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Forest Service

North Clack Integrated Resource Project

Water Quality Report

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for:
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Mt. Hood National Forest

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1.0 Introduction

This report documents existing conditions and provides analysis of potential environmental consequences to hydrologically related resources, related to the implementation of the North Clack Integrated Resource Project. The report includes the regulatory framework that would guide the implementation of this project, including Forest Plan standards and guidelines. The report also includes best management practices (BMPs) and project design features that would be required should the project be implemented.

The Forest has developed a proposed action to address the needs and opportunities within the project area. These activities emphasize enhancing forest health and growth, providing forest products, improving habitat for spotted owls, enhancing riparian habitat, and providing early-seral habitats. They also include changes to the transportation system to address areas of resource concern and to improve road conditions.

Hydrologically related resources are not directly related to the purpose and need. Hydrologically related resources were identified through the scoping process where concerns were expressed about temporary roads and the potential impacts related to the potential for sediment to reach streams. To ensure compliance with Forest Plan and State and Federal requirements, the hydrology report considers potential project-related effects on watershed and hydrologic resources, including water and sediment yield changes, and stream temperature.

2.0 – Analysis Framework

2.1 - Resource Indicators and Measures

The measures of analysis are used to predict the environmental effects of the proposed action and alternatives on water resources. Table 1 summarizes these resource indicators and measures.

Table 1. Resource indicators and measures for assessing effects to hydrologic resources

Resource Element	Resource Indicator	Measure	Used to address: Purpose, Need or Issue?	Source
Water Quality, Riparian and Channel Function and Watershed Function	Water yield Peak Streamflows	Aggregate Recovery Percentage	No	State Water Quality Standards, Forest Plan
Water Quality, Riparian and Channel Function and Watershed Function	Water yield Peak Streamflows	Road Drainage Stream Network Enhancement	No	State Water Quality Standards, Forest Plan

Resource Element	Resource Indicator	Measure	Used to address: Purpose, Need or Issue?	Source
Water Quality	Overall Water quality	Water quality limited streams (miles)	No	State Water Quality Standards, Forest Plan
Water Quality	Stream Temperature	Stream temperature compliance with State standard	No	State Water Quality Standards, Forest Plan
Water Quality	Sediment delivery roads	Tons per year delivered	Yes	State Water Quality Standards, Forest Plan
Water Quality	Sediment	Number of stream reaches that exceed in-channel fine sediment threshold	Yes	State Water Quality Standards, Forest Plan

2.2 - Summary

The analysis details that the action alternatives comply with direction in the Forest Plan, as amended, and that actions provide appropriate protection of water quantity and quality. Site-specific Project Design Criteria (PDCs) were developed for control of nonpoint source pollution. Cumulative effects were found to be minimal. Beneficial uses identified by the State of Oregon for waters in the project area include public domestic water supply and fish and aquatic life. A separate specialist report discusses the impacts and benefits to fish and other aquatic species.

Most of the elements of the proposed action have the potential to affect water. Some actions such as road decommissioning and road stormproofing are specifically designed to improve water quality and to restore in-stream flows to protect the timing, magnitude, duration, and spatial distribution of peak, high, and low flows.

The North Clack Integrated Resource Project is located in the Middle Clackamas River Watershed and the Helion Creek-Clackamas River, North Fork Clackamas River, and Roaring River subwatersheds. Most of the proposed actions and therefore most of the potential changes to water quality and quantity are in the North Fork Clackamas River subwatershed.

2.2.1 - Water Quantity

All of the subwatersheds, are below the threshold where increases in peak streamflows are detectable from The Effects of Forest Practices on Peak Flows and Consequent Channel Response Report (Grant et al. 2008). All the subwatersheds are below the threshold associated with the methodology for addressing cumulative watershed effects, watershed sensitivity, and hydrologic recovery associated with the Mt. Hood Forest Plan (USDA, 1990a). When the combined impacts of vegetation management and roads are examined all the subwatersheds are rated as properly functioning in the 6th Field Watershed Condition from the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017) and the Roaring River subwatershed is below the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads.

The North Fork Clackamas River and Helion Creek-Clackamas River subwatersheds are above the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads. A detailed hydrologic and geomorphic analysis indicated that peak streamflows are not impacting stream channel morphology in these subwatersheds.

2.2.2 - Stream Temperature

Stream temperatures are anticipated to remain at current levels with all alternatives. Protection buffers along streams include sufficient shade.

2.2.3 - Sediment

The largest contribution of sediment to steams comes from natural events including landslides. The largest contribution of sediment from management activities comes from roads. Some road related sediment can be minimized by proper maintenance and prompt repair of road problem areas.

With no action, sediment delivery to streams in may increase associated with the deteriorating road network. The current road network would see minimal levels of maintenance associated with reduced funding levels and may pose a risk of failure and may contribute sediment to streams. With no action, road decommissioning, stormproofing and restoration of unauthorized OHV routes would not occur and those sources of erosion and sedimentation would continue.

With the action alternatives, there would be some project elements that reduce sediment and others that increase it. The restoration actions that are specifically designed to reduce chronic sources of sedimentation include road decommissioning, road closure with stormproofing, road maintenance, road reconstruction, and restoration of unauthorized OHV routes. While these restoration actions may result in a short-term pulse of sediment during the work or after the first rain event, they would result in long-term reductions as they begin to function as intended to minimize the impact of sediment sources.

Some other elements of the action alternatives have the potential to dislodge soil particles which in turn may increase erosion. These activities include new temporary roads, landings, skid trails, yarding corridors and log haul. The action alternatives include Best Management Practices (BMP) to minimize the amount of erosion and sediment delivery.

There would likely be no measurable increase in sediment over background levels in the Helion Creek-Clackamas River and Roaring River subwatersheds. In the North Fork Clackamas River subwatershed the increase in sediment delivered to streams is estimated to be 1 percent over background levels. In the long term, after restoration actions are implemented and after temporary roads are rehabilitated, there would likely be a net reduction in annual sedimentation compared to the existing levels.

2.3 - Methodology and Analysis

2.3.1 - Field Reconnaissance

Interdisciplinary team members visited the project area including system roads, proposed temporary roads, and proposed harvest units to assess the potential water quality impacts and other concerns with proposed harvest units. Interdisciplinary team members including a hydrologist, geologist, soils scientist and fisheries biologist were involved with the creation of the proposed action and project design criteria.

2.3.2 - Models and assumptions

The following effects analysis utilizes research, relevant monitoring, field data and modeling to provide context, amount and duration of effects for each of the alternatives.

Geographic information system GIS analysis and modeling was completed for a variety of site conditions and parameters in the project area. Four different models were used to assess potential effects that could result from the proposed activities. They include the RAPID Stream Shade Assessment Model, Aggregate Recovery Percentage (ARP) model, the Stream Drainage Network Extension model, and the GRAIP_Lite model.

RAPID is a shade model that runs in ArcGIS that was developed to complete a shade assessment at the 5th field level and identify potential restoration sites. The utility of the model is to automate and streamline a shade assessment at the watershed scale for the preparation of Water Quality Restoration Plans (RAPID Tool Documentation). The RAPID Stream Shade Assessment Model is based on the Shadow Model from the 1980's -1993 that was developed to predict temperature increases from management activity (Stockdale 2013).

The Aggregate Recovery Percentage (ARP) model (a model-generated index) was used to assess the watershed's susceptibility to increased peak streamflows associated with rain-on-snow events and to determine whether watersheds in the planning area would meet the Mount Hood Land and Resource Management Plan (LRMP) (USDA 1990) standards for hydrologic recovery. The ARP model is a standard tool used by many Forest Service resource specialists throughout the Pacific Northwest. The model calculates the "hydrologic recovery" of a watershed, which serves as an indicator of the degree of effect to the hydrologic regime of a watershed that could be expected to result from landscape-scale changes to the condition and extent of the forest canopy.

The Stream Drainage Network Extension model was used to estimate the length of inboard ditches delivering runoff to streams at road-stream crossings. Where roads are in-sloped to a ditch, the drainage network can become extended, collecting surface water from the road tread and in places intercepting subsurface water exposed by roadcuts, potentially transporting this water more rapidly to the drainage network than the norm.

Sediment yield associated with the road system was estimated using the GRAIP_Lite model. GRAIP_Lite is a system of tools developed for ArcGIS that is used to model road-related sediment impacts to stream habitats (Nelson, Luce and Black 2018).

Table 2 Methods and Data Used for the Effects Analysis and Their Characteristics

Method/Data	Utility	Limitation
RAPID Stream Shade Assessment	The utility of the model is to automate and streamline a shade assessment at the watershed scale for the preparation of Water Quality Restoration Plans	Model utilizes a number of GIS-derived outputs including tree height, stream width, stream orientation, side slope, and canopy closure. These may differ somewhat from what is on the ground due to actual site conditions which are variable across the landscape.
Aggregate Recovery Percentage (ARP) Model	Gives a general idea about the condition of the hydrologic regime in a watershed. Model works well when validated with field data such as stream surveys.	Model utilizes a number of GIS-derived outputs and a tree-growth simulation model to determine hydrologic recovery. These may differ somewhat from what is on the ground due to actual site conditions which are variable across the landscape.
Stream Drainage Network Extension	Gives a general idea of the increase in the extent of the stream network associated with forest roads and the potential for increased magnitude of peak streamflows.	Model utilizes a number of GIS-derived outputs relative to road and stream locations and associated distance between ditch relief culverts. These may differ somewhat from what is on the ground due to variable mapping precision and actual site conditions.
GRAIP_Lite	Gives a general idea of potential sediment delivery from existing and planned road systems	Model utilizes a number of GIS-derived outputs relative to road location, road surface type, road functional class and road status. These may differ somewhat from what is on the ground due to variable mapping precision and actual site conditions. Delivery of sediment is estimated based on data from measured watersheds throughout the western United States. Similar to the Washington State Road Surface Erosion Model (Dubé et al. 2004), GRAIP_Lite is useful for comparing the relative differences in inherent or accelerated erosion rates in watersheds or from road segments. Modeled outputs are sediment values in tons/year, and are considered to be relative estimates and not absolute values (Dubé et al. 2004).

Method/Data	Utility	Limitation
		The accuracy of a predicted runoff or erosion rate is, at best, plus or minus 50 percent. At best, any predicted runoff or erosion value, by any model, will be within only plus or minus 50 percent of the true value. Erosion rates are highly variable, and most models can predict only a single value. Replicated research has shown that observed values vary widely for identical plots, or the same plot from year to year (Elliot et al. 2000).
Geographic Information System Generated Site Data	Provided additional site-specific data to support the effects analysis and improve its validity.	Since layers in GIS are periodically updated as new, more accurate data becomes available, there may be some variability in precision and resolution of spatial data. Accuracy is supported and refined by field verification.
Effectiveness of BMPs, Mitigation Measures, and Design Criteria to Minimize Effects to Water Resources and Hydrologic Processes	Effectiveness of various erosion control measures in reducing sedimentation is well documented. General effectiveness of buffers in reducing sediment delivery to water sources and other impacts is well established.	Effectiveness of various buffer widths on reduction of effects to surface water is not extensively documented in a wide variety of physical settings.
Stream Inventories	Provided reach-specific data for effects analysis. This data has been collected in a Nationally standardized protocol by trained resource professionals.	Some of the inventories are older and some conditions may have changed between the time the data was collected and the present time.

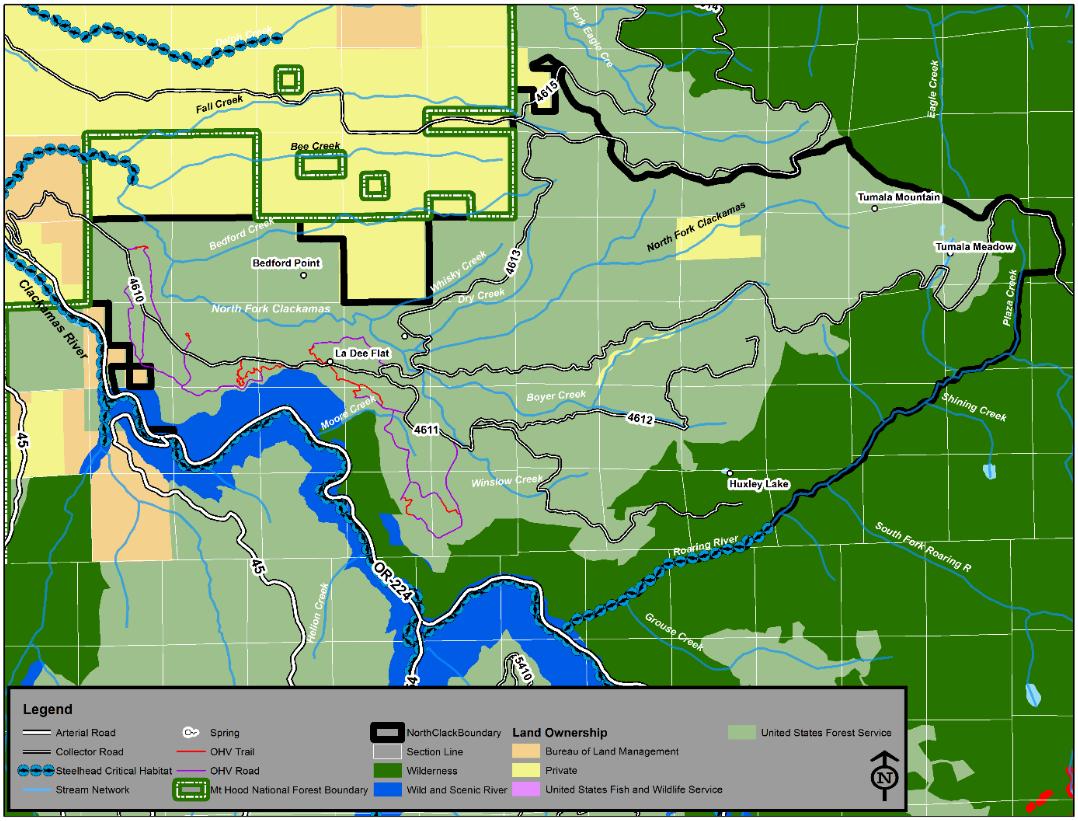

Figure 1 North Clackamas Integrated Resource Project

3.0 – GENERAL ENVIRONMENTAL SETTING

The general environmental setting is based, for the most part, on information from Watershed Analyses for the area associated with the North Clackamas Integrated Resource Project. A general description of the watershed and information on hillslope processes, water quantity and water quality are presented in this section.

The North Clack Integrated Resource Project is located in the Middle Clackamas River Watershed and the Helion Creek-Clackamas River, North Fork Clackamas River, and Roaring River subwatersheds.

Table 3 North Clack Integrated Resource Project associated Subwatersheds

Subwatershed	Acres	Percent of Project Area
Helion Creek-Clackamas River	4,446	18%
North Fork Clackamas River	14,072	57%
Roaring River	6,290	25%

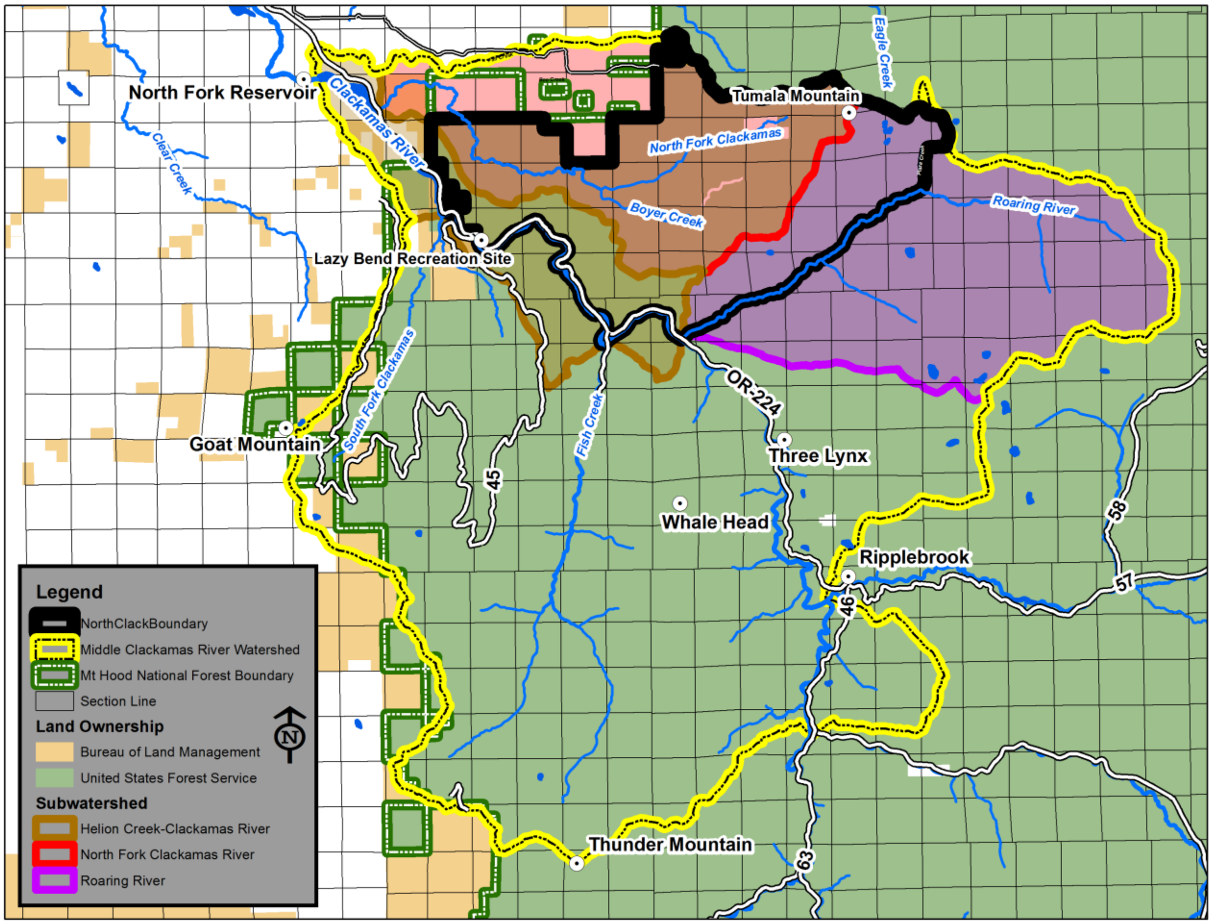

Figure 2 Project Area Watersheds used for Watershed Analysis

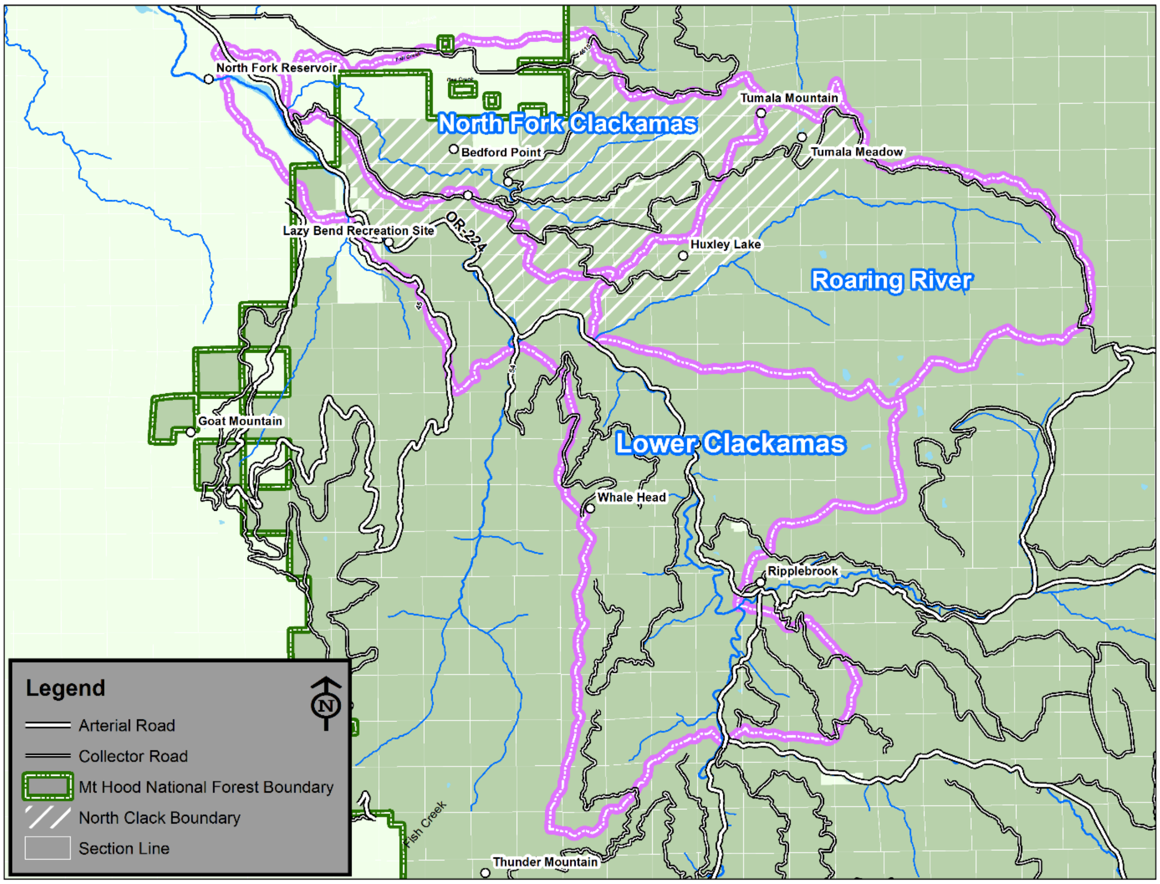

Figure 3 North Clack Project Area Watersheds used for Watershed Analysis

In the North Fork subwatershed elevations range from 4,770 feet at Tumala Mountain on the eastern perimeter of the project area to 660 feet at the confluence of the North Fork River with the slackwater of the North Fork Reservoir. The terrain ranges from steeply incised valley walls in the western third of the watershed to less incised, moderate to gently sloping ridges and drainages in the eastern two thirds of the watershed. The most notable landform in the watershed is Ladee Flats, a flat topped ridge formed when lava flows filled an old valley. The old valley walls have since been removed by fluvial erosion, leaving the resistant lava flows on the present day ridgetop. The river valley of the North Fork is narrow and steep and a waterfall two and a half miles from the confluence limits the passage of anadromous fish (USDA 1996b).

The magnificent geology of the Lower Clackamas Watershed[1] sets the stage for all other resource discussions. The underlying geologic feature of the Lower Clackamas River is the ancient lava flows from the Columbia Basin. Over 15 million years old, these lava flows are from the same parent source as the basalt outcroppings seen along the Columbia River Gorge. In fact,

[1] The area referred to as the Lower Clackamas Watershed in the Lower Clackamas Watershed Analysis is in the current Middle Clackamas 5th field watershed. The Lower Clackamas area assessed in the watershed analysis is a subset of the current Middle Clackamas 5th field watershed.

it is theorized the Columbia River once flowed in the same general vicinity as the Clackamas River. Along the Clackamas River from the Forest boundary upstream the remnants of the ancient lava flows are still seen. Towering basalt bluffs rise vertically from the river. These bluffs and outcroppings continue for the next 25 miles (USDA 1996a).

The Roaring River drainage is a steep river drainage flowing in a southwesterly direction to the Clackamas River. Smaller side drainages dissect the area and include Cougar Creek, Splintercat Creek, Tumala Creek, and the South Fork of the Roaring River. The lower section of the Roaring River is a spectacular narrow gorge, lined with basalt cliffs and talus slopes. Further upstream the canyon widens to steep, heavily-timbered slopes. Elevations in the drainage range from 996 feet at the confluence with the Clackamas River to 5,195 feet along the upper ridges and basins which form the headwaters. Prominent peaks and ridges around the drainage include Tumala Mountain (4,711 feet), Signal Buttes (5,159 and 5,195 feet), Indian Ridge (4,308 feet at its high point), and Grouse Point (4,554 feet) (USDA 1996c).

The PRISM Climate Group[2] 30 year normal annual precipitation[3] for the North Clack Integrated Resource Project area varies from 65 to 110 inches. Within the project area and the associated subwatersheds ephemeral and persistent snowpacks have been identified. The Climate change vulnerability assessment resources for national forests & grasslands in the Pacific Northwest (Staab et al. 2015) identified ephemeral and persistent snowpacks across Region 6 of the Forest Service. Snowpacks were classified as “ephemeral” if the April 1 snow water equivalent (SWE) was less than 1.5 inches during dry years (no snow) and greater than 1.5 inches during wet years (snow cover).

[2] http://www.prism.oregonstate.edu/

[3]At the end of each decade, average values for temperature and precipitation are computed over the preceding 30 years. The current set of 30-year normals covers the period 1981-2010

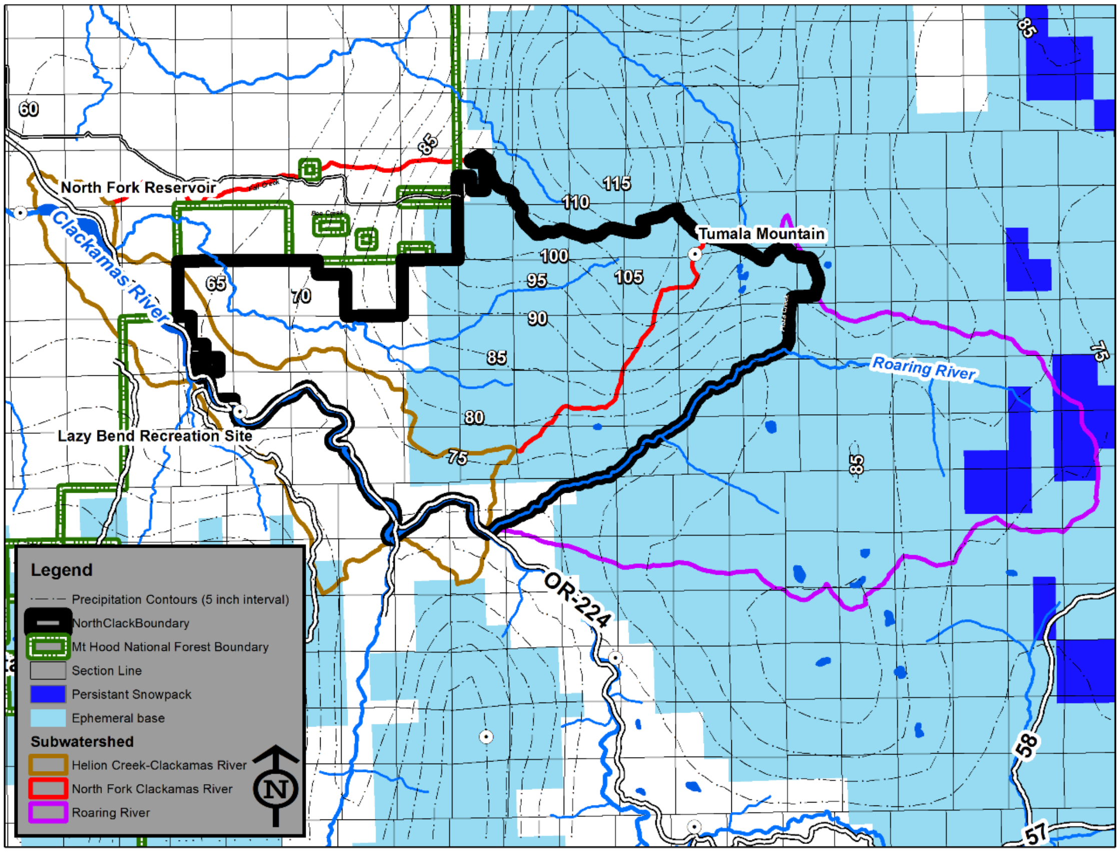

Figure 3 Average Annual Precipitation in the Project Area

3.1 - Hillslope Processes

3.1.1 - Sediment Production and Delivery to Streams

3.1.1.1 - North Fork Subwatershed

In general, this is not a watershed plagued by instability. Problems are largely limited to the deeply incised drainages in the western third of the watershed, where slope angles exceed 50% and sometimes 70%; and within the large ancient landslide deposits (Qls), also in the western portion of the watershed. There are some areas of steeper slopes in the eastern portion of the watershed where the relative potential for landsliding is high (USDA 1996b).

Historically, sediment delivery was more episodic than continual with high levels of delivery occurring during periods following recent large scale fires and floods. Causal agents for the sediment delivery were rain-on-snow events, floods or landslides. Currently, roads and timber harvest units also contribute to sediment delivery in North Fork (USDA 1996b).

Roads may deliver chronic levels of sediment to streams over long periods of time from unvegetated cutslopes and running surfaces. Impacts to water quality occur when sediment is delivered directly to the stream system at road crossings where runoff accumulated in road ditch lines is diverted directly into streams. Roads that are located in close proximity to streams can also deliver sediment via overland flow to stream channels from culvert outflow (USDA 1996b).

3.1.1.2 - Roaring River Subwatershed

The lower four miles of the river corridor is a narrow gorge with steep basalt cliffs and talus. Some of the drainages which are tributary to the lower Roaring River are extremely steep with unstable soils. Active landslides and debris flows are not uncommon in these steep drainages. Along the upper part of the river, valley bottoms are nearly flat or gently sloping and are mantled by soils derived from deep glacial tills (USDA 1996c).

Steep slopes (~ 35%) in the lower drainage below Tumala creek are considered to be moderately unstable to unstable and are subject to translational type slides such as debris slides and debris flows. Frequency and magnitude of these types of slides is also largely dependent on weather and precipitation. But they also are closely related to the underlying geology in the lower drainage in which the stratigraphy chiefly consists of alternating layers of resistant rock (igneous rocks of basalt and andesite) and weak rock (pyroclastic rocks of breccia, tuffs, and conglomerates) (USDA 1996c).

Reaches along the mainstem river can be unstable, especially below Tumala Creek where stream adjacent bank failures can occur frequently. Chronic sediment producers, these types of failures are common where steep sloped valley walls and outside corners of river meanders are continually undercut by the river (USDA 1996c).

Other mass wasting type events in the drainage are related to earthflows. There are two earthflow type landforms comprising about 830 acres in the northwest portion of the watershed. Both of the earthflows are benched on top of the steep, northwest slopes of the lower drainage below the South Fork confluence. Steep drainage ways that originate from the toes of these earthflows are very unstable. Additionally, the toes themselves, which are perched atop the steep slopes of the area, can be very unstable. As with most earthflows in the Clackamas river region, the toes and heads of these earthflows exhibit the greatest rates of movement. Areas between the toe and head generally exhibit slower or imperceptible rates of movement, such as soil creep, and can be considered moderately stable (USDA 1996c).

The function of mass wasting events in the sediment regime of the watershed contribute to the upper range of natural sediment production variability. Events are the "pulses" of sediment delivery which are closely related to large precipitation events (such as rain-on-snow) of the winter and runoff events of the spring. Within the context of this watershed, sediment delivering slides transfer stored fines from up-slope locations to sites along the valley bottom and contribute to natural floodplain development. Other materials such as coarse and large cobbles and gravels, as well as large woody debris, provide aquatic and fluvial components in streams or the river channel. Present ranges of sediment delivering landslides in the watershed are not believed to be outside of the background or natural ranges (USDA 1996c).

3.1.1.3 - Lower Clackamas Watershed

Between the lava flows of the Layered Resistant Rock - Steep Slopes (LRRSS) and Layered Resistant Rock - Steep Slopes (LRRSS) landform types are sedimentary accumulations of tuff and lahar deposits known as interbeds. Permeability changes at these interbeds result in potentially unstable slopes. One of the interbeds is regionally prominent and is known as the Vantage interbed. So many landslides have occurred near this interbed that a topographic bench has developed along part of its extent. The "Vantage Bench" is easily seen on topographic maps. Near Big Cliff the bench is at 1200 feet elevation; near Big Eddy, 1600 feet; near the mouth of Fish Creek, 1800 feet; near Three Lynx, 2800 feet. The Vantage Bench is an indicator of past landslide activity and of the potential for more landslides (USDA 1996a)

3.2 - Hydrology

3.2.1 - Water Quantity

3.2.1.1 - North Fork Clackamas Subwatershed

Peak flows are critical to watershed function. The relatively frequent peak flows (2-year to 25-year return period) are referred to as "channel forming" or "channel maintenance" flows, responsible for shaping the general character of stream channels, adjacent riparian areas, and associated habitats. The relatively infrequent (50-year to 100-year) peak flows are floods which generally transport and redistribute large quantities of sediment and debris, often causing damage to road infrastructure and dramatic changes to aquatic and riparian habitats (USDA 1996b).

A 100-year flood event recently occurred in the Clackamas River subbasin, in February 1996. Portions of the subbasin received extensive flood damage. Very little damage occurred in the North Fork watershed (USDA 1996b).

Flood events in the North Fork Clackamas River are similar to other documented floods in the Cascades. These peak flow events occur during the rainy season following a rapid and substantial depletion of snowpack during a prolonged rain-on-snow period in the "transient snow zone" (a zone of significant snowpack accumulation). This was demonstrated during the February 1996 flood event (USDA 1996b).

3.2.1.2 - Roaring River subwatershed

Peakflow events occur during the rainy season, following a rapid and substantial depletion of the snowpack during a prolonged rain-on-snow period in the "transient snow zone". The Roaring River transient snow zone is estimated to occur between 1500 feet and 4000 feet elevation (USDA 1996c).

3.2.1.3 - Lower Clackamas Watershed

Streamflow information for Lower Clackamas is very limited (USDA 1996a).

The most well documented flood event in the recent past was the 1964 flood. This flood approached the estimated 100 year frequency in the Clackamas drainage. Since 1964 the most recent major flood was in February 1996. Flood frequency numbers were not finalized at the time of this publication, but the most recent estimates were of a 50 to 100 year frequency on the Clackamas drainage. This recent event has likely triggered many channel changes and sediment input. Damages and changes have not yet been documented. An update of stream surveys and other baseline monitoring will be critical in determining changes in the Clackamas River stream system following this large flood event (USDA 1996a).

Peakflow events occur during the rainy season, following a rapid and substantial depletion of the snowpack during a prolonged rain-on-snow period in the "transient snow zone". The Lower Clackamas River transient snow zone is estimated to occur between 1500 feet and 4000 feet elevation. These elevations may vary locally; however, local verification of the transient snow zone for Lower Clackamas River was not available. The lower portion of the watershed is not in the transient zone, but the majority of the upper portions of the Lower Clackamas watershed are within the transient snow zone (USDA 1996a).

3.2.2 - Water Quality

3.2.2.1 - North Fork Subwatershed

The North Fork has three monitoring sites for profile sampling to determine temperature changes by stream order. They are located from the headwaters of North Fork to the confluence with Bedford Creek. These sites have continuous recorders and are located below Bedford Creek (lower), above Boyer Creek (middle), and in the upper North Fork (upper). Low flow summer stream temperatures were measured from 1991-95 during the months of June through September. There is a gradual increase in stream temperatures from the upper to the lower sites. The seven day maximum stream temperatures were within the range of natural variation for the Clackamas River subbasin 14.5 to 20.0 ^{0}C with the exception of 1993 when the water temperature was colder for both the middle and upper sites. The lower site exceeded the state water quality standard of 17.8 ^{0}C in 1994. North Fork temperatures are higher than Roaring River (an unimpacted watershed) but below the biological threshold for salmonids (20 ^{0}C to 23 ^{0}C) (USDA 1996b).

Macro-Invertebrates

Aquatic macro-invertebrate sampling was conducted on the North Fork below Bedford Creek in 1991 and 1995, and at the mouth of Boyer Creek in 1991. This type of sampling can provide important baseline information to help evaluate watershed condition and water quality. Data analysis was done using a modified Environmental Protection Agency (EPA) Rapid Bioassessment Protocol (USDA 1996b).

The 1991 results indicate that both North Fork and Boyer Creek have taxa typical of Western Cascade streams. They both contain higher percentages of taxa that are tolerant of sediment and temperature than intolerable taxa, which can indicate poor habitat quality due to increased stream temperatures, increased canopy openings, and/or fine sediment accumulation. The dominant functional feeding group is the collector/gatherers which can indicate a possible impairment or limitation in the stream habitat. An indicator of good water quality is a stream with high percentages of shredders and scrapers. North Fork has a low percentage of shredders which can indicate insufficient input of organic matter into the stream and/or limited stream retention capabilities such as logs and boulders to maintain the organic material in the channel. The lack of instream retention capabilities relates to North Fork's extensive stand replacement fires of the early and mid-1900's and correlates to today's riparian vegetation composed mainly of mid seral stands. Boyer Creek's low percentage of scrapers could be an indicator of sedimentation. Sedimentation is high in Boyer Creek with portions of road 4612 being a potentially high sediment concern (USDA 1996b).

3.2.2.1 - Roaring River Subwatershed

Relatively stable, cool temperatures are noted for the river compared to other watersheds, including wilderness drainages. There are very low fluctuations in daily temperatures (USDA 1996c).

Aquatic macro-invertebrate sampling was conducted at the mouth of Roaring River during the fall of 1991, 1993, and 1994 (data for 1993, and 1994 have not been analyzed). This type of sampling can provide important information to help evaluate watershed condition and water quality. Data analysis was done using a modified Environmental Protection Agency (EPA) Rapid Bioassessment Protocol. Results indicate Roaring River to be a "slightly impaired" watershed. Slightly impaired, refers to a high percentage of sediment tolerant mayflies, a low percentage of intolerant mayflies, a very high percentage of taxa in the collector/gathers functional feeding group and a low percentage of taxa in the shredders functional feeding group. Due to limited information that has been currently analyzed the "slightly impaired" condition of Roaring River could be the result of the small sample size in the Ecoregion to compare to, the result of the basin's fire history, historic mass movements and/or the residual effects of the 1964 flood (USDA 1996c).

3.2.2.2 - Lower Clackamas Watershed

Temperature data using continuous recorders were taken in 1994 for some of the subwatersheds and along the main Clackamas. Summer stream temperatures were during the months of July through September for most of the sites, however in some cases there is missing data for part of the month of July, during a time stream temperatures were elevated. The seven day maximum stream temperatures did not exceed the upper range of natural variability for the Clackamas River 14.5 - 20.0 ^{0}C for all the subwatersheds in 1994. The state water quality standard of 17.8 ^{0}C was exceeded at the Clackamas above South Fork and is at the standard on the Clackamas above Fish Creek. The temperatures are well below the biological threshold for salmonids (20 ^{0}C to 23 ^{0}C)(USDA 1996a).

3.3 - Aquatic and Riparian Effectiveness Monitoring Program

In this section the existing condition for the 6th field watersheds is based on datasets associated with the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017). The watershed monitoring module (also known as the Aquatic and Riparian Effectiveness Monitoring Program or AREMP) determines if the Northwest Forest Plan's (NWFP) aquatic conservation strategy is achieving the goals of maintaining and restoring the condition of watersheds. AREMP determined the status and trend of upslope/riparian watershed condition for sixth-field watersheds within the Northwest Forest Plan (NWFP) area. Upslope and riparian condition are based on mapped data (e.g. road density, vegetation) representing the years 1993 and 2012 for all watersheds with ≥5% federal ownership (Miller et al. 2017). Watersheds were scored from 0 to 100 for stream condition and upslope/riparian condition, separately. Watersheds were scored from 0 to 100 for upslope/riparian condition. Scores closer to zero signify adverse deviation from expectations; 100 denotes the high end of expectations (Miller 2017). This report includes factors that are related to water quality and quantity such as large wood, riparian habitat and fish passage that are addressed in more detail in the fisheries report.

The assessment was based on factors affecting five major aquatic processes: sediment production and delivery (mass wasting), wood production and delivery, riparian habitat, hydrologic processes (specifically peak flows), and fish passage. The status of each process was estimated based on impacts of road densities and vegetation conditions derived from mapped data, including road metrics from U.S. Forest Service and Bureau of Land Management geographic information system road layers and vegetation metrics derived from satellite imagery (Miller et al. 2017). The report includes factors that are related to water quality and quantity such as large wood, riparian habitat and fish passage that are addressed in more detail in the fisheries report.

The AREMP approach applies expert-derived criteria to regionally-available datasets (Lanigan and Gordon 2012).

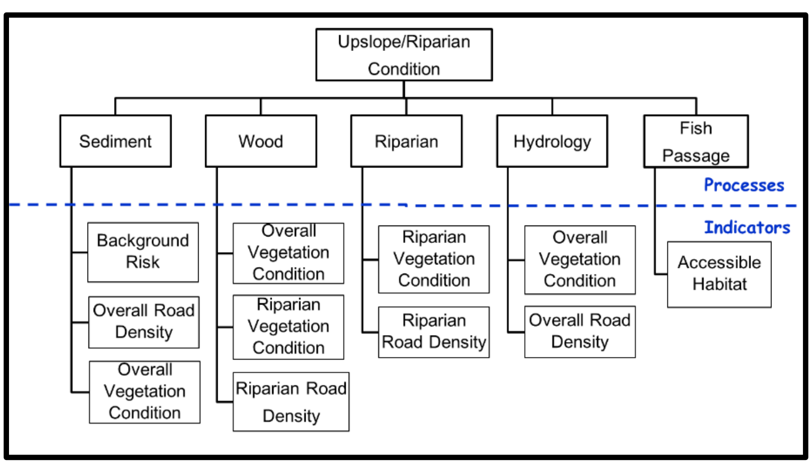

Figure 5 AREMP Major Aquatic Processes and Associated Indicators (Miller et al. 2017)

3.3.1 - Existing Condition

As stated earlier in this section of the existing condition is based datasets associated with the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017). The AREMP scores from 0 to 100 were converted to Watershed Condition Framework type of scores using the formula [2*((100-AretmpScore)/100)+1] (AREMP 2016).

The Watershed Condition Framework (WCF) is a separate process that uses nationally consistent reconnaissance-level methodology for classifying watershed condition, using a comprehensive set of 12 indicators that are surrogate variables representing the underlying ecological, hydrological, and geomorphic functions and processes that affect watershed condition. Primary emphasis is on aquatic and terrestrial processes and conditions that forest management activities can influence. The WCF provides an outcome-based performance measure for documenting improvement to watershed condition at forest, regional, and national scales. The Mount Hood National Forest was assessed in 2010. The process is described in the Watershed Condition Classification Technical Guide (USDA 2011).

Watershed condition classification is the process of describing watershed condition in terms of discrete categories (or classes) that reflect the level of watershed health or integrity.

Class 1 = Functioning Properly watersheds exhibit high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. These are considered to be functioning properly.

Class 2 = Functioning at Risk watersheds exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. These are considered to be functioning at risk.

Class 3 = Impaired Function watersheds exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. These are considered to have impaired function.

Both Watershed Condition Framework (WCF) and AREMP use the same general "multi-attribute" approach, in which a number of watershed indicators are evaluated individually and then their standardized scores are combined using a hierarchical model structure. However, the WCF differs considerably from the AREMP model in the watershed attributes used, how they are evaluated, and how they are combined. In terms of attributes used, the national model is more subjective, in that it relies on experts to rate each watershed, taking into account whatever data they may have. The AREMP approach is more mechanistic; it applies expert-derived criteria to regionally-available datasets. The national assessment includes many indicators for which consistent data are not available, whereas each AREMP indicator must be represented by a regional dataset (Lanigan and Gordon 2012).

The AREMP watershed indicators were used because the indicators were developed for processes in the area associated with the Northwest Forest Plan, the indicators evaluate whether the NWFP Aquatic Conservation Strategy (ACS) is achieving the goal of maintaining and restoring the condition of watersheds, and the ratings are more recent than the Watershed Condition Framework ratings.

Using the same break points for Properly Functioning, Functioning at Risk, and Not Properly Functioning as the WCF process the AREMP scores for process indicators were assessed.

Table 4 Overall Watershed Conditions and Aquatic Process Scores (Converted to Watershed Condition Framework type scores)

Subwatershed*	Watershed Condition	Sediment	Riparian	Wood	Hydrology
Helion Creek-Clackamas River	1.5	1.0	2.4	2.1	1.0
North Fork Clackamas River	1.7	1.0	2.1	1.9	1.5
Roaring River	1.2	1.0	1.3	1.4	1.0

- *Green = Properly Functioning, 1 to 1.6
- Yellow = Functioning at Risk, 1.7 to 2.2
- Red = Not Properly Functioning, 2.3 to 3

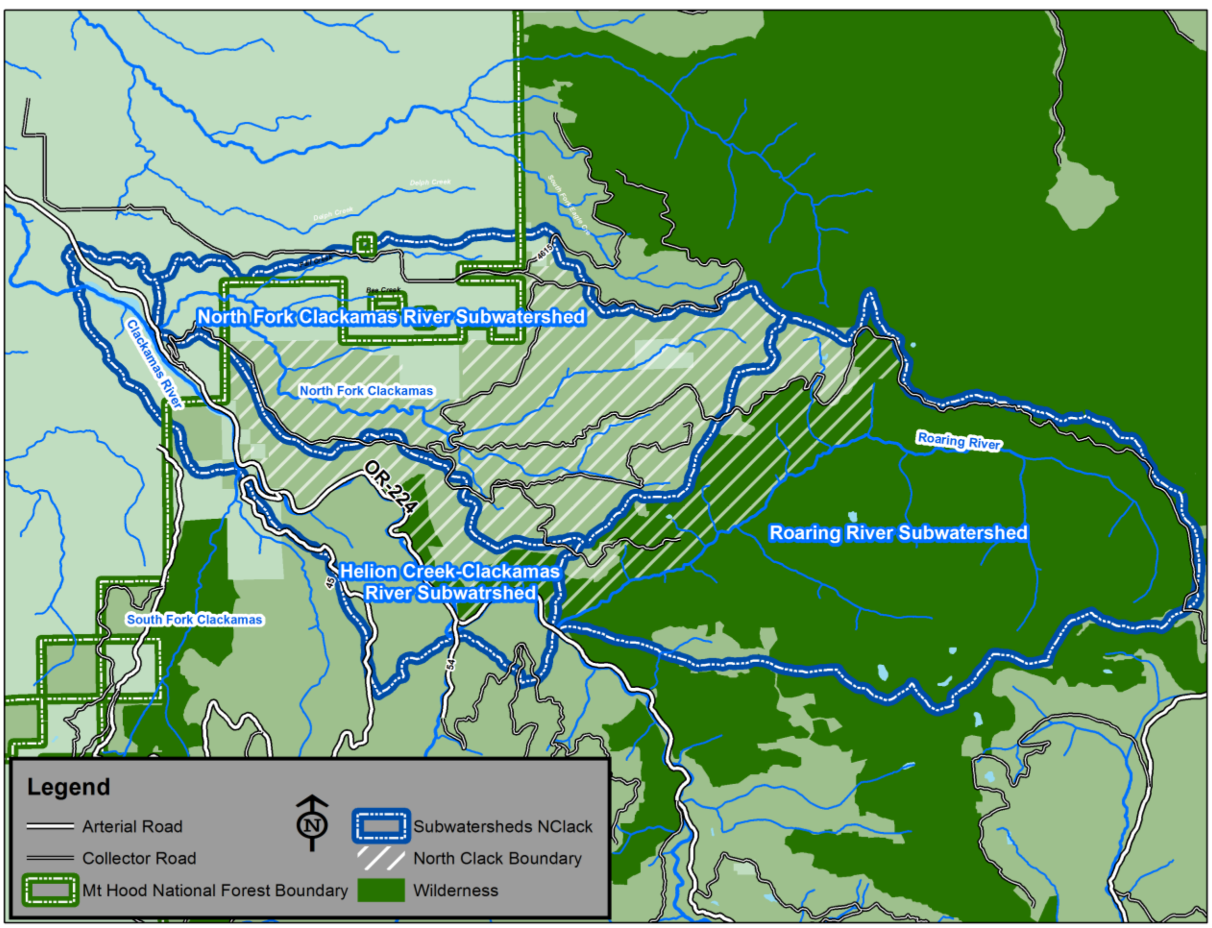

Figure 4 North Clackamas Integrated Resource Project Subwatersheds

3.3.1.1 - Sediment Production and Delivery (mass wasting)

High rates of sediment delivery to streams from episodic mass wasting events such as landslides and erosion have been shown to have detrimental effects on salmonids and other aquatic biota. Natural rates for these processes are determined by a variety of factors, including slope, concavity, soils, geology, geomorphology, and precipitation. Within the range of the Northern spotted owl, federal forest management affects these rates primarily through road and vegetation disturbances. To evaluate the process of sedimentation production and transport, the AREMP model used the difference between an estimated background rate of sediment delivery and the rate estimated given the status of road and vegetation disturbances (Miller et al. 2017).

3.3.1.2 - Riparian Shading and Habitat

Riparian conditions play a key role in a number of aquatic processes, including the effect of shading on stream temperatures, roots on bank stability, and the provision of habitat for a number of species. The AREMP model rates the condition of these processes using the average of two indicators: riparian vegetation condition and riparian road density (Miller et al. 2017). For each NWFP vegetation zone a reference distribution for mean tree diameter and canopy cover from areas with less than 10 percent disturbance based on historical data was calculated. Each attribute score was then based on the departure from the mean of this reference distribution, with a less than -5 percent departure receiving an undisturbed score of 100 and a greater than -45 percent departure receiving a score of 0. The minimum of the size and cover scores was taken as the watershed- wide vegetation indicator score because reference condition departures may be indicated by either metric alone (e.g. early and late seral may share the same cover metric but will differ by size). Because a large proportion of stream wood comes from the riparian area, a separate indicator was calculated explicitly for riparian vegetation condition, effectively giving it equal weight to the overall vegetation condition indicator (Miller et al. 2017).

3.3.1.3 - Wood Production and Delivery

Large wood plays a major role in structuring aquatic habitat in the PNW. Reeves et al. (2004) recommended assessing the wood production and delivery process by measuring forest composition and structure class. Previous reports used expert-derived thresholds for average tree size and canopy cover set by province (and in a few cases subprovinces). For each NWFP vegetation zone a reference distribution for mean tree diameter and canopy cover from areas with less than 10 percent disturbance based on historical data was calculated. Each attribute score was then based on the departure from the mean of this reference distribution, with a less than -5 percent departure receiving an undisturbed score of 100 and a greater than -45 percent departure receiving a score of 0. The minimum of the size and cover scores was taken as the watershed- wide vegetation indicator score because reference condition departures may be indicated by either metric alone (e.g. early and late seral may share the same cover metric but will differ by size). Because a large proportion of stream wood comes from the riparian area, a separate indicator was calculated explicitly for riparian vegetation condition, effectively giving it equal weight to the overall vegetation condition indicator (Miller et al. 2017).

3.3.1.4 - Hydrology

Upslope/riparian conditions affect the quantity and timing of water reaching the stream system and consequently the habitat of aquatic and riparian biota. No consistent regional data were available on dams and diversions, so this analysis was limited to the influences of road and vegetation changes on peak flows (Miller et al. 2017).

3.3.1.5 - Individual Indictors

The overall upslope/riparian condition assessment uses 6 indicators (background landside risk, overall road density, overall vegetation condition, riparian vegetation condition, riparian road density, accessible fish habitat) 4 of the indicators are detailed in the following table (background landslide risk and accessible habit are not included because background risk is not based on watershed management activities and for accessible fish habitat the process score and the indicator score is the same).

Using the same break points for good, fair, and poor condition as the WCF process the AREMP scores for individual indicators were assessed

The Good condition is the expected indicator value in a watershed with high geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is functioning properly with respect to that attribute.

The Fair condition is the expected indicator value in a watershed with moderate geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is functioning at risk with respect to that attribute.

The Poor condition is the expected indicator value in a watershed with low geomorphic, hydrologic, and biotic integrity relative to natural potential condition. The rating suggests that the watershed is impaired or functioning at unacceptable risk with respect to that attribute.

Table 5 Process Indicator Scores (Converted to Watershed Condition Framework type scores)

Subwatershed*	Riparian Road Density	Overall Road Density	Riparian Vegetation	Overall Vegetation
Helion Creek-Clackamas River	3.0	2.7	1.7	1.6
North Fork Clackamas River	2.6	3.0	1.5	1.6
Roaring River	1.0	1.0	1.6	1.7

- *Green = Good Condition, 1 to 1.6
- Yellow = Fair Condition, 1.7 to 2.2
- Red = Poor Condition, 2.3 to 3

3.3.2 - Trend Analysis

Using historical datasets, scores for each of the attributes were determined for two time periods: 1993, before the NWFP, and 2012 using the latest data available. Trend in condition scores for attributes and the overall watershed condition score was calculated by simply subtracting 1993 scores from 2012 scores. Positive trend scores indicate an improvement in condition and negative scores a decline.

The overall watershed condition scores indicated an improvement or neutral condition. The process scores also indicated an improvement or neutral condition except for sediment in North Fork Clackamas River and riparian in Roaring River.

Table 6 Overall Watershed Condition and Process Trend Scores

Subwatershed	Watershed Condition	Sediment	Riparian	Wood	Hydrology
Helion Creek-Clackamas River	3	0	1	2	11
North Fork Clackamas River	2	-1	5	3	3
Roaring River	0	1	-2	-1	0

The indicator values (other than riparian vegetation condition in Roaring River and overall vegetation condition in North Fork Clackamas River and Roaring River) indicate an improvement or neutral conditions.

Table 7 Indicator Value Trend Scores

Subwatershed	Riparian Road Density	Overall Road Density	Riparian Vegetation	Overall Vegetation
Helion Creek-Clackamas River	0	16	2	3
North Fork Clackamas River	10	0	0	-1
Roaring River	0	0	-3	-1

4.0 - Existing Condition

4.1 - Water Quantity

Peak streamflows of large magnitude in and downstream of the analysis area are generally generated by rain-on-snow events.

Flood events in the North Fork Clackamas River are similar to other documented floods in the Cascades. These peak flow events occur during the rainy season following a rapid and substantial depletion of snowpack during a prolonged rain-on-snow period in the "transient snow zone" (a zone of significant snowpack accumulation). This was demonstrated during the February 1996 flood event (USDA 1996b).

In the adjacent Sandy River basin record floods occur predominantly during November through January, caused by accumulated snow at lower elevations followed by a rapid rise in temperature, unusually high-elevation freezing levels, and heavy rainfall. In some instances, the ground is frozen prior to snow accumulation, producing more favorable conditions for high runoff (USDA 1976). 90% of the annual peak streamflow events in Whisky Creek (gaged for peak streamflows for water years 1965 through 1976) occurred during the November through January period indicating that these were most likely rain-on-snow events.

Changes in hydrologic processes associated with management activities can be grouped into two classes according to causal mechanisms. One class consists of change resulting from removing forest vegetation through harvest. A second class consists of changes in hydrologic processes that control infiltration and the flow of surface and subsurface water. This latter class is dominated by the effects of forest roads (USDA 1993).

Changes in hydrologic processes associated with the removal of forest vegetation through harvest can be assessed using the Aggregate Recovery Percentage (ARP) methodology. The ARP model was developed for use in the transient snow zone. It provides a methodology for indexing the susceptibility of a watershed to increased peak flows from rain-on-snow events associated with management created openings in the canopy. This method assumes that the greatest likelihood for significant, long-term cumulative effects on forest hydrologic processes is caused by created openings in the canopy (from both timber harvest and roads) that impact snow accumulation and snowmelt.

Changes in hydrologic processes that control infiltration and the flow of surface and subsurface water are dominated by the effects of forest roads. The relatively impermeable surfaces of roads cause surface runoff that bypasses longer, slower subsurface flow routes. Where roads are in-sloped to a ditch, the ditch extends the drainage network, collecting surface water from the road tread and intercepting any subsurface water exposed by roadcuts, and then transporting it to streams quicker than the norm. These changes in hydrologic processes are assessed by estimating the extension of the stream drainage network associated with roads.

A primary mechanism that changes the volume and timing of peak flows is the road network, which essentially increases the drainage density of channels, intercepts subsurface water, and decreases the time for overland runoff to reach the stream channel. Even though a watershed receives the same amount of precipitation, it is transported through the system much more quickly, thus resulting in higher peak discharges and resultant increases in stream power. This increased stream power can more effectively erode the streambed and banks. Because the total amount of water remains relatively constant, base flows decrease because the rapid runoff reduces the total amount of water that can infiltrate and be stored in the soil (Castro 2003).

4.1.1 - Aggregate Recovery Percentage

The Aggregate Recovery Percentage (ARP) model has been used to represent the proportion of a watershed in a "hydrologically mature" condition. The model was originally developed to model hydrologic recovery for timber harvest operations where most of the forest canopy was removed, and has been adapted for partial forest canopy removal that occurs during forest thinning projects. By measuring the percent of an area in a hydrologically recovered condition, the ARP model evaluates the risk of increased peak flows from rain-on-snow events. In stands with little or no forest canopy within the transient snow zone, more snow accumulates than beneath a partially or fully intact forest canopy.

The ARP model ranks recovery from 0 to 100, with 100 being fully recovered. Stands that have trees greater than 8 inches in diameter and over 70% canopy closure are considered hydrologically recovered. In the ARP model, stand age is used to determine whether stands meet these criteria. Recovery curves have been developed to model forest stand growth after either complete or partial removal of forest canopy, to determine when a forest stand has recovered hydrologically. A regeneration harvest would result in a stand that would be modeled at 0 % recovery, while a thinned stand would be modeled as having partial hydrologic recovery depending on the amount of forest canopy removed. As time goes by the plantations would grow and recovery would gradually occur. Depending on the quality of site conditions, full hydrologic recovery in the project area may take approximately 35 years after regeneration harvest.

For this analysis from 1,150 to 3,940 feet is considered to be the transient snow zone in this area. These elevations are based on the minimum lower boundary and maximum upper boundary of the transient snow zone from Effects of Forest Practices on Peak Flows and Consequent Channel Response: A State-of-Science Report for Western Oregon and Washington (Grant et al. 2008). The transient snow zone is an area in the basin where precipitation frequently falls as snow but then may melt a few days or weeks later, a cycle that may be repeated several times each winter. This transient snow zone can cause flooding if heavy rain and warm temperatures occur simultaneously when snow has accumulated ("rain on snow" events).

Stand alterations above this elevation would not likely affect peak flows while actions below this elevation could result in more runoff from non-hydrologically recovered stands when there is rapid melting during rain-on-snow events (Christner and Harr 1982).

Table 8 North Clackamas Project area Subwatersheds and associated Hydrologic Zones

Subwatersheds	Rain-dominated	Transient Snow Zone	Snow-dominated
Helion Creek-Clackamas River	25%	75%	0%
North Fork Clackamas River	2%	94%	4%
Roaring River	0%	65%	35%

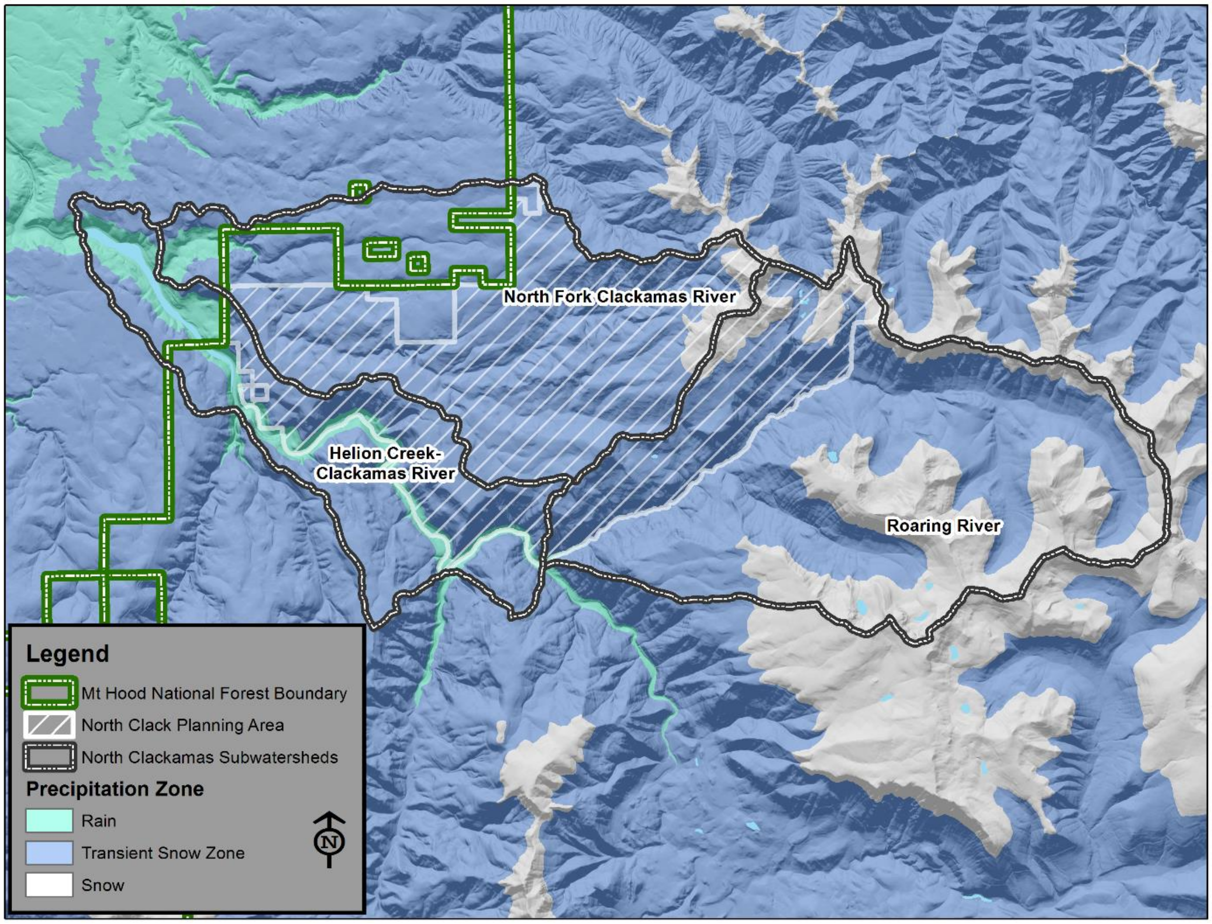

Figure 5 North Clackamas Project Area Transient Snow Zone

For this analysis all of the analysis subwatersheds are analyzed as being in the transient snow zone as at least 65% of the area of these subwatersheds are in this zone.

As timber harvest occurs either by complete or partial canopy removal, a portion of the watershed is no longer considered hydrologically mature if enough forest canopy is removed, thus the ARP for that drainage is reduced from 100% depending on the extent and intensity of timber harvest. Studies have shown that in forest openings, or areas that have had forest cover removed, snow accumulation is increased due to the loss of canopy interception. With higher levels of snow accumulation and increased rates of snowmelt in stands where sufficient canopy has been removed, there is the potential to generate more water during rain-on-snow events, which can contribute to increased peak stream flows. As an increasing portion of a watershed is put into an open or partially hydrologically immature condition, the potential for peak flows to be increased becomes greater. Over time, vegetation grows back and in 35 years would return to a hydrologic mature condition, thereby “recovering.”

The ARP analysis also addresses many other factors including:

- All past timber harvest, road construction, rock quarries, and other openings such as power lines;

- Projects that are under contract but not yet completed;
- Recent wildfires;
- Roads that have been recently decommissioned and others that are planned for the near future; (As these road beds begin to grow trees and close in they would become hydrologically recovered but this process would take approximately 35 years for full recovery.)
- Other ownership
- Other foreseeable actions.

To calculate an estimated ARP, the acres of all of the forest stands by stand origination date were tallied in the analysis watersheds. A spreadsheet was used to estimate hydrologic recovery for these stands assuming a 35 year period for a stand to reach full hydrologic recovery, when a stand has reached an average diameter of 8 inches and 70 % canopy closure. All past harvests are included but recent timber sales (since 2000) and those not yet completed are tracked by project name.

Table 9 Current Level of Hydrologic Recovery by 6th Field Watershed

Subwatershed	ARP Existing Condition	Impact Area Existing
Helion Creek-Clackamas River	84%	16
North Fork Clackamas River	82%	18
Roaring River	99%	1

The Effects of Forest Practices on Peak Flows and Consequent Channel Response Report (Grant et al. 2008) details (using the mean change for all reported data) that approximately 20 percent of an area can be harvested before increases in peak streamflows are detectable. Using the ARP values to reflect the percent of the area that is harvested all of the subwatersheds, are below the threshold where increases in peak streamflows are detectable from Grant et al. 2008.

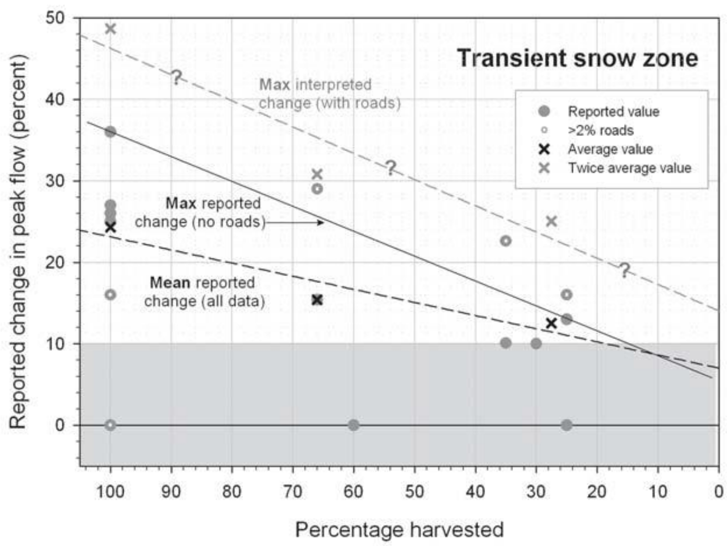

Figure 6 Reported Peak Flow Changes Based on Percentage of an Area Harvested

During development of the Mt Hood Forest Plan a methodology for addressing cumulative watershed effects, watershed sensitivity, and hydrologic recovery was developed to address Special Emphasis Watersheds and as part of the process a threshold of concern with respect to hydrologic recovery was recommended for all watersheds on the forest (USDA 1990a).

Much of the available literature, discussing the relationship between harvest/road disturbance and peak flows, implies a threshold of concern of approximately 25% of a watershed impacted. Watershed impact areas represent areas within watersheds which are hydrologically disturbed. This is the same as 75% threshold calculated using the Aggregate Recovery Percent (ARP) model for assessing hydrologic recovery in use on several National Forests and derived from research described in the previously cited references. As discussed previously, observations of Forest staff suggest that water quality and channel condition degradation are not solely related to the percentage of a watershed which has been disturbed by management activities, or which is in various states of hydrologic recovery (USDA 1990a).

Observations of different watersheds and application of the ARP methodology over a period of years suggested to various staff specialists that not all streams and watersheds respond similarly to a given level of disturbance (or recovery, as estimated by ARP values). Several watersheds, having undergone relatively less disturbance, appear to exhibit channel and water quality degradation related to increased peak flows, whereas other watersheds having comparatively greater amounts of harvest and roading appear to have little or no evidence of adverse watershed effects. These observations suggested to Forest staff that watershed response to management was related to factors affecting the inherent sensitivity of a watershed at least as much as to the extent and intensity of management (USDA 1990a).

Using a combination of professional judgment and experience, resource specialists (hydrologists, soil scientists, and fisheries biologists) at the Forest and District level identified twenty-eight "candidate" watersheds which were determined to be inherently sensitive due to their physical characteristics (soils, geology, channel morphology, susceptibility to snow-melt induced peak flows, etc.). Several watersheds which appear to have been heavily impacted by frequent timber harvest and road construction entries were also evaluated (USDA 1990a).

On the basis of observation and collective experience and judgment, Forest watershed and fisheries specialists developed a methodology for assigning, weighting, and summing values for various factors, yielding a unit less numerical rating, or index (USDA 1990a):

$$WS = EH + LS + SM + CS + BU$$

WS = Watershed Sensitivity (a unit less numerical value)
EH = Erosion Hazard
LS = Land Stability
SM = Snow Melt
CS = Channel Stability
BU = Beneficial Uses

On a Forest-wide basis, outside of Special Emphasis Watersheds, a watershed disturbance TOC of 35% has been recommended. This value allows more disturbance than the previously cited literature and applications of ARP seem to imply. Forest watershed staff believe that it represents a reasonable "threshold level of concern" which is applicable to the less-sensitive watershed lands outside of the recommended Special Emphasis Watersheds, reflecting observations of such lands to date (USDA, 1990a).

Table 10 Watershed Impact Area by Subwatershed

Subwatershed	Impact Area Existing
Helion Creek-Clackamas River	16
North Fork Clackamas River	18
Roaring River	1

Based on the watershed sensitivity analysis completed for the Forest Plan associated with special emphasis watersheds and current watershed impact areas all of the 6th field watersheds are below the disturbance TOC of 35% recommended for watersheds that are not designated as Special Emphasis Watersheds. Based on the current level of disturbance in the 6th field watersheds there is not a concern that vegetation manipulation alone in these areas would result in increased peak streamflows impacting identified processes of concern (sediment yield, bank scouring and mass wasting, channel configuration, summer water temperatures, fish habitat, pool quality, and in-stream cover).

As detailed earlier in this report the 6th Field Watershed Condition from the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017) indicates that for the hydrology indicator that all the subwatersheds in the planning area are in the properly functioning condition.

For the AREMP hydrology indicator the documentation states that upslope/riparian conditions affect the quantity and timing of water reaching the stream system and consequently the habitat of aquatic and riparian biota. This analysis assesses the influences of road and vegetation changes on peak flows (Miller et al. 2017).

The AREMP assessment factors in vegetative disturbance, roads and climate zone. The percent increases from roads and vegetation then summed to estimate the overall indicator for peak flow change.

4.1.2 - Stream Drainage Network Extension

Based on research on two basins in the Western Cascades of Oregon, 57% of their road length is connected to the stream network by surface flowpaths including roadside ditches and gullies below road drainage culverts (Wemple et al. 1996).

Water generated on the road prism can enter the natural stream channel network in a variety of ways (Furniss, Flanagan and McFadin 2000.):

- Inboard ditches delivering runoff to a stream at a road-stream crossing

- Inboard ditches delivering runoff to a cross drain (culvert, dip, waterbar, etc.) where sufficient discharge is available to create a gully or sediment plume that extends to a stream channel
- Other cross-drainage features, such as waterbars or dips, that discharge sufficient water to create a gully and/or sediment plume that extends to a stream channel
- Roads sufficiently close to streams so that the fillslope encroaches on the stream, such as at road-stream crossings
- Landslide scars on the road-fill that expose bedrock and create a surface flow path to an adjacent channel.

For this analysis the key process of concern is associated with inboard ditches delivering runoff to a stream where a road intercepts the stream. The increase in channel length due to the inboard ditch was calculated as the length of the ditch directly connected to the stream up to the next ditch relief structure. Based on experience with road decommissioning across the forest it was assumed that the average ditch relief culverts were spaced 350 feet apart.

Table 11 Stream Drainage Network Extension

Subwatershed	Existing Condition
Helion Creek-Clackamas River	9%
North Fork Clackamas River	7%
Roaring River	2%

It is generally accepted that based on considerations of gage and measurement error at high-flow events, a minimum detectable change in peak flow (detection limit) of ±10 percent for site-scale analysis. Percentage changes in peak flow that fall in this range are within the experimental and analytical error of flow measurement and cannot be ascribed as a treatment effect (Grant et al. 2008). Since this process increases flow routing efficiency and may result in increased magnitude of peak stream flows the 10% threshold was used to set a level of concern associated with this process. Based on the 10% threshold of concern for this process all of the analysis subwatersheds are below the threshold for concern.

In a study on the effects of forest roads on peak streamflows (LaMarche and Lettenmaier 2001) in the western slope of the Cascade Range in southwestern Washington forest roads alone were predicted to have increased the mean annual flood in the subcatchments from 2.2 to 9.5 percent, and from 2.9 to 12.2 percent for the ten-year event. The largest increases associated with forest roads (without harvest) were roughly equivalent to those predicted for harvest, without roads. The predicted increases in floods due to roads generally increase with flood return period, while vegetation effects decrease. The effects of roads and harvest on peak flows at the subcatchment (7th field watershed ~5000 acres) and catchment (6th field watershed ~20,000 acres) levels are essentially independent, and the combined effects on peak flows are therefore roughly additive.

Modeling studies for Washington watersheds suggest an approximate doubling of the percentage change in peak flows attributed to harvest alone when road construction is included in the model (Grant et al. 2008).

Since the effects of vegetation removal through harvest and roads are considered independent from each other and they are roughly additive they should be integrated when assessing management effects on peak streamflows within a watershed. However, at different scales that combined effects are not always apparent. At the hillslope scale, modeled as well as field-observed road ditch response was dependent on vegetation state, with higher road effects occurring below harvested hillslopes. The absence of such a synergy at the subcatchment and catchment levels may well be due to scaling issues (most likely due to desynchronization in the channel system) of peak flows from the collective hillslopes (LaMarche and Lettenmaier 2001).

Table 12 Watershed Impact Area by Subwatershed

Subwatershed	Impact Area Existing
Helion Creek-Clackamas River	16
North Fork Clackamas River	18
Roaring River	1

Watershed impact area varies from 1% to 18% and with the approximate doubling of the percentage change in peak streamflows attributed to harvest alone the North Fork Clackamas River and Helion Creek-Clackamas River subwatersheds are above the threshold where increases in peak streamflows are detectable.

Recent studies (Grant et al. 2008) support the inference that when present, peak flow effects on channels should be confined to a relatively discrete portion of the stream network: stream reaches where channel gradients are less than approximately 2% and streambed and banks are gravel and finer material. Peak flow effects on channel morphology can be confidently excluded in high-gradient (slopes >10%) and bedrock reaches, and are likely to be minor in most step-pool systems. On the other hand, if channels are gravel or sand-bedded, a more detailed hydrologic and geomorphic analysis may be warranted.

In the North Fork Clackamas subwatershed GIS determined stream gradients less than 2% were concentrated in the North Fork Clackamas River, Boyer Creek and Winslow Creek.

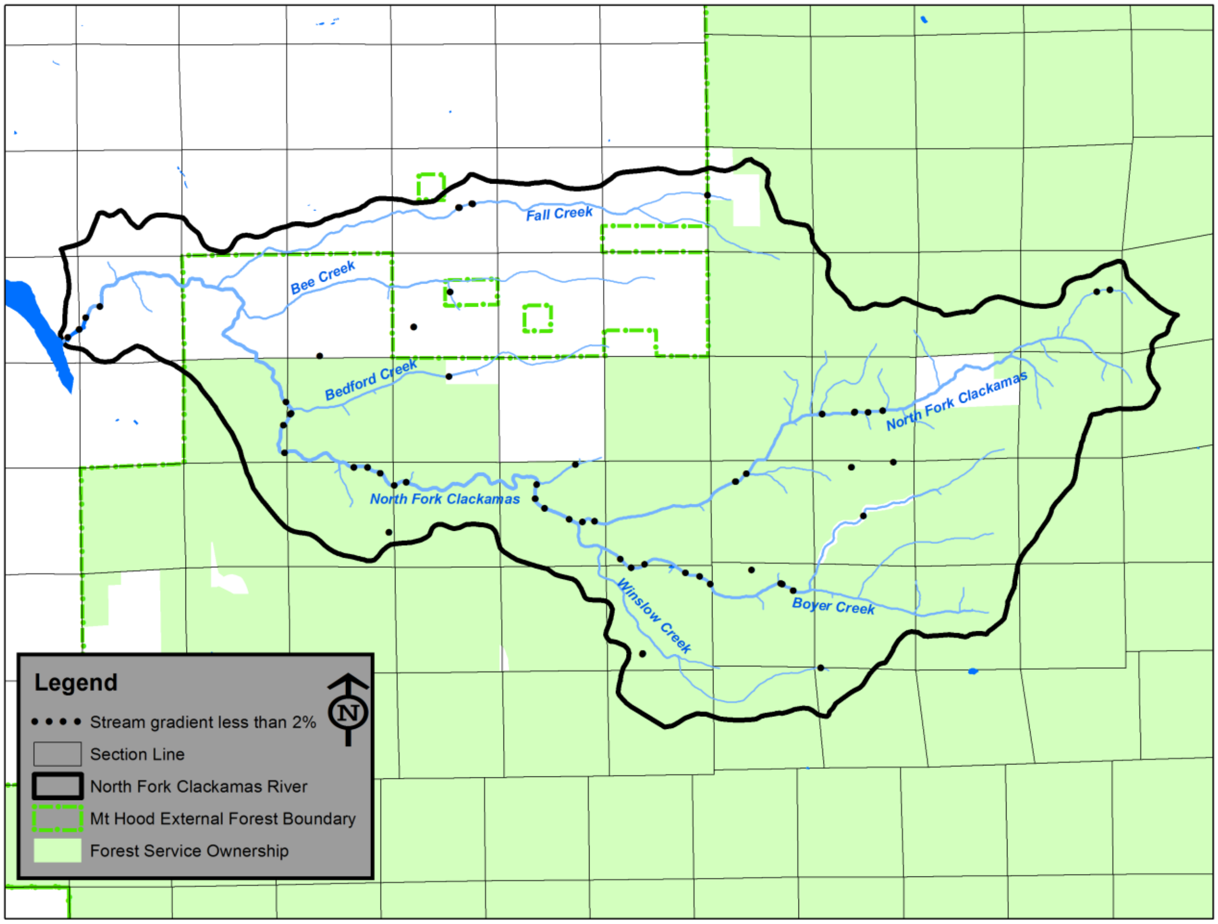

Figure 7 Areas with a Stream Gradient Less Than 2%

The existing ARP value for the Boyer/Winslow Creek 7th field watersheds is 97% so no further examination of this area appeared to be warranted based on the approximate doubling of the percentage change in peak flows attributed to harvest alone when road construction is included. Stream survey data for the North Fork Clackamas River (USDA 2016 and USDA 2017) indicated stream gradients for the North Fork Clackamas River from 3 to 12% and Rosgen (Rosgen 1996) channel types associated with slope ranges greater than 2%. The 2017 stream survey report for the Lower North Fork Clackamas River indicated a total of 125 feet of unstable bank was observed during this survey; and the 2016 Upper North Fork Clackamas River Stream Survey indicated 3.1 percent of the banks on the upper North Fork Clackamas River were documented as unstable at the time of the survey.

Table 13 North Fork Clackamas River Stream Survey data on Stream Gradient and Substrate

Stream Reach	Miles	Average Percent Gradient	Rosgen	Substrate
Upper NF Clackamas River R1	0.45	7	A3	Cobble/Boulder
Upper NF Clackamas River R3	0.31	4.5	A4	Gravel
Lower NF Clackamas River R3	2.80	5	B4	Gravel

Stream Reach	Miles	Average Percent Gradient	Rosgen	Substrate
Upper NF Clackamas River R2	0.90	8	A1	Bedrock
Lower NF Clackamas River R4	0.57	8	B4a	Gravel
Lower NF Clackamas River R6	0.31	6	A4	Gravel
Lower NF Clackamas River R2	1.40	2.9	B3	Cobble
Lower NF Clackamas River R1	3.00	3.3	B1	Bedrock
Lower NF Clackamas River R5	2.00	12	A1a+	Bedrock

Benthic Invertebrate Biomonitoring was completed by Aquatic Biology Associates in 1993 and 1994 in three sites in the North Fork Clackamas River (ABA 1995). The assessment indicated that at all sites silt covering slack water surfaces or silt entrained in sediments is low to low-moderate and that water quality does not appear to be limiting.

Table 14 Benthic Invertebrate Biomonitoring Results North Clackamas River

Site	Silt covering slack water surfaces	Silt entrained in sediments	Water Quality
North Fork Clackamas Lower Site	Low	Low	Water quality does not appear to be limiting
North Fork Clackamas Middle Site	Low-moderate	Low-moderate	Water quality does not appear to be limiting
North Fork Clackamas Upper Site	Low-moderate	Low-moderate	Water quality does not appear to be limiting

Based on stream survey data for stream gradient, Rosgen channel type, unstable streambanks; and benthic invertebrate biomonitoring peak flow effects on channel morphology are not currently of concern in the North Fork Clackamas River subwatershed.

Within the Helion Creek-Clackamas River the area where the stream gradient is less than 2% is the Clackamas River from the confluence with the Roaring River downstream to the pool associated with the North Fork Reservoir. This section of river typically flows through a moderate to steep slope basalt canyon, with a very narrow floodplain. The channel width averages approximately 100 feet, with the channel being constrained naturally by bedrock. This reach is characterized by large deep pools and long riffles, with the stream flowing over a substrate dominated by small boulders and cobble, with large boulders interspersed throughout. (USDA 1991). Since peak flow effects on channels should be confined to a relatively discrete portion of the stream network: stream reaches where channel gradients are less than approximately 2% and streambed and banks are gravel and finer material this area would be excluded because of the substrate of small boulders and cobble.

4.1.3 - Water Quantity Summary

All of the subwatersheds are below the threshold where increases in peak streamflows are detectable from The Effects of Forest Practices on Peak Flows and Consequent Channel Response Report (Grant et al. 2008). All the subwatersheds are below the threshold associated with the methodology for addressing cumulative watershed effects, watershed sensitivity, and hydrologic recovery associated with the Mt. Hood Forest Plan (USDA, 1990a). When the combined impacts of vegetation management and roads are examined all the subwatersheds are rated as properly functioning in the 6th Field Watershed Condition from the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017) and the Roaring River subwatershed is below the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads.

The North Fork Clackamas River and Helion Creek-Clackamas River subwatersheds are above the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads. A detailed hydrologic and geomorphic analysis indicated that peak streamflows are not impacting stream channel morphology in these subwatersheds.

4.2 - Water Quality

Rivers, streams, and lakes within and downstream of the treatment areas are used for boating, fishing, swimming, and other water sports. Additionally, the Forest streams provide habitat and clean water for fish and other aquatic biota, each with specific water quality requirements. The Clean Water Act (CWA) protects water quality for all of these uses.

The CWA requires States to set water quality standards to support the beneficial uses of water. Designated beneficial uses for waters in the project area include public domestic water supply, fish and aquatic life, wildlife and hunting, fishing, boating, water contact recreation, and aesthetic quality. The Act also requires States to identify the status of all waters and prioritize water bodies whose water quality is limited or impaired. For Oregon, the Department of Environmental Quality (DEQ) develops water quality standards and lists water quality limited waters. In addition, Region 6 of the Forest Service has entered into a Memorandum of Agreement (MOA) with the Oregon State DEQ to acknowledge the Forest Service as the Designated Management Agency for implementation of the CWA on National Forest land. In an effort to support the CWA, the Forest conducts a variety of monitoring and inventory programs to determine status of meeting state water quality standards as well as other regulatory and agency requirements.

In an average year, approximately 75 sites are monitored for water temperature throughout the Forest. In addition, other water quality monitoring occurs at various locations throughout the Forest depending on the year. This could be turbidity monitoring, instream sediment sampling, water chemical sampling, or surveys of physical stream conditions. Currently, approximately 25 miles of physical stream habitat is surveyed every year and to date approximately 1787 miles of stream have been surveyed or resurveyed. Some of the information collected during these surveys includes the number of pools and riffles, amount of large wood, riparian area condition and types, numbers of fish and other aquatic organisms, stream substrate and embeddedness.

4.2.1 - Section 303D

Section 303(d) of the CWA requires that water bodies violating State or tribal water quality standards be identified and placed on a 303(d) list. The Environmental Protection Agency (EPA) regulations also allow States and tribes to include threatened waters (that is, waters that display a downward trend that suggests water quality standards would not be met in the near future).

By direction of the CWA, where water quality is limited, DEQ develops Total Maximum Daily Load (TMDL) plan to improve water quality to support the beneficial uses of water. For water quality limited streams on National Forest System lands, the USDA Forest Service provides information, analysis, and site-specific planning efforts to support state processes to protect and restore water quality. The Clackamas Subbasin TMDL was approved by the Environmental Protection Agency on September 29, 2006. This TMDL among other issues addresses stream temperature in the project area.

The Forest developed a Water Quality Restoration Plan (WQRP) to serve as the TMDL Implementation Plan for the Willamette Basin TMDL. Under the WQRP the protection and recovery of water quality depends on implementation of the Forest Plan as amended. Key to this strategy are the standards and guidelines and the Aquatic Conservation Strategy (ACS) objectives for the protection, restoration, and active management of riparian areas.

The table below details the water quality status of streams in the project area with respect to sediment, temperature and biological criteria associated Oregon's 2012 Integrated Report Assessment Database and 303(d) List.

Table 15 Water Quality Status -Oregon's 2012 Integrated Report Assessment Database and 303(d) List – Streams in the North Clackamas Integrated Resource Project Area listed for Sediment, Temperature and Biological Criteria

Water Body	River Miles	Parameter	Status
Clackamas River	0 to 83.2	Biological Criteria	Cat 5: Water quality limited, 303(d) list, TMDL needed

The listing status reporting data indicates that this listing is based on 1 out of 1 samples from September 2006 at RM 59.41 outside WCCP regional criteria. This site is approximately 2.4 miles upstream of the confluence with the Collawash River and approximately 15.4 miles upstream of the confluence of the Clackamas and Roaring Rivers.

The North Fork Reservoir on the Clackamas River is 303(d) listed for Aquatic Weeds or Algae based on one health advisory issued by Oregon Harmful Algae Bloom Surveillance (HABS) program through October 2010 based on cell counts or toxicity levels

Bloom formation seems to be linked to nutrient-rich waterbodies (those influenced by animals and people where phosphorous and phosphate containing compounds such as fertilizers are used) (OHA). In aquatic ecosystems phosphorous is usually the limiting nutrient. Particulate inorganic nitrogen is mineral in origin and enters the stream channel primarily by soil erosion and sediment transport. Particulate organic phosphorus comes from a variety of sources and can enter the stream channel through fluvial transport or direct deposition (MacDonald et al. 1991).

For this watershed this parameter will be tracked in the assessment through sediment delivery.

The Clackamas River in this area is also 303(d) listed for lead and mercury and these parameters were not assessed because sources that come from human activities are not associated with forest management activities such as those associated with the North Clackamas Integrated Resource Project.

- Natural sources of lead include weathering of soil, forest fires and volcanoes. Sources of lead that come from human activity include the discharge of ammunition, leaded fuel in light aircraft and the combustion of coal and wood, as well as various processes in metal production and manufacturing. In addition, legacy issues such as leaded fuel can be a source of lead (ILA).
- The main source of mercury to most aquatic environments in the U.S. is from atmospheric deposition (rain, snow, dry particles). Some water bodies also receive mercury from direct discharge of industrial wastes, mining wastes, or naturally occurring mercury minerals. Although there has always been some mercury in the atmosphere from natural sources (volcanoes and degassing of elemental mercury from the oceans), human activities have increased the amount of mercury emitted to, and deposited from the atmosphere. Anthropogenic (human-caused) sources of mercury to the atmosphere are largely from combustion of materials that contain mercury, with coal-combustion (electric utility boilers and commercial/industrial boilers) being the largest source in the U.S., according to the 1997 EPA Report to Congress (USGS NAWQA).

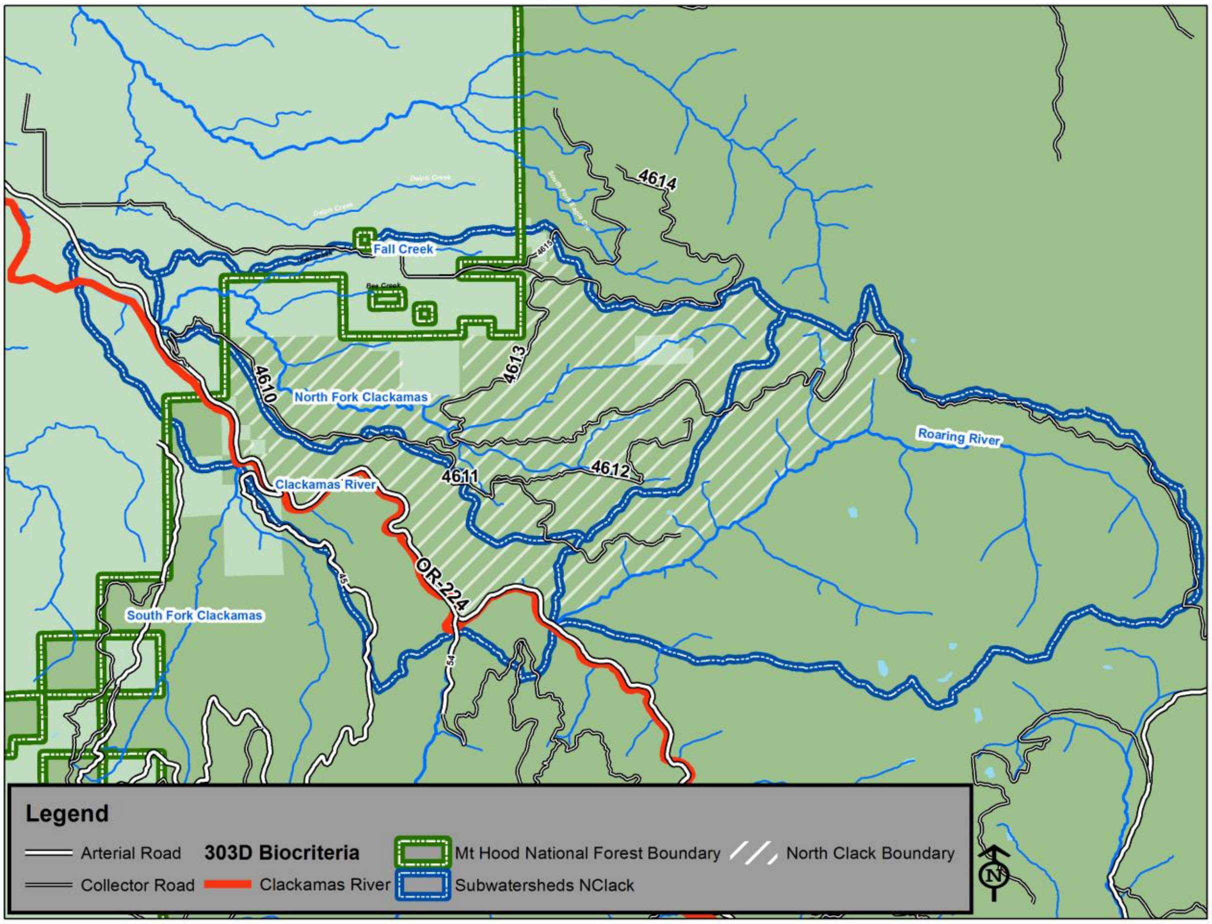

Figure 8 Oregon's 2012 Integrated Report Assessment Database and 303(d) List –Stream Status in the North Clackamas Integrated Resource Project area.

4.2.2 - Biological Criteria Assignment of Assessment Category

The following text is from: PREDATOR: Development and use of RIVPACS-type macroinvertebrate models to assess the biotic condition of wadeable Oregon streams (November 2005 models) (Hubler 2008)

> *The Oregon Department of Environmental Quality (DEQ) is responsible for protecting the waters of the state from pollution that may adversely affect drinking water, aquatic life and recreational uses. DEQ routinely monitors conventional water quality parameters such as nutrients, dissolved oxygen, pH, turbidity, conductivity and bacteria to report on the water quality status and trends in Oregon. However, resource limitations make it impractical to measure all the potential pollutants which may impair Oregon's waters. Aquatic insect communities are direct indicators of biological conditions and a surrogate for watershed health. They provide a cost effective screening tool for assessing and identifying problems that may require further examination.*
>
> *The PREDictive Assessment Tool for Oregon (PREDATOR) consists of three regional models that assess the biological integrity of wadeable streams across Oregon. DEQ*

developed the models to supply a scientifically rigorous bioassessment tool that is easy to apply and provides a more complete understanding of the stream conditions across Oregon.

The list of species generated from the reference locations is known as the "Expected" taxa list or "E". This list is compared to the captured aquatic insects or, "Observed" taxa ("O"), at an assessment site. The predictive model output is the observed to expected (O/E) taxa ratio. Scores less than one have fewer taxa at a site than were predicted by the model. Scores greater than one are either equivalent to the reference location or may have an enhanced insect community as a result of some type of enrichment.

If a single sample falls below the 10th percentile of the reference distribution, the sample is considered to be outside the reference distribution. We feel confident that a single sample score below the 10th percentile is not different simply by chance, but rather a true difference in biological condition exists (assuming the site is not an outlier for any reason). In this case, a single sample is sufficient to classify the stream reach as biologically disturbed, or "not supporting" the beneficial use. However, if a sample falls between the 10th and 25th percentiles of the reference distribution ("moderately disturbed"), there is less confidence that the O/E score is outside of the reference distribution. In this case, DEQ recommends repeated measures of O/E to determine if a significant difference in biological condition exists. We also recommend assessments include surveys of water quality, instream and riparian habitat, and remote sensing of the watershed (GIS) to provide insights into possible sources of disturbance. A site with a "most disturbed" O/E score and minimal signs of human influences may indicate that the site was not accurately modeled with the current set of reference sites. These are important findings that may be used to increase the future accuracy of predicting locally common reference taxa.

4.2.3 - Stream Temperature

Within the project area the following standards apply for stream temperature (Oregon Administrative Rule (OAR) 340-041-0028 Temperature)

- 13.0°C during times and at locations of salmon and steelhead spawning.
- 16.0°C during times and at locations of core cold water habitat identification.
- 18.0°C during times and at locations of salmon and trout rearing and migration.

The core cold water habitat requirement applies to all perennial streams in the analysis area. In addition the salmon and steelhead spawning criteria apply from September 1 to June 15 in the Clackamas River upstream of North Fork Reservoir and the sections of North Fork Clackamas River and Roaring River that are accessible to anadromous fish.

Stream temperatures from on-going Forest Service stream temperature monitoring, Forest Service Stream surveys, USGS monitoring and Portland General Electric monitoring were assessed for compliance with stream temperature standards.

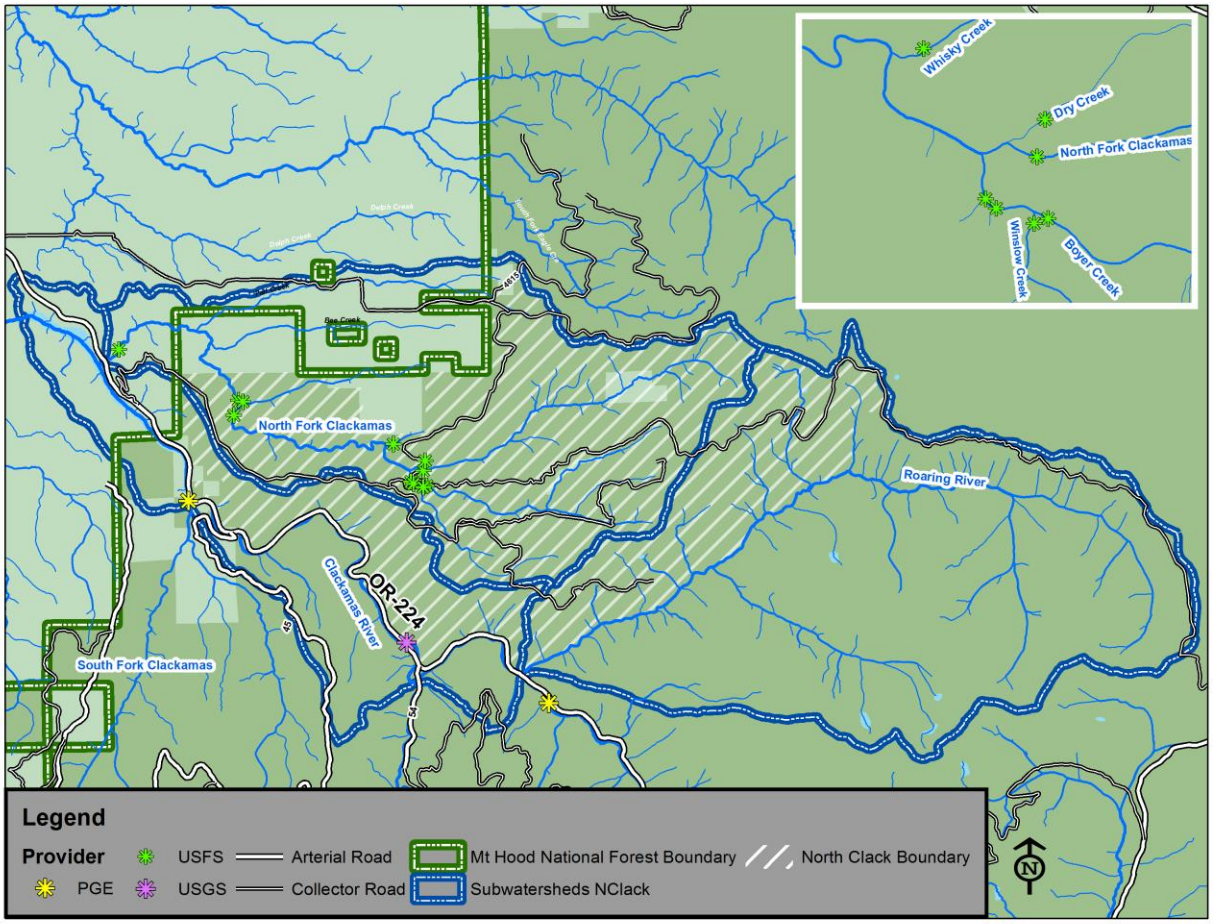

Figure 9 Stream Temperature Standards and Sample Sites – North Clackamas Integrated Resource Project

Table 16 Summary of Sites Where Stream Temperature Was Collected

Site	Source	Year	Met Temperature Standard
Boyer Creek mouth	USFS	Summer 1995	Yes
Boyer Creek near mouth	USFS	Summer 2017	Yes
Bedford Creek near mouth	USFS	Summer 2017	No
Clackamas River at Carter Bridge	USGS	2005	No
Clackamas River at Carter Bridge	USGS	2006	No
Clackamas River at Carter Bridge	USGS	2007	No
Clackamas River at Carter Bridge	USGS	2008	Yes
Clackamas River at Carter Bridge	USGS	2009	No
Clackamas River at Carter Bridge	USGS	2010	Yes
Clackamas River at Carter Bridge	USGS	2011	Yes
Clackamas River at Carter Bridge	USGS	2012	Yes
Clackamas River at Carter Bridge	USGS	2013	No
Clackamas River at Carter Bridge	USGS	2014	No
Clackamas River at Carter Bridge	USGS	2015	No

Site	Source	Year	Met Temperature Standard
Clackamas River at Carter Bridge	USGS	2016	No
Clackamas River at Carter Bridge	USGS	2017	No
Clackamas River below Oak Grove Powerhouse	PGE	Summer 2013	No
Clackamas River below Oak Grove Powerhouse	PGE	Summer 2014	Yes
Clackamas River below Oak Grove Powerhouse	PGE	Summer 2015	No
Clackamas River below Oak Grove Powerhouse	PGE	Summer 2016	No
Clackamas River below Oak Grove Powerhouse	PGE	Summer 2017	No
Clackamas River upstream of North Fork Reservoir	PGE	Summer 2013	No
Clackamas River upstream of North Fork Reservoir	PGE	Summer 2014	No
Clackamas River upstream of North Fork Reservoir	PGE	Summer 2015	No
Clackamas River upstream of North Fork Reservoir	PGE	Summer 2016	No
Clackamas River upstream of North Fork Reservoir	PGE	Summer 2017	No
Dry Creek near mouth	USFS	Summer 2017	Yes
North Fork Clackamas downstream Bedford WT	USFS	Summer 1996	No
North Fork Clackamas downstream Bedford WT	USFS	Summer 1997	No
North Fork Clackamas near 4613	USFS	Summer 1991	Yes
North Fork Clackamas near 4613	USFS	Summer 1997	Yes
North Fork Clackamas WT	USFS	Summer 1993	Yes
North Fork Clackamas WT	USFS	Summer 1994	No
North Fork Clackamas WT	USFS	Summer 1995	No
North Fork Clackamas upstream of Bedford Creek confluence	USFS	Summer 2017	No
Whisky Creek at 4613 Road	USFS	Summer 2017	Yes
Winslow Creek near mouth	USFS	Summer 2017	No

As detailed in the table the Clackamas River, North Fork Clackamas River downstream of Bedford Creek, Bedford Creek and Winslow Creek are the areas where standards for stream temperature were not met.

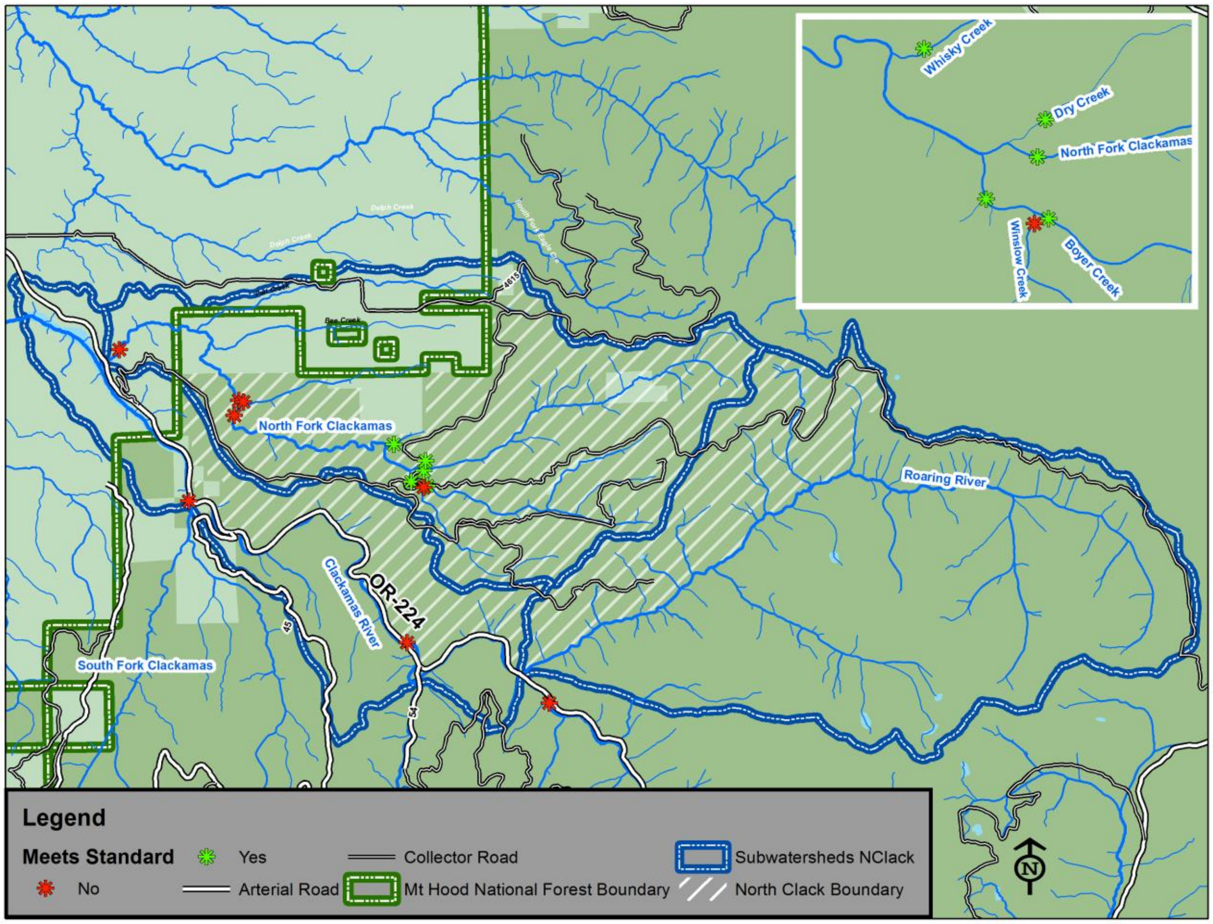

Figure 10 Stream Temperature Sites and Stream Temperature Standard Compliance Status

The NorWeST project and database team has developed a comprehensive, interagency stream temperature database for the northwestern U.S. Those data were used to develop accurate (R^2 = 90%; RMSE <1.0C), high- resolution (1 kilometer) stream temperature scenarios for 500,000 kilometers of streams and rivers (NorWeST).

The temperature database was compiled from hundreds of biologists and hydrologists working for dozens of resource agencies and contains more than 45,000,000 hourly temperature recordings at more than 15,000 unique stream sites. These temperature data are being used with spatial statistical stream network models to develop an accurate and consistent set of climate scenarios for all streams (http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html).

August mean stream temperature was the metric selected to be modeled in the NorWeST temperature model. Use of this metric allowed the largest proportion of data in the NorWeST observed temperature database to be used (~80%), which facilitated calibration of the model to thousands of unique stream sites across the region (NorWeST Modeled Stream Temperature Stream Points for the "Oregon Coast" Processing Unit, Metadata).

Sites associated with the North Clackamas Integrated Resource Project Area are in the Oregon Coast Processing Unit.

Model Prediction Accuracy[4]

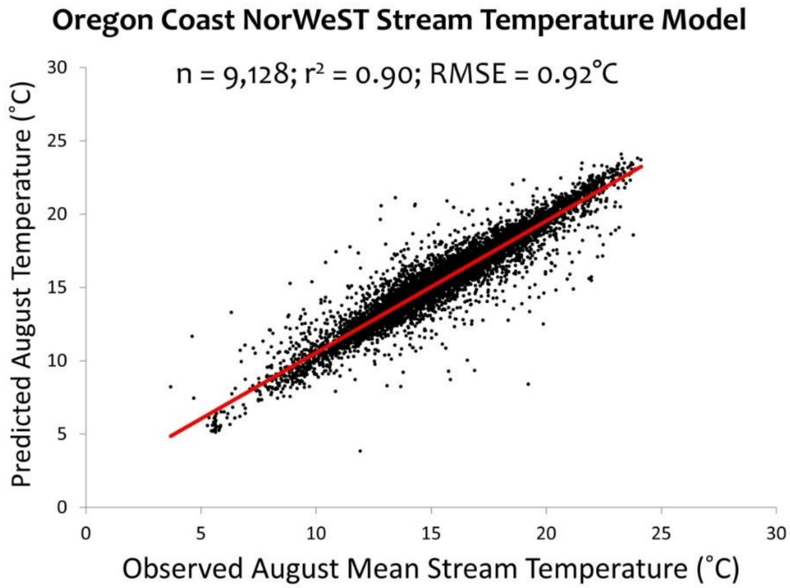

Figure 11 NorWest Stream Temperature Model Prediction Accuracy

[4]http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/downloads/images/Scenarios/OregonCoastModelResults.jpg

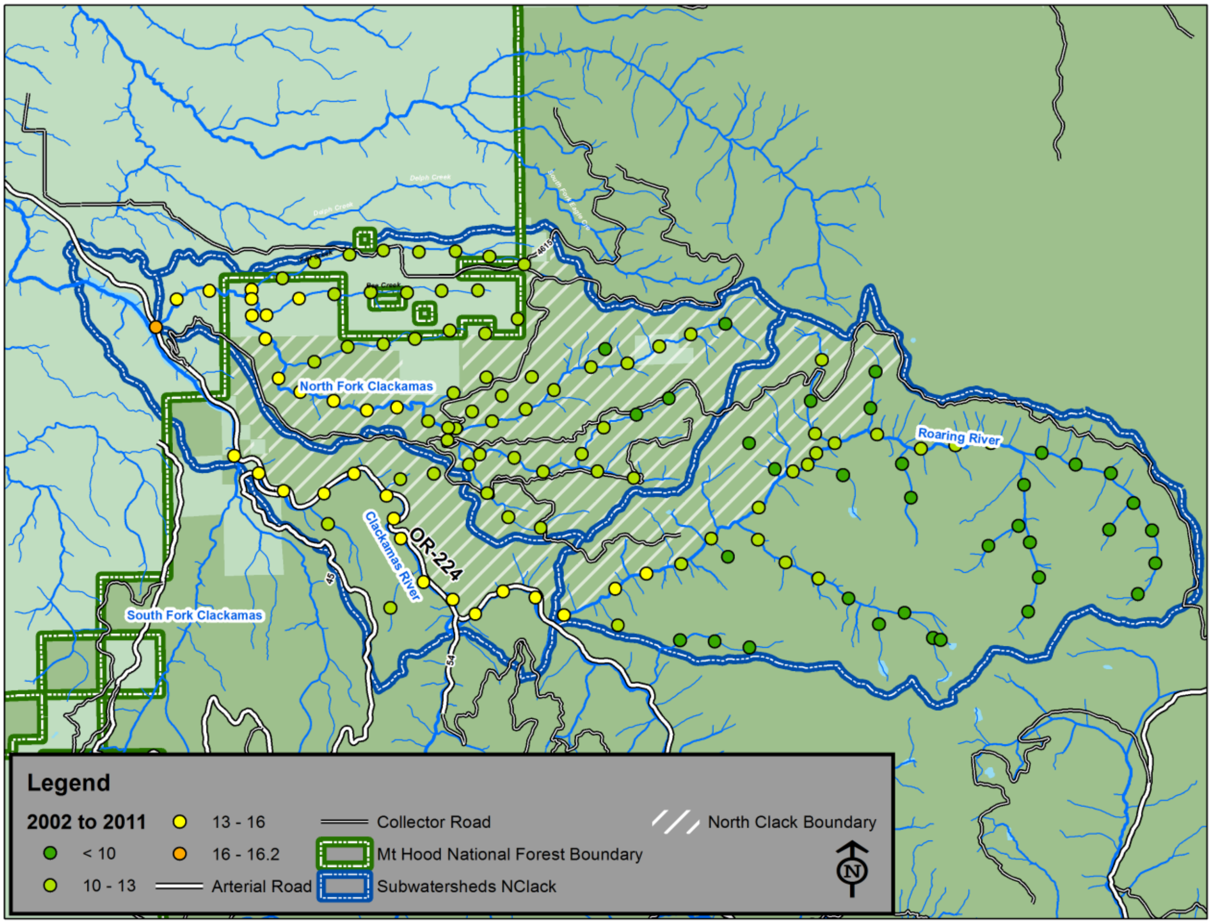

Figure 12 North Clackamas Project Area mean August Stream Temperature. (2002-2011) - Historical composite scenario representing 9 year average August mean stream temperatures for 2002 – 2011.

In an effort to compare NorWeST project stream temperatures to stream temperature standards the mean modeled stream temperatures for 2006 through 2011 were compared to the maximum of the 7 day average of the daily maximum at Carter Bridge and the mean value of the maximum of the 7 day average was 2.0^{0}C higher than the August mean modeled stream temperature. Using this relationship an estimated maximum 7 day average of the daily maximum dataset was created and is detailed in the map below. As shown in the map for the period from 2002 through 2011 modeled temperatures above 16^{0}C are limited to the Clackamas River and North Fork Clackamas river just upstream of Bedford Creek to the confluence with the Clackamas River.

Combining stream temperature data from monitored sites and the estimated stream temperatures based on NorWest data temperatures above 16^{0}C are limited to the Bedford Creek (based on temperature logger data), Clackamas River, North Fork Clackamas river just upstream of Bedford Creek to the confluence with the Clackamas River and Winslow Creek (based on temperature logger data).

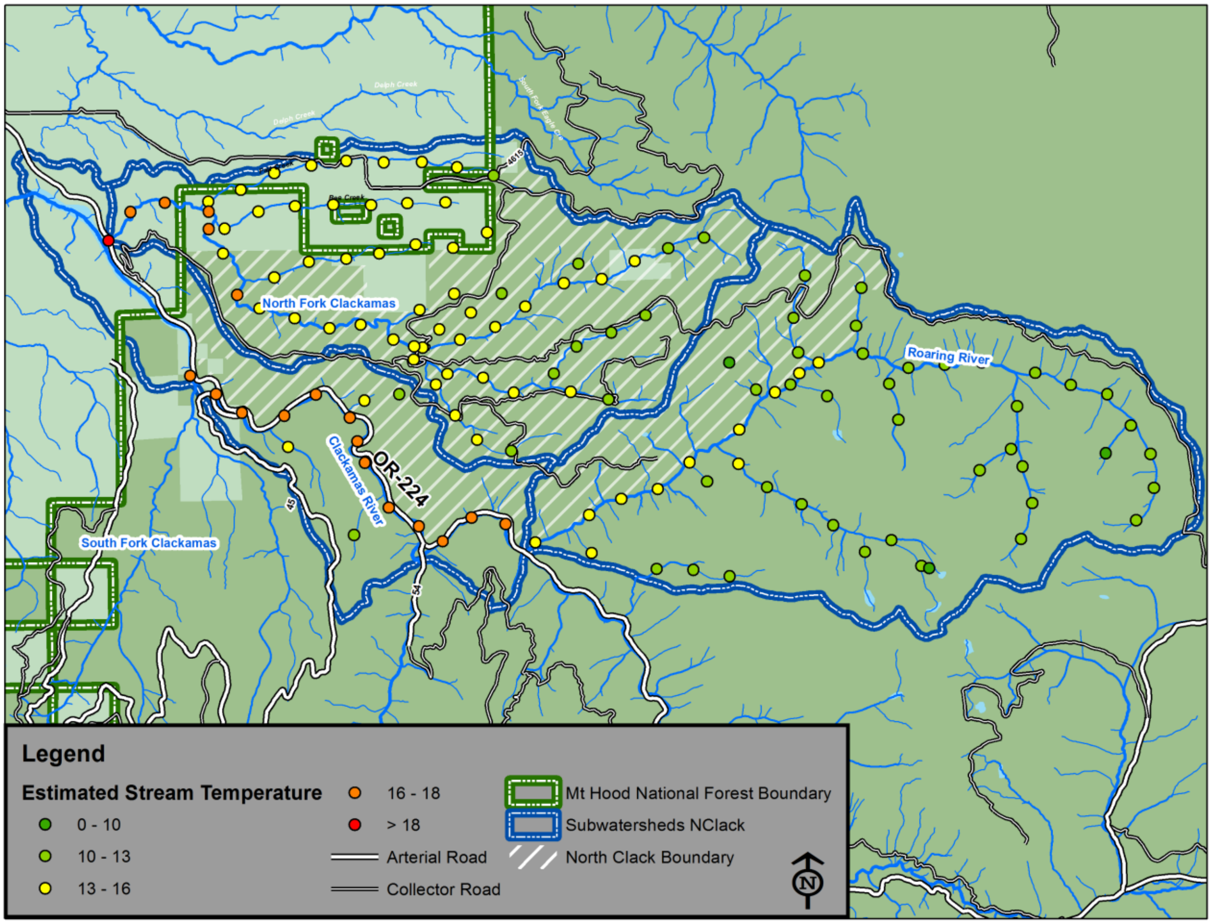

Figure 13 North Clackamas Project Area NorWest Stream Temperatures Adjusted to Estimate Daily Maximum for 2002 through 2011

4.2.3.1 - RAPID Stream Shade Assessment Model

Vegetation removal near water bodies has the potential of increasing solar radiation to surface water which in turn may increase water temperature so the RAPID Stream Shade Assessment Model was used to compare average existing shade to average potential shade in the project area.

RAPID is a shade model that runs in ArcGIS that was developed to complete a shade assessment at the 5th field level and identify potential restoration sites. The model uses vegetation databases developed by the Landscape Ecology, Modeling, Mapping and Analysis (LEMMA) group at the USFS Pacific Northwest Research Station and Oregon State University, the vegetation dataset is based on 2012 imagery. The utility of the model is to automate and streamline a shade assessment at the watershed scale for the preparation of Water Quality Restoration Plans (RAPID Tool Documentation).

The RAPID Stream Shade Assessment Model is based on the Shadow Model from the 1980's - 1993 that was developed to predict temperature increases from management activity

(Stockdale 2013). Five inputs are needed for Shadow including: tree height, stream width, stream orientation, side slope, and canopy closure (Stockdale 2013).

The stream buffer providing shade is 150 feet from the stream. This better represents the vegetation height, and averages out errors associated with satellite imagery. Side slope with an azimuth between 270 and 90 degrees provides shade to the stream (Stockdale 2013).

For the subwatersheds associated with the North Clackamas Integrated Resource Project average existing shade and average potential shade are identified in the table below. It should be noted that it appears that the RAPID Stream Shade Assessment Model only assesses the difference between existing and potential shade on National Forest or Bureau of Land Management lands that are available for vegetative manipulation.

Table 17 RAPID Stream Shade Assessment Model Results

Subwatershed	Existing Shade	Potential Shade
Helion Creek-Clackamas River	65	68
North Fork Clackamas River	69	72
Roaring River	76	78

As detailed in the table all the analysis watersheds associated with the North Clackamas Integrated Resource Project are within 3% of the average potential shade for the area.

4.2.4 - Sediment and Turbidity

For this analysis sediment delivery associated with natural background levels from landslides, wildfires, and road surfaces were examined.

Mass wasting is a natural process that occurs to some extent in most forested basins in the Pacific Northwest. The time scale (relative or absolute) of mass wasting in a basin is important to an understanding of the sediment mass balance of a watershed. Mass wasting events may occur on a return interval of one or two years, decades, centuries, or even millennia. While the smaller, more frequent events may cause the fresh scars seen on the landscape, the larger, infrequent events are probably the real shapers of the landscape. Both types of landslides are influential in their impact on physical resources. In a natural, unmanaged forested basin, the dynamic replenishment of material to the channels by mass wasting is essential to the diversity and health of the ecosystem (DNR 2011b).

Not all landslides deposit sediment directly in streams; sediments may be deposited on flood plains, glacial or alluvial terraces, or foot slopes, without reaching a stream. However, as basin area increases, the cumulative probability of either one small landslide entering a stream or one small failure triggering a debris torrent with catastrophic impact on habitat conditions increases (DNR 2011b).

A Forest-wide map of landslide risk was compiled in 2000 from the geomorphic mapping completed during watershed analyses. Each watershed, and eventually the entire Forest, had been divided into geomorphic map units, primarily based on geologic unit and slope angle. Each geomorphic map unit had then been assigned a qualitative descriptor of its propensity for landslides (high, medium, or low). The assignment of this adjective was based on landslide inventories. The map lumps all landslide types together (USDA 2003).

Using sediment delivery rates from undisturbed forested areas in an area classified as an unstable zone in the H.J. Andrews Experimental Forest (Swanson and Dyrness 1975) sediment delivered from the unstable zones (areas classified as high landslide risk or unstable acres from individual watershed assessments where the high landslide risk mapping was not available) in analysis watersheds associated with the North Clackamas Integrated Resource Project would be estimated to be in the range of 4,436 cubic yards of material delivered per year.

Table 18 Natural Background Levels of Sediment Yield – North Clackamas Integrated Resource Project

Subwatershed	Estimated Natural Background from Slides (cubic yards per year)
Helion Creek-Clackamas River[5]	2,328
North Fork Clackamas River	876
Roaring River	1,232

Besides substantially altering hydrologic processes, wildfire has been shown to affect water quality by increasing rates of erosion and sedimentation and increasing the concentrations of nutrients and other water quality constituents. Generally, the largest effects on water quality are directly or indirectly rated to increases in erosion and sedimentation.

Surface erosion from the 36 Pit Fire that burned in 2014 is another source of sediment in the project area. Based the Burned Area Report for fire the estimated sediment yield was 40.6 tons per acre. Initial post fire sediment yields decrease by one to two orders of magnitude the following year, and recover, with no measurable erosion, by the fourth year (Robichaud 2000). 3,908 acres burned in the Helion Creek-Clackamas River subwatershed and there were 173 acres within the fire perimeter in the North Fork Clackamas River subwatershed (90% of this area was classified as unburned or low soil burn severity with 9% classified as moderate burn severity).

The 36 Pit Fire has had 4 winter runoff periods and this is the period with no measurable erosion (Robichaud 2000) so the sediment yield from the fire was not assessed for this project.

The summary associated with geologic hazards at the 36 Pit Fire is from DeRoo 2014. In the areas of the 36 Pit Fire the very steep slopes are naturally prone to rockfall, rock slides, and debris flows and these three types of landslides are expected to increase in frequency. All three types become more likely after the holding capacity of ground vegetation and tree roots are decreased. Dead trees that topple over will dislodge loose rock and soil on the steep slopes when they impact the ground, initiating down slope movement that is likely to continue to the bottom of the slope. Whole trees and wood fragments are likely to accompany all three types of landslides expected here.

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[5] From Goat Mountain Thin Water Quality Specialist Report

Rockfall – Individual rocks can roll, tumble, free-fall down the very steep slopes at this fire. The rocks can range in size from gravel-size to large boulders that are 5-feet diameter. These rocks may have been partially supported by vegetation and with the removal of that support they can be easily dislodged by wind or the impact of a falling tree. Most of the fire area will experience rockfall.

Rock Slides – Collections of dislodged rock fragments, soil, and wood can slide down steep chutes that concentrate the material and deposit as a fan at the base of the slope. Rock slides here are expected to be shallow depth and relatively small (up to 100 cubic yards).

Debris flows - Debris flows are a type of landslide that typically occurs in a confined creek channel. Debris flows are mixtures of soil, rock, and water with the consistency of very wet concrete. They are capable of traveling long distances if the channel geometry allows. Debris flows can initiate from hillslope landslides that reach the channel and then transform into debris flows, or from the mobilization of channel material in very steep confined channels. Usually debris flows initiate during intense rainfall events. Debris flows can incorporate downed logs and knock over trees, sometimes creating log jams that may temporarily dam the channel. A dam-burst can restart the debris flow.

Water quality can be adversely affected by debris flows that transport large quantities of fine sediment. All the creeks and channels considered here are tributaries to the Clackamas River. The Vantage Member contains fine sediment that could be transported to the river. The Clackamas River already transports moderate quantities of fine sediment during storm events as a result of numerous active landslides along its banks further upstream from the fire. It is unlikely that the volume of fine sediment transported by fire-enhanced debris flows would be large enough to be noticeable in the Clackamas River.

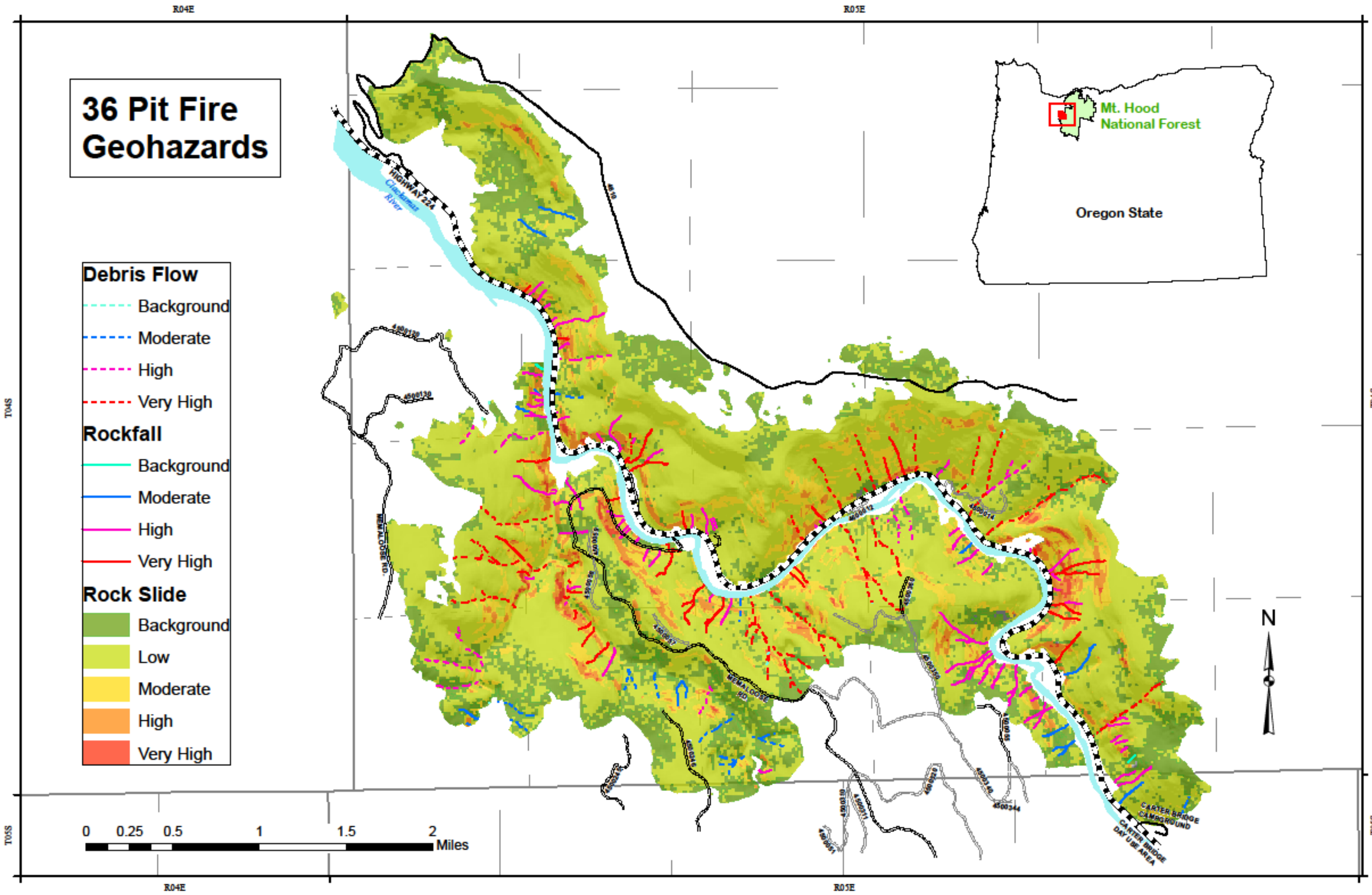

Figure 14 36 Pit Fire Geohazards

The potential sediment yield from to rockfall, rock slides, and debris flows assoicated with the 36 Pit Fire was not quantified because of the uncertainty associated with these type of events.

Surface erosion occurs when detachable soils on sufficiently steep slopes are exposed to overland flow and/or the impact of rainfall. Sediments introduced to streams from surface erosion processes are generally fine-grained and can influence water quality and aquatic habitat (DNR 2011).

Raindrop splash, freeze/thaw, dry ravel, and biogenic processes such as wind throw and animal burrowing are natural causes of soil detachment. Gravity and overland flow of water are natural transport mechanisms of the detached soil particles. Overland flow of water rarely occurs under natural forest conditions because the soil is usually protected by an absorbent, protective layer of organic material resulting from residue of the forest plants. Soil compaction can lead to overland flow and serious erosion consequences. Hillslope angle, soil texture as it affects how well the soil holds itself together, and climate are important influences on the inherent erosion hazard of the site (DNR 2011).

Any activity that strips the protective duff layer to the bare mineral surface may allow surface erosion. Surface erosion can also occur on compacted surfaces where the capacity of the soil to quickly absorb free water is diminished. The result is that water is readily channelized into surface flows. Among the activities most likely to cause surface erosion are roads, silvicultural practices involving high intensity broadcast burns or mechanical scarification, poor yarding practices, and natural processes such as wildfire (DNR 2011).

Forest management activities that accelerate soil detachment and transport include those that expose bare mineral soil to the weather and those that compact soil and/or intercept subsurface flow zones, encouraging overland flow include. Activities that expose bare mineral soil to the weather include road construction and maintenance; yarding techniques that disturb the duff layer such as skidder/tractor yarding, no suspension and one end suspension cable yarding; and site preparation techniques such as burning or scarification. Activities that compact soil and/or intercept subsurface flow zones include road and landing construction and skid trails (DNR 2011).

If water bars and other water control measures are neglected, runoff from roads, cut- and fill-slopes, skid trails, etc. can contribute to hillslope erosion. These features actively produce sediment in most watersheds, with construction practices and drainage design influencing how much sediment is delivered to streams (DNR 2011).

How far material can be transported on slopes, and how it behaves once it enters the stream, are largely determined by the nature of the slope and the texture of the sediment (DNR 2011).

Factors that influence delivery to the stream system include (DNR 2011):

Hillslope Erosion

- Proximity of erosion to the stream system
- Slope angle
- Soil texture, reflecting differences in the distance that various particle sizes would travel
- Areas where overland flow occurs

Road erosion

- Amount and condition of road prism area that drains directly into the stream system
- Traffic levels on the direct entry area of the road surface
- Material used for road surfacing

Some of the natural conditions that limit delivery of eroded soil to the stream include vegetated areas along streams that can filter out soil particles, and topographic conditions that prevent eroded material from entering the stream. Management practices that can limit delivery of eroded soil from hillslopes to the stream system include minimizing duff disturbance, water-barring and/or grass-seeding exposed areas near streams, and avoiding compacting the soil. Minimizing the road surface area that delivers directly into the stream, maintaining it according to the traffic levels, and limiting traffic during wet weather are management techniques that may help control the entry of erosion material into streams (DNR 2011).

Road networks in many upland areas of the Pacific Northwest are the most important source of management-accelerated delivery of sediment to anadromous fish habitats. The sediment contribution to streams from roads is often much greater than that from all other land management activities combined, including log skidding and yarding. Road related landsliding, surface erosion and stream channel diversions frequently deliver large quantities of sediment to streams, both chronically and catastrophically during large storms. Roads may have unavoidable effects on streams, no matter how well they are located, designed or maintained. Many older roads with poor locations and inadequate drainage control and maintenance pose high risks of erosion and sedimentation of stream habitats (USDA 1993).

Sediment yield associated with the existing road system was estimated for the North Clackamas Integrated Resource analysis watersheds using the GRAIP_Lite model.

GRAIP_Lite is a system of tools developed for ArcGIS that is used to model road-related sediment impacts to stream habitats. GRAIP_Lite uses a topographic model, along with other inputs, to create road segments, applies average vegetation parameters and calculates sediment production from individual road segments, uses a local polynomial fit to describe stream connection probabilities and fractional sediment delivery based on flow distance to streams, and accumulates routed sediment throughout the modelled stream network (Nelson, Luce and Black 2018).

When used for alternatives analysis, GRAIP_Lite allows the user to specify various treatment options for individual roads and then models the road-related sediment conditions at the initial condition (before work begins), disturbed condition (immediately post-work or during haul), and the recovered condition (once vegetation has recovered to normal values).

This model was selected because it allows for standardized and repeatable calculations of road surface erosion using the standard Forest Service road network GIS dataset.

Presentation of the GRAIP_Lite model results are intended to provide a means of comparing existing conditions with the proposed project in which both existing and proposed actions utilize the same assumptions and to give a comparison in broad terms of natural to management related sediment yields within the North Clackamas Integrated Resource Project area. As with the Washington State Road Surface Erosion Model (Dubé et al. 2004) it is appropriate to look at the relative differences in erosion estimates when comparing watershed areas or road segments, but the sediment values should always be regarded as estimates not absolute values. Any predicted runoff or erosion value--by any model--will be, at best, within plus or minus 50 percent of the true value. Erosion rates are highly variable, and the models predict only a single value. Replicated research has shown that observed erosion values vary widely for identical plots, and for the same plot from year to year (Elliot et al. 2000).

The road network used to estimate the sediment yield for the existing road system used the Forest Service road network dataset and where it was not available the BLM ground transportation dataset was used. Off-Highway Vehicle (OHV) routes (both authorized and unauthorized) were also added to the network.

Table 19 Estimated Sediment Yield from the Existing Road System – North Clackamas Integrated Resource Analysis Subwatersheds

Subwatershed	Estimated tons of Sediment Delivery per year from the existing road system
Helion Creek-Clackamas River	67.0
North Fork Clackamas River	359.3
Roaring River	61.5

4.2.4.1 - Turbidity

Turbidity is an optical measure of water clarity and is also an indicator of the amount and type of material contained in the water (USDA 1997).

Turbidity is an important parameter of drinking water for both aesthetic and practical reasons. Suspended matter provides areas where microorganisms may not come into contact with chlorine disinfectants, so high turbidity levels may limit the efficacy of normal treatment procedures (MacDonald et al. 1991).

Even at short-term pulses or exposure durations, the best available science includes research indicating that turbidity levels above 20-30 NTUs could cause gill flaring or irritation and adverse behavioral responses, which may involve alteration to feeding and social hierarchy. That same research showed that, as the turbidity levels moved from 30 up to 60 NTUs, feeding was found to be significantly reduced (USDC 2016).

Most studies of the effects of management activities on streams have measured suspended sediment rather than turbidity, as suspended sediment concentrations are not dependent upon the types of materials in suspension. Hence the effects of management activities on turbidity generally have to be inferred from the relatively numerous studies that have monitored suspended sediment concentrations. Extrapolation from these studies is usually possible because of the relationship between the concentration of suspended sediment and turbidity (MacDonald et al. 1991).

In general, the same activities that generate large amounts of suspended sediment will more or less proportionally increase turbidity (MacDonald et al. 1991).

There is limited turbidity data on the streams in the subwatersheds associated with the North Clackamas Integrated Resource project. Turbidity was measured by the USGS in the Clackamas River at Carter Bridge from April 4, 2005 to November 20, 2016. The chart of turbidity details that the 20 NTU level of turbidity is exceeded regularly and the 60 NTU level is exceeded at least once a year. The Carter Bridge site is at the upstream end of the planning area in the Helion Creek Clackamas River subwatershed so the area in the upstream of the project associated subwatersheds would be approximately 3.2 miles of the Clackamas River and the Roaring River subwatershed. Elevated levels of turbidity during storms maybe be associated with conditions in the Clackamas River upstream of the project area DeRoo 2014 stated the Clackamas River already transports moderate quantities of fine sediment during storm events as a result of numerous active landslides along its banks further upstream from the fire.

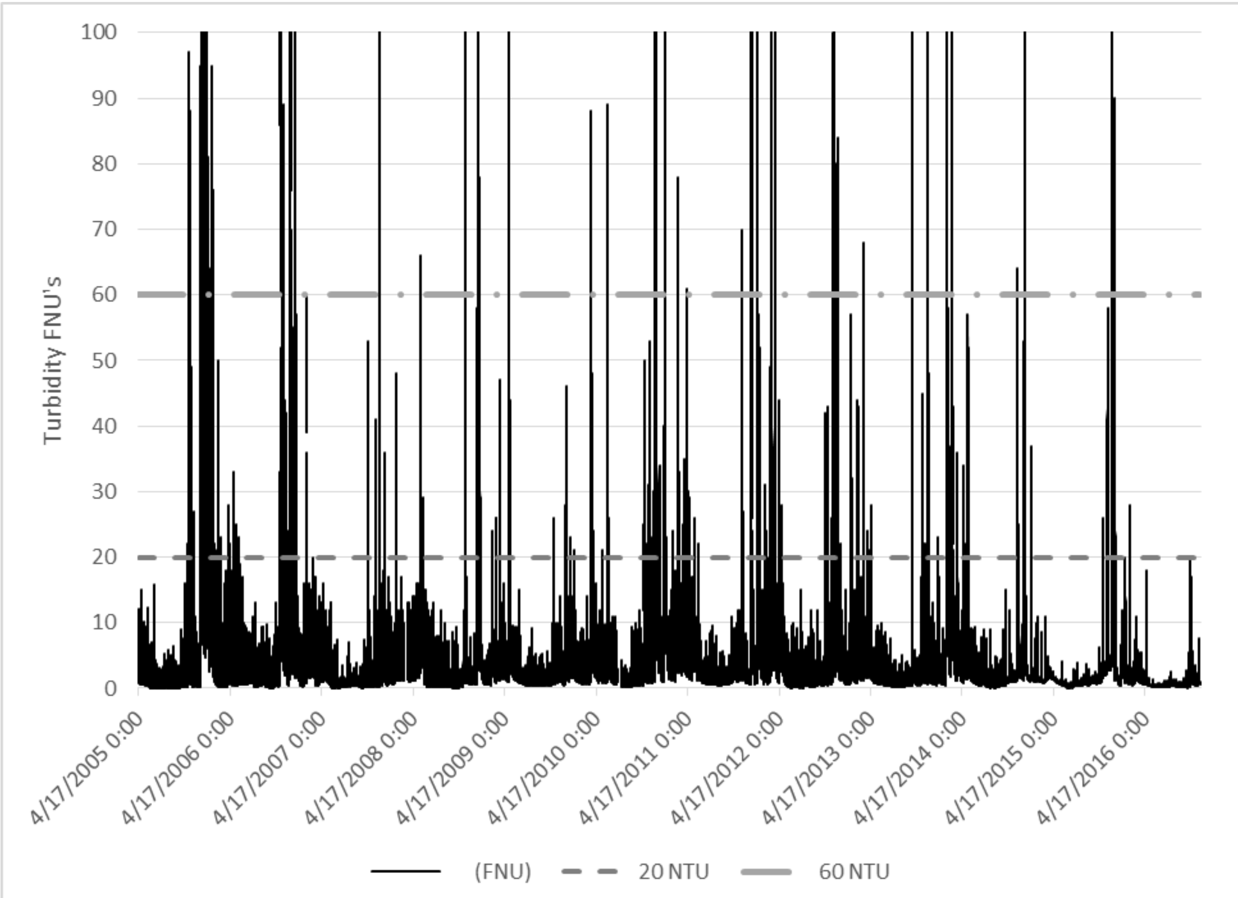

Figure 15 Turbidity in the Clackamas River at Carter Bridge from April 4, 2005 to November 20, 2016

4.2.4.2 - Sediment Routing

Sediment delivery from the road surface erosion is episodic and is expected to be spread out over time and space. Annual sediment yield is extremely difficult to predict due to the episodic nature of climatic events that initiate movement. With respect to the road system less than 10% of the road network often responsible for 90% of road sediment delivery (RMRS 2014).

Once road sediment enters a stream it interacts with the complex stream dynamics. In a study on the generation and fate of road-surface sediment in forested watersheds in Southwestern Washington (Bilby et al. 1989) "Approximately 34% of surveyed road drainage points entered streams mainly first- or second-order channels. Thus, the delivery of road sediment to larger streams often depended on its transport through these smaller channels. Small streams temporarily retained a high proportion of road sediment input to them. Coarser particles were retained at a higher rate than finer material. Due to the fine particle size of road sediment delivered to streams little effect of this material on the composition of streambed gravel could be discerned."

A series of experimental additions of road-surface sediment was made to two ephemeral streams to examine the downstream transport of this material as a function of discharge and channel characteristics. These small streams were found to store large amounts of sediment washed from road surface. There were significant differences in the transport of sediment in the two larger size categories between the two streams. These differences were due to a much greater amount of woody debris in the stream with the lower delivery rates, which acted to trap and hold sediment (Duncan et al. 1987)

Water and sediment routing in channels is controlled by large debris which may create a stepped profile. Stream energy is thereby dissipated at the relatively short, steep sections of channel so that much of the stream area may have a gradient less than the overall gradient of the valley bottom (Swanson and Lienkaemper 1978).

Woody material made up 75 to 85 percent of the obstructions that trapped sediment. In the case of the 60-hectare Watershed 2 in the H. J. Andrews Experimental Forest, average bedload export measured in a sediment basin has been 3.8 cubic meters per year for 1957-1976. In a 100-meter section above the basin, 20.1 cubic meters of sediment is stored behind organic debris. The entire length of perennial and intermittent channel is about 1700 meters, so in this watershed annual sediment yield is probably much less than 10 percent of material in storage. Additional, unfilled storage capacity is available within the channel system (Swanson and Lienkaemper 1978).

The overall storage capacity serves to buffer the sedimentation impacts on downstream areas when there are pulses of sediment input to channels. Scattered debris in channels reduces the rate of downstream sediment movement and tends to feed sediment through the stream ecosystem in a slow trickle, except in cases of catastrophic flushing events. These flushing events may scour a channel every few centuries, leaving the channel devoid of large organic debris and open to rapid transfer of bedload (Swanson and Lienkaemper 1978).

In a study that modeled sediment and wood storage dynamics in small mountainous watersheds (Lancaster et al 2001) "In a 3000-year simulation of the study area, woody debris flow deposits form dams on the main channel and lead to steps in the channel profile and terraces on the valley floor that persist in place even after nearly all deposited wood has decayed. Simulated sediment output from the network is relatively steady and shows little evidence of episodic input. Our results suggest that abundant wood plays a key role in moderating sediment flux from small basins following debris flow events".

"The simulation indicates, and our field observations confirm, that wood and sediment dynamics are strongly linked. The coupling between sediment and wood implies a strong coupling between forests and channels. Through this coupling, forest conditions "drive" channel conditions, and forests, sediment dynamics, and channels are inextricably linked."

These studies indicate that the episodic input of sediment associated with road surface erosion is metered by the stream system to provide a steady output of sediment.

4.2.4.3 - Stream Survey Data

In-channel fine sediment was evaluated based on stream surveys and surveys completed in 2016 associated with the North Clackamas Integrated Resource Project. Areas where surface fines (material less than 6 millimeters) exceed 20 percent of the substrate were identified. The threshold of concern for fine sediment is based on the relationship of embryo survival and percentage of substrate particles less than 6.35 mm for chinook, kokanee, rainbow, cutthroat and steelhead trout (Bjorn and Reiser in Meehan 1991). Above 20% surface fines, the survival of salmonid embryos decreases rapidly in that study.

The only site from the streams surveyed where fine sediment material less than 6 millimeters exceeds 20 percent of the substrate is Bedford Creek reach 1 and when this area was resurveyed in 2016 fine sediment levels were lower to the point where the threshold was not exceeded.

Table 20 In-Channel Fine Sediment Levels from Stream Surveys

Site	Year Surveyed	Protocol	% Less than 2mm	% Less than 6mm
Bedford	2016	Project pool tail crest	11%	12%
Bedford Cr. R1	2012	R6 Stream Survey	18%	24%
Bedford Cr. R2	2012	R6 Stream Survey	6%	6%
Bedford Cr. R3	2012	R6 Stream Survey	7%	9%
Boyer Cr R1	2012	R6 Stream Survey	10%	18%
Boyer Cr R2	2012	R6 Stream Survey	10%	15%
Boyer Cr R2	2012	R6 Stream Survey	5%	9%
Boyer Cr R3	2012	R6 Stream Survey	10%	11%
Boyer Cr R3	2012	R6 Stream Survey	14%	15%
Boyer Cr R4	2012	R6 Stream Survey	13%	20%
Boyer Cr R4	2012	R6 Stream Survey	14%	30%
Boyer Creek 2016	2016	Project pool tail crest	12%	16%
Dry Creek 2016	2016	Project	9%	7%
NF Clackamas River Lower R1	2017	R6 Stream Survey	10%	10%
NF Clackamas River Lower R1	2017	R6 Stream Survey	11%	12%
NF Clackamas River Lower R2	2017	R6 Stream Survey	14%	14%
NF Clackamas River Lower R2	2017	R6 Stream Survey	12%	12%
NF Clackamas River Lower R3	2017	R6 Stream Survey	6%	6%
NF Clackamas River Lower R3	2017	R6 Stream Survey	19%	19%
NF Clackamas River Lower R4	2017	R6 Stream Survey	5%	5%
NF Clackamas River Lower R4	2017	R6 Stream Survey	7%	7%
NF Clackamas River Lower R5	2017	R6 Stream Survey	7%	7%
NF Clackamas River Lower R5	2017	R6 Stream Survey	7%	7%

Site	Year Surveyed	Protocol	% Less than 2mm	% Less than 6mm
NF Clackamas River Lower R6	2017	R6 Stream Survey	3%	3%
NF Clackamas River Lower R6	2017	R6 Stream Survey	10%	10%
NF Clackamas River R1	2016	R6 Stream Survey	10%	16%
NF Clackamas River R1	2016	R6 Stream Survey	6%	16%
NF Clackamas River R2	2016	R6 Stream Survey	4%	4%
NF Clackamas River R2	2016	R6 Stream Survey	4%	11%
NF Clackamas River R3	2016	R6 Stream Survey	8%	12%
NF Clackamas River R3	2016	R6 Stream Survey	3%	5%
North Fork Clackamas River	2016	Project pool tail crest	10%	10%
Whisky Creek	2016	Project pool tail crest	11%	11%
Winslow Creek	2016	Project	9%	16%

Mt Hood Land and Resource Management Plan Standards FW-097 and FW-098 state: "Spawning habitat (e.g., pool tailouts and glides) shall maintain less than 20 percent fine sediments (i.e., particles less than 1.0 millimeter in diameter) on an area-weighted average. The area considered within the average should include only the stream reaches available for vegetative manipulation (e.g., Wilderness areas should not be included)". Stream surveys complete pebble counts in representative riffles[6] so the Mt Hood Land and Resource Management Plan Standards FW-097 and FW-098 would not appear to apply in this area since it is not spawning habitat (e.g. pool tailouts and glides). Mt Hood Land and Resource Management Plan Standards FW-099 and FW-100 states: "Riffle areas shall maintain less than 25 percent embeddedness on an area-weighted average. The area considered within the average should include only the stream reaches available for vegetative manipulation" so this would appear to be the standard used to assess fine sediment levels associated with stream surveys. All the surveyed streams meet this criteria

The matrix of pathways and indicators from National Marine Fisheries Service (NMFS), 1996 classifies less than 10% of the streambanks actively eroding as properly functioning.

Table 21 Matrix of pathways and indicators to evaluate properly functioning condition from NMFS 1996

Indicators	Properly functioning (PF)	At risk (AR)	Not properly functioning (NPF)
Streambank condition	>90% stable; i.e., on average, less than 10% of banks are actively eroding	80-90% stable	<80% stable

A query of the Aquatic Surveys application in the Forest Service's EDW (Enterprise Data Warehouse) for streambank erosion noted limited streambank erosion. Two sections of Roaring

[6] The first Wolman pebble count is performed in a representative riffle located at one-third of the reach's length; the second Wolman pebble count is performed in a riffle that is representative of the reach at two-thirds of the reach's length (Stream Survey Manual V2.12, 2012)

River have greater that 10% unstable banks associated with the 1996 flood event (estimated at a 50 to 100 year recurrence interval storm event (USDA 1996c)).

The stream survey of the Roaring River that was completed in 1996 noted:

A large amount of erosional activity was observed. Most of the high gradient tributaries in the lower 6 reaches (especially Reach 1) were blown out by the 1996 flood. Many of them were eroded down to bedrock and had huge alluvial fans with a variety of size class particles falling directly into the mainstem. Large sections of bank in the lower reaches were unstable and there were many hillslope failures which were eroding silt directly into the stream.

The vast majority of the Roaring River basin has not been subjected to human disturbances, leaving an unspoiled low elevation basin which is very rare for the region. Left in its natural state it can be a valuable source of information about natural systems which may not be found anywhere else.

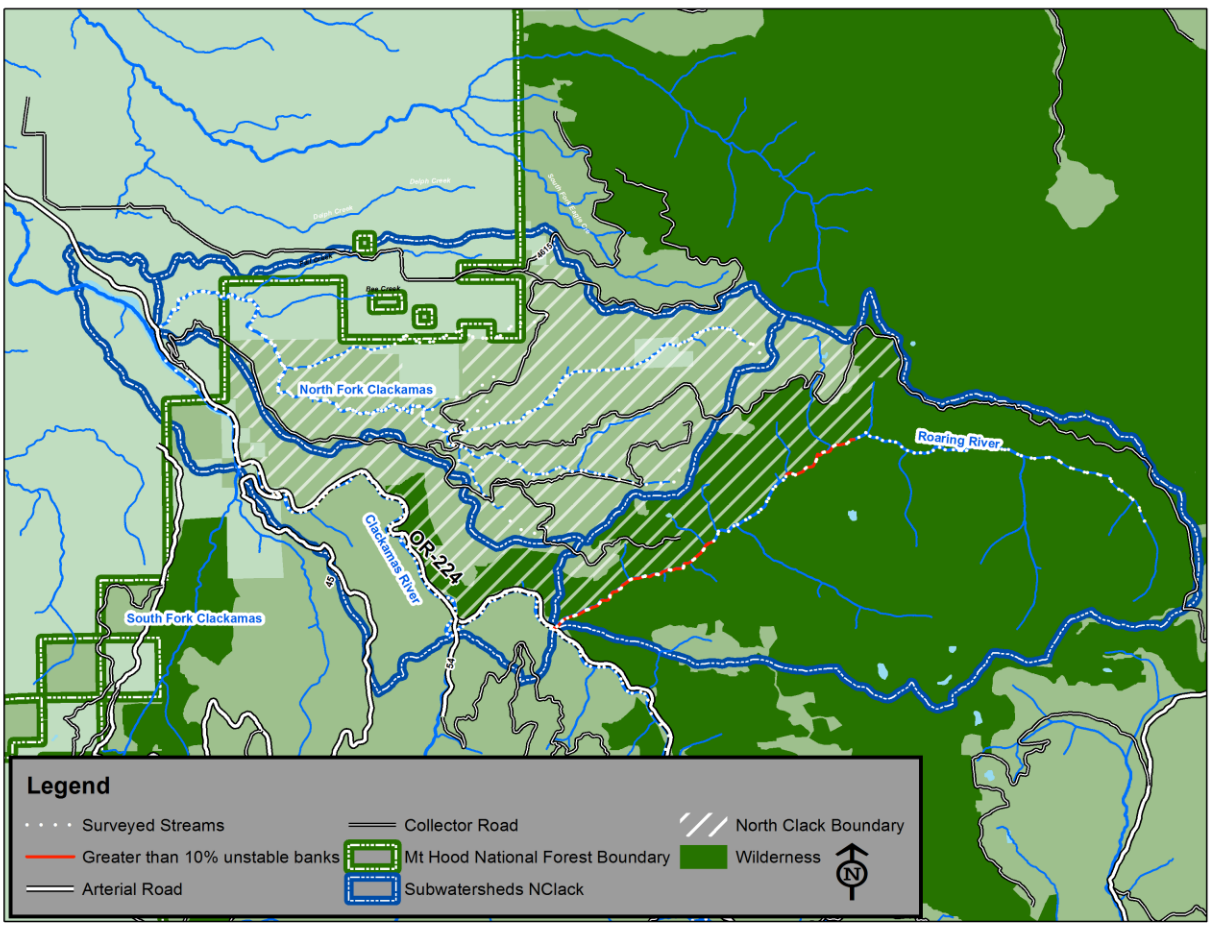

Figure 16 Surveyed Streams with Greater Than 10% Unstable Banks

4.2.4.3 - Benthic Invertebrate Biomonitoring

Benthic Invertebrate Biomonitoring was completed by Aquatic Biology Associates in 1993 and 1994 in three sites in the North Fork Clackamas River (ABA 1995).

Aquatic Biology Associates, Inc. (ABA) has developed a biomonitoring protocol for assessing benthic invertebrate communities; primarily for use in montane streams in western North America. The ABA Protocol is designed to detect impacts and trends of biotic/habitat integrity in montane watersheds, where monitoring objectives seek to document cumulative impacts from land management activities (ABA 1994).

The ABA protocol samples three stream habitat types to increase the scope of analysis of biotic and habitat integrity. The following paragraphs in italics are paraphrased from Benthic Invertebrate Biomonitoring & Bioassessment (ABA 1994).

Erosional Habitat is usually sampled in riffles. Riffles in montane streams usually support a rich and productive invertebrate community. Margins are defined as wetted or submerged substrates in slower water near shore. Stream margins are important rearing and refugia areas for many aquatic invertebrates. Coarse particulate organic matter, or detritus samples consist of well conditioned, higher nutrient detritus (typically deciduous leaves). A gallon bucket of this detritus (moderately packed) is taken from pockets on stream margins, pool bottoms, and leaf packs in faster current. Organic matter derived from terrestrial and aquatic vegetation is an important energy source for montane streams. It is the prime source for heavily shaded small streams.

Bioassessment categories have been tentatively assigned as follows.

- ***90-100% Very High**.*
- ***80-89% High.** High: habitat complexity, biotic integrity, taxa richness, % of cool adapted fauna, number of more specific microhabitat related taxa, etc. Low: numbers of highly tolerant taxa.*
- ***60-79% Moderate.** Moderate: as above. The benthic invertebrate community points to some habitat limitations.*
- ***40-59%** Low. Low: as above. The community reflects significant habitat and/or water quality limitations.*
- *< **40% Severe.** The community present has developed under habitat conditions that represent a severe departure from the ideal conditions.*

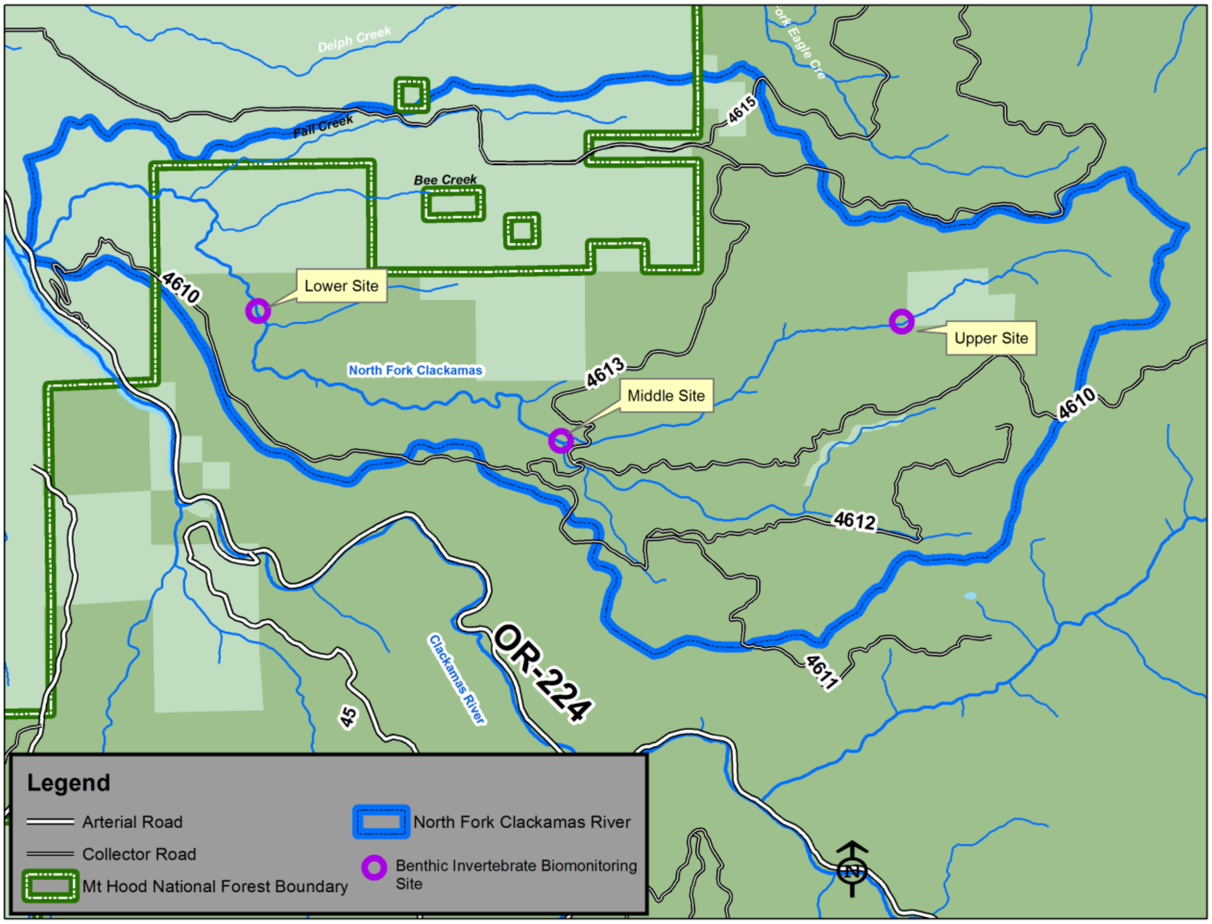

Figure 17 Benthic Invertebrate Biomonitoring Sites

Table 22 Total Bioassessment Scores North Fork Clackamas Lower site

Habitat	Integrity Category 1993 survey	Integrity Category 1994 survey
Erosional Habitat	Moderate	Moderate
Margin Habitat	Moderate	Moderate
Detritus Habitat	Low	Moderate

The moderate scores for all habitat types point to some habitat limitations.

Cold Water Biota (evaluated as intolerant mayflies, stoneflies, caddisflies and dipterans in bioassessment) are occasional, indicating that summer temperatures are high enough to be lethal to some cool/cold adapted taxa.

Sediment Tolerant Taxa (many negative indicator groups): Silt covering slack-water surfaces (margin, pools, alcoves) during low flows is low[7]; and is not a significant inhibitor of invertebrate

[7] The author of the document indicated some uncertainty with these conclusions

community development in these habitats. Silt entrained in sediments is low and probably is not a significant inhibitor of invertebrate community development.

Water quality does not appear to be limiting. There is no evidence of depressed dissolved oxygen levels, nutrient enrichment, low or high pH, or excessive alkalinity or sulfate.

Table 23 Total Bioassessment Scores North Fork Clackamas middle site

Habitat	Integrity Category 1993 survey	Integrity Category 1994 survey
Erosional Habitat	Moderate	High
Margin Habitat	Moderate	Low
Detritus Habitat	Moderate	Moderate

The moderate scores for all habitat types point to some habitat limitations.

Cold Water Biota (evaluated as intolerant mayflies, stoneflies, caddisflies and dipterans in bioassessment) are occasional-common, indicating that summer temperatures are not high enough to be lethal to most cool/cold adapted taxa.

Sediment Tolerant Taxa (many negative indicator groups): Silt covering slack-water surface (margin, pools, alcoves) during low flows is low-moderate[8]; and is not a significant inhibitor of invertebrate community development in these habitats. Silt entrained in sediments is low moderate and probably is not a significant inhibitor of invertebrate community development.

Water quality does not appear to be limiting. There is no evidence of depressed dissolve oxygen levels, nutrient enrichment, low or high pH, or excessive alkalinity or sulfate.

Table 24 Total Bioassessment Scores North Fork Clackamas Upper site

Habitat	Integrity Category 1993 survey	Integrity Category 1994 survey
Erosional Habitat	Moderate	Moderate
Margin Habitat	Moderate	High
Detritus Habitat	Moderate	High

The moderate scores for all habitat types point to some habitat limitations.

Cold Water Biota (evaluated as intolerant mayflies, stoneflies, caddisflies and dipterans in bioassessment) are common, indicating that summer temperatures are not high enough to be lethal to cool/cold adapted taxa.

Sediment Tolerant Taxa (many negative indicator groups): Silt covering slack-water surfaces (margin, pools, alcoves) during low flows is low-moderate[9]; and is not a significant inhibitor of invertebrate community development in these habitats. Silt entrained in sediments is low moderate and probably is not a significant inhibitor of invertebrate community development.

---

[8] The author of the document indicated some uncertainty with these conclusions

[9] The author of the document indicated some uncertainty with these conclusions

Water quality does not appear to be limiting. There is no evidence of depressed dissolved oxygen levels, nutrient enrichment, low or high pH, or excessive alkalinity or sulfate.

5.0 Direct and Indirect Effects

5.1- Water Quantity

5.1.1 - No Action Alternative

It is likely that past forest management activities (timber harvest and road building) in the North Clackamas Integrated Resource Project area have affected peak and base flows.

Under the no action alternative, the percentage of the watershed completely hydrologically recovered (in terms of ARP values) would continue to recover in terms of hydrologic recovery as young plantations grow. Existing road-related effects remain.

Under the no action alternative there would be no vegetation management activities including: variable density thinning in densely stocked stands, regeneration harvest, site preparation and planting, meadow burning, and fuel breaks; there would also be no road reconstruction, or new temporary road construction, so there would be no additional risk of peak flow increases due to these activities.

The proposed road repair and maintenance (with an objective to minimize sediment delivery to streams through maintenance of the design drainage of the road surface and road surfacing), temporary road construction with post activity rehabilitation of existing non-system roads, road decommissioning, stormproofing, and maintenance level changes would not occur. Therefore, the road related effects associated with these areas would continue.

5.1.2 - Action Alternatives

Table 25 Summary of Transportation System Management Actions

Purpose & Need	Proposed Actions
Manage the Road System to Allow for Safe Timber Hauling	Maintain and Repair Forest Service System Roads
Provide Access for Vegetation Management	Construct and Reconstruct Temporary Roads
Reduce Resource Risks and Maintenance Costs Associated with Forest Service System Roads	Decommission and Close Forest Service System Roads
Reduce Resource Risks and Maintenance Costs Associated with Forest Service System Roads	Convert Road to Non-Motorized Trail
Provide Access for Vegetation Management	Return Former Forest Service System Road Back to the System
Reduce Resource Impacts Associated with Unauthorized OHV Routes	Rehabilitate Unauthorized OHV routes

The following table shows the change in ARP values associated with project implementation that includes variable density thinning in densely stocked stands, regeneration harvest, site preparation and planting, meadow burning, and fuel breaks; and road management activities: road repair and maintenance, temporary road construction with post activity rehabilitation of existing non-system roads, road decommissioning, stormproofing, and maintenance level changes.

Table 26 ARP Values Associated with Implementation of the Action Alternatives

Subwatershed	ARP Existing Condition	Action Alternatives	Direct Effect
Helion Creek-Clackamas River	84	83	-1
North Fork Clackamas River	82	78	-4
Roaring River	99	99	0

The slight changes in ARP associated with the project would not likely cause any additional changes in stream channel stability or increases in peak flows beyond those described for the existing condition associated with vegetation manipulation alone.

The North Fork Clackamas River is slightly above the threshold threshold where increases in peak streamflows are detectable from The Effects of Forest Practices on Peak Flows and Consequent Channel Response Report (Grant et al. 2008) and in using the same hydrologic and geomorphic analysis that was used to assess the combined impacts of harvest and roads it does not appear that slight decrease in ARP would result in peak flow effects on channels.

Based on the watershed sensitivity analysis completed for the Forest Plan associated with special emphasis watersheds and current watershed impact areas all the analysis watersheds associated with the North Clackamas Integrated Resource Project Planning Area are below the disturbance TOC of 35% recommended for watersheds that are not designated as Special Emphasis Watersheds. As with ARP the slight changes in watershed impact area associated implementation of the proposed action would not have any different impacts than those described for the existing condition.

Table 27 Watershed Impact Area – North Clackamas Integrated Resource Project Subwatersheds

Subwatershed	Impact Area Action Alternatives
Helion Creek-Clackamas River	17
North Fork Clackamas River	22
Roaring River	1

5.1.2.1 - Stream Channel Network Extension

Stream channel network extension would stay the same as the current condition. The action alternative figures is during implementation when the temporary roads are being used and road decommissioning and closures have occurred on roads not being used, post action is when temporary roads have been rehabilitated and remaining road decommissioning and closure activities have been accomplished.

Table 28 Stream Drainage Network Extension

Subwatershed	Existing Condition	Action Alternatives	Post Action
Helion Creek-Clackamas River	9%	9%	9%
North Fork Clackamas River	7%	7%	6%
Roaring River	2%	1%	1%

Impacts associated with the Action Alternatives with respect to stream drainage network extension would be the same as those described in the existing condition.

The effects of vegetation removal through harvest and roads are considered independent from each other and they are roughly additive so they should be integrated when assessing management effects on peak streamflows within a watershed (LaMarche and Lettenmaier 2001).

Since the impacts of vegetative removal though harvest and roads are essentially the same as those described in the existing condition the integrated impacts would be considered to be the same as those described in the existing condition and are summarized below.

When the combined impacts of vegetation management and roads are examined all the subwatersheds are rated as properly functioning in the 6th Field Watershed Condition from the Northwest Forest Plan–The First 20 Years (1994-2013) Watershed Condition Status and Trend Report (Miller et al. 2017) and the Roaring River subwatershed is below the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads.

The North Fork Clackamas River and Helion Creek-Clackamas River subwatersheds are above the threshold where increases in peak streamflows are detectable associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads. A detailed hydrologic and geomorphic analysis indicated that peak streamflows are not impacting stream channel morphology in these subwatersheds.

5.2 - Water Quality

5.2.1 - No Action Alternative

5.2.1.1 – 303D Listed Streams

The Clackamas River (river mile 0 to 83.2) is 303D listed for biocriteria (waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities). The biocriteria is based on macroinvertebrate communities in Oregon’s perennial, wadeable streams.

The text below is from Monitoring Guidelines To Evaluate Effects Of Forestry Activities On Streams In The Pacific Northwest And Alaska (MacDonald et al. 1991).

> *The effects of forest activities on macroinvertebrate communities vary. Increases in the riparian canopy opening or the amount of organic material in the streams generally enhance aquatic insect populations. An increase in fine sediment usually has the opposite effect. Removing the riparian canopy decreases the input of terrestrial organic material and the number of detritivores. However, this decline often is overwhelmed by the corresponding increase in primary production and herbivorous insects. Several studies have documented an increase in primary productivity after partial or complete removal of the riparian canopy. However, no increase was found in Carnation Creek in coastal British Columbia, where phosphorus was found to be the limiting factor. Logging-induced increases in aquatic insects have been observed in northern California and the Oregon Cascades. While logging activities may increase total abundance, species diversity is usually reduced.*
>
> *Invertebrate communities also are affected by management practices on forest lands. Buffer strips 30 meters wide appeared to protect invertebrate communities from logging induced changes, but buffer strips 10 meters wide still resulted in a decrease in detrital inputs and macroinvertebrate densities. The net effect of logging on aquatic macroinvertebrates depends on the relative balance among all the controlling factors.*

Primary shade zones (areas of riparian vegetation directly adjacent to streams) along perennial streams would continue to fill in with understory vegetation. Sediment delivery to streams in the project area would remain at current levels or may increase associated with the deteriorating road network. The current road network would see minimal levels of maintenance associated with reduced funding levels and may pose a risk of failure and may contribute sediment to streams. It is anticipated that the macroinvertebrate community as assessed by Oregon Department of Environmental Qualities PREDictive Assessment Tool for Oregon would remain in the same range as the existing condition because primary shade zones and sediment inputs from roads are anticipated to stay at the current levels.

5.2.1.2 - Stream Temperature

Stream temperatures can be affected by processes that remove stream shade, alter channel structure, or alter the flow regime.

The natural watershed parameters that are most influential in determining stream temperature include: solar radiation, air temperature, stream width, stream depth, shading, and groundwater inflow. Forest practices can affect these parameters. For example, removal of riparian vegetation increases the solar radiation received by a stream reach; logging can alter streamflow, either decreasing or increasing summer low flows depending on local situations, and sedimentation can decrease channel depth and increase channel width (DNR 2011a).

Increased water temperature can often be traced to removal of shade-producing riparian vegetation along fish-bearing streams and along smaller tributary streams that supply cold water to fish-bearing streams Removal of streambank vegetation has resulted largely from timber harvest in riparian areas (USDA 1993).

Stream temperatures are anticipated to remain at current levels. Primary shade zones (areas of riparian vegetation directly adjacent to streams) along perennial streams would continue to fill in with understory vegetation as young plantations grow. Since these areas are already densely vegetated, it is not anticipated that this component would reduce stream temperatures any great degree within the project area. Increased peak streamflows have the potential to erode the streambed and banks, however it was concluded in the Water Quantity Section of this report that current peak streamflows are not adversely impacting stream channel morphology.

5.2.1.3 - Sediment

Sediment delivery to streams in the project area would remain at current levels or may increase associated with the deteriorating road network. The current road network would see minimal levels of maintenance associated with reduced funding levels and may pose a risk of failure and may contribute sediment to streams. Vegetation that impedes erosion and sediment delivery would be maintained.

The proposed road repair and maintenance (with an objective to minimize sediment delivery to streams through maintenance of the design drainage of the road surface and road surfacing), temporary road construction with post activity rehabilitation of existing non-system roads, road decommissioning, stormproofing, and maintenance level changes would not occur. Therefore, the road related effects associated with these areas would continue.

5.2.2 - Action Alternatives

5.2.2.1 - Stream Temperature

This alternative proposes to thin vegetation within Riparian Reserves. Vegetation removal near water bodies has the potential of increasing solar radiation to surface water which in turn may increase water temperature. Utilizing tools contained within the *Northwest Forest Plan (NWFP) Temperature TMDL Implementation Strategies: Evaluation of the Northwest Forest Plan Aquatic Conservation Strategy (ACS) and Associated Tools* (USDA 2012) necessary vegetation that is providing shade so that stream temperatures within treatment areas would not increase as a result of the proposed vegetation treatments is identified. The previously mentioned document is the result of work between the USFS and the BLM and identifies how to maintain sufficient stream shading to meet the Clean Water Act Water Quality Objectives while providing the opportunity to treat Riparian Reserve vegetation to improve riparian conditions. The State of Oregon DEQ conditionally approved the Strategy in September 2005 as the temperature TMDL implementation mechanism under the Clean Water Act.

The concept of the sufficiency analysis associated with the *Northwest Forest Plan (NWFP) Temperature TMDL Implementation Strategies: Evaluation of the Northwest Forest Plan Aquatic Conservation Strategy (ACS) and Associated Tools* (USDA 2012) is to maintain a primary shade zone of vegetation next to the stream and identify a secondary shade zone and other areas within the Riparian Reserves further away from the stream that can be treated to reach Riparian Reserve Objectives while maintaining stream temperatures. In order to maintain sufficient shade next to the stream, the primary shade zone is untreated. The size of this zone is dependent on the current height of the trees and the associated hill slope gradient. This relationship is shown in the table below.

Table 29 Width of Primary Shade Zone (feet) based on Slope (percent) and Tree Height (average height of stand in feet). Widths are measured by slope distance.

TREE HEIGHT	Hill Slope <30 %	Hill Slope 30 to 60 %	Hillslope >60 %
Trees < 20 feet	12 feet	14 feet	15 feet
Trees 20 to 60 feet	28 feet	33 feet	55 feet
Trees >60 to 100 feet	50 feet	55 feet	60 feet
Trees >100 to 140 feet	70 feet	75 feet	85 feet

The trees within the treatment areas of the project that are adjacent to perennial streams are approximately from 70 to 141 feet tall (based on the height of trees in units that are within 185 feet of a perennial stream) so the primary shade zone varies from 50 to 85 feet based on tree height and hill slope percent. This area would be left untreated next to perennial streams (with the exception of trees within skyline yarding corridors and restoration activities where trees would be felled into the stream) to maintain current stream shading and water temperatures.

The North Clackamas Project would use the following buffers (within these buffers, tree felling or yarding would not occur, with the exceptions for danger trees, approved skyline corridors and down wood enhancement projects). These buffers meet or exceed the width of primary shade zone as detailed in Northwest Forest Plan (NWFP) Temperature TMDL Implementation Strategies: Evaluation of the Northwest Forest Plan Aquatic Conservation Strategy (ACS) and Associated Tools (USDA 2012).

Table 30 Minimum Stream-Protection Buffer Widths

Distances in Feet	Intermittent Streams	Perennial Streams Hill Slope < 30%	Perennial Streams Hill Slope 30 to 60%	Perennial Streams Hill slope > 60%
Thinning	50	70	75	85
Sapling Thinning[10]	20	20	20	20

[10] Sapling thinning precommercially thins with hand power tools. Trees to be cut, generally average 3 to 4 inches in diameter and less than 20 feet in height; however actual sizes of cut trees would vary based on site-specific conditions and the need to meet other objectives.

Distances in Feet	Intermittent Streams	Perennial Streams Hill Slope < 30%	Perennial Streams Hill Slope 30 to 60%	Perennial Streams Hill slope > 60%
Regeneration Harvest	180	180	180	180

The streams that have a connection to listed fish habitat (LFH) were examined by the fisheries biologist and the minimum widths above were adjusted based on the proximity to listed fish habitat, and other factors such as stream gradient and orientation and the cumulative quantity of other past management along these streams.

Table 31 Prescribed Widths for Perennial Streams in Specific Units

Unit	Protection Buffer (feet)
4	125
6	111
50	89

Thinning within the secondary shade zone on perennial streams may occur; however, at least 50% canopy closure must remain in this treated zone (USDA 2009).

Increased peak streamflows have the potential to erode the streambed and banks, however it was concluded associated with the proposed action, peak streamflows are not adversely impacting stream channel morphology.

Associated with project design criteria that meet the Sufficiency Analysis, there should be no increase in stream temperature resulting from implementation of this project.

A replicated before-after-control-impact study was used to test effectiveness of the State of Oregon's riparian protection measures at minimizing increases in summer stream temperature associated with timber harvest (Groom et al. 2011). The study was conducted at 15 state forest sites in the Oregon Coast Range. Sites were situated along first- to third-order streams dominated by Douglas-fir (*Pseudotsuga menzeisii*) and red alder (*Alnus rubra*). Forest stands were 50 to 70 years old and were fire- or harvest-regenerated. Riparian protection measures included a no cut 25-foot buffer adjacent to the stream, and from 25 to 100 feet from the stream partial cutting is allowed as long as conifer density is at least Stand Density Index 25%, and 50 trees per acre are retained (with the objective for this area of a stand dominated by large conifer trees, or where hardwood-dominated conditions are expected to be the natural plant community, a mature hardwood/shrub community). For conifer stands, this equates to a basal area of 220 square feet or more per acre, inclusive of all conifers over 11 inches diameter at breast height (DBH). At a mature age (80-100 years or greater), this equals 40-45 conifer trees 32 inches in DBH per acre. Overall no change in maximum temperatures for state forest streams were observed. The riparian buffers associated with North Clackamas Integrated Resource Project include a minimum 70-foot no cut buffer for perennial streams indicating that these buffers retain more vegetation than the State of Oregon riparian protection buffers so it would be expected based on the results from the Groom study that there would be no impact to maximum summer stream temperatures associated with the implementation of North Clackamas Integrated Resource Project.

With respect to smaller streams relative to temperature effects, non-fish-bearing streams tend to be narrow channels in steeper constrained valleys. Near-stream vegetation and topographic features often shade the entire channel in such settings (Reeves et al. 2016).

The Action Alternatives include large woody debris placement in North Fork Clackamas River, Bedford Creek, and Winslow Creek (listed in priority order). This is proposed to create habitat diversity and to restore some natural stream processes. A fisheries biologist would select the trees to fell from areas that are fully stocked with trees and would avoid unstable areas or areas with a high water table.

Since the trees to be felled into the stream are from areas that are fully stocked with trees and a fisheries biologist would select the individual trees to fall there are no impacts to stream shade anticipated associated with this activity.

5.2.2.2 - Sediment

Some ground disturbing activities in this alternative have the potential to dislodge soil particles which in turn may increase erosion. These activities include new temporary roads, landings, skid trails, yarding corridors, in-stream large wood enhancement, riparian habitat enhancement and areas of road maintenance and repair. Amounts of erosion and sediment delivery are expected to be small due to maintaining protective ground cover along with implementation of Best Management Practices (BMP) or Project Design Criteria (PDC) as they are referred to in this document.

Within the stream protection buffer zone of proposed thinning units, some second-growth trees would be felled into streams. This is proposed to create habitat diversity and to restore some natural stream processes. Live trees would be felled. A fisheries biologist would select the trees to fall from areas that are fully stocked with trees and would avoid unstable areas or areas with a high water table.

The project fisheries biologist would select trees and ensure that project design criteria are incorporated into implementation contracts. The fisheries biologist would regularly coordinate with the project Contracting Officer Representative to ensure the project design criteria are being followed. Project design criteria include: Only live trees or down logs within the stream protection buffer of the unit would be added to streams; Only live trees that are 24 inches are less would be felled or pushed over; Where appropriate, down wood lying above a stream would be bucked so that at least one end falls into the stream; Trees or logs would be placed in a manner that creates new aquatic habitat and does not block fish passage ; The Oregon Department of Fish and Wildlife Guidelines for Timing of In-Water Work would be followed. Exceptions to these guidelines for timing of in-water work may be requested from appropriate regulatory agencies; When operating chainsaws near streams, a vegetable based bar oil would be used. A post-project review would be conducted after winter and spring high flows and adjustments would be made where necessary to provide for fish passage or to minimize bank erosion.

Access roads and associated haul routes were evaluated and road maintenance activities were identified with an objective to prevent sediment delivery to streams. Similar to road and landing construction, soil disturbing road maintenance activities would not occur during wet conditions as described in PDC C9.

Maintenance activities identified include the placement of new aggregate surfacing where necessary, blading, removing debris, brushing out encroaching vegetation, removing berms, and ditch and culvert inlet cleanout where needed. Aggregate road surfacing can minimize the amount of fine sediment from road surfaces entering streams following log haul, especially during and following rainfall events. Based on road tread surfacing factors used in the Washington State Road Surface Erosion Model (Dubé et al. 2004), going from pit-run or worn gravel to a competent gravel surface would result in a 60% reduction in road surface erosion if all other factors remain the same.

Road maintenance prior to log haul would help maintain the design drainage of the road surface which reduces the potential for larger sediment inputs that eventually may enter stream courses. Some road maintenance activities have the potential to increase road related erosion and sediment during rainfall events. This increase is associated primarily with blading, ditch cleaning and culvert cleaning on aggregate and native surface roads although ditch cleaning associated with paved roads is a potential sediment source. Implementation of BMPs and project design criteria (PDC) that include installation of erosion control measures to minimize or eliminate sediment introduction into streams would further reduce the risk of sediment introduction. Luce and Black (1999) noted that blading of aggregate roads with well-vegetated ditches yielded no increase in sediment production. Any sediment delivered to streams during these activities would be minimal, short-term duration, and undetectable at a sub-watershed (6^{th} field) or watershed (5^{th} field) scale. The probability of any degradation to water quality or fisheries resources caused by sedimentation due to road maintenance is low.

Log hauling would not measurably increase the amount of fine sediment in streams. The roads along the haul route have for the most part well vegetated road ditchlines that allow any eroded soil to be stored adjacent to the roads. Luce and Black (1999) noted that blading of aggregate roads with well-vegetated ditches yielded no increase in sediment production that would imply that and eroded material would be stored in the ditchline. The potential for sediment input into streams along the haul routes would be further minimized by permitting haul only when conditions would prevent sediment delivery to streams. Increased traffic associated with log haul is assessed with the GRAIP_lite model that is described later in this section.

Log Haul would be carefully monitored, particularly during periods when precipitation criteria from the condition based operations are exceeded and when it is likely to become too wet to operate. Depending on the surface type and specific design features of a road, haul and use by other heavy vehicles could damage the road or cause unacceptable resource impacts.

Haul would not be restricted on paved roads unless they are being damaged. Haul may occur when precipitation criteria from the condition based operations are exceeded on aggregate roads. Haul would be stopped immediately if road use is causing rutting of the road surface, ponding of water on the road, failure of any drainage structure, or any other action occurs which increases the sediment delivery to a stream. Generally haul would not occur when the rainfall figures associated with condition base operations have been met or exceeded. A temporary rain gauge may be installed near the transport route by written agreement with the Forest Service if automated sites are not available. Haul would not occur on native surfaced roads when precipitation criteria from the condition based operations are exceeded.

Haul would be stopped immediately if road use is causing rutting of the road surface, ponding of water on the road, failure of any drainage structure, or any other action occurs which increases the sediment delivery to a stream.

Perhaps the single greatest factor affecting generation of sediment from road surfaces is the amount of traffic. Traffic rate determines the quantity of sediment available for transport, while the rainfall determines the transport capacity (DNR 2011).

PDC restrict log hauling when necessary to minimize water quality degradation. Haul would be stopped if there is rutting of the road surface or a noticeable increase in the turbidity of water draining to the road ditches or at stream crossings. Reid and Dunne measured the effect of temporary non-use of roads and found heavily used roads that were not used for hauling for 2 days had a reduction to 13% of heavy use erosion rate (Dubé et al. 2004). Similar observations were made by Wooldridge and Sullivan and Duncan who found erosion rates dropped substantially without traffic even during heavy rainstorms. (Dubé et al. 2004).

Haul routes would be inspected weekly, or more frequently if weather conditions warrant. Inspections would focus on road surface condition, drainage maintenance, and potential sources of soil erosion and sediment delivery to streams.

Condition-based operating restrictions are intended to protect resources as well as, or better than previously used calendar-based restrictions. Since condition-based operations are relatively new, any ground-based operations that occur between November 1 and May 31 would be monitored to provide feedback and support adaptive management.

Road related activities with potential to change sediment yields including temporary road construction and associated rehabilitation, non-system road rehabilitation, system road decommissioning, and system road conversion to maintenance level 1 with associated stormproofing are summarized in the table below.

Table 32 Summary of Transportation System Management Actions

Action Alternatives
Maintain and Repair Forest Service System Roads
Construct and Reconstruct Temporary Roads
Decommission and Close Forest Service System Roads

Action Alternatives
Convert Road to Non-Motorized Trail
Return Former Forest Service System Road Back to the System
Rehabilitate Unauthorized OHV routes

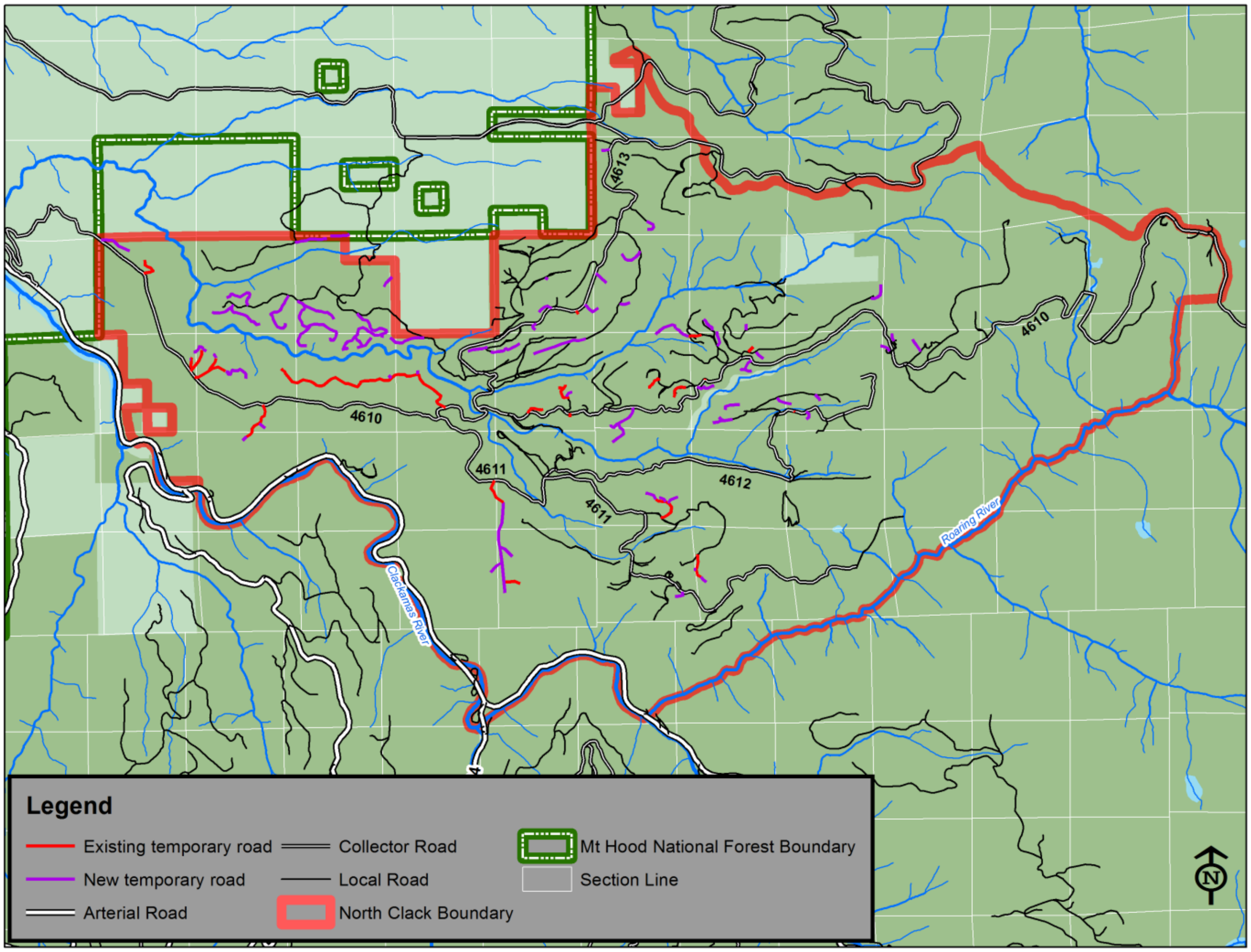

Figure 18 North Clackamas Integrated Resource Project Temporary Roads

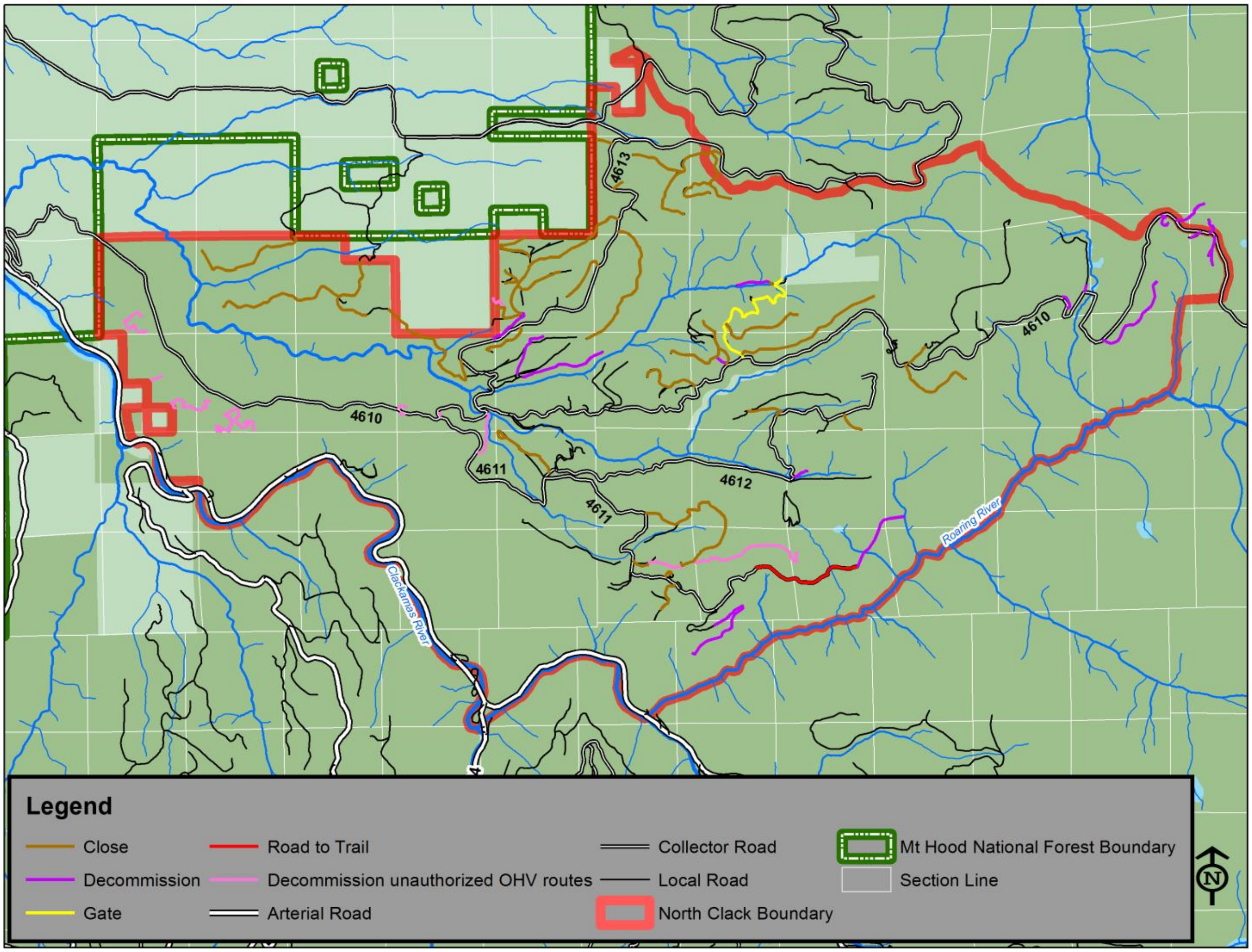

Figure 19 North Clackamas Integrated Resource Project Proposed Road Closures and Road Decommissioning and Off Highway Vehicle Trail Decommissioning areas

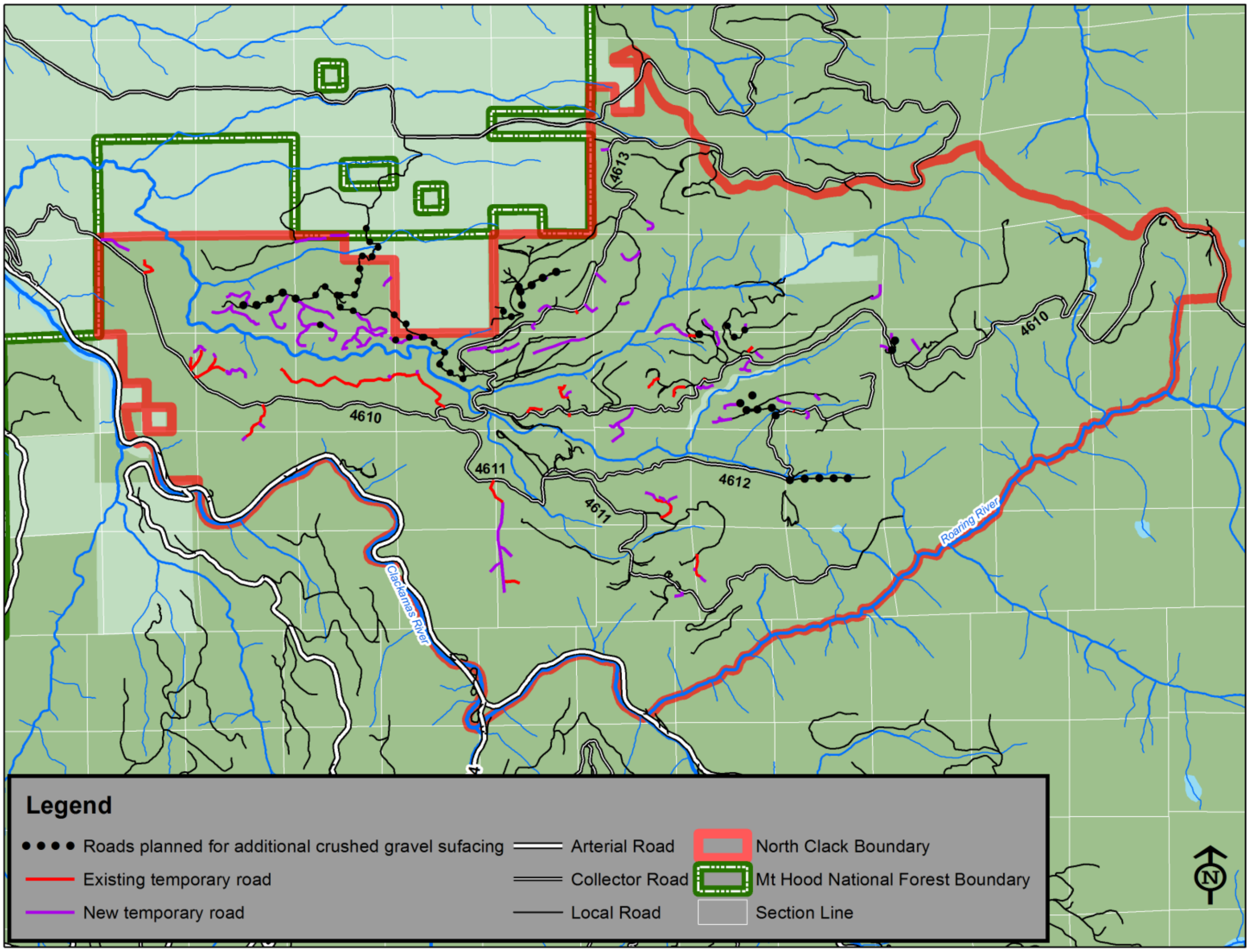

Figure 20 North Clackamas Integrated Resource Project roads planned for additional crushed gravel surfacing

Sediment yield associated with the road system was estimated for the North Clackamas Integrated Resource analysis watersheds using the GRAIP_Lite model.

Presentation of the GRAIP_Lite model results are intended to provide a means of comparing existing conditions with the proposed action in which both existing and proposed actions utilize the same assumptions and to give a comparison in broad terms of natural to management related sediment yields within the North Clackamas Integrated Resource Project area.

As with the Washington Road Surface Erosion Model (Dubé et al. 2004) it is appropriate to look at the relative differences in erosion estimates when comparing watershed areas or road segments, but the sediment values in tons/year should always be regarded as estimates not absolute values.

Any predicted runoff or erosion value--by any model--will be, at best, within plus or minus 50 percent of the true value. Erosion rates are highly variable, and the models predict only a single value. Replicated research has shown that observed erosion values vary widely for identical plots, and for the same plot from year to year (Elliot et al. 2000).

Table 33 Estimated Sediment Yield from the Road System

Analysis Watershed	Estimated tons of Sediment Delivery per year from the road system during the initial condition	Estimated tons of Sediment Delivery per year from the road system during the disturbed condition	Estimated tons of Sediment Delivery per year from the road during the recovered condition
Helion Creek-Clackamas River	67.0	62.4	56.8
North Fork Clackamas River	359.3	367.3	275.5
Roaring River	61.5	41.5	36.4

Table 34 Percent Changes Associated with Project Implementation

Analysis Watershed	Disturbed Condition Percent Change from Initial Condition	Recovered Condition Percent Change from Initial Condition
Helion Creek-Clackamas River	-7%	-15%
North Fork Clackamas River	2%	-23%
Roaring River	-33%	-41%

The initial condition is before work begins, the disturbed condition is immediately post-work or during haul, and the recovered condition is once vegetation has recovered to normal values.

Table 35 Estimated Sediment Yield from the Road System during the disturbed condition

Analysis Watershed	New road construction and haul	Roads closed, decommissioned or rocked	Net Change
Helion Creek-Clackamas River	4.1	-8.7	-4.6
North Fork Clackamas River	46.9	-39.0	8.0
Roaring River	2.6	-22.7	-20.1

The disturbed condition was modeled for the year of activity and for the modeling effort all roads would be constructed and used in the same year when in actuality the construction activities associated with the temporary roads would most likely be spread out over many years as different harvest units were accessed. In addition, all the roads planned for decommissioning or closure during the disturbed condition would also be modeled for the same year.

Road system activities associated with implementation of the Action Alternatives in the disturbed condition period would result in an estimated 33% reduction to a 2% increase when compared to the existing sediment yield from the road system. The period after the implementation of the Action Alternatives would result in an estimated 15% to 41% reduction in individual analysis watersheds.

The table below compares all quantified sources of sediment that were estimated (these comparisons should only be used in a broad sense to understand the differences in scale between the different sources).

Table 36 Sediment yield from quantified sources

Analysis Watershed	Estimated Natural Background from Slides (tons per year)[11]	Estimated tons of Sediment Delivery per year from the existing road system	Estimated Change in Sediment Yield during implementation of the Action Alternatives (tons per year the year of activity)	Estimated Reduction in Sediment Yield post implementation of the Action Alternatives (tons per year the year of activity
Helion Creek-Clackamas River	2,328	67.0	-4.6	-10.2
North Fork Clackamas River	876	359.3	8.0	-83.8
Roaring River	1,232	61.5	-20.1	-25.1

Table 37 Percent change in sediment yield from background levels

Analysis Watershed	Percent change from background levels (existing road network and background sed) disturbed condition	Percent change from background condition recovered condition
Helion Creek-Clackamas River	0%	0%
North Fork Clackamas River	1%	-7%
Roaring River	-2%	-2%

A suite of activities including outsloping of all new temporary roads, limiting haul on native surface roads to dry conditions, adding crushed gravel to identified road segments, decommissioning roads and unauthorized user created off-highway vehicle routes, closing roads (converting from maintenance level 2 to maintenance level 1), and stormproofing of system roads not used for haul that remain on the system have been identified to reduce sediment delivery to the stream system.

Arismendi et al 2017 found in a study on suspended sediment and turbidity after road construction/improvement and forest harvest in streams of the Trask River Watershed Study, Oregon minimal increases of both turbidity and suspended sediment concentration after road improvement, forest harvest, and hauling. The study concluded:

[11] Assumes 1.2 tons per cubic yard (the same ratio as was used for the 36 Pit Fire Burned Area Report)

Our findings of minimal increases in turbidity and suspended sediment concentration below road crossings contrasted with previous studies that documented larger and consistent increases in suspended sediment in streams after road construction/improvement and hauling. In the past, road drainage systems were designed to route water and the sediment it carried off the road and into a ditch and then to a stream as efficiently as possible. This practice has changed dramatically over the last several decades with the goal now being to route forest road runoff to the forest hillslopes and not to the stream. The location, construction, maintenance, and especially the lack of hydrological connectivity have been shown to contribute to disconnecting streams from road- related erosive processes. Forest management practices of diverting water off roads using water bars, moving sediment-laden water to depositional areas where water infiltrates into the soil, reducing sediment transport with sediment traps that dissipate energy, and installing relief culvert outlets are now more commonly used. Moreover, the use of less erosive surfacing material in roads has been promoted to minimize wet weather hauling impacts near streams. In the Pacific Northwest of United States, improvements in road construction and maintenance appear to be linked to recent trends of declining turbidity over time and lower sediment yield in streams.

After treatment, the magnitude of increased sediment transport due to road crossings compared to above roads seems to be minimal (less than four units of turbidity or suspended sediment concentration), but it is also consistent over time as is shown in our analysis of exceedances. Indeed, higher turbidity and suspended sediment concentration at the downstream location, compared to the upstream location, is more frequent after treatment in several of the sites. This could be influenced by the increased connectivity and larger watershed area of the downstream site as well as channel morphology at these sites.

Our study of effects of forest road improvement and forest harvest found no evidence to suggest that current management practices increased median fine-suspended sediment concentrations in streams above biologically meaningful levels. Turbidity and suspended sediment concentration below road crossings in our studied watersheds appeared to be far less than what was observed in studies under historical forest practices.

The results from Arismendi et al 2017 are similar to those from Temporal and Spatial Turbidity Patterns over 30 Years in a Managed Forest of Western Washington (Reiter et al. 2009). This study was completed in the west central Cascade Mountains of Washington in an area that has a marine Mediterranean climate with cool wet winters and warm, dry summers and the majority of the study watershed is in the transient snow zone (between 350 and 1,110 m at this latitude). This study concluded:

We utilized a water quality dataset collected over 30 years at four locations in the Deschutes River watershed (western Washington) to assess trends in turbidity and whether sediment control procedures implemented over this time period had any detectable influence. The sample sites ranged from small headwater streams (2.4 and 3.0 km2) to the mainstem of the Deschutes River (150 km2). Declining trends in

> *turbidity were detected at all the permanently monitored sites. The mainstem Deschutes River site, which integrates sediment processes from the entire study watershed, showed dramatic declines in turbidity even with continued active forest management. For the small basins, logging and road construction occurred in the 1970s and 1980s and turbidity declined thereafter, achieving prelogging levels by 2000. There are no temporal trends in flow that could be responsible for the observed trends in turbidity. Our results suggest that increased attention to reducing sediment production from roads and minimizing the amount of road runoff reaching stream channels has been the primary cause of the declining turbidity levels observed in this study.*

The temporary roads would be rehabilitated and revegetated immediately following completion of harvest operations to help reduce compaction, increase infiltration rates, minimize surface erosion, and re-establish natural drainage patterns.

Native surfaced temporary roads would be decompacted as needed with the jaws of a log loader or excavator. Cross-drains or water bars would typically be installed every 150 feet, or more frequently, where the road grade exceeds 5%. Actual placement distances may vary with topography to ensure proper drainage. Available logging slash, logs or root wads would be placed across the road and landing surface. Where slash, logs or root wads are not available in sufficient quantities, bare soils would be seeded and mulched. The coverage of effective ground cover would be sufficient to prevent off-site movement of soils as guided by Forest Plan standard and guideline FW-025 and by Forest Service Handbook 2509 (R6 supplement).

Decompacting the road surface during decommissioning or rehabilitation activities loosens the soil, thus making it more likely to be mobilized during the first significant run-off period unless the road is on relatively flat terrain, not near streams, or sufficient ground cover (mulch, woody debris, etc.) is provided. Since there is culvert removal associated with the proposed decommissioning and rehabilitation activities there is the potential to deliver sediment into stream channels during project implementation. Road obliterations near streams would have short-term, construction-related effects. These projects may cause a short-term degradation of water quality due to sediment input and turbidity. Streambank condition and habitat substrate may also be adversely affected. This would be a short-term effect since turbid conditions would dissipate soon after the in-stream work phase was completed, generally in a few hours. However, with careful project design with soil and water protection PDC's such as erosion control, these effects are expected to be of a limited extent and duration.

Project design criteria and associated BMPs for road decommissioning and rehabilitation would reduce the risk of sediment entering any stream course. The impacts to water quality caused by sedimentation due to road decommissioning and rehabilitation if any would be short-term and undetectable at the watershed scale.

Frequency and Characteristics of Sediment Delivery Pathways from Forest Harvest Units to Streams (Litschert and MacDonald 2009) indicated that timber harvest alone rarely initiated large amounts of runoff and surface erosion, particularly when newer harvest practices were utilized. Sediment delivery from timber harvest may be further reduced by locating skid trails away from streams, maintaining high surface roughness downslope of water bars, and promptly decommissioning skid trails following harvest. PDC associated with the North Clackamas Integrated Resource Project locate skid trails away from streams (PDC C7 and C8), maintain high surface roughness downslope of water bars (PDC C10); and ensure skid trails would be promptly rehabilitated (PDC C10).

The ability of PDC's in Washington State to reduce erosion and sediment delivery is documented in Effectiveness of Timber Harvest Practices For Controlling Sediment Related Water Quality Impacts (Rashin et al. 2006). In this study, the authors looked at 21 harvest sites that had a variety of treatments ranging from no buffers to buffers up to 66 meters (216.5 feet) wide. They found that "Of 157 individual erosion features determined to deliver sediment to streams during either the first or second year following timber harvest, 94 percent were located within 10 meters (33 feet) of the stream. Conversely, 74 percent of the 248 erosion features with no evidence of sediment delivery were greater than 10 meters from streams. The sediment routing survey results indicate that when erosion is initiated by ground disturbing activities within 10 meters (slope distance) of a stream, delivery of sediment was more likely than not." Stream protection buffers associated with this project are a minimum of 50 feet wide (~15 meters) outside of the areas where "delivery of sediment was more likely than not".

The Effects of contemporary forest harvesting on suspended sediment in the Oregon Coast Range : Alsea Watershed Study Revisited (Hatten et al. 2017) with an objective to determine the effects of contemporary harvesting practices on suspended sediment concentrations and yields determined while BMPs have evolved over time, the effectiveness of contemporary BMPs, particularly for harvesting practices, have not been thoroughly investigated, especially in comparison to historical practices (Hatten et al 2017). This study indicated that clearcut harvesting, using contemporary harvesting techniques and BMPs (i.e., stream buffers, smaller harvest units, no broadcast burning, leaving material in stream channels), had little effect on suspended sediment in the Oregon Coast Range. This suggests that retention of a riparian buffer and less intensive site preparation practices (broadcast burning was not conducted) may be effective at preventing additional sediment delivery to streams and reducing potential impacts to water quality and aquatic habitat across this region. The study isolated the effects of upland forest harvesting activity on sediment production as no new roads were constructed within the one of the watersheds studied.

Other studies also support the effectiveness of mitigating sediment delivery by maintaining a buffered area adjacent to surface water. Burroughs and King (1989) found that 80% of sediment reaching streams from roads in the first year after construction came from the fill slope of the road. They also found that transport distances and obstructions between the fill slopes and streams influenced the amount and likelihood of eroded material reaching these streams. Burroughs and King found that windrowed fill slopes, which would act very similar to unharvested Riparian Reserves in that there would be obstructions to flow, had an average travel distance of 3.8 feet for eroded material, and a maximum travel distance of 33 feet. Similar results were documented by Packer (1967). He found that "the most important factors that affect the distance that sediment moves are the spacing between down slope obstructions and an interaction between this spacing and the kind of obstruction”. He found that logs, rocks, and trees or stumps were the second, third, and fourth most effective materials in reducing sediment movement distances below roads. Travel distances were similar to those reported by Burroughs and King.

Design criteria that include undisturbed vegetative buffers of at least 70 feet along perennial streams and 50 feet along intermittent streams, only mechanical harvesting equipment used for tree falling would be allowed within 180 feet of listed fish habitat, or within 100 feet of other perennial streams, or within 80 feet of intermittent streams, use of erosion control (e.g. silt fences, wattles, straw bales, matting, mulch, slash, water bars, ditch check dams, grass seed, or other products) where necessary, and lower impact road maintenance techniques (fill slopes at stream crossings would be vegetated or otherwise stabilized such that road surface sediments are retained prior to entering the stream channel) would substantially reduce the amount of sediment reaching the streams from this work. Burroughs and King (1989) reported that measures such as erosion control blankets alone could reduce sediment production by 80 to 90 percent. This in conjunction with other measures such as minimizing the amount of ground disturbance and seeding these areas would further decrease the chance of short-term direct and indirect sediment production. With the above-mentioned design criteria, new temporary roads, landings, skid trails, yarding corridors, road maintenance, and road repair work are expected to have minimal effect on sedimentation.

5.2.2.3 - Sediment Routing

Sediment delivery associated with road surface erosion is spread out over time and space associated with road maintenance, construction, reconstruction and use. Once road sediment enters a stream it interacts with the complex stream dynamics. Due to the fine particle size of road sediment delivered to streams little effect of this material on the composition of streambed gravel could be discerned (Bilby et al. 1989).

A series of experimental additions of road-surface sediment was made to two ephemeral streams to examine the downstream transport of this material as a function of discharge and channel characteristics. These small streams were found to store large amounts of sediment washed from road surface. There were significant differences in the transport of sediment in the two larger size categories between the two streams. These differences were due to a much greater amount of woody debris in the stream with the lower delivery rates, which acted to trap and hold sediment (Duncan et al. 1987)

Water and sediment routing in channels is controlled by large debris which may create a stepped profile. Stream energy is thereby dissipated at the relatively short, steep sections of channel so that much of the stream area may have a gradient less than the overall gradient of the valley bottom (Swanson and Lienkaemper 1978).

The overall storage capacity serves to buffer the sedimentation impacts on downstream areas when there are pulses of sediment input to channels. Scattered debris in channels reduces the rate of downstream sediment movement and tends to feed sediment through the stream ecosystem in a slow trickle, except in cases of catastrophic flushing events. These flushing events may scour a channel every few centuries, leaving the channel devoid of large organic debris and open to rapid transfer of bedload (Swanson and Lienkaemper 1978).

In these low order streams, the concentrations and transport of suspended sediment seems to be highly influenced by the variability of local conditions (Arismendi et al. 2017).

These studies indicate that the episodic input of sediment associated with road surface erosion is metered by the stream system to provide a steady output of sediment.

5.2.2.4 – Sediment Summary

Associated with project implementation there may be sediment delivered to the stream system. The increase in sediment delivered from the existing condition to the stream system associated with project activities in the short term is not expected to increase over background levels in the Helion Creek-Clackamas River and Roaring River subwatersheds. Short term sediment yield is estimated to increase 1 percent over background levels in the North Fork Clackamas River subwatershed. Since there is not a projected increase over background levels in the Helion Creek-Clackamas River and Roaring River subwatersheds the discussion of potential impacts will focus on the North Fork Clackamas River subwatershed.

Sediment delivery would be spread out over time and space based on when and where harvest activities and restoration activities occur. There is a long term decrease in sediment predicated based on additions of crushed gravel, road decommissioning and closures. Once sediment enters a stream studies indicate that the episodic input of sediment associated with road surface erosion is metered by the stream system to provide a steady output of sediment. The overall storage capacity serves to buffer the sedimentation impacts on downstream areas when there are pulses of sediment input to channels. Scattered debris in channels reduces the rate of downstream sediment movement and tends to feed sediment through the stream ecosystem in a slow trickle, except in cases of catastrophic flushing events (Swanson and Lienkaemper 1978).

5.2.2.5 - Clean Water Act 303D Listed Streams

The Clackamas River (river mile 0 to 83.2) is 303D listed for biocriteria (waters of the state must be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities). The biocriteria is based on macroinvertebrate communities in Oregon’s perennial, wadeable streams.

Primary shade zones (areas of riparian vegetation directly adjacent to streams) along perennial streams have been identified and vegetation within these areas would be protected during vegetation management activities in order to maintain stream temperature.

Associated with project implementation in the Helion Creek-Clackamas River subwatershed where the Clackamas River from river mile 30 to 44 is located there is a net reduction in sediment delivered to the stream system predicted. There is the potential for small amounts of sediment delivered from certain project activities in the short term. Any sediment delivery would be spread out over time and space based on when and where harvest activities occur. There is a long term decrease in sediment delivery predicted.

Due to the small amount of sediment predicted to be delivered in the short to the stream system, the distribution of the sediment delivery of time and space and the decrease in predicted sediment delivery over the long term and the protection of primary shade zones there are no impacts anticipated to the macroinvertebrate community.

Primary shade zones (areas of riparian vegetation directly adjacent to streams) along perennial streams would be protected. There is not a projected increase in sediment yield over background levels. It is anticipated that the macroinvertebrate community as assessed by Oregon Department of Environmental Qualities PREDictive Assessment Tool for Oregon would remain in the same range as the existing condition because primary shade zones and sediment inputs from roads are anticipated to stay at or below the current levels.

5.2.2.6 - Surveyed Streams with Fine Sediment Concerns

Stream surveys and associated follow up surveys associated with this project did not identify any sites where in-channel fine sediment is a concern. Associated with the Action Alternatives the small amount of sediment predicted to be delivered in the short term to the stream system, the distribution of the sediment delivery of time and space and the decrease in predicted sediment delivery over the long term in channel fine sediment levels are expected to remain at current levels or lower.

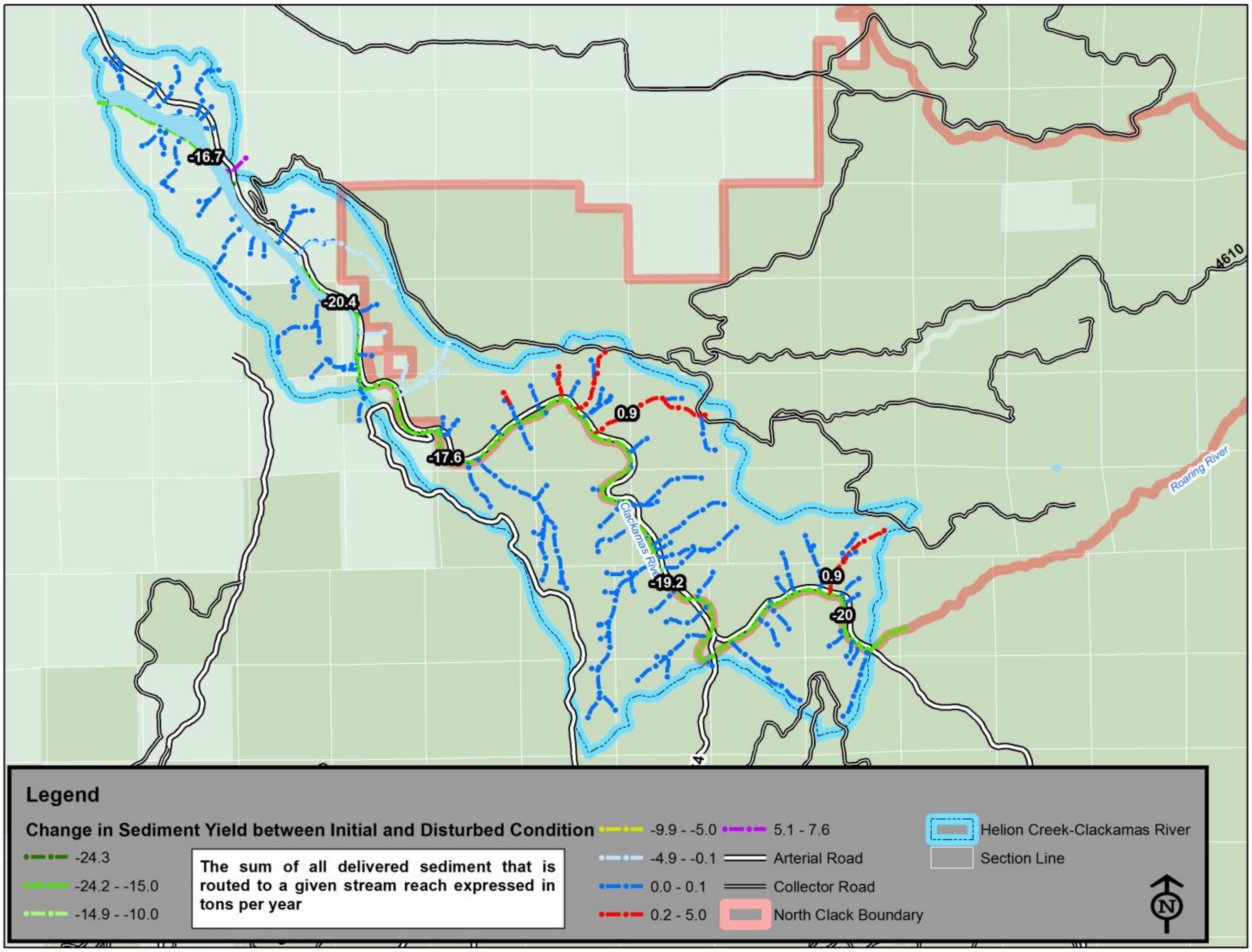

Figure 21 Helion Creek-Clackamas River Subwatershed Change in Road Segment Sediment Delivery (tons per year) from Existing Condition to Disturbed Condition Period

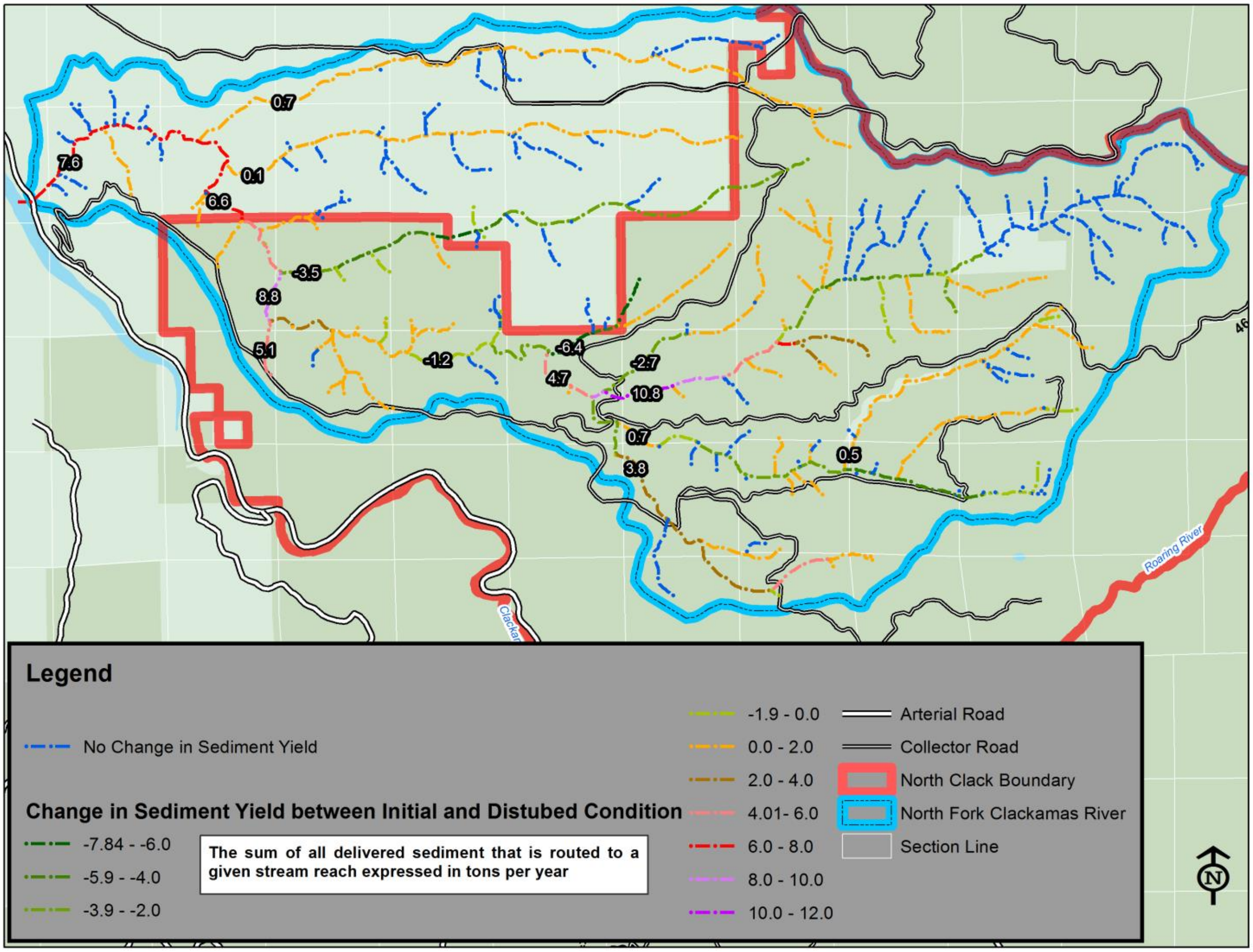

Figure 22 North Fork Clackamas River Subwatershed Change in Road Segment Sediment Delivery (tons per year) from Existing Condition to Disturbed Condition Period

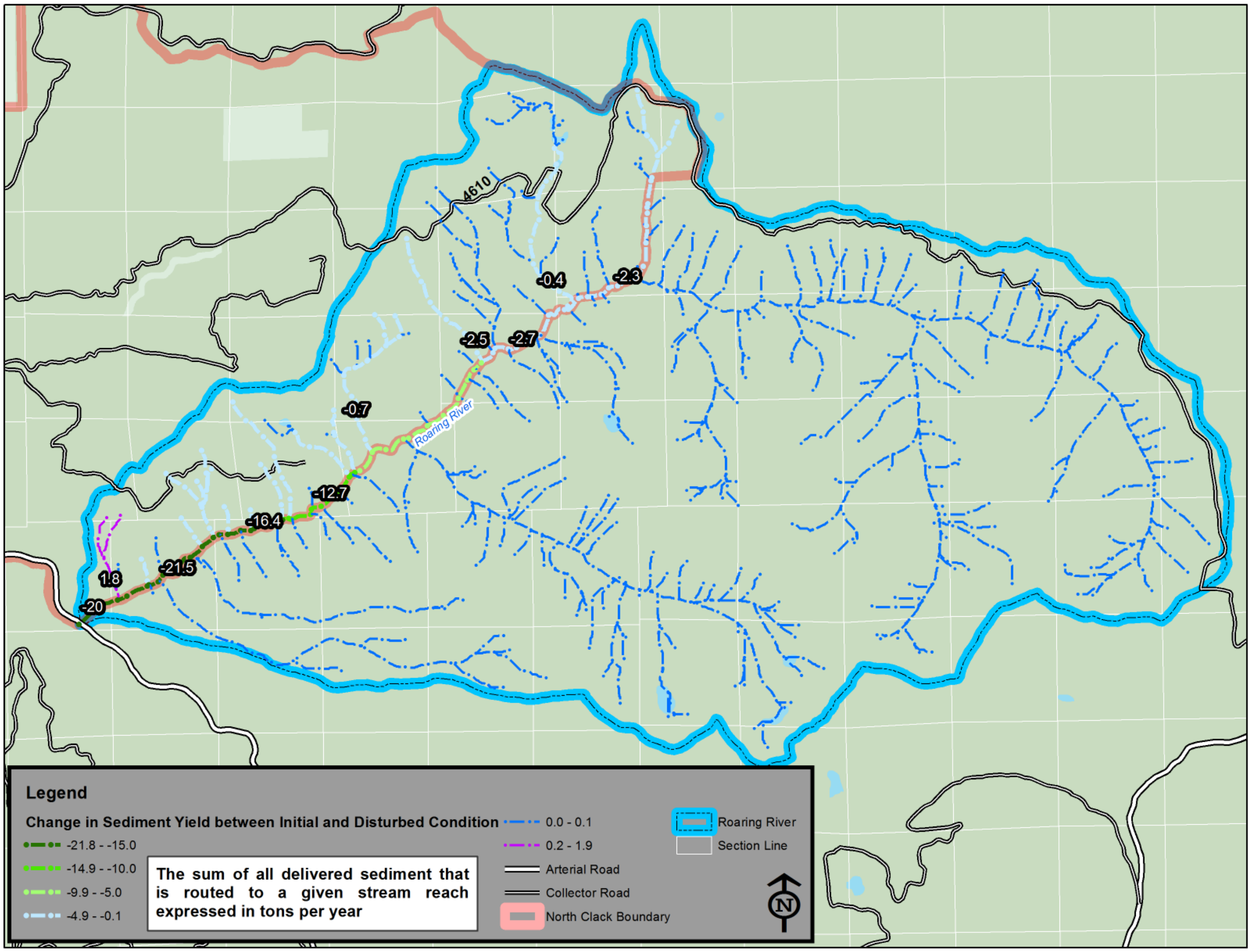

Figure 23 Roaring River Subwatershed Change in Road Segment Sediment Delivery (tons per year) from Existing Condition to Disturbed Condition Period

5.2.2.7 – Alternative 2

The effects of Alternative 2 would be very similar to the proposed action. There would be an additional 116 acres of regeneration harvest that would occur in units that are identified for thinning with Alternative 1. The change of 116 acres amounts to much less than 1% of the project area, therefore the effects of Alternative 2 would not be measurably different than those described for Alternative 1 in terms of water quantity and quality.

6.0 - Cumulative Effects

According to the Council on Environmental Quality's (CEQ) regulations for implementing NEPA, an action may cause cumulative impacts on the environment if its effects overlap in space and/or time with the effects of other past, present, or reasonably foreseeable future actions, regardless of what agency or person undertakes the action. Cumulative effects can result from individually minor, but collectively significant actions, taking place over a period of time (FERC 2006).

The combined analysis subwatersheds used throughout this analysis were selected for the analysis area for cumulative effects associated with project activities. The boundaries for the cumulative effects analysis area should be far enough downstream that direct effects from the North Clackamas Integrated Resource Project would not likely be measurable.

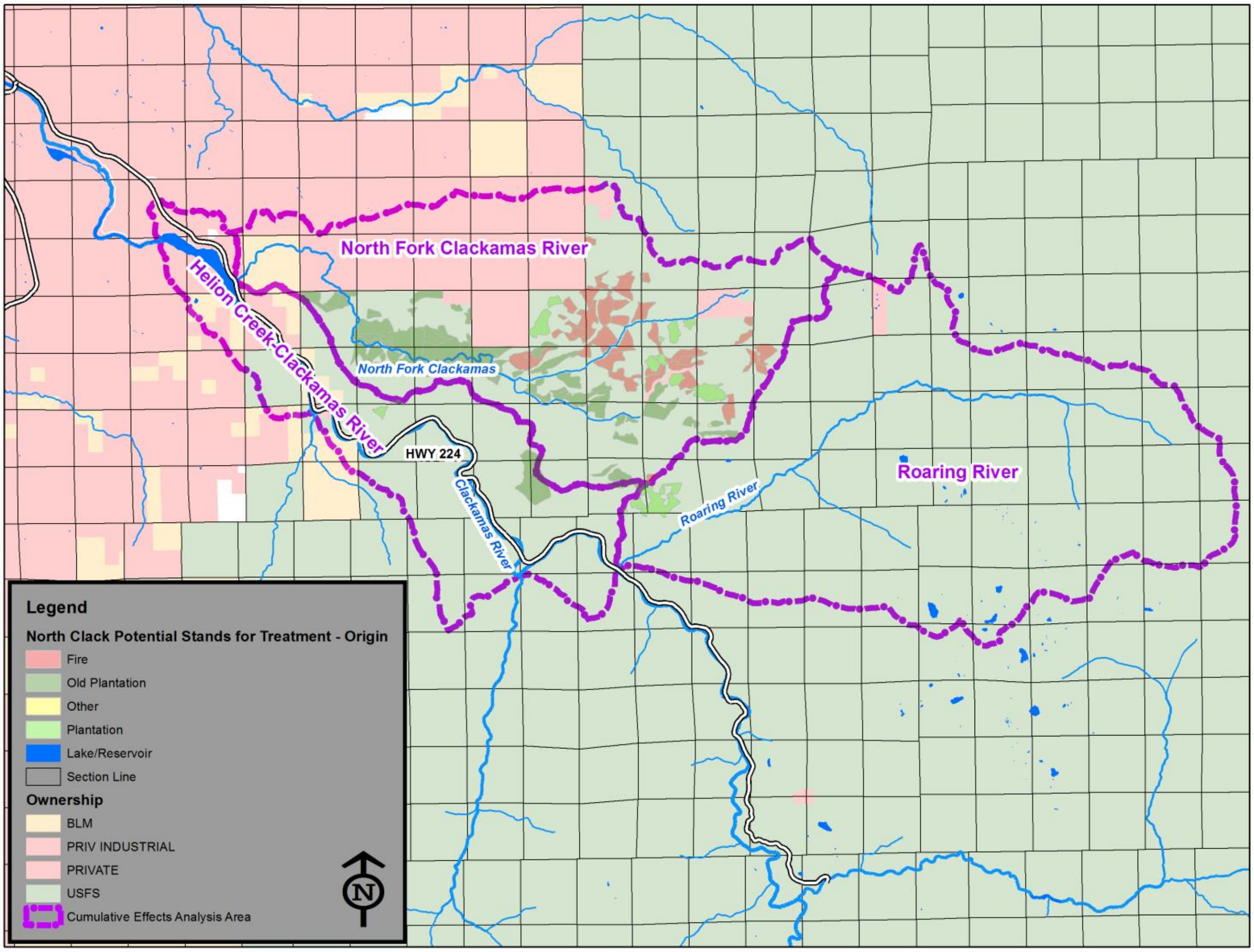

Figure 24 North Clackamas Integrated Resource Project Cumulative Effects Analysis Area

The time frame used to include or exclude actions varies by the type of action. Some impacts are considered permanent with no modeled recovery including permanent roads, quarries and the power line right-of way. Some impacts such as regeneration harvest would recover gradually over approximately 35 years.

There are ongoing thinning projects within the analysis area that are included in the analysis of cumulative effects.

The table below provides a qualitative summary of potential cumulative watershed effects. It shows existing and potential projects, effects from those projects that may result in cumulative effects with the North Clackamas Integrated Resource Project, whether these projects overlap in time and space and a brief description of expected impacts from the project. Findings of this summary are supported by the analysis which utilizes pertinent research, design features and applicable management standards and guidelines. A discussion that summarizes the cumulative effects of all of these projects follows this table.

Table 38 Qualitative Summary of Potential Cumulative Watershed Effects

Project	Measure	Overlap in Time & Space	Extent, Detectable?
Existing Old Regeneration Timber Harvest	Sediment	No	Most regeneration harvests in the project area happened 20 to 60 years ago. Due to the regrowth of vegetation and ground cover, there are few remaining effects to sediment.
Existing Old Regeneration Timber Harvest	Temperature	No	Most regeneration harvests in the project area happened 20 to 60 years ago. Due to the regrowth of vegetation and ground cover, there are few remaining effects to water temperature.
Existing Old Regeneration Timber Harvest	Quantity	Yes	Stands less than 35 years old have an effect on hydrologic recovery and are included in the ARP analysis.
Forest Service Vegetation Treatment Activities Planned or Underway [12]	Sediment	Yes	There may be an overlap in timing of these projects with the North Clackamas Integrated Resource Project; any sediment delivery to the stream system would not be measurable due to implementation of design criteria, and conformance with existing standards and guidelines on the existing projects.
Forest Service Vegetation Treatment Activities Planned or Underway	Temperature	Yes	Vegetation treatment projects conform to the Biological Assessment for the project or the Northwest Forest Plan Stream Temperature Sufficiency document to protect stream shade.
Forest Service Vegetation Treatment Activities Planned or Underway	Quantity	Yes	ARP analysis details a slight reduction in hydrologic recovery of areas when these activities are added, the assessment of the combined impacts of vegetation management and roads concluded that the area is not at risk for adverse impacts associated with increased peak streamflows.

[12] Includes 55 acres of thinning with Kid Timber Sale and 380 acres of thinning with Gruff Timber Sale.

Project	Measure	Overlap in Time & Space	Extent, Detectable?
Forest Service Road Related Activities [13]	Sediment	Yes	There is an estimated increase in sediment yield during implementation of the proposed action of 5.0 tons per year.
Forest Service Road Related Activities	Temperature	Yes	Stream drainage network extension is the same during the existing condition and disturbed period associated with the project indicating no new stream crossings that would create openings adjacent to streams. There are potential increases in stream temperature widely scattered over time and space associated with road brushing.
Forest Service Road Related Activities	Quantity	Yes	No cumulative water quantity effects due to design criteria implementation, and conformance with existing standards and guidelines. The Goat Mountain Thin Water Quality Specialist Report estimated that implementation of the proposed action would not impact stream drainage network extension.
Hazard Tree Removal	Sediment	Yes	There may be very small amounts of sediment delivered to the stream system over widely scattered areas associated with deposition of fine sediment into road ditchlines that are connected to the stream system during storm events.
Hazard Tree Removal	Temperature	Yes	Reductions of stream shade are reasonably certain to occur in a small number of areas scattered throughout the action area where multiple shade-producing trees are removed within 150 feet of a perennial stream, causing minor increases in water temperatures at the reach scale
Hazard Tree Removal	Quantity	Yes	Hazard trees are widely scattered so their removal would not impact ARP values because canopy cover of stands would not be impacted.
Ongoing Road Maintenance Activities	Sediment	Yes	Associated with this activity localized, short-lived increases in fine sediment in stream substrates or along channel margins may occur. However, proper road maintenance is likely to reduce chronic sediment inputs from roads over the long term.
Ongoing Road Maintenance Activities	Temperature	Yes	With road maintenance activities there are potential increases in stream temperature widely scattered over time and space associated with road brushing.
Ongoing Road Maintenance Activities	Quantity	Yes	No effects anticipated associated with this activity.

[13] Includes temporary road construction and associated rehabilitation, non-system road rehabilitation, system road decommissioning, and system road conversion to maintenance level 1 with associated stormproofing associated with the Goat Mountain Thin Project.

Project	Measure	Overlap in Time & Space	Extent, Detectable?
Portland General Electric Powerline Corridor Maintenance	Sediment	Yes	There is the potential for widely scattered and small amounts of sediment to be delivered to the stream system associated with the use of secondary roads for powerline pole maintenance and replacement.
Powerline Corridor Maintenance	Temperature	Yes	There is the potential to raise average and maximum stream temperatures for short reaches of streams associated with the use of secondary roads for powerline pole maintenance and replacement.
Powerline Corridor Maintenance	Quantity	Yes	ARP analysis includes power lines showing a very slight reduction in hydrologic recovery, however the analysis shows that the area is not at risk for adverse impacts associated with increased peak streamflows.
Recreation Site, Trail, and Administrative Structure Maintenance and Associated Public Use	Sediment	Yes	The heavy use of certain recreation sites along streambanks is likely to result in bank erosion, delivery of sediment, and increased channel width.
Recreation	Temperature	Yes	Depending on site-specific conditions, the combination of suppressed vegetation and increased width/depth ratios for heavily used streamside recreation sites are likely to increase stream water temperatures for heavily used streamsides at the scale of the stream reach.
Recreation	Quantity	Yes	No effects anticipated associated with this activity. Created openings and roads are assessed with ARP.
LaDee Flats Off-Highway Vehicle Area Public Use	Sediment	Yes	Sediment yield was assessed in the direct and indirect effects section of this report as the OHV trails were included in the road network assessed by GRAIP_Lite.
LaDee Flats Off-Highway Vehicle Area Public Use	Temperature	Yes	No effects anticipated because the trail network is outside if the primary shade zone of perennial streams.
LaDee Flats Off-Highway Vehicle Area Public Use	Quantity	Yes	No effects anticipated associated with this activity. Created openings and roads are assessed with ARP.
36 Pit Fire 2014 - 3,908 acres in Helion Creek-Clackamas River 173 acres in North Fork Clackamas River	Sediment	Yes	In the areas of the 36 Pit Fire the very steep slopes are naturally prone to rockfall, rock slides, and debris flows and these three types of landslides are expected to increase in frequency. All three types become more likely after the holding capacity of ground vegetation and tree roots are decreased. Dead trees that topple over would dislodge loose rock and soil on the steep slopes when they impact the ground, initiating down slope movement that is likely to continue to the bottom of the slope. Whole trees and wood fragments are likely to accompany all three types of landslides expected here (DeRoo 2014). The 36 Pit Fire has had 4 winter runoff periods and this is the period with no

Project	Measure	Overlap in Time & Space	Extent, Detectable?
			measurable surface erosion expected (Robichaud, 2000).
36 Pit Fire	Temperature	Yes	Other than the Clackamas River all the streams in the burned area are identified as intermittent on the field verified stream network dataset for the area. There are potential impacts to stream temperature associated with impacts to stream shade that may expose water to solar radiation.
36 Pit Fire	Quantity	Yes	The created openings associated with the fire were assessed using the ARP methodology.
BLM North Fork Clackamas Aquatic Restoration Project (including tree tipping, tree placement, and excavation using heavy equipment).	Sediment	Yes	Heavy equipment traverses the area between the road access point and the river. Short-term sediment inputs would likely occur until the erosion control methods of mulch and grass seed become effective. Projects are expected to have a long-term benefit to aquatic species.
BLM North Fork Clackamas Aquatic Restoration Project	Temperature	Yes	This project has the potential to impact stream temperature by directly impacting stream shade during tree tipping and placement operations exposing water to solar radiation.
BLM North Fork Clackamas Aquatic Restoration Project	Quantity	Yes	No effects anticipated associated with this activity.
Off-Highway Vehicle (OHV) Management Plan Implementation (Convert Road 4610113 to OHV trail, Decommission Road 4611132, 1.6 miles of OHV trail construction)	Sediment	Yes	Project may have short-term, construction-related effects. This project may cause a short-term degradation of water quality due to sediment input of a limited extent and duration. Project design criteria and associated BMPs would reduce the risk of sediment delivery to streams in the area.
Off-Highway Vehicle (OHV) Management Plan Implementation	Temperature	Yes	There is not the potential to raise average and maximum stream temperatures because construction activities would be outside the primary shade zone. Decommissioning activities in the primary shade zone are not anticipated to impact stream shade.
Off-Highway Vehicle (OHV) Management Plan Implementation	Quantity	Yes	No effects anticipated associated with this activity.
The Bureau of Land Management (BLM) Airstrip Thinning Timber Sale.[14]	Sediment	Yes	Design features for unit layout and logging implemented in the selected action would prevent sediment from logging units reaching streams. There is the potential for short term, limited extent sediment delivery associated with a temporary

[14] This project includes harvest of approximately 207 acres: thinning 201 acres and clearing 6 acres of vegetation within the road rights-of-way accessing harvest units. Constructing approximately 1.6 miles of new road. Road construction includes one temporary stream crossing. Renovate approximately 0.7 mile of existing stabilized or decommissioned road to the minimum standard necessary for hauling.

Project	Measure	Overlap in Time & Space	Extent, Detectable?
			road stream crossing. Under the selected action, roads would be maintained, reducing the risk of erosion and sedimentation associated with the existing road system. PDC are in place which result in no effect to listed fish, particularly relative to preventing sediment delivery to listed fish habitat.
Airstrip Thinning Timber Sale	Temperature	Yes	PDC are in place to protect stream temperature including meeting or exceeding minimum stream protection zone widths, minimum 100 feet wide on streams within 1 mile of LFH; no felling of trees within the primary shade zone on perennial streams and retaining minimum 50% average canopy closure within the secondary shade zone.
Airstrip Thinning Timber Sale	Quantity	Yes	ARP analysis includes this activity showing a very slight reduction in hydrologic recovery, however the analysis shows that the area is not at risk for adverse impacts associated with increased peak streamflows.
Existing Regeneration Timber Harvest Units on Private Land in the North Fork Subwatershed	Sediment	No	Recent regeneration harvest adjacent to North Fork Clackamas River, Bee Creek, Fall Creek and Bedford Creek has the potential for sediment delivery to the stream system. Hatten et al 2017 found that their study indicated that clearcut harvesting, using contemporary harvesting techniques and BMPs (i.e., stream buffers, smaller harvest units, no broadcast burning, leaving material in stream channels), had little effect on suspended sediment in the Oregon Coast Range
Existing Regeneration Timber Harvest Units on Private Land in the North Fork Subwatershed	Temperature	No	There may be slight increases in stream temperature associated with this activity. Groom et al. 2011 assessed the effects of timber harvest on stream temperatures on private lands where state forest practices rules were implemented. All 18 private land ownership study sites were clearcut. By the second year post-harvest it was found that maximum temperatures for private ownership sites increased pre-harvest to post-harvest on average by 0.7°C.
Existing Regeneration Timber Harvest Units on Private Land in the North Fork Subwatershed	Quantity	Yes	ARP analysis includes this activity showing a very slight reduction in hydrologic recovery, however the analysis shows that the area is not at risk for adverse impacts associated with increased peak streamflows.
Future Timber Harvest Activities on Private Lands Helion Creek – Clackamas River subwatershed	Sediment	Yes	15% of the Helion Creek-Clackamas River subwatershed is privately owned. Based on the assumption that stands over 50 years old are available for harvest approximately 4% of the land base in the watershed is currently available for harvest. BMPs are in place for water quality

Project	Measure	Overlap in Time & Space	Extent, Detectable?
			protection through the Oregon Forest Practices Act these BMPs include: activities near streams, lakes, and wetlands must include water quality protection; activities on slopes must include erosion and landslide control; road and skid trail use must prevent erosion into streams, lakes, and wetlands.
Future Timber Harvest Activities on Private Lands Helion Creek – Clackamas River subwatershed	Temperature	Yes	A recent study (Groom, 2011) assessed the effects of timber harvest on stream temperatures on private lands where state forest practices rules were implemented. All 18 private land ownership study sites were clearcut. By the second year post-harvest it was found that maximum temperatures for private ownership sites increased pre-harvest to post-harvest on average by 0.7°C.
Future Timber Harvest Activities on Private Lands Helion Creek – Clackamas River subwatershed	Quantity	Yes	Most of the lands in this area that have been determined to be available for harvest are on Portland General Electric Ownership where foreseeable clearcut logging is unlikely.
Future Timber Harvest Activities on Private Lands North Clackamas subwatershed	Sediment	Yes	BMPs are in place for water quality protection through the Oregon Forest Practices Act these BMPs include: activities near streams, lakes, and wetlands must include water quality protection; activities on slopes must include erosion and landslide control; road and skid trail use must prevent erosion into streams, lakes, and wetlands.
Future Timber Harvest Activities on Private Lands North Clackamas subwatershed	Temperature	Yes	A recent study (Groom, 2011) assessed the effects of timber harvest on stream temperatures on private lands where state forest practices rules were implemented. All 18 private land ownership study sites were clearcut. By the second year post-harvest it was found that maximum temperatures for private ownership sites increased pre-harvest to post-harvest on average by 0.7°C.
Future Timber Harvest Activities on Private Lands North Clackamas subwatershed	Quantity	Yes	30% of the North Fork Clackamas subwatershed is privately owned. Based on the assumption that stands over 50 years old are available for harvest less than 1% of the land base in the watershed is currently available for harvest in this area.

6.1 - Cumulative Effects Summary

6.1.1 - Water Quantity

The Mount Hood Land and Resource Management Plan states under standard FW-066 that "Cumulative effects analyses of management activities on water quality and/or stream channel stability (e.g., watershed impact analyses) shall include lands in all ownerships within the watershed." so that is the focus of this analysis.

The analysis watersheds used earlier in the document are used as the analysis area for cumulative effects.

The time frame used to include or exclude actions varies by the type of action. Some impacts are considered permanent with no modeled recovery including permanent roads, quarries and the power line right-of way. Some impacts such as regeneration harvest would recover gradually over approximately 35 years.

Harvest that has occurred outside of National Forest System Lands is included. Foreseeable future projects were listed in the activities with potential cumulative effects summary table earlier in this section. While there may be future logging or other management within the watershed, there are no current proposals with sufficient site specificity to conduct an analysis.

Past disturbances within the action area are the most substantial contribution to cumulative effects, and include fires, timber harvest, and road construction. There are ongoing thinning projects within the analysis area that are included in the analysis of cumulative effects.

The table below details the cumulative recovery of all stands in the watershed combined with the cumulative impact of all actions that have affected hydrologic recovery. It is a weighted average of the modeled recovery status of thousands of stands. While the restoration thinning and regeneration harvest associated with the Action Alternatives would likely be spread out over several years, it is modeled here as occurring in 2020.

Table 39 ARP Values Associated with Implementation of the Action Alternatives

Subwatershed	ARP	Impact Area
Helion Creek-Clackamas River	83	17
North Fork Clackamas River	78	22
Roaring River	99	1

The following discussion summarizes the material from the existing condition and direct and indirect effects section from this document.

The slight changes in ARP associated with the project would not likely cause any additional changes in stream channel stability or increases in peak flows beyond those described for the existing condition associated with vegetation manipulation alone.

The North Fork Clackamas River is slightly above the threshold of concern from The Effects of Forest Practices on Peak Flows and Consequent Channel Response Report (Grant et al. 2008) and in using the same hydrologic and geomorphic analysis that was used to assess the combined impacts of harvest and roads it does not appear that slight decrease in ARP would result in peak flow effects on channels.

Based on the watershed sensitivity analysis completed for the Forest Plan associated with special emphasis watersheds and current watershed impact areas all the analysis watersheds associated with the North Clackamas Integrated Resource Project Planning Area are below the disturbance TOC of 35% recommended for watersheds that are not designated as Special Emphasis Watersheds. As with ARP the slight changes in watershed impact area associated implementation of the Action Alternatives would not have any different impacts than those described for the existing condition.

The Roaring River subwatershed is below the threshold of concern associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads.

The North Fork Clackamas River and Helion Creek-Clackamas River subwatersheds are above the threshold of concern associated with the approximate doubling of the percentage change in peak flows attributed to harvest alone to integrate the impacts of roads and after a detailed hydrologic and geomorphic analysis it does not appear that peak streamflows are impacting stream channel morphology in these subwatersheds.

6.1.2 - Stream Temperature

Activities associated with North Clackamas Integrated Resource Project are not expected to increase water temperature due design criteria designed to maintain existing primary shade vegetation adjacent to streams. As described in the direct and indirect effects section, this project would maintain existing water temperatures.

Hazard tree removal, road related activities associated with the Goat Mountain thin project,

ongoing road maintenance activities, PGE powerline corridor maintenance, recreation site maintenance and use, BLM North Clackamas restoration project, and existing regeneration harvest units on private land all have the potential to impact stream shade and associated stream temperature, however these activities would be dispersed in time and space and all these activities would have water quality protection Best Management Practices in place to control impacts to stream temperature. No detrimental cumulative effects to stream temperature are expected as a result of activities within the cumulative effects analysis area. Project design features associated with all activities are aimed at controlling impacts to stream temperature.

6.1.3 - Sediment

Road related activities associated with the implementation of the Goat Mountain Thin Project are estimated to add 5.0 tons per year of sediment during the road construction and log haul portion of the project. If this is combined with the 17 tons per year reduction associated with the implementation of the North Clackamas Integrated Resource Project there would still be a 12 tons per year reduction from the projects. Ongoing vegetation treatment activities, hazard tree removal, ongoing road maintenance activities, PGE powerline corridor maintenance, recreation site maintenance and use, 36 Pit Fire, BLM North Fork Clackamas aquatic restoration project, OHV management plan implementation, BLM Airstrip thinning timber sale, existing regeneration harvest on private land and future timber harvest on private land all have the potential to introduce small amounts of sediment that would be dispersed in time and space (and all these activities would have water quality protection Best Management Practices in place to control erosion and sedimentation). No detrimental cumulative effects to instream sediment are expected as a result of activities within the cumulative effects analysis area. Project design features associated with all activities are aimed at controlling erosion and sedimentation reducing the potential of erosion and delivery of material to adjacent surface water.

7.0 - Applicable Management Direction

Numerous existing plans provide guidance for projects in the form of Standards and Guidelines (S & G) and recommended Best Management Practices (BMP). These documents include the Mt. Hood National Forest Land and Resource Plan (LRMP) (USDA 1990), the Northwest Forest Plan (NWFP) and associated supporting documents (USDA 1994) , and the Willamette Basin Water Quality Restoration Plan, Clackamas River Sub-basin (USDA 2009). A summary of applicable water quality S&G's and BMP's from these documents are displayed below.

Mt. Hood National Forest Land and Resource Plan Standards and Guidelines

- Standards and Guidelines dealing with BMP's – FW-54,55,56,57,58,59,60
- Standards and Guidelines dealing with analysis considerations – FW-61,62,63,64,65,66,67
- Standards and Guidelines dealing with drinking water protection –72,75,76
- Standards and Guidelines dealing with maintaining water quality (temperature and sediment) - FW-97,98,99,100,109,110,111,112,113,114,127,128,129,132,133,134,135,136

Northwest Forest Plan Standards and Guidelines:

- Standards and Guidelines dealing with Key Watersheds (NWFP ROD pg. C-7). The primary S&G that pertains to this project is no net increase of new roads in this Key Watershed.
- Standards and Guidelines dealing with Riparian Reserves (NWFP ROD pg. C-31 through C-38). The primary S&G's that pertain to this project are
- Timber Management: TM-1
- Roads Management: RF-2,5,7
- Watershed and Habitat Restoration: WR-1,2,3
- Fish and Wildlife Management: FW-1

7.1 - Mt. Hood National Forest Land and Resource Plan Standards and Guidelines

Table 40 – Assessment of Compliance with Forest Plan Standards for Water Quality and Water Quantity

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
FW-054	Water quality associated with management activities shall be in compliance with Oregon State requirements (Oregon Administrative Rules, Chapter 340-41) established in accordance with the Federal Clean Water Act (1977, amended 1987). See Forestwide Riparian Standards and Guidelines.	Yes	See assessment in Forestwide Riparian Standards and Guideline Section
FW-055, 056	Compliance with State requirements shall be met through planning, application, and monitoring of Best Management Practices. Best Management Practices (BMPs) describe the process which shall be used to implement the State Water Quality Management Plan on lands administered by the USDA-Forest Service.	Yes	Site-specific BMP prescriptions have been completed for this project. This project would go into a pool of similar projects to be selected for project level BMP implementation and effectiveness monitoring as per the National BMP Monitoring Protocol. If selected an IDT would evaluate whether the site-specific BMPs were implemented and the effectiveness of the BMPs. Condition-based operating restrictions are intended to protect resources as well as, or better than previously used calendar-based restrictions. Since condition-based operations are relatively new, any ground-based operations that occur between November 1 and May 31 would be monitored to provide feedback and support adaptive management.
FW-057, 058	Individual, general Best Management Practices which may be implemented (i.e., on a project by project basis) are described in General Water Quality Best Management Practices, Pacific Northwest Region, 11/88. Evaluations of ability to implement and estimated effectiveness shall be made at the project level.	Yes	The ability to implement and estimated effectiveness of BMPs for this project are assessed in an appendix to this report
FW-059	The sensitivity of the project shall determine whether the Site-specific BMP prescriptions are included in the environmental analysis, the project plan, or in the analysis files.	Yes	Site-specific BMP prescriptions have been completed for this project
FW-060	Management practices causing detrimental changes in water temperature or chemical composition, blockages of water courses, or deposits of sediment shall not be permitted (36 CFR 219.27 e). See Forestwide Riparian Area Standards and Guidelines.	Yes	See assessment in Forestwide Riparian Standards and Guideline Section
FW-061	Vegetation management activities on National Forest System Lands should be disperse in time and space to minimize cumulative watershed effects	Yes	Vegetation management activities are designed to comply with FW-062, FW-063, FW-064, FW-065, FW-066, and FW-067
FW-062	Not more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time.	Yes	Assessed in this section of the report

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
FW-063	Within the 15 major drainages on the Forest (Map Four-2) watershed impact areas shall not exceed 35 percent.	Yes	Assessed in this section of the report
FW-064	Watershed impact areas at the subbasin or area analysis level (i.e., typically 3000 to 6000 acres) should not exceed 35 percent.	Yes	Assessed in this section of the report
FW-065	Within selected "Special Emphasis Watersheds" (Map Four-3), watershed impact areas should not exceed the "thresholds of concern" (TOC) for watershed stability displayed in Table Four-12.	N/A	There are no Special Emphasis Watersheds associated with this project
FW-066	Cumulative effects analyses of management activities on water quality and/or stream channel stability (e.g., watershed impact analyses) shall include lands in all ownerships within the watershed.	Yes	Assessed in this section of the report
FW-067	Where land ownerships are intermingled, timber harvest scheduling should be coordinated to prevent adverse cumulative effects.	Yes	Assessed in this section of the report
FW-072	State and Federal water quality drinking water standards shall be met at all administrative and permitted facilities providing potable water. See Forestwide Administrative Sites and Special Uses Standards and Guidelines.	Yes	Administrative sites within the analysis area meet State and Federal drinking water standards
FW-075	The disposal or accidental discharge of petroleum products and hazardous materials on National Forest System lands shall be prevented.	Yes	Contracts for the implementation of the proposed activities would include provisions to prevent discharge or disposal of petroleum products or hazardous materials
FW-076	Potentially detrimental materials associated with management activities (e.g., pesticides, fertilizers, and road surface treatments) shall be prevented from entering water or other areas not intended for treatment. See Forestwide Forest Protection Standards and Guidelines regarding Hazardous Materials.	Yes	Contracts for the implementation of the proposed activities would include provisions to prevent detrimental materials from entering water
FW-097, 098	Spawning habitat (e.g., pool tailouts and glides) shall maintain less than 20 percent fine sediments (i.e., particles less than 1.0 millimeter in diameter) on an area-weighted average. The area considered within the average should include only the stream reaches available for vegetative manipulation (e.g., Wilderness areas should not be included).	Yes	Assessed in direct and indirect effects. There are road segments that have modeled sediment delivery to the stream system, however due to the small amount of sediment predicted to be delivered in the short term to the stream system, the distribution of the sediment delivery over time and space, and the decrease in predicted sediment delivery over the long term and that any episodic input of sediment associated with road surface erosion is metered by the stream system to provide a steady output of sediment it is not expected that the in channel fine sediment levels would change.

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
FW-099, 100	Riffle areas shall maintain less than 25 percent embeddedness on an area-weighted average. The area considered within the average should include only the stream reaches available for vegetative manipulation.	Yes	Assessed in direct and indirect effects. There are road segments that have modeled sediment delivery to the stream system, however due to the small amount of sediment predicted to be delivered in the short term to the stream system, the distribution of the sediment delivery over time and space, and the decrease in predicted sediment delivery over the long term and that any episodic input of sediment associated with road surface erosion is metered by the stream system to provide a steady output of sediment it is not expected that the in channel fine sediment levels would change.
FW-109	Summer water temperatures shall be maintained to protect existing on and off-Forest beneficial water uses (State Water Quality Standards, Oregon Administrative Rules, Chapter 340-410.	Yes	The Forest developed a Water Quality Restoration Plan (WQRP) (USDA 2009) to serve as the TMDL Implementation Plan for the Willamette Basin TMDL Under the WQRP the protection and recovery of water quality would depend on implementation of the Land and Resource Management Plans of the Mt. Hood National Forest as amended by the Northwest Forest Plan (NWFP). Project design criteria for timber sale projects on the Clackamas River Ranger District were developed to reduce any potential for adverse impacts to stream temperature as the result of thinning within riparian reserves, and to meet guidelines in the Northwest Forest Plan Temperature TMDL Implementation Strategy (2012). Activities associated with the North Clackamas Integrated Resource Project include no-cut stream protection buffers along perennial streams that are designed to meet stream temperature goals by avoiding harvest in the primary shade zone and retaining shade producing vegetation. In addition, thinning in the secondary shade zone would not result in less than 50% canopy closure post harvest.
FW-110	Forest management activities shall not cause water temperatures to: (1) exceed 58^0 F. on any day, or (2) increase more than 2^0 F.[15]	Yes	See response to FW-109
FW-111	Where natural maximum stream temperatures exceed 58 degrees F, forest management activities shall not cause any measurable increase in the maximum water temperature.	Yes	See response to FW-109

[15] Forest Plan Interpretation #9 states: The most current State Water Quality standard for water temperature identified for each basin in OAR Chapter 340, Division 41 should be used to determine compliance with Forest-wide standards FW-110 and FW-111.

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
FW-112	Stream Shading should be increased where: (1) State water quality standards are routinely exceeded (e.g., annual occurrence) during summer low water flow periods (2) Elevated water temperatures, due to management activities, are likely to reduce on-Forest or off-Forest water related values.	Yes	See response to FW-109
FW-113	State water quality standards for turbidity shall be met.	Yes	Contracts for the implementation of the proposed activities would include provisions for erosion prevention and control to control sediment delivery and associated turbidity.
FW-114	No more than a 10 percent cumulative increase in natural in stream turbidity should be allowed to result from forest management activities (Oregon Administrative Rules 340, Div. 41).	Yes	See response to FW-113
FW-127	Forest management activities shall not cause water temperatures to exceed water quality standards established for fish bearing streams (see Class 1, II and Fish Bearing Class III Streams Standards and guidelines).	Yes	See response to FW-109
FW-128	Stream shading should be increased where: (1) State water quality standards are routinely exceeded (i.e., annual occurrence) during summer low water flow periods. (2) Elevated water temperatures, due to management activities, are likely to affect down-stream water related values.	Yes	See response to FW-109
FW-129	Sediment loading shall be minimized and stream channel conditions maintained to meet State water quality standards for turbidity (see Class I, II and Fish Bearing Class III Streams Standards and Guidelines).	Yes	See response to FW-113
FW-132	Channel and bank stability should not be deteriorated beyond existing conditions and should be restored to natural conditions.	Yes	Assessed in direct and indirect effects section
FW-133	Activities and practices which could result in ground disturbance such as rills, furrows, erosion, compaction, puddling, etc., should be minimized.	Yes	See response to FW-113
FW-134	Maintenance of noncommercial trees should be encouraged.	Yes	No cut stream buffers on intermittent streams, seeps and springs are designed to meet Aquatic Conservation Objectives including: Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
			distributions of coarse woody debris sufficient to sustain physical complexity and stability.
FW-135	Conifer and hardwood trees necessary for stream bank stability, long term wood input, and diversity of wildlife and plant communities should be maintained.	Yes	No cut stream buffers on intermittent streams, seeps and springs are designed to meet Aquatic Conservation Objectives including Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.
FW-136	At least 100 percent of potential and naturally occurring large woody material (both quantity and quality) within seeps and springs or lying within or across the channels of Class IV streams should be maintained.[16]	Yes	No cut stream buffers on intermittent streams, seeps and springs are designed to meet Aquatic Conservation Objectives including #8 Maintain and restore the species composition and structural diversity of plant communities in riparian areas and wetlands to provide adequate summer and winter thermal regulation, nutrient filtering, appropriate rates of surface erosion, bank erosion, and channel migration and to supply amounts and distributions of coarse woody debris sufficient to sustain physical complexity and stability.

7.1.1 – Additional Discussion on Standards and Guidelines

There are several Forest Plan standards and guidelines that address hydrologic recovery. The ARP model ranks recovery from 0 to 100 with 100 being fully recovered. The Forest Plan refers to a maximum watershed impact area or threshold of concern which are the inverse of ARP with 0 being fully recovered. The ARP numbers are subtracted from 100 to get watershed impact area or threshold of concern.

Vegetation management activities on National Forest System lands should be dispersed in time and space to minimize cumulative watershed effects. Not more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time. FW-062, FW-063 and FW-064 were assessed on National Forest System lands only.

[16] Forest Plan Interpretation #2 states: Amend FW-136 to delete the reference to "potential" LWD. It would therefore read: "At least 100 percent of naturally occurring large woody material (both quantity and quality) within seeps and springs or lying across the channels of Class IV streams should be maintained."

Table 41 Forest Plan Standards for Cumulative Watershed Effects

Code	**Cumulative Watershed Effects**
FW-062	Not more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time.
FW-063	Within the 15 major drainages on the Forest (Map Four-2) watershed impact areas shall not exceed 35 percent.
FW-064	Watershed impact areas at the subbasin or area analysis level (i.e., typically 3000 to 6000 acres) should not exceed 35 percent.
FW-065	Within selected "Special Emphasis Watersheds" (Map Four-3), watershed impact areas should not exceed the "thresholds of concern" (TOC) for watershed stability displayed in Table Four-12.
FW-066	Cumulative effects analyses of management activities on water quality and/or stream channel stability (e.g., watershed impact analyses) shall include lands in all ownerships within the watershed.

FW-062 states that “Not more than 35 percent of an area available for vegetative manipulation should be in a hydrologically disturbed condition at any one time”. FW-63 indicates a maximum watershed impact area of 35% for major drainages. The table below indicates that the major drainages associated with the North Clackamas Integrated Resource Project lands available for vegetative manipulation are below the 35% standard.

Table 42 Lands Available for Vegetative Manipulation in a hydrologically disturbed condition (FW-062)

Major Drainage	Existing Condition	Proposed Action	Alternative 2
Lower Clackamas River	7%	8%	9%

FW-64 indicates watershed impact area at the subbasin or area analysis level should not exceed 35 percent. Watershed impact area varies from 5% to 17% associated with implementation of the North Clackamas Integrated Resource Project. FW-64 was evaluated at the 7th field (or combined 7th field watershed) scale for the North Clackamas subwatershed. The Helion Creek-Clackamas River and Roaring River subwatersheds were evaluated at the subwatershed scale.

Table 43 Area Analysis Watershed Impact Areas North Fork Subwatershed

Drainage	Existing Condition - 2019	Proposed action - 2020	Alternative 2 - 2020
Boyer/Winslow	3%	9%	9%
Fall/Bee/Bedford	5%	9%	9%
Upper North Fork	2%	8%	9%
Lower North Fork	3%	17%	17%

Table 44 Area Analysis Watershed Impact Areas Helion Creek-Clackamas River and Roaring River Subwatersheds

Drainage	Existing Condition 2020	Proposed action 2020	Alternative 2 - 2020
Helion Creek-Clackamas River	5%	5%	5%
Roaring River	13%	15%	15%

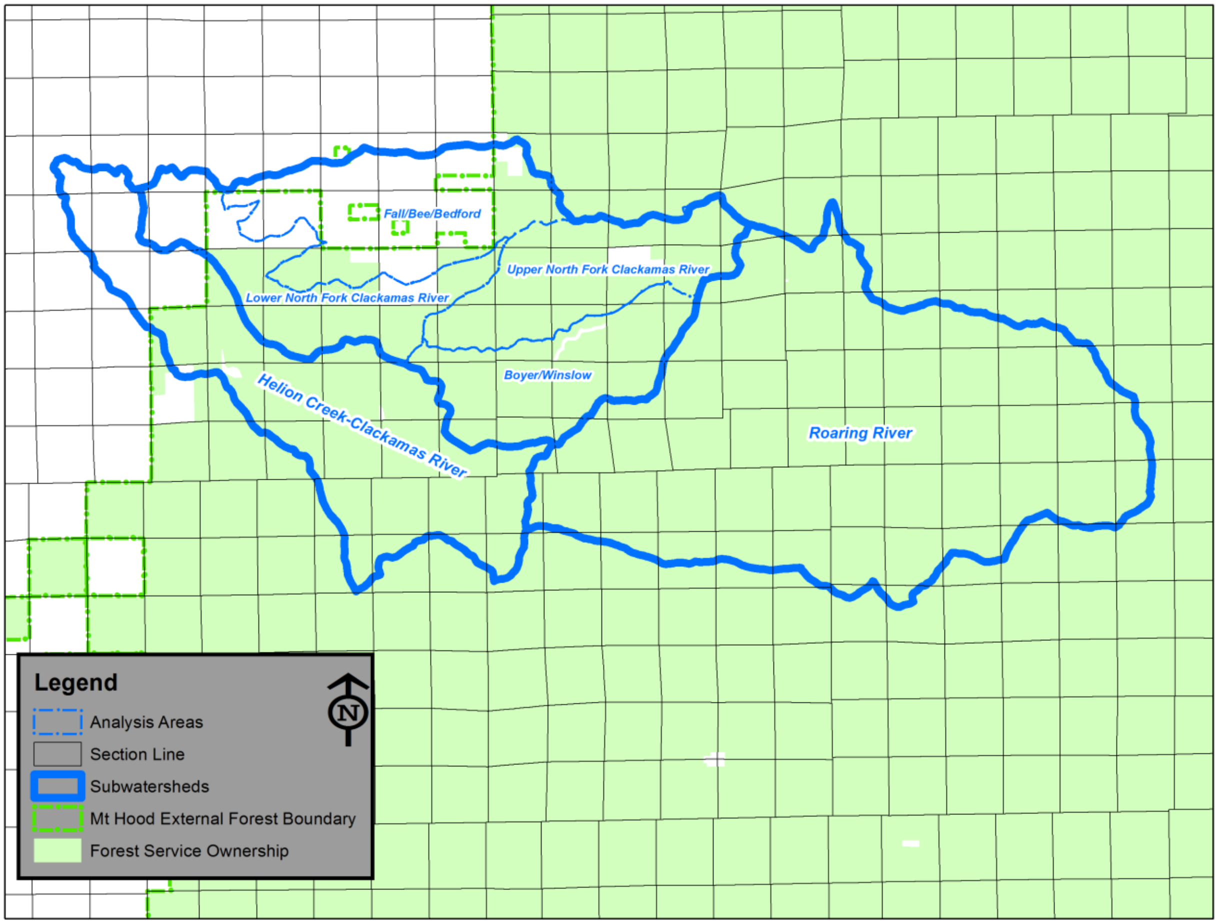

Figure 25 Analysis Watersheds used for FW-64

FW-065 does not apply because there are no Special Emphasis Watersheds in the project area.

FW-066 was assessed in the Cumulative Effects section of the report.

7.2 – Northwest Forest Plan Standards and Guidelines

Table 45 Compliance With Key Standards And Guidelines from The Northwest Forest Plan Standards And Guidelines For Riparian Reserves

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
TM-1	Prohibit timber harvest, including fuelwood cutting, in Riparian Reserves, except as described below. Riparian Reserve acres shall not be included in calculations of the timber base.	Yes	See TM-1a, TM-1b and TM-1c
TM-1a	Where catastrophic events such as fire, flooding, volcanic, wind, or insect damage result in degraded riparian conditions, allow salvage and fuelwood cutting if	Not applicable	

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
	required to attain Aquatic Conservation Strategy objectives.		
TM-1b	Salvage trees only when watershed analysis determines that present and future coarse woody debris needs are met and other Aquatic Conservation Strategy objectives are not adversely affected	Not applicable	
TM-1c	Apply silvicultural practices for Riparian Reserves to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain Aquatic Conservation Strategy objectives	Yes	The Purpose and Need (North Clack Integrated Resource Project Information Sheet) states that for Riparian Reserves and Late Successional Reserves "The desired condition is a multi-layer canopy with large diameter trees, well-developed understory, more than one age class, and sufficient quantities of snags and down woody debris. These desired conditions are described in the Forest Plan on page Four-67 and in the Northwest Forest Plan on pages B-5, B-6 and C-32."
RF-2	For each existing or planned road, meet Aquatic Conservation Strategy objectives by	Yes	See RF-2 subsections below
RF-2a	Minimizing road and landing locations in Riparian Reserves	Yes	Addressed through PDC C4, D2 Road and landing locations were reviewed by the projects interdisciplinary team of agency resource specialists to minimize road and landing locations in Riparian Reserves
RF-2b	Completing watershed analyses (including appropriate geotechnical analyses) prior to construction of new roads or landings in Riparian Reserves.	Yes	Watershed Analyses have been completed for the associated watersheds
RF-2c	Preparing road design criteria, elements, and standards that govern construction and reconstruction.	Yes	Addressed through PDC Sections D and E
RF-2d	Preparing operation and maintenance criteria that govern road operation, maintenance, and management.	Yes	Addressed through PDC Sections E and G
RF-2e	Minimizing disruption of natural hydrologic flow paths, including diversion of streamflow and interception of surface and subsurface flow	Yes	Addressed through PDC D4, D5, D8, E7, F20
RF-2f	Restricting sidecasting as necessary to prevent the introduction of sediment to streams	Yes	Addressed through PDC D3, D4
RF-2g	Avoiding wetlands entirely when constructing new roads.	Yes	Addressed through PDC D2
RF-5	Minimize sediment delivery to streams from roads. Outsloping of the roadway surface is preferred, except in cases where outsloping would increase sediment delivery to streams or where outsloping is unfeasible or unsafe. Route road drainage away from potentially unstable channels, fills, and hillslopes.	Yes	Addressed through PDC D3, D4, D6, D7, E2, E3, E4, E5, E8, E9. E10

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
RF-7	Develop and implement a Road Management Plan or a Transportation Management Plan that will meet the Aquatic Conservation Strategy objectives. As a minimum, this plan shall include provisions for the following activities	Yes	See RF-7 subsections below
RF-7a	Inspections and maintenance during storm events.	Yes	Addressed through PDC C9, G1
RF-7b	Inspections and maintenance after storm events	Yes	Addressed through PDC C9, G1
RF-7c	Road operation and maintenance, giving high priority to identifying and correcting road drainage problems that contribute to degrading riparian resources.	Yes	North Clack Integrated Resource Project Information Sheet Transportation System Management Purpose and Need states "The desired condition is to have a landscape accessed by an appropriate network of roads that provide for management access and visitor safety while minimizing risk to aquatic resources. These desired conditions are described in the Forest Plan on pages Four-3, Four-5 & Four-34 and the Northwest Forest Plan on page C-32."
RF-7d	Traffic regulation during wet periods to prevent damage to riparian resources	Yes	Addressed through PDC C9, G1
RF-7e	Establish the purpose of each road by developing the Road Management Objective.	Yes	North Clack Integrated Resource Project Information Sheet Transportation System Management for Reducing Resource Risks and Maintenance Costs states "In 2015, the Forest completed a Travel Analysis Report (TAR) which was a synthesis of previous efforts and set the stage for project-level decisions about whether to retain roads, close or decommission them, and what level of maintenance they should receive. Based on a review of previous travel management analyses and recommendations, there remain opportunities to make additional adjustments to the transportation system to either reduce resource risks or maintenance costs. There is also a commensurate need to consider long-term administrative and public access needs when making proposals to change the transportation system within the project area."
WR-1	Design and implement watershed restoration projects in a manner that promotes long-term ecological integrity of ecosystems, conserves the genetic integrity of native species, and attains Aquatic Conservation Strategy objectives	Yes	North Clack Integrated Resource Project Information Sheet Aquatic/Riparian Habitat Enhancement states: The desired condition for streams, lakes and riparian areas is for them to be fully functional to meet the needs of aquatic and riparian species and to provide clean water. A primary purpose of this project is to enhance aquatic and riparian habitat.
WR-2	Cooperate with federal, state, local, and tribal agencies, and private landowners to develop watershed-based Coordinated	Yes	The Forest Service works with the Clackamas River Basin Council that has diverse representatives from over twenty stakeholder

Code	Standard and Guidelines Applicable to Project	Plan Conformance Achieved	Comments
	Resource Management Plans or other cooperative agreements to meet Aquatic Conservation Strategy objectives.		groups. The mission of the Clackamas River Basin Council is "We foster partnerships for clean water and to improve fish and wildlife habitat and the quality of life for those who live, work and recreate in the watershed"
WR-3	Do not use mitigation or planned restoration as a substitute for preventing habitat degradation.	Yes	North Clack Integrated Resource Project Information Sheet Aquatic/Riparian Habitat Enhancement states: The desired condition for streams, lakes and riparian areas is for them to be fully functional to meet the needs of aquatic and riparian species and to provide clean water. A primary purpose of this project is to enhance aquatic and riparian habitat.
FW-1	Design and implement fish and wildlife habitat restoration and enhancement activities in a manner that contributes to attainment of Aquatic Conservation Strategy objectives.	Yes	North Clack Integrated Resource Project Information Sheet Aquatic/Riparian Habitat Enhancement states: The desired condition for streams, lakes and riparian areas is for them to be fully functional to meet the needs of aquatic and riparian species and to provide clean water. A primary purpose of this project is to enhance aquatic and riparian habitat

7.2.1 - Key Watersheds

Key Watersheds are a system of large refugia comprising watersheds that are crucial to at-risk fish species and stocks and provide high quality water. The Aquatic Conservation Strategy includes two designations for Key Watersheds. Tier 1 (Aquatic Conservation Emphasis) Key Watersheds contribute directly to conservation of at-risk anadromous salmonids, bull trout, and resident fish species. They also have a high potential of being restored as part of a watershed restoration program. The network of 143 Tier 1 Key Watersheds ensures that refugia are widely distributed across the landscape. While Tier 2 (other) Key Watersheds may not contain at-risk fish stocks, they are important sources of high quality water.

Standards and guidelines for Key Watersheds include:

- Reduce existing system and non-system road mileage. If funding is insufficient to implement reductions, there would be no net increase in the amount of roads in Key Watersheds.
- Key Watersheds are the highest priority for watershed restoration.

Within the project area as defined by the analysis watersheds there is 30,349 acres of the Tier 1 Key Watershed associated with Roaring River (27,132 acres) and Clackamas River/Oak Grove Fork River Corridor Key Watershed (3217 acres).

In the Roaring River Key Watershed there are 173 acres of preliminary North Clackamas Integrated Resource Project vegetation management actions and 31.6 miles of road. There are 1.2 miles of road closure (conversion from maintenance level 2 to maintenance level 1) and 5.7

miles of road decommissioning or road to trail activities. There are 0.2 miles of temporary roads planned.

In the Clackamas River/Oak Grove Fork River Corridor Key Watershed there are no preliminary North Clackamas Integrated Resource Project vegetation management actions and 13.8 miles of road.

Project activities are consistent with Standards and Guidelines because there would be no net increase in the amount of roads in the Key Watershed.

8.0 - Other Compliance

8.1 - Willamette Basin TMDL: Clackamas Subbasin TMDL

The Forest developed a Water Quality Restoration Plan (WQRP) (USDA 2009) to serve as the TMDL (Total Maximum Daily Load) Implementation Plan for the Willamette Basin TMDL. Under the WQRP the protection and recovery of water quality will depend on implementation of the Land and Resource Management Plan of the Mt. Hood National Forest as amended by the Northwest Forest Plan (NWFP). Paramount to recovery is adherence to the Standards and Guidelines of the NWFP to meet Aquatic Conservation Strategy (ACS) objectives including protection, restoration, and active management of riparian areas.

The Oregon Department of Environmental Quality ODEQ has formally recognized and supported that the NWFP and the Northwest Forest Plan Temperature TMDL Implementation Strategies (USDA 2012) will serve as the temperature TMDL implementation mechanism pursuant to the Clean Water Act.

Project design criteria for timber sale projects on the Clackamas River Ranger District were developed to reduce any potential for adverse impacts to stream temperature as the result of thinning within riparian reserves, and to meet guidelines in the Northwest Forest Plan Temperature TMDL Implementation Strategy (USDA 2012). Activities associated with the North Clackamas Integrated Resource Project include no-cut stream protection buffers along perennial streams that are designed to meet stream temperature goals by avoiding harvest in the primary shade zone and retaining shade producing vegetation. In addition, thinning in the secondary shade zone would not result in less than 50% canopy closure post harvest.

8.2 - Oregon State Drinking Water Source Areas

The North Clackamas Integrated Resource Project area contains a portion of the surface water drinking water source area for the City of Estacada, the entire area of all the analysis watersheds are within this public water system. The North Clackamas Integrated Resource Project contains 7% of the total area of the water source area for the City of Estacada

Amendments made in 1996 to the federal Safe Drinking Water Act provide the means to protect drinking water at its source. In developing the amendments, Congress recognized the need to go beyond traditional emphasis on treatment to address new challenges to provide clean drinking water. The act's amendments mandated that states conduct "source water assessments" for all public water systems. These assessments include delineating contribution zones or source areas for all groundwater and surface water- supplied public water systems and identifying potential sources of contamination for drinking water in each state. Source water assessments are required for all systems with at least 15 hookups or that serve more than 25 people year-round.

The process for developing a Drinking Water Protection Plan includes an Assessment Phase and a Protection Phase. The Assessment Phase includes delineating the area that serves as the source of the public water supply; inventorying the potential risks or sources of contamination and determining the areas most susceptible to contamination has been completed. The development of a protection plan associated with the protection phase is voluntary and has not been completed for the Drinking Water Source Areas within the project area and therefore, no management guidelines or protection standards have been established.

Table 46 Potential Contaminant Sources North Clackamas Integrated Resource Project area

Public Water System	Potential Contaminant Sources Name	Activity	Risk
City of Estacada	Managed forest lands - BLM &/or USFS	Managed Forest Land - Clearcut Harvest (< 35 yrs.)	Higher
City of Estacada	Unofficial campground on the mainstem Clackamas	River Recreation - Heavy Use (inc. campgrounds)	Moderate
City of Estacada	Lazy Bend Campground - USFS	Campgrounds/RV Parks	Moderate
City of Estacada	Big Eddy Day Use Area - USFS	River Recreation - Heavy Use (inc. campgrounds)	Moderate
City of Estacada	Cluster of several campgrounds - USFS	Campgrounds/RV Parks	Moderate
City of Estacada	Lazy Bend Campground - USFS	UST - Decommissioned/Inactive	Lower

There are six potential contaminant source areas identified in the North Clackamas Integrated Resource Project area on National Forest System Lands. The higher risk area identified as managed forest lands appears to be on private land based on the description and recent aerial imagery. There are best management practices in place for the protection of water quality for the activities identified as potential contaminant sources including vegetation management activities, developed recreation sites, and dispersed use recreation. Project design features associated with all activities are aimed at protecting water quality for municipal use.

8.3 - Compliance with the Clean Water Act

The Federal Clean Water Act (CWA) (33 U.S.C. § 1251 et seq.) is the foundation for surface water quality protection in the United States. The objective of the CWA, as articulated in section 101, is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. This law uses a variety of regulatory and non-regulatory tools to control direct pollutant discharges from point sources and manage polluted runoff from nonpoint sources to waters of the United States (USDA 2012a).

In the CWA, Congress gave States and tribes the option for taking primary responsibility for water pollution control. (States will be used in the rest of this report to signify both States and those tribes that have received approval from the U.S. Environmental Protection Agency (EPA) for treatment as a State under the CWA.) As a result, most States and many tribes have taken on that responsibility and, therefore, water quality standards, procedures, rules, and regulations differ from one State to another. The Forest Service, as an agency of the Federal Government, is required to comply with all Federal, State, and local requirements for water pollution control in the same manner and to the same extent as any nongovernmental entity (CWA section 313) (USDA 2012a).

The Forest Service strategy for control of nonpoint source pollution is to apply appropriate BMPs using adaptive management principles. This strategy involves applying approved BMPs, monitoring the implementation and effectiveness of the BMPs, and using the monitoring results to inform and improve management activities (USDA 2012a).

It is the responsibility of the Forest Service as a Federal land management agency through implementation of the Clean Water Act (CWA), to protect and restore the quality of public waters under their jurisdiction. Protecting water quality is addressed in several sections of the CWA including sections 303, 313, and 319. Best Management Practices (BMPs) are used to meet water quality standards (or water quality goals and objectives) under Section 319. (USDA 1999)

In the Memorandum of Understanding MOU finalized in January 2014 between the USDA Forest Service Region 6 Regional Forester and the State of Oregon Department of Environmental Quality (DEQ) Director procedures for agencies to cooperatively implement Federal and State water quality regulations on National Forest System (NFS lands), meet State water quality standards and support beneficial uses of water were identified (USDA 2014).

This MOU documents the U.S. Forest Service and DEQ strategy for managing and controlling point and nonpoint source (NPS) water pollution from U.S. Forest Service-managed lands in the State of Oregon. This MOU sets out the procedures for the Forest Service and DEQ to cooperatively implement State and Federal water quality rules and regulations. The physical, chemical, and biological conditions of “Waters of the State” that support beneficial uses (defined in Oregon Revised Statute (ORS), Chapter 468B - Water Quality and Oregon Administrative Rules (OAR), Division 41) would be protected, restored, and maintained by working in a proactive, collaborative, and adaptive manner through this MOU (USDA 2014).

DEQ recognizes the Forest Service as the Designated Management Agency for water quality management on National Forest System lands. The agreement relies on the National Best Management Practices (BMP) program, Watershed Condition Framework, Land and Resource Management Plans, and Water Quality Restoration Plans (for impaired waters) as the primary mechanisms for compliance (USDA 2014).

The DEQ sets water quality standards, assesses water quality against those standards, coordinates with the Forest Service on collection and interpretation of water quality data and list/de-listing decisions, coordinates with the Forest Service on Total Maximum Daily Loads (maximum amount of pollution that water can receive and still meet standards) and Water Quality Restoration Plans for impaired waters, provides technical assistance, reviews and comments on Land and Resource Management Plans and projects, requests Forest Service review of new rules, issues permits, and takes enforcement actions (USDA 2014).

The Forest Service protects and restores water quality to meet federal and state water quality standards, implements National BMPs (including associated monitoring and adaptation of BMPs), and the Watershed Condition Framework. Reviews national BMPs to determine the need for Regional supplement. Provides technical assistance interpreting data. For impaired waters, participates in TMDL development, and prepares or revises Water Quality Restoration Plans (WQRPs) which are the equivalent to State TMDL Implementation Plans (USDA 2014).

In addition the Mt. Hood Land and Resource Management Plan (USDA, 1990) contains the following Standards and Guidelines with respect to the implementation of BMP's.

Compliance with State requirements shall be met through planning, application, and monitoring of Best Management Practices. Best Management Practices (BMPs) describe the process which shall be used to implement the State Water Quality Management Plan on lands administered by the USDA Forest Service. FW-055, FW-056

Individual, general Best Management Practices which may be implemented (i.e. on a project by project basis) are described in General Water Quality Best Management Practices, Pacific Northwest Region, 11/88. Evaluations of ability to implement and estimated effectiveness shall be made at the project level. FW-057, FW-058

The sensitivity of the project shall determine whether the site-specific BMP prescriptions are included in the environmental analysis, the project plan or the analysis files. FW-059

Site-specific Water Quality Best Management Practices, with the express purpose of limiting non-point source water pollution, are incorporated into the proposed action and associated project design criteria for this project.

BMPs were originally compiled from Forest Service manuals, handbooks, contract and permit provisions, and policy statements. BMPs were further refined to address recommendations in General Water Quality Best Management Practices, Pacific Northwest Region, November 1988. Finally BMPs were refined to meet National Best Management Practices for Water Quality Management on National Forest System Lands - Volume 1: National Core BMP Technical Guide (USDA 2012a).

The following is an excerpt from the National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide (USDA 2012a).

The National Core BMPs are deliberately general and non-prescriptive. Although some impacts may be thought of as characteristic of a management activity, the actual potential for a land use or management activity to impact water quality depends on:

1. The physical, biologic, meteorological, and hydrologic environment where the activity takes place (e.g., topography, physiography, precipitation, stream type, channel density, soil type, and vegetative cover).

2. The type of activity imposed on a given environment and the proximity of the activity area to surface waters.

3. The magnitude, intensity, duration, and timing of the activity.

4. The State designated beneficial uses of the water in proximity to the management activity and their relative sensitivity to the potential impacts associated with the activity.

These four factors vary throughout the lands administered by the Forest Service. It follows then, that the extent and kind of potential water quality impacts from activities on NFS lands are variable, as are the most appropriate mitigation and pollution control measures. No solution, prescription, method, or technique is best for all circumstances.

The National Core BMPs cannot include all possible practices or techniques to address the range of conditions and situations on all NFS lands. Each BMP has a list of recommended practices that should be used, as appropriate or when required, to meet the objective of the BMP. Not all recommended practices would be applicable in all settings, and there may be other practices not listed in the BMP that would work as well, or better, to meet the BMP objective in a given situation. The specific practices or methods to be applied to a particular project should be determined based on site evaluation, past experience, monitoring results, new techniques based on new research literature, and other requirements. State BMPs, Forest Service regional guidance, land management plans, BMP monitoring information, and professional judgment should be used to develop site-specific BMP prescriptions.

The Interdisciplinary Team has examined the applicable general National Core BMPs and developed more specific and prescriptive Project Design Criteria (PDCs) to implement the intent of the BMPs.

Some of the PDCs are standard practices and others were tailored specifically for this project based on site-specific conditions. They were developed based on many years of experience and an understanding of recent research. The team evaluated the PDCs and rated their “ability to implement” and “effectiveness.” This analysis is in an appendix to the hydrology specialist report and is incorporated by reference. The analysis found that the PDCs had a moderate to high ability to implement and a moderate to high level of expected effectiveness, meaning that all practices would be implemented and effective at least 75% of the time. Past monitoring on the Clackamas River Ranger District indicated that PDCs were implemented as planned on 85% of the samples and were effective at avoiding impacts to water quality on 94% of the samples (See the appendix to this report that summarizes data found in the Forest’s annual monitoring reports available on the Forest’s web site.)

8.3.1 - Forest-Wide Monitoring

In an effort to support the Clean Water Act, the Forest conducts a variety of monitoring and inventory programs to determine status of meeting state water quality standards as well as other regulatory and agency requirements. In an average year, approximately 75 sites are monitored for water temperature throughout the Forest. In addition, other water quality monitoring occurs at various locations throughout the Forest. This could be turbidity monitoring, in-stream sediment sampling, water chemical sampling, or surveys of physical stream conditions. Currently, approximately 25 miles of physical stream habitat is surveyed every year and to date approximately 1787 miles of stream have been surveyed or resurveyed. Some of the information collected during these surveys includes the number of pools and riffles, amount of large wood, riparian area condition and types, and numbers of fish and other aquatic organisms. This data is compiled and summarized in Forest Monitoring Reports available on the Forest's web site. The effectiveness of the techniques included as PDCs in this project and on the projects that have been implemented in recent years has been validated because Forest-wide monitoring has shown an ongoing trend of improving conditions for processes that impact water quality. The PDCs in this project have been refined where appropriate based on past monitoring to make them more implementable and more effective.

This project would go into a pool of similar projects to be selected for project level BMP implementation and effectiveness monitoring as per the National BMP Monitoring Protocol. If selected, an IDT would evaluate whether the site-specific BMPs were implemented and the effectiveness of the BMPs.

8.3.2 - Project Level Monitoring

Prior to and during implementation, a multi-stage process is used on the Forest to ensure that a project is implemented as planned. Before beginning the on-the-ground presale process, which includes layout of the units, designating the trees to retain, and cruising the timber, the Presale Forestry Technicians and Presale Crew members meet with the Interdisciplinary Team (IDT) to transition to the implementation phase of the project. Resource specialists identify any resource concerns in individual units or highlight any key project design criteria on a unit-by-unit basis. After the presale work is completed, the project moves into the appraisal and contract preparation phase. One of the first steps in the process is to complete the Contract Project Design & Implementation Crosswalk Form. The purpose of the crosswalk is to ensure that all components of the NEPA Decision, including the project design criteria and terms and conditions from consultation, are incorporated into the contract. For each required component of the NEPA decision, the crosswalk identifies how and what stage in the process the component would be addressed (e.g., presale, contract, sale administration, post contract monitoring). The information generated from the crosswalk process is used to guide the contract preparation process and to identify any issues that need to be addressed by resource specialists. The crosswalk is usually prepared by the primary person responsible for developing the appraisal and contract, and signed by the District Ranger.

Prior to advertisement, a final review is conducted to ensure that the contract is prepared with the proper contract provisions and language; the project design criteria are properly inserted and contractually enforceable; and, the contract and appraisal meets Forest Service Handbook, Forest Service Manual and Stewardship Guide (where applicable) regulations and direction. This final review may be informal or may be formalized in a Forest-level review or “Plan-in-Hand”. “Plan-in-Hand” reviews are randomly selected and may or may not include the North Clackamas Integrated Resource Project. The goal of this formal review is to monitor and evaluate forest resource management prescriptions, to measure compliance with goals and objectives, and to make adjustments when needed. The “Plan-in-Hand” review is summarized in a letter to the Forest Supervisor which is included in the final appraisal/contract packet.

During implementation, the Sale Administrator in conjunction with the Forest Service Representative and Contracting Officer are responsible to ensure that the contract is administered properly throughout all stages of implementation. The sale administration team monitors compliance with the contract which contains the provisions for resource protection, including but not limited to: seasonal restrictions, snags and coarse woody debris retention, stream protection, erosion prevention, soil protection, road closure and protection of historical sites. The Sale Administrator records observations demonstrating compliance as well as any concerns/issues on inspection reports that are signed by both the Forest Service and Purchaser Representative. The inspection reports would also document any resolutions that have been identified. As needed during the implementation process, the sale administration team may request a resource specialist or Line Officer to come for a field visit to discuss a resource issue that has been identified. Also, a resource specialist may visit a project without a formal request to conduct monitoring and to make sure that the project is being implemented as directed by the NEPA decision.

Condition-based operating restrictions are intended to protect resources as well as, or better than previously used calendar-based restrictions. Since condition-based operations are relatively new, any ground-based operations that occur between November 1 and May 31 would be monitored to provide feedback and support adaptive management.

Monitoring of noxious weeds and invasive plants would be conducted where appropriate to track changes in populations over time and corrective action would be prescribed where needed.

The ability to implement the techniques included as PDCs is moderate to high because of these multiple checks.

/s/ Todd Parker
Hydrologist
Mt. Hood National Forest

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