USACE photo

Mill Creek Forebay

April 2022

US Army Corps
of Engineers ®
Walla Walla District

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (Corps) and The Nature Conservancy entered into a national partnership in 2002 to create the Sustainable Rivers Program (SRP). The fundamental goal of the SRP is to identify, refine, and implement environmental strategies at Corps water infrastructure projects to improve environmental flows and project operations.

In 2021, a proposal was approved for the Corps, Walla Walla District to evaluate the potential for environmental flow improvements in the Mill Creek Diversion Dam (Diversion Dam) forebay. Providing effective fish passage at the Diversion Dam is a critical part of Mill Creek Project (Project) operations. Mid-Columbia River steelhead (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*), both listed as "Threatened" under the Endangered Species Act (ESA), migrate through the Project footprint to high quality spawning habitat upstream of the dam in the headwaters of Mill Creek. Project operations and maintenance (O&M) affect the physical habitat and water quality these species rely on.

The Mill Creek watershed has a substantial number of supportive stakeholders and partners, including local and state governments, local Tribes, and concerned citizens. Collectively, these entities form the Mill Creek Work Group, and they are committed to making environmental improvements in the Mill Creek basin. In Fiscal Year 2021, the Corps project delivery team was funded to conduct a workshop with the Mill Creek Work Group to document existing and ongoing data collection and research efforts and identify opportunities in the Diversion Dam forebay. This summary report documents the workshop findings, recommendations, and potential environmental and O&M benefits that could be further developed as part of ongoing efforts and potential new projects.

The workshop and other existing data and reports identified myriad fish passage and rearing benefits, and terrestrial wildlife benefits from stream channel and restoration work in the Diversion Dam forebay. Additionally, the Corps identified the following Project operational benefits that may be realized by a restoration effort:

- Levee scour protection
- Improved Levee toe drain function
- Improved management of coarse and fine sediments and debris

Recommended Actions: Workshop participants identified the following Actions to achieve both environmental and O&M benefits:

- Engineered log jams
- Sediment removal
- Submerged weir structures
- Constructed wetlands
- Invasive species control
- Native vegetation planting

Conceptual Management Plan: The Conceptual Management Plan ("Plan") was developed to achieve environmental and O&M benefits.

The Plan would include all Recommended Actions above except the submerged weir structures and would improve a large area of the floodplain by developing new side channels and wetlands, and improving existing side channels and wetlands. Significant fish rearing and migration benefits would be realized from side channel activation and other floodplain improvements, to include restoration of riparian vegetation. Sediment and debris management would occur from either sediment transport or deposition on the floodplain, depending on how the project was designed. The northern channel along the levee would be moved south to protect the levee from scour damage.

Next Steps: The Corps team would work to identify acceptable options for habitat restoration along the levee to ensure that stream channel alterations would not impact the operation and maintenance of a new fishway currently in design at the Diversion Dam. Additionally, an unrelated stream restoration project, to be executed by the Walla Walla County Conservation District, is being planned upstream of the Diversion Dam forebay on privately owned lands. The Corps and the Walla Walla County Conservation District would need to coordinate designs and schedules to ensure the two projects are compatible where they would join at the Corps property boundary.

MILL CREEK FOREBAY SUSTAINABLE RIVERS PROJECT

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
cfs	cubic feet per second
Corps	US Army Corps of Engineers
CTUIR	Confederated Tribes of the Umatilla Indian Reservation
Diversion Dam	Mill Creek Project Diversion Dam
EDS	energy dissipating stabilizer
ELJ	engineered log jam
ESA	Endangered Species Act
ETS	Engineering Technical Support
°F	degrees Fahrenheit
FACStream	Functional Assessment of Colorado Streams
FCI	functional capacity index
fps	feet per second
FY	Fiscal Year
NAVD 88	North American Vertical Datum of 1988
O&M	operations and maintenance
PALS	Post-assisted log structure
Project	Mill Creek Project
SPF	standard project flood
SRP	Sustainable Rivers Program
USGS	US Geological Survey
WDFW	Washington Department of Fish and Wildlife

SECTION 1 – INTRODUCTION

IMAGE 1: MILL CREEK FOREBAY. LOOKING EAST FROM DAM. SEPTEMBER 2021 (USACE image)

SECTION 1 – INTRODUCTION

The US Army Corps of Engineers (Corps) and the Nature Conservancy developed a national partnership for the Sustainable Rivers Program (SRP) in 2002. The fundamental goal of the SRP is to identify, refine, and implement environmental strategies for water management with environmental benefits at Corps water infrastructure Projects.

River flows that create conditions needed to foster and sustain freshwater ecosystems are referred to as "environmental flows". Because reservoirs provide an opportunity to affect the timing and magnitude of river flows, they can increase benefits if environmental flow strategies are implemented to include improved fish migration and water quality. At the same time, they can better support aquatic plants and animals that rely on these river flows for their survival.

SRP funding is competed nationally among Corps projects where river flow may be improved or augmented to benefit both the environment and Project operations. In 2021, a proposal was

submitted and awarded to evaluate the potential for environmental flow improvements in the Walla Walla District, Mill Creek Diversion Dam (Diversion Dam) forebay. The Diversion Dam is considered a 'dry dam' under the SRP, because Mill Creek flows through the Diversion Dam as run-of-river and water is only stored when the outlet capacity is exceeded by flood flows, forcing spill and diversion.

Potential opportunities in the Diversion Dam forebay include improvements in water temperature, fish rearing habitat complexity and availability, levee scour protection, and sediment management.

1.1 Scope

The Mill Creek Project (Project) is located approximately 3.5 miles east of the City of Walla Walla, within the Mill Creek watershed (Figure 1) and is operated by the Corps, Walla Walla District, for authorized missions of flood risk management and recreation. The Project consists of an off-stream storage reservoir and two diversion structures on Mill Creek. Project staff implement a strong environmental stewardship program.

Providing effective fish passage at the main flood management Diversion Dam is a critical part of Project operations. Mid-Columbia River steelhead (*Oncorhynchus mykiss*) and bull trout (*Salvelinus confluentus*), both listed as "Threatened" under the Endangered Species Act (ESA), migrate through the Project footprint to spawn in the headwaters of Mill Creek in the Blue Mountains. Project operations and maintenance (O&M) affect the physical habitat and water quality these species rely on. The O&M program recently completed ESA consultation, resulting in biological opinions from both the National Marine Fisheries Service and the US Fish and Wildlife Service. The design process for a new and more effective Diversion Dam fishway is currently underway.

The Walla Walla County Mill Creek Flood Control District is located directly downstream of the Project. It consists of a leveed channel upstream and downstream of the City of Walla Walla and a concrete channel through the city. These features were originally constructed by the Works Progress Administration and then the Corps but are now managed by Walla Walla County. In 2021, the Corps completed a flood risk study with Walla Walla County, which recommended relatively minor improvements to the existing channel and levees, and a change to the Project Water Control Manual (WCM) flood operation trigger from 1,400 cubic feet per second (cfs) to 1,700 CFS.

An Engineering Technical Support effort (Renholds et al. 2022) investigated relocating the Mill Creek Channel as it enters Federal property. While channel relocation may be driven by dam safety, this SRP project seeks to identify concepts for environmental and operational improvements in the 40-acre forebay which would be complementary to the stream channel relocation recommendations presented by Renholds et al (2022).

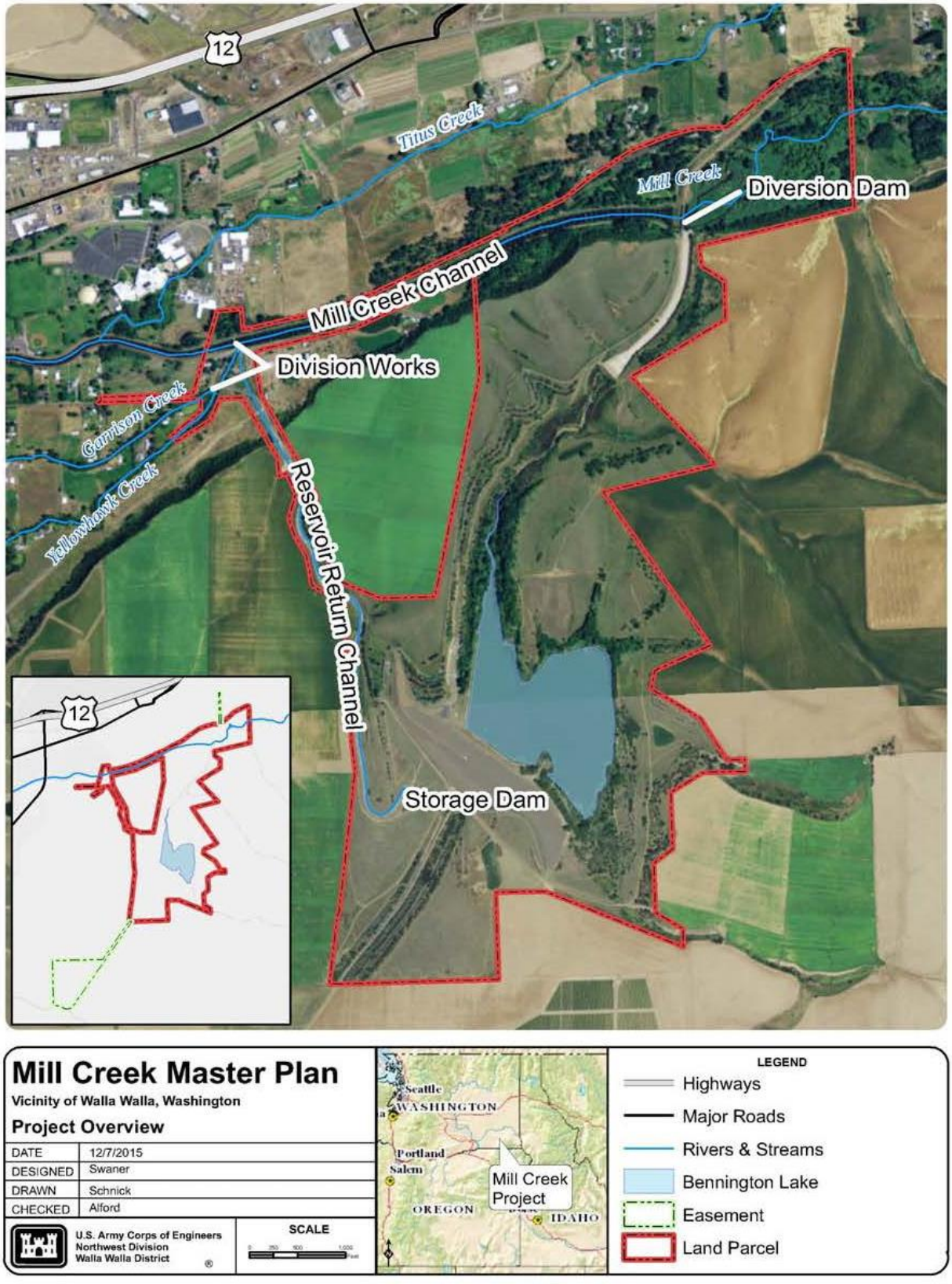

FIGURE 1: PROJECT OVERVIEW

The Mill Creek watershed has a substantial number of supportive stakeholders, including local and state governments, local Tribes, and concerned citizens. Collectively, these entities form the Mill Creek Work Group, and they are committed to making environmental improvements within the Mill Creek watershed.

Fiscal Year (FY) 2021 SRP funding was used to conduct a workshop with the Mill Creek Work Group to document existing and ongoing data collection and research efforts. This summary report documents the workshop findings, recommendations, and potential out-year actions. If fully realized, the implementation of changes identified through the SRP process could have positive and lasting environmental effects, including benefits to ESA-listed fish species.

The following paragraphs contain a brief description of activities and products accomplished to date:

- **Sustainable Rivers Workshop:** The NWW SRP team coordinated a workshop April 1, 2021 at Mill Creek's Rooks Park to bring Mill Creek Work Group members together with scientific experts and environmental practitioners, introduce them to the SRP, access local expertise, and share the significant work already being done throughout the watershed. Facilitators guided brainstorming sessions to produce ideas that could potentially increase environmental benefits through modified operations or other work done in the Diversion Dam forebay. The goal of the workshop was to develop a set of recommendations to maximize ecological functions in the Diversion Dam forebay. Meeting notes from the workshop are located in Appendix A.

- **Summary Report from Mill Creek Sustainable Rivers Workshop:** This summary report includes a description of ongoing work and relevant research throughout the watershed, as well as specific recommendations coming from the workshop.

1.2 Mill Creek Project Description

Construction of the Mill Creek Project was completed by the Corps in 1942. The recreation area comprises 699 acres along Mill Creek in Walla Walla County, Washington (Figure 1). The Project consists of the Diversion Dam which is located on the upstream end of the Mill Creek Flood Control Project on Mill Creek at river mile 11.4. Associated structures consist of the low-flow outlet, fish ladder, spillway, intake canal headworks and intake canal, Diversion Dam dike, and debris barriers (Figure 1-5). The purpose of the Diversion Dam is to raise the water level behind the dam during floods to make it possible to divert floodwaters from Mill Creek through the intake canal headworks and intake canal and into the storage reservoir, Bennington Lake.

Bennington Lake is an off-stream reservoir (Virgil B. Bennington Lake), which provides recreational fishing and flood storage, and associated wildlife lands. The Project provides flood risk management to the City of Walla Walla by diverting flows that exceed channel capacity into the 225-acre off-stream reservoir. Since 1942, nearly $80 million in potential flood damages have been prevented by the combined storage and channel operations.

1.3 Study Area

The Diversion Dam forebay (Figure 2) is the focus of this study. It comprises approximately 40 acres on the Federal footprint.

FIGURE 2: MILL CREEK DIVERSION DAM FOREBAY STUDY AREA

1.4 Watershed Efforts by Other Organizations

Habitat restoration efforts have been completed by other groups and organizations throughout the watershed and in close proximity to the Project. They include projects by the Tri-State Steelheaders (a non-governmental Washington State regional fisheries enhancement group), Walla Walla County Conservation District, and the Confederated Tribes of the Umatilla Indian Reservation (CTUIR).

- **Tri-State Steelheaders:** A 2009 assessment of the Mill Creek Channel identified that the energy dissipating stabilizers (EDS) and the concrete channel that runs through Walla Walla created a barrier to fish passage. To improve fish passage at the EDS, the Corps and the Tri-State Steelheaders are placing a "V-notch" system in the EDS. This is done by removing a section from the EDS and inserting a concrete vault with a V-notch at the upstream and downstream end of the vault. After being secured in place, the V-notch lowers and concentrates water flow.

  The Tri-State Steelheaders are also working to improve passage through the concrete channel by installing "roughness panels." The panels are created by

pouring concrete in a predetermined form engineered to interrupt the water flow. Sections of the concrete channel are being removed and replaced with these engineered panel sections, and resting pools are being added where fish can rest and regain their energy. Existing baffles in the concrete channel are also being reconfigured to provide better flow for juvenile fish. The CTUIR is a project partner for this work.

- **Walla Walla Conservation District:** The Walla Walla Conservation District is actively working with willing landowners to improve Mill Creek floodplain function and floodplain reconnection directly upstream of the Project, from river miles 12 to 18.5. Features in their conceptual plans include large woody debris and log jam placement, side-channel and floodplain connections and improvements, and native plant restoration. Construction is expected to occur between 2023 and 2027.

- **Confederated Tribes of the Umatilla Indian Reservation:** The CTUIR monitor the downstream migration of juvenile salmonids using a screw trap in the Diversion Dam forebay. The trap is usually operated from late winter to the end of May or early June. Water temperatures in Mill Creek are the primary limiting factor for trap operations and, when water temperatures exceed 60.8 to 62.6 degrees Fahrenheit (°F), the trap is removed.

SECTION 2 – EXISTING CONDITIONS

IMAGE 2: THE FOREBAY IN MID SPRING. APRIL 2021 (USACE image)

SECTION 2 – EXISTING CONDITIONS

This section provides a general inventory of those existing conditions that could be influenced by an undertaking in the Project footprint, including climate, hydrology, fish and wildlife, and vegetation.

2.1 Project Configuration and Operations

The Mill Creek Channel through the City of Walla Walla was completed in 1948. The non-federal project is located approximately 1 mile downstream of the Federal project. Although the concrete section through the City is designed to handle flows up to 5,400 cfs (Corps, 2021), the leveed sections of the channel between the Mill Creek Project and the City only have a capacity of 3,500 cfs. Beginning in Water Year 2022, the Stage 1 Flood flow of 1,400 cfs triggering water diversion into Bennington Lake will increase to 1,700 cfs. The "standard project flood" for the Project is 18,000 cfs above the Diversion Dam and 11,000 cfs below the dam (Corps, 2008).

The diversion works include a reinforced concrete Diversion Dam with a 250-linear-foot ogee spillway, gated intake canal, and a low-flow outlet and fish ladder on the south side of the dam (Figure 3). Two other notable project features upstream of the Diversion Dam include a 2,200-

linear-foot earthen Diversion Dam levee on the right bank and a 400-linear-foot cable-style debris barrier supported by steel cribs. For low flows of less than 400 cfs, Mill Creek is routed through the radial sluice gate and fish ladder while, during seasonal high flows, the project is operated to maintain a forebay pool that extends around 600 linear feet upstream of the Diversion Dam to a normal elevation of 1264.3 feet (North American Vertical Datum of 1988 [NAVD 88]).

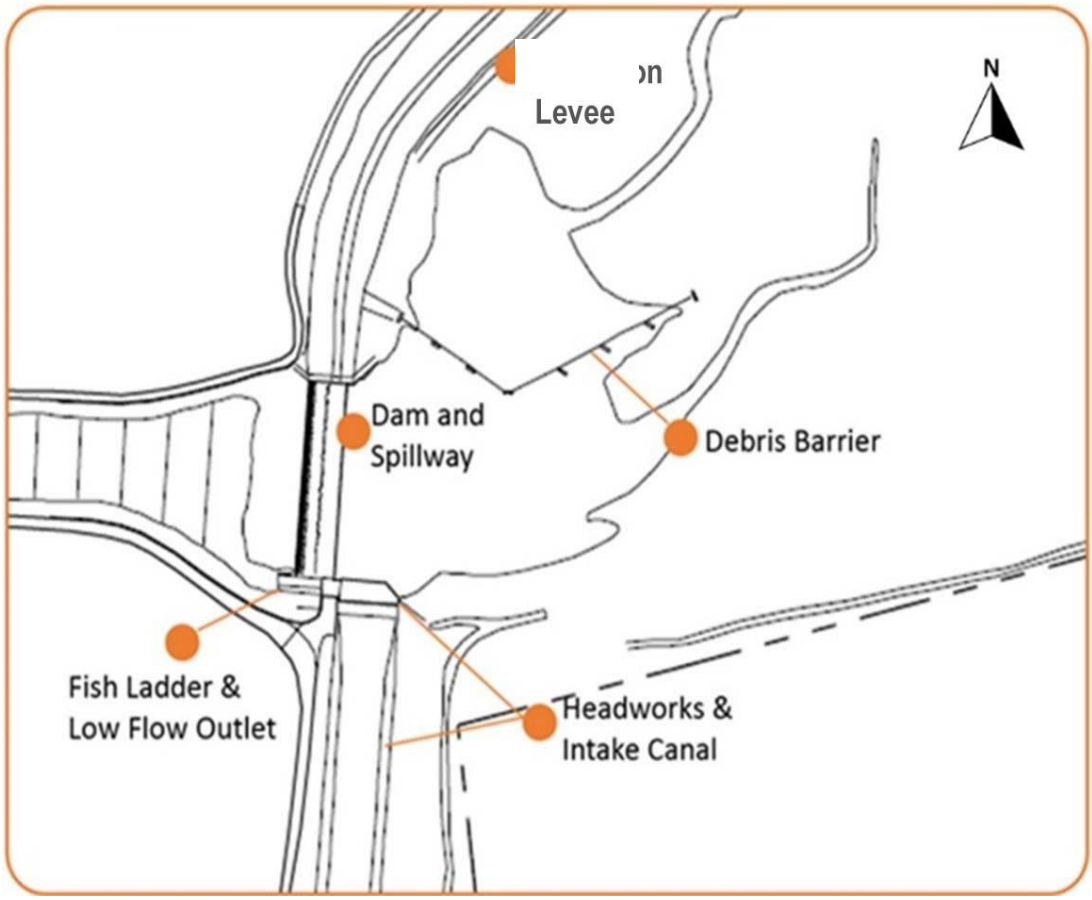

FIGURE 3: MILL CREEK DIVERSION DAM FEATURES. FLOW IS FROM RIGHT TO LEFT.

The Mill Creek Diversion Dam fish ladder was constructed in 1982 to allow upstream fish passage around the dam. The ladder is 6.5 feet wide, 86 feet long, and about 6 feet high. A 24-inch-wide by 81-inch-high slide gate at the exit is designed to operate fully open under normal conditions. Water levels within the ladder vary from 0.5 to 2 feet at the entrance, to 1 to 1.5 feet at the intermediate weirs, to 1 to 2 feet at the exit. The wide range of water levels at the entrance is caused by the varying amount of flow through the low-flow outlet and the water level in the stilling basin below the entrance.

The Diversion Dam fish ladder is designed to operate at flows less than 400 cfs and at forebay elevations ranging from 1,253 to 1,256 feet. Mill Creek flows range from as low as 10 cfs up to 60 cfs during summer. Steelhead pass the Diversion Dam year-round while bull trout pass

largely during late summer for their spawning migration to the Mill Creek headwaters. Video observations by the Corps suggest fish passage at the Diversion Dam begins to be obstructed at around 200 cfs, which is common during winter when steelhead may be migrating toward the Mill Creek headwaters for spawning. Fish passage is entirely blocked when flow begins to spill over the spillway at 400 cfs. The ladder is operated year-round, except during maintenance or when flow is expected to exceed 400 cfs, which occurs on average 10 days a year. During periods of higher flow, the ladder is closed to limit debris accumulation.

A new fish ladder that meets current fish passage criteria and operates over a wider flow range is currently in design at the Walla Walla District. Construction will be dependent on out-year budgets. With a new ladder design, the stilling basin may also be modified to prevent stranding adult fish and to improve downstream passage conditions for juvenile fish.

2.2 Hydrology and Flood Flows

Mill Creek is 37 miles long and drains 165 square miles within the Walla Walla watershed (Figure 4). It originates on the western slopes of the Blue Mountains and flows through 15 miles of mountainous terrain before it enters the Walla Walla Valley about 2 miles east of the City of Walla Walla. The Mill Creek water elevations range from 5,500 feet at the headwaters to 590 feet at its confluence with the Walla Walla River.

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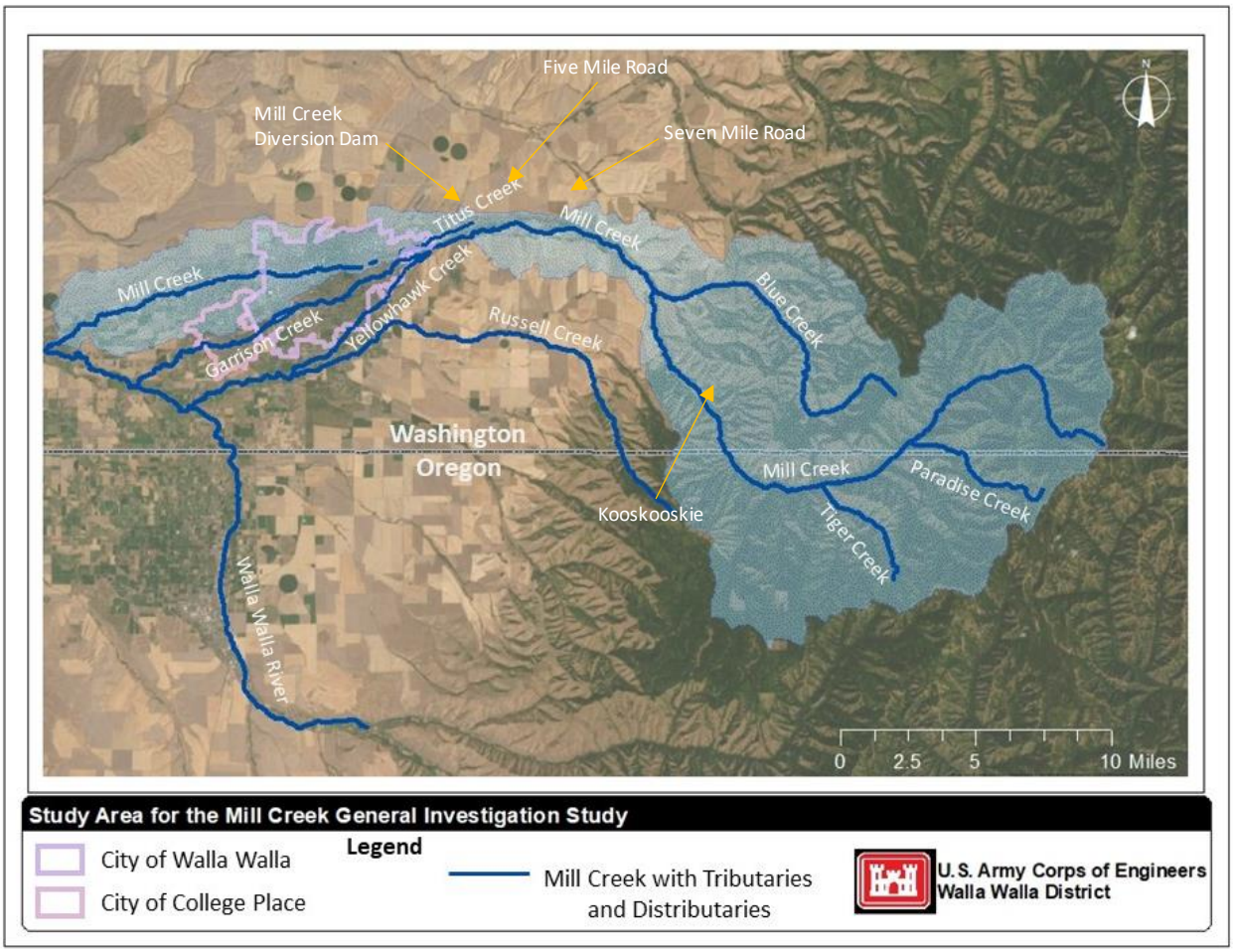

FIGURE 4: MILL CREEK WATERSHED MAP.

The annual streamflow pattern for Mill Creek is snowmelt driven, and typically consists of moderate to high flows from November through June and low flows from July through October. The US Geological Survey (USGS) has measured flows since 1997 at the Five Mile Bridge, approximately 1.5 miles upstream of the Diversion Dam (Figure 5). Summer base flows average around 20 cfs to 30 cfs upstream of the dam. Bennington Lake is filled for recreation use each spring after the risk of flooding events has passed. This recreational filling can occur until June 15 each year if flows are high enough (TetraTech, 2017).

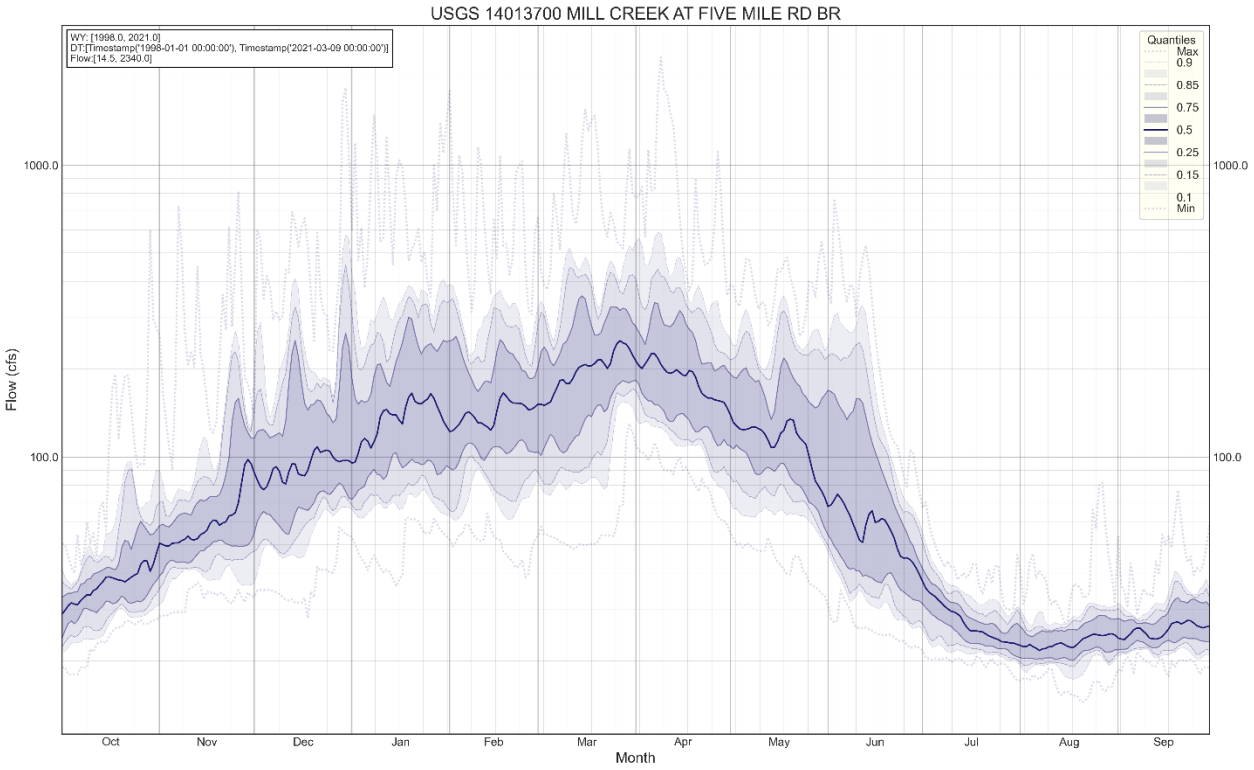

FIGURE 5: ANNUAL MEAN-DAILY HYDROGRAPH PERCENTILES FOR MILL CREEK AT FIVE MILE ROAD (USGS 14013700), FROM 1998 THROUGH 2020

Statistics of mean-daily flow-duration-frequency for Mill Creek above the Diversion Dam were computed for the 1998 to 2020 period of record at USGS station 14013700 at Five Mile Road. As mentioned earlier, when incoming flows are above 400 cfs, the low flow outlet sluice gate at the Diversion Dam is closed and the pool elevation is allowed to rise until it overflows the spillway crest. The data in Table 1 indicate that the frequency of conditions where a backwater pool is expected to form (brown-shaded area) has a high likelihood of occurring in most years and could be of sufficient duration to allow a substantial amount of suspended fine sediment to deposit in the forebay backwater. The mean daily discharge at the Five Mile Bridge gage exceeded 400 cfs around 4.5 percent of the time between 1998 and 2020.

Flood flows in the study area most commonly occur at 400 cfs (Stage 1 Flood). This action floods the forebay creating a small impoundment, while incoming flow begins to activate the forebay floodplain (Figure 6).

TABLE 1. FLOW DURATION FREQUENCY FOR MILL CREEK AT FIVE MILE ROAD (USGS 14013700), FROM 1998 THROUGH 2021

Percent Chance Exceedance	Duration Days						
	1	3	7	15	30	60	90
	Mean Daily Discharge (cfs)						
0.2	3,994	3,528	2,892	1,958	1,182	718	550
0.5	3,363	2,921	2,323	1,574	1,001	647	509
1	2,927	2,509	1,953	1,327	878	594	477
2	2,524	2,134	1,628	1,111	764	540	443
5	2,033	1,687	1,256	866	626	469	395
10	1,688	1380	1,012	706	530	414	355
20	1,359	1,092	793	563	439	355	309
50	918	719	523	388	317	265	234
80	639	491	368	288	240	197	173
90	535	408	313	254	211	169	145
95	465	353	278	231	191	149	126
99	362	273	228	200	162	117	94

Flow duration statistics computed via EMA Log Pearson III distribution with unweighted station skew.
Unshaded values indicate flows exceeding the 1400 cfs Bennington diversion criteria.
Brown shaded values indicate flows exceeding the 400 cfs gate control criteria (Stage 1 Flood).
Blue shaded values indicate flows without notable backwater effects in the forebay and represent normal flow ranges.

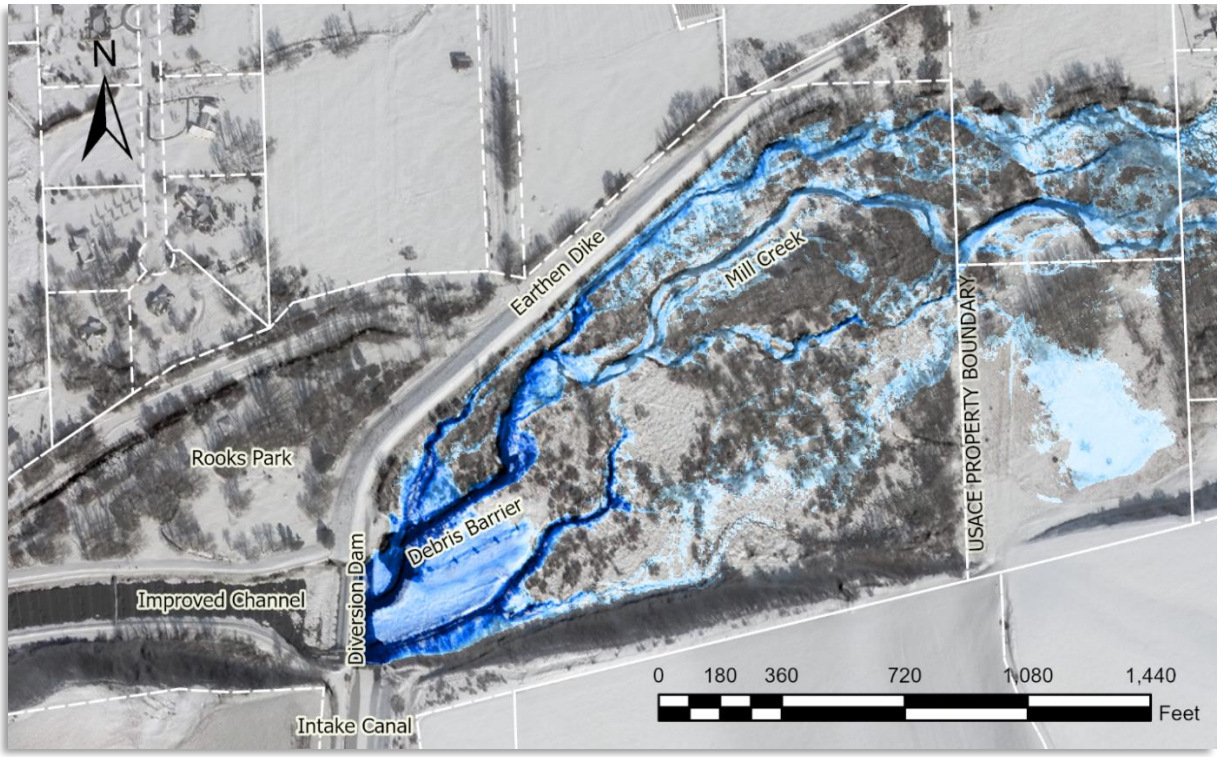

FIGURE 6: MILL CREEK FOREBAY AT APPROXIMATELY 400 CFS FLOW. MAIN CHANNELS ARE SHADED CHANNELS AND THE FOREBAY FLOODPLAIN IS ACTIVATED. FLOW IS FROM RIGHT TO LEFT. PHOTO FROM 7 MARCH 2019.

Flood flows in the Mill Creek Basin are relatively flashy, with the two largest recorded flood events resulting from rain-on-snow during the month of February. The largest floods of record were 6,800 cfs in February 1996 on frozen ground, and 6,500 cfs in February 2020 on saturated ground. The next two largest floods occurred in April 1931 (6,000 cfs) and May 1906 (5,200 cfs), prior to completion of the Mill Creek Project. Although the Diversion Dam can dampen local hydraulics in the upstream backwater, erosive forces and sediment loading associated with large flood flows will need to be considered during the design of any proposed SRP actions. The combined 1-hour unregulated peak flow values developed for the Mill Creek General Investigation study (Corps, 2021) are presented in Table 2.

TABLE 2. COMBINED 10 HOUR UNREGULATED FLOW PEAK VALUES FOR MILL CREEK.

Annual Exceedance Probability (Percent)	Combined 1-Hour Unregulated Peak Flow (cfs)		
	Peak	5% Lower Confidence Level	95% Upper Confidence Level
0.2	13,971	8,228	23,722
0.5	9,050	5,777	14,176
1	6,678	4,503	9,904
2	5,048	3,573	7,131
5	3,612	2,645	4,931
10	2,718	2,120	3,484
20	1,962	1,624	2,371
50	1,132	987	1,299
80*	697	599	812
90*	540	449	650
99*	298	229	389

** Identifies typical flood flows at the Mill Creek Diversion Dam.*

To accommodate the recommended change to the Stage 1 Flood diversion trigger from 1,400 cfs to 1,700 cfs, a temporary procedure change was issued by the Mill Creek Operations Project Manager to comply with the 1,700 cfs. The increase to 1,700 cfs will remain in operation through the changes to the WCM. Presently, at 1,400 cfs, all diversion gates are opened 2 percent or 25 cfs and held until flow reaches 1,700. At that time, flow diversion would follow the Stage 3 Flood Standard Operating Procedure, passing a maximum of 3,000 cfs down Mill Creek.

2.3 Climate

The ecoregion has a severe, mid-latitude climate, with both continental and Mediterranean influences. It is marked by warm, dry summers and cold winters. The mean annual temperature ranges from approximately 30°F to 50°F. The hot season lasts for approximately 4 months, from June through September, with an average daily high temperature above 82°F. The cold season also lasts for approximately 4 months, from November through February, with an average daily high temperature below 50°F. The frost-free period extends from 30 to 160

days. Summer stream temperatures are a limiting factor for native fish communities in Mill Creek, as it often exceeds 68°F from July through August (or even into September).

As with temperature, the mean annual precipitation ranges widely, depending on elevation: from about 8.7 inches in low valleys to over 80.7 inches at higher elevations. Mean annual precipitation over the Mill Creek Watershed averages around 46 inches annually. While rain is possible from July through September, the wet season is typically from October through June. The two months of July and August typically have no precipitation.

2.4 Morphology

When Mill Creek enters the Walla Walla Valley, it can generally be characterized as a dynamic gravel cobble bed channel, with a dominant thread and intermittent side channel bifurcations. These bifurcations provide access to a contiguous, but relatively narrow, floodplain bounded by agriculture and rural land use. In the 3-mile-long reach from Seven Mile Bridge to the Diversion Dam (Figure 4), the morphology includes typical riffle/pool sequences with lateral point bar deposition features, a bankfull width-to-depth ratio between 15 and 25, an average planform sinuosity of 10 percent (Figures 7-8), and a channel slope just over 1 percent at around 60 feet per mile (TetraTech, 2017).

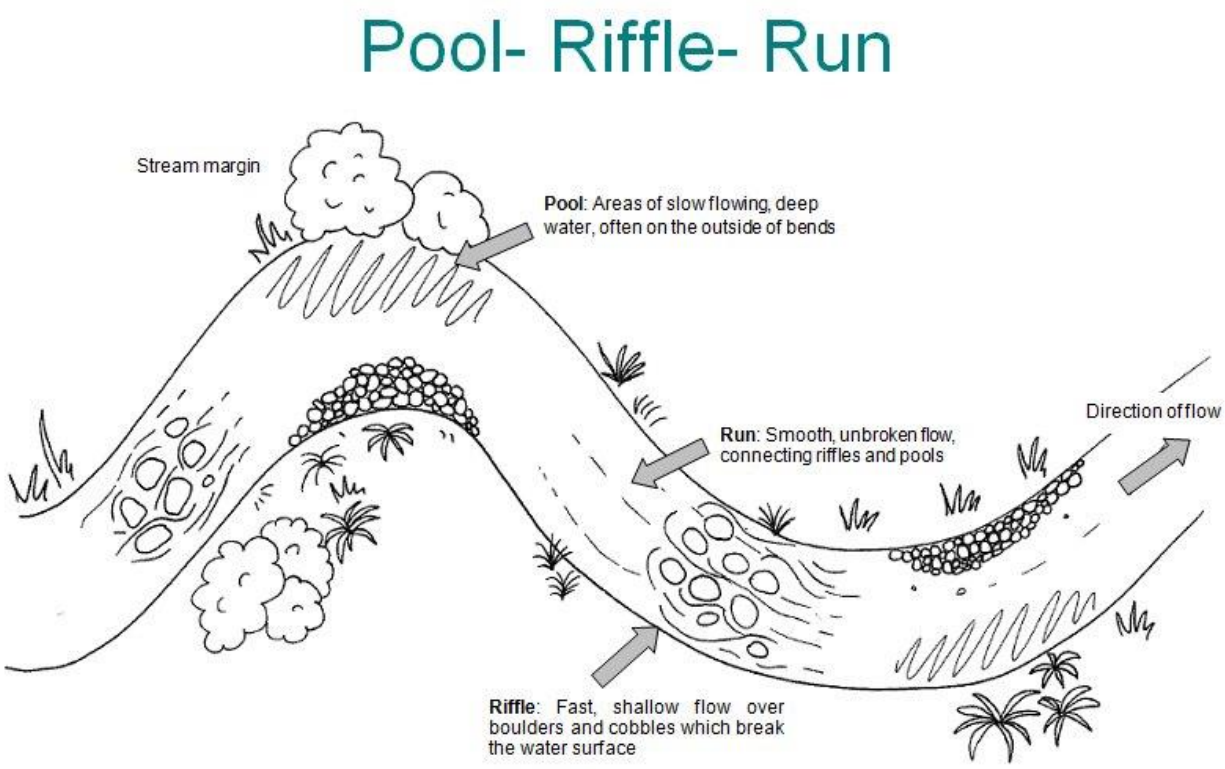

FIGURE 7: EXAMPLE RIFFLE-RUN-POOL SEQUENCE OF A NATURAL STREAM.

FIGURE 8: MILL CREEK LATERAL PROFILE IN JUNE 2019. TOP PHOTO IS DOWNSTREAM OF FIVE MILE BRIDGE. BOTTOM PHOTO IS DOWNSTREAM OF SEVEN MILE BRIDGE. FLOW DIRECTION IS FROM RIGHT TO LEFT.

In the 3-mile reach upstream of the Diversion Dam, the channel is generally in dynamic equilibrium with the prevailing flow and sediment regime. Notable sediment storage along the channel margins is prevalent and some mid-channel bars have formed, indicative of a future trend towards braiding in over-widened channel segments. Lateral channel migration is occurring at unstable meander bends with vertical eroding banks, as well as some locations where side channels that capture overbank flow are widening and/or downcutting. In addition, sediment deposition and planform adjustment were found to coincide with the presence of large woody debris dams in the main channel.

The Mill Creek channel carries a significant volume of sediment from the headwaters down to the Diversion Dam. In the reach below the Five Mile Bridge, the Corps (2011) observed that the channel bed was seasonally dynamic during the spring freshet, with a median particle size of very coarse gravel with non-imbricated coarse sand in the interstitial space and a surficial armor layer of small cobble. Channel and floodplain areas with hydraulic shadows were observed to be overlain with fine sediment, supporting both emergent and well-established riparian vegetation (see Section 2.6).

The channel morphology and flow patterns in the sub-reach upstream of the Diversion Dam are influenced by a combination of dynamic factors, including the seasonal forebay backwater extending about 600 linear feet upstream of the spillway, sediment deposition upstream of the debris barrier, split flow conditions, and periodic O&M removal of sediment deposits. As discussed in Section 2.3, the outlet gate at the Diversion Dam is closed at flows greater than 400 cfs creating a pool in the forebay to allow for diversion to Bennington Lake. The flood flow exceedance threshold for diversion to Bennington Lake is 1,700 cfs (see Section 2.3), but the

lake is still filled annually at lower flows for recreation. This can require the forebay pool to be held high for an extended duration.

While not well defined, flows above 400 cfs appear to be greater than or equal to the upstream channel bankfull capacity, and are capable of delivering substantial quantities of both coarse bedload and suspended washload sediment to the Diversion Dam forebay. Figure 9 depicts the depth and backwater extents for a nominal flow of 500 cfs with the outlet and diversion works closed and the spillway active. Under these conditions, forebay velocities average 0.25 feet per second (fps), with an average shear velocity less than 0.1 fps and sediment coarser than fine sand deposits requiring periodic O&M removal.

About 250 linear feet upstream of the Diversion Dam, a debris barrier was constructed in 1984. It is made of steel cable mesh supported by structural cribs intended to trap large woody debris and ice (Figure 10). This barrier is located within the seasonal backwater extents and influences local flow patterns and sediment deposition. A vegetated gravel bar upstream of the debris barrier has continually increased in size over the last decade.

FIGURE 9: AERIAL PHOTO FROM JUNE 2019

FIGURE 10: FOREBAY DEBRIS BARRIER. LOOKING SOUTHEAST AFTER VEGETATION CLEANING IN AUGUST 2011 (USACE image)

At the upstream extent of the seasonal backwater, a consolidated silt bed has formed that is resistant to erosion (Figure 11). Prior investigations (Corps, 2011) have observed gravel bedload moving over the top of this layer (Figure 12) at flows less than 400 cfs when the outlet gate is open, suggesting that erosion resistant lenses of silt may influence the vertical channel profile at the transition to a seasonal forebay backwater pool.

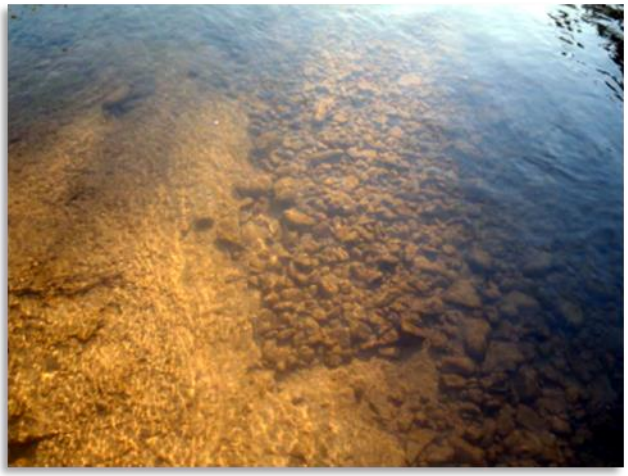

FIGURE 12: GRAVEL BEDLOAD ON TOP OF CONSOLIDATED SILT BED ABOVE THE DEBRIS BARRIER AT THE UPSTREAM EXTENT OF THE SEASONAL BACKWATER (USACE image)

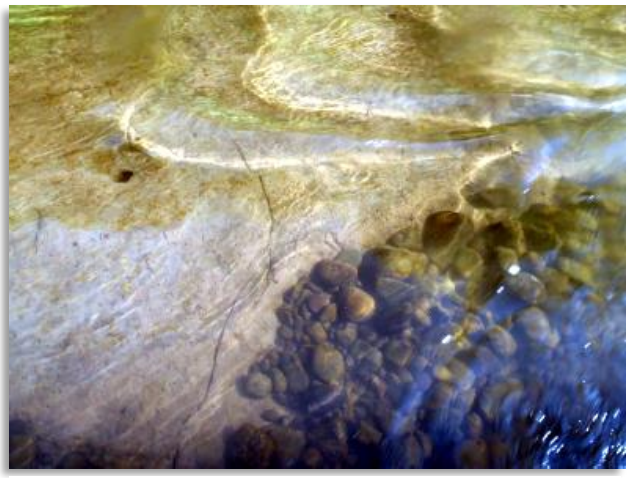

FIGURE 11: GRAVEL BEDLOAD (USACE image)

Incoming flow to the project from Mill Creek is split into two prominent parallel channels offset with a narrow riparian area (Figure 13). This flow split occurs about 1500 linear feet upstream of the east property boundary where shoaling and debris in Mill Creek appears to be routing flow onto the right overbank floodplain at magnitudes as low as 100 cfs (Figure 14).

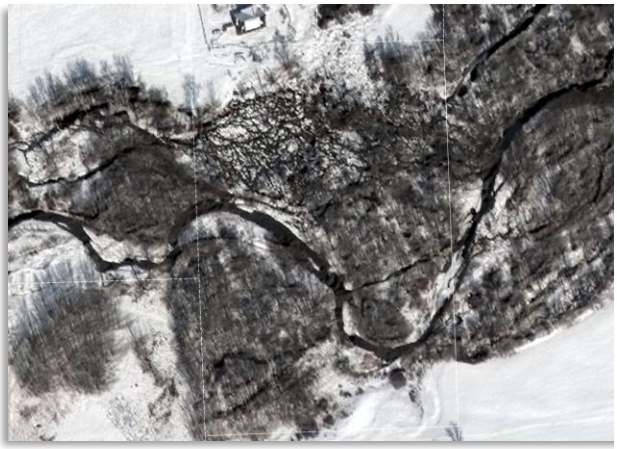

FIGURE 13: SITE UPSTREAM OF CORPS PROPERTY BOUNDARY WHERE MILL CREEK FLOW SPLIT IS OCCURRING. MARCH 2018

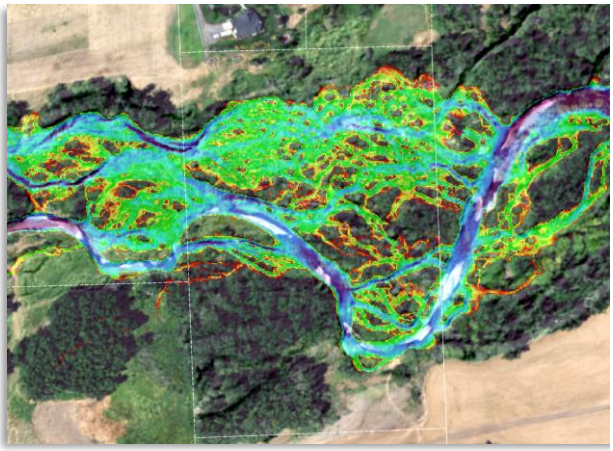

FIGURE 14: PROVISIONAL OVERBANK FLOW PATHS. JUNE 2019

While floodplain activation can be desirable from an ecological perspective, the split channel within the Mill Creek project extents has raised some concern. The alignment of the northern channel runs parallel to the toe of the Diversion Dam levee, increasing risk relative to scour and seepage. Project personnel have observed that the northern channel within the Project footprint has been incrementally increasing in size and capturing more flow over time (Figure 15). Provisional analysis indicates an approximate 55/45 flow split between the primary (southern) channel and the secondary (northern) channel at a nominal discharge of 400 cfs. Numerous overbank flow paths are activated at larger flows, which is expected to influence

overall flow partitioning. In addition, there is a notable elevation difference between the two channels depending on the flow. Elevation data indicates that the northern channel averages about 1 foot lower than the primary (southern) channel in the east half of the property upstream of the forebay. There are small side channels that create preferential flow paths draining from the primary channel right bank to the north.

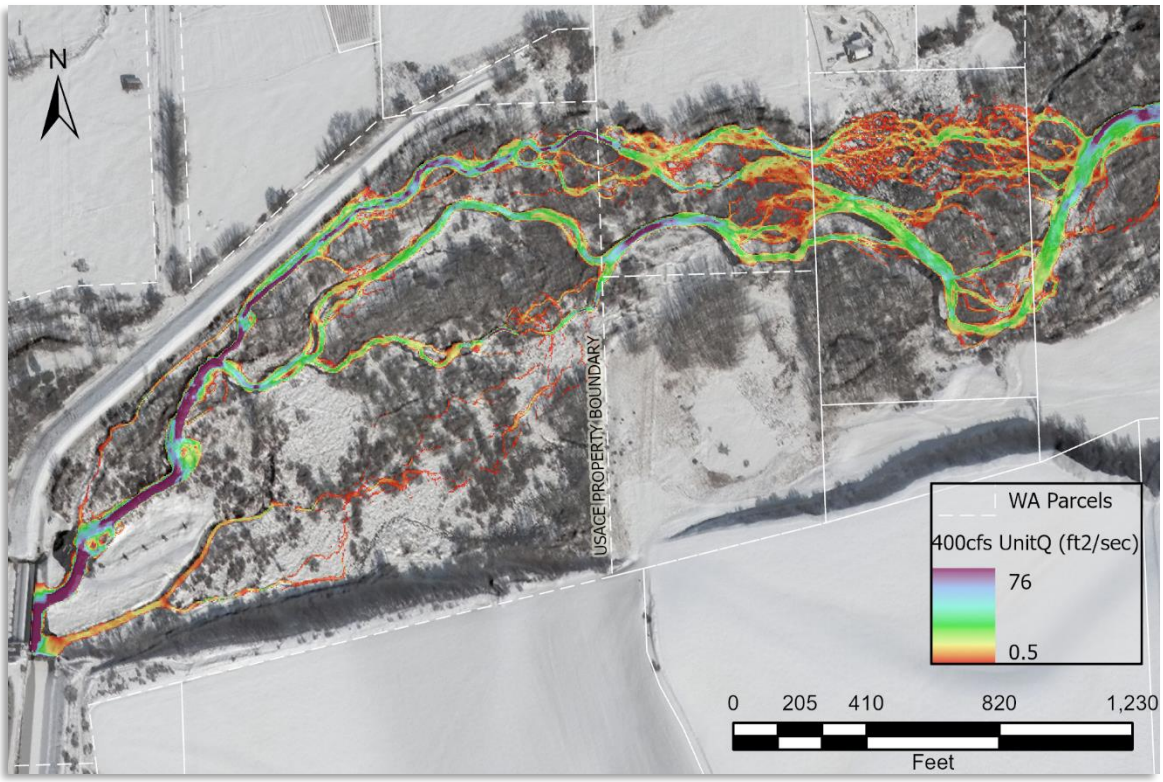

FIGURE 15: UNIT DISCHARGE (CFS/FOOT) FOR MILL CREEK UPSTREAM OF THE DIVERSION DAM AT 400 CFS INFLOW WITH OUTLET GATE OPEN. AIR-PHOTO DATE IS 7 MARCH 2019.

2.5 Fish and Wildlife Resources

The Project provides habitat for approximately 170 different species of fish and wildlife (Corps 2016). The close proximity of the Project to the City of Walla Walla allows the community to experience wildlife viewing for educational, recreational (both passive and consumptive), and aesthetic purposes. Wildlife common to the project include mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), Rocky Mountain elk (*Cervus canadensis nelsoni*), striped skunk (*Mephitis mephitis*), cottontail rabbits (*Sylvilagus floridanus*), coyote (*Canis latrans*), and bobcat (*Lynx rufus*). Many bird species can also be found here, including the red-shafted flicker (*Colaptes auratus*), mourning dove (*Zenaida macroura*), ring-necked pheasant (*Phasianus colchicus*), and valley quail (*Callipepla californica*), along with a variety of swallows, sparrows, thrushes, and owls.

The diverse vegetation on the Project provides habitat for a wide variety of wildlife. Limited development along its banks allows Mill Creek to serve as an important corridor for wildlife from the Blue Mountains to the Project. The trees, shrubs, and grasses upstream of the Project provide excellent cover and forage opportunities. Heavy willow growth is predominant in the Diversion Dam forebay, although it is partially removed periodically to prevent the restriction of flood flows.

Since the Project's inception, it has been co-managed through various agreements with Washington Department of Fish and Wildlife (WDFW). The WDFW helped develop favorable conditions for upland games birds, and they release ring-necked pheasants annually for hunting. The WDFW also plants between 5,000 and 40,000 rainbow trout (*Oncorhynchus mykiss*) in Bennington Lake each year. The lake serves the valley as a put-and-take fishery and is one of two public fishing lakes in the Walla Walla Valley.

Mill Creek is a migration corridor for ESA-listed Mid-Columbia River steelhead and bull trout as they move through the Project to their spawning and rearing habitat in the headwaters. Many other fish species also exist within the Project footprint, including mountain whitefish (*Prosopium williamsoni*), bridgelip sucker (*Catostomus columbianus*), redside shiner (*Richardsonius balteatus*), freshwater sculpin (*Cottus spp*.), dace (*Rhinichtys* spp.), and brook lamprey (*Lampetra richardsonii*).

2.6 Vegetation Resources

The southeast Washington region is comprised primarily of large grain farms with narrow, forested riparian strips. Historically, sagebrush-steppe was the dominant vegetation community, transitioning into pine and fir forest at the foot of the Blue Mountains to the east.

The rolling land around the lake supports modified Palouse prairie vegetation. Three types of vegetation classes are found within the Project: 1) terrestrial – those plant communities lying within the Project footprint; 2) riparian – the grasses, shrubs, trees, etc., that grow along the stream and help control erosion and aid in filtering the water; and 3) wetland – plants such as cattails (*Typha* spp.), sedges (*Carex* spp.), bulrush (*Scirpoides holoschoenus*), etc., that have adapted to being in a submerged and saturated condition for much of the year. To a great extent, these different types of vegetation determine the wildlife niches, habitats, and their associated values. Nearly 70 percent of the Project is classified as upland vegetation, with upland field comprising 67 percent of this total. The remaining portions of the Project consist of riparian (7.6 percent), wetlands (6.7 percent), lacustrine (7 percent), riverine (2.1 percent), and urban (9.2 percent) cover types (Corps, 2016). Trees and shrubs have been planted over former croplands on the Project in an effort to improve wildlife habitat by providing cover and the interspersion of plant communities.

Within the study area, 22 acres are classified as "freshwater forested/shrub wetland" and 7 acres are classified as "freshwater emergent wetland" (Figure 16). The herbaceous plant community is dominated by invasive reed canary grass (*Phalaris arundinacea*), but the woody

plant community includes native black cottonwood (*Populus trichocarpa*) and several native willow (*Salix* spp.) and alder (*Alnus* spp.) species.

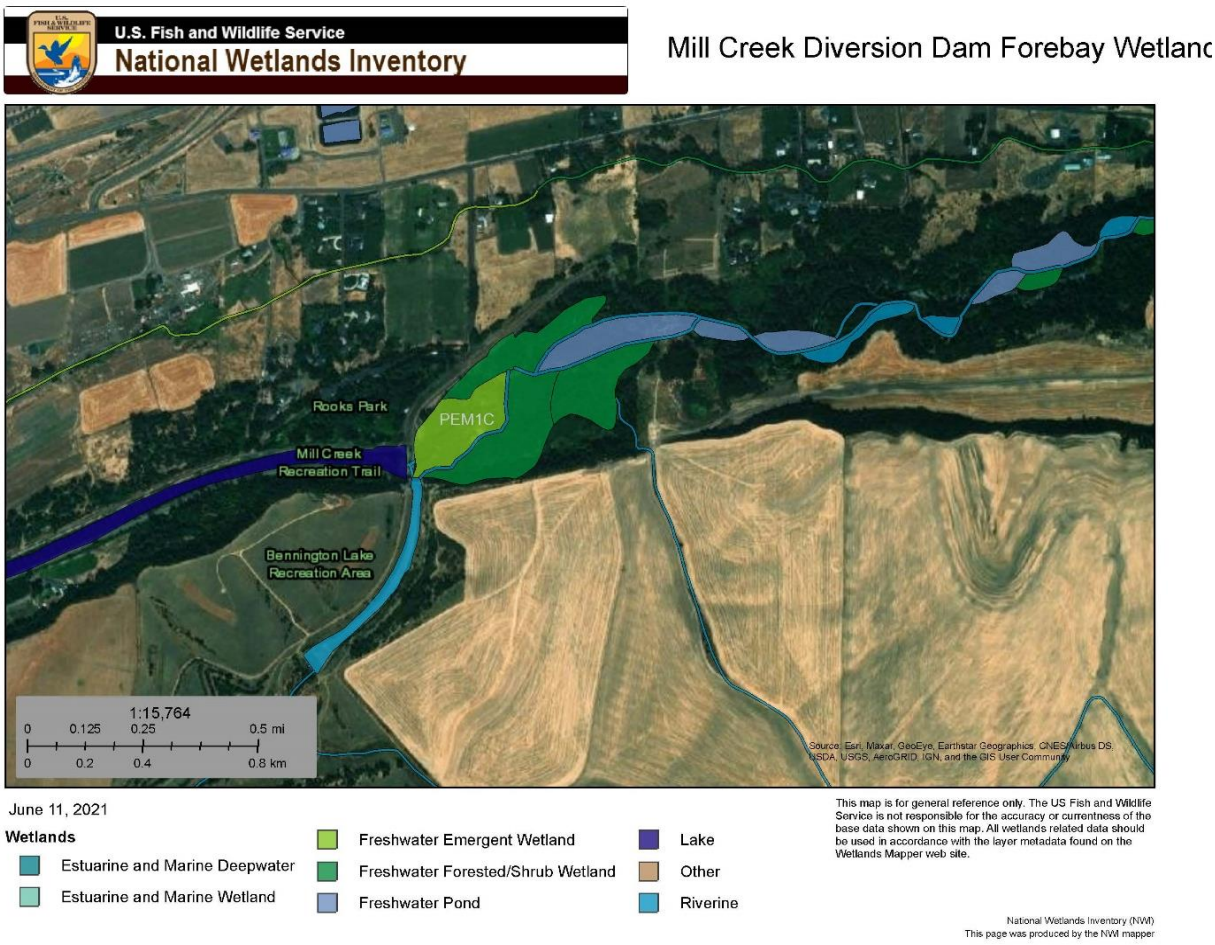

FIGURE 16: NATIONAL WETLANDS INVENTORY FOR THE MILL CREEK DIVERSION DAM FOREBAY AND STUDY AREA

SECTION 3 – RECOMMENDATIONS

IMAGE 3: VIEW OF DIVERSION DAM AND SPILLWAY FROM RIGHT BANK OF MILL CREEK. SEPTEMBER 2021 (USACE image)

SECTION 3 –RECOMMENDATION

The PDT and workshop participants loosely applied a Corps planning process type of analysis to identify problems and opportunities and used this to guide the development of actions that could be taken in the forebay.

3.1 Scoping Workshop

On April 1, 2021, the Corps hosted an all-day workshop with the Mill Creek Work Group and other stakeholders interested in the improvement of environmental conditions within the Mill Creek Watershed. The purpose of this meeting was to share information about restoration activities already occurring within the watershed, introduce the SRP, and discuss the prospects for the Corps to improve environmental conditions in the Diversion Dam Forebay at the Project.

Stakeholder groups that participated in the meeting included the following:

- **The Confederated Tribes of the Umatilla Indian Reservation:** The CTUIR is a union of the Cayuse, Umatilla, and Walla Walla Tribes. The CTUIR operates a weir in the forebay to monitor the downstream migration of juvenile salmonids.

- **Washington State Department of Ecology:** The Washington State Department of Ecology is working with a 15-member Strategic Plan Advisory Committee to develop a watershed plan that will guide water resource conservation and management over the next 30 years. They act as the Water Master for Mill Creek, Garrison Creek, and Yellowhawk Creek at the Division Dam.

- **Washington Conservation Corps:** The Washington Conservation Corps is an AmeriCorps program implemented through the Washington State Department of Ecology. They provide work crews for environmental restoration projects.

- **Walla Walla 2020:** Walla Walla 2020 is a non-profit civic group dedicated to plan for and undertake projects to create a positive and sustainable future in the Walla Walla Valley. Since the group's inception in 1988, they have promoted practices and systems to protect and enhance the quality of life in the Walla Walla Valley.

- **Tri-State Steelheaders:** The mission of the Tri-State Steelheaders is to foster sustainable populations of native salmonids in southeastern Washington, northeastern Oregon, and north central Idaho. A non-profit organization, they work closely with landowners, volunteers, Tribes, conservation organizations, and state and Federal agencies to implement projects and promote education and research programs.

- **Snake River Salmon Recovery Board:** The Snake River Salmon Recovery Board was created by Washington State Legislation to develop and oversee implementation of salmon recovery plans for the Snake River Basin. The Board is structured as a committee that recommends policies, programs, and funding consistent with the regional salmon recovery plans to those with authority to implement. (https://snakeriverboard.org/about-us/)

- **Walla Walla Basin Watershed Council:** The Walla Walla Basin Watershed Council was established in 1994, and originally worked only on the Oregon side of the Walla Walla Basin. They have since expanded their efforts into the State of Washington, and are dedicated to enhancing, restoring, and protecting native fish populations and their habitat, water quality, and overall watershed health. They are working to accomplish this through community education and by working in collaboration with local, state, Federal, and Tribal natural resource managers, private landowners, and the public.

- **Washington Department of Fish and Wildlife (WDFW):** WDFW is the organization responsible for conserving and protecting the fish, wildlife, and ecosystem resources of Washington State. They also endeavor to provide sustainable recreational and commercial opportunities for State residents. WDFW staff work with CTUIR staff to facilitate the Mill Creek Work Group.

- **Walla Walla County Conservation District:** While the Walla Walla Conservation District was unable to participate in the meeting, they are very interested in the SRP, and are committed to solving complex environmental issues through voluntary cooperation with private landowners. They have many ongoing projects within the Walla Walla Valley that support both fish passage and irrigation needs.

3.2 Problems

Workshop participants collaborated to identify problems in the Mill Creek forebay. They identified the following:

- Warm water temperatures
- Sedimentation and removal cost
- Levee scour concerns due to lateral stream channel migration
- Debris management – debris regularly builds up in the forebay and must be removed manually
- Flooding
- Impaired coarse sediment/gravel transport past the Diversion Dam
- Groundwater recharge
- Invasive plant species
- Low native plant species abundance and diversity

3.3 Opportunities

Workshop participants identified the following opportunities for environmental improvements in the forebay at the Project:

- Rebalance the hydraulic head within the channel to reduce downcutting
- Stabilize lateral stream movement by such actions as revegetating banks and in-channel structures, increasing sinuosity, increasing channel baseflow depth, improving fish passage, and adding large woody debris attached to the banks
- Provide more predictable floodplain connectivity by increasing floodplain storage and near-surface aquifer recharge
- Manage sediment more effectively, by using storage vs. routing (cobble vs. fine sediment)
- Increase native vegetation abundance, diversity, and structure
- Decrease water temperature
- Improve juvenile fish rearing habitat

- Improve Diversion Dam sediment and debris management
- Reduce levee scour and saturation risk by redirecting stream flow

3.4 Constraints

A constraint typically involves resource, legal, or policy considerations that limit the type of actions that could be taken to solve identified problems. All Federal undertakings must comply with Federal, state, and local laws, regulations, and policies. The following constrains were identified for any projects in the Diversion Dam forebay:

- Cannot interfere with the project purpose of providing flood risk management for the City of Walla Walla
- Current entry and exit points for water at the Diversion Dam must be maintained

No actions may be implemented on private land upstream (east) of the Mill Creek forebay, but they could potentially be integrated with coincident agency actions (e.g., Washington Department of Ecology Floodplains by Design Program).

3.5 Management Actions

The following actions and tools were suggested by workshop participants as options to provide benefit to the Mill Creek operations and ecosystem function:

3.5.1 Engineered Log Jams

Engineered log jams (ELJ) could be used to reinforce bank-lines, redirect flow, increase margin roughness and complexity, and reduce near bank stress. They are typically installed in sequence and integrated within reinforced bank-lines with a foundation extending below scour depth. Near the northeast property boundary, ELJs could be installed to redirect flow south back to the main channel, keeping water away from the levee. These could be constructed at various levels of structural integrity, balancing acceptable risk with appropriate materials and installation methods. A lower cost compliment to ELJs are post-assisted log structures (PALS) which could be effectively installed at the inlets and outlets of various side channels and floodplain swales to capture debris and fine sediment and redirect overbank flows. The PALS would provide shelter and habitat for fish and other wildlife.

3.5.2 Sediment Removal

By removing sediment via excavator from the forebay, side channels could be reopened. The landscape could be reshaped to allow stream meanders, direct water away from the levees, and establish wetlands upstream of the dam. Also, dredging immediately upstream of the Diversion Dam to elevation 1261 (NAVD 88) would allow a pooling area to be re-established.

3.5.3 Submerged Weir Structures

The installation of optimally placed submerged weir structures could provide multiple improvements. First, such structures could direct fine sediment to settle in places where it could be more easily dredged out when necessary. If sediment load is accurately calculated, these structures could be designed and placed in such a way that sediment could develop wetlands and associated plant communities and provide habitat for about 20 years between dredging efforts.

3.5.4 Constructed Wetlands

Wetlands could be constructed along the levee toe by placing fill to create a terrace in place of the current channels and revegetated with wetland species. The channels would provide a natural area of water movement or collection. This action could be combined with ELJs or PALS to provide levee toe scour protection, as well as juvenile salmon and steelhead rearing, water quality, and wildlife benefits.

3.5.5 Invasive Species Control

Implement ongoing invasive species control through the District's Integrated Pest Management Plan for reed canary grass and other incidental species. It is expected that this would require 3-5 years of intensive effort with annual monitoring and follow on. Methods could include chemical treatment, mechanical treatment, burning, and using goats to graze the grass. Reed canary grass removal would support native plant species diversity and restoration providing ecosystem benefits including cover and food sources for pollinator insects, nesting birds, and other fish and wildlife.

3.5.6 Native Vegetation Planting

Additional native plantings in the forebay of cottonwood, alder, willow, and other native grasses and forbs would provide terrestrial and aquatic habitat and stream temperature cooling. Woody vegetation is removed from the levee toe and dredged area upstream of the Diversion Dam, but woody plants are present and may grow throughout the eastern approximately two-thirds of the forebay. Planting would be included in every Enhancement Action requiring earthwork.

3.6 Conceptual Management Plan

The team considered the proposed Management Actions to develop a Conceptual Management Plan (Plan) illustrated in Figure 17, that would modify the channel, floodplain, and forebay to improve fluvial processes and conditions. It would focus on both the upstream channels along the levee and the downstream transition to a minimal seasonal backwater pool. This Plan includes all Management Actions identified in the workshop except for the Submerged Weir

Structures. The weirs were not considered further because they would pond water rather than improve stream flow, which is counter to the ecosystem benefits of the other management actions.

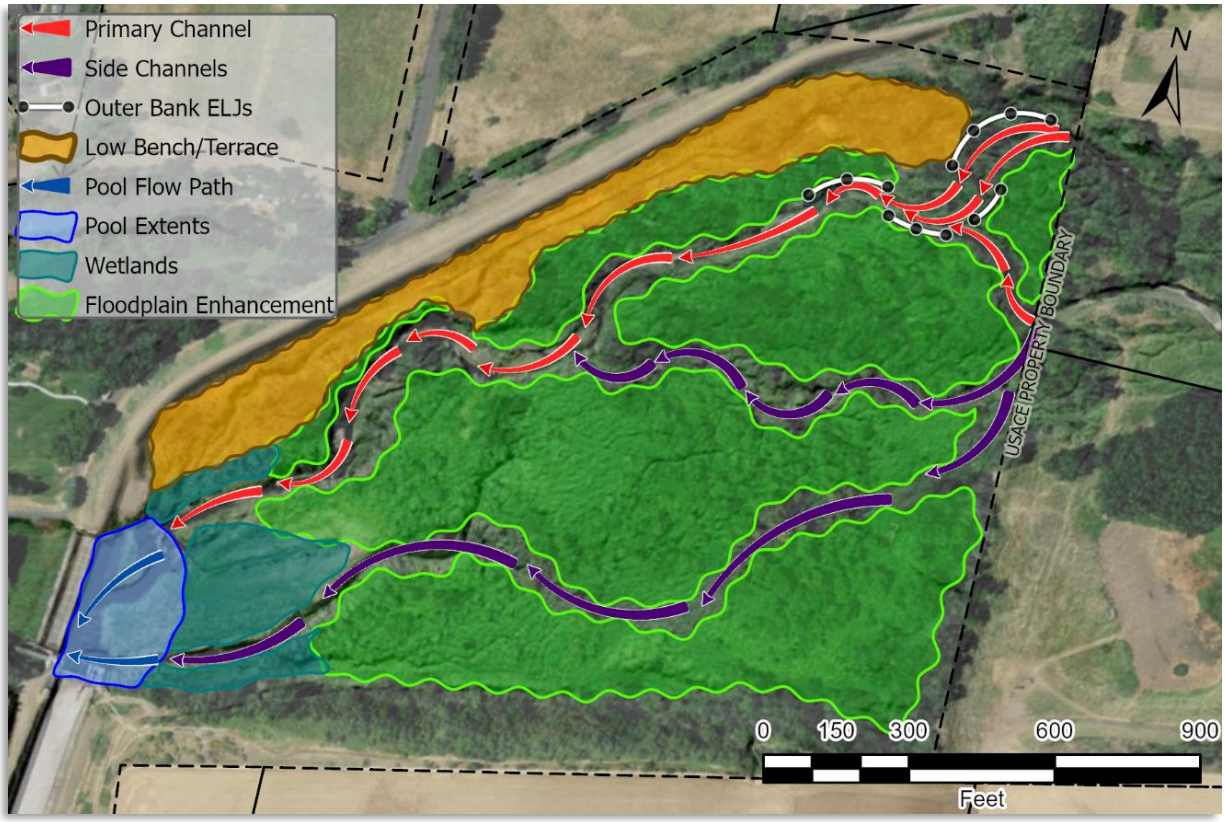

FIGURE 17: CONCEPTUAL MANAGEMENT PLAN ILLUSTRATION

Implementation of the Plan would consist of the following:

- ELJs and/or PALS would be placed strategically near the property line to direct the north channels south so that they curve south with a minimum radius of curvature of 60 feet. Flow from those channels would be captured by the main river channel and the floodplain and side channels to the south.
- Wetland development and improvement in the floodplain would consist of some sediment removal with reed canary grass control and then revegetation with a diversity of native plants.
- Side-channel development and improvement on the floodplain would occur via sediment removal and possibly ELJ placement to enhance side channel activation in spring, reed canary grass control and revegetation with native shrubs for fish rearing cover and food sources.

- The terrace shown in Figure 17 along the levee toe would be an additional wetland feature.
- Wetland development or restoration would occur around the pool area upstream of the Diversion Dam via sediment removal, reed canary grass control, and replanting with native wetland species.

The intent of the Plan would be to rebalance stream grade, sinuosity, and lateral movement of the main channel in the sub-reach upstream of the Diversion Dam. Results could include the following:

- Improved fish and wildlife habitat complexity
- Creation of additional rearing habitat for juvenile steelhead and bull trout
- Increased wetland food and cover sources to benefit waterfowl and terrestrial wildlife
- Levee scour protection by pushing the north channels south and establishing a new wetland area along the levee toe
- Sediment and debris capture on the floodplain to reduce Project O&M at the Diversion Dam.
- More predictable flow patterns and sedimentation trends
- Improved riffle-run-pool sequence in the primary stream channel
- Increased presence and stability of large woody debris
- Increased floodplain storage and near surface aquifer recharge
- Increased riparian vegetation and canopy quality

3.6.1 Technical Considerations of the Conceptual Management Plan

There are technical constraints with the Plan as well, including the downstream weir crest elevation of 1264.3 (NAVD88) and the mechanical limitations of the diversion headworks. The current location of the debris barrier must also be considered if the primary channel is realigned to the south. This could necessitate reconfiguring the location and layout of the debris barrier.

The authorized project purposes of flood risk management and recreation, along with limitations imposed by biological opinions, have created multiple operational constraints. However, it may be possible to consider minor operational deviations (e.g., flow shaping via ramping rates, durations, and pulsing) during non-flood events.

3.7 Habitat Modeling

The Plan was evaluated for biological benefits using the Functional Assessment of Colorado Streams (FACStream) model. Although the model was originally developed to evaluate streams

within the State of Colorado, the model is applicable to ecoregions within eastern Washington (Trumbo, 2019) and has been used on multiple Walla Walla District Planning Studies.

The FACStream model is a reach-scale functional assessment tool that rates functional condition according to the degree of impairment of ten ecological variables. Each of these variables describes a foundational driver of stream health. The scores for these variables are combined as a weighted average to provide overall reach condition score, and then compared to a reference condition. The resulting functional capacity index (FCI), an index value between 0 and 1 that measures the degree of aquatic functioning of the reach on a percent scale, is calculated directly from the condition score. In addition, a letter grade is assigned to the FCI based on the scholastic grade scale for simplistic reach condition evaluation.

The FACStream model incorporates all aspects of stream function, including riparian and floodplain integrity and connectivity, which encompasses habitat benefits to the myriad wildlife that inhabit Mill Creek and its riparian corridor. Therefore, it is representative of habitat quality and function at the ecosystem level. The evaluation of ecosystem benefits compares each alternative model score to a reference reach, and alternatives with the score nearest to or better than the reference reach score provide the highest ecosystem function.

The FACStream model results for the reference reach, existing condition in the study area, and the Plan are presented in Table 3. Modeling results suggest that the maximum treatment under the Enhancement Concept would improve the habitat functional capacity in the study area to slightly better than the upstream reference reach, while the medium treatment would score slightly lower than the reference reach.

The FACStream model results show that the Plan provides an ecosystem improvement over existing condition. The instream woody structures and roughened riffles provide habitat complexity for fishes and invertebrates, as well as hydraulic habitat features like pools with woody debris that benefit migrating and rearing fishes.

Table 3. FACStream Scores for Existing Condition and Channel Alterations

Reach/Enhancement Options	FCI	FCI Delta[1]	Letter Score[2]
Reference Reach	0.82	--	A-
Existing Condition	0.66	-0.16	B
Conceptual Management Plan	0.84	0.02	A-

[1]The FCI Delta was calculated by subtracting the reference reach score from the with-enhancement project score to show the difference between the enhanced condition and optimal reference condition.
[2]Overall FCI letter score is calculated on a separate formula than the scholastic score used for individual model variables (Johnson et al., 2015).

Flow redirection from the north levee, coupled with side-channel development and enhancement would effectively divert flow from the levee and prevent scour during high flow

events. Side-channels would be activated frequently and flow for a longer period of time across the spring juvenile steelhead outmigration season, providing optimal off-channel rearing habitat.

While the floodplain in the forebay is generally activated each year, the activation frequency and duration would improve and encompass a larger area by directing flow south from the current main channels. This would increase sediment and debris retention on the floodplain, which is expected to reduce the maintenance requirements for Diversion Dam operations.

SECTION 4 – NEXT STEPS

IMAGE 4: VIEW ACROSS FOREBAY BETWEEN THE DEBRIS BARRIER AND DIVERSION DAM. SEPTEMBER 2021 (USACE image)

SECTION 4 – NEXT STEPS

There are some considerations for successful implementation of the Plan described below. These include items of coordination, data gathering, and implementation to further refine the Plan. The most significant items include the following:

1. A stream restoration project is planned by the Walla Walla Conservation District on private lands upstream of the Corps property boundary between the years of 2023 and 2027. The Corps and the Walla Walla Conservation District should coordinate regarding project features and timing of construction in order to ensure both upstream and downstream improvements remain stable and functional.

2. Floodplain and side-channel design optimization is critical. Flow diverted from the upstream property boundary south into side-channels and onto the floodplain would need to be modeled to ensure side-channels remain flowing and functional during the spring steelhead outmigration to avoid fish stranding. Additionally, ensuring sediment

flow and capture on the floodplain is an important function for project operations. Therefore, floodplain and side-channel optimization, proper sediment capture on the floodplain, and a design constraint to avoid fish stranding should be considered in implementation of the Plan.

3. The Plan shows a terrace along the levee toe where flow had been directed south. A wetland is the preferred habitat feature for overall environmental benefits along the levee toe, but flow seepage under the levee is drained off through a toe drain on the north side of the levee. The toe drain presents a maintenance issue as it plugs with roots from trees and other plants, which reduces its function and increases risk of levee failure during flood events. The potential for the wetland construction to affect the levee toe drain function will need further investigation.

4. A new fishway and low-flow outlet to the Diversion Dam are being designed and will be constructed on the north side of the Diversion Dam, opposite of the current location. Ensuring proper creek channel alignment as it enters the settling pool at the dam is critical to maintain fishway exit and flood gate function and can inform potential for coarse sediment sluicing and any associated WCM adjustments needed to accommodate that operation.

With this information, the project delivery team will be better situated for project construction and can identify the potential to request additional SRP funds for WCM changes.

SECTION 5 – REFERENCES

IMAGE 5: VIEW ACROSS FOREBAY LOOKING NORTH. LEVEE SEEN IN THE DISTANT TREE LINE. SEPTEMBER 2021 (USACE image)

SECTION 5 – REFFERENCES

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