Yakima RM 89.5- Floodplain Restoration

Technical Memo: Site Assessment

SUBMITTED TO
Yakama Nation
Wildlife Resources Management Program

January, 2018

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Toppenish, WA

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1. Introduction

1.1 OVERVIEW

The Yakima River RM 89.5 Floodplain Restoration Project area includes approximately 900 acres of historical floodplain along approximately 4 miles of the mainstem Yakima River. The Yakima River is 214 miles long and is a major tributary in the Columbia River basin (Figure 1). The project area is located on the border of, but contained entirely within, the Yakama Indian Reservation. The site is managed by the Yakama Nation Wildlife Resources Management Program. Current land uses include wildlife habitat conservation, agriculture with ditched irrigation on the west side, and sparse residential development next to the project area. This technical report provides a summary of the existing geomorphic, hydrologic, and ecologic conditions of the site. The content of this assessment is compiled from existing data and reports combined with 2017 field surveys and hydraulic modeling. This assessment serves as a baseline evaluation of site conditions and will be used to support the development of restoration treatment alternatives to improve floodplain and habitat conditions throughout the project area.

1.2 GOALS AND OBJECTIVES

The overarching goal of this project is to improve floodplain and side-channel connectivity to the mainstem river to restore high-quality habitat for native avian, terrestrial, and aquatic communities. The project objectives are:

1. To the extent possible, increase inundation of floodplain, wetland, and side-channels—emphasizing the area cut off by levee construction
2. Reduce or not increase flood hazard for properties adjacent to the project area
3. Enhance fish and wildlife habitat in the floodplain, side channels, and mainstem Yakima River

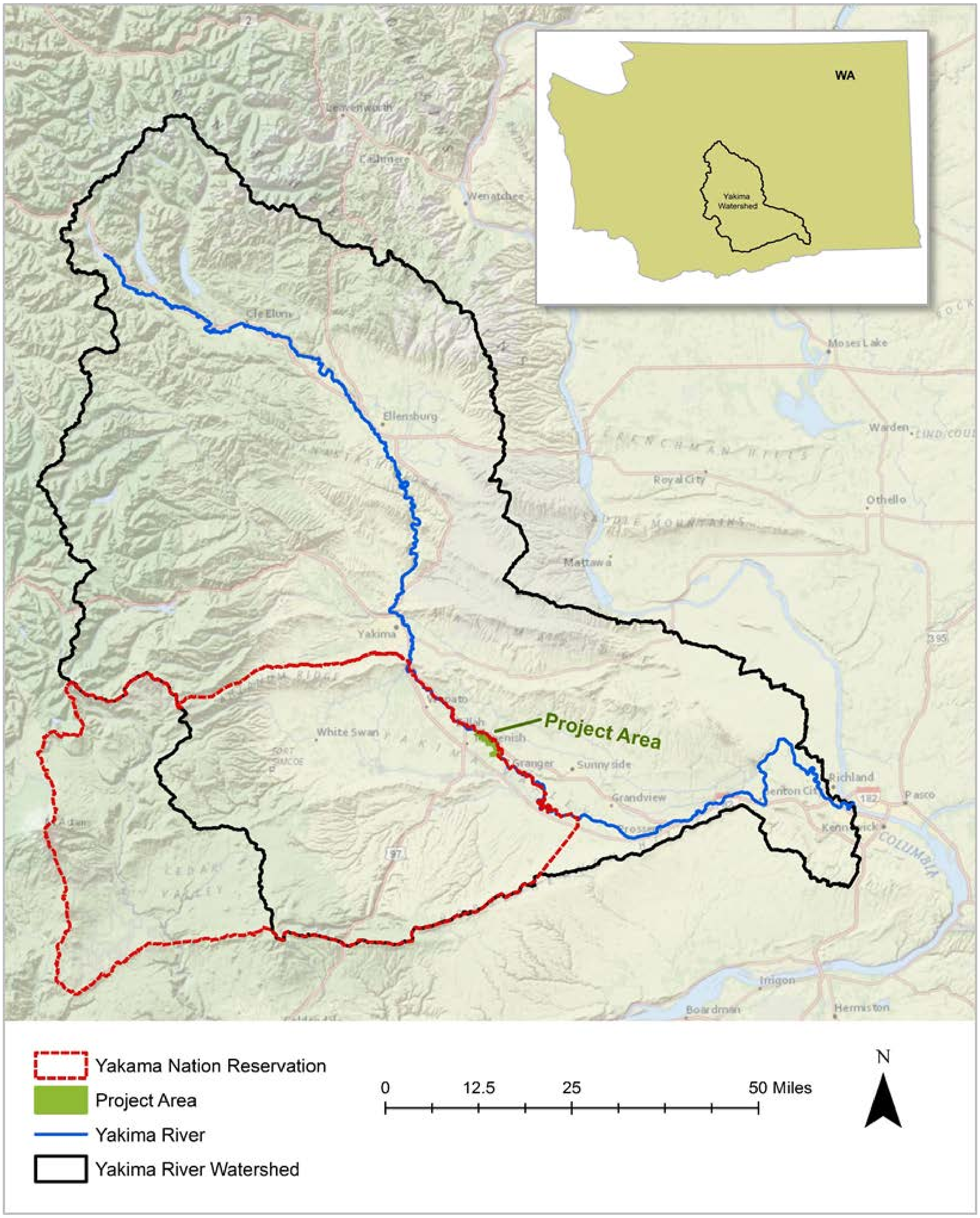

Figure 1. Yakima River Watershed with Project Area in green.

1.3 PROJECT AREA

The project area includes approximately 900 acres of floodplain on the river right (west) side of the Yakima River as well as the mainstem Yakima River between river miles 87 and 91 (Figure 2). The modern active floodplain within the project area has very low down-valley gradient (0.19%) and ranges from 0.8 miles to 0.1 miles wide relative to the modern location of the mainstem Yakima River. Irrigation ditching, roads, bridges, gravel mining, and agriculture have encroached on what was historically an active floodplain at least 2 miles wide less than a hundred years ago (based on aerial photos and observations of topographic scarring). The ungraded portions of the modern floodplain have irregular surface topography with multiple historical channel pathways and meander scars. There are pockets of active floodplain on the east side of the Yakima River between the channel and a partially-confining natural terrace. A 3,400-foot long levee constructed in the late 1970s near RM 89.5 halted local lateral migration and disconnected the mainstem channel from its adjacent and downstream floodplain. Upstream from the project area, irrigation infrastructure including dams and irrigation diversions alter the site's natural seasonal flow regimes. The two diversions immediately upstream from the project area (Wapato and Sunnyside) are estimated to reduce average summer flow by two thirds (USBR, 2017a; Yakama Nation, 2017).

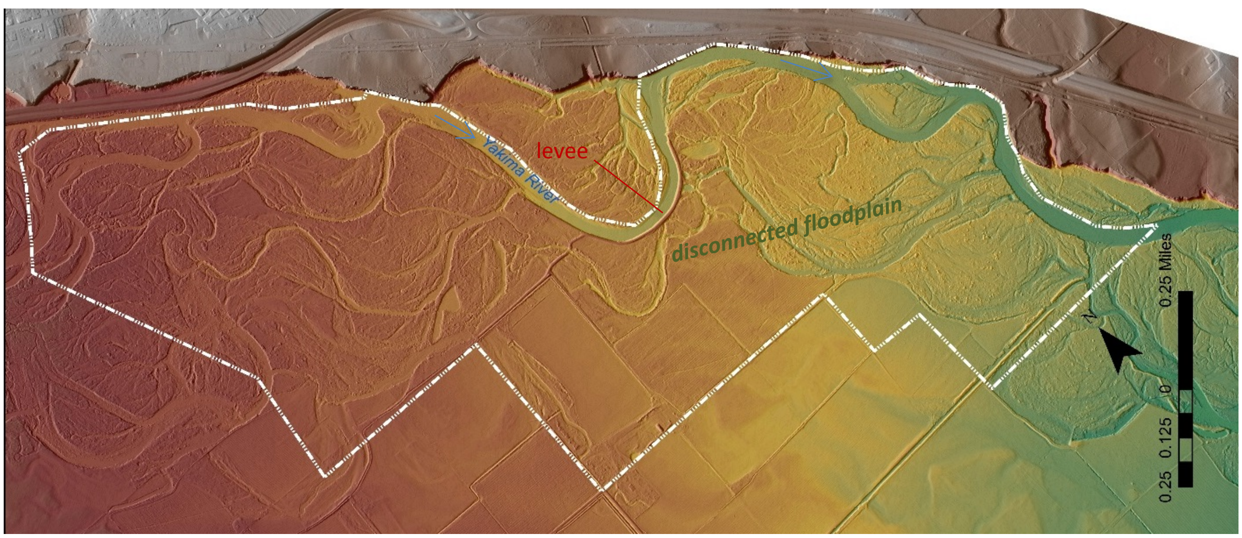

Figure 2. Project area showing the levee and disconnected floodplain. Basemap: LiDAR (WCI, 2015)

Floodplain wetland and riparian areas along the Yakima River support important cultural resources and provide critical wildlife habitats in the otherwise arid and semi-arid Yakima Valley. These ribbons of ecologic diversity provide critical resources to avian, terrestrial, and aquatic species such as shelter, mobility corridors, food and nutrient production, and varied life-stage habitats. A few of the important cultural resources offered by functioning floodplain wetlands and riparian areas include traditional foods and fibers. A well-functioning floodplain ecosystem is dependent on the frequency and duration of access to surface and groundwater resources.

The modern floodplain at the project area contains multiple meander scars. Some of the scars retain water (oxbows) and thus provide annual or seasonal wet-environment habitats that support a myriad of aquatic and riparian plants as well as birds, mammals, reptiles, amphibians, and insects. However, hydrologic flow regime alterations, built infrastructure (bridges, levees, irrigation, etc.), and a reduction in functioning floodplain due to human land-use encroachment have diminished the quantity and quality of habitat available along the mainstem Yakima River, including within the project area. Reconnecting floodplain processes and side-channel habitat therefore have significant potential to improve floodplain ecosystem dynamics and complexity. These actions are expected to yield important cultural resource and habitat benefits for aquatic, terrestrial, and avian species.

Figure 3. Disconnected groundwater-fed oxbow downstream of levee with vegetated banks. (Photo: Inter-Fluve, June 2017)

Figure 4. Oxbow pond survey on Oct 4, 2017. (Photo: Inter-Fluve)

2. Site Surveys

Inter-Fluve staff visited and surveyed the project area during multiple site visits. The initial site visit occurred on June 27, 2017. After existing data review and analysis, field-based surveys of the site were completed by Inter-Fluve survey teams on October 3 and 4 and again on November 9 and 10, 2017. Field surveys were completed to support hydraulic model development and evaluate existing geomorphic and ecologic conditions within the project area to inform restoration treatment design. The site surveys included topography and bathymetry of selected areas to validate, supplement, and update the available high-resolution LiDAR data (WCI, 2015). These efforts focused on surveying channel and floodplain features that were wetted when the LiDAR data were collected. Bathymetry of the mainstem channel was collected with boat-mounted sonar equipment during the November survey and those data were used to update the modern form and location of the channel since the 2015 LiDAR flight. In addition to acquisition of topographic data, field surveys noted general conditions and trends of the existing geomorphology, hydrology, and ecology of the project area.

Figure 5. Mainstem Yakima River at RM 89.5 – looking upstream. The vehicle is parked on the road atop the large boulder riprap levee. (Photo: Inter-Fluve, June 2017)

3. Assessment – Existing Site Conditions

3.1 GEOLOGIC SETTING

The project area is located within the wide Yakima Valley between Ahtamun Ridge and Toppenish Ridge. These ridges and underlying basement geology of the Yakima Valley are composed primarily of layers of Columbia River Basalt and interbedded layers of sedimentary rock (formed 16.5 to 14.5 million years ago). The east-west trending ridge and valley topography were created by north-south tectonic compression that formed the Yakima Fold Belt between 16 and 10.5 million years ago (Reidel et.al, 2003; Tolan et al., 2009). The Yakima Valley is a relatively low gradient alluvial valley that subtly dips eastward. The valley's alluvium is a combination of aeolian material (loess and volcanic ash), colluvium (local hillslope contributions), and fluvial deposits sourced from headwater channels in the volcanic and glaciated Cascade Mountains, local Yakima Fold Belt ridges, and backwater flood deposits from the Columbia River.

The last glacial processes during the Pleistocene and early Quaternary epochs contributed significantly to surficial deposits within the Yakima Basin that continue to influence modern geomorphology and sediment supply. Although glaciers did not advance down the Yakima River to the project area during the last glacial maximum (~24,000 years ago), sediment produced by glacial erosion was transported to the basin via rivers, floods, and wind (Jones et al., 2006).

Over forty glacial outburst floods, collectively known as the Missoula Floods, occurred at the end of the Pleistocene, between approximately 19,000 and 12,000 years ago. The source of these floods was Glacial Lake Missoula, which was impounded by the Purcell Trench Lobe of the Cordilleran Ice Sheet near the western border of Montana, along what is now known as the Clarks Fork River Valley. When the ice dam was periodically breached, massive quantities of water were released, producing several catastrophic floods that scoured eastern Washington and flowed down the Columbia River and out to the Pacific Ocean (Benito & O'Connor, 2003; Clague et al., 2003). A hydraulic constriction on the Columbia River at Wallula Gap backed water into the Yakima River

Valley, backfilling it with a thick layer of flood deposit alluvium. The backwater flood deposits, known as the Touchet Beds, filled the valley to approximately 1,080 feet elevation. The flood deposits are composed of sands, silts and some clay (Bently et al, 1980). Fine-grained loess, transported via wind from more proximal sources such as the Cascades, contributed additional sediment to the basin during the Quaternary.

Throughout the Holocene (~12,000 years ago to present), rivers in the Yakima Valley have been responding to the large quantities of relatively fine-grained alluvium deposited by the Missoula Floods. During that time the Yakima River has eroded into, reworked, and occupied multiple pathways through the Missoula flood deposits. The general lateral process of the mainstem channel has been eastward but the wide low gradient valley produced extensive channel meandering and flow paths. The resulting topography in the project area is a heavily scarred complex floodplain on the west side of an active meandering mainstem channel, with high Touchet terraces on the east side.

Figure 6. Yakima River at RM 89.5 – on river right looking downstream. (Photo: Inter-Fluve June 2017)

3.2 CLIMATE

The climate of the lower Yakima Valley generally consists of dry, warm summers and cold, relatively wet winters. The majority of the precipitation throughout the basin falls as rain and snow in the winter and spring (PRISM Climate Group, Oregon State University, 2017). There is a large difference in annual precipitation received across the basin. The headwaters to the north and west receive an average of approximately 90 inches and 30 inches of precipitation a year, respectively, while the project area receives only about 8 inches annually.

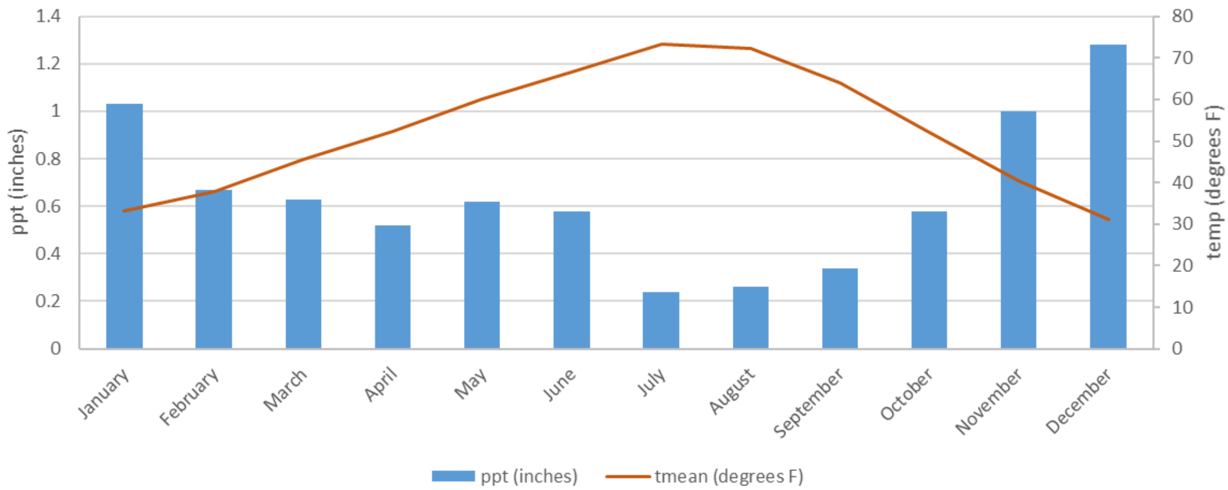

Figure 7. Average monthly (30 yr. normal) precipitation (ppt) and temperature (tmean) at the project site. (PRISM 2017)

In the assessment area, mean average daily air temperatures throughout the winter (Dec – Feb) are around 34°F, with a minimum of 24°F and a maximum of 47°F. As a result, snow accumulations in the assessment area vary from year to year. The mean average daily air temperature in the summer months (June – August) is 71°F with average maximums and minimums fluctuating between about 52°F and 90°F (PRSIM Climate Group, Oregon State University, 2017).

3.3 LAND USE HISTORY AND HUMAN FEATURES

Historical conditions are considered to be those that were present prior to the large-scale human alterations brought on by Euro-American influences and settlement in the early 1800s. Historical conditions in the project area would have been influenced by resource utilization on the part of dense populations of native peoples and relatively unimpaired ecological function. These conditions tend to represent the conditions to which native plant and animal species were best adapted. In many cases, restoration to historical conditions will be impossible or inappropriate; however, historical conditions do provide a reference point to help determine how habitats and processes have changed and to inform site potential and the identification of restoration objectives.

Humans have inhabited the Yakima Valley for thousands of years (Yakama Nation, 2011). Early land use was limited to hunting and gathering by native peoples that had presumably minimal impact on the landscape and riparian corridor of the Yakima River. The Yakama and other Sahaptin peoples did not encounter horses until ~1730 (Haines, 1938). In 1840, Kamiakin traded horses for the Hudson Bay Company's cattle, and Yakamas hired to drive cattle over Naches Pass in 1841 are noted as acquiring stock (Gossett, 1964). The Yakima Valley and surrounding areas became a commercial grazing hub, and by 1874 Yakama tribal members owned approximately 13,000 horses and 1,200 head of cattle (Heidenreich, 1931). Increased grazing along with beaver and fur trapping in the early 1800s likely began to alter riparian habitats in the area. European settlement in the mid-1800s also brought agricultural practices that transformed the landscape. The Yakama Indian Reservation was established by the Treaty of 1855 and was ratified in 1859. Built canal irrigation was used as soon as 1860 for small scale crop production by the Yakama people (Yakama Nation, 2011).

The modern irrigation system is extensive and now supports one of the most productive agricultural regions in the state.

Land surveys, LiDAR, historical air photos, and the underlying geology provide some insight into historical channel forms and the evolution of the Yakima River and its floodplain over the last 200 years. In the area near the Yakima RM 89.5 project area, topographic signatures and aerial photos indicate that the historical floodplain was at least 2 miles wide – over twice the width of the modern floodplain. Multiple mainstem and side channel pathways were likely frequently activated across the broad low-gradient historical floodplain surface. Based on topographic scarring and imagery, channel meandering—as well as an overall eastward lateral migration and downstream transverse migration—were very active. The lateral processes likely resulted in plentiful large wood recruitment from the vegetated floodplain that supported complex aquatic habitat in the channel. Beaver activity likely influenced both habitat complexity and geomorphology throughout the side channels and floodplain. Floodplain inundation would have been much more frequent prior to the construction of the upstream dams and the extensive irrigation canals in place today. Similarly, summer base-flows would have also been larger than they are today. The historical floodplain was probably vegetated with a mosaic of native riparian trees, shrubs, forbs, and grasses. Vegetation density would have varied across the surface depending on proximity to surface and ground water. It is assumed that this healthy complex riparian corridor in the semi-arid region of the Yakima Valley was an ecologic oasis, thriving with terrestrial, avian, and aquatic species.

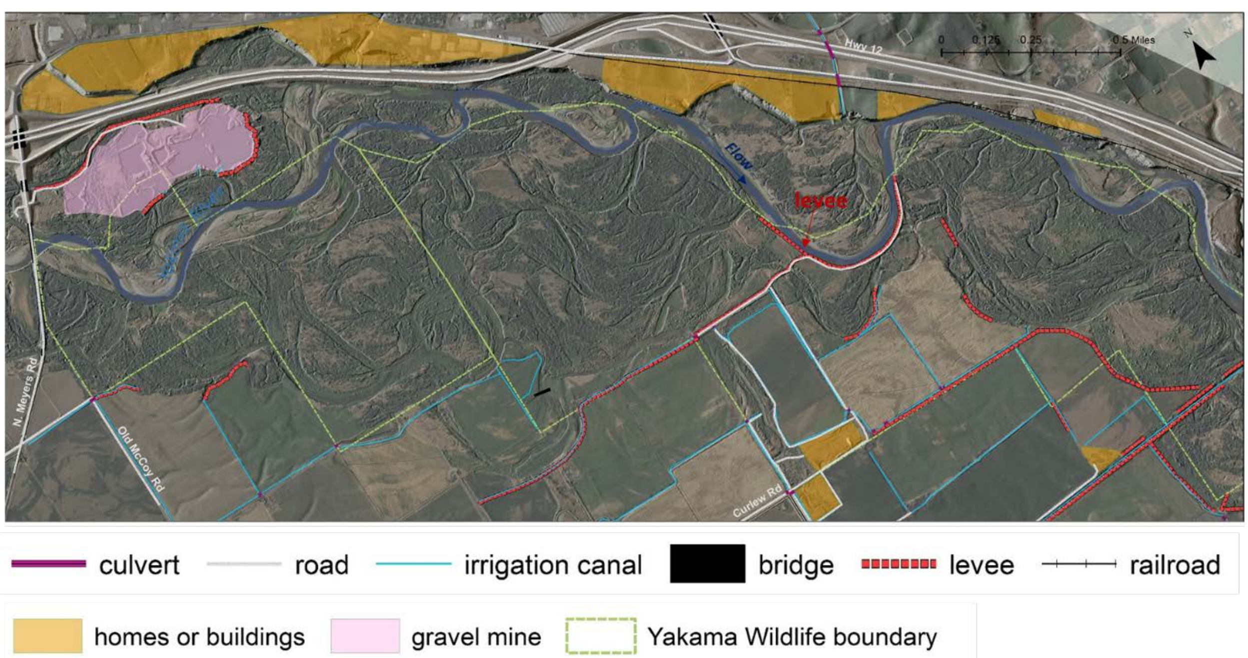

Figure 8. Primary human-built features that influence the modern channel and floodplain. Homes and development on river left are located atop the Touchet terrace and out of the modern floodplain.

Based on the historical aerial photo record (1937 to present), habitat conditions of the modern floodplain and channels within the project area have been most impacted by agricultural land use and levee construction. The local anthropogenic influences on the modern channel and floodplain are mapped in Figure 8. Agriculture was well established in the Yakima River basin by 1937, with levees, ditches, and agricultural fields present south of the project area. The Evergreen Highway (Hwy 22) and bridge over the Yakima River were also already in place during this time. A gravel pit mine that began in the late 1950s now occupies approximately 85 acres of river-left (east) floodplain near the upstream extent of the project area immediately downstream of the North Meyers Road bridge crossing. Floodplain clearing and agriculture encroachment occurred up until 1979 in several areas, including downstream of the mainstem levee on the river right side of the meander bend. The levee and road were installed here by 1979 to arrest the southward bank migration and to reduce flooding impacts to agriculture and home sites. Currently, the floodplain at and downstream of the mainstem levee is disconnected except at large flood events from the mainstem channel by the large boulder riprap feature that extends 3,400 feet along the meander bend. Within the project area, the channel is bounded on the east side by a high terrace of Missoula Flood deposits with human infrastructure on top of it, such as roads, homes, a railroad, and the town of Zillah. Select historical photos of the site are provided in Figure 9.

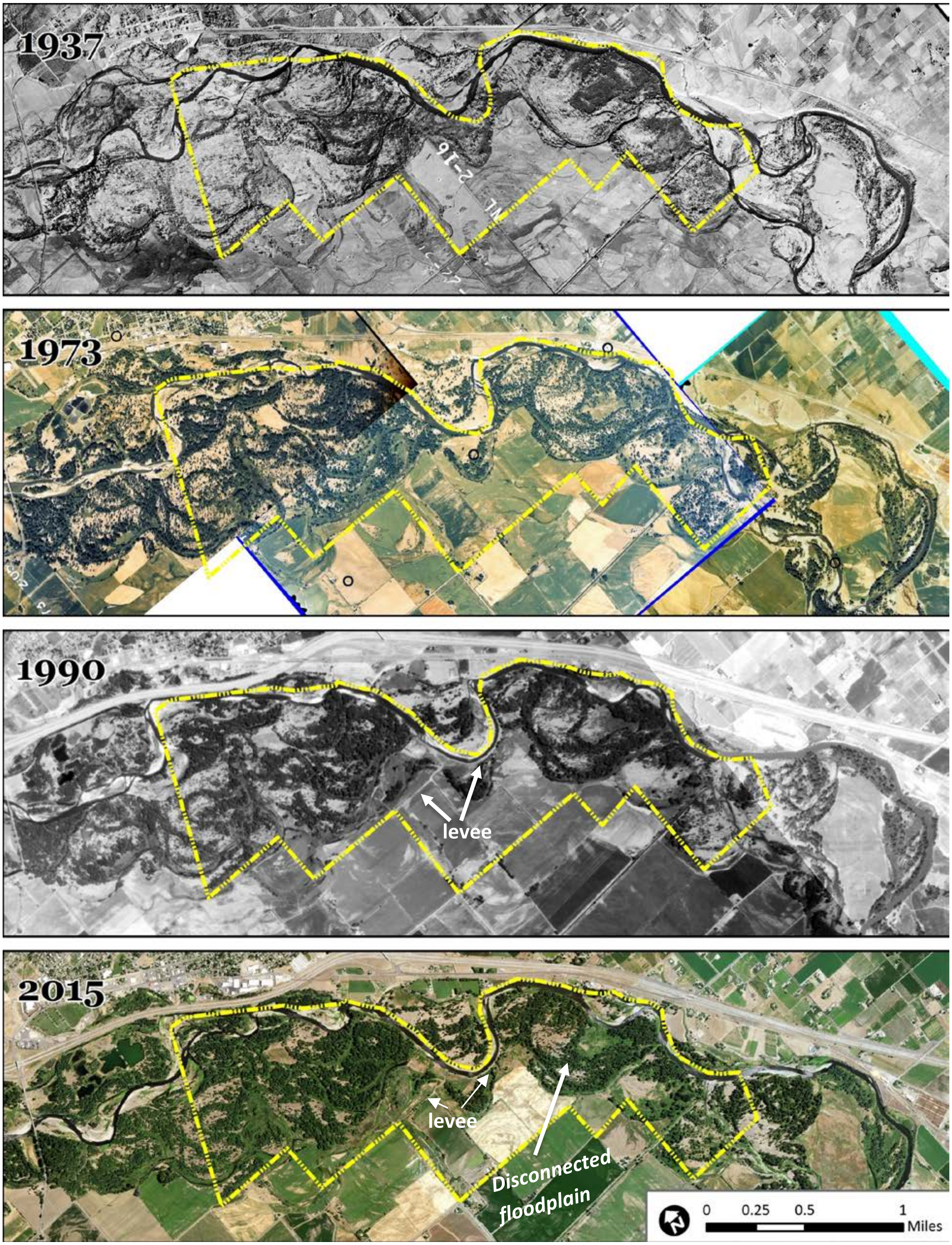

Figure 9. Historical aerial photos of the project area: 1937, 1973, 1990, 2015.

3.4 HYDROLOGY

Hydrologic Setting

The Yakima River drains approximately 6,150 square miles from its headwaters in the Cascade Range to its mouth at Richland, Washington (see Figure 1). The Yakima River basin is a primary tributary to the Columbia River. At the project site, near Zillah, Washington, the Yakima's upstream drainage area is approximately 3,700 square miles. The Yakima is fed primarily by snowmelt in its uppermost reaches, with additional tributary inputs throughout the watershed. The largest volume tributaries converge with the river upstream of the town of Yakima. This reflects the river's west to east transition from areas of higher precipitation in the east Cascade mountains to the semi-arid interior of the Columbia Basin. The Yakima Valley is an important zone of agricultural production because of the extensive irrigation and water retention infrastructure. These features regulate and alter the channel's annual hydrograph at the project area. Water retention includes a series of large dammed reservoirs (Keechelus Lake, Kachess Lake, and Cle Elum Lake) in the headwaters near Snoqualimie Pass that release water for use during the dry summer and fall down to the smaller irrigation diversion dams at Roza, Parker/Wapato, and Sunnyside (Figure 10).

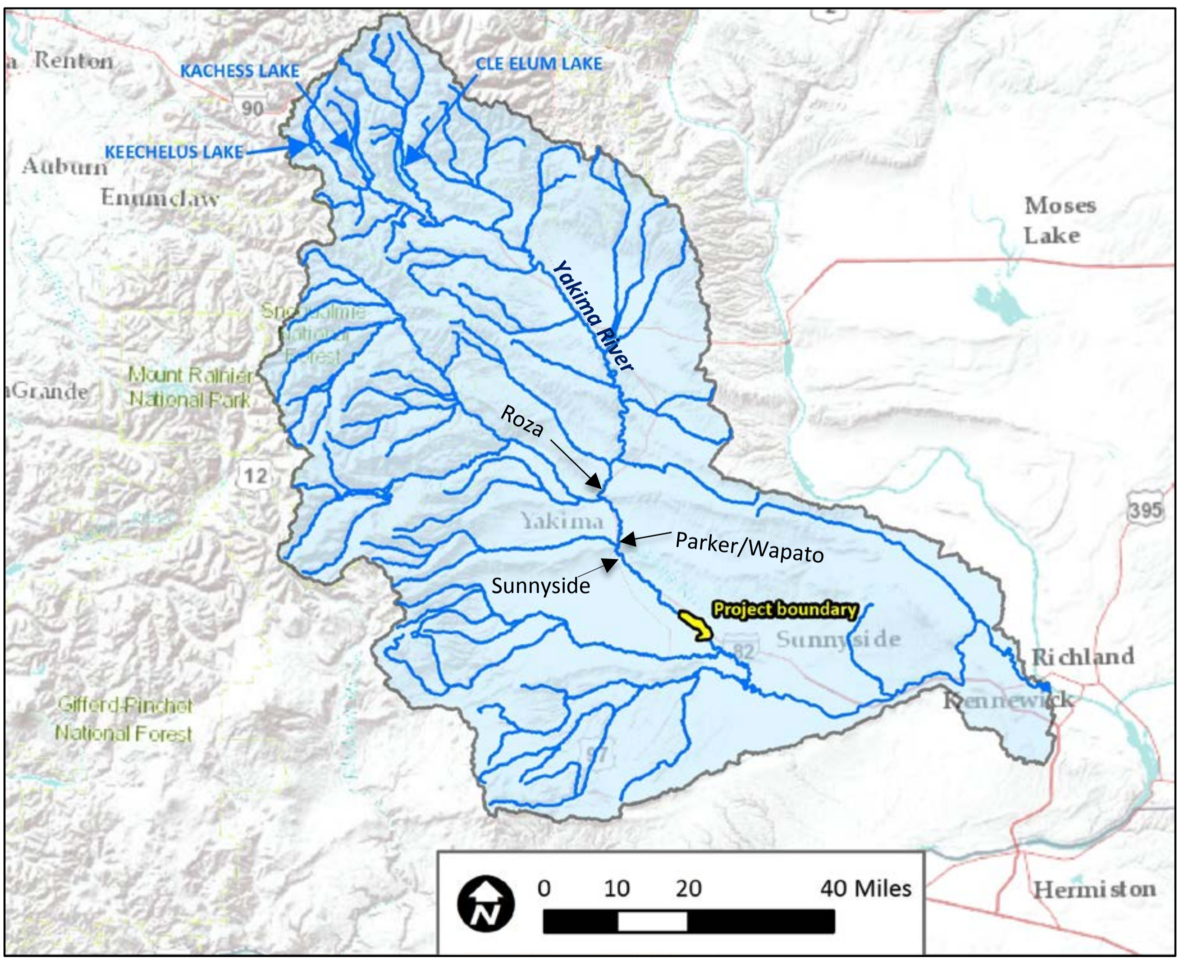

Figure 10. Yakima River watershed.

Surface Water

Surface water discharge at the project area is characterized for this assessment using the stream gage at Parker, WA – which is located 17 miles upstream. This gage is located immediately downstream of the Sunnyside Irrigation Canal diversion. The gage is considered fairly representative of the flow at the project site because there are no other major diversions between there and the project. Irrigation return flows do contribute a variable and unknown amount of surface and groundwater recharge back to the channel within the project area.

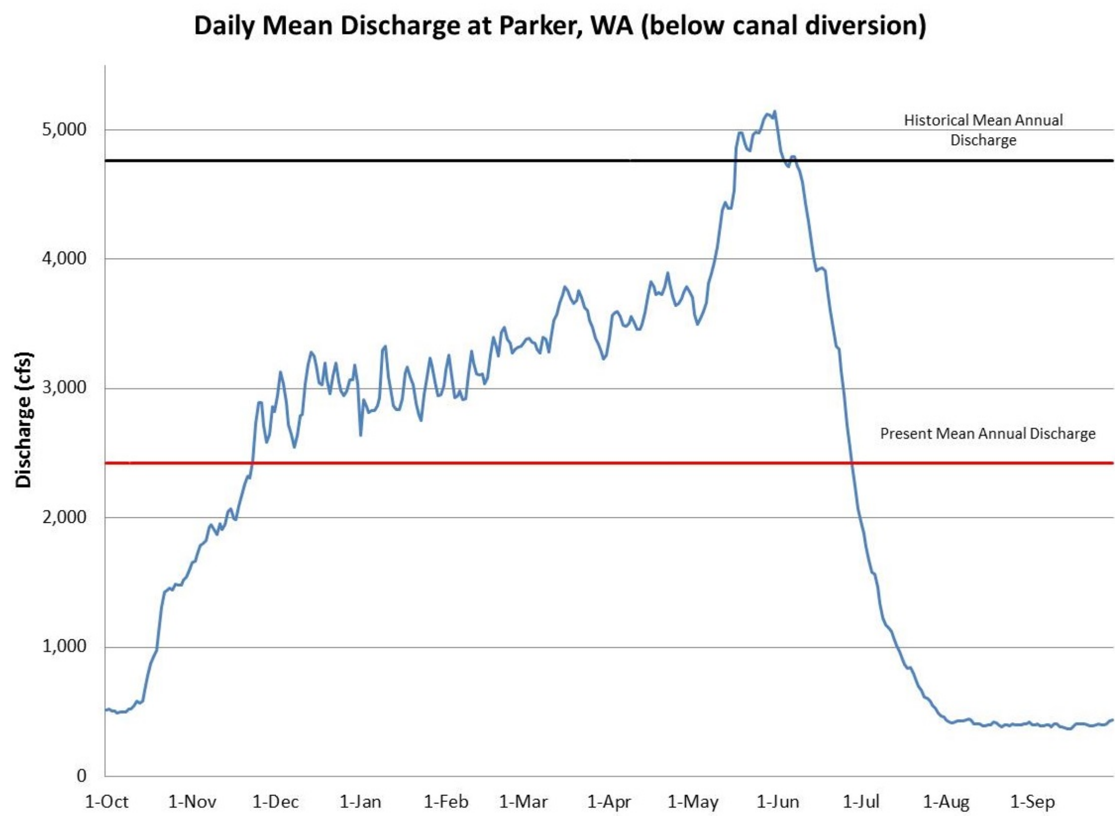

Figure 11: Mean daily discharge values at the Parker, WA gage with historical pre-dam (1900-1935) mean annual discharge and post-dam (1935-2017) mean annual discharge plotted (USBR, 2017a; USGS, n.d.)***.***

The mean daily discharge hydrograph, after upstream dam development and substantial irrigation infrastructure was on-line (1935-2017), is provided in Figure 11. Although the average monthly precipitation for the project area is highest Nov-Jan (see Figure 7), the greatest discharge usually occurs in the spring when snow melt and rain-on-snow events occur in the headwater tributaries. Surface water in the mainstem Yakima River is diverted for irrigation upstream of the project at the Sunnyside Canal diversion located immediately upstream of the Parker discharge gage. This diversion notably reduces flow in the mainstem to supply water to the Yakima Valley from late spring through mid-October. The irrigation usage results in a muted hydrograph at the project site. The Bureau of Reclamation estimates that current summer base-level flows are one third of the historical, pre-dam discharge. According to USBR discharge data cited by the Yakama Nation, mean annual discharge at the Parker diversion has been reduced from an unregulated average of 4,765 cubic feet per second to 2,390 cubic feet per second (USBR, 2017a; Yakama Nation, 2017). The historical and modern mean annual discharge values are plotted above on Figure 11 for reference. An example of a muted annual hydrograph is provided in Figure 12, where the 2016 gaged discharge data is plotted next to the USBR's computed natural flow estimates. The natural flow estimates represent flow without the influence of the upstream reservoirs and irrigation diversions (USBR, 2017b).

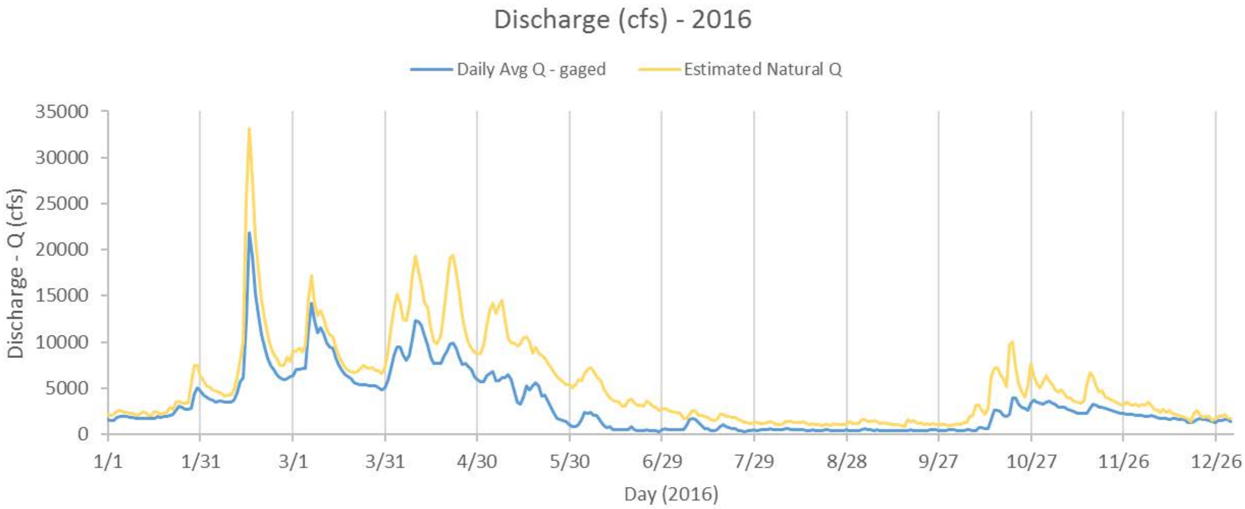

Figure 12. Daily discharge data at the Parker gage for 2016. Gaged flow data are compared to USBR natural flow estimate discharge without reservoirs and irrigation diversions.

Peak Flows

Peak flow data available at the Parker, WA gage from 1935 to present were used to estimate the discharge and recurrence frequency for the 2, 10, 25, 50, and 100-year flood events. Data after 1935 was used for this analysis because it represents discharge after upstream dam construction. In addition to the peak flow analysis undertaken with the gage data, peak flows were also estimated using StreamStats (2017), which uses regression equations developed by the USGS (Mastin et al., 2016). The peak flows from 1935 to 2016 and the estimated discharge for select flood events are provided in Figure 13. The StreamStats output reported that estimates were extrapolated with unknown standard error. Given the range of error possible, the StreamStats results should be considered with caution. The peak flow estimates from both analyses are provided in Table 1. The data collected at the Parker gage differs somewhat from the values provided using the USGS Streamstats program, with gaged discharge data values being larger for flows with return intervals greater than 5 years. These differences are likely due to a combination of factors, including the magnitude and timing of irrigation withdrawals, occasional flow releases during extreme precipitation events, and the nature of the Streamstats regression equations themselves, with inherent uncertainties that may not well approximate a local site.

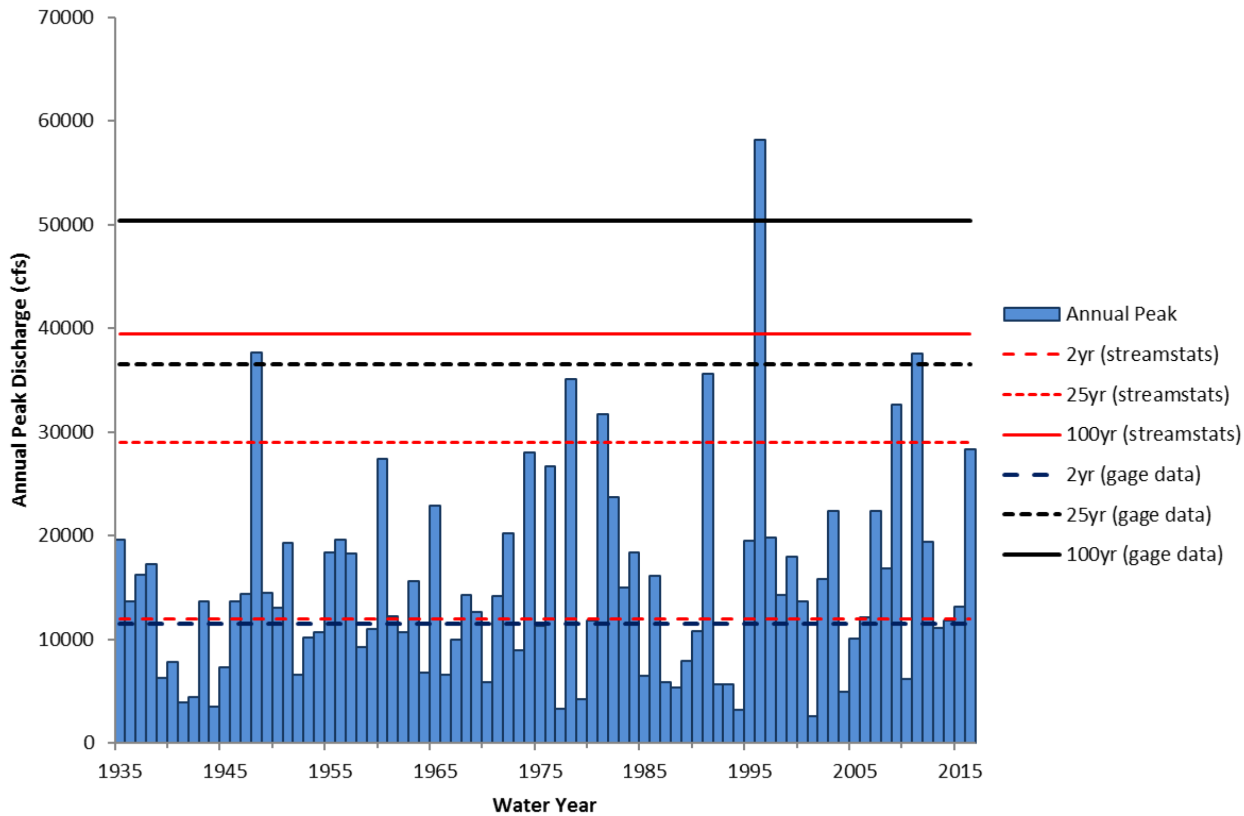

Figure 13. Annual peak flows from 1935-2016 at Parker, WA (USBS and USBR gage 12505000). 2-, 25-, and 100-year flood discharges are presented from both gaged data (black) and USGS Streamstats (red).

Table 1: Comparison of flood discharge recurrence intervals as derived by gaged discharge data (1935-2017) and the USGS Streamstats program.

Recurrence Interval (years)	Discharge (cfs; data-derived)	Discharge (cfs; USGS Streamstats)
2	11,440	11,900
10	27,450	22,600
25	35,367	29,000
50	43,463	34,200
100	50,359	39,500

Groundwater

Annual water retention in oxbow features and mature riparian forests across the floodplain indicate that groundwater is an important component to the hydrology and ecology of the project area. Groundwater and surface water elevation data were collected at the site from a series of monitoring wells from May 31 to November 28, 2017. No other groundwater data specific to the site are currently available. The monitoring wells were installed, monitored, and data collected by Cris Morton, a research graduate student from Central Washington University. Morton also performed the initial analysis on the data and shared it with Inter-Fluve for review (December 2017). The groundwater well sites are mapped in Figure 14.

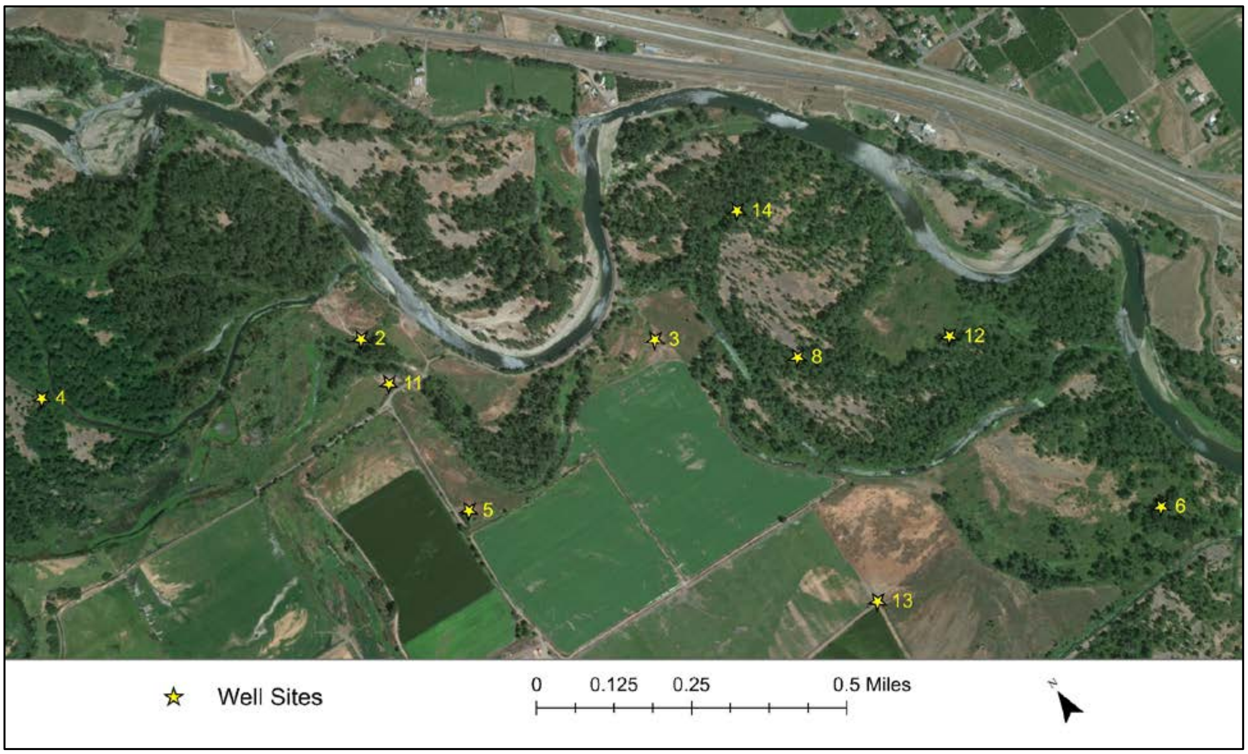

Figure 14. Groundwater welll site locations (Cris Morton 2017). note: surface water stage wells not included.

Although the time-duration of data collection are limited, the data do provide some insight into seasonal water table elevation variability and groundwater relationships to the channels and floodplain. Wells 4, 11, and 6 have the most complete data sets (May – November 2017) and their reported water table elevations are plotted in Figure 15. As expected, the elevation of the water table at Well 4 in the upstream end of the project area is higher than Well 11 and Well 6, which are located further downstream. Of interest is the difference in the seasonal variability expressed at the three wells. Well 4 is located next to a perennially wetted side channel. Its data expresses a gradual, relatively subtle lowering of the groundwater table during the summer months. Well 11 is located in a meadowed area with seasonal ponds that are disconnected from the channel by the levee but fed by irrigation return flow in the summer. The water table here has an early summer lowering trend that, after stabilizing for a couple of months, rapidly increases in mid-August and then spikes and drops in autumn. The 2.5-meter fluctuation in water table elevations here likely reflects inputs from seasonal irrigation return flow and storm/high-flow events. Well 6 is located in the downstream portion of the project area in an abandoned swale approximately 550 feet from the mainstem channel. Similar to Well 4, Well 6 groundwater table data express a relatively gradual seasonal variability of summer-month lowering but at a more exaggerated scale of change, most likely due to it being located in a part of the floodplain (downstream of levee) disconnected at low-flow from surface water inputs.

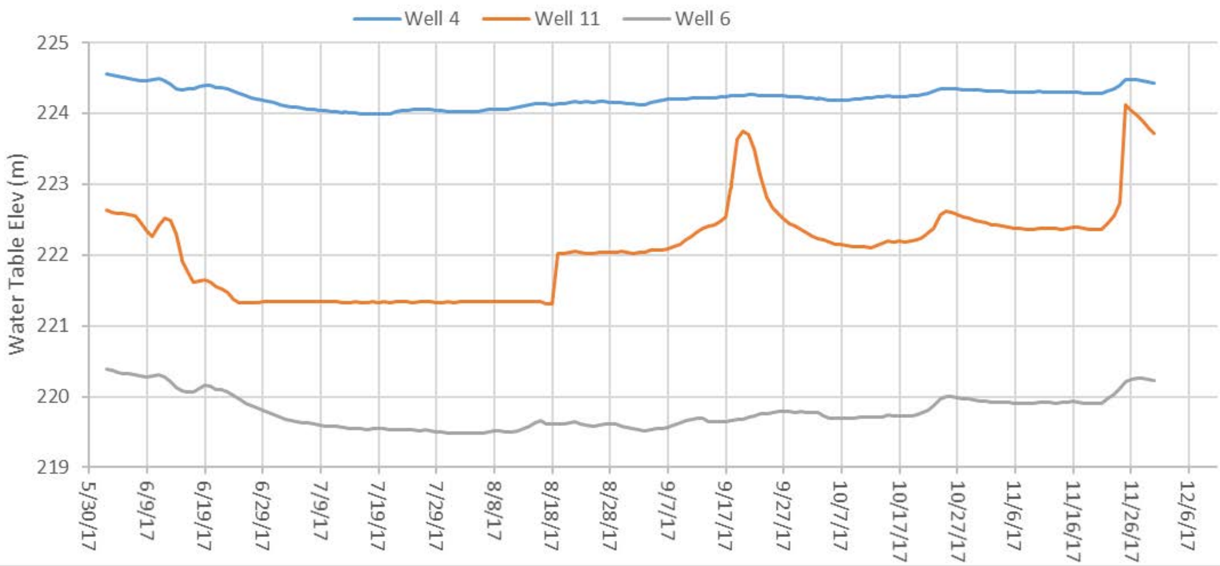

Figure 15. Groundwater table elevations at Wells 4, 11, and 6 from preliminary analysis (Morton 2017).

We then examined the cross-valley water table elevations perpendicular to mainstem channel flow at the three well sites for discrete days in October and November. This was done to gain some understanding of groundwater transfer through the floodplain on the days data was available. The surface water elevations collected by Inter-Fluve during field survey (Oct 3-4 and Nov 9-10, 2017) from oxbow ponds, active side channel, and the mainstem Yakima River on or near cross-valley transect lines that included well sites 4, 11, and 6 were compared. The water surface elevation data suggests that on the survey days in 2017 irrigated agriculture, canals, and return flow from the land west of the project area influence water table elevations within the project are. Holding capacity of the ponds and beaver dam activity are other variables to consider. The water surface elevations in off-channel features west of the mainstem were often several feet higher than that of the mainstem channel perpendicular to the feature. This effect is likely greatest in dry-season months. Clearly, groundwater connectivity is occurring throughout the project area but, it is a complex system with seasonal and localized variabilities influenced by human infrastructure and resource management. Additional data collection and a more thorough analysis should provide more information on these intricacies.

3.5 GEOMORPHOLOGY

The project area is located between RM 91 and 87 in what is referred to as the Wapato Reach of the Yakima River. The Wapato Reach extends from Union Gap (at RM 110) to Mabton Bridge (at RM 60). According to the Wapato Reach Assessment Report (ICF & R2, 2012), the Wapato sub-reaches upstream of the project area have slightly higher average gradients (0.22% and 0.25%) compared to the site (0.19%), while the sub-reaches downstream have a lower average gradient (0.09% and 0.02%). However, the reported substrate for the project area has a more varied and larger grain size distribution than the upstream reaches. This appears to be related to a grade break at the upstream end of the project area. Figure 16 illustrates the geomorphic variability in grain size, channel planform, and longitudinal profile from the data presented in the Wapato Reach Assessment Report.

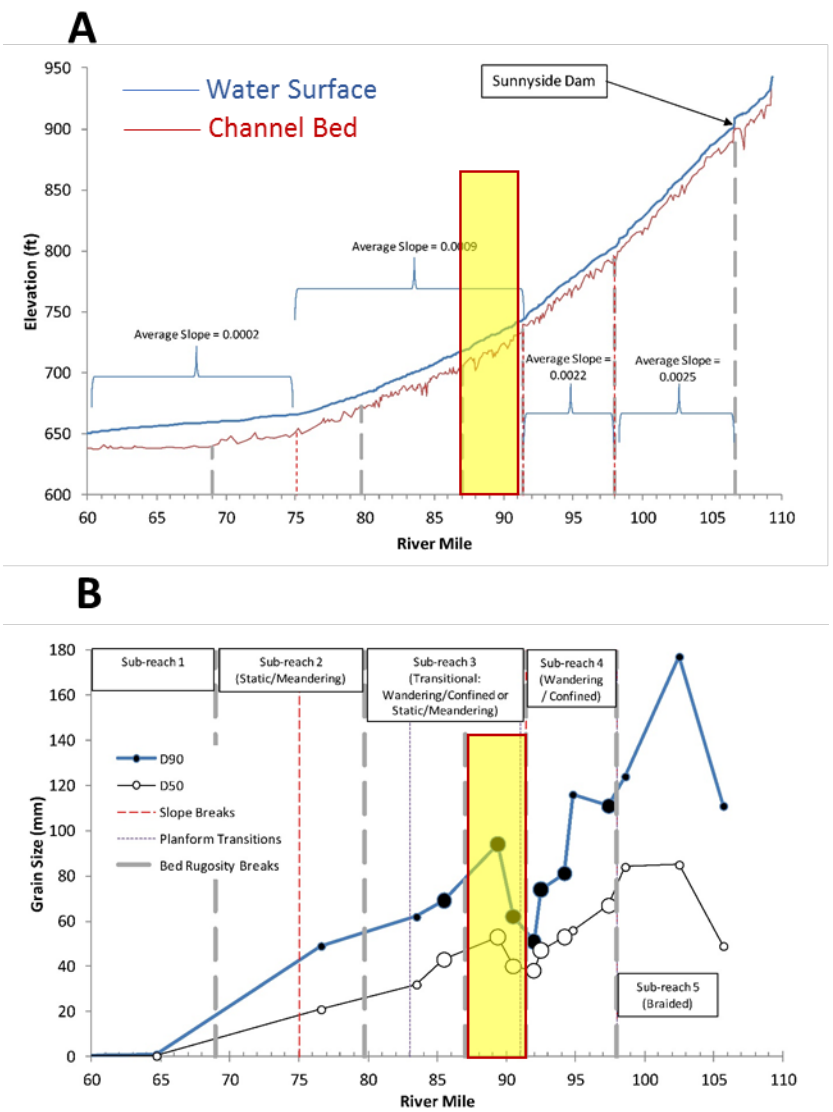

Figure 16. Yakima RM 89.5 project area highlighted with yellow box. A) longitudinal profiles of the Wapato sub-reaches; B) planform, substrate grainsize, and grade break locations of the Wapato sub-reaches. Modified Figure 4-1, page 48 from the Wapato Reach Assessment Report (ICF & R2, 2012).

The geomorphology of the Yakima River at the RM 89.5 project area reveals both historical and modern landscape evolution. Anthropogenically imposed spatial constraints and flow alterations over the past 170 years are influencing modern geomorphic processes. This section provides a brief discussion of the existing geomorphic conditions and trends of the channels, floodplain, and off-channel wetland features within the project area (Figure 17).

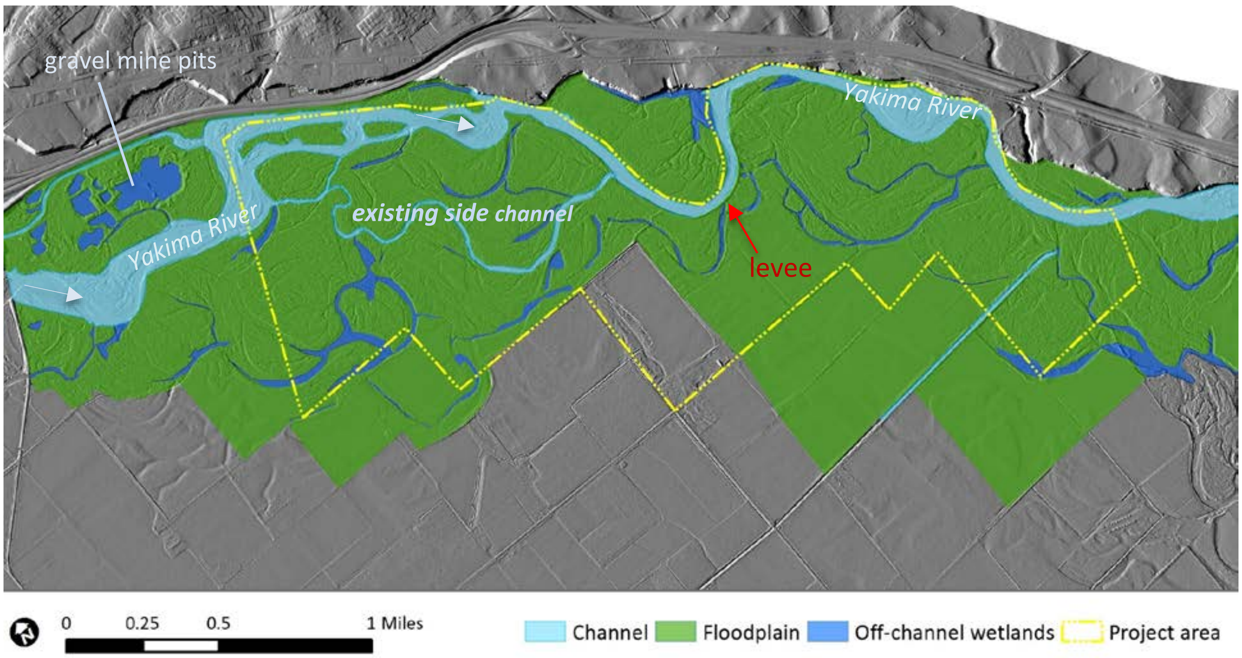

Figure 17. Map of channels, floodplain, and off-channel wetland features at the project area.

Channels

Mainstem

The Mainstem Yakima River at the project area is laterally active, except at the levee (RM 89.5). The mainstem channel has wide low-elevation point and mid-channel bars that are exposed during low flow periods. The bars and bed of the channel are composed primarily of gravel and cobble with coarse sand. This section of the Yakima River is generally considered a depositional zone (Mooney, 2008). Large active side and mid-channel bars are exposed during low-flow periods, especially in the upstream half of the project area (Figure 18). Active channel width is approximately 150 feet at baseflow and can reach 700 feet wide when the bars are inundated.

Figure 18. Active gravel-cobble bar and low, well-vegetated floodplain along the mainstem Yakima River. (Photo: Inter-Fluve Oct 2017)

Channel meander scars visible on the modern and abandoned floodplains in proximity to the project area indicate that this section of the Yakima River was historically laterally active. Over the last several decades some lateral channel processes have continued here despite anthropogenic confinements. The North Meyers Road Bridge upstream of the project area controls and confines the location of the mainstem channel and promotes localized scour. The construction of the 3,400-foot meander-bend levee in the mid-section (Figure 19) in the late 1970s arrested lateral processes at the levee as well as for 0.4 miles upstream. However, channel complexity and lateral processes continue downstream of the levee. Where it occurs, lateral migration and floodplain inundation result in large wood recruitment from the adjacent vegetated floodplain. The large wood and associated debris accumulate as jams where flow hydraulics and channel geometry allow. The large wood jams, especially in the upstream section of the project area, provide additional channel complexity and have influenced channel pathway changes.

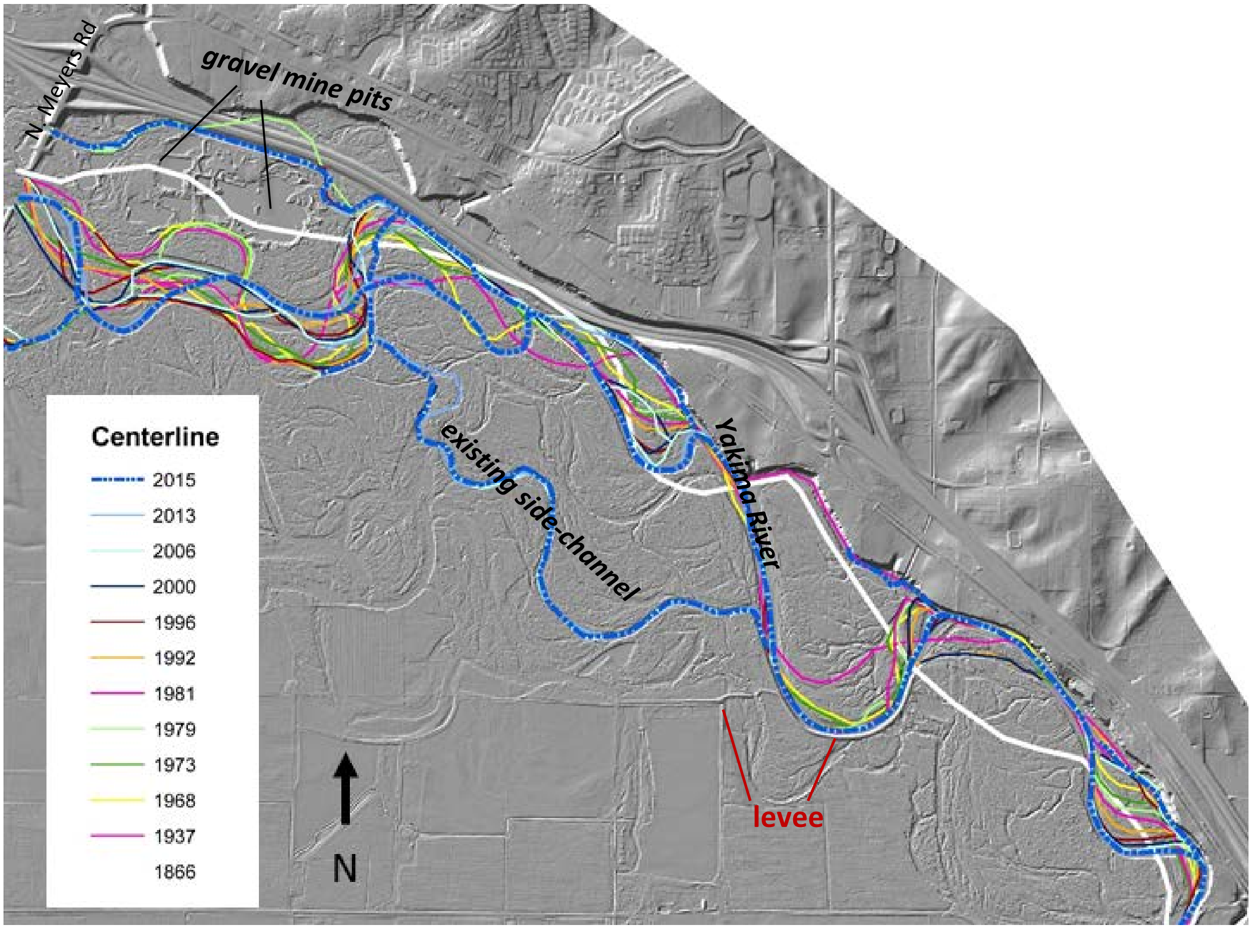

Figure 19. Historical channel centerline alignment extracted from historical aerial photos (1937-2015) and the GLO maps of 1866.

Active lateral processes, braiding, and bar development at the upstream end of the project area have resulted in periodic changes to the upstream connection between the mainstem and the existing side channel. Today the connection is at a backwater off the mainstem channel that contains a relatively deep pool (>6ft), which appears to be maintained by scour during high-flow events. This modern backwater scour pool is located in what has periodically, over the last 35 years, been the primary mainstem flow path. Downstream of the side-channel connection point, channel form is primarily single-thread meandering with active bars and a few high-flow activated secondary flow paths.

Lateral channel processes with active bar arrangements are expected to continue in the mainstem channel except at and immediately upstream of the constructed levee. Upstream and at the levee, the channel will continue to be locked in place (Figure 20). This will maintain a stable point bar position on river left and scour in the bed of the channel along the levee. Flow hydraulics here will continue to result in bedload deposition downstream at the next meander bend. Channel complexity will remain low along the levee if the structure remains in place without habitat enhancement treatments.

Figure 20. Mainstem levee at RM 89.5. (Photo: Inter-Fluve, Oct 2017)

Existing Side Channel

The existing side channel (see Figure 17 and Figure 19) in the upper portion of the project area flows through the floodplain year-round. It has been a connected side channel to the mainstem for a few decades, based on historical air photos. Channel width in the side channel varies from approximately 25 feet in the upstream sections to approximately 50 feet in the downstream section. Similarly, pool depth in the upstream section is approximately 2-3 feet and increases in the downstream section to 2-5 feet. The side channel has a mixed bedload of sand and gravels with accumulations of fines in low-velocity pools and backwater areas. Sediment accumulations as point bars and bed features occur throughout, indicating frequent (likely annual) bedload mobility. A relatively complex mix of channel units (riffle, pool, glide) exist throughout with pool length and depth increasing in the downstream third of the side channel. Modern lateral processes are subtle and expressed primarily in the upstream half. As a result, banks are relatively well vegetated and in some places, are steep. Connectivity of the existing side channel to other off-channel floodplain features generally occurs only during high-flow events. However, groundwater exchange between the floodplain and the channel is expected year-round. The route of exchange between surface and groundwater is assumed to vary depending on the relative elevation of surface water and groundwater (i.e. seasonal saturation).

Large wood jams at the upstream-most end of the side channel are accumulations of material supplied by mainstem lateral recruitment. Otherwise, large wood recruitment in the existing side-channel is supplied primarily via tree-fall. Mature trees are taller than the width of the channel, thus a single contribution is often channel-spanning and adds important localized habitat complexity (Figure 21). The geomorphic and hydrologic condition of the existing side channel are expected to remain relatively stable as long as connectivity to the mainstem at the upstream end is maintained.

Figure 21. Existing side channel at mid-section with well-vegetated banks and tree-fall. (Photo: Inter-Fluve Oct 2017)

Floodplain

The modern floodplain (see Figure 17) is a very low gradient (0.19%) surface that ranges from 0.8 miles to 0.1 miles wide in the project area. Based on surface and cut bank exposures, it is composed primarily of coarse sand, gravels, and cobble topped with a silt to sandy loam in areas of alluvial accumulations such as floodplain surfaces and abandoned channel scars. The topography of the floodplain is irregular and scarred with multiple abandoned channel pathways and scroll bars that are at various stages of infilling and connectivity. Floodplain development is occurring along the margins of the active channels up and downstream of the mainstem levee, though likely at a decreased rate compared to the pre-regulated flow regimes.

Surface water connectivity of off-channel wetland features (oxbows) via inundation occurs on average annually for a relatively short period of time starting at approximately 6,500 cfs. Floodplain surface inundation is expected to occur only every two years at between approximately 11,500 to 15,000 cfs, based on hydraulic modeling, air photos, and observations made by Yakama Nation staff. The floodplain at and downstream of the mainstem levee near RM 89.5 was disconnected after levee construction in 1979. Levee construction included the boulder riprap levee along the mainstem channel as well as extension levees that perpendicularly dissect the floodplain. In 2007, a small breach was excavated in the floodplain extension levee 300 feet from the mainstem levee that allows surface water to flow from the upstream floodplain through to the floodplain and oxbow features downstream of it -- but only during flood events (~ 7,500 – 11,000 cfs) for relatively short durations of time. Otherwise, the floodplain at and downstream of the mainstem levee remains disconnected locally from the channel. Increasing the frequency and duration of floodplain connectivity of this portion of the project area is expected to provide important benefits to the quality and quantity of habitat available in the project area.

Figure 22. Levee extension breach across the floodplain to reactive floodplain connectivity during high-flow or flood events. (Photo: Inter-Fluve June 2017)

The composition of the floodplain (coarse sand to cobble) supports groundwater exchange and recharge through the floodplain to and from the channels and from the wide agricultural valley west-northwest of the project area. The modern floodplain is fairly well-vegetated with a mix of riparian forests (dominated by cottonwood) and thick shrubs in the topographically lower areas; and grasses, forbs and noxious weeds in the higher or less inundated areas. The muted modern hydrograph and levee reduce floodplain activation and thus increase the potential for noxious weed encroachment in the downstream portion of the project area.

Gravel Mine Pits

Gravel mine pits that began in the late 1950s now occupy approximately 85 acres of river-left (east) floodplain upstream of the project area, immediately downstream of the North Meyers Road bridge crossing. Levees constructed around the pits are likely meant to keep overbank flow and/or the mainstem channel from migrating into the pits. If the mainstem channel migrates into the pits, the pits would likely capture the mainstem and redirect flow away from the existing side channel and floodplain on river right. The potential for the channel to migrate laterally into the pits is a possibility based on historical channel meandering patterns and should be considered when evaluating the long-term restoration efforts for the area. Remediation of the pits into a functioning floodplain surface is recommended to support natural channel processes including lateral migration and maintained connectivity to existing and restored floodplain features.

Off-Channel Wetland Features

There are several off-channel wetland features (oxbows and high-flow activated side-channels) within the floodplain throughout the project area (see Figure 17). Except for one dug pond (the "baseball cap") most of the off-channel wetland features are located in abandoned channel scars. If the abandoned channel feature is deep enough, it is wetted by groundwater inputs during low flow periods. High-flow events capable of inundating the floodplain can contribute surface flow to the off-channel features. This is expected to occur in the upper half of the project area starting at approximately 6,200-6,500 cfs. The duration and extent of surface water inundation into the off-channel features is dependent on the flow event and the relative elevation of the feature to the mainstem channel. If surface inundation is substantial, strings of oxbow features otherwise disconnected at low-flow periods connect to form temporary side channels through the floodplain during higher flows.

Figure 23. Off-channel wetland feature (oxbow) wetted by groundwater with a beaver dam pond. (Photo: Inter-Fluve Oct 2017)

The wetted oxbows at and downstream of the levee are wetted during flood flows of at least 8,000 – 11,000 cfs or more. Activation of these features occurs only when surface flow across the upstream floodplain is capable of flowing through the 2007 levee extension breach. Many of the off-channel features that are wetted annually by groundwater host beaver dams that create extended retention ponds. Infrequent inundation of the off-channel oxbow features has allowed the beaver dams to mature to elevations 3-4 feet high. The muted modern hydrograph of the Yakima River and anthropogenic confinements (bridges and levee) have reduced surface flow into and through the off-channel wetland features. Irrigation runoff and return flows from the adjacent floodplain to the west have likely increased summer-month water depths in several of the oxbows. Without efforts to increase the frequency and duration of surface water connectivity to off-channel wetland features, the habitat benefits they provide will continue to be limited and they will likely gradually be infilled with fine overbank sediment deposits.

3.6 HABITAT CONDITIONS

The project area provides a habitat corridor for avian, terrestrial, and aquatic species in an otherwise semi-arid valley dominated by agricultural land use and some urban development. The Yakima River corridor, including the project area, contains a myriad of floodplain habitats and vegetation communities that vary according to elevation and distance from water sources and human disturbance (vegetation removal). These habitat types can generally be classified as aquatic, riparian, and transitional (Figure 24). Aquatic habitats include the mainstem channel, side channels, and wetland features. Riparian habitats occur along the margins of aquatic habitats and their banks. Transitional habitat areas are terrestrial but they are seasonally wetted and/or have relatively shallow access to groundwater. Transitional habitats occur on higher floodplain surfaces than the riparian zones and host a mix of riparian trees, shrubs and upland grasses. This section of the report provides brief summary descriptions of the existing aquatic and terrestrial (riparian and transitional) conditions at the site.

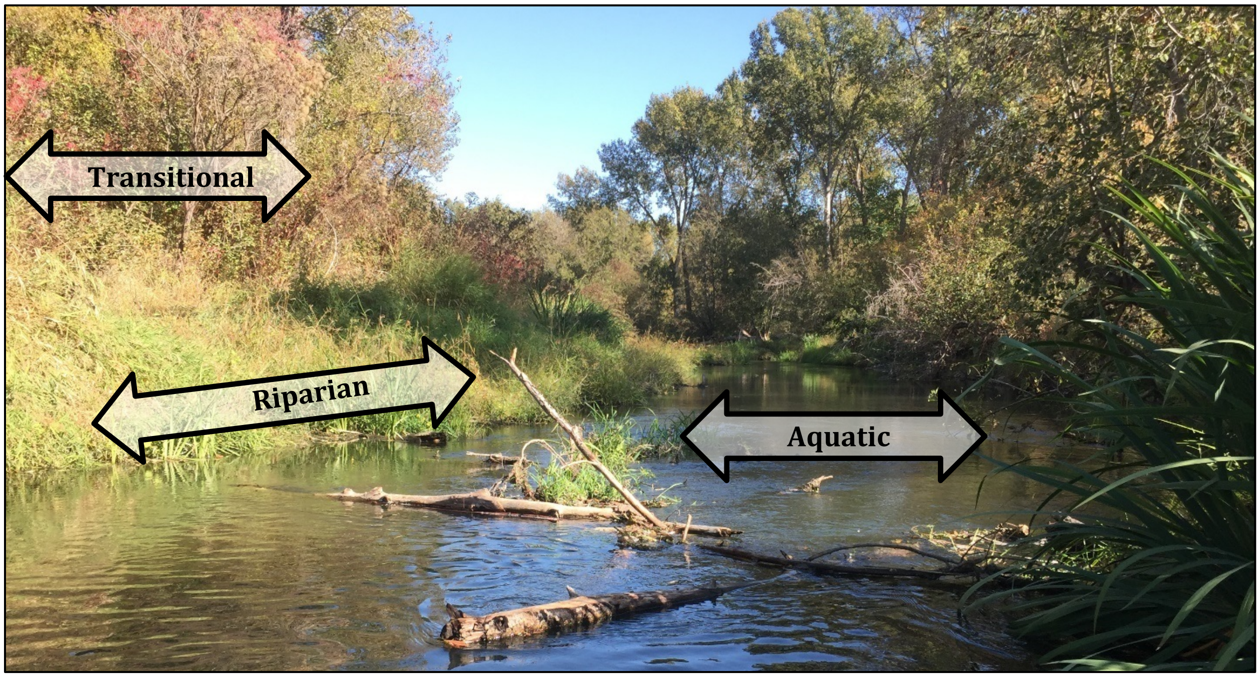

Figure 24. Three primary habitats found within the project area. Looking downstream in connected side channel.

Aquatic Habitat

Species of Concern

The Yakima River supports many native and non-native aquatic species (i.e. insects, amphibians, turtles, fish, plants) at varied levels of population security (USBR, 2008). Primary aquatic species of concern in the Yakima River include several anadromous fishes, including fall Chinook Salmon (*Oncorhynchus tshawytscha*), spring Chinook Salmon, steelhead (*Oncorhynichus mykiss*), Sockeye Salmon (*Onchorhynchus nerka*), and Pacific Lamprey (*Entosphenus tridentatus*) (Figure 25). Of particular interest at the study area are summer steelhead, which are a threatened species, and Pacific lamprey, which are a species of concern.

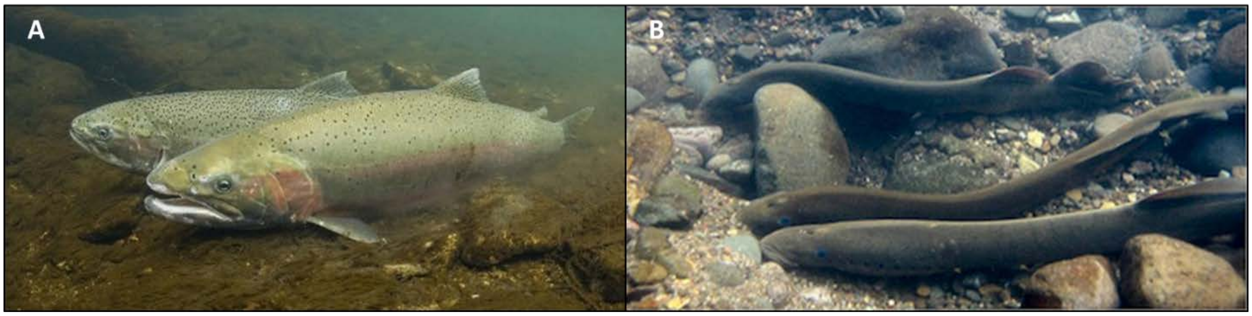

Figure 25. Steelhead (A) and Pacific Lamprey (B) are both important fisheries resources in the Yakima basin. Photo source: Columbia River Inter-Tribal Fish Commission (http://critfc.org/) photos by National Parks Service (A) and the US Fish and Wildlife Service (B).

Steelhead in the Yakima Basin are part of a genetically distinct population that is listed as Threatened under the Endangered Species Act (ESA) (NMFS, 2009). Prior to European settlement, an estimated 20,800 to 100,000 steelhead returned to the Yakima Basin annually compared to an average of 1,764 per year from 1985 to 2006 (Conley et al., 2009). The steelhead population is heavily dominated by native fish since no hatchery fish have been planted in the Yakima Basin since 1993.

Adult steelhead return to the Yakima River in September and overwinter in deep pools with low velocity before migrating to spawning grounds between January and May when flows increase and water temperatures are cooler (Yakama Nation, 2011). Spawning occurs from early March to early May, with juveniles emerging from late May to early July. Juveniles exhibit a stream-type life history where they rear in freshwater for at least 1 year prior to outmigration during spring flows. Age 0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover. Older juveniles prefer faster moving water including deep pools and runs (High et al., 2006; Hillman & Miller, 1989).

Pacific lamprey is a species of concern in Washington State, and have been in steep decline in the Columbia Basin due to several factors including dam operations, water diversions, habitat degradation, and pollution (Columbia River Inter-Tribal Fish Commission, 2011). Pacific lamprey are currently present in low numbers in the Yakima Basin as a result of the Yakama Nation Lamprey Translocation Program (Beals & Lampman, 2016). Only one adult lamprey was counted at Prosser Dam from 1984 to 2001, while higher counts have been observed since 2002. The average at the dam from 2006 to 2016 was 19 individuals per year.

Adult upstream migration of Pacific lamprey occurs from late March through October in the Yakima River, with peak migration in April. Spawning generally occurs from March through July at temperatures between 10 and 15°C (50-59°F). Preferred spawning habitat is in low gradient runs and pool tail-outs. Hatching date varies according to water temperature and is typically around 15 days after spawning. Ammocetes, the larval stage of the lamprey, spend 15 days in the redd after hatching before drifting downstream to suitable rearing habitats. Rearing habitat typically consists of low gradient areas with low water velocity, soft substrate, and organic material. Ammocetes can rear in freshwater for up to 7 years, during which time they filter feed on diatoms and suspended organic material. Juvenile downstream-migration occurs between July and October and includes metamorphosis into macropthalmia (adult stage), similar to smoltification in salmonids. Macropthalmia migrate to the ocean during high flows in fall and spring (Columbia River Inter-Tribal Fish Commission, 2011).

Aquatic habitat conditions - channels

The existing aquatic habitat conditions in the RM 89.9 project area are generally tolerable for steelhead and marginal for Pacific lamprey. Habitat improvements such as reactivation of side channels to the mainstem and reconnection of off-channel habitat to the main and existing side channel have the potential to notably improve aquatic habitat conditions within the project area. Channel unit (riffle, pool, glide) sequencing, active lateral migration processes, and the presence of large wood occur in the mainstem in the project area – except along the riprap levee in the mid-section. These characteristics support desired habitat complexity. The existing side channel in the upstream portion of the project area is annually wetted and also contains large wood, overhanging vegetation and channel unit complexity. Both the existing side-channel and margin areas of the mainstem channel offer some low velocity habitat for rearing juvenile salmonids. Juvenile salmonids were observed in the mainstem backwater at the upstream end of the existing side channel in November 2017 (Figure 26A). Low-velocity alcoves and other connected off-channel features where fines accumulate offer good habitat conditions for lamprey (Crandall & Wittenbach, 2015).

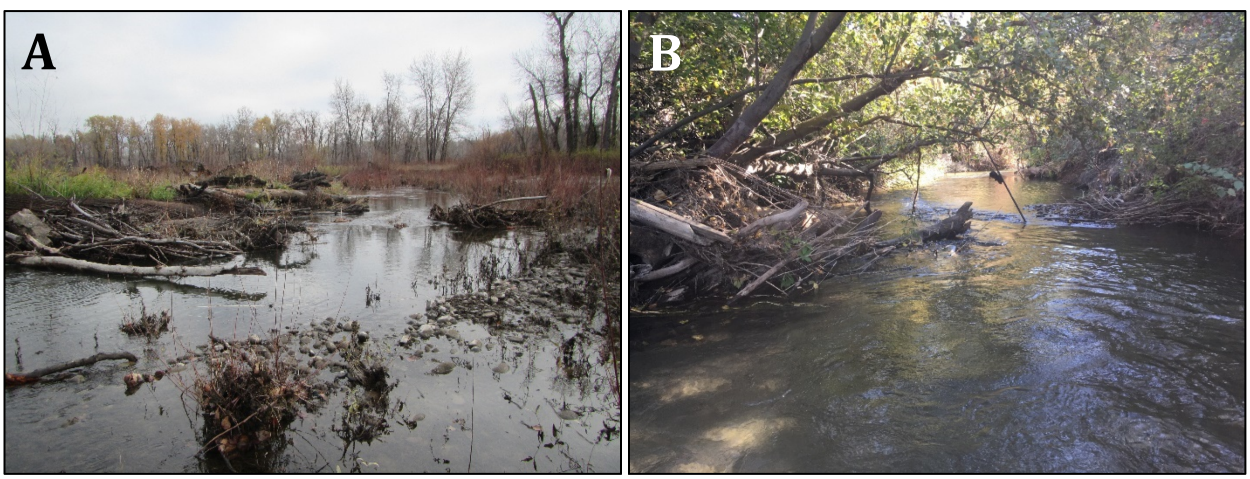

Figure 26. A) Existing high quality mainstem back-water habitat at upstream end of project area where juvenile salmonids were observed Nov 2017, and B) good slow-velocity habitat in existing side channel Oct 2017. Photos: Inter-Fluve

Aquatic habitat conditions – off-channel wetlands

Habitat conditions in the off-channel wetland features vary depending on proximity to agricultural development. Some of the wetted oxbows on the west side of the project area border cleared agricultural pastures, levees, and roads that offer no shade or habitat cover and produce less diverse nutrients to the wetland habitat. Some of the off-channel wetland features receive surface water irrigation ditch inputs and/or agricultural field runoff. The temperature and quality of the water received from the agricultural lands bordering the wetland features is currently unknown, but may pose risks to some aquatic species. Some of the flood-activated oxbows likely pose stranding risks to fish at their current frequency of inundation. Nevertheless, some of the off-channel wetland features generally provide good habitat conditions that include well-vegetated banks that provide shade and nutrients, material for beaver dam construction, and groundwater influx. Good quality wetland aquatic habitat also supports multiple avian species that depend on the food and materials they supply.

Many of the annually wetted oxbow features are home to beaver. Well-established beaver dams have created a series of wetland ponds in several of the oxbows (Figure 27). The ponds contain high amounts of fine sediment and organic material, both of which are required by lamprey ammocetes for rearing. Juvenile salmonids such as steelhead have also been known to rear in beaver dam complexes, and benefit from the food production and velocity refuge offered by these habitats (Pollock et al., 2015). Under current conditions, the ecosystem services such as nutrient processing and water quality are only realized during high-flow events that connect these areas hydrologically with the Yakima River. If these features were reconnected to the mainstem channel on a more frequent basis, these habitat benefits could be expanded and utilized.

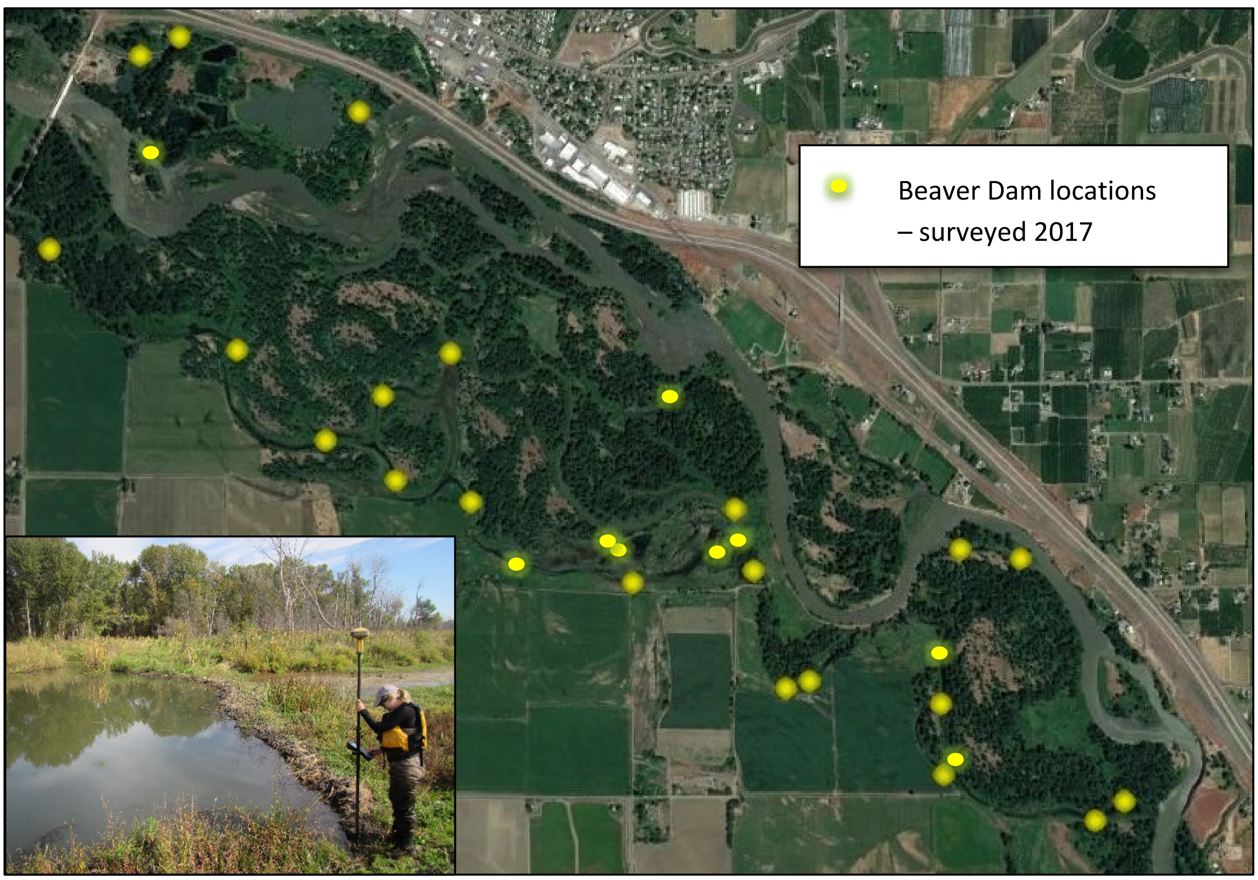

Figure 27. Beaver dam locations within the project area -- surveyed by Yakama Nation staff and Inter-Fluve (2017).

Riparian

There are riparian habitats along the mainstem, side channel, and off-channel features throughout the project area. This habitat type sequences from emergent vegetation along the margins of the wet features (i.e. sedges and rushes) to terrestrial bands of hydrophilic plants up the banks where soil moisture allows. Where human disturbance and clearing has not occurred, the project area has relatively intact, diverse, high quality riparian habitat that hosts a variety of species (e.g. amphibians, beaver, water fowl, and other birds).

Figure 28. Riparian habitat along off-channel wetland oxbow ponds. (Photo: Inter-Fluve October 2017)

The diversity and extent of the existing riparian habitat at the project area varies depending on bank slope, human vegetation disturbance, and annual flow rates. Where banks are steep, the riparian habitat is narrower and often less complex than the gradually sloping banks that can host wide riparian habitat bands (Figure 29).

Figure 29. Steep bank with cleared vegetation on the left; naturally vegetated riparian habitat on the right in a disconnected oxbow pond in the downstream portion of the project area. (Photo: Inter-Fluve Oct 2017)

Where vegetation clearing and agriculture occur next to the bank of surface water features, riparian habitat is simplified and consists primarily of emergent vegetation such as sedges and rushes (Figure 30). Riparian vegetation clearing occurs along the off-channel wetland features located along the west side of the project area.

Figure 30. Simplified riparian vegetation along oxbow in northwestern portion of the project area. (Photo: Inter-Fluve Oct 2017)

Along the mainstem and existing side channel, riparian habitat occupies the relatively stable banks and emergent riparian vegetation is limited to calm backwater areas where low-flow velocity allows it to establish. Riparian bank vegetation is generally well established along the existing side channel. Riparian vegetation along the mainstem Yakima is more patchy but present where flow hydraulics allow. Active lateral processes result in natural revegetation processes along new or active banks.

Invasive grasses (i.e. Reed Canary) are encroaching on the mainstem and side-channel banks, which reduces riparian habitat diversity.

Figure 31. Existing side channel with varied riparian habitat compositions. (Photo: Inter-Fluve Oct 2017)

Figure 32. Yakima River near RM 90 with varied riparian habitat composition. (Photo: Inter-Fluve Oct 2017)

Transitional

The transitional habitat occupies the remaining portions of the floodplain not considered aquatic or riparian. Transitional habitat offers a mix of vegetation types depending on frequency of surface inundation, access to groundwater, soil moisture holding capacity, and vegetation clearing. The diversity of the transitional areas offer habitat to a wide variety of avian and terrestrial species such as birds of prey, rabbits, reptiles, coyotes, deer, song birds, and bear. The habitat condition and diversity are least healthy along the western border of the project area where there is vegetation clearing and agricultural uses. Forest density is highest in topographic depressions such as abandoned channels. An understory of shrubs (i.e. rose, snowberry, dogwood, hawthorne), sometimes impassably thick, occur on slightly lower and more frequently wetted floodplain surfaces where the more well-drained floodplain surfaces or areas of clearing host an understory of grasses and forbs. Slightly higher floodplain surfaces (less frequently inundated with accumulated fines on the surface) and areas of clearing are not forested but instead are dominated with grasses, forbs, and weeds. Establishment of non-native plants such as Himalayan blackberry and a variety of weeds was observed and are expected to continue to be an issue in disturbed or roaded areas.

Figure 33. Transitional floodplain habitat with open areas of grass and forbs. (Photo: Inter-Fluve Oct 2017)

Figure 34. Transitional floodplain habitat with thick understory of brush (Photo: Inter-Fluve Oct 2017).

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