Coweeman Headwaters Design Project

Preliminary Basis of Design Report

SRFB#16-1668

prepared for

Lower Columbia Fish Recovery Board

prepared by

WATERWAYS CONSULTING, INC.

John Dvorsky, Principal
1020 SW Taylor St. Suite 380
Portland, Oregon 97205

LOWER COLUMBIA FISH ENHANCEMENT

Brice Crayne, Project Manager
12404 SE Evergreen Highway
Vancouver, WA 98683

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1.0 INTRODUCTION

1.1 Overview

The Coweeman River Headwaters Design Project is being led by the Lower Columbia River Fish Enhancement Group (LCFEG), sponsored by the Lower Columbia Fish Recovery Board (LCFRB), and funded by the Salmon Recovery Funding Board (SRFB). The project aims to increase the productivity of salmon and steelhead along 3.7 contiguous miles of channel in the upper, headwater reaches of the Coweeman River and Baird and Skipper Creeks. The Coweeman River offers a unique opportunity to enhance fish productivity in the Lower Columbia River region due to the lack of dams and the fact that the first natural barrier to the fish passage is at Washboard Falls at RM 31 (upstream of the project area). The headwaters are also almost entirely managed by a single landowner, Weyerhaeuser, and the watershed supports populations of key salmonids such as fall Chinook, winter steelhead, and coho. Despite the enhancement potential, no concerted efforts have yet been undertaken to improve the quality and quantity of fish habitat in the headwaters portion of the Coweeman River and its tributaries.

Historic forestry practices and splash damming in the headwater reaches, especially splash damming until 1926, and dynamiting of in-stream boulders, removed natural roughness elements and flushed much of the large wood and mobile bed material from the upper reaches. Re-accumulation of wood and gravel has been inhibited by the lack of new recruitment of large, mature conifers that act as key logs capable of creating and maintaining log jams in this high energy environment. As a result, reaches that previously contained mixed bedrock-alluvial channels now flow over bedrock, limiting the quantity of available spawning and rearing habitat. Although the watershed contains abundant supplies of cold water and suitable-sized sediment, the limited wood supply and corresponding roughness elements prevents the accumulation of bed material, limiting the productivity of salmon and steelhead. Based on this, the primary goal of the project is to re-introduce complexity and hydraulic roughness, thereby increasing planform variability which supports pool formation, development of spawning beds, and other critical habitat elements.

This Preliminary Basis of Design Report was prepared to provide the following:

- A general description of the project area,
- A summary of the limiting factors affecting fish production in the project area,
- The range of alternatives and associated enhancement measures proposed to address these limiting factors,
- The field investigation and data collection efforts utilized to the support the preliminary design of the enhancement measures, and
- Specific design elements chosen to meet key project objectives.

The Preliminary Basis of Design Report is being submitted as part of the preliminary engineering design package and cost estimate for the larger project area. These submittals will be reviewed by the Lower Columbia Fish Recovery Board's Technical Advisory Committee (TAC), which will provide comments and input on the preliminary design and assist the LCFEG with selection of a preferred project alternative. Following selection of a preferred alternative, which will also include selection of project subset phases and priorities, the LCFEG and its design consultant will develop Final Designs and Basis of Design Report for Phase 1, incorporating TAC comments and input.

1.2 Project Objectives

The Coweeman River Headwaters Design Project was originally conceived to address key limiting factors identified in the Lower Columbia Salmon and Steelhead Recovery and Subbasin Plan – Coweeman Subbasin (2010). Key limiting factors to be addressed include:

- Habitat Diversity – Lack of stable instream woody debris
- Habitat Diversity – Altered habitat unit composition
- Floodplain Function – Restricted floodplain access/channel migration
- Floodplain Function – Disrupted hyporheic process
- Forest Practices – Splash dam logging (historical)

To address the key limiting factors, the following enhancement actions were proposed:

- ***Install large wood as roughness elements:*** This enhancement action consists of installing large wood to alter local hydraulic conditions to encourage storage and sorting of delivered bedload to enhance spawning in mainstem and tributary reaches where the streambed is predominantly bedrock and spawning beds are limited or ephemeral.
- ***Install large wood for habitat complexity:*** This enhancement action consists of installing large wood in existing pools, along channel margins, and in connected off-channel or alcove areas to improve habitat for summer rearing and winter high flow refugia.
- ***Install large wood to increase floodplain connectivity:*** This enhancement action consists of installing channel spanning structures in lower gradient, moderately incised reaches of the mainstem of the Coweeman and lower Baird Creek to induce bed aggradation and restore floodplain connectivity. This is meant to be a process-based approach to enhancing side channel creation and maintenance rather than a prescriptive approach.
- ***Utilize large wood and a focused riparian planting effort to encourage beaver activity:*** This enhancement action would focus on reintroducing the physical and biological building blocks necessary to facilitate increased beaver activity, dam building, and enhancement of coho rearing habitat. This action is specifically focused on the portion of Skipper Creek that is within the project area.

During the preliminary design phase and associated reconnaissance-level assessment of the project area, the key limiting factors were evaluated and/or confirmed on a reach-by-reach basis to develop a reach-scale prescription of enhancement actions that most effectively address the key limiting factors.

2.0 EXISTING CONDITIONS

2.1 General Description and Land Use Summary

The Coweeman River watershed, a primary tributary to the Cowlitz River, encompasses approximately 200 mi^2 of primarily forested lands in Cowlitz County, Washington (Figure 1). The project area is located in the headwaters of Coweeman River and encompasses the mainstem of the Coweeman from River Miles 25.8 to 28.2 (Sub-basin Planning Reaches 15 through 19) and the lower portions of Baird Creek (Sub-basin Planning Reach 1A) and Skipper Creek (Sub-basin Planning Reach 1) (Figure 2).

Figure 1: Map of the Coweeman River subwatershed within the context of watersheds within the lower Columbia River management area. The Coweeman River is a major tributary to the Cowlitz River and enters the Cowlitz River near its confluence with the Columbia.

FIGURE 2

Overview of Coweeman Headwaters project area including the mainstem Coweeman, Baird Creek, and Skipper Creek. A total of 3.7 miles of channel are included in the project area.

COWEEMAN HEADWATERS DESIGN

PRELIMINARY BOD REPORT
FEBRUARY 2018

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The entire project area occurs on timber property owned by Weyerhaeuser, providing a predictable land management overlay that provides an opportunity to work with a single property owner who has a history of partnering with organizations seeking to enhance aquatic habitat. Weyerhaeuser owns land throughout the watershed, including the entire headwaters from approximately river mile (RM) 24.5 upstream, including all tributaries. The reaches of the mainstem Coweeman and the key tributaries of Baird and Skipper Creeks that are within the project area have the potential to provide long-term, cold water spawning and rearing habitat for fall Chinook, coho, winter steelhead, anadromous cutthroat trout, Pacific lamprey, and other resident fish. Other parts of the watershed are threatened by private development, which is less regulated than forestry land, increasing the long-term restoration value of Tier 1 aquatic habitat in the headwater reaches.

Natural processes in the headwaters of the Coweeman have been severely impacted by historic forestry practices, including logging of riparian buffers, direct removal of large wood and other roughness elements such as boulders from the channel, and splash damming. Even under current forest management practices, restoration of natural processes is limited due the presence of a network of permanent logging roads that disrupt the hydrology and natural sediment delivery, clear-cut harvesting and associated forest monocultures, and the legacy effect of splash damming and removal of roughness elements. Current forest management practices do have the benefit of protecting riparian buffers, which will ultimately provide a source of large wood to adjacent stream channels in reaches where conifers occur within the buffer in sufficient densities (Herger, 1996).

2.2 Geology and Geomorphology

The dominant surficial geologic material underlying the project area within the headwaters of the Coweeman River is basalt, as is typical of most river basins in the southwestern Washington Cascade mountains. The valley morphology of the Coweeman River, within the project area, can be characterized as alternating between unconfined, lower gradient reaches and confined, higher gradient reaches. These conditions are dictated by structural folds and faults that influence local channel morphology and physical habitat conditions. Reaches that are less confined and lower gradient exhibit wider floodplains, a higher potential to develop thicker alluvial layers over the underlying bedrock, and increased opportunities for the natural development of secondary channels, periodic avulsions, and associated off-channel habitats (Figure 3).

Historically a series of persistent and redundant logjams, combined with other roughness elements such as large boulders, dictated the morphology of the Coweeman River and its tributaries. Log jams acted as grade control, storing and sorting sediment, creating a complex mosaic of primary and secondary channels, and increasing profile variability. Persistent log jam complexes provided numerous benefits to fish including creation of spawning beds, creation and maintenance of off-channel rearing habitat, escape cover and high flow refuge habitat for summer and winter rearing, scour elements for large pool development, and deeper layers of coarse alluvium that enhance hyporheic exchange. Direct removal and limited opportunities for natural recovery of log jams resulted in a loss of the physical conditions that supported the formation of key habitat elements.

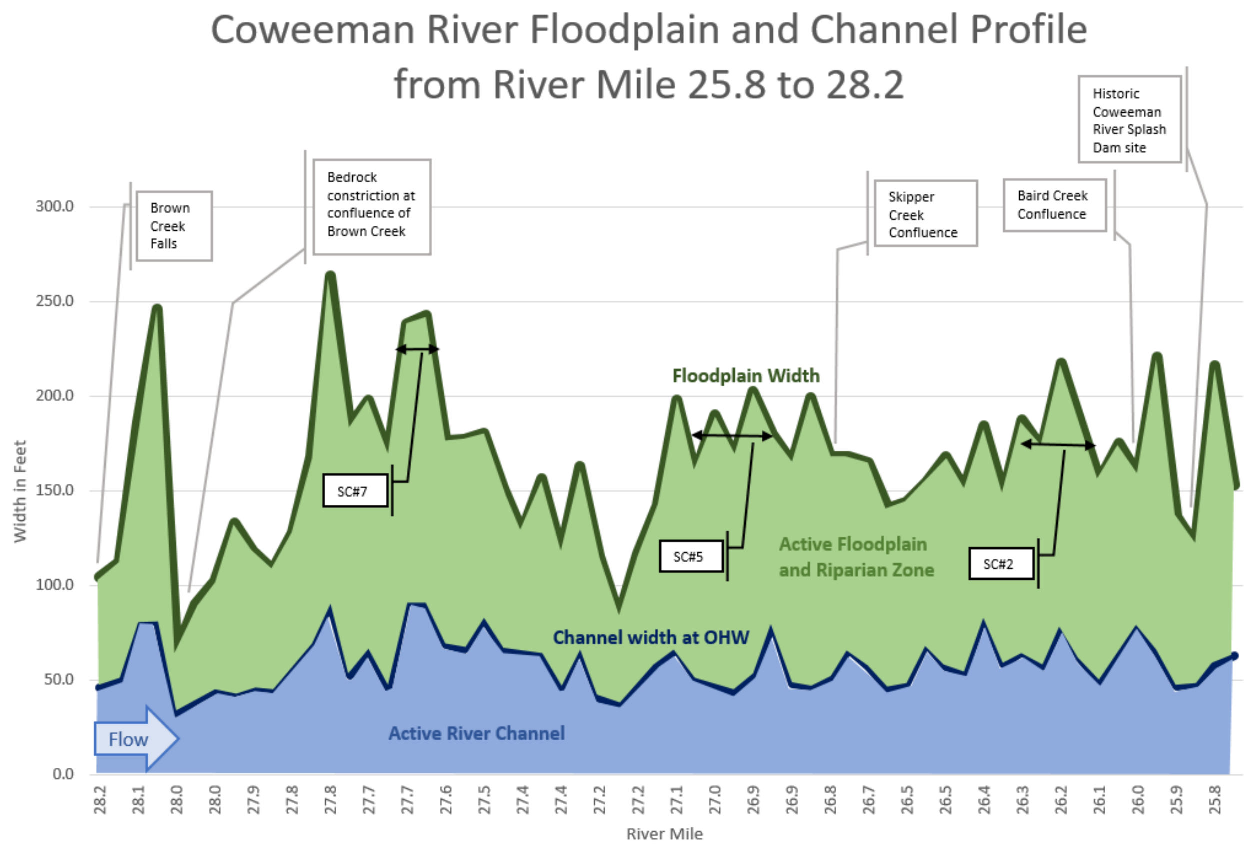

Figure 3: Estimates of channel width at Ordinary High Water (OHW) and 100-year floodplain width for the Coweeman mainstem within the project area, adjusted to River Mile.

Cowlitz County historical records indicate splash damming was used extensively in the Coweeman and key tributaries such as Baird Creek. At the peak of logging there were about a half-dozen dams on the Coweeman that were used to transport millions of board feet of old growth logs to the mills in Kelso, Washington. Splash damming continued until 1926 when lawsuits ensued following damage to people, livestock, and crops (Cowlitz Historical Quarterly, 1977). This practice removed all of the log jams from the system and scoured the channel down to bedrock in most areas, dramatically impacting the available salmon habitat. In the wider, low gradient reaches, scouring and incision of the channel to bedrock also resulted in loss of off-channel habitats as the primary channel became disconnected, or connected less frequently, from adjacent floodplain areas. While the practice of splash damming ceased in the 1920's in the Coweeman headwaters, some remnant the dams are still evident on the landscape and are having inputs on local channel morphology, especially the remnant dam on Baird Creek at River Mile 3.07.

2.3 Hydrology

The Coweeman River Headwaters project area drains an area of approximately 37.7 square miles, just downstream of the confluence of Baird Creek. Elevations in this portion of the watershed range from 680 feet to 4,520 feet. The watershed sits entirely within the western portion of the Cascade Mountains, producing mean annual precipitation of approximately 88 inches per year. A majority of the precipitation falls in late fall and winter. Winter precipitation typically falls as rain except in higher elevations where snow is common. Although most of the watershed is below the elevation of persistent winter snow cover, the watershed does experience periodic heavy snow falls which may lead to rain on snow flood events. The most significant peak flow events, like 1996, consist of warm, high intensity rainfall events following periods of heavy snow that extend into lower elevation areas.

The Coweeman River was gaged continuously from 1950 to 1984 but has not been gaged since, except for a single peak flow measurement taken in 1996. The gage was located at the lower end of the watershed, near Kelso, and gaged a drainage area of 119 square miles. The Coweeman River Headwaters project area is located in the upper portion of the watershed with a drainage area of approximately 37.7 square miles. Consequently, the streamflow data collected at the gage provides limited value to understand peak or low flow discharges in the project area given the significant difference in drainage area and land use.

To develop an estimate of peak discharges in the Coweeman River within the project area, several statistical methods were used including Drainage Area Ratios from gaged sites and a Regional Regression Method using data from gaged watershed. The Regional Regression method and development of an estimate of a key low flow statistic referred to as the 7-Day 10-Year Low Flow Discharge, a web-based GIS tool developed by the United States Geological Survey (USGS), known as StreamStats, was used. The tool delineates watersheds from a given point along a stream network and utilizes regional regression equations to estimate peak flow discharges for the watershed above that point. Peak flow estimates for the 2-, 10-, 25-, 50-, and 100-year recurrence interval peak flows were generated and are summarized in Table 1 (USGS 2013). Streamstats also provided an estimate of the 7-Day, 10-Year Low Flow Discharge of 14.6 cfs. This represents a drought year, summer baseflow condition.

The Drainage Area Ratio method consists of calculating peak flow estimates for the 2-, 10-, 25-, 50-, and 100-year recurrence interval peak flows at gaged sites and then multiplying those results by the ratio of the drainage area in the project area and the drainage area of the gaged watershed where the recurrence interval peaks were calculated. This approach makes the assumption that both watersheds are similar in their geology, land use, and drainage basin characteristics. The Drainage Area method was evaluated for the historic Coweeman River gage near Kelso, WA (USGS ID 1424500; Drainage Area of 119 square miles) and Winston Creek, a tributary to the Cowlitz River near Mayfield Lake (USGS ID 14237500; Drainage Area of 37.8 square miles). The results for the project site using these two gages is summarized in Table 1.

Table 1. Coweeman Headwaters peak flows estimated regional regression equations and drainage area ratio methods.

Peak Flow Event	StreamStats Regional Regression (in cfs)	Drainage Area ratio from Coweeman R. (in cfs)	Drainage Area ratio from Winston Creek (in cfs)
2-year	1,840	1,587	1,184
10-year	3,480	2,618	2,147
25-year	4,360	3,142	2,659
50-year	5,070	3,525	3,050
100-year	5,820	3,924	3,439

2.4 Fish Habitat and Limiting Factors

2.4.1 Fish Habitat Conditions

The primary salmonid species of interest in the project area are winter steelhead, fall Chinook, and coho. Lamprey and cutthroat trout are also found in the project area, though there is limited data on their status and distribution. The Coweeman River Subbasin Plan (2010) rates the current status of fall Chinook and coho as very low and winter steelhead as low with the viability for recovery rated as very high for fall Chinook and high for winter steelhead and coho. Historic returns, based on modeling, for fall Chinook, winter steelhead, and coho were estimated to be 3500, 900, and 5000 adults, respectively. Current returns for these three species were estimated to be 300, 350, and less than 50 adults. The target number of returns, based on modeling of potential basin-wide recovery, were estimated to be 900, 500, and 1200 adults for fall Chinook, winter steelhead, and coho, respectively.

The project area falls within mainstem Coweeman Reaches 16, 17, and 18, Baird Reach 1A, and Skipper Reach 1A of the Ecosystem Diagnostic and Treatment (EDT) analyses. The EDT is an ecosystem model that links the quantity and quality of habitat and its use by different life history stages to salmonid performance, as measured by abundance and productivity. The EDT analysis of project area reaches identifies Reaches 16 and 17 of the mainstem Coweeman as a moderate priority for fall Chinook, Reaches 16 and 17 as high priority for coho, with Reach 16 being the highest priority of all mainstem Coweeman reaches. All reaches of the mainstem, Baird, and Skipper within the project area are listed as high priority for winter steelhead recovery.

A habitat assessment completed by Weyerhaeuser in 1996 revealed that the upper Coweeman has low pool frequencies and depths. As stated previously, this may be a function of the lack of roughness elements, such as large wood, that limit profile variability, with most areas within the project area exhibiting a thin veneer of alluvium overlaying bedrock. This limits formation of deeper pools due to the resistance of the underlying bedrock to scour, with pools only forming in the most advantageous locations.

Redd surveys conducted during the past decade by WDFW, combined with recent field observations from LCFEG and Waterways Consulting staff provide valuable information about how the lack of roughness elements impacts spawning opportunities and success in the mainstem Coweeman and Baird Creek, especially for mainstem spawners like Chinook and winter steelhead when scouring flows can impact redds. Evaluating the spatial pattern of redd distribution using the WDFW data suggests that spawning “hot spots”, defined as locations where redds were observed almost every year, typically occur at tributary mouths, whereas other locations do not show consistent locations of mapped redds. This suggests that available patches of suitable spawning habitat along much of the mainstem and on Baird Creek is ephemeral and dependent on localized conditions that do not persist over time due to the lack of stable roughness elements, such as key pieces of large wood. Consequently, persistent spawning habitat is only available at tributary mouths where a constant supply of suitable-sized gravel is being transported by the tributaries to the mainstem channels. Redd construction in areas other than the tributary mouths occurs opportunistically in response to the presence of localized patches of gravel that is easily mobilized during high flow events.

2.4.2 Limiting Factors

In Table H-3 of the Lower Columbia Fish Recovery Board Coweeman Subbasin Assessment (2010) egg incubation is listed as the most critical limiting factor for all three species, followed by spawning (temperature) and fry colonization (habitat diversity) for Chinook, and winter rearing and summer rearing (habitat diversity) for coho and steelhead. During our site visits in April, 2017 we observed multiple examples where steelhead attempted to excavate a redd but hit bedrock after 4-8” and had to move upstream to find deeper gravel. This condition, where suitable gravel may exist for spawning but is often too shallow, occurs throughout the mainstem Coweeman and Baird Creek reaches of the project area. These conditions are common in rivers like the Coweeman that were historically splash dammed (Herger, 1996) and now lack suitable roughness elements to reaggrade the streambed and store and sort delivered sediment long-term. Table 2 describes the limiting factors, by species, and the enhancement actions proposed to address them.

Over the course of two years of field observations in the upper watershed, LCFEG has been able to field-truth the limiting factors for the three, primary species. In the spring, high numbers of fry have been observed—mostly coho—in Baird Creek and margin habitat areas of the mainstem. If the system is fully seeded in the spring, egg incubation is likely not limiting coho, suggesting that the fry-to-smolt life stage (summer and/or winter rearing habitat) may be limiting their productivity. These observations suggest that measures to increase summer and winter rearing habitat would increase survival of these life stages and increase the number of smolts. The most efficient way to do this would be to reverse the impacts of past land management activities that have led to moderate channel incision, a lack of persistent roughness elements in the channel, and the loss of channel-floodplain interactions.

Table 2: Description of limiting factors of Fall Chinook (CHK), coho (CO), and winter steelhead (STLD) as listed in table H-3 of the LCFRB Coweeman Subbasin Assessment.

Limiting Factor	Species most impacted	Field Observations	Enhancement Action
Egg incubation*	CHK, CO, STLD	Lack of key pieces of large wood results in shallow, ephemeral patches of suitable spawning habitat that is prone to mobilization and transport during high flow events.	Increase the number of key pieces of large wood in the system by constructing channel-spanning ELJs anchored to exposed bedrock.
Fry colonization	CHK	Despite a relatively wide floodplain, the river is channelized and lacks off-channel rearing areas.	Habitat complexity structures placed throughout project area; Reactivation of off-channel rearing habitat through active bed aggradation.
Winter rearing*	CO & STLD	Mainstem and Baird Creek are moderately incised and lack large woody structures that provide high flow refugia necessary to keep juveniles in the upper watershed; overall lack of beaver activity in tributaries like Skipper.	Active measures to reaggrade the streambed to reactivate off-channel habitat by constructing channel spanning ELJ's; Bank margin ELJ's to provide high flow refugia; beaver habitat enhancement in Skipper Creek.
Summer rearing	CO & STLD	Pools are exposed and lack cover from avian or aquatic predators.	Active measures to reaggrade the streambed to reactivate off-channel habitat by constructing channel spanning ELJ's; Habitat complexity structures in existing pools.

*LCFEG field observations in 2016 and 2017 lead us to believe egg incubation is the primary limiting factor for Chinook and winter rearing is the primary limiting factor for coho and steelhead

Field observations also indicated multiple examples where steelhead had to adjust their redd site to find deeper gravel, or spawning habitat was lacking altogether where bedrock was exposed at the surface. These observations suggest that while the fish are currently maximizing the available spawning habitat, there is more potential to increase available spawning area and overall productivity of the upper watershed. Again, adding persistent roughness elements to the channel will result in bedload aggradation and storage and sorting of the supplied sediment to create persistent spawning habitat.

Current commercial forestry practices include harvest cycles between 30-50 years, at which time the timber stand is cut and replanted. These dense monocultures of even-aged stands of Douglas fir lack the characteristics of a natural coniferous forest ecosystem. They typically do not support a three-staged canopy structure that would include ground cover and mid and over-story canopies, and very little light penetrates the understory due to the density of planting. Consequently, they do not provide functional habitat for most animals that inhabitat a more natural ecosystem. Despite attempts by timber managers to mitigate for impacts associated with the current land use, management of much of the upper watershed as a tree farm results in ecological impacts that are felt in unmanaged areas, such as the stream and riparian environment. Road development adds a chronic source of fine sediment to adjacent waterways that impacts the quality of available spawning habitat. It also results in changes to the hydrology by providing more efficient pathways for water to flow to primary stream channels, impacts floodplain connectivity at crossing locations, and disrupts natural sediment and large wood transport to stream channels by disrupting natural landslide and debris flow activity.

Management of the forest as tree farms also forces animals, such as elk, to almost exclusively utilize riparian corridors for food, resulting in competition with beaver for habitat and food resources (Baker et al, 2012). Beaver have been shown to be an important element is creating rearing habitat for juvenile coho (Pollock et al, 2004). Restoration of beaver habitat in low gradient, low energy tributary channels, such as Skipper Creek, could be expected to improve coho rearing habitat and production of coho smolts in a tributary that has been shown to consistently produce coho redds.

2.4.3 Proposed Enhancement Actions

In the late 1990's, Jim Fisher at Weyerhaeuser implemented habitat enhancement measures within the project area and subsequently monitored the success of these actions. Large wood placement in the mainstem Coweeman and several tributaries was completed in 1998 and a full report of these efforts was completed in Fall, 1999. Some of the conclusions from this report include:

- Log placement in tributaries will have little to no impact on stream morphology if logs are not placed into the channel of the stream,
- The prescription for the upper Coweeman was 1 piece of LWD per 4 channel widths and they recommended to overload this to ensure long-term wood loading persists, and
- In mainstem channels, attempts should be made to increase the stability of logs (i.e. anchoring to bedrock or ballasting with boulders).

These recommendations, along with our understanding of current habitat conditions, past impacts, and key limiting factors, by species, were used to develop specific habitat enhancement actions for the project area. To assist with characterizing limiting factors for different portions of the project area, the project area was divided into reaches (see Sheet C1 of Appendix A). Reach breaks were based on a variety of factors that included geomorphic characteristics (e.g. – confined versus unconfined channels), the presence of bridge crossings, tributary confluences, and design considerations such as construction access or sources of large wood. A total of nine reaches were identified for the mainstem of the Coweeman (CW1 through CW9), four reaches for Baird Creek (BR1 through BR4) and two reaches for Skipper Creek (SK1 and SK2).

Large wood ballasting requirements associated with high energy conditions on the Coweeman mainstem and Baird Creek are anticipated to consist of anchoring directly to bedrock or importing boulders to act as ballast. Bedrock anchoring has been used extensively by LCFEG on recent and ongoing large wood projects on the Washougal and has been shown to be an effective way of retaining key pieces in high energy environments where active channel widths often exceed wood supply dimensions and bedrock is present.

To evaluate the opportunity and feasibility of relying on bedrock anchoring as ballast, most of the project area was mapped to identify locations and extent of bedrock exposures. The channel bed was mapped as either bedrock dominated, alluvial, or mixed bedrock-alluvial. The unmapped areas in Reaches CW7 and CW8 consist of the Browns Creek, Browns Falls, and the confined bedrock gorge downstream of Browns Creek. The mapping provided design guidance on where bedrock anchoring could be used and where boulders will need to be imported to provide the required ballast.

<u>Channel Spanning Engineered Log Jams – Bed Aggradation and Spawning Habitat</u>

Both the mainstem Coweeman River and Baird Creek have been scoured down to bedrock by historic splash dam practices. These conditions have persisted due to the lack of large roughness elements, such as key pieces of large wood. The bedrock streambed is irregular and has undulations and chutes with occasional flat sheets. There are numerous outcrops along the margins and several bedrock lips where key

Photo 1: This bedrock lip in the mainstem Coweeman will be enhanced with a channel-spanning ELJ that will enhance storage and sorting of bedload and create spawning habitat for Chinook, steelhead, and coho.

logs would have historically hung up. These locations represent opportunities to mimic these natural conditions by anchoring channel-spanning structures at these locations. Photo 1 is an image taken from atop an outcrop that extends across the river. This is an ideal place to anchor a channel-spanning structure to build up spawning gravels, back up water during high flow events (creating off-channel habitat and increasing connectivity to the floodplain), and deepen and expand the existing pool. Figure 4 shows a typical planview detail from the preliminary engineering drawings (Sheet C12 in Appendix A) that illustrates the proposed enhancement action for these areas. The combination of channel-spanning structures and complexity structures will increase available spawning habitat as well as create protected environments for fry post-emergence and juvenile rearing.

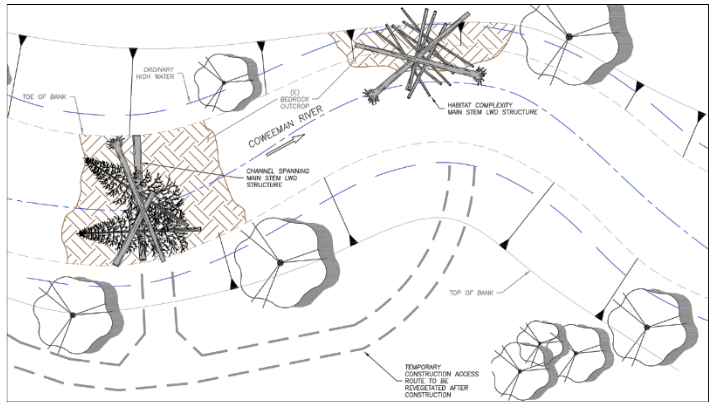

Figure 4: Drawing from design plans Sheet C12 illustrating typical Coweeman River LWD structure types.

Baird Creek is especially scoured to bedrock upstream of the 1600 Road bridge and downstream of the Rose Valley Road bridge. These sections are highly limited in spawning habitat because there is a lack of structure to retain the substrate as it is transported along the bedrock bed of the channel. By anchoring woody debris directly to the bedrock, spawning-sized substrate will be retained and locally sorted due to the variability in localized hydraulic conditions due to the presence of the roughness element.

While bedrock pools can provide some summer rearing habitat, as discharge and flow velocity increases, conditions become less suitable for rearing. Fall Chinook have out-migrated by winter and coho seek out off-channel or lower velocity areas, such as beaver ponds on smaller tributaries, to overwinter. Juvenile steelhead that are rearing in Baird Creek over the summer prefer to overwinter in the same reach by seeking low velocity areas in the interstitial spaces in riffles and pocket pools created by logjams. In bedrock-dominant streams, these conditions don't exist. By anchoring woody debris to the bedrock in Baird Creek, the physical habitat necessary to support all life stages of steelhead will be provided. The


Photo 2: Example of lower gradient reach on the mainstem Coweeman (Reach 5) where channel spanning structure would improve channel-floodplain dynamics.

constructed physical habitat elements created by placement of large wood will provide areas of low water velocity, build up the alluvial layer, and allow more steelhead to reside in Baird Creek throughout the winter.

Channel Spanning Engineered Log Jams – Bed Aggradation and Floodplain Reconnection

Historic splash damming and the limited potential for recruitment of key pieces of large wood has resulted in channel incision down to bedrock that has significantly reduced the frequency and duration of floodplain access. Much like the removal of a beaver dam, channel incision focuses the energy of the river into a single-thread channel, increases velocity, mobilizes and transports stored sediments, and reduces habitat diversity. A study in British Colombia found that the removal of beaver and their dams from 1968 to 2004 simplified channel structure which created an estimated fivefold increase in mean flow velocity (Green & Westbrook, 2009). In the mainstem and larger tributaries, this process resulted from splash damming and the removal of log jams and other roughness elements. In the smaller tributaries that have lower gradient habitat, loss of beaver and their dam and pond systems has had a similar impact.

In reaches along the mainstem Coweeman where the historic floodplain is broad, the channel gradient low, and there are only moderate levels of incision, there is an opportunity to restore natural channel and floodplain dynamics by aggrading the mainstem (Photo 2). Two reaches of the mainstem Coweeman (Reaches CW2 and CW5) were identified as ideal candidates for this treatment. The overall channel gradient is low (less than 2%), the valley is wide (on the order of 200+ feet), and remnant side channels still persist on the broad floodplain surfaces. By aggrading the mainstem from one two feet, using channel spanning log structures anchored to bedrock, the frequency of overbank flow would increase significantly.

Under existing conditions, channel incision results in overbank flow only occurring during higher magnitude, infrequent events (5+ year recurrence or greater). Consequently, water only accesses the floodplain when the water is turbid, resulting in fine sediment deposition in historic floodplain channels, further reducing the value of these habitats. By restoring a more natural frequency of floodplain inundation, these floodplain areas become more dynamic and self-maintaining. Instead of the floodplain being engaged only once every few years for a short period of time, the floodplain will be engaged several times a year and for longer periods.

This approach to improving channel-floodplain dynamics focuses on the natural process, rather than dictating the location of inlets to side channels and the location, extent and size of the side channels. By constructing a series of channel spanning and lateral log jams in the mainstem channel of these low gradient reaches the delivered coarse bedload will accumulate and activate the whole floodplain, restoring the natural process. The results will allow the river to braid, plug, abandon, and create new channels, creating a diversity of habitat that will support various life stages and species of salmonids.

Typical conditions in the Coweeman River include intermittent bedrock pools separated by continuous riffles as seen in Photo 3. Without wood to break up and sort the substrate, the river channel has become a plane bed channel consisting of an unsorted mix of boulders, cobble, gravel, and sand with small pockets of sorted spawning substrate. While riffles are important for macroinvertebrate production, the water is generally less than 2 feet deep (based on field observations) and research shows that "parr of all salmonid species strongly avoid areas with depths <0.2 m [0.7 ft], and steelhead and cutthroat parr showed increasing densities as unit depths increased up to at least 1 m [3.3 ft]" (Cramer & Ackerman, 2008). Thus, adding large wood to these reaches will further aggrade the riffles, increase the extent and depth of the pools, and increase hyporheic exchange as the overall profile variability increases (i.e. – amplitude of pool:riffle along the longitudinal profile).

Photo 3: Typical conditions in Coweeman River with pool in background, steep bank on one side of floodplain, riparian zone on opposite bank, and continuous riffle without any wood.

<u>Lateral Jams and Opportunistic LWD Placement – Summer and Winter Rearing Habitat</u>

Lateral jams and habitat complexity log structures would be interspersed into the reaches where channel spanning structures are being installed to provide summer and winter rearing habitat for juveniles. These structures will take advantage of areas where bedrock is not exposed along the entire width of the channel but instead outcrops along the margins (Figure 4). In locations where pools already exist that are high quality, habitat complexity logs will be installed to provide escape cover for summer rearing. Elsewhere, the lateral jam structures will be constructed along the margin of the active channel, extend into the adjacent riparian forest, and provide complex escape cover habitat that can also provide low velocity refugia during high flow events.

<u>Alder Thinning and Understory Regeneration – Coho Summer and Winter Rearing Habitat</u>

Skipper Creek has also incised into a relatively broad floodplain due to lack of in-channel structure. The overstory is dominated by alder with very little understory. Where alders have fallen over into the channel, due to banks undercutting, or large wood has been recruited, these roughness elements provide grade control and pools are formed where flow plunges over the embedded log (Photo 4). The large wood also aggrades the stream channel for a long distance upstream, improving floodplain connectivity and encouraging development of a complex network of primary and secondary channels.

Photo 4: Example of wood acting as grade control in Skipper Creek, aggrading gravel upstream, improving floodplain access, and creating a downstream plunge pool and spawning bed at pool tailout.

Despite being incised, the creek is providing quality spawning habitat for coho. WDFW redd surveys and field observations in Skipper Creek suggest that spawning habitat is not as much of a limiting factor for coho as is winter rearing habitat. The low gradient, low energy condition in Skipper Creek, and the broad nature of its floodplain, suggests it would have historically supported a robust beaver community. To attempt to improve overwintering habitat for coho in Skipper Creek, the most cost-effective approach would be to restore conditions that would be favorable for beavers to construct dams and ponds, which has been shown to create high quality coho rearing habitat (Pollock, 2004). To accomplish this, the enhancement action would consist of cutting down alders into the channel and floodplain to aggrade the channel and reconnect the floodplain. This would be combined with an active planting program which would also seek to deter elk grazing. As discussed previously, elk have been shown to compete with beaver in conditions where browsing habitat is limited. Due to the adjacent forest management practices, it is likely that a program to restore understory species, such as willow, would not be successful unless elk were excluded. The project area would be planted densely with willow and other understory species that beaver would utilize to construct dams. The overall approach would be low impact and only require a chainsaw to drop the alders and hand labor to install the vegetation and associated browse protection. Furthermore, a temperature study recently conducted on Skipper Creek suggests that removal of some of the alder canopy would likely not create an impaired condition (Appendix B).

3.0 PRELIMINARY DESIGN ALTERNATIVES

3.1 Development of Alternatives

The enhancement actions described above were developed in response to the limiting factors that were determined by others and confirmed by the project team. In most cases, the proposed enhancement actions consist of reintroducing large wood to the channel in a way that restores the physical habitat that fall Chinook, winter steelhead and coho rely on. The type of large wood structure constructed in a particular area depends on the reach-specific limiting factors that have been identified and the site-specific opportunities that exist that can be addressed through construction of large wood structures.

The specific types of large wood structures (e.g. – channel spanning, lateral, complexity) are not new. These structures have been used for over a decade to enhance physical habitat and improve conditions for salmonids. Consequently, the design of these structures is less about what is going to be constructed but how they are going to be constructed. Questions such as the size of the wood, the source of the wood, and how the wood will be secured to prevent the wood from mobilizing, which may limit the overall benefit provided by the wood or impact infrastructure as it moves downstream. The design process also evaluated the feasibility of attempting to reengage side channels that are still on the landscape but have limited benefit due to impacts such as channel incision or floodplain sedimentation.

Given the types of enhancement actions that are being proposed and the questions being addressed through the design process, the identification and potential selection of project alternatives was more narrowly focused on the range of options associated with the large wood supply, if and how side channels should be enhanced, and what ballasting techniques should be used. Furthermore, given the size of the project area, which encompasses 3.7 miles of channel, how should implementation of the project be phased to conform with typical cost ranges available through grants and be sized to allow for construction of a particular phase within the limited in-water work window.

3.1.1 Large Wood Supply

Due to the remote nature of the project area and the desire to meet key piece volume requirements (>75' long trees and >20 inch diameter; Fox and Bolton 2007), the most cost-effective way to supply the large wood is to utilize local wood sources. Local wood could consist of either purchasing trees from somewhere in the tree farm or carefully selecting trees from the adjacent buffers where a suitable number of conifers are available that could be used without impacting canopy closure targets or desired stand densities.

To evaluate wood sourcing alternatives on a reach by reach basis, project team members completed an in-depth evaluation of the entire project area to evaluate potential sources of wood within the adjacent buffers. This was done by walking all of the reaches and mapping significant stands of conifers. The mapping consisted of inventorying all of the conifers greater than 12" dbh within 150' of the waterway (see Sheets C2 through C8 in Appendix A). The design drawings in the Appendix show the potential tree harvest locations (approximate) and lists the proposed number of trees to be utilized from each harvest area. The number of conifer trees inventoried only includes trees greater than 12" dbh. The less/greater than symbol, included as a note in the drawings, identifies the relative size of the trees available which are split into two categories: 12-24" dbh and greater than 24" dbh. The number in parenthesis represents the number of conifer trees that could potentially be used in the project. For example, in Reach BR2, in the middle of the Reach (see Sheet C2 in Appendix A) there is a mapped stand of trees where there are 16 trees available that are >24" dbh and 23 trees available that are 12-24" dbh. The project is proposing to utilize 10 of the 39 trees available (26%) in this 0.71-acre harvest plot.

Throughout the project area we plan to utilize no more than 30% of the available conifer trees in a particular stand. In comparison, the Washington State Department of Natural Resources "Leave Tree Requirements" requires 20 conifer trees >12"dbh per acre be left standing when landowners harvest from the RMZ (WAC 222-30). In the example discussed above, the plot has 39 trees available in 0.71 acres, which would allow for commercial harvest of 14 trees in this plot, which is greater than the 10 trees proposed in the example in Reach BR2. That said, according to DNR staff, forest practices do not apply if the trees are not being harvested, but instead are being used for onsite or local riparian enhancement projects operating under a WDFW Hydraulic Project Approval (HPA). Consequently, the Leave Tree Requirements are only being used as a guideline to protect forest health rather than a hard and fast rule. These trees were left by Weyerhaeuser during previous harvests on adjacent hillsides are not currently available to Weyerhaeuser for harvest.

As part of this design process we reached out to WDFW wildlife biologists and researchers from Oregon State University to gage their support for utilization of these trees for fish habitat. Local WDFW wildlife biologists stated that if we met or exceeded DNR guidelines for harvest in the riparian area, and replanting is occurring, the overall impact to wildlife will be short term and ultimately beneficial. The proposed activity should provide uplift associated with utilizing these trees for instream habitat enhancement. This will in turn increase the diversity in the riparian forest, increase food sources for deer and elk, and aid in the overarching goal of increasing fish abundance.

Research coming out of Oregon State University suggests that productivity of headwater streams in the Cascade Mountains are light-limited (Kaylor & Warren, 2017) and that instream habitat restoration alone may be limited if not considered as part of a holistic approach to habitat restoration (Roni, et al., 2002). By thinning the RMZ and using that wood for instream habitat, the proposed project will improve physical habitat conditions (pool-riffle ratio, sediment retention, sediment sorting, pool frequency, etc.) as well as increase periphyton production and ultimately fish populations.

In addition to evaluating the number of trees that could potentially be utilized within each stand, the assessment included an evaluation of equipment access conditions to both the stand of trees and to the channel to determine if the salvaged trees would be just felled (no rootwad) or would be pushed over with the rootwad attached. It was also determined if additional equipment, such as cable, block, and tackle would be required to move the salvaged tree from its felled location to a desired location in the channel to maximize habitat potential. Table 3 summarizes the wood source for each of the reaches in the mainstem Coweeman and Baird Creek.

Table 3: Table describing restoration prescription strategies based on equipment accessibility and wood supply. Local wood supply are trees that are immediately adjacent to the river and can be tipped or felled directly into the river. Imported wood supply means the wood will be provided from the adjacent tree farm.

Reach	Prescription Strategy	Wood Source
CW1	LWD placement using heavy equipment	Local
CW2	LWD placement using heavy equipment; side channel #2	Imported
CW3	LWD placement using heavy equipment or helicopter placement	Imported
CW4	LWD placement by directional felling and manipulation with winch, blocks, and tackle; some heavy equipment access	Local
CW5	LWD placement using heavy equipment or helicopter placement; side channel #5	Local and Imported
CW6	LWD placement by directional felling and manipulation with winch, blocks, and tackle; some heavy equipment access	Local
CW7	LWD placement by directional felling and manipulation with winch, blocks, and tackle; some heavy equipment access; side channel #7	Local and Imported
CW8	LWD placement by directional felling and manipulation with winch, blocks, and tackle	Local
CW9	LWD placement using heavy equipment	Local
BR1	LWD placement using heavy equipment	Imported
BR2	LWD placement using heavy equipment	Local
BR3	LWD placement using heavy equipment	Local
BR4	LWD placement by directional felling and manipulation with winch, blocks, and tackle	Local

Reach CW3: wood delivery alternative analysis

Reach CW3 (see Sheet C4 in Appendix A) lacks a local supply of large wood and equipment access, though possible, is potentially challenging. The reach break between CW2 and CW3 is at the top of Side Channel #2. All the wood that is proposed for installation in Reaches CW2 and CW3 must be imported. The reach break between Reaches CW3 and CW4 is at the next equipment access location where there is also local wood available. Reach CW3 is approximately 760 feet long (0.14 miles) with a wood loading recommended at 9 key pieces. A total of 8 wood structures (~one per 100') are proposed in Reach CW3, consisting of between 3-5 pieces of wood within each structure. Of those, 2 or more pieces would be large enough to be defined as key pieces, for a total of 18 proposed key pieces in the reach. For the Coweeman River, a key log is approximately 9 cubic meters (based on Fox and Bolton, 2007).

The channel bed in Reach CW3 consists of a mix of boulders, cobble, gravel, and sand with few exposed bedrock outcrops. This makes equipment navigation in the river channel an undesirable option due to concerns about turbidity and ecological disturbance. To limit disturbance, helicopter placement of wood may be the most strategic and ecologically sensitive way to place the logs. Unfortunately, helicopter placement of large wood, especially pieces large enough to be considered a key piece on the mainstem Coweeman, is expensive, imprecise, and makes ballasting the log difficult.

Reach CW5: wood delivery alternative analysis

The reach break between Reaches CW4 and CW5 is just downstream of the Skipper Creek confluence and the reach break between Reaches CW5 and CW6 is near the upstream end of Side Channel #5, where wood availability increases along the right bank, downstream and adjacent to Camp Coweeman (see Sheet C5 in Appendix A). Access into CW5 depends on cutting a temporary access route through a young stand of trees within a Weyerhaeuser timber plot. The creation and decommissioning of this temporary access road would likely require a forest practices permit, based on preliminary discussions with the Department of Natural Resources (DNR).

Reach CW5 is approximately 1380’ long, with guidance requiring 17 key pieces, not including the side channel. Installation of a total of 6 large wood structures are proposed for Reach CW5, consisting of 3 to 5 logs per jams and a total of 18 key pieces. The channel bed in Reach CW5 consists of boulders, cobble, gravel, and sand with a few exposed bedrock outcrops, much like conditions in Reach CW3, making equipment access difficult, unless the temporary access road discussed above is constructed. There are bedrock outcrops on the left bank that could be utilized for anchoring, though access (pending approval from Weyerhaeuser) is on the right bank, making it inevitable that any placement with equipment would require traversing the river channel.

Reach CW5 also includes a 0.10 mile long side channel, referred to as Side Channel #5. Enhancement of the side channel is proposed, consisting of excavating several pools along the remnant alignment of the side channel (see Sheet C11 in Appendix A). The proposed enhancements to the side channel will require that equipment access is secured to this reach.

Alternative Analysis Discussion for Wood Delivery to Reaches CW3 and CW5

Overall, there are two potential options for treating Reaches CW3 and CW5. The options include using heavy equipment access to supply and install large wood, or helicopter placement of large wood combined with on-the-ground anchoring to bedrock or boulders. The selected approach will ultimately influence the phasing options, as discussed in Section 3.1.3. Although the preferred approach is reach-specific, selection of a preferred approach in one reach may affect other reaches. For example, if the most feasible option for a particular reach is to utilize a helicopter to deliver wood, it may make more sense to do additional reaches using a helicopter given the high initial cost of mobilizing the helicopter.

1. Use large, heavy equipment to deliver and place wood and boulders but reduce overall wood loads to minimize number of trips and overall disturbance. Large equipment (330-class excavator) is necessary to manipulate key logs. Consequently, this approach will require that river crossings are minimized, except where absolutely necessary, and also may require that the overall number of large wood pieces be limited to 2 or 3 key pieces per structure to minimize the number of trips that are necessary through sensitive areas. This alternative offers the highest certainty of success to accomplish desired habitat conditions associated with building spawning habitat and creating pools for rearing because the large wood can be manipulated with high precision and be appropriately ballasted. This alternative may cause the most short-term ecological damage and may require additional turbidity control measures.
2. Use a helicopter to place wood and boulders in the river using slightly smaller diameter LWD to decrease overall ballast requirements and the amount of helicopter time[1] by allowing for the delivery of multiple pieces of wood at a time. Because it may be challenging to deliver pieces large enough to qualify as key pieces, the approach would be to build larger jams (6 to 8 pieces) that would act together to exhibit key piece characteristics. Each jam will meet overall wood volume recommendations but no single piece would meet the key piece requirements. Boulders would be carried in by helicopter in bulk bags, cargo nets, or carriage. This alternative would likely result in less ecological impact but may be more difficult to meet the habitat objectives given the size of the large wood and the lack of precision associated with helicopter placement of wood. It would also likely be a more expensive alternative and limits opportunities for active enhancement of the side channels.

3.1.2 Side Channel Reconnection Alternatives

Side channels provide important aquatic habitat, especially for overwintering coho, because they often are characterized by low velocity conditions. They can also sometimes provide high quality summer rearing habitat if, for example, they intersect the flow path of cold water tributaries, groundwater or perennial springs. Side channels form through a variety of processes, with the most common side channels occurring in reaches of a river system with a broad floodplain where the floodplain is frequently accessed by flows, typically during the high flow season. The side channel itself is either formed along the alignment of a lower roughness, higher velocity portion of the floodplain or along the alignment of an historic primary channel that moved to a different location along the floodplain due to a

[1] LCFEG plans to continue restoration efforts on Baird Creek upstream of the current project boundary and treatment will likely consist of placement of wood using a helicopter. If coordinated property, this area could be combined with the treatments proposed in Reaches CW3 and CW5 to spread the overall cost of mobilization.

channel avulsion. The latter is the typical process and suggests a dynamic interaction between the channel and floodplain as a result of the balance between flow, sediment and debris in lower gradient reaches.

An initial evaluation of the mainstem Coweeman identified the potential for up to seven side channels throughout the project area that could potentially be enhanced to improve their function and provide more off-channel rearing habitat. During the field assessment phase of the project that was carried out to support the preliminary design, a total of four side channels were identified as providing opportunities for restoration and flagged for further evaluation. Those side channel are located in Reaches CW1, CW2, CW5, and CW7. Additional survey data was collected at each of these sites with Side Channel #1 removed as an option given its limited potential to reconnect due to significant elevation difference between the bed elevations in Reach BR1, at the mouth of Baird Creek, and the invert elevation of the remnant side channel (see Appendix C). The side channels in Reaches CW2, CW5, and CW7 were retained as part of the preliminary design, though it was determined that Side Channel #7, in Reach CW7, did not require a special treatment approach other than adding channel and floodplain logs consistent with treatments elsewhere in Reach CW7.

In Side Channel #2 and Side Channel #5, cross-section and longitudinal profile data showed that moderate levels of channel incision along the mainstem Coweeman has resulted in less frequent flow interactions with the side channels. This appears to have resulted in sedimentation of the upstream half of both of these side channels. Active reconnection of side channel areas in habitat restoration projects through the Pacific Northwest has had mixed results. In many cases, side channel enhancement actions have consisted of attempting to reconnect an existing side channel by excavating a new channel inlet and strategically placing large wood around the inlet area to attempt to create favorable hydraulic conditions to maintain the inlet and prevent it from filling in. Unfortunately, this approach is rarely successful and over time the inlet either fills with sediment or is plugged by debris. The lack of success is often not a result of a lack of an intensive design approach. Instead it is usually a result of not addressing the underlying causes of why the side channels are filling and recognizing that these are dynamic systems that resist a design approach that is expected to be static.

The natural process that has been disrupted in the case of Side Channel #2 and Side Channel #5 is the lack of roughness elements in the mainstem channel, resulting in a lack of natural grade control that has eroded the streambed to bedrock and limits frequent channel-floodplain interactions. As discussed previously, restoring this natural process consists of constructing channel spanning and lateral log structures in the mainstem channel and adding additional roughness to the floodplain. These log structures will encourage bed aggradation that will enhance channel-floodplain interactions and restore historic dynamics. The proposed approach avoids identifying specifically where a new side channel inlet will be created. Instead, the process will be restored to force an inlet to be created based on local hydraulics, sediment supply, and debris loading.

Large wood structures will be constructed in the mainstem and floodplain along the entire length of unconfined portions of Reaches CW2 and CW5 to provide grade control redundancy, limit opportunities for flanking, and to let the river determine the most suitable locations for inlets and outlets, their dimensions, and their frequencies of interaction. Alternatively, we could invest a significant amount of design effort and use heavy equipment to construct a side channel inlet, excavate a portion of the side channel alignment, and install log structures to attempt to provide stability to the constructed features. That alternative was not determined to be a cost-effective strategy and may present a high risk of failure.

3.1.3 Project Phasing Alternatives

Due to the scope, scale, and estimated cost of the proposed enhancement actions within the project area, implementation will likely be broken up into three separate construction phases. Feedback from the LCFRB TAC will help determine site-specific restoration strategies. Selection of preferred strategies will determine implementation costs and ultimately scope and scale of construction phases. This section provides a set of potential phasing options based on our understanding of site logistics, the enhancement measures being proposed, the anticipated grant funding opportunities, and the amount of work that a contractor could be expected to complete within the limited in-water work window in any given summer.

Implementation Phasing Assuming Heavy Equipment Access to Reaches CW3 and CW5 (Figure 5)

1. Coweeman Headwaters Restoration Phase I – 2018 SRFB Grant Round
   - Construct Reaches CW1 and CW9 of the Coweeman Mainstem
   - Construct all Baird Creek reaches (Reaches BR1 through BR4)
2. Coweeman Headwaters Restoration Phase II – 2020 SRFB Grant Round
   - Construct Reaches CW2, CW3, and CW4 on the mainstem Coweeman (includes Side Channel #2)
   - Construct Reach SK2 of Skipper Creek
3. Coweeman Headwaters Restoration Phase III – 2022 SRFB Grant Round
   - Construct Reaches CW5, CW6, CW7, and CW8 of the Coweeman Mainstem (includes Side Channel #5)

From a geomorphic standpoint, implementation should begin at the downstream end of the project area and work its way upstream. This is to provide opportunities for sediment to be trapped in the downstream structures first. The exception is that the first phase also includes construction of Reach CW9, which is at the upstream end of the project area within the mainstem Coweeman. This reach was included since the primary objective in Reach CW9 is to enhance fish passage over Brown Creek Falls. Brown Creek Falls creates a complete barrier to fall Chinook in most years. This project has been identified as a priority by WDFW to provide additional access upstream to fall Chinook so it was added in the first phase of the project. This is the preferred strategy for Phase I implementation.

Ecologically, the four Baird Creek reaches appear to be the most degraded within the project area and provide the best opportunity for uplift for winter steelhead, which was identified in the Subbasin Plan (2010) as a high priority area. Baird Creek also has fewer constraints than some of the mainstem Coweeman reaches in terms of accessibility for construction and/or availability of local materials, including a large boulder pile adjacent to the road at the Reach B2 and B3 split (Photo 5). Part of the treatment prescription in reach BR3 is to open the channel directly upstream of the 1600 Road bridge by

Photo 5: Looking downstream along Baird Creek (reach BR3) where a large boulder pile is restricting the floodplain. Boulders can be repurposed for ballast and/or removed to restore historic channel widths.

pulling boulders out of the active creek channel. The manmade boulder stockpile is currently restricting the creek from utilizing about half of its floodplain. Boulders removed from this stockpile will be repurposed as ballast throughout all construction phases.

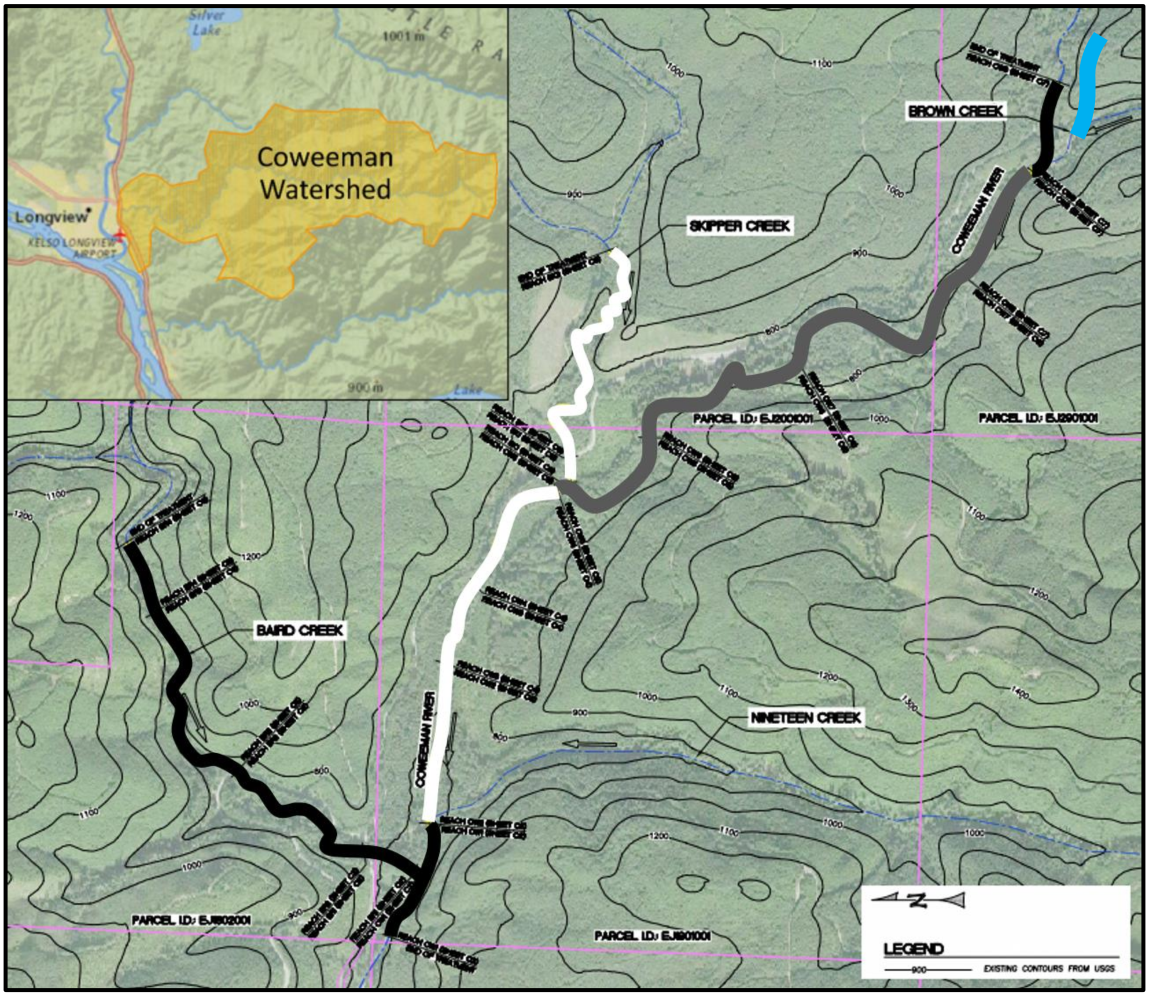

Figure 5: Map showing implementation strategy broken up into Phase I (Black), Phase II (White), and Phase III (Grey); assumes heavy equipment access to CW3 and CW5 (with or without helicopter material transport)

Implementation Phasing Assuming only Helicopter Access to Reaches CW3 and CW5 (Figure 6)

1. Coweeman Headwaters Restoration Phase I – 2018 SRFB Grant Round
   - Construct Reaches CW1, CW8, and CW9 of the Coweeman Mainstem
   - Construct all Baird Creek reaches (Reaches BR1 through BR4)
2. Coweeman Headwaters Restoration Phase II – 2020 SRFB Grant Round
   - Construct Reaches CW2, CW4, CW6, and CW7 on the mainstem Coweeman (includes Side Channel #2)
   - Construct Reach SK2 of Skipper Creek

3. Coweeman Headwaters Restoration Phase III – 2022 SRFB Grant Round
    - Construct Reaches CW3 and CW5 of the Coweeman Mainstem using helicopters to place logs
    - Construct Reach BR5+ (Remainder of EDT Reach 1A, 1B and 2); This element not included in current design but would be included in a helicopter treatment phase if funded as a project

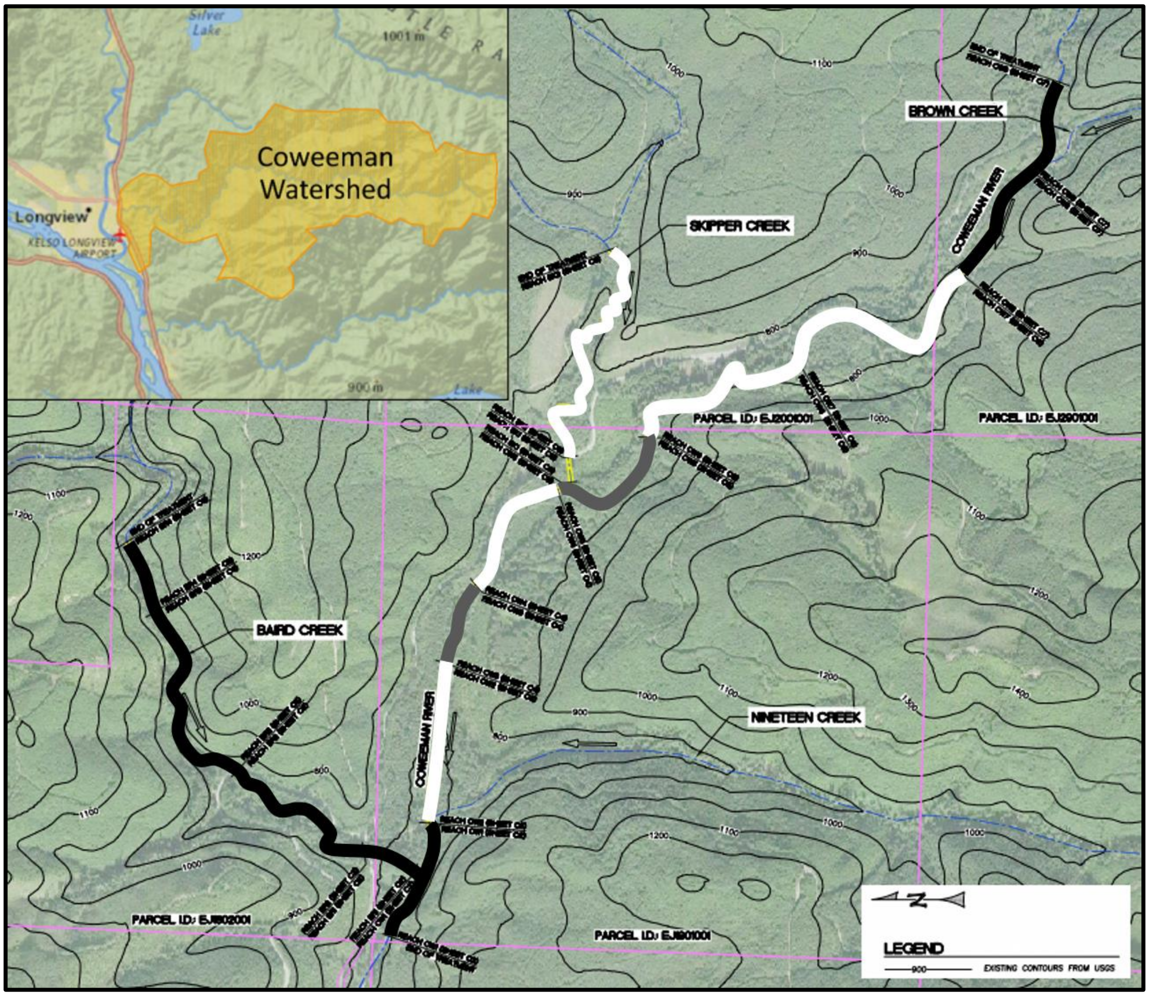

Figure 6: Map showing implementation strategy broken up into Phase I (Black), Phase II (White), and Phase III (grey); assumes helicopter treatment in CW3 and CW5 and would likely include expansion of treatment into Baird Creek 1B (EDT).

4.0 STAKEHOLDER PROCESS

The Coweeman Headwaters Design project has actively engaged stakeholders to provide input through all phases of the design process. Stakeholder input and comments are valued because many of the stakeholders identified by LCFEG are active participants in managing the natural resources in the headwaters of the Coweeman River. The design process attempts to incorporates information, reports, data, and field observations of professionals that have spent years inventorying, assessing, and developing strategies to manage the anadromous fish resources in the Coweeman River watershed. Stakeholder engagement has been a continuous and ongoing process with LCFEG having frequent communications and field visits with a variety of individuals that are involved in management of the forest, the infrastructure, and the wildlife.

Independent of these more informal discussion, LCFEG has assembled a stakeholder review committee that has met twice to provide input on the project and comments on the submitted work products. The organizations represented on the stakeholder review committee include Weyerhaeuser, Washington Department of Fish and Wildlife, Washington Department of Natural Resources, Lower Columbia Fish Recovery Board, and Cowlitz County, a representative of the kayaking community (Barry Bruner). Stakeholder review meetings occurred on May 6, 2017 to provide input on the project approach and conceptual level design, and on January 9, 2018 to provide input on the preliminary design. Table 4 summarizes the input provided by the stakeholder at each of the review meeting and how those comments were addressed.

Table 4: Summary of comments provided by stakeholders at the two stakeholder review committee meetings and how the comments were/are being addressed.

	Comment	How Addressed
Stakeholder Meeting #1	*Access routes need to be mapped out for review by DNR and Cowlitz Tribe*	DNR attended a site visit with LCFEG to review access routes and suggested that the HPA will address access issues/impacts in all areas except where a forest practices permit may be required. The Cowlitz Tribe has been notified about the project and funding will be requested during implementation to meet cultural resources review requirements.
	Reach out to Cowlitz Tribe to initiate cultural resources review	See response to previous comment.
	Limit amount of access routes from the 1600 Road to minimize traffic in tree farm	This was discussed during a site visit with Weyerhaeuser engineer, Frank Jongenburger. The outcome was that Frank would like to address this on a case by case basis through their right of entry permitting as was done with the SF Johnson Creek project along the mainline in Toutle (4100 Road).
	Water temperature data for Skipper Creek	Water temperature data is currently being collected in Skipper Creek. Preliminary results suggest that Skipper Creek is not impaired for temperature. Following completion of data collection, a brief letter report will be prepared summarizing the results.
	Incorporate Brown Creek falls low flow passage into design	Design developed with a phasing approach that prioritizes this barrier. A formal amendment was completed to incorporate this falls into the scope of the design.
	Wood anchoring locations/protocols included in design document	The locations of the proposed structures, their general orientation, and method of ballasting are included in the preliminary engineering design and accompanying design report.
	Add riparian hatches to design document	Included on drawings in portions of project area where riparian enhancement is proposed.
	The project needs to consider recreational and research-related boating safety	LCFEG met with a representative of the kayaking community (Barry Brunner) who indicated that the project area is upstream of where most kayakers and experienced kayakers know how to avoid hazards. WDFW concerns were addressed by committing to either low profile channel spanning structures or ensuring that higher profile structures only occupy 60-80% of the cross-section.
Stakeholder Meeting #2	*Concerns raised about proposed enhancement actions in Skipper Creek since it is a hot spot for coho spawning*	LCFEG and WDFW convened a site visit to discuss the watershed and what is limiting coho overall. It was determined that winter rearing habitat is more of a limiting factor than spawning habitat and that the proposed approach will provide significant benefit to coho. Site visit attendees from WDFW included Lisa Brown, James Lamperth, and Thomas Wadsworth.
	WDFW Wildlife staff may have concerns about felling trees from corridor	This was discussed in person with Eric Holman at WDFW and he was supportive of the approach including the enhancement measured proposed in Skipper Creek to support beaver and the restoration of sediment trapping functions in Coweeman and Baird as he expects these to enhance floodplain and riparian functions.
	Need clearer idea of limiting factors and how specific treatments are addressing the limiting factors	This was addressed through a detailed discussion in the design report and the preliminary engineering design.

5.0 REFERENCES

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APPENDIX A

Preliminary Engineering Designs

APPENDIX B

WDFW Temperature Monitoring Study, 2018

Summary of Recent Temperature Monitoring by LCFEG on Skipper Creek

January 31, 2018

TO: Brice Crayne, LCFEG

FROM: Jamie Lamperth, WDFW, jamie.lamperth@dfw.wa.gov

Brice:

Here is a summary of the Coweeman River thermal environment in 2014. The write-up is from an unpublished WDFW report and should be considered a draft presentation. We have stream temperature data from 2013-2017 that could be summarized in a similar way if necessary. Stream temperature in 2014 was very similar to all other years of record except 2015 which was warmer than the other years.

COWEEMAN RIVER STREAM TEMPERATURE MONITORING, 2014

Methods

Stream temperature is one of the most important environmental factors influencing the distribution, life history, and health of aquatic poikilotherms such as salmonids (Brannon et al 2004; Richter and Kolmes 2005). In the Coweeman River basin, year-round stream temperature monitoring began in 2012 in order to describe and monitor through time the thermal regime of the basin, and to better understand the thermal environment experienced by salmonids at various life stages. Currently, 15 sites are being monitored with spatially-fixed temperature data loggers (Optic Stowaway Temp; Onset Computer Corporation, Pocasset, MA; accuracy ± 0.2°C); 11 sites in the main stem and five sites in tributary habitats. The main-stem sites are at rkm 0.2, 10.8, 14.9, 17.9, 21.7, 25.0, 30.1, 35.7, 40.4, 44.0, and 50.8. The tributary sites are in Goble (rkm 0.1 and 8.5), Mulholland (rkm 0.1), and Baird (rkm 0.5) creeks, the largest tributaries in the basin. There was a temperature data logger at rkm 2.5 in Mulholland Creek but it was lost in 2014. Temperature data from the main stem at rkm 0.2 are not included in this year's analysis because the logger at his site was buried in fine substrate for much of the 2014 deployment and the resultant data are not representative of stream temperature at this site; diel variability in the summer was much less than expected and overall summer temperature was cooler than expected.

Temperature monitoring sites at the microhabitat scale were selected by considering water depth, water velocity, and distance to an anchor point. Loggers were typically placed in pool/glide habitat to minimize dewatering during low flow periods, in locations with water velocities sufficient to produce well-mixed water (i.e., minimize influence of microhabitat temperature differences), and near stream-side anchor points to minimize movement and bank-stranding during high stream discharge events. Temperature differences in the vicinity of several loggers were evaluated by probing the area with a hand-held thermometer to ensure that the temperature data that was collected was a general representation of the reach and not a microhabitat anomaly. Temperature differences were not found near any of the monitoring sites. Each logger was housed in a white polyvinyl chloride pipe (to protect the logger from natural disturbances and to reflect solar radiation) perforated with drill holes (to maximize water movement across the sensor) and secured to a stable stream side feature with braided cable. Data were downloaded from the units *in situ* on several occasions using the HOBO Waterproof Shuttle (Onset Computer Corporation, Pocasset, MA; Part No. U-DTW-1).

Temperature data were summarized and compared to thermal criteria for select life stages of Chinook, coho, and steelhead recommended by the Environmental Protection Agency (EPA 2003) and Richter and Kolmes (2005). The thermal criteria are based on literature reviews and represent the upper optimal temperature for physiological processes at a given life stage for these cold-water species. The EPA uses the maximum 7-day average of the daily maximum stream temperature (7DADM), a metric that occurs once per year and identifies the warmest thermal conditions fish are exposed to at a weekly time scale in a given year. Richter and Kolmes (2005) provide complimentary criteria using weekly mean temperatures; a metric that can be used to continually assess thermal conditions throughout the year.

Temperatures were evaluated for the following three life stages: incubation and fry emergence combined, juvenile rearing, and smoltification. To do this, time periods were defined for each life stage based on empirical data from the Coweeman basin and temperatures during these time periods were compared to the upper optimal temperatures thresholds. Incubation and fry emergence evaluations were limited to Chinook and coho as data on steelhead emergence time in the basin was not readily available at the writing of this report. Juvenile rearing temperatures were evaluated for all species. Smoltification evaluations were limited to coho and steelhead, the two species that fully smolt in the Coweeman River. Weekly mean temperature was used to evaluate thermal conditions during all the life stages while maximum 7DADM was only used to evaluate juvenile rearing habitat.

Results

Stream temperature in the Coweeman River basin showed seasonal patterns of thermal heterogeneity (Figure 14). From mid-fall to late winter, weekly mean temperature was similar throughout the basin with among-site temperature difference typically between 0.5 °C and 1.5 °C. Beginning in late winter (March), thermal heterogeneity increased with cooler temperatures higher in the basin and warmer temperatures lower in the basin. Stream temperature difference between the upper and lower mainstem reached the maximum from mid-July to early-August with weekly mean temperature differences approaching 6.5 °C. Weekly mean temperatures ranged from 1.9 °C in December and February to 20.7 °C in August. The minimum and maximum instantaneous temperatures were 0.0 °C and 24.2 °C, respectively. The temperature patterns in 2014 were very similar to 2013 patterns.

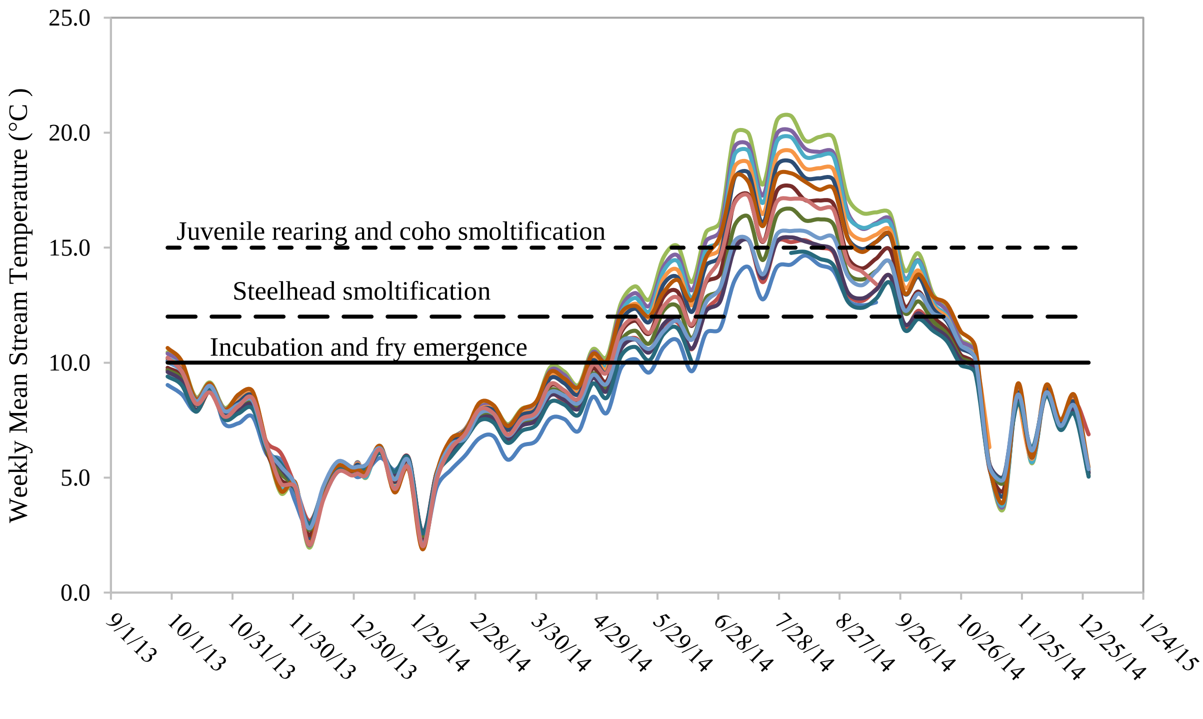

Figure 1. Weekly mean temperature at 14 monitoring sites in the Coweeman River basin, WA from September 29, 2013 to December 31, 2014. Each colored line represents one site. Horizontal lines indicate upper optimal temperature for incubation and fry emergence (10°C, solid line), steelhead smoltification (12°C, long dash), and both juvenile rearing and coho smoltification (15°C, short dash) (Richter and Kolmes 2005).

Temperatures in the Coweeman River were generally within optimal thresholds for life stages occurring outside of summer months (i.e., incubation, fry emergence, and smoltification); however, temperature during the summer generally exceeded the optimal thresholds for juvenile rearing. Weekly mean temperature during the incubation and fry emergence period for Chinook and coho only exceeded the optimal temperature criterion during the first 2 weeks of the evaluation (Table 23). Likewise, weekly mean temperature met the optimal criterion for all but one week (the last week of each evaluation period) during the coho and steelhead smoltification time frames. In stark contrast, nearly all sites (12 of 14 sites) not only exceeded the optimal weekly mean temperature criterion for juvenile rearing but did so for an extended period (5 – 15 weeks). The two uppermost sites on the main-stem Coweeman were the only sites that met the juvenile rearing criterion (Figure 15). The maximum 7DADM metric yielded similar results as weekly mean temperature for juvenile rearing conditions.

Table 1. The number of weeks and proportion of stream temperature monitoring sites that did not meet upper optimal temperature thresholds for select life stages of Chinook (CHK), coho (COH), and steelhead (STD) in the Coweeman River basin, WA. Evaluation period is the time period that the temperature criteria were evaluated for each life stage and are based on empirical data collected in the basin.

Species	Life Stage	Evaluation Period	Weekly Mean Temperature Criteria[a]	Number of Weeks Criteria Not Met	Proportion of Sites Where Criteria Were Not Met
CHK, COH	Incubation and Fry Emergence	9/29/13 - 3/15/14	10ºC	1 - 2	0.57
CHK, COH, STD	Juvenile rearing	1/1/14 - 12/31/14	15ºC	5 - 15	0.86
COH	Smoltification	3/2/14 - 6/14/14	15ºC	1	0.07
STD	Smoltification	3/2/14 - 5/17/14	12ºC	1	0.29

[a] Criteria from Richter and Kolmes (2005)

The maximum 7DADM ranged from 16.1 °C to 23.7 °C and occurred between Aug 4 and Aug 6 across the 14 monitoring sites (Figure 16). The EPA (2003) recommends that maximum 7DADM should not exceed 16.0 °C for “core” juvenile rearing habitat (i.e., moderate to high densities of juveniles) or 18.0 °C for “non-core” rearing habitat (i.e., moderate to low juvenile density). None of the sites met the “core” rearing habitat criterion and only two of the sites (the highest elevation sites and the same two sites that met the weekly mean criterion) met the “non-core” rearing habitat criterion.

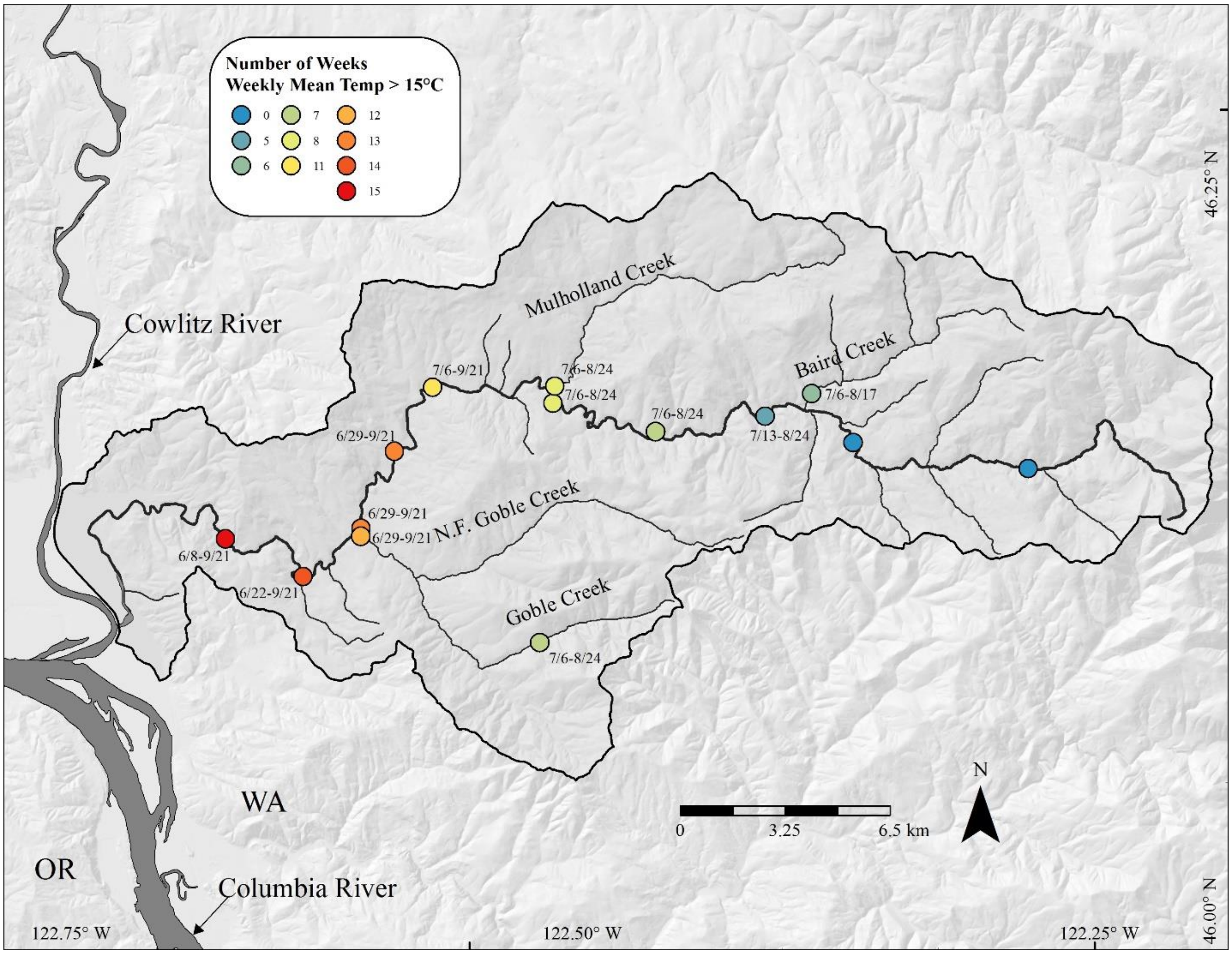

Figure 2. A map displaying the number of weeks that weekly mean temperature was greater than 15.0 ºC, the upper optimal temperature criterion for Chinook, coho, and steelhead juvenile rearing (Richter and Kolmes 2005), in 2014 at 14 monitoring sites in the Coweeman River basin, WA. Data labels are the range of dates when stream temperature exceeded 15.0 ºC.

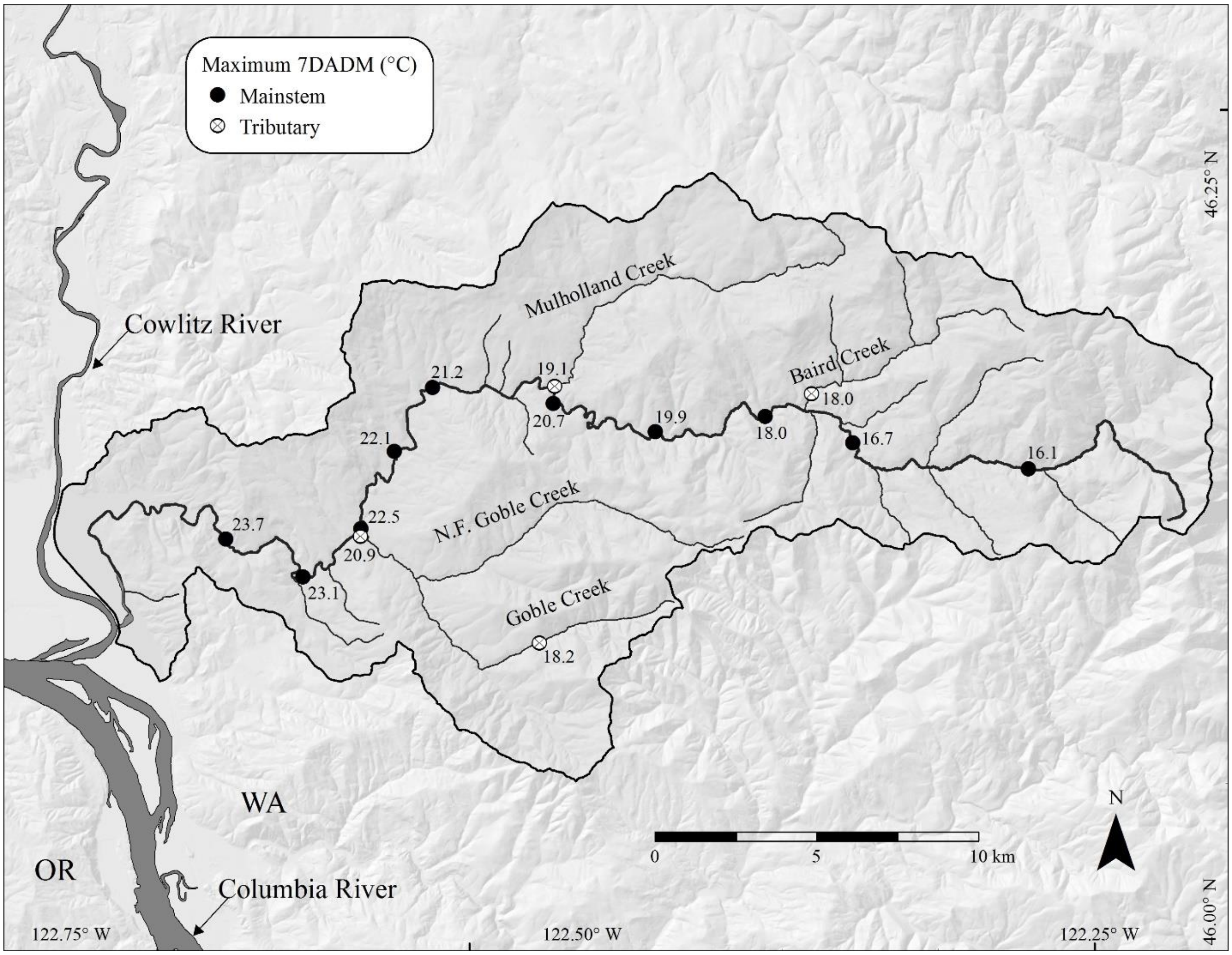

Figure 3. Map of the Coweeman River basin, WA showing the maximum 7-day average of the daily maximum stream temperature (°C) in 2014 at 14 monitoring sites.

Maximum 7DADM temperatures decreased with increasing elevation (Figure 17), a typical pattern observed with stream temperature (Isaak and Hubert 2001; Steel et al. 2016). The elevation-temperature pattern along the mainstem also showed two “cooling” zones and two “warming” zones evident by the rate of temperature increase (°C/m (elevation)) as water flows in a downstream direction, where a low rate of increase indicates a cooling zone and a high rate of increase indicates a warming zone. The cooling zones occurred between rkms 25.0 and 35.7 and 44.0 and 50.8, and the warming zones occurred between rkms 40.4 and 35.7 and rkms 25.0 and 21.7. Data do not exist at this time to explain these observations; however, it is likely that a combination of factors are contributed to the varying rates of increase including the amount of solar radiation exposure controlled by topography and canopy cover, stream depth, and substrate composition (Caissie 2006).

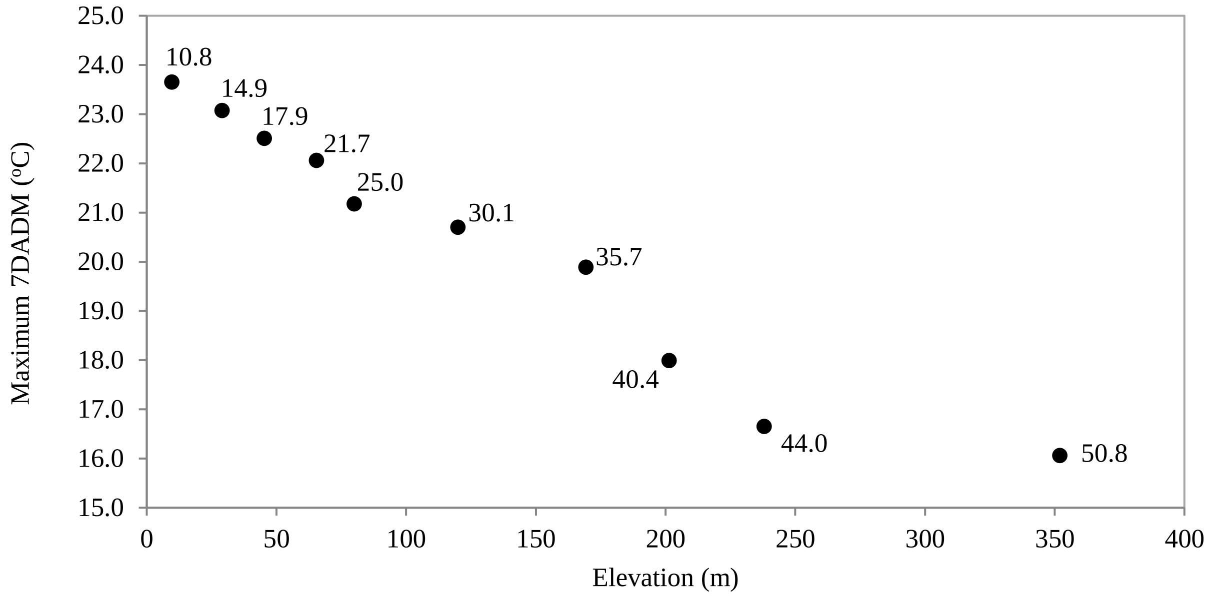

Figure 4. Maximum 7-day average of the daily maximum stream temperature in relation to elevation in the main-stem Coweeman River, WA in 2014. Data labels are river kilometers.

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Isaak, D. J. and W. A. Hubert. 2001. A hypothesis about factors that affect maximum summer stream temperatures across montane landscapes. Journal of the American Water Resources Association 37: 351-366.

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APPENDIX C

Overview of Elevation Data Collected in Project Area

Collected in summer of 2017

LEGEND

△2	SURVEY CONTROL POINT
POINT NUMBER ×ELEVATION DESCRIPTION	SURVEY POINT
▬ ▪ ▬	RIVER/STREAM FLOWLINE

COWEEMAN RIVER AND BAIRD CREEK CONFLUENCE SURVEY POINTS

SCALE: 1" = 60'

NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 665.33' WAS ESTABLISHED AT SURVEY CONTROL POINT #1 (½"X24", IRON ROD) USING GPS.

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COWEEMAN RIVER AND BAIRD CREEK CONFLUENCE SURVEY POINTS

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

C.1

COWEEMAN RIVER SIDE CHANNEL 2 SURVEY POINTS

SCALE: 1" = 60'

LEGEND

△2	SURVEY CONTROL POINT
POINT NUMBER ×ELEVATION DESCRIPTION	SURVEY POINT
▬ · ▬	RIVER/STREAM FLOWLINE

NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 719.86' WAS ESTABLISHED AT SURVEY CONTROL POINT #10 (½"X24", IRON ROD) USING GPS.

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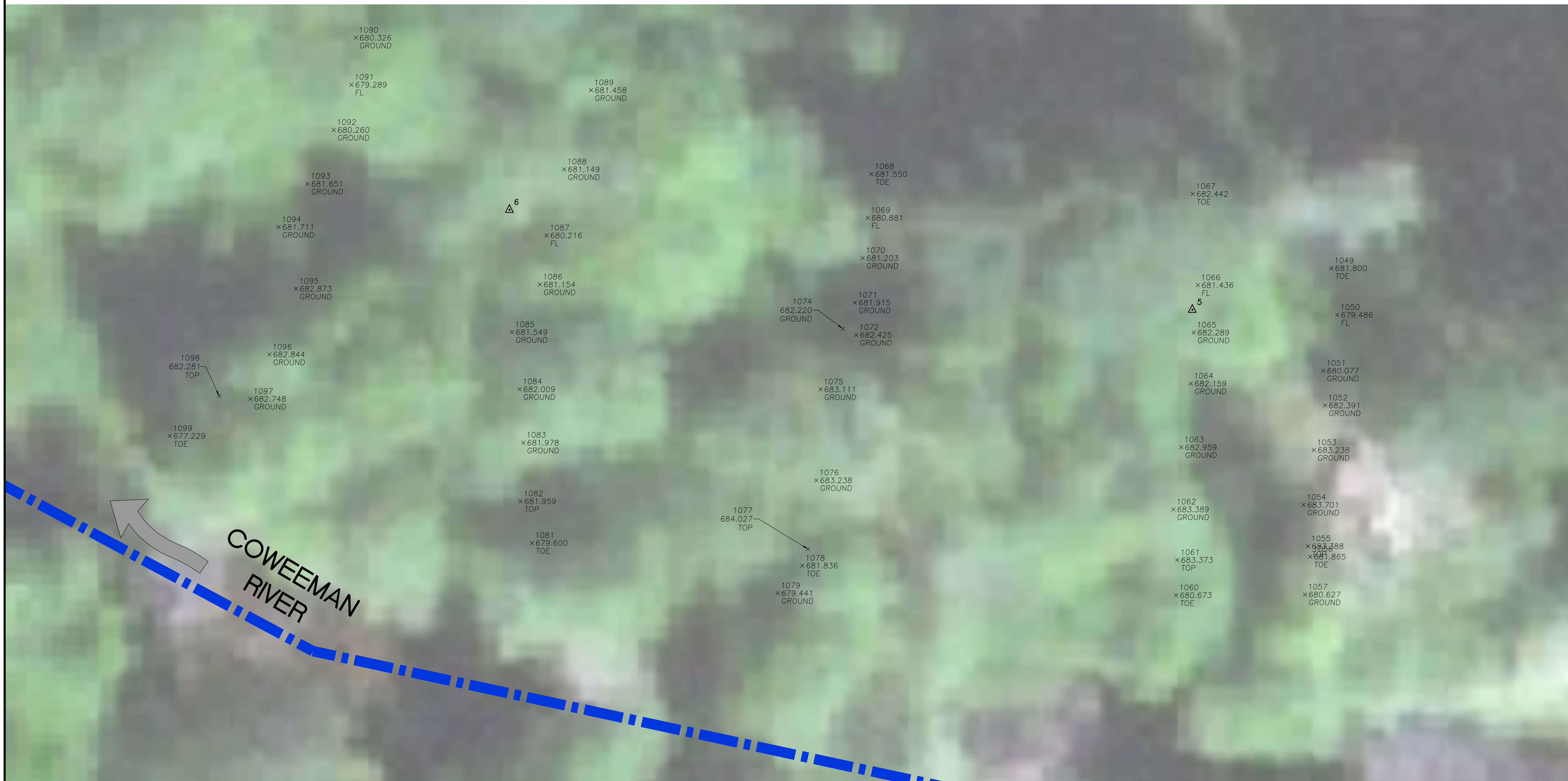
COWEEMAN RIVER SIDE CHANNEL 2 SURVEY POINTS

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

C.2



COWEEMAN RIVER SIDE CHANNEL 5 SURVEY POINTS

SCALE: 1" = 20'

LEGEND

△2	SURVEY CONTROL POINT
POINT NUMBER ×ELEVATION DESCRIPTION	SURVEY POINT
▬ ▪ ▬	RIVER/STREAM FLOWLINE

NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 681.85' WAS ESTABLISHED AT SURVEY CONTROL POINT #5 (½"X24", IRON ROD) USING GPS.

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COWEEMAN RIVER SIDE CHANNEL 5 SURVEY POINTS

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

C.3

LEGEND

$\triangle^2$ SURVEY CONTROL POINT

POINT NUMBER
×ELEVATION
DESCRIPTION — SURVEY POINT

COWEEMAN RIVER SIDE CHANNEL 7 SURVEY POINTS

SCALE: 1" = 40'

NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 844.32' WAS ESTABLISHED AT SURVEY CONTROL POINT #15 (½"X24", IRON ROD) USING GPS.

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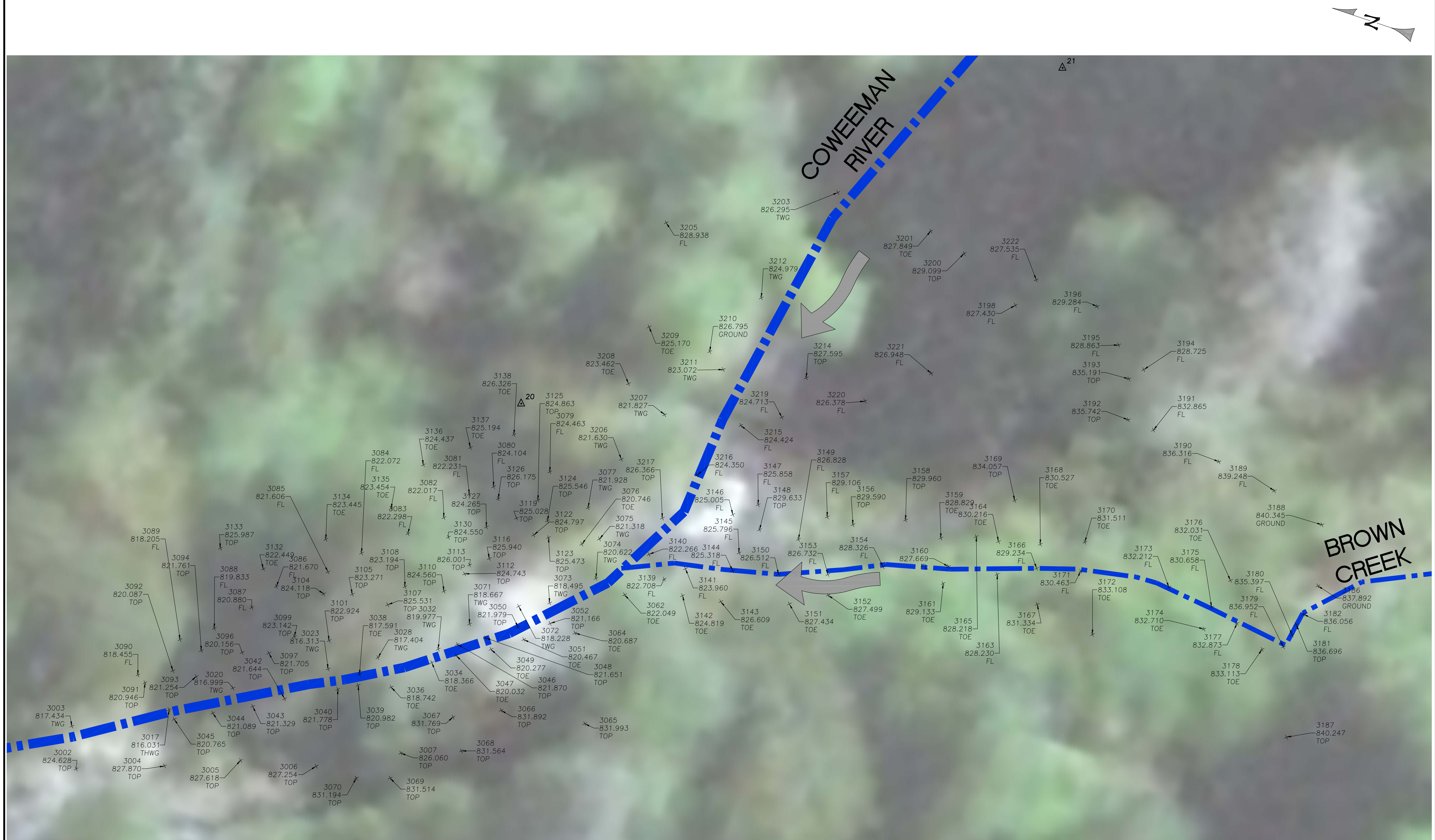
COWEEMAN RIVER SIDE CHANNEL 7 SURVEY POINTS

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

C.4



LEGEND

△2	SURVEY CONTROL POINT
POINT NUMBER ×ELEVATION DESCRIPTION	SURVEY POINT
▬ ▪ ▬	RIVER/STREAM FLOWLINE

COWEEMAN RIVER AND BROWN CREEK CONFLUENCE SURVEY POINTS

SCALE: 1" = 20'

NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 829.52' WAS ESTABLISHED AT SURVEY CONTROL POINT #20 (½"X24", IRON ROD) USING GPS.

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COWEEMAN RIVER AND BROWN CREEK CONFLUENCE SURVEY POINTS

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

FIGURE

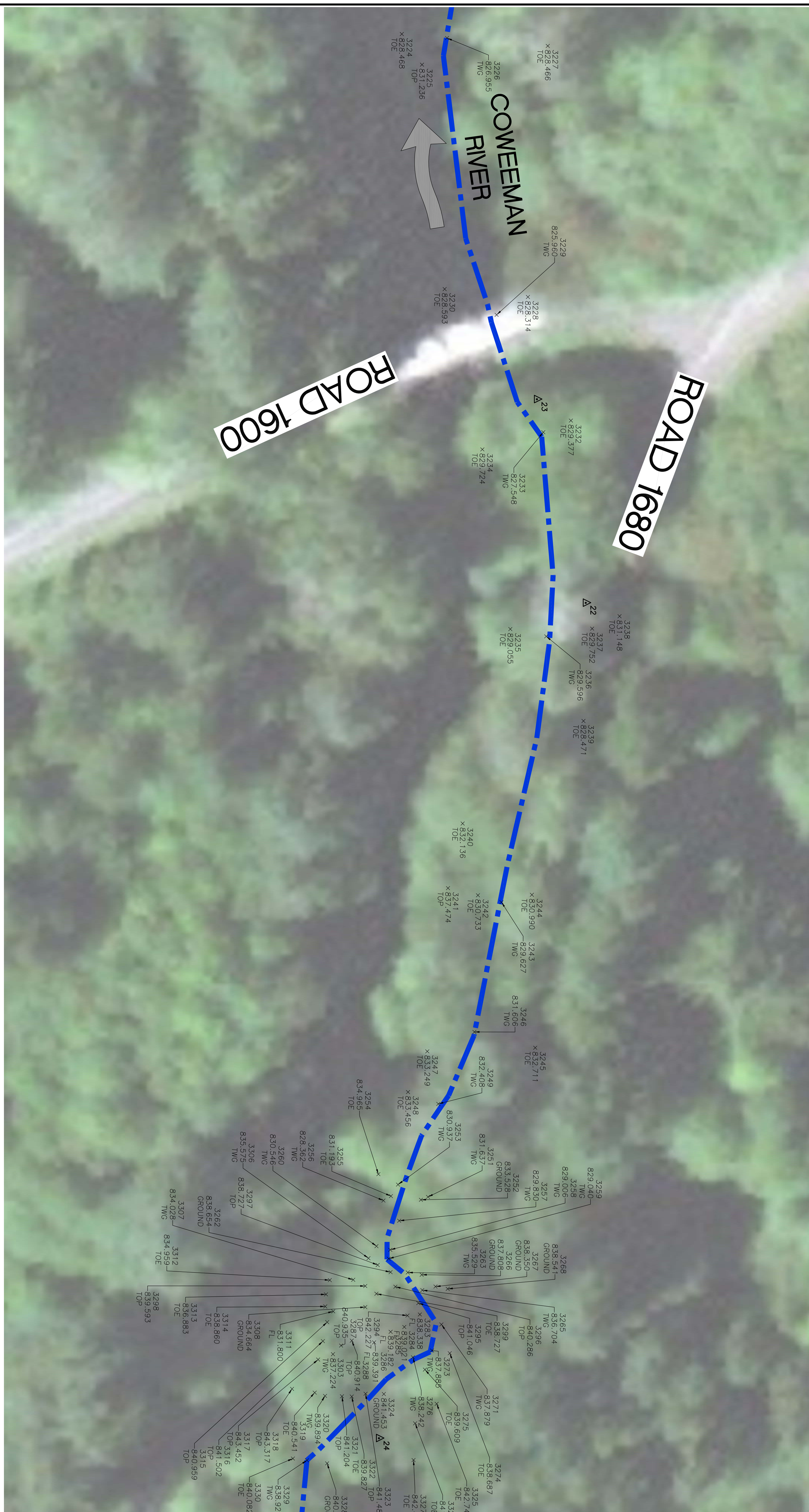
C.5

LEGEND

- SURVEY CONTROL POINT
- POINT NUMBER ×ELEVATION DESCRIPTION — SURVEY POINT
- RIVER/STREAM FLOWLINE

BROWN CREEK FALLS SURVEY POINTS

SCALE: 1" = 40'



NOTES:

1. ELEVATION DATUM: AN ASSUMED ELEVATION OF 829.52' WAS ESTABLISHED AT SURVEY CONTROL POINT #20 (1"x24" IRON ROD) USING GPS. SEE FIGURE C.5

FIGURE C.6

BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS

0 1"

BROWN CREEK FALLS SURVEY POINTS

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