Twisp River - Newby Narrows Cut 3 Concepts

Basis of Design Report

Yakama Nation Fisheries

December 2021

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PREPARED FOR

Yakama Nation Fisheries
401 Fort Road
Toppenish, WA

PREPARED BY
Inter-Fluve
501 Portway Ave.
Hood River, OR 97031

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1. Preface

Newby Narrows Cut 3 project reach is between River Mile (RM) 9.75 and 10.5 on the Twisp River. In 2017, the Newby Narrows project (Phases 1-2) completed a significant amount of work within the reach. Since then, adjacent private land has been acquired by the Yakama Nation along the north (river left) floodplain surface that warrants the investigation of new opportunities within the reach, or opportunities that may be supportive of the previous work. Concepts described in this report focus on opportunities on Yakama Nation property within the project reach (Figure 1).

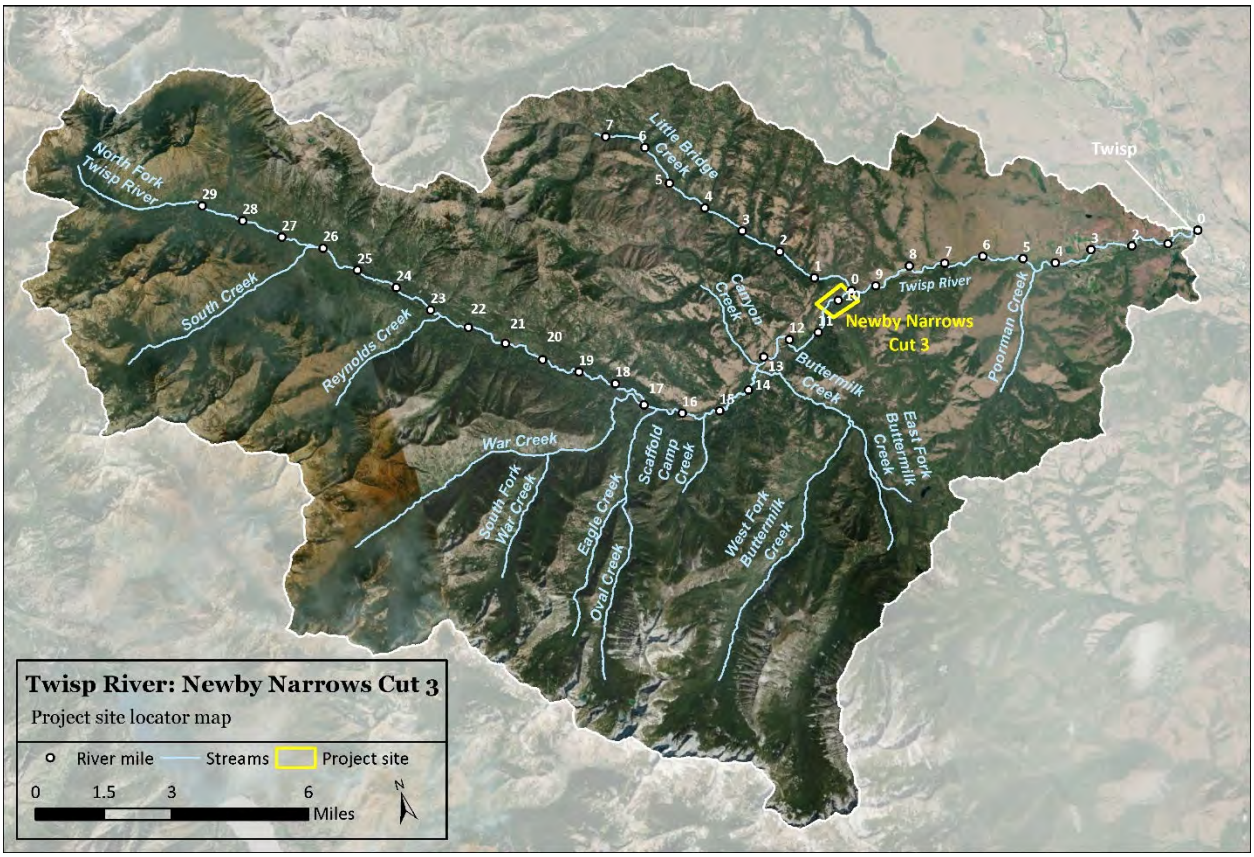

Figure 1. Project reach location map.

The goal of the proposed project is to enhance adult spawning and juvenile rearing habitat for ESA-listed endangered Upper Columbia spring Chinook Salmon (*Oncorhynchus tshawytscha*) and threatened summer steelhead (*Oncorhynchus mykiss*) in accordance with the 2017 Biological Strategy (UCRTT 2017). Bull trout (*Salvelinus confluentus*) and west slope cutthroat trout would also benefit from the project.

1.1 NAME AND TITLES OF SPONSOR, FIRMS AND INDIVIDUALS RESPONSIBLE FOR DESIGN

The project is sponsored by Yakama Nation Fisheries (YN). Inter-Fluve is the engineering design firm. Mike McAllister (PE) is the licensed engineer of record for this project and Mike Brunfelt (LG) is on the design team.

1.2 LIST OF PROJECT ELEMENTS THAT HAVE BEEN DESIGNED BY A LICENSED PROFESSIONAL ENGINEER

Mike McAllister (PE) is the licensed engineer of record for this project. Project elements include the following, with BPA HIP activity and risk category included:

Table 1. Activity categories and risk included in the project.

Description of Proposed Enhancement	Work Element	HIP Category	HIP Risk Level
Log structure construction to improve main channel habitat suitability and stability	Install habitat-forming natural material instream structures	2d	Medium
Low floodplain enhancement to improve off-channel habitat	Improve secondary channel and wetland habitats	2a	Medium
Revegetation of all disturbed surfaces	Riparian vegetation planting	2e	Low

1.3 EXPLANATION AND BACKGROUND ON FISHERIES USE (BY LIFE STAGE – PERIOD) AND LIMITING FACTORS ADDRESSED BY THE PROJECT

Fish species known to utilize the project areas include ESA-listed (endangered) spring Chinook Salmon, ESA-listed (threatened) summer steelhead and Bull Trout, and unlisted Westslope Cutthroat Trout, Pacific Lamprey, Mountain Whitefish, and non-native Brook Trout (Figure 2). While Chinook Salmon, steelhead, and Bull Trout are focal species for this habitat enhancement project, the work is expected to benefit all species present.

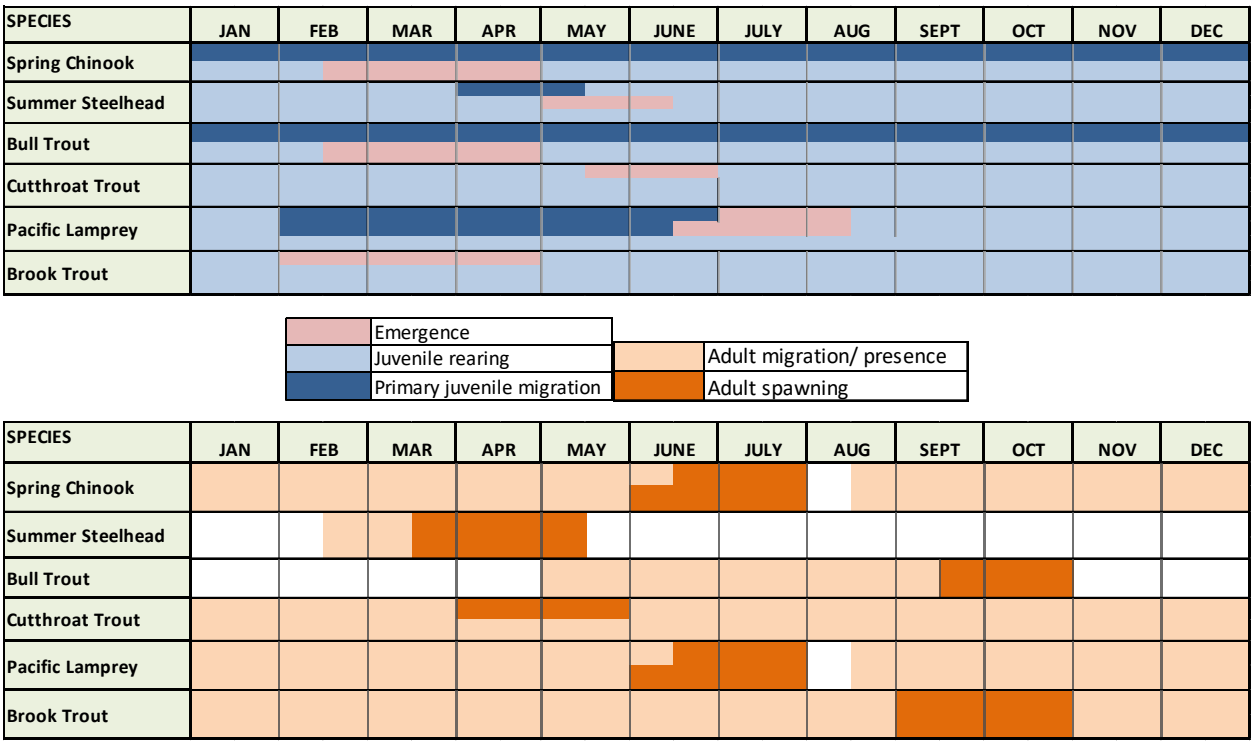

Figure 2. Life history timing of fish species within the Upper Twisp River.

1.3.1 Summer steelhead

Adult summer steelhead destined for the Twisp River pass Wells Dam from July through May, with peak migration in September. Most adults overwinter in the Wells pool, while some hold in large pools in the mainstem Methow River. Adult summer steelhead enter the Twisp River from February through May, holding in deep pools with overhead cover (NWPCC 2004). Spawning begins in late March, peaks in late-April, and lasts through May. Egg survival is highly sensitive to intra-gravel flow, temperature and is particularly sensitive to siltation earlier in the incubation period (Healy 1991). Fry emerge from the redds 6-10 weeks after spawning (Peven 2003).

Age-0 juveniles spend their first year primarily in shallow riffle habitats, feeding on invertebrates and utilizing overhanging riparian vegetation and undercut banks for cover (Moyle et al. 2002, US Fish and Wildlife Service 1995). Age-0 steelhead use slower, shallower water small boulder and large cobble substrate (Hillman et al. 1989). Older juveniles prefer faster moving water including deep pools and runs over cobble and boulder substrate (US Fish and Wildlife Service 1995). Juveniles out-migrate between ages one and four, though some hold over and display a resident life history form. Smolts begin migrating downstream from natal areas from April through mid-May (NWPCC 2004).

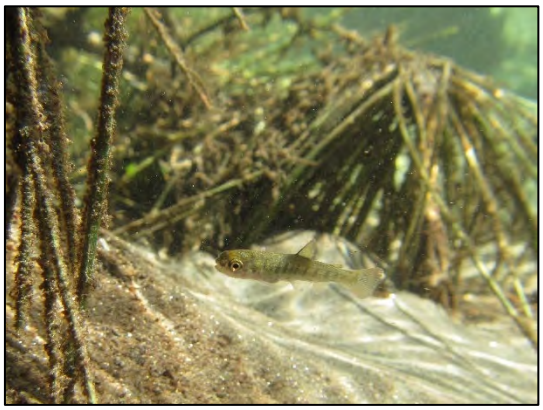

Figure 3. Sub yearling steelhead resting behind a constructed log structure (Entiat basin, WA).

1.3.2 Spring Chinook

Spring Chinook enter the Twisp River from late May through early September, with peak spawning occurring in late August and early September (Inter-Fluve 2016). Spawning in the Twisp River is concentrated between RM 10 and 27 (Inter-Fluve 2016). Fry emerge in the spring and seek out backwater or margin areas with lower velocities, dense cover, and abundant food (Quinn 2005). Near-shore areas with eddies, large woody debris, undercut tree roots, and other cover are very important for post-emergent fry (Hillman et al. 1989, Healy 1991). Age-1 parr move into deeper pools with resting cover in natal streams and migrate to smaller tributaries for extended periods of rearing. On the Twisp River, juvenile rearing occurs downstream of RM 27 (Inter-Fluve 2016). Spring Chinook express a stream-type life history where they rear for 1 year in freshwater before out-migrating as yearlings from late February through early May.

Figure 4. Yearling spring Chinook feeding in the Entiat River

1.3.3 Bull Trout

The Twisp River supports a population of resident, fluvial, and adfluvial bull trout (NWPCC 2004). Bull Trout from the Columbia River migrate into the Methow subbasin from May through June (BioAnalysts 2002, 2003). Spawning occurs in the Twisp River from RM 22 to 29, and other tributaries from mid- September through October. Bull trout juveniles rear in headwater streams for at least two years before migrating downstream as adults or sub-adults to express fluvial, adfluvial, or resident life histories in downstream reaches (McPhail and Baxter 1996).

1.3.4 Limiting factors for resident and anadromous fish

Ecological concerns for the Twisp River have been summarized in the document *A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region* (UCRTT 2017). The Regional Technical Team (RTT) identified several ecological concerns or limiting factors affecting habitat conditions in the Upper Twisp River. They are:

1. Peripheral and transitional habitats – Reconnect disconnected side channels or where low wood loading has changed the inundation frequency, improve hydraulic connection of side channels and wood complexity within the side channels;
2. Channel structure and form (instream structural complexity) – Install large wood and engineered log jams in strategic locations to provide short-term habitat benefits and intermediate-term channel form and function benefits;
3. Channel structure and form (bed and channel form) – Remove levees, undersized bridges, bank armoring and other human features;
4. Riparian Condition – Restore conditions in degraded areas, improve large woody debris (LWD) recruitment, fence riparian areas and wetlands;
5. Food – Estimate amount of nutrients needed in the assessment unit, and increase nutrients to the watershed using hatchery carcasses and/or carcass analogs;
6. Sediment – Road management, reduction, and maintenance to restore sediment and large wood recruitment rates within riparian and upland areas; and
7. Species interactions – Reduce or eliminate brook trout in high-density areas.

1.4 LIST OF PRIMARY PROJECT FEATURES CONSTRUCTED OR NATURAL ELEMENTS

The proposed project actions address Ecological Concerns 1, 2, & 4 identified in the Biological Strategy. Key components of the proposal are to (1) create a new perennial side channel, and (2) construct mainstem large wood structures.

The Newby Narrows project reach was previously enhanced in 2016 and 2017 with salmon restoration actions including five mainstem large wood structures, and a new side channel on river-right (south) floodplain. The project actions described below are possible now that Yakama Nation has acquired new properties in the Newby Narrows project reach. The proposed project actions would not detract from the performance or value of the 2016-17 projects. The locations of proposed habitat alternatives and their locations relative to the previous actions can be viewed in the drawings (Appendix A).

1.4.1 Side Channel

The project reach could support a new side channel through the north (river-left) floodplain surface on land now owned by the Yakama Nation. The side channel inlet condition would be well suited between two existing log structures constructed in 2017. This location does not interfere with the

existing log structures and is at a location near the top of riffle. The mainstem riffle elevation here helps to provide slope through the new side channel. The side channel slope based on this inlet location is ~0.31%. Having a side channel inlet at a more downstream location that is nearer to the 2017 side channel outlet was considered, but the position lower on the mainstem riffle causes a lower slope (0.21%), which could be too mild and prone to deposition. Therefore, the configuration would have flow from the 2017 side channel outlet entering the Twisp mainstem approximately 150 feet downstream of the proposed new side channel inlet on the opposite side of the river. The mainstem channel between the proposed side channel inlet and the 2017 side channel outlet would have reduced flow due to the new side channel diverting some flow off the mainstem upstream of the return flow from the 2017 side channel. The side channel outlet is shown on Yakama Nation property near a large 10-foot-high mid-channel boulder.

Immediate ecological uplift would come in the form of channel complexity by creating anastomosing planforms that have been missing from the recent landscape due to anthropogenic pressures. By distributing water to multiple channels, salmonids benefit from increased margin habitat, reduced predator habitat, and narrower canopy to provide shade on water. Hyporheic exchange could be expected to be equal or better than existing conditions. Over time, channel forms will adjust by gravel deposition and riparian response, reducing mainstem channel width as portions of channel forming flows are distributed to the side channels. In future design phases, a planting plan can be included that anticipates the narrower mainstem and can speed up riparian vegetation colonizing the new bars.

Imported logs with roots will be used to provide habitat within the side channel, and roughness to cause complex flow patterns and dissipate flood energy (Figure 5).

Figure 5. Large wood in the 2017 Newby Narrows Side Channel

Most of the vegetation within the potential clearing limits of a new side channel are 12 inches in diameter or less. There are larger trees intermixed and during the preliminary design process, larger trees could be avoided, or selected for removal. All trees and shrubs removed from the side channel footprint would be salvaged and used to enhance side channel habitat by providing complex physical textures that are not easily provided by the imported logs alone (Figure 6).

Figure 6. Salvaged trees and shrubs incorporated as habitat in the 2017 Newby Narrows Side Channel

Access and staging would occur in the existing open field that was also used for staging in the 2017 Newby Narrows project. All of the side channel work is sited on Yakama Nation property as shown in Okanogan County property maps. Property line staking would confirm exact property line locations prior to final construction plans.

1.4.2 Mainstem Large Wood Structures

Gravel Bar Log Structure

Flow to the side channel inlet could be improved by a log structure installed on the gravel bar on the opposite side of the river (river-right). This structure would create roughness and channel encroachment that lifts hydraulic head and drives flow to river-left and the inlet.

Bar Apex Log Structure

A bar apex log structure opportunities exist within the project reach. The first is located about 500 feet upstream of the side channel inlet. The site is just downstream of a bedrock pool near the Twisp River Road. This bar apex structure could improve the reach by:

- Retaining natural wood transported into the reach.
- Improving split flow to a small side channel running near the left bank.
- Encouraging lateral migration of the right bank. Right bank migration would undermine and incorporate natural vegetation and trees into the channel to enhance natural habitat along the edge. Right bank migration could then induce a meander cycle that leans the thalweg into the left bank further downstream, which would tie in well with the new side channel (Figure 7).

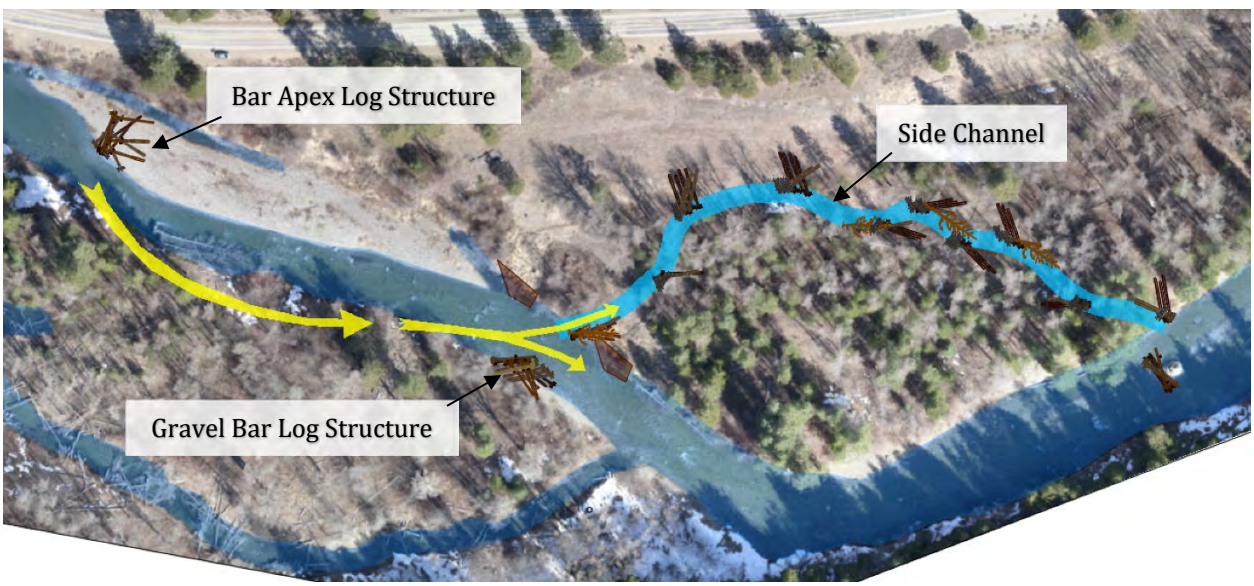

Figure 7. Project actions and future channel meander trend

Boulder Log Structure

A second bar apex log structure would be constructed at the face of a large 10-foot-high mid-channel boulder near the proposed side channel outlet. The logjam would improve high-flow and low-flow

salmonid rearing habitat, and likely improve spawning gravel retention downstream of the structure (Figure 8).

Figure 8. Big boulder in channel

1.5 DESCRIPTION OF PERFORMANCE/ SUSTAINABILITY CRITERIA FOR PROJECT ELEMENT S AND ASSESSMENT OF RISK OF FAILURE TO PERFORM, RISK TO INFRASTRUCTURE, POTENTIAL CONSEQUENCES, AND COMPENSATING ANALYSIS TO REDUCE UNCERTAINTY

1.5.1 Infrastructure and flood risk

There appears to be no increase in infrastructure flood risk related to the project. The work area is on Yakama Nation land, the project sponsor. Change in baseflood elevations due to project actions will be assessed in future design phases..

1.5.2 Design criteria

Ground based heavy equipment will be used to construct the project. Large wood structures will be stabilized to maintain position and function during high flow by using partial burial of logs and bracing to timber piles. The side channel creation requires excavation. Removed materials would be hauled to an approved upland fill location.

1.5.3 Risk of failure to perform

There are performance risks associated with beaver activity and sediment loading floods that could cause temporary or permanent infilling of the side channel. Natural wood loading could cause the side channel to capture more or less flow than the designed/constructed condition.

However, the project reach is well suited for inducing meander processes and creating anastomosing channel forms and floodplain complexity that would be natural in this reach but are relatively absent other than the 2016 and 2017 project implementations. Importing large wood to make mainstem log structures are likely to cause a response in the river, but in this location, channel migration and bedform adjustments are intended and should not be considered undesirable outcomes.

Uncertainty is reduced by predicting the likely response of the river to new project actions, and arranging these project actions so that they support each other (Figure 7).

1.6 DESCRIPTION OF DISTURBANCE INCLUDING TIMING AND AREAL EXTENT AND POTENTIAL IMPACTS ASSOCIATED WITH IMPLEMENTATION OF EACH ELEMENT

Disturbance will be limited to access routes, the side channel footprint, and extents of log burial. Excavation and hauling will largely remain within the side channel limits, working back to the main access point. Trees will be avoided to the extent possible. All removed trees will be utilized in the project to provide habitat or floodplain roughness.

The timing of construction will be associated with the permitted in-water work period for work mainstem log structures and side channel connections. It is reasonable to assume the side channel would be completed within the normal in-water work period, but scheduling around contractor availability, late or prolonged snowmelt and runoff, or closures due to wildfire may require some side channel work to be done “in the dry” during days or weeks outside of the in-water work window.

2. Resource Inventory and Evaluation

2.1 DESCRIPTION OF PAST AND PRESENT IMPACTS ON CHANNEL, RIPARIAN AND FLOODPLAIN CONDITIONS

The project reach is responsive to large wood accumulation and could migrate and alter its planform if large trees accumulate along river bends and on gravel bars. However, roads, timber harvest, mining, and fires, have altered the watershed and indirectly the project reach. Downstream of the USFS boundary, land has been cleared for pasture and/or residential development. Levees and riprap have been installed to protect these properties from flood impacts and channel migration. These disturbances have depleted the valley bottom of large wood that would eventually be recruited by the river through natural processes and create natural salmonid habitat (cover and pools). Although the valley bottom has patches of trees, a large percentage of the trees are in a young seral stage that will take decades to mature enough to create habitat if they enter the active stream channel.

2.1.1 Instream flow management and constraints in the project reach

There are no known instream flow management constraints.

2.2 DESCRIPTION OF EXISTING GEOMORPHIC CONDITIONS AND CONSTRAINTS ON PHYSICAL PROCESSES

Bedrock geology in the upper Twisp headwaters is composed of intrusive ingenious rocks. Upstream of the project reach near RM 16 the northeast (left) side of the valley is composed of sedimentary and volcanic rocks and the southwest (right) side of the valley composed of metamorphic rocks. Downstream of this RM 16 the valley lies entirely within the zone underlain by sedimentary and volcanic rocks. Existing geomorphic conditions in the Upper Twisp are those left behind following alpine glacial advance and retreat. Alpine glacial advances ran down the Twisp River valley following the NW to SE trending structural fault zone that divides the rock types described above.

During glacial melt and retreat the valley was filled with alluvium. During this time, tributaries formed perpendicular confluences to the valley depositing alluvium eroded from their watersheds onto the valley forming alluvial fans. Debris torrent processes then and now occur in steeper tributary drainages especially following stand replacing fires and over time have episodically transported sediment to the valley floor and Twisp River channel. As glacial retreat proceeded, melt water and sediment supply that filled the valley lessened. The reduction in sediment supply enabled the Twisp to slowly cut down through deposited glacial alluvium and today is primarily controlled vertically by bedrock contacts and alluvial fan deposits. At Newby Cut 3, bedrock contact occurs near the proposed upstream bar apex structure and large immobile boulders control grade near the downstream end of the project reach.

Historically the river has been free to migrate across alluvial segments of valley bottom. The Newby Cut 3 reach is relatively free of infrastructure protection and is therefore able to migrate except when controlled by natural bedrock or large boulders described above.

2.3 DESCRIPTION OF EXISTING RIPARIAN CONDITION AND HISTORICAL RIPARIAN IMPACTS

Riparian vegetation is in good condition adjacent to the channel within the project reach. Large cottonwood trees are intermixed with younger age classes of riparian cottonwood, alder, willow and dogwood.

2.4 DESCRIPTION OF LATERAL CONNECTIVITY TO FLOODPLAIN AND HISTORICAL FLOODPLAIN IMPACTS

The north floodplain, where the side channel is proposed, has good potential for restoring lateral connectivity. No previous flood protection berms exist.

2.5 TIDAL INFLUENCE IN PROJECT REACH AND INFLUENCE OF STRUCTURAL CONTROLS (DIKES OR GATES)

Not applicable to this project.

3. Technical Data

3.1 INCORPORATION OF HIP SPECIFIC ACTIVITY CONSERVATION MEASURES FOR ALL INCLUDED PROJECT ELEMENTS

HIP conservation measures will be met through the project design and requests for variances will be submitted for any conservation measures that cannot be met.

3.2 SUMMARY OF REACH INFORMATION AND MEASUREMENTS (SURVEY, BED MATERIAL, ETC) USED TO SUPPORT ASSESSMENT AND DESIGN

3.2.1 Elevation data

Project survey was completed in 2015, and 2021. The 2015 survey was completed for the Newby Narrows project constructed in 2017. The recent 2021 survey was completed to supplement the 2015 survey and extend the hydraulic analysis downstream. New temporary control points were installed during the 2021 survey.

3.2.2 Fish use

Fish presence and life-stage timing data were taken from the 2017 Biological Strategy (UCRTT 2017), Methow Subbasin Plan (NWPCC 2004), Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan (UCSRB 2007), Middle Twisp Reach Assessment, and empirical PIT tag and screw trap data from Columbia River Data Access in Real Time (DART 2018). Habitat preference information was taken from the primary literature.

3.2.3 Aerial images

Historical air photo images back to 1998 were examined, but are not included in this report. The project reach is controlled by both bedrock and significant boulder substrate. No significant change in planform was observed in the photo records.

3.3 SUMMARY OF HYDROLOGIC ANALYSES CONDUCTED, INCLUDING DATA SOURCES AND PERIOD OF RECORD INCLUDING A LIST OF DESIGN DISCHARGE (Q) AND RETURN INTERVAL (RI) FOR EACH DESIGN ELEMENT

The peak flow hydrology used in the Newby Narrows are summarized in Table 2. Hydrologic analysis was conducted by USBR in 2008 and represents estimated return frequency discharge in the project reach.

Table 2. Peak Discharge at RM 13.6 from USBR (2008). Downstream end of the project is RM 10.

Recurrence flow	Downstream of Eagle Creek	2-YR	5 -YR	10-YR	25-YR	50-YR	100-YR
Discharge (cfs)		1,587	2,362	2,910	3,637	4,202	4,786

3.4 SUMMARY OF SEDIMENT SUPPLY AND TRANSPORT ANALYSES CONDUCTED, INCLUDING DATA SOURCES INCLUDING SEDIMENT SIZE GRADATION USED IN STREAMBED DESIGN

The Middle Twisp River Reach Assessment and Restoration Strategy collected several representative pebble counts (Interfluve, 2015) that included the Newby Cut 3 project reach. Mobile bed particles on bars and riffles bracketing the project area are summarized in Figure 9. D84 is approximately 180mm (6") and D50 of 90mm (3.5"). Within the downstream half of the project reach, large immobile boulder lag deposits control slope near and downstream of the Yakama Nation owned property line.

Observations of riverbank, riverbed, and floodplain scour indicate underlying substrate is likely to be similar across the valley at the elevations and alignments of the proposed side channel. Therefore, it appears likely a side channel could be formed within the floodplain surface without importing streambed materials. Based on field observations, it is likely large boulder substrate will be encountered in the lower half of a side channel project near the Yakama Nation property line, further stabilizing any created side channel alignment.

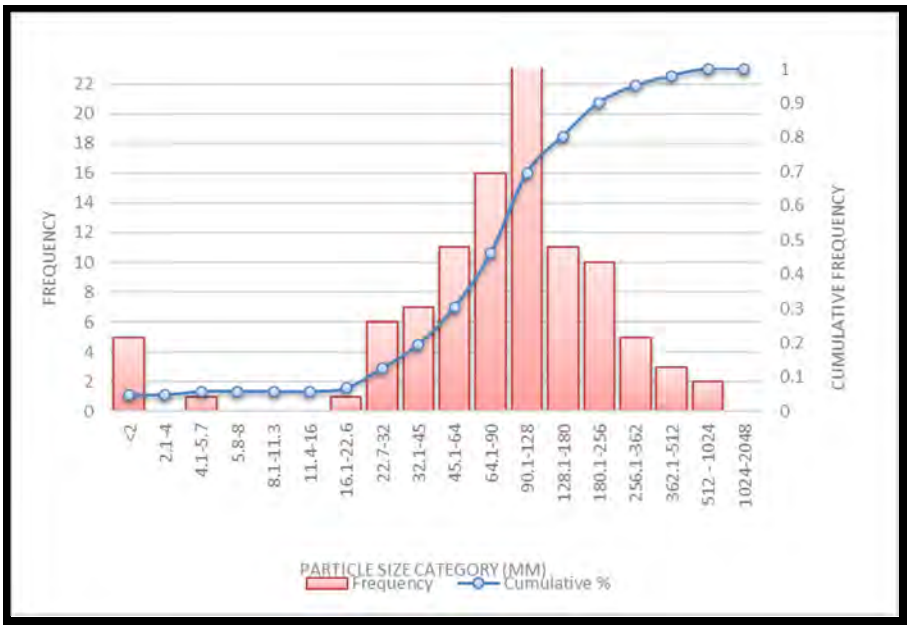

Figure 9. Mobile bed pebble count results representing the project reach. Significant boulder immobile bed deposits exist within the project reach are not represented in the mobile bar and riffle pebble count data presented above.

3.5 HYDRAULIC MODELING OR ANALYSES CONDUCTED AND OUTCOMES – IMPLICATIONS RELATIVE TO PROPOSED DESIGN

Existing channel and floodplain hydraulics were simulated using the U.S. Army Corps of Engineers Hydraulic Engineering Center River Analysis System (HEC-RAS 6.1; USACE 2021). One-

dimensional (1D) and two-dimensional (2D) hydraulic models were developed. 2D modeling was developed for 2-yr through 25-yr recurrence floods to predict the hydraulic conditions of these relatively frequent habitat forming flows. The 1D model was developed for the 50-yr and 100-yr floods to predict flood impacts to insured structures in preparation for FEMA compliance modeling in future design phases.

3.5.1 2D Model Setup

The model geometry is based on an existing conditions digital terrain model (DTM) that was developed using a combination of aerial LiDAR acquired 2018 (DNR LiDAR Portal) and ground/bathymetric survey data collected by Inter-Fluve staff in the 2015 and 2021. A side channel was constructed within the project reach in 2017. While the new side channel was captured by the 2018 LiDAR, the high density of installed large wood and beaver dams mischaracterized the side channel, so the design DTM was incorporated into the model terrain surface and roughness applied to represent the woody debris and structures.

The 2D model geometry consists of a computational grid with a nominal cell size ranging between 10 and 30 feet. Break lines were added to align cell faces along high ground features. A spatially varying hydraulic roughness (Manning's n) layer was created by hand-digitizing regions with similar land cover throughout the model domain. In general, roughness coefficients were applied to these regions based on field observations, aerial photos, and professional judgement. Roughness values for each landcover region were based on published guidelines of one-dimensional roughness coefficients (Arcement & Schneider, 1989) for corresponding channel types and vegetation conditions, and then decreased with the understanding that 2D roughness values should be less than those published for 1D models where the terrain surface is based on LiDAR and inherently represents channel and floodplain irregularities (Robinson et al., 2019). Manning's 'n' or roughness values corresponding with various types of land cover and channel characteristics were input to the 2D model as follows:

- Main channel (gravel/cobble): 0.032
- Side channel (varying wood densities): 0.05-0.075
- Gravel bar (minimal vegetation): 0.038
- Vegetated Gravel Bars: 0.1
- Floodplain with thin riparian forest: 0.08
- Moderately dense riparian forest: 0.1
- Dense riparian forest: 0.15
- Meadow: 0.055
- Relic channel: 0.09
- Alcove: 0.08
- Existing wood accumulations: 0.1-0.25
- Road embankment: 0.065

The 2- through 25-year flood events listed in Table 2 were incorporated into a synthetic quasi steady-state hydrograph with periods of steady flow (at the tabulated discharges) connected by smooth transition periods to create a stair-step like pattern. The periods of steady flow allow the model to come steady state condition, which facilitates the interpretation of hydraulics at specific discharges. A normal depth boundary condition was applied at the downstream end of the model domain, assuming a slope of 0.013 ft/ft.

3.5.2 1D Model Setup

The 1D model geometry is based on the same existing conditions DTM as the 2D model. The model is 2,600 feet along the Twisp River and covers the same extent as the 2D model. The model consists of 18 cross sections with station-elevation data based on of the existing conditions DTM. The cross-sections were developed directly in HEC-RAS, using the built-in cross-section development tools in RAS Mapper. Cross-section station elevation points were filtered to approximately 100 points, using the "minimize area change" functions in HEC-RAS. The cross section layout is included in Appendix B.

Roughness values for each landcover region were based on published guidelines of one-dimensional roughness coefficients (Arcement & Schneider, 1989) for corresponding channel types and vegetation conditions. The manning n in the main channel ranged from 0.042 to 0.045, from 0.1 to 0.12 in the overbank and was 0.65 in the previously constructed side channel.

A normal depth boundary condition was applied at the downstream end of the model domain, assuming a slope of 0.013 ft/ft. The upstream boundary condition was defined as the flow input for the 50-Year and 100-Year flood events listed in Table 2. Steady flow computation methodology was used for the model, assuming a subcritical flow regime.

3.5.3 Model Results

2D modeled depths and velocities for the 2-year through 25-year flood events, and tables and figures summarizing hydraulic properties of the 50- and 100-year floods from the 1D model are shown in Appendix B.

A new side channel on the inside of the river meander would have equal or greater slope than the mainstem, and with appropriate design of channel dimensions and roughness, could maintain sediment transport continuity.

Proposed project actions were not modeled at the concepts design phase.

3.6 STABILITY ANALYSES AND COMPUTATIONS FOR PROJECT ELEMENTS, AND COMPREHENSIVE PROJECT PLAN

Wood ballast computations are not included in the concepts phase. For future design phases, it is anticipated that ballast using both burial and vertical piles will be used for the project work in the Newby Cut 3 reach. Stability analysis will follow professional practice guidelines for large wood design (Knutson and Fealko 2014 and USBR and ERDC 2016), stream habitat restoration (Cramer

2012), Stability of Ballasted Woody Debris Habitat Structures (D'Aoust and Millar 2000) and institutional knowledge combined with professional judgment.

3.7 DESCRIPTION OF HOW PRECEDING TECHNICAL ANALYSIS HAS BEEN INCORPORATED INTO AND INTEGRATED WITH THE CONSTRUCTION – CONTRACT DOCUMENTATION

The preceding analysis is the basis for conceptual design plans only.

3.8 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A LONGITUDINAL PROFILE OF THE STREAM CHANNEL THALWEG FOR 20 CHANNEL WIDTH UPSTREAM AND DOWNSTREAM OF THE STRUCTURE SHALL BE USED TO DETERMINE THE POTENTIAL FOR CHANNEL DEGRADATION

Not applicable to this project.

3.9 FOR PROJECTS THAT ADDRESS PROFILE DISCONTINUITIES (GRADE STABILIZATION, SMALL DAM AND STRUCTURE REMOVALS): A MINIMUM OF THREE CROSS-SECTIONS – ONE DOWNSTREAM OF THE STRUCTURE, ONE THROUGH THE RESERVOIR AREA UPSTREAM OF THE STRUCTURE, AND ONE UPSTREAM OF THE RESERVOIR AREA OUTSIDE OF THE INFLUENCE OF THE STRUCTURE) TO CHARACTERIZE THE CHANNEL MORPHOLOGY AND QUANTIFY THE STORED SEDIMENT

Not applicable to this project.

4. Construction – Contract Documentation

4.1 INCORPORATION OF HIP GENERAL AND CONSTRUCTION CONSERVATION MEASURES

The enclosed restoration concept designs are consistent with the HIP conservation measures. At later design stages, more detailed standard conservation measures will be included in the drawings and specifications.

4.2 DESIGN – CONSTRUCTION PLAN SET INCLUDING BUT NOT LIMITED TO PLAN, PROFILE, SECTION AND DETAIL SHEETS THAT IDENTIFY ALL PROJECT ELEMENTS AND CONSTRUCTION ACTIVITIES OF SUFFICIENT DETAIL TO GOVERN COMPETENT EXECUTION OF PROJECT BIDDING AND IMPLEMENTATION

Concept drawings are attached. Later design phases will provide design drawings, bid list, and specifications in greater detail to support project bidding and implementation.

4.3 LIST OF ALL PROPOSED PROJECT MATERIALS AND QUANTITIES

Imported and installed large wood/trees are shown in the concept drawings as approximate configurations and quantities. Final quantities of large wood will be determined in later design phases. It is expected that threaded rod will be used to meet stability criteria in proposed log structures.

A new side channel alignment is shown in the concept drawings. Excavation quantity will be quantified in later design phases.

4.4 DESCRIPTION OF BEST MANAGEMENT PRACTICES THAT WILL BE IMPLEMENTED AND IMPLEMENTATION RESOURCE PLANS INCLUDING:

Later stages of design will include:

- Construction sequence
- Work area isolation and dewatering plan
- Erosion and pollution control plan
- Planting plan
- List of proposed equipment and refueling management plan

4.5 CALENDAR SCHEDULE FOR CONSTRUCTION/IMPLEMENTATION PROCEDURES

A construction timeframe has not been determined. Work will be conducted within the seasonal in-water fish work window as it applies to each project component.

4.6 REACH OR PROJECT SPECIFIC MONITORING TO SUPPORT POLLUTION PREVENTION AND/OR ABATEMENT

To be completed during later design phases.

5. Monitoring and Adaptive Management Plan

Monitoring and adaptive management plans will be determined at the discretion of the Yakama Nation. It is anticipated that following project construction, a monitoring plan will be completed at a scale and level of effort similar to previous Yakama Nation projects constructed within the Methow Basin.

6. References

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7. Appendices

A – Concept Drawings

B – Hydraulic Model Results

Appendix A
Concept Drawings

TWISP RIVER - NEWBY CUT3

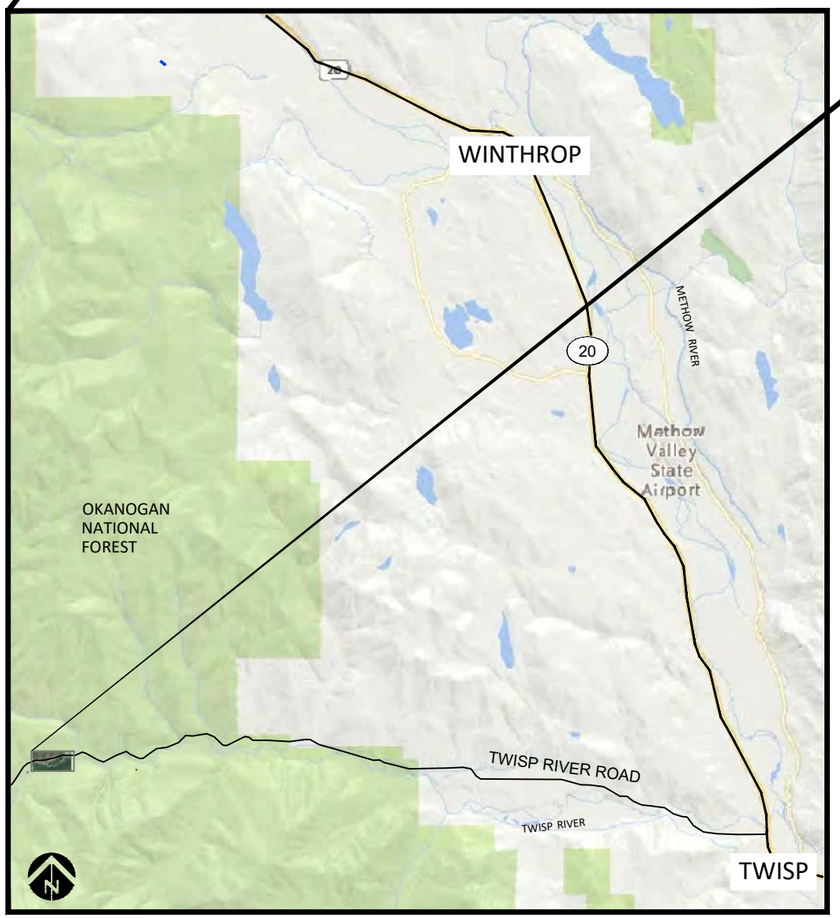
FISH HABITAT ENHANCEMENT PROJECT

Conceptual Design Drawings

December, 2021

Yakama Nation Fisheries

2 JOHNSON LANE
WINTHROP WA, 98862



VICINITY MAP

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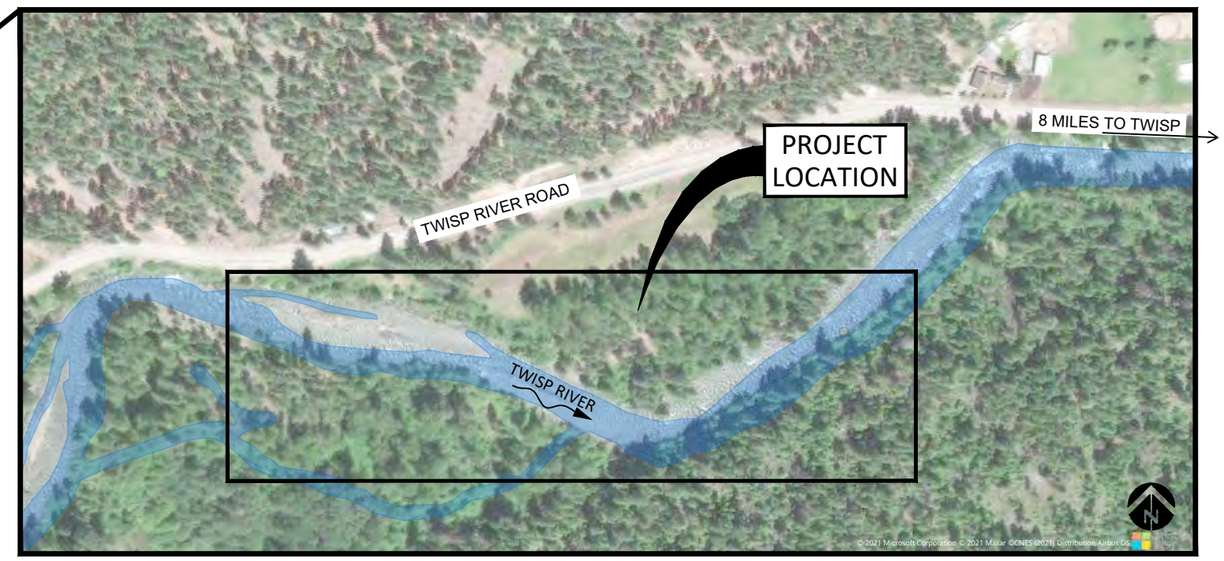

SITE MAP

SITE LOCATION

OKANOGAN COUNTY, WASHINGTON

LATITUDE: 48°22'37" NORTH
LONGITUDE: 120°17'49" WEST

WATERBODY: TWISP RIVER
TRIBUTARY OF: METHOW RIVER

SHEET INDEX

1 - COVER SHEET
2 - SITE OVERVIEW
3 - BAR APEX LOG STRUCTURE
4 - GRAVEL BAR LOG STRUCTURE
5 - BOULDER LOG STRUCTURE
6 - SIDE CHANNEL - PLAN & PROFILE
7 - SIDE CHANNEL TYPICAL DETAILS

NO.	BY	DATE	REVISION DESCRIPTION

MM DRAWN	MB DESIGNED	JJ CHECKED
JJ APPROVED	12/31/21 DATE	PROJECT

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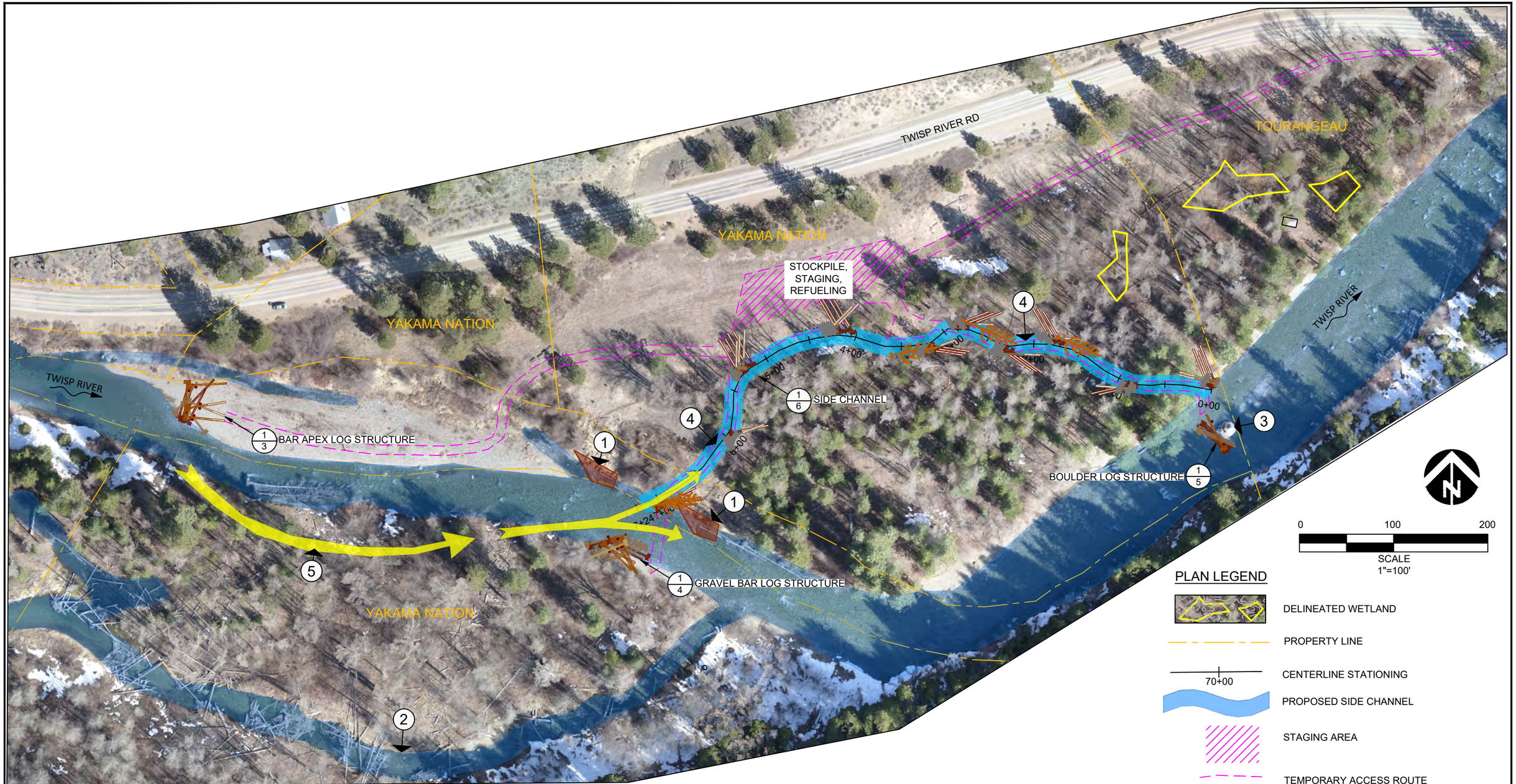
COVER SHEET



CALL-OUT NOTES

1. EXISTING LOG STRUCTURES, CONSTRUCTED IN 2017
2. PHASE 1 NEWBY SIDE CHANNEL, CONSTRUCTED IN 2018
3. EXISTING LARGE BOULDER IN MIDDLE OF RIVER
4. UTILIZE SIDE CHANNEL FOOTPRINT TO ACCESS RIVER AND LOG STRUCTURES
5. FUTURE CHANNEL MEANDER TREND

NO.	BY	DATE	REVISION DESCRIPTION

MM	MB	JJ
DRAWN	DESIGNED	CHECKED
JJ	12/31/21	
APPROVED	DATE	PROJECT

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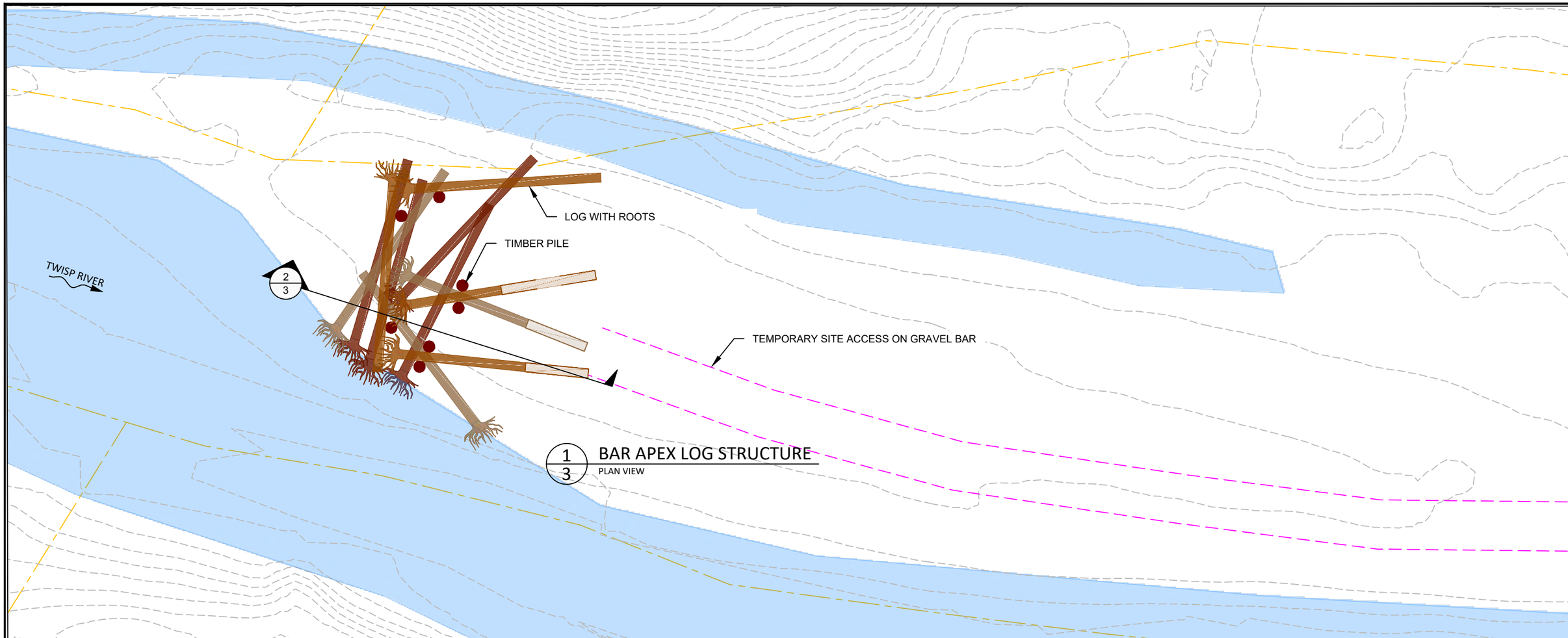
SITE OVERVIEW



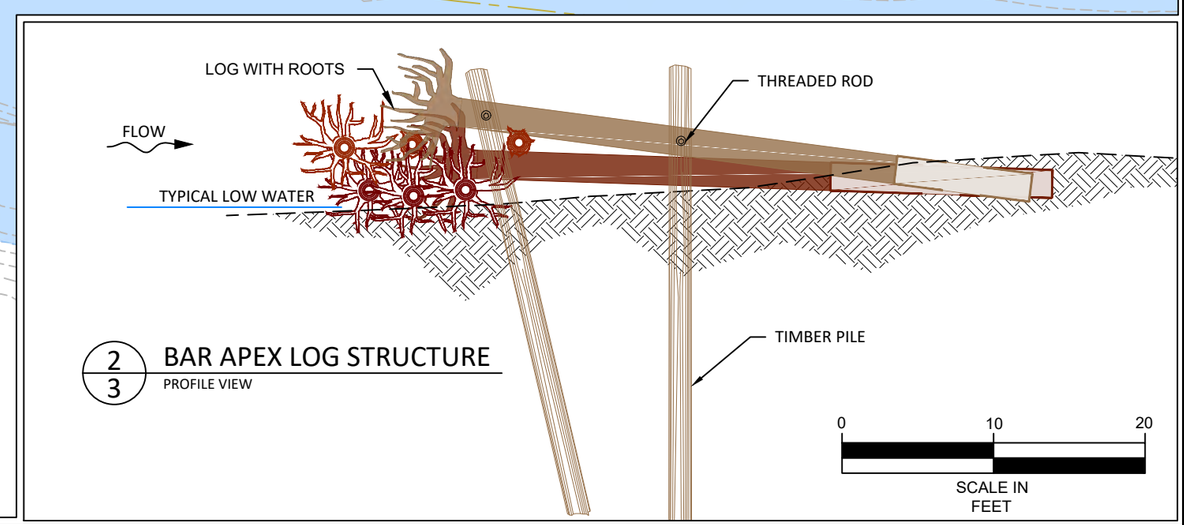
1/3 BAR APEX LOG STRUCTURE
PLAN VIEW

PLAN LEGEND

PROPERTY LINE

TEMPORARY ACCESS ROUTE

0 20 40
SCALE IN FEET



2/3 BAR APEX LOG STRUCTURE
PROFILE VIEW

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DRAWN	DESIGNED	CHECKED
JJ	12/31/21	
APPROVED	DATE	PROJECT

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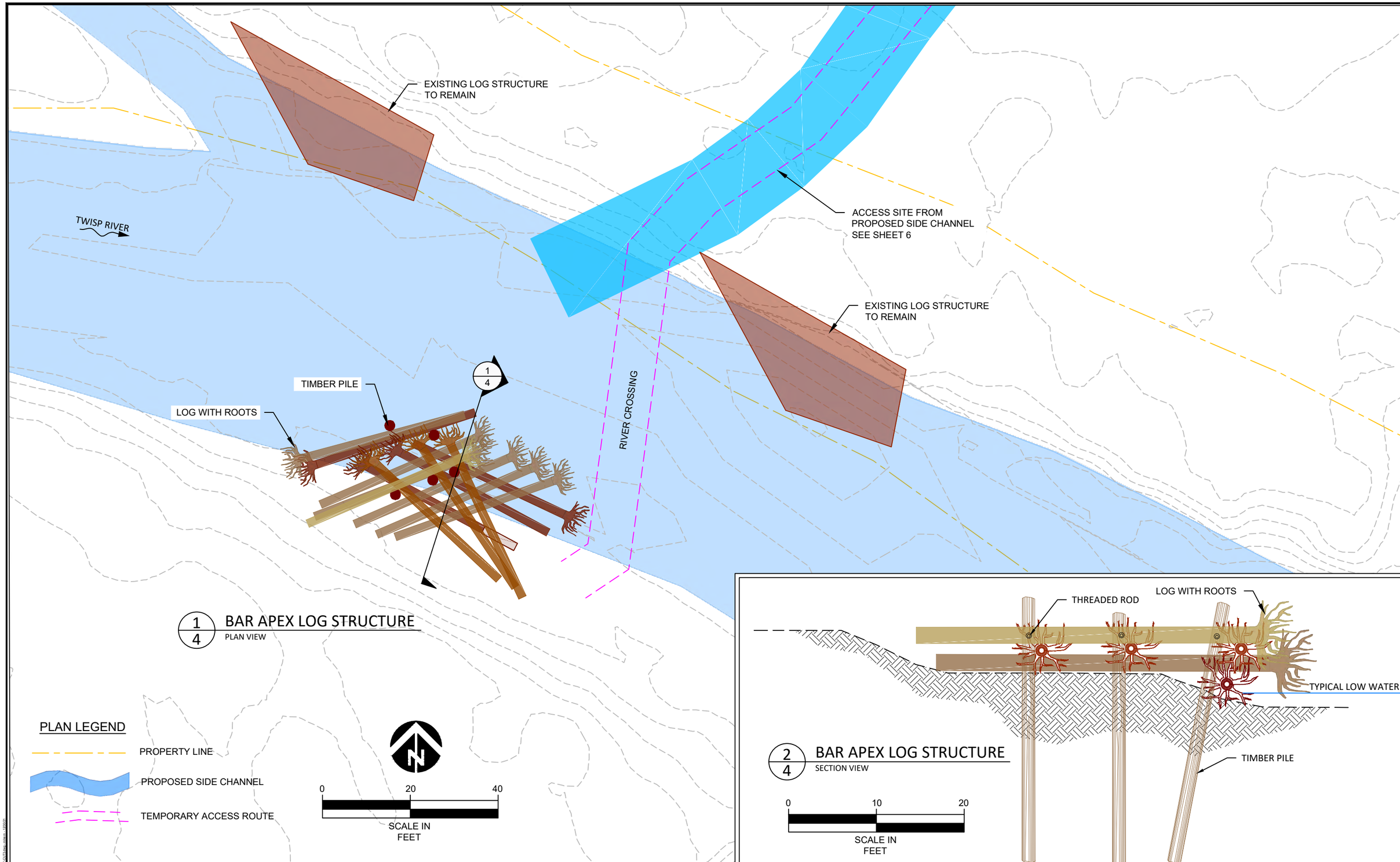
BAR APEX LOG STRUCTURE



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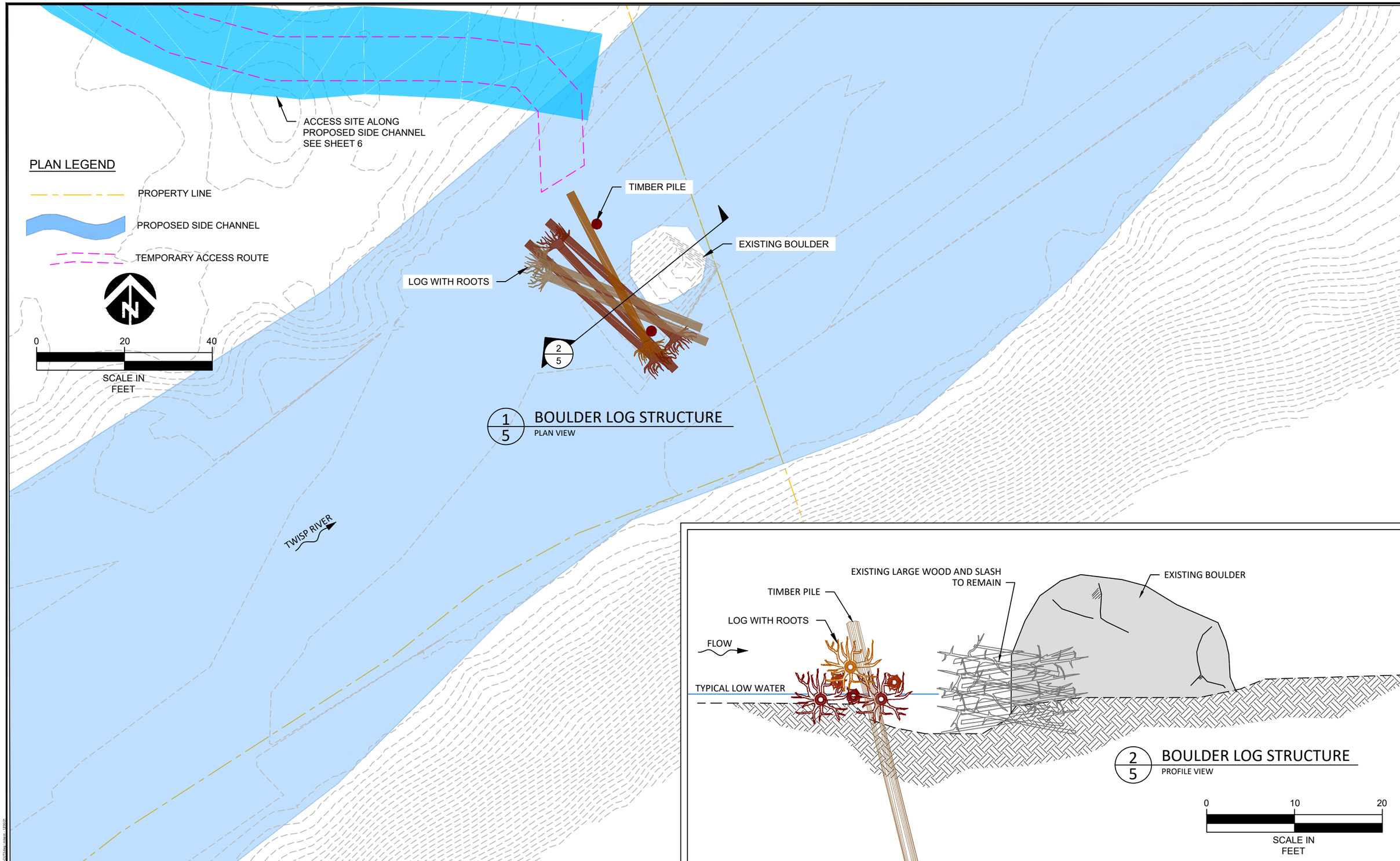
GRAVEL BAR LOG STRUCTURE

SHEET
4 OF 7



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APPROVED	DATE	PROJECT

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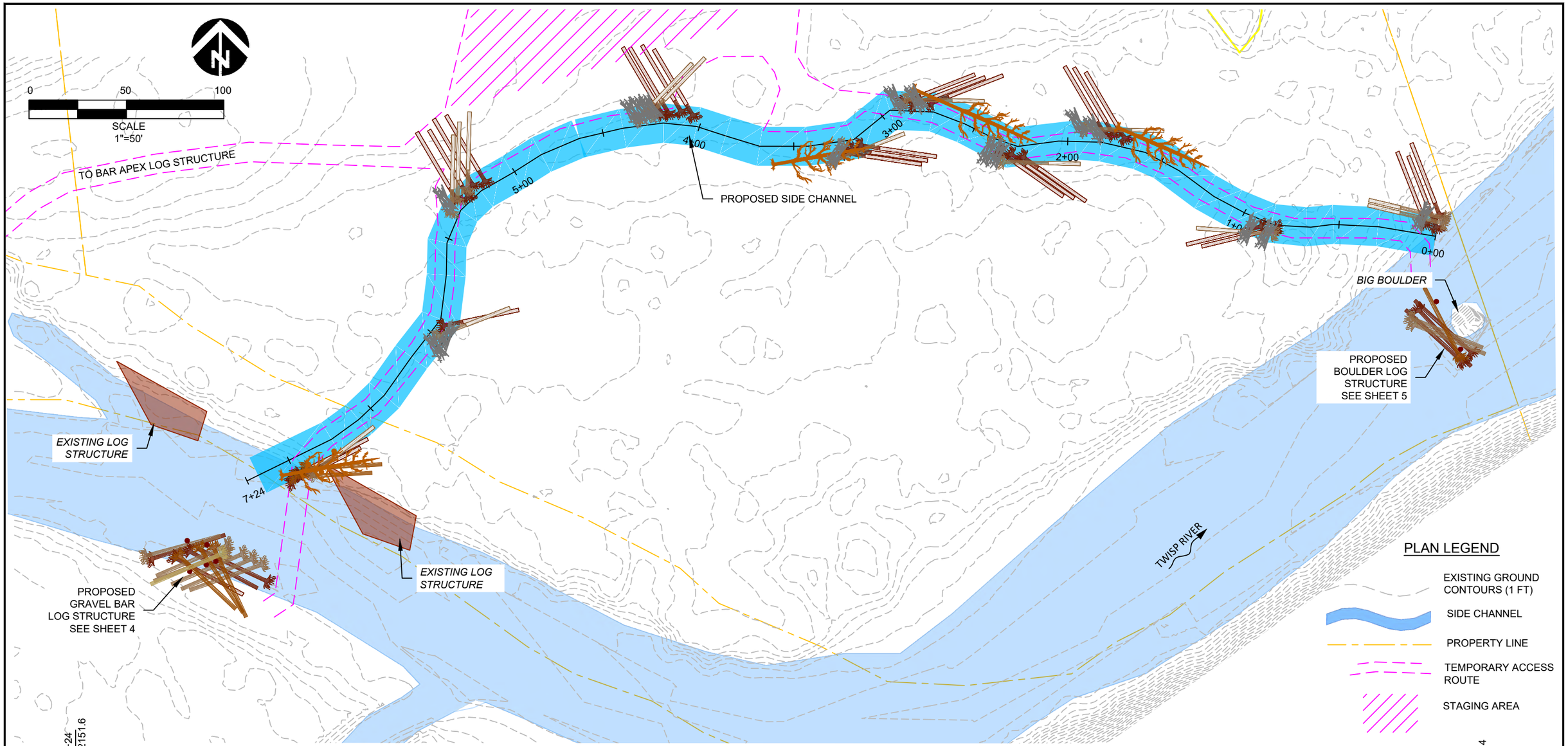
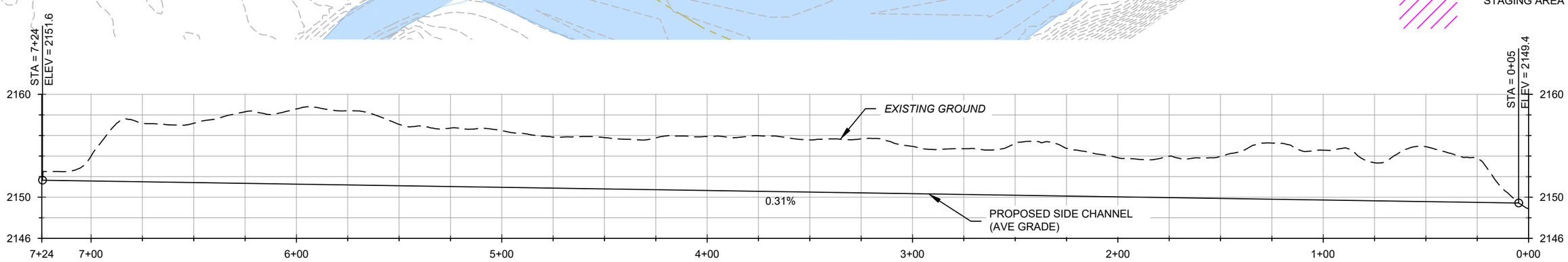
BOULDER LOG STRUCTURE

SHEET
5 OF 7





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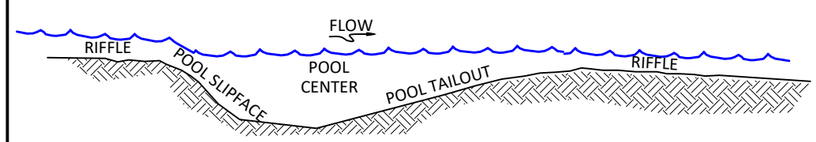
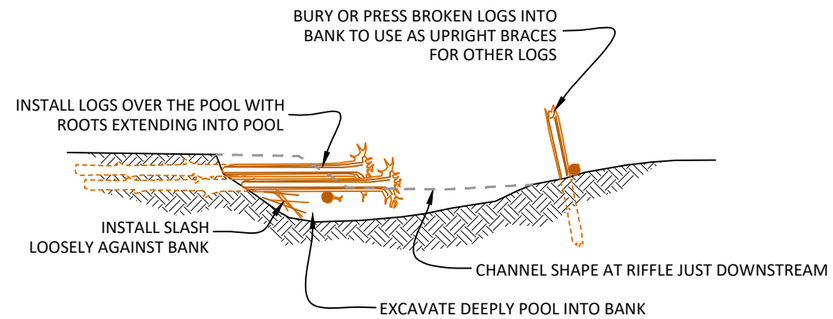
SIDE CHANNEL - PLAN & PROFILE

SHEET
6 OF 7



1/7 PROFILE VIEW - TYPICAL POOL AND RIFFLE
NOT TO SCALE

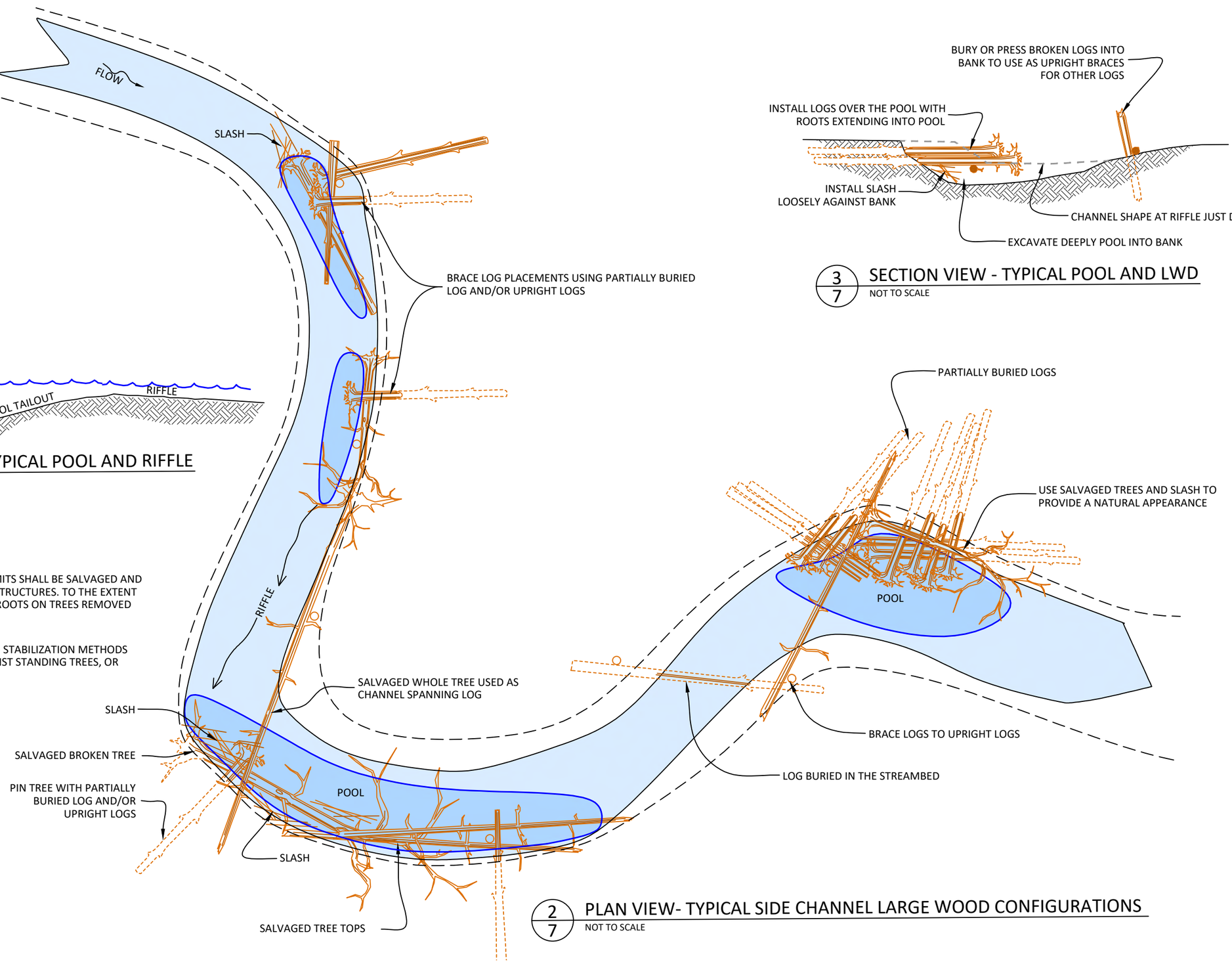


3/7 SECTION VIEW - TYPICAL POOL AND LWD
NOT TO SCALE

NOTES:

1. TREES AND SHRUBS WITHIN CLEARING LIMITS SHALL BE SALVAGED AND REUSED AS LOGS AND SLASH IN HABITAT STRUCTURES. TO THE EXTENT PRACTICABLE, PRESERVE BRANCHES AND ROOTS ON TREES REMOVED DURING CLEARING AND GRUBBING.

2. WOOD STRUCTURES SHALL BE STABILIZED. STABILIZATION METHODS INCLUDE PARTIAL BURIAL, BRACING AGAINST STANDING TREES, OR TIMBER PILES.



2/7 PLAN VIEW- TYPICAL SIDE CHANNEL LARGE WOOD CONFIGURATIONS
NOT TO SCALE

NO.	BY	DATE	REVISION DESCRIPTION

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JJ	12/31/21	
APPROVED	DATE	PROJECT

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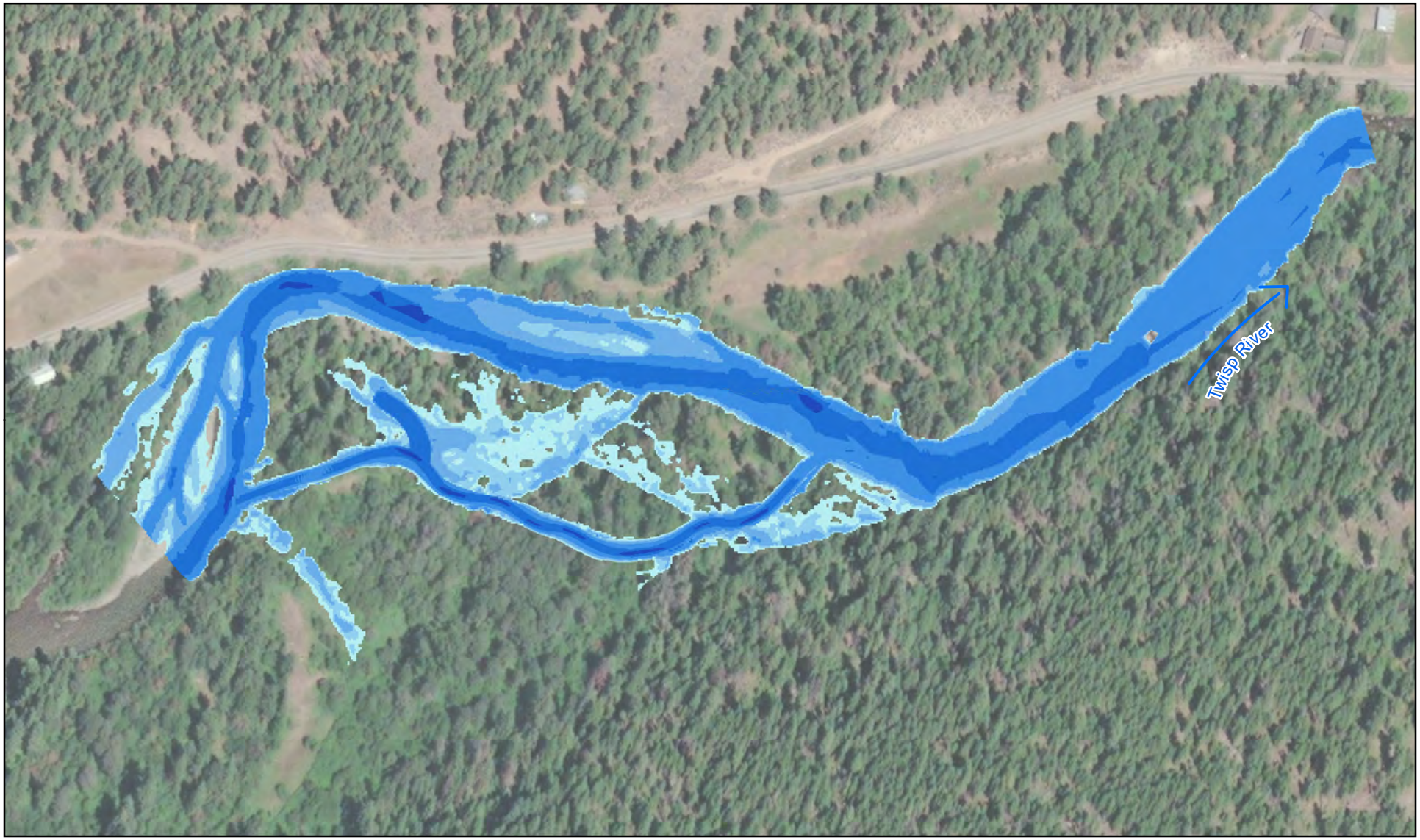
SIDE CHANNEL TYPICAL DETAILS

SHEET 7 OF 7

Appendix B
2D & 1D Hydraulic Model Results



Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

2-year Flood (1,587 cfs)

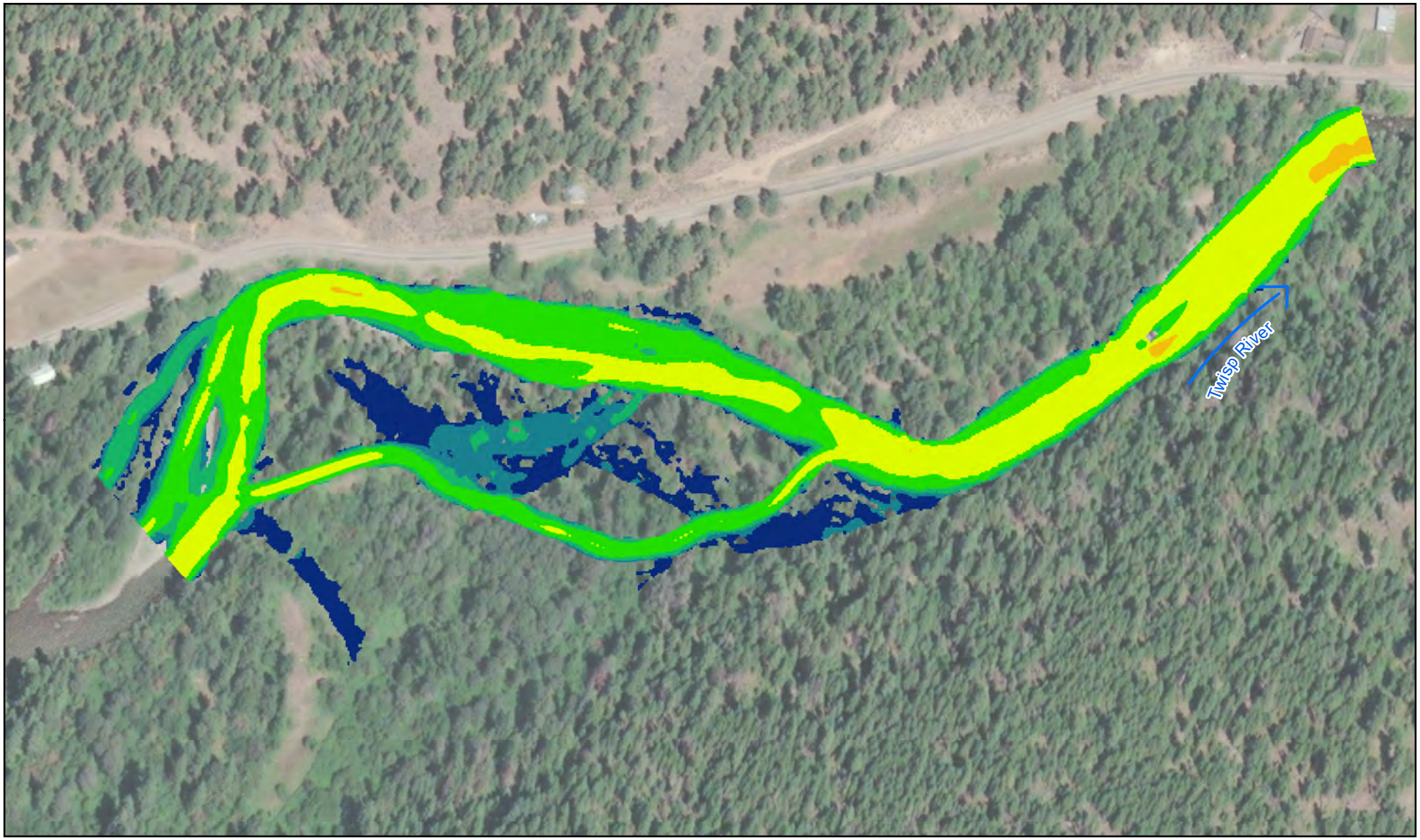
Modeled Depth (ft)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

0 150 300

N



Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

2-year Flood (1,587 cfs)

Modeled Velocity (ft/s)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

0 150 300

N

Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

5-year Flood (2,362 cfs)

Modeled Depth (ft)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

0 150 300

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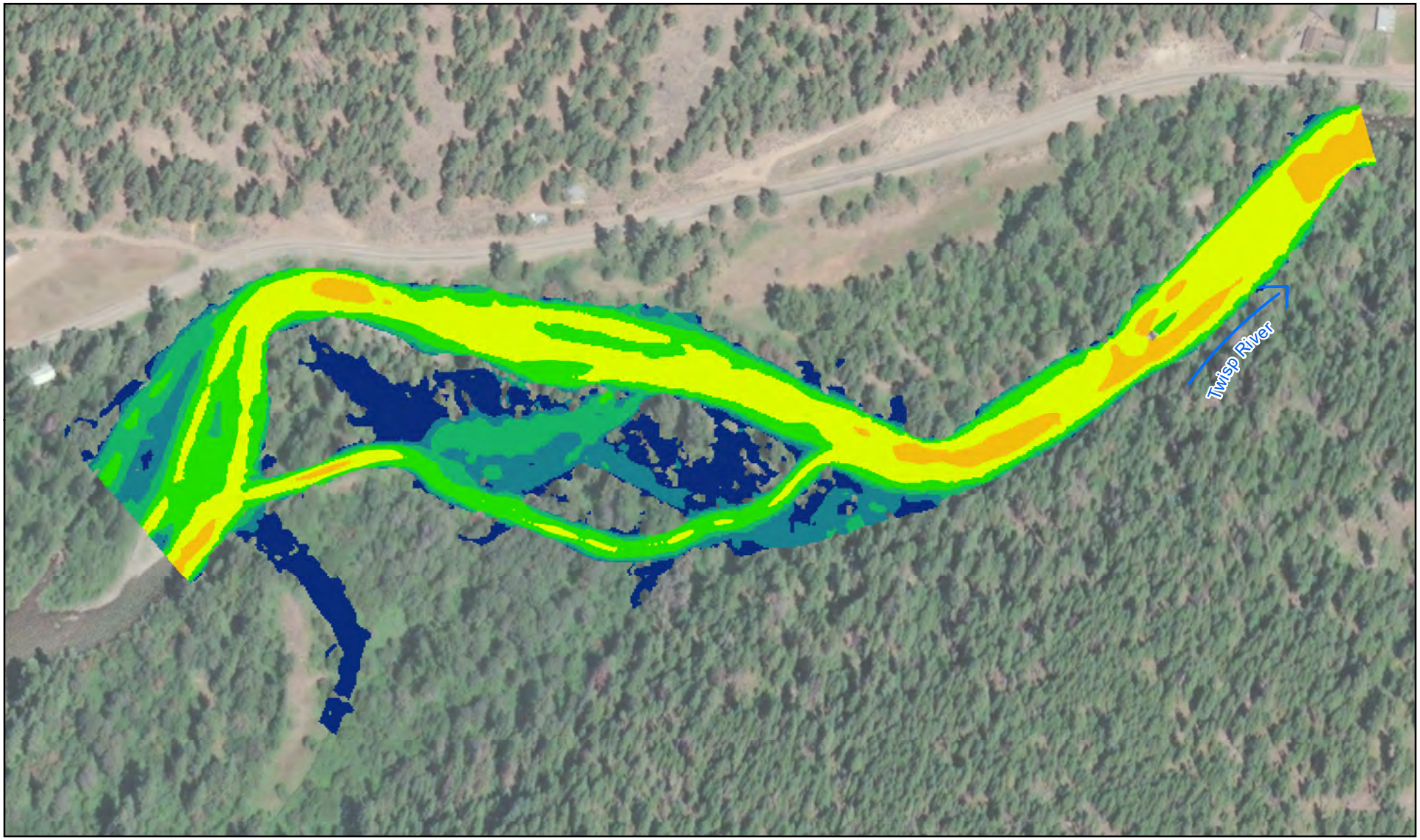

Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

5-year Flood (2,362 cfs)

Modeled Velocity (ft/s)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

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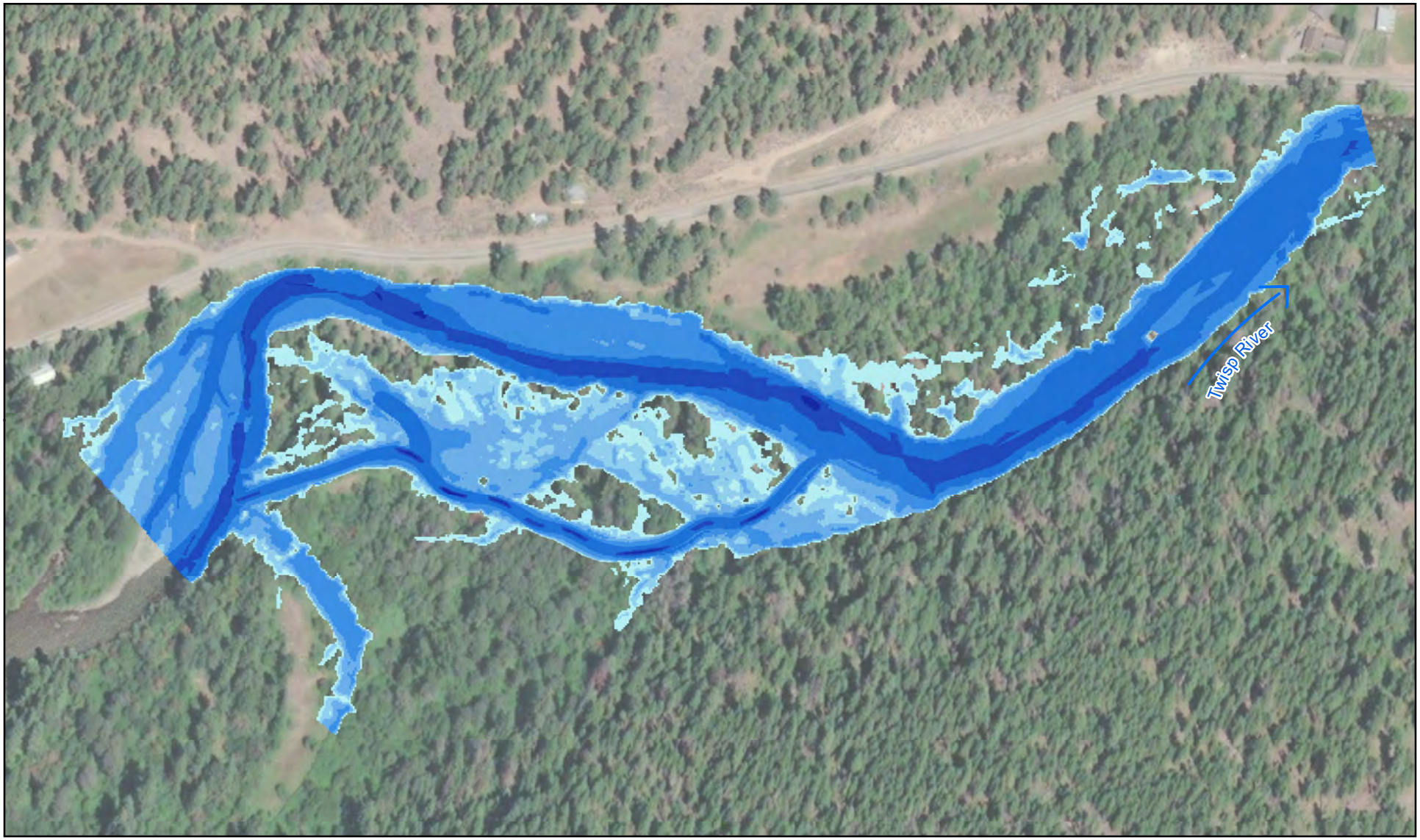

Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

10-year Flood (2,910 cfs)

Modeled Depth (ft)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

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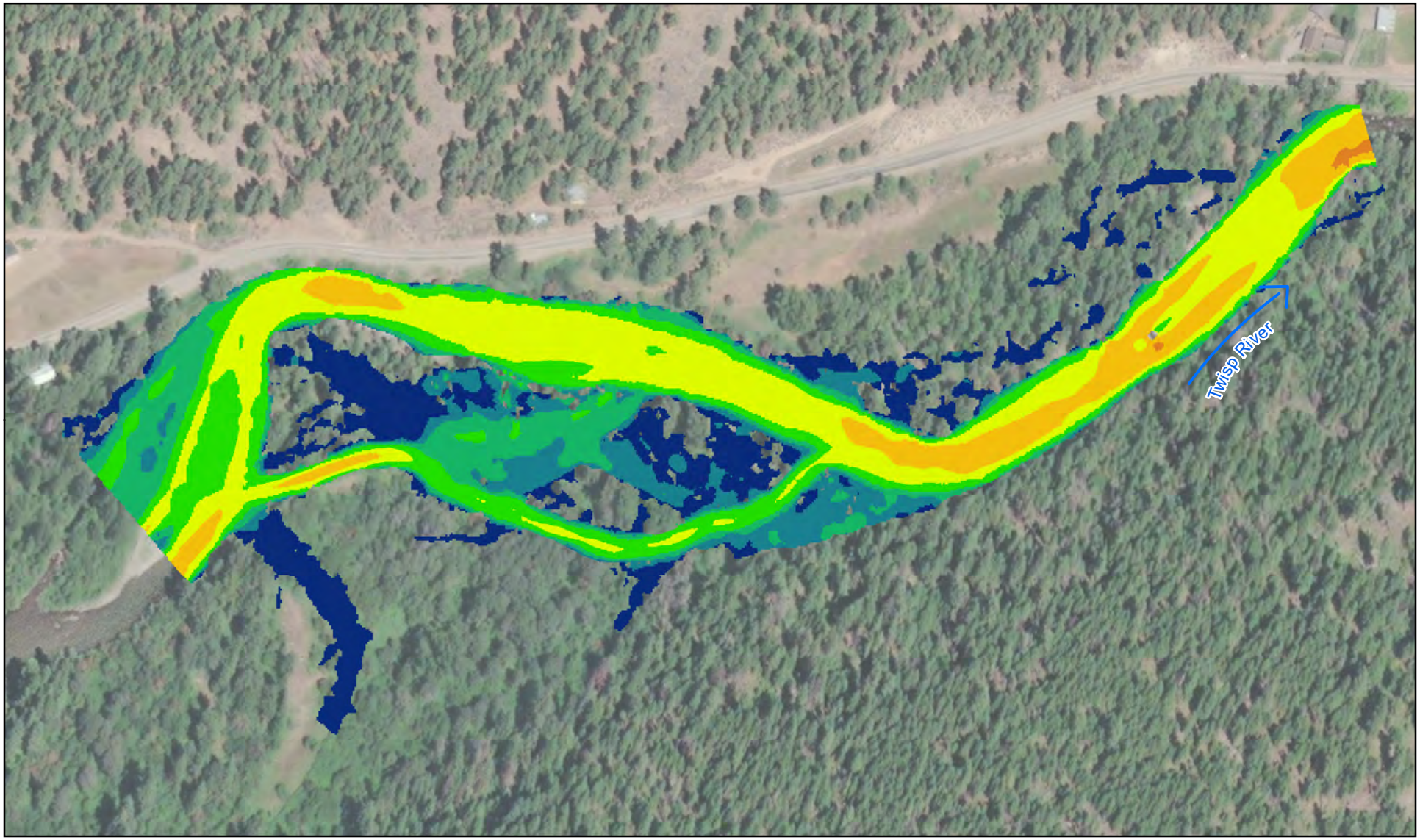

Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

10-year Flood (2,910 cfs)

Modeled Velocity (ft/s)

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Feet

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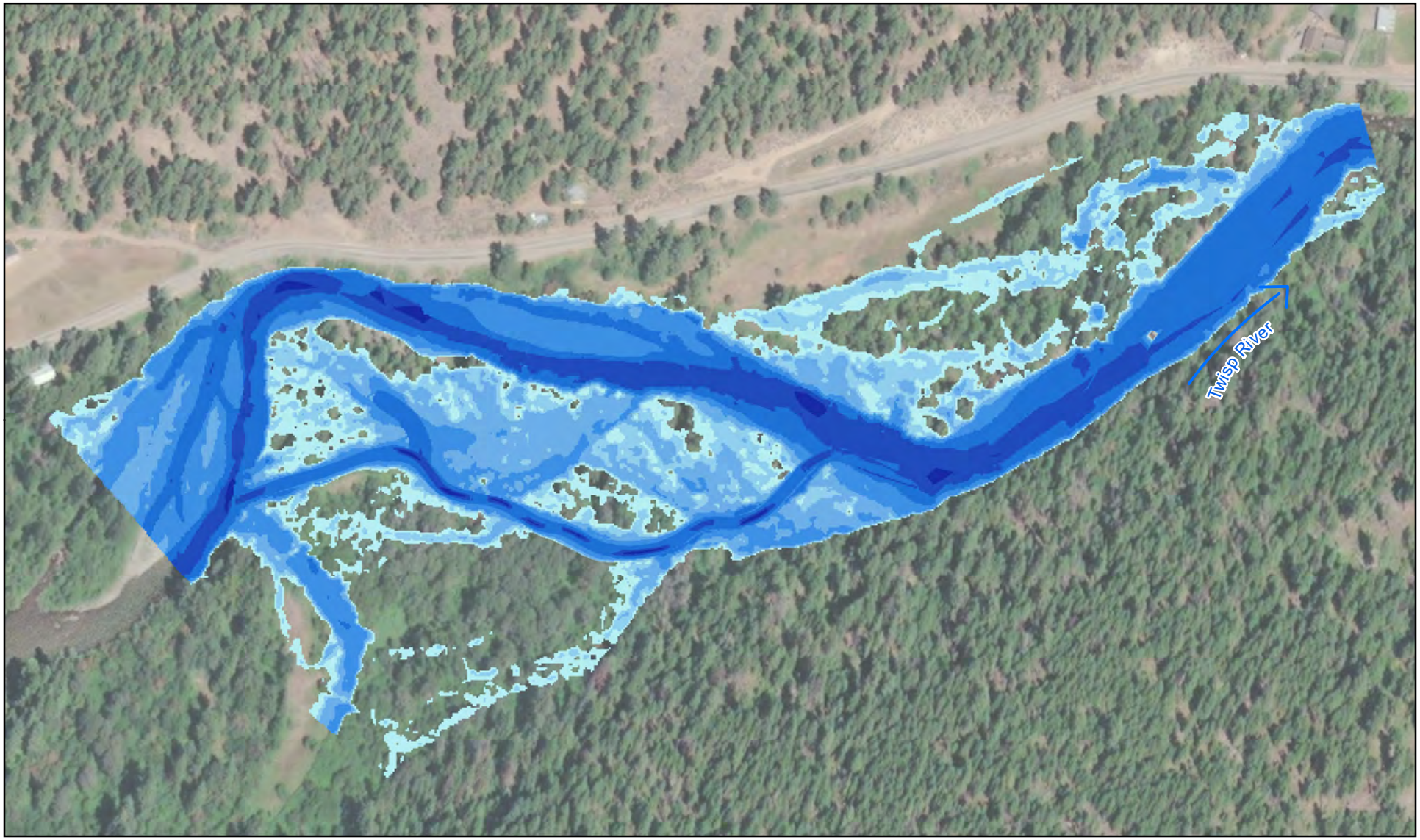


Twisp River - Newby Cut 3

Existing Conditions

Okanogan County, WA

25-year Flood (3,637 cfs)

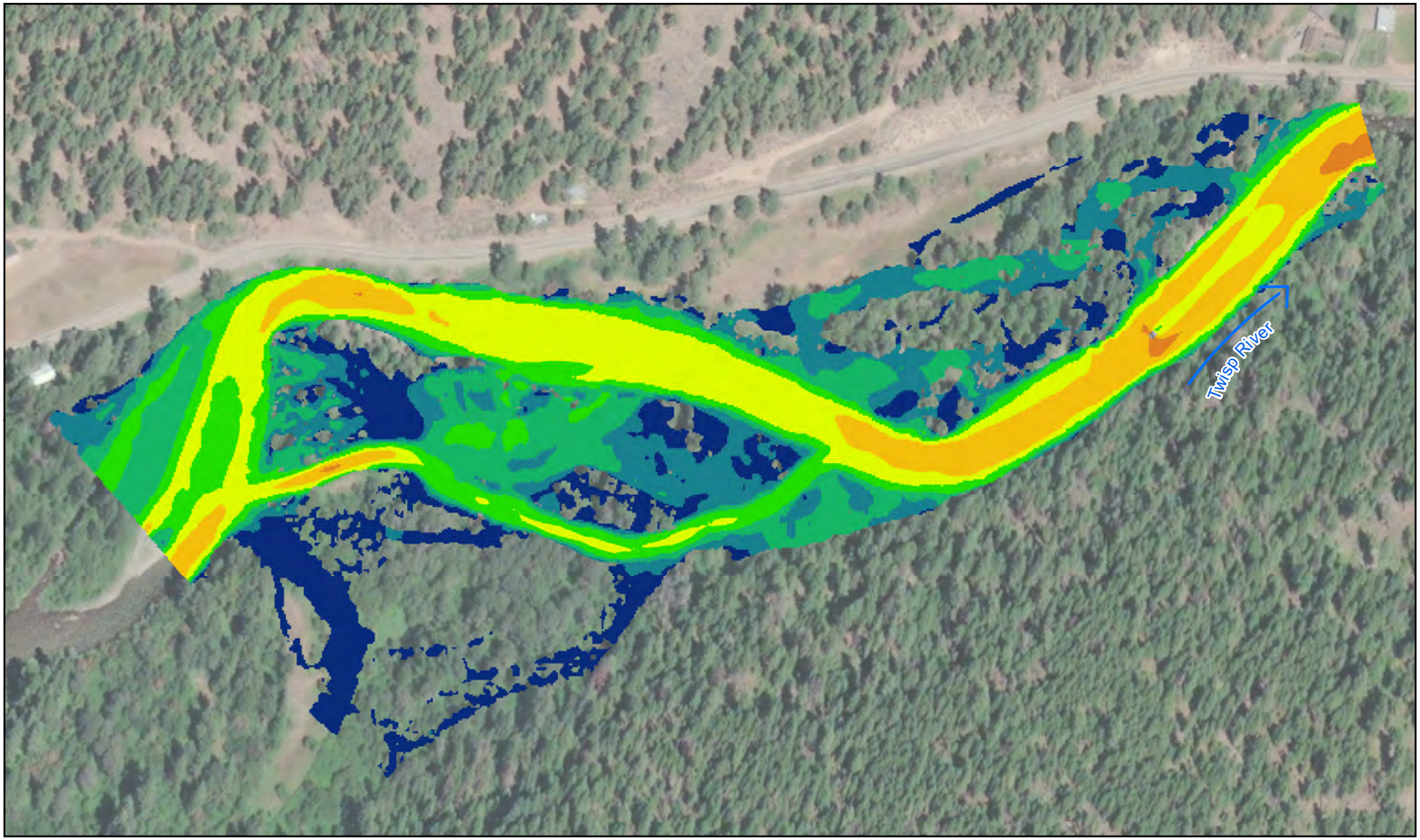
Modeled Depth (ft)

< 0.5 | 0.5 - 1 | 1 - 2 | 2 - 4 | 4 - 6 | 6 - 8 | 8 - 10 | > 10

Feet

0 150 300

N



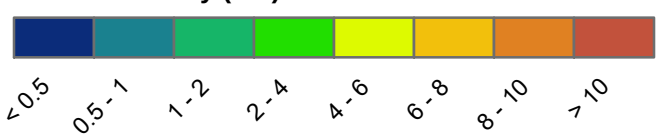
Twisp River - Newby Cut 3

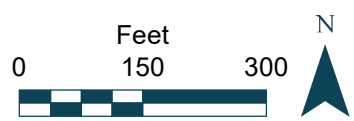
Existing Conditions

Okanogan County, WA

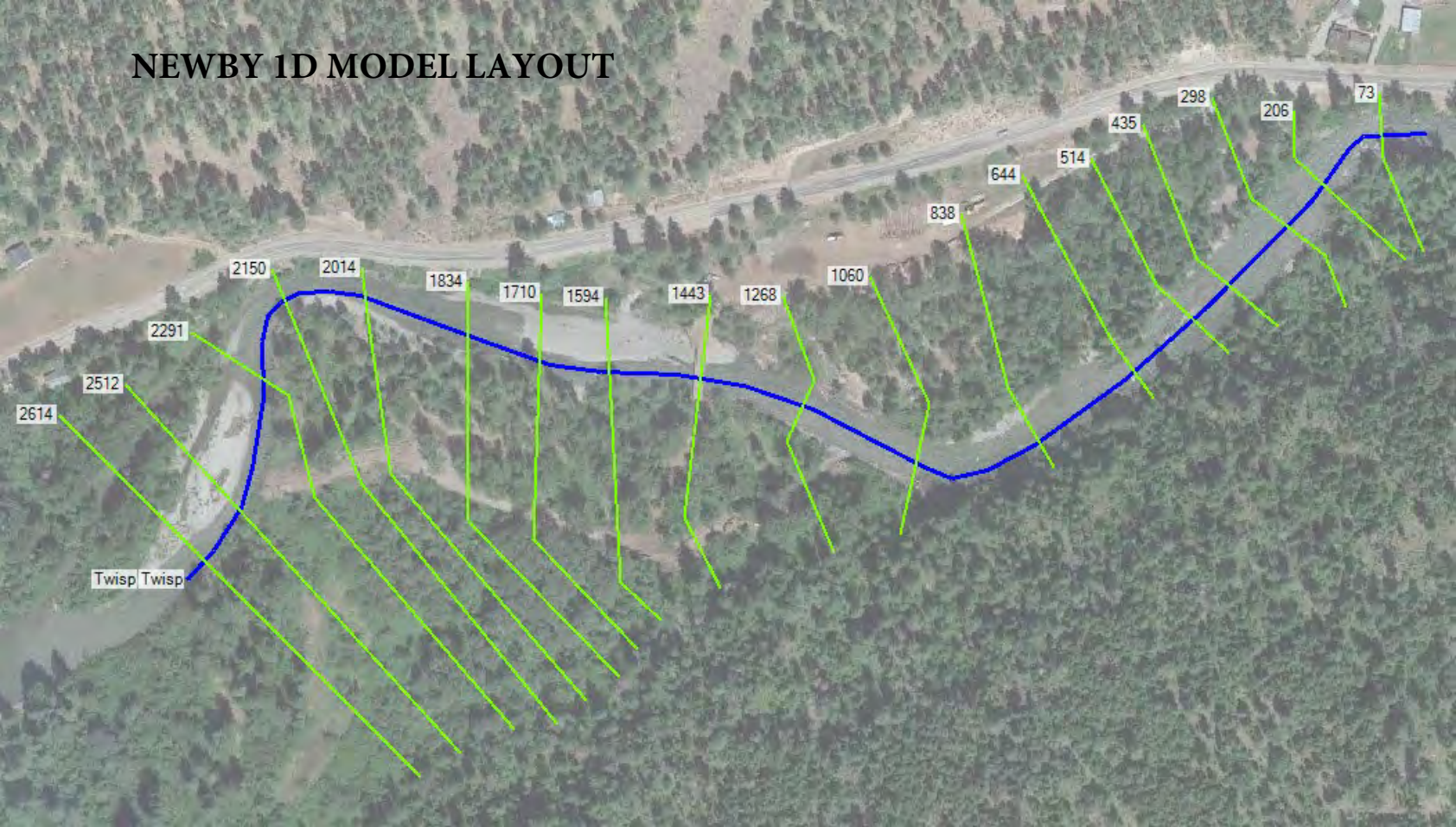
25-year Flood (3,637 cfs)

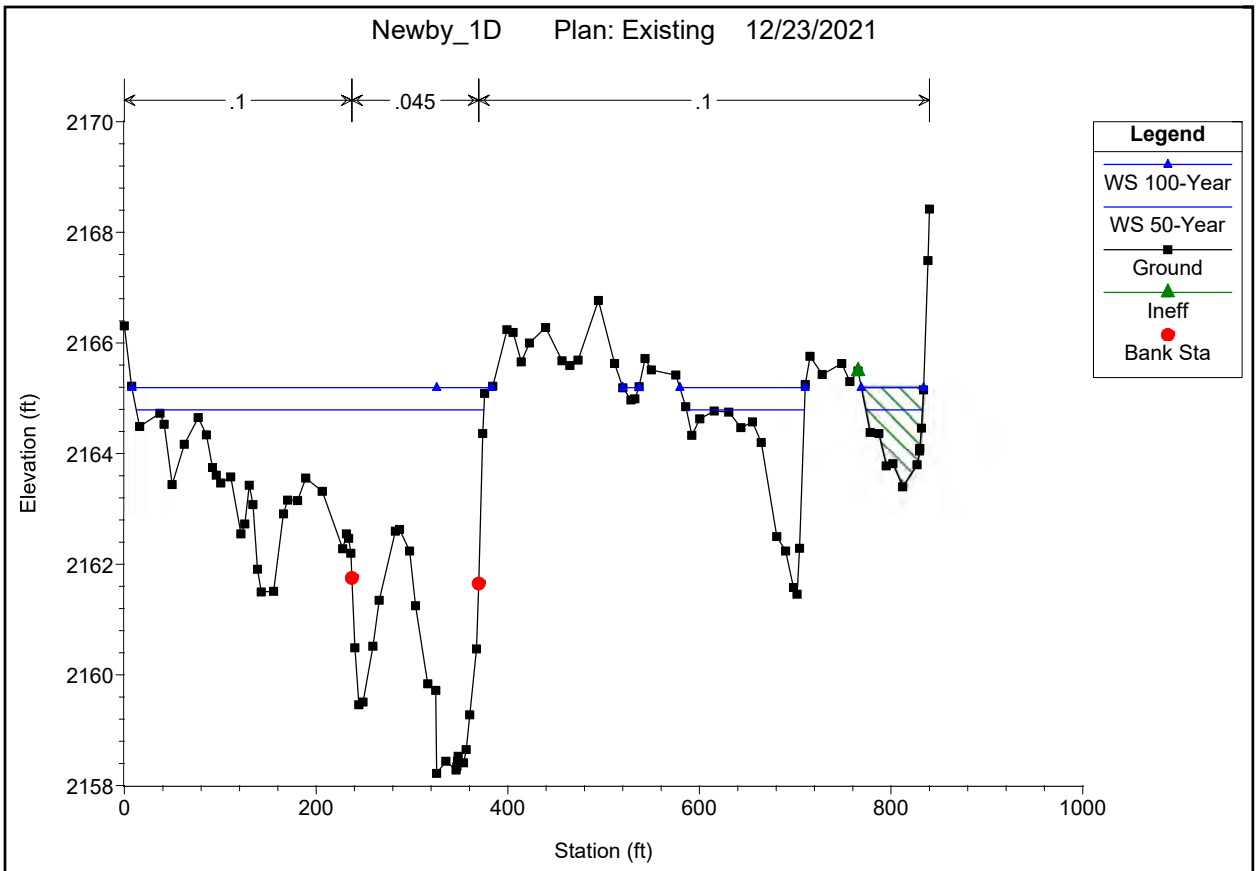
Modeled Velocity (ft/s)





NEWBY 1D MODEL LAYOUT




Newby_1D Plan: Existing 12/23/2021
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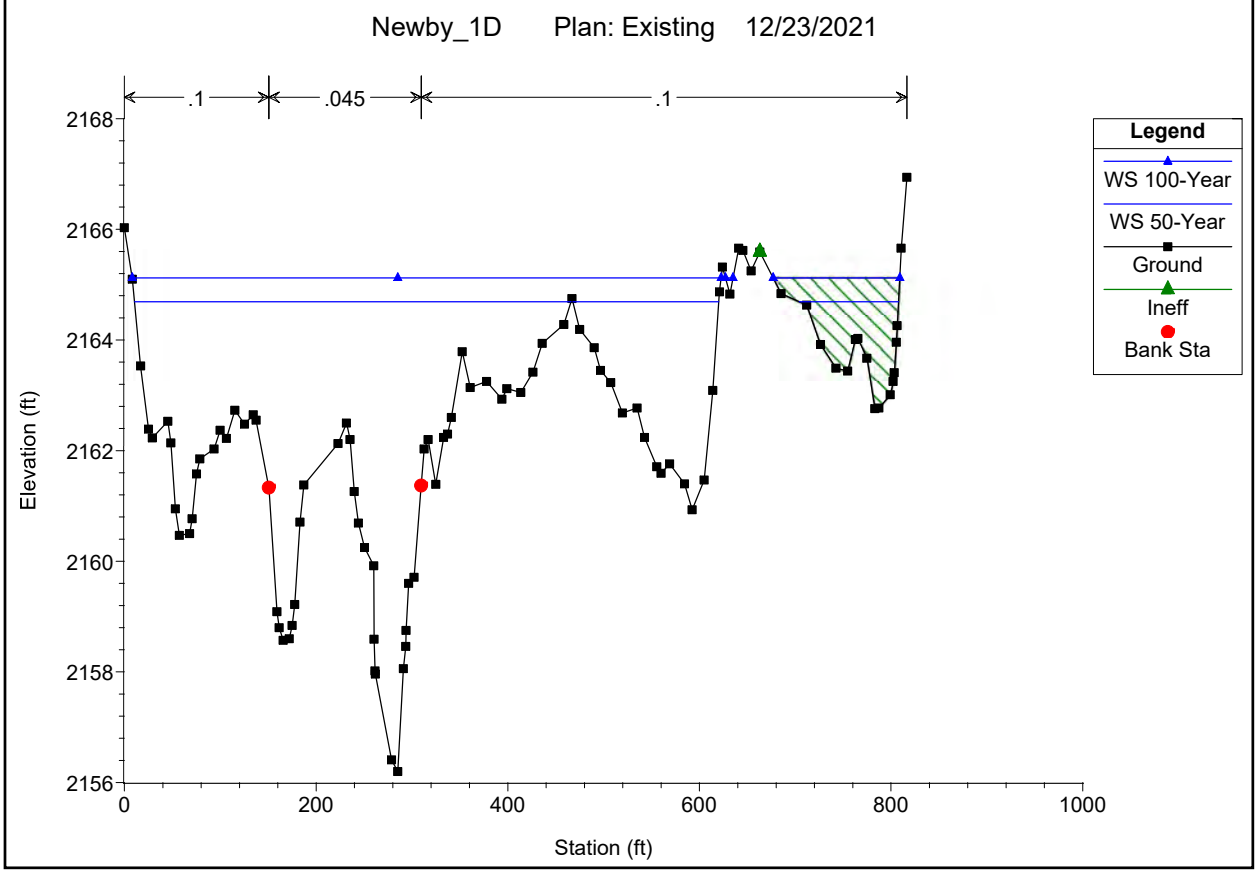
Newby_1D Plan: Existing 12/23/2021
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WS 50-Year
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2166
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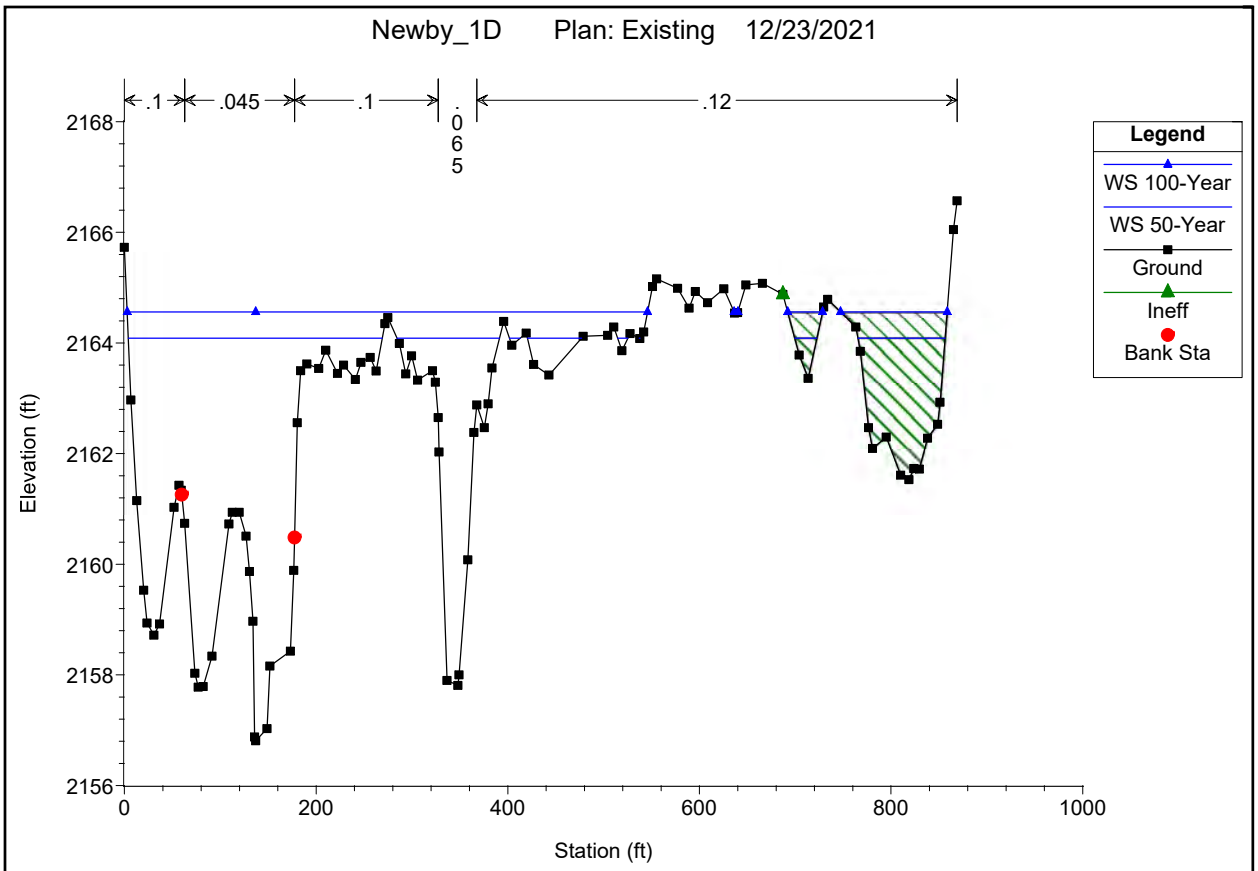
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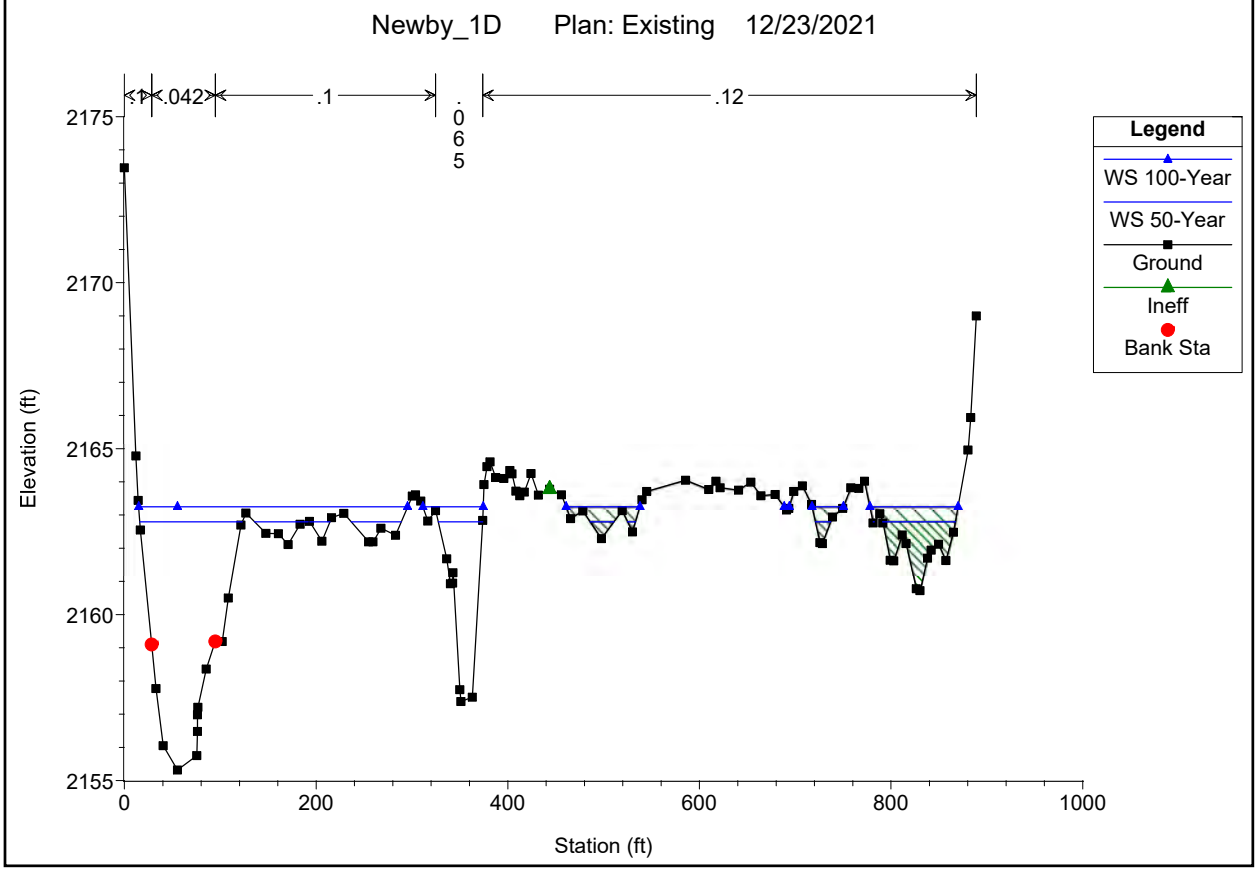
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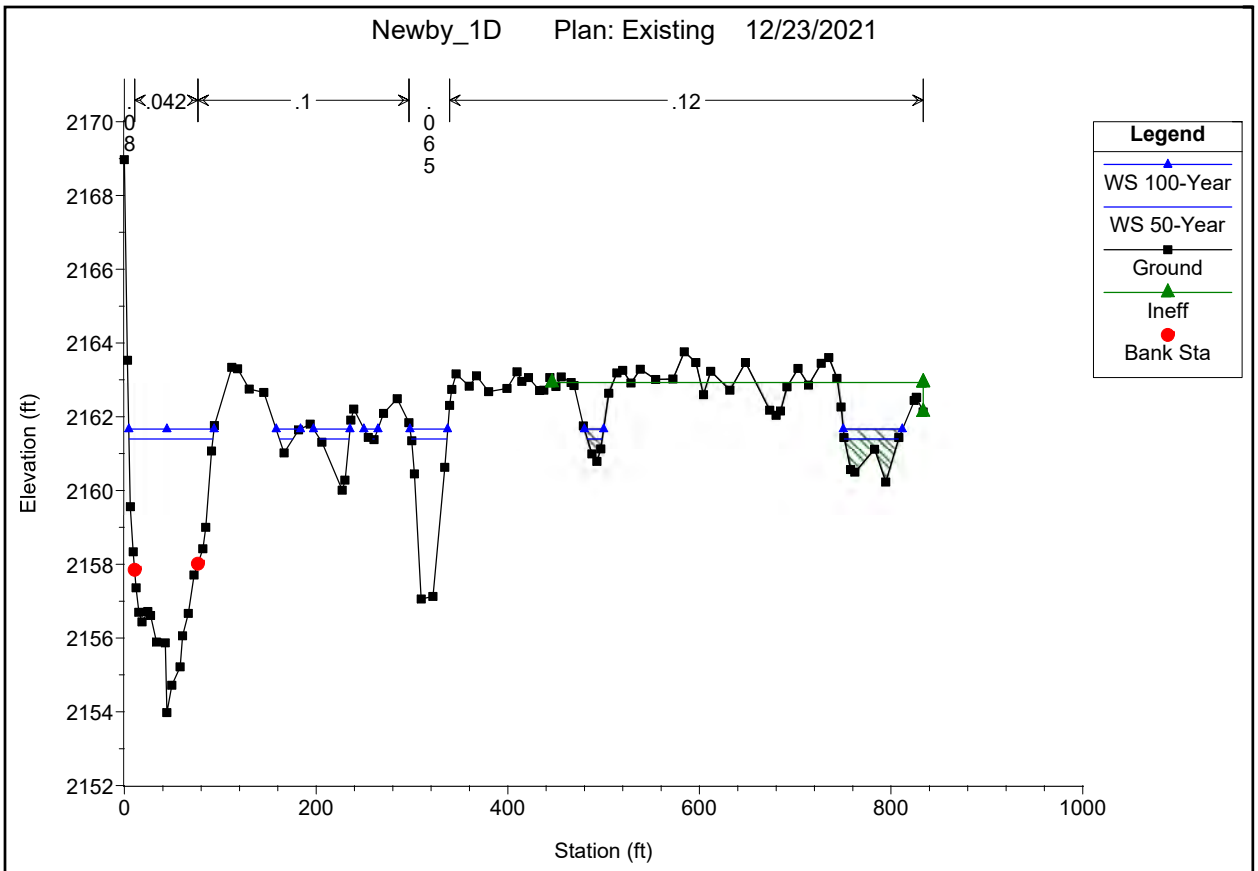
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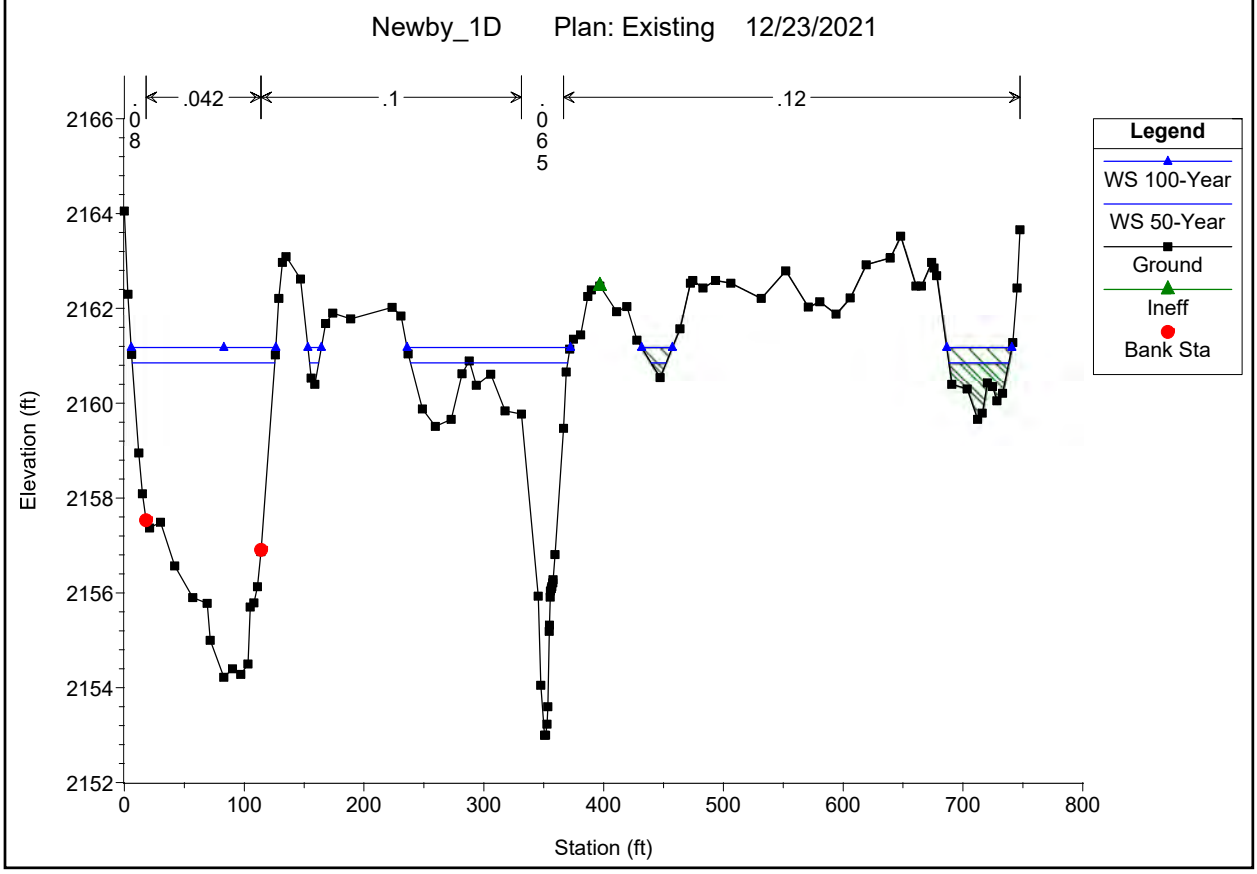
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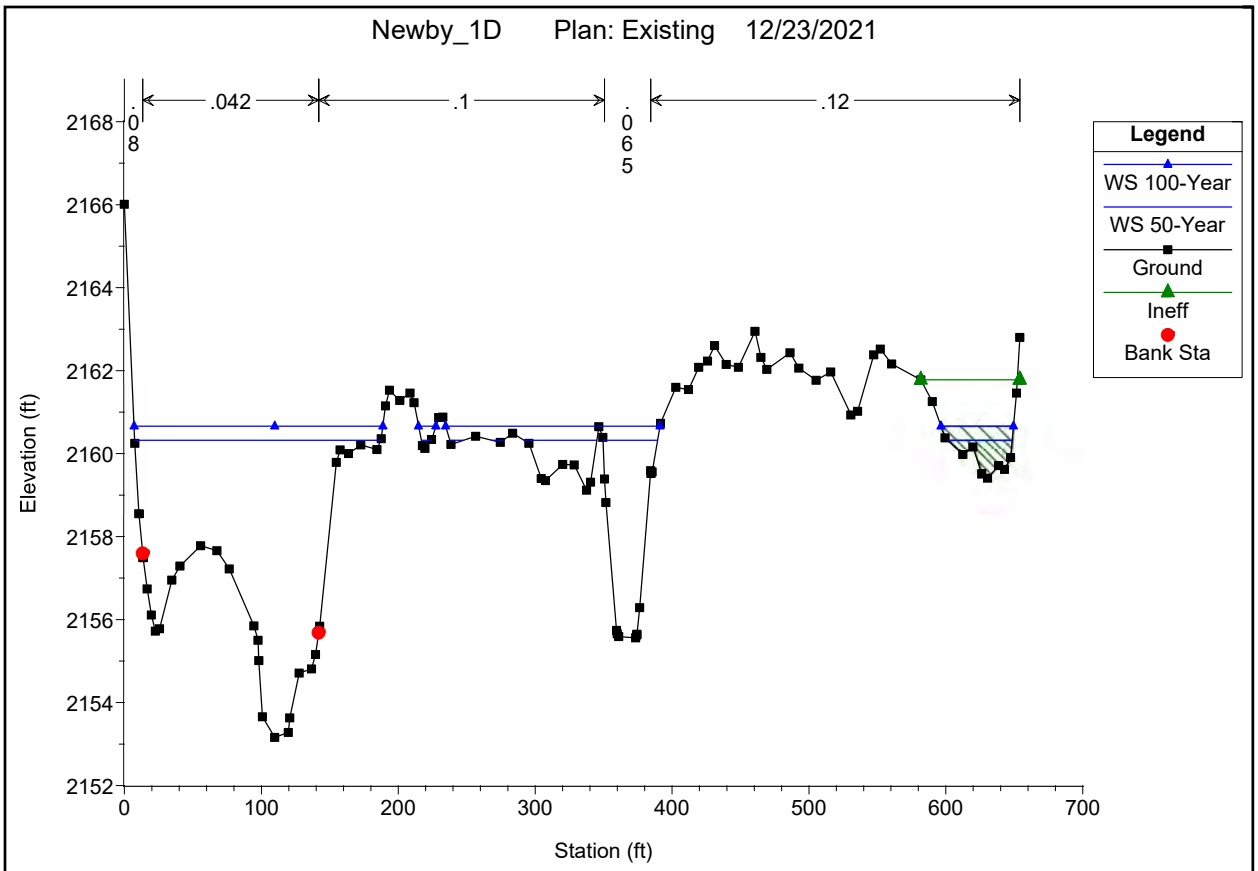
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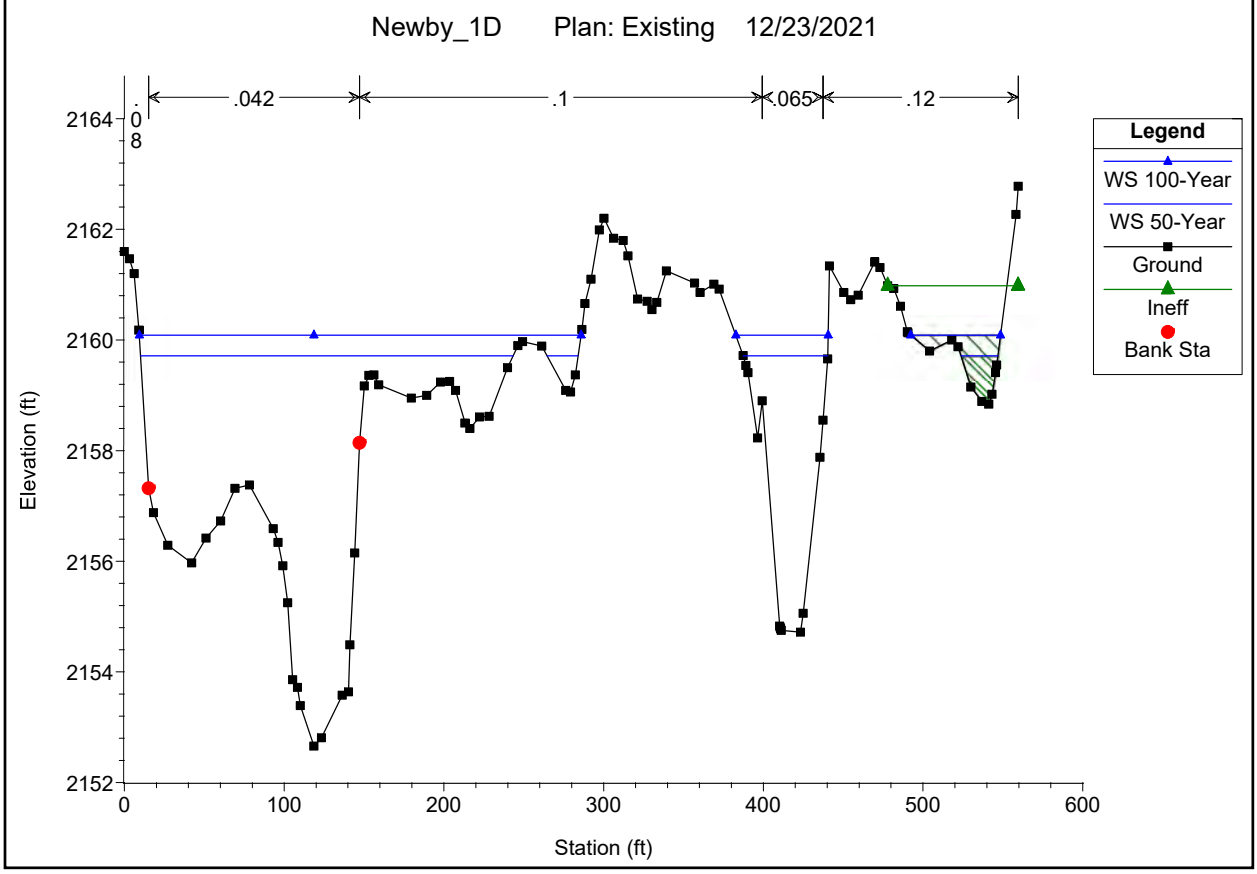
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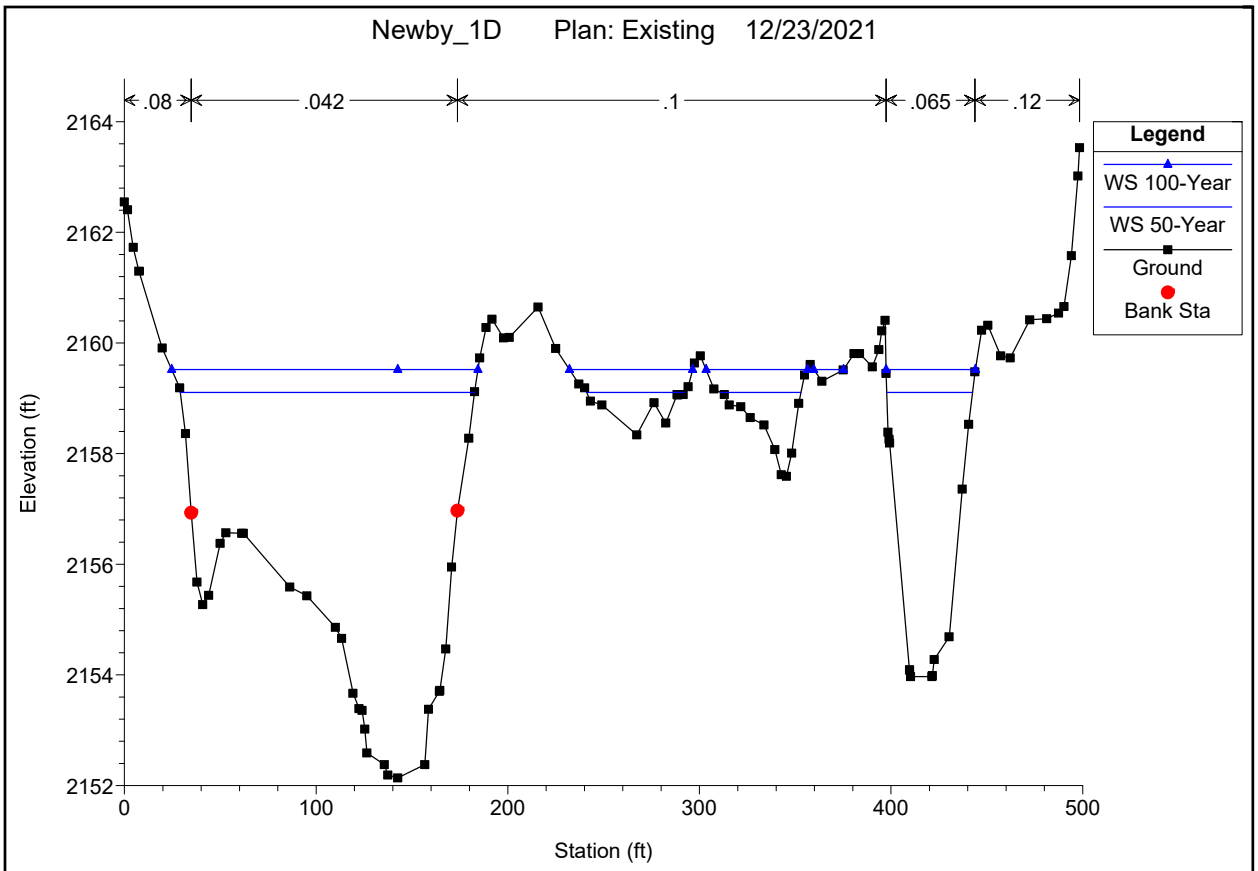
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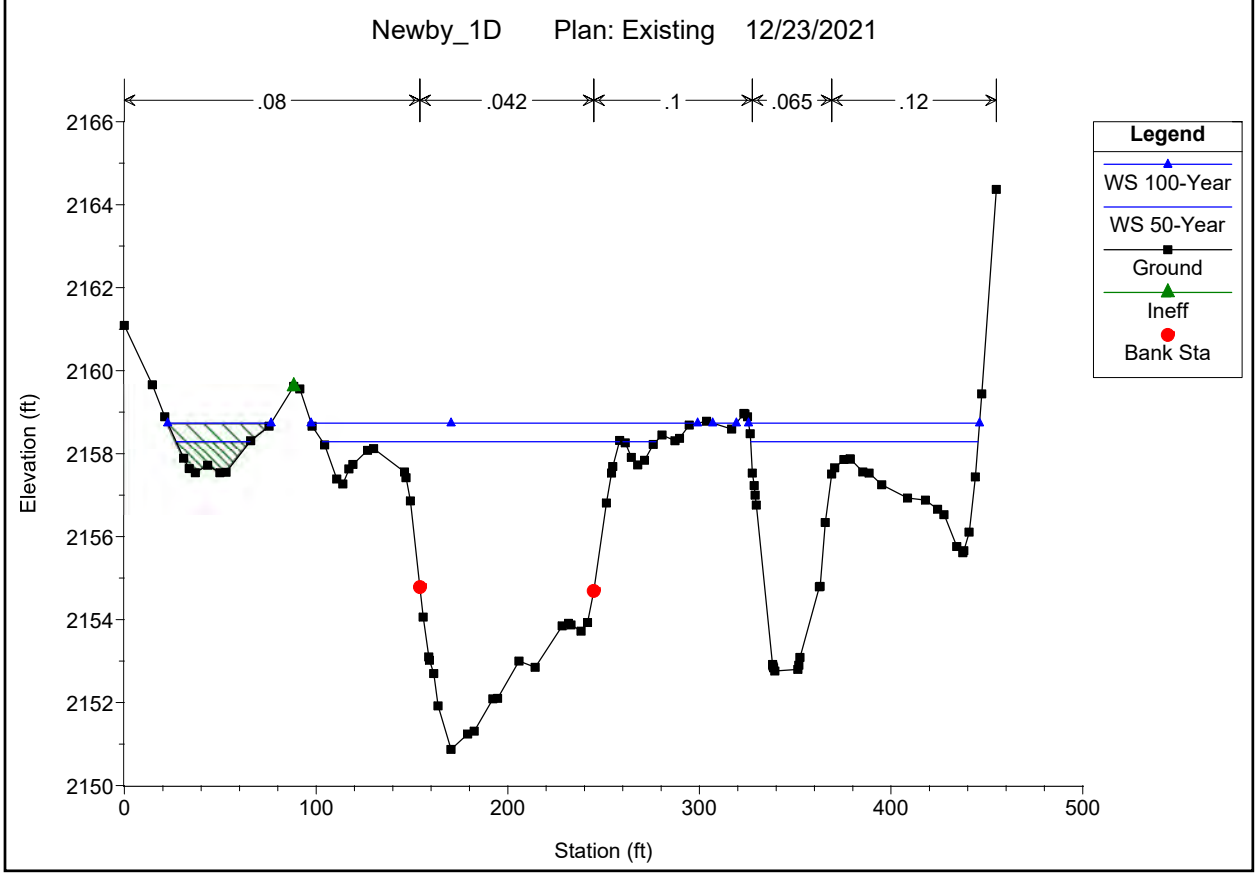
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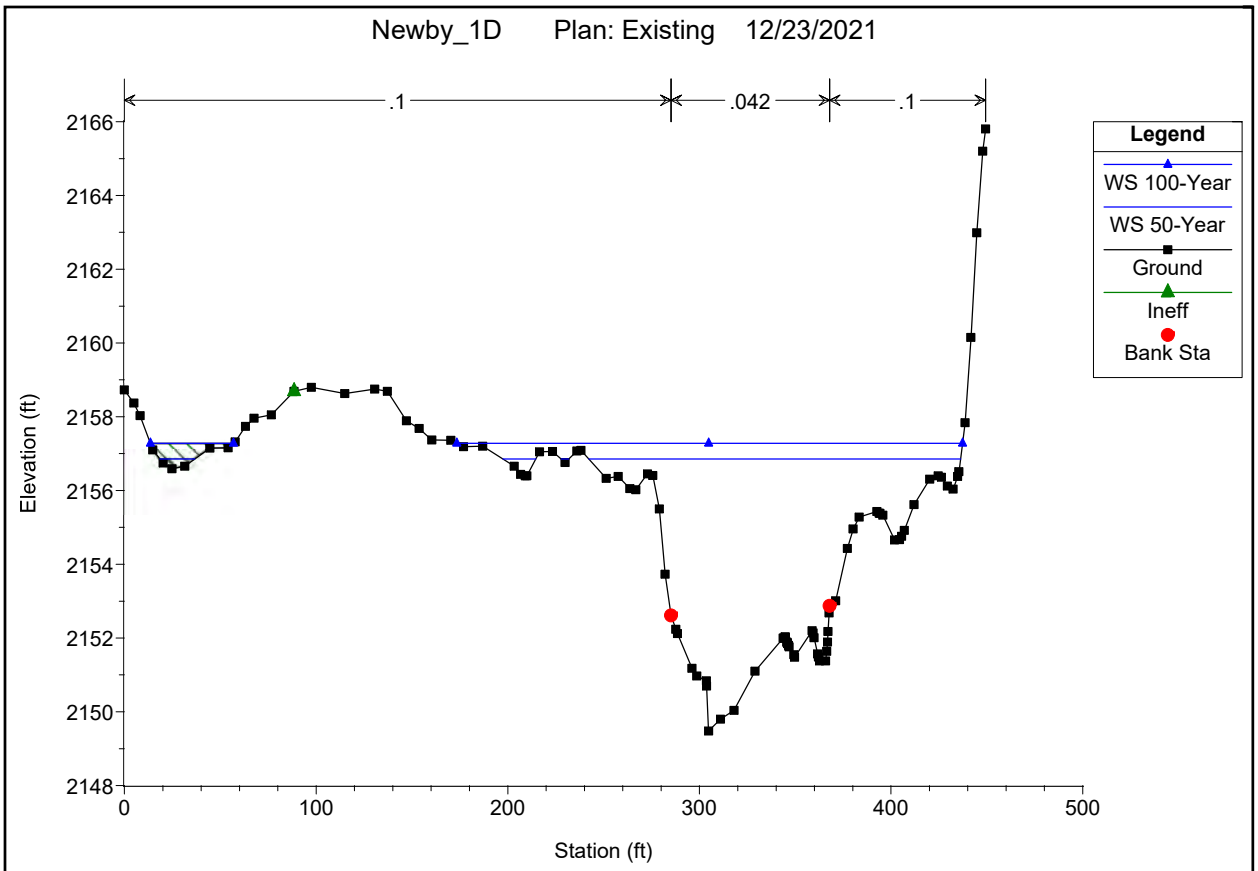
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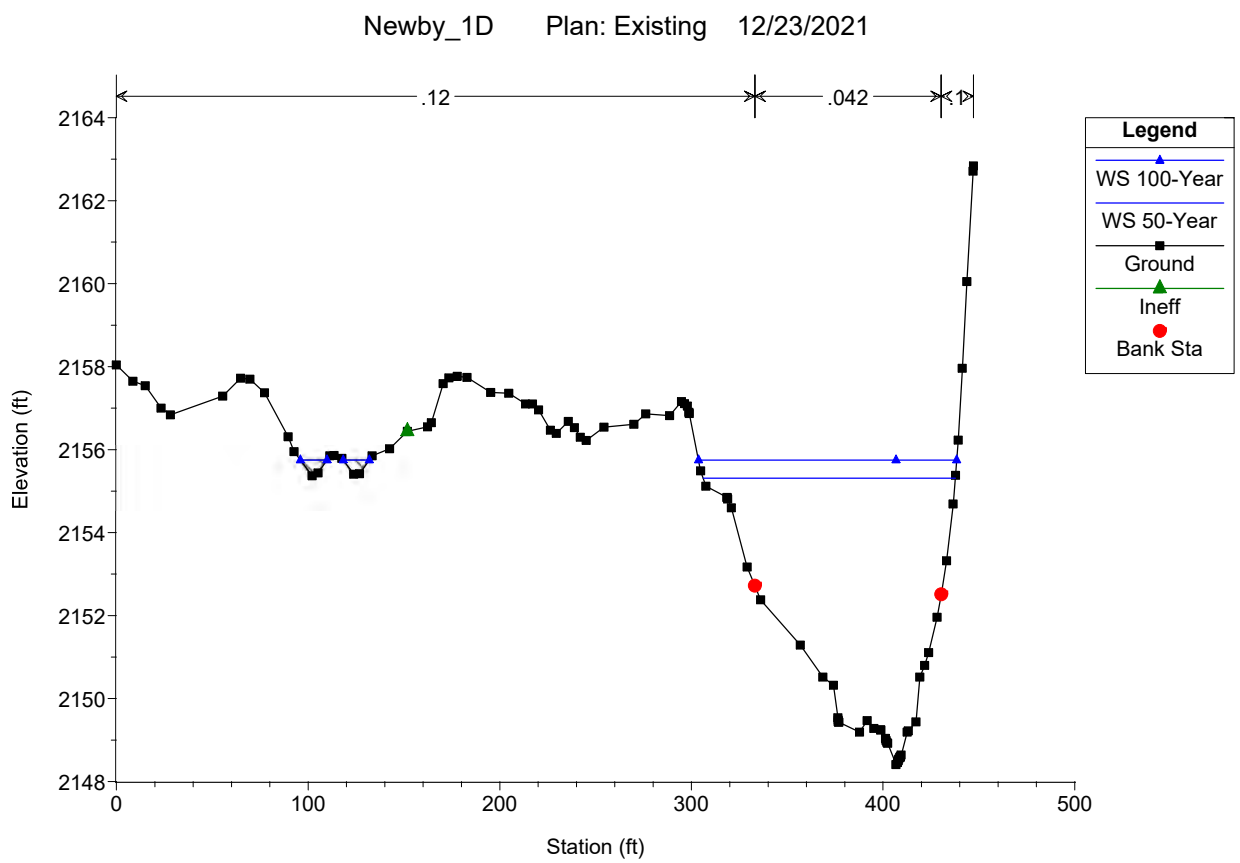
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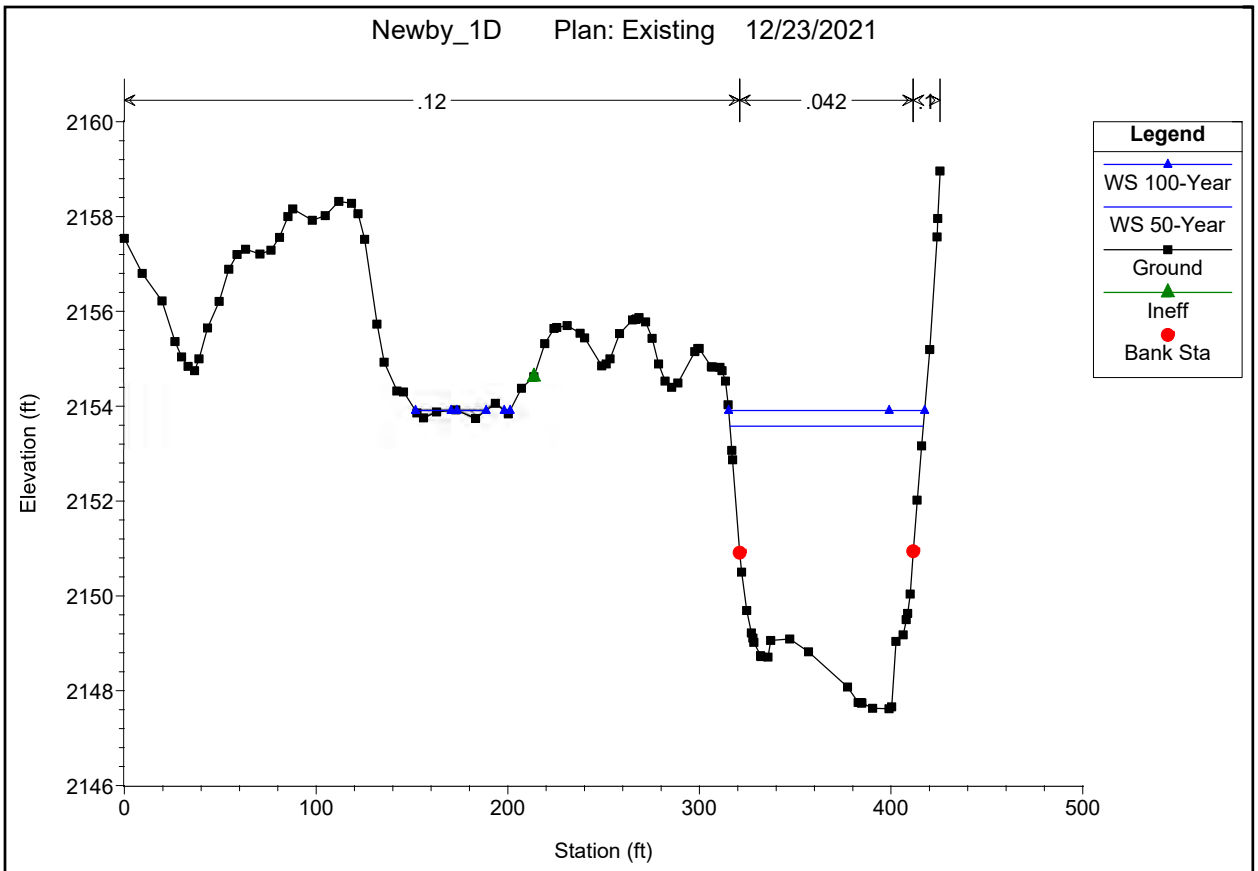
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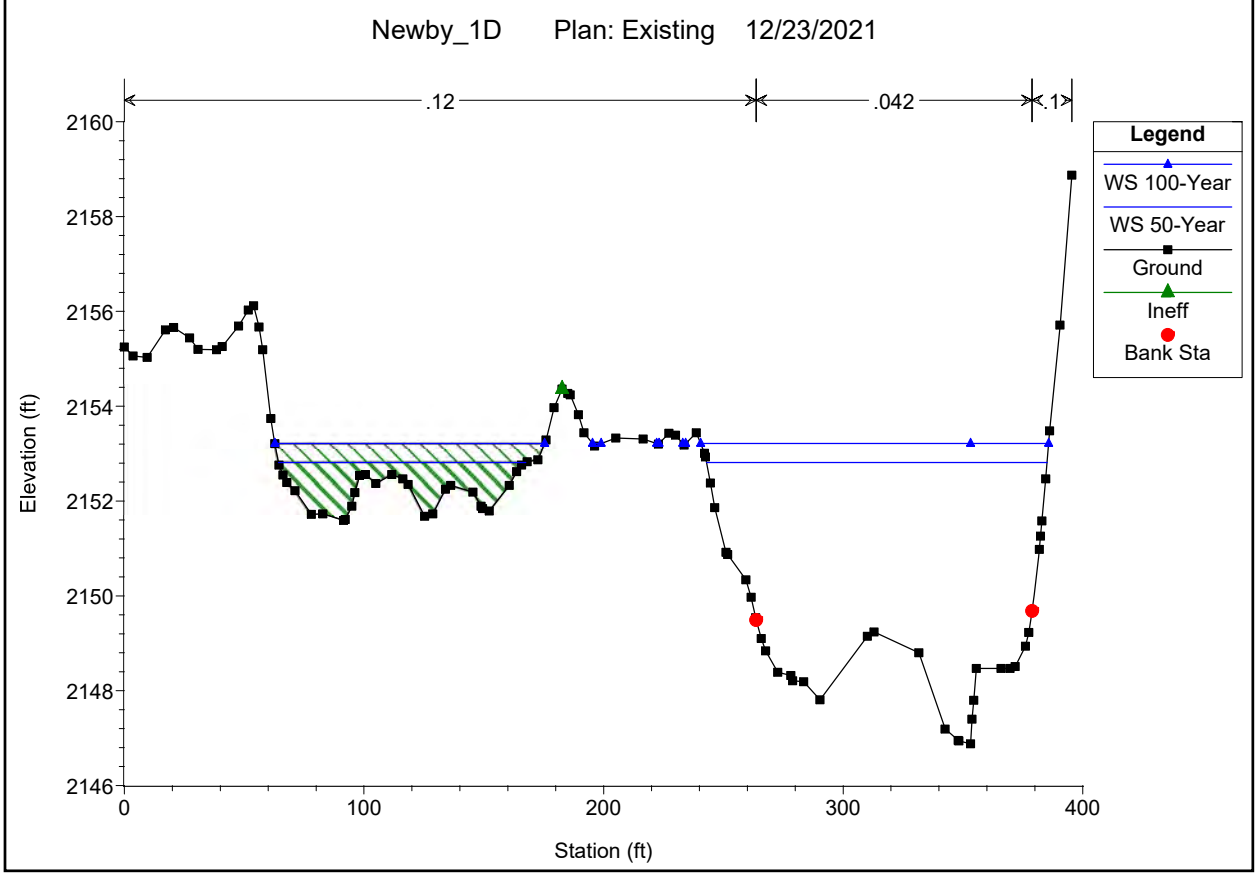
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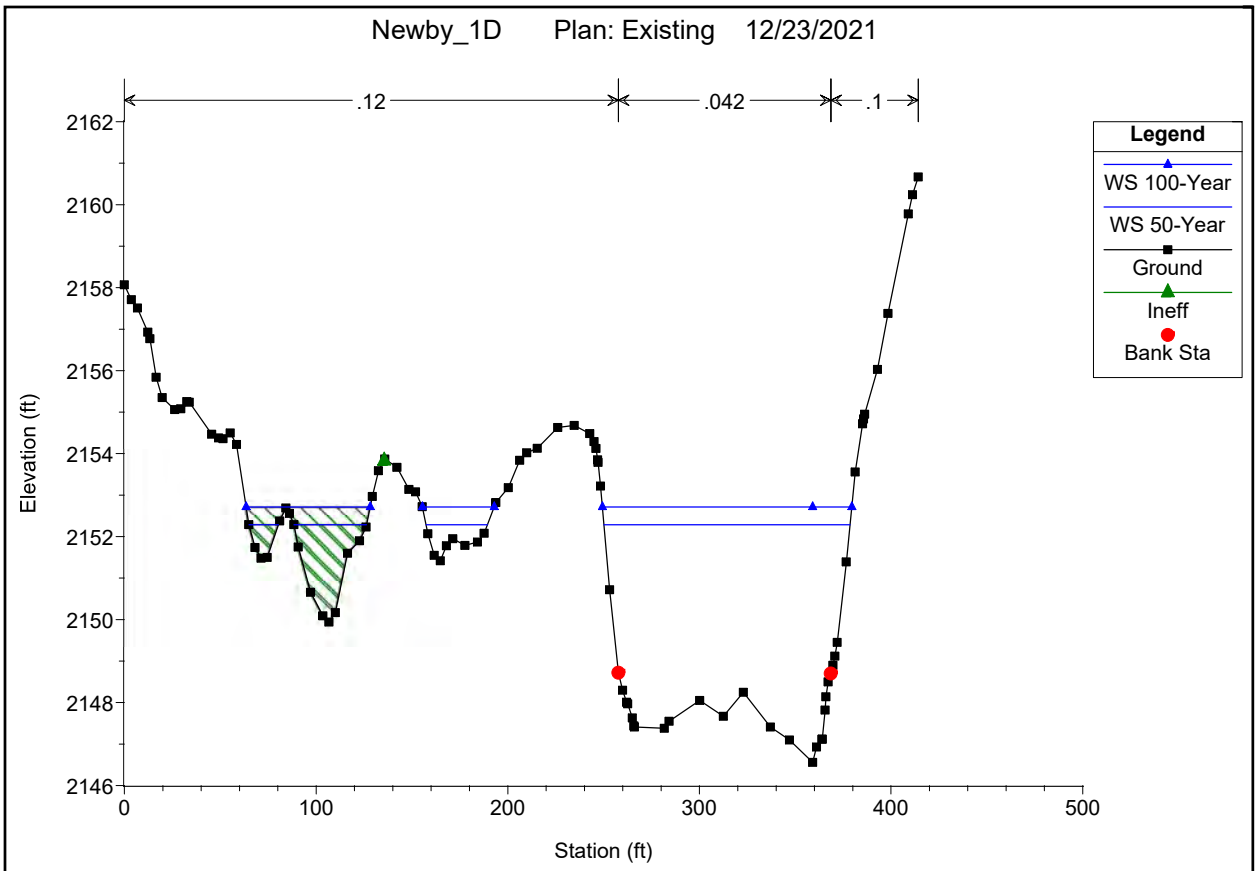
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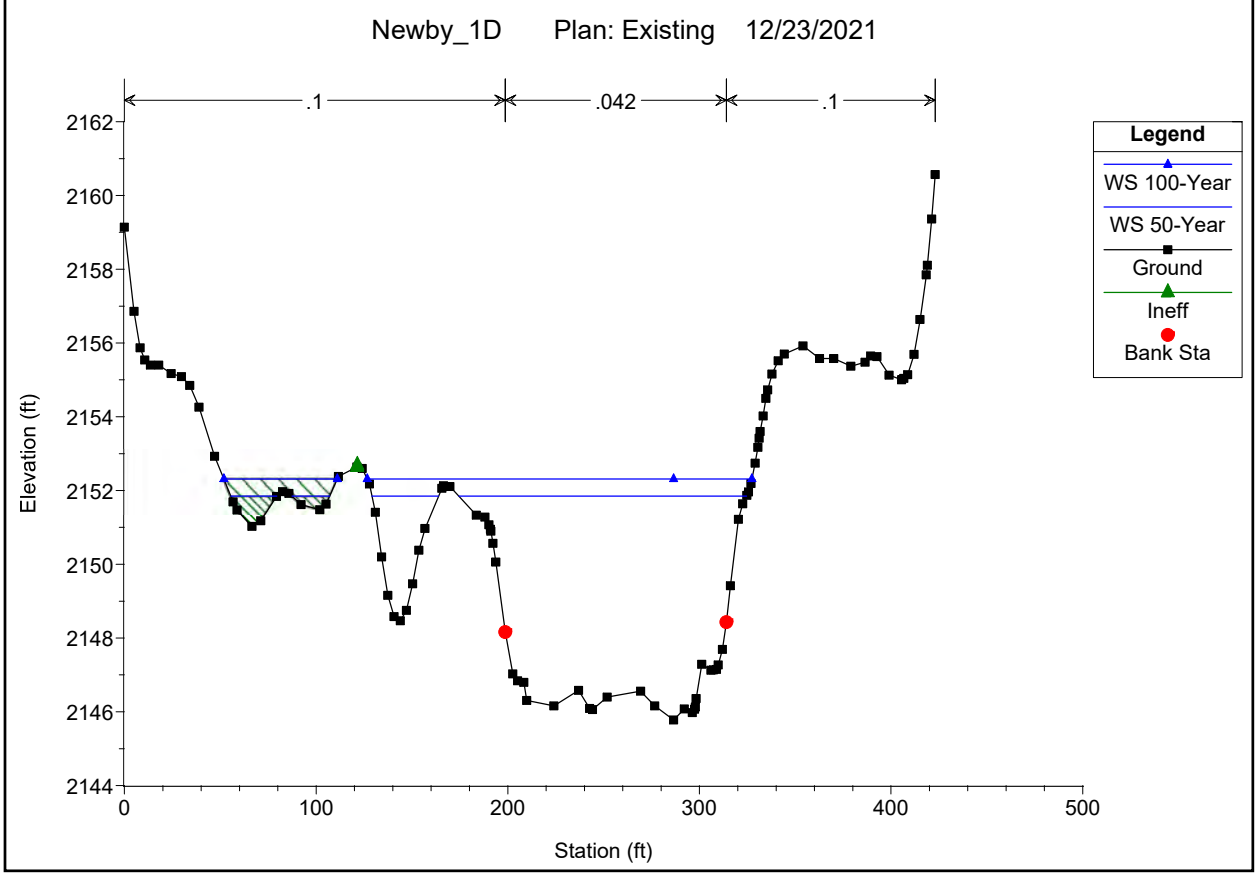
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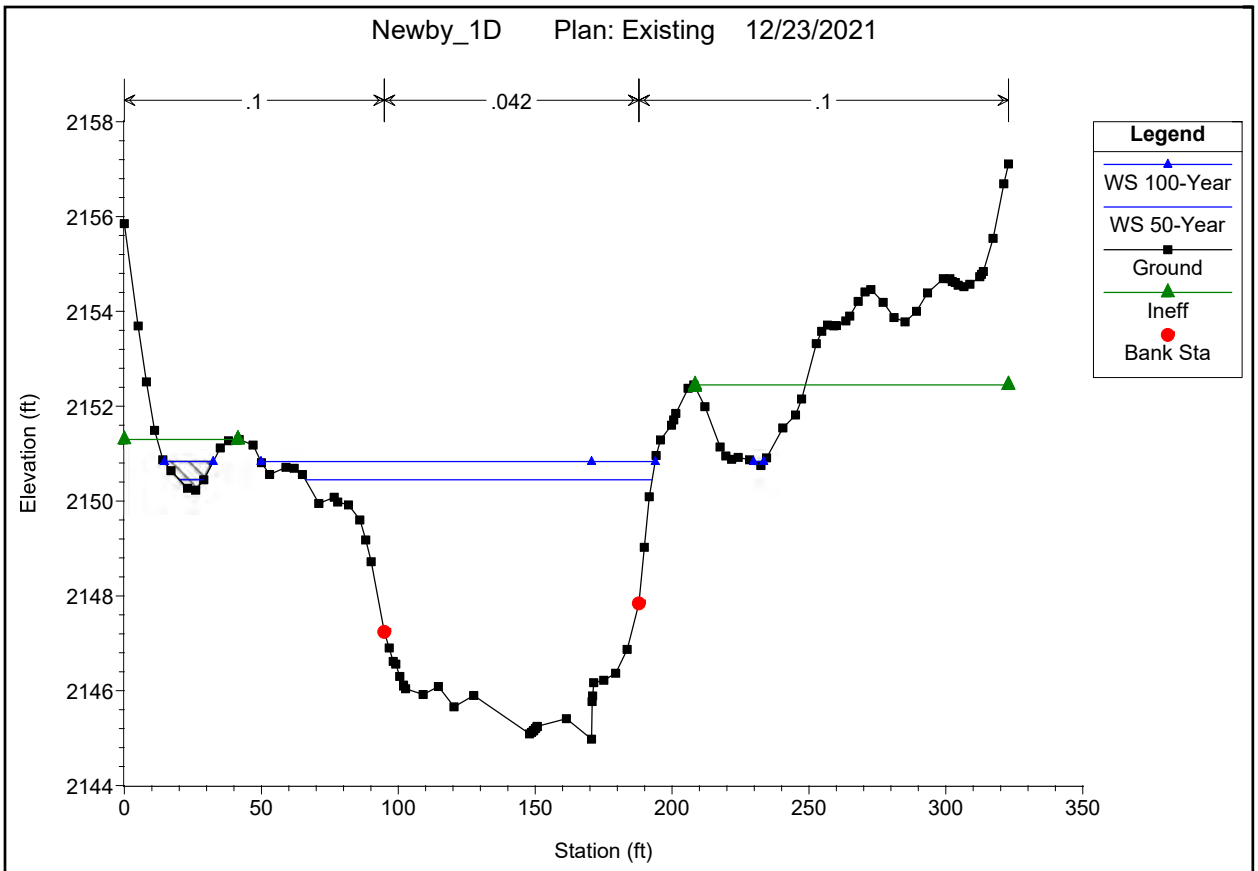
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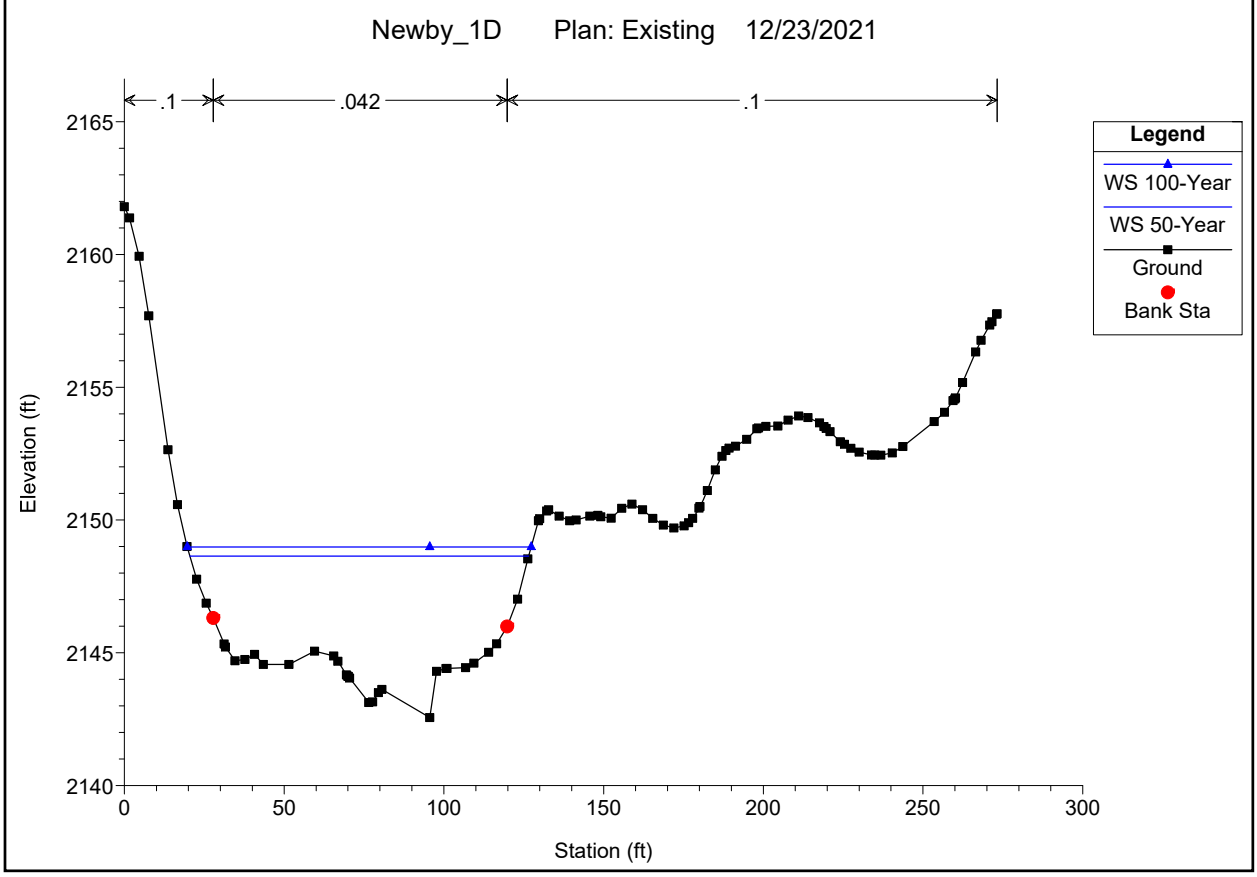
Newby_1D Plan: Existing 12/23/2021
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Plan: Existing Twisp Twisp RS: 2614 Profile: 50-Year

E.G. Elev (ft)	2165.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.52	Wt. n-Val.	0.100	0.045	0.100
W.S. Elev (ft)	2164.79	Reach Len. (ft)	113.80	102.10	92.40
Crit W.S. (ft)		Flow Area (sq ft)	318.52	592.67	117.70
E.G. Slope (ft/ft)	0.004869	Area (sq ft)	318.52	592.67	168.15
Q Total (cfs)	4202.00	Flow (cfs)	415.74	3671.74	114.52
Top Width (ft)	544.69	Top Width (ft)	224.82	132.30	187.57
Vel Total (ft/s)	4.08	Avg. Vel. (ft/s)	1.31	6.20	0.97
Max Chl Dpth (ft)	6.57	Hydr. Depth (ft)	1.42	4.48	0.92
Conv. Total (cfs)	60221.0	Conv. (cfs)	5958.2	52621.6	1641.3
Length Wtd. (ft)	102.52	Wetted Per. (ft)	225.51	134.42	130.17
Min Ch El (ft)	2158.22	Shear (lb/sq ft)	0.43	1.34	0.27
Alpha	2.02	Stream Power (lb/ft s)	0.56	8.30	0.27
Frctn Loss (ft)	0.31	Cum Volume (acre-ft)	3.91	30.11	8.22
C & E Loss (ft)	0.09	Cum SA (acres)	2.76	6.14	6.01

Plan: Existing Twisp Twisp RS: 2614 Profile: 100-Year

E.G. Elev (ft)	2165.70	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.50	Wt. n-Val.	0.100	0.045	0.100
W.S. Elev (ft)	2165.19	Reach Len. (ft)	113.80	102.10	92.40
Crit W.S. (ft)		Flow Area (sq ft)	410.86	646.45	174.25
E.G. Slope (ft/ft)	0.004336	Area (sq ft)	410.86	646.45	249.93
Q Total (cfs)	4786.00	Flow (cfs)	591.46	4004.57	189.97
Top Width (ft)	587.52	Top Width (ft)	229.49	132.30	225.72
Vel Total (ft/s)	3.89	Avg. Vel. (ft/s)	1.44	6.19	1.09
Max Chl Dpth (ft)	6.97	Hydr. Depth (ft)	1.79	4.89	1.08
Conv. Total (cfs)	72685.9	Conv. (cfs)	8982.6	60818.1	2885.2
Length Wtd. (ft)	102.54	Wetted Per. (ft)	230.20	134.42	162.64
Min Ch El (ft)	2158.22	Shear (lb/sq ft)	0.48	1.30	0.29
Alpha	2.15	Stream Power (lb/ft s)	0.70	8.06	0.32
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	5.25	32.59	10.99
C & E Loss (ft)	0.09	Cum SA (acres)	3.61	6.14	7.46

Plan: Existing Twisp Twisp RS: 2512 Profile: 50-Year

E.G. Elev (ft)	2164.90	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.21	Wt. n-Val.	0.100	0.045	0.100
W.S. Elev (ft)	2164.69	Reach Len. (ft)	162.40	220.40	101.70
Crit W.S. (ft)		Flow Area (sq ft)	360.67	753.07	562.28
E.G. Slope (ft/ft)	0.002089	Area (sq ft)	360.67	753.07	668.01
Q Total (cfs)	4202.00	Flow (cfs)	458.95	3165.75	577.31
Top Width (ft)	711.55	Top Width (ft)	140.07	159.20	412.28
Vel Total (ft/s)	2.51	Avg. Vel. (ft/s)	1.27	4.20	1.03
Max Chl Dpth (ft)	8.49	Hydr. Depth (ft)	2.58	4.73	1.82
Conv. Total (cfs)	91930.1	Conv. (cfs)	10040.7	69259.2	12630.1
Length Wtd. (ft)	196.99	Wetted Per. (ft)	140.65	162.01	309.30
Min Ch El (ft)	2156.20	Shear (lb/sq ft)	0.33	0.61	0.24
Alpha	2.17	Stream Power (lb/ft s)	0.43	2.55	0.24
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)	3.02	28.54	7.34
C & E Loss (ft)	0.01	Cum SA (acres)	2.28	5.80	5.37

Plan: Existing Twisp Twisp RS: 2512 Profile: 100-Year

E.G. Elev (ft)	2165.33	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.21	Wt. n-Val.	0.100	0.045	0.100
W.S. Elev (ft)	2165.12	Reach Len. (ft)	162.40	220.40	101.70
Crit W.S. (ft)		Flow Area (sq ft)	421.19	821.28	696.82
E.G. Slope (ft/ft)	0.001877	Area (sq ft)	421.19	821.28	855.10
Q Total (cfs)	4786.00	Flow (cfs)	556.88	3467.18	761.94
Top Width (ft)	754.50	Top Width (ft)	142.49	159.20	452.81
Vel Total (ft/s)	2.47	Avg. Vel. (ft/s)	1.32	4.22	1.09
Max Chl Dpth (ft)	8.92	Hydr. Depth (ft)	2.96	5.16	2.17
Conv. Total (cfs)	110467.8	Conv. (cfs)	12853.7	80027.5	17586.6
Length Wtd. (ft)	194.32	Wetted Per. (ft)	143.10	162.01	321.50
Min Ch El (ft)	2156.20	Shear (lb/sq ft)	0.34	0.59	0.25
Alpha	2.18	Stream Power (lb/ft s)	0.46	2.51	0.28
Frctn Loss (ft)	0.43	Cum Volume (acre-ft)	4.16	30.87	9.82
C & E Loss (ft)	0.01	Cum SA (acres)	3.13	5.80	6.74

Plan: Existing Twisp Twisp RS: 2291 Profile: 50-Year

E.G. Elev (ft)	2164.41	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.33	Wt. n-Val.	0.100	0.045	0.069
W.S. Elev (ft)	2164.09	Reach Len. (ft)	154.80	140.70	77.60
Crit W.S. (ft)		Flow Area (sq ft)	211.00	606.54	305.67
E.G. Slope (ft/ft)	0.002860	Area (sq ft)	211.00	606.54	479.56
Q Total (cfs)	4202.00	Flow (cfs)	403.71	3139.36	658.93
Top Width (ft)	565.23	Top Width (ft)	55.59	117.80	391.84
Vel Total (ft/s)	3.74	Avg. Vel. (ft/s)	1.91	5.18	2.16
Max Chl Dpth (ft)	7.28	Hydr. Depth (ft)	3.80	5.15	1.10
Conv. Total (cfs)	78566.4	Conv. (cfs)	7548.4	58697.7	12320.2
Length Wtd. (ft)	131.96	Wetted Per. (ft)	56.48	120.21	280.62
Min Ch El (ft)	2156.81	Shear (lb/sq ft)	0.67	0.90	0.19
Alpha	1.51	Stream Power (lb/ft s)	1.28	4.66	0.42
Frctn Loss (ft)	0.52	Cum Volume (acre-ft)	1.95	25.10	6.00
C & E Loss (ft)	0.07	Cum SA (acres)	1.92	5.10	4.43

Plan: Existing Twisp Twisp RS: 2291 Profile: 100-Year

E.G. Elev (ft)	2164.89	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.33	Wt. n-Val.	0.100	0.045	0.074
W.S. Elev (ft)	2164.56	Reach Len. (ft)	154.80	140.70	77.60
Crit W.S. (ft)		Flow Area (sq ft)	237.71	662.53	471.48
E.G. Slope (ft/ft)	0.002623	Area (sq ft)	237.71	662.53	706.30
Q Total (cfs)	4786.00	Flow (cfs)	464.54	3479.31	842.15
Top Width (ft)	694.64	Top Width (ft)	56.78	117.80	520.06
Vel Total (ft/s)	3.49	Avg. Vel. (ft/s)	1.95	5.25	1.79
Max Chl Dpth (ft)	7.75	Hydr. Depth (ft)	4.19	5.62	1.27
Conv. Total (cfs)	93449.7	Conv. (cfs)	9070.5	67935.7	16443.5
Length Wtd. (ft)	130.84	Wetted Per. (ft)	57.76	120.21	375.39
Min Ch El (ft)	2156.81	Shear (lb/sq ft)	0.67	0.90	0.21
Alpha	1.72	Stream Power (lb/ft s)	1.32	4.74	0.37
Frctn Loss (ft)	0.48	Cum Volume (acre-ft)	2.94	27.12	8.00
C & E Loss (ft)	0.08	Cum SA (acres)	2.76	5.10	5.61

Plan: Existing Twisp Twisp RS: 2150 Profile: 50-Year

E.G. Elev (ft)	2163.83	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.03	Wt. n-Val.	0.100	0.042	0.073
W.S. Elev (ft)	2162.80	Reach Len. (ft)	145.90	136.40	54.60
Crit W.S. (ft)	2161.40	Flow Area (sq ft)	23.16	405.20	238.36
E.G. Slope (ft/ft)	0.005678	Area (sq ft)	23.16	405.20	327.24
Q Total (cfs)	4202.00	Flow (cfs)	38.29	3560.05	603.66
Top Width (ft)	408.74	Top Width (ft)	12.36	66.40	329.98
Vel Total (ft/s)	6.30	Avg. Vel. (ft/s)	1.65	8.79	2.53
Max Chl Dpth (ft)	7.48	Hydr. Depth (ft)	1.87	6.10	1.17
Conv. Total (cfs)	55763.8	Conv. (cfs)	508.1	47244.6	8011.1
Length Wtd. (ft)	125.17	Wetted Per. (ft)	12.91	67.73	206.58
Min Ch El (ft)	2155.32	Shear (lb/sq ft)	0.64	2.12	0.41
Alpha	1.67	Stream Power (lb/ft s)	1.05	18.63	1.04
Frctn Loss (ft)	0.92	Cum Volume (acre-ft)	1.54	23.46	5.28
C & E Loss (ft)	0.04	Cum SA (acres)	1.80	4.80	3.79

Plan: Existing Twisp Twisp RS: 2150 Profile: 100-Year

E.G. Elev (ft)	2164.33	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.08	Wt. n-Val.	0.100	0.042	0.074
W.S. Elev (ft)	2163.25	Reach Len. (ft)	145.90	136.40	54.60
Crit W.S. (ft)	2161.77	Flow Area (sq ft)	29.02	435.19	347.54
E.G. Slope (ft/ft)	0.005553	Area (sq ft)	29.02	435.19	512.69
Q Total (cfs)	4786.00	Flow (cfs)	51.73	3965.44	768.83
Top Width (ft)	550.89	Top Width (ft)	13.58	66.40	470.91
Vel Total (ft/s)	5.90	Avg. Vel. (ft/s)	1.78	9.11	2.21
Max Chl Dpth (ft)	7.93	Hydr. Depth (ft)	2.14	6.55	1.32
Conv. Total (cfs)	64226.8	Conv. (cfs)	694.2	53215.1	10317.5
Length Wtd. (ft)	124.19	Wetted Per. (ft)	14.21	67.73	266.77
Min Ch El (ft)	2155.32	Shear (lb/sq ft)	0.71	2.23	0.45
Alpha	2.00	Stream Power (lb/ft s)	1.26	20.30	1.00
Frctn Loss (ft)	0.93	Cum Volume (acre-ft)	2.46	25.35	6.91
C & E Loss (ft)	0.06	Cum SA (acres)	2.63	4.80	4.73

Plan: Existing Twisp Twisp RS: 2014 Profile: 50-Year

E.G. Elev (ft)	2162.87	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.47	Wt. n-Val.	0.080	0.042	0.072
W.S. Elev (ft)	2161.39	Reach Len. (ft)	173.70	179.90	80.50
Crit W.S. (ft)	2160.85	Flow Area (sq ft)	13.59	345.85	160.91
E.G. Slope (ft/ft)	0.009783	Area (sq ft)	13.59	345.85	200.94
Q Total (cfs)	4202.00	Flow (cfs)	38.33	3604.49	559.18
Top Width (ft)	241.96	Top Width (ft)	5.93	65.90	170.13
Vel Total (ft/s)	8.08	Avg. Vel. (ft/s)	2.82	10.42	3.48
Max Chl Dpth (ft)	7.41	Hydr. Depth (ft)	2.29	5.25	1.64
Conv. Total (cfs)	42483.1	Conv. (cfs)	387.5	36442.2	5653.4
Length Wtd. (ft)	165.28	Wetted Per. (ft)	7.14	67.29	100.54
Min Ch El (ft)	2153.98	Shear (lb/sq ft)	1.16	3.14	0.98
Alpha	1.45	Stream Power (lb/ft s)	3.28	32.72	3.40
Frctn Loss (ft)	1.10	Cum Volume (acre-ft)	1.48	22.29	4.95
C & E Loss (ft)	0.24	Cum SA (acres)	1.77	4.60	3.47

Plan: Existing Twisp Twisp RS: 2014 Profile: 100-Year

E.G. Elev (ft)	2163.34	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.68	Wt. n-Val.	0.080	0.042	0.072
W.S. Elev (ft)	2161.67	Reach Len. (ft)	173.70	179.90	80.50
Crit W.S. (ft)	2161.27	Flow Area (sq ft)	15.23	363.81	192.87
E.G. Slope (ft/ft)	0.010524	Area (sq ft)	15.23	363.81	253.86
Q Total (cfs)	4786.00	Flow (cfs)	46.60	4067.61	671.79
Top Width (ft)	288.35	Top Width (ft)	6.14	65.90	216.30
Vel Total (ft/s)	8.37	Avg. Vel. (ft/s)	3.06	11.18	3.48
Max Chl Dpth (ft)	7.69	Hydr. Depth (ft)	2.48	5.52	1.44
Conv. Total (cfs)	46652.3	Conv. (cfs)	454.3	39649.6	6548.4
Length Wtd. (ft)	164.40	Wetted Per. (ft)	7.49	67.29	136.69
Min Ch El (ft)	2153.98	Shear (lb/sq ft)	1.34	3.55	0.93
Alpha	1.54	Stream Power (lb/ft s)	4.09	39.72	3.23
Frctn Loss (ft)	1.14	Cum Volume (acre-ft)	2.39	24.10	6.43
C & E Loss (ft)	0.28	Cum SA (acres)	2.60	4.60	4.29

Plan: Existing Twisp Twisp RS: 1834 Profile: 50-Year

E.G. Elev (ft)	2161.53	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.68	Wt. n-Val.	0.080	0.042	0.070
W.S. Elev (ft)	2160.85	Reach Len. (ft)	121.20	124.00	123.60
Crit W.S. (ft)		Flow Area (sq ft)	21.32	486.63	242.86
E.G. Slope (ft/ft)	0.004787	Area (sq ft)	21.32	486.63	276.35
Q Total (cfs)	4202.00	Flow (cfs)	40.24	3489.56	672.19
Top Width (ft)	318.86	Top Width (ft)	11.48	96.10	211.28
Vel Total (ft/s)	5.60	Avg. Vel. (ft/s)	1.89	7.17	2.77
Max Chl Dpth (ft)	7.85	Hydr. Depth (ft)	1.86	5.06	1.63
Conv. Total (cfs)	60733.0	Conv. (cfs)	581.6	50435.9	9715.5
Length Wtd. (ft)	123.93	Wetted Per. (ft)	11.97	96.77	153.14
Min Ch El (ft)	2154.22	Shear (lb/sq ft)	0.53	1.50	0.47
Alpha	1.40	Stream Power (lb/ft s)	1.00	10.78	1.31
Frctn Loss (ft)	0.59	Cum Volume (acre-ft)	1.41	20.57	4.51
C & E Loss (ft)	0.03	Cum SA (acres)	1.73	4.26	3.12

Plan: Existing Twisp Twisp RS: 1834 Profile: 100-Year

E.G. Elev (ft)	2161.93	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.75	Wt. n-Val.	0.080	0.042	0.072
W.S. Elev (ft)	2161.18	Reach Len. (ft)	121.20	124.00	123.60
Crit W.S. (ft)		Flow Area (sq ft)	25.19	517.81	293.12
E.G. Slope (ft/ft)	0.004910	Area (sq ft)	25.19	517.81	349.75
Q Total (cfs)	4786.00	Flow (cfs)	51.23	3919.65	815.12
Top Width (ft)	348.43	Top Width (ft)	12.34	96.10	239.99
Vel Total (ft/s)	5.72	Avg. Vel. (ft/s)	2.03	7.57	2.78
Max Chl Dpth (ft)	8.17	Hydr. Depth (ft)	2.04	5.39	1.83
Conv. Total (cfs)	68299.8	Conv. (cfs)	731.2	55936.3	11632.3
Length Wtd. (ft)	123.92	Wetted Per. (ft)	12.89	96.77	164.48
Min Ch El (ft)	2154.22	Shear (lb/sq ft)	0.60	1.64	0.55
Alpha	1.47	Stream Power (lb/ft s)	1.22	12.42	1.52
Frctn Loss (ft)	0.60	Cum Volume (acre-ft)	2.31	22.28	5.87
C & E Loss (ft)	0.04	Cum SA (acres)	2.56	4.26	3.87

Plan: Existing Twisp Twisp RS: 1710 Profile: 50-Year

E.G. Elev (ft)	2160.91	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.59	Wt. n-Val.	0.080	0.042	0.070
W.S. Elev (ft)	2160.32	Reach Len. (ft)	110.60	116.60	127.40
Crit W.S. (ft)		Flow Area (sq ft)	8.84	562.94	204.35
E.G. Slope (ft/ft)	0.004793	Area (sq ft)	8.84	562.94	226.65
Q Total (cfs)	4202.00	Flow (cfs)	14.06	3668.38	519.56
Top Width (ft)	345.49	Top Width (ft)	5.80	128.60	211.10
Vel Total (ft/s)	5.41	Avg. Vel. (ft/s)	1.59	6.52	2.54
Max Chl Dpth (ft)	7.16	Hydr. Depth (ft)	1.53	4.38	1.25
Conv. Total (cfs)	60692.8	Conv. (cfs)	203.1	52985.3	7504.4
Length Wtd. (ft)	118.06	Wetted Per. (ft)	6.43	129.73	166.81
Min Ch El (ft)	2153.16	Shear (lb/sq ft)	0.41	1.30	0.37
Alpha	1.29	Stream Power (lb/ft s)	0.65	8.46	0.93
Frctn Loss (ft)	0.60	Cum Volume (acre-ft)	1.37	19.08	3.79
C & E Loss (ft)	0.00	Cum SA (acres)	1.71	3.94	2.52

Plan: Existing Twisp Twisp RS: 1710 Profile: 100-Year

E.G. Elev (ft)	2161.29	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.63	Wt. n-Val.	0.080	0.042	0.072
W.S. Elev (ft)	2160.66	Reach Len. (ft)	110.60	116.60	127.40
Crit W.S. (ft)		Flow Area (sq ft)	10.88	606.46	272.43
E.G. Slope (ft/ft)	0.004729	Area (sq ft)	10.88	606.46	311.82
Q Total (cfs)	4786.00	Flow (cfs)	18.66	4125.01	642.33
Top Width (ft)	403.84	Top Width (ft)	6.24	128.60	268.99
Vel Total (ft/s)	5.38	Avg. Vel. (ft/s)	1.72	6.80	2.36
Max Chl Dpth (ft)	7.50	Hydr. Depth (ft)	1.74	4.72	1.26
Conv. Total (cfs)	69598.1	Conv. (cfs)	271.4	59985.9	9340.8
Length Wtd. (ft)	118.18	Wetted Per. (ft)	6.99	129.73	219.09
Min Ch El (ft)	2153.16	Shear (lb/sq ft)	0.46	1.38	0.37
Alpha	1.40	Stream Power (lb/ft s)	0.79	9.39	0.87
Frctn Loss (ft)	0.58	Cum Volume (acre-ft)	2.26	20.68	4.93
C & E Loss (ft)	0.00	Cum SA (acres)	2.54	3.94	3.15

Plan: Existing Twisp Twisp RS: 1594 Profile: 50-Year

E.G. Elev (ft)	2160.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.59	Wt. n-Val.	0.080	0.042	0.069
W.S. Elev (ft)	2159.71	Reach Len. (ft)	161.60	150.80	143.20
Crit W.S. (ft)		Flow Area (sq ft)	6.01	538.99	227.47
E.G. Slope (ft/ft)	0.005459	Area (sq ft)	6.01	538.99	240.58
Q Total (cfs)	4202.00	Flow (cfs)	8.69	3561.88	631.43
Top Width (ft)	328.60	Top Width (ft)	5.02	132.10	191.47
Vel Total (ft/s)	5.44	Avg. Vel. (ft/s)	1.45	6.61	2.78
Max Chl Dpth (ft)	7.05	Hydr. Depth (ft)	1.20	4.08	1.35
Conv. Total (cfs)	56874.4	Conv. (cfs)	117.6	48210.3	8546.4
Length Wtd. (ft)	149.75	Wetted Per. (ft)	5.56	134.08	170.48
Min Ch El (ft)	2152.66	Shear (lb/sq ft)	0.37	1.37	0.45
Alpha	1.29	Stream Power (lb/ft s)	0.53	9.05	1.26
Frctn Loss (ft)	0.68	Cum Volume (acre-ft)	1.35	17.60	3.11
C & E Loss (ft)	0.03	Cum SA (acres)	1.69	3.59	1.93

Plan: Existing Twisp Twisp RS: 1594 Profile: 100-Year

E.G. Elev (ft)	2160.71	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.62	Wt. n-Val.	0.080	0.042	0.071
W.S. Elev (ft)	2160.09	Reach Len. (ft)	161.60	150.80	143.20
Crit W.S. (ft)		Flow Area (sq ft)	8.03	588.30	295.74
E.G. Slope (ft/ft)	0.005143	Area (sq ft)	8.03	588.30	323.18
Q Total (cfs)	4786.00	Flow (cfs)	12.41	4000.38	773.21
Top Width (ft)	390.55	Top Width (ft)	5.81	132.10	252.65
Vel Total (ft/s)	5.36	Avg. Vel. (ft/s)	1.54	6.80	2.61
Max Chl Dpth (ft)	7.43	Hydr. Depth (ft)	1.38	4.45	1.51
Conv. Total (cfs)	66738.6	Conv. (cfs)	173.1	55783.5	10782.0
Length Wtd. (ft)	149.68	Wetted Per. (ft)	6.43	134.08	198.76
Min Ch El (ft)	2152.66	Shear (lb/sq ft)	0.40	1.41	0.48
Alpha	1.38	Stream Power (lb/ft s)	0.62	9.58	1.25
Frctn Loss (ft)	0.65	Cum Volume (acre-ft)	2.23	19.08	4.01
C & E Loss (ft)	0.03	Cum SA (acres)	2.52	3.59	2.39

Plan: Existing Twisp Twisp RS: 1443 Profile: 50-Year

E.G. Elev (ft)	2159.59	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.49	Wt. n-Val.	0.080	0.042	0.067
W.S. Elev (ft)	2159.11	Reach Len. (ft)	178.40	175.00	200.50
Crit W.S. (ft)		Flow Area (sq ft)	5.43	616.27	214.41
E.G. Slope (ft/ft)	0.003887	Area (sq ft)	5.43	616.27	214.41
Q Total (cfs)	4202.00	Flow (cfs)	5.79	3644.92	551.29
Top Width (ft)	291.16	Top Width (ft)	5.72	138.87	146.56
Vel Total (ft/s)	5.03	Avg. Vel. (ft/s)	1.07	5.91	2.57
Max Chl Dpth (ft)	6.97	Hydr. Depth (ft)	0.95	4.44	1.46
Conv. Total (cfs)	67398.6	Conv. (cfs)	92.8	58463.2	8842.5
Length Wtd. (ft)	178.78	Wetted Per. (ft)	6.15	140.35	149.08
Min Ch El (ft)	2152.14	Shear (lb/sq ft)	0.21	1.07	0.35
Alpha	1.24	Stream Power (lb/ft s)	0.23	6.30	0.90
Frctn Loss (ft)	0.68	Cum Volume (acre-ft)	1.33	15.60	2.36
C & E Loss (ft)	0.01	Cum SA (acres)	1.67	3.12	1.38

Plan: Existing Twisp Twisp RS: 1443 Profile: 100-Year

E.G. Elev (ft)	2160.03	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.51	Wt. n-Val.	0.080	0.042	0.069
W.S. Elev (ft)	2159.52	Reach Len. (ft)	178.40	175.00	200.50
Crit W.S. (ft)		Flow Area (sq ft)	8.59	673.74	283.05
E.G. Slope (ft/ft)	0.003667	Area (sq ft)	8.59	673.74	283.05
Q Total (cfs)	4786.00	Flow (cfs)	8.39	4107.65	669.96
Top Width (ft)	339.06	Top Width (ft)	10.19	138.87	190.00
Vel Total (ft/s)	4.96	Avg. Vel. (ft/s)	0.98	6.10	2.37
Max Chl Dpth (ft)	7.38	Hydr. Depth (ft)	0.84	4.85	1.49
Conv. Total (cfs)	79030.3	Conv. (cfs)	138.5	67828.9	11062.9
Length Wtd. (ft)	179.07	Wetted Per. (ft)	10.64	140.35	192.89
Min Ch El (ft)	2152.14	Shear (lb/sq ft)	0.19	1.10	0.34
Alpha	1.33	Stream Power (lb/ft s)	0.18	6.70	0.80
Frctn Loss (ft)	0.65	Cum Volume (acre-ft)	2.20	16.89	3.01
C & E Loss (ft)	0.01	Cum SA (acres)	2.49	3.12	1.66

Plan: Existing Twisp Twisp RS: 1268 Profile: 50-Year

E.G. Elev (ft)	2158.90	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.61	Wt. n-Val.	0.080	0.042	0.073
W.S. Elev (ft)	2158.29	Reach Len. (ft)	173.80	208.20	146.80
Crit W.S. (ft)		Flow Area (sq ft)	36.20	511.19	291.34
E.G. Slope (ft/ft)	0.003731	Area (sq ft)	56.08	511.19	291.34
Q Total (cfs)	4202.00	Flow (cfs)	32.46	3479.46	690.08
Top Width (ft)	329.28	Top Width (ft)	89.42	90.70	149.16
Vel Total (ft/s)	5.01	Avg. Vel. (ft/s)	0.90	6.81	2.37
Max Chl Dpth (ft)	7.42	Hydr. Depth (ft)	0.71	5.64	1.95
Conv. Total (cfs)	68788.7	Conv. (cfs)	531.5	56960.3	11297.0
Length Wtd. (ft)	201.63	Wetted Per. (ft)	51.50	91.46	152.38
Min Ch El (ft)	2150.87	Shear (lb/sq ft)	0.16	1.30	0.45
Alpha	1.57	Stream Power (lb/ft s)	0.15	8.86	1.05
Frctn Loss (ft)	0.93	Cum Volume (acre-ft)	1.20	13.34	1.20
C & E Loss (ft)	0.05	Cum SA (acres)	1.48	2.66	0.70

Plan: Existing Twisp Twisp RS: 1268 Profile: 100-Year

E.G. Elev (ft)	2159.37	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.63	Wt. n-Val.	0.080	0.042	0.076
W.S. Elev (ft)	2158.73	Reach Len. (ft)	173.80	208.20	146.80
Crit W.S. (ft)		Flow Area (sq ft)	60.39	551.76	365.72
E.G. Slope (ft/ft)	0.003576	Area (sq ft)	101.09	551.76	365.72
Q Total (cfs)	4786.00	Flow (cfs)	69.35	3868.70	847.95
Top Width (ft)	388.43	Top Width (ft)	110.75	90.70	186.98
Vel Total (ft/s)	4.89	Avg. Vel. (ft/s)	1.15	7.01	2.32
Max Chl Dpth (ft)	7.86	Hydr. Depth (ft)	1.06	6.08	1.96
Conv. Total (cfs)	80030.5	Conv. (cfs)	1159.7	64691.6	14179.2
Length Wtd. (ft)	200.68	Wetted Per. (ft)	57.44	91.46	190.45
Min Ch El (ft)	2150.87	Shear (lb/sq ft)	0.23	1.35	0.43
Alpha	1.70	Stream Power (lb/ft s)	0.27	9.44	0.99
Frctn Loss (ft)	0.90	Cum Volume (acre-ft)	1.98	14.43	1.52
C & E Loss (ft)	0.05	Cum SA (acres)	2.24	2.66	0.79

Plan: Existing Twisp Twisp RS: 1060 Profile: 50-Year

E.G. Elev (ft)	2157.92	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.07	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2156.86	Reach Len. (ft)	146.50	221.30	243.40
Crit W.S. (ft)	2155.57	Flow Area (sq ft)	42.38	469.95	108.88
E.G. Slope (ft/ft)	0.005823	Area (sq ft)	45.40	469.95	108.88
Q Total (cfs)	4202.00	Flow (cfs)	41.21	3993.27	167.52
Top Width (ft)	233.39	Top Width (ft)	82.29	82.70	68.40
Vel Total (ft/s)	6.76	Avg. Vel. (ft/s)	0.97	8.50	1.54
Max Chl Dpth (ft)	7.37	Hydr. Depth (ft)	0.66	5.68	1.59
Conv. Total (cfs)	55064.6	Conv. (cfs)	540.0	52329.3	2195.3
Length Wtd. (ft)	221.18	Wetted Per. (ft)	64.94	84.17	68.88
Min Ch El (ft)	2149.48	Shear (lb/sq ft)	0.24	2.03	0.57
Alpha	1.50	Stream Power (lb/ft s)	0.23	17.25	0.88
Frctn Loss (ft)	1.44	Cum Volume (acre-ft)	1.00	10.99	0.52
C & E Loss (ft)	0.01	Cum SA (acres)	1.14	2.25	0.33

Plan: Existing Twisp Twisp RS: 1060 Profile: 100-Year

E.G. Elev (ft)	2158.42	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.14	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2157.28	Reach Len. (ft)	146.50	221.30	243.40
Crit W.S. (ft)	2156.00	Flow Area (sq ft)	79.93	505.10	138.16
E.G. Slope (ft/ft)	0.005736	Area (sq ft)	95.47	505.10	138.16
Q Total (cfs)	4786.00	Flow (cfs)	71.54	4469.70	244.76
Top Width (ft)	307.22	Top Width (ft)	155.13	82.70	69.39
Vel Total (ft/s)	6.62	Avg. Vel. (ft/s)	0.90	8.85	1.77
Max Chl Dpth (ft)	7.80	Hydr. Depth (ft)	0.72	6.11	1.99
Conv. Total (cfs)	63190.4	Conv. (cfs)	944.6	59014.2	3231.6
Length Wtd. (ft)	220.99	Wetted Per. (ft)	112.69	84.17	69.96
Min Ch El (ft)	2149.48	Shear (lb/sq ft)	0.25	2.15	0.71
Alpha	1.67	Stream Power (lb/ft s)	0.23	19.02	1.25
Frctn Loss (ft)	1.40	Cum Volume (acre-ft)	1.59	11.90	0.67
C & E Loss (ft)	0.01	Cum SA (acres)	1.71	2.25	0.36

Plan: Existing Twisp Twisp RS: 838 Profile: 50-Year

E.G. Elev (ft)	2156.48	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.16	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2155.31	Reach Len. (ft)	162.90	194.70	198.20
Crit W.S. (ft)		Flow Area (sq ft)	26.37	478.10	11.39
E.G. Slope (ft/ft)	0.007310	Area (sq ft)	26.37	478.10	11.39
Q Total (cfs)	4202.00	Flow (cfs)	27.39	4156.02	18.58
Top Width (ft)	131.54	Top Width (ft)	26.96	97.30	7.28
Vel Total (ft/s)	8.15	Avg. Vel. (ft/s)	1.04	8.69	1.63
Max Chl Dpth (ft)	6.90	Hydr. Depth (ft)	0.98	4.91	1.56
Conv. Total (cfs)	49146.5	Conv. (cfs)	320.4	48608.8	217.3
Length Wtd. (ft)	194.58	Wetted Per. (ft)	27.14	98.14	7.83
Min Ch El (ft)	2148.41	Shear (lb/sq ft)	0.44	2.22	0.66
Alpha	1.13	Stream Power (lb/ft s)	0.46	19.33	1.08
Frctn Loss (ft)	1.53	Cum Volume (acre-ft)	0.88	8.58	0.19
C & E Loss (ft)	0.02	Cum SA (acres)	0.95	1.79	0.12

Plan: Existing Twisp Twisp RS: 838 Profile: 100-Year

E.G. Elev (ft)	2157.00	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.25	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2155.75	Reach Len. (ft)	162.90	194.70	198.20
Crit W.S. (ft)		Flow Area (sq ft)	38.73	520.50	14.72
E.G. Slope (ft/ft)	0.007078	Area (sq ft)	44.47	520.50	14.72
Q Total (cfs)	4786.00	Flow (cfs)	48.24	4711.57	26.19
Top Width (ft)	162.22	Top Width (ft)	56.91	97.30	8.01
Vel Total (ft/s)	8.34	Avg. Vel. (ft/s)	1.25	9.05	1.78
Max Chl Dpth (ft)	7.34	Hydr. Depth (ft)	1.32	5.35	1.84
Conv. Total (cfs)	56889.0	Conv. (cfs)	573.4	56004.3	311.3
Length Wtd. (ft)	194.52	Wetted Per. (ft)	29.63	98.14	8.67
Min Ch El (ft)	2148.41	Shear (lb/sq ft)	0.58	2.34	0.75
Alpha	1.16	Stream Power (lb/ft s)	0.72	21.21	1.33
Frctn Loss (ft)	1.53	Cum Volume (acre-ft)	1.35	9.30	0.24
C & E Loss (ft)	0.03	Cum SA (acres)	1.36	1.79	0.14

Plan: Existing Twisp Twisp RS: 644 Profile: 50-Year

E.G. Elev (ft)	2154.93	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.35	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2153.58	Reach Len. (ft)	109.80	129.00	141.20
Crit W.S. (ft)		Flow Area (sq ft)	6.74	447.48	6.76
E.G. Slope (ft/ft)	0.008432	Area (sq ft)	6.74	447.48	6.76
Q Total (cfs)	4202.00	Flow (cfs)	8.51	4183.28	10.20
Top Width (ft)	100.89	Top Width (ft)	5.10	90.60	5.18
Vel Total (ft/s)	9.12	Avg. Vel. (ft/s)	1.26	9.35	1.51
Max Chl Dpth (ft)	5.96	Hydr. Depth (ft)	1.32	4.94	1.30
Conv. Total (cfs)	45760.2	Conv. (cfs)	92.7	45556.4	111.1
Length Wtd. (ft)	128.88	Wetted Per. (ft)	5.76	91.67	5.82
Min Ch El (ft)	2147.62	Shear (lb/sq ft)	0.62	2.57	0.61
Alpha	1.05	Stream Power (lb/ft s)	0.78	24.02	0.92
Frctn Loss (ft)	1.01	Cum Volume (acre-ft)	0.81	6.51	0.14
C & E Loss (ft)	0.11	Cum SA (acres)	0.89	1.37	0.09

Plan: Existing Twisp Twisp RS: 644 Profile: 100-Year

E.G. Elev (ft)	2155.45	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.54	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2153.91	Reach Len. (ft)	109.80	129.00	141.20
Crit W.S. (ft)		Flow Area (sq ft)	8.55	477.56	8.60
E.G. Slope (ft/ft)	0.008788	Area (sq ft)	11.07	477.56	8.60
Q Total (cfs)	4786.00	Flow (cfs)	11.91	4759.79	14.30
Top Width (ft)	138.95	Top Width (ft)	42.46	90.60	5.89
Vel Total (ft/s)	9.67	Avg. Vel. (ft/s)	1.39	9.97	1.66
Max Chl Dpth (ft)	6.29	Hydr. Depth (ft)	1.48	5.27	1.46
Conv. Total (cfs)	51053.8	Conv. (cfs)	127.1	50774.2	152.6
Length Wtd. (ft)	128.87	Wetted Per. (ft)	6.50	91.67	6.60
Min Ch El (ft)	2147.62	Shear (lb/sq ft)	0.72	2.86	0.72
Alpha	1.06	Stream Power (lb/ft s)	1.01	28.49	1.19
Frctn Loss (ft)	1.01	Cum Volume (acre-ft)	1.25	7.07	0.19
C & E Loss (ft)	0.14	Cum SA (acres)	1.17	1.37	0.11

Plan: Existing Twisp Twisp RS: 514 Profile: 50-Year

E.G. Elev (ft)	2153.81	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.00	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2152.81	Reach Len. (ft)	83.30	79.90	86.50
Crit W.S. (ft)		Flow Area (sq ft)	38.71	508.83	10.48
E.G. Slope (ft/ft)	0.007312	Area (sq ft)	108.05	508.83	10.48
Q Total (cfs)	4202.00	Flow (cfs)	61.48	4123.08	17.44
Top Width (ft)	245.41	Top Width (ft)	123.96	115.20	6.24
Vel Total (ft/s)	7.53	Avg. Vel. (ft/s)	1.59	8.10	1.66
Max Chl Dpth (ft)	5.93	Hydr. Depth (ft)	1.87	4.42	1.68
Conv. Total (cfs)	49139.5	Conv. (cfs)	719.0	48216.6	203.9
Length Wtd. (ft)	79.98	Wetted Per. (ft)	21.08	116.08	6.99
Min Ch El (ft)	2146.88	Shear (lb/sq ft)	0.84	2.00	0.68
Alpha	1.14	Stream Power (lb/ft s)	1.33	16.21	1.14
Frctn Loss (ft)	0.55	Cum Volume (acre-ft)	0.67	5.10	0.12
C & E Loss (ft)	0.01	Cum SA (acres)	0.73	1.07	0.07

Plan: Existing Twisp Twisp RS: 514 Profile: 100-Year

E.G. Elev (ft)	2154.30	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.08	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2153.21	Reach Len. (ft)	83.30	79.90	86.50
Crit W.S. (ft)		Flow Area (sq ft)	47.56	554.95	13.11
E.G. Slope (ft/ft)	0.007067	Area (sq ft)	160.86	554.95	13.11
Q Total (cfs)	4786.00	Flow (cfs)	78.73	4684.02	23.25
Top Width (ft)	263.63	Top Width (ft)	141.55	115.20	6.88
Vel Total (ft/s)	7.77	Avg. Vel. (ft/s)	1.66	8.44	1.77
Max Chl Dpth (ft)	6.33	Hydr. Depth (ft)	1.64	4.82	1.91
Conv. Total (cfs)	56932.4	Conv. (cfs)	936.5	55719.3	276.6
Length Wtd. (ft)	80.00	Wetted Per. (ft)	29.34	116.08	7.74
Min Ch El (ft)	2146.88	Shear (lb/sq ft)	0.72	2.11	0.75
Alpha	1.15	Stream Power (lb/ft s)	1.18	17.80	1.32
Frctn Loss (ft)	0.53	Cum Volume (acre-ft)	1.03	5.54	0.15
C & E Loss (ft)	0.01	Cum SA (acres)	0.94	1.07	0.09

Plan: Existing Twisp Twisp RS: 435 Profile: 50-Year

E.G. Elev (ft)	2153.25	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.97	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2152.29	Reach Len. (ft)	124.50	137.10	139.00
Crit W.S. (ft)		Flow Area (sq ft)	28.79	520.06	20.52
E.G. Slope (ft/ft)	0.006479	Area (sq ft)	84.14	520.06	20.52
Q Total (cfs)	4202.00	Flow (cfs)	28.64	4135.38	37.98
Top Width (ft)	213.76	Top Width (ft)	92.86	110.90	10.00
Vel Total (ft/s)	7.38	Avg. Vel. (ft/s)	0.99	7.95	1.85
Max Chl Dpth (ft)	5.73	Hydr. Depth (ft)	0.73	4.69	2.05
Conv. Total (cfs)	52202.7	Conv. (cfs)	355.8	51375.1	471.8
Length Wtd. (ft)	136.91	Wetted Per. (ft)	40.46	111.46	10.66
Min Ch El (ft)	2146.56	Shear (lb/sq ft)	0.29	1.89	0.78
Alpha	1.14	Stream Power (lb/ft s)	0.29	15.01	1.44
Frctn Loss (ft)	0.66	Cum Volume (acre-ft)	0.49	4.16	0.09
C & E Loss (ft)	0.09	Cum SA (acres)	0.52	0.86	0.06

Plan: Existing Twisp Twisp RS: 435 Profile: 100-Year

E.G. Elev (ft)	2153.75	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.04	Wt. n-Val.	0.120	0.042	0.100
W.S. Elev (ft)	2152.72	Reach Len. (ft)	124.50	137.10	139.00
Crit W.S. (ft)		Flow Area (sq ft)	47.11	567.63	25.01
E.G. Slope (ft/ft)	0.006216	Area (sq ft)	127.72	567.63	25.01
Q Total (cfs)	4786.00	Flow (cfs)	50.74	4686.57	48.70
Top Width (ft)	232.41	Top Width (ft)	110.60	110.90	10.91
Vel Total (ft/s)	7.48	Avg. Vel. (ft/s)	1.08	8.26	1.95
Max Chl Dpth (ft)	6.16	Hydr. Depth (ft)	1.03	5.12	2.29
Conv. Total (cfs)	60705.1	Conv. (cfs)	643.5	59443.9	617.7
Length Wtd. (ft)	136.86	Wetted Per. (ft)	46.97	111.46	11.67
Min Ch El (ft)	2146.56	Shear (lb/sq ft)	0.39	1.98	0.83
Alpha	1.19	Stream Power (lb/ft s)	0.42	16.32	1.62
Frctn Loss (ft)	0.64	Cum Volume (acre-ft)	0.75	4.51	0.11
C & E Loss (ft)	0.10	Cum SA (acres)	0.70	0.86	0.08

Plan: Existing Twisp Twisp RS: 298 Profile: 50-Year

E.G. Elev (ft)	2152.50	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.66	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2151.85	Reach Len. (ft)	101.50	91.60	86.80
Crit W.S. (ft)		Flow Area (sq ft)	87.62	619.85	13.55
E.G. Slope (ft/ft)	0.003713	Area (sq ft)	103.61	619.85	13.55
Q Total (cfs)	4202.00	Flow (cfs)	106.19	4081.81	14.00
Top Width (ft)	228.50	Top Width (ft)	102.63	115.40	10.47
Vel Total (ft/s)	5.83	Avg. Vel. (ft/s)	1.21	6.59	1.03
Max Chl Dpth (ft)	6.07	Hydr. Depth (ft)	1.49	5.37	1.29
Conv. Total (cfs)	68960.1	Conv. (cfs)	1742.7	66987.6	229.8
Length Wtd. (ft)	91.75	Wetted Per. (ft)	60.32	116.10	11.12
Min Ch El (ft)	2145.78	Shear (lb/sq ft)	0.34	1.24	0.28
Alpha	1.24	Stream Power (lb/ft s)	0.41	8.15	0.29
Frctn Loss (ft)	0.53	Cum Volume (acre-ft)	0.22	2.36	0.03
C & E Loss (ft)	0.08	Cum SA (acres)	0.24	0.50	0.02

Plan: Existing Twisp Twisp RS: 298 Profile: 100-Year

E.G. Elev (ft)	2153.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.71	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2152.31	Reach Len. (ft)	101.50	91.60	86.80
Crit W.S. (ft)		Flow Area (sq ft)	118.49	673.46	19.17
E.G. Slope (ft/ft)	0.003607	Area (sq ft)	159.63	673.46	19.17
Q Total (cfs)	4786.00	Flow (cfs)	145.42	4619.45	21.13
Top Width (ft)	259.90	Top Width (ft)	131.22	115.40	13.28
Vel Total (ft/s)	5.90	Avg. Vel. (ft/s)	1.23	6.86	1.10
Max Chl Dpth (ft)	6.53	Hydr. Depth (ft)	1.64	5.84	1.44
Conv. Total (cfs)	79693.7	Conv. (cfs)	2421.4	76920.4	351.8
Length Wtd. (ft)	91.79	Wetted Per. (ft)	73.46	116.10	13.97
Min Ch El (ft)	2145.78	Shear (lb/sq ft)	0.36	1.31	0.31
Alpha	1.31	Stream Power (lb/ft s)	0.45	8.96	0.34
Frctn Loss (ft)	0.51	Cum Volume (acre-ft)	0.34	2.56	0.04
C & E Loss (ft)	0.09	Cum SA (acres)	0.35	0.50	0.04

Plan: Existing Twisp Twisp RS: 206 Profile: 50-Year

E.G. Elev (ft)	2151.90	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.45	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2150.45	Reach Len. (ft)	154.70	133.30	68.70
Crit W.S. (ft)	2149.79	Flow Area (sq ft)	26.11	428.42	5.82
E.G. Slope (ft/ft)	0.009959	Area (sq ft)	27.29	428.42	5.82
Q Total (cfs)	4202.00	Flow (cfs)	35.95	4157.08	8.96
Top Width (ft)	135.52	Top Width (ft)	37.69	93.00	4.83
Vel Total (ft/s)	9.13	Avg. Vel. (ft/s)	1.38	9.70	1.54
Max Chl Dpth (ft)	5.47	Hydr. Depth (ft)	0.91	4.61	1.21
Conv. Total (cfs)	42105.9	Conv. (cfs)	360.3	41655.8	89.8
Length Wtd. (ft)	133.21	Wetted Per. (ft)	29.17	94.03	5.51
Min Ch El (ft)	2144.98	Shear (lb/sq ft)	0.56	2.83	0.66
Alpha	1.12	Stream Power (lb/ft s)	0.77	27.49	1.01
Frctn Loss (ft)	1.51	Cum Volume (acre-ft)	0.07	1.26	0.01
C & E Loss (ft)	0.03	Cum SA (acres)	0.08	0.28	0.01

Plan: Existing Twisp Twisp RS: 206 Profile: 100-Year

E.G. Elev (ft)	2152.42	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.59	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2150.83	Reach Len. (ft)	154.70	133.30	68.70
Crit W.S. (ft)	2150.27	Flow Area (sq ft)	40.00	463.77	7.87
E.G. Slope (ft/ft)	0.009852	Area (sq ft)	46.33	463.77	8.01
Q Total (cfs)	4786.00	Flow (cfs)	54.20	4718.84	12.96
Top Width (ft)	165.57	Top Width (ft)	62.91	93.00	9.67
Vel Total (ft/s)	9.35	Avg. Vel. (ft/s)	1.35	10.17	1.65
Max Chl Dpth (ft)	5.85	Hydr. Depth (ft)	0.89	4.99	1.33
Conv. Total (cfs)	48217.5	Conv. (cfs)	546.1	47540.8	130.6
Length Wtd. (ft)	133.21	Wetted Per. (ft)	45.43	94.03	6.66
Min Ch El (ft)	2144.98	Shear (lb/sq ft)	0.54	3.03	0.73
Alpha	1.17	Stream Power (lb/ft s)	0.73	30.87	1.20
Frctn Loss (ft)	1.50	Cum Volume (acre-ft)	0.10	1.36	0.02
C & E Loss (ft)	0.03	Cum SA (acres)	0.13	0.28	0.01

Plan: Existing Twisp Twisp RS: 73 Profile: 50-Year

E.G. Elev (ft)	2150.36	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.72	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2148.64	Reach Len. (ft)			
Crit W.S. (ft)	2148.38	Flow Area (sq ft)	9.41	394.41	9.83
E.G. Slope (ft/ft)	0.013006	Area (sq ft)	9.41	394.41	9.83
Q Total (cfs)	4202.00	Flow (cfs)	18.23	4163.39	20.38
Top Width (ft)	106.06	Top Width (ft)	7.33	92.00	6.74
Vel Total (ft/s)	10.16	Avg. Vel. (ft/s)	1.94	10.56	2.07
Max Chl Dpth (ft)	6.08	Hydr. Depth (ft)	1.28	4.29	1.46
Conv. Total (cfs)	36845.3	Conv. (cfs)	159.8	36506.8	178.7
Length Wtd. (ft)		Wetted Per. (ft)	7.70	93.20	7.26
Min Ch El (ft)	2142.56	Shear (lb/sq ft)	0.99	3.44	1.10
Alpha	1.07	Stream Power (lb/ft s)	1.92	36.27	2.28
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

Plan: Existing Twisp Twisp RS: 73 Profile: 100-Year

E.G. Elev (ft)	2150.88	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.90	Wt. n-Val.	0.100	0.042	0.100
W.S. Elev (ft)	2148.99	Reach Len. (ft)			
Crit W.S. (ft)	2148.72	Flow Area (sq ft)	12.07	425.97	12.27
E.G. Slope (ft/ft)	0.013005	Area (sq ft)	12.07	425.97	12.27
Q Total (cfs)	4786.00	Flow (cfs)	25.62	4732.99	27.39
Top Width (ft)	107.69	Top Width (ft)	8.16	92.00	7.53
Vel Total (ft/s)	10.63	Avg. Vel. (ft/s)	2.12	11.11	2.23
Max Chl Dpth (ft)	6.43	Hydr. Depth (ft)	1.48	4.63	1.63
Conv. Total (cfs)	41968.7	Conv. (cfs)	224.7	41503.8	240.2
Length Wtd. (ft)		Wetted Per. (ft)	8.61	93.20	8.12
Min Ch El (ft)	2142.56	Shear (lb/sq ft)	1.14	3.71	1.23
Alpha	1.08	Stream Power (lb/ft s)	2.42	41.23	2.74
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			