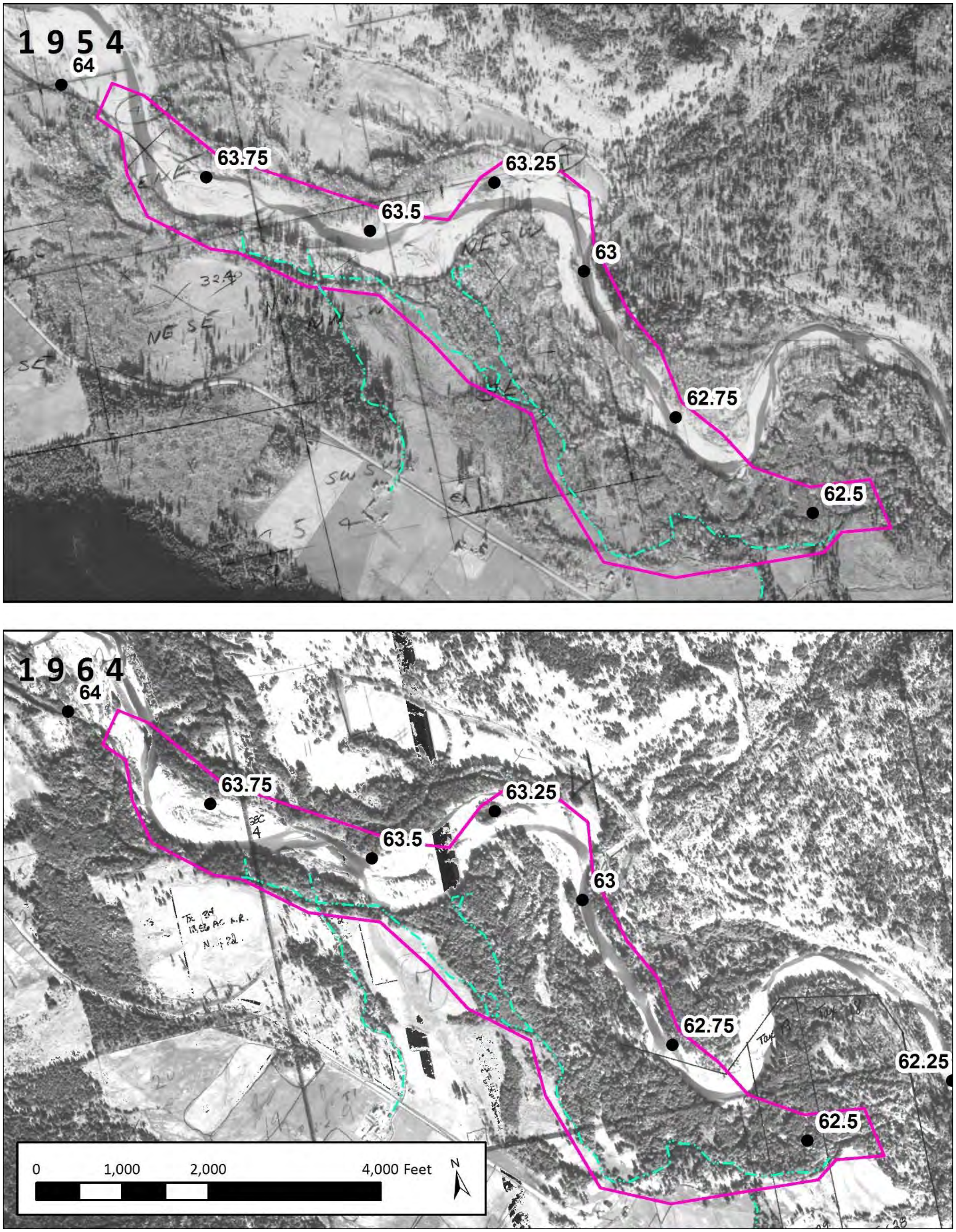


Figure 9. Aerial imagery from 1954 and 1964 of the Fawn Creek project area. Sloan-Wickert Slough and ditches shown in cyan. Images courtesy of USGS Earth Explorer.

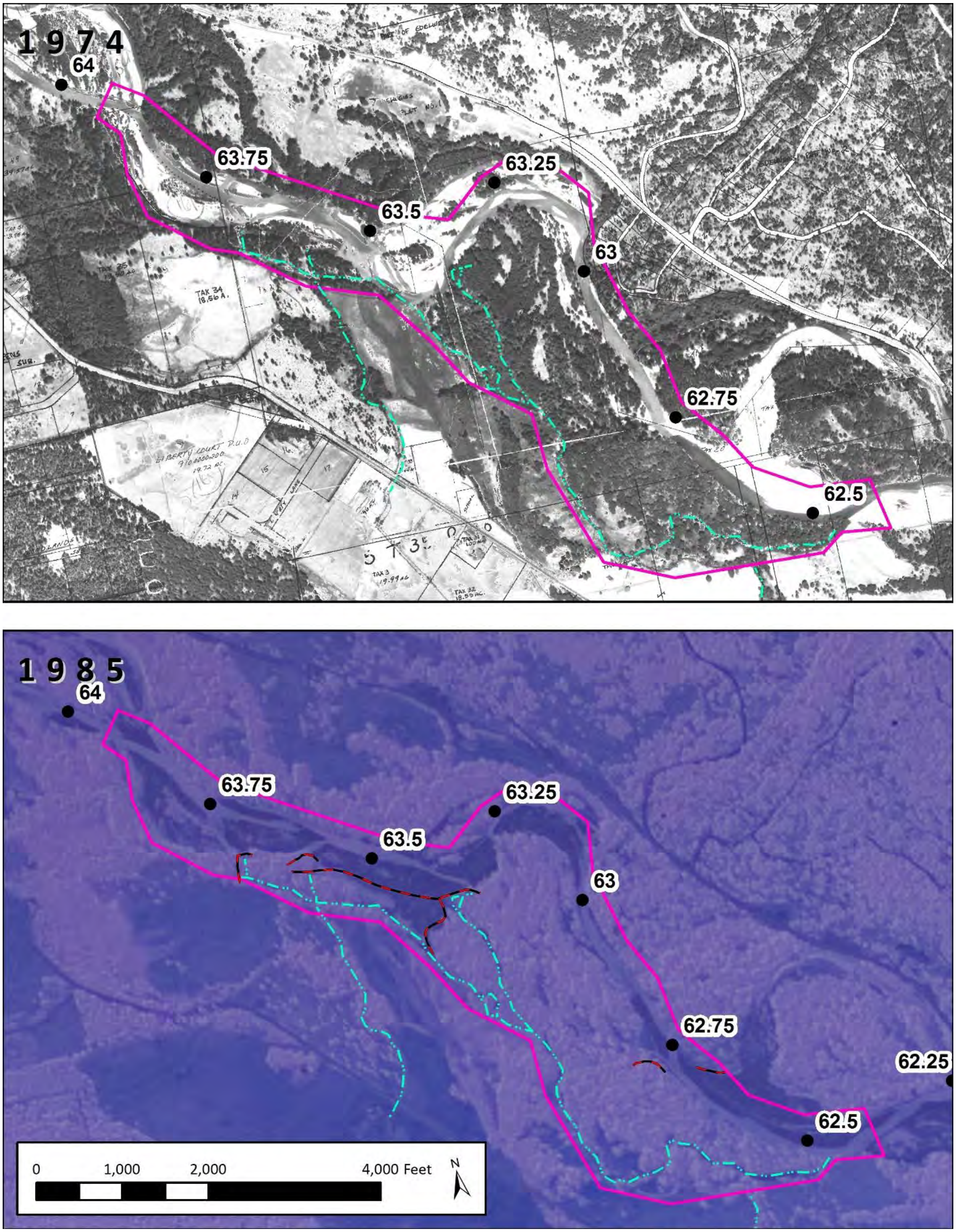


Figure 10. Aerial imagery from 1974 and 1985 of the Fawn Creek project area. Sloan-Wickert Slough and ditches shown in cyan, levees shown in red/black. Images courtesy of USGS Earth Explorer.

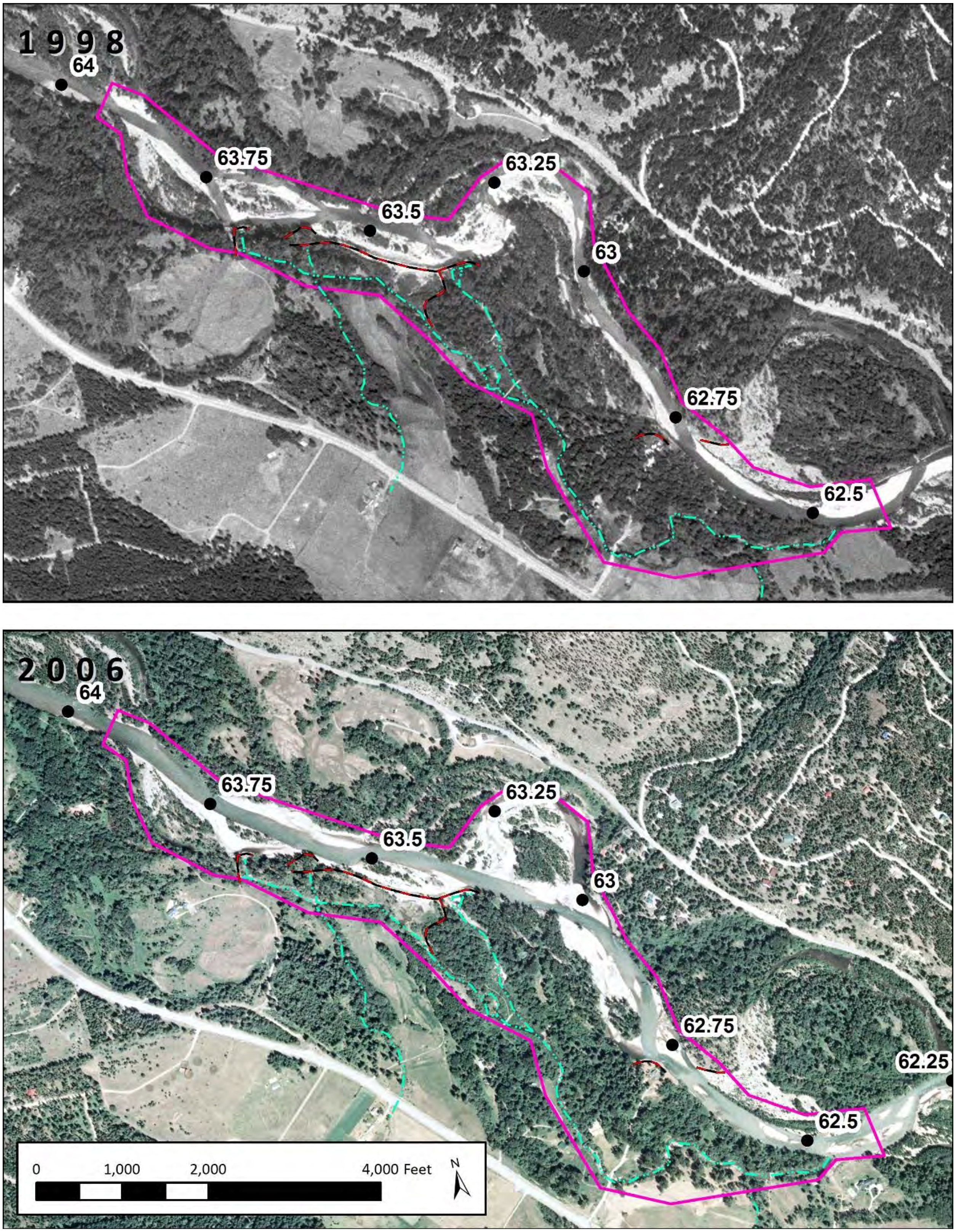


Figure 11. Aerial imagery from 1998 and 2006 of the Fawn Creek project area. Sloan-Wickert Slough and ditches shown in cyan, levees shown in red/black. Images courtesy of USGS Earth Explorer.

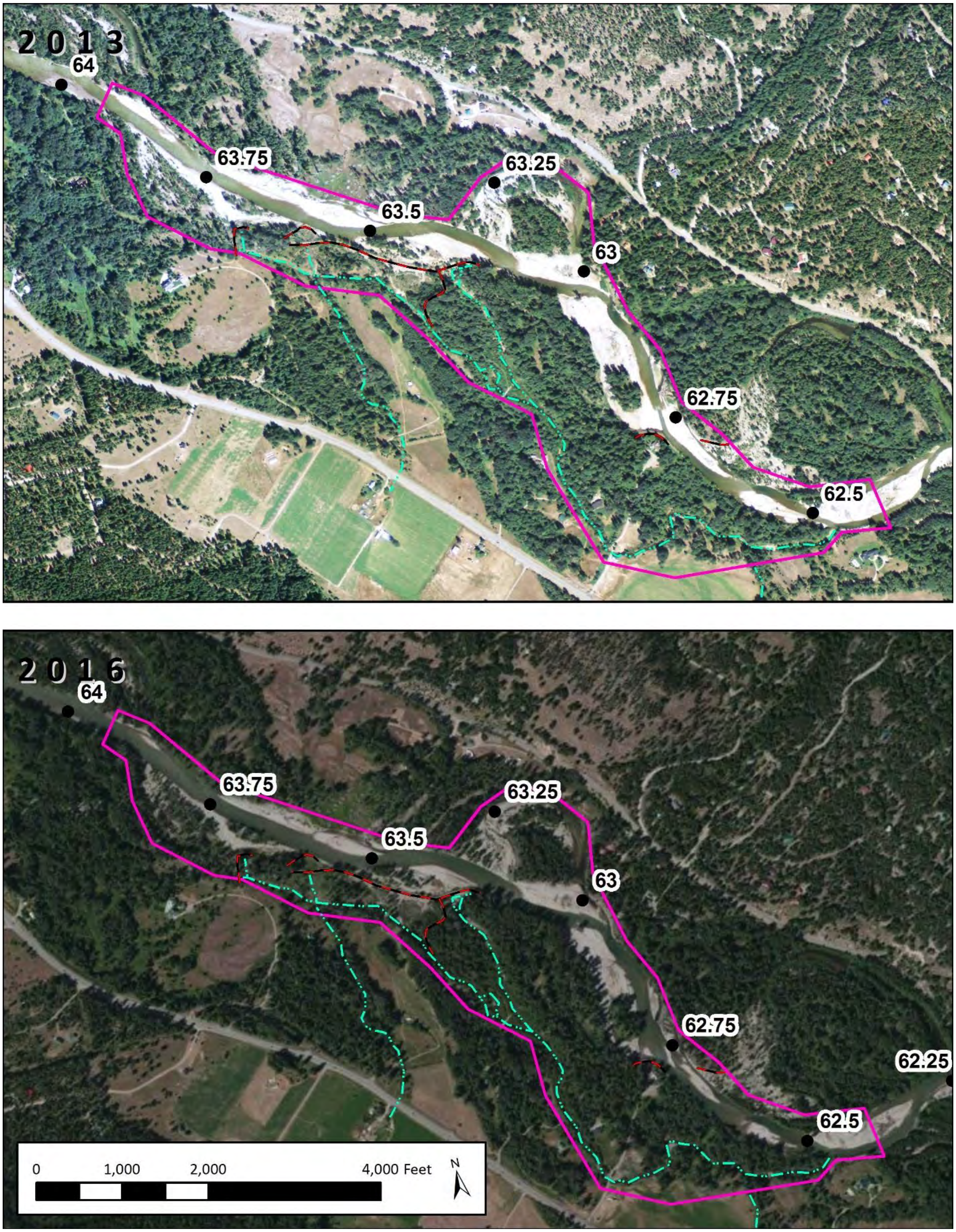


Figure 12. Aerial imagery from 2013 and 2016 of the Fawn Creek project area. Sloan-Wickert Slough and ditches shown in cyan, levees shown in red/black. Imagery courtesy of USGS Earth Explorer and Microsoft Bing.

2.2.3 Historical land use and constructed features – Weeman

The Weeman project area was historically used for agriculture, residential development, and log drives. The main impairments in the project area are the Weeman Bridge, Highway 20, and riprap installations. These impairments halted channel migration at the bridge, upstream of the bridge, and at the upstream and downstream ends of the project area. The bridge constricts the channel in the middle of the project area and has disconnected the historical floodplain approximately 1,000 and 2,000 feet upstream and downstream of the bridge, respectively. A number of small culverts (12- to 18-inch diameter corrugated metal piles) pass under Highway 20 west of the Weeman Bridge. These culverts route road side ditch flow and some floodplain flow down valley.

A series of historical aerial photos is presented below in Figure 13 through Figure 17. The earliest photos from 1945 (Figure 13) are not early enough to show conditions prior to human disturbance: the floodplain has been cleared in several areas and a bridge over the Methow River is in place. The river right floodplain at RM 61.25 is unvegetated and wet, suggesting it was connected to the Methow or had just recently become disconnected. The main channel appears to be straightened and incised upstream of the bridge.

The main channel widened considerably between 1945 and 1948 (Figure 13 and Figure 8). Channel widening is visible from RM 61.25 to 61.5, and downstream of the bridge from the large 1948 flood. The main channel also migrated to the south between RM 60.75 and 61.0. Southerly channel migration also occurred upstream of the project area (left edge of image). By 1948, a new bridge had been constructed over the Methow River and more riparian clearing had taken place since 1945.

The 1954 image shows some channel widening and floodplain inundation through the left floodplain at RM 60.75. A drainage ditch is visible on river right near RM 60.7 and may have been dug to drain the floodplain. Revegetation of exposed bar surfaces occurred between 1954 and 1964 (Figure 14). The channel upstream of the project area continued migrating south towards RM 61.75. The channel at the downstream end of the project area had migrated to the west.

Channel migration at RM 61.75 occurs up to the 1974 image, after which channel migration stops after the installation of a pushup levee and riprap (Figure 15). This feature severely limited connectivity to the river right floodplain. The main channel also migrated to the south between RM 60.75 and 61.0. West channel migration at the downstream end of the project area (downstream of RM 60.75) appears to have been halted in 1974 presumably through riprap installation to protect the road. Riparian vegetation has grown in on the floodplain and exposed bar surfaces.

Channel conditions in 1998 and 2006 show bar formation between RM 60.75 and 61.0 (Figure 16). During this time, further vegetation growth occurred in the floodplain and riparian areas.

Channel migration between RM 60.75 and 61 continued between 2013 and 2015 (Figure 17). Channel migration in this area was constrained by the bridge upstream and the river right riprap at the downstream end of the project area.

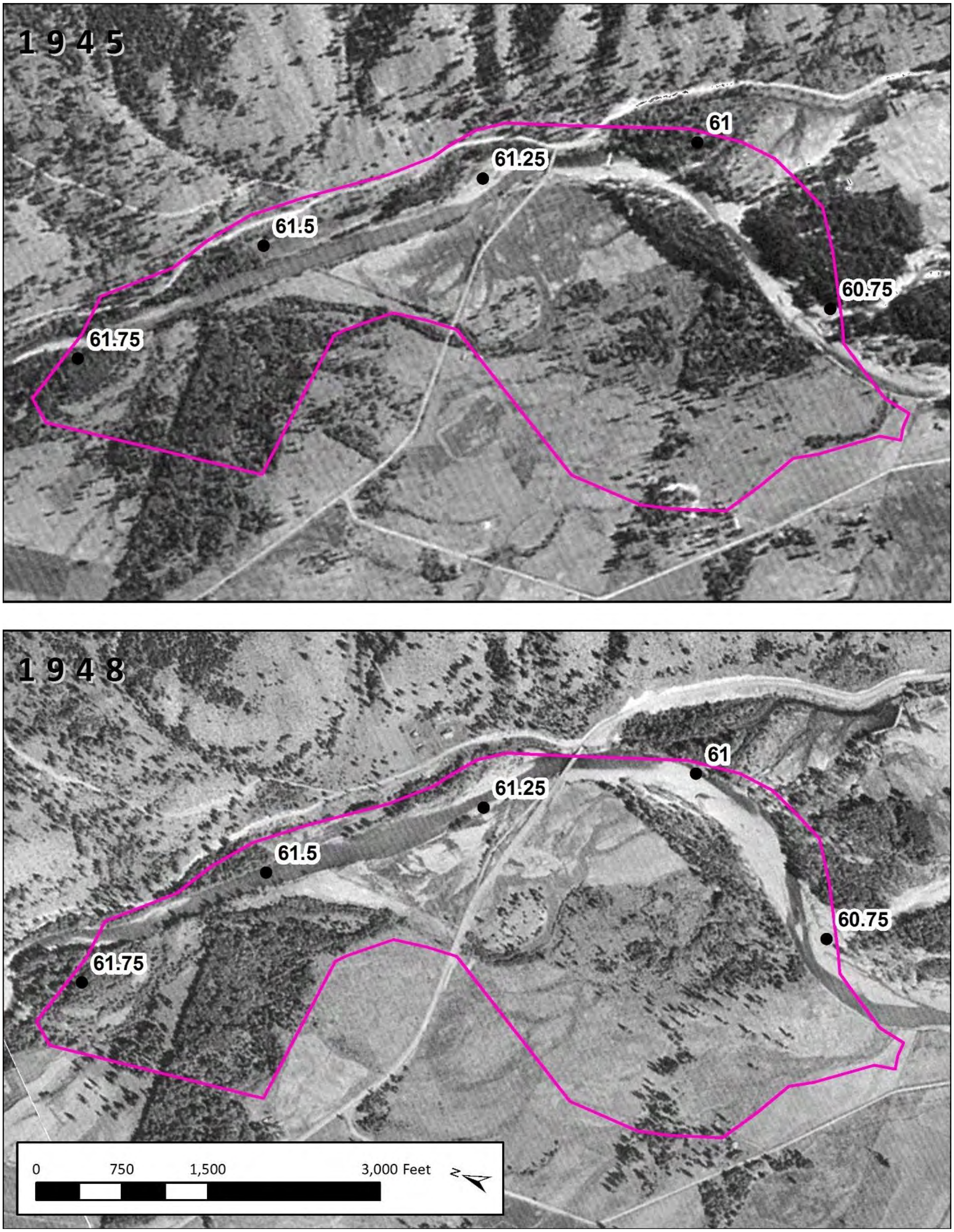


Figure 13. Aerial imagery from 1945 and 1948 of the Weeman project area. Images courtesy of USGS Earth Explorer.

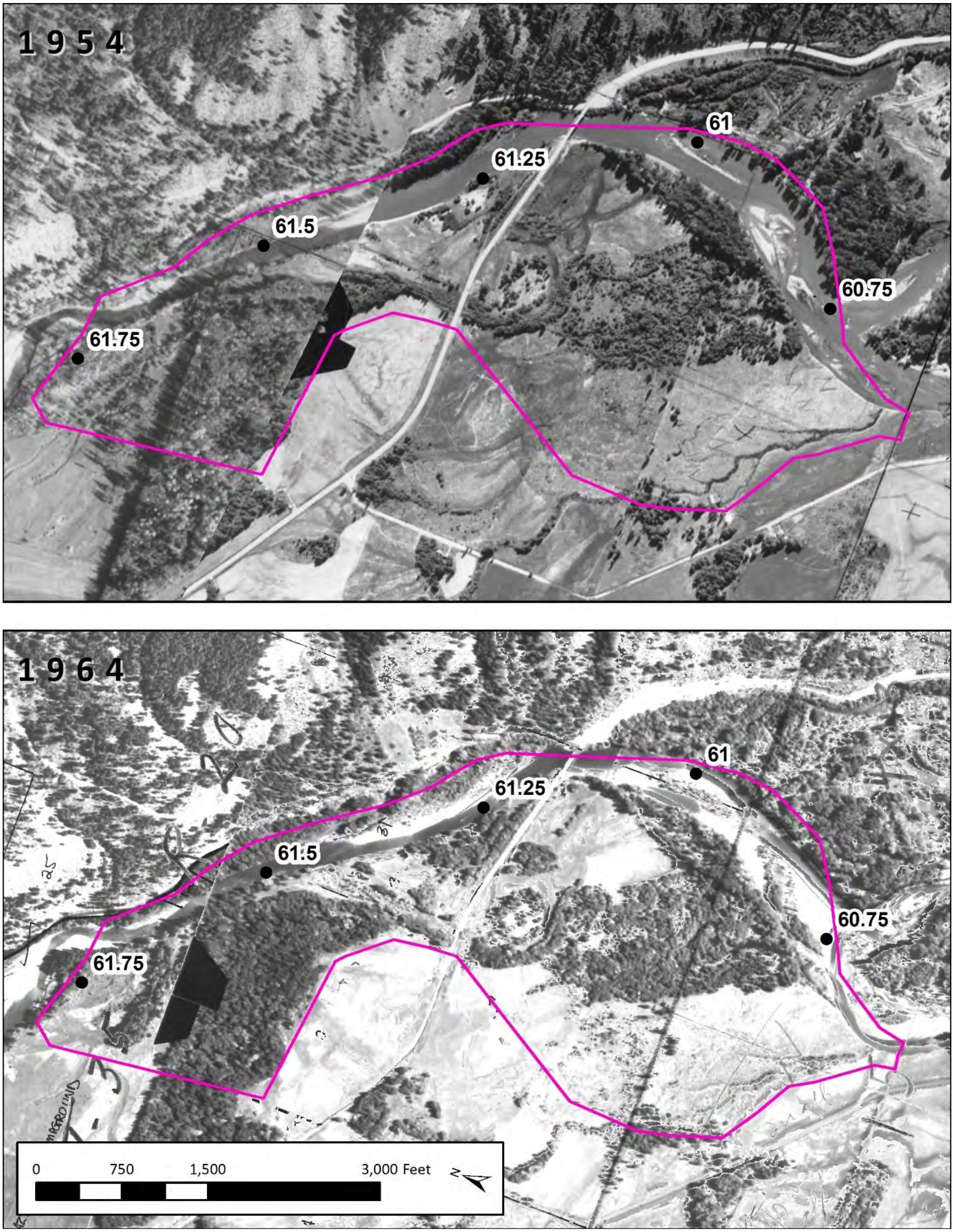


Figure 14. Aerial imagery from 1954 and 1964 of the Weeman project area. Images courtesy of USGS Earth Explorer.

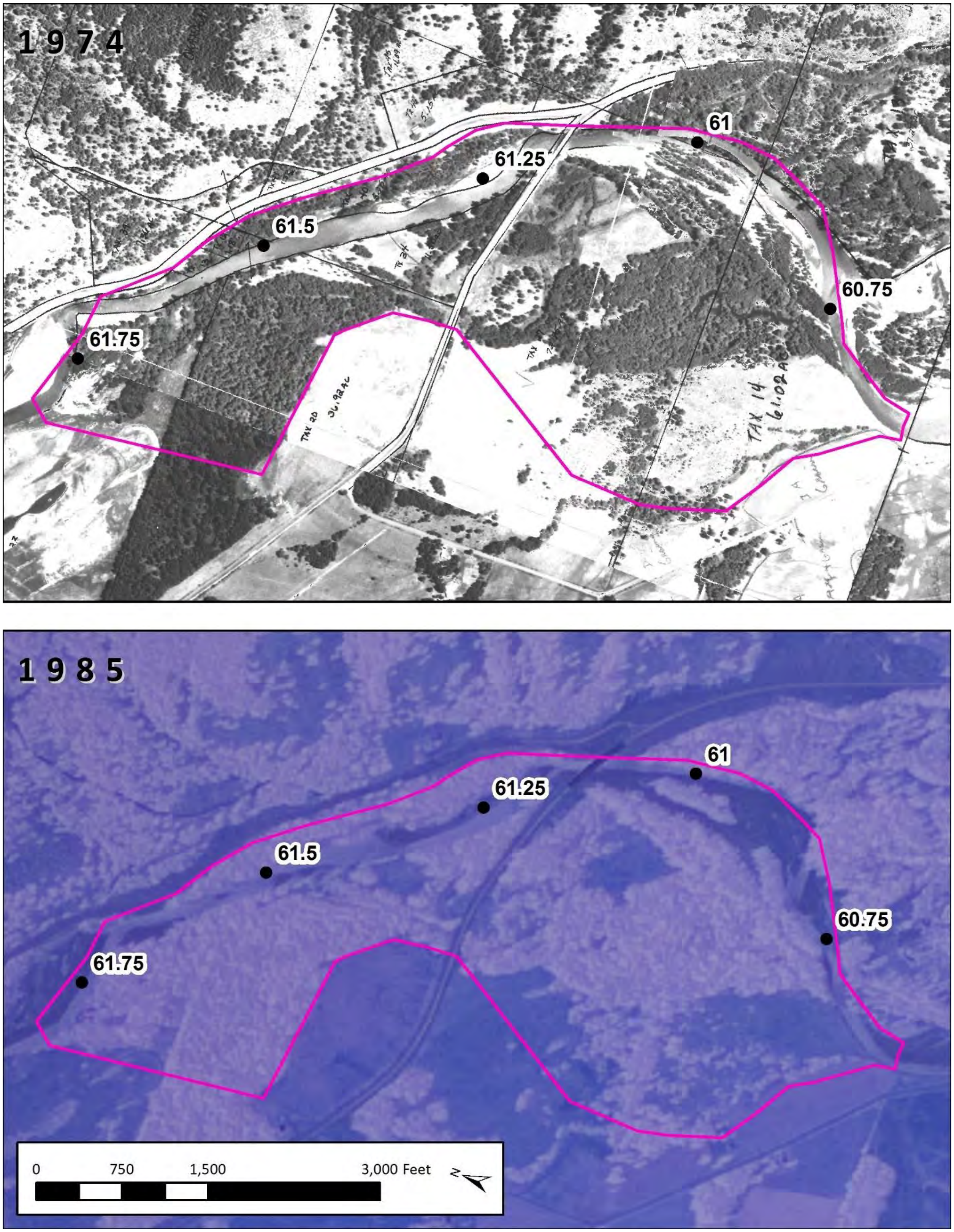


Figure 15. Aerial imagery from 1974 and 1985 of the Weeman project area. Images courtesy of USGS Earth Explorer.

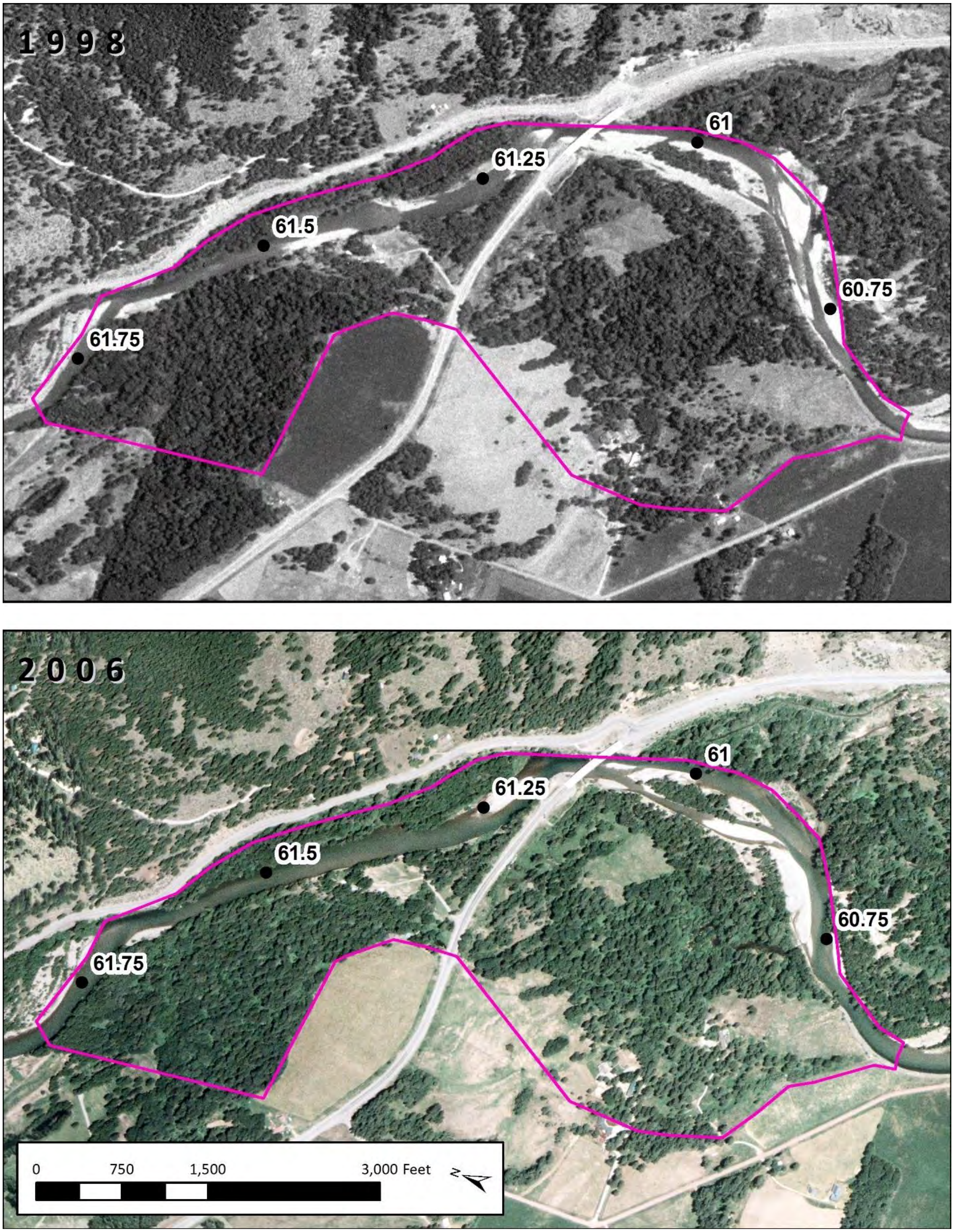
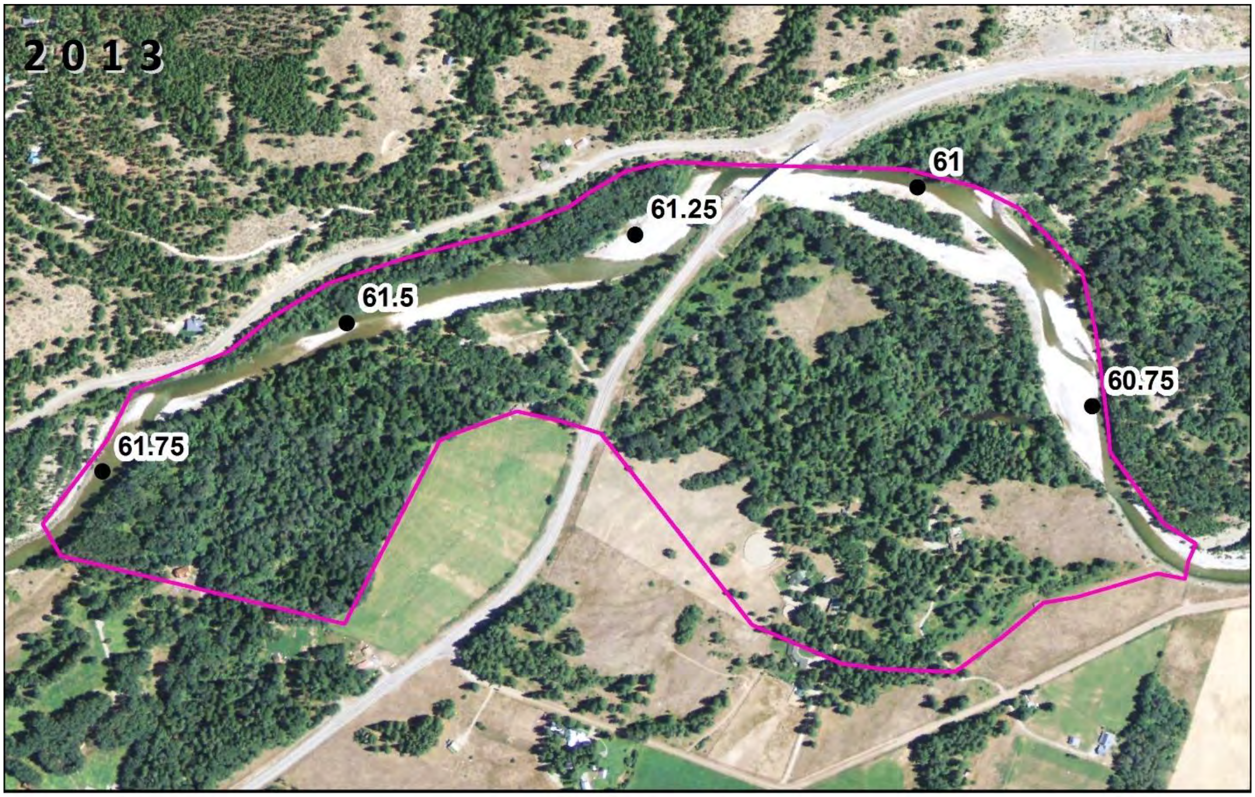


Figure 16. Aerial imagery from 1998 and 2006 of the Weeman project area. Images courtesy of USGS Earth Explorer.



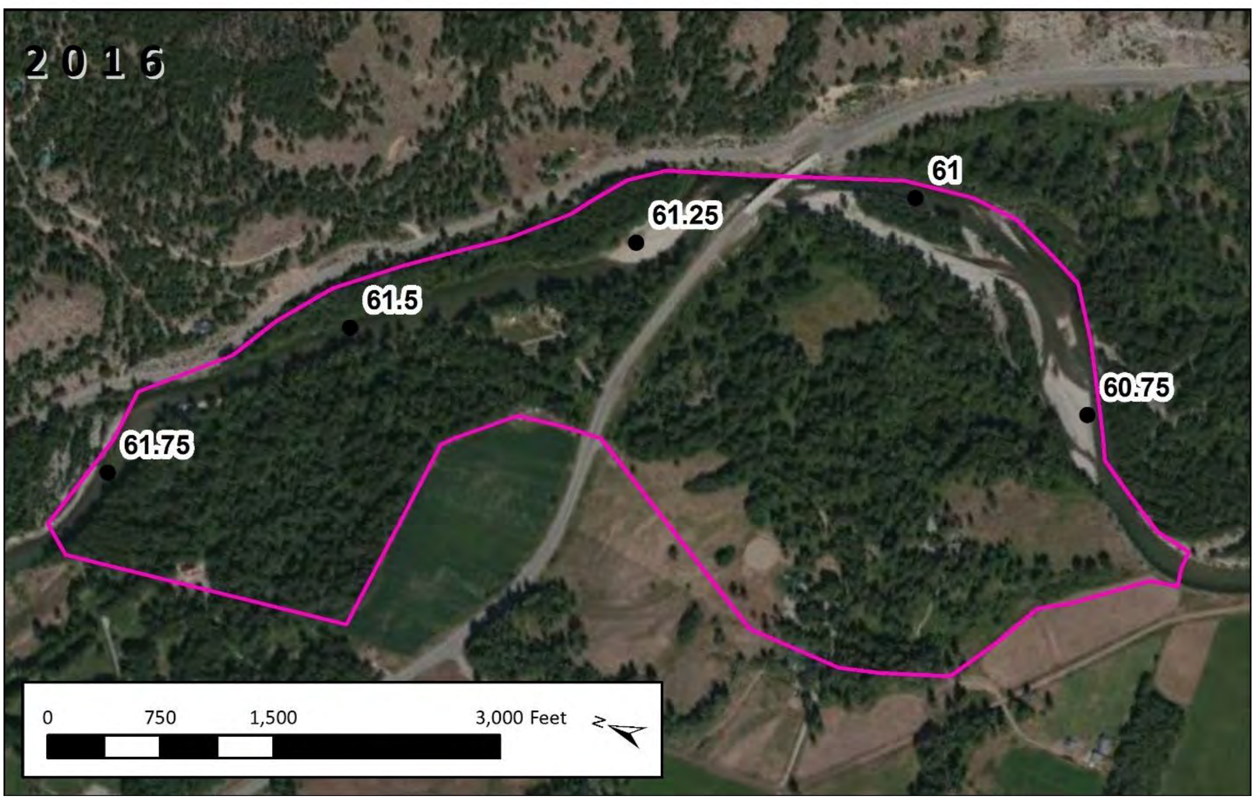


Figure 17. Aerial imagery from 2013 and 2016 of the Weeman project area. Imagery courtesy of USGS Earth Explorer and Microsoft Bing.

2.3 FISH USE AND HABITAT CONDITIONS

2.3.1 Fish Use

Current fish use in the project areas include ESA-listed (endangered) spring Chinook, ESA-listed (threatened) steelhead and bull trout, and non-listed westslope cutthroat trout. Spring Chinook salmon, steelhead, and bull trout spawn and rear in the project area. Bull trout also use the area for overwintering (UCSRB 2015).

Spring Chinook spawning peaks in late August and early September with Upper Methow spawners concentrated between RM 61-68. Steelhead spawning occurs from March through May. Juvenile rearing for Chinook salmon and steelhead occurs in the project areas year-round. Both spring Chinook and steelhead redds have been documented in the project areas (Figure 18, Figure 19).

Steelhead and spring Chinook are considered stream-type salmonids because they spend one or more years in freshwater as juveniles. They therefore rely more heavily on quality freshwater habitat compared to fish that migrate rapidly downstream following emergence. Upper Columbia juvenile steelhead reside in their natal streams for 2 years on average, and residencies of up to 7 years have been observed (Peven et al. 1994, Mullen et al. 1992).

This project area was considered a high priority for restoration as part of the 2015 Upper Methow Reach Assessment. The Fawn and Weeman Projects were both rated as Tier 1 projects. These projects were rated higher than other projects further upstream because of existing impairments (and recovery potential) but also because these reaches are perennially wetted and do not exhibit the annual subsurface conditions present in upstream reaches. These reaches are considered "gaining" reaches because they generally receive inputs of groundwater to the stream (Konrad 2003). These conditions make these reaches more hospitable to year-round use by fish and suggest that there may be important thermal benefits, especially if floodplain habitats can be reconnected.

2.3.2 Fish Habitat Conditions

As described in Sections 2.2.2 and 2.2.3 above, there have been significant past human uses of the area that have impacted aquatic habitat. These include riprap, levees, riparian clearing, residential development, recreational development, transportation corridors, stream cleanouts, and stream and floodplain manipulations to maintain surface water diversions. Past avulsions in the area are likely at least partially due to the effects of artificial confinement. Levees and bridges have reduced hydrologic and fish habitat connectivity to floodplains and side-channels. Aquatic, riparian, and floodplain habitats, and the processes that support them, are significantly impaired compared to historical conditions.

The Reach Based Ecosystem Indicators (REI) analysis performed as part of the 2015 Upper Methow Reach Assessment (Inter-Fluve 2015) is a good general indicator of habitat conditions in the study area. For both Reach 1 (Weeman Site) and Reach 2 (Fawn Site), 9 of the 11 habitat indicators were rated as either "At Risk" or "Unacceptable". These included Large Woody Material, Pools, Off-Channel Habitat, Riparian Structure, Riparian Disturbance, Canopy Cover, Floodplain Connectivity, Bank Stability/Channel Migration, and Vertical Channel Stability. Only Main Channel Barriers and Dominant Substrate/Fine Sediment were rated as "Adequate".

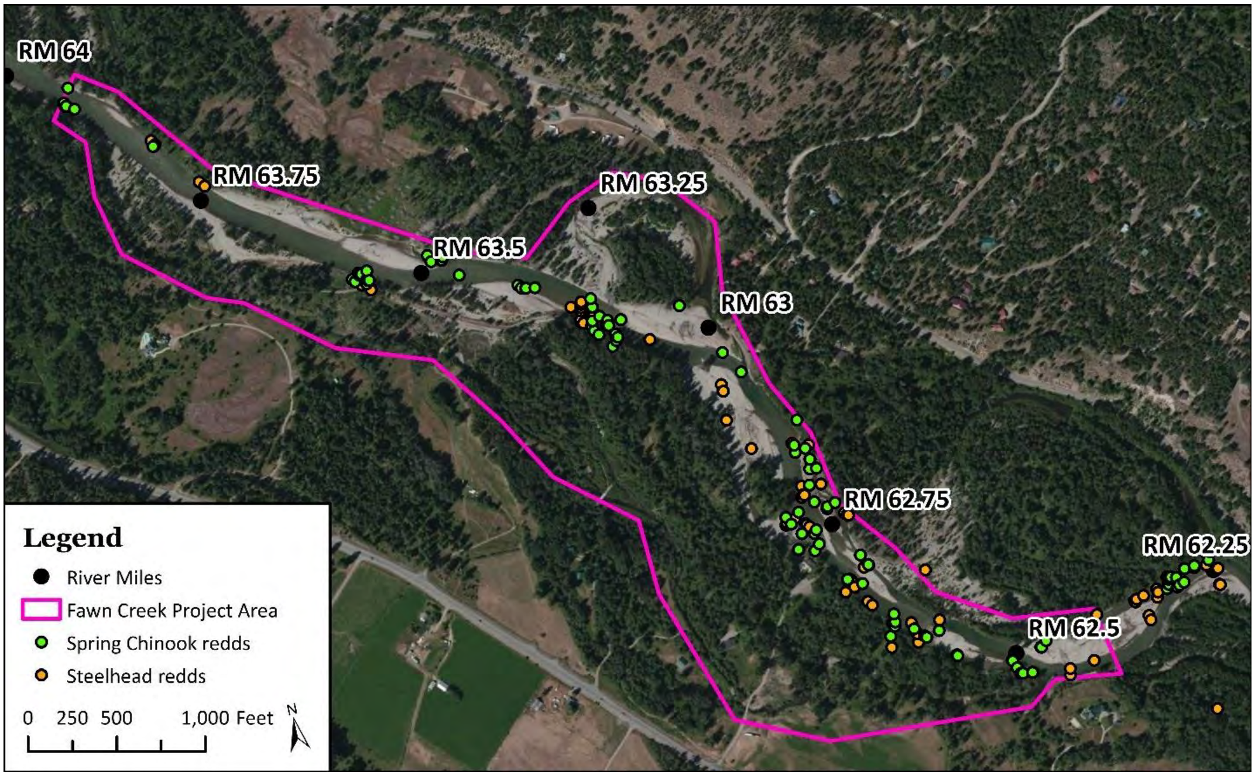


Figure 18. Spring Chinook and steelhead redds surveyed from 2005-2009. Data acquired from UCSRB online GIS and Data Library, retrieved August 22, 2016.

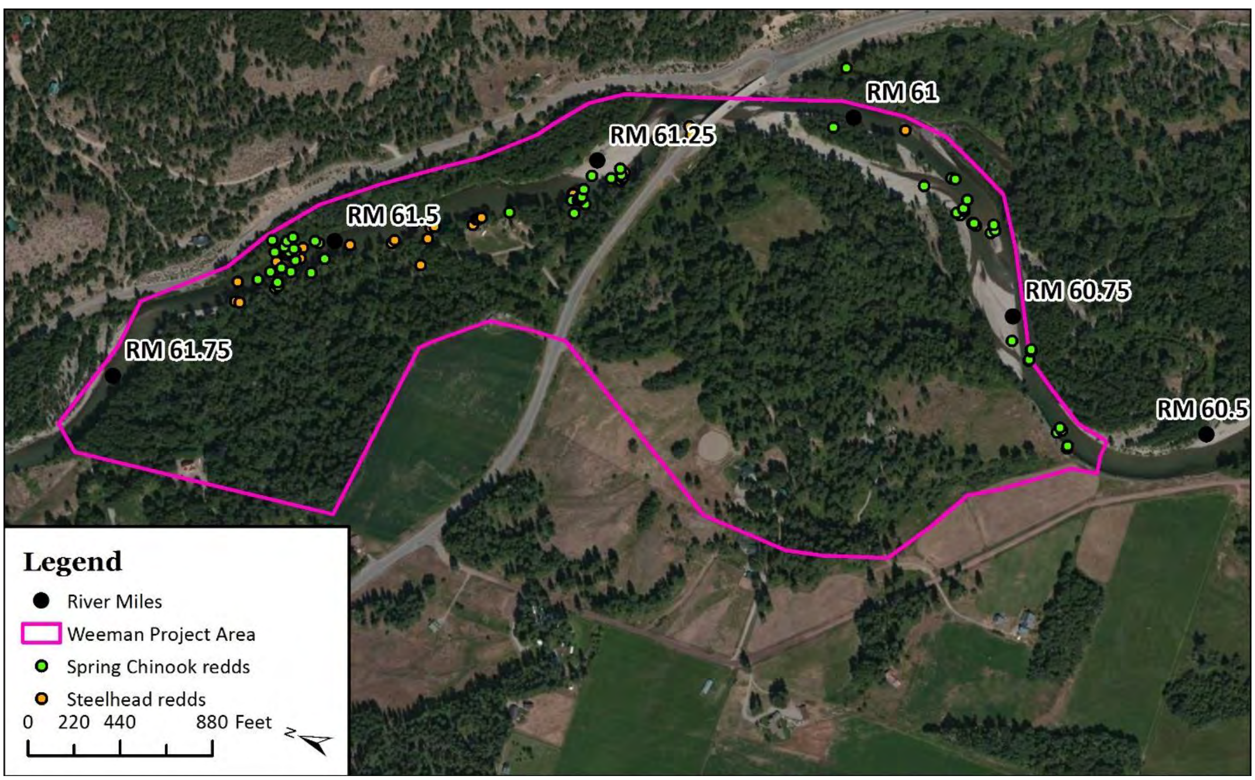


Figure 19. Spring Chinook and steelhead redds surveyed from 2005-2009. Data acquired from UCSRB online GIS and Data Library, retrieved August 22, 2016.

2.4 HYDROLOGY

2.4.1 Hydrologic Setting

The Upper Methow River watershed is located in western Okanogan County, Washington, in the eastern Cascades. The Methow River empties into the Columbia River near Pateros, Washington. Fawn Creek enters the project area at RM 62.85 and Goat Creek enters the Methow River upstream of the project area at RM 71.3. The Upper Methow Reach Assessment should be referenced for a more complete discussion of the hydrologic setting.

Methow River hydrology is driven by precipitation in the form of snow and the subsequent spring snowmelt. Peak discharge usually occurs from May to July and the river returns to baseflow by September (Figure 20). Mean annual flow is 525 cubic feet per second based on annual average flows from 1993-2013 (USGS 2014). Portions of the upper Methow have gone dry during drought years, with all flow contained within the unconsolidated alluvial bed (Inter-Fluve 2015). Note that this is not the typical condition for the Methow River within the project areas.

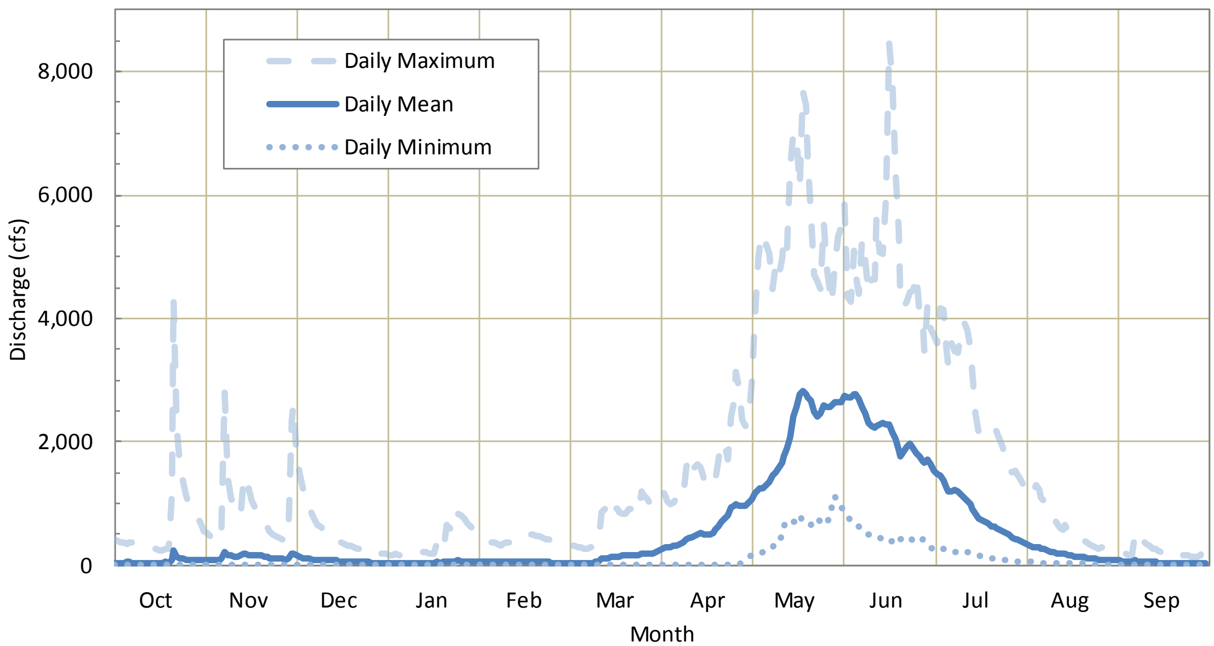


Figure 20. Average, maximum, and minimum values of average daily flows for the period between 1991 to 2015 (USGS gage #12447383 – Methow River above Goat Creek near Mazama, WA).

2.4.2 Flood History

The largest flood event on the Methow River, recorded with discharge gages, was in 1948. The peak discharge recorded for the 1948 flood at the Peteros gage (USGS #12449950) was 46,700 cfs and estimated[2] to be 31,360 cfs at Winthrop, WA. Other notable flood events occurred in the Methow Valley in 1894 and 1972. Methow River discharge data from the Goat Creek gage are available since 1991 (Figure 21). The highest flow in this time period was a 10- to 25- year flood event in 1999.

[2] The estimated discharge at Winthrop was determined by subtracting the gaged discharge on the Twisp River from the gaged discharge on the Methow River below Twisp, WA on the same day in 1948 (USBR 2010)

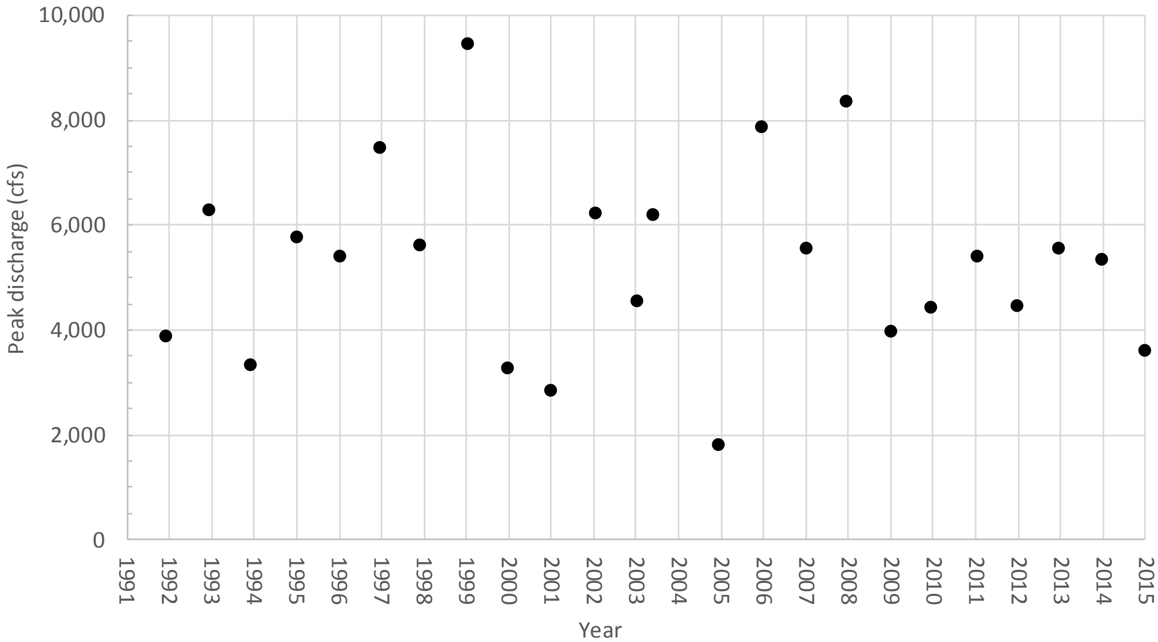


Figure 21. Annual peak floods at the Methow River gage near Goat Creek (USGS #12447383).

2.4.3 Peak Flows

The US Bureau of Reclamation (USBR) in 2008 completed a geomorphic assessment (USBR 2008) for nearly 80 river miles of the Methow Subbasin, which included hydrologic analysis for subbasins covering both the Fawn and Weeman project areas. We used flows generated from this analysis for the 2D modeling of the project area. The peak flows and the October mean discharge for the project areas are shown in Table 1. The peak flow values are based on a local and regional gage analysis (USBR 2008). To be conservative, with respect to peak flow hydraulics, flows at the upstream model boundary used the estimated basin flows for the subbasin boundary at the downstream end of the study area (just downstream of the Weeman project) with only the estimated Fawn Creek flows subtracted. The estimated Fawn Creek flows were added laterally to the model at the Fawn Creek confluence. For comparison, we performed a log Pearson III flood frequency analysis on the Goat Creek gage despite the short period of record. Most values were close to the USBR values but slightly less, confirming that the USBR values were more conservative from a hydraulic impacts perspective.

Table 1. Flows for the project areas used in the hydraulic model.

Recurrence flow	October mean	2-YR	5 -YR	10-YR	25-YR	50-YR	100-YR
Discharge (cfs)	29	5,965	7,841	8,966	10,277	11,186	12,043

2.4.4 Ice flows

Ice flow conditions are known to exist on the Upper Methow River within the project reach. Ice flows develop when river ice formed in the cold winter months breaks up during the late winter and spring warming. Break up timing, river stage, and the volume of ice accumulated before breakup all control the energy and potential channel alterations that may occur. Ice jams have the potential to alter the course of the river in the same way a large log jam would. This type of disturbance can create complex instream and floodplain habitats within forested floodplains, and has the potential to impact proposed project elements.

The risk of an ice jam damaging constructed log jams within the project reach is considered relatively low. However, an ice jam could alter conditions within the flow-through side channel. If an ice jam developed in a side channel and caused substantial sediment deposition, flows could be altered in the side channel. However, ice flows are not a common event and are considered a low risk to project performance.

2.5 VEGETATION

The vegetation in the riparian corridor throughout the project areas is variable. Vegetation canopy heights are dominated by trees ranging from 25 to 100 feet tall (Figure 22 and Figure 23). The overstory is primarily composed of cottonwood and Douglas fir with some ponderosa pine and western redcedar. The understory is dominated by alder and dogwood. Riparian clearing has occurred for agriculture, home sites, transportation/recreation corridors, and timber harvest. Although a patch mosaic of varying vegetation ages and heights persist at the project areas, riparian clearing has reduced stand age and has changed species composition. The corresponding direct and indirect impacts on stream-related functions include reduction in shade, bank stability, floodplain roughness, and sources for large wood.

The main impairment in regards to riparian dynamics within the project areas is reduced wood recruitment. Historically, the project areas would have had a high frequency of large wood and log jams throughout the channel as a result of recruitment by bank erosion and avulsions. Levee construction, transportation infrastructure, and riprap have reduced channel migration and wood recruitment at both the Fawn and Weeman sites.

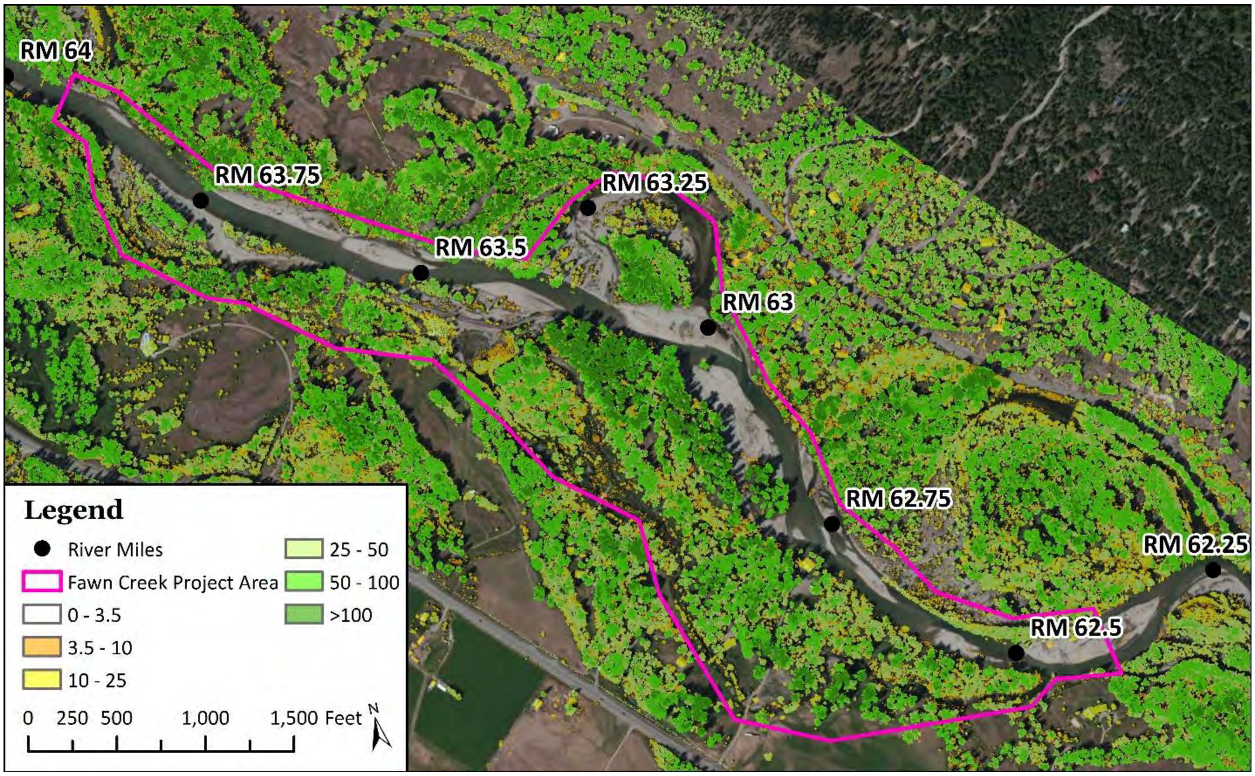


Figure 22. Canopy height (in feet) in the Fawn Creek project area. Data acquired by calculating the height difference between the LiDAR first return data and the ground data.

Figure 23. Canopy height (in feet) in the Weeman project area. Data acquired by calculating the height difference between the LiDAR first return data and the ground data.

2.6 HYDRAULIC MODELING

Although flow pathways, wetted widths, and flow velocity can be observed on the landscape and recorded by collecting survey data or imagery, the information is only relevant to the conditions during that particular time and flowrate. Parameters such as velocity and depth can be difficult to measure in the field, particularly during flooding. Hydraulic modeling is useful for predicting the effects of a range of flow conditions on the existing landscape. It is also an industry-standard tool for predicting effects of possible enhancement actions. Thus, hydraulic modeling is important for evaluating how various project configurations relate to the hydraulic properties of channels and floodplains. For the Fawn Creek and Weeman Bridge project, two-dimensional (2D) hydraulic models were developed for existing conditions and the proposed design conditions. Comparing hydraulic models of existing and proposed conditions helps optimize project designs and predict their impacts on site hydraulics. The 2D hydraulic models for the site were developed in the U.S. Army Corps of Engineers HEC-RAS 5.0 software (USACE 2016) for modeling the hydraulics of water flow through natural rivers and other channels. The following sections describe HEC-RAS 5.0 and document the development and output processing of the existing and proposed conditions.

2.6.1 Model Capabilities and Limitations

HEC-RAS 5.0 was used in its two-dimensional (2D) unsteady flow simulation mode with the capacity to model the complex flow patterns, on-site water storage, and temporally variable boundary conditions. The 2D hydraulic model calculates depth averaged water velocities (including magnitude and direction), water surface elevation, and mesh cell face conveyance throughout the simulation. Other hydraulic parameters, such as depth, shear stress, and stream power, can be calculated after the simulation. The model does not simulate vertical variations in velocities or complex three-dimensional (3D) flow eddies.

2.6.2 Model Extent

The project model extends from approximately river mile to 60.5 up to river mile 64, and spans across the valley to elevations well above the 100-year flood elevation, see Figure 24. The model covers both the Fawn Creek and Weeman Bridge project areas. The upstream extent of the model is located at a relatively confined section, 1,500 feet upstream of the Fawn Creek project area. The downstream extent of the model is located 1,000 feet downstream of where the proposed Weeman Bridge side channel would rejoin the main channel. Figure 22 shows the model area coverage.

2.6.3 Model Terrain

The exiting conditions model terrain was developed using both ground/bathymetric survey data collected by Inter-Fluve staff in 2016 along with aerial LiDAR acquired[3] in 2015 (Quantum Spatial 2016). Model terrain was primarily based on LiDAR for the floodplain and hillslopes with select use to help define certain gravel bars where survey data were sparse. Model terrain was primarily ground/bathymetric survey data for river and side channel bathymetry; active channel areas that may have changed since the LiDAR flight; and other areas of interest, including regions where potential project elements may occur.

[3] LiDAR was collected over the project area in June and July 2015.

The LiDAR provided a 1 meter (3.28 feet) horizontal resolution bare earth digital elevation model (DEM) raster for the entire site, including floodplain areas and valley hillslopes. The ground and bathymetric survey data (points and break lines) were used to create a triangulated irregular network (TIN) surface for the surveyed areas. The ground survey surface was then resampled to a 1-foot resolution DEM raster and pasted over[4] the LiDAR DEM to create the existing conditions model terrain. The proposed condition model terrains incorporated the design grading TIN surfaces into the existing conditions terrain following a similar process. The model terrains are projected on the Washington State Plane North Zone, North American Datum 1983 (NAD83), coordinate system with US feet distance units. The terrain elevations are in US feet relative to the North American Vertical Datum of 1988 (NAVD88).

2.6.4 Model Geometry

The 2D model geometry used a multi-resolution computational mesh adjusted according to terrain complexity and areas of interest. The nominal mesh spacing in complex areas of the main channel and side channels of interest was 10 feet. A coarser nominal spacing of 24 feet was used in more uniform portions of the main channel; on flatter regions of the floodplain; and at the model edge along the valley toe/hillslope. Break lines were also added to further refine the mesh along the tops of banks, channel alignments, and narrow ridge features (e.g. levees). Although the average computation mesh size was greater than the terrain resolution, the modeling capabilities of HEC-RAS 5.0 integrates the sub-grid terrain into the computations. This capability allows small features such as narrow channels and floodplain hummocks to be shown in the model output.

2.6.5 Model Roughness

Roughness coefficients (Manning's n values) are used by the 2D model to calculate flow energy losses, or frictional resistance, caused by channel bed materials and floodplain vegetation. Existing conditions roughness coefficients were applied across the model extent to represent the various types and densities of vegetation or surface conditions. Roughness coefficients were modified in the proposed conditions models to represent immediate post construction conditions. In general, roughness regions were delineated based on field observations, aerial photos, and proposed designs. Roughness values for each region were selected using published guidelines (Arcement & Schneider 1989) for channel types and vegetation conditions. In general, roughness values were consistent with the Upper Methow Reach Assessment (Interfluve 2015) SRH-2D model with some refinements in extent and characterization. Table 2 summarizes the roughness coefficients used in the models.

Table 2: Roughness coefficients used in the 2D model.

Region description	Manning's n value
Road, paved	0.02
Main active river channel, typical cobble/gravel bed	0.04

[4] The ground survey surface superseded the LiDAR surface within the irregular extent of the ground survey. No transitional buffer between the ground survey and the LiDAR DEMs was used, occasionally resulting in minor surface discontinuities.

Region description	Manning's n value
Existing side channels; typically, former main channel areas	0.05
Proposed side channels; average across whole channel	0.06
Open forests and uplands; typically, sparse vegetation/understory	0.07
Brush; typically, woody with a medium density	0.08
Proposed grading areas; typically levee removal followed by large wood placement and woody planting	0.08
Proposed large wood structures: perimeter and top	0.10
Mature forest, dense understory vegetation, scattered LWD	0.13

2.6.6 Model Discharges

The modeled discharges[5] of interest included a low flow of 105 cfs, a moderate flow of 500 cfs, along with the 2-, 5-, 10-, 25-, 50- and 100-year recurrence interval event peak flows listed in Table 1. These discharges were incorporated into a synthetic hydrograph with periods of steady flow (at the discharges of interest) connected by smooth transition periods to create a stair-step like pattern. The periods of steady flow allow the model to come to a quasi-steady state condition improving the interpretation of hydraulics at discharges of interest.

2.6.7 Model Boundary Conditions

HEC-RAS 5.0 2D models require boundary conditions at the upstream and downstream ends of the model to control the flow into and out of the model extent. The synthetic hydrograph described above was applied as the upstream boundary condition. The flow was initially distributed along the boundary assuming normal flow depth at a friction slope estimated from the average channel slope upstream of the model (0.003 feet per foot). The downstream boundary condition assumed normal flow depth at a friction slope estimated from the average channel slope downstream of the model (0.005 feet per foot).

2.6.8 Model Output

To examine the inundation patterns, velocities, and other hydraulic parameters within the model extent for existing and proposed conditions, the RAS Mapper utility of HEC-RAS 5.0 was used to generate results in the form of raster data sets at the discharges of interest. These raster data sets were then loaded into an ESRI ArcMap file to prepare various figures depicting inundation extent and velocity magnitude for existing and proposed conditions.

[5] Discharge values are reported as the combined discharge of the Methow River and Fawn Creek. Other minor tributary contributions within the model extent are included in the upstream boundary condition discharge for the Methow River.

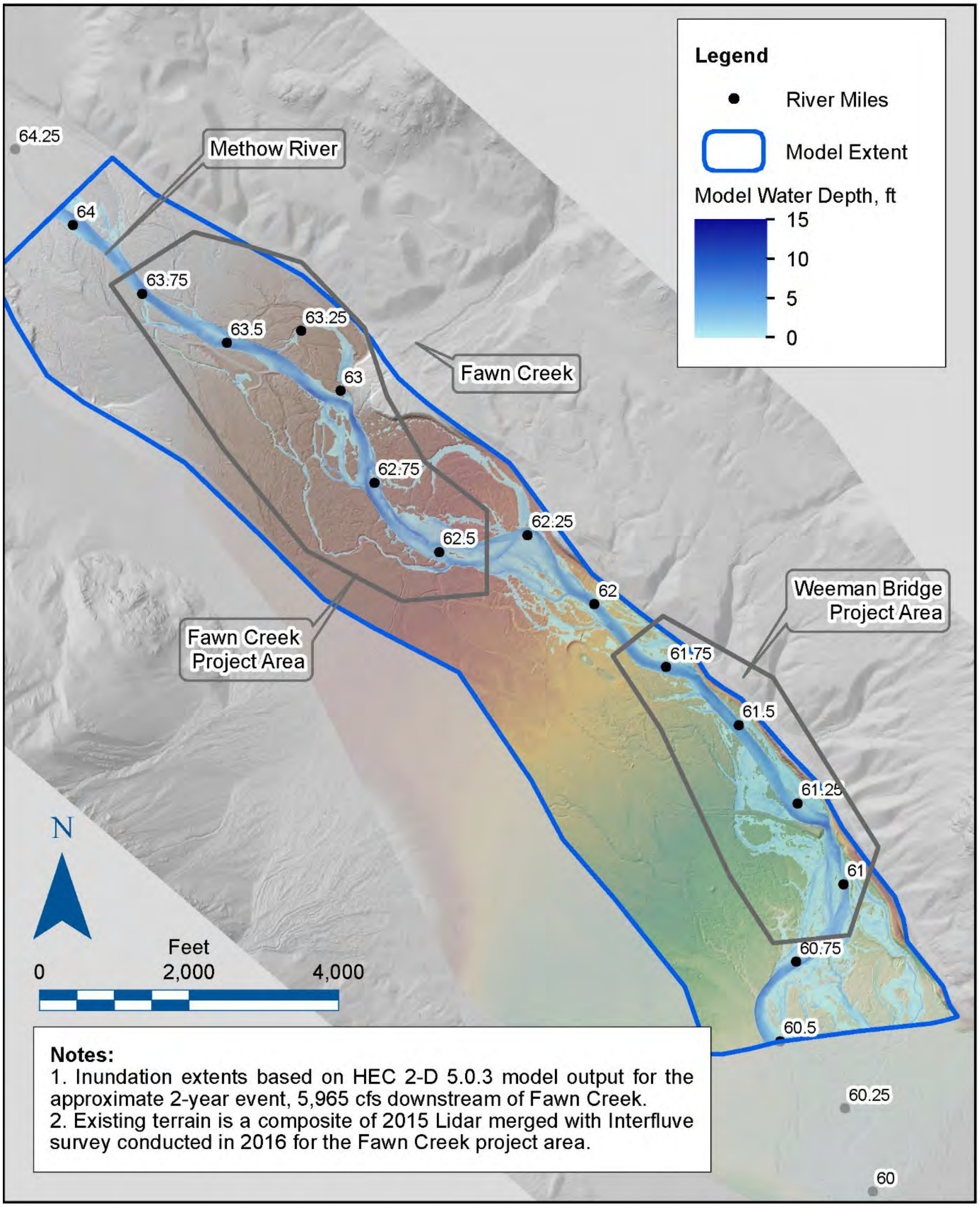


Figure 24: Fawn Creek and Weeman Bridge Project Area 2D Hydraulic Model Extent.

2.6.9 Model Validation

The model was validated using select oblique aerial photos taken during a high-flow event with known gauged discharge. The flood photos were taken on May 22, 2008, and captured the equivalent of a 1.8 year flow recurrence. The daily average discharge at the gauged[6] site at River Mile 65.5 was 3,680 cfs with an estimated discharge at the model downstream extent of 4,184 cfs. Figure 25 shows examples of model inundation comparisons to flood photos near the Fawn Creek and Weeman Bridge sites. Comparisons were in general agreement, showing similar flood inundation extents.

In addition to the flood photos, water level data collected with remote data loggers were used to understand relationships between seasonal flows, temperatures, and stage in several locations. Specifically, data logger water surface elevations were compared with modeled water surface elevations corresponding to known gage flows. The comparison indicated generally good agreement between observed and modelled water surface elevation data in the main channel. In the side channel within the Fawn Creek project area, low flow water surface elevations maintained by groundwater were not captured by the surface flow 2D model.

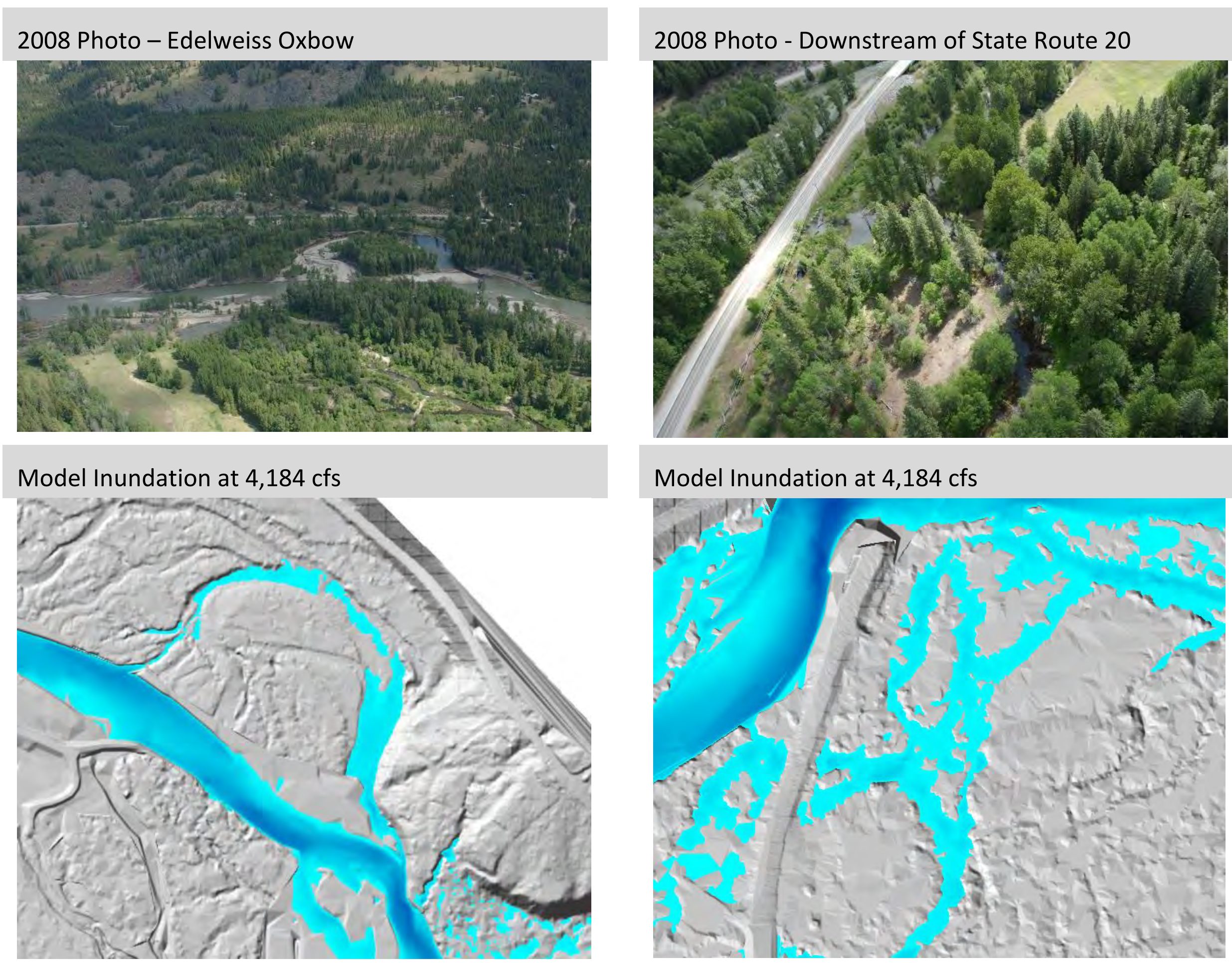


Figure 25: Fawn Creek and Weeman Bridge Project Area High Flow Validation Examples

[6] USGS Gage 12447383 Methow River Above Goat Creek Near Mazama, Wa

2.6.10 Model Findings

The existing conditions floodplain inundation extents are presented for the Fawn and Weeman sites for the 2-year and 100-year recurrence interval floods in Figure 26 through Figure 29 below. At the Fawn Creek site at the 2-year recurrence interval peak flow, the model shows inundation in the Edelweiss and Fawn Creek oxbows along with flow down the existing side channel (Figure 26). At the 100-year recurrence interval peak flow, the model shows more extensive inundation including many additional floodplain flow paths. The model does not show inundation adjacent to the existing side channel at the 100-year recurrence interval peak flow (Figure 27). At the Weeman Bridge site at the 2-year recurrence interval peak flow, the model shows inundation on the right bank floodplain up to State Route 20 with flow passing through the existing culverts (Figure 28). At the 100-year recurrence interval peak flow, the model shows more extensive inundation including flow over State Route 20 west of the Weeman Bridge (Figure 29).

More detailed modeling results, including results comparing existing to proposed water depth and inundation extents, are presented graphically in Appendix B and narratively in Sections 4.1.7 and 4.2.5, following the discussion of the alternatives. The figures in Appendix B cover a number of discharges of interest including 510 cfs representing a typical July receding limb of the spring hydrograph, as well as the 2-, 5-, and 100-year return period peak flows.

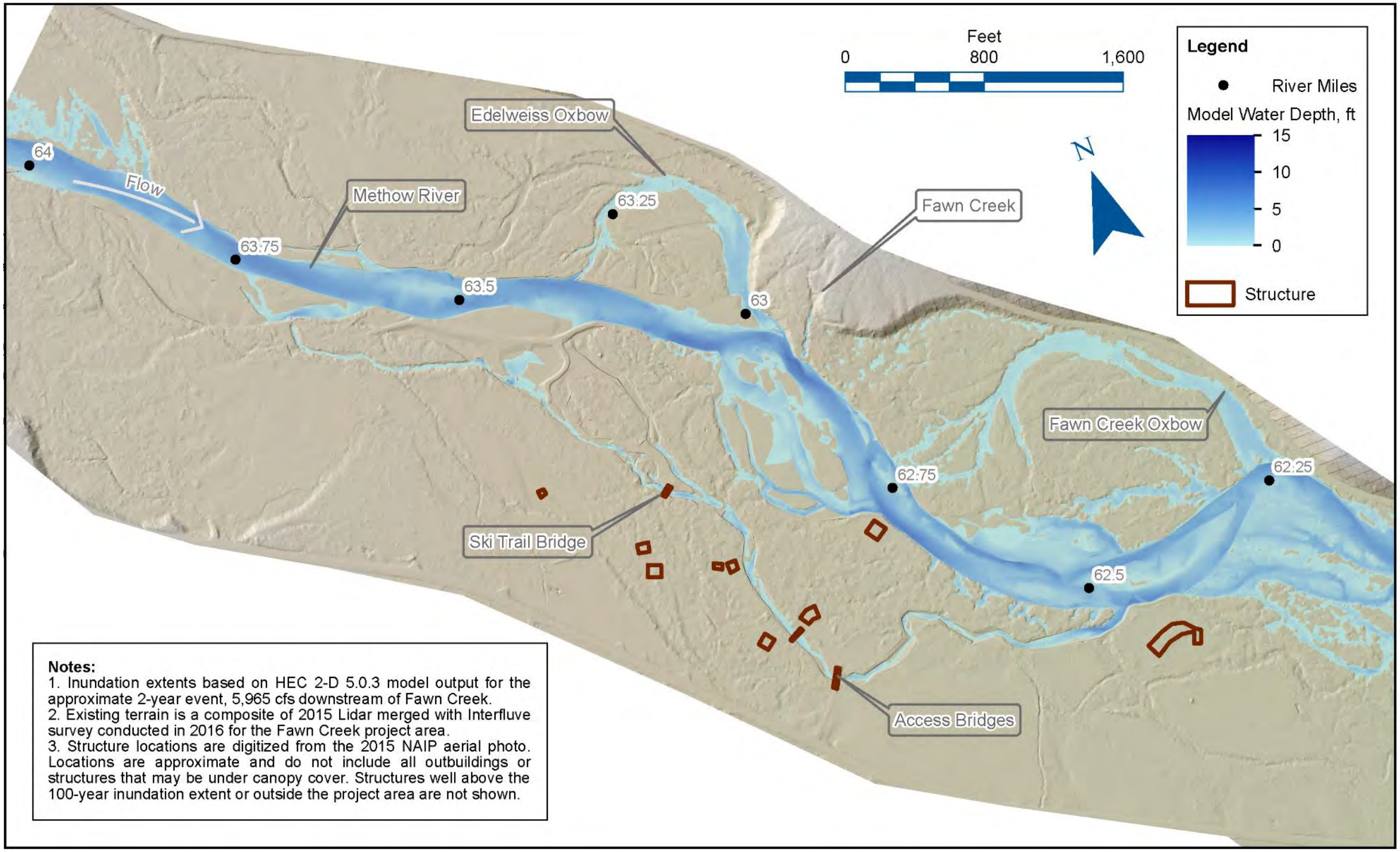


Figure 26: 2-Year Inundation Extents – Existing Conditions Fawn Creek.

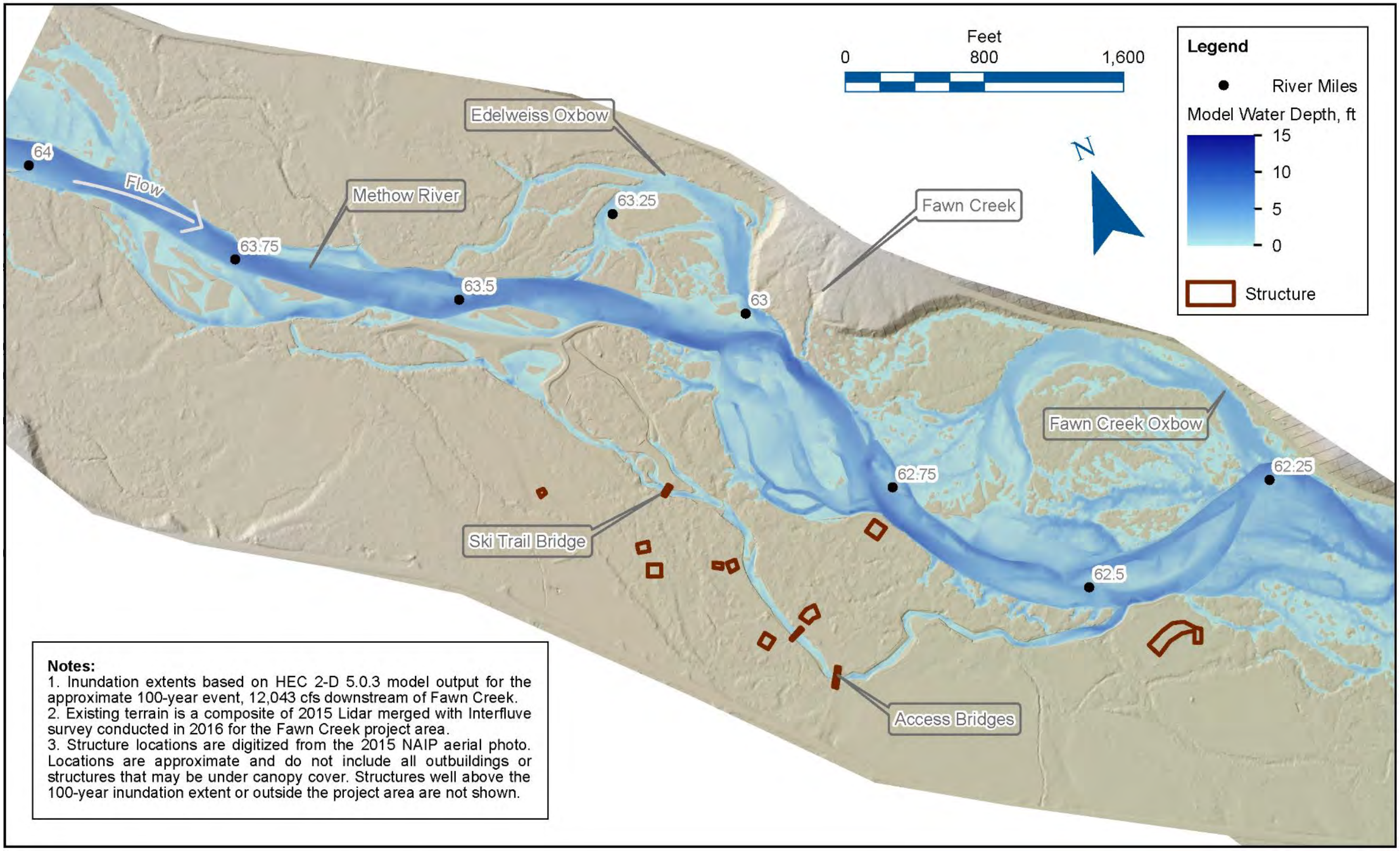


Figure 27: 100-Year Inundation Extents – Existing Conditions Fawn Creek.

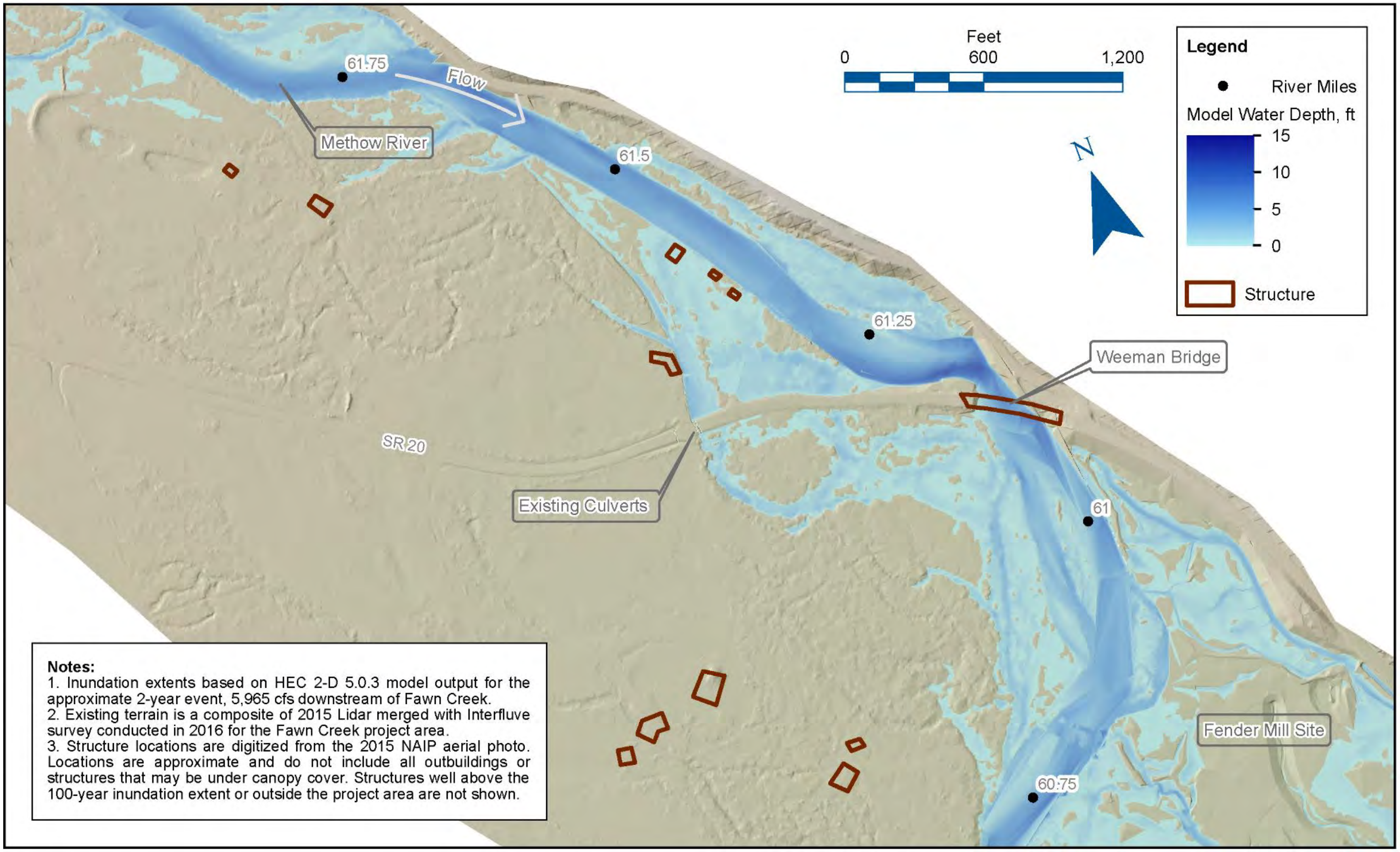


Figure 28: 2-Year Inundation Extents – Existing Conditions Weeman Bridge.

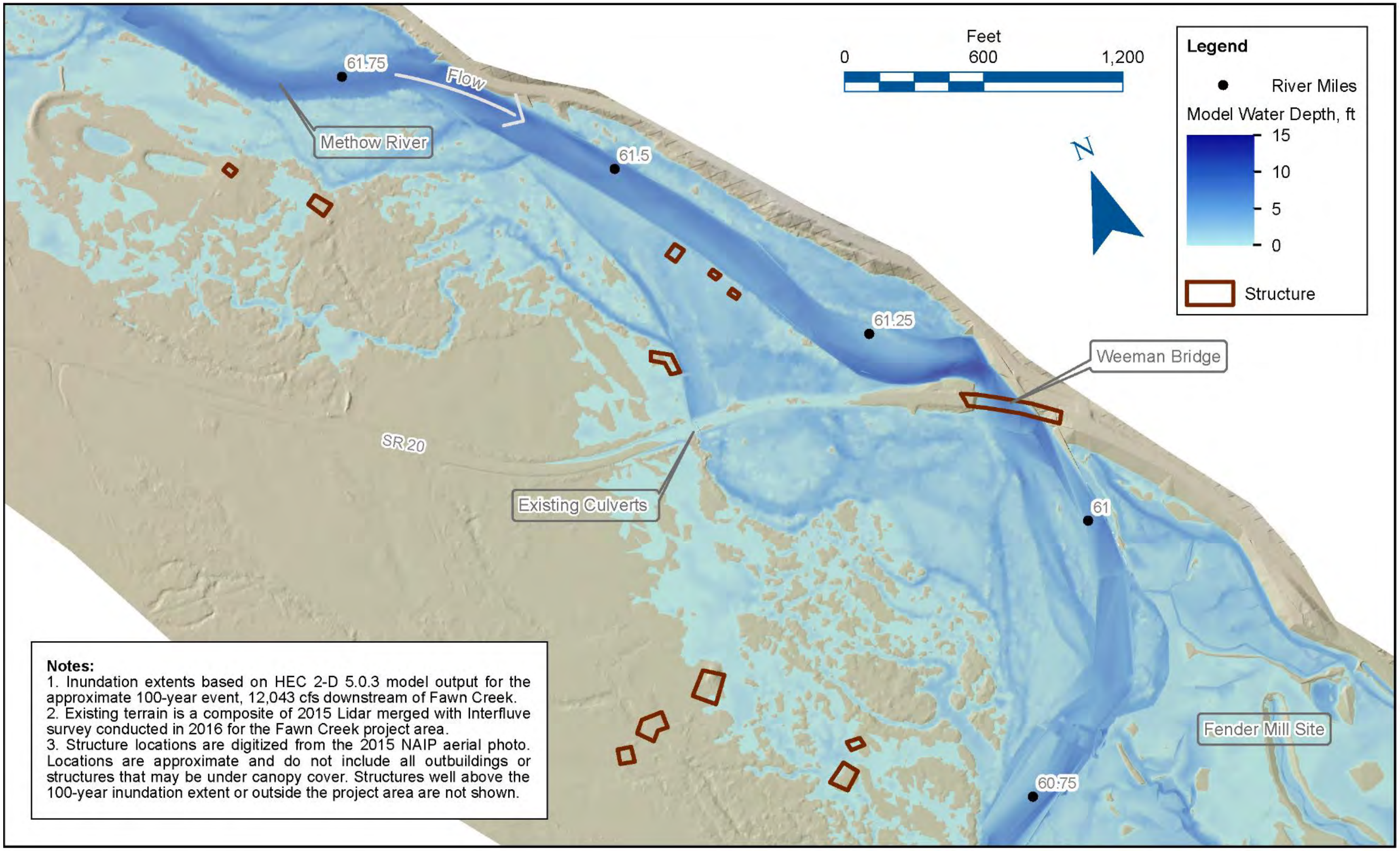


Figure 29: 100-Year Inundation Extents – Existing Conditions Weeman Bridge.

3. Design criteria

Design criteria have been developed to incorporate stakeholder objectives, the RTT Biological Strategy, the YN Reach Assessment, physical river constraints, construction impacts, aesthetics, and recreational user risk. Design criteria serve three primary purposes: 1) to clearly document and communicate specific project objectives and constraints, 2) to help inform and guide the design process to meet project objectives, and 3) provide a basis for future performance monitoring. The design criteria include preliminary performance criteria as well as prescriptive criteria. The design criteria are divided into 6 categories: Habitat, Geomorphology/Hydrology, Engineering and Risk, River Safety, and Construction Impacts.

3.1 HABITAT

- Increase the quantity and quality of main channel and off-channel spawning and rearing habitat for ESA-listed salmon and steelhead, including
  - Overhead cover
  - Hydraulic complexity
  - Pool scour
  - Velocity refuge
  - Thermal refuge
  - Increased food sources
  - Off-channel rearing
  - Sediment/bedload retention, storing, and sorting
- Increase habitat connectivity

3.2 GEOMORPHOLOGY/HYDROLOGY

- Design projects that are consistent with current and projected hydrologic and geomorphic patterns and processes
- Allow for naturally dynamic and deformable processes to operate, within the constraints imposed by existing landownership, infrastructure, and safety considerations
- Increase the potential for future large wood recruitment and retention
- To the extent possible, remove bank armoring that disconnects side-channels and reduces floodplain connectivity
- Design side-channels to maintain sediment transport continuity in order to maximize design life and reduce in-filling to the extent practicable

3.3 ENGINEERING AND RISK

- Do not increase flooding or erosion risk of public or private infrastructure
- Provide adequate ballasting of placed logs to withstand high flows that overtop the structures

3.4 RIVER SAFETY

- Take into account visibility of structures from upstream and room for avoidance
- Take into account structure form to minimize entrapment potential

3.5 CONSTRUCTION IMPACTS

- Minimize impacts to intact wetland habitat
- Locate and configure construction access routes to utilize existing access where possible and to minimize impacts to existing mature riparian vegetation
- Utilize onsite resources or plan channel alignments to take advantage of existing natural features where feasible (e.g. trees, beaver dam locations)

4. Project Alternatives

4.1 FAWN CREEK SITE

4.1.1 Overview of Alternatives

Various interrelated actions are being considered to achieve restoration objectives. These actions have been packaged into 4 restoration concept alternatives that are presented here and in the drawing set that accompanies this report. Some actions are mutually exclusive and others are not. The 4 alternatives are logical combinations of actions and are provided as a means for comparison and for presentation of the types of approaches being considered. It is acknowledged, however, that there are other combinations of actions that could be packaged together to form viable alternatives. The 4 alternatives are generally described below in Table 3. The alternatives are presented in no order of priority.

Table 3. Overview of alternatives and the components included in them.

Alternative	Component						
	Levee breach channel	**Levee removal**	**Side-channel excav.**	**Alcove**	**Porous plug in side channel**	**New relief channel to mainstem**	**Large wood structures (size varies)**
#1 - Levee Breach and Side-Channel	X		X *(1,400 LF)*	X *(400 LF)*			X *(48)*
#2 - Levee Removal		X *(13,000 CY)*					
#3 - Levee Removal, Side-Channel, and Relief Channel	X	X *(13,000 CY)*	X *(1,400 LF)*	X *(400 LF)*	X *(330 CY)*	X *(350 LF)*	X *(56)*
#4 -Mainstem Large Wood							X *(36)*

4.1.2 Alternatives Considered but not Carried Forward

There are several actions or variations of actions that have been considered as part of the design analysis but that have not been carried forward to this concept alternative stage. These primarily include alternative locations for the levee breach. Potential upstream and downstream breach locations line up well with the side-channel complex but connect to the main channel at high flow channels or gravel bars. These situations could affect the reliability for year-round flow and since they are located in more depositional zones, bedload accumulation could affect inlet conditions. Another potential side-channel inlet connection point was considered further upstream, closer to RM 64. The benefit of an upstream connection includes more side-channel habitat and a connection point that may be less prone to main channel incision associated with the recent past avulsion downstream; however, this scenario would require considerably more excavation, may be subject to erosion from lateral channel migration, and includes more feasibility challenges from a landownership perspective. Additionally, preliminary hydraulic modeling of this scenario indicated an increase in inundation extent at the 100-year peak flow in the vicinity of existing homes and other structures.

Other combinations of actions were also considered. In particular, full levee removal plus select side-channel excavation but without a relief channel to the mainstem. However, this scenario increased the extent of flood inundation towards the highway and on private properties, so this combination was not moved forward as a concept alternative.

4.1.3 Alternative 1 – Levee Breach and Side-Channel

Description

This alternative breaches the levee and excavates a perennial flow-through side-channel that connects up with the existing floodplain side-channel system. The remainder of the levee upstream and downstream of the breach location would remain in place. The breach is located where the main channel currently abuts the river and has been in this same location for the past 10 years. Excavation would occur along the upstream 1,400 feet of the side-channel, eventually tying into existing grade, with no excavation in the downstream portion of the side-channel. There is the potential to create a groundwater-fed backwater alcove that connects up to the new side-channel and that takes advantage of existing channel scars and a relic irrigation canal to provide additional habitat diversity with minimal additional investment. Total net excavation for the side-channel is approximately 2,300 cubic yards, and 960 cubic yards for the groundwater-fed alcove. Large wood complexity would be installed throughout the excavated portion of the side-channel and alcove, and potentially also placed within the downstream (non-excavated) portion of the side-channel as well. Planting native riparian woody vegetation would occur within and around the areas disturbed during construction.

Potential Benefits

The primary benefit of this alternative is enhanced fish passage into the side-channel and increased potential for year-round use of the side-channel complex by juvenile and adult salmonids. Re-connecting the side-channel would provide rearing complexity, temperature refuge, flood refuge, and potential for new spawning habitat. The total length of the side-channel that would receive enhanced connectivity and instream habitat treatment is 5,400 feet. The new alcove, which would be expected to provide important thermal refugia, is approximately 400 feet long. There would be approximately 48 new large wood structures placed within the side-channel and alcove. Riparian restoration work along the side-channel and alcove would improve long-term riparian function. In total, these treatments would be expected to improve the habitat indicators that were listed as "At Risk" or "Unacceptable" in the 2015 Reach Assessment, including especially the indicators for Large Woody Material, Pools, Off-Channel Habitat, Riparian Structure, Riparian Disturbance, and Floodplain Connectivity.

In addition to more flow through the side-channel itself, this alternative also provides a modest increase of inundation of the adjacent floodplain during floods (2 to 100-year events), which would have ecological and flood-flow dampening benefits. However, these inundation increases also impact existing infrastructure near the downstream end of the side channel.

Recent research in the Methow Basin has shown significant increases in fish abundance in side-channels following restoration (Martins et al. 2014). Other studies have shown that side-channels with deep pools have increased juvenile salmonid survival (Martens and Connolly 2014). Modeling-based assessments of restoration work in the basin have also shown that increasing floodplain and off-channel habitat connectivity and channel complexity would be expected to increase terrestrial detritus, periphyton, aquatic invertebrates, and fish biomass (Benjamin and Bellmore 2016).

Design Considerations/Constraints

Alteration to the levee system would require coordination and approvals from appropriate entities with jurisdiction over the levee – both Okanogan County and WA Dept of Ecology were involved in various phases of its construction. Reconfiguration of the ski trail would also be required, potentially requiring a simple bridge over the new side-channel or re-routing of the trail in this area. This will require coordination with stakeholders.

It will be necessary to provide sediment continuity through the side-channel complex. Introducing river flow into the side-channel will also introduce sediment into the side-channel. Long-term accumulation of sediment in the side-channel could affect its long term function. Sediment transport competency would need to be analyzed and incorporated into the final design configuration. An initial analysis of channel sediment transport competency, given the preliminary proposed side channel slope of 0.34% compared to the steeper adjacent main channel slope of 0.50%, suggests that additional steps may need to be taken to increase the sediment transport competency of the side channel.

There is some potential for flooding or erosion impacts to downstream properties as this scenario results in slightly more floodplain inundation adjacent to downstream portions of the side-channel at the 5-year flood and above. This increased inundation is shallow and low velocity, but it nevertheless occurs on surrounding private properties and needs to be considered. It would also be necessary to control for potential channel avulsion (capture) through the newly opened side-channel. This scenario is unlikely given the bed lowering that has occurred on the mainstem due to the mainstem channel avulsion at RM 63 between 1998 and 2003, but it nevertheless warrants further consideration and incorporation of control measures if necessary.

4.1.4 Alternative 2 – Levee Removal

Description

This alternative removes the levee system on the river-right bank near RM 63.5. The site would be recontoured to match surrounding ground. Total net excavation for the levee system is approximately 13,300 cubic yards. The riprap along the bank could either be completely removed or toe riprap protection left in place to control channel migration. Large wood structures would be placed along the former levee alignment to provide direct habitat benefits. These structures would also serve to provide interim stability following construction until newly planted riparian vegetation could become established. Planting native riparian woody plants would occur within and around the areas disturbed during construction.

Potential Benefits

This alternative provides an increase of inundation of the adjacent floodplain during floods (2 to 100-year events), which would have ecological and flood-flow dampening benefits. As mentioned previously for Alternative 1, past modeling-based research suggests that improving floodplain connectivity will increase terrestrial detritus, periphyton, aquatic invertebrates, and fish biomass (Benjamin and Bellmore 2016). This is also an economical approach, with relatively little cost.

These treatments would be expected to improve some of the habitat indicators that were listed as "At Risk" or "Unacceptable" in the 2015 Reach Assessment, including the indicators for Large Woody Material, Riparian Structure, Riparian Disturbance, Floodplain Connectivity, and Bank Stability/Channel Migration.

Design Considerations/Constraints

Alteration to the levee system would require coordination and approvals from appropriate entities with jurisdiction over the levee – both Okanogan County and WA Dept of Ecology were involved in various phases of its construction. It may also be necessary to re-route the ski trail, and possibly build a new trail bridge. This will require coordination with stakeholders.

With this scenario, there is the potential for long-term channel migration and erosion, especially if the riprap is completely removed from the levee. This could be controlled using large wood structures, which could be designed to a range of stability criteria depending on objectives.

There is some potential for flooding or erosion impacts to downstream properties as this scenario results in slightly more floodplain inundation adjacent to downstream portions of the side-channel at flows greater than the 5-year flood. This increased inundation is shallow and low velocity, but it nevertheless occurs on surrounding private properties and needs to be considered.

Removing the levee would activate the side-channel complex at high flows, and over time, could result in a greater degree of activation and channel expansion. This could increase the risk of main channel avulsion (capture) in the future. This scenario is unlikely given the bed lowering that occurred on the mainstem at RM 63 between 1998 and 2003, but it nevertheless warrants further consideration.

4.1.5 Alternative 3 – Levee Removal, Side-Channel, and Relief Channel

Description

This alternative incorporates the components of the previous two alternatives. It also adds an additional component, which is a new relief channel that connects from the existing side-channel complex to the mainstem, entering the mainstem near RM 62.75. A porous "plug", constructed using large wood, stone, and gravel/cobble, would be placed in the side-channel just downstream of where the new connector channel leaves the side-channel. The porous plug could be configured in a number of ways, including seepage only, narrow surface water connection at low flow (that may be fish passable), or only a narrow surface water connection at higher flows. The plug and connector channel are provided to avoid any increase in flooding on downstream properties and the highway. The existing lower portion of the side-channel downstream of the plug would remain perennially wetted as it is now, and would receive additional flow through the porous plug from the newly connected side-channel upstream. The excavation quantities for the levee removal and side-channel are the same as presented before for the previous alternatives. The additional excavation quantity for the porous plug and relief channel is approximately 330 cubic yards and 3,200 cubic yards, respectively. As with the other alternatives, planting native riparian woody plants would occur within and around the areas disturbed during construction.

Potential Benefits

The combined benefits of the previous two alternatives, described previously, are realized with this alternative. These include the potential for greater fish passage, increased juvenile salmonid rearing quality and quantity, new spawning habitat, and increased floodplain functions including flood-flow dampening and nutrient exchange. This alternative maximizes habitat and ecological functions, particularly as long-term floodplain processes are restored. Futhermore, model results for this alternative do not show an increase flooding to nearby properties and infrastructure compared to the other alternatives.

Design Considerations/Constraints

As with the previous alternatives, alteration to the levee system would require coordination and approvals from appropriate entities with jurisdiction over the levee – both Okanogan County and WA Dept of Ecology were involved in various phases of its construction. Reconfiguration of the ski trail would also be required, potentially requiring a simple bridge over the new side-channel or re-routing of the trail in this area. This will require coordination with stakeholders.

Also similar to the previous alternatives, there are areas of potential uncertainty and risk that will need to be further analyzed and addressed as part of the design phase. These include flooding impacts, the potential for channel migration, sediment transport competency, and stream channel avulsion. These warrant further consideration and incorporation of control measures if necessary. With respect to sediment transport competency, the upstream portion of the side channel will need similar considerations to increase its competency as in Alternative 1, while the steeper relief channel may be more likely to provide sufficient competency relative to the main channel and the upstream portion of the side channel.

4.1.6 Alternative 4 – Mainstem Large Wood

Description

Large wood and log jams are proposed throughout the mainstem and in associated active side-channels and alcoves throughout the project area. These wood placements provide a combination of direct habitat and geomorphic function depending on their location, size, and configuration. We describe here 4 different large wood structure types, although there is frequently overlap between functions.

Apex Log Jams – apex log jams emulate a large tree deposited on a developing point bar and the subsequent accumulation of additional woody material and the development of split-flow conditions (i.e. side-channels). Apex log jams encourage native wood deposition up against the constructed wood structure and gravel deposition in the hydraulic shadows produced by the structure. Apex log jams create horseshoe-shaped scour pools around the head of the structure, which can provide low flow habitat.

Margin Log Jams – margin log jams are placed along channel margins, oftentimes along the outside of meander bends to enhance juvenile rearing and adult holding habitat complexity. The size and configuration of the jams can vary greatly, with the intent to generally mimic the types of margin wood structures found in natural systems. Margin jams are frequently placed along the outsides of bends where wood would naturally accumulate via tree-fall from bank erosion but where, due to human impacts, the riparian trees are no longer available or are of insufficient size.

Bank Log Jams – bank log jams provide direct habitat in the form of pool scour and cover, but compared to margin jams, are designed to provide a greater degree of hydraulic and geomorphic influence on the channel. This influence could include forcing lateral channel migration/erosion, discouraging erosion, or guiding flows into a side-channel. Bank jams can be used in combination with other bank jams or apex jams to constrict the main channel cross-section to backwater flow to activate side-channels. Oftentimes, bank jams are located in areas where the rate of bank erosion is higher than normal due to human-related impacts, such as riparian clearing or channel incision related to artificial confinement. In these cases, they provide a degree of stability until newly planted riparian trees can become established and are able to provide long term natural stability. Bank Log Jams combine both active and passive habitat creation. Immediate habitat is created during installation as pools are excavated and complex wood formations provide overhead cover and visual separation among fish. Habitat is also created passively as the river responds to the structure through scour, shifting channel planform, and bar deposition.

Side-Channel/Alcove Large Wood – side-channel large wood consists of smaller structures or even individual pieces that are designed to provide direct habitat complexity and cover. Local pool scour would be expected around the structure itself but these placements would not be expected to have a significant influence on channel hydraulics or geomorphology. These structures can be placed in a wide array of locations, and are best suited to where smaller wood structures or individual pieces would naturally accumulate. This includes in side-channels, alcoves, along channel banks, and on gravel bars.

Potential Benefits

In the Upper Methow Reach Assessment (Inter-Fluve 2015), the Fawn project area (Reach 2) had 64.3 pieces/mi and 2.9 jams/mi and was rated as "unacceptable" for large wood. Installing log jams in the Mainstem Methow River would mimic the habitat forming function of natural log jams and mitigate for the reduced wood inputs due to clearing of riparian forests. Large wood enhancement can buy time between installation of the structure and the time in which naturally recruited wood enters the channel from restored riparian areas. Wood provides an array of ecological functions. Benefits for salmonid juvenile rearing include cover, complexity, velocity refuge, pool scour, and a substrate for macroinvertebrate production. Benefits to adult fish include pools and cover for holding and gravel capture and sorting for spawning. Geomorphic functions may include hydraulic complexity, split-flow, erosion control, hydraulic roughness, lateral channel migration, capture of fluvially-transported wood, and side-channel activation. Habitat and geomorphic functions by structure type are described above in the Description section.

Design Considerations/Constraints

The primary design considerations include access, construction feasibility of mid-channel structures, anchoring requirements, and river recreational safety. As much of the site is heavily vegetated private land, there will be coordination and planning needed to establish acceptable access roads – and rehabilitation of access routes will be required upon completion of the project. Structures located in mid-channel areas may be challenging to construct depending on the water year and permitting requirements for stream crossings and dewatering. Consultations with permitting agencies should occur early to determine feasibility of construction of specific installations. It will be necessary to establish stability criteria for the structures, and any limitations on anchoring techniques. These considerations will inform log jam engineering design. All log treatments would need to consider boater or recreational user safety and may result in a reduction in the intensity and profile of any wood treatment described above.

4.1.7 Hydraulic Modeling Summary for Fawn Creek Alternatives

The inundation extents and flow depths for the existing and proposed conditions models are summarized in Table 4 through Table 7. The Edelweiss and Fawn Creek oxbows are labeled on the existing conditions drawing in Appendix A. The Levee Side Channel is the restored side-channel in Fawn Creek Alternative 1 and 3. General Floodplain refers to floodplain areas outside the side channel and oxbows.

In general, the Fawn Creek project area proposed alternatives show increased right bank floodplain connectivity and inundation over the whole range of modeled discharges. Alternatives 1 and 3 show increased flow depths and habitat availability in the levee side channel at all modeled discharges. Alternative 2 shows increased flow depths in the levee side channel at and above the 2-year return period peak discharge. Alternatives 1 and 2 show increased right bank floodplain inundation at the 100-year return period peak flow, including additional inundation near and around existing homes and outbuildings. Alternative 3 shows only limited right bank floodplain inundation increases upstream of the proposed side channel plug, and no right bank floodplain inundation increases downstream of the side channel plug.

Table 4: Fawn Creek Project Area Model Findings Summary – 510cfs

	Model			
Area	Existing	Alternative 1	Alternative 2	Alternative 3
Main Channel	Flows contained within channel, some split flow at bars, 5-foot average flow depth			
Edelweiss Oxbow	No flow			
Levee Side Channel	Groundwater	Flow through	Groundwater	Flow through
Fawn Creek Oxbow	No flow			
General Floodplain	No flow			

Table 5: Fawn Creek Project Area Model Findings Summary – 2-year Return Period Peak Flow

	Model			
Area	Existing	Alternative 1	Alternative 2	Alternative 3
Main Channel	Main channel 8-foot average flow depth, flows down well connected side channels			
Edelweiss Oxbow	Shallow flow through			
Levee Side Channel	Shallow flow through	Deeper flow through	Shallow flow over levee removal	Shallow flow over levee removal, flow out relief channel
Fawn Creek Oxbow	Shallow flow through			
General Floodplain	Limited inundation			

Table 6: Fawn Creek Project Area Model Findings Summary – 5-year Return Period Peak Flow

	Model			
Area	Existing	Alternative 1	Alternative 2	Alternative 3
Main Channel	Main channel 10-foot average flow depth, more flows down well connected side channels			
Edelweiss Oxbow	Well connected, deeper flows			
Levee Side Channel	Shallow flow through, outlet backwatered	Deeper flow through	Moderate flow over levee removal, deeper flow in channel	Moderate flow over levee removal, majority of flow out relief channel
Fawn Creek Oxbow	Moderate flow through			
General Floodplain	Moderate inundation, no infrastructure impacts			

Table 7: Fawn Creek Project Area Model Findings Summary – 100-year Return Period Peak Flow

Area	Model			
	Existing	Alternative 1	Alternative 2	Alternative 3
Main Channel	Main channel 12-foot average flow depth Deeper flows down most side channels			
Edelweiss Oxbow	Well connected at two location on upstream end, deeper flows			
Levee Side Channel	Shallow flow through, outlet backwatered	Deeper flow through, flows onto floodplain along channel	Deeper flow over levee removal, flows onto floodplain along channel	Deeper flow over levee removal, flows routed back to main channel at side channel plug
Fawn Creek Oxbow	Wide connection at upstream end over bank, deeper flow through			
General Floodplain	Left floodplain inundation, no right floodplain inundation	Left and right floodplain inundation, increase in right floodplain inundation relative to existing, including impacts to infrastructure		Left floodplain inundation, limited right floodplain inundation

4.2 WEEMAN BRIDGE SITE

4.2.1 Overview of Alternatives

Two treatment actions/alternatives are provided for the Weeman site. These include excavation of a flow-through side-channel and main channel large wood placements. These are not mutually exclusive. Several other alternatives were considered but were not carried forward to this conceptual design stage. These are discussed below.

4.2.2 Alternatives Considered but not Carried Forward

There may be the potential for side-channel and off-channel enhancement that does not include crossing of SR-20. These treatments could include connected alcove/backwater habitat or the creation of a groundwater-fed channel. These treatments would not provide as much habitat as the longer flow-through channel that is included in the concepts, but they could potentially be considered if the longer side-channel cannot be carried forward. The potential for a groundwater-fed channel would require further investigations of groundwater flow potential.

4.2.3 Alternative 1 – Side-Channel

Description

This alternative includes excavation of a 4,000 foot long flow-through side-channel in the river-right floodplain between RMs 61.5 and 60.75. The side-channel alignment would cross SR-20 through a culvert or bridge. A stream-simulation culvert design using either a pipe arch (closed bottom) or open-bottom arch would likely be suitable and the most practical and cost effective. The alignment takes advantage of existing floodplain channel scars. The side-channel would have pools and riffles and large wood placements for complexity and cover. Near the upstream end, there is the potential to create a groundwater-fed backwater alcove that connects up to the new side-channel and that takes advantage of existing channel scars. At this stage, the alcove length is assumed at approximately 600 feet. Total net excavation is approximately 14,800 cubic yards for the side-channel and 750 cubic yards for the groundwater-fed alcove. Planting native riparian woody plants would occur within and around the areas disturbed during construction.

Variations to the side-channel location were considered. At the upstream end, the location was established to avoid an area with an existing alcove and mature cedar trees and to be above a downstream hydraulic control (riffle crest) in the main channel. At the downstream end, there is a wetland area to the west of the proposed side-channel outlet. Emptying the side-channel into this wetland area was considered, but in the end the alignment was moved east to avoid excavation impacts in the wetland. Furthermore, we decided it was important to retain the wetland as a unique type of salmonid rearing habitat different than the flow-through side-channel.

Potential Benefits

The new side-channel would provide new off-channel habitat for juvenile and adult salmonids that contains complex pool-riffle habitat with abundant large wood complexity. The project would provide greater habitat quantity and quality, primarily for juvenile rearing but also potentially for spawning. The project would also provide greater connectivity to floodplain habitats, directly through excavation and by routing water to existing low areas on the floodplain. Additionally, the project provides a greater potential for nutrient exchange between the main channel and floodplain. Because of the road fill associated with SR-20, down-valley floodplain flow has been intercepted through this area. This project would enhance flow through this area and would create a habitat type that would naturally exist in this type of setting but that doesn't currently exist due to floodplain fill and artificial confinement.

These treatments would be expected to improve the habitat indicators that were listed as "At Risk" or "Unacceptable" in the 2015 Reach Assessment, including especially the indicators for Large Woody Material, Pools, Off-Channel Habitat, and Floodplain Connectivity.

Design Considerations/Constraints

More flow would be introduced through the channel, which flows through private properties. Although the project does not significantly increase inundation of the adjacent floodplain areas, potential impacts to landowners via flood inundation or erosion will need to be considered in the final design phase. Although modeling indicates a slightly reduced 100-year inundation extent, that reduction is contingent on the water crossing remaining open. If the crossing becomes clogged, the inundation extents would likely be similar to existing conditions at the 100-year event. Long-term accumulation of sediment in the side-channel could affect its long term function. Sediment transport competency would need to be provided for the final design configuration. An initial analysis of channel sediment transport competency, given the preliminary proposed side channel slope of 0.44% compared to the slightly flatter adjacent main channel slope of 0.40%, suggests that the sediment transport competency of the side channel may be similar to the main channel.

Reconfiguration of the ski trail would also be required, potentially requiring a simple bridge (or 2) over the new side-channel or re-routing of the trail in this area. This will require coordination with landowners and other stakeholders.

The new stream channel crossing at SR-20 will require traffic control and likely a temporary bypass during construction. Use of a closed-bottom culvert (e.g. pipe-arch) would require less impacts to traffic, whereas an open bottom arch that requires the pouring of concrete footings would require more lengthy and expensive traffic management.

4.2.4 Alternative 2 – Mainstem Large Wood

Description

Large wood and log jams are proposed throughout the mainstem in the project area. These wood placements provide a combination of direct habitat and geomorphic function depending on their location, size, and configuration. In the Fawn section above, we describe four different structure types and their general function. For the Weeman project, we primarily would rely on apex jams and bank jams. The apex jams would serve to enhance split-flow conditions and to encourage the formation of vegetated island complexes. The bank jams would be used along the armored bank margin on river-left just upstream of the Weeman Bridge and on river-left at the downstream end of the site. The upper bank jams are designed to provide margin complexity to a bank that is relatively fixed in place due to the highway location. The downstream jams are designed to increase complexity and pool scour near the riprap bank and cleared pasture area on river-right.

Large wood placements were considered in the main channel near RM 61 and in nearby downstream areas; however, there is a potential for wood placements at these locations to cause a main channel avulsion affecting recently restored habitat (Fender Mill Project, Yakama Nation Fisheries, 2015). For these reasons, no log jams were identified for this location, but could be considered again in the future depending on geomorphic conditions.

Potential Benefits

In the Upper Methow Reach Assessment (Inter-Fluve 2015), the Weeman project area (Reach 1) had the lowest large wood counts for the entire Reach Assessment area (19 miles). There were only 2.5 pieces/mi and no jams. It was rated as "unacceptable" for large wood. Installing log jams in the Mainstem Methow River would mimic the habitat forming function of natural log jams and mitigate for the reduced wood inputs due to clearing of riparian forests. Large wood enhancement can buy time between installation of the structure and the time in which naturally recruited wood enters the channel from restored riparian areas. Wood provides an array of ecological functions. Benefits for salmonid juvenile rearing include cover, complexity, velocity refuge, pool scour, and a substrate for macroinvertebrate production. Benefits to adult fish include pools and cover for holding and gravel capture and sorting for spawning. Geomorphic functions may include hydraulic complexity, split-flow, erosion control, hydraulic roughness, lateral channel migration, capture of fluvially-transported wood, and side-channel activation.

Design Considerations/Constraints

The primary design considerations include access, construction feasibility of mid-channel structures, anchoring requirements, and river recreational safety. As much of the site is heavily vegetated private land, there will be coordination and planning needed to establish acceptable access roads – and rehabilitation of access routes will be required upon completion of the project. Construction of the bank jams just upstream of the Weeman Bridge could require some traffic control. Structures located in mid-channel areas may be challenging to construct depending on the water year and permitting requirements for stream crossings and dewatering. Consultations with permitting agencies should occur early to determine feasibility of construction of specific installations. It will be necessary to establish stability criteria for the structures, and any limitations on anchoring techniques. These considerations will inform log jam engineering design. All log treatments would need to consider boater or recreational user safety and may result in a reduction in the intensity and profile of any wood treatment described above.

4.2.5 Hydraulic Modeling Summary for Weeman Alternatives

The inundation extents and flow depths for the existing and proposed conditions models are summarized in Table 8 through Table 11. The General Floodplain refers to floodplain areas outside the proposed side channel.

In general, the Weeman Bridge project area floodplain is inundated at lower discharges relative to the Fawn Creek project area. The proposed Weeman side channel alternative provides increased off channel area without an increase in floodplain inundation. Notably, at the 100-year return period peak flow, the model actually indicates a potential reduction in floodplain inundation and water levels around the west side approach to the Weeman Bridge. At these peak flows, the proposed side channel and new water crossing under State Route 20 provide additional floodplain flow conveyance and reduce the ponding that currently takes place on the upstream side of the road. This reduction in ponding is contingent on the new water crossing remaining open, without being obstructed by debris or sediment.

Table 8: Weeman Bridge Project Area Model Findings Summary – 510cfs

	Model	
Area	Existing	Proposed
Main Channel	Flows contained within channel, some split flow at bars, 5-foot average flow depth	
Proposed Side Channel	N/A	Shallow flow through
State Route 20	No water along road ditch	Water through new crossing
General Floodplain	No flow	No flow

Table 9: Weeman Bridge Project Area Model Findings Summary – 2-year Return Period Peak Flow

	Model	
Area	Existing	Proposed
Main Channel	Flows out on floodplain, 8-foot average flow depth	
Proposed Side Channel	N/A	Moderate flow through
State Route 20	Water along road ditch	Water through new crossing
General Floodplain	Moderate inundation	

Table 10: Weeman Bridge Project Area Model Findings Summary – 5-year Return Period Peak Flow

	Model	
Area	Existing	Proposed
Main Channel	Flows out on floodplain, 10-ft average flow depth	
Proposed Side Channel	N/A	Moderate flow through
State Route 20	Water on edge of road	Water through new crossing
General Floodplain	Extensive inundation	

Table 11: Weeman Bridge Project Area Model Findings Summary – 100-year Return Period Peak Flow

	Model	
Area	Existing	Proposed
Main Channel	Flows out on floodplain, 12-ft average flow depth	
Proposed Side Channel	N/A	Deep flow through
State Route 20	Water flowing over road	Water through new crossing and on edge of road
General Floodplain	Extensive inundation, including right bank terraces	

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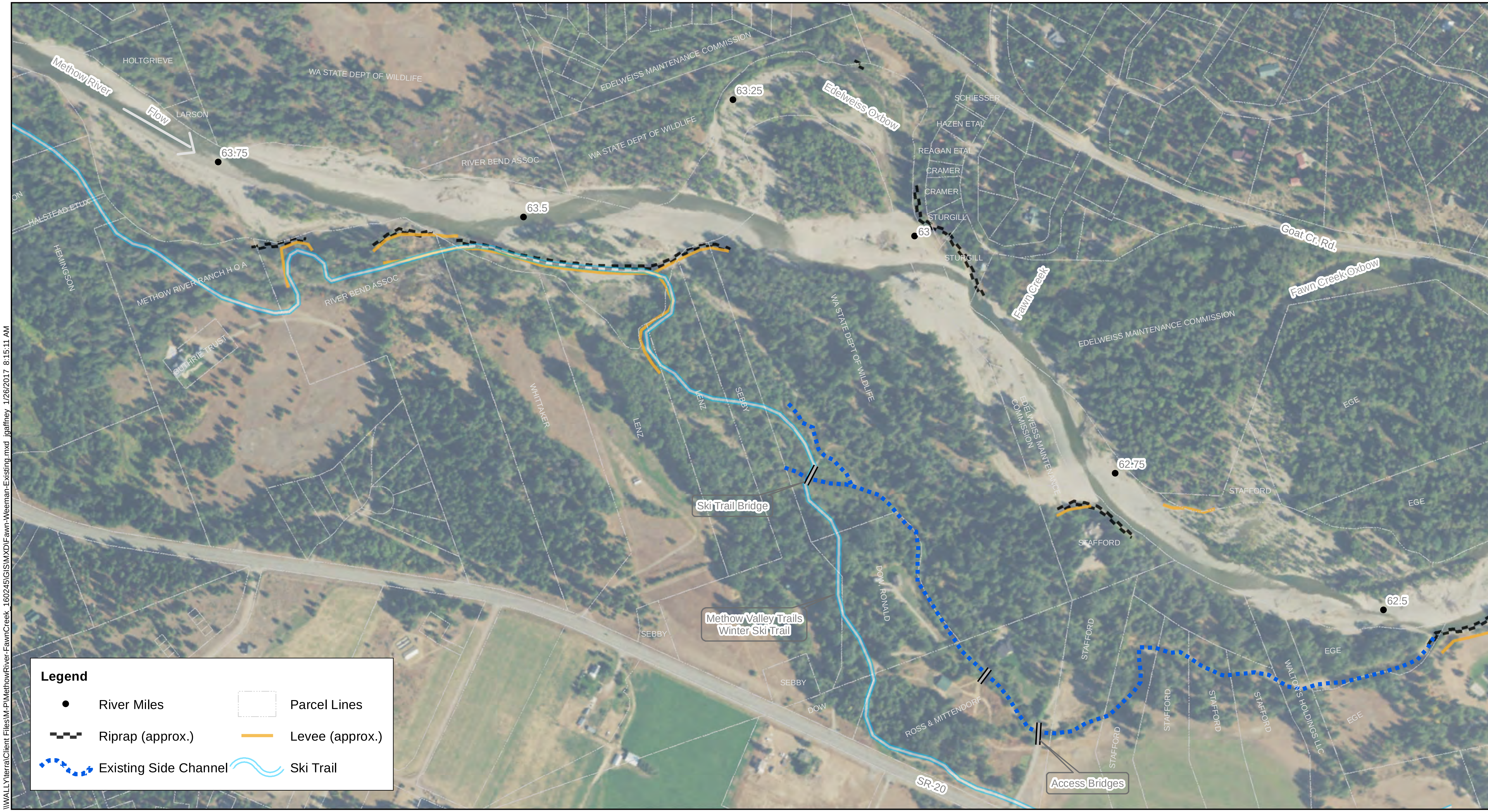
Appendix A

Concept Drawings

Upper Methow River – Fawn Creek & Weeman

Habitat Restoration Concept Design Report

January 27, 2017



N

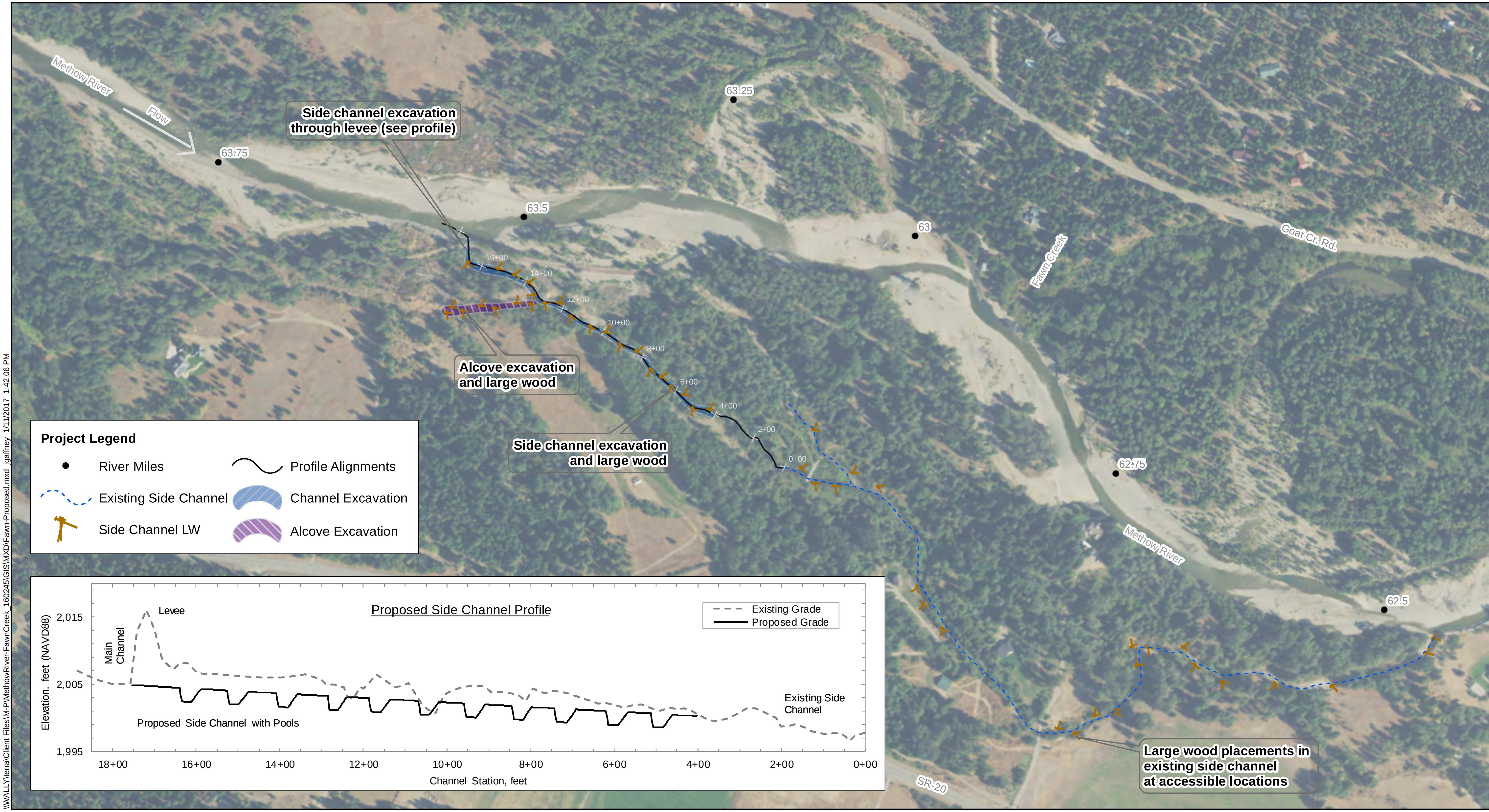
Feet

0 400 800

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.
2. Parcel lines and ownership from Okanogan County, WA as of January 2017.
3. Ski trails delineated from Methow Trails winter recitation map as of January 2017.

Existing Project Area Conditions - Figure F1

Fawn Creek Project Area
Methow River, WA
Yakama Nation Fisheries



inter·fluve inc.

Yakama Nation Fisheries

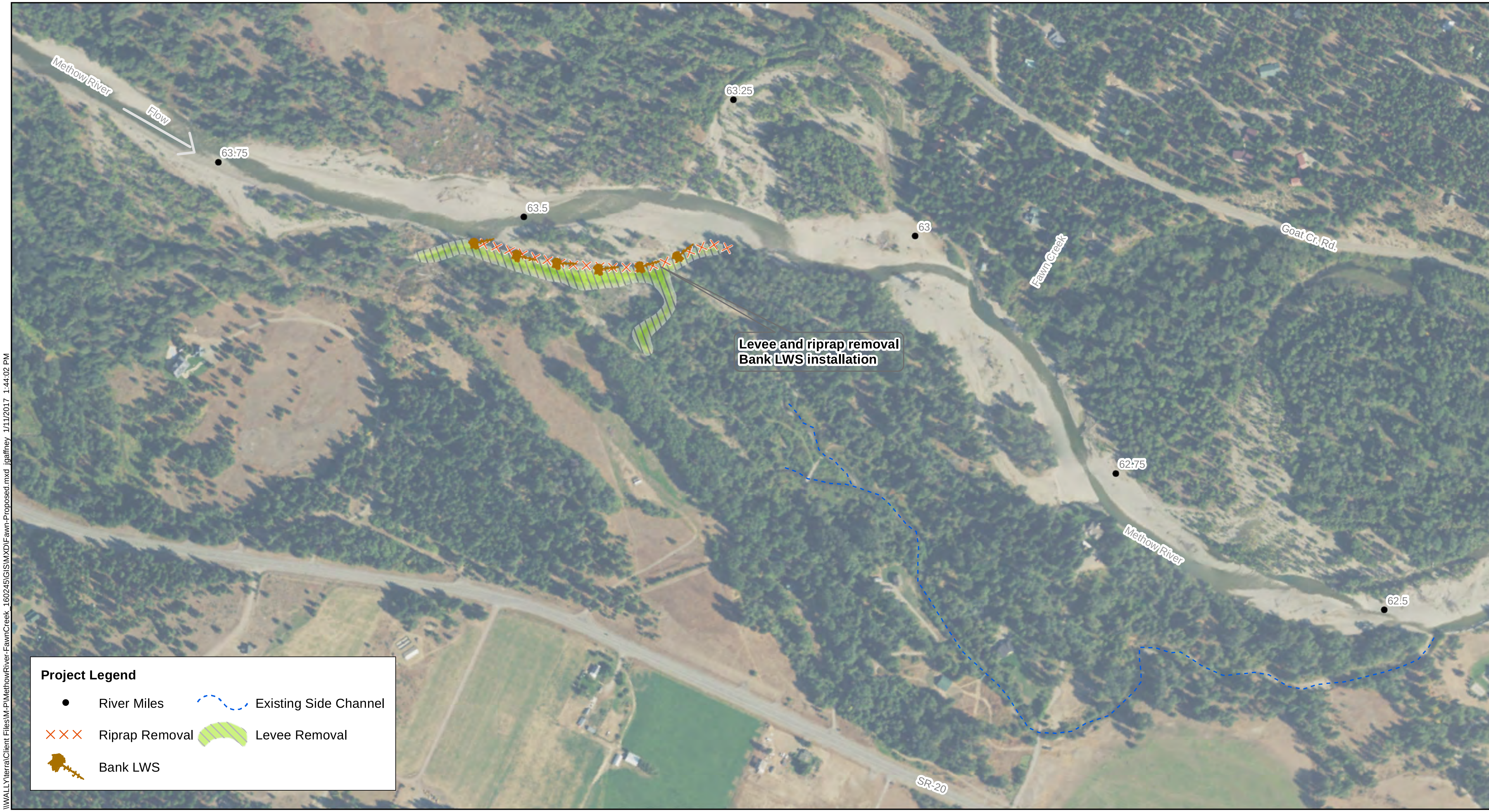
N

Feet
0 400 800

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure F2
Alt. 1 - Side Channel and Alcove

Fawn Creek Project Area
Methow River, WA
Yakama Nation Fisheries



\\WALLY\terra\Client Files\M-P\MethowRiver-FawnCreek_160245\GIS\MXD\Fawn-Proposed.mxd jgaffney 1/11/2017 1:44:02 PM

inter·fluve inc.

Yakama Nation Fisheries

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Feet
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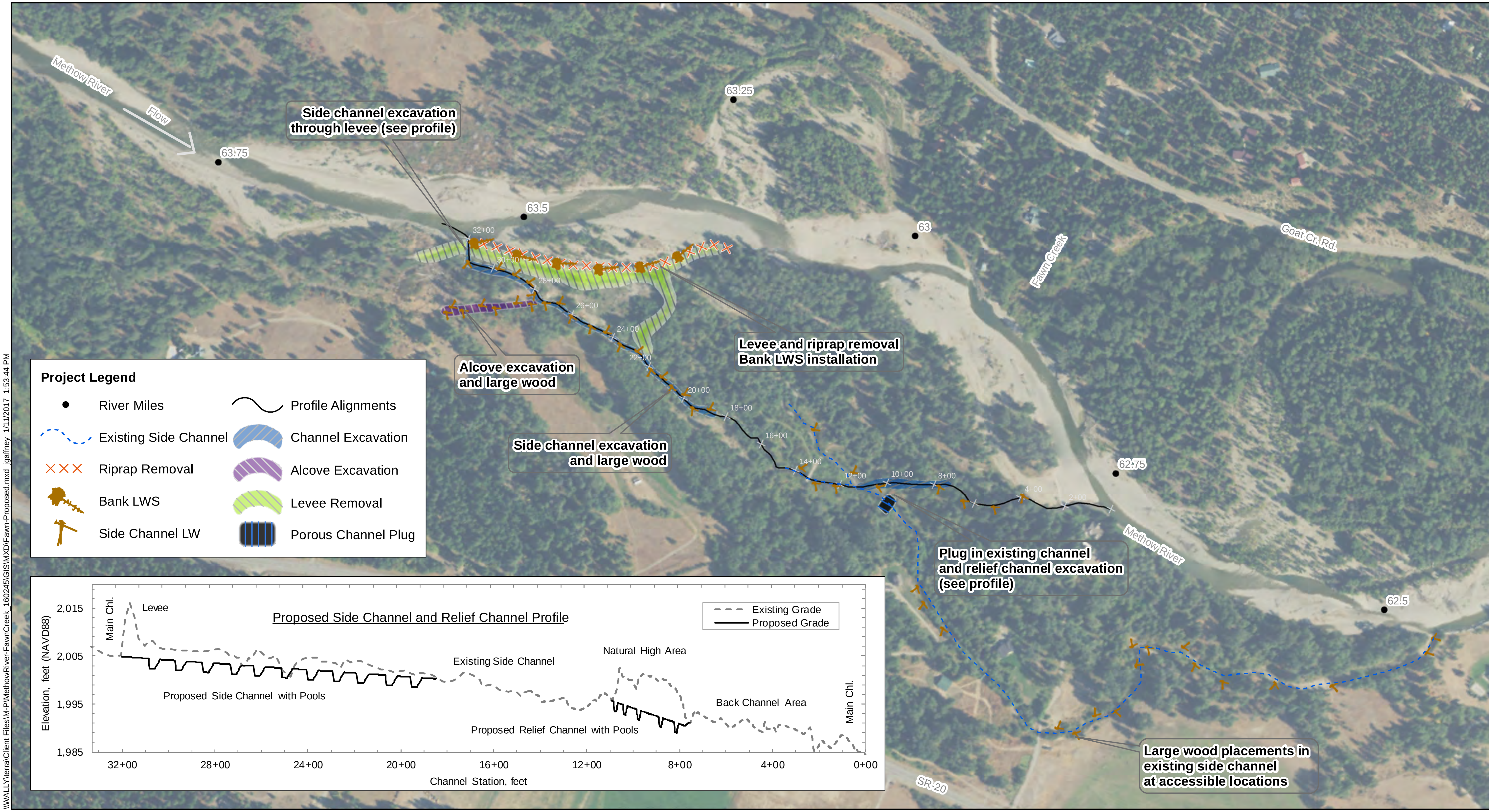
Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure F3
Alt. 2 - Levee Removal and Bank LWS

Fawn Creek Project Area
Methow River, WA
Yakama Nation Fisheries



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Yakama Nation Fisheries

N

Feet
0 400 800

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure F4
Alt. 3 - Side Channel, Alcove, Plug, and Levee Removal

Fawn Creek Project Area
Methow River, WA
Yakama Nation Fisheries

inter·fluve inc.

Yakama Nation Fisheries

N

Feet
0 400 800

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure F5
Alt. 4 - Main Channel Large Wood

Fawn Creek Project Area
Methow River, WA
Yakama Nation Fisheries

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N

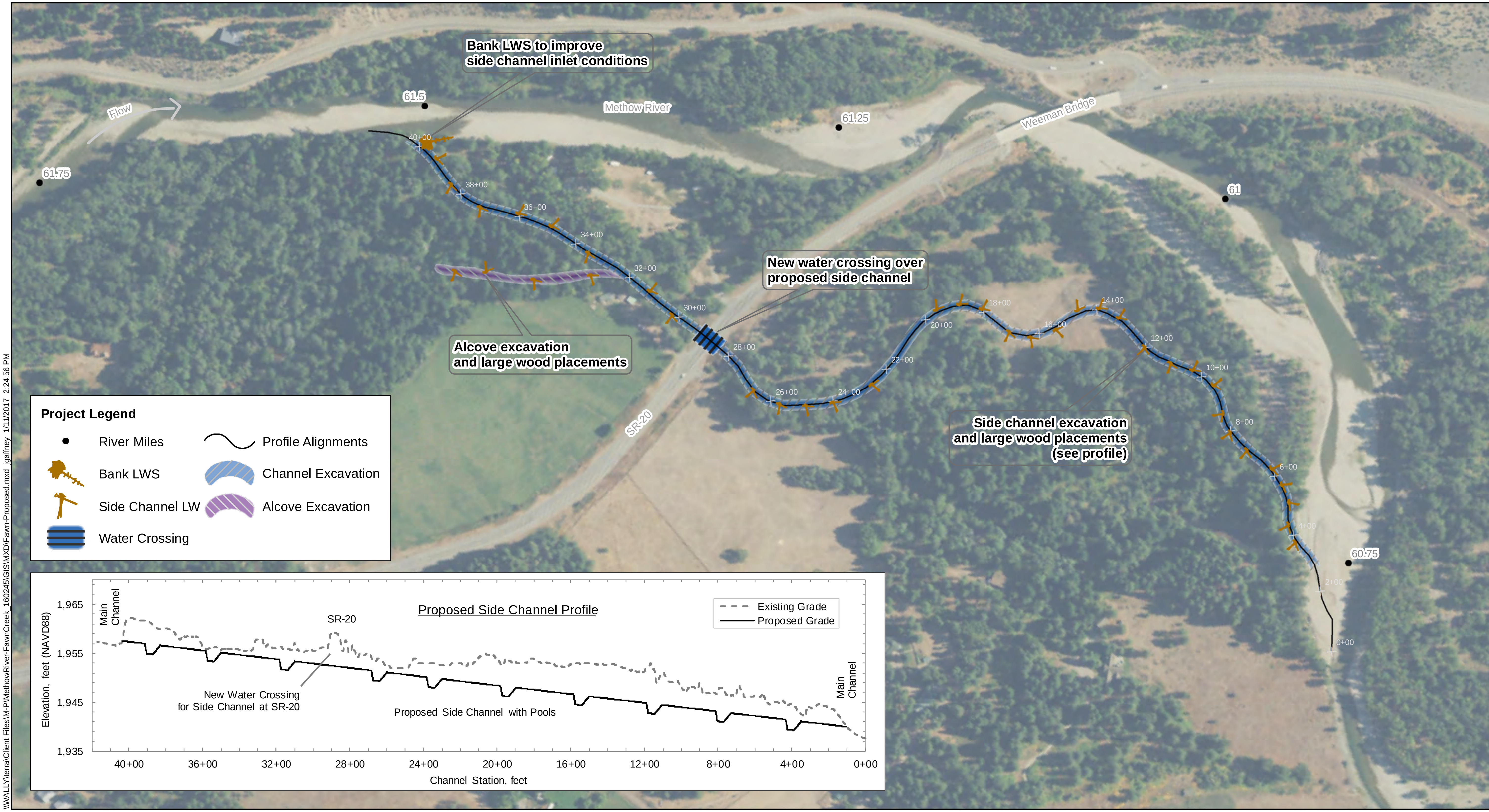
Feet

0 300 600

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.
2. Parcel lines and ownership from Okanogan County, WA as of January 2017.
3. Ski trails delineated from Methow Trails winter recitation map as of January 2017.

Existing Project Area Conditions - Figure W1

Weeman Bridge Project Area
Methow River, WA
Yakama Nation Fisheries



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N

Feet
0 300 600

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure W2
Side Channel and Alcove

Weeman Bridge Project Area
Methow River, WA
Yakama Nation Fisheries

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N

Feet
0 300 600

Base Data Notes:
1. 2015 NAIP aerial photo shown. Photo taken September 11 2015 with a mean daily discharge as recorded at the Mazama USGS 12447383 gage of 10 cubic feet per second.

Conceptual Project Layout - Figure W3
Main Channel Large Wood

Weeman Bridge Project Area
Methow River, WA
Yakama Nation Fisheries