Concept Basis of Design Report

Lower Kittitas Reach Floodplain Reconnection Project

Yakima River, Ellensburg, Washington

U.S. Department of the Interior April 2024

Mission Statements

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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Lower Kittitas Reach Floodplain Reconnection Project

Yakima River, Ellensburg, Washington
Columbia-Pacific Northwest Region

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Cover Photo: Existing conditions Yakima River Floodplain, 2021. (Reclamation)

Acronyms and Abbreviations

Acronym or Abbreviation	Description
BLM	Bureau of Land Management
cfs	Cubic Feet per Second
County	Kittitas County
FEMA	Federal Emergency Management Agency
HEC-RAS	Hydrologic Engineering Center’s River Analysis System
LiDAR	Light Detection and Ranging
NEPA	National Environmental Policy Act
Project	Lower Kittitas Reach Floodplain Reconnection Project
Reclamation	Bureau of Reclamation
ROM	Relative Order of Magnitude
RV	Recreational Vehicle
Schaake	Schaake Habitat Improvement Project
TAG	Technical Advisory Group

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1 Introduction

Kittitas County (County) and the Bureau of Reclamation have partnered to develop a conceptual design and phasing plan for the Lower Kittitas Reach Floodplain Reconnection Project (Project). The Project intent is to reconnect floodplain habitat along the Yakima River within the Lower Kittitas Reach in Kittitas County, Washington. The 700-acre Project includes 2.7 miles of the Yakima River, between Hansen Pits and Ringer Loop Road (Figure 1). The Project goals and objectives; characterization of site conditions, including historic impacts; and technical data used to provide proof of concept, assessment of alternatives, and a description of the concept selected for the Project are provided herein. Notable considerations for future phases of the design are also included.

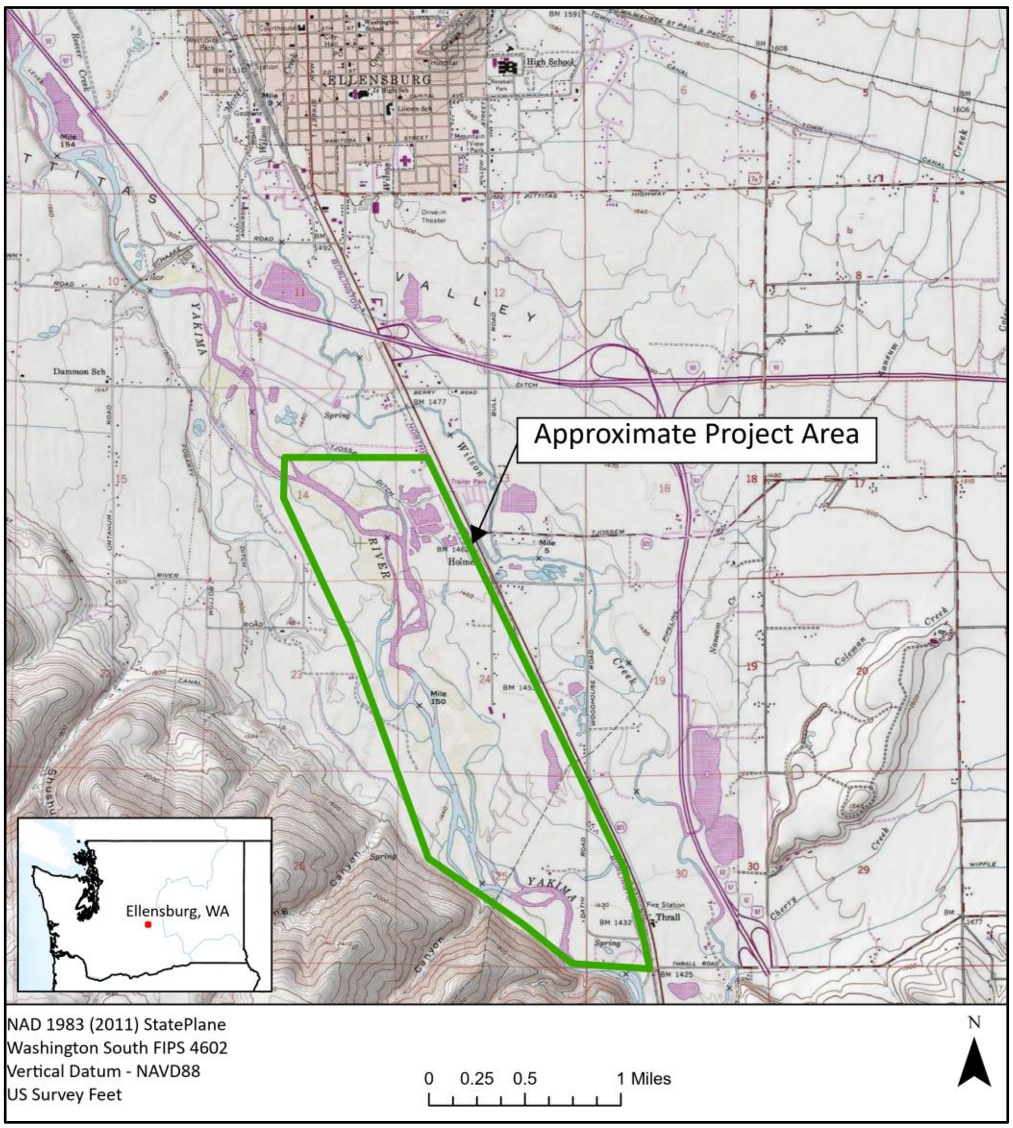

Figure 1: Location of the Kittitas Reach Restoration Project near Ellensburg, Washington.

1.0 Goals and Objectives

Vision Statement: Divest from failing flood infrastructure and restore natural riverine processes for the purposes of creating and maintaining salmonid habitat, while allowing for flood compatible uses.

Goal 1: Habitat restoration.

- Promote natural fluvial processes to create and maintain spatial complexity and dynamicity through the removal of bank revetments, reconnection of side-channel habitats, and floodplain recontouring to promote floodplain engagement and support floodplain gallery forest establishment.
- Improve the quantity and quality of salmonid habitat, with an emphasis on year-round rearing habitat and consideration of non-normative summer high flow hydrology.
- Address potential negative effects of floodplain gravel pit ponds (water warming, warm water fisheries production, fish stranding) and restore to habitat suitable for salmonids where feasible.

Associated Limiting Factors:

- Reduction in overall quantity of off-channel habitat because of roads, levees, and channel filling.
- Degradation of site-scale habitat complexity in existing mainstem and off-channel habitats due to presence of invasive vegetation such as reed-canary grass and lack of overhead cover, and large and small woody debris in off-channel habitats.
- Elimination of normative flow hydrology in the watershed; extended periods of high (irrigation) flows through the summer months have significantly reduced the quality and quantity of available summer rearing habitat for juvenile salmonids.

Objectives:

1. Reconnect the disconnected floodplain for the purposes of floodplain engagement and dynamicity and to support cottonwood gallery forest development and maintenance. Improve floodplain connectivity by removing levees, berms, bank revetments, and other artificial floodplain features to provide floodplain engagement during and above the 1.5-year recurrence interval flood.
2. Recontour areas of the floodplain to provide a continuous bandwidth of connected floodplain at an inundation frequency that promotes the long-term, dynamic floodplain processes required to create and maintain functioning side-channel and off-channel (overflow and groundwater channel) areas, wetland areas, and support development and maintenance of mesic cottonwood galleries of various successional stages, providing opportunities to recruit wood for instream habitat complexity.
3. Improve connectivity to existing side channels and off-channel habitat suitable for year-round juvenile rearing and non-normative flow conditions by providing perennial surface

water connections from the main channel or other existing active side channels to existing relic side channel features and their accessible floodplains.

4. Create new side channels and off-channel habitat suitable for year-round juvenile rearing and during non-normative high summer flow conditions by grading new, perennially connected side channels and frequently connected floodplains into the recontoured floodplain areas.
5. Address floodplain degradation from gravel pits and artificial floodplain ponds by:
   a. Creating connected side-channel habitat with appropriate flows and depths to support salmonids and not warm-water species.
   b. Create riparian habitat at suitable elevations to support cottonwood and other riparian forest vegetation to provide shading and cover of riverine and open-water habitat. Provide sufficient width to allow an approximately 50-year riparian buffer to anticipated channel migration.
   c. If ponds are retained, reduce potential negative impacts on fisheries (e.g., groundwater warming supporting warm-water fisheries, potential stranding).

Goal 2: Divest from failing flood infrastructure.

Objectives:

1. The Kittitas County Flood Control Zone District is not maintaining the failing Hansen Pits levee and seeks to strategically manage flood flows across its land holdings.
2. Inform stakeholders and nearby landowners of the likely impacts and outcomes of the project.
3. Address increases in off-site flood risk impacting private property that are directly associated with proposed site modifications/restoration plans.

Goal 3: Maintain flood compatible agricultural uses.

Objectives:

1. Reconfigure the existing spray field to align with areas reserved for flood compatible agriculture.
2. Preserve or provide new stock watering opportunities on agricultural lands.

Goal 4: Provide passive recreational opportunities where provision of access does not impact key riparian resources including listed salmonids and critical habitat.

Objectives:

1. Improve pedestrian site access to Bureau of Land Management (BLM) property.
2. Allow for a cross-property trail network. Restoration plans will consider logistics required for trail establishment and maintenance.
3. Identify appropriate locations for trailheads and parking.

1.1 Habitat Restoration Design Elements

Habitat Objective 1: Reconnect the disconnected floodplain for the purposes of floodplain engagement and dynamicity, and to support cottonwood gallery forest development and maintenance.

Design Element 1: Regrade the Hansen Pits levee, the downstream private berm, bank revetments, and farm roads to allow for floodplain connectivity at 6,000 cubic feet per second (cfs), the 1.5-year flood recurrence interval at this location. The Hansen Pits levee is effectively disconnecting the northern half of the project area from frequent flood events.

Design Element 2: Establish a floodplain revegetation strategy that identifies locations where traditional planting methods are desired and locations where novel revegetation strategies, such as the utilization of agricultural practices (field preparation, tilling, and irrigation) may be appropriate.

Habitat Objective 2: Recontour areas of the floodplain to provide a continuous bandwidth of connected floodplain.

Design Element 3: Recontour elevated floodplain sections within the southern half of the project area. This section of the project area is too high in elevation to support riparian vegetation and is not engaged by project components described in Design Element 1. Floodplain recontouring for floodplain engagement will be informed by elevations that correspond to 6,000 cfs.

Habitat Objective 3: Improve connectivity to existing side channels and off-channel habitat.

Design Element 4: In the northern half of the project area, off-channel habitat exists but has been disconnected by an irrigation headgate and old farm roads through the property. These features limit access to Spring Creek, a groundwater-fed floodplain side-channel that has the potential to provide excellent rearing habitat given stable, year-rounds flows.

Habitat Objective 4: Create new side channels and off-channel habitat.

Design Element 5: Side-channel and off-channel (i.e., floodplain) habitat is lacking in the southern half of the project area. Target grading elevations within this area will be informed by elevations that allow floods to re-establish off-channel and elevations that correspond with high summer irrigation flow and low summer post flip-flop flows. These target elevations are in development and will also consider riparian plant establishment, maintenance, and natural recruitment.

Habitat Objective 5: Address floodplain degradation from gravel pits/artificial floodplain ponds.

Design Element 6: Restore the Hansen Pits Gravel Ponds by improving the river connection for the most-westward cell and filling the ponds for the purposes of creating areas of sufficient elevation to support riparian, riverine and depressional wetlands; potential side channel restoration; and eliminating warm-water habitat for predatory fish.

Design Element 7: The design approach for the remaining floodplain ponds is under development. Ponds with a surface water connection sufficient for fish migration during the 1.5-year flood are prioritized for treatment, addressing stranding and predatory species concerns.

Constraints

- For the 1-percent annual chance event: no increased flood risk on neighboring structures or mitigate any increased flood risk.
- No increased flood risk to railroad.
- No increased risk to William's natural gas pipeline.

Other Considerations

- A restoration design that balances cut and fill between project elements is desired.
- The Federal National Environmental Policy Act (NEPA) process will be required for actions on BLM lands. The BLM previously issued an Environmental Assessment for Ringer Site Enhancement and Recreation Management (BLM 2017). This Environmental Assessment analyzed a Proposed Action for several activities intended to improve riparian, floodplain, and instream habitat combined with an expanded, non-motorized, trail system to improve recreational experiences and recreation access within the project area. Since this Environmental Assessment was issued, the ownership of neighboring properties has changed from private to public (County owned), which expands opportunities for enhanced habitat and recreational opportunities by working in collaboration across property ownership.
- To realize these broader habitat restoration and recreation benefits, cooperative management between the County and BLM will be necessary and mechanisms to cooperation should be considered.
- Kittitas County Public Works currently uses the Hansen Pits parcel as a storage yard, and it is expected to be maintained as such while being compatible with the restoration design.

1.2 Project Team

Project partners consist of County and Reclamation staff, which lead a Technical Advisory Group (TAG) established by the County to collectively review and provide feedback on the design. Reclamation has provided conceptual design and hydraulic modeling to demonstrate proof of concept, as well as established a phasing plan prioritizing certain elements of the design. The County intends to contract the Project design to final, and Reclamation is expected to provide technical support through final design. Details of the TAG are provided in Table 1.

Table 1: Technical Advisory Group

Name	Title	Agency/Firm	Project Role
Arden Thomas	Water Resource Program Manager	Kittitas County	Project Manager
Christopher Cuhaciyan	Hydraulic Engineer	Reclamation	Designer/Modeler
Tim DeWeese	Civil Engineer	Reclamation	Designer
Carolyn Gombert	Hydraulic Engineer	Reclamation	Hydraulic Modeler
Rob Hilldale	Hydraulic Engineer	Reclamation	Hydraulic Modeler
Jennifer Nelson	Fish and Wildlife Biologist	Washington Department of Fish and Wildlife	TAG Member
Sean Gross	Fisheries Biologist	National Oceanic and Atmospheric Administration	TAG Member
Katrina Strathmann	Restoration Ecologist	Mid-Columbia Fisheries	TAG Member
Chris Sheridan	Restoration Program Coordinator	BLM	TAG Member
Diane Priebe	Outdoor Recreation Planner	BLM	TAG Member
Cindy Preston	Aquatic Property and Acquisition Specialist	Washington Department of Natural Resources	TAG Member
Danielle Squeochs	Hydrologist	Yakama Nation	TAG Member
Elizabeth Butler	Salmon Recovery Grants Manager	Recreation and Conservation Office	TAG Member
Hope Rieden	Restoration Manager	Washington Department of Natural Resources	TAG Member
John Marvin	Habitat Coordinator	Yakama Nation	TAG Member
Mike Bosko	Upper Yakima Project Manager	Mid-Columbia Fisheries	TAG Member
Curtis Bryan	Wenatchee Field Manager	BLM	TAG Member

2 Site Conditions

The Project lies within the lower half of the Kittitas Reach of the Yakima River, one of several broad floodplain valleys along the Yakima River. These broad valleys historically consisted of large floodplains that were well connected to the river. With sediment loads and large wood inputs associated with snowmelt-dominated flood flows, frequent dynamic channel switching (i.e., avulsion) processes would occur (Stanford 2002). These natural processes provided excellent instream and riparian habitat for the formerly abundant salmonid population that was produced in the Yakima River Basin. Additionally, being near the head of the canyon, these lower floodplains have been noted to have the greatest potential for dynamic floodplains and groundwater exchange providing high potential for floodplain restoration with a goal to restore natural processes.

Flood barriers protecting public and private property for agricultural, residential, and gravel mining purposes have heavily impacted the Project area. The Hansen Pits levee exists along the north end of the Project and a private berm connects to and extends downstream from this levee. Combined, the levee and berm have disconnected more than 3000 feet of main and side channel from the historic floodplain of the Yakima River. Though these structures have been failing and currently allow low velocity floodwater into the previously protected areas, they continue to maintain a barrier between the river and its floodplain.

Private property on the west floodplain, across from the Project area, is also protected by flood control levees and berms. Though the levee disconnects a portion of this west floodplain, a significant portion of this floodplain remains well-connected, high-quality habitat for salmonids in its existing condition. Target elevations established on the east floodplain generally align with existing elevations on the west floodplain.

In addition to constructed flood barriers, Yakima River hydrology is managed with several storage reservoirs upstream. As a result, flood magnitude and sediment inputs have been significantly reduced from historic conditions, reducing channel migration and avulsion frequency (WSE 2021). This management approach has also reduced inputs and storage of large wood, an important element in sustaining a thriving and resilient floodplain habitat mosaic. A uniquely managed hydrologic regime through this reach known as “flip-flop” provides irrigation water to downstream diversions at high flow rates for an extended period during summer months. This regime, along with reduced sediment and large wood inputs, impacts otherwise naturally occurring riparian habitat development processes and reduces juvenile salmonid rearing habitat due to water velocities exceeding the swimming abilities of the young fish (WSE and Herrera 2015).

Several large ponds known as the Hansen Pits located at the north end of the Project are the result of a former gravel mining operation. One of the ponds, immediately behind the Hansen Pits levee, is already connected to the river due channel migration through a portion of the levee. Given that the levee is actively eroding, and more frequent flooding is being observed behind the levee, a channel migration and avulsion risk analysis was performed for the Project area (WSE 2021). The analysis indicated that under existing conditions, ongoing Yakima River channel migration is occurring at the south end of the Hansen Pits levee. This channel migration combined with a network of relict side channels in the floodplain creates channel avulsion risks. The Yakima River is expected to migrate into the southwest portion of the Hansen Pits and further activate the east floodplain, increasing the potential for channel migration and avulsion. If the east floodplain is actively engaged by removing the levee, or if natural riverine processes further erode the levee, flood depths and extents will increase on the east floodplain, increasing risk to private property and homes.

Former land-use activities on the floodplain have left a footprint of defunct and abandoned agricultural infrastructure including barns, houses, berms, ditches, headgates, culverts, and farm roads. Gravel mining also occurred on the private properties, leaving large ponds surrounded by gravel berms. Cattle grazing and clearing land for cultivation have degraded the riparian vegetation condition as well. To realize the benefits of a floodplain reconnection project, these impacts require corrective actions. They will help rejuvenate the floodplain and develop a resilient, complex, healthy, and self-sustaining, natural condition.

3 Technical Data and Analyses

This Project is immediately downstream from the recently completed Schaake Habitat Improvement Project (Schaake). Much of the technical data and analyses used here for concept development are based upon data and analyses from Schaake. Schaake modeling included the downstream Project area to ensure all areas with potential changes in flood conditions had been assessed throughout the design process, providing an excellent starting point for the current Project. The following sections of this report describe how these data were used and improved upon to evaluate the Project.

3.1 Topography and Bathymetry

The proposed conditions topo-bathymetric surface used for hydraulic modeling on Schaake was appended in AutoCAD Civil3D with further data to represent the following existing Project conditions.

- Schaake Project data (Reclamation 2019):
    - Light Detection and Ranging (LiDAR) survey (Optimal Geomatics 2009)
    - Riverbottom Road Survey (Kittitas County 2012)
    - Tjossem Access Channel Survey (Reclamation 2004a)
    - Tjossem Ditch Survey (Reclamation 2006)
    - Wilson Creek Survey (CH2M 2016)
    - Yakima River Bathymetric Survey (Reclamation 2012)
    - Schaake design surfaces (construction complete 2021)
- Recently collected lower Kittitas Reach data:
    - Kittitas County survey crew
        - Spring Creek bathymetric survey
        - Private driveways and homesites
        - Hansen Pits levee survey
    - Hansen Pits bathymetric survey

Proposed conditions have been represented using this surface as a baseline, with surface modifications performed using tools within HEC-RAS. Refer to section 3.3 for details.

3.2 Hydrology

The hydrologic data and analysis used here were originally developed by CH2M (2016) to support the design of the Schaake Project. Their hydrology report focused on determining an appropriate statistical distribution as an alternative to the Log-Pearson III method, as much of the flow at this location is regulated by upstream reservoirs and traditional methods do not properly represent regulated systems. Other design discharges beyond peak-flow return-interval floods were also determined and suggested in the CH2M report, including the largest peak flows set to match Federal Emergency Management Agency (FEMA) flood flows, and several lower flows associated with the summer irrigation flow regime. The CH2M recommended flows are used in the current analysis with the addition of 1.25- and 1.5-year discharges, which were estimated from a plot of the CH2M

(2016) values (Figure 1). A "high summer irrigation flow" of 4,200 cfs has also been added, approximating a discharge that often occurs during the late irrigation season for several weeks to months. Discharges used in this design, their sources, and application are provided in Table 2.

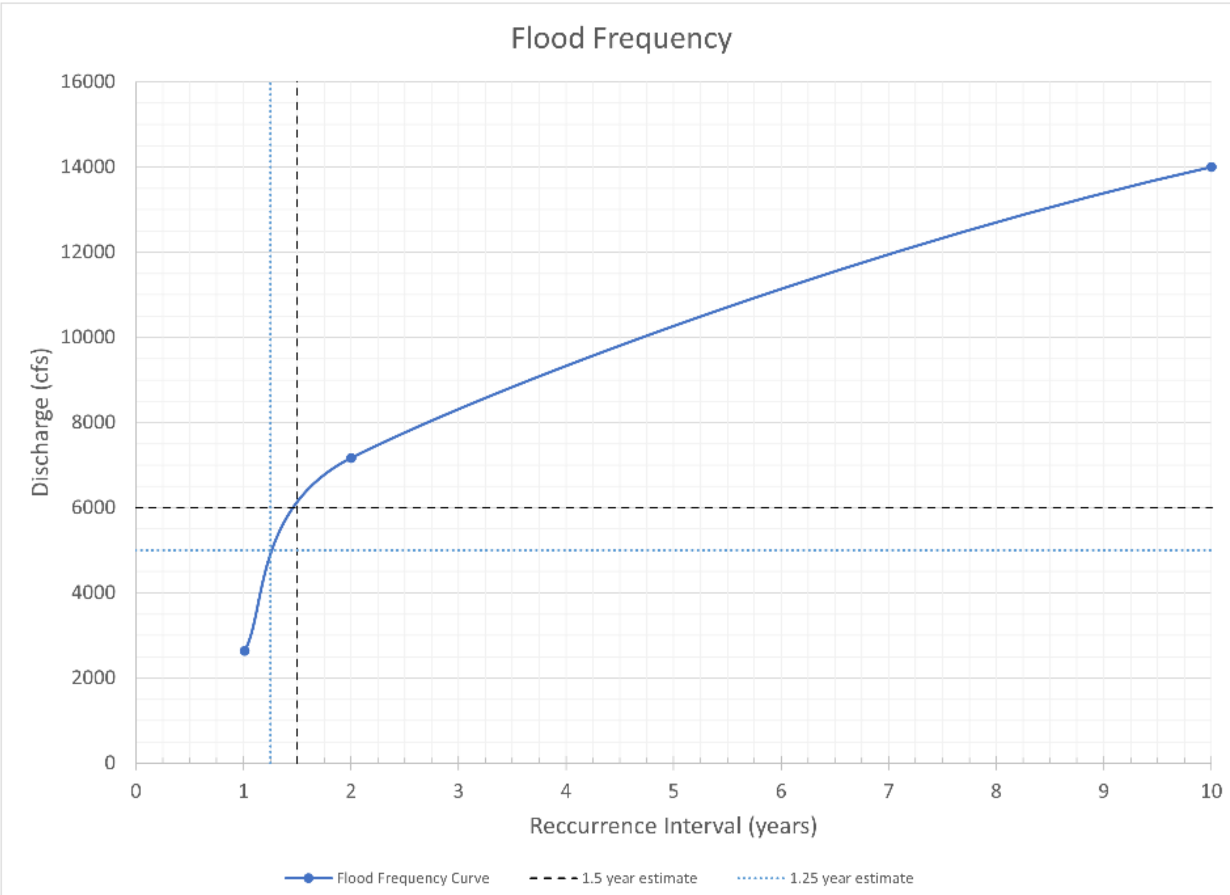

Figure 2: Flood frequency data from the CH2M (2016) hydrology report were used to develop a trendline and interpolate the 1.25- and 1.5-year peak flow discharges.

Table 2: Design discharges, sources, and descriptions. *Flows not modeled and not used during the conceptual design that are likely to be useful in future design milestones.

Name or Return Interval in Years	Discharge (cfs)	Source	Description/Comment
Low Habitat Flow	700	CH2M, 2016	Used to set the lowest flow when side channels were to connect and initiate flow on Schaake.
1.01	2,640	CH2M, 2016	Discharge with the least amount of juvenile salmonid habitat availability (Reclamation 2008).
Summer Irrigation Flow	3,500	CH2M, 2016	Occurs for an extended time during the growing season.
High Irrigation Flow	4,200	Reclamation	High end of what can occur for an extended time during the growing season.
1.25*	4,800	Reclamation, 2019	Low-end of bankfull discharge possibility.
1.5	6,000	Reclamation, 2019	Design discharge used to set overtopping (i.e., designed bankfull discharge).
2	7,170	CH2M, 2016	Expect minor flooding
10	14,000	CH2M, 2016	Expect major flooding
20*	17,400	CH2M, 2016	
50*	22,800	CH2M, 2016	
100	32,300	FEMA, 1981	Large-scale flooding
500*	43,600	FEMA, 1981	

A target discharge for floodplain engagement is an important design parameter and several factors were considered in selecting this flow for the conceptual design effort. For the Schaake Project, a design discharge of 6,000 cfs was used as the threshold value. Several floodplain activating events have occurred since the completion of the Schaake project and observations during these events fit well with expectations of how much, how often, and to what extent the floodplains should be getting activated. In addition, the riparian vegetation, both planted and through natural recruitment, is responding very well. It is healthy, dense, and has consistent and substantial new growth from year-to-year.

Using peak discharges from the 1.25- to the 1.5-year return interval for the floodplain engagement tends to provide an optimal balance for river and floodplain function, in our experience, as demonstrated in the previous paragraph with Schaake. On the low end, the 1.25-year discharge (estimated at 4,800 cfs) is close to the managed high summer irrigation flow (estimated at 4,200 cfs). The high summer irrigation flow often occurs for months at a time in the growing season, which could be problematic for riparian vegetation. It may be beneficial to err on the higher side and use the 1.5-year (6,000 cfs) as the target for floodplain engagement to provide enough depth of unsaturated soil. As mentioned, this appears to be functioning well on the Schaake Project, which has similar potential for the Project reach.

3.3 Hydraulic Modeling

3.3.1 Hydraulic Modeling Background

Hydraulic modeling for the Project was advanced compared with modeling efforts typical for a conceptual-level project. The hydraulic modeling performed for Schaake included this Project area to assist designing Schaake with a no-rise condition for the privately owned lands adjacent to, and now part of, this Project. For Schaake, Reclamation developed an SRH2D hydraulic model that extended from Umptanum Road to the mouth of the canyon below Ringer Loop Road.

Early iterations for this Project were completed with this SRH2D model, but the process was cumbersome due to the large model size, data sharing, and different staff making the surface model changes and others running the hydraulic modeling. A decision was made to export the SRH2D model and import it to HEC-RAS 6.3. This conversion allowed course surface changes and model runs to be turned around much faster. A technical memorandum describing the SRH2D effort up until this point is available (Reclamation 2024).

The two-dimensional HEC-RAS model retained the same roughness values as those of the calibrated SRH2D model. Because the two models have different ways of solving the hydraulic equations, they have slightly different results; meaning that using the same roughness values results in a HEC-RAS model that is not calibrated. The results, however, are similar enough to be reasonable for this effort, likely within a few tenths of a foot. Being conceptual and more exploratory in nature, and because the difference between the proposed and existing condition is the critical metric for this effort, a decision was made to move ahead with the uncalibrated version. Future efforts could revert to the calibrated SRH2D model or use existing data to calibrate the HEC-RAS model, depending on the modeler's preference. Alternatively, all new topographic and bathymetric data could be considered, which would require a new calibration dataset.

The County has collected drone-based aerials and developed new topographic models based on flights and a ground survey conducted in the spring of 2023. These new data were flown at a lower elevation and are 12 years newer. A significant improvement they show over the older LiDAR is that the elevations in the heavily vegetated areas are lower. The 2009 data was suspected of being artificially high in those areas, which likely caused significant differences in water flow from reality.

3.3.2 HEC-RAS Modeling and Results

The HEC-RAS 6.3 model provides tools for topo-bathymetric surface modification within the application, enabling quick iterative model runs to evaluate hydraulic changes associated with surface edits. Thirty-one iterative proposed condition surface edits and associated hydraulic model runs were conducted. These iterations included surface adjustments to the elevations that levees were excavated to between the Yakima River and Hansen Ponds, adjustments to the location and size of flood mitigation features, and adjustments to the size, shape, and elevations of side channel and associated floodplain features. The process was performed to ensure no rise around the private residences, while maximizing river-floodplain connection and function. Final topo-bathymetric surface modeling results can be found in Appendix A. Note that the private berm around the house in the recreational vehicle (RV) park was not built until recently and is not included in the 2009

LiDAR or related modeling products, but the removal of that berm is part of the proposed effort as demonstrated on the concept.

Hydraulic modeling results for the bankfull (6,000 cfs), 2-year peak flow (7,140 cfs), 10-year peak flow (14,000 cfs), and the 100-year peak flood event (32,300 cfs) are in Appendix B. These include the existing and proposed conditions as well as difference maps. As a proof of concept, these model results indicate that the removal of levees and berms in the project area is feasible. It requires flood mitigation features to be constructed, but they can be built far from the river, smaller, and near the areas that require protection. This makes them subtle on the landscape and opens up large areas of floodplain to flooding and improved flooding with substantial benefits to the riparian zone, river, and associated ecological functions.

4 Alternatives Assessment and Selection

The following alternatives have been presented and discussed by the TAG. These alternatives are provided in Sheets 6-9 in Appendix C.

Alternative 1 Basic: The basic alternative focuses on what the County views as the minimally required project elements to 1) address flooding to private properties related to the deteriorating levee and 2) reconnect the floodplain to the river in the areas where private property has been purchased for this purpose. This alternative does not address a minimum 50-year channel migration/avulsion buffer zone recommended in WSE 2021; therefore, significant risk of pit capture exists.

Project elements for this alternative include levee and berm removal, improved flood mitigation features for private property, headgate removal, cleanup and recontouring of old homesites, cleanup and recontouring of former RV park, minimally filling a portion of Hansen Pits along the Yakima River immediately adjacent to the current levee breech, and enough floodplain recontouring to provide the needed fill to complete these features.

Alternative 2 Advanced: The advanced alternative includes the basics of protecting properties and reconnecting the floodplain and adds further focus on developing juvenile salmonid habitat in side channels and on the floodplain, establishing a large riparian buffer between the river and the remaining Hansen Pits (greater than the minimum suggested migration/avulsion protection zone suggested by WSE), and providing a continuous bandwidth of riparian and side channel habitat from the previous Schaake Project through to the end of this Project area.

Activities in this advanced alternative include the Basic alternative items plus an additional 42.6-acres of well-connected floodplain and riparian area, additional and proportional Hansen Pit fill with a more substantial river migration buffer, 2.1-miles of new side-channels, 1.5-miles of enhanced side channels, and three new side channel connections.

Alternative 3 Full Fill of Hansen Pits: Hansen Pits has long been a topic of discussion related to its immediate proximity to the river and negative impacts to the native fishery. Complete filling of the ponds would restore this legacy mining impact to appropriate floodplain conditions including a large riparian zone benefiting the entire riverine ecosystem.

Full fill of Hansen Pits includes the basic and advanced alternatives items plus complete fill of Hansen Pits except for the northernmost pond. This effort would require a large amount of material. To generate the material on site would require extensive floodplain development excavation, but a course evaluation of the available materials suggests this may be possible. Extensive floodplain development may, however, impact passive recreational opportunities.

Estimate of Probable Cost: A relative order of magnitude (ROM) estimate of probable cost was performed to compare potential costs as an additional parameter in comparing alternatives. The ROM estimate used course values from similar projects and considered significant construction cost elements such as surveying, water management, earthwork, habitat wood, and revegetation. Design contingencies were applied to account for elements not yet addressed at this conceptual stage of design. Earthwork is the clear driver of cost due to the large quantity of material required to fill the ponds. Earthwork quantities of 48,000, 225,000, and 410,000 cubic yards of material were used in the estimates for each of the Alternatives 1 through 3, respectively. The ROM estimates of probable costs are provided in Table 3.

Selection of Alternative 2 as the Preferred Alternative: Alternative 2 was selected as the preferred option by the TAG as the appropriate direction for advancing the designs. Reasons for this selection are largely based upon the opportunity, potential, and value at this site, which is uniquely situated at the bottom end of the wide, low, and dynamic valley as noted by Stanford (2002). Objectives addressed by each alternative and the ROM estimate of probable costs are provided in Table 3. A narrative summary of the expected benefits for each alternative is provided herein.

Reconnecting the river to the floodplain through removal of barriers is of high value and would provide immediate benefits, as would be provided in Alternative 1. Alternative 1 also addresses potential flooding impacts to private residences associated with levee and berm removal, in addition to allowing flood-compatible agricultural use and passive recreational opportunities. However, the preferred alternative does all of this and takes advantage of a substantial opportunity to provide a large riparian buffer to the remaining Hansen Pits, provides many acres of additional floodplain habitat development with a continuous bandwidth of connected floodplain throughout the project reach, and adds miles of reconnected and newly constructed side channel habitat. The extensive floodplain and side channel network provides ample opportunity for floodplain forest restoration with the benefit of natural riparian vegetation recruitment and maintenance mechanisms. Project benefits are much greater over Alternative 1. The availability and balance of on-site materials, site benefits, costs, effort, and balance of disturbance, help this Alternative 2 stand out.

While Alternative 3 provides nearly everything in Alternative 2, it is not as favorable. The cost relative to the benefit is high: the amount of material needed nearly doubles, the amount of site disturbance nearly doubles, and only a relatively small amount of riparian area (approximately 15 acres) is gained that is some distance (600-800 feet) from the river.

Table 3: Alternatives decision table including objectives met and probable cost.

Objective	Alternative 1	Alternative 2	Alternative 3
Reconnects floodplain disconnected by levees/berms	✓	✓	✓
Provides floodplain continuity through the project reach		✓	✓
Improves existing side channel and off channel habitat		✓	✓
Provides new side channel habitat		✓	✓
Provides an effective channel migration buffer at Hansen Pits		✓	✓
Addresses flooding of private residences	✓	✓	✓
Allows flood compatible agricultural use	✓	✓	✓
Allows passive recreational opportunities	✓	✓	✓
Estimate of probable cost	**$4M**	**$13M**	**$21M**

5 Conceptual Design of the Preferred Alternative

5.1 Design Approach

This Project focuses on improvements that allow reconnection of the eastern floodplain of the river located on public lands, including those owned by Kittitas County and the BLM. These improvements include removing infrastructure that currently block the river from the floodplain and excavating new side channels and floodplain areas to improve connections where they remain limited after removing the levees and berms. Only limited work within the banks of the Yakima River is being considered. This work includes removal of levee and berm material within ordinary highwater and related bank realignment and protection in that area. Work is not currently being considered on the mostly privately owned western floodplain.

The design team considered an approach to reconnecting the eastern floodplain that is similar to valley-bottom reset restoration approaches, or what is sometimes referred to as Stage-0 design and construction. This approach in the context of this project would set floodplain excavation elevations such that floodwaters are allowed to access a low floodplain without any constructed channels within it. In the ideal situation, the floodwater would do work on the floodplain sediments and soils and ultimately create its own, naturally functioning channels.

Application and suitability of the Stage-0 design approach requires evaluation of the specific context of a restoration project. This approach is typically applied to an entire river valley bottom, which means all the water coming down the valley does work shaping new channels and floodplain, and it does so daily. Stage-0 projects are also completed in areas where the valley slope and river discharge are in balance with one another and with the sediment supply and size. For example, a river with a

1.5-year recurrence interval discharge of 400 cfs may have a slope of around 2 percent and therefore has potential for doing work to create channels. In the case of a side channel on a large river, the slope is quite small. At this location, a 400 cfs side channel has a slope of less than one-quarter of 1 percent, which would result in excessively low unit stream power and little energy available to perform the work to build and shape river channel and floodplain features.

A further concern is the water surface elevation that the river would have to reach to access the excavated surface. In this case, if the floodplain surface was set to the high summer irrigation level of 4,200 cfs, the surface would only have water an average of 8 percent of the time. The surface could be set lower, but because of the large extents, the excavation costs would rise dramatically. With limited time to apply little power, it may take an excessively long time for a Stage-0 project to mature at this location. Competing with widespread and fast-growing reed canary grass in the area, the goals of the project may never be achieved with this type of design and construction.

Given these considerations, it makes sense to design and build the side channels and floodplains to function naturally while ensuring immediate habitat uplift and growth of native vegetation. This can be achieved with natural process design using limited engineered structures to provide a high functioning starting point that allows dynamic behavior to form natural conditions. This restoration approach will benefit from changes that occur post-project implementation but is not dependent upon certain post-project changes.

5.2 Design Details

The Advanced alternative has been further developed since selection as the preferred alternative. Conceptual design drawings can be found in Appendix C and include the following major features that relate back to specific goals and objectives (see Section 1.0).

Major Conceptual Design features are as follows:

- Excavation and removal of existing levees and berms
    - 2,083 feet of failing and former PL99 levee at Hansen Pits.
    - 1,422 feet of failing levee and berm from Hansen Pits down to the head of the "fishhook side channel."
    - 874 feet of unofficial berm at the former RV park.
    - 1,185 feet of unofficial berm/pond excavation spoils at "football ponds."
    - 1,751 feet of access-road berm around the "camel pond."
- Flood mitigation features
    - Raise Stone Road to maximize setback of a flood mitigation feature to protect private homes.
    - Provide a setback berm at over 2,200 feet from the mainstem river to protect private homes; the large setback allows minimal berm construction.
    - Fill existing and defunct ditches to reduce and naturalize flood flow patterns.

- Remove existing and defunct headgate structure to promote natural channel and floodplain migration, development, and habitat.
- Partially fill Hansen Pits with locally excavated material to provide natural floodplain and riparian areas with natural rates of channel migration.
- Floodplain recontouring to allow connection at 1.5-year flood events and promote establishment and maintenance of riparian forests.
- New side channels and new side channel connections.
- Cleanup of former homesites and provide natural recontouring to blend into the surrounding floodplain.
- Floodplain roughness elements using large wood treatments and riparian forest revegetation.
- Channel complexity in side channels using various natural material based treatments.

The conceptual design improves the connection between the Yakima River and the adjacent floodplain (Table 4) providing natural levels of flooding. Subsequent floodplain processes are greatly improved including surface disturbance, nutrient and seed deposition, juvenile fish habitat and access, and natural side channel processes including creation, maintenance, and abandonment. The concept also works well with the proposed land uses including areas set aside for habitat, recreation, agriculture, and private lands (Figure 3). Areas near the Yakima River will receive more water, more often, and have significant habitat improvements. Private lands will be protected through flood mitigation features. Agricultural lands will remain on relatively high ground with infrequent flood access, but more often than has been occurring and at more natural recurrence intervals.

Table 4: Additional areas of floodplain expected with proposed concept.

Event/Discharge	Existing Floodplain (Acres)	Proposed Floodplain (Acres)	Added Floodplain (Acres)	Added Wetted Area (Acres)
Bankfull/6,000 cfs	129.6	139.0	9.4	11.8
2-year/7,170 cfs	238.9	276.5	37.7	40.0
10-year/14,000 cfs	793.3	873.9	80.5	82.9
100-year/32,300 cfs	1,634.4	1,434.5	(199.9)	(197.5)

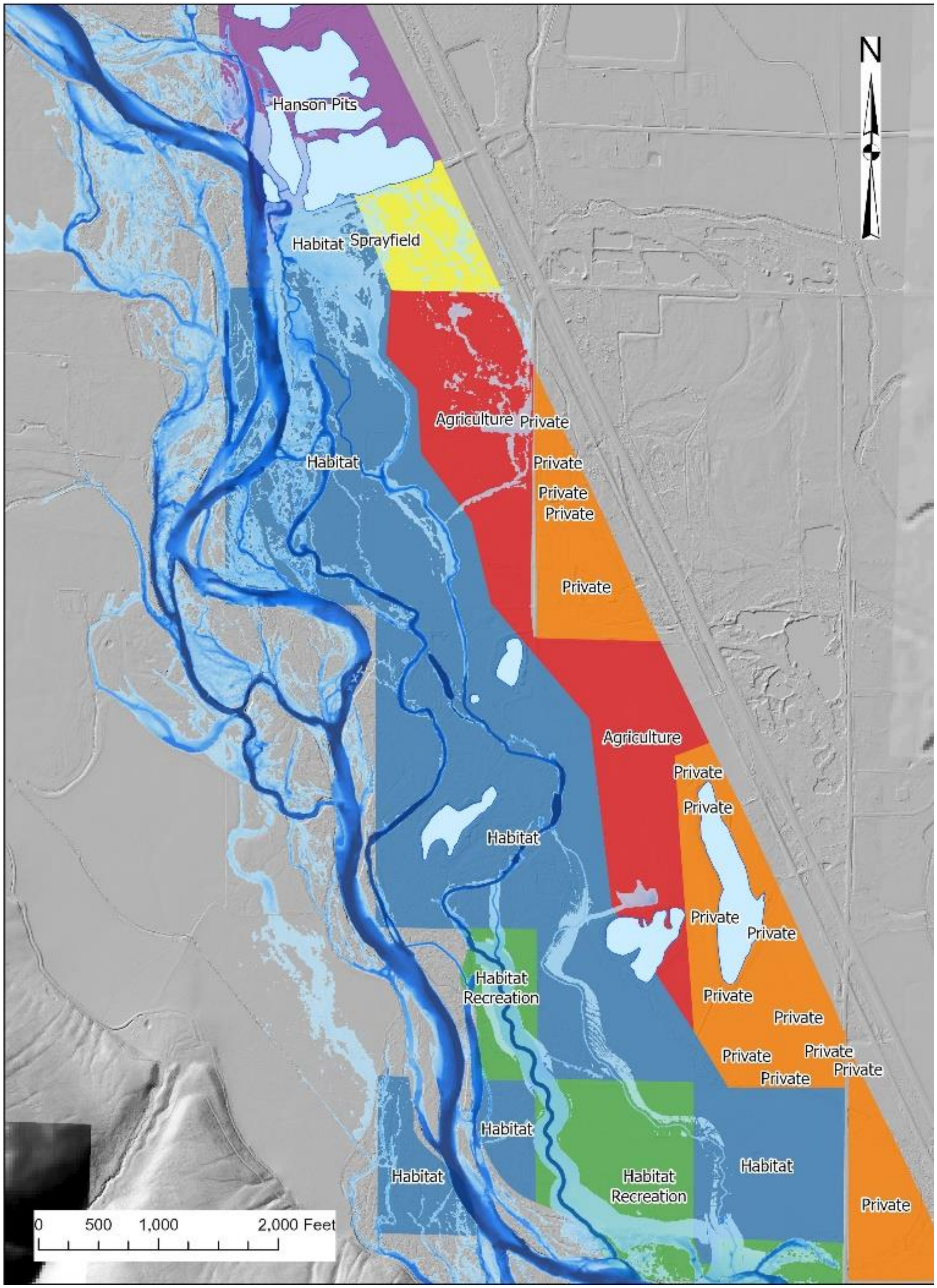

Figure 3: Land use in the project area with the proposed 2-year peak flow inundation boundary. The proposed actions work well with the intended uses of the land.

5.3 Future Design Considerations

As this is a conceptual level design, not all design details have been addressed and additional details will need to be evaluated through future design phases. The following list summarizes the known additional details; more are likely to be revealed throughout the design process:

1. Exact interstate gas pipeline location, depth, and cover requirements.
2. Test pits of in-situ material gradations and quantities for suitability analysis in flood mitigation berm features.
3. Cultural resources survey to determine if excavation is possible.
4. Review and incorporate Mid-Columbia Fisheries Enhancement Group vegetation design elevation considerations into the design where possible and appropriate (Table 5).
5. Old LiDAR appears high in tree canopy area. Possibly replace LiDAR with newer County data or other supplemental data.
6. Flood modeling shown east of the railroad and Canyon Road may not accurately represent existing or proposed conditions and should be reviewed; all culverts and bridges that may allow Yakima River water to access the east side likely have not all been included in the model.
7. Note that areas of levee constructed with concrete and other debris are likely to require offsite disposal.
8. Survey and flag the private flood protection features in the field for review and approval.
9. Yakima River hydraulics at the Hansen Pits levee removal area may influence the bend shape, large wood design, and pond fill material selection and placement to manage channel migration rates and risk.
10. Side channels have not been geomorphically or hydraulically designed. They have only been generally sized, and elevations set, to function with respect to the desired hydrology.
11. Large wood and in-channel habitat treatments have not been explicitly designed. Conceptual side channel complexity detail and example potential treatments provided in Sheets 16-18 in Appendix C should be considered in terms of certainty versus process-based (dynamic) behavior.
12. Evaluate the cost-benefit of utilizing gravel berms around the smaller ponds to improve aquatic habitat in these smaller ponds, versus utilizing this material for Hansen Pits restoration activities.
13. Extending the restoration footprint across onto BLM property ownership is currently understood to be feasible, especially since the Ringer Site Habitat Enhancement and Recreation Management Environmental Assessment included similar restoration elements (new channel creation, large wood habitat structures, revegetation of disturbed sites, floodplain vegetation planting and management, BLM 2019). Should extending the restoration footprint onto BLM property be determined to not be feasible, or should

feasibility still be pending when the County is ready to implement restoration activities, the restoration footprint will need to be restricted to County-owned property.

14. FEMA No Rise Analysis.
15. A geomorphic review of the project reach is recommended to further inform design details. The project reach is dynamic and a more complete understanding of anticipated river changes and how these changes may interact with restoration features and inform restoration approaches is desired.
16. Avulsion risk of constructed project. Dynamic behavior is desired and expected, but an understanding of the potential for sudden, significant Yakima River channel avulsion is desired.
17. Address flood impacts on County storage yard.
18. Ensure construction access and grading limits minimize disturbance to existing vegetation.

The design strategy should be integrated with a revegetation strategy that links habitat design element to potential revegetation approaches (Table 5). Future design phases will more explicitly consider sequencing considerations.

Table 5: Riparian and wetland revegetation design considerations and approach.

Condition/Design Element	Approach
Pond fill	Forested wetland • Fill material to wetland conditions (ponding water greater than 2 weeks annually). • Create hummocks, peninsulas, or other in-pond areas to allow increased shade through reforestation. Allow for moderate-duration (3 years) access to planting areas. • Mechanical or deep-plant of adventitious-rooting species.
Floodplain recontouring (Inset floodplain cut)	Riparian reforestation • Cut to inundation at 6000 cfs, or if not inundated at 6000 cfs then cut to less than 3-foot depth to groundwater at summer dry season. • Mechanical or deep-plant of adventitious-rooting species.
Channel cut	Riparian reforestation • Restore forested areas disturbed by construction.
Berm cut or Ditch fill	Riparian reforestation • Restore forested areas disturbed by construction. • Cut or fill to inundation at 6000 cfs, or if not inundated at 6000 cfs then cut to less than 3-foot depth to groundwater at summer dry season. • Mechanical or deep-plant of adventitious-rooting species.
Infrastructure removal	Planting strategy based on elevation above groundwater, size of area, and other considerations. Refer to the revegetation plan in

Condition/Design Element	Approach
	Appendix C. Evaluate ability to cut to less than 3-foot depth to groundwater at summer dry season.
Planting area outside construction footprint	Planting strategy based on elevation above groundwater, size of area, and other considerations. Refer to the revegetation plan in Appendix C.

6 References

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7 Appendix A - Topo-Bathymetric Surface Model

See attached.

8 Appendix B - Hydraulic Model Results

See attached.

9 Appendix C - Conceptual Drawings

See attached.