Clear and Clearwater Creeks Alternatives Analysis

SUBMITTED TO
Gifford Pinchot National Forest
Mt Adams Ranger District

October, 2022

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1 Introduction

Restoration treatment alternatives for Clear and Clearwater Creeks were developed from observations and analyses performed as part of the geomorphic assessment[1] and an estimation of the feasibility of ground-based equipment access. Several key observations from the assessment provide direction for treatments:

- Certain reaches lack stable, persistent large wood, likely a result of past human management actions;
- Large wood accumulations—stabilized by key pieces—were observed to be the driver of a multi-channel planform and the channel and habitat complexity observed in certain reaches; and,
- Reaches that lack geomorphic complexity are also lacking key pieces; and, the forest surrounding many of those reaches are devoid of large trees (i.e., no source for key piece recruitment).

In light of these observations, the restoration treatments proposed for this alternatives analysis are focused on wood placement. Given the remoteness of Clear and Clearwater Creeks, the alternatives for this project are focused on the means and methods by which wood could be added to these systems. Options considered include wood placed via heavy lift helicopter, wood delivered via helicopter and placed with ground-based equipment, wood delivered and placed via ground-based equipment, and wood placed using both helicopter and ground-based equipment. The last option reduces the access requirements for ground-based equipment and increases the stability of the placed material.

The alternatives analysis presented below discusses division of the study reaches into project sites, the alternatives determined to be feasible for those project sites, and feasibility considerations for each alternative in each of the project areas.

[1] Clear and Clearwater Creek Geomorphic and Hydraulic Assessment Memo. 2022. Prepared for the Gifford Pinchot National Forest, United States Forest Service by DJ&A, P.C. and Inter-Fluve, Inc.

2 Alternatives

2.1 PROJECT AREAS & CONSTRUCTION ALTERNATIVES

In total, seven potential areas for restoration work were delineated along Clear and Clearwater Creeks based on the locations of project opportunities identified in the field. Construction alternatives for the proposed large wood structures are outlined below. The feasibility of construction alternatives was based on prior experience but not vetted for possible permit or landowner constraints. Four construction and large wood delivery alternatives are proposed as follows:

<u>Alternative 1: Helicopter Only</u> – A helicopter will place wood to construct large wood structures. This alternative does not require the development of staging areas on the floodplain but may require temporary access routes to construction sites, development of staging areas for materials and helicopter re-fueling, and previously decked large wood to be used in the project. Reasonable ingress and egress of helicopter crews will be required for all helicopter work within project areas. Helicopter wood placement is a feasible construction alternative in all proposed project areas depending on stability criteria for the placed wood.

<u>Alternative 2: Helicopter Construction / Ground Machine Reinforcement</u>– A helicopter will place large wood in areas accessible by excavator with attached vibratory driver. Following helicopter placement, an excavator will reinforce the structures by driving vertical logs into the earth at strategic locations throughout the structure via vibratory driver. This alternative requires the development of temporary access routes to construction sites but minimizes ground disturbance by eliminating the need for haul trucks and onsite wood staging.

<u>Alternative 3: Helicopter Delivery / Ground Machine Construction</u>– Large wood will be delivered by a helicopter and then structures will be constructed by ground-based equipment. Similar to Alternative 2, this alternative requires the development of temporary access routes to the locations of large wood structures and the development of wood staging areas on the floodplain, but reduces the number and type of vehicles travelling to sites relative to a purely ground-based approach. This is a feasible construction alternative where temporary access routes for ground-based equipment can be developed and minimizes ground disturbance that would result from ground-based wood delivery.

<u>Alternative 4: Ground-based Equipment Only</u> – Large wood structures will be constructed by ground-based equipment, with large wood delivered to staging areas on the floodplain via haul truck, skidder, or similar means. This alternative requires the development of temporary access routes to the locations of large wood structures for excavators, the development of wood staging areas on the floodplain, and access routes to the staging areas from existing roads passable to log trucks. This alternative is only proposed for the two lowermost project areas of Clear Creek where access from Spencer Road (FS-93) is most feasible.

The locations of the five project areas along Clear Creek and potential access routes are shown in Figure 1 (note that larger format maps are available in Appendix A). Helicopter only construction (Alternative 1) is feasible for all five sites while all machine-based construction alternatives (Alternatives 2-4) are only proposed at project areas one and two, the downstream-most project sites. Construction without helicopter operations (Alternative 4) is feasible for Clear Creek project areas one and two due to ease of access from where Spencer Road crosses the floodplain, and all access options originate in the vicinity of this crossing. A decommissioned road on the east side of Clear Creek could allow ground-based machine access to the upstream project areas (Figure 1), but this route crosses many tributaries and is located on the hillslope above the floodplain. It will likely require the re-installation of several crossings and the construction of new, temporary access routes through steep terrain, from the decommissioned road to the floodplain and project sites. In contrast, construction access routes across select areas of the valley bottom and bar surfaces are flatter and more easily created, restored, and/or enhanced following construction activity.

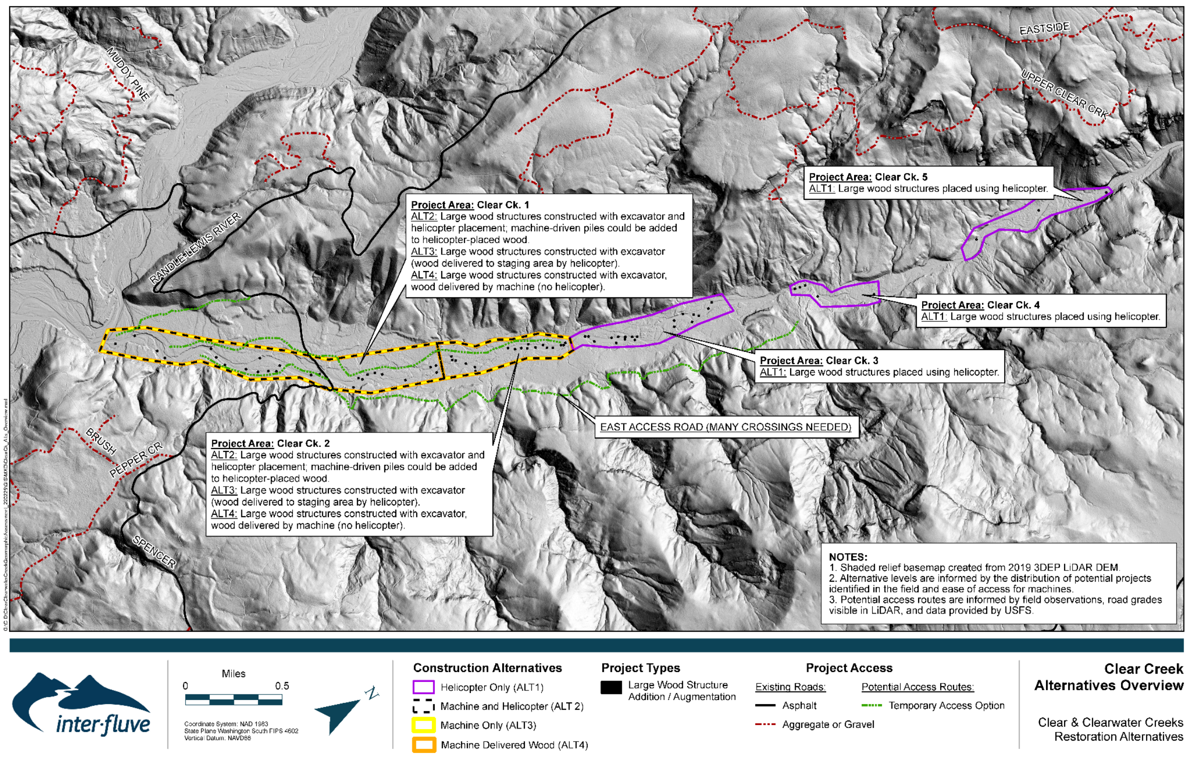

Figure 1: Map of Clear Creek project sites and construction alternatives.

The location of the two project areas along Clearwater Creek are shown in Figure 2 (note that larger format maps are available in Appendix A). Access to Clearwater Creek is more limited than to Clear Creek, requiring significant re-establishment of decommissioned or destroyed roads (access via Randle-Lewis River Rd.) or crossing the Muddy River (access via Smith Creek Trailhead Rd.). All Clearwater Creek project sites require helicopter operations to deliver wood to the floodplain as wood delivery by truck and/or machine is not considered feasible or could not be completed at a total cost less than helicopter delivery volumes proposed in the projects. Large wood structure construction using machines (Alternatives 2 and 3) are proposed for the downstream project site on Clearwater Creek, and machine access to remove the bridge which crosses Clearwater Creek just upstream of the confluence with the Muddy River is included for all construction alternatives.

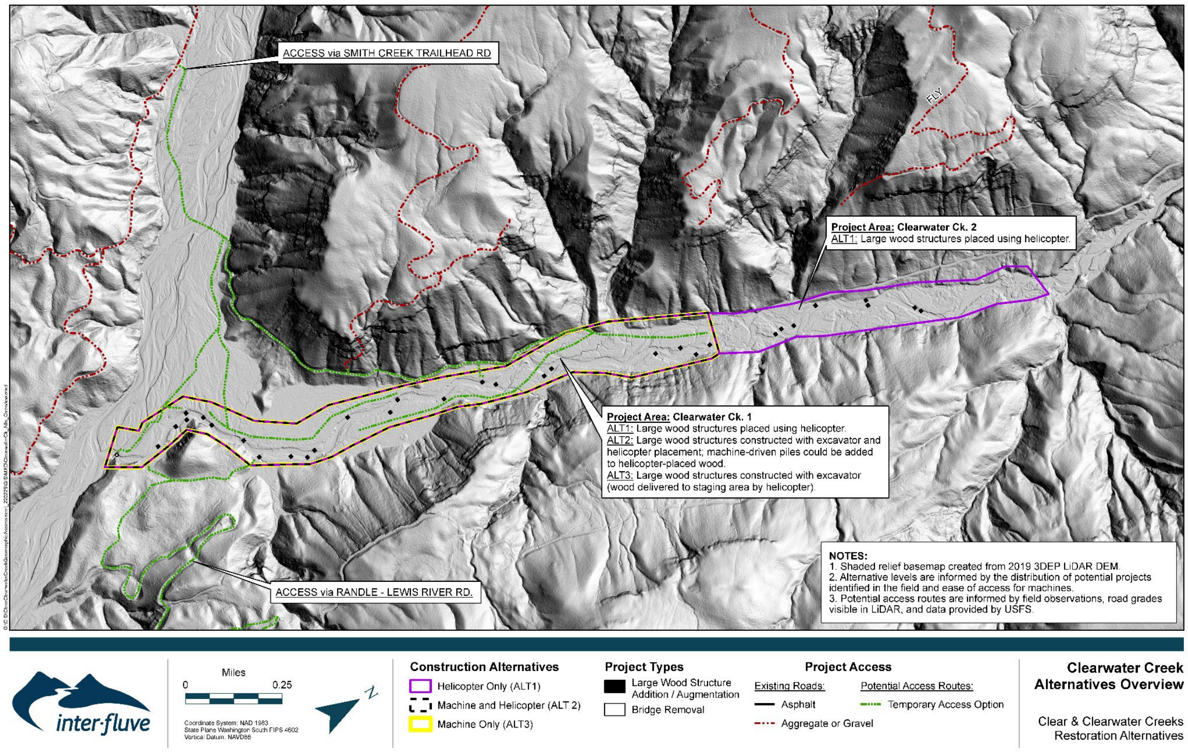

Figure 2: Map of Clearwater Creek project sites and construction alternatives.

2.2 PROPOSED TREATMENTS

As identified in the geomorphic assessment, the proposed treatment for each of the project areas and alternatives consists of various forms of wood loading. The proposed projects will import logs with root wads to a nearby staging area, and place them in the channel and adjacent floodplain using either a heavy lift helicopter (Figure 3) or ground-based equipment. The proposed structures, regardless of method of placement, will enhance channel complexity in zones where they are able to influence geomorphic processes (e.g., sediment sorting, lateral migration, plane bed scour). The wood structures will be constructed by directing the helicopter pilot on the placement and orientation of each large wood piece (Figure 4) or with excavator operators constructing structures per plan. Individual wood pieces will be concentrated laterally and vertically to provide the stability required during channel forming flows (and higher) to drive bed movement (vertical and lateral), floodplain inundation, side channel development, gravel sorting and deep pool scour. To achieve these large wood-forced geomorphic processes and resulting habitat complexity, various configurations of wood structures are proposed for the project and are described as follows.

Figure 3. Heavy lift helicopter moving large wood into White Creek near Mount Adams, WA. Photo credit: Yakima-Klickitat Fisheries Project

Figure 4. Helicopter placed wood structures on the Twisp River, WA. (Photo credit: Yakama Nation)

Apex Wood Structures

Apex large wood structures are intended to sort sediments, rack mobile wood, and promote split-flow conditions. These structures are sited adjacent to existing side channels or low swales in the floodplain, or in proximity to river banks that have mature trees at the edge. Structures sited next to swales and side channels are intended to push flow into those features so they are wetted more frequently, while structures sited next to banks are intended to encourage large wood recruitment into the river from the banks. Both uses of the structure reduce instream velocity and sort sediments, providing surfaces that can be recolonized by pioneer vegetation. The structure may be ballasted with vertical logs, sediment, additional wood, and/or braced against existing stable wood. For this project, there are many opportunities to achieve the function of an apex wood structure by loading existing, stable rootwads with additional wood. This increases the stability of helicopter-placed wood. Slash is placed beneath exposed rootwads along the upstream face of the structure to add complexity. Deep-rooted plants can be incorporated into the structure to facilitate revegetation of the structure footprint and add a stabilizing influence.

Figure 5. Apex-type wood structures built with a helicopter (left) and ground-based equipment (right).

Bank-attached Wood Structures

Bank-attached wood structures are proposed for locations where existing pools lack cover, or where additional roughness is desired. These structures can be placed via heavy lift helicopter or ground-based equipment, and they can be stabilized with driven vertical logs, sediment, or additional wood ballast. These structures promote pool scour, sort sediment, and provide shaded cover habitat. For this project these structures are also proposed to be created by adding wood to either previously constructed structures or existing snags.

Tipped Whole Trees

Tipped whole trees can create a substantial geomorphic influence by racking mobile wood, sorting sediment, and encouraging the formation of split-flow conditions and avulsions. In particular, the Clear Creek floodplain—which features older stands of trees—contains a number of large trees that could be tipped. Trees can be tipped with ground-based equipment (e.g., excavators, cable, and block and tackle setups) and potentially via helicopter. With ground-based equipment, trees can typically be tipped with rootwads intact; however, the helicopter tips trees by breaking the stem and thus does not include the rootwad. Tipped trees are proposed for this project in instances where large trees are available, the location is determined to respond favorably to the tree, and where they would/or to add additional ballast and complexity to other proposed features.

2.3 LARGE WOOD STABILITY ANALYSIS

Large wood stability was assessed at a conceptual level to facilitate estimates of total wood volume and to gauge ballast requirements for each alternative under varying flow conditions. Both passive and active methods of ballasting were considered, including self-ballast, timber piles (i.e., vertical logs), and soil overburden. Appropriate ballasting methods can vary based on a number of factors, such as construction methods, site access, and size of the large wood material and hydraulic forces at various flood flows. The methods considered in this analysis are as follows:

- For helicopter-placed wood, large wood stability is typically achieved through self-ballast, which requires sufficient weight above the water surface under design conditions to counteract the buoyant and hydraulic forces. Self-ballast can also be enhanced by using mature trees along the channel banks to brace top layer logs. Vertical stacking can be used to provide ballast and emulate the mass of larger sized large wood to develop similar key piece stability, longevity and complexity.
- Where heavy equipment access is possible, helicopter-placed wood can be also be augmented with timber piles. While not always necessary, timber piles can add additional stability to helicopter-placed wood in higher risk areas, and reduce the structure height (vertical stacking) in a given large wood configuration that would be required to maintain stability during comparative high flows.
- Driven, vertical logs can also be used to ballast machine-based large wood placements in the same manner as they would in helicopter placed wood. In configurations that are along the channel bank, heavy equipment can also be used to bury a portion of the logs to provide additional ballast through soil overburden not possible during helicopter placements.

With the project currently at a planning level, there are a number of uncertainties that can significantly impact the large wood stability calculations. Available large wood size and volume, risk tolerance, hydrology, hydraulics, and structure configuration are just some of the variables typically considered in large wood stability analyses, and each of these are expected to be refined as the design progresses. As such, the current stability analysis utilizes a volume-based approach, and uses the relationship between the submerged and unsubmerged portions of the large wood placements to assess stability at a variety of flow depths. Top-of-bank heights were geospatially estimated at each proposed large wood structure location, and used as a proxy for flow depth. Flow depths were subsequently used to determine the corresponding structure height that would be required to achieve a self-ballasted factor of safety of 1.2.

The total wood volume for each alternative was estimated by assuming that 25% of the total 3-dimensional structure footprint is occupied by wood, which is a conservative assumption derived from detailed large wood design on similar projects. The wood volume for machine-placed structures were similarly estimated, although the total structure height was reduced to 2-feet above the corresponding top-of-bank height, assuming that the added stability of active ballasting methods could reduce the total structure height. The resultant relationships between wood volume and flow depth are highlighted in Figure 5.

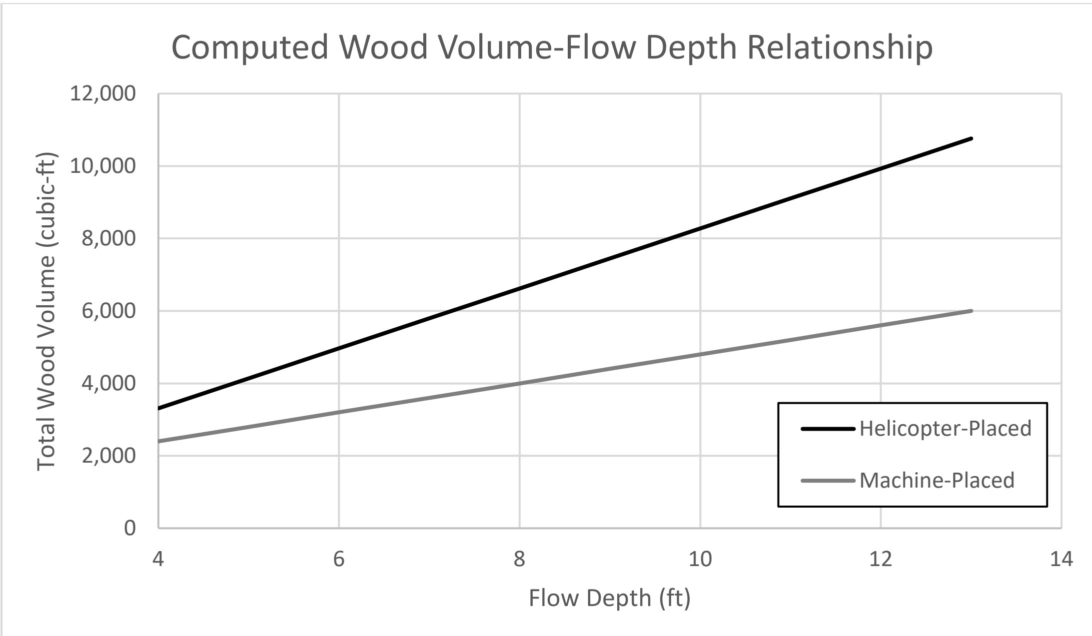

Figure 6. Computed wood volume-flow depth relationship required to achieve a factor of safety of 1.2.

Using an assumed factor of safety of 1.2 allows for future flexibility in the design, based on site specific topographic and hydraulic characteristics. It's important to note that the designs can be refined in subsequent design phases to achieve varying degrees of stability under site-specific conditions. Figure 7 highlights how the factor of safety in a general structure configuration changes with flow depth, for different heights of self-ballasted large wood structures. A range of structure heights are presented, conservatively estimated from the LiDAR and generalized for the entire study area. For machine-placed structures, there is substantially more flexibility in the structure heights and target factors of safety, as active ballasting methods are expected to be used (e.g., partial burial and/or pile ballasted with threaded rod).

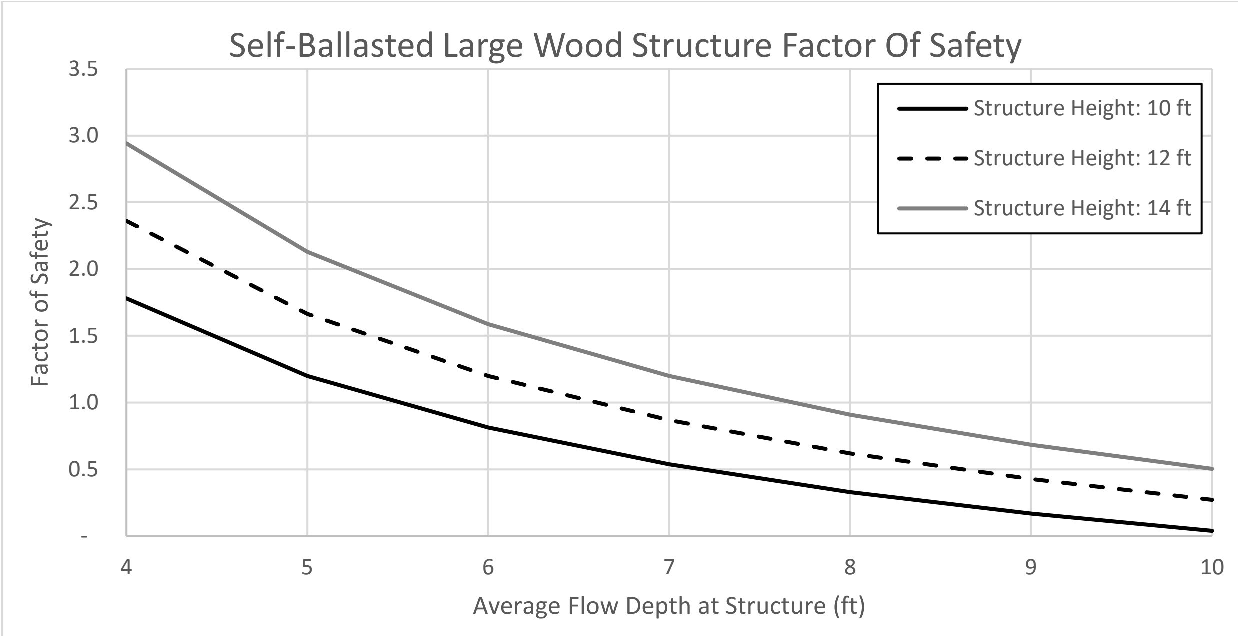

Figure 7. Self-ballasted large wood structure factor of safety variation with flow depth. Note that the structure heights displayed in this figure are conservative estimates of the structure heights needed in the study area. Future design stages will require further evaluation to determine site-specific structure heights.

2.4 ALTERNATIVE DESCRIPTIONS

The details of each project site along Clear and Clearwater Creeks are described, including the details of the large wood structures, access considerations, and construction alternatives proposed for each project site. Accompanying the descriptions provided below, Appendix A includes maps which show the location and type of each proposed large wood structure, the location of trees identified for tipping into the channel, proposed access routes, and other project area details of each project site. An approximate number of logs required for each project area are estimated on volume-based stability considerations and the assumption that large wood structures will be constructed using an average log size of 40 feet in length, 22-inch diameter logs with rootwad attached (approximately 125 ft^3 per log). Further design will refine log size criteria, possibly requiring larger diameter material.

2.4.1 Clear Creek Projects

Clear Creek Project 1 proposes the construction and/or enhancement of 29 large wood structures and tipping trees from the floodplain into the channel in 7 locations. Machine access is feasible at this site for excavators and for machine/truck-based wood delivery, and all construction alternatives are options for this site. Large wood structure treatments for this project include 4 structures that add to existing wood in the channel and/or the floodplain, 21 apex structures, and 4 bank attached/buried structures. If constructed using the helicopter-only method (Alternative 1), the large wood structures would be composed of approximately 188,000 ft^3 of wood, roughly 1,500 logs. If the alternative to construct with ground-based equipment is selected (Alternatives 2, 3, 4), whereby structures could be stabilized by driving vertical logs, approximately 114,000 ft^3 of wood (roughly 910 logs) would be required.

Clear Creek Project 2 proposes the construction and/or enhancement of 18 large wood structures and tipping trees from the floodplain into the channel in 4 locations. Machine access is feasible at this site for excavators and for machine/truck-based wood delivery, meaning that all construction options are available for this site. Large wood structure treatments for this project include 8 structures that add to existing wood in the channel and/or the floodplain and 10 apex structures. If constructed using the helicopter-only method (Alternative 1), the large wood structures would be composed of approximately 108,000 ft^3 of wood, roughly 870 logs. If constructed with ground-based equipment enabling the use of driven vertical logs (Alternatives 2, 3, 4), approximately 67,000 ft^3 of wood (roughly 535 logs) would be required.

Clear Creek Project 3 proposes the construction and/or enhancement of 24 large wood structures. Ground-based machine access to this site would require reestablishment of the decommissioned road on the east side of Clear Creek and the establishment of temporary access routes descending from the road to the floodplain, therefore only Alternative 1 is proposed for this site. Proposed treatments include 22 structures that add to existing wood in the channel and/or the floodplain, and 2 apex structures, composed of approximately 180,000 ft^3 of wood (roughly 1,445 logs).

Clear Creek Project 4 proposes the construction and/or enhancement of 6 large wood structures which add to existing wood in the channel and/or the floodplain. Machine access at this site is possible if the entirety of the decommissioned road on the east side of Clear Creek is reestablished. However, under current circumstances, helicopter-only construction (Alternative 1) is proposed. Wood structures would consist of approximately 46,500 ft^3 of wood, or roughly 370 logs.

Clear Creek Project 5 proposes the construction and/or enhancement of 6 large wood structures which add to existing wood in the channel and/or the floodplain. Ground-based machine access is not anticipated to be feasible for this site, and therefore, only Alternative 1 (wood-loading via helicopter) is proposed. Large wood structures would consist of approximately 45,500 ft^3 of wood, or roughly 365 logs.

2.4.2 Clearwater Creek Projects

Clearwater Creek Project 1 proposes the construction and/or enhancement of 36 large wood structures, tipping one large fir tree into the channel, and removing the bridge at the confluence of Clearwater Creek and the Muddy River. Excavator access is feasible at this project site, and the site is most readily accessed by crossing the Muddy River from Smith Creek Trailhead Road. Depending on the nature of that crossing, it is anticipated that wood will need to be delivered to project sites by helicopter. Alternatives 1-3 are feasible for this project area. Proposed large wood structures for this project include 24 structures that add to existing wood in the channel and/or the floodplain, 11 apex structures, and 1 bank attached/buried structure. If constructed using the helicopter-only method (Alternative 1), the large wood structures would be composed of approximately 230,000 ft^3 of wood, roughly 1,830 logs. If constructed with ground-based equipment (Alternatives 2, 3), approximately 140,000 ft^3 of wood (roughly 1,115 logs) would be required.

Clearwater Creek Project 2 proposes the construction and/or enhancement of 8 large wood structures. Ground-based equipment access via the Clearwater Creek floodplain upstream of the Project 1 would require removal of portions of existing valley-spanning jams and is thus assumed infeasible. Therefore, only Alternative 1 was considered for this project area. Proposed large wood treatments at this site include 4 structures that add to existing wood in the channel and/or the floodplain and 4 apex structures. The projected wood volume is approximately 54,000 ft^3 of wood, roughly 430 logs.

3 Feasibility Considerations

Site access is the primary consideration for constructability and feasibility, as the access dictates construction methods, log delivery methods, ecological impacts of construction, and ultimately habitat uplift. The project areas are on United States Forest Service (USFS) land and ecological impacts or areas of concern have not been discussed. Therefore, what has been presented may require alteration or deletion based on future collaboration and knowledge of specific USFS requirements within the proposed project areas.

3.1 CONSTRUCTION METHODS

3.1.1 Machine-Based Construction

The feasibility of machine-based construction is largely governed by the ability to access the project sites with heavy equipment. Many areas are difficult to access and may require significant temporary access road construction in some areas to get from the more established roads where tracked equipment would likely be delivered and staged, to sites identified for large wood structures. There are decommissioned roads that run along portions of the project reach in some areas that could be reestablished and used for temporary access; however, a review of the LiDAR data shows that there could be multiple tributary and drainage crossings that would likely require establishing culverts or temporary bridges.

Temporary access through the floodplain between the project sites with tracked equipment is expected to require less impactful road improvements, and would most likely consist of clearing fallen trees and other vegetation to make a path wide enough to travel between sites. While the heavy equipment performing the construction (e.g., large excavators) would only use the temporary access roads for a single ingress/egress, many of the project sites are separated from the main roads by miles, and construction crews would need to use the temporary access routes daily to transport personnel, fuel, and other miscellaneous construction equipment. Temporary access roads are typically decommissioned and revegetated with native vegetation following construction and are assumed receive a similar treatment for this project.

3.1.2 Helicopter-Based Construction

When compared to machine-based construction methods, helicopter-based construction is typically much less impactful given that no temporary access routes are needed to install the large wood material. However, the large wood needs to be staged, decked, and continuously sorted for helicopter transport during construction, and therefore a large staging area or areas are required.

The two main feasibility considerations for helicopter-based construction are cost and lift capacity. The hourly rate for helicopters is substantially higher than that of typical heavy equipment; however, the efficiency and ability to move a large volume of wood in a relatively short amount of time can offset the high cost. Helicopters are also limited in lift capacity, which restricts the size of trees that can be moved. Maximum hook weights (i.e., lift capacity) for a 234 model Chinook helicopter is 28,000 pounds. The smaller model 107-II Vertol has a maximum hook weight of 11,500 pounds. However, lift capacity is affected by a number of factors, including elevation, wind, temperature (high), and fuel cycles that can lower the maximum specified hook weights provided listed above. Larger lift capacities equate to higher costs, but also equate to higher efficiency. Matching lift need with wood size and volume determines the most efficient helicopter to use in a project.

3.2 LOG DELIVERY

Log delivery is another important feasibility consideration that is related to the construction method chosen. The access road considerations described in Section 3.1 are specific to ingress/egress of construction equipment and do not account for log delivery using ground-based methods. For ground-based construction methods, logs would need to be delivered to the project sites using a standard log truck or to a nearby stockpile site where they would be skidded or trucked with an off-road dump truck. Based on experience, ground-based access to several areas is likely infeasible due to slopes, soft soils, uneven terrain, and the prohibitive costs of access route construction.

Alternatively, logs can be delivered to small stockpiles adjacent to ground-based construction sites using a helicopter. Creating multiple stockpiles increases the ecological impacts; however, the impacts are far less than what would be required to make access road improvements that are suitable for log delivery over long distances.

Another consideration related to log delivery is crossing the river channel where needed to install large wood structures. “Wet Crossings” are minimally impactful, and typically a viable option to get tracked equipment across the channel one time as needed. However, transporting logs across the channel with equipment or trucks would require multiple trips, thus likely requiring a temporary bridge or other measures to reduce impacts to the stream channel.

3.3 HABITAT UPLIFT

There are many project areas that are simply infeasible for heavy equipment to access due to the factors described previously. The inability to access certain areas reduces the amount of treatable area, thus reducing the potential habitat uplift. In sites where heavy equipment access is feasible, there is potentially more flexibility in the size and configuration of large wood material that could be installed, which could translate to increased habitat uplift. In areas with relatively easy access a significant reduction in cost per structure is possible. A summary of feasibility considerations for each project area, and how those may pertain to habitat uplift, is provided in Tables 1 and 2.

Table 1. Alternative summary for Clear Creek.

Clear Creek						
Alt	**Project Areas[1]**	**Total Stream Length[2] (ft)**	**Proposed Volume of Wood Additions[3,4] (ft^3)**	**Estimated Number of Trees[3,4]**	**Expected Habitat Uplift**	**Construction Considerations**
1	1,2,3,4,5	30,430 (5.8 mi)	576,040	4,600	Distributed wood treatment, via heavy lift helicopter, would add much needed complexity to largest possible treatment area.	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 1. Wood stability depends on volume of wood placed.
2	1,2	17,560 (3.3 mi)	457,495	3,700	Achieves wood placement in areas most deficient of in situ, stable large wood. Vertical logs increase longevity, and likely, geomorphic effectiveness of structures.	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 2. Wood stability improved with vertical logs and/or burial.
3	1,2	17,560 (3.3 mi)	185,200	1,500	Achieves wood placement in areas most deficient of in situ, stable large wood. Vertical logs increase longevity, and likely, geomorphic effectiveness of structures.	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 3. Wood stability improved with vertical logs and/or burial. Establishment of temporary access through wetlands and potentially sensitive areas will need to be evaluated.
4	1,2	17,560 (3.3 mi)	185,200	1,500	Achieves wood placement in areas most deficient of in situ, stable large wood. Vertical logs increase longevity, and likely, geomorphic effectiveness of structures.	Wood stability improved with ground-based machine placement, vertical logs, and/or burial. Establishment of temporary access through wetlands and potentially sensitive areas will need to be evaluated.

Notes:
1. Refer to Appendix A for maps of project areas.
2. Total stream length is the length of the included project areas, measured along an approximate thalweg as interpreted from the LiDAR. Multiple threads and side channels were not included in the length measurement.
3. Wood volumes are based on assumptions about structure sizes and estimated for the entire project area.
4. The equivalent log quantities shown in the table assume an average log dimension of a 22-inch diameter, 40-foot long rootwad log. Required log dimensions will be determined in the design process.

Table 2. Alternative Summary for Clearwater Creek.

Clearwater Creek						
Alt	**Project Areas[1]**	**Total Stream Length[2] (ft)**	**Proposed Volume of Wood Additions[3,4] (ft^3)**	**Estimated Number of Trees[3,4]**	**Expected Habitat Uplift**	**Construction Considerations**
1	1,2	14,820 (2.8 mi)	278,510	2,200	Distributed wood treatment, via heavy lift helicopter, would add much needed complexity to largest possible treatment area	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 1. Wood stability depends on volume of wood placed.
2	1	9620 (1.8 mi)	190,400	1,500	Achieves wood placement in areas most deficient of in situ, stable large wood. Vertical logs increase longevity, and likely, geomorphic effectiveness of structures.	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 1. Wood stability improved with vertical logs and/or burial.
3	1	9620 (1.8 mi)	136,600	1,100	Achieves wood placement in areas most deficient of in situ, stable large wood. Vertical logs increase longevity, and likely, geomorphic effectiveness of structures.	Distances to source decks, turn times, size of trees, total volume of wood, and accessibility for ground crews all need to be considered for Alternative 1. Wood stability improved with vertical logs and/or burial. Establishment of temporary access through wetlands and potentially sensitive areas will need to be evaluated.

Notes:

Refer to Appendix A for maps of project areas.

Total stream length is the length of the included project areas, measured along an approximate thalweg as interpreted from the LiDAR. Multiple threads and side channels were not included in the length measurement.

Wood volumes are based on assumptions about structure sizes and estimated for the entire project area.

The equivalent log quantities shown in the table assume an average log dimension of a 22-inch diameter, 40-foot long rootwad log. Required log dimensions will be determined in the design process.

4 Cost Estimate

The planning level costs for each alternative are provided in Table 3 and Table 4. The costs are primarily based on the estimated volume of wood, which varies substantially between alternatives given the wide range in project area for each alternative. As such, costs were normalized to a "per log" basis, to facilitate comparison between the alternatives and estimate the order of magnitude log quantities. These "per log" costs assume an average log (with an attached rootwad) dimension of 22-inch diameter and 40 feet long, which is on the larger end of a typical log used in a stream restoration project. It's important to note that the log quantities are highly sensitive to the size of the large wood material, and it is anticipated that relatively large logs (i.e., larger than the average size used to develop the cost estimates) would be used in some capacity in these projects.

Wood procurement can also greatly affect project cost, and therefore large wood prices in the cost estimate conservatively include purchase, delivery, and handling, with price assumptions that are based similar projects that have been recently completed. Additional variables such as the type and size of wood, as well as the staging area locations can affect helicopter turn times. Log weights for helicopter transport were assumed based on a green density of 47 lb./cubic ft, and relatively long turn times were factored in to the alternatives that include helicopter placement or delivery. Given this high degree of uncertainty at the current planning level phase, the estimated costs should be expected to have an accuracy range between -30% and +50%, per AACE guidelines.

Table 3. Planning level cost estimate for Clear Creek project Alternatives.

	Clear Creek												
	Quantity					**Unit Cost**				**Cost**			
	Alt 1	**Alt 2**	**Alt 3**	**Alt 4**	**Unit**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**
Miscellaneous[1]										**$ 100,000**	**$ 100,000**	**$ 75,000**	**$ 75,000**
Mobilization/Demobilization	1	1	1	1	LS	$ 100,000	$ 100,000	$ 75,000	$ 75,000	$ 100,000	$ 100,000	$ 75,000	$ 75,000
Staging, Storage, Access[2]										**$ 6,000**	**$ 16,000**	**$ 14,000**	**$ 32,000**
Staging Areas	3	2	1	1	AC	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 6,000	$ 4,000	$ 2,000	$ 2,000
Temporary Access	0	4	4	4	MI	$ -	$ 3,000	$ 3,000	$ 7,500	$ -	$ 12,000	$ 12,000	$ 30,000
Large Wood[3,4]										**$ 8,100,000**	**$ 7,800,000**	**$ 2,300,000**	**$ 2,300,000**
Large Wood Installation[3]	576,040	457,495	185,200	185,200	CF	$ 14	$ 17	$ 12	$ 12	$ 8,100,000	$ 7,800,000	$ 2,300,000	$ 2,300,000
Equivalent Log Quantity[4]	*4,600*	*3,700*	*1,500*	*1,500*	*EA*				*Per-Log Project Cost*	*$ 1,800*	*$ 2,100*	*$ 1,600*	*$ 1,600*
									Sub-Total	**$ 8,206,000**	**$ 7,916,000**	**$ 2,389,000**	**$ 2,407,000**
									Contingencies (30%)	$ 2,461,800.0	$ 2,374,800.0	$ 716,700.0	$ 722,100.0
									Project Totals (Rounded Up)	**$ 10,700,000**	**$ 10,300,000**	**$ 3,200,000**	**$ 3,200,000**

Abbreviations

LS= Lump Sum, AC = Acre, MI=Mile, CF= Cubic Feet, EA= Each

Notes:

1. Mobilization/Demobilization is a lump sum estimate and includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site.
2. Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate.
3. Large wood includes purchase, delivery, stockpiling, and installation of large wood material.
4. Large wood costs are based on an assumed volume of large wood material for the entire project area, and the actual log quantities may vary substantially based on the size and shape of the large wood material available. The Equivalent log quantities shown in the table assume an average log dimension of a 22" dbh, 40-foot long rootwad log.

Table 4. Planning level cost estimate for Clearwater Creek project alternatives.

	Clearwater Creek									
	Quantity			Unit	Unit Cost			Cost		
	Alt 1	Alt 2	Alt 3		Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Miscellaneous[1,2]								**$ 140,000**	**$ 140,000**	**$ 115,000**
Mobilization/Demobilization[1]	1	1	1	LS	$100,000.0	$100,000.0	$75,000.00	$ 100,000	$ 100,000	$ 75,000
Bridge Removal[2]	1	1	1	LS	$ 40,000.0	$ 40,000.0	$ 40,000.0	$ 40,000	$ 40,000	$ 40,000
Staging, Storage, Access[3]								**$ 4,000**	**$ 14,000**	**$ 14,000**
Staging Areas	2	1	1	AC	$ 2,000	$ 2,000	$ 2,000	$ 4,000	$ 2,000	$ 2,000
Temporary Access	0	4	4	MI	$ -	$ 3,000	$ 3,000	$ -	$ 12,000	$ 12,000
Large Wood[4,5]								**$ 3,900,000**	**$ 3,300,000**	**$ 1,700,000**
Large Wood Installation[4]	278,505	190,400	136,600	CF	$ 14	$ 17	$ 12	$ 3,900,000	$ 3,300,000	$ 1,700,000
Equivalent Log Quantity[5]	*2,200*	*1,500*	*1,100*	*EA*			*Per-Log Project Cost*	*$ 1,800*	*$ 2,300*	*$ 1,600*
							Sub-Total	**$ 4,044,000**	**$ 3,454,000**	**$ 1,829,000**
							Contingencies (30%)	$ 1,213,200.0	$ 1,036,200.0	$ 548,700.0
							Project Totals (Rounded Up)	**$ 5,300,000**	**$ 4,500,000**	**$ 2,400,000**

Abbreviations

LS= Lump Sum, AC = Acre, MI=Mile, CF= Cubic Feet, EA= Each

Notes:

1. Mobilization/Demobilization is a lump sum estimate and includes mobilization of all equipment and personnel to the project site, project site preparation not covered under other bid items, and other miscellaneous items that may be needed to perform the project work. Mobilization/Demobilization assumes a single mobilization/demobilization of equipment to the project site.
2. Includes demolition, offsite haul, and legal disposal of the existing bridge (Placeholder Estimate)
3. Staging, Storage, Access includes all site preparation required to allow equipment and personnel to access the work areas. Staging, Storage, Access assumes that all access will be temporary and fully decommissioned once the project is complete. Improvements such as temporary culverts, bridges, or other geotechnical measures that may be necessary for slope stabilization are not included in this estimate.
4. Large wood includes purchase, delivery, stockpiling, and installation of large wood material.
5. Large wood costs are based on an assumed volume of large wood material for the entire project area, and the actual log quantities may vary substantially based on the size and shape of the large wood material available. The Equivalent log quantities shown in the table assume an average log dimension of a 22" dbh, 40-foot long rootwad log.

5 Discussion and Conclusion

A concept-level alternatives analysis for project opportunities with the general goals of improving habitat complexity for the spawning and rearing life stages of spring Chinook and Coho salmon has been developed for Clear and Clearwater Creeks on the Gifford Pinchot National Forest. Based on field observations of in site large wood and desktop analyses, alternatives were differentiated based on the means and methods by which large wood could be added to these systems. Options considered include wood placed via heavy lift helicopter, wood delivered via helicopter and placed with ground-based equipment, wood delivered and placed via ground-based equipment, and wood placed using both helicopter and ground-based equipment.

Cost estimates for each of the alternatives were developed from wood volume estimates and assumptions regarding wood purchase, deliver, stockpiling, and installation. It is assumed that wood would be acquired at market prices, however the USFS may be in a position to provide much of the material required. Therefore, the estimated costs for each alternative could be refined with more information on actual wood costs, available tree sizes, and harvest locations.

The extents of each of the alternatives, as assumed for this assessment, are detailed above and displayed Appendix A. With limited project resources, there are opportunities to scale back or phase each of the alternatives. Efforts to scale back the alternatives should be made by prioritizing specific, or focusing on fewer, project areas. To best affect the project goals, the volume of wood and density and sizes of proposed structures should be kept similar to those used for this alternatives analysis.

Phasing project areas is another option to implement treatments with limited resources. Based on physical characteristics, Project Area 1 on Clear Creek and Project 1 on Clearwater Creek should be prioritized as they were generally less geomorphically complex than the other areas. Both project areas have relatively straightforward access, though crossing the Muddy River is required to reach Clearwater. Biological factors, such as redd densities or observed fish use, could be used to either further discretize these project areas or prioritize the remaining areas.

Appendix A Alternative Maps