Appendix M – Temperature and Precipitation Technical Report

TEMPERATURE AND PRECIPITATION

TECHNICAL REPORT

TRINITY RIVER WATERSHED RESTORATION PROJECT

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PROJECT #63121 (FOREST SERVICE)

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U.S. Department of Agriculture, Forest Service

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ACRONYMS

ACS	Aquatic Conservation Strategy

AF	acre-feet
BLM	U.S. Bureau of Land Management
BMPs	Best Management Practices
CBM	Condition-based Management
CDFW	California Department of Fish and Wildlife
CVP	Central Valley Project
DOI	U.S. Department of the Interior
EA	Environmental Assessment
EC	Environmental Commitments
EPA	Environmental Protection Agency
ESA	Endangered Species Act
GHG	greenhouse gas
HUC	Hydrologic Unit Code
LRMP	Land and Resource Management Plan
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NWFP	Northwest Forest Plan
NWI	National Wetlands Inventory
Project	Trinity River Watershed Restoration Project
Reclamation	Bureau of Reclamation
Regional Water Board	North Coast Regional Water Quality Control Board
RFO	Redding Field Office
ROD	Record of Decision
RMP	Resource Management Plan
STNF	Shasta-Trinity National Forest
TRD	Trinity River Division
TRRP	Trinity River Restoration Program
USACE	U.S. Army Corps of Engineers
USC	United States Code
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

1. Introduction and Summary

This technical report analyzes the temperature and precipitation-related effects of proposed restoration activities that are part of the Trinity River Watershed Restoration Project (Project). Adverse effects from early European settlement, roads, mining, logging, wildfire and a highly-sought-after water supply, have led to the need for restoration activities proposed by this Project. These activities intend to meet certain restoration objectives, which have been developed over time and incorporate state and federal recovery plan goals (NMFS 2014, CDFG 2004, EPA 1998, EPA 2001).

The incremental addition of GHG emissions from millions of individual sources has been shown to collectively have a large impact on a global scale on temperature and precipitation patterns and trends. These changes are not attributable to any single action but are exacerbated by a series of actions. Thus, this analysis addresses impacts to temperature and precipitation with that concept in mind.

Table 1-1. Summary of Effects of Precipitation and Temperature Effects and Proposed Action

Resource	Climate-Related Effects	Project Effects
Regional Conditions	Northern California temperatures are expected to increase by 5 to 9 degrees Fahrenheit (°F) by the end of the century, reducing soil moisture, decreasing snowpack, shifting species distributions, and altering wildfire behavior.	The proposed project would result in temporary greenhouse gas (GHG) emissions during construction. Long-term benefits would be increased wetlands and riparian areas that may sequester carbon, as well as improved watershed function that would increase wildfire resiliency, provide habitat refugia from temperature and precipitation extremes and prevalence of drought, and improve habitat conditions for vulnerable species.

Resource	Climate-Related Effects	Project Effects
Stream and River Water Temperature	Klamath Basin water temperatures have risen approximately 0.9^{0}F (0.50C) per decade between 1960 and 2001. 1.2^{0}F (0.65^{0}C) per decade between 1995 and 2017. Climate change impacts to water temperatures are likely to continue to increase, resulting in declining habitat conditions for cold water fish and aquatic species.	Water conservation projects that would augment streamflow during high water temperatures and/or low streamflow can enhance likelihood of survival for a few aquatic T&E individuals of which there are already low in numbers. Restoration of rivers and streams creates complex stream morphology and can lead to increased habitat availability for cold water fish species and amphibians. Lowering floodplains, restoring and creating wetlands and riparian areas, and restoring stream geomorphic processes can help to improve temperature and draught conditions that are exacerbated by increased average temperatures and prevalence precipitation extremes and drought, by creating conditions that allow for water to be retained in the watershed for longer periods of time, sequestering atmospheric carbon in both soils and vegetation, providing refugia for wildlife species during temperature extremes and wildfire, and providing habitat for rearing and spawning cold water fish species.
Forested Ecosystems	Warmer air temperatures primarily impact mixed conifer and ponderosa forests by increasing evaporative demand (Restaino et al. 2016), which enhances water stress and associated growth declines and tree mortality and contributes to catastrophic wildfire.	Restoration activities to reduce the spread of invasive plant species would improve native vegetative species survival rates. Measures to promote soil moisture include vegetative community enhancement, water conservation actions, and floodplain reconnection activities.
Riparian Reserves	Riparian areas and the associated microclimate are highly sensitive to environmental changes. Disruptions occur commonly after high flow events or loss due to wildfires that can cause riparian system nutrient accumulations to reach disruptive thresholds that suddenly change the system from a carbon sink to a source	Long-term beneficial effects are expected as a result of: • The Proposed Action would include restorative treatments that would improve health of the riparian and aquatic habitats and the connectivity to neighboring habitats for refuge from inhospitable changes from increased average temperatures and prevalence precipitation extremes and drought. • Removing invasive species/noxious weeds in riparian corridors is highly desirable to prevent further spread that could occur during flooding events from extreme precipitation events.

Resource	Climate-Related Effects	Project Effects
Wetlands	Compared to all terrestrial ecosystems, wetlands have the highest carbon density, which makes them play an important role in global biogeochemical and carbon cycles and increased average temperatures, precipitation extremes, and prevalence of drought (Kayranli et al. 2010). Climate change is identified as a major threat to wetlands. Warmer air temperature effects will increase evaporation from wetland areas and could promote drying around perimeter of wetland features. More extreme precipitation events along with increased air temperatures are expected to promote photosynthesis that could maintain wetlands as carbon sinks. Decreased precipitation, however, could have the opposite effect and wetlands may become sources of carbon loss.	Process-Based Restoration (PBR) techniques using woody materials, soil, and rock to slow water flows, spread and share flow into areas that may have dried up can successfully promote water retention in a drying stream, spring, or wetland area.

2. Proposed Action

The Trinity River Restoration Program (TRRP) was established to restore the fisheries of the Trinity River affected by dam construction and related diversions of the Trinity River Division (TRD) of the Central Valley Project (CVP). Administered by the Bureau of Reclamation (Reclamation), TRRP is a partnership of federal and state resource agencies, Tribes, and Trinity County. TRRP works to restore the processes and attributes of a properly functioning river and watershed to support the recovery of diminished salmon and steelhead populations while retaining the Trinity and Lewiston Dams' delivery of water and power to the Trinity River and California's Central Valley.

TRRP is the lead agency and the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) are cooperating agencies for the Project, the purpose of which is to improve instream and riparian habitat at a watershed scale and to accelerate the recovery of north coast salmon populations (coho salmon, steelhead, and Chinook salmon), thereby fulfilling tribal trust responsibilities and obligations to local communities as well as recreational and commercial fishing industries (per the Shasta-Trinity National Forest Land and Resource Management Plan and state and federal recovery plan goals [NMFS 2014; California Department of Fish and Game 2004]).

The following describes the overall objectives of the Proposed Action:

- Restore and improve instream conditions sufficient to support all life stages of salmonids and other aquatic species.
- Restore upstream and downstream fish passage for all life stages of salmonids.
- Restore continuous paths for wood dispersal, nutrient cycling, sediment transport, and movement of other vegetative material essential for productive aquatic habitat.
- Maintain or restore native plant communities and vegetative structure impacted by invasive plants and pathogens, while rehabilitating eroding streambanks to improve water quality, shade conditions, and large wood recruitment.
- Repair, replace, or remove ineffective instream structures.
- Restore and improve riparian and meadow habitat in order to promote healthy conditions for aquatic and terrestrial wildlife populations.
- Improve late summer/fall base flow conditions through process-based restoration, water conservation improvements, and meadow restoration.

The Proposed Action consists of a suite of instream and riparian restoration activities that are designed to meet the objectives described above. Detailed descriptions of each of the proposed activity categories are included in Chapter 3 of the Project's Environmental Assessment (EA) document. Proposed Activities are grouped into three general categories: instream habitat restoration; upslope habitat restoration; and road maintenance, rehabilitation, and decommissioning activities. The activities proposed under each of these categories are summarized below.

1. Instream Habitat Restoration:
   - Restoration and Enhancement of In-Channel Habitat
   - Floodplain Restoration

- Removal or Retrofitting of Fish Passage Barriers, Small Dams, Flood Gates, Pilings and Other In-water Structures
- Water Conservation Projects
- Salmon Carcass Placement
- Remote Site Incubators

2. Upslope Habitat Restoration:

- Bioengineered Bank Stabilization
- Aquatic, Wetland, Riparian, and Upslope Habitat Enhancement

3. Road Maintenance, Rehabilitation, and Decommissioning Activities:

- Road Maintenance
- Road Rehabilitation
- Road Decommissioning

The Proposed Action is designed to comply and help achieve the desired outcome of the Aquatic Conservation Strategy (ACS), which is described Appendix C of the Project Environmental Assessment (EA), and in Appendix B6 of the Northwest Forest Plan (NWFP; Forest Service 1994). The ACS is a framework to guide the restoration and maintenance of the ecological health of watersheds and aquatic ecosystems on public lands within the habitat range of anadromous fish in the Pacific Northwest.

2.1 Project Location and Timing

The proposed activities would occur within a portion of the Trinity River watershed shown in Figure 2-1 below. Individual restoration actions would take place in and along tributaries of and the mainstem Trinity River (both above and below the Lewiston and Trinity dams) on both private (with permission of the landowner) and public lands (primarily managed by the USFS and BLM). The interrelationships between increased average temperatures, precipitation extremes, and prevalence of drought and proposed activities to be implemented in certain areas are described in this technical report.

Key watersheds within the restoration activity area include North Fork Trinity River, South Fork Trinity River, Canyon Creek, and New River. These watersheds are particularly important because of the instream habitat that they provide for aquatic species. Within these watersheds, new roads are prohibited in roadless areas, and a no net increase of roads outside roadless areas is enforced by the USFS with the intent of preventing further habitat degradation.

For the EA, including this technical report, effects analyses were performed generally using the hydrological unit code 10 (HUC 10) watersheds. See Table 2-1 for watersheds included in the Project activity area.

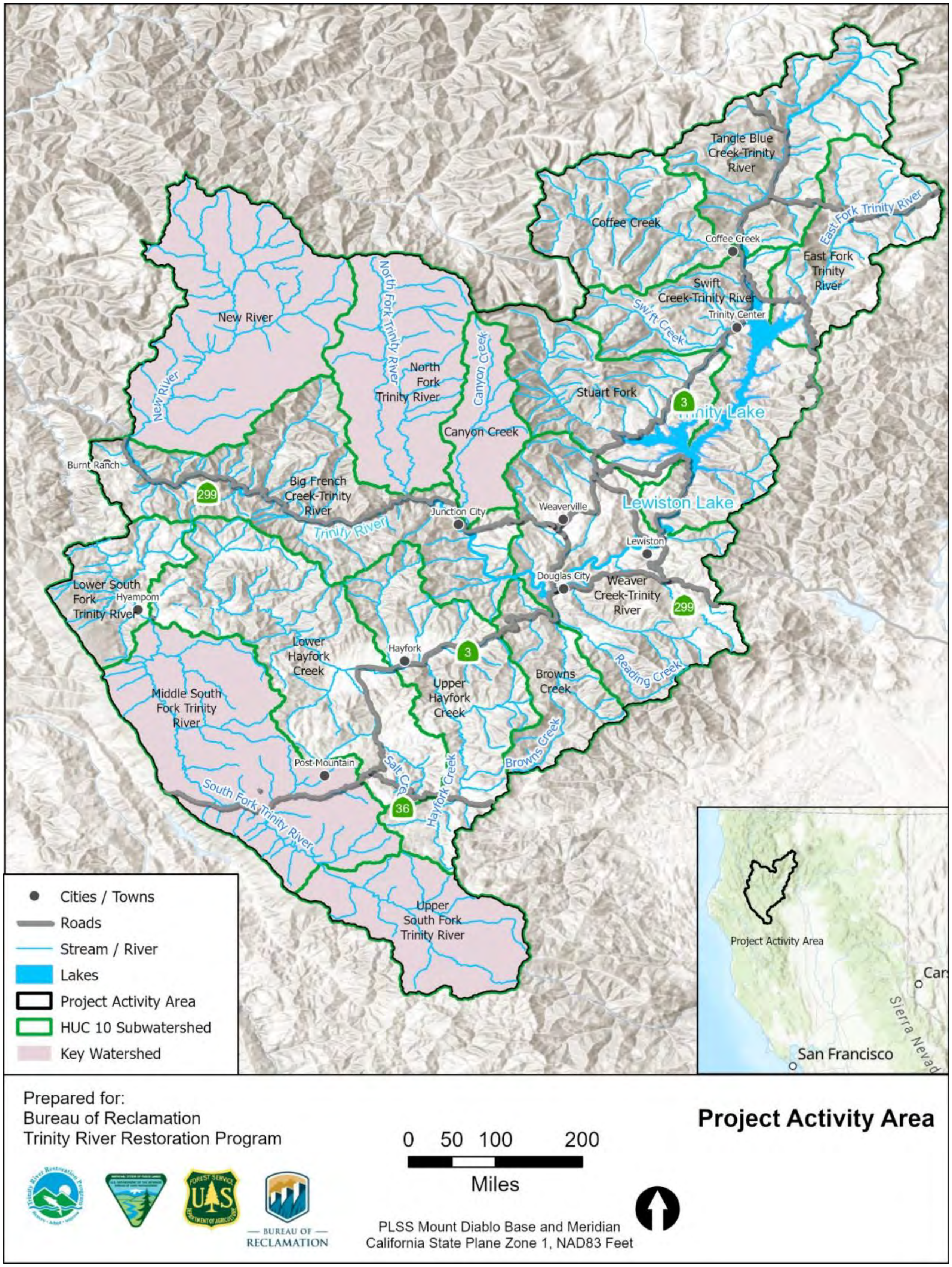

Figure 2-1. Project Activity Area (including Key Watersheds)

Table 2-1. HUC 10 Watersheds within the Trinity River Basin.

Subregion (HUC 4)	Basin (HUC 6)	Subbasin (HUC 8)	Watershed (HUC 10)	HUC 10 Number	Acres in Project Activity Area
Klamath-Northern California Coastal 1801	Northern California Coastal 180102	Trinity California 18010211	Big French Creek-Trinity River[1]	1801021111	153,325
			Browns Creek	1801021106	47,110
			Canyon Creek[4]	1801021108	41,033
			Coffee Creek	1801021101	74,835
			East Fork Trinity River	1801021103	74,335
			Horse Linto Creek-Trinity River[2]	1801021112	0
			New River[4]	1801021110	149,597
			North Fork Trinity River[4]	1801021109	97,483
			Stuart Fork	1801021104	88,264
			Swift Creek-Trinity River	1801021105	121,055
			Tangle Blue Creek-Trinity River	1801021102	101,393
			Weaver Creek	1801021107	142,030
		South Fork Trinity 18010212	Lower South Fork Trinity River[3,4]	1801021205	44,229
			Lower Hayfork Creek	1801021203	142,161
			Upper Hayfork Creek	1801021202	105,697
			Middle South Fork Trinity River[4]	1801021204	145,776
			Upper South Fork Trinity River[4]	1801021201	73,634

1. [1] A portion of Big French Creek is excluded from the Project activity area, namely the Sharber Creek HUC 12 subwatershed, because it is in the Six Rivers National Forest.
2. [2] Horse Linto Creek is located in the Six Rivers National Forest and is not included in the Project activity area.
3. [3] A portion of Lower South Fork Trinity River is excluded from the Project activity area, namely Grouse, Mingo, and Old Campbell Creeks (HUC 12 subwatersheds), because they are located in the Six Rivers National Forest.
4. ACS Key Watersheds

3. Environmental Setting

From its headwaters in the Salmon-Trinity Mountain range, in Trinity County, California, the Trinity River flows westward for 112 miles then enters the Klamath River near the town of Weitchpec, California. The Trinity River passes through Trinity and Humboldt counties and the Hoopa Valley (Hoopa Tribe) and Yurok Indian Reservations. The Klamath River flows northwesterly for approximately 40 miles from its confluence with the Trinity River before entering the Pacific Ocean near Requa, California.

The Trinity River watershed is located within two different geologic provinces: the inland Klamath Mountain and Coast Range provinces. Plate tectonics processes took a relatively thin oceanic plate and collided with a thicker, more buoyant continental crust, uplifting and deforming it to produce today's complex landscape. The Coast Range Province consists primarily of the Franciscan Assemblage and South Fork Mountain Schist, which is composed of generally unstable rocks of sedimentary and volcanic origin. The majority of the Trinity River basin lies within the Klamath Mountain Province to the east, formed by older metamorphic and igneous intrusive or plutonic rocks. Large granitic intrusions exist in the headwaters of Grass Valley Creek and along Rush and Weaver creeks, all originating in the Trinity Alps, which are part of the Salmon-Trinity range. Highly erodible slopes in these tributaries are a chronic source of fine sediment to the Trinity River system.

The Trinity River is an important water source for irrigation, hydroelectricity generation, and critical habitat for threatened and endangered salmonid species. River channels are formed and maintained by the dynamic interaction of three primary components: sediment of various size classes, varying quantities and ages of vegetation, and varying amounts of water. Complex interactions between these three components define the geomorphic environment and provide a diversity of physical structures (Sherer 2007). This complexity provides a variety of riverine and riparian habitats that can be used by different aquatic species under a range of flows.

Historically, the Trinity River functioned as a dynamic river reach that provided quality spawning and rearing habitat for anadromous fish. During the period of heavy gold mining that began in 1849 when gold was discovered in California, the mining practices and water diversions that were constructed wreaked havoc in Northern California, including the Trinity River basin. Roads were built rapidly in order to access gold first. The steep rugged terrain and complex geology of the region did not impede development. Virtually all tributaries have been subjected to hydraulic mining activities that removed streamside vegetation, thereby increasing water temperatures for lack of shade. Within the mainstem Trinity River, the limited distribution of coho salmon can likely be explained, at least in part, by water temperature (Reclamation 2019). The biological productivity and fish carrying capacity of much of the Trinity River basin has been reduced (USFWS and HVT 1999; EPA 2001). In addition, degradation of freshwater habitat has been pervasive in the Lower Klamath River contributing to declines in native fish runs (Gale and Randolph 2000).

The construction of Trinity Dam (California's 3rd largest reservoir holding 2.4 million acre-feet [MAF]) began in 1956 and was finished by 1962 as part of the Central Valley Project (CVP) to provide water for the agricultural farms of the Central Valley and for consumption in Southern California. Lewiston Dam was constructed just a year later as the afterbay of the Trinity Power Plant. Lewiston Dam is now the upper limit of anadromous fish migration on the Trinity River as no fish passage facilities have been built to allow fish to move further upstream. In addition, numerous barriers that deter the passage of aquatic organisms exist throughout the watershed.

At times, 90% of the Trinity River flow had been diverted to the Sacramento River basin, also contributing to the decline of Chinook salmon, coho salmon, and steelhead (NMFS 2014). This caused severe degradation of aquatic habitat of the Trinity River due to loss of deep-water habitats and a limited ability to maintain cool water temperatures required for cold-water fish survival. The minimal flows released were insufficient to maintain the Trinity River below the dams and, much of the mainstem between Lewiston and the North Fork Trinity River confluence became confined to a narrow channel bordered by densely vegetated berms. Today, flow diversion from the Trinity River basin to the Sacramento River basin has been adjusted so that about 50% of flows are kept in the Trinity River system downstream of the dams.

3.1 Northern California Climate Conditions

The climate of Northern California is characterized by cool wet winters and hot dry summers. The Trinity River is predominantly a rain-fed river. Annual precipitation in the watershed averages 57 inches. Precipitation ranges from 37 inches in lowlands around Weaverville and Hayfork, to as high as 85 inches in mountain ranges closer to the coast. The highest Trinity River flows occur between December and April. Large intense Pacific storms frequently strike California's north coast causing rapid runoff events and flooding. The high rainfall rates combined with rugged geography results in extremely fast runoff and a high risk of flooding during winter storms. Large volumes of rock and sediment carried by floods are spread along the streams forming wide alluvial channels. Almost no precipitation occurs in summer (August through October). Very low flow and warm waters limit available fisheries habitat. The primary source of summer flow is groundwater base flow and snowmelt (when snowfall persists at higher elevations).

The TRRP continues to add sediment (gravel) within the 40-mile reach downstream of the Lewiston Dam and fine sediment impairment in the Grass Valley Creek area has been remediated (e.g., from the Hamilton ponds). In addition, TRRP-managed flows have been implemented yearly since 2004. Ongoing monitoring efforts by TRRP partners continue to document improvements in aquatic habitat use, alluvial processes, and riparian vegetative communities along the mainstem. Continued sediment augmentation projects are intended to improve anadromous fish spawning and rearing habitat in the Trinity River mainstem.

Air temperatures are rising and snowmelt is occurring much more rapidly. Significant increases in average mean annual temperatures between +1.66 to +2.76°F have been recorded at all the local weather stations (Butz et al. 2022). In recent years, the Trinity River watershed has been in a state of moderate to extreme drought with record high temperatures. Warmer temperatures reduce the snowpack and alter the seasonality and runoff volumes of the hydrograph; the result of which is larger runoff events occurring earlier in the year due to a shift in precipitation falling as rain rather than snow (OEHHA 2023). The altered hydrograph patterns strain the ability of reservoir water managers (in this case, Reclamation) to provide cold-water releases for salmonids because of reduced cold water storage. Anadromous salmonids are dependent on cold-water to support their life cycle; therefore, the lack of cold water further stresses these vulnerable fish populations. Simultaneously, human demands for water are increasing at a time when streams are at all-time low-flow levels. Water warms more rapidly in shallow streams that have been depleted from water use demands, reducing and sometimes eliminating suitable cold-water aquatic habitat that is critical for fish survival.

Asarian et al. (2023) completed a review and synthesis of Trinity River mainstem and tributary water temperature data, and concluded the following with respect to increased average temperatures, precipitation extremes and prevalent drought:

> *Snowpack is likely to decline substantially as air temperatures rise (Micheli et al. 2018). For example, under a high-emissions scenario, average snow water equivalent in areas above 3,000 ft elevation is predicted to decline from 11.6 inches in 1981–2010 to 4.3 inches in 2040–2069 and 1.6 inches in 2070–2099 (Micheli et al. 2018). The combination of more rain, less snow, and earlier snowmelt will cause earlier runoff and lower flows in spring and summer (CDWR and USBR 2016, Mote et al. 2014)... The date by which 50% of annual runoff has occurred is predicted to shift 9–42 days (varies by site scenario) earlier in the 2070s (USBR 2016). In the mainstem Trinity River, but not the tributaries, these changes will be somewhat ameliorated by capturing runoff in Trinity Reservoir.*
>
> *Water temperatures in the Trinity River and its tributaries are highly affected by river flow in the spring and summer… so are likely to rise substantially. Based solely on rising air temperatures, not including hydrologic effects (which as noted in the previous sentence are likely to be strong), water temperatures at several sites in the Trinity River Basin are predicted to increase 0.6–1.3°C (Flint and Flint 2012). In the adjacent Salmon River watershed, mean daily maximum August stream temperatures are predicted to be warmer than the 1990–2017 baseline by 0.9–2.0°C under the reduced-emission RCP4.5 scenario or 1.7–3.3°C under the high-emission RCP8.5 scenario, depending on the reach, with larger rivers warming more than small streams (Asarian et al. 2019).*

Storage in Trinity Reservoir is expected to be substantially impacted … in the future with both lower end of September storage volumes… and warmer release temperatures...

3.2 Trinity River Watershed Temperatures

Water temperatures in Trinity River tributaries vary on a seasonal cycle and typically range between 68^0 to 84^0F (20^0 to 29^0C) in the summer (July – August) and temperatures at or below freezing in the winter (December – February). Asarian et al. (2023) describe the watershed temperatures:

Mid-summer temperatures tend to be higher at sites with larger drainage areas, although there are many exceptions to this trend (i.e., high temperatures at Rush Creek and low temperatures at Horse Linto Creek). At most sites, water year type appears to exert a strong influence on temperatures during spring runoff (April–July), with much cooler temperatures in wetter years than drier years.

The temperature of the Trinity and Lewiston reservoirs is affected by the temperature of the un-dammed tributaries above the dams; and mainstem Trinity River temperatures are influenced both by the timing and temperature of dam releases and by the temperature and timing of runoff from watershed tributaries that enter the river below the dams (Watercourse Engineering 2002, cited in Asarian et al. 2023). The temperature of reservoir water at depth, which is released into the mainstem, is typically cold but increases when the reservoir is drawn down. Temperature increases are most notable during periods of prolonged draught when the Trinity Reservoir has been drawn down to very low levels (Asarian et al. 2023). In a synthesis of 87 years of temperature data for the Trinity Watershed, Asarian et al. (2023) found that previous studies indicate that water elevations below 750,000 acre-feet (AF) tend to increase the occurrence of thermally problematic conditions for cold water fish. Overall, water temperatures at release depths from the Trinity Dam have been approximately 1.8^0F (1^0C) warmer during the period between 1998 and 2019, when compared to previous periods. Air temperature increases have risen in the region, as discussed above; and is likely have an impact on both the temperature of the Trinity Reservoir as well as the tributaries above and below the dam.

Asarian et al. (2023) note that it is difficult to quantify response of water temperatures to increased average temperatures, precipitation extremes, and prevalence of drought; and that current predictions likely underestimate the magnitude of the increases that are likely to occur. In their review of stream temperature studies, they found that water temperatures in the Klamath Basin watersheds, including the Trinity Watershed, increased approximately 0.9^0F (0.5^0C) per decade between 1960 and 2001. Temperatures within streams in the Klamath Basin increased 1.2^0F (0.65^0C) per decade between 1995 and 2017. These increases indicate that regional and Trinity River watershed stream temperatures have increased and that increases are becoming greater in magnitude, over the past 55 years, in conjunction with increased average temperatures, precipitation extremes, and prevalence of drought. The degradation of ecological conditions of the Trinity River mainstem below Lewiston Dam, and its tributaries is identified in Asarian et al.'s (2023) review as an exacerbating factor to stream temperature characteristics:

[T]hermal heterogeneity allows ectothermic organisms like juvenile salmonids to choose water temperatures that maximize digestion rates and growth given their food intake (Brewitt and Danner 2014; Brewitt et al. 2017) or to seek refuge from warm summer temperatures where cold water pools (Nielsen et al. 1994; Brewitt and Danner 2014; and others)…historical land use (i.e., mining) and damming and diversion have severely limited the range of temperatures present in

the unrestored channel during spring when flows are elevated but cannot spread out on floodplains.

3.3 Vegetation, Ecosystems and Wildfire

3.3.1 Forested Ecosystems

Years of wildfire exclusion has led to crowded overstocked conifer tree stands competing for space, water, and sun. This leaves forests more prone to insects, disease, and wildfire. Ecosystem damage is inevitable when wildfires occur under these conditions. The amount of live forest land in the Shasta-Trinity National Forest (STNF) decreased from 1990 to 2020 by about 57,884 acres. Roughly 98,500 acres burned at moderate and high burn severities (82% and 18%, respectively) in the Trinity River watershed over the last 15 years (2008-2023). This averages 0.5% (6,566 acres) of the watershed burned per year. Roughly half of the moderate burn severity areas are assumed to retain live vegetation.

The 2020 August Complex wildfire burned more than 1.3 million acres on multiple national forests and was the second largest fire in the Trinity River watershed, burning 36,000 acres. Eighty percent of the lands burned in the Trinity River watershed over the last 15 years had the most damage during the fires that occurred in 2015 and 2020. Salvage of dead trees occurred on most of the private lands, but little salvage occurred on federal lands due to dead trees deteriorating more rapidly than it takes to complete the NEPA process and salvage effort.

The forests in the Trinity River watershed are primarily evergreen forests, consisting of ponderosa pine (*Pinus* ponderosa) and Douglas-fir (*Psuedotsuga menziesii*). Stand ages are mostly over 80 years old with fewer young stands. Total ecosystem carbon stocks or pools, which is the amount of carbon stored in a forest ecosystem system, decreased by 0.4% in the Trinity River watershed from 1991 to 2020, and the primary disturbance influencing carbon uptake and storage, excluding soil carbon, was timber harvest. Carbon stocks, excluding soil carbon, the Trinity watershed would have been approximately 0.2% higher in 2011 if timber harvest had not occurred since 1990 and another 0.4% higher in 2020 if wildfires had not occurred. Soil biogenic carbon values, also known as carbon sequestration or storage, have high uncertainty because of data and modeling limitations and are likely underestimated. Forest stand development dynamics, a myriad of disturbances, climatic patterns, and environmental fluctuations have impacted ecosystem carbon uptake and storage in the watershed.

Disturbances such as wildfires, insects, and disease are likely to increase, with consequent effects on forest carbon. Carbon uptake and storage in the watershed may be increasingly vulnerable to numerous threats related to increased average temperatures, precipitation extremes, and prevalence of drought and its interactions with forest patterns and processes.

3.3.2 Wetlands and Aquatic Habitats

The highest aerial cover of emergent herbaceous wetlands occurs in the Swift Creek (2,093 acres), Stuart Fork (949 acres), East Fork Trinity River (676 acres), and Coffee Creek (142 acres) HUC 10 watersheds. Other HUC 10 watersheds, including Big French Creek, Middle South fork Trinity River, and Weaver Creek, have less than 100 acres of emergent herbaceous wetlands, while Canyon Creek, Lower Hayfork, New River, North Fork Trinity River, and Upper South Fork Trinity River have less than 10 acres of emergent herbaceous wetlands. The highest aerial cover of woody wetlands occurs in Coffee Creek (1,002 acres), Tangle Blue Creek (441 acres), Swift Creek (310 acres), and Weaver Creek (218 acres). The remaining watersheds have less than 100 acres of woody wetlands.

The Swift Creek Trinity River has the highest aerial cover of open water with 6,970 acres. Stuart Creek has 3,128 acres of open water, East Fork Trinity River has 586 acres, and Big French Trinity River has 241 acres of open water. The remaining watersheds have between zero and about 200 acres of open water. Big French Creek Trinity River, Middle south Fork Trinity River, and Stuart Fork have the highest acreage of deciduous forest.

Wetland and aquatic habitats will experience increased use and pressures as many wildlife species are seeking water sources in wetland and aquatic areas that are subject to physical shrinkage and water quality impacts as a result of increased average temperatures, precipitation extremes, and prevalence of drought.

3.3.3 Riparian Reserves

The riparian zone is an extremely dynamic area connecting aquatic and terrestrial ecosystems. It is one of the most diverse, complex, and active transitional habitats on Earth, supporting very high biodiversity (Naiman and Decamps 1997; Tockner and Stanford 2002). Riparian areas and the associated microclimate are highly sensitive to environmental changes. Disruptions occur commonly after high flow events or loss due to wildfires that can cause riparian system nutrient accumulations to reach disruptive thresholds that suddenly change the system from a carbon sink to a source (Naiman and Decamps 1997).

Instream large wood that is provided to streams and rivers from trees within the riparian zone has an important role in fluvial and biological processes. Accumulations of wood typically have at least one large wood piece upon which debris jams form. Instream wood piles dissipate stream energy, trap moving materials, and form instream habitat. Depending on size, position in the channel, and geometry, they can resist and redirect water currents, causing the erosive power of water to become spatially heterogeneous, thereby creating a mosaic of aquatic habitats. Maintaining and promoting continuity of healthy functioning riparian zones is key to providing refuge for aquatic and terrestrial wildlife species during transitional climatic stress.

4. Environmental Consequences

The focus of the following effects analysis is on existing and projected future temperature and precipitation effects to processes and conditions in the Trinity River basin that would be affected by the Proposed Action alternative or without implementation of the Project restoration activities (No Action alternative).

4.1 Climate Change Effects

4.1.1 GHG Emissions

The Road Construction Emissions Model Version 9.0.0 was used to estimate GHG emissions for combustible fuel using assumptions of how many and what types of vehicles and machinery would be used to complete construction of project activities (CAPCOA 2024). Several projects ranging from minor culvert replacements to complex construction of wetland and stream habitat would be implemented each year throughout the watershed. Minor and complex projects would likely require hauling and transporting materials, excavation, and grading, which would generate GHG emissions from diesel- and gasoline-powered vehicles and equipment. More complex projects would also involve grubbing and land clearing, lowering of floodplains, creation of side channels and new channel alignments, excavation of ponds, removal of trees and vegetation, installation of upland and in-channel features, and extensive revegetation and monitoring. Medium and large size projects may also include road decommissioning and rehabilitation.

To determine the effect of the Proposed Action, a "carbon footprint" was developed based on the project activities potential generation of GHGs (primarily carbon dioxide [CO_2]). Project activities that would offset potential impacts were weighed into the equation. For minor projects, the calculation is based on up to 1 week of construction and one piece of equipment. Medium-sized projects would require up to a month of construction, and large projects would be extensive restoration efforts that would take up to a year. The calculation is based on up to 50 projects of varying sizes and complexity being completed in a year. Table 4-1 outlines the maximum GHG that is estimated to be produced by a single project and cumulatively during a year.

Based on the calculations in Table 4-1, annual GHG emissions associated with the use of heavy equipment would be measurable with the range of project activities. Emissions would be limited to the project construction period and GHG emissions and any effects on increased average temperatures, precipitation extremes, and prevalence of drought would be at least partially offset in the long-term by the benefits from restoration activities that increase the amount of riparian and upland vegetation.

Table 4-1. Estimated Maximum GHG, Measured as CO_2, by Project Size, per Year.

Size	Description	Estimated CO_2 per Site (tons)	Potential Number of Projects per year	Estimated Maximum CO_2 (tons)
Small	May take up to a week to complete not including restoration and monitoring; smaller than 1 acre; example: culvert replacement, remote site incubator installation, road maintenance activities	2.7	35	94.5
Medium	May take up to a month to complete not including restoration and monitoring; smaller than 10 acres; road decommissioning, road rehabilitation, small instream or upslope habitat restoration projects	22.1	10	221.0
Large	May take up to six months to complete not including restoration and monitoring; larger than 10 acres; large tributary or mainstem in-stream or upslope restoration project	304.2	5	1,521.0
All			**50**	**1,836.5**

4.1.2 Avoidance and Minimization for GHG Emissions

Due to the high fire hazard and history of equipment-caused fires in Trinity County, construction contractors would be required to follow BLM's applicable regulations as well as California PRC 4428–4442 during dry periods to minimize the potential for the initiation and spread of fire from the work site. Compliance with these federal and state requirements would reduce the potential for emissions due to wildland fire.

Environmental commitments listed in Appendix B are incorporated into the Proposed Action to reduce effects on GHG emissions. The following measures would be used to enhance the awareness of increased average temperatures, precipitation extremes, and prevalence of drought when implementing project activities:

- Provide project contractors with educational material about fuel efficiency and incentives.
- Promote incentives for contractors to initiate ride-sharing programs.
- Promote the use of energy-efficient and alternative fuel construction equipment and transportation fleets through contract incentives.
- Require contractors to provide recycling bins for onsite waste materials.
- Provide incentives for contractors to use reusable water containers rather than plastic-bottled water.
- Provide incentives for contractors to hire locally to reduce travel time.
- Require reusable batteries for equipment that can use them.

4.2 Trinity River Watershed Temperatures

The Proposed Action would have a potential beneficial effect on stream and river temperatures that are being adversely impacted by increased average temperatures, precipitation extremes, and prevalence of drought. Restoration of rivers and streams creates complex stream morphology and can lead to increased habitat availability for cold water fish species and amphibians. Lowering floodplains, restoring and creating wetlands and riparian areas, and restoring stream geomorphic processes can help to improve temperature and draught conditions by creating conditions that allow for water to be retained in the watershed for longer periods of time, sequestering atmospheric carbon in both soils and vegetation, providing refugia for wildlife species during temperature extremes and wildfire, and providing habitat for rearing and spawning cold water fish species.

In addition to in-channel and upslope restoration, proposed water conservation activities would augment streamflow during high water temperatures and/or low streamflow can enhance likelihood of survival for a few aquatic T&E individuals of which there are already low in numbers.

The No Action alternative would result in no beneficial effect that would reduce or offset increased average temperatures, precipitation extremes, and drought impacts in the watershed.

4.3 Vegetation, Ecosystems, and Wildfire

4.3.1 Forested Ecosystems

The Middle South Fork Trinity River and Big French Creek watersheds have the most forested land of all of the HUC 10 watersheds in the Trinity River basin. Long-term effects as a result of increased air temperatures are anticipated. The snowpack is less likely to fully develop when air temperatures are higher; and when it does develop, increased temperatures could cause early and rapid runoff, sometimes in the form of rain on snow events. High temperatures cause increased water evaporation and temperature of surface waters, which decreases surface and subsurface water storage and degrades water quality. Increased air temperatures also depletes soil moisture. Decreases in both soil moisture and water availability causes a reduction in forest growth rates and decreased carbon over the landscape. In addition to suppressed forest growth, the potential for wildfire has also increased. Wildfires are also likely to cause significant carbon storage losses, not only within the Trinity River basin but within the entire region.

These effects would continue under the No Action alternative while the Proposed Action would address these effects in the Project activity area to some extent. Restoration activities to reduce the spread of invasive plant species would improve native vegetative species survival rates. Measures to promote soil moisture include vegetative community enhancement, water conservation actions, and floodplain reconnection activities.

4.3.2 Wetland and Aquatic Habitats

If the Proposed Action alternative is implemented, measures would be taken to decrease water loss and enhance water storage such as the mechanical and process-based restoration techniques that include using native materials, wood, rocks to plug and slow down water movement and to promote activation of the floodplain, improve stream morphology, and establish wetland and aquatic habitat. These activities would promote resilience within these aquatic ecosystems. The Swift Creek and Stuart Fork HUC 10 watersheds include the largest overall area classified as wetlands and water (see the EA Appendix J, Vegetation, Botany and Wetlands Technical Report). Restoration activities to reduce the spreading of invasive plant species would improve native wetland vegetative species survival rates. Measures to promote wetland soil moisture would include vegetative community enhancement, in-stream and upslope restoration techniques, water conservation actions, and floodplain reconnection activities.

4.3.3 Riparian Reserves

The proposed Watershed Restoration Project has been designed to assist TRRP, BLM, USFS, and partner organizations in achieving these nine ACS objectives for the Trinity River watershed. The Trinity Watershed-riparian reserves are discussed in the EA Appendix C, ACS Compliance; and in the EA Appendix J, Vegetation, Botany and Wetlands Technical Report).

With ongoing disruptions within the riparian zone as a result of flood events anticipated as a result of precipitation extremes and a decrease in large wood recruitment due to wildfires, the No Action alternative would continue the trend of riparian ecosystem functions becoming increasingly limited within the Trinity River basin.

With the Proposed Action, 16 HUC 10 watersheds would be targeted for restoration activities focused on riparian reserves. The Proposed Action would include restorative treatments that would improve health of the riparian and aquatic habitats and the connectivity to neighboring habitats for refuge from inhospitable changes from increased average temperatures, precipitation extremes, and prevalence of drought. Long-term beneficial effects are expected as a result of restoration within the riparian reserves that enhance floodplains and develop or restore access to diverse aquatic habitats would provide some of the most desirable long-term effects that enhance riparian and aquatic habitat and floodplain connectivity. In addition, removing invasive species/noxious weeds in riparian corridors is highly desirable to prevent further spread that could occur during extreme precipitation events.

The Project was developed using the ACS objectives that would benefit populations of native cold-water fishes throughout their life cycles and would help maintain the diverse mosaic of habitat types on the landscape that are essential for population resilience (Beechie et al. 2013). The Project focuses on riparian vegetation and instream habitat improvements that increase channel complexity and instream habitats. Removing and improving roads is intended to not only restore fluvial processes while also improving water quality by reducing erosion and instream sedimentation; but also to remove barriers that have prevented access to upstream aquatic habitats upstream that are presently inaccessible.

5. Regional Effects

Regional effects include the short- and long-term impacts of a project together with the past, present, and future actions of other projects that may or have been occurring in the Trinity Watershed region. The analysis considered other actions that have affected or could affect temperature and precipitation as the Proposed Action alternative. The effects of past actions are reflected in the descriptions of existing conditions. Lands in the vicinity of the Project activity area include USFS-, BLM-, and privately-owned land.

Climate change will likely exacerbate the incremental and regional effects from past, present, and future actions, including cannabis farming, residential development, resources extraction, wildland fire control, fuels reduction, and aquatic habitat restoration, when taken together with the Proposed Action and the No Action alternative.

5.1 Cannabis Farming

In 2018, the State of California legalized the recreational use of cannabis, as well as the cultivation and manufacture of cannabis plants and products. In Trinity and Humboldt counties, there are many cannabis farms which collectively reduce flow volume and increase discharge of waste and pollutants in streams which affects water quantity and quality in the Project activity area. Presently, there is no watershed scale evaluation of the effects of cannabis farming on aquatic habitat in the Trinity River or to particular streams from cannabis farms and illegal cannabis cultivation on public lands The operation of cannabis farms throughout the watershed will continue to negatively affect aquatic resources in the Trinity River and tributaries that are being taxed by increased average temperatures, precipitation extremes, and prevalence of drought (NMFS 2020). The Proposed Action would help to improve watershed health that is being impacted by cannabis farming and further exacerbated by increased average temperatures, precipitation extremes, and prevalence of drought.

5.2 Residential Development

Human population growth in the Project activity area is expected to remain relatively stable over the next 10 years as California's economy continues to recover from a long-lasting nationwide recession. The recession has had significant economic impacts at both the statewide and local scales with widespread impacts to residential development and resource industries such as timber and fisheries. However, some development will continue to occur which, on a small-scale, can affect localized aquatic habitat resources that are impacted by increased average temperatures, precipitation extremes, and prevalence of drought. Once development and associated infrastructure (e.g., roads, drainage, and water development) are established, the effects to aquatic species are expected to be permanent (NMFS 2020). Anticipated effects to aquatic resources include loss of riparian vegetation, changes to channel morphology and dynamics, altered hydrologic regimes (increased storm runoff and increased water diversions for residential use), increased sediment loading, and elevated water temperatures where shade-providing canopy is removed (NMFS 2020). The project would improve the overall aquatic habitat resilience and function that is affected by both residential development and by increased average temperatures, precipitation extremes, and prevalence of drought.

The presence of structures and/or roads near waters may lead to the removal of large wood to protect those structures from flood impacts, which may be more frequent under increased average temperatures, precipitation extremes, and prevalence of drought. The anticipated effects on vegetation resources from continued residential development are expected to be sustained and locally intense. Commonly, there are also effects of home pesticide use and roadway runoff of automobile pollutants, introductions of invasive species to nearby streams and ponds, and loss of riparian and upland habitat due to land clearing activities. All these factors associated with residential development can have negative effects on vegetation resources by impacting vegetation communities and habitat for special status species. However, population growth rate in Trinity County decreased by about 11% between 2010 and 2019 (U.S. Census Bureau 2020). This may indicate a trend that could ameliorate or reduce the effects of residential development (NMFS 2020). Improved watershed conditions may result in greater resiliency for residential properties and communities in the region by reducing catastrophic consequences of flooding, draught, and wildlife.

5.3 Resource Extraction

Resource-based industries are likely to continue to have an influence on environmental conditions within the Project activity area for the indefinite future. Logging continues to be conducted throughout the HUC 10 watersheds. Some mining for gravel, aggregate, and minor precious metals occurs on the Trinity River floodplain and a few tributary watersheds. If flow is decreased by mining operations, riparian vegetation could be affected. The lack of protective measures in existing regulatory mechanisms, including land management plans (e.g., State Forest Practice Rules), contributes in varying degrees to stress on forest resources. However, resource extraction industries have adopted management practices that reduce many of their most harmful impacts, which were unknown or not commonly used until recently (NMFS 2020).

The proposed project may result in improved watershed conditions through in-channel and upslope restoration; culvert replacement, road maintenance, and rehabilitation of roads that may be used for extraction activities; and decommissioning of roads that contribute to diminished watershed health. Restoration activities would result in increased ecosystem function and health, including providing habitat and resilience for vegetation communities that may be impacted by resource extraction.

5.4 Wildland Fire Control and Fuels Reduction

The Klamath River watershed which includes the Trinity River watershed is completely within a “Priority Landscape” designated to address the Wildfire Crisis Strategy. This work is to reduce and control the spread of wildland fires. It frequently includes the removal or modification of vegetation and construction of firebreaks to prevent fire progression, but also through backfires that also control the spread of fire. Fuels reduction is often employed by BLM and USFS to proactively prevent wildfires or to slow the spread of fire, especially near human structures. The BLM has initiated the Statewide Wildland Urban Interface Fuels Treatments (SWFT) program (BLM 2023). Fuels reduction treatments are intended to reduce fire by modifying the vegetation structure, density, and fuel loads by removing live and dead vegetation.

Fuels reduction is proposed more often in and adjacent to the Wildland Urban Interface. Streams and wetlands create a natural fire break, and most fuels reduction treatments would not affect streams or riparian habitat. Because Project restoration activities would improve and increase native vegetation, increase and activate larger floodplain areas, reconnect aquatic habitat and stream habitat, increase habitat for native vegetation the Proposed Action would offset some of the loss of vegetation from fuels reduction and would not add incrementally to regional effects. The Proposed Action would also result in increased refugia during wildfire and improved resiliency in the watershed.

5.5 Aquatic Habitat Restoration

Since 2009, the TRRP has implemented Trinity River mainstem projects at all the Phase 1 channel rehabilitation sites named in the 2000 Master EIR and at nine of the Phase 2 sites. The Deep Gulch and Sheridan sites were constructed in 2017. The Bucktail site constructed in 2008 was expanded in 2016 to include additional areas. The Dutch Creek project was constructed in 2020. The Chapman Ranch Phase A site was constructed in 2019 and the Phase B site was completed in 2021. The Oregon Gulch project was completed 2023. Sky Ranch, Upper Conner Creek, and Sawmill are proposed to be completed in the next few years. These mainstem projects are anticipated to restore riparian vegetation by creating a greater diversity of wetland and riparian habitat within the Trinity River floodplain.

The TRRP continues to add sediment (gravel) within the 40-mile reach downstream of Lewiston Dam and fine sediment impairment in the Grass Valley Creek area has been remediated (e.g., from the Hamilton ponds). In addition, TRRP-managed flows have been implemented yearly since 2004. Ongoing monitoring efforts by TRRP partners continue to document improvements in aquatic habitat use, alluvial processes, and riparian vegetative communities along the mainstem.

Beyond TRRP's mainstem channel rehabilitation and sediment augmentation projects, there have been several restoration and road sediment reduction projects implemented by various agencies and organizations throughout the Trinity River watershed. While some of these were considered in the 2009 Master EIR, USFS, Five Counties Salmonid Conservation Program, Watershed Research and Training Center, and Trinity County Resource Conservation District have been funded for and/or completed additional projects intended to improve watershed conditions, restore aquatic habitat, improve aquatic connectivity, and reduce road-related sediment delivery to streams and rivers. These watershed restoration projects are intended to improve water quantity and quality as well as rearing habitat in the Trinity River watershed. Watershed and mainstem aquatic restoration activities would have a beneficial effect on natural resources impacted by increased average temperatures, precipitation extremes, and prevalence of drought.

5.6 Conclusion

The Proposed Action would have an overall long-term benefit on the Trinity Watershed including the evergreen mixed conifer forests and wetlands, but specifically in the rivers, tributary streams and riparian reserves. Climate change has and will continue to negatively impact the regional and Trinity Watershed temperature and water quality, upland, riparian, and wetland ecology. This project proposes long term benefits to aquatic, riparian and watershed resources, with relatively minor short-term adverse effects. There are no adverse regional effects as a result of the implementation of the Proposed Action.

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