Hydrology Specialist Report

Introduction

The purpose of this report is to analyze the effects of timber sale harvest and other associated activities proposed under the Hwy 46 Environmental Impact Statement (EIS). This assessment builds on the soil analysis of soil stability and compaction to determine effects, design elements, and restoration opportunities for hydrology, riparian resources and water quality.

The 31,295 acre-project area is located in the Breitenbush River fifth field watershed (HUC 1709000501). Approximately 4,046 acres were considered for treatment as commercial timber harvest and other activities to enhance stand growth and structural complexity maintain and enhance Riparian Reserve process and function. This project would variably thin up to 2,549 acres of previously managed and fire-regenerated stands to enhance growth and structural complexity. Other project objectives are to enhance understory habitat, provide early seral habitat, promote hardwood conversion, restore sugar pine, improve visuals, and restore meadow habitat. An integral component of the project is to enhance conditions in riparian areas to meet Aquatic Conservation Strategy Objectives (Appendix B). These actions will be found within the Hwy 46 project area with a legal description of T9S, R6E, sections 1, 11 – 15, 21 – 28, 35 and 36, T9S, R7E, sections 3 – 36, T9S, R8E, sections 7, 18, 19, 30 and 31, T10S, R7E, sections 1 – 6 and 8 – 12, T10S, R8E, section 6.

The Aquatic Conservation Strategy (ACS) in the 1994 Northwest Forest Plan requires a comprehensive watershed analysis for all fifth field watersheds. The Breitenbush Watershed Analysis (WA) was completed in October 1996 and updated in February 2014. Specific recommendations of the original WA and its revision that apply to water and terrestrial resources of the project area include:

- Thin young overstocked stands that have not been precommercially thinned
- Commercial thinning in some 30-39 year old stands
- Treatment in 81-120 year old stands to improve stand diversity and stand health
- Sugar pine restoration
- Meadow and huckleberry enhancement
- Riparian corridor restoration to increase vegetative diversity, instream wood and riparian vegetation conditions.
- Large wood placements in creeks to benefit habitat for fish and wildlife and stream processes and functions.
- Improve channel complexity and floodplain connectivity in the Breitenbush River and tributaries
- Restore riparian habitat and improve water quality in the Short Lake Area. Realign/decommission Short Lake Road.
- Implement road decommissioning, storage, and drainage improvements throughout the watershed, culvert replacements in Devils and Short Creeks
- Stand management in north part of watershed for fuels management
- Use of prescribed fire for restoration in sugar pine and huckleberry areas
- Hazardous fuels reductions in plantations and enhancement and restoration of fuel breaks throughout the watershed
- Improve aesthetics in the watershed: enhance views of scenic attributes and landscape along major travelways.

Specific Project Description

See chapter 2 for full project descriptions. Alternative 1 is the No Action Alternative. None of the proposed treatments would occur in this alternative.

Alternative 2 treats 3,136 acres while maintaining 910 acres in skips in previously managed units. Thinning intensities are varied and generally based on average tree diameter and stocking levels. Dominant tree release gaps (DTR), ranging in size from ¼- ½ acre in size would encompass 74 acres. Gaps, one to three acres in size, would make up 46 acres and be primarily outside of the Riparian Reserve. Early seral habitat creation would make up 43 acres. Shelterwood harvest as sugar pine habitat restoration would make up 92 acres. Riparian Reserve treatment would occur on 781 acres in this alternative. The primary shade zone would be buffered out of the commercial treatments to protect all existing effective shade and secondary shade zone would be maintained at 50% canopy closure to protect microclimate as required by the Willamette TMDL Implementation Strategy (USDA 2012). Restoration driven streamside treatment within the no-harvest buffers would occur along 3.2 miles of streams, or over 20 acres, as small gaps and density reduction, to increase riparian area productivity (hardwood release), structural and species diversity, in addition to 5 acres of riparian meadow restoration. This alternative constructs and reconstructs 9.12 miles of temporary roads and maintains 108 miles of existing haul route. Reconstruction of system roads would reestablish drainage and improve the condition of the road system while reducing the vegetation and interception associated with these roads. Ten rock pits are proposed for use for material to improve road surfaces for hauling; four of these would have further pit development or expansion. Following completion of the sales, 9.12 miles of constructed or re-opened temporary roads would be stabilized and decommissioned. An additional 8.88 miles of roads would be decommissioned and 4.07 miles would be stabilized and stored along with the Short Lake road that would be re-routed, after vegetation treatments were completed.

Alternative 3 is similar to Alternative 2 but would harvest only in plantations, not in natural stands. Understory habitat enhancement, fuels reductions, and riparian treatment projects would also occur. Meadow restoration (Unit 32a) and most of the sugar pine restoration would be excluded from this alternative. The Short Lake Reroute would occur in this alternative.

Table 1. Comparison of Alternatives

Project Element	Unit of Measure	Alternative 1	Alternative 2	Alternative 3
Thinning Within Entire Project Area				
Thin leaving 40-110 trees per acre	Acres	0	2488	1872
Gaps	Acres	0	48	29
Dominant Tree Release (DTR) gaps	Acres	0	73	61
Sugar Pine Shelterwood Cut	Acres	0	92	9
Early Seral Creation	Acres	0	43	14
Understory Habitat Enhancement	Acres	0	155	155
Hazardous Fuels Reduction	Acres	0	229	193
Meadow Restoration	Acres	0	8	0
Streamside Treatments	Acres	0	20	20
Skips				
Skips (untreated area within original managed stand boundaries)	Acres	N/A	910	689
Logging System				
Ground-based yarding	Acres	0	926	766
Skyline yarding with one-end suspension	Acres	0	1510	1163
Helicopter yarding	Acres	0	317	56
Ground-based stream crossings	Each	0	16	15

Skyline stream crossings	Each	0	124	65
Total number of landings	# of landings	0	616	488
Roads and Access				
Length of haul routes	Miles	0	108	98
Pre-haul road maintenance	Miles	0	108	98
Road Realignments	Miles	0	1	1
New temporary road construction	Miles	0	5.1	3.0
Re-open existing spur roads	Miles	0	4.01	3.3
Road storage	Miles	0	4.07	4.07
Road decommissioning	Miles	0	8.88	8.88
Culvert upgrades	Number of	0	42	32
Fuels Treatments				
Grapple pile and burn	Acres	0	871	790
Handpile pile and burn	Acres	0	26	15
Burn landings	Number of	0	580	464
Post-harvest Underburn	Acres	0	1102	586

Analysis Methods

Analysis of the project area involved both office and field review of project area.

The hydrologist analyzed stream temperature data from 10 sites, including long-term monitoring sites and additional project specific sites since 2006. Level II stream surveys were completed on major streams in the project area between 2002 and 2014 and included detailed measures of stream morphology, streamflow, streambed substrates, large wood counts and riparian characteristics. This data was used in conjunction with unit-level riparian reconnaissance to assess the need for treatment to improve riparian conditions.

Fisheries, hydrology, wildlife, botany, and silviculture specialists surveyed all potential units in the project area. Seasonal aquatics technicians surveyed the units and streams during the 2014 and 2015 summer seasons, walking through each of the proposed units and surrounding areas, recording any streams and wet areas that were encountered with a handheld GPS unit. Aquatics technicians also inventoried culverts and surveyed road conditions throughout the project area. Aquatics staff (hydrologist and fisheries biologists) visited the majority of the riparian units. In these units with primarily class 2 and 3 streams, aquatics staff assessed Riparian Reserves to determine if ACSO's were being met, and documented treatment and buffer needs. Photos of stands, GIS information and field data were utilized in discussion and development of site-specific prescriptions with the interdisciplinary team.

Existing data from the Willamette National Forest Geographic Information System (GIS) database was queried to provide stream density, road density, stand condition (age), riparian connectivity, special habitat locations, types of aquatic habitats, and fish distribution. Aquatic specialists gathered data on current and historic watershed condition from the Breitenbush Watershed Analysis and through GIS analysis of a USFS vegetation database (FSVeg) and high-resolution satellite imagery (WorldView2). Aggregate Recovery Percentage (ARP) was utilized to analyze effects of thinning on peak flow and standard observations of past activities within the watershed considered when determining effects to hydrology, stream channel, water quality and riparian conditions.

Using existing road layers and proposed road changes, the hydrologist used the GRAIP-lite model of the GIS-based NetMap toolset to generate road-related sediment delivery (Benda et al 2007) estimates by alternative. Inputs to the model include slope derived from a 10-meter digital elevation model, NHD

streams layer, roads (operational maintenance levels and surface type), and base rate of annual road erosion. Compared with the WEPP model, commonly used for road-sediment generation estimates, GRAIP-lite tool provides more realistic estimates of sediment delivery. The GRAIP-lite model is also limited, however, in that it cannot be adjusted to reflect the effects of hauling traffic and comparisons between alternatives are more restricted to differences in miles of new or re-opened road, decommissioning or realignment of roads and any changes to maintenance level or surface type. The IDT used the 2014 Willamette Road Investment Strategy as a starting point to review road status changes in the planning area. Road segments that were modeled as having high aquatic risk and were not needed for future timber use (accessing plantations) were considered highest priority for decommissioning. Where future access was needed but not in the near-term, these high-risk roads and others were recommended for closure with additional monitoring and hydrologic stabilization.

Changes to the affected environment and cumulative effects from the 2017 wildfires were analyzed using the 2500-8 Burned-Area Report (USFS, 2017). Modifications to the proposed project were considered for all treatment types in the areas affected by the fires and the suppression activities.

Alternative treatments were analyzed for their effects on hydrology, stream channels, water quality, and riparian conditions at various scales to assess both positive and negative effects and to predict progress towards desired future conditions. Analysis by aquatic specialists used a combination of field reconnaissance, GIS-based analysis, past management records, and professional judgment to evaluate and compare effects of the proposed actions at the local site, the 6th field sub-watershed and 5th field watershed scales.

Affected Environment

Watershed Hydrology

Landscape

The project area is located within the Western (Middle) Cascades physiographic province within the mid-section of the Breitenbush Watershed on the Detroit Ranger District. Landforms range from glaciated upland benches and head walls to dissected V-shaped valleys with steep side slopes and shallow rocky soils at the higher elevations. In mid- to lower-elevations, landforms range from large-scale, stabilized slump/earthflow complexes, to small localized areas of actively unstable ground, to the deeper glacial and alluvial substrates of the upper Breitenbush River. Landforms, slope stability, and soils are discussed in greater detail in the Soils and Geology Report.

The Breitenbush Watershed is a fifth field watershed under the 1994 Northwest Forest Plan Aquatic Conservation Strategy. The Breitenbush River is tributary to the North Santiam River, which joins with the South Santiam River near the confluence with the Willamette River, within the Columbia River Basin. The project area encompasses three subwatersheds within the Breitenbush Watershed. The majority (63%, 19,743 acres) of the project area is in the sixth field Upper Breitenbush River Subwatershed. The South Fork Breitenbush River and North Fork Breitenbush Subwatersheds respectively make up 19% (5,994 acres) and 17% (5,204 acres) of the project area, respectively. Less than one percent of the project area includes small portions of the Humbug Creek, Lower Breitenbush and Cub Creek sub-watersheds.

The Breitenbush River flows westward from the center of the project area from the confluence of its North and South Forks in the eastern Marion County. Major tributaries of the Breitenbush include East Humbug, Fox, Scorpion, Short and Mansfield Creeks entering from the north and Leone, Hill, Devils and Skunk Creeks from the south. The drainages that form this portion of the watershed are typical, low to moderate elevation, dendritic, stream systems. Many stream channels have been altered by both glacial and earthflow activity. These areas often contain a complex drainage pattern that parallels earthflows and

fault lines. The Breitenbush River follows a fault line that is a conduit for the hot, hydrothermal waters of the Breitenbush Hot Springs at the upper end of the river below the North and South forks.

Stream Flow/Disturbance History

The hydrology of the Breitenbush Watershed is similar to other typical watersheds within the Western Cascades. The hydrology is dominated by rain inputs and snow/glacial melt from Mt. Jefferson and the High Cascades. Figure 1 shows the average stream flow (discharge) by month for the period of record of the Breitenbush River (Water Years 1933 through 2014). Flows in the winter through spring generally average between 800 and 900 cubic feet per second (cfs) and begin to decline as snowpack and snowmelt diminish in June. Mean annual discharge for the Breitenbush River is 621 cfs. The maximum record of 16,900 cfs occurred during the December 1964 flood event and the lowest flow recorded was 81 cfs pn October 10, 2015. Low flows typically occur in September, averaging 157 cfs. Of special note, 2015 had the lowest flow on record for the Breitenbush River, which replaced the previous record low flow of 87 cfs, from September 2, 1940 and September 24, 2001.

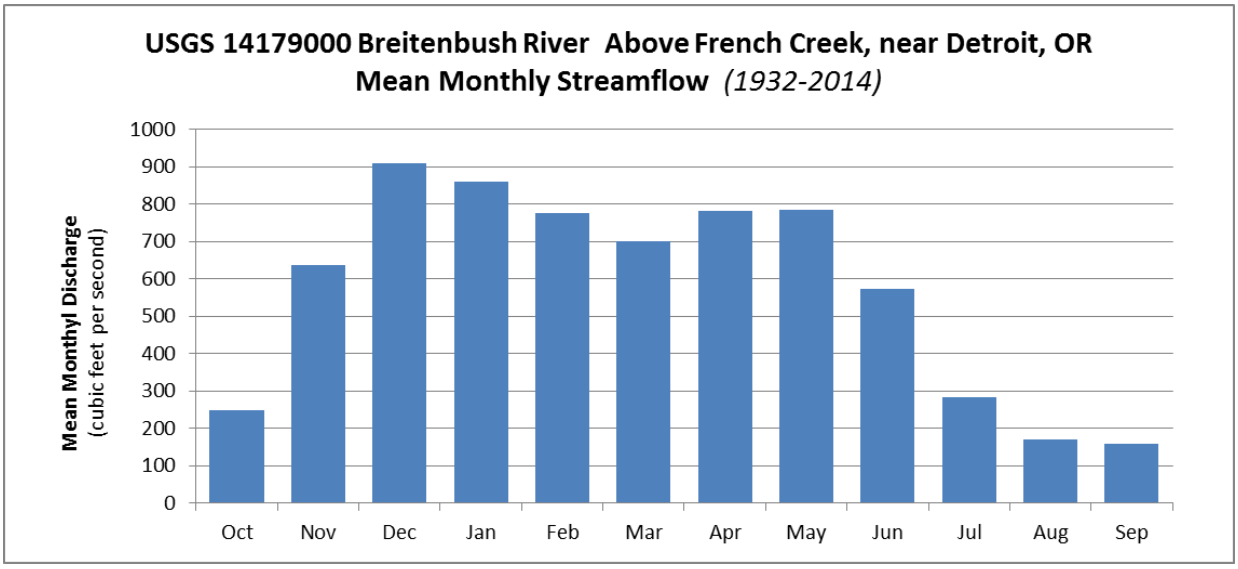

Figure 1. Mean monthly stream flow of Breitenbush River

Peak flows are predominately generated by rain-on-snow events in the transient snow zone, which occur between 1,200 and 4,900 feet elevation (Harr, 1981; Jones and Grant, 1996). Rain-on-snow events are considered the primary effect on peak flows. The transient snow zone covers approximately 88.6% of the Hwy 46 project area. Peak flows occur between October and May. While there is significant variability year to year in magnitude of peak flow, there are no noticeable trends of annual peak flows during this long period of record (Figure 2). The 2017 Scorpion and Little Devil wildfires are estimated to have increased peak flow rates minimally by 1.1 to 1.2 times (See Attachment A).

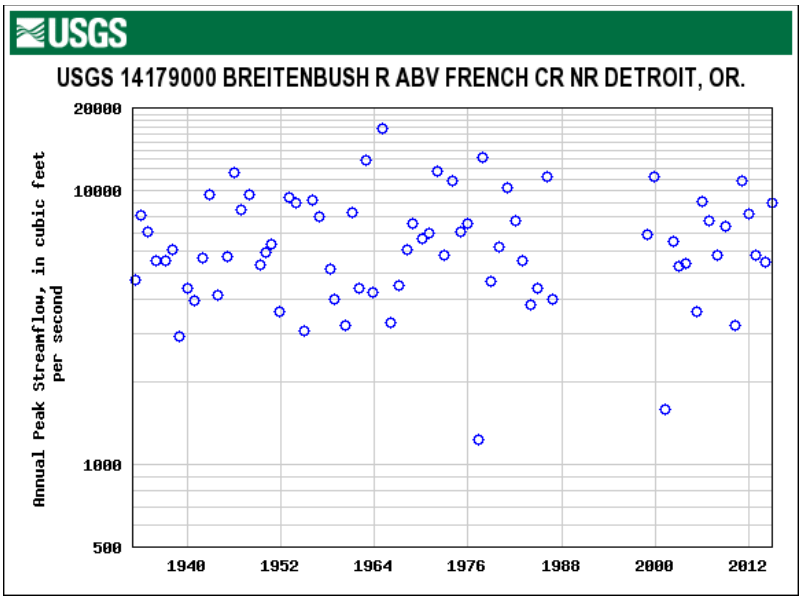

Figure 2. Peak flow event history for the Breitenbush River. Gage records of annual peak stream flows are shown from 1933 to 2015 (no data available for 1987 to 1997).

Past management activities and management induced changes have influenced the hydrology of the watershed. Intensive logging began in the project area in the Mid-19th century by railroad and conventional cable logging operations and continued into the 20th century. Vegetation removal caused increased peak flows, creating a change mechanism for stream channel complexity, and streams of the project area are still recovering. The combination of wood removal due to treatment of logging slash and salvage of merchantable trees from riparian areas, and hill slopes being opened to snow accumulation and rain-on-snow events led to an increase in peak flows that scoured channels down to bedrock and large boulders. These channels then became effective conduits for moving water, substrate, wood and fine organic material off the landscape. Habitat complexity, diversity of species, and aquatic richness were greatly reduced due to the high-energy nature of these streams. Within the last 20 years channel conditions have started to gain some of the complexity, diversity, and richness back as peak flows decrease because of stand regeneration and Riparian Reserve protection. Stand conditions are developing to provide future large wood and hydrologic recovery is occurring within the upland areas.

The 31,295 acre Hwy 46 Project Area contains 19,958 acres of managed stands, or 63.8% of the project area. Ninety of the 125 proposed treatment units have been managed wholly or in part in the past by clearcut, shelterwood or commercial thinning. Projects involving timber harvest on the Willamette National Forest are analyzed for their cumulative impact on the quantity and timing of peak flows and water yields using an accounting methodology known as Aggregate Recovery Percentage (ARP), as required by the Forest Plan. The ARP model compares the acres of an analysis area within the transient snow zone that are recovered against a threshold value (Midpoint) that was calibrated for the area during development of the Forest Plan. The midpoint values were developed based on the soil, geology, vegetation, climate, and stream channel conditions of each sub-watershed and are intended to represent a minimum safe level of vegetative recovery in the sub-watersheds to prevent significant alteration of peak flow regimes as a result of management activities. Recovery generally occurs when stand diameters average 8” diameter breast height and crown closures exceed 70%. The analysis is based on data extracted from the Forest’s VEGIS database, which includes information about all past harvest activities in the sub-watershed. Inputs to the model were updated following the 2017 Whitewater Fires and reflect current condition post-fire.

With an average Aggregate Recovery now estimated over 90% and well over the threshold of concern of 74%, the area's sub-watersheds are moving into a vegetative condition that buffers the effect of snow accumulation. Over the past 15 years, management has moved away from clear-cutting to density management (variable) thinning. Snow accumulates in thinned areas in lesser amounts and therefore does not pose the same risk to rain-on-snow events. Regeneration harvest units (15-20 years old) still exist within the project area, allowing accumulation of snow, but these plantations are growing at a rate expecting full recovery within 15 years. Currently, hydrology is responding well within its natural range with the existing vegetation components of the project area. This area includes the following sub-watersheds with corresponding thresholds of concern for Aggregate Recovery Percentage (ARP) within the Breitenbush Watershed:

Table 2 Aggregate Recovery Percentages Threshold of Concern

Subwatershed	Subwatershed Acres	Threshold of Concern % (midpoint ARP*)	Current Condition (2017*)
Upper Breitenbush	20,395	70-75	92.28
North Fork Breitenbush	16,254**	75	93.82
South Fork Breitenbush	13,082	73	95.47

* Midpoint ARP was originally calculated for subdrainages as part of the 1990 Willamette National Forest Plan. Under the subdrainage classification, the Upper Breitenbush split as the "Middle Breitenbush" and "Devil's Creek" subdrainages. The average midpoint ARP was calculated from the subdrainages that fall within each subwatershed.

**While the total area of the North Fork Breitenbush subwatershed is 16,254 acres, only 10,935 acres are actually within Forest Service boundaries and have an available existing vegetation layer. The percent of watershed was calculated using the 10,935 acres for which data was available.

Stream Channels

From the first order stream channels in the headwaters to the fifth order Breitenbush River stream channels within the project area exhibit a dendritic pattern. Rosgen type A, B and C channels are present within the proposed project area. Type A channels are characterized by high gradient, transport channels on valley walls and contains larger, volcanic substrates, whereas Type C channels occur in lower gradient, meandering sections of the Breitenbush River on alluvial and colluvial substrates.

Type B channels are present in higher order channels such as Breitenbush River and Devils Creek that flow over cobble and small boulder substrates. Sediments typically move through these channels alternating between flow transport in higher gradients and deposition in lower gradients and by receding flows where channel obstructions, such as boulders and large wood, dissipate flow energies. Channel bar mobilization, stream bank erosion, and debris torrent activity from the steeper terrains feed streams with structure and sediment. The majority of the fine sediment is transported out of the system and into the Detroit Reservoir. Intense precipitation is episodic in nature, and often generates peak flows that are a major disturbance mechanism for stream channels and associated riparian areas in the project area. Stream channels in headwater streams are predominantly intermittent due to the lack of water and sediment storage.

Sediment storage capacity is moderated as streams transition from headwaters to alluvial reaches. Streams transport sediment through these streams with the storage being related to structure found within the channel and lower gradient reaches in the valley bottoms. Deep alluvium/ colluviums on valley floors are frequently related to ongoing earthflow and episodic landslide activities. Material from upslope failures build terraces in third and fourth order stream channels that are shaped and reshaped by peak flow events. Base flow of streams in these forested drainages is derived largely from saturated alluvium and colluvium in valley bottoms and bedrock fractures. The various land types on this terrain are generally well drained in the surface soil and moderately rapid in the subsoil. Major water storage areas occur in toes of slumps and earthflows. Glacial deposits are present on the valley bottoms providing high amounts of groundwater

storage areas. During downstream transport in the channel, stream water mixes with groundwater in the inter-gravel flow (hyporheic zone).

Past management effects to the channels include reduction of large wood, channel bank disturbance, development of new channels following skidding patterns, and increased sediment. Historic logging practices channelized water creating new stream channels that have developed riparian characteristics. In addition, large wood was actively “cleaned out” of the stream channels. Major runoff events, such as the 1964 and 1996 floods, resulted in channel morphologic changes and sediment and large wood transport and deposition. Level II stream surveys conducted in 2002-2014 found that in-stream large wood in the Breitenbush River was below pre-management levels and also low for all the surveyed tributaries (Byars, Devils, Humbug, East Humbug, Hill, Leone, Mansfield, Bummer, Horsetail and Short Creeks, and the North and South forks of the Breitenbush River). Large wood in streams is slowly improving through natural recruitment of fallen large conifers from unmanaged riparian areas, large wood restoration projects, riparian stand fall and leave projects and development of large wood adjacent to the channels.

Over the last 20 years the riparian condition and channels are gradually recovering needed complexity due to natural processes, changed land management techniques, and an improved understanding of the importance of channel complexity.

Forest Service aquatics technicians completed field surveys and GPS-mapped a total of 60.2 miles of stream channels in and around each treatment unit within the planning area. The field surveys and corresponding GIS work assure more accurate placement of buffers and Riparian Reserve prescriptions. Recorded and updated in the project GIS database are the following types of channels in context with treatment units in the Hwy 46 planning area:

- Class I and II– Public drinking water source or fish-bearing, perennial: 43.4 miles, 13%
- Class III - Perennial, non-fish bearing: 58.7 miles, 17.9%
- Class IV - Intermittent, ephemeral: 227.1 miles, 69.0%

Riparian Conditions

Riparian Reserves in the Northwest Forest Plan were designed to protect the health of aquatic systems and provide incidental benefit to terrestrial species. Specific aquatic resources benefited by high functioning Riparian Reserves include water quality and stream function for all aquatic organisms. Riparian Reserves also provide habitat for riparian dependent species and dispersal and travel corridors for terrestrial organisms. The Aquatic Conservation Strategy was developed with nine specific objectives to maintain and restore Riparian Reserves to meet these objectives. Approximately 43% of the entire project area (13,502 acres) is designated as Riparian Reserves. Present day riparian conditions are shaped by natural and human disturbances, including flooding, mass wasting, timber harvest, fire, and construction of railroads, powerlines and roads.

The oldest stands of trees found in the watershed are aged at approximately 550 years old, dating back to the early 1600s when fires burned over most of the watershed and district-wide. It is also estimated that approximately one-third of the watershed burned in the 1890s, the most active period of fire history, leaving about one-third of the watershed in a younger (<50 year old) age class. There have been numerous large fires documented in the watershed back to 1900 including the largest of these, Firecamp Lakes Fire which burned 2,000 acres in 1914. The Humbug, Fox and Scorpion drainages have the most active fire history in the watershed (Garza, 1995). Depending on their size and intensity, these fires were disturbance mechanisms that contributed to the current riparian conditions, from diverse complex riparian areas that burned less severely, if at all, and dense monocultures in the stem-exclusion stage, naturally derived from high intensity stand replacing fires. Additional very recent fires during Summer 2017 encompassed 1,783

acres in the Hwy 46 project area with 1,017 acres of those having a low to moderate soil burn severity and the remaining 764 acres in unburned condition. Over the entire Breitenbush Watershed, 4,633 acres were in fire perimeters with 2,793 of those low to moderate severity, and the rest rated as unburned or very low severity. There were no areas of high soil burn severity in the Watershed. Within these perimeters, 1,275 acres were in Riparian Reserves within the Hwy 46 project area, again which were predominately unburned or low severity. Only an estimated 10 acres of Riparian Reserve were rated as moderate soil burn severity.

Timber harvest began in the watershed on a significant level with railroad logging in the 1930s primarily up to the Humbug Creek confluence. Road construction began in the project area in the 1940s, with timber harvest accelerating in the 1950s and peaking on National Forest system lands in the 1970s and 80s. Up through the 1980s, harvest was primarily by regeneration or clear-cut. Prior to implementation of the Northwest Forest Plan in 1994, much of this activity removed riparian vegetation that once provided large wood and shade to the small intermittent and perennial tributary streams in the project area. In addition, most clear-cuts were replanted primarily with Douglas fir at much higher stocking densities than natural for the purpose of maximizing timber production, even in riparian areas.

As a result, many of these stands, including those in today's Riparian Reserves were set on a management-induced trajectory that has led to artificially dense, conifer-dominated stands, with tree densities above the natural range of variability expected in this area. Riparian areas are dominated by Douglas-fir with minor amounts of other conifers. Depending primarily on elevation and aspect, other conifers include western hemlock, western red cedar, noble fir, pacific silver fir, and grand fir. These riparian areas also include scattered patches of red alder and big leaf maple. Except for the lower reaches of the Breitenbush River, which were logged by railroad, the larger streams in the watershed were largely excluded from regeneration harvests and remain in a more natural condition (Breitenbush Watershed Analysis, 1996).

Within the project area, early-seral and late-seral vegetation is currently at the lower end of the natural range of variability (Breitenbush Watershed Analysis 1996). In late-seral stands, shrubs and herbs are re-initiated as conifers die and create gaps in the canopy. A recent study of riparian plant communities in northwest Oregon (McCain 2005) provides data on "relatively unmanaged" conditions. The study describes riparian and upland plant communities based on geomorphic features (e.g. in-channel, cobble bars, terraces, floodplain, etc.). On the "steep banks/terraces" and "high terraces/major floodplain" features common to streams in the project area, deciduous trees had typical percent cover values of 15 to 64%. Valley cross-sections (300-foot riparian transects) on 3rd and 4th order "relatively unmanaged" streams in the west Cascades had a hardwood basal area of 7 to16 square feet/acre and hardwoods were present throughout the 300-foot transect. This study suggests that in "relatively unmanaged" riparian plant communities, there is typically a hardwood, shrub, and herb component. These deciduous and herbaceous species provide many benefits to riparian and aquatic ecosystems, including better food resources and higher productivity for aquatic invertebrates compared to conifer-dominated systems (Wipli et al 2007); increased nitrogen fixation, organic matter cycling, and soil fertility (Compton et al. 2003); and wildlife benefits.

With a lack of both early- and late-seral vegetation classes that have a large deciduous and herbaceous component, it follows that these species are underrepresented on the current landscape. This is further supported by analysis of existing vegetation using high resolution satellite imagery. Aquatics specialists completed an analysis of the Breitenbush Watershed and project area Riparian Reserves a GIS- based WorldView2 Satellite Imagery and eCognition software analysis of the Breitenbush Watershed (Figures 29-30). WorldView2 imagery highlights areas of high chlorophyll production, which helps distinguish between deciduous and coniferous vegetation. Based on results of this analysis, approximately 88% of Riparian Reserves in the Breitenbush watershed are conifer-dominant and only 2% are deciduous-

dominant (trees and shrubs). Approximately 2% are mixed conifer and deciduous, and 8% are non-forest (Figure 3).

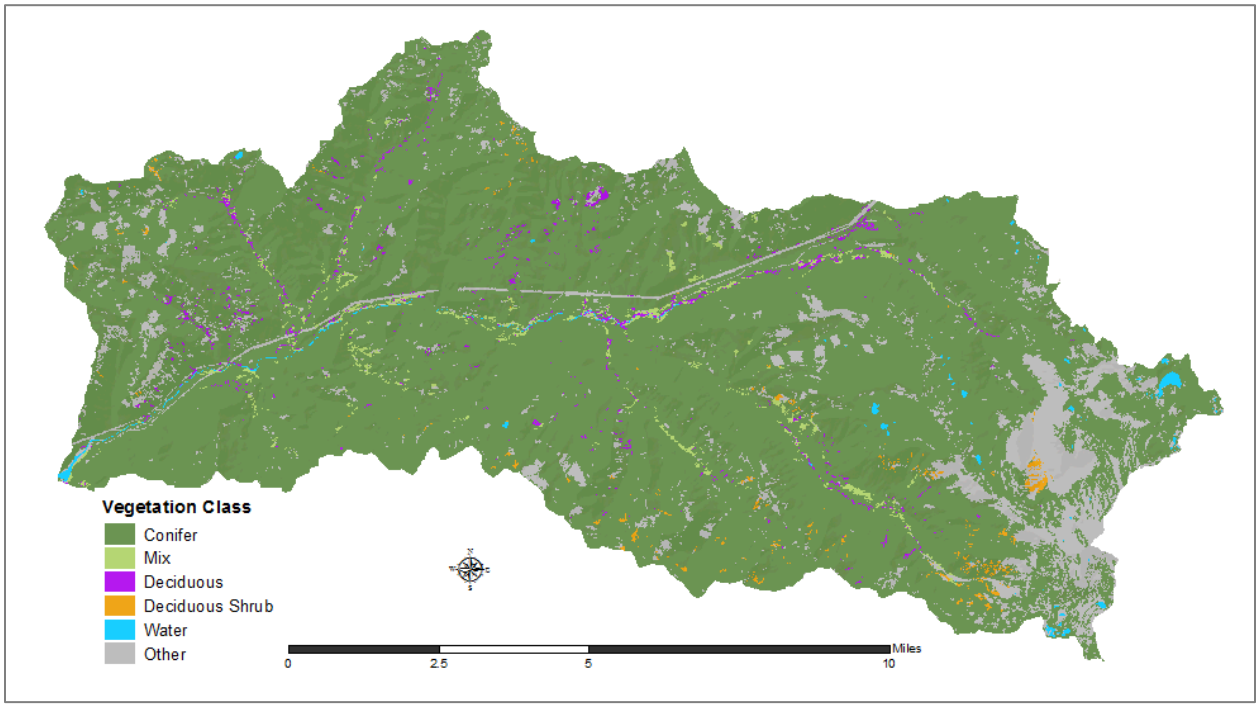

Figure 3. Vegetation classification of the Breitenbush Watershed using high resolution satellite imagery (Worldview2) and eCognition software.

Within the scale of the Hwy 46 project area (Figure 4), approximately 91% of Riparian Reserves are conifer-dominant and less than 2% are deciduous-dominant (trees and shrubs) (Table 3). Approximately 2.6% are mixed conifer and deciduous, which occur primarily in late-seral stands along the Breitenbush River. The results of this landscape-scale analysis reveal a very low abundance of deciduous species and are corroborated by surveys at the stand scale, where dense conifers dominate Riparian Reserves and there is often a lack of understory development and species diversity. Some portions of Riparian Reserves is previously un-managed areas within the project area have higher structural and species diversity and are providing adequate stream shade, root strength and bank stability, sediment filtration and nutrient cycling, large wood supply to waterbodies and floodplains, organic matter input to waterbodies, and habitat for riparian-dependent wildlife; these riparian areas are found to be achieving ACS objectives or are on close trajectory to doing so. These riparian areas serve as a reference of desired future condition, guiding development of riparian prescriptions.

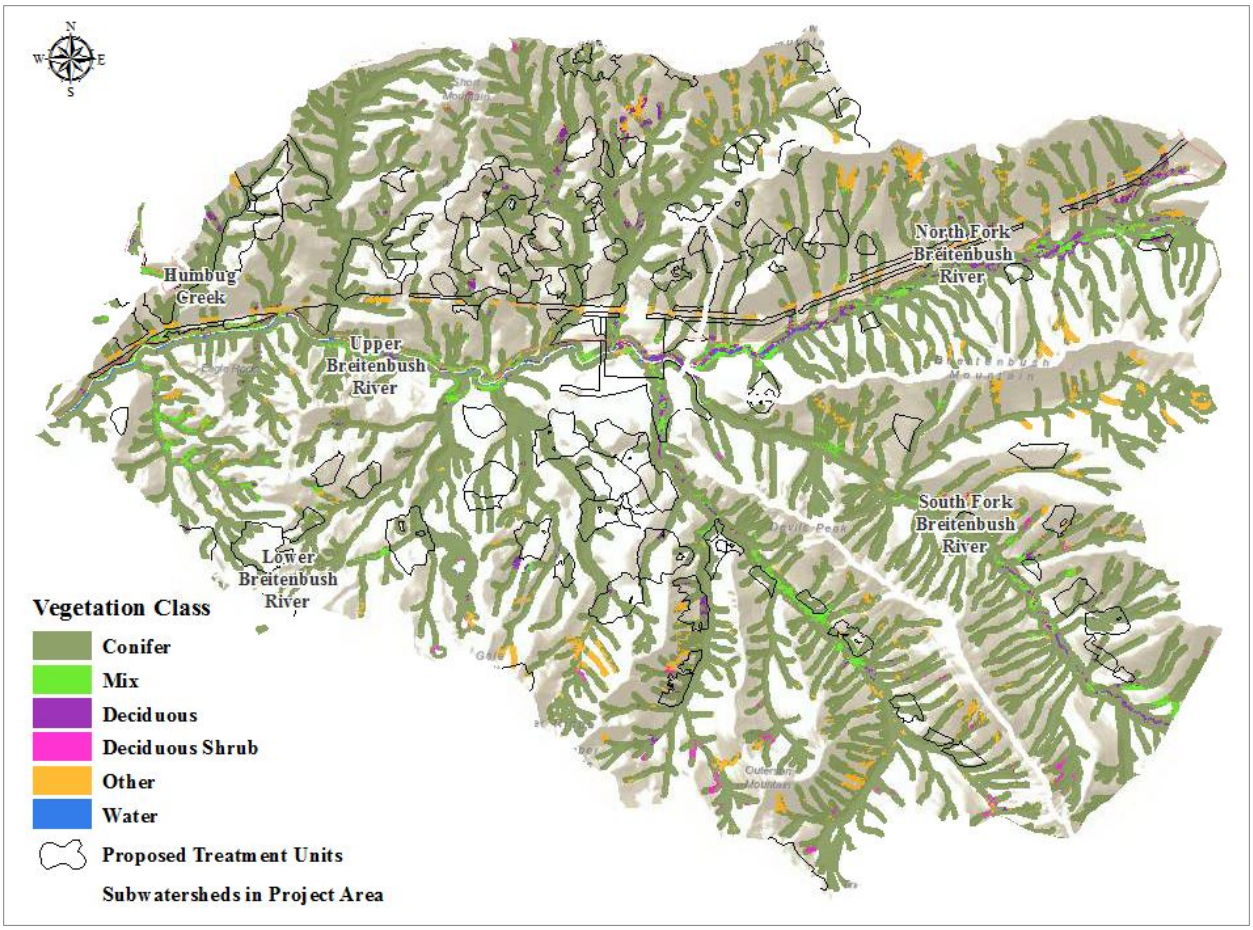

Figure 4. Vegetation classification within the Riparian Reserves of the project area and subwatersheds using high-resolution satellite imagery (Worldview2) and eCognition software.

Table 3. Vegetation Class of Riparian Reserves within the project area.

Vegetation Class	Acreage in Project Area	Percent of Project Area	Acreage in Riparian Reserve	Percent of Riparian Reserve
Conifer	28,659	92%	12,268	91%
Mixed	534	1.7%	350	2.6%
Deciduous	348	1.1%	230	1.7%
Deciduous-Shrub	101	0.32%	43	0.3%
Other	1,586	5.1%	578	4.3%
Water	55	0.2%	34	0.2%

Of 1,458 acres of Riparian Reserve within the proposed (Alternative 2) units, 996 acres (68% have been harvested in the past, and are considered plantations. Approximately 462 acres (31%) are considered natural and have not been managed, though most of these are in similar condition to past regeneration harvested Riparian Reserves due to stand replacing fires around the turn of the last century. Riparian stands proposed for commercial thinning treatment are a combination of plantations created after clear-cut harvesting and natural fire regenerated areas. All of the plantation stands and most of the older natural stands are considered to be in the stem exclusion structural stage. Riparian stands to be treated are considered to be in the stem-exclusion stage.

Relative tree densities and structural stages of stands are considered to be outside the range of natural variability. Stands are densely stocked and relatively young, averaging 68 years old (ranging from 26 to 145 years old). Stand densities in the proposed units range from 75 to 397 TPA (trees per acre), averaging 198. In contrast, research in the Coast Range and Western Cascades by Tappeiner et al (1997) and Poage and Tappeiner (2002) indicates that existing old growth stands developed with natural stand densities of 40 to 60 conifers per acre. Pollock et al (2005) found that "riparian stands often develop in a much more open structure, such that stem exclusion is much less common and understory vegetation usually is present throughout the development of a forest." Stem exclusion stands have dense crowns that block out light to the forest floor and limit understory species and structure development (Oliver and Larson, 1990). The trees are competing for sunlight, water, and nutrients causing reduced tree growth and vigor as well as limiting understory vegetation. Suppressed understories are mostly limited to shrubs and herbs with a few small trees scattered throughout. The existing lack of complexity and diversity may be limiting nutrient cycling, deciduous organic matter input to waterbodies, and habitat for riparian-dependent wildlife.

Photo 1. Example of overstocked, conifer dominant stand lacking structural and species diversity within Riparian Reserves (Unit 520).

Aquatics specialists observed limited amounts of downed wood in Riparian Reserves that were field visited on the ground, however on the watershed scale, the amount of course woody downed debris is still within the range of natural variability. The DECAID Analysis (Appendix F) found that natural accumulations of down woody debris fall within the range of natural variability in the Breitenbush Watershed. Stand ages in parts of this project area indicate that fires were very prevalent in the last 70 to 130 years; these fires were natural, human caused or management-induced. Older plantations with lower utilization standards retained considerable large down woody debris. Younger plantations, with commercially higher utilization standards, removed much of this type of woody material. The most recent plantations, which had down woody debris objectives, again began to accumulate larger material within riparian areas.

In addition to streamside areas, riparian areas also include lakes and wetlands. Short Lake and Leone Lake are the only named lakes in the proposed project area. Both lakes have their origins as sag ponds created from depressions related to slump activity, Short Lake is managed as special use area for recreation, aesthetics and ecological values. The project area also contains three other small lake/ponds and numerous wetlands, including swamps, meadows, seeps and springs, which are mapped as Special Habitats (SHABs). Wetland areas are generally small in size and scattered throughout the project area. Most were created either by glacial or slump action. These naturally-formed features add to the complexity and value of groundwater systems.

In general, riparian conditions appear to be partially functioning and on a slow trend toward recovery for this Western Cascade environment. While riparian conditions are generally recovering into the natural range of variability from past management activities, riparian stands selected for treatment are low in s*tructural and species diversity,* limited in large wood and would benefit from restorative treatment.

Water Quality:

Water quality is generally high and of high value, in part due to hyporheic flow, for most of the streams associated within the project area. Stream banks and floodplains are generally well vegetated and stable. Surface waters mix with groundwater in the inter-gravel flow (hyporheic zone). Water quality parameters monitored in the project area have been found to fall within the natural range of variability for West Cascade streams. Sediment and water quality conditions are recovering from past timber harvest activities, though naturally occurring landslides and debris flows in unstable areas of the watershed are chronic sediment sources to some streams and downstream waters. Geothermal areas provide unique hydrology to few locations in the valley bottoms along the Breitenbush River. Hot and highly mineralized water surfaces as seeps or springs these areas.

The Oregon Department of Environmental Quality currently lists portions of the Breitenbush River and South Fork Breitenbush River as water quality impaired (303(d) listed). These segments were submitted in 2010 by DEQ to the Environmental Protection Agency (EPA) and approved. At this writing, no TMDL has been approved by EPA for these listings, so they are considered Category 5: 303(d), TMDL needed. It is anticipated that the lists may change during the NEPA and implementation timelines of this project, due to ongoing legal disputes. The Breitenbush River from the mouth to river mile 12.2, and the South Fork Breitenbush River, from its mouth to river mile 1.6 are listed for Biological Criteria. The Biological Criteria listing indicates that the waters are not of *sufficient quality to support aquatic species without detrimental changes in the resident biological communities*. This assessment is based on a single benthic macroinvertebrate sample collected in 1999 in the reach not having a representative number of taxa present as compared to a regional reference condition. The South Fork of the Breitenbush River, from mouth to river mile 9.4 is listed for sedimentation, based on a single sample collected in 1999.

The Breitenbush is a domestic water supply, considered to be of high quality and value to the Breitenbush Community and City of Detroit, downstream of the project area. Wells also supply water to the Humbug, Cleator Bend and Breitenbush Campgrounds up river from these municipalities. The City of Salem uses the North Santiam River below Detroit Dam as its primary public water drinking water supply. The Breitenbush River is a major tributary of the North Santiam River contributing to Salem's municipal water supply.

Stream Shade and Temperature

Past harvest near stream channels increased solar radiation inputs and caused subsequent increases in thermal loading of streams. Past harvest has affected approximately 67% of the Riparian Reserve network within the project area. Past harvest practices involved removal of all vegetation. Increased water temperature resulted until such time that shade recovered with regrowth on the site. Today, much of the streamside shade in the previously harvested units of this project area is currently functioning in early to

mid-seral vegetation conditions. Many of these areas are now light limited due to closed canopies and primary production in steams may be limited by light exclusion.

Existing condition for temperature in the project area varies widely, attributable to differences in geomorphology, stream channel orientation, and position in the landscape. Stream temperature data were collected at 10 locations in the project area during the summer months (June through September). The data were collected for a minimum of two seasons with a maximum of 10 seasons. Figure 5 below summarizes the stream temperature data for the Breitenbush Watershed. Changes in the range of maximum temperatures from one water year to the next are attributable to inter-annual differences in precipitation and stream flows. Region-wide low winter snowpack and spring rains in the 2016 water year led to low stream flows and subsequent increased stream temperatures, as depicted in Figure 5 for many streams. The annual timing of the maximum temperature occurred between July and August in all instances. This suggests that any past management impacted only the increased value for maximum temperature and has not affected inter-annual variability or annual timing of peak temperatures.

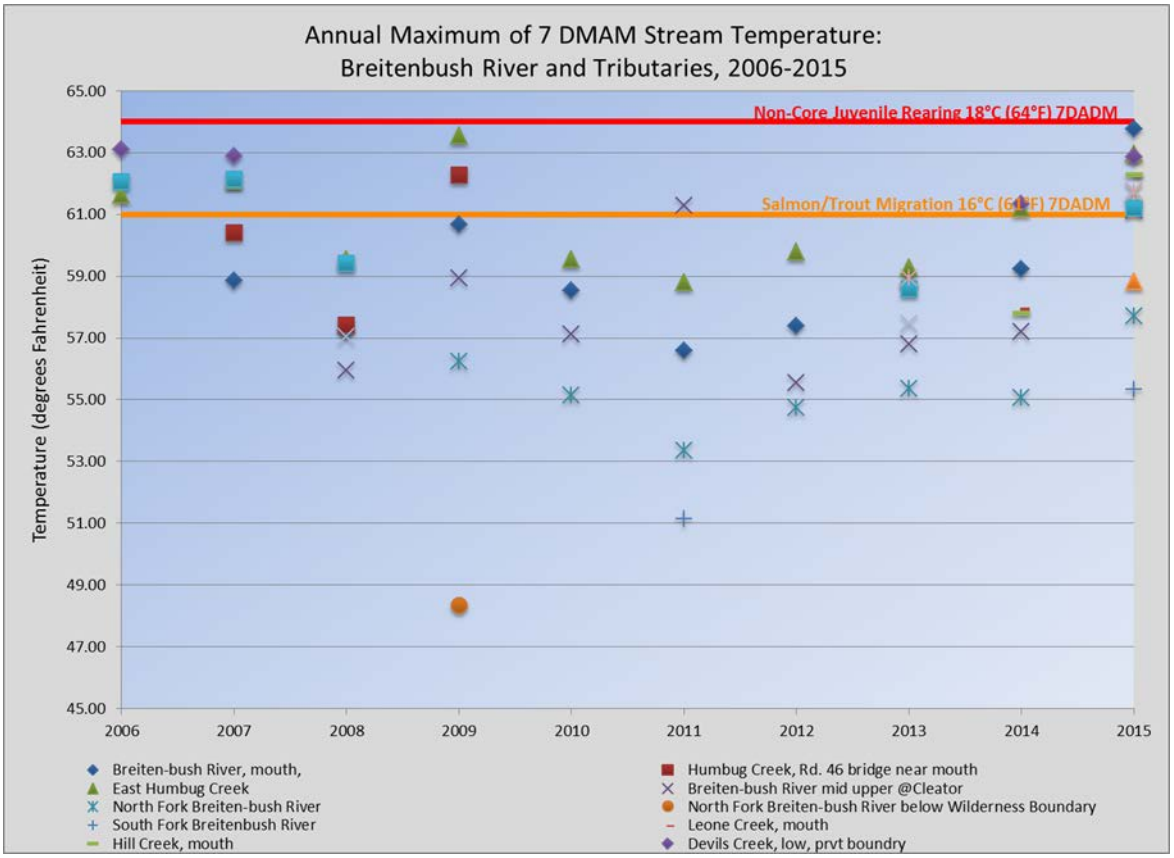

Figure 5. Maximum 7day Moving Average of Daily Max Stream Temperatures in Breitenbush River and tributaries: 2006-2015.

The EPA's Guidance for Pacific Northwest State Temperature Water Quality Standards are 61°F and 64°F for salmon and for trout migration and for non-core juvenile rearing respectively. The State of Oregon's Department of Environmental Quality (DEQ) has set thresholds for Total Maximum Daily Loads for waterbodies in the Willamette basin (Willamette TMDL) to achieve water quality standards. With the issuance of the Willamette Basin TMDL for water temperature (2006) and the subsequent completion of the Willamette TMDL Water Quality Restoration Plan (2008) by the Willamette National Forest and others, all streams have been delisted in the 2010 DEQ database. No streams in the Breitenbush Watershed and Hwy 46 project area are currently listed as a "303d" water quality limited water body.

Sedimentation

Existing sources of sedimentation in streams include hillslope erosion, mass wasting, and road-related erosion. The stability of hillslopes and stream channel banks are closely tied to the water quality of the project area. The majority of the geologic terrain and soils within the Hwy 46 proposed treatment units are not inherently prone to extensive erosion due to high infiltration limiting overland flow unless disturbed as discussed in the Soils Specialist Report (located in the project file). Past timber harvest methods resulted in compaction levels varying from 12 to 16% for most of the units of harvested with ground-based logging systems. However, four units exceeded the 20% maximum allowed by the Forest Standards and Guidelines (Soils Specialist Report). With increasing levels of compaction, there is an increased risk of surface erosion due to greater overland flow and less infiltration.

Unstable land types were considered when designing the boundaries of the treatment units and buffers. Stream channels generally transport mobilized sediments into the Detroit Reservoir where the majority settles out. However, fine clay particles can persist as turbid waters in the Breitenbush River. Intensive studies in the late 1990s on suspended sediment and turbidity in the Breitenbush River were conducted by the US Geological Survey, the Forest Service, the Pacific Northwest Research Station, State University researchers and Washington D,C.'s General Accounting Office. The joint effort found hydrated clays (smectite) originating from the toes of earthflows and older and weathered Miocene and Oligocene period basalt and andesitic lithologies in the East Humbug, Short, and Mansfield Creeks to be the main source of sediment and turbidity (Uhrich & Bragg 2003). During larger flood events, these suspended sediments can persist in the river past Detroit Dam down to the Pacific Ocean.

The 2016 water year in particular was marked by a noticeable increase in turbidity in Short Creek (Figure 32) and Cultus Creek, both contributing to the Breitenbush River and further downstream. Field reconnaissance by the Soils Scientist confirmed the re-activation of the Short Creek slump and a subsequent massive debris flow that will continue to contribute fine sediments downstream in future years. The numerous slope failures in this area of Short Creek recently and over the last 150 years are deemed naturally occurring, as no active land management has occurred in that area (Shank, 2013). Additionally, in early 2016, another new slide occurred in the watershed contributing considerable turbidity to Breitenbush River. Field reconnaissance by the Soils Scientist also found the turbidity source of landslide activity in the upper Cultus Creek drainage, encompassing about 5 acres of hillslope. Analysis of past aerial photos indicated that this area had a history of instability and timber harvest (Shank, 2016). Both of these recent slides are anticipated to deliver sediment downstream and contribute to turbidity over the next decade or more.

Figure 6. Recent Short Creek debris flow, about mid-way up. *Photo by J. Sheahan Alonso, 5/27/2016*

The 2017 Whitewater Fires increased sediment erosion rates by 1.7-3.8 percent in the burned area perimeters. Post-fire analysis of sediment delivery potential to streams was conducted based on ratings of Soil Burn Severity. Areas of Moderate to High SBS and steep slopes increase the potential for overland flow and delivery of sediments into streams within Riparian Reserves, however with less than 10 acres across the three fires burning in Riparian Reserves at a severity of moderate or higher, there is minimal potential increase in overland delivery of sediments to streams in the Project Area. There is a slightly increased hazard of debris flows in the Little Devil fire perimeter (See Attachment A: *Hwy 46 Detailed Post-Fire Hydrology Analysis)*.

Road-stream crossings can also provide direct contact with the channel and direct pathways for sediment movement to stream channels. Road crossing failures and streams running down earthflows or slumps cause pulses of sediment that move downstream and eventually reach mainstem channels and the Detroit Reservoir. Poorly designed placement of roads historically and limited maintenance of a few roads, has led to road-related sediment delivery due to inadequate drainage spacing or blocked culverts and subsequent concentration of runoff and road surface erosion. Road maintenance reduces the risk associated with these crossings by cleaning the inlets and preventing crossing failures. Road maintenance is a high priority for management located in the East Humbug, Short, Mansfield and Devils Creek drainages.

Since implementation of the Forest Plan in 1990, road maintenance activities have worked to eliminate many of these unstable fill situations. Even so, roads continue to be a large source of human-caused sedimentation in the project area, and a few old roads still carry water during winter storm events essentially extending the stream system and occasionally diverting flow from natural stream channels. Additional impacts to streams within the project areas include failing culverts and displacement from steep road headwalls. Road densities over 3.5 miles of road per square mile are considered “Not Properly Functioning” (FEMAT 1993). Sub-watershed road densities in the project area range from 1.70 to 5.15 miles per square mile. The Lower Breitenbush River Sub-watershed exceeds the threshold for properly functioning, but only 1% of the sub-watershed is within the Hwy 46 Project Area.

Table 4. Road Densities by Subwatershed

Subwatershed	Acres	Square Miles	Percent of Subwatershed in Planning Area	Road Density (mi/mi^2)
Upper Breitenbush River	20,395	31.87	96%	3.42
South Fork Breitenbush River	13,082	20.44	32%	1.35
North Fork Breitenbush River	16,255	25.40	46%	1.70
Lower Breitenbush River	9,203	14.38	1%	5.15

The GRAIP-lite tool in the NetMap roads GIS toolset was also used to analyze road sediment production and delivery to streams. Estimated sediment from the GRAIP-lite model for existing roads in the Hwy 46 project area and haul roads extending out of the project area is approximately 95 cubic yards of sediment delivered to streams per year. In comparison, the 1999-2000 USGS study of turbidity and suspended sediment estimated an annual load of 20,100 tons for Breitenbush River (Uhrich & Bragg, 2003). The 2017 Whitewater Fires, are estimated to have increased overall road-related sediment delivery to streams in the project area by 6 tons/year for the first 2-5 years following the fire. The wildfire suppression activities involved re-opening and blading some previously closed roads, with some drainage and sediment delivery concerns (See Attachment A).

Desired Future Condition

Historically, flood, drought, fire, wind, snow, ice, and land movement all played a natural role in determining the diversity of conditions. The desired future condition for the Breitenbush Watershed is to have a properly functioning watershed at the fifth field scale, including restored natural processes and disturbance mechanisms that allow the watershed to maintain diversity and complexity. The desired future condition for aquatic resources in the Breitenbush Watershed is to have continuous and diverse habitat for riparian dependent species and high water quality in riverine, wetlands, and floodplain areas. Water bodies and associated riparian areas will contribute to the diversity and dispersion of fish, wildlife and plant species within sub-drainages and the larger watershed. Stream channels will provide diverse, stable habitat for aquatic species as well as maintaining or enhancing water quality. Vegetation in uplands will be managed to provide diverse stands of conifer and hardwood vegetation which provide habitat for riparian dependent species. The amount of large woody material, both down and standing will be maintained at or above current levels providing for natural appearing and improved channel conditions.

The desired future conditions for hydrology, stream channel and water quality within the project area meet Aquatic Conservation Strategy Objectives (see Appendix B, Objectives 1, 2, 8 and 9) and include:

- Accumulation of woody material to mimic historic levels within riparian areas for the benefit of both aquatic and terrestrial species.
- A diversity of flow within the historic range which allows for a diversity of species to exist within riparian areas and sustains natural patterns of sediment, nutrient and wood routing. No increase in peak flow that exceed natural range of variability.
- Maintenance of wet areas and hyporheic zones; no net loss.
- Maintenance of channel conditions that represent natural range. No excessive bank or bed erosion.
- Reduction of stream energies through channel complexity including wood, boulders and channel substrate.
- Broad range of diversity associated with the riverine systems, including functioning Rosgen channel types A, B and C.
- Maintenance of a transportation system that allows public access while minimizing effects to aquatic resources.
- Maintenance of stream shade and water filtration in riparian areas such that water quality remains within the range that maintains the biological, physical and chemical integrity of the system, and benefits survival, growth, reproduction, and migration of individuals composing aquatic and riparian communities.

The desired future condition for riparian conditions for all proposed treatment areas is to provide healthy, vigorous growing stands that have a diverse native species composition and structure. Stand treatments will be consistent with Aquatic Conservation Strategy Objectives by increasing structural diversity and developing large conifers:

- Stands of various conifer species will predominate with a variety of hardwoods, shrubs, herbs, and forbs developing.
- Promote a well-developed understory with a scattered mix of large snags and down wood.
- Accumulation of woody material to mimic historic levels within riparian areas for the benefit of both aquatic and terrestrial species.
- Within the Late-Successional Reserve, stands will be set on an accelerated trajectory for developing late-successional conditions by developing multiple canopy layers and larger trees.

Environmental Consequences

Unless otherwise noted, the geographic scale used to assess direct, indirect and cumulative effects for aquatic resources includes the project activity units, the project area and the Upper Breitenbush, South Fork Breitenbush and North Fork Breitenbush sub-watersheds.

Table 5: Management Indicators for Assessing Effects to Hydrology Resources		
Issue	**Management Indicator**	**Justification**
Peak Stream Flow and Disturbance History	Aggregate Recovery Percent (ARP), soil burn severity	ARP Mid-point values are specified in the Forest Plan, 2017 wildfires soil burn severity affect infiltration and runoff
Riparian Reserves	Acres of Riparian Reserves Treated, stand condition in Riparian Reserve	See Appendix C: Aquatic Conservation Strategy Objectives
Stream temperature	Treatment within the primary shade zone, fire intensity (canopy cover)	Northwest Forest Plan Temperature TMDL Implementation Strategy (May 25, 2012)(USDA & USDI Bureau of Land Management, 2012), fire intensity/canopy cover mortality indicates potential cumulative effect changes to stream shading from 2017 fires.
Effects of sediment on aquatic resources would be analyzed looking at sedimentation from roads	Field reconnaissance observations, GRAIP-lite sediment modeling (Benda et al 2007) and professional judgment, post-fire BAER analyses: debris flow potential, soil erosion increase	Best Science, post-fire BAER analyses identify cumulative effects

Direct and Indirect Effects

Stream Flows/Disturbance

Alternative 1 – No Action

Implementation of the No-Action alternative would maintain managed timber stands that do not have a live crown ratio (percent of the tree with limbs) sufficient to reach full potential across the landscape, including riparian areas. The stands would experience reduced growth rates due to competition as transpiration rates decrease due to loss of canopy crown diameters. This could result in potential increase in summer flows due to the decline in the stands ability to utilize available water. There is a higher likelihood of reduced tree health, which limits the ability of tree crowns to intercept and hold snow increasing the risk for tree damage and breakage by snow load accumulation. Infiltration rates would also be affected by the loss of canopy and the drip that occurs from snow interception. Reduced canopies are more exposed to latent heat transfer and rapid snow loss, which reduces the contact time the water stored in the snow, has with the soil (Harr, 1981). However, changes in surface flows would be very small and immeasurable. With ARP values projected to remain well above Midpoint, Alternative 1, No Action, would result in no changes to existing peak flows based on vegetation removal. However, lack of density

reduction and fuel treatments of overstocked stands would retain an increased risk of high severity wildfire or disease outbreaks. High severity wildfire or disease outbreaks on the watershed level would have the potential to increase peak flows in the 3 to 5 year period following the event.

The meadow in Unit 32a would not be treated for restoration under the No Action alternative. Lack of treatment would result in continued growth of existing trees and encroachment of younger conifers. Subsequent reduction in available light from shading and water from increased evapotranspiration to herbaceous meadow species would further the loss of the meadow habitat. Over time in the absence of treatment or natural disturbance, the meadow would successionally advance to a forested condition all together.

The No-Action alternative would maintain the effects of past artificial disturbance mechanisms, road crossings, and associated ground disturbances. Several miles of roads are in poor condition and funnel water to stream crossings or into alternative drainages. Road maintenance activities that prevent the road prisms from becoming sediment sources would largely be deferred. Without maintenance, road drainage facilities such as culverts would continue to degrade the natural hydrology near road systems within the project area. At the fifth field watershed scale, hydrological effects are anticipated to remain within the existing natural range of variability.

Alternative 2

Under Alternative 2, thinning stands would change the hydrology by reducing competition for light, water, and nutrients in the thinned stands. There would be increased snow accumulation on the thinned acres, roads and landings. A short-term (5 to 10 years) increase in discharge during the wet and the dry periods would occur as a result of thinning. Increased snow accumulation (wet period) would create small increases in peak flows (Jones, and Grant, 2001), and reduced canopy (dry periods) would reduce transpiration rates which could account for small increases in summer flows. These potential changes in discharge and peak flow are not likely to create detrimental effects and would likely be immeasurable due to the limited spatial extent and type of thinning treatment (Pike and Scherer 2003).

Early seral habitat creation, gaps, shelterwood cut, and meadow restoration activities have greater reductions in canopy closure than thinning. Effects of canopy closure reduction include: reduced interception and transpiration, increased snow accumulation, runoff associated with rain-on-snow and water storage, and increased availability of water and nutrients for remaining trees and other vegetation.

Under Alternative 2, meadow restoration in Unit 32a would remove encroaching conifers to enhance habitat for wet meadow vegetation species, pollinators and wildlife. Approximately 3 to 5 trees per acre would be retained, along with the largest relic trees. Opening of the canopy would reduce canopy interception of precipitation, retain snowpack longer into the spring, and reduce evapotranspiration from shallow groundwater, leading to increased storage and duration of available shallow groundwater to support meadow vegetation. The resulting hydrology of the meadow is anticipated to be characteristic of seasonally saturated herbaceous slope wetland with increased saturation of soils from precipitation and snowmelt and decreased transpiration loss. A small intermittent stream channel near the middle bottom of the unit would correspondingly also experience longer duration stream flow, though it would still remain intermittent. Channel stability of the intermittent stream is not expected to change as portions of the stream where the channel becomes incised are buffered from tree removal and runoff is anticipated to be muted by increased storage.

Understory Habitat Enhancement treatment in units 54, 82, 89, 92, and 560 would thin conifers less than 7” dbh to reduce shading of ground vegetation. Felling will be done by hand, no material would be removed from site, and there will be no overstory removal. Therefore, no hydrological effects are anticipated from this treatment.

Instability, displacement, compaction, and nutrient loss are the main soils and geology impacts with potential to affect hydrology in the project area. Hydrology effects from these vary with the most important being the movement of water through subsurface and surface zones. Any change in the characteristics of these zones could influence the rate and ability of the water to enter the shallow water table. Use of design elements during implementation would either avoid or minimize effects to soil to keep them below thresholds established in the Forest Plan, in this case, less than 20% of a treatment area. Correspondingly, subsequent effects on hydrology would be localized and not readily apparent when scaled to the watershed area.

To prevent subsurface flow from surfacing in swales by ground-based thinning and piling activities, pre-bunched log piles would be staged at least 50 feet away from ephemeral swales and channels. Any crossings with ground-based equipment would be perpendicular to stream channels and swales as designated. Under Alternative 2, 16 ground-based crossings of have been identified to facilitate removal of wood from treated areas. These crossings would cross small intermittent streams; no perennial streams would be skidded across. Temporary placement of bunk logs and slash will be utilized to facilitate skidding of logs without doing damage to stream banks and channel bottoms. This work will be done in the dry season when there is no or reduced flow in these channels and all logs and slash will be removed from channels prior to the next wet season. From the intermittent crossing locations, there may be a small flush of fine sediment (1/2 cubic yard or less) during the first winter flow after treatments have occurred, but due to the amounts of slash following harvest, the effect would be localized with downstream sediment movement staying under 100 feet from each crossing.

Skid trails, landings, yarding corridors and roads serve as compacted surfaces, locally reducing soil water infiltration and increasing surface runoff and downslope erosion potential. As the Soils report specifies, new road construction and re-opening of temporary spur roads would marginally increase road densities in the short-term. This would be a slightly greater increase for Alternative 2. Decommissioning an additional 8.88 miles of road in this project would reduce subwatershed densities by 0.21 miles per square mile in the Upper Breitenbush River Subwatershed and 0.07 miles per square mile in the North Fork Breitenbush Subwatershed. Additionally, 4.07 miles of currently open roads would be closed, yet retained on the system for future use. Roads to be closed that have high aquatic risk for stream channel diversion potential or stream crossing failure would be hydrologically stabilized with waterbars and pulled culverts as needed.

Following harvest, most commercially thinned units will be underburned to treat slash and reduce fuel loading. Fire intensities will vary with fuel loading within the units, but could reach high intensities. Loss of vegetation, in addition to timber harvest can decrease precipitation interception and increase runoff. With acceptable mortality in overstory trees of 0-10% from, overstory canopy closure could be reduced slightly more than just reductions from the thinning treatment alone. In the sugar pine treatment stands where a more open canopy is part of the objective, overstory mortality could be higher (5-15%). Understory and ground cover vegetation will be reduced immediately but will grow back quickly in the near-term. With duff retention standards in place, underburning will only have minor effects to soils. A mosaic-like effect of reduced understory vegetation and duff on the forest floor is anticipated. Ignition of the underburns would take place outside of Riparian Reserves, providing some buffer of undisturbed ground cover between the burned areas and the streams. In considering the negligible to minor effects of underburning to canopy closure, understory cover, and soils condition, is not likely that changes to hydrological processes of interception and runoff would be measurable nor would they create detrimental effects (Pike and Scherer 2003). Effects to runoff would be similar for HFR treatments. No effects to runoff are anticipated from pile burning treatments due to the low acreage of affected ground.

Stream flow changes anticipated are well within the variation of normal flows and should not generate a condition that the channel has not responded to through time. Short-term changes may be evident in the time of a peak and the duration of flow throughout the year due to changes in transpiration rates and

routing of flows. Yet these changes are short lived until such time that the stand closes canopy and utilizes the available water for the site. These changes would be more likely in drainages with more intensive treatments, such as in Unit 32a where the goal is to restore meadow hydrology. Such short-term changes in localized drainages are still minor and not anticipated on a subwatershed scale. With the area's recovery percentage currently well above the threshold and minor reductions in post-treatment ARP values, no altered peak flow changes are anticipated from the implementation of the proposed actions.

Current vegetative conditions in all three subwatersheds exceed 15 points above the Aggregate Recovery Percentage (ARP) midpoint threshold. Exceeding the ARP threshold by 10 points means that sub-watershed canopies are considered fully recovered and that cumulative effects are not anticipated for rain-on-snow events, or for the overall hydrology of the sub-watershed. Provided site-specific prescriptions are followed, it is not anticipated that these actions or any reasonably foreseeable future action would create an adverse downstream effect.

Table 5 Aggregate Recovery Percentages by subwatershed

Subwatershed	**Sub-watershed Acres**	**Average* Threshold of Concern %** (midpoint ARP)	**Alt 1 (No Action)**	**Alt 2**	**Alt 3**
Upper Breitenbush	20,395	74.3	92.28	88.19	89.32
North Fork Breitenbush	16,254	75	93.82	90.61	90.61
South Fork Breitenbush	13,082	73	95.47	94.75	94.75

* Midpoint ARP was originally calculated for subdrainages as part of the 1990 Willamette National Forest Plan. Under the subdrainage classification, the Upper Breitenbush split as the "Middle Breitenbush" and "Devil's Creek" subdrainages. The average midpoint ARP was calculated from the subdrainages that fall within each subwatershed.
**While the total area of the North Fork Breitenbush subwatershed is 16,254 acres, only 10,935 acres are actually within Forest Service boundaries and have an available existing vegetation layer. The percent of watershed was calculated using the 10,935 acres for which data was available.

In conclusion, variably thinning stands and local disturbances by proposed project activities are anticipated to cause only small scale, minor changes well within the natural range of hydrological variability. Due to the design elements that avoid or limit impacts, implementing this project is expected to produce little, if any effect to the hydrology of the project area under Alternative 2 as compared to the No-Action Alternative.

Alternative 3

Compared to Alternative 2, Alternative 3 treats almost 500 fewer acres, does not commercially thin in any stands greater than 80 years of age, and does not restore the meadow in Unit 32a. Alternative 3 has less ground compaction and disturbance from reduced harvest acreage and a slightly lower road density and during implementation than Alternative 2. Post-implementation road densities would be the same for Alternative 2 and 3, which are lower than Alternative 1 due to decommissioning of 8.88 miles of road. ARP percentages would be equal to Alternative 2 for the South Fork Breitenbush and North Fork Breitenbush subwatersheds, and 1.2% higher for the Upper Breitenbush subwatershed. Given similar or less impacts as compared to Alternative 2 and use of the same design elements, the effects of Alternative 3 are similarly expected to produce little, if any effects to the hydrology of the project area as compared to the No-Action alternative.

Riparian Conditions

Alternative 1 – No Action

Under a No-Action alternative, riparian conditions would develop the characteristics of structure, openings and down wood naturally over time (decades) and would maintain a higher overstory canopy cover than the action alternatives in the near term. A higher canopy cover prohibits sunlight to penetrate lower canopy levels and the forest floor. It suppresses the vigor and growth of individual large trees, vegetation development in the understory and future recruitment of structural wood in stream channels. Reduced vigor occurs due to the increased competition and damage that may occur from snow or insects. Higher canopies naturally break open over the long term (>100 years) when lower canopy development is anticipated to recover.

Future recruitment of large trees in stream channels is an integral component of riparian diversity, quality aquatic habitat and structural integrity. Current rates of large wood recruitment, provided mostly by stem mortality (from competition, disease, wind and snow downed trees) and bank erosion, would be maintained. Alternative 1 would provide a slightly higher rate of in-stream wood recruitment compared to the action alternatives. Where the action alternatives protect 90% of the wood recruitment zones, the no action alternative would protect 100%. In some streams, recruitment trees are of sufficient size to meet ACS Objectives (Appendix B), but in other streams with small diameter riparian stands the aquatic benefit is limited, namely through the reduced ability to store sediment and organic matter and contribute to habitat forming processes (e.g. scour). Though small wood has some value, particularly in the smaller headwater reaches, the longevity of recruited small diameter trees is short-lived, as they break down through abrasion and decomposition more rapidly compared to large trees. Small diameter trees are also more likely to be transported out of the system. In-stream wood abundance is low for most streams in the project area and is largely due to past management, historic flooding, and the lack of large enough sized wood to remain stable in channels.

It is anticipated that the No-Action alternative would have little effect on the long-term objective to create stand diversity and shade due to the natural growth and the resiliency of the stands to respond to change. However, the rate of change would be slower for stand diversity and complexity development within the short term (<100 years). Desired riparian conditions – high species and structural diversity with large dead and down wood – would slowly develop over time (several decades) and depend solely on natural thinning events (stem exclusion mortality and disturbance). Without management to increase the abundance of deciduous and herbaceous vegetation in dense, conifer-dominant stands, ecosystem productivity would remain at relatively low levels. Accelerated restoration of riparian stands that currently do not meet ACS Objectives would not be accomplished.

In addition, the currently dense riparian stands would be at greater risk to high severity fire, insect infestation, and disease – all carried more efficiently through overstocked stands. Although these are natural disturbance processes that contribute to forest habitat and diversity, a large disturbance event, or one of high severity, has the potential to reduce vegetation, large woody material, and stream shade across large areas of Riparian Reserves. Research conducted in the Pacific Northwest has shown that while fire severity may be lower along perennial streams due to relatively cool and moist conditions, fire severity along intermittent streams can be similar to adjacent upland areas (Tollefson 2004). In fact, under some circumstances, riparian areas can become corridors of increased fire spread (Pettit 2007).

Alternative 2

The Northwest Forest Plan (NWFP) prohibits timber harvest in Riparian Reserves except as needed to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain ACS Objectives (NWFP Standards and Guides, TM-1(c)). Riparian reserves make up approximately 36% of the area within the proposed units (1,458 acres). Landscape and stream reach assessments, coupled with field reconnaissance, indicate that current conditions of the Riparian Reserves

on the watershed scale are outside the natural range of variability, with many areas not meeting desired vegetation characteristics needed to attain ACS Objectives. Of 1,458 acres of Riparian Reserve within the proposed units, 996 acres (68%) have been harvested in the past as plantations. Approximately 462 acres are considered natural and have not been managed, though most of these are in similar condition to past regeneration harvested Riparian Reserves due to stand replacing fires around the turn of the century (See Silviculture Report). Therefore, there is a need to manage parts of the Riparian Reserves to accelerate attainment of desired conditions. Other areas, however, are currently meeting desired vegetation characteristics and management is not necessary. In some cases, maintaining and/or restoring each one of the ACS Objectives can be a balancing act with trade-offs. For example, to meet the riparian vegetation objectives ("species composition and structural diversity of plant communities" and "habitat to support well distributed populations of native plant, invertebrate and vertebrate riparian dependent species") in young, dense conifer stands, a common silvicultural tool is to remove overstory density to encourage understory growth and structural development. Removal of overstory density, however, could potentially lead to increased thermal loading or reduction of wood volume available for recruitment. Because of these trade-offs, we carefully balance conflicting objectives based on watershed conditions and characteristics of each waterbody and adjacent riparian area.

Alternative 2 proposes both active and passive management of Riparian Reserves: thinning, gap creation, down wood augmentation, and no treatment. Within Riparian Reserves, stand-specific treatments were prescribed by the Silviculturist in consultation with the District Hydrologist and Fish Biologist and are listed in the Design Elements in Chapter 2. Stand treatments promote variable density within and among stands, including Riparian Reserves, by leaving skips, varying thinning intensities, and introducing gaps in selected stands (see the Silviculture Report). Within Riparian Reserves, no-treatment buffers protect stream shade, bank stability, large wood recruitment and other riparian processes; outside of the buffers, treatments in Riparian Reserves are designed to meet or accelerate meeting ACS objectives. Unit design elements developed by the interdisciplinary team directed the management action and the protection needed to accomplish resource goals.

Within Riparian Reserves, stand treatments under Alternative 2 would be consistent with the Aquatic Conservation Strategy by increasing structural and biological diversity and developing large conifers. Across the landscape, including Riparian Reserves within the Late-Successional Reserve, stands would be on an accelerated trajectory for developing late-successional conditions by developing multiple canopy layers and larger trees. Improvement in stand health would also reduce the likelihood of catastrophic fire that could remove entire portions of the landscape and negatively affect watershed stability and its ability to provide high water quality and fish habitat. Appendix E discusses how Aquatic Conservation Strategy Objectives will be met with the project. Following are descriptions of the types of treatments proposed and the considerations for analysis with each.

Table 6. Riparian Reserve acres proposed for treatment

Activity	Riparian Reserve Acres Proposed for Treatment			
	Alternative 1	Alternative 2		Alternative 3
	Total	Total	Over 80	Total
Timber Harvest Treatments	**0**	**708**	**190**	**528**
Thinning	0	703	187	528
Sugar Pine Restoration	0	0	0	0
Quality Early Seral	0	0	0	0
Meadow Restoration	0	3	3	0
DTR Gaps (1/4-1/2 acre)	0	2	0	0

Non-commercial Treatments	**0**	**73**	**3**	**73**
Understory Habitat Enhancement	0	4	1	4
Hazardous Fuels Reduction	0	49	2	49
Streamside Treatment	0	20	0	20
Total Treatment	**0**	**781**	**193**	**601**
No Treatment	N/A	677	208	474
Total Riparian Reserves in proposed units	N/A	1,458	401	1,075
Total Riparian Reserves in Project Area	13,502			
Percent of Riparian Reserve Commercially Thinned	0	5.2	1.4	3.9
Percent of Riparian Reserve Treated	0	5.8	1.4	4.4
Total Riparian Reserves in Watershed	27,925			
Percent of Riparian Reserve Commercially Thinned	0	2.5	0.7	1.9
Percent of Riparian Reserve Treated	0	2.8	0.7	2.1

Thinning in Riparian Reserves

Under Alternative 2, thinning treatments are proposed for Riparian Reserves to meet the objectives related to this project. Riparian Reserves represent 36% of the 4,046 acres of units proposed for treatment under Alternative 2. Approximately 708 acres of the 1,458 acres of Riparian Reserves (49%) would be variably thinned to meet project objectives, representing 5.2% of the Riparian Reserves in the Project Area. Thinning intensities would match the prescription for the rest of the unit, and would retain canopy closure well above 50% in all stands. Where riparian areas are developing the needed characteristics naturally, no thinning was prescribed. Riparian Reserves that were found to be achieving or near achieving ACSO's are fully buffered to the first site tree potential height (172 feet).

The body of literature on the effects of thinning on stream and forest ecosystems is quite extensive. The interdisciplinary team considered several key factors in determining where this type of treatment would be beneficial for the attainment of ACS objectives. In-stream wood recruitment, upland down woody material levels, stand structure, and species composition are described below. Stream temperature, sediment, riparian microclimate, and other factors are described in the sections below. Alternative 2 would treat approximately 781 acres within Riparian Reserves. Appendix G details where treatments are proposed within Riparian Reserves and the vegetation objectives for each unit in Alternative 2 and 3.

Stand Structure and Species Composition

Based on a review of existing literature and stand development theory, Spies et al. (2013) found that the "greatest potential ecological benefits of thinning to accelerate the development of older forest structure (e.g. large trees, large dead trees, spatial structure and compositional heterogeneity, etc.) come in dense uniform plantations less than 80 years and especially less than 50 years old." The benefits of thinning in stands over 80 years old are more variable. Stand conditions were reviewed for each waterbody and recommendations were based on multiple variables, not just age. These factors included tree height and diameter, stand density, species composition, and understory development.

Most stands where thinning would occur within Riparian Reserves are under 80 years old (75%), however, 187 acres of Riparian Reserves in stands aged over 80 years old would be thinned in Alternative 2. Appendix G provides a detailed description of Riparian Reserve treatments by unit, including rationale for treatment, the no-harvest buffer widths, and stand age. Where thinning is proposed within Riparian Reserves, increases in abundance of understory vegetation, species diversity, stand structural diversity,

and tree growth at a faster rate than background levels are expected. Some modeling has shown that young conifer stands, if left untreated, would follow a trajectory towards forest structure found in certain reference conditions (Pollock et al. 2012); Reference conditions were considered to have mature, late-successional conifer dominated stands with abundant large trees in the overstory, abundant large snags, and a well-developed understory of shade-tolerant trees. However, according to Harrington et al. (2005) thinning tends to increase shrub cover and greatly increase within-stand variability where shrub cover is absent before treatment. Riparian thinning can also promote the development of late successional forest attributes of value to many riparian and upland-associated species (Pabst et al. 2008, Harrington et al. 2005). Based on recent research (Ruzicka et al, 2014), increased tree growth within no-treatment buffers adjacent to thinned stands has been shown to occur. In their study, trees responded to an apparent edge effect up to 15 m (49 feet) downslope of thinned areas and we expect to have similar beneficial effects in no-treatment buffers. Because Alternative 2 has more thinning in Riparian Reserves than Alternative 3, 703 and 528 acres, respectively, the benefits in Alternative 2 would be greater.

In order to add additional structural complexity, vegetative diversity, and habitat diversity to stands, some of the Riparian Reserve stands proposed for thinning also have small gap creation, totaling approximately 2 acres. These small ¼-acre gaps would increase stand diversity and productivity, enhancing terrestrial habitats, which are also a component of the ACS objectives (see Wildlife Section and Appendix B). These gaps are planned primarily out of the Riparian Reserves but may have portions extending into the outer Riparian Reserve beyond the secondary shade zone. Table 7 shows a list of these proposed units.

Table 7. Proposed Wildlife and DTR Gaps within outer Riparian Reserve for Alternatives 2 and 3

Unit	DTR Gaps in Unit		Approximate Gap Acres in Riparian Reserve
	Number of gaps	Gap Size	
320	6	¼ acre	0.3
350	2	¼ acre	0.4
380	4	¼ acre	0.7
400	3	¼ acre	0.3
520	6	¼ acre	0.4
Total	21	¼ acre	2.1

<u>In-Stream Wood</u>

In-stream wood is important to the health of aquatic habitats, and many researchers have studied the areas along streams where wood recruitment typically occurs. Wood recruitment zones vary from as little as 8 meters (26 feet) up to about 45 meters (148 feet) depending on various factors (Benda and Bigelow 2014, Spies et al. 2013). According to Benda and Bigelow (2014), wood source areas are highly variable, but are strongly correlated to tree height and the dominant wood recruitment process for each stream reach. They found that in managed forests of the Cascades Range, where bank erosion and tree mortality are the dominant wood recruitment processes, 90% of in-stream wood originated from within about 8 meters (26 feet) of stream channels and the remaining 10% is supplied from a distance equivalent to one tree height. Figure 25 shows the source distance curves for wood in Benda and Bigelow (2014). In less managed and unmanaged forests, 90% of in-stream wood originated from about 13 meters (43 feet) of stream channels.

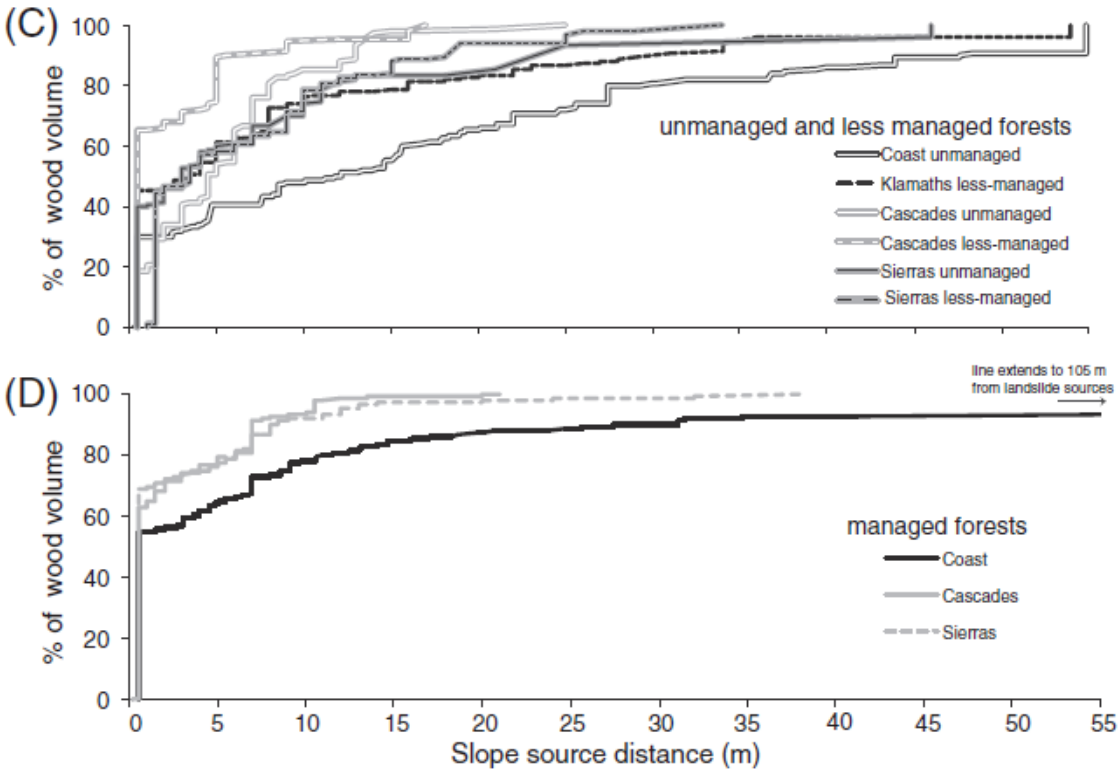

Figure 7. Source Distance Curves for Study Area (Brenda and Bigelow 2014)

Meleason et al. (2003) used the simulation model OSU STREAMWOOD was used to evaluate the potential effects of different riparian thinning scenarios on wood recruitment to streams over time. In one scenario, they modeled the contribution of wood from forest plantations (up to 120 years old in a Douglas-fir – western hemlock forest), beyond no-harvest buffers of varying widths. The results suggest that no-harvest buffers greater than 10 meters (33 feet) from the stream channel contributed minimal amounts of wood volume to streams. In a similar study that modeled effects of no-harvest buffers of 10 meters, as well as effects of single and double entry thinnings with no stream buffer and tree-tipping at various rates, Benda et al (2015) found that a 10-meter buffer maintained 93% of the in-stream wood in comparison to no treatment. This percentage increased and eventually was nullified by tipping up to 12% directly into the streams.

In McDade et al. (1990), the mean wood source distance for first, second, and third order Cascade and Coast Range streams in mature and old growth stands was approximately 10 meters. Conifer tree heights in these stands ranged from 40 to 80 meters (131 to 262 feet). Johnson et al. (2011) demonstrates that in streams adjacent to undisturbed mature or old-growth forests in central and southern British Columbia, 90% of the wood at 90% of the study sites originated within 18 m (59 feet) of the channel. Robison and Beschta (1990) determined that the probability of a tree falling into a stream channel is primarily a function of tree height and distance from the stream. The upper crown of a tree, however, particularly in managed stands, is not of sufficient size to be considered of functioning size in the channel (i.e. large enough to influence stream morphology). Therefore, the "effective tree height" – the height to the minimum diameter and length necessary for the wood to qualify as "of functioning size" – is a more appropriate standard to use for assessing source area distance.

Burton et al (2016) evaluated the effects of buffer width from repeated forest thinning treatments on wood loading in small headwater streams of previously managed stands. The streams with the smallest buffers of 6 meters had the greatest volumes of large woody debris recruited, as compared with the streams that had 15 meters and 70 meters. The unexpected finding that smaller buffers led to more recruitment is thought to be due to reduced competition leading to increased growth of trees outside of the buffer, as well as increased growth of trees within the buffer due to increased side-lighting. Contributions of slash, tree tops, etc. from harvest operations may also account for some of this. Burton et al found that the majority of wood recruitment appears to come from within 15 meters of the stream channel, in addition to other sources upstream that are delivered by mass wasting events and re-distribution. Burton et al suggests thoughtful consideration of applying silvicultural treatments within the first site tree potential of streams to increase large wood to channels and use of more proactive directional felling techniques to accelerate large wood recruitment.

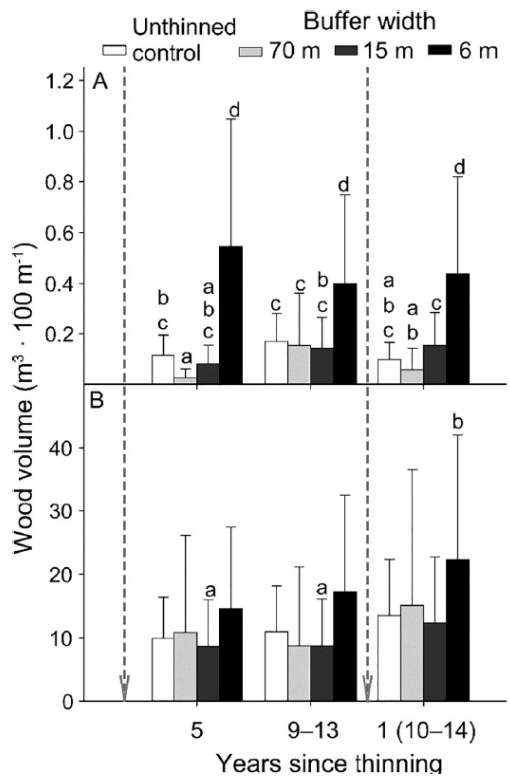

Figure 8. From Burton et al (2016) Effect of wood volume recruitment to small channels by width of no-harvest buffer.

In all of the proposed riparian thinning stands, an area near the stream was designated as a no-harvest buffer to protect wood recruitment zone, channel stability and other riparian values. The overall goal for developing wood recruitment zones was to protect 90% of the trees that could potentially be recruited to the stream channel. This level of future wood input is thought to be sufficient levels to sustain physical complexity and stability required by the ACS Objectives while allowing for treatments to improve vegetation and accelerate the growth of future in-stream wood. This no-harvest buffer ranges in width depending on specific conditions in each unit (i.e. site stability, width and gradient of stream, vegetation characteristics, etc.) and by stream type (i.e. seasonally flowing streams, perennial non-fish bearing streams, and fish bearing streams). Because all perennial waterbodies (Class 1, 2, and 3) have 60-foot minimum shade protection buffers, the wood recruitment zones will also be protected. Based on the research findings, a primary wood recruitment zone of 30 feet from each side of narrow (typically the intermittent class 4) stream channels was defined for young, dense stands within the project area, where bank erosion and tree mortality are the dominant wood recruitment processes and average tree heights range from 56 to 114 feet. No harvest buffers ranging from 30 feet to 172 feet. Along the wider perennial and fish bearing streams where average tree

heights ranged from 70 feet to 114 feet, no-treatment buffers range from 60 feet to 344 feet depending on riparian area conditions.

Given that research has shown that the greatest amount of wood supply comes from 100 feet on either side of perennial stream channels, thinning beyond 60-foot no-treatment buffer (in the secondary shade zone) has some potential to affect large wood supply. Under Alternative 2, future wood recruitment would be affected by thinning within secondary shade zone (60-172 for perennial streams). Thinning within 30 to 60 feet of intermittent streams would protect 90% of the wood recruitment zone. Thinning outside these buffers has the potential to reduce some intermediate-sized wood recruitment into stream channels. Loss would create an intermediate term, 10 to 30 year, period that intermediate wood would not be recruited into the channel through the natural thinning of the stand. However, due to the height of the trees being thinned (56 to 114 feet), there is a very low percentage (< 5%) chance that wood of an appreciable size removed by thinning from outer Riparian Reserves would fall and reach the channel, and most wood supply would still be coming from no-treatment buffers and skips as well as existing sources of large wood within the unmanaged portions of the project area.

Terrestrial Down Wood

In addition to in-stream wood, numerous studies have been conducted that address both the specific roles of down wood in ecosystem as well as its ecological function for wildlife and aquatic species. However, it is less easy to quantify the exact levels of down wood expected to have occur in the upland portions of Riparian Reserves assuming there were no human impact to the forest since these are subject to many variants. Only two management rotations in Douglas-fir stands have been estimated to reduce the abundance of dead wood by 90% compared to levels in natural old-growth systems (Rose et. al.). It should be noted that stands go through a “U” shaped pattern of down wood development naturally; and depending on stand age, a fluctuation of LWM is expected. With thinning prescriptions targeting densities of 40-100 TPA, these are still greater than natural stand densities of 40-60 TPA. Therefore, down wood resulting from continued stand development is expected to be higher in these stands than typically found in naturally regenerated stands. Thinning will reduce the biomass and number of stems available for wood recruitment from physical and suppression caused mortality (Luz and Halpern 2006) in the short to intermediate term.

Across the project area, current levels of down wood are within estimated historical ranges (see Appendix F: DECAID Analysis for more information). As the Breitenbush Watershed is currently within the range of natural variability for downed wood and the proposed thinning in Riparian Reserves only represents 2.5 percent of the entirety of Riparian Reserves in the Breitenbush, short to intermediate term reductions to terrestrial wood recruitment are anticipated within in the unit but these are minor on the watershed scale. On the contrary, “fall and leave only” treatments in Riparian Reserves would have additional benefits to increase upland course down woody debris in the Riparian Reserves, this type of approach would be difficult to balance resulting fuel loading from downed trees with enough falling to achieve desired diversity objectives. The watershed is currently within the range of natural variability for downed wood, so it was not targeted as a needed restorative treatment activity for Riparian Reserves in this project area. This minor reduction in upland downed wood in Riparian Reserves is considered a tradeoff towards improving vegetative species and structural diversity in Riparian Reserves (ACS Objectives viii and ix), the latter of which is currently not within the natural range of variability and in greater need of restorative treatment on a watershed scale.

No Treatment in Riparian Reserve

Included in Alternative 2, some stands will be left in their current relatively intact condition. The 677 acres of no-treatment portions of the Riparian Reserves were selected where ACSO’s are being achieved, are on a close trajectory towards being achieved, or added protection of existing habitats would be needed. These no-treatment areas are either partial buffers within the Reserves or full Riparian Reserves.

The Riparian Reserves in these units and several others show existing stand and vegetation diversity, sensitive habitat, soil stability issues, temperature sensitivity, or existing quality aquatic habitat so no thinning was recommended within the Riparian Reserves. Information on proposed silvicultural treatments in Riparian Reserves, or non-treatment, can be found in Appendix G.

Streamside Treatments

Several streams were identified during field surveys to have a shortage of large woody material within the channel or floodplain, lack of riparian diversity, and/or opportunity for hardwood release. Selected streams for treatment were chosen for their vegetation characteristics at the sub-watershed scale and at the site-specific scale. The large majority of riparian stands along the entire length of the streams in units 6, 100, 190, 430, and 520 are dense plantations lacking structural and species diversity. In these five young plantation units, fall and leave treatment would occur in approximately 20 to 75% of the units' no-harvest buffers along approximately 3.2 miles of streams to reduce densities, open the canopies, increase growth and vigor of remaining trees, and add medium to large wood to forest floor and stream channels (Table 8). These treatments will occur with consideration to protecting or enhancing future shade trees and large wood that have potential to contribute to conditions in-stream in the long term.

Due to the evidence of historic debris flows through Unit 430, this unit was identified specifically as having a high potential for large wood recruitment via an intermittent stream channel downstream less than ¼ mile to the North Fork Breitenbush River. This very dense monoculture stand has evidence of historical debris flows history, with a high potential to serve as a source of large wood downstream. Stream habitat in the North Fork Breitenbush River is largely lacking in large wood and this passive treatment would contribute to its restoration. Treatment would entail falling and leaving individual trees scattered along the riparian area or small groups of trees. The integration of directionally falling trees into the stream along with no-harvest buffers in thinned units increases the recruitment of large wood instream on the site scale (Benda et al, 2015) but due to the conservative number of miles proposed for streamside treatment, this is negligible on the watershed scale.

Table 8. Proposed Streamside Treatments for Alternatives 2 and 3

Unit	Stream	Treatment Description	Estimated Acres	Class 2 Stream Miles	Class 3-4 Stream Miles
6	Fox Creek	Fall and leave to 70 TPA density patches along the lower Fox Creek downstream of tributary confluence.	2.6	0.25	-
100	Leone Creek and tribs	Fall and leave to 70-90 TPA density along the entire north side and patchy thinning with small gaps on south side of the southwest stream channel. Also fall and leave along parts of Leone Creek and east tributary to Leone in north part of units. Tip trees into streams.	7.6	-	1.0
190	Hill Creek	Lightly fall and leave in small hardwood release gaps within the 60 foot no-harvest buffer treat along Hill Creek.	2.3	0.4	-
430	Class IV tributary to North Fork Breitenbush river	Fall and leave trees into stream channel as source wood for the North Fork Breitenbush River downstream within 50 feet of the channel to 90 TPA.	2.2	-	0.2

520	Unnamed Class 3 and 4 streams	Fall and leave to 70-90 TPA within 60 foot no-harvest buffer on all streams, with 3-4 small hardwood release gaps along the class 3 streams.	5.5	-	0.8 (class 3) 0.5 (class 4)
Total Estimated Streamside Treatment			20	0.65	2.5

Approximately 4 acres of small near-stream gaps are proposed within units 100, 190, and 520 (Table 8 above). There are several objectives for these treatments including increased light availability for primary productivity and increased deciduous vegetation for allochthonous material (decomposition of organic matter imported from outside the stream). Historic timber harvest and dense conifer revegetation in the project area have resulted in a lack of deciduous vegetation along many streams. Homogenous conifer stands near streams such as these have been shown to impact the food supply and thus the lifecycle of macro-invertebrates (Hoover 2011). In converse, mature and old-growth stands exhibit a mixture of heterotrophic (shaded) and autotrophic (lighted) habitats within stream reaches (Stovall 2009, Warren 2013).

Research and field surveys indicate that near-stream gaps may be appropriate in certain situations:

- drainages with dense conifer canopy (i.e. plantations) where stream productivity may be relatively low
- lower gradient reaches (<10%) that have higher potential to retain and process organic inputs
- streams tightly coupled to biological hotspots
- streams with low sensitivity to thermal loading and erosion
- riparian areas within plant associations that should have a hardwood/deciduous component

Small near-stream gaps would increase light availability to streams by 20 to 30% to increase primary productivity and increase the hardwood component in order to begin to emulate old-growth characteristics. Canopy gaps have been shown to play a major role in providing light to streams within old growth stands and is significantly higher in those reaches than within younger (~60 years old) closed canopy stands (Warren 2013). Some removal of trees out of the gaps may be required in order to allow regeneration of early serial species. However, these trees would be left in the Riparian Reserves for large woody material. Monitoring will be an integral component of this project. All of the proposed near-stream gaps are within young plantations <60 years old.

Other Treatments

Prescribed Fire

Within some of the commercial thinning units and all of the hazardous fuels reduction units, the introduction of low severity fire into patches of Riparian Reserves is anticipated. Fire would not be ignited in any Riparian Reserves, but would be allowed to back into the Reserves. The fire would then burn in a mosaic pattern rather than requiring a fire line around the Reserves, which would potentially result in erosion. At low burn severities, large wood would not be removed from the Reserves. In addition, with local differences in soil moisture and relative humidity, the pattern of burning in the Riparian Reserves is expected to resemble a patchwork mosaic of unburned and lightly burned sites. In the unburned portions, the existing understory vegetation, including conifers, would be retained. In lightly burned areas, understory conifers would experience some mortality, but fire adapted species such as willow and other hardwood shrubs would re-sprout and, in some instances, be stimulated into increased growth in response to the disturbance. The net result would be increased plant species and stand structural diversity, with a closer resemblance to historic stand condition than non-thinned plantations. Somewhere in the range of 5 to 105 acres of Riparian Reserve in commercial thinning units and 49 acres in hazardous fuel reduction units could be affected under Alternative 2. This range of affected acreage is based on the

design criteria of fire only being allowed to back into the Riparian Reserves and an estimated 5-25% of those Riparian Reserve acres being impacted. The 25% represents a likely maximum and the "worst-case scenario".

Roads and Landings

Proposed road decommissioning would remove 4.2 miles of roads no longer needed from Riparian Reserves. These decommissioned roads would be restored to more natural riparian conditions with level of decommissioning treatment (passive to high degree of treatment) to be determined for each individual road segment.

Wherever possible, temporary roads would be located on ridge tops, gentle slopes, or would utilize locations previously disturbed by historic logging that have not been decommissioned. Those segments located within the Riparian Reserves would be located well outside of the primary shade zone (approximately 60 to 80 feet) and cross perpendicular to the stream where necessary. Two temporary road stream crossings are proposed on class 3 perennial streams (Units 62 and 64). Crossing locations would be approved by hydrology/fisheries staff during layout and would have temporary culverts installed and removed following harvest.

Operations will minimize the number of landings in Riparian Reserves by restricting landings to existing roadbeds wherever possible and locating them a minimum of 100 feet away from any streams. Up to 15 new landings in Riparian Reserves could be located off the existing road prism in addition to the estimated 137 that would be on existing disturbed ground. The maximum effect of new disturbance from temporary roads and landings in Riparian Reserves is equivalent to up to 5.9 acres. Sixteen ground-based (skid trail) stream crossings are proposed to access portions of units. Impacts to large wood are expected to be similar to those of thinning treatments. Typical rates of re-vegetation start occurring within 2 decades from natural regeneration if the disturbed area is not replanted. All temporary roads and landings in Riparian Reserves would be decommissioned after treatment activities are completed following BMP's and additional design elements, including removal of any temporary crossings, sub-soiling the approaches and spreading slash over sub-soiled areas.

Rock Pits

Under Alternative 2, nearby rock sources are needed for use to upgrade roads to hauling standards. Of the nine pits that are proposed to be used for material, only one (Lower Skunk) is located within the Riparian Reserve. Any expansion, additional development, or reclamation of Lower Skunk Pit would occur outside of the Riparian Reserve and be assessed in a separate analysis with development of a Pit Plan.

Summary of Alternative 2 on Riparian Reserves

In summary, Alternative 2 would treat approximately 781 acres within Riparian Reserves. The alternative commercially thins more Riparian Reserve area than the other alternatives (708 and 180 more acres than Alternatives 1 and 3, respectively) that would benefit from treatment towards achieving ACSO's. Thinning under this alternative includes 187 acres of Riparian Reserves that are in fire-regenerated stands with stand ages greater than 80 years old, whereas the other alternatives do not propose any treatment in Riparian Reserves greater than 80 years old. Additionally, 2 acres of small gaps would be created in the outer Riparian Reserve beyond the secondary shade zone and 4 acres of near-stream (primary shade zone) gaps. Approximately 3.2 miles of stream would have large wood enhancement through fall and leave treatments.

The impacts of thinning on in-stream large wood and future recruitment would be very minor at the watershed, project, and reach scales because only 708 acres, less than 2.5% and 5.2%, respectively of the Breitenbush Watershed and project level Riparian Reserve acreage, would be thinned in Alternatives 2. Within those units, approximately 90% of the wood recruitment zones would be protected. The minor

reduction in wood recruitment to streams and uplands would occur at a very slow rate due to the naturally slow rate of the dominant wood recruitment processes (bank erosion and tree mortality) of streams in the project area. The beneficial impacts of thinning to accelerate tree growth would also be very minor at all scales due to the relatively small area treated and slow rates of tree growth. The beneficial impacts of thinning on riparian forest structure and diversity would be minor at the watershed scale due to the limited area of treatment, but would have measureable beneficial impacts at the project and unit scales. Benefits of thinning are well documented, would start occurring within 3 to 5 years, and would persist for decades.

Analysis and field reconnaissance of Riparian Reserves by fisheries and hydrology personnel on a unit by unit basis assured that Riparian Reserve prescriptions would provide for small wood inputs from no-harvest buffers and fall and leave in the short term (1 to 2 decades) while treating outer portions of Riparian Reserves for long-term (2 to 5 decades or more) shade, wood source and terrestrial habitat complexity. Recruitment of large-wood in streams would be reduced in the near term on the unit scale but increased in the mid to long-term on the watershed scale. The proposed management of Riparian Reserves in Alternative 2 would not deter attainment of and would largely benefit ACS Objectives. As Alternative 2 treats more acreage of Riparian Reserve towards attaining these objectives than other alternatives, Alternative 2 offers the greatest opportunity to improve ACSO's in Riparian Reserves on the watershed scale. The Aquatic Conservation Strategy compliance document (Appendix B) explains how each Objective is maintained or improved.

Alternative 3

Alternative 3 proposes to treat 601 acres of Riparian Reserve. Effects to riparian conditions would be similar to Alternative 2 with the exception that 180 less acres would be treated. No Riparian Reserves that have stand ages greater than 80 years old would be treated, including meadow restoration in Unit 32a, leaving these reserves remaining in current condition and on a slower trajectory towards achieving ACSO's. Alternative 3 offers a greater opportunity to improve ACSO's in Riparian Reserves on the watershed scale than Alternative 1, but lesser opportunity than Alternative 2.

Thinning in Riparian Reserves

Approximately 528 acres of Riparian Reserve would be thinned under Alternative 3, with thinning in plantations only (no thinning in fire-regenerated stands over 80 years old). Approximately 175 less acres of Riparian Reserve thinning would occur under Alternative 3. The effects of thinning in Riparian Reserves would be similar to Alternative 2, though with less acres affected. The effects of not thinning the additional 175 acres of Riparian Reserve would represent a 0.7% difference on the watershed scale.

No Harvest in Riparian Reserve

As with Alternative 2, Alternative 3 proposes to leave 480 acres of fire regenerated stands untreated given that ACSOs are either being achieved or are on a trajectory towards being achieved, or additional protection of existing habitats was needed with similar effects as discussed for Alternative 2.

Streamside Treatments

Under Alternative 3, streamside treatments would remain the same as Alternative 2 and have similar effects.

Other Treatments

<u>Prescribed Fire</u>

Post-harvest underburning treatment would occur in 516 fewer acres across units and 50 fewer Riparian Reserve acres under Alternative 3. The number acres of Riparian Reserve affected by Hazardous Fuels Reduction treatments would remain the same. Effects would be similar as Alternative 2 with slightly less acres treated.

Temporary Roads
Alternative 3 would have about 1.2 miles of temporary roads and up to 15 new landings off-the-existing-road-prism in Riparian Reserves. Disturbance from temporary roads and new landings would amount to approximately 5.5 acres of disturbance, slightly less than Alternative 2. The number of temporary crossings for ground based skidding and hauling would be the same as Alternative 2. Design elements for landings and temporary roads would be the same for both alternatives.

Rock Pits
Use of rock pits and subsequent effects to Riparian Reserves are the same as Alternative 2.

Summary of Alternative 3 on Riparian Reserves

In summary, Alternative 3 would treat approximately 587 acres within Riparian Reserves, and all other treatments would be the same as Alternative 2. Effects on riparian conditions would be similar to Alternative 2. With fewer acres thinned than Alternative 2, dense Riparian Reserves untreated would be more prone to wildfire, disease, and infestation, and there would be no benefits from 8 acres of meadow restoration.

Stream Shade and Temperature

Alternative 1 – No Action

Activities that affect stream-shading vegetation would not occur, and direct, indirect, or cumulative effects of this alternative on stream temperature are not anticipated. Water temperatures in streams in the project area would continue to recover toward more natural levels as riparian vegetation that was disturbed or removed by management activities prior to implementation of the Northwest Forest Plan re-grows and re-establishes streamside shade. No indirect effects on stream temperatures due to implementation of this alternative are anticipated.

However, with the increased risk of high severity wildfire, which is carried more easily through dense stands, this may affect water quality in the future. The corresponding loss of vegetation and duff may affect temperatures and microclimates around the edges of the streams and wetlands. Most of the streams and seasonal wet meadows go dry during the summer when temperatures are typically an issue. So increased stream temperature at the current vegetation conditions or after a high-severity fire is not expected in most of the class 4 streams in the project area. Microclimates, however, would be affected after a high-severity fire.

Alternative 2

The system of Riparian Reserves under the ACS provides zones around streams, wetlands, and water bodies that contribute to protecting or restoring the physical, chemical, and biological integrity of these waters, which is the major goal of the Clean Water Act. For all action alternatives, treatments within riparian areas have been designed to comply with the “Northwest Forest Plan Temperature TMDL Implementation Strategies – Evaluation of the adequacy of the Northwest Forest Plan Riparian Reserves to achieve and maintain stream temperature water quality standards” (TMDL 2012).

The Strategy outlines how stream shade can be protected to prevent solar radiation from heating streams, providing calculations for determining the effective stream shading based on tree height, bank/hill slope, aspect and location. At a minimum, the Strategy prescribes no-thin buffers to protect stream shade within the primary shade zone, the riparian area adjacent to perennial stream channels that provides stream shade for the period of greatest solar loading. The secondary shade zone, which provides shade in the morning and afternoon, and also located within the first site potential tree may have some thinning allowed up to 50% canopy closure that does not result in any loss of stream shading. For an even-aged site with 60-100 foot tall trees, the approximate primary shade zone ranges from 50-60 feet depending on and increasing

with slope. This varies with stream width, aspect, and location. To comply with the stream temperature standards, no-harvest buffers were developed to eliminate management effects. These buffers were developed based in part by calculating the width of primary and secondary shade zones.

Research has shown that in many cases significant changes in stream temperature are not observed with partial no-harvest buffers within the Riparian Reserve width (Levno and Rothacher 1967, Brown and Krygier 1970, Swift and Messer 1971, Macdonald et al. 2003). In several cases, buffer distances less than one site potential tree have been shown to protect water temperature. Typically the primary shade zone is half of the site potential tree height. Gomi et al. (2006) reported maximum daily temperatures in headwater streams did not increase significantly when 30- and 90-foot buffers were applied.

Intermittent (Class 4) streams are dry during the portion of the year when elevated temperatures occur and therefore temperature is not as significant an issue. However, no-harvest buffers of 30 feet which were designed for other resource objectives would provide substantial shade regardless. Much of the stream-influenced microclimate would also be preserved since the gradients are strongest within the first 20-30 feet (Anderson 2007) and a portion of the canopy cover throughout the rest of the Riparian Reserve would be maintained. In all of the units with proposed thinning in Riparian Reserves, conifer densities are high and would benefit from thinning.

No-harvest buffers on Class 3 streams have varying widths developed in part to accelerate species and structural diversity while protecting effective shade. All of the Class 3 streams within the proposed harvest units have a minimum 60-foot no-harvest buffer to retain effective stream shade and terrestrial microclimates (Anderson 2007). It should be noted that “no-harvest” and “no-treatment” differ, whereas in a “no-harvest” buffer, trees may not be commercially cut and milled, but may be cut and felled for other purposes – such as for streamside restoration treatment where specified and stream crossings/equipment access. A “no-treatment” buffer would not have any trees cut or any other active management treatment within the buffered area and includes no-harvest buffers. The majority of perennial streams (Class 1 and 2) are protected with a minimum of a 100-foot no-harvest buffer to retain effective stream shade. Where thermal loading, soil stability, desired stand characteristics, etc. are present; no-harvest buffers are wider to meet ACS objectives. Within the no-harvest buffer of units with streamside treatment (Units 6, 100, 190, 430, and 520) up to 20 acres would have fall and leave thinning and small gaps within the primary shade zone (See Table 10). The current canopy cover for the proposed streamside treatment units is 80-90%. Gaps would be placed and thinning treatments heavier on the north and east sides of the channels where solar radiation is less.

The meadow restoration in Unit 32a would occur under this alternative, however the Class 4 stream associated with the meadow is currently dry by early summer. Any increased duration of streamflow associated with the treatment, decreased evapotranspiration, and increased groundwater storage would be minimal and not affect downstream water temperatures.

Small openings in old growth stands are common; and localized warming as a result of the proposed gaps are expected to result in similar conditions remaining within the range of natural variability (Warren 2013). Most studies relevant to shade recovery after clear-cut and other “heavy” harvests predict substantial return to pre-harvest levels within 5 to 7 years of treatment (Brown 1970; Feller 1981; Harr 1988). These recovery predictions assume the rapid return of bankside understory vegetation, because canopy shade provided by second-growth forests will require 10 to 20 years (Beschta 1987, Johnson 2000). Canopy openings in these gaps would likewise be transitory and revegetate quickly. In addition to protection for excessive thermal loading, the proposed gaps are in streams flowing through locations where hyporheic exchange can provide additional offsets to warming.

There are sixteen proposed temporary stream crossings as part of Alternative 2 for ground-based equipment to skid logs across to landings. All of these would cross intermittent Class 4 streams (Units 5,

24, 44, 62, 64, 110, 220, 470, and 520); No perennial streams would be used for ground-based crossings. Class 4 streams are dry during the summer when water temperature is typically a concern. Historic skid roads will be used where possible. This would allow for already compacted areas to be re-used then properly sub-soiled and re-vegetated in order to reduce overall compaction levels. Based on implementation of the design features outlined in Chapter 2, which reduce the acres of disturbance due to temporary roads and skid trails as well as field observations during project reconnaissance; a minimal direct effect is anticipated at a localized level within a few feet downstream of the temporary road crossings. No landings would be located in the primary shade zone of streams (approximately 60 -80 feet), though up to 15 new landings encompassing approximately 5 acres total would potentially be located in the secondary shade zones a minimum of 100 feet from the stream channel.

Additionally two perennial stream crossings are proposed in Units 62 and 64 for temporary roads used to haul logs from landings. At the perennial stream crossings, the width of the clearing needed to establish the crossings would not create a detrimental change in temperature or shade because the primary and secondary shade zones of the adjacent riparian area would retain sufficient canopy closure to these narrow streams to provide shade. A few short segments of other temporary roads would enter the outer portion of Riparian Reserves but not cross any streams.

Due to protection of primary and secondary shade zones, water temperatures of streams within the project area would continue to recover toward more natural levels as riparian vegetation re-grows and re-establishes streamside shade. Additionally, many of the treatment units are over-stocked plantations with small diameter riparian trees. Thinning within the secondary shade zone would increase growth of the remaining trees. These treatments would increase the shrub and understory vegetation, which would increase effective shading as well. Small incremental increases in the rate of recovery as a result of implementing Alternative 2 are anticipated to improve conditions over the long term.

Based on implementation of the design elements outlined in Chapter 2 as well as field observations during project reconnaissance; a minimal direct effect is anticipated at a small/localized level only within a few feet downstream of the temporary road crossings. No long-term indirect increases of stream temperature are anticipated within the project area as a result of these alternatives. Incremental increases or a decrease in the rate of recovery as a result of implementation of either action alternative is not anticipated.

Additionally, thinning of dense stands and managing fuel loading helps reduce the risk of high severity wildfire. This in turn reduces the risk of impacts to stream shade, temperature, and microclimate.

Alternative 3

Alternative 3 would have less acres of thinning than Alternative 2, though these “eliminated” acres are all outside the primary shade zone and would not have any effect on stream shade and temperature. The meadow restoration in Unit 32a would not occur under this alternative, however the Class 4 stream associated with the meadow is currently dry by early summer. This would not change in this alternative. Overall, the effects to stream shade and temperature are similar to Alternative 2.

Sedimentation and Roads

Alternative 1 – No Action

Rates of road related sediment yield are estimated to remain relatively unchanged under Alternative 1 (No Action). Alternative 1 would not correct existing road erosion problems that result in chronic sedimentation to streams. Landscape delivery of fine sediment, as modified by the road and stream-crossing network, would remain as it is and subject only to scheduled maintenance. Without timber harvest related road maintenance, the existing budgetary trend would result in only the main roads being maintained. Culverts that are not maintained could plug and cause washouts. The resulting sediment

plumes could be detrimental to fish and amphibians. Over several decades, these road issues would stabilize as the disturbed areas re-vegetates. However, no project-related storage or decommissioning would occur. Tables 9 and 10 on the following pages provides a comparison of road related sediment delivery to streams between all Alternatives.

Alternative 2

Project activities with potential to affect water quality by increasing sediment delivery to streams are road construction, reconstruction and maintenance, timber haul and log skidding. Road construction can create sediment during pioneering, excavating and development of road prism and placement of crossings. Timber haul can affect sediment delivery when done during wet conditions on non-paved surfaces. Log skidding can create compacted surfaces that create pathways for sediment laden water.

Best Management Practices will be utilized and project design elements are prescribed for each of the following activities to prevent or mitigate these effects.

- No-cut buffers and equipment exclusion buffers are designated to reduce delivery of sediments generated from harvest practices upslope.
- Trails for log skidding will be designated to prevent flow paths to streams and minimize compaction.
- Road work will be done in the dry season.
- Wet weather haul will be restricted to roads that are structurally sufficient and pre-identified in this project analysis.
- Wet weather haul will occur only during conditions that support proper road use.
- All non-paved roads used for wet weather haul will be rocked with at least 4 inches of aggregate material, with minimum size determined by road slope and proximity to streams.
- On all wet weather haul routes, additional cross-drains leading off onto the forest floor will be constructed approximately 100-200 feet above stream crossings within 1000 feet of Listed Fish Habitat to minimize direct delivery of road sediments to streams.

Road work associated with the Hwy 46 Project would also include replacement of a number of culverts that are currently in poor condition or inadequately sized to pass 100-year flood flows (Q100). These culverts currently pose an elevated risk of fill failure. Discussions with engineering personnel indicated that an average fill volume is around 250 cubic yards. This material is at risk of entering the streams and potentially generating debris torrents if the existing culverts fail. However, replacement would require in-stream work in these locations. Work will be done during non-flow periods for intermittent streams, and engineering practices such as sediment barriers and flow bypass would minimize impacts on perennial streams. Flows in perennial streams are expected to be less than 1.0 cubic feet per second when work occurs. Localized effects would occur during the replacement of the culverts and the stream crossings after the first flow and for a limited length downstream. It is not possible to do this work without some sediment delivery, and accurate estimates are not predictable. Depending on weather behavior and other variable factors, sediment yields should fall between 0.5 and 1.5 cubic yards per installation.

Under Alternative 2, approximately 41 stream crossing culverts on planned haul routes that are in poor condition or currently undersized would be replaced or upgraded. Table 9 provides a summary of these replacements and the potential amount of fill material that would have a reduced risk of entering streams. It also estimates the amount of sediment produced from the culvert replacements. The maximum estimate of sediment yields from the culvert replacements would be approximately 62 and 54 cubic yards for Alternative 2 and 3, respectively. In comparison, the estimated volume of fill stabilized is 10,250 cubic

yards for Alternative 2. Alternative 2 would reduce the long-term potential for runoff effects and culvert failures that may affect Riparian Reserves or water quality to the greatest extent.

Table 9. Approximate culvert replacements in perennial and intermittent streams by alternative in the Hwy 46 Project.

Alternative	Stream Type	Number of Culverts Installed/Replaced/ Removed	Cubic Yards of Fill Stabilized	Sediment Yields from Culvert Replacements (Cubic Yards)
Alternative 1	None	0	0	0
Alternative 2	Perennial	27	6250	13.5 - 41.5
	Intermittent	14	3500	7-21
	Total	41	10,250	20.5 - 61.5
Alternative 3	Perennial	22	5,500	11 - 33
	Intermittent	14	3,500	7 - 21
	Total	36	9,000	18 - 54

As part of road storage and decommissioning, a number of culverts on perennial and intermittent streams would be removed along with the fill material to stabilize the stream crossings. Based on GIS review, it is estimated that up to 7 perennial and 32 intermittent stream crossings would be stabilized with the proposed decommissioning activities and up to 17 intermittent stream crossings with the proposed road storage. The culvert removals would stabilize approximately 14,000 cubic yards of material. While work would be done during no to low-flow stream conditions during the in-water-work period and other BMP's would be followed, 28-84 cubic yards could be delivered to streams during decommissioning activities.

An analysis of estimated sediment delivery from roads in the project area was completed using the GRAIP-lite toolset in the NetMap Tools GIS model. The analysis was conducted for each alternative by applying changes in addition of temporary roads, decommissioning of roads, and changes to surface type and road maintenance levels associated with the action alternatives (Table 10). Despite construction of new temporary roads, improvements to haul routes (drainage and rocking) would decrease road generated sediment delivery to streams in the project area by 12 cubic yards annually when the project is implemented. It should be noted this does not account for the amount of haul or distinguish between wet or dry weather hauling. The new road construction and reconstructed roads will be graded and up to current standards. In addition to the 29.9 miles of paved roads that would be utilized for wet weather haul, up to 77.6 miles of non-paved roads could be used for wet weather haul; non-paved roads that are used for wet weather haul would meet wet weather design specifications, including rocking with four inches of surface rock. Temporary roads used for wet weather haul will also be rocked, though exactly which roads these would be is unknown. As a worst-case scenario, they were all considered native surface in the model input. Wet weather haul will not be permitted on native surface roads. Combined with the road improvements, the construction and subsequent decommissioning of temporary roads, the additional activities of road realignments (0.3), road decommissioning (8.7 mi) and the Short Lake Reroute (0.4 mi), would further reduce road sediment delivery by another 14 cubic yards annually.

Table 10. Comparison of GRAIP-lite modeled road sediment delivery by Alternative

Alternative	Description	Cubic yards of sediment delivered/year
Alternative 1	all existing roads in Hwy 46 + haul routes	95
Alternative 2	Alt 2 Implementation Total	83
	Alt 2 Post sale/posts decommissioning Total	69
	Alt 2 Total	78

Alternative 3	Alt 3 Implementation Total	78
	Alt 3 Post sale/posts decommissioning Total	74
	Alt 3 Total	70

Hauling during wet weather conditions would likely lead to road sediment erosion and fine sediment delivery to streams, however, installation of additional cross-drains above stream crossings and rocking the road surface will improve road drainage and minimize sediment delivery to stream channels. Additional cross-drains in the model nor sediment delivery associated with wet versus dry weather hauling based on amount of hauling traffic are not accounted for in this model. No effects are anticipated during dry weather construction, haul and removal when Best Management Practices are used during all operations.

Nearby rock sources are needed for use to upgrade and maintain roads to hauling standards and minimize fine sediment delivery to streams. Nine pits are proposed to be used for material but are generally located well away from streams. The current limits of lower Skunk Pit is located within 100 feet of Skunk Creek, a perennial class 3 stream. Extraction of material from this pit could lead to fine sediment delivery to Skunk Creek, but would be minimized by following BMP's. Any expansion, additional development, or reclamation of Lower Skunk Pit would occur outside of the Riparian Reserve and be assessed in a separate analysis with development of a Pit Plan.

Alternative 3

Thirty-six stream crossing culverts that are currently in poor condition or undersized would be replaced or upgraded (Table 9). The maximum estimate of sediment yields from the culvert replacements would less than Alternative 2 by approximately 7.5 cubic yards less (54 cubic yards total). However, five culverts that are in need of replacement would not be replaced, with approximately 1,250 cubic yards of fill not stabilized in this Alternative. Road decommissioning and storage effects would be the same as Alternative 2. Alternative 3 would reduce the long-term potential for runoff effects and culvert failures that may affect riparian conditions or water quality but to a lesser extent than Alternative 2.

Fewer miles of new temporary roads and existing spurs would be constructed and re-opened than Alternative 2. There would also be fewer miles of haul routes, and subsequently wet weather haul miles, maintenance/reconstruction, and culvert upgrades than Alternative 2. There would be no difference in number of roads decommissioned or stored, realignments and re-routes, or rock pit use than Alternative 2. Slightly less road-generated sediment would be produced and delivered to streams with Alternative 3 during project implementation (Table 10). However in the mid-to longer term there would be a higher risk of culvert failure and fill release with Alternative 3, because less miles of road would be brought up to standards and fewer culverts upgraded to proper sizing and condition.

Cumulative Effects

The cumulative effects of the proposed project plus the projects listed in the *Past, Present, and Reasonably Foreseeable Actions Relevant to the Cumulative Effects Analysis* (Appendix D) are considered at the local and 6th field subwatershed scale. Effects of a cumulative nature are those effects which independently do not pose a risk to water quality yet, when added together may have some measurable effect on hydrology, riparian conditions or water quality. All recent and planned timber harvest, riparian habitat complexity development, and road improvement and decommissioning projects were and will be designed with similar protection measures, design features, and Best Management Practices that minimize effects to water quality and aquatic resources.

Alternative 1

Cumulative effects of Alternative 1 would range from no measurable effect to beneficial effects on hydrology, stream channels, water quality, and riparian conditions for approximately 25 years. At that time, stand conditions and large wood recruitment levels could change and would begin to show delayed effects on hydrology, stream channels and water quality. Riparian stand diversity, understory development, and large wood (>36 inch diameter) recruitment in stream channels would be delayed from recovering to desired future conditions. Implementation of the CMLG road drainage improvement project and the North Fork Breitenbush Restoration in the next 5 years would provide some potential improvements to stream flows and water quality; however, an ongoing and longer term lack of road maintenance may cause road drainage structures to fail raising risks to water quality and stream channel routing. Ongoing concerns with road sediment delivery from non FS-system roads in the powerline corridor are anticipated to continue as well as continued fine sediment delivery to the Breitenbush River from the Short Creek slide debris flow. As a result of the recent 2017 wildfires, which burned a combined 2759 acres in the South Fork Breitenbush Subwatershed and 891 acres in the Upper Breitenbush Subwatershed were generally of low soil burn severity and fire intensity. The low severity coupled with the low percentage of subwatershed acreage will slightly increase peak flow responses (1.2 times and 1.1 times increase for the South Fork Breitenbush and Scorpion Creeks, respectively). An increase in sediment erosion and delivery to streams is anticipated in the first 2-5 years post-fire. Post-fire BAER and suppression repair treatments include storm-proofing roads that are threatened from increased runoff and erosion will minimize the potential fire-related impacts in the Breitenbush Watershed. Timber harvest, geology/soils, and social influences on these parameters are anticipated to remain unchanged from the current condition and potential positive effects to the riparian conditions in the diversity and health of the ecosystem would be delayed.

Cumulative Effects for Alternatives 2 and 3

Stream Flows/Disturbance

Breitenbush Hot Springs Resort is the only privately held land in the project area. Although its lands are managed primarily for recreation, impacts to streams may occur with infrastructure in the stream channel and floodplains for drinking water and hydropower generation. The powerline corridor represents a vast swath of federally owned land that is primarily managed by BPA and PGE. Vegetation growth is managed in this corridor to suppress interference with powerlines. A vast network of non-system roads are used to access towers and lines. Numerous stream crossings are associated with these roads, with instances where stream channels have been created or diverted. These effects are anticipated to continue.

The planning subwatersheds are well recovered from an ARP standpoint and cumulative effects for peak flows are not anticipated, even coupled with the minor increases resulting from the 2017 Wildfires. It is not anticipated that implementing either action alternative with their accompanying design elements would create an adverse downstream hydrologic effect relating to peak flows. With the protection buffers and restrictions placed on activities adjacent to wet areas and streams it is not anticipated that cumulative effects would be associated with the hydrology of the groundwater dependent areas found within the area.

Additive ground-disturbing activities of the proposed action alternatives are not anticipated to impact stream channel conditions through time with the proposed mitigations and Best Management Practices. Planned restoration of the North Fork Breitenbush River with placement of large wood structures along approximately 5 miles will have a long-term benefit to stream channels on the subwatershed scale. The effects of these individual actions have a cumulative minor effect on the local site scale in the near-term and negligible to beneficial effect on stream channels/disturbance on the sub-watershed scale in the long-term.

Riparian Conditions

Within the 2017 wildfire perimeters, 1,275 acres were in Riparian Reserves within the Breitenbush Watershed. These were predominately unburned or low severity. Only an estimated 10 acres of Riparian Reserve were rated as moderate soil burn severity. The powerline corridor crosses approximately 35 streams in the project area and is maintained in early seral vegetation condition to suppress powerline interference. Riparian areas in this corridor will continue to be managed for early seral condition and continue to have a negative effect on the site scale, but this is and will continue to be minor on the subwatershed scale. In contrast, thinning Riparian Reserves would maintain and improve overstocked forest conditions to meet ACS objectives, and streamside treatments of the proposed action to increase structural and species complexity and diversity would have positive effects at the site scale but little discernable cumulative effects at the subwatershed scale due to the limited scale of treatments. Minor losses wood recruitment within riparian areas in the near-term from thinning outside of no-treatment buffers as part of the proposed action, will be offset for the intermediate to long-term through the accelerated development of larger wood to be recruited in the long term. Each of the projects listed in Appendix D were analyzed for effects to riparian conditions and were found to have negligible effect, minor effect or beneficial effect.

Stream Shade and Temperature

Though some riparian areas burned in the 2017 Wildfires, very little burned at fire intensities high enough to result in tree mortality and subsequent loss of canopy cover and stream shading. Stream temperatures are not expected to increase as a result of the fires. The powerline corridor would continue to be managed in early seral condition, maintaining numerous small segments of minimal shade within in the corridor area. The proposed action would have minor to negligible impacts to shade in the near-term due to use of no-treatment buffers that protect existing shade, leading to no detrimental cumulative effects at the sub-watershed scale. Along with the other recent, ongoing, and likely foreseeable future actions, stream shade would be maintained in the short-term and be maintained or increase slightly in the long-term as tree canopies respond to reduced densities and increased vigor in riparian areas.

Sedimentation and Roads

There is an increased potential of sediment delivery to the South Fork Breitenbush and its tributaries to do increased soil erosion, debris flow probability and road interception of runoff. The post-fire suppression rehab work and planned drainage improvements on the 2231870 road system will help offset these impacts prior to implementation of the Hwy 46 project. Short-term effects of the proposed action alternatives on sediment would be associated with designated crossings, road maintenance and road reconstruction, and would be short lived and localized, gone after the first storm event that provides sufficient flow. By utilizing BMPs during winter haul, this activity will also be managed to prevent detrimental sedimentation that could cumulatively affect water quality when haul routes cross multiple streams. However, the long-term beneficial effects of fixing and maintaining roads outweigh the short term negative impacts as part of the with the proposed action and the reasonably foreseeable CMLG Legacy roads project may slightly improve water quality in the long term by improving road drainage and reducing road surface erosion and sediment delivery to streams. Well-maintained roads efficiently drain runoff through properly sized culverts and protect fills from becoming saturated and catastrophically failing. The 8.88 miles of planned road decommissioning and road closure with hydrologic stabilization in areas of higher aquatic risk will further reduce road-related sediment delivery in the long-term. Within the powerline corridor, non-FS powerline access roads that do not currently adhere to best management practices along with a high density of road-stream crossings, would continue to have minor impacts on sedimentation on the site and negligible on the subwatershed scales. In reviewing the reasonably foreseeable future projects found within the project record it is anticipated that the proposed action along with these foreseeable future actions would have negligible to beneficial minor effects in the near to long-term; and would not generate any adverse cumulative effects on sedimentation.

Consistency with Direction and Regulation

All proposed action alternatives would comply with the following directions and regulations:

Willamette National Forest Plan, including applicable Standards and Guidelines The Willamette National Forest Land and Resource Management Plan (USDA, 1990a; as amended by USDA/USDI, 1994) played a major role in determining the Purpose and Need and in the development of all the alternatives. The action alternatives comply with all aspects, standards, and guidelines of the Forest Plan., This analysis is tiered to the Final Environmental Impact statement for the Forest Plan (USDA, 1990b).

Northwest Forest Plan including applicable Standards and Guidelines Actions analyzed in the Hwy 46 EIS are consistent with the Forest Plan standards and guidelines that have been discussed and disclosed throughout this document. This project is consistent with the goals and management direction analyzed in the Willamette National Forest Land and Resource Management Plan FEIS and Record of Decision as amended.

**The Northwest Forest Plan Record of Decision and Standards and Guidelines (USDA, `1994b) that amended the Willamette National Forest Plan (USDA, 1990a) Survey and Manage:** The Northwest Forest Plan Record of Decision and Standards and Guidelines (USDA, `1994b) that amended the Willamette National Forest Plan (USDA, 1990a) contains a requirement (page C-4) to survey for and manage known sites of a variety of animal and plant species determined to be dependent upon late-successional forest conditions and which are considered to be genuinely rare or where insufficient information exists to determine their status (USDA/USDI, 1994 ROD, page 1). These standards and guidelines do not contain specific direction on how known sites should be managed (it defers specific prescriptive details to subsequent analyses) but does say, of known site management, that “in most cases the appropriate actions will be protection of relatively small sites, on the order of tens of acres” (USDA/USDI, 1994b, pages 4 and 5). All habitat suitable for species on the survey and manage list that could be affected by the proposed actions has been surveyed based upon current policy.

Clean Water Act The Federal Water Pollution Control Act, popularly known as the Clean Water Act, is a comprehensive statute aimed at restoring and maintaining the chemical, physical and biological integrity of the nation’s waters.

Under Section 303(d) of the Clean Water Act, the State has not identified any stream in the planning area as a water quality-limited water body due to elevated temperatures.

All action alternatives including various project design elements, associated mitigation, and Best Management Practices (BMPs) are consistent with current management direction for protecting water quality including Willamette Forest Plan Standards and Guidelines, Aquatic Conservation Strategy (ACS) Objectives (at the watershed analysis area) and the Federal Clean Water Act.

Implementation of required BMPs would ensure protection of water quality and beneficial uses under all alternatives.

The alternatives all meet and conform to the Clean Water Act, Amended 1982. This Act establishes a non-degradation policy for all federally proposed projects. None of the action alternatives would degrade water quality below its current condition and standards set by the State of Oregon. This is accomplished through project design and planning, application and monitoring of Best Management Practices (BMPs; see the mitigating measures discussed above), and adherence to the Northwest Forest Plan's Aquatic Conservation Strategy Objectives (See the Hydrology and Fisheries and Report and the water quality discussion in this EA under Issue 1). This project is in compliance with the Northwest Forest Plan Temperature Total Maximum Daily Load Implementation Strategy (USDA and USDI, 2012), which addresses water temperature concerns in compliance with the Clean Water Act.

General Water Quality Best Management Practices Handbook (Pacific Northwest Region, November 1988). Oregon State Best Management Practices (BMPs) are employed to maintain water quality and are certified by the Environmental Protection Agency for meeting the Clean Water Act.

The Oregon Smoke Management Plan - Oregon Department of Environmental Quality and the Oregon Department of Forestry are responsible for regulating all prescribed burning operations.

State BMPs are employed to maintain water quality

Executive Orders 11988 Floodplain Management and 11990 Protection of Wetlands These orders direct Federal Agencies to avoid, to the extent possible, both short-term and long-term adverse impacts associated with the modification of floodplains and wetlands. None of the alternatives presented in this EA have specific actions that adversely affect floodplains or wetlands. Proposed activities comply with these orders and USDA Departmental Regulation 9500-3.

NW Forest Plan Temperature TMDL Implementation Strategies (2012) The provisions of the NW Forest Plan Temperature TMDL (Total Maximum Daily Load) Implementation Strategies (USDA and USDI, 2012) apply to streams not meeting State water quality standards for temperature. The document is incorporated by reference and available for public review at the Detroit Ranger District office. The implementation strategies outlined in this document “provide a basis for analyzing stream shade, effects of shade on stream temperature, and management of riparian areas to meet water quality and broader objectives embodied in the NW Forest Plan Aquatic Conservation Strategy (ACS)” (USDA and USDI 1994, p. B9 -B17). As required by section 303 (d) of the Clean Water Act, the State of Oregon must keep a list of water quality impaired water bodies.