



# Kinnickinnic River Corridor Plan

Dam Removal Scenario: Summary of Ecological Impacts

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SUBMITTED TO:

City of River Falls, WI

and



SEH

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## Executive Summary

On July 12, 2016, the City of River Falls, WI, approved SEH's contract to conduct a corridor planning study for the Kinnickinnic River. Central to the river corridor plan is the pending decision regarding relicensing of two hydroelectric facilities, Junction Falls Dam and Powell Falls Dam, and the ultimate fate of the two dams. As part of the corridor planning study, SEH teamed with Inter-Fluve to conduct a desktop assessment of potential ecological effects to trout habitat, downstream mussel populations, and fish passage along the Kinnickinnic River under a dam removal scenario.

In general, dams convert the energy and other conditions associated with river systems to conditions typical of low-energy lake or pond systems, reducing the viability of species that have evolved in rivers and stream and don't adapt well to their altered environment. Within impoundments, including Lake George and Lake Louise in River Falls, heterogeneous stream bed features, and whole channels, are often buried in a relatively homogenous layer of fine sediment, temperatures are elevated, and nutrients are stored for future release. Although conducive for warm water species like sunfish and carp, these conditions often do not meet the requirements for the brook and brown trout fisheries the Kinnickinnic River is known for. Removing the Junction and Powell Falls Dams will reduce these issues within the impoundment reaches. A re-naturalized channel will reestablish the energy requirements for supporting riverine process and function, including creation and maintenance of heterogeneous habitat elements. Additionally, dam removal will reconnect flow and sediment transport between healthier reaches up-and downstream. Dam removal incorporates some ecological risk as well, especially risks associated with the release of impounded sediment and the sediment management option selected. Silt, sand, and organics potentially released during removal can smother spawning gravel, reduce food sources, increase floodplain deposition and entrenchment, and result in unattractive turbid water. The sediment will eventually be evacuated or reworked in the bed and bars, but short term impacts could be significant, especially considering the Kinnickinnic River's existing sand load. However, these sediment impacts can be minimized by actively dredging the sediments and inclusion of downstream

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sediment traps as part of the removal process. Either way, long term changes in the physical habitat following dam removal should result in increased abundance and diversity of riverine fishes and other riverine species.

## Potential Impacts on Trout Habitat

Any discussion of the ecological effects of dam removal includes the assumption that dam removal will cause a reversal of the ecological impacts of dam construction and maintenance. Therefore, it is important to discuss the effects of existing dams on river ecology. These effects are well documented (e.g., Baxter 1977, Ward and Stanford 1979, 1987; Armitage 1984; Petts 1984). Dams cause dramatic changes in the riverine environment, not only in the impoundment area, but also in the river channel above and below the impoundment (Ward and Stanford 1983, Ligon et al. 1995). The most pronounced changes occur within the impoundment and downstream where flow regimes, natural transport of sediments and nutrients, and temperatures are altered. In general, habitat characteristics within the impoundment shift from a free-flowing stream, which favors lotic plants and animals, to a lake for which those species are not adapted. More detailed impacts of the two Kinnickinnic River dams on channel ecology, and the associated impact of dam removal, are outlined below:

*Lentic conditions* – Optimal trout habitat requires cold, free-flowing stream conditions. Free flowing conditions are correlated to scour and deposition, and ultimately, channel heterogeneity. Turbulence also increases dissolved oxygen concentrations. The dams block flow, minimizing flow energy in the lake-like impoundments. Dam removal will increase flow velocities, thereby improving stream habitat, both of which favor improved trout populations. Under a dam removal scenario, gravel channel bed substrates, critical for trout spawning, would also be restored within the impoundments, as higher flow velocities will likely transport and expose more gravel material (Staggs et al. 1995, Kanehl et al. 1997, Cole 1983, Li et al., 1987, Ross 1991).

*Fragmentation of habitat* – Currently riverine habitat upstream and downstream of the impoundments are fragmented by slow water and warmer water conditions (Schreiber 1998).

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Although fish passage may continue to be limited after dam removal due to the presence of the historic waterfalls, the ponded conditions would be eliminated.

*Disruption of nutrient flow* – Dams often cause nutrient pulsing, where fine sediment containing nitrogen and phosphorous are stored during normal and low flow conditions are pushed downstream as a “pulse” of nutrient laden water and sediment. During floods. Removal of dams minimizes fine sediment and nutrient storage, and therefore, minimizes nutrient pulsing (Stanley and Doyle 2002, Ward and Stanford 1979)

*Disruption of sediment transport* – The Kinnickinnic River continually and naturally transports fine silts, and during floods, also transports sand and gravel. The impoundments act as large sediment traps, in this case storing many thousands of cubic yards of silt and sand. Potential trout habitat in the impoundment reaches, such as riffles and pools, are currently covered with a homogenous layer of fine materials. Removal of the dams and the stored sediment restores this trout habitat within the impoundments (Minshall 1984, Cordone and Kelly 1961, Benke et al. 1984, Waters 1995, Ligon et al 1995, Wohl and Cenderelli 2000).

*Altered temperatures* –Top Release or “Run of the River” Dams, like the current configuration of Powell and Junction Dams, cause an increase in downstream stream temperature due to solar exposure and increased residence time in the impoundments. Trout prefer water temperatures between 50-65°F, and removal of the dam helps to lower stream temperatures (Walks et al. 2000, Ward and Stanford 1989).

## Downstream Impacts

A comprehensive review of the short and long term impacts of dam removal can be found in Bednarek (2001) and Bushaw-Newton et al. (2002). Perhaps the most significant impact of dam removal is the release of sediment that accumulated behind the dam. In the case of River Falls, approximately 149,000 cubic yards and 162,000 cubic yards of sediment are stored within Lake George and Lake Louise, respectively (Inter-Fluve 2016). For full restoration of a stable stream channel planform and cross sectional area (dependent on ultimate width of floodplain),

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approximately 120,000 to 130,000 cubic yards of impoundment sediment would need to be passively released downstream or instead actively removed. (Inter-Fluve 2017).

*Bedload sediment* - Rapid drawdown and removal without sediment management would likely temporarily cause similar sediment problems downstream of the dams as those observed within the current impoundments, including homogenization of habitat and burial of spawning and rearing habitat (e.g. exposed gravel riffles). Large pulses of sediment can move downstream following floods, and can inundate natural sediments, suffocating fish eggs and macroinvertebrates, eliminating pool and riffle habitat, covering redds and increasing overbank flooding. The downstream effects of full (passive) sediment release are documented in the Inter-Fluve sediment management recommendations for the River Falls dams (Inter-Fluve 2016 and 2017). Sediment impacts on habitat are often short lived, but can vary greatly depending on the sediment character and transport magnitudes. Currently, Kinnickinnic River bed material includes a relatively large percentage of sand, suggesting the river likely still transports legacy sediment from past agricultural periods with more bank and surface erosion. Downstream of the dam, there are long reaches with relatively homogenous bedforms. Still, the amount of sediment stored behind the dams would likely cause additional impacts as described above, likely raising the channel bed elevation, further inundating habitats, and causing additional overbank flooding. Given that the Kinnickinnic River has a high groundwater to surface water ratio, it is likely that impacts from passively released sediment would persist for many years following removal. For this reason, the River Falls Dam Removal Feasibility Report (Inter-Fluve 2017) recommends impounded sediment be actively managed, stabilized, and mainly rely on sediment excavation and constructed stream stability treatments (e.g. vegetative plantings, fabric encapsulated lifts, large wood placement, riffle structures, etc).

*Suspended sediment* - As the structure of the dam is removed, sediment that accumulated behind the dam will begin moving downstream carried by the increased velocity of flowing water. Fine organic and inorganic sediments will be mobilized and held in suspension. Fine sediment entrained by removal can increase the *turbidity* or cloudiness of the water that may travel far downstream and persist for weeks or months (Perrin et al 2000, Gray and Ward 1982).

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It may reoccur with each substantial flow event until sediments deposited over the historic channel are eliminated or a new stream channel is formed (Doeg and Koehn 1994). As with any pollutant, the impact on aquatic species depends on the concentration and exposure time, both of which can vary dramatically in a dam removal scenario. The degree of biotic impact from suspended and deposited sediment depends on many factors including:

- Timing of removal
- Precipitation/flooding
- Sediment size
- Sediment character (cohesion etc.)
- Drawdown or sediment removal method (if any)
- Size of the impoundment
- Depth of impounded sediment
- Floodplain/streambank restoration

Suspended sediment in natural, stable streams does not produce mortality in fish, and laboratory experiments exposing fish to suspended sediment showed mortality only at extremely high concentrations (Cordone and Kelley 1961, Wallen 1951, Waters 1995). Timing dam removals when flood risk is low can aid in reducing turbidity levels. Moderately high levels of turbidity persisted for less than 30 days following winter removal of the Appleton Dam on the low gradient Pomme de Terre River and the Frazee Dam on the low gradient Otter Tail River in Minnesota (Rye 2000).

## Potential Impacts on Downstream Mussel Populations

The same physical attributes that lead to changes in macroinvertebrate and fish communities also effect mussels. Freshwater mussels favor the stable substrate beds and moving water of rivers. Increases in fine sediment load and(or) storage, as is often the case behind dams, can lead to the decline of mussel populations (Cordone and Kelley 1961, Hughes and Parmalee 1999). Mussel larvae, or glochidia develop in the gills of certain fish species particular to each mussel group. Dams can be barriers to the passage of certain fish upon which mussels depend for glochidia development. Biologists in Minnesota report declines in the population of the pink heelsplitter mussel upstream of the Morehouse Dam on the Straight

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River, which prevents the passage of freshwater drum, the host fish for pink heelsplitter parasitic larvae (Davis 1987). Because fish and mussel populations are so closely linked (Vaughn and Taylor 2000), fragmentation of fish habitat and mussel communities by dams leads to unstable populations which are more likely to die out within those reaches and ultimately the entire stream system. Upstream fish passage may be limited due to the presence of the natural cascades , but there will be an improvement in downstream fish movement following removal.

For the *River Falls Dam Removal Feasibility Study* (Inter-Fluve 2017), the WDNR completed an official Endangered Resources Review (ERR) for the Kinnickinnic River through the impoundments to the confluence of the St Croix River and deemed no adverse impacts to fish and mussels under a dam removal scenario (Inter-Fluve 2017). A literature review and conversation with WDNR staff also provided minimal additional understanding of the current makeup of mussel communities within and below the two impoundments (Inter-Fluve 2017). Little mussel research has been conducted along the Kinnickinnic River, and one past survey, completed upstream and downstream of River Falls, found no mussels present. (Inter-Fluve 2017). The lack of studies focused on mussel communities within the Kinnickinnic River makes determining a cause for the apparent paucity of mussels or any potential dam or dam removal impacts on mussel populations specific to this system difficult. However, the WDNR recommended conducting native mussel relocations prior to dam removal and associated water drawdown (Inter-Fluve 2017). Removal of the dams without active sediment management would likely result in further degradation of mussel habitat downstream of the dams. Management of sediment or removal of sediment during dam removal can ensure that downstream populations will be minimally affected.

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## Management Option: Sediment Removal Prior to Dam Removal

Most of the downstream impacts associated with dam removal are associated with released sediment, and are based on a more “passive” sediment management scenario, where a large percentage of the impoundment sediments are allowed to pass downstream during and after removal. The volume and character of the impounded sediment at River Falls indicates potential for adverse, long-term biotic impacts upon release of these impounded sediments, and thus, sediment should be managed by trapping, excavation, or dredging as part of the dam removal process. This “active” management scenario likely will be required as a condition of permitting. Under this management scenario, the volume of impoundment sediment allowed to freely transport downstream will be dramatically reduced. Construction of sediment traps disturbs the stream immediately downstream of the dam, and offers only a temporary solution to sediment movement, because unless they are dredged, the trapped sediments will eventually move downstream during a flood event. Dredging after partial drawdown or excavation of dried impoundment sediments can be used to remove the bulk of impoundment sediments before they are eroded downstream.

Although many of the short term sediment impacts associated with dam removal are negative, the overall impacts are positive. Under either an active or passive sediment management scheme, long term changes in the physical habitat following dam removal should result in increased abundance and diversity of riverine fishes and other riverine species as newly available habitats are exploited (Burroughs et al. 2001, Catalano et al. 2001, Nelson and Pajak 1990, Stanley et al. 2002).

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## Fish Passage Analysis

*Review of the Kinnickinnic River Fishery* - An inventory of the condition of the Kinnickinnic River fishery was discussed in the 2017 Dam Removal Feasibility report (Inter-Fluve, 2017).

Highlights from the report, related to the fishery are outlined below;

- WDNR considers the Kinnickinnic River and South Fork of the Kinnickinnic River as a Class 1 Trout Stream however Lake Louise and Lake George are not listed as trout waters.
  - Historically, fish species that have inhabited the Kinnickinnic River include brook trout, mottled scuplin, white sucker, smallmouth bass, brook stickleback, and fathead minnow. Crappie, green sunfish, black bullhead, and carp inhabit Lake George and Louise. (WDNR 1971)
  - Brown trout have been introduced and managed as a game fish in the Kinnickinnic River for the past century.
  - A self-sustaining brook trout population can be found within the South Fork of the Kinnickinnic River and near the headwaters of the Kinnickinnic River..
  - In 2015 WDNR assessed the Kinnickinnic River as having exceptionally high quality and high density of brown trout within the main stem. (WDNR 2015). Over the last 10 years, brown trout densities and number of large size trout have ranked in the 95<sup>th</sup> percentile across the state. Furthermore the WDNR 2015 survey showed that brown trout catch per effort rates just downstream of the City's dams ranked in the 78<sup>th</sup> percentile.
  - Trout densities are generally higher above the two dams due to cooler water and more stable flows (Shreiber 1998)
  - According to a WDNR Endangered Species Review, no animal species of concern were determined within the project limits.
  - Coldwater streams in Wisconsin are potentially under stress based on climate forecast models. The Coldwater Fish and Fisheries Working Group (Mitro et al., 2010) incorporated the Kinnickinnic River stream temperature data set to develop
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climate change forecast models as it relates to available stream length for Wisconsin cold water species. Predictions from their statistical models for a best, moderate, and worst case climate warming scenario indicate a 7.9%, 33.1 % and 88.2% statewide loss in stream length for brown trout, respectively. The models show a more significant reduction instream length for brook trout (43.6%, 94.4%, and 100%, respectively).

- Recorded water temperature data has shown the stream reaches downstream of the dam are warmer than reaches upstream of the dam (Kiap-Tu-Wish 2014). In the downstream reaches, recorded summer stream temperatures exceeded optimal brown trout conditions 21-48% of the time compared to 3-10% of the time upstream of the dams (Schreiber 1998).

*Natural Bedrock Cascades* - The Powell Falls and Junction Falls Dams were constructed on or near natural bedrock cascades that historically may have prohibited or limited fish passage. Photo 1 depicts the three natural bedrock cascades (lower, middle, upper) at Junction Falls in 1865 prior to dam construction. Based on the 2016 City's bathymetry survey within the two impoundments, and cursory review of as-built drawings of the two dams, the total vertical drop at Junction Falls from the projected sill of the upper most cascade (toe of the existing dam) to the toe of the lowest cascade is approximately 21-feet. Existing survey data depicting the vertical height and spacing of each natural cascade (lower, middle, upper) at Junction Falls is unknown at this time, and is recommended to be collected for further design and assessment. The total vertical drop at Powell Falls from the toe of the dam to the downstream stream elevation is approximately 4.5-ft but should be confirmed via a topo survey. For fish passage assessment, the hydraulic vertical height under certain flow conditions, the stream-wise spacing between each cascade, and the pool volume and depth (>2ft) between each cascade should be considered.

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Photo 1: Junction Falls Predam- 1865

*Target Species*- For a fish passage analysis, adult brook trout (*Salvelinus fontinalis*) are considered the target species for fish passage analysis since they are the weakest swimming native trout species in the region, are self-sustaining in reaches along the Kinnickinnic River system, and prior restoration efforts in the area have targeted this species. The fish passage analysis assumes if brook trout can pass then so will brown trout.

*Swimming and Leaping Capabilities*- Fish Passage through natural or turbulence (e.g. rock cascades or waterfalls) or artificial (e.g. perched culvert) barriers (i.e., “barriers”) can be accomplished through either swimming or jumping. Fish can pass barriers by swimming through “green” water at their burst swimming speed (i.e., sustainable over 5 seconds) or their sustained swimming speed (i.e., sustainable over several minutes; (Table 1). Fish can also pass barriers by leaping out of the water at their burst speed at various trajectories. Brook trout can ascend high waterfalls if there are resting spots or small steps along the way (Kondratieff and Myrick 2006). Leaping height and distance are directly related to burst speed and leaping trajectory through a

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basic projectile equation (Powers and Orsborn 1985). Passage through leaping can be prevented if the plunge pool contains a turbulence barrier that prevents fish from gaining traction to leap.

Table 1. Swimming and jumping abilities of juvenile and adult brook trout.

<b>Parameter</b>	<b>Brook Trout (&lt;5.9")</b>	<b>Brook trout (&gt;5.9")</b>
<b>Burst speed (&lt;5 seconds)</b>	11.6 ft/sec	12.4 ft/sec
<b>Sustained speed (minutes)</b>	6 ft/sec (Peake et al. 1997)	
<b>Maximum passable waterfall height</b>	2.1 feet (Kondratieff and Myrick 2006)	2.4 feet (Kondratieff and Myrick 2006)

Data on burst and sustained swimming speeds are scarce, and the methodology often produces results that underrepresent true burst speeds (Castro-Santos, Sanz-Ronda, and Ruiz Legazpi 2013). Brook trout swimming speeds reported here, based on calculations from data reported by Myrick and Kondratieff, are higher than most published swimming velocities, and are more representative of true burst/leaping speeds of free-swimming fish in a river environment. Leaping height and distance for various trajectories were calculated using these metrics to eventually assess passage through the natural cascades according to the projectile equation from Bell (1985;Figure 1).

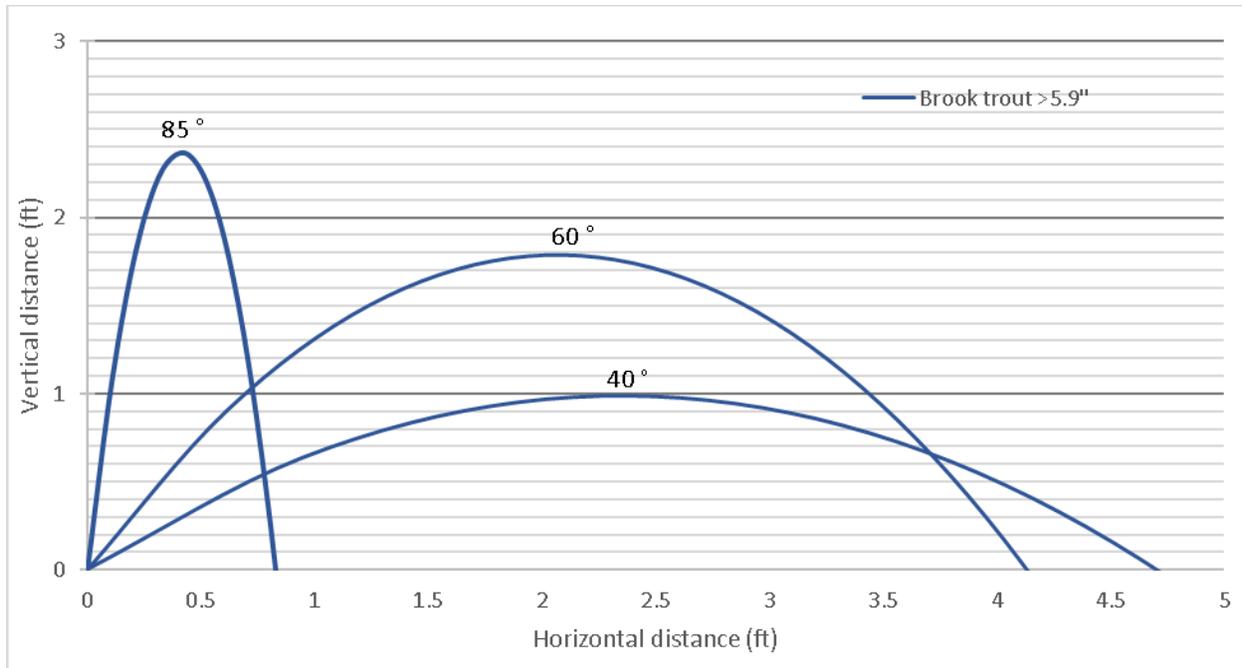


Figure 1. Leaping trajectories for adult brook trout using equations from Bell (1985).

*Fish Passage Metrics* – Based on hydraulic modeling output (e.g. water surface elevations and velocities) for a dam removal scenario, fish passage can be assessed based on comparing the species swimming capabilities during select seasonal flow conditions to determine if the barrier is passable or acts as a velocity or turbulence/leaping barrier. Turbulence barriers can prevent fish passage when energy is dissipated in a cavitating plunge pool. Energy dissipation factor (EDF, ft-lb/s/ft<sup>3</sup>) represents the energy dissipation per unit volume of water in a plunge pool due to turbulence (WDFW 2000). EDF is used in this application to assess whether or not a pool is too turbulent for a fish to gain an effective velocity. EDF is calculated according to the following equation:

$$EDF = y \times Q \times H/V$$

where  $y$  is the unit weight of water (62.4 lb/ft<sup>3</sup>),  $Q$  is river discharge (ft<sup>3</sup>/s),  $H$  is hydraulic vertical drop height (ft), and  $V$  is volume of receiving plunge pool (ft<sup>3</sup>). EDF values over 16 indicate a turbulence barrier that prevents fish passage (NMFS 2011).

The following assumptions and simplifications have been made in developing fish passage criteria for this evaluation:

1. Brook trout have a fish condition of 1.0.
2. EDF values over 16 create a turbulence barrier and are not passable.
3. Brook trout burst speed is 12.4 ft/sec as back-calculated from laboratory based leaping study on adult brook trout. (Myrick and Kondratieff, 2005).
4. Fish exit the plunge pool at their maximum burst speed when leaping.
5. Fish length is added to neither jumping height nor distance

*Hydrologic Analysis* - Exceedance flow intervals for fish passage assessment was not completed based on limited gage data that can be applicable to the two dam locations. However, the FOTK 2017 report reviewed monthly average flows (2003-2014) at the USGS gage station approximately 7.5-miles downstream of the dams and scaled the reported flows to the watershed size at Junction and Powell Falls. When scaled by watershed area, the average daily flow for the year at Junction Falls Dam is 58 cfs and varies between an average of 50 cfs in January and 79 cfs in March. At Powell Falls Dam, the calculated average daily flow for the year is 71 cfs, with a January daily average of 61 cfs and a March daily average of 97 cfs. (Inter-Fluve, 2017). Average monthly daily flows were greatest in the spring, most likely during spring thaw conditions. For a detailed fish passage assessment, exceedance flows should be determined for a critical migratory window or seasonal timeframes for the target species.

*Invasive Species and Fish Pathogens Review* - During further design and assessment phases, fish passage analysis should account for the WDNR's 2014 Fish Passage Guidance program as it relates to the assessment and prevention of connecting segregated systems with aquatic invasive species and fish pathogens (including VHS) as well as introducing non-native species (covered under the authority of the NR 40 permit). Although not investigated under this project, it's assumed, based on the WDNR's current designation and assessment of the river, that the risk for spreading invasive species or fish pathogens in a dam removal scenario would be minimal or insignificant.

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*Fish Passage Assessment.* A preliminary fish passage assessment could not be completed considering FEMA's 2011 effective hydraulic model does not include the two impoundments or dams. No flood profile is available showing the hydraulic vertical drop between the currently exposed cascades at Junction Falls. In addition, the updated hydraulic model created by teaming partners under this project does not account for a proposed condition reflecting a dam removal scenario and presence of all of the natural cascades. Further fish passage analysis can be created during final design, once completed detailed hydrologic and hydraulic models are in place and applicable hydrologic data is available or processed.

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