

Muir Woods National Monument  
California

US Department of the Interior  
National Park Service



# Salmon Habitat Enhancement and Bridge Replacement Project at Muir Woods

FINAL ENVIRONMENTAL ASSESSMENT



June 2018



# Table of Contents

<b>Chapter 1 Purpose and Need for Action .....</b>	<b>1-1</b>
1.1 Introduction .....	1-1
1.2 Purpose .....	1-2
1.3 Need.....	1-2
1.4 Goals .....	1-6
1.5 Summary of Public Scoping Comments .....	1-6
1.6 Scope of the Environmental Assessment .....	1-6
1.7 Environmental Topics Dismissed from Further Analysis .....	1-7
1.8 Environmental Topics Retained for Further Analysis .....	1-8
 <b>Chapter 2 Alternatives .....</b>	 <b>2-1</b>
2.1 Introduction .....	2-1
2.2 No Action Alternative.....	2-1
2.3 Creek Restoration Alternatives.....	2-1
2.4 Pedestrian Bridge Replacement Alternatives .....	2-18
2.5 Construction Methods.....	2-27
2.6 Operations and Maintenance Activities.....	2-41
2.7 Best Management Practices.....	2-41
2.8 Alternatives Considered and Dismissed from Further Analysis .....	2-41
 <b>Chapter 3 Affected Environment .....</b>	 <b>3-1</b>
3.1 Introduction .....	3-1
3.2 Cultural Resources.....	3-1
3.3 Threatened or Endangered Species .....	3-18
3.4 Geology: Soils and Bedrock.....	3-21
3.5 Visitor Use and Experience.....	3-22
3.6 Transportation.....	3-22
3.7 Wildlife Habitat.....	3-22
3.8 Water Resources and Hydrologic Processes .....	3-23
3.9 Vegetation .....	3-30
3.10 Visual Resources.....	3-31
3.11 Soundscapes.....	3-31
3.12 Air Quality and Greenhouse Gas Emissions .....	3-32
 <b>Chapter 4 Environmental Consequences .....</b>	 <b>4-1</b>
4.1 General Methodology for Assessing Impacts.....	4-1
4.2 Cumulative Impacts Analysis Methodology .....	4-1
4.3 Cultural Resources.....	4-2
4.4 Threatened or Endangered Species .....	4-10
4.5 Geology: Soils and Bedrock.....	4-20
4.6 Visitor Use and Experience.....	4-25

4.7	Transportation.....	4-31
4.8	Wildlife Habitat.....	4-35
4.9	Water Resources and Hydrologic Processes .....	4-39
4.10	Vegetation.....	4-55
4.11	Visual Resources.....	4-61
4.12	Soundscapes.....	4-65
4.13	Air Quality and Greenhouse Gas Emissions .....	4-69
<b>Chapter 5 Consultation and Coordination.....</b>		<b>5-1</b>
5.1	Compliance with Agency Consultation Requirements .....	5-1
5.2	Internal Scoping.....	5-5
<b>Chapter 6 List of Preparers.....</b>		<b>6-1</b>
<b>Chapter 7 References.....</b>		<b>7-1</b>

## Appendices

Appendix A	Riprap Condition Report
Appendix B	California Environmental Quality Act Checklist
Appendix C	Response to Comments
Appendix D	Best Management Practices

## Figures

Figure 1-1.	Proposed Action Location (Revised).....	1-3
Figure 1-2.	Juvenile Salmonid Use of Wood Jams.....	1-5
Figure 2-1.	Creek Restoration Alternative 1 (Revised) .....	2-7
Figure 2-2.	Creek Restoration Alternative 2 (Revised) .....	2-10
Figure 2-3.	Creek Restoration Alternative 3 (Revised) .....	2-12
Figure 2-4.	Creek Restoration Alternative 4 (Revised) .....	2-14
Figure 2-5.	Creek Restoration Alternative 5 (Revised) .....	2-17
Figure 2-6.	Actions Common to all Pedestrian Bridge Replacement Alternatives .....	2-21
Figure 2-7.	Typical Bridge Cross Section .....	2-23
Figure 2-8.	Bridge 2 Designs .....	2-25
Figure 2-9.	Bridge 3 Designs .....	2-26
Figure 2-10.	State Park Lands and Staging Areas .....	2-29
Figure 2-11.	Proposed Equipment Access for Riprap Removal Upstream of Bridge 2 .....	2-31

Figure 2-12.	Proposed Equipment Access for Riprap Removal Downstream of Bridge 2 .....	2-38
Figure 2-13.	Pedestrian Bridge abutment options.....	2-40
Figure 2-14.	Cat 308 Excavator .....	2-39
Figure 2-15.	DW60 Wheel Dumper .....	2-41
Figure 3-1.	Direct Area of Potential Effects Sheet 2 of 11 .....	3-3
Figure 3-2.	Percent of pool and shallow water habitats in Redwood Creek between 1995 and 2015 for Reaches 1-6. Reach 6 (outlined) contains the Proposed Action. ....	3-19
Figure 3-3.	Height of ground surface above the channel bed in MWNM. Channel cross-sections illustrate typical channel geometry and bank height. The channel at all cross-sections were surveyed and extended across the floodplain using the 2010 LiDAR data (NHE 2017).....	3-28
Figure 3-4.	Floodplain inundation within Muir Woods for flows with recurrence intervals between 2 and 100 years (NHE 2017). ....	3-29
Figure 4-1.	Sediment Budget for Phase 1 of Creek Restoration.....	4-45
Figure 4-2.	Sediment Budget for Phase 2 of Creek Restoration.....	4-46

## Tables

Table 2-1.	Summary of Creek Restoration Alternative Elements.....	2-5
Table 2-2.	Summary of Pedestrian Bridge Replacement Alternative Elements .....	2-19
Table 3-1.	Riprap condition and visibility .....	3-15
Table 3-2.	Summary of flood-frequency estimates at the four bridge sites and Fern Creek confluence with Redwood Creek within Muir Woods. ....	3-25
Table 4-1.	Flow Capacity for Bridges 1 through 4 under existing, Pedestrian Bridge Replacement Alternative A, Pedestrian Bridge Replacement Alternative B, and Pedestrian Bridge Replacement Alternative C.....	4-51
Table 5-1.	Regulatory Permits, Approvals, and Consultations Relevant to the Proposed Action.....	5-3

# Acronyms and Abbreviations

## A

ABAAS	Architectural Barriers Act Accessibility Standard
APE	area of potential effect

## B

BA	biological assessment
BAAQMD	Bay Area Air Quality Management District
BMP	best management practice
Br.	bridge

## C

CARB	California Air Resources Control Board
CBA	choosing by advantage
CCC	Civilian Conservation Corps
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFM	cubic feet per minute
CFR	Code of Federal Regulations
CGS	California Geological Survey
CH <sub>4</sub>	methane
CNPS	California Native Plant Society
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> e	carbon dioxide equivalent
CRLF	California red-legged frog
CWA	Clean Water Act
CY	cubic yard(s)

## D

dBA	decibel
DBH	diameter at breast height
DPS	distinct population segment

DS	downstream
<b>E</b>	
EA	environmental assessment
EIS	environmental impact statement
EO	executive order
ESA	Endangered Species Act
ESU	evolutionarily significant unit
<b>F</b>	
FEMA	Federal Emergency Management Agency
FIRM	flood insurance rate map(s)
FWCA	Fish and Wildlife Coordination Act
<b>G</b>	
GGNRA	Golden Gate National Recreation Area
GHG	greenhouse gas
GMP	general management plan
<b>I</b>	
IRMA	Integrated Resource Management Applications
<b>L</b>	
LF	linear feet
LWD	large woody debris
<b>M</b>	
MT	metric ton
MWNM	Muir Woods National Monument
<b>N</b>	
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NHE	Northern Hydrology and Engineering
NHPA	National Historic Preservation Act
NHTSA	National Highway Traffic Safety Administration
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxides
NPS	National Park Service

NRCS	National Resources Conservation Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity units
<b>P</b>	
PM	particulate matter
<b>R</b>	
RWQCB	Regional Water Quality Control Board
<b>S</b>	
SFAN	San Francisco Bay Area Network
SOD	sudden oak death
SWPPP	stormwater pollution prevention plan
SWRCB	State Water Resources Control Board
SWD	small woody debris
<b>T</b>	
t/y	tons per year
<b>U</b>	
US	upstream
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
<b>V</b>	
VOC	volatile organic compound
<b>W</b>	
WRCC	Western Regional Climate Center

# Chapter 1

## PURPOSE AND NEED FOR ACTION

### 1.1 Introduction

The Draft Environmental Assessment (EA) has completed its public review process, resulting in revisions prior to release of this Final EA. Comments received on the Draft EA, and responses to those comments, are provided as Appendix C of this Final EA. In response to public comments, changes were made to portions of the Draft EA, as reflected in this Final EA. Also, in a commitment to thoroughness, the National Park Service (NPS) has incorporated several minor, self-initiated project additions/clarifications into the Final EA. Several figures have been revised to reflect these changes with “Revised” noted in the figure title, and two new figures were added. These clarifications do not substantially alter the project or the significance conclusions in this EA, nor would they result in any new impacts not analyzed in the Draft EA.

Designated a national monument in 1908, Muir Woods National Monument (MWNM) has a rich cultural and natural history. MWNM protects old-growth redwood forest, as well as the portion of Redwood Creek that flows through the park. Channel processes have been altered for many decades, and watershed-level issues have resulted in channel incision in Redwood Creek and MWNM. Most of the project reach is highly disconnected from its floodplain. Management actions in the 20th century exacerbated the loss of sediment that would have helped the channel recover its connection to the floodplain and maintain in-channel complexity for habitat. During the 1930s, the Civilian Conservation Corps (CCC) placed rock armoring (riprap) along the banks of Redwood Creek. This riprap is now understood to interfere with natural channel processes, which are important for habitat creation and ecological health of the creek and nearby forest. Additionally, during much of the 20th century, the NPS removed fallen logs from the creek. Although this practice ended by the late 1980s, the rate of large-diameter wood in the channel is still significantly below that in unaltered channels in old-growth redwood forests. Without wood, there is little opportunity to trap sediment in the creek and recover from incision. As a combined result of incision, bank hardening, and a low rate of wood, the project reach is oversimplified and does not provide good habitat for the resident Coho salmon (*Oncorhynchus kisutch*), a federally and state-listed endangered species. Four existing non-historic wooden pedestrian bridges that cross Redwood Creek within MWNM function to provide a visitor experience of the creek and connect to trails on hillslopes on both sides of the creek. These bridges are aging and constraining the stream channel, and are in need of replacement.

All life stages of Coho salmon occur in Redwood Creek. Although a high rate of Coho spawning occurs in the project reach, juvenile abundance is lowest within the project reach. Juvenile numbers have been low overall in Redwood Creek in recent years, but are lowest in MWNM. The Central California Coast evolutionarily significant unit (ESU) of Coho has been listed as endangered under the federal Endangered Species Act (ESA). Improvements to juvenile Coho habitat within MWNM would likely improve juvenile survivorship because such improvements would provide rearing closest to much of the spawning area. Steelhead trout (*O. mykiss*) (steelhead) are also present in Redwood Creek. The Central California Coast distinct population segment (DPS) is listed

as threatened under the federal ESA. Project actions would benefit steelhead as well as Coho salmon.

### ***Proposed Action***

NPS is proposing to enhance juvenile Coho habitat within Redwood Creek through a suite of in-channel actions to improve the conditions most needed for juvenile salmon to survive. Proposed actions include the removal of some riprap from banks and burial of some of this riprap, placement of large woody debris (LWD), and installation of small woody debris (SWD) structures often referred to as “beaver dam analogs.” NPS also proposes to replace the four existing pedestrian bridges. These activities are collectively referred to as the Salmon Habitat Enhancement and Bridge Replacement Project at MWNM, and are referred to in this EA document as the Proposed Action. Figure 1-1 displays the location of the Proposed Action. The majority of proposed activities would occur within MWNM. Actions proposed to occur on California State Parks land include staging during Phase 1, staging at Alice Eastwood Campground, use of Alice Eastwood Road for site access for bridge construction and Phase 1 restoration activities, the use of Kent Canyon or Pantoll ranger station as potential riprap storage locations, and floodplain grading and riprap removal in the vicinity of the Plaza.

Both creek restoration and bridge replacement actions were identified in the General Management Plan (GMP) and were analyzed programmatically in the GMP Environmental Impact Statement (EIS) (NPS 2014). This EA analyzes a specific plan to complete these actions.

## **1.2 Purpose**

The purpose of this action is to enhance habitat for juvenile Coho salmon and natural stream processes, as well as to replace four aging pedestrian bridges across Redwood Creek. Although some trail realignment or removal may occur as part of the Proposed Action, this document is not intended as a comprehensive master trail plan for MWNM. Future trail adjustments may be made that would reduce impacts on channel function, but those trail modifications would not entail in-stream actions. All proposed trail relocations are those needed to meet the goals of the proposed action.

## **1.3 Need**

The project is needed to address low juvenile Coho abundance in Redwood Creek and bridges that are deteriorating. Coho salmon are at risk of extirpation within Redwood Creek (Fong et al. 2016). Data collected over some 15 years by NPS demonstrates that the in-stream action that is most likely to support the Coho salmon population consists of improving juvenile Coho salmon habitat within MWNM. There are two critical life stage weak points for Coho in Redwood Creek: the number of returning spawning adults and the survival rate of fry to juveniles. The Proposed Action address the survival rate of fry to juveniles.



C:\Users\GIS\Documents\ArcGIS\PROJECTS\16039\_GGNPC\_CohoCompliance\mxd\Public\Final\Fig1-1\_Location.mxd 5/2/2018 RH

BaseMap Sources: Esri, HERE, DeLorme, Mapmy India, © OpenStreetMap

**Figure 1-1  
Project Location**

- Project Area
- Trail
- Redwood Creek and Tributaries
- Muir Woods National Monument boundary
- Mt. Tamalpais State Park

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project

The decline of Coho salmon habitat has occurred due to multiple factors of many decades. The legacy of CCC riprap placement and past removal of LWD are two of the many factors that have led to poor habitat conditions for juvenile Coho in the MWNM reach of Redwood Creek. While Redwood Creek in MWNM has relatively high numbers of spawners, juvenile rearing is low in this reach (Fong et al. 2016). This reach has low numbers of channel pools, which are important for juvenile rearing (Fong et al. 2016). Pools associated with LWD provide high-quality juvenile habitat, as shown in Figure 1-2. Increased juvenile habitat in MWNM (near spawning grounds) would increase survival of juvenile Coho. Other actions, particularly the Redwood Creek Coho Salmon Captive Rearing Project, are addressing the number of returning adults in the short term. Even if the numbers of adult spawners are increased in Redwood Creek, the creek still needs better habitat for survival of fry to the juvenile stage. The Proposed Action is highly complementary to the other management actions undertaken in the watershed, including the extensive restoration project undertaken at Big Lagoon, restoration in the Banducci Reach of Redwood Creek, and other ongoing NPS management actions to protect Coho salmon. Removal of riprap and placement of LWD within the channel would increase rearing habitat for juvenile salmon by increasing habitat complexity and supporting pool formation. Enhancing natural stream processes within Redwood Creek would also have a beneficial impact on the primeval redwood forest, which is important for future visitor experience of MWNM.

The CCC-era riprap is considered a contributing element to the cultural landscape in MWNM, which is listed in the National Register of Historic Places (NRHP) (Auwaerter and Sears 2006). Three dams that also date to the CCC era are located within MWNM and continue to function today as grade control within Redwood Creek. One of the dams, Log Check Dam, retains sufficient integrity to be a contributing element to the NRHP-eligible cultural landscape. These features represent erosion control practices and fine workmanship conducted by the CCC.

Pedestrian bridges in MWNM (Bridges 1 through 4 crossing Redwood Creek) are reaching the end of their useful life due to degrading structural integrity. The bridges, particularly Bridges 2 and 3, are restricting natural stream flow and have been damaged by woody debris and high water. Bridges 2 and 3 can only currently accommodate the 2-year flow, and are flooded at larger storm flows (Northern Hydrology and Engineering [NHE] 2017). Bridge 1 can currently accommodate the 25-year flow, while Bridge 4 can accommodate the 50-year flow (NHE 2017). The bridges' abutments constrain the channel, and the ability to pass LWD is limited. Replacement of the bridges with longer spans, higher elevations, and a rustic design would enhance and support habitat restoration goals, improve visitor safety and accessibility, ensure long-term structural integrity and decrease maintenance needs, and enhance the rustic character of the monument through bridge design. Longer spans are needed to meet both the flood-flow conveyance and pedestrian accessibility goals. MWNM is committed to meeting Architectural Barriers Act Accessibility Standard (ABAAS) for outdoor areas in the bridge designs.

**Figure 1-2** Juvenile Salmonid Use of Wood Jams

This wood jam occurs downstream of MWNM (downstream of the Dipsea crossing). In a March 2017 snorkeling survey, this wood jam had the highest count of juvenile Coho and steelhead in or near MWNM. Juvenile salmon prefer the deeper water and cover provided by wood jams.

## 1.4 Goals

The five goals of the Proposed Action are defined below.

1. Enhance winter/spring habitat for Coho fry and juveniles and summer habitat for Coho and steelhead juveniles through in-stream actions, floodplain enhancement, and bank revegetation.
2. Mitigate and minimize adverse effects to the cultural resources to the extent possible while also allowing an updated understanding of conservation to be achieved for the health of the channel, salmon populations, and redwood forest.
3. Restore natural geomorphic processes where possible, given constraints to channel function such as the existing trail system and the need to maintain much of the channel bank revetment as a cultural resource.
4. Replace pedestrian bridges with new designs that improve projected channel function, accommodate visitor access for all users, and enhance the rustic character of MWNM.
5. Reestablish floodplain connectivity where feasible, given existing constraints such as trails on top of banks, to provide winter salmonid habitat, decrease channel high flow velocities, and increase groundwater recharge.

Additional measurable objectives for achieving primary goals are:

- Increase sediment retention and deposition in the project reach to re-aggrade the channel and reconnect the floodplain over the long term.
- Increase the frequency of LWD and SWD.
- Decrease channel high flow velocities.
- Increase pool depth.
- Increase the frequency of pools.

## 1.5 Summary of Public Scoping Comments

A public scoping meeting about this project was conducted on September 20, 2016, and public scoping comments were accepted through October 21, 2016. Fourteen comment letters were received from private citizens, environmental organizations, and nonprofits including People for a Golden Gate National Recreation Area, Sierra Club, Marin Conservation League, Save our Seashore, Watershed Alliance of Marin, National Parks Conservation Association, Environmental Action Committee of West Marin, and Mount Tam Task Force. The majority of comments focused on increasing the extent of habitat enhancement in the Proposed Action. Other major themes addressed in the comments include effects on trails, details of bridge designs and locations, timing of the project, impact analysis and mitigation, as well as the overall National Environmental Policy Act of 1969 (NEPA) process. In addition, several public agencies participated in field visits and provided input on the potential actions, including National Marine Fisheries Service (NMFS), Regional Water Quality Control Board (RWQCB), California Department of Fish and Wildlife (CDFW), California State Parks, and U.S. Army Corps of Engineers (USACE). Comments and other input were used to refine the alternatives presented in Chapter 2 of this EA.

## 1.6 Scope of the Environmental Assessment

This EA analyzes the No Action and Proposed Action alternatives and their respective potential impacts on the environment. This EA has been prepared in accordance with the NEPA, as amended,

and implementing regulations, 40 Code of Federal Regulations (CFR) Parts 1500–1508: Protection of Environment, 43 CFR Part 46: Implementation of the National Environmental Policy Act of 1969, Director’s Order 12: Conservation Planning, Environmental Impact Analysis, and Decision-making (NPS 2011) and its handbook (NPS 2001, 2015a), Section 106 of the National Historic Preservation Act of 1966 (NHPA), and section 7 of the ESA.

Although a number of projects are being considered in the Muir Woods area, this EA is limited to those actions described in Chapter 2, Alternatives. This project is related in geographic area but not connected to the projects described in Section 4.2, Cumulative Impacts Analysis Methodology.

The actions described herein:

- do not trigger another action;
- can proceed independent of other actions;
- are not interdependent on the implementation of any of the projects described in the cumulative effects section (Chapter 4);
- and do not depend on any of the projects described in the cumulative effects section (Chapter 4) for their implementation.

The actions proposed herein would affect trails within MWNM as the project proposes trail changes as part of creek habitat restoration and bridge replacement work. However, this EA is not a comprehensive trail planning effort for MWNM, and the scope of this EA related to trail changes is limited to only those changes described herein. The actions described herein meet the "independent utility" test in that they could be implemented with or without the implementation of any other project taking place in the MWNM area.

## 1.7 Environmental Topics Dismissed from Further Analysis

Three resource topics have been eliminated from further analysis based on the nature and scope of the Proposed Action. A brief summary and description of each of these resource topics is provided below.

### ***Nightsky***

Night work would not occur during implementation of the Proposed Action, thus there would be no impact on nightskies. Therefore, the topic was dismissed from further analysis in this document.

### ***Socioeconomics***

The Proposed Action would generate economic activity from minimal increases in employment during construction, creating beneficial economic effects; however, such effects would be small due to the short-term nature of construction. As such, the Proposed Action would not be anticipated to meaningfully affect the local economy or community character. Therefore, the topic was dismissed from further analysis in this document.

### ***Environmental Justice***

The Proposed Action would not result in disproportionate health or environmental effects on minorities or low-income populations or communities. Therefore, this topic was dismissed from further analysis in this document.

## ***Land Use Impacts Related to Population and Housing Growth***

The Proposed Action would not affect local or regional land use or controls of the adjacent area, including growth of population or housing because the project will only consist of creek restoration actions and bridge replacement within MWNM. The project would also not displace housing or anyone within the MWNM or the adjacent local area. Therefore, this topic was dismissed from further analysis in this document.

## **1.8 Environmental Topics Retained for Further Analysis**

### ***Air Quality and Greenhouse Gas Emissions***

The removal and burial of riprap, removal of existing bridges, and construction of new bridges would result in localized emissions at the monument because of temporary construction activities. Therefore, this impact topic is carried forward for detailed analysis.

### ***Cultural Resources***

To comply with Section 106 of the NHPA, NPS must “take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register [of Historic Places].” MWNM was entered into the NRHP in 2008, excluding a 50-acre parcel added in 1974. The Final GMP/EIS identified trail modifications and targeted riprap removal along Redwood Creek as a minor adverse cultural resource impact (NPS 2014). The document concluded that, when combined with the preservation of other elements, the Section 106 determination of effect on historic structures, districts and cultural landscapes for MWNM would be no adverse effect (NPS 2014). Several trails are contributing elements to the NRHP-eligible property. The riprap along Redwood Creek, constructed between 1934 and 1938, is also considered a contributing element to the NRHP-eligible property. Therefore, this impact topic is carried forward for detailed analysis.

### ***Threatened or Endangered Species***

The Proposed Action is intended to improved habitat for Coho salmon as well as steelhead trout. Northern spotted owl (*Strix occidentalis caurina*) is an additional species that may be impacted by the Proposed Action. Critical habitat for marbled murrelet (*Brachyramphus marmoratus*) is located on California State Park property immediately surrounding MWNM, but is not located within the monument itself. The California red-legged frog (CRLF) (*Rana draytonii*) is known to occur and breed downstream of the monument. Therefore, this impact topic is carried forward for detailed analysis.

### ***Geology: Soils and Bedrock***

Placement of LWD would have an impact on soils through the use of the cable grip hoist method of log movement. Rerouting of trails would also have an impact on soil resources. The Final GMP/EIS identified targeted riprap removal as a long-term moderate beneficial impact on geologic resources and soils (NPS 2014). Therefore, this impact topic is carried forward for detailed analysis.

### ***Visitor Use and Experience***

One of the basic purposes of the NPS is to provide visitors opportunities to enjoy the parks. Implementation of the Proposed Action would impact visitor use and experience during construction due to construction activities and temporary closures of portions of some trails. The project as a whole is intended to improve visitor experience and would contribute to the goal of presenting MWNM as a contemplative outdoor setting where visitors experience the primeval

forest and learn about the monument's place in United States conservation history (NPS 2014). Therefore, this impact topic is carried forward for detailed analysis.

### ***Soundscapes***

Anthropogenic noise would temporarily increase during implementation of the Proposed Action because of construction activities, equipment, vehicular traffic, and crews. Acoustic impacts from construction would be temporary and would have temporary effects on visitors, employees, or natural soundscape conditions. Therefore, this impact topic is carried forward for detailed analysis.

### ***Transportation***

The Proposed Action could affect local transportation during riprap removal/burial and bridge removal and construction due to increased truck traffic in the vicinity of MWNM. Therefore, this impact topic is carried forward for detailed analysis.

### ***Wildlife Habitat***

The Proposed Action would have short-term construction-related effects on wildlife and wildlife habitat and long-term effects on habitat due to changes in hydrology and geomorphology within Redwood Creek. Therefore, this impact topic is carried forward for detailed analysis.

### ***Water Resources and Hydrologic Processes***

The Proposed Action would take place within and across waters of the United States and would affect hydrology. The different alternatives would have different effects on these resources. Also, the Proposed Action may have effects on sedimentation. Therefore, this impact topic is carried forward for detailed analysis.

### ***Vegetation***

Implementation of the Proposed Action would have an effect on vegetation within the monument. These effects would be both short term due to construction and longer term based on changes in the channel due to removal of riprap and future channel evolution. Revegetation of channel banks where riprap is removed would occur. Additionally, sensitive plant species including locally rare species are located within MWNM. Therefore, this impact topic is carried forward for detailed analysis.

### ***Climate Change***

The Proposed Action is anticipated to have minimal effects on climate change due to the release of greenhouse gas emissions during construction. Climate change would also have an effect on the project. Therefore, this impact topic is carried forward for detailed analysis. This impact topic will be addressed within each relevant impact topic and will not be addressed under a separate section.

### ***Visual Resources***

Creek restoration activities and bridge replacement would both have temporary and long-term effects on visual resources within MWNM. Creek restoration activities would result in a channel that is more similar to conditions occurring in unaltered old-growth forests. Visual conditions near the channel would be more complex, with increased large wood in the channel and a less manicured visual condition. Visitors would experience a greater range of old-growth forest characteristics along Redwood Creek. Replaced bridges will be longer and higher than the existing bridges. This impact topic is carried forward for detailed analysis.

### 2.1 Introduction

This chapter describes alternatives for the various elements of the Proposed Action (Creek Restoration and Bridge Replacement) consistent with the purpose of, and need for, action. As the different project elements are somewhat independent of one another, they are described as element alternatives. For actions described as occurring on the right or left bank of Redwood Creek, these directions are relative to the view looking downstream.

The Proposed Action must provide for both visitor use and resource protection (NPS 2006). The Final GMP/EIS for Golden Gate National Recreation Area and MWNM National Monument (2014) states that “portions of the main trail and bridges could be relocated to allow for creek and floodplain restoration and improvements to the integrity of the redwood forest ecosystem” and “the historic creek stabilization rock work could be removed in targeted areas to restore natural creek functions important to forest health.” Removal of all historic riprap in Redwood Creek was not considered as an alternative, as it does not meet the GMP guidance of targeted riprap removal. The elements described below represent a range of reasonable and feasible approaches to achieve these goals. These elements are also in line with NPS management policies regarding watershed and stream processes (NPS 2006).

Modifications to trails identified as part of Creek Restoration and Pedestrian Bridge Replacement Alternatives do not represent the full set of possible trail modifications that could benefit channel function. These alternatives identify trail modifications that are needed to remove riprap and replace bridges. These trail changes are intended to keep existing trail corridors accessible to visitors. Other future trail modifications may be possible and may allow further improvements in channel or forest function but would not require additional riprap removal or other in-stream actions.

### 2.2 No Action Alternative

Under the No Action Alternative, no actions would be taken to improve habitat for salmonids or to encourage more natural geomorphic processes. No riprap would be removed, no LWD would be installed, and the four pedestrian bridges would either not be replaced or be replaced in-kind (same location, same material, same size). Under this scenario, it could be assumed that some trees may still fall in the channel intermittently. The trails network within MWNM would not change.

### 2.3 Creek Restoration Alternatives

Because all of the creek restoration alternatives focus on restoring habitat complexity within Redwood Creek, all would be guided by the same strategy, and all would have certain key project elements in common. To avoid redundancy, the following section describes the project elements that would be implemented with all creek restoration action alternatives. Table 2-1 summarizes elements in each Creek Restoration Alternative.

### ***Actions Common to All Creek Restoration Alternatives***

- NPS would conduct revegetation on creek banks and areas of the forest floor impacted by implementation. Revegetation on creek banks would only use native species, and would include species that would provide overhanging branches for cover for fish.
- Grade control would be installed in a small incised tributary on the east side of the creek just upstream of Cathedral Grove. Broken pieces of riprap removed during other project actions would be installed both by a small excavator where there is access and by hand in a series of check dams extending over approximately 150 linear feet (LF) of the tributary. Small equipment would reach the downstream end of the tributary by travelling a short distance on the main trail from Cathedral Grove to the tributary. It would not cross a wooden footbridge on the main trail. Slash may be placed in the tributary between the check dams to help trap sediment. The purpose of the grade control is to help reverse the incision that has occurred in this reach and potentially raise groundwater elevations on a very localized scale, which may help protect instream flows. The check dams may also capture sediment behind them and. This is a small-scale experimental action. As part of this action, a series of about six groundwater monitoring wells will be installed near the tributary and a control area to evaluate results.
- Heavy equipment would be used to excavate pools and build adjacent bars/riffles at wood jams. These actions would create immediate summer rearing habitat (pools) and enhance winter rearing depth as well as velocity.
- An undermined bank adjacent to the entrance boardwalk extending approximately 20 LF will be filled with riprap to prevent erosion or further undermining. A sewer line under the adjacent boardwalk will remain in place even after other segments of the sewer line would be moved farther from the creek; the entrance boardwalk is essential infrastructure for visitor resources. The rock will be placed so as to remain in a smooth line with other riprap both upstream and downstream of this feature.
- Erosion control methods may integrate the use of existing rock backing material (the 6- to 12-inch rock behind the riprap) to protect bank slopes without the use of erosion control fabric where there is sufficient banking material and the bank slope is adequate.
- Any toe material that occurs as part of a riprap segment will be removed along with the other riprap rock and the creek bed will be rebuilt to the existing grade with suitable native material.
- SWD structures referred to as “beaver dam analogs” will be installed intermittently throughout the project reach. They will be installed as part of the initial implementation but will also be added and/or modified in subsequent years to respond to new channel conditions. Most will extend across only about 50 to 75 percent of the channel and will initially target low-velocity areas to trap sediment. Where banks are suitably stable or do not support infrastructure, a few structures will span the channel to create ponds, trap sediment, provide low-velocity refuge for fry and juvenile salmonids, and aggrade the channel over time. They will also be used to help create low-velocity refuges at drainage confluences. The structures will extend about 1 to 2 feet above the bed. Those spanning the channel would incorporate segments of no more than 0.5 feet above the bed, as needed to accommodate fish passage. Many would be installed in association with other wood installations. The specific locations and characteristics of these dams have not been precisely determined, but they will be sited and designed as part of the construction design process.
- Riprap removed during Phase 1 would be buried in the channel, while riprap removed during Phase 2 would be offhauled.

### **Creek Restoration Alternative 1**

This alternative consists of in-stream actions mostly upstream of Bridge 3, with some actions upstream of Bridge 1 to enhance Coho habitat by removing riprap and installing large woody debris, as identified in *Salmon Habitat Restoration at Muir Woods Site Analysis, Conceptual Designs and Impact Analysis* (Northern Hydrology and Engineering [NHE] 2017). The 2017 NHE report identifies riprap segments that would be most suitable for removal, with the goal of improving juvenile rearing habitat for Coho as well as improving overall forest and riverine ecology. This alternative includes removal of 1,019 LF of riprap (30 percent of total riprap) over approximately 1 mile of channel and relocation of approximately 32 to 50 existing downed trees from upland areas into the channel into 17 locations (Figure 2-1). Pools near LWD installation would be excavated in some areas to provide immediate salmonid habitat. This alternative would result in an increase in summer habitat of approximately 15 percent and an increase in winter/spring Coho habitat of approximately 24 m<sup>2</sup>/100m. To reduce potential erosion after riprap removal, banks where riprap has been removed would be treated based on conditions at each specific location. Approximately 58 percent of banks are expected to be regraded to a 1V:1.5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have substantial mature root structures behind existing riprap, and since the roots can be very effective at resisting erosion, added treatments are not expected to be needed in those locations. Most actions would be conducted as part of Phase 1 implementation (mostly upstream of Bridge 3), and about 70 percent of the Phase 1 areas would have such bank erosion control, while the rest appear to have existing adequate root structure. Construction phases are described in detail in Section 2.5.

At riprap segment L10, which would be removed, base rock remains in the top of bank where an asphalt trail was removed by NPS in 2000. Since the base rock has prevented reestablishment of native plant cover, it would be removed from the former trail alignment (about 6 inches below the surface) to allow plant reestablishment that will better stabilize the bank after riprap removal. To maintain the same elevation of the ground surface, excess soil generated when some banks are sloped will be placed on the top of bank where the rock was removed. A layer of 6-inch rock occurs behind riprap segment R10 and extends about 4 to 5 feet behind the riprap to the valley wall. Since most of this segment cannot be removed without cutting all the way up to the valley wall, which could lead to future hillslope destabilization, this segment is not proposed for removal. As segment R10 is no longer proposed for removal, this has reduced the total length and percentage of riprap to be removed, as shown above.

The upstream half of segment L11 (L11A) would be re-stabilized, with its downstream end keyed into the bank well. This would provide long-term protection to the trail while allowing riprap removal at the downstream end of this segment (L11B). It would be re-stabilized using typical hand/mechanical methods to recreate a wall as it originally appeared. It will not consist of a newly engineered bank stabilization.

While all riprap upstream of Bridge 3 will be removed without the need to close trails within MWNM, the removal of a segment R6 just upstream of Bridge 2 will require temporary closure of the trail on the east side of the creek. Visitors will still have access upstream of Bridge 2 via the trail on the west side of the creek

### **Creek Restoration Alternative 2**

This alternative consists of all actions in Creek Restoration Alternative 1, plus additional habitat enhancement through riprap removal at the Plaza, and removal of a portion of trail and an additional riprap segment in Cathedral Grove (Figure 2-2). This alternative includes removal of 1,357 LF (40 percent) of riprap, representing an increase of 338 LF compared to Creek Restoration

Alternative 1. The 140 LF segment riprap (L7) in Cathedral Grove would be removed. As part of this action, the western side of the asphalt loop trail (approximately 350 LF) on the top of bank at Cathedral Grove would be removed prior to riprap removal.

With an existing split trail through Cathedral Grove, the main (eastern) leg of the trail would remain in place. A new trail configuration and gathering area in Cathedral Grove would be planned and implemented as part of a separate planning process. To reduce potential erosion after riprap removal, banks would be treated based on conditions at each specific location. About 45 percent of banks are expected to be regraded to a 1V:1.5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have substantial mature root structures behind existing riprap, and since the roots can be very effective at resisting erosion, added treatments are not expected to be needed in those locations. Most actions would be conducted as part of Phase 1 activities (mostly upstream of Bridge 3), and about 60 percent of the Phase 1 riprap removal areas would have such bank erosion control, while the rest appear to have adequate root structure. Construction phases are described in detail in Section 2.5. This alternative expands the geographic area of improvements to Coho habitat throughout more of the project reach, and would increase both summer and winter/spring Coho habitat.

### ***Creek Restoration Alternative 3***

This alternative consists of all actions in Creek Restoration Alternative 2, plus additional habitat enhancement through terracing of the right floodplain and installation of three engineered log jams in the channel adjacent to the Plaza (Figure 2-3). Bank treatments to reduce erosion described in Creek Restoration Alternative 2 would be used. Approximately 5,400 square feet would be terraced at two elevations, with a low terrace at about a 1-year flood elevation and a higher terrace at about a 1.5- to 3-year flood elevation. The existing landscape on the right bank consists of a high bench that does not function as floodplain. No redwood trees occur in the footprint of the proposed terracing. Approximately four to five mature alders are rooted between the top of the bank and the channel. These alders may be affected, or terracing may be able to protect them in place. Approximately 400 cubic yards (CY) of material would be excavated and would most likely be off-hauled to a landfill or, if possible, reused on site as part of re-contouring. The engineered log jams would be constructed using approximately 50 large-diameter logs (anticipated to be eucalyptus [*Eucalyptus* spp.]) imported from a separate project within the Redwood Creek watershed.

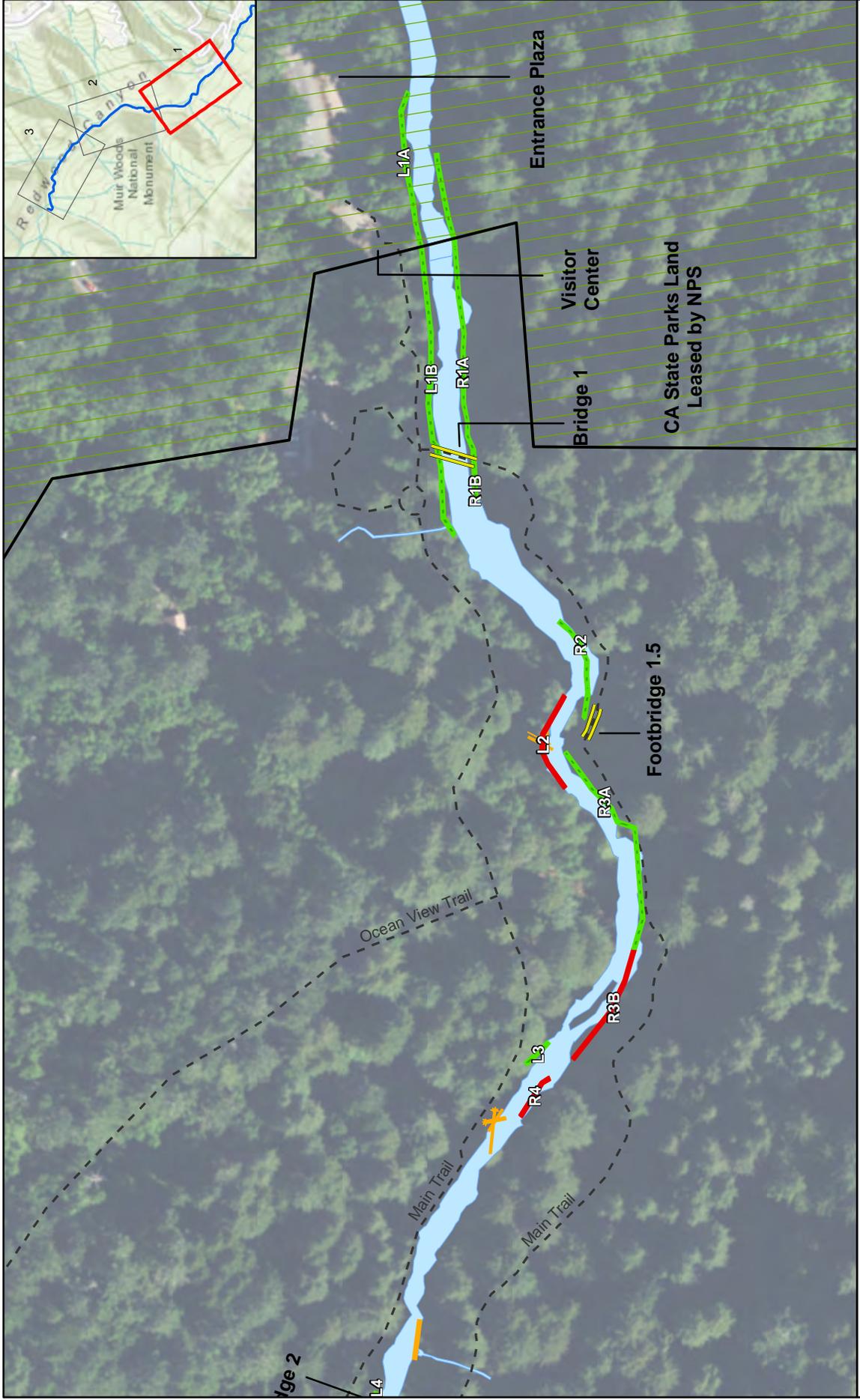
The root tissue of the eucalyptus logs would be manually ripped prior to installation to prevent eucalyptus from resprouting; this method has been used successfully before in other projects in Redwood Creek. The jams would be large structures with interwoven logs to provide cover, create scour, and trap sediment and would be persistent. Structures located against the right bank would be designed to encourage creation of secondary channels and lift flows onto the terraces.

These proposed actions are intended to address some of the channel incision in this reach by reconnecting a channel with its floodplain and encouraging storage of sediment on both the new floodplain and in the channel. The added cover, low-velocity refuge, and formation of scour pools and secondary channels would enhance habitat for juvenile salmonids.

**Table 2-1.** Summary of Creek Restoration Alternative Elements

	Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5 ( <i>Preferred Alternative</i> )
<b>Minimum Riprap Removal Area</b>	Mostly upstream of Bridge 3, but not including Cathedral Grove. One segment upstream of Bridge 2, and three segments upstream of Bridge 1.				Mostly upstream of Bridge 3, including Cathedral Grove. One segment upstream of Bridge 2, and five segments upstream of Bridge 1.
<b>Riprap Removal Area at Plaza</b>	None		Downstream of Bridge 1	(adjacent to Plaza)	
<b>Additional Riprap Removal Area</b>	None				Two locations where advance trail relocation is required: Between Bridges 1 and 2 and near Fern Creek
<b>Total Riprap Removal and % of All Riprap</b>	<b>1019 (30%)</b>	<b>1357 (40%)</b>	<b>1357 (40%)</b>	<b>1627 (48%)</b>	<b>1627 (48%)</b>
<b>Percent of All Visible Riprap Removed</b>	40		50		
<b>Phase I Riprap Burial</b>	234 CY		267 CY		293 CY
<b>Special Habitat Treatments:</b>	None	None	Lower the right bank at Plaza to floodplain elevation	Add alcove near footbridge 1.5 Area	Add Alcove near footbridge 1.5 Area and lower the right bank at Plaza to floodplain elevation
<b>Minimum Trail Alteration</b>	None		Remove one side of loop trail at Cathedral Grove (350 LF)		
<b>Additional Trail Alteration</b>		None			Relocate up to 440 LF on right bank near footbridge 1.5 and remove footbridge 1.5; relocate 115 LF on left bank near Fern Creek

	Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5 (Preferred Alternative)
<b>Large Woody Debris – Locations</b>	US of Br. 3 - @ 12 US of Br. 2 - @ 4 US of Br. 1 - @3 <b>Total: @ 19 Locations</b>	US of Br. 3 - @ 12 US of Br. 2 - @ 4 US of Br. 1 - @3 <b>Total: @ 19 Locations</b>	US of Br. 3 - @ 12 US of Br. 2 - @ 4 US of Br. 1 - @3 DS of Br. 1: @3 <b>Total: @ 22 Locations</b>	US of Br. 3 - @ 12 US of Br. 2 - @ 4 US of Br. 1 - @3, Plus Alcove Area: @1 DS of Br. 1: @3 <b>Total: @ 23 Locations</b>	
<b>Large Woody Debris Logs: Estimated Number and % of Fallen Logs on Floodplain, Hillslopes</b>	40–55 / 9 to 15%				
<b>Approximate Number of Imported Logs (for Plaza Area Only)</b>	None		50		
<b>Small Woody Debris Structures– Beaver Dam Analogs</b>	Intermittent locations throughout the project reach, to be added to and modified over time. Most will only partially span the channel; a few will span the channel.				



**Revised Figure 2-1**  
**Creek Restoration Alternative 1**  
 Sheet 1 of 3

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

	Bridge		Muir Woods National Monument
	Redwood Creek		Mt. Tamalpais State Park
	trails		
	Large Woody Debris		

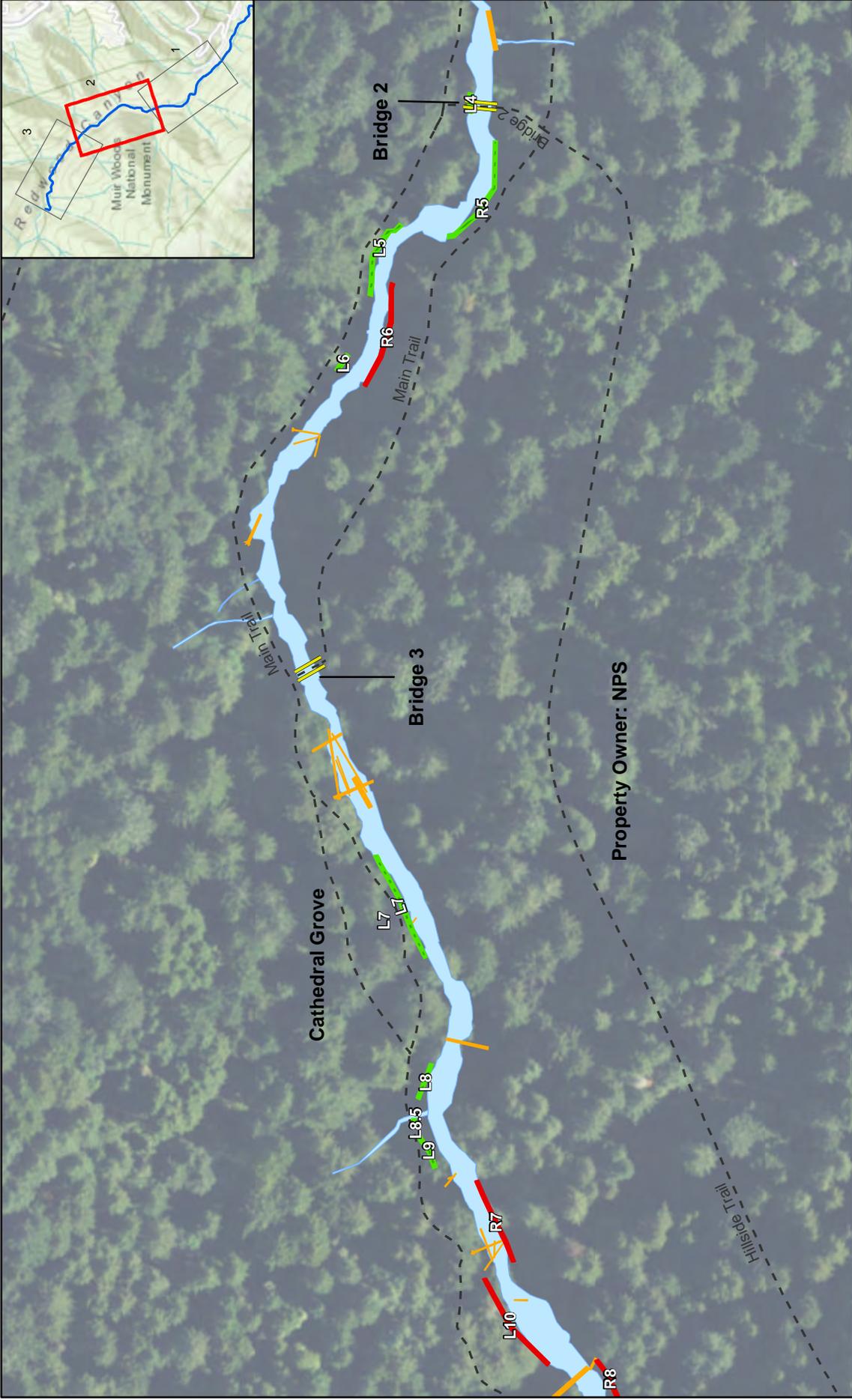
**Proposed Riprap Treatments**

- No Action
- Remove

Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)

# Revised Figure 2-1 Creek Restoration Alternative 1 Sheet 2 of 3

## Muir Woods National Monument Salmon Habitat Enhancement and Bridge Replacement Project



Muir Woods National Monument

Proposed Riprap Treatments

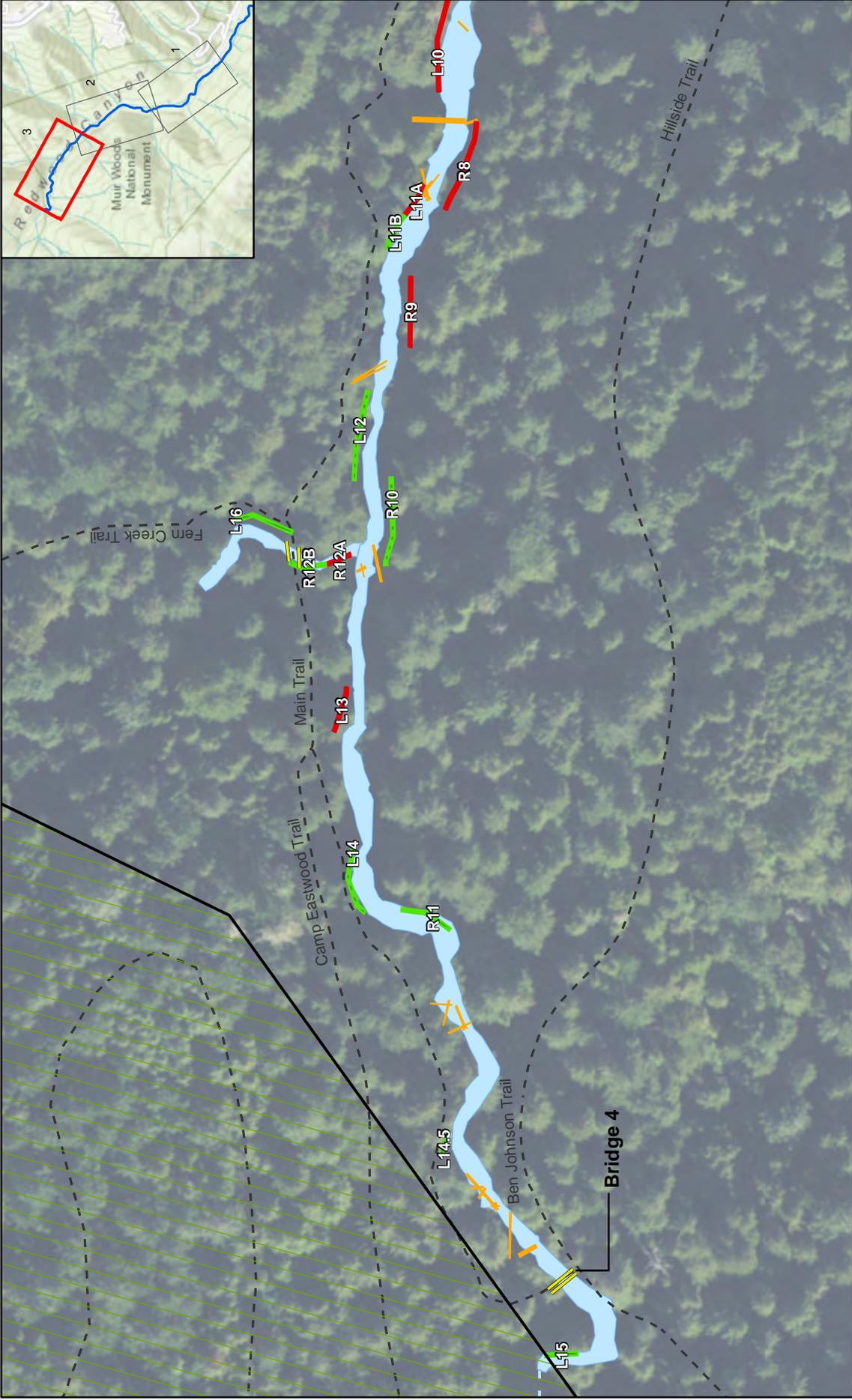
Bridge  
Redwood Creek  
trails  
Large Woody Debris

No Action

Remove

Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)





### Revised Figure 2-1

#### Creek Restoration Alternative 1

Sheet 3 of 3

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project

**Proposed Riprap Treatments**

- No Action
- Remove

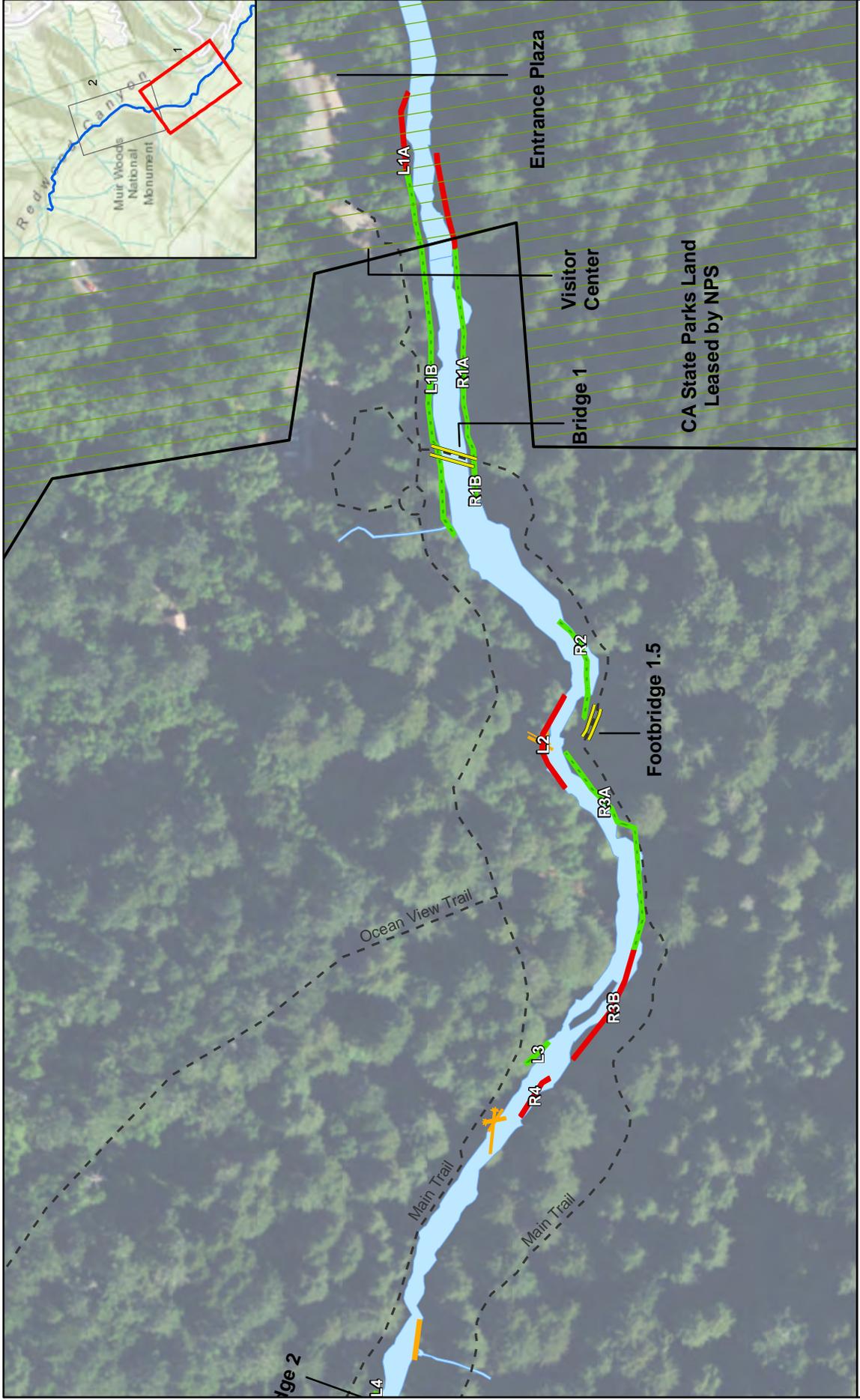
Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)

**Legend:**

- Bridge
- Redwood Creek
- trails
- Large Woody Debris
- Muir Woods National Monument
- Mt. Tamalpais State Park

**Scale:** 0 50 100 200 Feet

**North Arrow:**



**Revised Figure 2-2**  
**Creek Restoration Alternative 2**  
 Sheet 1 of 2

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

**Proposed Riprap Treatments**

- No Action
- Remove

**Trail Removal**

- Trail Removal

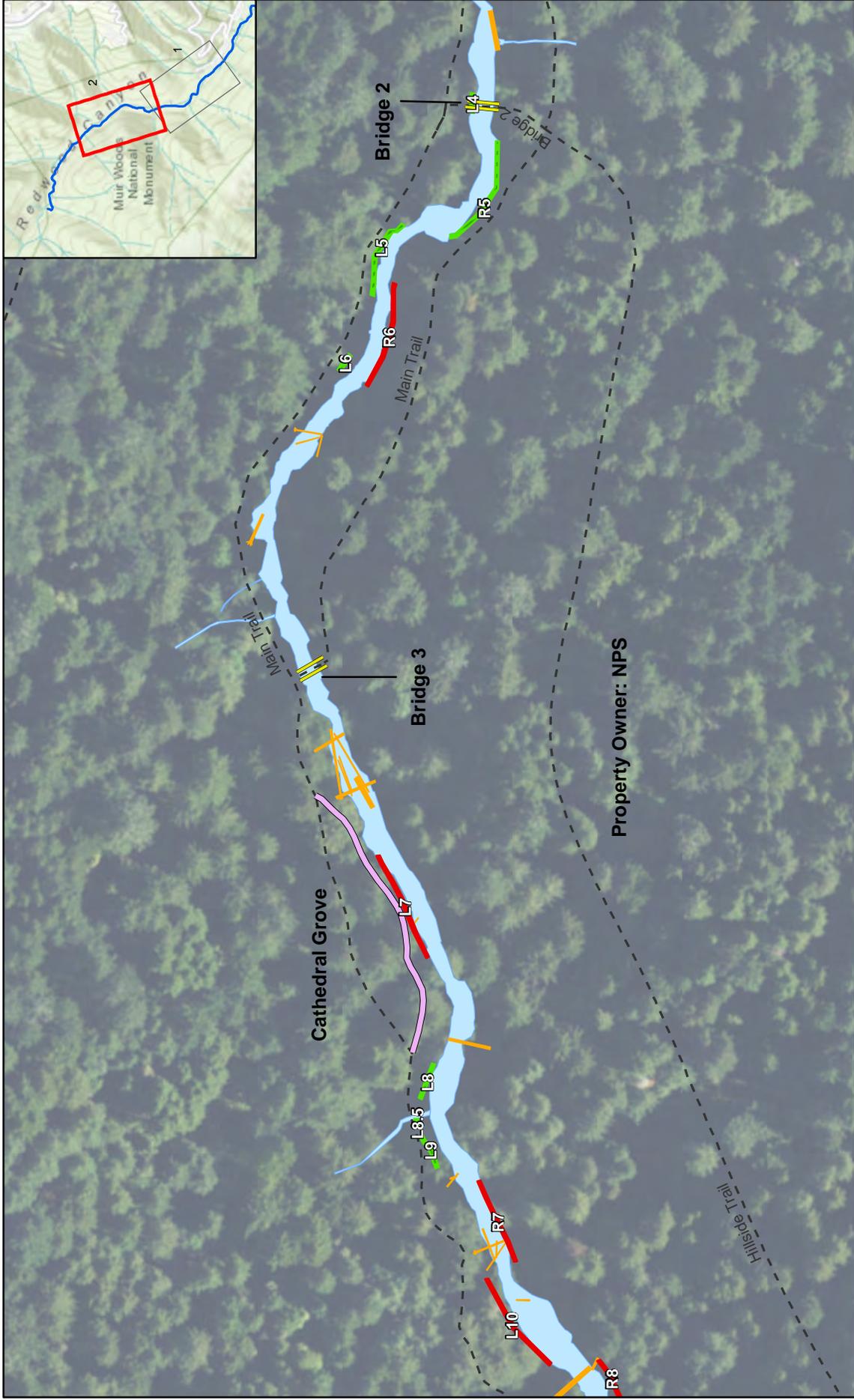
**Legend**

- Bridge
- Redwood Creek
- trails
- Large Woody Debris
- Muir Woods National Monument
- Mt. Tamalpais State Park

**Note:** Riprap segments sequentially numbered R (for right bank) and L (for left bank)

**Scale:** 0 50 100 200 Feet

**North Arrow**



**Revised Figure 2-2**  
**Creek Restoration Alternative 2**  
 Sheet 2 of 2

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

**Proposed Riprap Treatments**

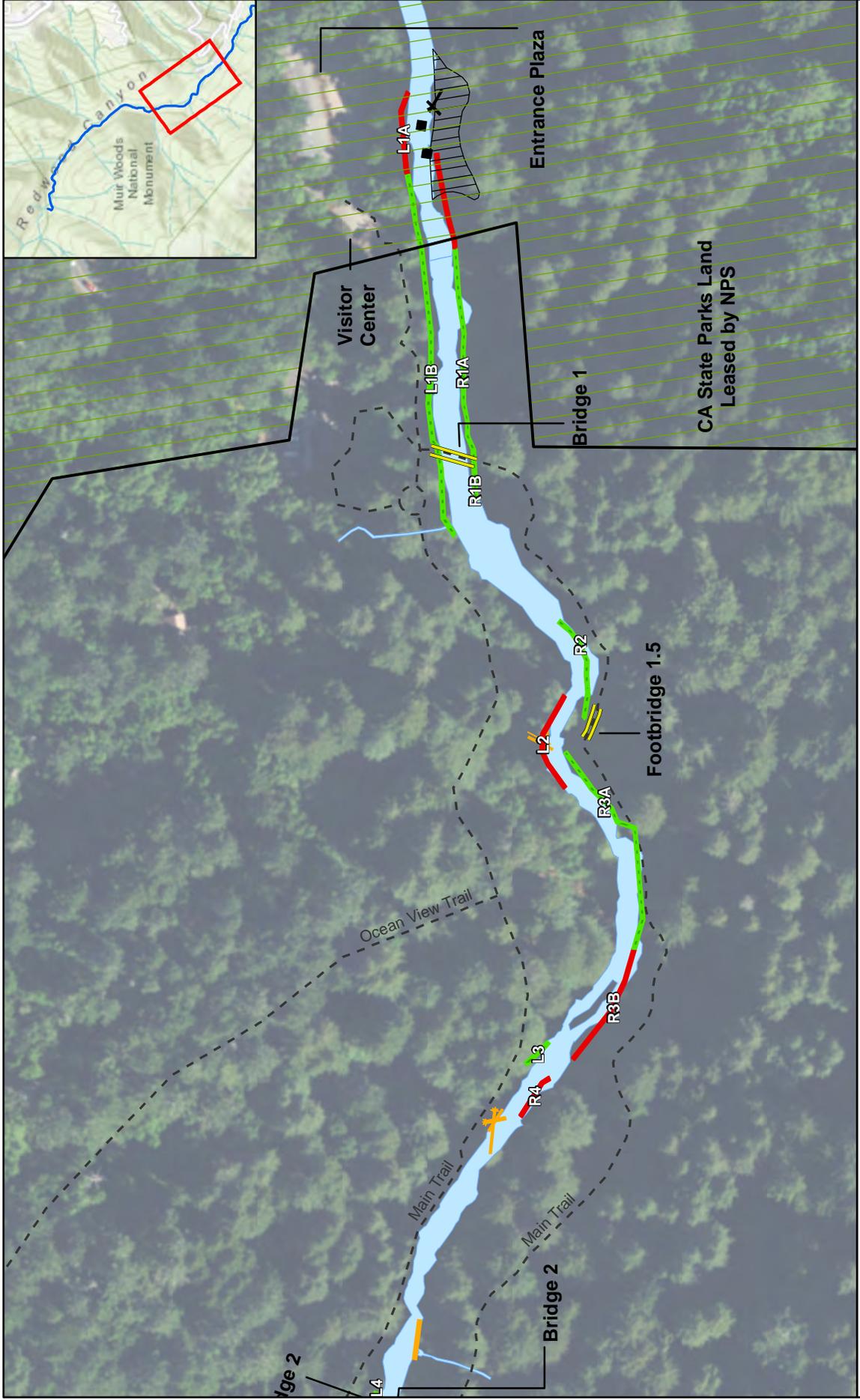
- No Action (Green diagonal lines)
- Remove (Red)

**Legend**

- Bridge (Yellow line)
- Redwood Creek (Blue)
- trails (Dashed line)
- Large Woody Debris (Orange rectangle)
- Trail Removal (Pink line)
- Muir Woods National Monument (Black outline)

**Scale:** 0 50 100 200 Feet

**Note:** Riprap segments sequentially numbered R (for right bank) and L (for left bank)



### Revised Figure 2-3 Creek Restoration Alternative 3

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project

	Floodplain Grading		Proposed Riprap Treatments		Floodplain Grading
	Redwood Creek		No Action		Redwood Creek
	Muir Woods National Monument		Remove		Muir Woods National Monument
	Mt. Tamalpais State Park		Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)		Mt. Tamalpais State Park
	Bridge				
	trails		Large Woody Debris		
			Engineered LWD		

0 50 100 200 Feet

North Arrow

### ***Creek Restoration Alternative 4***

This alternative consists of all actions in Creek Restoration Alternative 2, plus additional habitat enhancement via installation of three engineered log jams near the Plaza, excavation of an alcove and installation of LWD in the vicinity of the small footbridge referred to informally as “footbridge 1.5”, and additional riprap removal that would require modification of two trail segments as follows (Figure 2-4). This alternative would result in removal of 1,627 LF (48 percent) of riprap, representing an increase of 608 LF compared to Creek Restoration Alternative 1, and an increase of 270 LF compared to Creek Restoration Alternatives 2 and 3. To reduce potential erosion after riprap removal, banks will be treated based on conditions at each specific location. About 45 percent of banks are expected to be regraded to a 1V:1:5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have substantial mature root structures behind existing riprap, and since the roots can be very effective at resisting erosion, added treatments are not expected to be needed in those locations. Most actions (73 percent of all riprap removal proposed in this alternative) would be conducted as part of Phase 1 activities (mostly upstream of Bridge 3), and about 60 percent of the Phase 1 riprap removal areas would have such bank erosion control, while the rest appear to have adequate existing root structure. Construction phases are described in detail in Section 2.5. These actions provide more complex habitat for Coho as well as increased summer and winter/spring habitat.

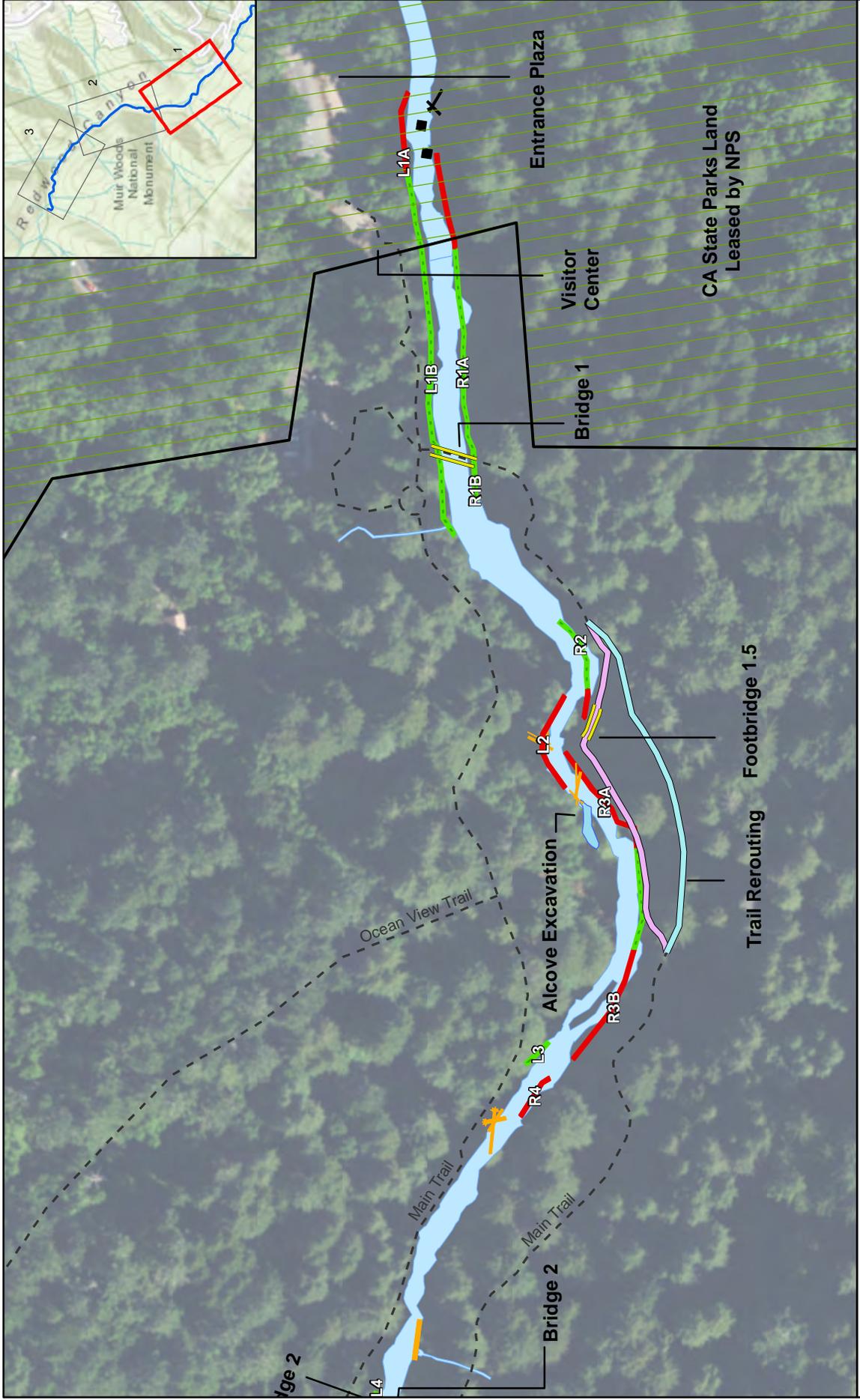
The implementation of these actions is dependent upon completion of new trail segments routed through the forest farther from the channel. All of the forested areas proposed for new trail segments are flat, extend more than a channel width from the top of the bank, can avoid impacts to redwood trees, and present good options for smooth connections to the existing trail alignment.

Approximately 33 LF of riprap segment R2 and approximately 148 LF of segment R3a would be removed on the west side of Redwood Creek upstream of Bridge 1. Approximately 60 to 80 LF of asphalt trail on the top of the west bank, footbridge 1.5, would also be removed. A drainage area at footbridge 1.5 would be enhanced as an alcove. The relocated trail segment would extend up to 440 LF.

Approximately 88 LF of riprap (segment L12) on the east side of the creek just downstream of Fern Creek would be removed. There is a buried rock drain lens in the center of this riprap segment. It is approximately 15 feet wide and extends about 20 feet from the riprap to the existing trail. Additional investigation of this drain lens would be conducted to identify any treatments related to its removal. Approximately 115 LF of asphalt trail on the east side of the creek just downstream of Fern Creek would be relocated farther away from the channel.

### ***Creek Restoration Alternative 5 (Preferred Alternative)***

Creek Restoration Alternative 5 includes all actions in Creek Restoration Alternative 4, plus the floodplain terracing described in Alternative 3 (Figure 2-5). Bank treatments to reduce erosion described in Creek Restoration Alternative 4 would be used. This alternative provides the maximum amount of improvements to Coho habitat. It includes the maximum extent of riprap removal that can be conducted without affecting infrastructure, existing grade controls, or existing LWD structures. Infrastructure that is protected includes the sewer line under the entrance boardwalk, trails not modified, and a water line along some areas of the left bank up to Fern Creek Trail. Several riprap segments are not proposed for removal because of the risk of the channel outflanking existing grade control, including two cascades and six historic channel-spanning log grade controls.



**Revised Figure 2-4**  
**Creek Restoration Alternative 4**  
 Sheet 1 of 3

Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project

Bridge	Redwood Creek	Proposed Riprap Treatments	Trail Reroute
trails	Large Woody Debris	No Action	Trail Removal
Engineered LWD	Remove	Muir Woods National Monument	Mt. Tamalpais State Park

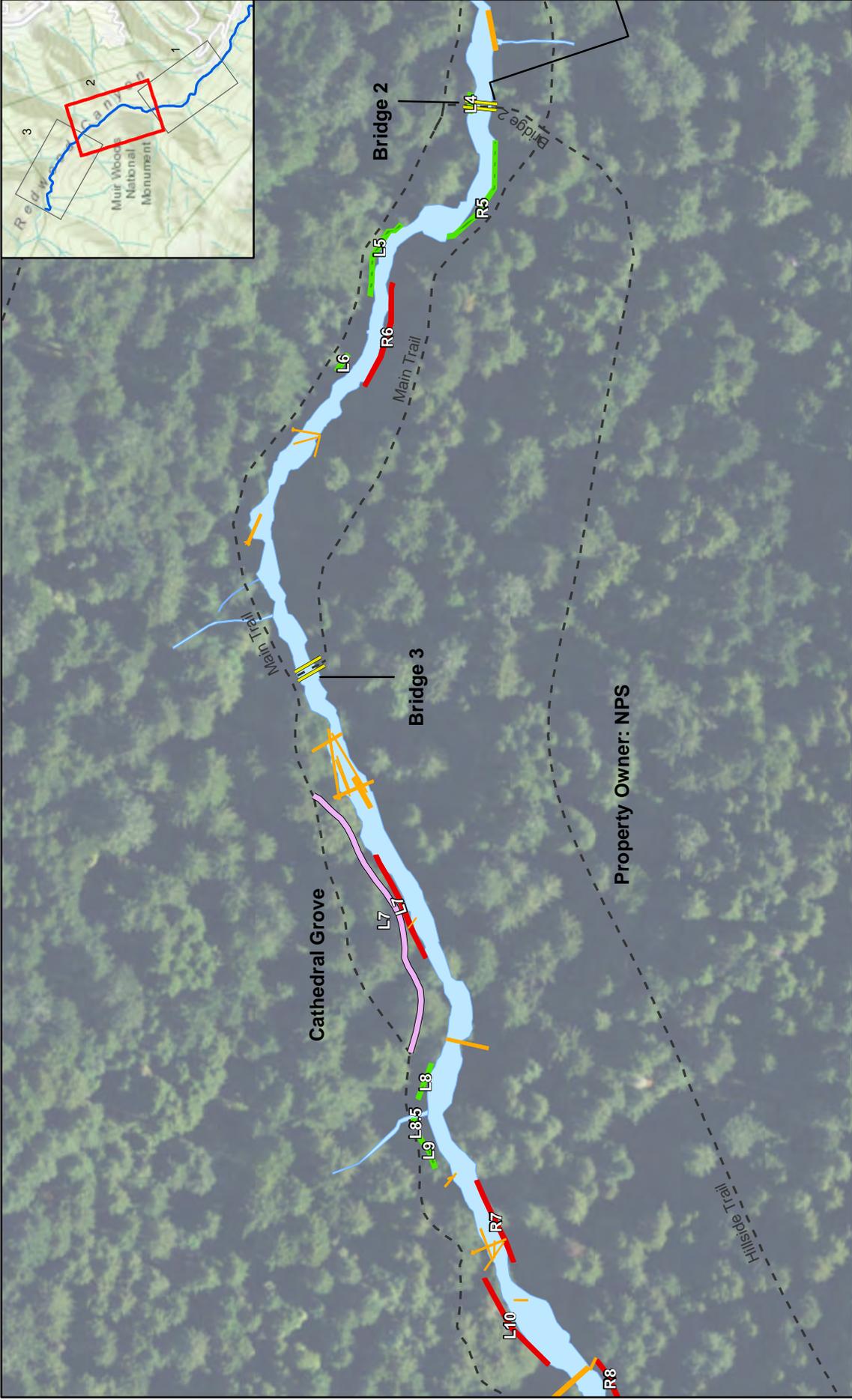
Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)

0 50 100 200 Feet

North arrow pointing up.

**Revised Figure 2-4**  
**Creek Restoration Alternative 4**  
 Sheet 2 of 3

Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project



	Bridge		Trail Reroute
	Redwood Creek		Trail Removal
	trails		Muir Woods National Monument
	Large Woody Debris		Mt. Tamalpais State Park
	Engineered LWD		

**Proposed Riprap Treatments**

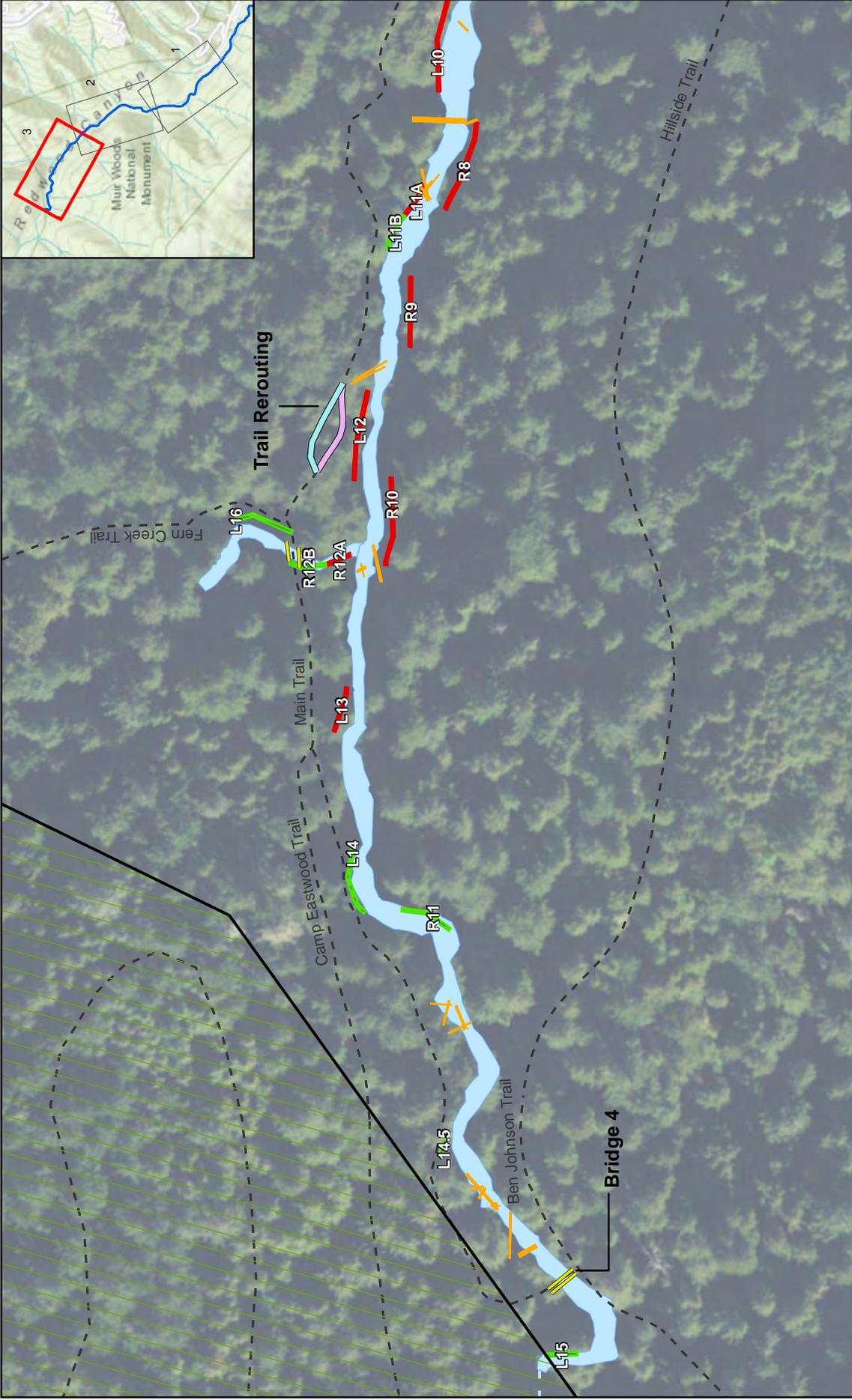
	No Action
	Remove

Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)

0 50 100 200 Feet

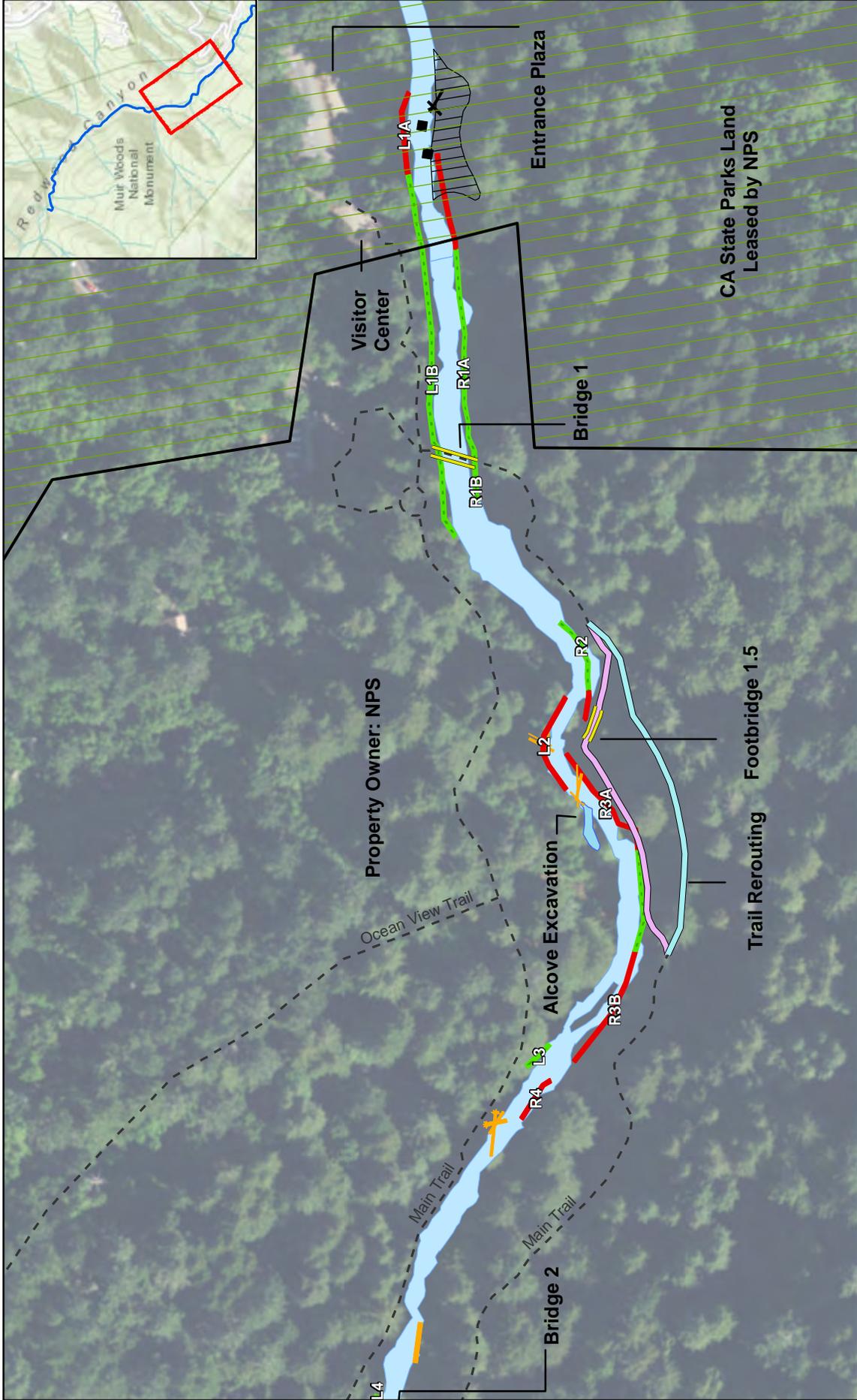
**Revised Figure 2-4**  
Creek Restoration Alternative 4  
Sheet 3 of 3

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project



	Bridge		Redwood Creek		Trail Reroute
	trails		No Action		Trail Removal
	Large Woody Debris		Remove		Muir Woods National Monument
	Engineered LWD		Mt. Tamalpais State Park		

Note: Riprap segments sequentially numbered R (for right bank) and L (for left bank)



**Revised Figure 2-5**  
Creek Restoration Alternative 5

**Proposed Riprap Treatments**

- Bridge
- Redwood Creek
- trails
- Large Woody Debris
- Engineered LWD

**Proposed Riprap Treatments**

- No Action
- Remove

**Legend**

- Trail Reroute
- Trail Removal
- Floodplain Grading
- Muir Woods National Monument
- Mt. Tamalpais State Park

**Scale:** 0 50 100 200 Feet

**Note:** Riprap segments sequentially numbered R (for right bank) and L (for left bank)

**Muir Woods National Monument Salmon Habitat Enhancement and Bridge Replacement Project**



## 2.4 Pedestrian Bridge Replacement Alternatives

Four existing pedestrian bridges in MWNM are deteriorating due to age, and would be replaced by bridges which would be designed to provide improved flood conveyance while enhancing the rustic and historic character of MWNM. Designs for Bridges 2 and 3 would require trail rerouting, while designs for Bridges 1 and 4 would not. All alternatives would have certain key project elements in common. All of the forested areas proposed for new trail segments are relatively flat, extend more than a channel width from the top of the bank, can avoid impacts to redwood trees, and present good options for smooth connections to the existing trail alignment. Table 2-2 summarizes elements in each Pedestrian Bridge Replacement Alternative.

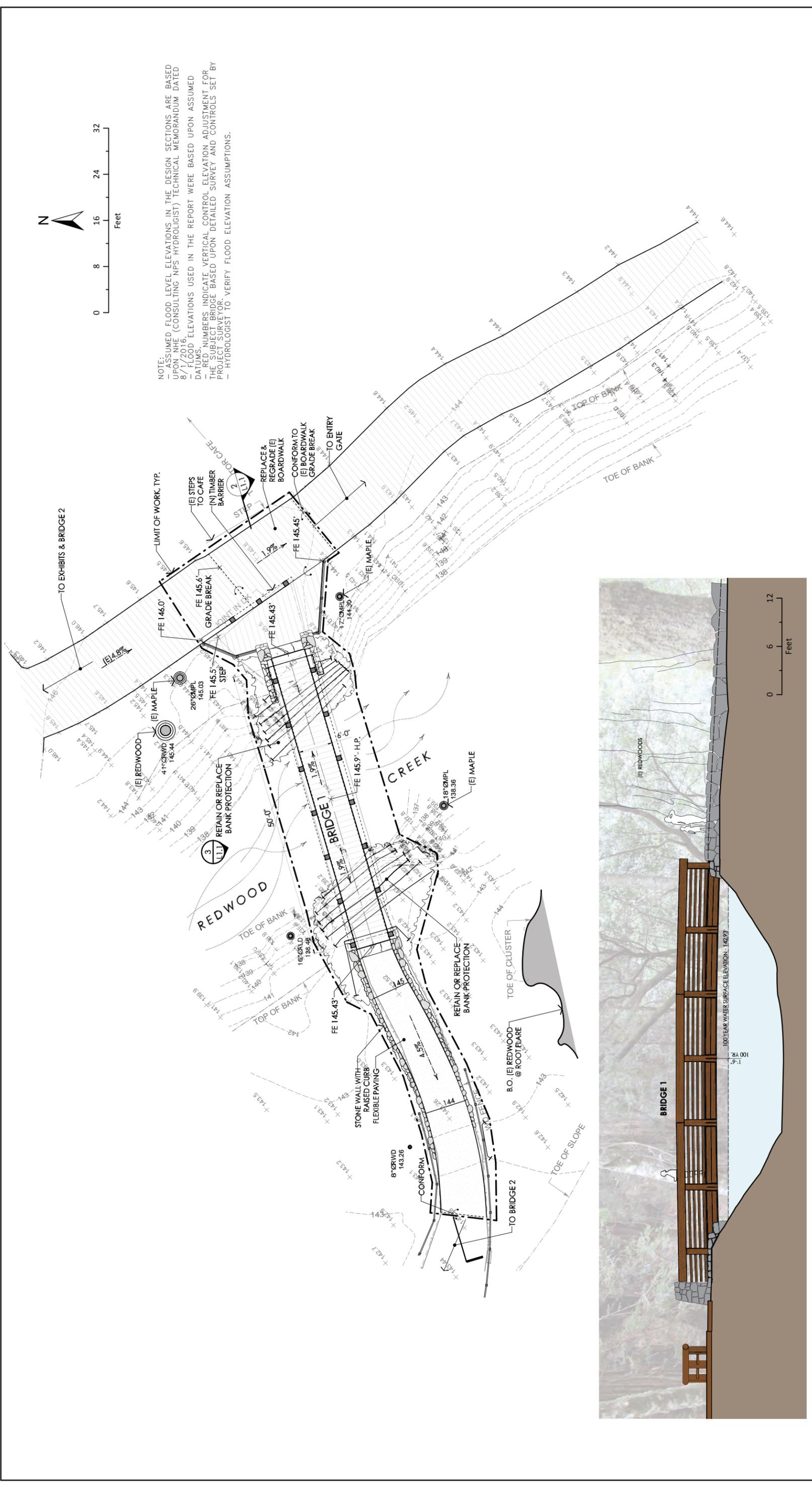
### ***Actions Common to All Pedestrian Bridge Replacement Alternatives***

- NPS would replace Bridges 1 and 4 to pass a 100-year storm flow. This action would require minor increases to bridge span to ensure passage of a 100-year storm flow with 18 inches of freeboard (Figure 2-6). Bridge 1 would have an approximately 50 LF span and Bridge 4 would have an approximately 45 LF span.
- Bridge 2 would have an approximately 52 LF span and Bridge 3 would have an approximately 45 LF span. The height for these bridges would vary depending upon the alternative.
- Bridges would be of a clear span design over the stream channel, able to accommodate from 25- to 100-year flood flows (based on existing channel conditions). New abutments would be relocated farther from the creek but still in the 100-year floodplain.
- The approaches to all new bridges would be designed to connect the existing trail network with the new bridges.
- Existing abutments for Bridges 1 through 4 would be removed. Historic riprap surrounding the Bridge 1 abutments and riprap in the vicinity of the Bridge 2 left bank abutment would not be removed. Non-historic riprap surrounding the Bridges 2, 3, and 4 abutments would be retained, replaced in-kind, or replaced with other bank protection measures. Additional site investigations are needed to determine specific bank protection designs. Depending on whether riprap is retained or other bank protection measures are used, the modeled flood elevations used in this EA could be affected. NPS will strive to meet the stated objectives of passing the 100-year or 25-year flood flow to the maximum extent possible. Riprap or bank protection would only affect local flood elevations in the vicinity of the particular bridge and immediately upstream, and would not worsen existing flood issues.
- Bridge designs and associated redesigned trail approaches will meet ABAAS for outdoor areas and all grades will aim to be less than 5 percent.
- Bridges would be a steel stringer design with wood decking and guardrails (Figure 2-7). Guardrails are needed to comply with current safety codes. Bridges 1 and 4 would include a minor arched camber. Bridges 2 and 3 would include a more significant arched camber.
- New/rerouted trails would either be boardwalk or flexible paving, which could include asphalt, compacted shale, or other materials. The lengthened boardwalks/transitions between bridge and trails may require piers placed within the 100-year floodplain.
- Areas of existing trail removal would be decompacted, restored, and revegetated with native plants.

**Table 2-2.** Summary of Pedestrian Bridge Replacement Alternative Elements

	<b>No Action Alternative</b>	<b>Alternative A: Bridges 2/3, 25-year</b>	<b>Alternative B: Bridges 2/3, 100-year</b>	<b>Alternative C (Preferred): Bridge 2, 25-year and Bridge 3, 100-year</b>
<b>Bridge 1</b>	Replaced in kind. Accommodates 25-year storm	50 LF span; accommodates 100-year storm, 18 inches freeboard.		
<b>Bridge 2</b>	Accommodates 2-year storm	52 LF span; accommodates 25-year storm; 15 inches freeboard at peak of arch.	52 LF span; accommodates 100-year storm; 14 inches freeboard at peak of arch.	52 LF span; accommodates 25-year storm; 15 inches freeboard at peak of arch.
<b>Bridge 3</b>	Replaced in kind. Accommodates 2-year storm	45 LF span; accommodates 25-year storm; 12 inches freeboard at peak of arch.	45 LF span; accommodates 100-year storm; 13 inches freeboard at peak of arch	
<b>Bridge 4</b>	Bridge would be replaced in kind. Accommodates 50-year storm	45 LF span; accommodates 100-year storm, 18 inches freeboard.		
<b>Trail Rerouting</b>	No changes to trails will occur	<p>No reroutes for Bridges 1 and 4; bridge approaches would require minor trail construction and adjusted grades within existing alignment.</p> <p>At Bridge 2, approx. 120 LF of new boardwalk to be installed on east side of creek and 20 LF of new boardwalk on west side of creek.</p>	<p>No reroutes for Bridges 1 and 4; bridge approaches would require minor new trail construction and adjusted grades within existing alignment.</p> <p>At Bridge 2, approx. 140 LF of new boardwalk to be installed on east side of creek and 40 LF of new boardwalk on west side of creek.</p>	<p>No reroutes for Bridges 1 and 4; bridge approaches would require minor new trail construction and adjusted grades within existing alignment.</p> <p>At Bridge 2, approx. 120 LF of new boardwalk to be installed on east side of creek and 20 LF of new boardwalk on west side of creek.</p>

	<b>No Action Alternative</b>	<b>Alternative A: Bridges 2/3, 25-year</b>	<b>Alternative B: Bridges 2/3, 100-year</b>	<b>Alternative C (Preferred): Bridge 2, 25-year and Bridge 3, 100-year</b>
<b>Trail Rerouting</b>	No changes to trails will occur	At Bridge 3, approx. 120–160 LF of new trail and 30 LF of boardwalk would be installed on east side of creek; 35 LF of new boardwalk on west side of creek; total = approx. 205 LF boardwalk, approx. 120 to 160 LF trail.	At Bridge 3, approx. 120–160 LF of new trail and 50 LF of boardwalk would be installed on east side of creek; 50 LF of new boardwalk on west side of creek; total= approx. 280 LF boardwalk, approx. 120 to 160 LF trail.	At Bridge 3, approx. 120–160 LF of new trail and 50 LF of boardwalk would be installed on east side of creek; 50 LF of new boardwalk on west side of creek; total= approx. 240 LF boardwalk, approx. 120–160 LF trail.
<b>Grades</b>	No changes	Bridge gradient and redesigned trails to bridges would meet ABAAS. All grades would be under 5%.		
<b>Bridge Abutments</b>	No changes	Existing abutments would be removed. New abutments would be installed during construction.		
<b>Bridge Design</b>	No changes to gathering areas	Steel stringer bridge, guardrails.  Bridges 1 and 4 would include a minor arched camber.  Bridges 2 and 3 would include a more significant arched camber.	Steel stringer bridge, guardrails.  Bridge 1 and 4 would include a minor arched camber.  Bridges 2 and 3 would include a more significant arched camber; and Bridge 2 would require a 10-foot-long guardrail, each side of bridge on the boardwalk.	Steel stringer bridge, guardrails.  Bridges 1 and 4 would include a minor arched camber.  Bridges 2 and 3 would include a more significant arched camber.
<b>Gathering Area</b>	No changes	Bridge 2 would have approx. 20x20-foot gathering area on east side of creek.	Bridge 2 would not include a gathering area.	Bridge 2 would have approx.. 20x20-foot gathering area on east side of creek.
<b>Restoration Area</b>		Gathering area and Bridge 2 trail alignment restored; trail on east side of Bridges 2 and 3 restored.	Gathering area and existing trail alignment at Bridge 2 would be restored; trail would be outside of 100-year floodplain; trail on east side of Bridges 2 and 3 would be restored.	



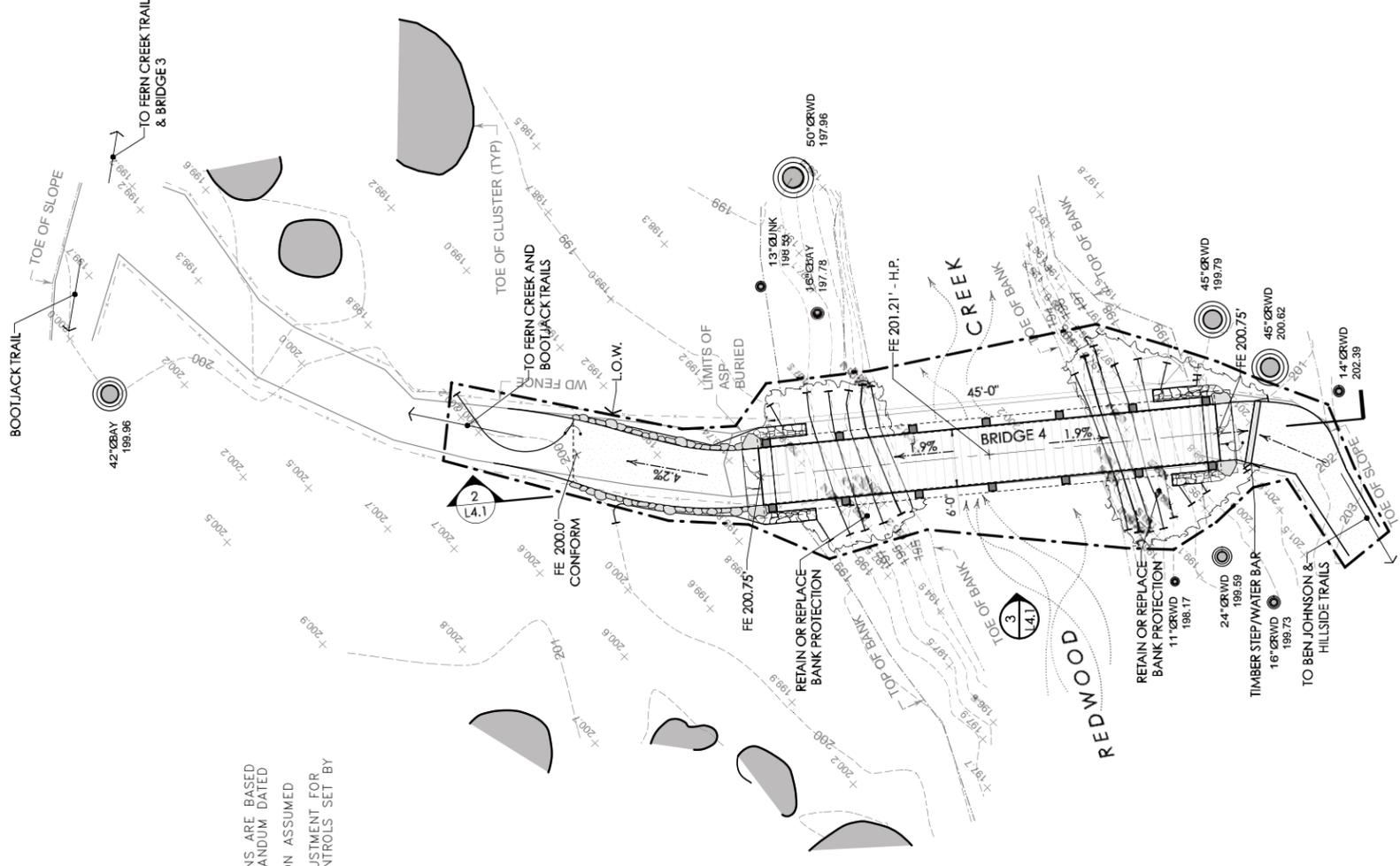
NOTE:  
 - ASSUMED FLOOD LEVEL ELEVATIONS IN THE DESIGN SECTIONS ARE BASED UPON NHE (CONSULTING NPS HYDROLOGIST) TECHNICAL MEMORANDUM DATED 8/1/2016.  
 - FLOOD ELEVATIONS USED IN THE REPORT WERE BASED UPON ASSUMED DATA.  
 - RED NUMBERS INDICATE VERTICAL CONTROL ELEVATION ADJUSTMENT FOR THE PROJECT SURVEYOR.  
 - HYDROLOGIST TO VERIFY FLOOD ELEVATION ASSUMPTIONS.

Source: Roth LaMotte 2017

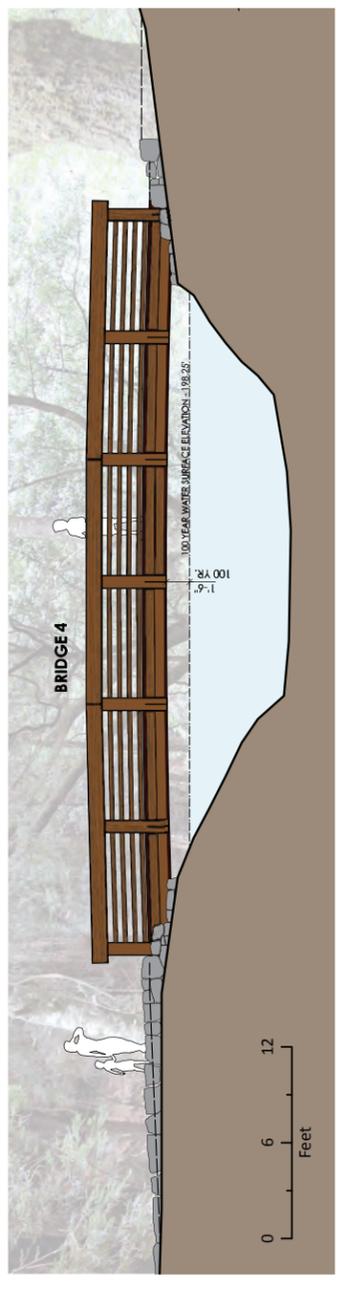
**Figure 2-6, Sheet 1 of 2.**  
**Actions Common to All Pedestrian Bridge Alternatives**

Salmon Habitat Enhancement and Bridge Replacement Project Environmental Assessment





NOTE:  
 - ASSUMED FLOOD LEVEL ELEVATIONS IN THE DESIGN SECTIONS ARE BASED UPON NHE (CONSULTING NPS HYDROLOGIST) TECHNICAL MEMORANDUM DATED 8/1/2016.  
 - FLOOD ELEVATIONS USED IN THE REPORT WERE BASED UPON ASSUMED DATUMS.  
 - RED NUMBERS INDICATE VERTICAL CONTROL ELEVATION ADJUSTMENT FOR THE SUBJECT BRIDGE BASED UPON DETAILED SURVEY AND CONTROLS SET BY PROJECT SURVEYOR.  
 - HYDROLOGIST TO VERIFY FLOOD ELEVATION ASSUMPTIONS.



Source: Roth LaMotte 2017

**Figure 2-6, Sheet 2 of 2.**  
**Actions Common to All Pedestrian Bridge Alternatives**

Salmon Habitat Enhancement and Bridge  
 Replacement Project Environmental Assessment

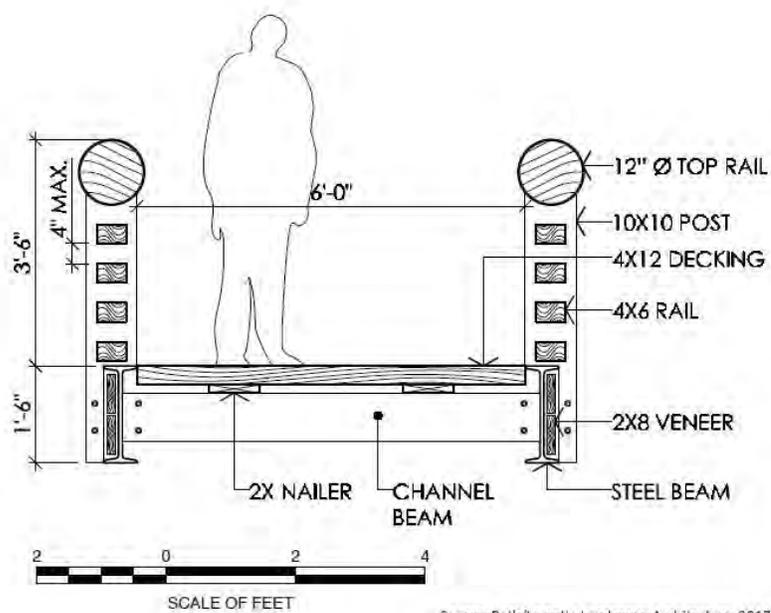


### ***Pedestrian Bridge Replacement Alternative A***

Under this alternative, spans for Bridges 2 and 3 would be lengthened and the clearance under the bridge would be raised to pass a 25-year storm event (Figures 2-8 and 2-9). Bridge 2 would have 15 inches of freeboard at the peak of the arch in a 25-year storm event, while Bridge 3 would have 12 inches of freeboard at the peak of the arch in the same event. Existing abutments would be removed and new abutments would be placed farther from the creek channel.

For Bridge 2, this alternative replaces the asphalt trail on either side of the bridge with a boardwalk to connect to the main trail network to improve visitor experience, safety, and reduce maintenance needs.

Approximately 120 LF of new boardwalk would be installed on the east side of the creek, and approximately 20 LF of new boardwalk on the west side of the creek. Approximately 80 LF of asphalt trail on the east side of the bridge would be removed and restored. The existing large paved area on the east side of the bridge would be removed and areas closest to the creek would be restored. Bridge 2 would have a small approximately 20-by-20-foot gathering area on the east side of Redwood Creek.



**Figure 2-7.** Typical Bridge Cross Section

For Bridge 3, this alternative replaces the asphalt trail with a new boardwalk and flexible paving trail to connect to the main trail network. Approximately 120 to 160 LF of new trail and approximately 30 LF of boardwalk would be installed on the east side of the creek, and approximately 35 LF of new boardwalk on the west side of the creek. This would result in new disturbance for re-alignment of trail, but also restoration where the approximately 130 LF of existing asphalt trail would be removed.

### ***Pedestrian Bridge Replacement Alternative B***

Under this alternative, spans for Bridges 2 and 3 would be the same length as under Pedestrian Bridge Replacement Alternative A but would be raised 9 inches (Figures 2-8 and 2-9). They would be designed to pass a 100-year storm event. Bridge 2 would have 14 inches of freeboard at the peak of the arch in a 100-year storm event, while Bridge 3 would have 13 inches of freeboard at the peak of the arch in the same event. Existing abutments would be removed and new abutments would be placed farther from the creek channel.

For Bridge 2, approximately 140 LF of new boardwalk would be installed on the east side of the creek, and approximately 40 LF of new boardwalk would be installed on the west side of the creek. This would result in new disturbance for re-alignment of the trail, but also restoration where approximately 80 LF of existing asphalt trail and the informal gathering area would be removed. The rerouted trail would be outside of the 100-year floodplain. This alternative would require

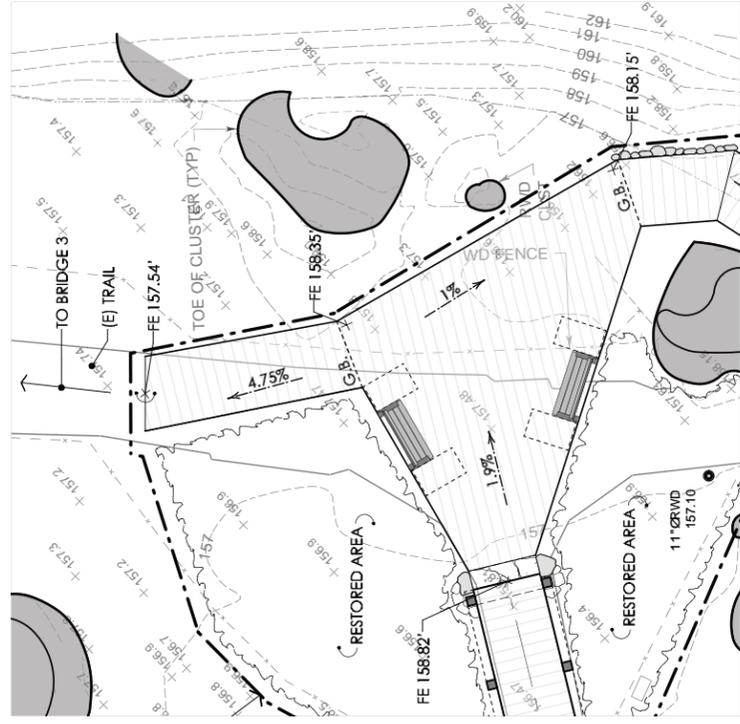
approximately 10 LF of guardrail on the boardwalk approaches to Bridge 2 for safety and accessibility reasons, and would not include a gathering area at Bridge 2.

For Bridge 3, this alternative would require trail rerouting involving approximately 120 to 160 LF of new trail and installation of approximately 50 LF of boardwalk installation on the east side of the creek and approximately 50 LF of new boardwalk on the west side of creek. As with Pedestrian Bridge Replacement Alternative A, approximately 130 LF of existing asphalt trail would be removed and restored. This would require an area of new disturbance for the rerouted trail, but allows the trail to be pulled back from the stream with restoration of existing paved trail area. This would also provide different visitor experience through a wooded area, which is not generally provided on the valley floor.

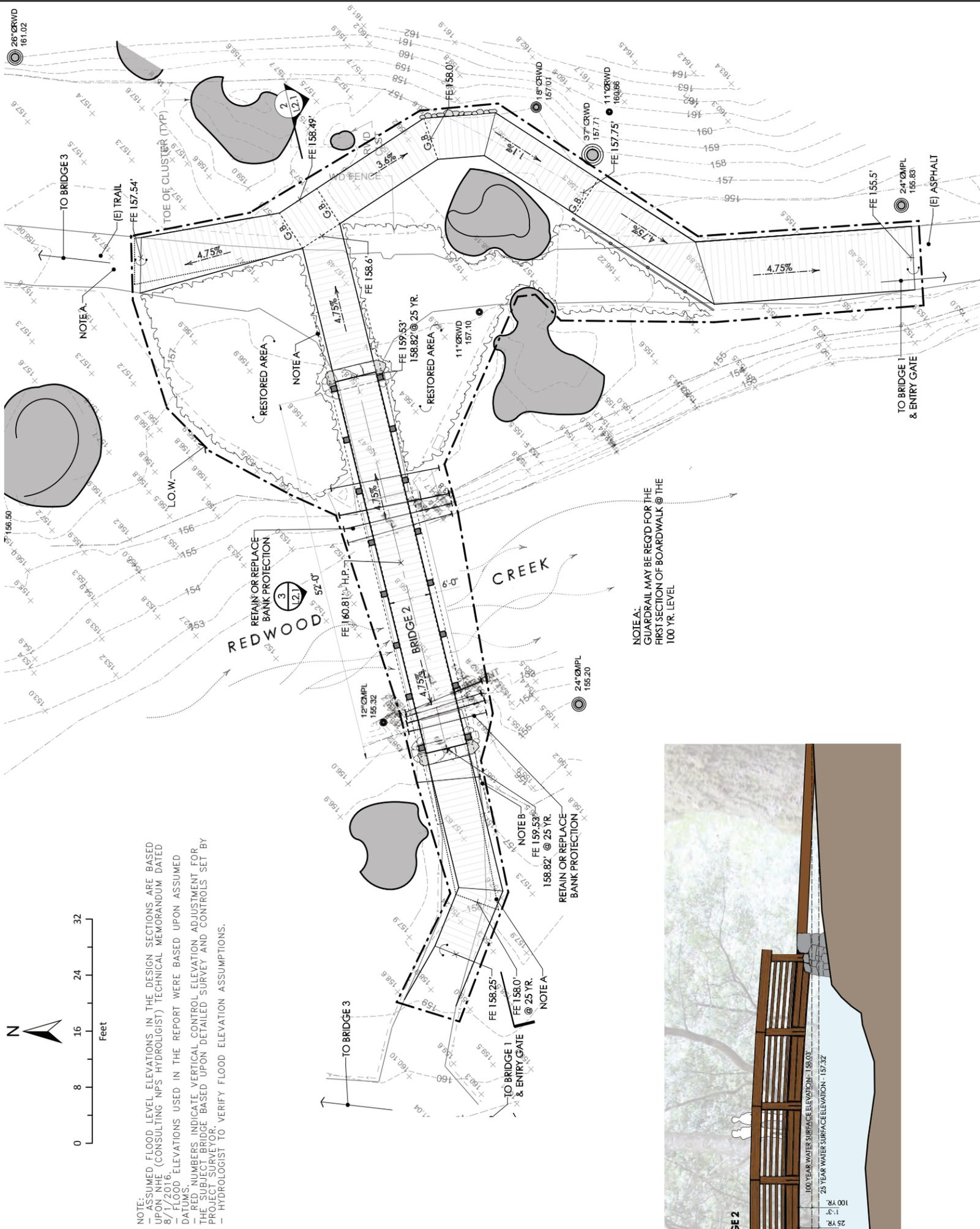
### ***Pedestrian Bridge Replacement Alternative C (Preferred Alternative)***

Under this alternative, the span of Bridge 2 would be lengthened and designed to pass a 25-year storm event and Bridge 3 would be lengthened and designed to pass a 100-year storm event (Figures 2- 8 and 2-9). Bridge 2 would have 15 inches of freeboard at the peak of the arch in a 25-year storm event, while Bridge 3 would have 13 inches of freeboard at the peak of the arch in a 100-year storm event. Under this alternative, the gathering area at Bridge 2 is retained. Habitat benefits of the longer span at Bridge 3 are significantly greater than habitat benefits for the longer span at Bridge 2. Additionally, this alternative requires less rerouting and replacement of existing trails at Bridge 2 than Alternative B.

For Bridge 2, this alternative would have the same design as described in Pedestrian Bridge Replacement Alternative A. For Bridge 3, this alternative would have the same design as described in Pedestrian Bridge Replacement Alternative B.

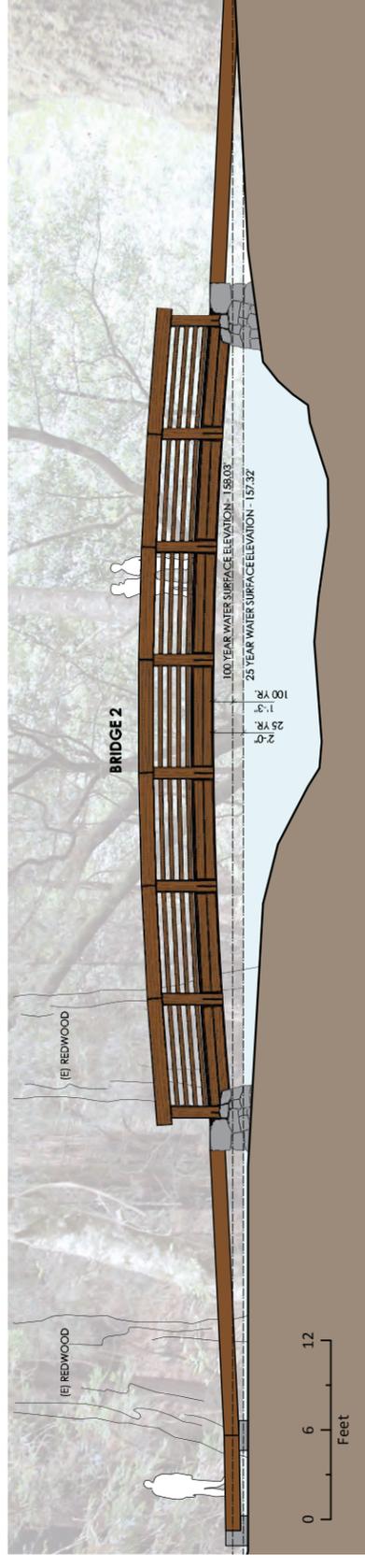


BRIDGE 2 ALTERNATIVE: BOARDWALK GATHERING AREA & RAMP EXTENTS - (ASSUMES BRIDGE ELEV. CLEARS 25 YR. FLOOD LEVEL).



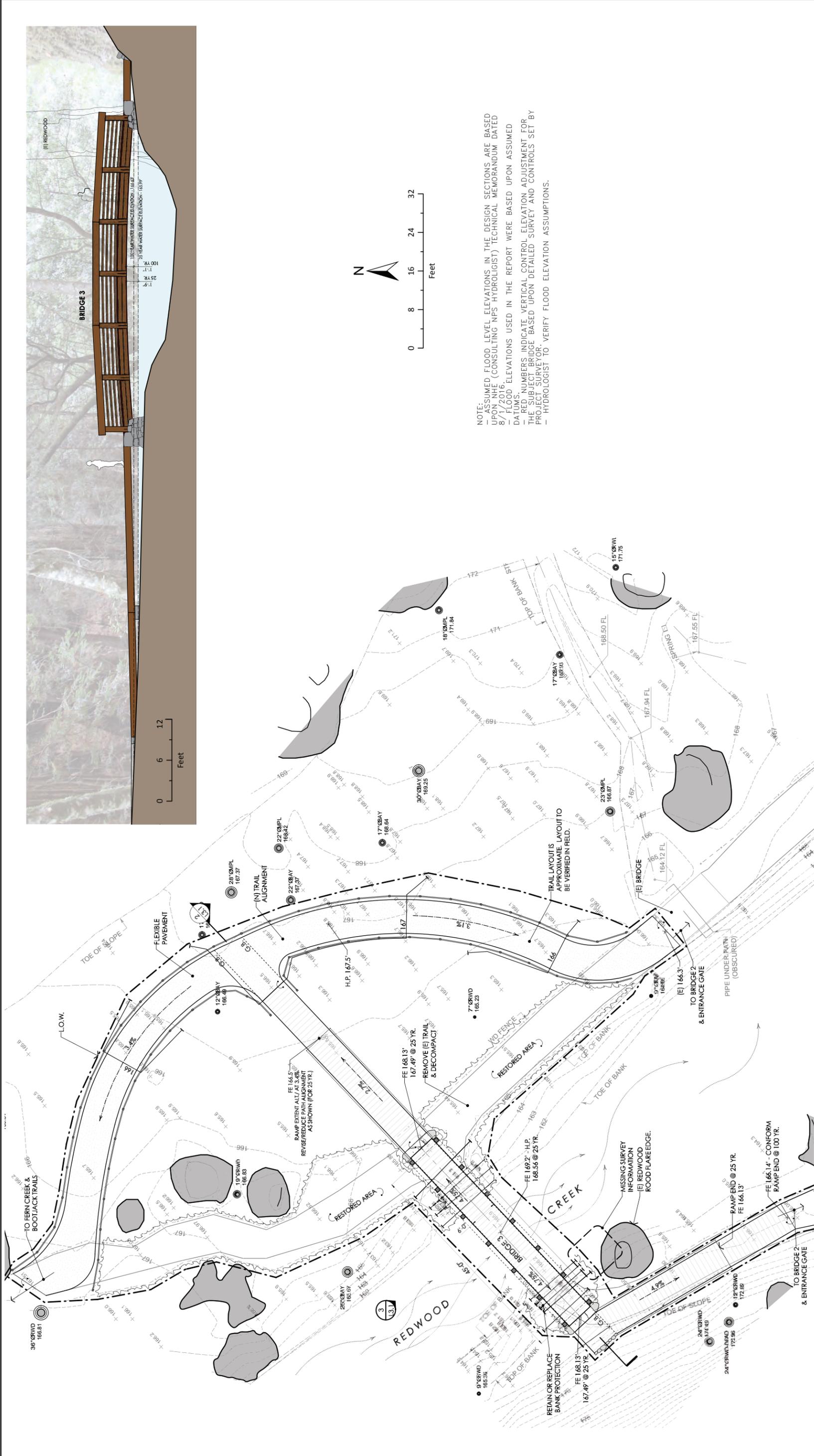
NOTE:  
 - ASSUMED FLOOD LEVEL ELEVATIONS IN THE DESIGN SECTIONS ARE BASED UPON NHE (CONSULTING NPS HYDROLOGIST) TECHNICAL MEMORANDUM DATED 8/1/2016.  
 - FLOOD ELEVATIONS USED IN THE REPORT WERE BASED UPON ASSUMED DATUMS.  
 - RED NUMBERS INDICATE VERTICAL CONTROL ELEVATION ADJUSTMENT FOR THE SUBJECT BRIDGE BASED UPON DETAILED SURVEY AND CONTROLS SET BY PROJECT SURVEYOR.  
 - HYDROLOGIST TO VERIFY FLOOD ELEVATION ASSUMPTIONS.

NOTE A:  
 GUARDRAIL MAY BE REQ'D FOR THE FIRST SECTION OF BOARDWALK @ THE 100 YR. LEVEL.



Source: Roth LaMotte 2017

**Figure 2-8**  
**Bridge 2 Alternatives**  
 Salmon Habitat Enhancement and Bridge Replacement Project Environmental Assessment



NOTE:  
 - ASSUMED FLOOD LEVEL ELEVATIONS IN THE DESIGN SECTIONS ARE BASED UPON NHE (CONSULTING NPS HYDROLOGIST) TECHNICAL MEMORANDUM DATED 8/1/2016.  
 - FLOOD ELEVATIONS USED IN THE REPORT WERE BASED UPON ASSUMED DATUMS.  
 - RED NUMBERS INDICATE VERTICAL CONTROL ELEVATION ADJUSTMENT FOR THE SUBJECT BRIDGE BASED UPON DETAILED SURVEY AND CONTROLS SET BY PROJECT SURVEYOR.  
 - HYDROLOGIST TO VERIFY FLOOD ELEVATION ASSUMPTIONS.

Source: Roth LaMotte 2017

**Figure 2-9**  
**Bridge 3 Alternatives**  
 Salmon Habitat Enhancement and Bridge Replacement Project Environmental Assessment

## 2.5 Construction Methods

There are many constraints to traditional construction methods at MWNM. Equipment access is limited by two extensive boardwalks that would not support heavy equipment. The forest floor is sensitive, due to both redwood root systems and understory vegetation. Visitor use is heavy within the park, and visitors use trails 7 days per week. Additionally, there are multiple biological constraints and work windows, including the salmonid spawning season, northern spotted owl nesting season, songbird nesting season, and marbled murrelet nesting season.

Revegetation during the first phase of creek restoration actions is anticipated to be largely salvaged or transplanted material from within MWNM, while revegetation in later years would also consist of nursery stock grown from locally collected materials. All plants for restoration will be grown by or under guidance of NPS's native plant nurseries. Revegetation for bridge replacement actions may consist of both salvaged and nursery stock.

Preparation of a stormwater pollution prevention plan (SWPPP) is anticipated for this project. Erosion control and sedimentation best management practices (BMPs) would be conducted per the SWPPP and would be implemented in each phase.

NPS would prepare a detailed plant protection plan based on specific areas to be impacted by any proposed actions. NPS would thoroughly review potentially impacted areas in advance and identify either any special-status or locally rare species as well as native plants that would be protected (more details on rare plant surveys are provided in BMPs BIO-11 through BIO-13) (see Appendix D). This plan would also identify invasive species that should be controlled prior to implementation of proposed action (more detail in BMP-7). Based on the species and potential impacts, a plan would be made to either (a) avoid the area if necessary due to the presence of a sensitive species; (b) salvage plants if they are salvageable; (c) trim branches/leaves if the plants would easily resprout, (d) cover with plywood or other protective materials, or (e) other types of activities. Salvaged plants would be removed either immediately before impact or possibly approximately 1 month in advance. These plants would be either replanted in other disturbed areas immediately or stored in an area with a water source, and then replanted either immediately after work is completed in a specific zone or during the typical winter planting period. All BMPs described in Appendix D would be implemented.

### ***Creek Restoration***

Some construction activities, such as staging, stockpiling, and transport of materials would take place on California State Parks land. These include use of the Alice Eastwood Campground for the first phase of the Creek Restoration, hauling up Alice Eastwood Road to Panoramic Highway, and the work at the Plaza. Figure 2-10 shows the park boundaries and the location of California State Park land.

Construction is anticipated to be conducted in two or more phases. The riprap removal work upstream of Bridge 2 is anticipated to be conducted first, and the riprap removal work downstream of Bridge 2 is anticipated to be conducted in a later year.

The methods described in this section are divided by phases and geographic areas of the Proposed Action and are not specific to the alternatives described above. Thus, riprap selected for removal under any of the Creek Restoration Alternatives would be removed using the methods described below based on its location within Redwood Creek. Phase 1 riprap removal consists of riprap removal between Bridge 2 and Bridge 4. Installation of LWD in this work area may or may not be concurrent with Phase 1 riprap removal, depending on funding, crew availability, limited work window, timing of contract award, or other factors. Riprap segment R4 could potentially be

removed during either Phase 1 or Phase 2. This segment consists of small rocks which can be removed by hand. Both removal and off-haul of this segment would use hand methods such as wheelbarrows. Installation of beaver dam analogs would occur during both Phase 1 and Phase 2 activities. During Phase 1, beaver dam analogs may be located throughout the project reach. The Phase 2 work zone would include all actions downstream of Bridge 1, as well as any riprap removal, alcove construction, or LWD installation identified in the footbridge 1.5 area. Beaver dam analogs would be added during Phase 2. Installation of LWD between footbridge 1.5 and Bridge 2 could occur in either phase.

### Upstream of Bridge 2

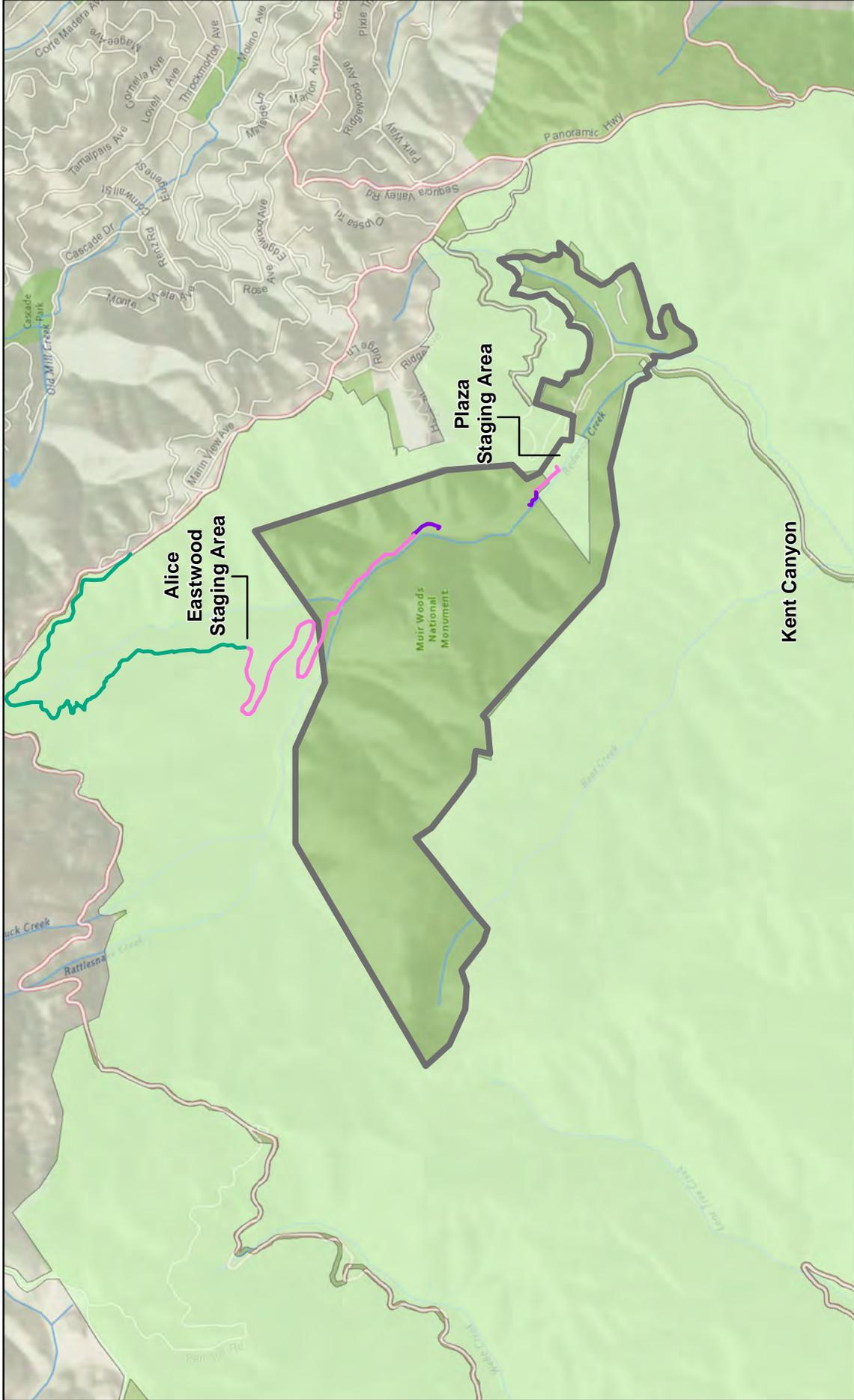
#### *Phase 1 Riprap Removal (Excluding Segment R6)*

Equipment would be mobilized to the California State Parks Alice Eastwood Group Camp, where a staging area would be established. The staging area would be delineated by fencing such as orange environmentally sensitive area fencing and/or temporary 6-foot-high chain-link fencing.

Equipment mobilized for in-channel work upstream of Bridge 2 would use Alice Eastwood Road, to the Camp Eastwood Trail, to the intersection with the main trail at MWNM (see Figures 2-10 and 2-11). Alice Eastwood Road is on California State Parks property. From the intersection with Panoramic Highway, the upper segment of Alice Eastwood Road is paved and leads to the California State Parks Alice Eastwood Group Camp. The lower segment of the road is dirt from the Alice Eastwood Group Camp to MWNM. The dirt segment has numerous gullies, and the gullies would be treated as needed for mobilization and hauling by the construction crew prior to use to reduce long-term sediment delivery. Treatment may include minor grading and filling of gullies and potentially some ditching. These gullies were recognized as a source of sediment in the Pacific Watershed Associates 2002 sediment source survey and were evaluated as medium and medium low priorities for treatment. The gully on the dirt segment of the Alice Eastwood Road currently washes sediment to the asphalt trail at Muir Woods, within 25 feet of the creek. Any damage to Alice Eastwood Road would be repaired following the completion of hauling.

Prior to any heavy equipment entering the channel, the work area would be dewatered and fish and wildlife removed following the steps described in Appendix D, *Best Management Practices*. A cofferdam (either traditional sandbag/polyethylene design or a water-filled cofferdam) would be installed at approximately creek station 2000. The pump bypass would be installed near the Camp Eastwood trail junction with the Main Trail, and the discharge pipe would be located just upstream of Bridge 3 to maintain clean flows at the same natural flow rate downstream of the work zone. Once the pump is turned on, it would need to run continuously 7 days per week to prevent water from flowing through the work zone. Discharge from Fern Creek would also need to be rerouted or plugged to avoid draining into the work zone; it is conceivable that if flows are higher than usual at the time that another pump could be needed, but it is likely that these flows will be able to be rerouted without the use of an additional pump. If any small tributaries are actively draining at the time of work, their flows will also be rerouted or plugged to avoid draining into the work zone.

To provide equipment access to the channel, a ramp would be constructed between the main trail and Redwood Creek, near the cofferdam. Removal of small areas of fencing and minor clearing and grubbing could occur at the ramp location. Fencing would be rebuilt at the completion of the project. The ramp design is anticipated to consist of high strength woven geotextile fabric (e.g., Mirafi 500X) with a layer of geogrid (e.g., Mirafi BX1200) capped with 6 to 8 inches of aggregate. The aggregate design mix would be constrained by the choice of geo-grid used for the ramp or whether geo-grid is used at all. The ramp, including all materials used for its construction, would be removed after activities in the channel are completed; and the forest floor would be decompacted



**Figure 2-10**  
**State Park Lands and Staging Areas**  
 Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project

using the same method described for asphalt trail removal below. This ramp will also be used daily for access to the channel for all personnel and equipment during work in this area. Once reaching MWNM, the equipment would cross approximately 100 feet of forest floor to enter Redwood Creek via the ramp. The route would then be located within the creek, extending from this upstream point in the creek down to the Cathedral Grove reach, a distance of approximately 1,400 LF of channel. All riprap from the Cathedral Grove area (riprap segment L7) to the upstream-most riprap segment proposed for removal (L13) would be removed using this route.

The channel in this route is straight and has no wood jams to dismantle. There are a few small-diameter logs spanning the channel from top of bank to top of bank, but these do not extend to the water and can be picked up and replaced or relocated to a location that will function more effectively for habitat. The bed material is mostly cobble. One large-diameter instream log occurs near this area but it will not need to be moved. It is located downstream of the area where heavy equipment would be operating.

The equipment anticipated to be used in this area would be three mid-sized excavators, two to four haul carts (e.g., Wacker DW50), a skid steer, a hydraulic hammer (at least one for the mid-sized excavator and/or skid steer). A minimum of two laborers is anticipated. It is anticipated that much of the rock in this area can be removed and buried without being broken up; however, some may need to be broken up before removal and burial. The excavator would operate throughout the channel reach to remove the large 1- to 2-ton boulders from channel banks. The riprap would then be buried in the channel in a nearby location.

Riprap burial would be conducted upstream of Bridge 2 across approximately 550 linear feet of the channel, and would disturb approximately 11,775 square feet of channel through excavation (NHE 2018). Riprap burial would be conducted by placing rock riprap in a 5-foot deep trench extending from the center of the channel towards the outer margins of the channel (but not including the channel margins). Due to the angle of repose of natural gravel and sand, a 5-foot excavation depth would result in the top of the excavation being approximately 15 feet wider than the bottom of the excavation (NHE 2018). Thus, if a 2-foot wide piece of riprap was buried, the top of the excavation would be approximately 17 feet wide. The width of the channel in burial areas limits the width of potential riprap burial. Riprap burial that is too shallow has the potential to limit stream bed scour and pool development. Thus, riprap would be placed a minimum of 3 feet to the top of the riprap below the current bed surface elevation so as not to interfere with pool formation (NHE 2018). Excavated material would be stored in small stockpiles adjacent to the excavation areas.

Excess bed material displaced by the burial of riprap and creation of pools would be used to create instream bars and elevated riffle crests. During channel excavation, the surface layer of the streambed, typically consisting of coarser material (e.g., cobble and gravel), will be segregated from the subsurface materials. This coarser material will be placed as the final surface layer of the channel in excavated areas except in deeper pools where bed material generally contains a higher percentage of smaller, finer material.

Following burial of riprap, the channel bed would be restored to a similar condition as existing conditions; i.e., filling gaps between rocks and cobble with native bed material, compacting the bed material to a similar level as the undisturbed stream bed, shaping backfill and instream bars to a similar topography, and placing coarser material as a surface layer. Riprap burial would be conducted far enough from viable pools to avoid disturbing these features. Riprap burial zones would be segmented with unexcavated, natural bed areas to avoid creation of longitudinal voids in the subsurface. Minor use of carts to transport some rock a short distance may be needed, but rock would not be transported up to the Alice Eastwood Campground for stockpiling or reloading.



**Figure 2-11**  
**Proposed Equipment Access for Riprap Removal Upstream of Bridge 2**

Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project

Zone of Dewatering  
 Existing Riprap Location  
 Bridge  
 Primary Route for Large Excavator  
 Route On Trail  
 Trail  
 Ramps

0 95 190 380 Feet

This method of burying riprap removed from banks upstream of Bridge 2 was selected after a geomorphologist from a regulatory agency made a site visit and suggested it would be preferable to retain material in the creek, rather than off-hauling it, since the channel is incised and aggradation is desirable. This led NPS to investigate the feasibility of burying the riprap in the channel. It also became apparent that burying the riprap is substantially faster and less expensive than off-hauling it, not only because the off-hauling itself is slow and expensive, but because the costs of protecting a vulnerable water line under 1.75 miles of the Alice Eastwood Road were better understood and would have been very high if 10-CY trucks were to be used. Riprap burial has additional benefits for channel complexity by creating riffle-run-pool-glide sequences and more natural bars that will help the development of the low flow channel. This method will also help to build the channel towards the long-term goal of better connection with the floodplain. This method also allows access by a sizeable excavator, which allows for a greater range of actions:

1. Vegetation on banks can easily be salvaged by equipment. Vegetation would be removed, set aside during the work, then replaced in the bank by the equipment.
2. Notches in banks could be created for placement of logs or holes in the channel could be pre-dug to embed the logs in the channel, providing added stability.
3. Pools can be excavated prior to wood placement. Although pool configurations may change in the long term during winter events, configurations would provide some near-term juvenile habitat.
4. Any excavated pool material can be placed at an in-stream bar. Again, although this geomorphic configuration will change, it may help to jump start the desired creation of in-channel complexity.

#### *Phase 1 Riprap Removal (Segment R6)*

For riprap segment R6, which is upstream of Bridge 2 but downstream of Bridge 3, the riprap removal method would be as described below.

A cofferdam, similar to that described above, would be installed just upstream of Bridge 3. A third cofferdam may be necessary to prevent bypass water from migrating upstream into the work area and will be assessed further prior to the final design. A secondary pump and bypass would be constructed in this area, with the terminal end of the discharge pipe located downstream of segment R6. This area would be dewatered as described in Appendix D, *Best Management Practices*. Dewatering of this portion would be conducted for a shorter period of time. An overlap in operation of this dewatering pump and the upstream dewatering pump would occur because the segment R6 riprap would be offhauled using the dewatered portion of the channel described above.

Two ramps would be constructed to allow equipment access to segment R6. These ramps would be located at Bridge 3 and slightly upstream of segment R6. They would be constructed and removed similarly to the ramp at creek station 2000, but would be less substantial because they would be used for a shorter period of time.

A smaller excavator would travel down the channel using the Alice Eastwood Road and the primary channel route described above. The excavator would drive out of the channel at the Bridge 3 ramp to the main trail. It would then drive down the main trail on the east side of the channel to re-enter the channel using the ramp located slightly upstream of segment R6. A smaller excavator is required because the trail is narrow in this area. Since the excavator would be smaller than the one used farther upstream, it is likely that the segment R6 rocks would have to be broken up in order to load them into the carts. Hydraulic and/or pneumatic equipment would be used to break down the rock.

The riprap removed from this segment would also be buried in the channel just upstream of the bank where they are removed, following the same methods used upstream.

Because a large redwood tree fell into the creek in the middle of this riprap segment in January 2017 and since the tree could not be easily relocated without cutting it, a method has been identified to remove riprap from the banks on both sides of the fallen tree. Equipment will use the method described above to remove riprap on the upstream side of the fallen tree. To access riprap on the downstream side of the tree, equipment will ramp up the right bank of the creek upstream of the tree, drive a few yards on the main trail on the west side of the creek, and re-enter the creek downstream of the fallen tree. The methods for burying the riprap will be the same as those for the rest of this segment. The right bank used for the ramp will be regraded, as originally planned, and covered with erosion control fabric. This modification will not require additional dewatering.

### *Asphalt Trail Removal*

This methodology is also applicable to asphalt trail removal downstream of Bridge 2. Removal of asphalt trail and any base rock would be conducted by an excavator or other small equipment using methods that would not disturb the ground surface below the base rock. It may be necessary to build a ramp from the creek to the top of bank for equipment to reach the trail. Equipment would scrape in shallow movements to avoid impacts to possible roots beneath the trail. Removal of all of the base rock is very important or the area will not easily develop vegetative cover. Material would be off-hauled to the Alice Eastwood Campground, where it would then be off-hauled in small trucks with small loads. The use of 10-CY trucks on Alice Eastwood Road would be avoided to avoid impacts to the water line under the paved segment of the road. The asphalt would be hauled to campground either using the same creek route used for other equipment access, as described above, or if loads are small enough and will not impact boardwalks, they may be off-hauled via the trail route to the campground. Asphalt would be transported to Redwood Landfill in Novato for recycling.

The subsurface would then be decompacted using hand methods to avoid potential impacts to tree roots. Shovels would be inserted into the ground surface about 1-foot deep in multiple directions at 1-foot centers throughout the area. The ground would then be heavily covered with organic debris from the forest floor, with mulch a minimum of 4 to 6 inches thick. Surface water would be allowed to infiltrate over the next year before planting. This method would be repeated about 6 months to 1 year later, prior to planting.

### *Existing Water Line at Muir Woods*

The route of an existing water line which extends from the Alice Eastwood area and likely along the left bank of Redwood Creek requires investigation prior to construction. This line once served drinking fountains that have since been removed, but the line has been retained for fire protection. The investigation is needed to ensure proposed actions would not interfere with this line.

### *Existing Water Line at Alice Eastwood*

A water line extends down the center of the paved Alice Eastwood Road from Panoramic Highway to the campground. It is an old line that is at a shallow elevation and prone to breaking. The water line is known to occur at 10 highly vulnerable locations under about 550 LF of the road, which would have needed to be protected by trench plates throughout the construction period if 10-CY trucks were to have been used for hauling along Alice Eastwood Road. In addition, another 15 vulnerable water line locations occur under the road and would have required barriers but could still be vulnerable if heavy trucks are used. Therefore, construction activities will avoid the use of 10-CY trucks which would require a greater level of protection to the water line and road at substantial expense, and will instead require the use of only small pick-up sized trucks. Protection

of the road and water line during ingress and egress by an excavator or similar equipment will be accomplished by placing plywood as the excavator travels down the road. This method is feasible for the one-time ingress-egress of a piece of equipment, but it is not logistically feasible if the road were used repeatedly by 10-CY trucks. The water line under the road is known to generally withstand use by pick-up trucks and small vehicles without breaking. A preconstruction water pressure test will be conducted to identify any existing leaks in the line. A contractor will be required to reimburse California Department of Parks and Recreation for the repair of any leaks that occur during the contractor's use and will conduct a post- construction water pressure test to demonstrate the system is in good working order prior to closing out. This method will also be used for any bridge construction in which heavy trucks use the Alice Eastwood Road.

### *Hauling and Location of Rock Disposal*

Rocks removed during Phase 2 of the project are expected to be stockpiled at the Kent Canyon storage area or possibly some would be stockpiled at the State Parks Pantoll ranger station or at the top of the dirt portion of Alice Eastwood Trail for reuse either by NPS or State Parks in the future, or if storage capacity is not sufficient, rock may be made available for non-park uses. Kent Canyon is on lower Muir Woods Road, approximately 1 mile downstream from the MWNM entrance (Figure 2-10). To access the storage area, trucks operating during Phase 2 of the project would drive from the entrance to MWNM and about 2 miles down to Kent Canyon. Driving time for a haul trip could be slowed by visitor traffic at MWNM if hauling is done during peak visitor hours. It may be possible to haul during off-peak hours. NPS would take actions as needed to prevent traffic from backing up during busy periods, using means such as a traffic flagger. During Phase 1 of the projects, no trucks would be driving down Panoramic Highway or Upper Muir Woods Road to transport rock.

Due to the use of the large excavator, it is likely that many of the 1- to 2-ton rocks can be stockpiled intact and will therefore be more valuable for potential future reuse. It is possible some rocks might be delivered to other currently unidentified locations.

### *Trail Closures*

Alice Eastwood Road from the Alice Eastwood Group Camp may be closed periodically during Phase 1, for pedestrian safety but closure would be intermittent during periods of mobilization and demobilization. Alice Eastwood Group Camp is an active recreation site operated by Mount Tamalpais State Park, with two group camp sites. Past uses of the land in the vicinity of the Alice Eastwood Group Camp include Mount Tamalpais-Muir Woods Railway and a CCC work camp. Other nearby routes such as Fern Creek Trail would remain open. Signs informing visitors that the area is being used for construction access would be installed during construction. However, LWD installation may be occurring at the same time as riprap removal, and LWD installation would require trail closure. Trail closure may be focused on selective areas for LWD installation, instead of broad areas of trail closure. Signage and alternative routes would be provided for any trail closures.

### *Campground Closure*

The Alice Eastwood Group Camp would likely remain open to visitors during the Phase 1 implementation except during brief periods of mobilization or demobilization. A small portion of the campground parking lot would be fenced off for staging, but no operations for stockpiling and loading would take place at the parking lot. The parking lot would likely be used for staging for up to about three months, likely beginning in early August.

### LWD Installation

Installation of LWD in the channel would occur both within and outside of the routes identified for riprap removal. See Figure 2-1 for detail on location and movement direction for logs proposed for

LWD installation. LWD would be installed using a combination of methods, including a cable hoist and drag method as well as the use of heavy equipment. Use of heavy equipment associated with LWD installation would only be conducted when the channel is dewatered during the pre-spawning season, which typically concludes on October 15. LWD installation via cables and hand methods may extend into winter months if weather conditions allow.

The primary method of LWD installation will entail the use of a cable and grip hoist system. This method lifts one end of the tree in the air while the other is dragged on the ground. Existing downed logs present in MWNM would be moved into the channel to act as LWD. In areas accessible by heavy equipment, a notch in the bank or a hole in the creek bed may be pre-dug for placement of the wood via the cable method. Backfilling of gravels around an embedded trunk tip would most likely be conducted by hand. Designs will maximize the number of log pieces in a jam, which would increase the sediment storage potential of wood jams, the roughness of the structure, the complexity of scour and fill patterns, and the length of channel that is influenced by the structure. As described above, heavy equipment would be used to excavate pools and build adjacent bars/riffles at wood jams.

The rigging uses wire rope with grip hoists. The grip hoists put the wire rope under tension. A rigging crew would set up the rigging in trees surrounding the log to be moved. A detailed rigging plan would be prepared approximately 1 to 2 months prior to LWD relocation. Crews would climb trees using a Swedish ladder (a sectional aluminum ladder) for safety. The use of spurs, which enter trees approximate 1.5 inches, would not be permitted for tree climbing. Nylon strapping would be placed around the tree to secure the rigging. Trees would be protected from damage by placing 2x4 planks between bark flutes as well as padding the area to be strapped. One end of the target log would be raised and the log would be dragged into the creek. A rut would be created as the log is dragged. This rut would be filled using shovels and rakes, following placement of the LWD. There would also likely be temporary trampling of vegetation surrounding the logs moved into the channel. For logs installed in areas where riprap will not be removed, dewatering of the channel is not anticipated. This is based on the idea that under natural recruitment of LWD into the channel, trees fall when the channel is wet and inhabited. The grip hoist method has been used by both NPS and State Parks trail crews in and near Muir Woods and is a commonly used technique in back country areas without access for equipment.

If any logs for LWD must be cut, the following method would be used to avoid leaving a visible clean cut on the end of the log. A wedge and a sledge hammer would be used to splinter the end of the log by using an existing crack in the end of the log. The exposed end would be left splintered, as it might appear after a fall. It may be feasible to first cut the log with a chainsaw and then splinter the remaining end. Duff would also be used to bury a new cut at the end of a log. Finished cuts should not appear as visible cuts but as roughened, splintered ends.

A few bay laurel (*Umbellularia californica*) trees may be removed to allow relocation of LWD. In order to incorporate two large redwood logs that fell in January 2017 into the LWD designs, two small redwood trees (less than 1 foot diameter at breast height [DBH]) would be removed and reused within the Redwood Creek channel. Two small diameter redwood trees (less than 1 foot DBH) may also be removed to allow a large diameter redwood, which fell naturally during winter storms in early 2017, to be rolled into the channel upstream of Bridge 2. They would be reused as LWD in the channel to create a complex jam.

The LWD designs call for piles of SWD to be placed in the channel before large logs are placed on top of them. The SWD would be collected from a variety of locations around MWNM where fallen or hazardous trees have been cut by the trail crew and piles of slash remain.

### SWD Installation

In addition to the SWD that would be used in combination with LWD, some SWD would be installed as structures referred to as beaver dam analogs. These features would consist of small-diameter wooden posts embedded several feet deep in a line across a segment or all of the channel, with a few feet extending above the bed. Posts would preferably be from locally sourced Douglas fir trees, but otherwise would consist of untreated wood. Small-diameter branches would be woven between the posts. Slash from hazard trees cut in MWNM would be collected and used as SWD. Some SWD would be collected elsewhere in the watershed. Where the goal is to pond water, native soil, weed-free straw, and cobbles would be packed at the base of the woven branches, but soil packing may not be needed in all locations. In locations where heavy equipment would not otherwise be working, the posts would be installed by hand-operated powered post drivers or using simple non-powered post pounders. Where heavy equipment is already working, the posts may be installed using vibratory post drivers attached to heavy equipment. Where the creek is not already dewatered for access by heavy equipment for other actions, the creek would not be dewatered to install the beaver dam analogs and fish would not be relocated. Stewards and volunteers are likely to participate in the other steps of installation and would participate in the ongoing adaptation of these features to new channel conditions.

### Phase 2 Downstream of Bridge 2

These methods pertain to the Plaza Area, which extends from Bridge 1 downstream to the Plaza, and the footbridge 1.5 area, which includes riprap segments R3, a portion of R2, and L2. Phase 2 work would be conducted in a similar manner to Phase 1 work, with a larger excavator used downstream of Bridge 1. LWD installation downstream of Bridge 1 would occur in Phase 2. Installation of BMPs required by the SWPPP would occur, and are anticipated to be similar to those for Phase 1.

Phase 2 mobilization would require a police escort for the delivery of the 20-ton excavator. The Plaza Area would be used as the staging area for this phase of work. The primary equipment access and haul route for the Plaza Area would be between Bridge 1 and the Plaza (see Figure 2-12). Large equipment can easily access this area from the Plaza. The existing sewer line in the Plaza area would not be impacted by project actions.

A cofferdam, dewatering pump, and bypass pipe would be set up near the footbridge 1.5 area. This area would be dewatered and fish and wildlife would be removed as described in Appendix D, Best Management Practices. It may be possible to use an electric pump in this location, but if this is not feasible a diesel pump would be used. A ramp would be constructed at in the Plaza Area and would be similar to the ramp described above at station 2000. This ramp would be the primary route for equipment entering the channel as well as off-hauling riprap. A large excavator would enter the channel from the Plaza and travel upstream to remove riprap downstream of Bridge 1. Track trucks, wheel loaders, or carts like those to be used in Phase 1 would be used to haul the rock out of the creek and up to the Plaza. The 10-yard-trucks will be loaded at the Plaza Area. During Phase 2, approximately 450 CY (760 tons) of riprap would be removed in approximately 128 truck trips.

Ramps would be built at Bridge 1 and in the footbridge 1.5 area, similar to the Phase 1 ramp described at Bridge 3. The riprap in the footbridge 1.5 area would be removed by a smaller excavator (such as that described for riprap segment R6 above). It would travel from the Plaza, up the channel haul route to Bridge 1, and exit the channel on the right bank just downstream of Bridge 1. From there, it would drive on the asphalt trail along the right bank to the work zone. Much of this removal may be conducted from the bank itself; however, the excavator would also enter the channel in this area and dewatering would occur as described above. To off-haul, the carts would travel back down the asphalt trail, down the ramp on the immediate downstream side of Bridge 1,

down the channel to the Plaza area, and up the ramp to the Plaza. In addition to riprap removal, the excavator would be used in the footbridge 1.5 area to excavate an alcove in an existing gravel bar along the left bank. The excavated material would be placed as part of a channel feature and would not be exported.

#### *LWD Installation*

LWD in the Plaza area would consist of imported large-diameter logs with root wads. The excavator would handle and install all of these logs.

There is some LWD proposed for installation that is outside of the riprap removal zones. As with the upstream area, the wood in these areas is expected to be mostly installed using the cable and grip hoist methods.

### **Bridge Construction**

Bridge construction would have a phased approach, in which 2 bridges would be replaced in one year, and the other 2 bridges would be replaced 2 years later. Bridges 1, 2, 3, and 4 would be demolished. Temporary bridging (scaffolding) would be constructed just above the water line under and outside the footprint of the bridge alignment. The bridging would act as temporary access between banks as well as serving as a working platform. All decking would be unbolted, the glulams would be blocked up off of the scaffold and cut into pieces. Those pieces would be dragged off the platform via cable and winch and removed from the site for disposal. This approach eliminates the need for overhead lifting and protects Redwood Creek from construction debris. The existing abutments would be removed and replaced farther from the creek. If dewatering is needed to remove the abutments, the same BMPs and protocols would be followed as described for the Creek Restoration Actions.

The new foundation type may vary from bridge to bridge depending upon the results of geotechnical subsurface exploration. Potential foundation types under consideration are pile cap and shallow/spread footings (Figure 2-13). These foundations would require excavation to the bottom of the cap or footing. Spoils would be offhauled or reused on site/at adjacent sites where feasible. Helical piles may be used, or micropiles. Helical piles are typically installed using relatively lightweight portable or track-mounted equipment and require a minimum of hand labor to construct. Micropile construction would entail drilling a small-diameter vertical shaft, placing a high-strength, large-diameter length of steel rebar, and then filling the excavation with neat cement grout. Micropile drilling would require high-speed pneumatic drills.

Materials for bridge construction would be staged in the laydown space at the existing parking area behind the visitor/administration building and would be coordinated with other parallel NPS construction projects. Steel beams would be transported in smaller sections from the staging areas at Camp Alice Eastwood (for Bridge 4) or the old parking area (for Bridges 1, 2, and 3) on heavy-duty dollies either rolled by hand or pulled by an excavator. Bulky and heavy materials would be transported with rubber tracked carriers. Model and type of tracked carriers may vary with materials required. For Bridges 2 and 3, portions of the existing asphalt trail would be removed. For Bridge 4, the eastern approach ramp would be constructed using excavation spoils, local stone, and local logs (if available). Beam sections would be winched across onto the platform constructed during demolition, aligned, blocked into place, and bolted together and to the beam seat. This method is intended to eliminate the need for overhead lifting. Wood railings and decking would be sourced from sustainable sources of wood and would be certified by the Forest Stewardship Council or similar certification to the extent possible.



Use of Alice Eastwood Road would follow procedures to protect the waterline discussed above in creek construction methods. As with this creek construction use of the campground area as a staging area, State Parks may choose to temporarily close the campground, depending on the period and duration of its use. Disturbed areas of the streambank would be regraded and revegetated. Area where asphalt is removed for trail rerouting would be decompacted and revegetated as described for the Creek Restoration Actions. Materials from demolition of Bridges 1, 2, and 3 would be removed using the existing trail system. Bridge 4 would be removed using the Alice Eastwood Road. Materials for Bridges 1, 2, and 3 would be transported along the trails along Redwood Creek. Materials for Bridge 4 would likely be transported on Alice Eastwood Road. Precaution would be taken to protect the existing boardwalk, and when necessary the boardwalk would be replaced in kind if damaged.

During construction of each bridge, visitors would be rerouted along alternate access routes such as the trails on the west side of Redwood Creek, Hillside Trail, portions of the trails on the east side of Redwood Creek, and Canopy View Trail during construction of each bridge.

### ***Schedule***

Creek restoration actions are expected to begin on the ground in summer 2018 and continue through October 2018, consistent with BMPs BIO-4 and BIO-77. Phase 1 riprap removal is anticipated to occur over about an 8-week on-the-ground work period, with LWD installation in the first year likely extending later into the winter months in the same year. An additional period of LWD installation would occur in the following year. Phase 2 is anticipated to also occur over about 8 weeks during the low-flow season in a later year.

Bridge construction is scheduled to start in 2019 or 2020, with a second construction season in 2021. Two bridges would be removed and replaced during each of the construction years. Construction is anticipated to occur over an approximately 4.5-month period within each construction year. Construction is likely to occur in June, consistent with BMPs BIO-4 and BIO-7, and continue through October.

### ***Equipment***

Equipment that is anticipated to be used for the Proposed Action consists of the following items.

#### **Bridge Replacement**

Bridge replacement equipment may vary, depending on the method of bridge anchoring.

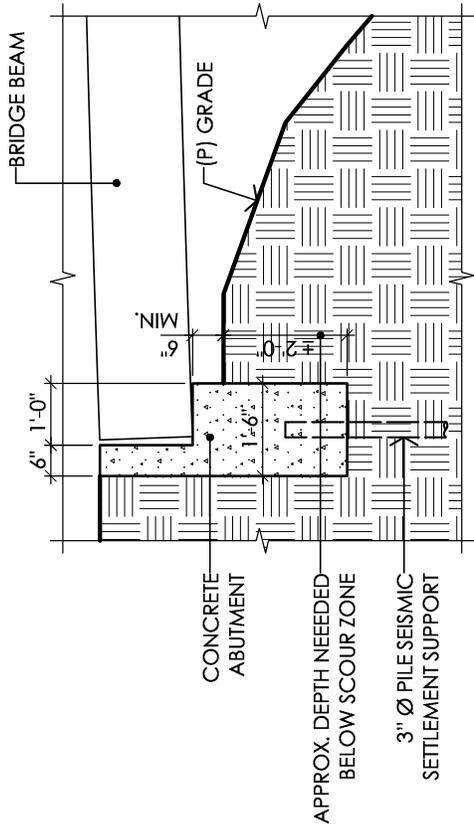
Helical piles would require a small excavator or a hydraulic pump on a small trailer. Micropile installation would require a small drill rig or possible hydraulic portable drill rig. Shallow spread footings could be hand-dug or may require the use of a small excavator.

#### **Creek Restoration**

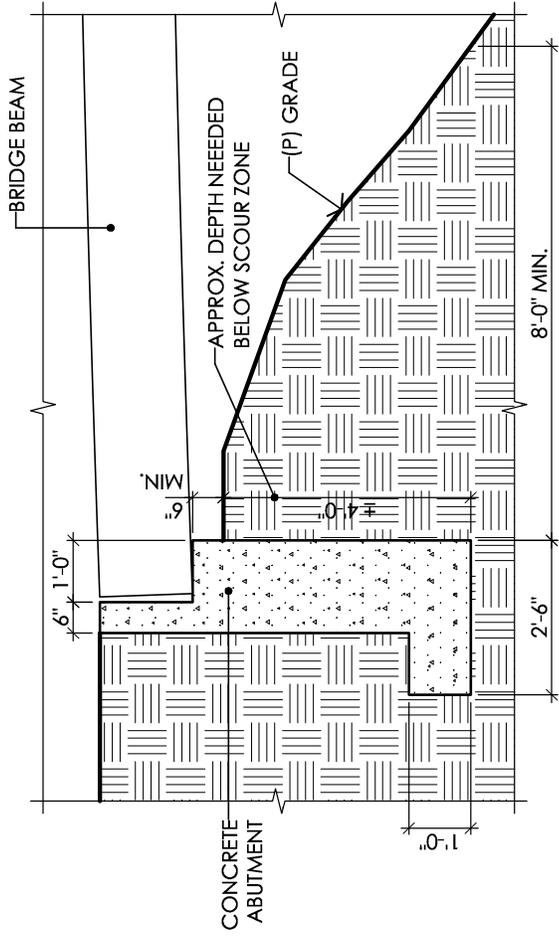
- Tracked excavators (Cat 308, John Deere 160, and Komatsu PC88 or similar, see Figure 2-14)
- Tracked haul carts (CanyCom S25A or similar)
- Noise-attenuated dewatering pumps for dewatering (6-inch diesel, as well as potentially electric for the Phase 2 pump)
- Hydraulic and/or pneumatic equipment to break rock when removing riprap segment R6 boulders



**Figure 2-13.** Cat 308 Excavator



**CONCRETE ABUTMENT - OPTION 2**  
**PILE SUPPORT - 50' BRIDGE, TYP.**



**CONCRETE ABUTMENT - OPTION 1**  
**SPREAD FOOTING - 50' BRIDGE, TYP.**



**Figure 2-13**  
**Pedestrian Bridge Abutment Options**  
 Salmon Habitat Enhancement and Bridge  
 Replacement Project Environmental Assessment

- Articulated haul carts (DW60 Wheel Dumper or similar, see Figure 2-15)
- Diesel 375 cfm compressor
- Supplemental hand tools
- Tracked loader (Mustang MTL 50, Komatsu CK35, or similar)
- 10-CY dump trucks

#### Other Equipment

- Diesel compressor
- Tracked haul carts
- Cable and winch
- Hand tools



**Figure 2-15.** DW60 Wheel Dumper

## 2.6 Operations and Maintenance Activities

Rerouting of trails in the footbridge 1.5 and Fern Creek areas would result in decreased future trail maintenance and closures, as trails would be relocated farther from the creek and thus would be less prone to flooding.

Routine maintenance of pedestrian bridges will continue. Replacement of the pedestrian bridges would result in less long-term maintenance, as the bridges would be subject to less water and debris damage, compared to the current bridges. Replacement of the current glulam bridges with steel stringer bridges with wood decks would also result in less future maintenance due to the superior durability of these materials. Additionally, the new bridge design would allow for easier replacement of parts than existing glulam bridges. The decking and railing materials sit on top of the steel stringer frame that supports the bridge. These bridge components can be replaced if damaged and would not require replacement of the entire bridge structure. Replacement of some portions of asphalt trail with boardwalk would result in increased future maintenance, as part of ongoing trail maintenance in MWNM.

If woody debris relocates and becomes stranded at a location that threatens infrastructure or visitor safety, then MWNM Operations staff would remove woody materials and relocate it in the channel. MWNM staff would follow appropriate BMPs to minimize potential impacts to other resources. Depending on circumstances and timing, actions may need additional review under the park NEPA processes.

## 2.7 Best Management Practices

Best Management Practices are listed in Appendix D.

## 2.8 Alternatives Considered and Dismissed from Further Analysis

### *Grade Control of Other Tributaries*

All creek restoration alternatives include installing grade control at an incised tributary just upstream of Cathedral Grove. Installation of grade control on other incised tributaries was not

considered as an alternative because the overall treatment of tributaries was considered to be outside the scope of this project. Some tributaries have grade control at the confluence with the mainstem of Redwood Creek. Actions were considered to remove this grade control to provide better off-channel winter habitat for salmon; however, this action was dismissed because of the risk of inducing further incision in the existing tributaries. Instead, the use of SWD structures referred to as beaver dam analogs is proposed to aggrade the mainstem near the confluence of drainages.

### ***Grade Control within Redwood Creek***

NPS considered an action to install grade control in the Redwood Creek channel to address the long-term effects of incision. The intent of such an action would be to reactivate the channel with its floodplain and, possibly, increase groundwater elevations to better maintain instream flows during the dry season. The action could have consisted of reusing removed riprap to build grade control structures that would capture sediment and aggrade the channel 1 to 2 feet, depending on the structure. However, this action was dismissed because there are no appropriate locations to install such structures. Actions using SWD structures were incorporated into the Proposed Action because these structures can serve a similar purpose as boulders but are highly adaptable over time and are inexpensive to install. If rock grade control structures were used, they would require stable, reinforced banks on either side to prevent outflanking by high flows, and no such location was identified that would be suitable for highly engineered and robust boulder grade control. In comparison, SWD structures can be adaptively built instead of built at a large scale in one construction period, and suitable locations for SWD structures are more easily identified. If the intent were to allow banks to erode to generate sediment to be trapped behind the grade control, the approach would be ineffective because there are no channel banks other than those identified in the preferred alternative where bank erosion could occur without affecting existing infrastructure (including a sewer line under the entrance boardwalk, a water line extending along the left bank to Fern Creek, boardwalks, and trails). A single grade control structure, depending on a height of 1 to as much as 2 feet, would have extended its effect only 80 to 100 LF upstream given the channel gradient, so up to as many as 30 to 40 structures would have been needed in the mile-long reach to aggrade the whole channel. The effect would be a highly-engineered system that is not suited for MWNM.

Muir Woods is identified in the GMP as a Cultural Landscape with historic significance. The range of actions which can be conducted under the GMP that may alter the landscape consist of “targeted riprap removal” and some trail relocation to improve channel function. It does not provide for a large number of rock grade control structures and extensive bank erosion control measures. Instead, the preferred alternative addresses incision through a long-term approach, by adding wood to significantly increase the sediment storage capacity of the channel and to use angled channel-spanning logs where possible. A moderate approach to reusing some boulders mid-channel will be employed in the preferred alternative without building channel-spanning grade controls.

### ***Removal of Bridge 1***

Removal of the existing Bridge 1 without replacement was initially considered as an alternative. However, removal of Bridge 1 would likely require major changes to trails and visitor experience in MWNM. This alternative would limit opportunities for an accessible loop and would concentrate visitor use of the boardwalk and trails on the east side of the creek. It would eliminate the most heavily used loop through the woods, which extends from the entrance on the east side of the creek to Bridge 2 or 3 and back on the west side of the creek. This would also eliminate access and unique views around Bohemian Grove on the west side of the creek. The GMP supports the use of side trails in the woods in order to avoid concentrating visitors on the main trail. It also encourages the development of thematic interpretive trails to experience different parts of the park. Thus Bridge 1

removal would be more properly considered under a comprehensive trail plan, which is outside the scope of this EA.

### ***Removal of Bridge 3***

Removal of the existing Bridge 3 without replacement, and removal of the trail segment between Bridges 2 and 3 on the west side of Redwood Creek, were initially considered as an alternative. Bridge 3 is heavily used by visitors as it provides a 1-mile loop through the woods. Bridge 3 allows for more trail options for visitors. It also provides NPS with management flexibility when trails must be closed to due to hazards such as a tree falling over a trail. The trail segment between Bridges 2 and 3 also helps distribute visitors throughout the woods rather than keeping them all along one trail. Removal of Bridge 3 would result in a major, permanent effects on use patterns and visitor opportunities within MWNM. For these reasons, this action was dismissed as an alternative.

## Chapter 3

# AFFECTED ENVIRONMENT

### 3.1 Introduction

This chapter presents information about the existing environment at MWNM. Issues and impact topics discussed in this chapter include cultural resources, threatened and endangered species, visitor use and experience, geology and soils, transportation wildlife habitat, vegetation, water resources and hydrologic processes, visual resources, and climate change (where applicable within the impact topics). Two recent EAs describe the affected environment in and around MWNM (NPS 2015, NPS 2016a) and were utilized in authoring the affected environment for this EA.

### 3.2 Cultural Resources

#### *Area of Potential Effects*

The implementing regulations for Section 106 of the National Historic Preservation Act (NPHA) of 1966, found at 36 CFR 800, require that an area of potential effects (APE) must be established to determine and define the “geographic area or areas within which an undertaking may directly or indirectly cause alterations to the character or use of historic properties, if such properties exist and is influenced by the scale and nature of an undertaking. It encompasses both those areas where proposed actions might occur that would directly impact cultural resources, as well as adjacent areas that contain resources that might be indirectly affected” (36 CFR 800.16(d)).

To assess the effects of this undertaking on all historic resources that might be affected, the general APE includes the entire Muir Woods Historic District. The areas that the project would directly affect (the Direct APE) include the channel and both banks of Redwood Creek for approximately 5,110 LF, from the vicinity of the restrooms at the Entry Plaza, upstream to just above Bridge 4; a small portion of Fern Creek (approximately 125 LF), upstream from its confluence with Redwood Creek, is also in the Direct APE. The Direct APE also includes approximately 275 LF of a tributary upstream of Cathedral Grove. Additionally, the Direct APE includes the Camp Eastwood Trail, Alice Eastwood Road, and the paved parking lot of the Alice Eastwood Group Camp. The parking lot would be used for Creek Restoration Phase 1 staging and bridge construction staging, and the Alice Eastwood Road and Camp Eastwood Trail would be used as an access route which is why these features are included in the Direct APE. The Direct APE extends 10 feet from the edge of Camp Eastwood Trail and from the edge of the pavement along Alice Eastwood Road. The Direct APE encompasses portions of the Main Trail (also known as Redwood Creek Trail) and Bridges 1 through 4. Also included in the Direct APE are potential trail relocations, areas of potential disturbance from dragging logs to the creek channel, and access routes for equipment to be used for project actions in the creek channel, which cause the Direct APE boundaries to be irregular. A detailed map of the Direct APE, including known resources (trails, riprap, and bridges), is shown in Figure 3-1.

### ***Properties Listed in the National Register of Historic Places***

**Muir Woods National Monument.** The monument is one of the great examples of the early development of the conservation movement in the late 19th and early 20th centuries to preserve an old-growth forest of coast redwoods. Theodore Roosevelt declared it a national monument in 1908 under the provisions of the Antiquity Act of 1906. The portion of MWNM as it existed at the end of the period of significance (1907–1947) was entered into the national register in 2008 as a historic district. For a property to be eligible for the NRHP, it must meet at least one of four main criteria, as listed under 36 CFR 60.4:

- **Criterion A.** The property is associated with events that have made a significant contribution to the broad patterns of our history; or
- **Criterion B.** The property is associated with the lives of persons significant in our past; or
- **Criterion C.** The property embodies the distinctive characteristics of a type, period, or method of construction, or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components may lack individual distinction; or
- **Criterion D.** The property has yielded or may be likely to yield, information important in prehistory or history.

The monument was found to be nationally significant under criterion A and criterion C for the contributions of William Kent and the conservation movement, its use of rustic park architecture, and as an example of Emergency Conservation Work/Civilian Conservation Corps programs in the 1930s, as well as its association with the signing of the United Nations Charter in 1945 (Auwaerter and Sears 2006). Five buildings and 22 structures (dating 1922–1940) are significant under criterion C as representative examples of pre-World War II-era rustic design characteristic of NPS buildings built during that era. Contributing elements to the monument within the Direct APE include the following (see Figure 2-1 for locations):

- Main Trail
- Ben Johnson Trail
- Cathedral Grove
- Bohemian Grove
- Redwood Creek riprap (referred to as stone revetment [Auwaerter and Sears 2006])
- Alice Eastwood Road (the 300 feet of road within MWNM)
- Bohemian Grove Trail
- Redwood Forest

Cathedral Grove (named for visitors' experience of the grove as a sacred space) is historically significant as the location for the United Nations Conference on International Organization's memorial service for President Franklin D. Roosevelt, who had died just weeks before his planned participation in the conference. United Nations Conference on International Organization held the memorial service in Roosevelt's honor on May 19, 1949 (Auwaerter and Sears 2006).

Property Owner: NPS

CA State Parks Land  
Leased by NPS

Visitor  
Center

Entrance  
Plaza

Main Trail

L1A

R1A

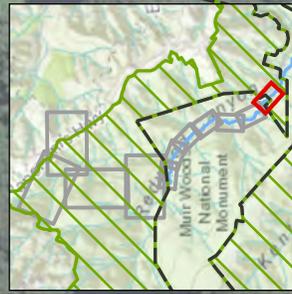
L1B

R1B

R1A

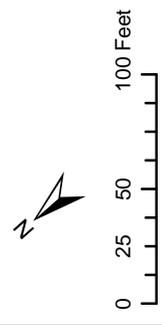
R1B

Bohemian Grove Trail



- Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)
- Design Logs: Existing Location
- Design Logs: Relocated
- Other Logs

- Existing Riprap Location
- Bridge
- Trail
- Muir Woods National Monument
- Mt. Tamalpais State Park
- Redwood Creek and Tributaries

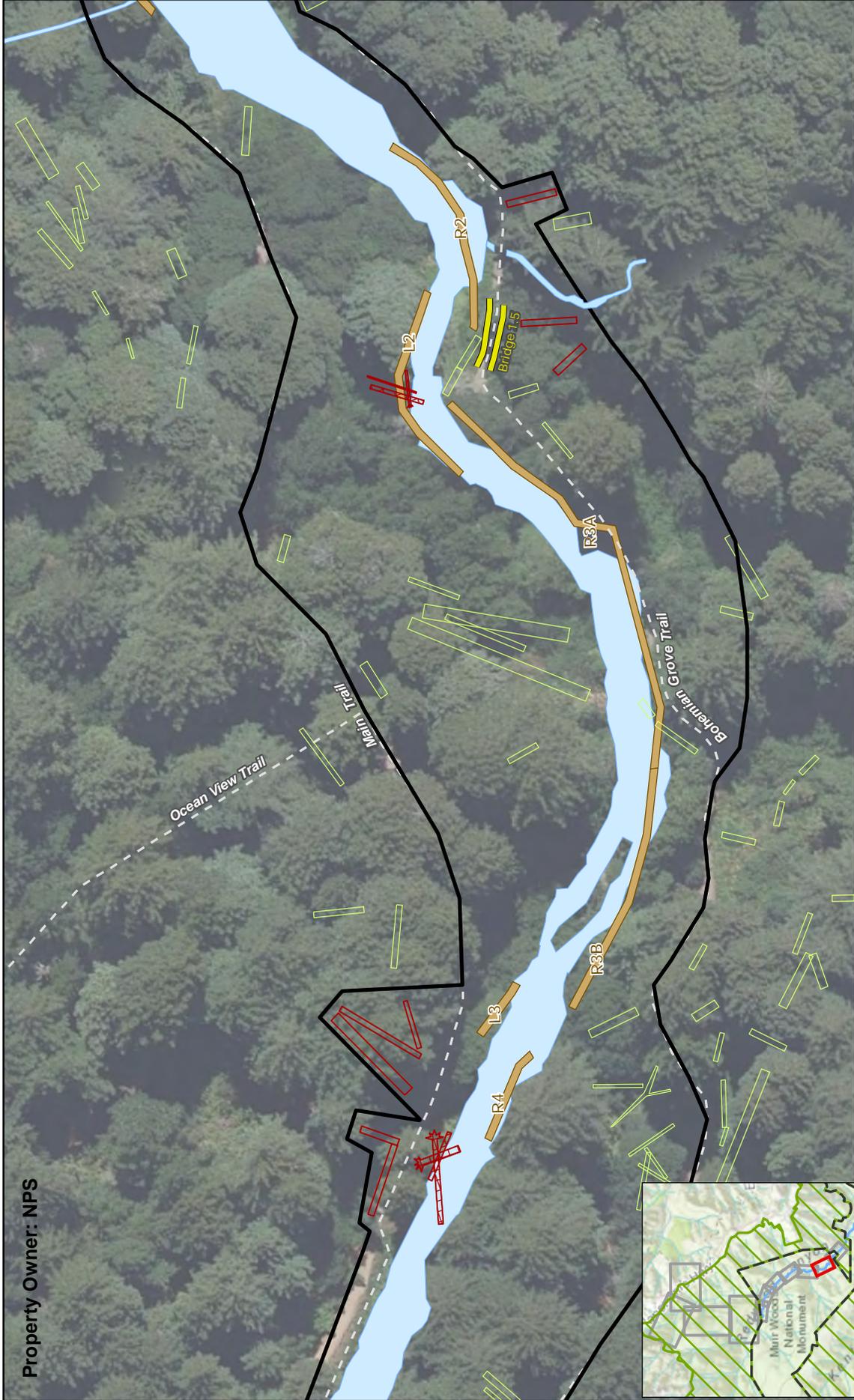


**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 1 of 11

Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project

C:\Users\GIS\Documents\ArcGIS\PROJECTS\16039\_GN\PC\_Coho\Compliance\mxd\Public\Final\Fig3-1\_DetailedAPE.mxd 10/2/2017

Property Owner: NPS



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
Sheet 2 of 11

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)	Existing Riprap Location
Design Logs: Existing Location	Bridge
Design Logs: Relocated	Trail
Other Logs	Muir Woods National Monument
	Redwood Creek and Tributaries

Property Owner: NPS



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
Sheet 3 of 11

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

Direct APE (24.8 acres: 14.2  
acres NPS, 10.6 acres CA State  
Parks)

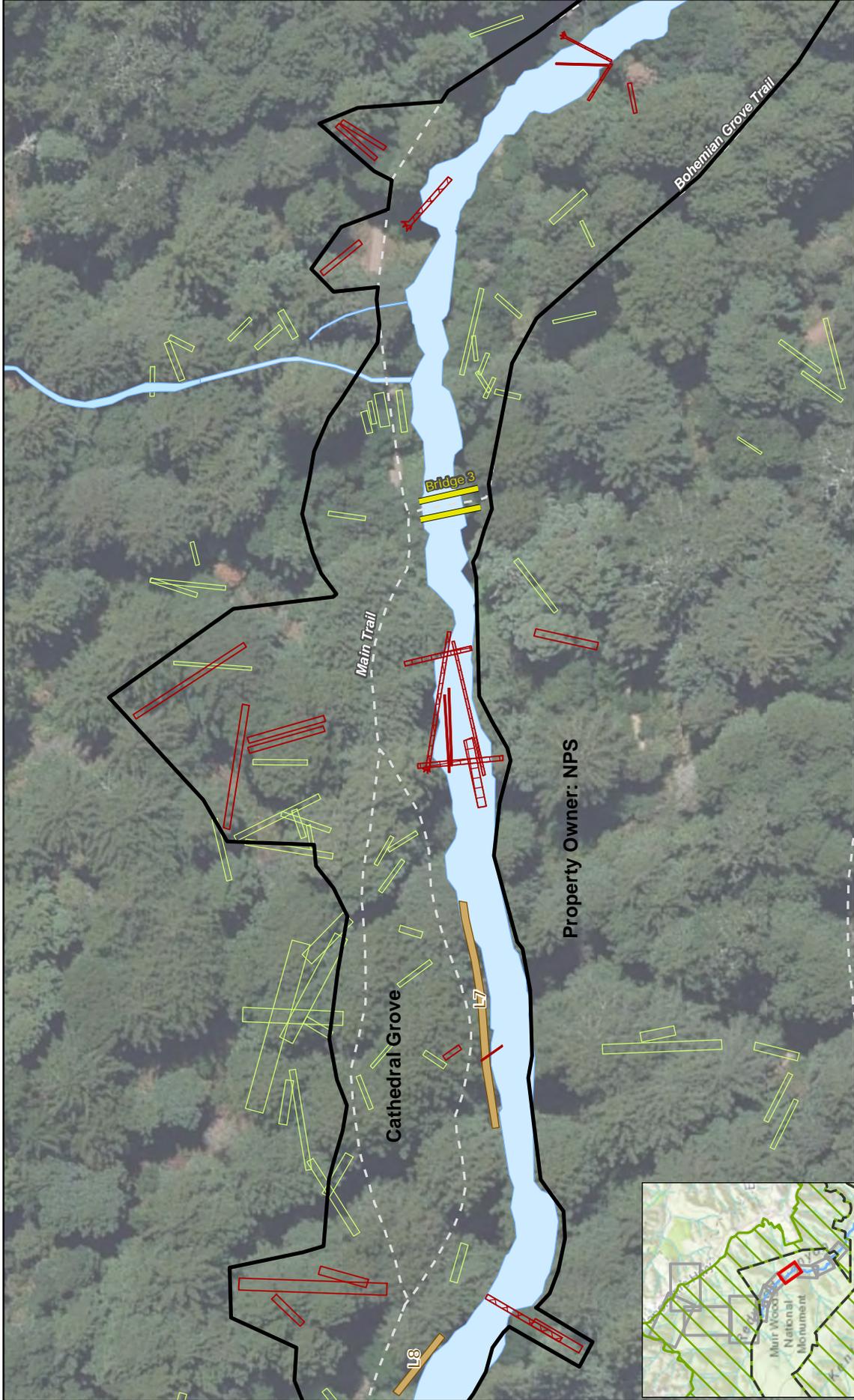
Design Logs: Existing Location  
Design Logs: Relocated  
Other Logs

Existing Riprap Location  
Bridge  
Trail

Muir Woods National Monument  
Redwood Creek and Tributaries

0 25 50 100 Feet

N



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 4 of 11

**Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)**

**Design Logs: Existing Location**

**Design Logs: Relocated**

**Other Logs**

**Existing Riprap Location**

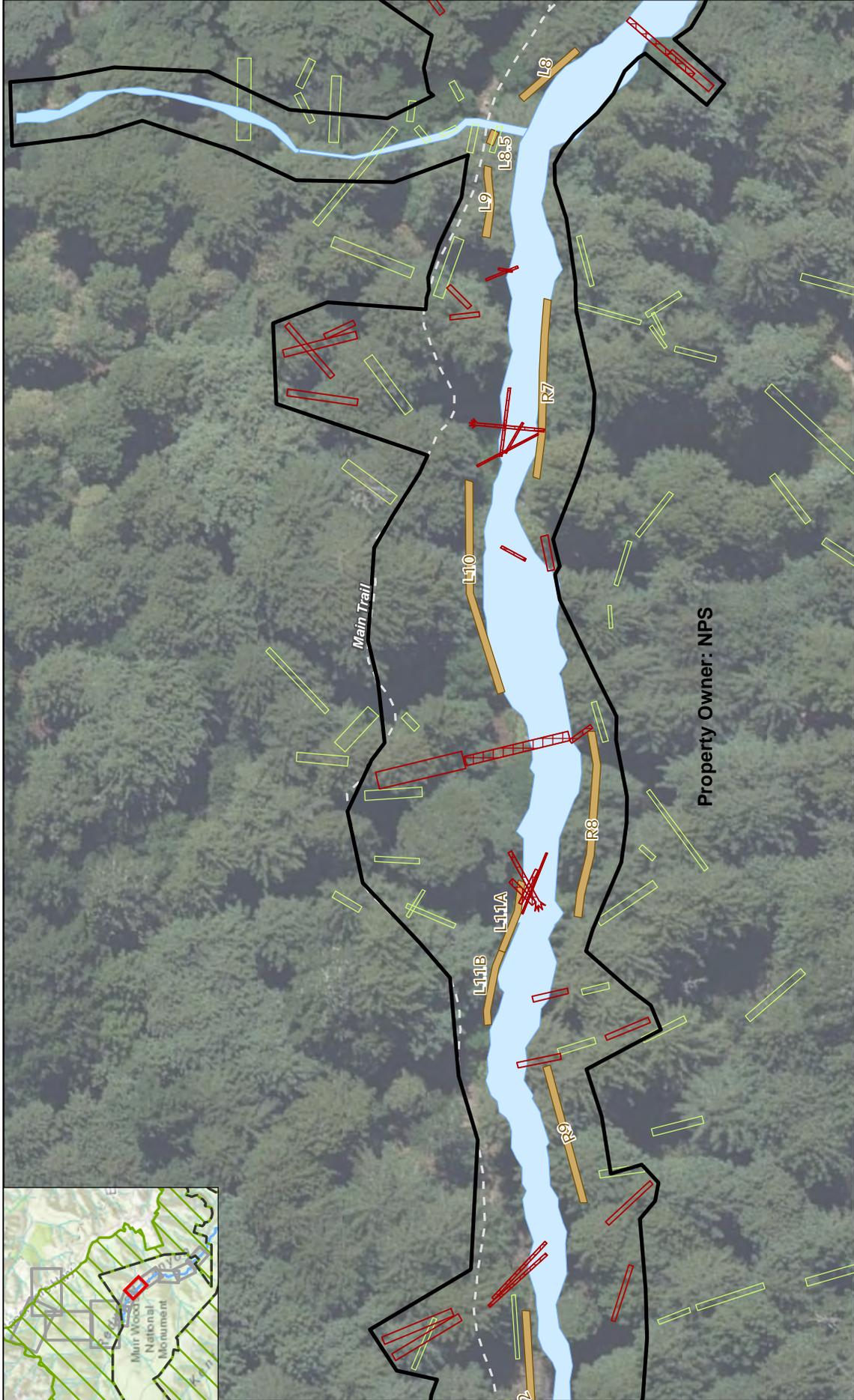
**Bridge**

**Trail**

**Muir Woods National Monument**

**Redwood Creek and Tributaries**

**Muir Woods National Monument Salmon Habitat Enhancement and Bridge Replacement Project**



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 5 of 11

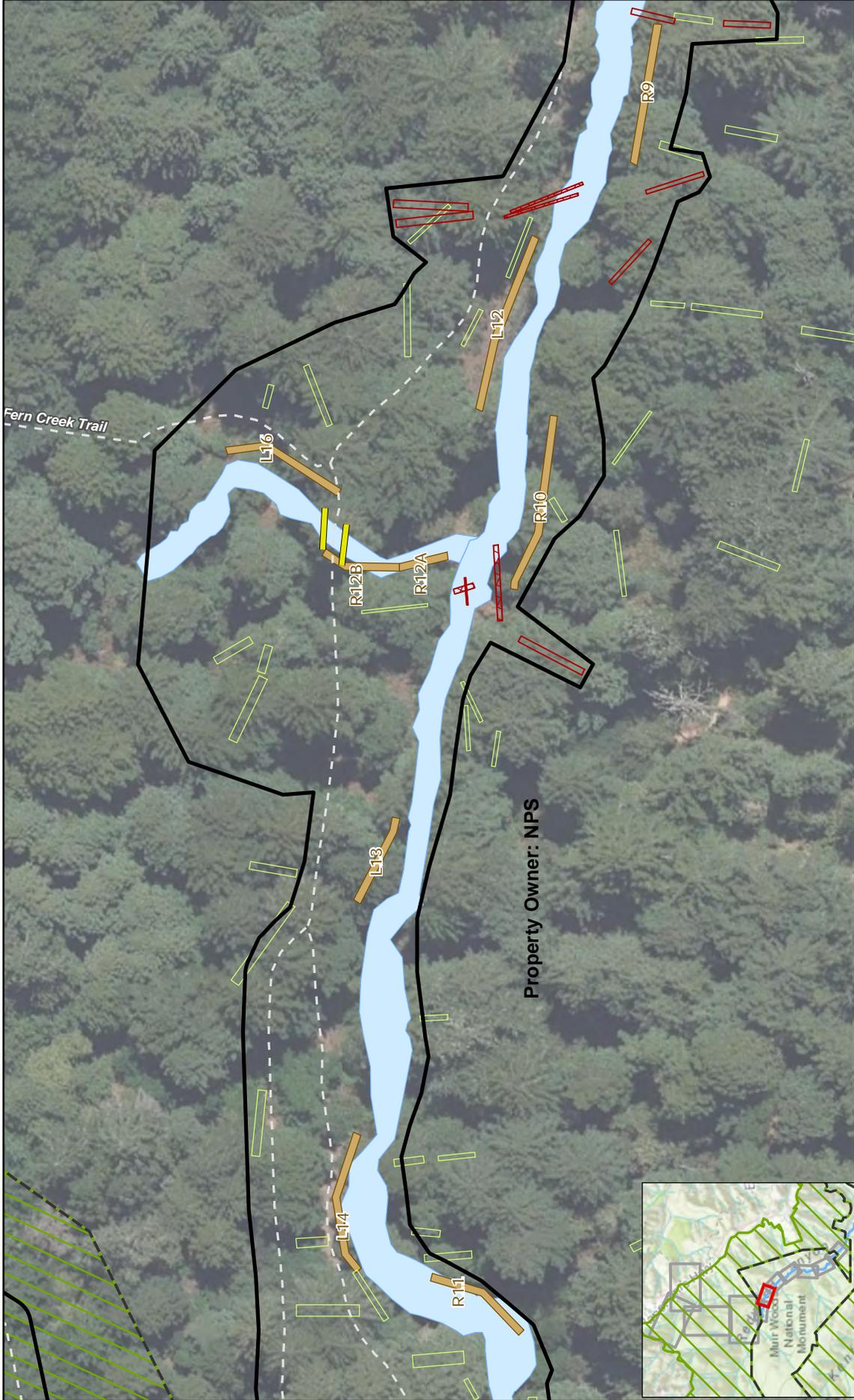
**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)	Existing Riprap Location
Design Logs: Existing Location	Trail
Design Logs: Relocated	Muir Woods National Monument
Other Logs	Redwood Creek and Tributaries

Property Owner: NPS

0 25 50 100 Feet

N

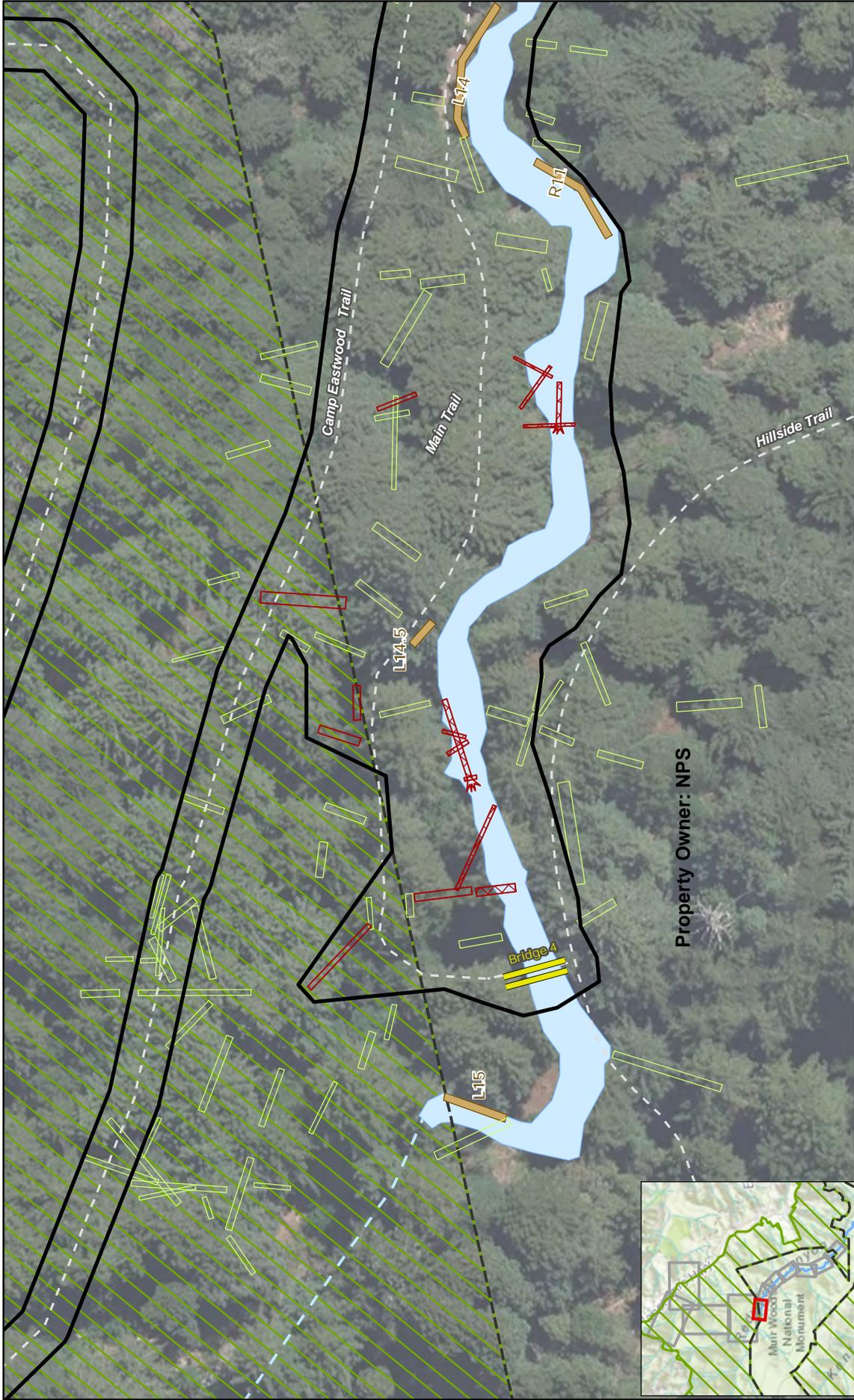


**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 6 of 11

	Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)		Existing Riprap Location		Muir Woods National Monument
	Design Logs: Existing Location		Bridge		Mt. Tamalpais State Park
	Design Logs: Relocated		Trail		Redwood Creek and Tributaries
	Other Logs		Muir Woods National Monument		

**Muir Woods National Monument Salmon Habitat Enhancement and Bridge Replacement Project**

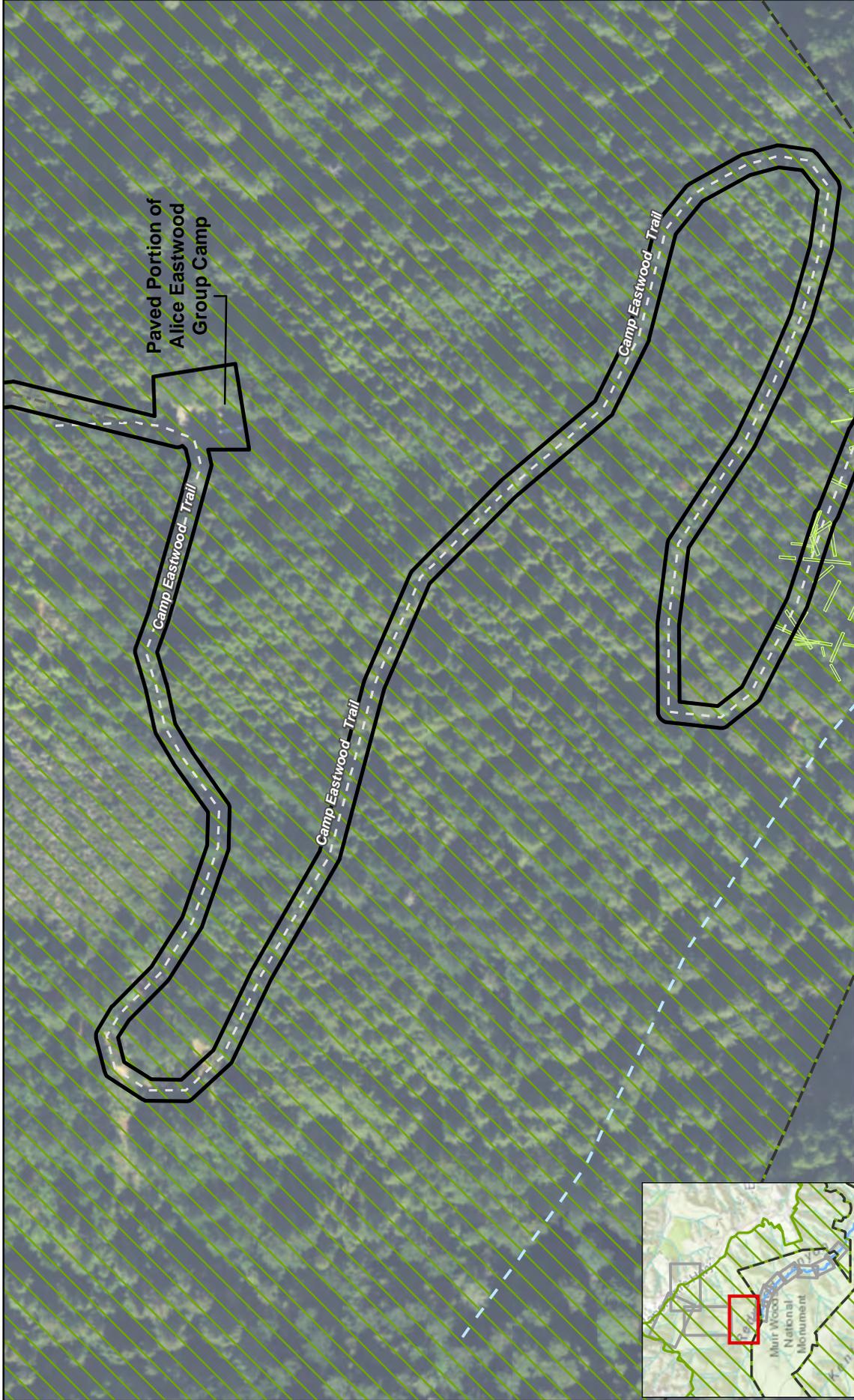
C:\Users\GIS\Documents\ArcGIS\PROJECTS\16039\_GGNPC\_CohoCompliance\mxd\PublicFinal\Fig3-1-DetailedAPE.mxd RH 10/2/2017



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 7 of 11

Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)	Existing Riprap Location	Muir Woods National Monument
Design Logs: Existing Location	Bridge	Mt. Tamalpais State Park
Design Logs: Relocated	Trail	Redwood Creek and Tributaries
Other Logs	Muir Woods National Monument	

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 8 of 11

**Muir Woods National Monument**  
**Salmon Habitat Enhancement and**  
**Bridge Replacement Project**

Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)  
 Design Logs: Existing Location  
 Design Logs: Relocated  
 Other Logs  
 Existing Riprap Location  
 Trail  
 Alice Eastwood Road (paved)  
 Muir Woods National Monument  
 Mt. Tamalpais State Park  
 Redwood Creek and Tributaries

0 65 130 260 Feet  
 N



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 9 of 11

Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)  
 Design Logs: Existing Location  
 Design Logs: Relocated  
 Existing Riprap Location  
 Trail  
 Alice Eastwood Road (paved)  
 Mt. Tamalpais State Park  
 Redwood Creek and Tributaries

0 65 130 260 Feet  
 N

Muir Woods National Monument  
 Salmon Habitat Enhancement and Bridge Replacement Project



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 10 of 11

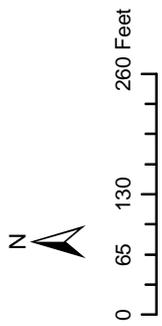
<p>Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)</p> <p>Design Logs: Existing Location</p> <p>Design Logs: Relocated</p>	<p>Existing Riprap Location</p> <p>Alice Eastwood Road (paved)</p> <p>Mt. Tamalpais State Park</p> <p>Redwood Creek and Tributaries</p>	<p>Muir Woods National Monument</p> <p>Salmon Habitat Enhancement and Bridge Replacement Project</p>
---	---	--



**Revised Figure 3-1**  
**Direct Area of Potential Effects (APE)**  
 Sheet 11 of 11

Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project

-  Direct APE (24.8 acres: 14.2 acres NPS, 10.6 acres CA State Parks)
-  Existing Riprap Location
-  Alice Eastwood Road (paved)
-  Mt. Tamalpais State Park
-  Redwood Creek and Tributaries
-  Design Logs: Existing Location
-  Design Logs: Relocated



## ***Archeology***

Several obsidian artifacts have been determined to have originated in MWNM within the Direct APE or its immediate vicinity (Gavette 2017). Three artifacts were recovered and turned in to park staff sometime before January 2, 1958, when they were entered into the museum record. Additionally, two projectile points were recovered in 1963 and 1966, respectively (Gavette 2017). NPS conducted an archeological survey of a portion of the project's Direct APE in December 2016 (Gavette 2017). In addition to conducting an inspection of the ground surface, 15 auger borings were placed throughout the Direct APE to evaluate the potential for buried archaeological remains. The depth of the auger borings varied, ranging in depth from 23 centimeters to 90 centimeters. No cultural materials were identified in the Direct APE as the result of the surface inspection and subsurface auger borings.

In order to augment the archaeological fieldwork previously conducted by NPS in December 2016, Horizon Water and Environment archaeologists conducted a supplemental pedestrian survey and subsurface auger testing on August 23 and 24, and October 6, 2017. Approximately 15 acres of supplemental survey was conducted in the APE, including a pedestrian survey of Alice Eastwood Road and the Alice Eastwood Campground parking lot, and other areas not previously surveyed, and seven auger borings in the proposed floodplain grading across Redwood Creek from the Visitors Center.

The pedestrian survey consisted of visual inspection of the surface, where visible, for any archaeological materials. Much of the supplemental areas subjected to survey were heavily vegetated and leaf litter covered much of the native surface; consequently, the visibility of the surface was very low. Therefore, the survey approach consisted of two archaeologists spaced at varying distances (5 to 10 meters) depending on the accessibility of the terrain given the vegetation cover and slope, as well as fallen trees. Any exposed surfaces, in addition to cut banks along the creek, were more closely inspected. No archaeological resources were identified by the pedestrian survey. The subsurface testing consisted of seven auger borings that ranged in depths from 30 centimeters to 1 meter. No archaeological resources were identified as a result of the boring program.

## ***Riprap Assessment***

Horizon Water and Environment Architectural Historian Kara Brunzell performed a field visit to document historic riprap along Redwood Creek on November 10 and December 27, 2016 (Brunzell 2017). This riprap is considered locally significant for criteria C. Golden Gate National Recreation Area (GGNRA) staff have categorized the riprap within MWNM into 34 sections for the purposes of the Proposed Action. Visibility of riprap segments from public trails was previously assessed by NPS. All sections of riprap, totaling 3351 LF, were inspected, photographed, and recorded. Letter grades for condition were assigned in the field to each numbered section (where a variety of conditions were present within a single numbered section, multiple grades were utilized). The condition assessment key developed for the evaluation is provided below. A narrative description of each numbered section is provided in the Conditions Assessment Report included in Appendix A. The results of the assessments are presented in Table 3-1.

Table 3-1. Riprap Condition and Visibility

Left or Right Bank (Facing Downstream)	Riprap Segment (starting downstream)	Riprap Condition	Visible from Trail?	Approximate Length (LF)	Creek Restore Alternative 1	Creek Restore Alternative 2	Creek Restore Alternative 3	Creek Restore Alternative 4	Creek Restore Alternative 5 (Preferred Alternative)
L	1-A*	C-	Not Visible	151	no	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>
R	1-A *	B-	Visible	111	no	yes <sup>2</sup>	yes <sup>2</sup>	yes <sup>2</sup>	yes <sup>2</sup>
L	1-B	C+	Slightly Visible	397	no	no	no	no	no
R	1-B	B-	Visible	344	no	no	no	no	no
<b>Bridge 1</b>									
L	2	B	Visible	128	yes	yes	yes	yes	yes
R	2 (downstream segment)	A-	Not Visible	33	no	no	no	yes	yes
R	2 (upstream segment)	A-	Not Visible	18	no	no	no	no	no
L	3	C-	Not Visible	39	no	no	no	no	no
R	3-A (downstream segment)	B+	Not Visible	148	no	no	no	yes	yes
R	3-A (upstream segment next to grade to grade control)	B+	Not Visible	105	no	no	no	no	no
R	3-B	C+	Visible	151	yes	yes	yes	yes	yes
R	4	C	Visible	13	yes	yes	yes	yes	yes

Left or Right Bank (Facing Downstream)	Riprap Segment (starting downstream)	Riprap Condition	Visible from Trail?	Approximate Length (LF)	Creek Restore Alternative 1	Creek Restore Alternative 2	Creek Restore Alternative 3	Creek Restore Alternative 4	Creek Restore Alternative 5 (Preferred Alternative)
<b>Bridge 2</b>									
L	4	C-	Visible	46	no	no	no	no	no
L	5	B-	Visible	79	no	no	no	no	no
R	5	A	Visible	135	no	no	no	no	no
L	6	C-	Visible	23	no	no	no	no	no
R	6	A-	Visible	128	yes	yes	yes	yes	yes
<b>Bridge 3</b>									
L	7	B-/B	Visible	141	no	yes	yes	yes	yes
R	7	A-	Visible	118	yes	yes	yes	yes	yes
L	8	C+	Not Visible	55	no	no	no	no	no
R	8	A	Visible	108	yes	yes	yes	yes	yes
L	8.5	D	Not Visible	49	no	no	no	no	no
L	9	C+	Not Visible	23	no	no	no	no	no
R	9	A-	Visible	82	yes	yes	yes	yes	yes
L	10	B+	Visible	131	yes	yes	yes	yes	yes
R	10	A-	Not Visible	104	no	no	no	no	no
R	11	B	Visible	49	no	no	no	no	no
L	11 - A	C-	Visible	59	yes <sup>3</sup>				
L	11 - B	B	Visible	26	no	no	no	no	no
L	12	A-	Not Visible	104	no	no	no	yes	yes
R	12 - A	C	Visible	39	yes	yes	yes	yes	yes

Left or Right Bank (Facing Downstream)	Riprap Segment (starting downstream)	Riprap Condition	Visible from Trail?	Approximate Length (LF)	Creek Restore Alternative 1	Creek Restore Alternative 2	Creek Restore Alternative 3	Creek Restore Alternative 4	Creek Restore Alternative 5 (Preferred Alternative)
R	12 - B	B-	Visible	26	no	no	no	no	no
L	13	B+	Visible	62	yes	yes	yes	yes	yes
L	14	C-	Not Visible	79	no	no	no	no	no
L	14.5	B-	Not Visible	20	no	no	no	no	no
L	16	C+	Visible	72	no	no	no	no	no
<b>Bridge 4</b>									
* Segment L1A is completely on State Parks Land. Approximately 100 feet of segment R1A is located on State Parks land. A total of approximately 210 feet of riprap would be removed from State Parks land under Creek Restoration Alternatives 2-5.									
<sup>1</sup> Approximately 112 feet would be removed from the downstream end of this segment									
<sup>2</sup> Approximately 98 feet would be removed from this segment									
<sup>3</sup> Segment L11A would not be removed in Phase 1 but may be removed or modified if its conditions change and need maintenance									

#### Condition Assessment Key

A – excellent condition: *Intentionally placed, tightly fitted rocks; few or no missing rocks; appears stable.*

B – good condition: *Intentionally placed rocks range from loosely to tightly fitted; some missing rocks or apparently unstable areas; overall appears stable.*

B-/C+ – fair condition: *intentionally but loosely stacked rocks, or tightly stacked with missing rocks.*

C – poor condition: *Rocks appear jumbled or randomly stacked; portions missing or fallen into the creek; areas appear unstable.*

D – not present or not visible: *Section has either fallen away completely or is fully embedded in creek bank.*

## ***Pedestrian Bridges***

Four existing non-historic bridges cross Redwood Creek in the Direct APE. NPS constructed these bridges in the 1990s to replace older bridges. The current bridges are constructed of glulam, a modern engineered wood product. The glulam is deteriorating, and the bridges will need to be replaced within the next few years. At least two of the bridges obstruct the flow of the creek during floods. In addition, because of their streamlined design and modern materials, the design of the existing bridges is not compatible with the rustic historic character of MWNM, which is an NRHP-listed historic district. Existing bridge locations align with the trails along Redwood Creek.

## ***Tribal Consultation***

To date, the Federated Indians of Graton Rancheria have not indicated that properties of traditional cultural values are associated with this Proposed Action or exist within the Direct APE.

## **3.3 Threatened or Endangered Species**

Three species federally listed as threatened or endangered are present within MWNM: Coho salmon, steelhead, and northern spotted owl. Additionally, MWNM contains potentially suitable habitat for the marbled murrelet, which is federally listed as threatened. These species are described below.

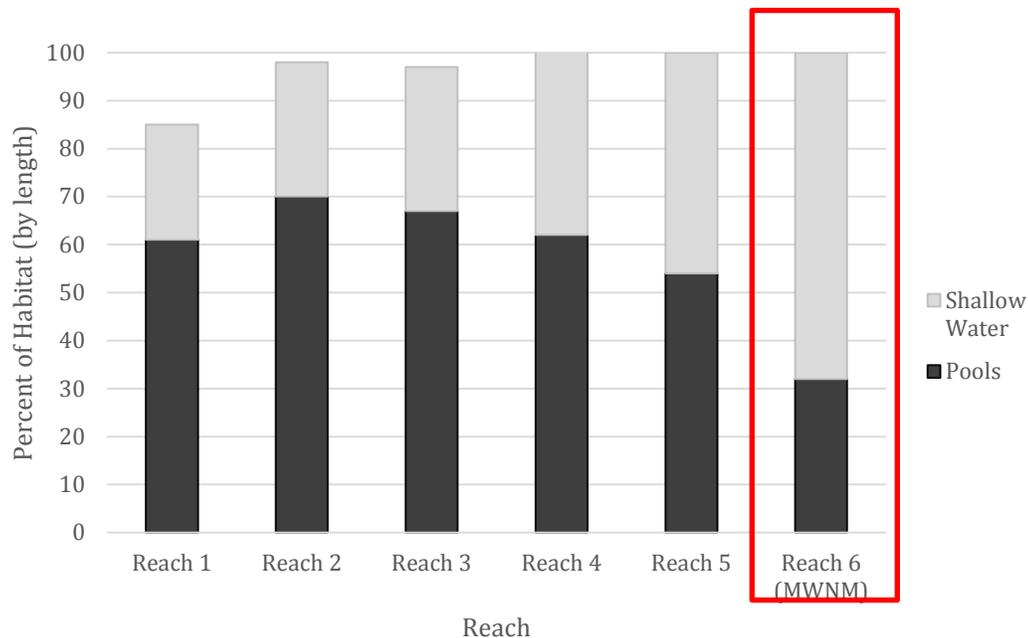
### ***Coho Salmon***

Coho salmon in Redwood Creek belong to the Central California Coast ESU, which was upgraded from threatened to endangered in June 2005 (70 CFR 37160). Critical habitat for this ESU is present within Redwood Creek and includes the creek and adjacent riparian habitat (70 CFR 52488).

Habitat characteristics required for successful Coho salmon development include (1) clean loose gravels free of fine sediment, needed for spawning and egg development; (2) adequate pools and natural instream cover for juveniles; (3) connected alcoves and off channel habitats for juveniles to survive winter flows; (4) clean cool water; and (5) unimpaired passage to and from the ocean (National Oceanic and Atmospheric Administration [NOAA] 2012). Redwood Creek within MWNM provides spawning and limited rearing habitat for this species. As described above, habitat for juvenile Coho salmon has deteriorated over the years due to past management practices such as installation of riprap along the channel and removal of LWD which resulted in loss of pools in the stream (Fong et al. 2016). CDFW (formerly California Department of Fish and Game [CDFG]) identified Redwood Creek as a priority restoration area for the recovery of this species (CDFG 2004).

Coho are at risk of extirpation from the Redwood Creek watershed (Fong et al. 2016). Population levels for all three cohorts (age classes) of Coho salmon are well below recovery targets set by NMFS (Fong et al. 2016). Coho salmon need pools for summer rearing habitat, when water levels in the creek are low, particularly pools deeper than 1.6 feet. MWNM is dominated by low water habitats. Fong et al. (2016) found that average residual water depths for flatwater habitats during summer 2015 for Reach 6 of Redwood Creek in MWNM was 0.4 feet. These shallow water depths may be suitable habitat for stream invertebrates and juvenile steelhead, but are not conducive summer rearing habitat for juvenile Coho salmon (Fong et al. 2016). The number of pools and the amount of LWD in the reach of Redwood Creek in MWNM are lower than other reaches of the creek outside of MWNM, and the lack of pools has been recognized since 1976 (Fong et al. 2016). Figure 3-2 shows the percentage of habitat by length across Redwood Creek reaches, with Reach 6 (MWNM) showing the lowest percentage of pool habitat. Additionally, there is a significantly lower percentage of pools deeper than 1.6 feet in MWNM compared to other reaches (Fong et al. 2016). A

study in the Redwood Creek watershed concluded that lack of summer habitat provided by deep pools (i.e., greater than 0.5 meters with complex cover combined with low late-summer and fall flows in the lower creek was the primary factor limiting Coho salmon production in the watershed during dry years (Smith 2001).



**Figure 3-2.** Percent of pool and shallow water habitats in Redwood Creek between 1995 and 2015 for Reaches 1-6. Reach 6 (outlined) contains the Proposed Action.

Juvenile Coho are typically associated with low velocity pools or off-channel habitats with complex cover, especially that provided by LWD (Shirvell 1990; Bustard and Narver 1975; Nickelson et al. 1992). The frequency of LWD within Redwood Creek is low overall, and the lowest densities have been reported within MWNM (NHE 2017). Compared to streams in undisturbed old-growth forests, Redwood Creek in MWNM has less large diameter woody debris, and fewer long (>15 meter) pieces of LWD (NHE 2017). The lowest density of LWD within the Proposed project area occurs between Bridge 3 and Bridge 4 (Fong et al. 2016). The riprap has prevented channel migration and thus limited natural recruitment of LWD into the creek (NHE 2017). The pedestrian bridges, which are undersized for stream flow, have also limited the transport of LWD in this reach of Redwood Creek.

A 3-year Coho salmon captive rearing program was initiated to address poor adult survivorship. This program entails capturing a portion of the juvenile Coho Salmon present in Redwood Creek and rearing them in captivity at Warm Springs Fish Hatchery, located at Lake Sonoma. Captive rearing is a temporary measure to prevent extirpation of Coho salmon in Redwood Creek. Juvenile Coho salmon were collected from Redwood Creek in 2014, 2015, and 2016. Three- to four-year-old adults will be released into Redwood Creek to spawn; the first round of adults was released into Redwood Creek in winter 2015-16, and a second larger release was conducted on December 8, 2016. The last planned release will be in the winter of 2018. This program is a collaboration between CDFW, the NMFS, the U.S. Army Corps of Engineers, the California Department of Parks and Recreation, NPS, the Golden Gate National Parks Conservancy, and the Friends of Lake Sonoma.

## ***Steelhead***

Steelhead within the Redwood Creek watershed belong to the Central California Coast DPS (NOAA 2015). This DPS was originally federally listed as threatened in 1997 (63 FR 32996) and reaffirmed as threatened in 2006 (71 FR 834). Critical habitat for this DPS is present within Redwood Creek, encompassing the lateral extents of the creek up to the ordinary high water line (70 FR 52488).

Habitat requirements for juvenile steelhead are similar to those of Coho salmon (NPS 2005).

## ***Northern Spotted Owl***

The northern spotted owl is federally listed as threatened in Washington, Oregon, and California (55 CFR 26114). This species is known to occur within MWNM (Gardali and Geupel 2000). Marin County is the southernmost limit of this species range (U.S. Fish and Wildlife Service [USFWS] 2011) No critical habitat for northern spotted owl is present in MWNM. The nearest designated critical habitat is north of Highway 1, approximately 0.7 mile north of the project area.

Through the majority of their range, northern spotted owls are mainly found in old-growth coniferous forests, but in Marin County they inhabit a variety of forest types including second-growth and old-growth Douglas fir (*Pseudotsuga menziesii*), coast redwood (*Sequoia sempervirens*), bishop pine (*Pinus muricata*), mixed conifer-hardwood, and evergreen hardwood forests (Ellis and Harrigan 2016). Range expansion of Barred Owl (*Strix varia*) is a threat to northern spotted owl (USFWS 2011). Barred Owls were first documented to breed in MWNM in 2007 (Ellis and Harrigan 2016). In 1999, two pairs of northern spotted owls occupied MWNM, but since 2010 northern spotted owls have not established an activity center within the boundaries of MWNM (Ellis and Harrigan 2016). Other threats to northern spotted owl in Marin County include habitat loss, structural changes in forest heterogeneity due to sudden oak death (SOD), genetic isolation, disturbance from human recreational pressures, and West Nile virus (Press et al. 2010).

## ***Marbled Murrelet***

The marbled murrelet is federally listed as threatened in Washington, Oregon, and California (57 FR 45328), and is listed as endangered under CESA. This species is a seabird which spends the majority of its life on the ocean, but nests in old-growth forests up to 50 miles inland (USFWS 1997). Portions of Mt. Tamalpais State Park and County-owned land directly adjacent MWNM are designated critical habitat for this species. However, the designated critical habitat for marbled murrelet does not include MWNM.

In 1997 and 1998 systematic surveys for marbled murrelet were conducted in MWNM and no marbled murrelet were observed (Gardali and Geupel 2000). Studies assessing offshore distribution of marbled murrelet did not observe this species in the ocean waters adjacent to MWNM (Briggs et al. 1987, Ralph and Miller 1995, as cited in Gardali and Geupel 2000). Additionally, eggshell surveys in 1999 did not identify any marbled murrelet eggshells, and relatively few trees within MWNM appear to provide suitable nesting habitat for this species (Gardali and Geupel 2000).

## ***California Red-legged Frog***

Although CRLF are present approximately 1.6 miles south of MWNM (CDFW 2016), they are not expected within MWNM itself as there have been no documented adults or juveniles in upper Redwood Creek and suitable breeding habitat is not present in MWNM (Stillwater and Horizon 2011).

### 3.4 Geology: Soils and Bedrock

MWNM is located in southern Marin County, west of San Francisco Bay, within the northern Coast Range of California's geomorphic provinces. The physical landscape and topography of the Mt. Tamalpais and Muir Woods area reflect a history of tectonic forces, active since the Mesozoic Era initiation of plate collision and subsequent subduction of the Pacific Plate beneath the North American Plate (California Geological Survey [CGS] 2002). Regionally, the northwestern trending ranges of southern Marin run generally parallel to the northwest/southeast trending San Andreas Fault, located in the Pacific Ocean just off-shore the Marin Headlands (CGS 1991). However, more locally in the Mt. Tamalpais area, ridges and crestlines radiate around the mountain peak in all directions, with MWNM located in the Redwood Creek watershed southeast of the Mt. Tamalpais peak.

Proximity to the San Andreas Fault Zone results in a high degree of bedrock fracturing and deformation. At MWNM, most of the underlying rock is of the Franciscan assemblage, a highly deformed mixture of sedimentary, metamorphic, and igneous rocks of late Jurassic and Cretaceous marine origin that reflect the tectonic compressional and subduction processes of the region (Wahrhaftig 1994 and Blake et al. 2000 as cited in National Parks Conservation Association 2011). More specifically within the MWNM, incoherent shale and sandstone dominate the monument, with relatively steep slopes that tend to be highly susceptible to mass wasting (California Geological Survey 1991).

Soil is the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants (U.S. Department of Agriculture [USDA], National Resources Conservation Service [NRCS] 2017). Soils are influenced by several environmental factors including climate (precipitation, temperature, available moisture, etc.), macro- and microorganisms, topographic relief, parent rock material, land use practices, and time.

Bedrock is overlain with loam to very gravelly loam soils from the Centissima-Barnabe complex (USDA, NRCS 2016). The Centissima-Barnabe complex primarily derives from weathered soft sandstone, shale, and chert. This soil is typically the most commonly encountered soil type within the monument and supports all of the slope redwood stands (McBride and Jacobs 1978). Soils generally range in thickness from 20 to 33 inches above bedrock. This soil unit exhibits high runoff and a moderate susceptibility to erosion. The Redwood Creek streambed is characterized by a mix of gravel and cobble with some areas of oversized rock riprap with few fine materials.

Settlement and development in the watersheds draining Mt. Tamalpais and MWNM began as early as 1841 (Auwaerter and Sears 2006). Intensification of land uses in the watershed for logging and agricultural purposes in the 19th century changed vegetation and land cover conditions resulting in other hydrologic and geomorphic effects. Erosion and sediment transport increased with these land use changes and the creeks likely enlarged or incised to accommodate increased runoff and sediment loads (Stillwater Sciences 2004).

Substantial development for access roads and visitor amenities for Muir Woods began in the mid-1880s (Auwaerter and Sears 2006). Expanding public use led to further road improvements and other developments during the first half of the 20th century, resulting in continued soil disturbance and increased erosion within Muir Woods and the project area.

More recently, a natural resources assessment completed in 2011 ranked the soil conditions at MWNM as fair because of historic logging, grazing, farming, residential development, and compaction from pedestrians (National Parks Conservation Association 2011). In recent years, efforts have been made to restore and improve soil conditions by removing paved trails in favor of

raised boardwalks and fencing sensitive areas prone to erosion to protect soil from compaction from pedestrian traffic.

### 3.5 Visitor Use and Experience

Title 54 of the United States Code, states that one of the purposes of the National Park Service is providing for visitor “enjoyment of scenery, natural and historic objects, and wildlife” while leaving these resources “unimpaired for the enjoyment of future generations” (54 USC 100101(a)). According to the GMP EIS, the purpose of MWNM “is to preserve the primeval character and ecological integrity of the old-growth redwood forest for scientific values and inspiration” (NPS 2014). The GMP also established a visitor experience goal of fostering “the visitor’s deep personal connection to the monument and discovery of the values and enjoyment of the natural environment.” Visitors come to experience the immensity of the redwoods, the sights and sounds of nature, and the history of the monument. Visitor use and experience at MWNM is influenced by high visitation levels that lead to adverse impacts on transportation to and from the monument, parking, as well as walking within the monument. Large crowds generate noise and detract from the overall experience in the monument. With the implementation of the first phase of the Reservation System (anticipated in late 2017 or early 2018), days with extremely high daily visitation levels (>4,500) would be minimized or eliminated, visitation would be more evenly distributed over the course of a day, and, numbers of visitors per hour during peak times of the day would be reduced (NPS 2015). These changes would reduce the effects of crowding on visitors.

The trails in the monument, particularly those between the Entrance Station and Bridges 1 and 2, are heavily-trafficked, especially in the summer months. The bridges in the monument connect trails on both sides of Redwood Creek and provide visitors with the ability to walk loops of varying lengths and to see more of the monument. Trails on both sides of Redwood Creek also help disperse crowds.

### 3.6 Transportation

High visitation rates and limited parking and road capacity have adversely impacted transportation to and within MWNM resulting in traffic congestion, illegal parking, and unsafe conditions for pedestrians. During peak visitation times, traffic can back up along Muir Woods Road, Panoramic Highway, Highway 1, and onto Highway 101. As part of a plan to address this, in 2015, shoulder parking areas on upper and lower Muir Woods Road were fenced off to prevent parking and an additional parking lot was added at lower Conlon Avenue. The upcoming implementation of a parking reservation system (NPS 2015) and the Sustainable Access Project (NPS 2016a) will enable NPS to better manage visitation rates, parking availability, and transportation options in the monument.

### 3.7 Wildlife Habitat

Several types of wildlife habitat are present within the areas where the Proposed Action may occur, including aquatic habitat in Redwood Creek, riparian habitat along the creek, redwood forest, and wetland habitat adjacent to the creek.

Redwood Creek provides habitat for invertebrates, fish, amphibians, and reptiles; mammals also use the creek as a source of prey and water. Currently, habitat complexity within the creek is limited due to the presence of riprap lining the channel (Environmental Science Associates 2014) and past removal of LWD. Aquatic invertebrates are an important food source for juvenile salmonids. Kimball and Kondolf (2002) found that aquatic invertebrate abundance and family

diversity were significantly greater in non-riprapped portions of Redwood Creek in MWNM compared to riprapped portions of the creek.

Amphibians such as California giant salamander (*Dicamptodon ensatus*) and Pacific chorus frog (*Pseudacris regilla*) are present in MWNM (Stillwater and Horizon 2011). California giant salamander larvae are found in a variety of aquatic habitats, and adults are found in surface litter in terrestrial habitats, as well as underground (Fong and Howell 2006).

The monument provides nesting and foraging habitat for many bird species. The bird species most commonly observed in MWNM include Pacific-slope Flycatchers (*Empidonax difficilis*), Pacific Wrens (*Troglodytes troglodytes*), Chestnut-backed Chickadees (*Parus rufescens*), Golden-crowned Kinglets (*Regulus satrapa*), Brown Creepers (*Certhia americana*), and Dark-eyed Juncos (*Junco hyemalis*) (Gardali and Geupel 2000). Wilson's Warbler (*Wilsonia pusilla*), a neotropical migrant warbler, also nests in MWNM (Gardali and Geupel 2000).

Bats are known to both forage and roost in MWNM (Heady and Frick 2004). Bat species detected in MWNM include California myotis (*Myotis californicus*), Yuma myotis (*Myotis yumanensis*) silver-haired bat (*Lasionycteris noctivagans*), big brown bat (*Eptesicus fuscus*), western red bat (*Lasiurus blossevillei*), hoary bat (*Lasiurus cinereus*), and Townsend's big-eared bat (*Corynorhinus townsendii*) (Heady and Frick 2004). Most bat activity occurs in the riparian corridor (Heady and Frick 2004). In a study by Heady and Frick (2004), silver-hair bats have been captured in the redwood habitats in MWNM but not in the downstream hardwood riparian habitat, while Yuma myotis showed an opposite pattern of being present in hardwood riparian habitat and absent in redwood grove. Several species of bats have been observed using redwood hollows as maternity roosts, day roosts, or night feeding roosts, and bats also use other features such as bark crevices as roosting habitat (Heady and Frick 2004). The majority of the species detected in MWNM are found there year-round (Heady and Frick 2004).

## 3.8 Water Resources and Hydrologic Processes

### ***Watershed and Topography***

MWNM lies within the 8.8-square-mile Redwood Creek watershed U.S. Geological Survey [USGS] 2016a). The headwaters of Redwood Creek include the Fern Creek, Spike Buck Creek, and upper Redwood Creek tributaries that originate on the steep southern slopes of Mt. Tamalpais (elevation of 2,571 feet). The headwater tributaries flow south and southeastward coalescing at the confluence of Redwood Creek and Fern Creek at approximate elevation of 230 feet. Downstream of this confluence point, Redwood Creek flows at the bottom of Redwood Canyon, a northwest trending gorge characterized by steep, densely wooded slopes and a relatively narrow fluvial floodplain. Redwood Creek runs adjacent to the Redwood Creek Trail toward the main gate and entrance to MWNM. Topography in the project area generally slopes toward Redwood Creek, perpendicular to the flow direction of the creek. The project area ranges in elevation from approximately 140 to 300 feet above mean sea level (USGS 2015).

Downstream of MWNM, Redwood Creek arcs to a more southwest flow direction as it opens up to Frank Valley, which is a wider riparian corridor and alluvial floodplain than the more confined creek alignment found upstream in the MWNM. Kent Creek joins Redwood Creek 0.9 miles downstream of the MWNM. Downstream of Santos Meadow, approximately 0.7 miles downstream of the Kent Creek confluence, Redwood Creek bends to a more southerly alignment as it heads towards the Big Lagoon estuary and the Muir Beach river mouth at the Pacific Ocean.

The Redwood Creek watershed is largely undeveloped, with protected forest land managed by the Marin Municipal Water District, California State Parks (Mt. Tamalpais State Park), and NPS (MWNM

and the Golden Gate National Recreation Area [GGNRA] at Muir Beach) (Stillwater and Horizon 2011). The contributing watershed area upstream of the project area is approximately 1.9 square miles (USGS 2016a).

### ***Climate***

The project area has a Mediterranean climate characterized by cool, wet winters and warm, dry summers. Average temperatures range from 40 degrees Fahrenheit (°F) to 70 °F throughout most of the year, and temperatures below freezing are extremely rare (Stillwater and Horizon 2011). Annual precipitation at MWNM varies greatly year to year, but averages 37.4 inches, mostly occurring October through May, with November through March being the wettest period (Western Regional Climate Center [WRCC] 2016). Fog drip is estimated to provide an additional 10 to 20 inches of water to vegetation annually, or 10 to 40 percent of the annual water supply for vegetation, but exact volumes have not been measured in the Redwood Creek Watershed (Weeks 2006 and Dawson and Siegwolf 2007, as cited in Stillwater and Horizon 2011).

### ***Hydrology***

Redwood Creek is the primary hydrologic feature and resource in the project area (Marin Coastal Hydrologic Unit, Fern Creek Hydrologic Unit 2201300003). As described above, the creek's headwaters originate approximately 2.5 miles northwest of the project area on the southwestern slopes of Mt. Tamalpais. As Redwood Creek enters MWNM, the longitudinal profile of the creek flattens considerably, with bed slope decreasing to less than 2 percent slope.

Streamflows in Redwood Creek vary greatly. During the spring and summer dry season, flows are shallow and low magnitude. During the late fall, winter, and early spring months, flows can be quite large responding to winter precipitation events. Baseflow, the flow in the creek fed by groundwater and deeper soil moisture and not specifically related to a single storm event, generally increases over the wet season months and then recedes into the spring and summer.

Measurements taken in the late-1980s and 2003–2004 at the Redwood Creek Bridge located at the downstream end of the project area, showed summer flows of less than 1 cubic foot per second (cfs) and peak winter flows of approximately 30 to 170 cfs occurring with different storm events (Stillwater and Horizon 2011). More recent measurements from a monitoring station on Redwood Creek approximately 1.5 miles downstream from the project area showed the daily discharge ranged from periods of no flow to a maximum of 431 cfs (USGS 2016b); older records show a high flow of 2,150 cfs (USGS peak flow data Station No. 11460150 1962-1973 as cited in Coopridge 2004).

A hydrologic assessment estimated potential flood flows at the four existing bridges in the project area and the Fern Creek/Redwood Creek confluence (NHE 2017). The flow magnitude-frequency relationships are summarized in Table 3-2, where peak discharges for different return intervals are provided at these locations. Bridges 2 and 3 have the least flood capacity and are only able to effectively pass the 2-year peak-flood flow (NHE 2017). Bridge 1 can pass the 2-, 5-, 10- and 25-year peak-flood flows, while Bridge 4 can pass all peak-flood flows except the 100-year event (NHE 2017).

**Table 3-2.** Summary of flood-frequency estimates at the four bridge sites and Fern Creek confluence with Redwood Creek within Muir Woods.

Return Interval (year)	Chance Exceedance (%)	Bridge 4 (cfs)	Fern Creek (cfs)	Bridge 3 (cfs)	Bridge 2 (cfs)	Bridge 1 (cfs)
2	50	240	368	397	401	426
5	20	427	651	699	707	750
10	10	541	822	883	892	947
25	4	672	1,016	1,091	1,103	1,170
50	2	766	1,157	1,242	1,255	1,331
100	1	864	1,303	1,398	1,413	1,498
500	0.2	1,080	1,623	1,741	1,759	1,864

Source: NHE 2017

As discussed in Chapter 1, the CCC installed check dams and rock revetments along approximately 57 percent of the creek channel within MWNM during the 1930s (NPS 2014). These physical modifications altered the channel shape and form, creating a wider channel, and restrained geomorphic processes of bank erosion, channel migration, and resulting recruitment of LWD into the channel. However, it is noted that the baseline hydrologic condition in Redwood Creek at the time these channel modifications were made was already severely altered due to land use practices, vegetation removal, and soil compaction since the 19th century. In other words, runoff response to rainfall events was very likely increased and amplified due to the past land use alterations in the watershed that reduced the ability for the watershed to infiltrate rainfall. The check dams, grade control structures, and rock revetments placed in the 1930s likely reduced the increased or exacerbated erosion from high runoff conditions (Stillwater and Horizon 2011). The check dams have since been removed but the revetments and many grade control structures remain on portions of the creek. Although some natural processes have returned, the creek has more shallow water including riffle and flatwater habitats and less deep water pool habitat than would naturally occur within a similarly sloped stream, and less large woody debris (Fong 2002, as cited by NPS 2014; Stillwater and Horizon 2011).

### **Groundwater**

MWNM is underlain by Franciscan bedrock. Although groundwater may percolate and fill fractures, joints, and shear zones, Franciscan rocks are considered impermeable and non-water bearing. This results in a “perched” groundwater table where water contained in the soil and weathered rock pools above the bedrock, accumulating during the wet season and diminishing during the dry season. Some of this water may eventually percolate downwards into the bedrock or flow laterally along the top of the bedrock until finding water-bearing sedimentary units or until daylighting in the banks or bed of creeks, ponds, springs, or other surface waters. As such, there are no operating groundwater wells in MWNM; however, springs located upstream of the MWNM supply water for use by the Marin Municipal Water District (NPS 2014).

### **Water Quality**

The San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan) describes water quality standards for regional waterbodies (San Francisco Bay RWQCB 2015). The standards include beneficial uses of waterbodies and the water quality objectives that protect these beneficial uses. Redwood Creek has multiple possible beneficial uses including, but not limited to, agricultural,

municipal, and domestic supply; freshwater replenishment; coldwater and warmwater habitat, fish migration and spawning, wildlife habitat, and preservation of rare and endangered species; shellfish harvesting; and contact or noncontact water recreation (San Francisco Bay RWQCB 2015). These uses are for the entire length of the creek, not just the reach in the project area.

The San Francisco Bay Area Network (SFAN) Inventory and Monitoring Program monitors two sites close to the project area, Fern Creek and the mainstem of Redwood Creek downstream of the MWNM entrance under the Muir Woods Road bridge. The Fern Creek sampling location is off of the Fern Creek Trail just upstream of the confluence with Redwood Creek. The program measures water temperature, dissolved oxygen, pH, specific conductance, turbidity, nitrogen, and bacteria.

Water temperature in Redwood Creek was generally within the optimal temperature range for juvenile Coho salmon (10 degrees Celsius [ $^{\circ}\text{C}$ ] to  $15.6^{\circ}\text{C}$ ) with just a few short-term exceedances (Armour 1991 as cited by Wallitner 2016). Water temperature in Redwood Creek were comparable but slightly cooler, ranging from  $8.5^{\circ}\text{C}$  to  $15.7^{\circ}\text{C}$  with a median of  $12.8^{\circ}\text{C}$ . Temperatures in Fern Creek were comparable but slightly cooler, ranging from  $8.2^{\circ}\text{C}$  to  $15.0^{\circ}\text{C}$  and a median of  $12.1^{\circ}\text{C}$ . (Wallitner 2016).

All dissolved oxygen measurements for the 2013–2014 water-year sampling exceeded the RWQCB established dissolved oxygen minimum of 7 milligrams per liter (mg/L) (RWQCB 2015). Redwood Creek had a wider range of dissolved oxygen measurements (7.53 mg/L to 11.43 mg/L) than those in Fern Creek (9.05 mg/L to 11.81 mg/L) (Wallitner 2016). Measurements of pH for both streams were well within the standard of 6.5 to 8.5, and ranged from 7.09 to 8.08 (Wallitner 2016).

The RWQCB does not specify criteria for specific conductance; however, to support diverse aquatic communities in freshwater streams, specific conductance should be below 500 microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ) (Behar 1997, as cited by Wallitner 2016). Specific conductance values ranged from 121.3  $\mu\text{S}/\text{cm}$  to 264.9  $\mu\text{S}/\text{cm}$  in Redwood Creek and 88.4  $\mu\text{S}/\text{cm}$  to 199.9  $\mu\text{S}/\text{cm}$  in Fern Creek.

Turbidity levels of up to 41.1 nephelometric turbidity units (NTU) and 35.8 NTU have been recorded in Redwood Creek and Fern Creek, respectively, and exceeded the 25 NTU ecological objective (NPS 2016c; Wallitner 2016). However, high turbidity levels do not persist over long periods with the median values much lower at 0.46 NTU for Redwood Creek and 0.47 NTU Fern Creek. These turbidity measurements occurred during a period when the natural bank erosion rate is approximately  $0.0015 \text{ m}^3\text{m}^{-1}\text{a}^{-1}$  (Stillwater Sciences 2004).

The RWQCB has not established a numeric water quality criterion for nitrate; however, an ecological threshold of 0.30 mg/L is frequently used as the threshold to limit eutrophication in streams (Roche et al. 2013, as cited by Wallitner 2016). Nitrate as nitrogen was low in Redwood Creek and Fern Creek sampling locations, approximately 80 percent of the samples reporting levels below the detection limit (Wallitner 2016).

Chemical analysis of samples collected during the 2015 and 2016 water-years generally characterize the chemical signature of Redwood Creek (NPS 2016b). Samples collected in the project area at Bridge 1 showed high levels of magnesium and moderate to low concentrations of other metals, including calcium, sodium, iron, nickel, and potassium. Aluminum, arsenic, and chromium were also detected at very low levels. These metals likely occur naturally and several of these elements were not detected during smaller flow events. Naturally occurring hydrocarbons were occasionally detected in low concentrations at Bridge 1 during the 2015 and 2016 sampling events (NPS 2016b). No polycyclic aromatic hydrocarbons were detected in Redwood Creek in the project area in the 2015 and 2016 samples.

## ***Floodplains***

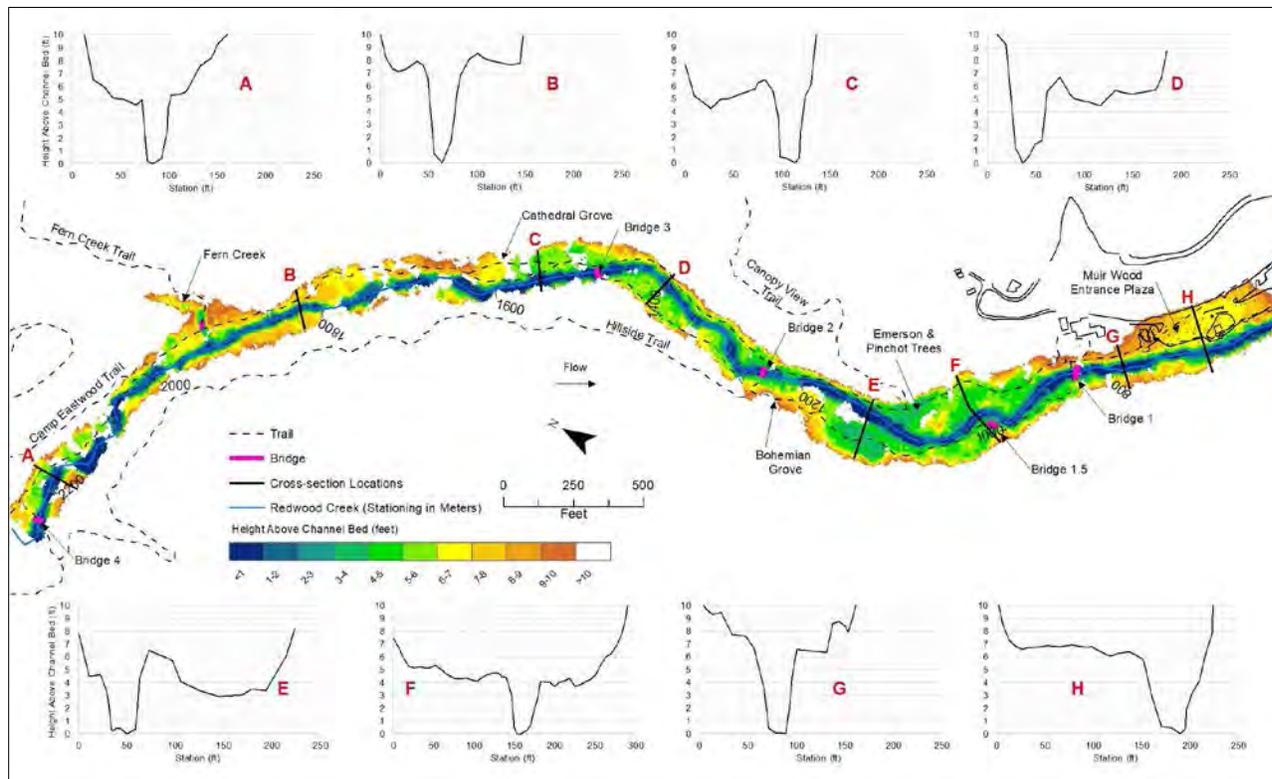
The project area historically contained more overbank floodplain and terrace areas that would be inundated by larger streamflows on a more frequent basis than under current conditions (Environmental Science Associates 2014; Ryan 2016). Channel inundation of historic floodplains of Redwood Creek within MWNM has been reduced through streambed incision, in which the channel bed deepens and more water is contained within the channel banks (Environmental Science Associates 2014, Ryan 2016, NHE 2017). Channel incision occurred throughout Frank Valley and in MWNM and was most likely related to extensive land use changes throughout the watershed in the late 19th and early 20th centuries, which increased the rate and quantity of flow to the channel, coupled with the substantial loss of riparian vegetation. Subsequent modification of the channel shape in MWNM, consistent removal of in-channel LWD, and streambank stabilization structures, prevented the project reach from rebuilding sediment deposits that would have reconnected the channel to its floodplain. Some grade control structures were installed within MWNM in the 1930s, including three rock cascades and six log-grade controls. These features most likely prevented much of the more severe incision that occurred just downstream of MWNM.

NHE estimated the height of the bank from the channel bed in MWNM using LiDAR data for the terraces and ground survey data of the channel elevation (NHE 2017). Figure 3-3 shows banks are typically 5 to 7 feet above the channel bed, with distinct variations. Bank heights are highest between Fern Creek and approximately 200 feet upstream of Bridge 3, with bank heights typically greater than 6 feet above the channel bed. The lowest bank heights occur between Bridges 1 and 2, with bank heights in the 3- to 4-foot range. Downstream of Bridge 1, bank height increases to more than 6 feet.

The area with the lowest bank heights has several important features that may contribute to low bank elevations. A 3-foot-diameter grade control log installed in 1932 near the Emerson and Pinchot Tree initially raised the channel bed. A log jam has formed in this location and a second large wood jam has formed shortly downstream, which also retains sediment. The rock check dam that was constructed in 1934 near Bridge 1 and partially dismantled in the 1960s also still provides grade control for this subreach.

Floodplain inundation under different flow frequencies is shown on Figure 3-4. An analysis by NHE using LiDAR, channel surveys, and a hydraulic model show a 2-year-flow is generally contained within the channel banks and only overtops inset terraces. This lack of floodplain inundation under an average event is indicative of the floodplain disconnection in the project reach. The lowest banks between Bridges 1 and 2 are inundated between the 5- and 10-year events. In other locations, larger events are required to result in floodplain inundation; a 25-year event is necessary to inundate the floodplain at Cathedral Grove, and an approximate 100-year event is needed before the floodplain between Bridge 4 and Cathedral Grove becomes inundated (NHE 2017).

According to Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs), no floodplains have been identified within MWNM (FEMA 2009). However, some areas are designated as “areas in which flood hazards are undetermined, but possible” (FEMA 2009). Hydraulic analysis indicates that the current channel generally contains 10-year peak-flood flow in most of the project area with limited overbanking occurring near Bridge 3, Bridge 2, and adjacent the Entry Plaza (NHE 2017). Under 100-year peak flood flow, flooding is extensive throughout the project area. Various climate models predict either increases or decreases in regional precipitation by 2080; however, there is a consensus that storm intensity and frequency, as well as flood events would be expected to increase, including scouring events (Stillwater and Horizon 2011, 2014; Walsh et al. 2014 as cited in NPS 2017).



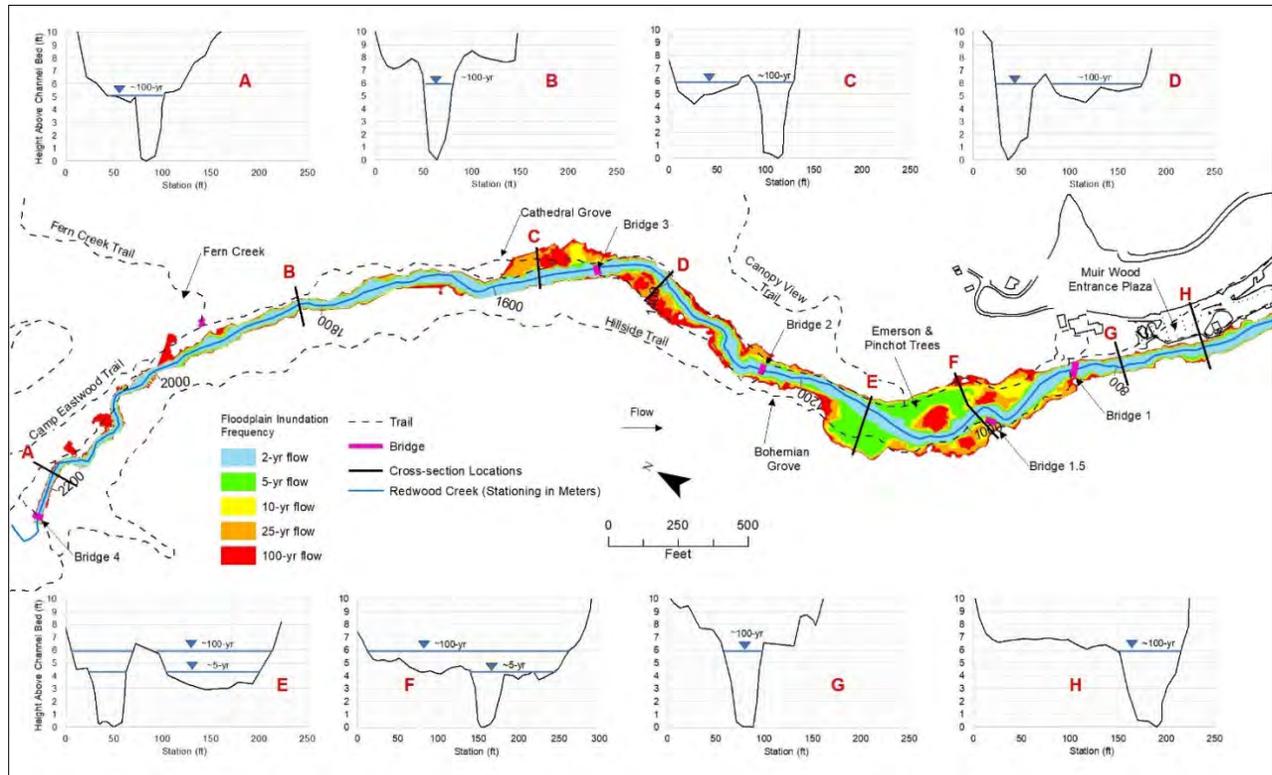
**Figure 3-3.** Height of ground surface above the channel bed in MWNM. Channel cross-sections illustrate typical channel geometry and bank height. The channel at all cross-sections were surveyed and extended across the floodplain using the 2010 LiDAR data (NHE 2017).

### **Geomorphic Processes**

The sediment budget refers to the mass balance of sediment generated, stored, and transported through a watershed. In general, sediment source areas are more typically found in upslope and watershed headwater areas. Sediment is typically transported downstream into mid-watershed locations where it is variably stored or further transported downstream. Lower watershed areas are typically more depositional in receiving sediment loads from the watershed upstream. Though these general tendencies exist, at any given time, at any location in a watershed, sediment can be variably eroded, transported, deposited, or just stored in relative quiescence.

A sediment budget was developed for Redwood Creek using watershed models, field assessments of sediment sources, dendrochronology, channel surveys, sediment transport models, and sediment yields from neighboring watersheds (Stillwater Sciences 2004). Under the existing condition, the bank erosion at Muir Woods is below what is considered to be the current natural bank erosion rate in the watershed because of the extensive bank revetment (Stillwater Sciences 2004). Common to other watersheds from the region, sediment delivery from basin slopes occurs through a combination of fluvial processes such as sheetwash erosion and runoff and also by mass movement processes such as slumps, earthflows, landslides, and debris flows. The Stillwater 2004 sediment budget estimated that 46 percent of the basin slopes have been mapped as landslide prone areas. The estimate annual bank erosion immediately downstream of MWNM is  $0.015 \text{ m}^3\text{a}^{-1}\text{a}^{-1}$ . The current sediment production within Muir Woods has been very limited by the presence riprap. Stillwater Sciences provided context for sediment production rates in Redwood Creek. They reported, 'Sediment production rates are higher than a large, mainly lowland urban watershed in

Washington State, equitable with those derived in the neighboring Lone Tree Creek, lower than those in the nearby agricultural Bolinas watershed, and far lower than the steeper and wetter watersheds of north coastal California subject to commercial forestry disturbances.’ (Stillwater Sciences 2004).



**Figure 3-4.** Floodplain inundation within Muir Woods for flows with recurrence intervals between 2 and 100 years (NHE 2017).

Development of MWNM also included alteration of the natural environment and Redwood Creek itself. As described in Chapter 1, the CCC armored much of Redwood Creek in the project area with rock riprap to control streambank instability, bank erosion, and overbank flooding. The placed riprap provides additional shear strength to the streambanks and reduces the degree of physical channel processes such as channel migration, bank erosion, and the release and transport of sediment and input to the downstream creek system. Channel migration is a geomorphic process that occurs as streams adjust their morphology as they work toward a dynamic equilibrium to reflect watershed runoff and sediment conditions. Since the riprap prohibits channel widening and migration, channel sinuosity in the project area remains low, resulting in relatively high flow velocity un conducive for the deposition of sediment and development of instream bars and pool-riffle morphology. This solidified channel form hinders natural recovery from historic incision. In addition, with channel migration is hindered, this may obstruct development of habitat for aquatic organisms and terrestrial species in the channel corridor.

In addition to the bank riprap, the CCC also installed several instream grade control structures. The CCC riprap bank lining and grade control structures were in response to basin-wide logging and grazing disturbance, and downstream channelization for—all resulting in significant channel incision throughout the watershed and extending into MWNM. Since the 1900s, Redwood Creek in

MWNM experienced several periods of incision resulting in the lowering of the streambed by approximately 10 feet in some areas (Environmental Science Associates 2014). Historic floodplain elevations of approximately 4 and 10 feet above the present creek elevation provide evidence of this process. In areas outlined for work under Creek Restoration Alternative 1, there is not a 10-foot difference between the creek bed and the floodplain. The constructed grade control structures in MWNM may limit the effects of incision compared to downstream reaches. The primary grade control in MWNM is a constructed rock cascade adjacent the Entry Plaza, which provides about 10 feet of vertical drop, and is where the incision is the most pronounced in the project area (Environmental Science Associates 2014).

## 3.9 Vegetation

### **Redwood Forest**

Redwood forest is the dominant plant community in MWNM. Coast redwoods are the dominant tree species, covering approximately two-thirds of the land area (Schirokauer et al. 2003). The largest redwood trees in MWNM grow along the valley floor of Redwood Canyon (Steers et al. 2014). In addition to redwood trees, Douglas fir, California bay laurel (*Umbellularia californica*), and tanoak (*Notholithocarpus densiflorus*) are also common in the redwood forest (Steers et al. 2014). The herbaceous understory in the redwood forest is dominated by various ferns including western sword fern (*Polystichum munitum*) and lady fern (*Athyrium filix-femina* var. *cyclosorum*), and redwood sorrel (*Oxalis oregana*). Old-growth redwood forests have been found to store more carbon aboveground than any other forest type (Van Pelt et al. 2016).

### **Riparian Forest**

Red alder (*Alnus rubra*) and big leaf maple (*Acer macrophyllum*) are found bordering Redwood Creek within the monument (Steers et al. 2014). Vegetation adapted to wet conditions such as giant horsetail (*Equisetum telmateia* var. *braunii*) is also common here.

### **Special Status Plants**

The only CNPS-ranked plant known to occur within MWNM is California bottlebrush grass (*Elymus californicus*) (Integrated Resource Management Applications [IRMA] 2005). This species has a California Rare Plant Rank of 4.3, a rank described as “Plants of Limited Distribution” with a threat rank of “Not very threatened in California (less than 20 percent of occurrences threatened / low degree and immediacy of threat or no current threats known)” (California Native Plant Society [CNPS] 2017). This species is known to occur near Redwood Creek, but not along its banks. Locally rare plants are present along Redwood Creek, and may be present within the project area. These species include western burning bush (*Euonymus occidentalis*), coastal brookfoam (*Boykinia occidentalis*), Indian hemp (*Hoita macrostachya*), western azalea (*Rhododendron occidentale*), and leopard lily (*Lilium pardalinum* spp. *pardalinum*) (IRMA 2005; pers. comm. Forrestel 2017). Leopard lily has no federal, state, or CNPS listing, but is of concern to MWNM natural resource management staff because they believe it was more widespread in MWNM in the past (Steers 2013). Some locally rare or special-status plants may be present within the project area.

### **Invasive Species**

A total of 86 non-native plants are listed as present or probably present within MWNM (IRMA 2005) however park staff have documented at least 125 non-native, invasive plants in the park. Invasive plants within MWNM include broadleaved forget-me not (*Myosotis latifolia*), panic veldt grass (*Ehrharta erecta*), and English ivy (*Hedera helix*) (IRMA 2005, NPS 2016c). Panic veldt grass is

of particular concern for spread during construction projects due to its rapid life cycle, presence within the project area, and affinity for disturbed areas. Volunteer and staff removal efforts have reduced the presence of invasive plants within MWNM (NPS 2016c).

### **Plant Pathogens**

Plant pathogens within the genus *Phytophthora* are known to occur within MWNM. The pathogen *Phytophthora ramorum* causes the plant disease SOD and is known to occur within MWNM (Davidson et al. 2003). The pathogen results in SOD in tanoak and several oak species, and also causes twig and foliar diseases in other species including California bay laurel, Douglas-fir, and redwood (Davidson et al. 2003). California bay laurel appears to be a major reservoir of *P. ramorum* inoculum (Davidson et al. 2003). Of the known hosts of *P. ramorum*, tanoak is the most susceptible to SOD (Davidson et al. 2003). Spores of *P. ramorum* can be found in soil and water in addition to plant material (California Oak Mortality Task Force 2004). SOD has caused extensive tanoak mortality as well as some coast live oak mortality within MWNM.

Soil-born species of *Phytophthora* have been identified in both GGNRA nurseries and in the wild (Shor 2016). Soil-born *Phytophthora* species are common in nursery and agricultural settings and some species, such as *P. cinnamomi*, have the potential to cause extensive plant mortality in wildland settings. NPS is working to limit the spread of these plant pathogens. GGNRA has identified a variety of *Phytophthora* species both on nursery stock and on wild plants in the park and is working to limit the spread of these plant pathogens through improved sanitation practices in the park nurseries, during project implementation and by staff.

## **3.10 Visual Resources**

Visual resources are a major part of the visitor experience at MWNM, with the primary draw being views of towering redwoods. In addition to trees and other vegetation, from the monument's trails, visitors take in views of Redwood Creek and its tributaries, wildlife, and manmade features including bridges, boardwalks, benches, historic markers, and riprap revetments installed by the CCC that give the creek a less natural, more manicured appearance (NPS 2006).

## **3.11 Soundscapes**

The current MWNM soundscape includes both natural and manmade sounds. Natural sounds from flowing water, wildlife, and wind are generally perceived as pleasing and a positive part of the visitor experience, while manmade noise from vehicles, people talking, etc. is typically perceived negatively. Research conducted in MWNM showed that large percentages of visitors were exposed to, and annoyed by, visitor-caused noises such as loud groups and children (Manning et al. 2009). Ambient noise levels in MWNM are typically low, with summer season daytime averages ranging from roughly 30 dBA in the more remote backcountry areas to 40 dBA near the road and Entry Plaza (U.S. Department of Transportation [USDOT] 2011). Due to higher rainfall and streamflows, winter season daytime averages are a bit higher at approximately 40 and 55 dBA for backcountry and entrance area, respectively. Noise levels at night tend to be lower. In quieter areas of the monument, noise from manmade sources like aircraft is more noticeable. During the summer, in the less busy sections of the monument, natural soundscapes devoid of aircraft, vehicle, or other manmade noises are audible about a third of the time, while in the busier areas of the monument near the road, noise from other visitors and vehicles is audible most of the time and largely natural soundscapes are only audible a small percent of the time. Natural sounds are more predominant during the less busy winter months (USDOT 2011).

The park has implemented “quiet zones” in an attempt to improve soundscapes in certain areas, such as in Cathedral Grove. Upcoming changes to parking and transportation at the monument may decrease manmade noise levels in the monument as well.

## 3.12 Air Quality and Greenhouse Gas Emissions

### *Air Quality*

In the San Francisco Bay Area, the main air pollutants of concern are ozone and particulate matter, though clean air from the Pacific Ocean generally helps keep air pollution levels low along the Marin County coast (Bay Area Air Quality Management District [BAAQMD] 2016). Based on data collected at Point Reyes National Seashore, MWNM likely has relatively high nitrogen deposition and estimated acid pollutant exposure compared to other parks in the Inventory and Monitoring Program, but has a low ranking for ozone (Sullivan 2016). Compared to other parks, Point Reyes National Seashore (and by extension, MWNM) has “relatively high background haze and low natural background visibility” though visibility has improved over the last 25 years (Sullivan 2016; Interagency Monitoring of Protected Visual Environments [IMPROVE] 2016). It should be noted that due to the dense forest and steep canyon walls found in MWNM, such background haze and visibility most likely does not affect views within the monument.

Under US National Ambient Air Quality Standards (NAAQS), Marin County is in marginal non-attainment for ozone, moderate non-attainment for particulate matter (PM) 2.5, and maintenance/moderate non-attainment for carbon monoxide (U.S. Environmental Protection Agency [USEPA] 2016a). De minimis emission levels for the county have been set at 100 tons per year (t/y) for nitrous oxides (NO<sub>x</sub>), PM 2.5, and carbon monoxide, and 50 t/y for volatile organic compounds (VOCs) (USEPA 2016b).

### *Greenhouse Gas Emissions*

#### Climate Change and Greenhouse Gases

Climate change is impacting California resources: warmer air and surface water temperatures, different precipitation patterns, rising sea levels, and ocean acidification are all examples of this change. Human influence on climate change is clear and human-caused emissions of greenhouse gases (GHGs) are the highest in history. Because GHGs (carbon dioxide [CO<sub>2</sub>], methane [CH<sub>4</sub>], and nitrous oxide) persist and mix in the atmosphere, emissions anywhere in the world affect the climate everywhere in the world.

Global climate change is already affecting ecosystems and societies throughout the world. Climate change adaptation refers to the efforts undertaken by societies and ecosystems to adjust to and prepare for current and future climate change, thereby reducing vulnerability to those changes. Human adaptation has occurred naturally over history; people move to more suitable living locations, adjust food sources, and more recently, change energy sources. Similarly, plant and animal species also adapt over time to changing conditions; they migrate or alter behaviors in accordance with changing climates, food sources, and predators.

In 2014, total California GHG emissions were 441.54 million metric tons of carbon dioxide equivalents (MT CO<sub>2</sub>e) (California Air Resources Control Board [CARB] 2016a). This represents a 2.7 million metric ton decrease in total GHG emissions from 2013 and an overall decrease of approximately 9.4 percent since peak levels in 2004. Overall trends in the inventory demonstrate that the carbon intensity of California’s economy is declining (the amount of carbon per million dollars of gross domestic product) representing a 28 percent decline since 2001 (CARB 2016b).

In 2014, the transportation sector of the California economy was the largest source of GHG emissions, accounting for approximately 36 percent of the total emissions (CARB 2016a). On-road vehicles accounted for most of the emissions in the transportation sector. The industrial sector accounted for approximately 21 percent of the total emissions, and emissions from electricity generation were about 20 percent of the total. The rest of the emissions are made up of various sources (CARB 2016a).

### Federal Policy

At the federal level, USEPA has developed regulations to reduce GHG emissions from motor vehicles and has developed permitting and reporting requirements for large stationary emitters of GHGs. On April 1, 2010, USEPA and the National Highway Traffic Safety Administration (NHTSA) established a program to reduce GHG emissions and improve fuel economy standards for new model year 2012–2016 cars and light trucks. On August 9, 2011, USEPA and the NHTSA announced standards to reduce GHG emissions and improve fuel efficiency for heavy-duty trucks and buses. In August 2016, the USEPA and NHTSA jointly finalized Phase 2 Heavy-Duty National Program standards to reduce GHG emissions and improve fuel efficiency of medium- and heavy-duty vehicles for model year 2018 and beyond (USEPA 2017).

On October 5, 2009, Executive Order (EO) 13514, Federal Leadership in Environmental, Energy, and Economic Performance, was issued by the Council on Environmental Quality (CEQ). The EO required federal agencies to set a 2020 GHG emissions reduction target within 90 days, increase energy efficiency, reduce fleet petroleum consumption, conserve water, reduce waste, support sustainable communities, and leverage federal purchasing power to promote environmentally responsible products and technologies.

On August 1, 2016, the CEQ released final guidance on the consideration of GHG emissions and climate change in NEPA review (CEQ 2016). This is an update to guidance issued in draft form in February 2010 and December 2014. The guidance encourages agencies to include a quantitative assessment of GHG emissions. The guidance states that the assessment of direct and indirect climate change effects should account for upstream and downstream emissions and includes guidance on biogenic sources of GHG emissions from land management actions.

# Chapter 4

## ENVIRONMENTAL CONSEQUENCES

### 4.1 General Methodology for Assessing Impacts

Direct, indirect, and cumulative impacts are described in accordance with CEQ regulations (40 CFR 1502.16), and the context and intensity of impacts are assessed (40 CFR 1508.27). Where appropriate, BMPs that would reduce potential adverse impacts are also described and incorporated into the evaluation of impacts. A full list of BMPs can be found in Appendix D. Appendix B provides a checklist which has been prepared to support any necessary evaluation of the project pursuant to the California Environmental Quality Act (CEQA) by relevant lead and responsible agencies with discretionary approval authority over some or all of the project.

### 4.2 Cumulative Impacts Analysis Methodology

Cumulative impacts are defined as “the impact on the environment which results from the incremental impact of the action when added to other past, present, or reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions” (40 CFR 1508.7/8). The temporal scale for the cumulative impacts analysis includes past actions through reasonably foreseeable future actions.

Cumulative impacts are determined for each impact topic by combining the impacts of the alternative being analyzed and other past, present, and reasonably foreseeable actions that would also result in beneficial or adverse impacts. Some of these actions are in the early planning stages, so the evaluation of cumulative impacts is based on a general description of the projects. Unless cited otherwise, the information regarding other projects was derived from the Muir Woods Sustainable Access Project EA (NPS 2016a). The remainder of this section discusses other projects that are planned in the immediate vicinity of MWNM.

#### ***Muir Woods Reservation System***

The MWNM Reservation System project is divided into two phases. Phase 1 was completed in February 2016 and included the establishment of a parking barrier system along Muir Woods Road. To improve traffic safety and to prevent parking along the shoulder, approximately a mile of posts and cables were installed along the Muir Woods Road shoulder. Additionally, erosion and sediment control measures were installed.

Phase 2 of the reservation system includes management of motor vehicle access and parking changes, which would reduce peak visitation levels. Reservations for private vehicles and the Muir Woods Shuttle would occur through a third-party-operated system. A separate system would be used for reservation of commercial vehicle parking spots. This system would reduce the number of vehicles parked on the Muir Woods Road shoulder (NPS 2015).

#### ***Muir Woods Road Bridge Replacement Project***

Muir Woods Road bridge, which is located just south of the MWNM boundary, has been identified for replacement by Marin County due to structural deficiencies, bridge alignment and safety issues,

as well as undermining of the bridge due to scour. Improvements associated with the bridge replacement are anticipated to extend along Muir Woods Road from approximately 400 feet west of the bridge to 600 feet east of the bridge, and would involve realigning the road in this area and moving the bridge slightly downstream. Access to MWNM would be maintained throughout implementation of this project. Construction is anticipated to begin in 2019.

### ***Muir Woods Road Rehabilitation Project***

The Muir Woods Road Rehabilitation Project would repair damage from landslides and flooding, as well as resurfacing 2.4 miles of asphalt road. It would also repair or replace culverts, which would ameliorate drainage issues and reduce sediment inputs to Redwood Creek. Completion of planning for the project is anticipated in 2017, and construction is expected to begin in 2019 (County of Marin 2016).

### ***Muir Woods Water/Wastewater Line Replacement***

Starting in 2017 and ending in 2018, NPS plans to repair and enhance water and wastewater lines as well as portions of the potable water and wastewater collection systems in MWNM. The relocation of the sewer line that currently extends along the bank of Redwood Creek will protect the creek water quality from a potential spill.

### ***Muir Woods Sustainable Access Project***

This project would improve the entry area of MWNM. NPS would modify the configuration of the Entry Plaza and several parking lots, but would maintain the same number of parking spaces for privately owned vehicles as currently exists within the monument. NPS would remove all parking from the Entry Plaza, although administrative vehicular access would remain. A new pedestrian bridge would be installed at the Dipsea Trail crossing of Redwood Creek. The existing restrooms in the Entry Plaza would be relocated, and a second restroom would be constructed. The two wastewater lift stations would be replaced. Existing roadside parking would be eliminated on Muir Woods Road and disturbed areas between Conlon Avenue and the Muir Woods Road Bridge would be revegetated with plants native to MWNM (NPS 2016a).

## **4.3 Cultural Resources**

### ***Methodology and Assumptions***

This analysis on potential impacts to cultural resources is based on the results of an archaeological survey of the Proposed Action's Direct APE (Gavette 2017) and a conditions assessment of the riprap that lines Redwood Creek (Brunzell 2017). The riprap is a contributing element to the NRHP-listed Muir Woods National Monument Historic District. The analysis was guided by the criteria of adverse effect provided in the implementing regulations of Section 106 of the NHPA under 36 CFR 800.5, Assessment of Adverse Effects.

The conclusion section of each of the action alternatives addresses three topics: (1) NEPA impacts to individual historic features within MWNM, such as the historic riprap; (2) NEPA impacts to MWNM as a whole; and (3) impacts to MWNM under Section 106 of the National Historic Preservation Act.

## ***Impacts of the No Action Alternative***

### Analysis

Under the No Action Alternative, existing management would continue and no actions would be taken to improve habitat for salmonids or to encourage more natural geomorphic processes. No riprap would be removed, no LWD would be installed, and the four pedestrian bridges would either not be replaced or be replaced in-kind (same location, same material, same size). The trails network within Muir Woods Historic District would not change. Public use of the trails and pedestrian bridges would continue, but there would be no new adverse or beneficial impacts on cultural resources in these areas, including the Main Trail, Ben Johnson Trail, and Redwood Creek riprap, all of which are contributing elements to the Muir Woods Historic District.

### *Conclusion*

Under the No Action Alternative, there would be no new adverse or beneficial impacts on cultural resources. Consequently, the No Action Alternative would have no adverse effects.

## ***Creek Restoration Alternatives***

### Impacts of Actions Common to All Creek Restoration Alternatives

#### *Analysis*

Since creek banks are often considered archeologically sensitive, an adverse impact on previously unidentified subsurface archeological resources could occur from ground disturbance during removal or burial of the riprap. However, the earth-disturbing activities would also be monitored to minimize any impacts on archeological resources, per BMP CR-1 (see Appendix D).

Grade control in the form of check dam construction would similarly have a beneficial long-term impact by slowing erosion and preserving historic riprap.

All Phase 1 Creek Restoration Alternatives would use Alice Eastwood Road, a contributing element to the Muir Woods Historic District, as an access route. Existing gulying in the dirt portion of the road would be repaired prior to use of the road for the Proposed Action, which would improve the condition of the road. Use of the road would not change its historical alignment, and the road would be restored to at least its pre-project condition once the project is complete.

Additionally, all Creek Restoration Alternatives would have a beneficial effect on the health of the redwood forest, which is the primary contributing landscape element within the Muir Woods Historic District (NPS 2007). The majority of contributing elements to the Muir Woods Historic District would remain unaffected by the Creek Restoration Alternatives.

### *Conclusion*

Under all creek restoration alternatives, impacts on cultural resources would be direct, short- and long-term, and minor. Minor adverse impacts would be mitigated or offset by corresponding beneficial impacts.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Under Creek Restoration Alternative 1, habitat restoration activities would result in removal of about 1,019 LF of historic riprap and burial of Phase 1 portions. Sections targeted for removal under Creek Restoration Alternative 1 constitute about 30 percent of the riprap, causing major

short- and long-term adverse impact to the historic riprap, which is a contributor to the Muir Woods Historic District.

Adverse impacts to historic riprap will be partially addressed by preservation of some of its most visible sections, the careful recordation of the riprap, and rehabilitation of CCC features on Muir Woods trails per BMP CR-4 (see Appendix D). Roughly 60 percent (about 1336 of 2533 LF) of visible riprap would be preserved under Creek Restoration Alternative 1.

Construction activities would result in additional minor short-term impacts to trails that are contributors to the Muir Woods Historic District. These impacts would be mitigated by locating staging and stockpiling areas away from trails that are contributors to the Muir Woods Historic District.

### *Conclusion*

Under Creek Restoration Alternative 1, impacts on historic riprap would be direct, long-term, and major. Historic riprap would be permanently destroyed by habitat restoration activities; therefore, Creek Restoration Alternative 1's adverse impacts cannot be fully mitigated. However, because the erosion-control rock revetments are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, when combined with actions common to all alternatives, Creek Restoration Alternative 1's impacts to historic resources would be long-term, minor, and adverse. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Under Creek Restoration Alternative 2, one leg of the trail in Cathedral Grove (a contributor to the Muir Woods Historic District) would be removed, resulting in major short- and long-term adverse effect on the trail as a contributor to the Muir Woods Historic District. Additional historic riprap (totaling roughly 1,357 LF constituting 40 percent of total riprap) would be removed (with a portion buried in the channel) resulting in major short- and long-term adverse effect on the riprap as a contributing feature to the Muir Woods Historic District.

Adverse impacts to historic riprap will be partially mitigated by preservation of some of its most visible sections, the careful recordation of the riprap, and rehabilitation of CCC features on Muir Woods trails per BMP CR-4 (see Appendix D). Roughly 50 percent (about 1,080 of 2,355 LF) of visible riprap will be preserved under Creek Restoration Alternative 2.

Construction activities would result in additional minor short-term impacts to trails that are contributors to the Muir Woods Historic District, including erosion. These impacts would be mitigated by locating staging and stockpiling areas away from trails that are contributors to the Muir Woods Historic District.

### *Conclusion*

Under Creek Restoration Alternative 2, impacts on historic riprap and trails would be direct, long-term, and major. Historic riprap would be permanently destroyed by habitat restoration activities and one side of the loop of the historic trail in Cathedral Grove (a contributor to the Muir Woods Historic District) would be destroyed; therefore, Creek Restoration Alternative 2's adverse impacts cannot be fully mitigated. However, because the trails and erosion-control rock revetments are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, when combined with the actions common to all alternatives and the actions taken

under Creek Restoration Alternative 1, Creek Restoration Alternative 2's impacts to historic resources would be long-term, minor, and adverse. The impacts of Creek Restoration Alternative 2 are slightly greater than those under Creek Restoration Alternative 1, as 10 percent more of the visible riprap will be removed. Visible riprap is more important as a cultural resource compared to non-visible riprap. Therefore, the difference between impacts for the two alternatives is moderate. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Under Creek Restoration Alternative 3, the same amount of historic riprap and the same portion of the Cathedral Grove trail would be removed as in Creek Restoration Alternative 2, resulting in major short- and long-term adverse effect on the riprap as a contributing feature to the Muir Woods Historic District. This alternative also includes creek bank terracing, which may have adverse impacts on archeological resources that may potentially be discovered in archeologically sensitive creek banks. Such potential impacts will be mitigated by archeological monitoring, as described in BMP CR-1 (see Appendix D).

#### *Conclusion*

Under Creek Restoration Alternative 3, impacts on historic riprap and trails would be direct, long-term, and major. Historic riprap would be permanently destroyed by habitat restoration activities. A leg of the historic trail in Cathedral Grove (a contributor to the Muir Woods Historic District) would be destroyed; therefore, Creek Restoration Alternative 3's adverse impacts cannot be fully mitigated. However, because the trails and erosion-control rock revetments are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, when combined with the actions common to all alternatives and the actions taken under Creek Restoration Alternatives 1 and 2, Creek Restoration Alternative 3's impacts to historic resources would be long-term, minor, and adverse. Because additional floodplain terracing does not result in adverse effects to historic resources, there is no difference between impacts for Creek Restoration Alternative 2 and Creek Restoration Alternative 3. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Creek Restoration Alternative 4

#### *Analysis*

Under Creek Restoration Alternative 4, two sections of trails that are contributors to the Muir Woods Historic District would be rerouted, resulting in major short- and long-term adverse effects on the trails as contributors to the Muir Woods Historic District. Habitat restoration activities will result in additional 270 LF of riprap removal, resulting in major short- and long-term adverse effects on the riprap as a contributing feature to the Muir Woods Historic District. None of the additional riprap removed, however, is visible; therefore, the difference between the creek restoration alternatives is minor in terms of impacts to cultural resources. The adverse impacts to the trails and riprap, as discussed above, will be partially addressed by preservation of some of its most visible sections, the careful recordation of the riprap, and rehabilitation of CCC features on Muir Woods trails by implementing BMP CR-4 (see Appendix D).

### *Conclusion*

Under Creek Restoration Alternative 4, impacts on historic riprap and trails would be direct, long-term, and major. Historic riprap would be permanently destroyed by habitat restoration activities, a leg of the trail in Cathedral Grove (a contributor to the Muir Woods Historic District) would be destroyed, and up to 555 LF of other trails (also contributors to the Muir Woods Historic District) would be rerouted; therefore, Creek Restoration Alternative 4's adverse impacts cannot be fully mitigated. However, because the trails and erosion-control rock revetments are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, Creek Restoration Alternative 4's impacts to historic resources would be long-term, minor, and adverse. Because additional trails and riprap will be removed under Creek Restoration Alternative 4, its impacts are moderately greater than Creek Restoration Alternatives 2 and 3. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Creek Restoration Alternative 5

#### *Analysis*

Under Creek Restoration Alternative 5, riprap removal, trail removal, and trail relocation would be the same as under Alternative 4. This alternative also includes creek bank terracing, which may have adverse impacts on archeological resources that may potentially be discovered in archeologically sensitive creek banks. Such potential impacts will be mitigated by archeological monitoring, as described in BMP CR-1 (see Appendix D).

#### *Conclusion*

Under Creek Restoration Alternative 5, impacts on historic riprap and trails would be direct, long-term, and major. Historic riprap would be permanently destroyed by habitat restoration activities, and a leg of the trail in Cathedral Grove (a contributor to the Muir Woods Historic District) would be destroyed; therefore, Creek Restoration Alternative 5's adverse impacts cannot be fully mitigated. However, because the trails and erosion-control rock revetments are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, when combined with the actions common to all alternatives and the actions taken under Creek Restoration Alternatives 1 through 4, impacts to historic resources would be long-term, minor, and adverse. Because additional floodplain terracing does not result in adverse effects to historic resources, there is no difference between impacts for Creek Restoration Alternatives 1 through 5. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives

#### *Analysis*

Under all pedestrian bridge replacement alternatives, replacement of the four pedestrian bridges across Redwood Creek is likely to require the use of heavy equipment. Motorized heavy equipment used could include bulldozers and trucks, which could cause erosion and thus may result in an adverse effect to historic riprap or trails. The four bridges are non-contributors to the historic district, and therefore bridge replacement would not result in an impact to a historic resource. Historic riprap protecting the Bridge 1 abutments and Bridge 2's left bank abutment would not be

removed. There is no historic riprap in the vicinity of Bridge 3 and Bridge 4, so removal of their abutments would not impact a historic resource. Since creek banks are often considered archeologically sensitive, an adverse impact on subsurface archeological resources could occur from ground disturbance during removal of the abutments and excavation of bridge foundations. However, the earth-disturbing activities would also be monitored per BMP CR-1 (see Appendix D) to minimize any impacts on previously unidentified archeological resources.

Pedestrian bridge construction would use Alice Eastwood Road, a contributing element to the Muir Woods Historic District, as an access route. Under all pedestrian bridge replacement alternatives, bridges would be replaced at their current locations and no bridges would be removed without replacement. Specifically, replacement of Bridges 1 and 3 at their current locations maintains access to Bohemian Grove and the Bohemian Grove Trail; the grove and trail are both contributing elements to the historic district.

Under all pedestrian bridge replacement alternatives, design of replacement bridges would be in keeping with the rustic historic character of MWNM. A prior footbridge design study identified incompatibility with the rustic aesthetic as a negative feature of the current bridges (Haesloop and Molinski 2014). Bridge decks would be steel stringers, which will give the structures a profile with a slight arch (<5 percent) that would not be highly visibly noticeable and that blends into the natural environment. The simplicity of the design (which has often been used for vernacular rural bridges) is also compatible with the rustic aesthetic. Hand rails and seating would be either log construction or wood veneer, materials that are more compatible with the historic setting than the modern manufactured wood product of the current bridges. Earthen ramps and natural stone accents would also complement the natural and historic settings. Existing bridges are of modern design and appearance and a departure from the romanticized rustic aesthetic that characterized the landscape during the historic period; the new bridges will enhance the historic character of MWNM.

### *Conclusion*

Under all pedestrian bridge replacement alternatives, impacts on cultural resources would be direct, short- and long-term, and minor. However, because the trails that are contributors to the historic district are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, actions common to all pedestrian bridge replacement alternatives, impacts to historic resources would be long-term, minor, and adverse. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Pedestrian Bridge Replacement Alternative A

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative A, spans for Bridges 2 and 3 would be lengthened and designed to pass up to a 25-year peak-discharge event with 15- and 12-inch freeboard at the peak of the arch, respectively (Figures 2-8 and 2-9). Existing abutments would be removed and new abutments would be placed at a distance farther from the creek (Figures 2-7 and 2-8). For Bridge 2, approximately 80 LF of existing asphalt trail would be removed and 120 LF of new boardwalk would be installed on the east side of creek and 20 LF of new boardwalk on the west side of the creek, and a small approximately 20- by 20-foot boardwalk gathering area would be built on the east side of the creek. For Bridge 3, approximately 130 LF of existing asphalt trail leading to the east side of the crossing would be removed and the trail would be relocated and replaced with approximately 120 to 160 LF of flexible paving. The approaches to the bridge would

require approximately 30 LF of boardwalk on the east side of the creek and approximately 35 LF of boardwalk on the west side of the creek.

### *Conclusion*

Under Pedestrian Bridge Replacement Alternative A, impacts on trails that are contributors to the historic district would be direct, long-term, and minor. Trails that are contributors to the historic district would be permanently altered by bridge lengthening and alterations to approaches; therefore, Pedestrian Bridge Replacement Alternative A's adverse impacts cannot be fully mitigated. However, because the trails are among many cultural landscapes, buildings, and structures that are considered contributors to the historic district, when combined with actions common to all alternatives, Pedestrian Bridge Replacement Alternative A's impacts to historic resources would be long-term, minor, and adverse. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative B, the spans for Bridges 2 and 3 would be lengthened and designed to pass up to a 100-year peak-discharge event with 13- and 14-inch freeboard at the peak of the arch, respectively (Figures 2-8 and 2-9). Existing abutments would be removed and new abutments would be placed farther from the creek. For Bridge 2, on the east side of the creek approximately 80 LF of existing asphalt trail would be removed and replaced with approximately 140 LF of new boardwalk and approximately 40 LF of new boardwalk would replace asphalt trail on the west side of creek. For Bridge 3, approximately 130 LF of existing asphalt trail leading to the east side of the crossing would be removed and the trail would be relocated and replaced with approximately 120 to 160 LF of new flexible paving trail. The approaches to the bridge would require approximately 50 LF of new boardwalk on the east side of the creek and approximately 50 LF of new boardwalk on the west side of creek. The rerouted trail would be to be pulled back from the channel.

### *Conclusion*

Under Pedestrian Bridge Replacement Alternative B, the bridge approaches are slightly longer than under Pedestrian Bridge Replacement Alternative A, so the impacts to trails that are contributors to the historic district are greater than under Pedestrian Bridge Replacement Alternative A. However, the difference between bridge approach length is minor. Therefore, adverse impacts to historic resources under Pedestrian Bridge Replacement Alternative B would be similar to potential impacts discussed above for Pedestrian Bridge Replacement Alternative A. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative C, the impacts associated with Bridge 2 would be as described for Pedestrian Bridge Replacement Alternative A, and Bridge 3 impacts would be as described in Pedestrian Bridge Replacement Alternative B.

### *Conclusion*

Under Pedestrian Bridge Replacement Alternative C, some bridge approaches are slightly longer than under Pedestrian Bridge Replacement Alternative A and others are the same, so the impacts to trails that are contributors to the historic district are greater than under Pedestrian Bridge Replacement Alternative A but less than Pedestrian Bridge Replacement Alternative B. However, the difference between bridge approach length is minor. Therefore, adverse impacts to historic resources under Pedestrian Bridge Replacement Alternative C would be similar to potential impacts discussed above for Pedestrian Bridge Replacement Alternative A. This alternative will have an adverse effect under Section 106. However, since this action would not render MWNM ineligible for listing in the NRHP it is not considered a significant adverse environmental impact under NEPA.

### **Cumulative Impacts**

Cumulative adverse impacts from other past, current, and future projects in MWNM include ground disturbance and excavation, and impacts to historic trails, bridges, and riprap. Previous studies have not revealed archeological sites in the creek channel or on the creek banks; therefore, no adverse impacts to archeological resources are anticipated. However, ground disturbance resulting from construction activities could potentially reveal the existence of currently unknown archeological sites. Earth-disturbing activities should, therefore, be monitored for cultural resources. If any resources were discovered, construction would be stopped, and the NPS would follow the procedures outlined in 36 CFR 800.13 (Post-Review Discoveries). If no resources are discovered and if the procedures outlined in 36 CFR 800.13 are followed, construction should not result in adverse impacts to archeological resources.

Continued public use of the trails would potentially result in heavy use of the Main Trail and/or Ben Johnson Trail. Muir Woods is extremely popular and experiences heavy visitation year-round, with daily average visitation rates ranging from a low of approximately 1,500 in January to a high of approximately 4,700 in July (NPS 2015). Daily visitors to Muir Woods can number in the thousands in a single day, and the majority of these visitors walk on park trails, potentially creating overuse, particularly on unpaved paths such as the Ben Johnson Trail. Public use is unlikely to result in an adverse effect to historic riprap, since visitors are not allowed to enter the creek bed.

Implementation of the Muir Woods Reservation System will reduce peak visitation levels at MWNM by limiting access and parking for motorized vehicles. These actions would reduce peak use of the Muir Woods Historic District and would, therefore, have a beneficial effect.

The Muir Woods Road Bridge Replacement Project will replace a bridge on Muir Woods Road outside of the Muir Woods Historic District. Replacement of the bridge would have no effect on the Muir Woods Historic District.

The Muir Woods Road Rehabilitation Project will involve repairs and resurfacing work along parts of Muir Woods Road, as well as repair or replace culverts. No archeological resources are known to exist within the project area. While the project is in an area potentially sensitive for archeological remains, the Road Rehabilitation Project will have no adverse impacts on cultural resources, as NPS will monitor the work and will follow the procedures for post-review discoveries, pursuant to 36 CFR 800.13, if archeological materials are uncovered during construction.

The Muir Woods Water/Wastewater Line Replacement includes the repair and enhancement of water and wastewater lines, along with portions of the potable water and wastewater collection systems and two lift stations in MWNM. These actions will involve ground disturbance and excavations that have the potential to uncover archeological remains, although no archeological

resources have been discovered in the project area. Similar to the Road Rehabilitation Project, this project will be monitored in archeologically sensitive areas and follow the procedures under 36 CFR 800.13 if archeological materials are discovered during construction. Therefore, the Water/Wastewater Line Replacement should have no adverse effect on cultural resources.

The Muir Woods Sustainable Access Project would modify the configuration of the Entry Plaza and several parking lots, remove all parking from the Entry Plaza except for administrative parking, install a new pedestrian bridge at the Dipsea Trail crossing of Redwood Creek, relocate the existing restrooms in the Entry Plaza, and construct a second restroom. This project will have no adverse effect on cultural resources because (1) known archeological sites will be avoided; (2) 36 CFR 800.13 will be followed if archeological materials are discovered during construction; and (3) the new Dipsea Trail bridge and restrooms will be designed to meet the Secretary of the Interior's Standards for the Treatment of Historic Properties.

### ***Conclusion***

Overall, cumulative impacts on cultural resources would be direct, short- and long-term, and minimal because known archeological sites would be avoided, areas of archeological sensitivity would be monitored, and new structures would be designed to follow the Secretary of the Interior's Standards for the Treatment of Historic Properties. Several of these projects would include ground disturbance in the vicinity of areas identified as archeologically sensitive but cumulatively would have no adverse effect on cultural resources as known sites will be avoided, sensitive areas will be monitored, and 36 CFR 800.13 will be followed if archeological materials are discovered during construction. Similarly, replacement of the Dipsea Trail Bridge, and construction of new bathrooms would follow the Secretary of the Interior's Standards for the Treatment of Historic Properties and thus have no adverse impact on the Muir Woods Historic District.

Considering the creek restoration and pedestrian bridge replacement alternatives as a whole, the Proposed Action would result in direct, long-term, and major adverse impacts that cannot be mitigated to historic riprap, and minor potential adverse impacts to trails and archeological resources that can be mitigated and there will be adverse effects under Section 106. However, because the trails and erosion-control rock revetments are among many cultural features that are considered contributors to the historic district, there would be no adverse effect on the Muir Woods Historic District.

## **4.4 Threatened or Endangered Species**

### ***Methodology and Assumptions***

This analysis examines the potential for actions associated with each of the alternatives to affect threatened or endangered species or their habitats at MWNM. Chapter 3 described federally threatened and endangered species known to occur or potentially occurring at the monument. The area of analysis includes all habitats within the boundary of MWNM, as well as downstream reaches of Redwood Creek which could potentially be impacted by water quality and sedimentation changes.

The marbled murrelet has not been documented at MWNM or at the adjacent State Parks areas around the Alice Eastwood campground or road, and is not expected to be impacted under the Proposed Action. If marbled murrelet were to be present, effects would be similar to those described for northern spotted owls. Implementation of BMP BIO-7 (see Appendix D), which requires construction activities that would raise noise levels above ambient conditions within suitable marbled murrelet breeding habitat to occur outside the breeding season (March 15 to July 31) and to occur outside the hours from two hours before sunset to two hours after sunrise

during the late breeding season (August 1 to September 15), would further reduce the potential for impacts. Because no impacts to marbled murrelet are expected to result from the Proposed Action, this issue is not discussed further.

CRLF are not expected within the project area as there have been no documented adults or juveniles in upper Redwood Creek and suitable breeding habitat is not present in MWNM (Stillwater and Horizon 2011). Implementation of the following BMPs would further reduce the potential for impacts: BIO-2, which restricts night, dawn, and dusk work, BIO-3, which requires removal of trash that could attract predators of CRLF, BIO-5, which requires screening of dewatering pump intakes to prevent entrapment of CRLF, and BIO-18, which requires reconnaissance surveys and other avoidance measures (see Appendix D for details). Because no impacts to CRLF are expected to result from the Proposed Action, this issue is not discussed further.

### ***Impacts of the No Action Alternative***

#### Analysis

**Coho Salmon.** The No Action Alternative would result in continued poor rearing conditions for juvenile Coho within MWNM. Under the No Action Alternative, no LWD would be added to Redwood Creek, although some natural recruitment of LWD could potentially occur. However, the historic removal of LWD from MWNM means that there would continue to be a low level of LWD in the creek.

In-kind replacement of pedestrian bridges would result in construction impacts to Redwood Creek such as sedimentation and disturbance of bank vegetation, but it would be expected that standard BMPs such as those described in Appendix D would be employed to minimize impacts on Coho salmon.

**Steelhead.** Impacts on steelhead under the No Action Alternative would be similar to those described for Coho salmon because of the habitat overlap between the two species. However, steelhead are not considered at risk of extirpation from Redwood Creek.

**Northern Spotted Owl.** Construction activities to replace the pedestrian bridges in-kind would result in indirect short-term impacts to northern spotted owls due to increased noise from construction equipment.

#### Conclusion

Under the No Action Alternative, Coho salmon and steelhead critical habitat would continue to be affected by poor rearing conditions as a result of historic management practices. Direct and indirect adverse impacts would persist over the long term. Northern spotted owl would be temporarily affected by construction activities for bridge replacement. Overall, the No Action Alternative is likely to adversely affect threatened or endangered species.

### ***Creek Restoration Alternatives***

Unless otherwise noted, evaluations of impacts are based on NHE's 2017 report, *Salmon Habitat Restoration at Muir Woods, Site Analysis, Conceptual Designs and Impact Analysis*.

#### Impacts of Actions Common to all Creek Restoration Alternatives

##### *Analysis*

All alternatives would result in removal and translocation of juvenile Coho salmon and steelhead from the areas to be dewatered within Redwood Creek and temporary loss of low quality rearing habitat. This would require a take authorization from NMFS. Revegetation of disturbed creek banks

would result in overhanging branches that would provide cover for Coho salmon and steelhead. Under all stream action alternatives, there would be a beneficial increase in stream habitat complexity for listed salmonids over the No Action Alternative with removal and burial of some riprap and addition of LWD. The presence of new LWD would help with retention of SWD, as well as pool formation and maintenance. Impacts of riprap removal and burial, and LWD addition are analyzed in more detail in each Creek Restoration alternative below. Installation of SWD (beaver dam analogs) would increase habitat complexity by the creation of upstream ponding and downstream plunge pools, changes in deposition and erosion processes, and changes in thermal heterogeneity (Bouwes et al. 2016). Installation of these features has been shown to increase density and survival of juvenile steelhead without adverse effects on migration (Bouwes et al. 2016). Malison et al. (2014) found that juvenile Coho salmon heavily used early-successional beaver pond habitat (similar to habitat created by beaver dam analogs). Only some of the beaver dam analogs would be channel-spanning, typically in areas where both banks are stable. Channel-spanning beaver dam analogs are anticipated to have similar effects to those described in Bouwes et al. (2016), while beaver dam analogs that are not channel spanning would have smaller effects on salmonid habitat, but would include the creation of low-velocity refugia. Installation of beaver dam analogs is anticipated to trap sediment within Redwood Creek and aggrade the channel over time. The habitat changes and sediment trapping caused by installation of beaver dam analogs would have long-term beneficial impacts on Coho salmon and steelhead.

Installation of grade control to reduce incision in a tributary to Redwood Creek would be conducted during the summer when the tributary is dry. This work period, combined with the BMPs identified in Appendix D, would eliminate or reduce the potential for sediment to wash into Redwood Creek. Installation of grade control would reduce erosion, indirectly benefitting salmonids due to decreased sedimentation in spawning areas. Grade control also has the potential to locally raise groundwater elevations at the base of the drainage area and to store more water that becomes available to the channel later in the season, which could have minor long-term beneficial impacts on salmonids. Grade control installation would be by hand and would not be expected to significantly increase temporary noise in the vicinity of the installation, and thus is not anticipated to impact northern spotted owls.

### *Conclusion*

Removal of juvenile salmon from areas to be dewatered would result in minor short-term adverse impacts on juvenile Coho salmon and steelhead. Revegetation of disturbed areas would result in minor long-term beneficial impacts on Coho salmon and steelhead. Installation of SWD (beaver dam analogs) would have major long-term beneficial impacts on juvenile Coho salmon and steelhead. Installation of grade control on the tributary to Redwood Creek would have minor long-term beneficial impacts on salmonids, and is not anticipated to impact northern spotted owl.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

**Coho Salmon.** Creek actions including removal of riprap, burial of Phase 1 segments of riprap in the channel, excavation of pools, and placement of LWD would result in changes in stream habitat that would be beneficial to Coho salmon. Channel migration would result in undercut tree root systems, which creates deep undercut banks that serve as velocity refuge and cover essential for rearing fish (NHE 2017). Implementation of the actions proposed in Creek Restoration Alternative 1 could result in short-term adverse impacts to Coho salmon through sedimentation caused by channel migration; however adverse effects such as downstream reductions in spawning habitat and downstream increases in turbidity will be minimized through revegetation and restoration of banks per BMP BIO-15 (see Appendix D). Dewatering of the channel, burial of some riprap, and the

presence of heavy equipment in the channel could also result in short-term impacts to Coho salmon, which would be avoided or reduced by the BMPs described in Appendix D, specifically BMP-1, -2, -4, -5 and BIO-1, -2, -4, and -5. These BMPs require measures such as defining the work area and dewatering area, removing fish from the dewatering area, dewatering the work area, implementing measures to reduce equipment impacts, using biodiesel, biological training of workers, and limiting the in-water work window to June 15 to October 31. Impacts to specific Coho salmon habitat types are described below.

#### *Spawning Habitat*

The highest density of Coho spawning in Redwood Creek occurs in MWNM (Fong et al. 2016). While removal of riprap is not anticipated to substantially change Coho salmon spawning habitat, LWD addition is anticipated to improve spawning habitat by increasing the exchange of subsurface and surface flows (NHE 2017). Burial of Phase 1 riprap would temporarily disturb approximately 550 linear feet of channel, some portions of which provide spawning habitat. Following riprap burial, the channel bed would be restored to similar condition to pre-disturbance. Where existing riffles are converted to pools through natural channel processes or channel recontouring following riprap burial, a decrease in spawning habitat may occur (NHE 2017). However, the channel in the project area has a disproportionately large area of flat planar bed compared to other reaches of Redwood Creek and the conversion of some of this area to more natural features would not be anticipated to have a large impact on the availability of spawning habitat. Spawning habitat also occurs in Redwood Creek downstream of MWNM (Fong et al. 2016). Mobilization of stream banks would result in increased sediment load into Redwood Creek (see Section 4.5, *Geology* and Section 4.9, *Water Resources and Hydrology* for a more detailed discussion). Detailed long-term observation of spawning habitat within Redwood Creek has not shown burial of spawning gravel from other sediment sources (such as eroding banks) (Mike Reichmuth, NPS, personal observation, Feb. 1, 2017). In addition, sedimentation will be minimized by restoring and revegetating disturbed banks through implementation of BMP BIO-15 (see Appendix D). For these reasons, the additional fine sediment generated from restoration activities is not anticipated to have adverse impacts on downstream spawning habitat.

#### *Summer Rearing Habitat*

The number of pools within MWNM would increase, as would habitat complexity associated with LWD. Increased rearing habitat in proximity to spawning habitat reduces time and energy that young fish expend seeking out suitable habitat following emergence (NHE 2017). Good rearing habitat created adjacent to high quality spawning habitat creates well-connected habitats that will increase overall rearing habitat capacity in the watershed. Under current poor habitat conditions, young salmon are displaced downstream where they are either eaten or potentially they over-saturate existing habitats. Increased rearing habitat in MWNM also provides better spatial distribution of juveniles throughout the watershed and minimizes risk to population from catastrophic events that affect certain segments of the creek (e.g., drought impacts affecting lowest part of creek)

This alternative has the most limited area of direct action, and has the least benefit of the alternatives. Riprap removal and LWD installation under Creek Restoration Alternative 1 would result in increases in summer rearing habitat between Bridge 1 and Bridge 4 from the existing mean of 32 percent of the channel length to approximately 47 percent, an increase of approximately 15 percent. Riprap burial in Phase 1 would also create summer rearing habitat. LWD installation would result in summer habitat creation after flows are sustained at sufficiently high levels to mobilize the bed and scour pools. This would result in long-term beneficial impacts on Coho salmon.

### *Winter/Spring Rearing Habitat*

Coho rear in areas that are adjacent to cover, have water low velocities, and have sufficient depth for the specific life stage. Shallow water habitats supported much lower numbers of juvenile Coho salmon and steelhead than pools during winter 2017 snorkel surveys. Fish that emerge (fry) during high flows can be swept downstream and mortality can increase if refugia from velocity are not readily available (Lestelle 2007). Fry prefer shallow, low velocity water in backwater pools and along channel margins adjacent to bank cover which may include woody debris, undercut banks and roots (Lestelle 2007). Under all creek restoration alternatives the revegetation of creek banks and incorporation of LWD should increase the amount of available habitat for coho fry. As described in Chapter 3, Affected Environment, the highest density of spawning in Redwood Creek occurs in MWNM (Fong et al. 2016), and the presence of pools and complex habitat in proximity to spawning habitat would likely increase juvenile abundance in MWNM. Currently, winter/spring rearing habitat is 11 m<sup>2</sup>/100m. Under Creek Restoration Alternative 1, winter/spring rearing habitat would increase to approximately 45 m<sup>2</sup>/100m. This would result in long-term beneficial impacts on Coho salmon.

**Steelhead.** Steelhead and Coho salmon can use similar habitat, but steelhead will also use more large rock cover. As temperatures drop, steelhead are also known to use loose rock substrates for cover from 10 to 490 cm in diameter in proportion to their body size (Bustard and Narver 1975; Hartman 1965). Loss of interstitial space in riprap would be offset by other habitats (such as LWD). Impacts on steelhead under Creek Restoration Alternative 1 would be similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Creek Restoration Alternative 1, noise and the presence of equipment and crews during construction activities could result in direct, short-term impacts on northern spotted owls. Implementation of BMP measures BIO-1, -2, -3, and -6 would reduce the potential for adverse impacts on northern spotted owls. These measures include biological training of workers; no Proposed Action activities at night, dawn, or dusk; removal of waste; and pre-construction surveys for this species (see Appendix D). Long-term indirect adverse effects could occur if channel migration causes loss or degradation of occupied habitat (e.g., nest trees, prey resources); however, this is considered a negligible impact.

### *Conclusion*

Implementation of Creek Restoration Alternative 1 would result in major long-term beneficial impacts to Coho salmon, steelhead, and their critical habitat within the project area. Temporary adverse impacts to these species would be reduced by implementation of BMPs described in Appendix D, specifically BMP-1, -2, -4, -5 and BIO-1, -2, -4, and -5. These BMPs require measures such as defining the work area and dewatering area, removing fish from the dewatering area, dewatering the work area, implementing measures to reduce equipment impacts, using biodiesel, biological training of workers, and limiting the in-water work window to June 15 to October 31 (see Appendix D).

This alternative could result in short-term temporary adverse impacts on northern spotted owl due to construction noise. Implementation of BMPs BIO-1, -2, -3, and -6, would reduce the potential for adverse impacts on this species (see Appendix D). These measures include biological training of workers; no Proposed Action activities at night, dawn, or dusk; removal of waste; and pre-construction surveys for this species. Long-term adverse impacts to northern spotted owl would be negligible.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

**Coho Salmon.** Under Creek Restoration Alternative 2, effects on Coho salmon would be similar to those described under Creek Restoration Alternative 1. The geographic area of habitat enhancement would be expanded to include the Entry Plaza area and Cathedral Grove. Both summer and winter/spring rearing habitat would increase, due to the development of pools from the removal of the additional 338 LF of riprap and burial of a portion of this riprap. Summer habitat would increase to 49 percent of the channel length and winter/spring rearing habitat would increase to 48 m<sup>2</sup>/100m (NHE 2017). This increase in habitat would result in greater beneficial impacts compared with Creek Restoration Alternative 1.

**Steelhead.** Effects on steelhead under Creek Restoration Alternative 2 would be similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Creek Restoration Alternative 2, effects on northern spotted owl would be similar to those described under Creek Restoration Alternative 1.

#### *Conclusion*

Implementation of Creek Restoration Alternative 2 would result in additional long-term beneficial impacts in the project area to Coho salmon, steelhead, and their critical habitat compared to Creek Restoration Alternative 1.

This alternative could result in short-term temporary adverse impacts on northern spotted owl due to construction noise, which would be reduced by implementation of the BMPs described in Creek Restoration Alternative 1. Long-term adverse impacts to northern spotted owl would be negligible.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

**Coho Salmon.** Under Creek Restoration Alternative 3, effects on Coho salmon would be similar to those described under Creek Restoration Alternative 2 but with additional benefits. This alternative addresses incision in the area of the creek that is most incised. Both summer and winter rearing habitat would increase, due to the development of pools from the removal of the additional riprap segments and the installation of engineered log jams in the Entry Plaza area. Summer habitat would be created in the form of large, deep pools in the vicinity of the constructed wood jams, and would increase 2 percent compared to Creek Restoration Alternative 2 (NHE 2017). However, the increased value of the created jam pools is much higher than the arithmetic increase would suggest. In winter 2017, the four existing log jam pools in MWNM had on average 17 Coho salmon and 12 steelhead per pool. A mean number of two Coho salmon and six steelhead juveniles were observed in all other pools. Winter/spring habitat will be expanded throughout the reach due to increased velocity refuge, expanded cover, and increase depth where new pools are formed. The terracing of the right bank at the Plaza would add approximately 5,380 square feet of inset floodplain to this reach of river corridor which would result in an immediately larger area and wider variety of winter rearing habitat compared with Creek Restoration Alternative 2. The changes would result in an increase of 3 m<sup>2</sup>/100m compared to Creek Restoration Alternative 2 (NHE 2017). This increase in habitat would result in greater beneficial impacts compared with Creek Restoration Alternative 2.

**Steelhead.** Effects on steelhead under Creek Restoration Alternative 3 would be the similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Creek Restoration Alternative 3, effects on northern spotted owl would be similar to those described under Creek Restoration Alternative 2.

#### *Conclusion*

Implementation of Creek Restoration Alternative 3 would result in additional long-term beneficial impacts in the project area to Coho salmon, steelhead, and their critical habitat compared to Creek Restoration Alternative 2.

This alternative could result in short-term temporary adverse impacts on northern spotted owl due to construction noise, which would be reduced by implementation of the BMPs described in Creek Restoration Alternative 1. Long-term adverse impacts to northern spotted owl would be negligible.

#### Impacts of Creek Restoration Alternative 4:

##### *Analysis*

**Coho Salmon.** Under Creek Restoration Alternative 4, effects on Coho Salmon would be similar to those described under Creek Restoration Alternative 2. Both summer and winter/spring rearing habitat would increase, due to the development of pools from the removal of the additional riprap segments. The excavation of an alcove in the footbridge 1.5 drainage area would immediately increase both summer and winter rearing habitat. Summer habitat is anticipated to increase to approximately 53 percent of the channel length, an increase of 2 percent compared to Creek Restoration Alternative 4. Winter/spring rearing habitat would increase by approximately 3 m<sup>2</sup>/100m compared to Creek Restoration Alternative 3. Relocating up to 555 LF of trail farther from the channel in two areas and gaining creek-side vegetation in these areas would also be beneficial. This increase in habitat would result in greater beneficial impacts compared with Creek Restoration Alternative 2.

**Steelhead.** Effects on steelhead under Creek Restoration Alternative 4 would be the similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Creek Restoration Alternative 4, effects on northern spotted owl would be similar to those described under Creek Restoration Alternative 2.

#### *Conclusion*

Implementation of Creek Restoration Alternative 4 would result in additional long-term beneficial impacts in the project area to Coho salmon, steelhead, and their critical habitat compared to Creek Restoration Alternative 1. Temporary adverse impacts to these species would be reduced by implementation of BMPs described in Creek Restoration Alternative 1.

This alternative could result in short-term temporary adverse impacts on northern spotted owl due to construction noise, which would be reduced by implementation of measure BMPS described in Creek Restoration Alternative 1.

#### Impacts of Creek Restoration Alternative 5:

##### *Analysis*

**Coho Salmon.** Under Creek Restoration Alternative 5, effects on Coho salmon would be similar to those described under Creek Restoration Alternative 4; however, terracing of the right bank would add approximately 5,380 square feet of inset floodplain to this reach of river corridor which would result in an immediately larger area and wider variety of winter/spring rearing habitat compared with Creek Restoration Alternative 4. Summer habitat would be similar to Creek Restoration Alternative 4, while winter/spring rearing habitat would increase by 3 m<sup>2</sup>/100 m compared to

Creek Restoration Alternative 4. Creek Restoration Alternative 5 provides the maximum habitat enhancements for Coho salmon.

**Steelhead.** Effects on steelhead under Creek Restoration Alternative 5 would be the similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Creek Restoration Alternative 5, effects on northern spotted owl would be similar to those described under Creek Restoration Alternative 4.

### *Conclusion*

This alternative provides the most habitat benefit to Coho salmon, steelhead, and their critical habitat. Short-term adverse impacts to northern spotted owl would be similar to Creek Restoration Alternative 4. Temporary adverse impacts to these species would be reduced by implementation of BMPs described in Creek Restoration Alternative 1.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives

#### *Analysis*

**Coho Salmon.** Replacement of Bridges 1 and 4 with bridges that accommodate the 100-year flood flow with 18 inches of freeboard could have temporary adverse effects on Coho salmon due to construction-related effects such as dewatering (if required), sedimentation, or disturbance of existing in-channel habitat. Long-term minor beneficial effects could result from improving in-channel habitat conditions by removing flow restrictions.

**Steelhead.** Impacts on steelhead under Actions Common to all bridge alternatives would be similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under actions common to all Bridge Alternatives, noise and the presence of equipment and crews during construction activities could result in direct, temporary impacts on northern spotted owls.

#### *Conclusion*

Implementation of actions common to all pedestrian bridge replacement alternatives could result in temporary adverse impacts to Coho salmon and steelhead which would be reduced by implementation of BMPs described in Appendix D, specifically BMP-1, -2, -4, -5 and BIO-1, -2, -4, and -5. These BMPs require measures such as defining the work area and dewatering area, removing fish from the dewatering area, dewatering the work area, implementing measures to reduce equipment impacts, using biodiesel, biological training of workers, and limiting the in-water work window to June 15 to October 31 (see Appendix D). Minor long-term benefits to Coho salmon and steelhead would also result. These actions would also result in short-term temporary adverse impacts on northern spotted owl due to construction noise, which would be reduced by implementation of measures BIO-1, -2, -3, and -6 (see Appendix D). These measures include biological training of workers; no Proposed Action activities at night, dawn, or dusk; removal of waste; and pre-construction surveys for this species.

### Impacts of Pedestrian Bridge Replacement Alternative A

#### *Analysis*

**Coho Salmon.** Replacement of Bridges 2 and 3 with bridges that span the 25-year flood could have temporary minor adverse effects on Coho salmon due to construction-related effects such as sedimentation or the presence of heavy equipment in the channel. Long-term beneficial effects

could occur due to the lengthening of the spans to accommodate high flood flows and improve transport of LWD within Redwood Creek.

**Steelhead.** Impacts on steelhead under Pedestrian Bridge Replacement Alternative A would be the similar to those described for Coho salmon because of the habitat overlap of the two species.

**Northern Spotted Owl.** Under Pedestrian Bridge Replacement Alternative A, noise and the presence of equipment and crews during construction activities could result in direct, temporary impacts on northern spotted owls.

### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative A would result in temporary adverse impacts to Coho salmon and steelhead from construction which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. It would also result in minor long-term habitat improvements for these species. Pedestrian Bridge Replacement Alternative A would result in short-term minor temporary adverse impacts on northern spotted owl due to construction noise, which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Impacts on threatened and endangered species resulting from implementation of Pedestrian Bridge Replacement Alternative B would be similar to impacts from Pedestrian Bridge Replacement Alternative A. The larger span of Bridges 2 and 3 would have potentially minor enhanced benefit to salmonids relative to Pedestrian Bridge Replacement Alternative A. Rerouting of trails would have potential minor adverse effects on northern spotted owl if prey resources (such as woodrats) are impacted.

#### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative B would result in temporary adverse impacts to Coho salmon and steelhead from construction which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. It would also result in long-term habitat improvements for these species due to the improved stream function and LWD transports compared to Pedestrian Bridge Replacement Alternative A. Pedestrian Bridge Replacement Alternative B would result in short-term minor temporary adverse impacts on northern spotted owl due to construction noise which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Impacts on threatened and endangered species of implementation of Pedestrian Bridge Replacement Alternative C would be intermediate to the impacts described in Pedestrian Bridge Replacement Alternatives A and B. Habitat benefits of the longer span at Bridge 3 are significantly greater than the habitat benefits of having the longer span at Bridge 2.

### **Conclusion**

Implementation of Pedestrian Bridge Replacement Alternative C would result in temporary adverse impacts to Coho salmon and steelhead from construction which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. It would also result in minor long-term habitat improvements for these species. Pedestrian Bridge Replacement Alternative C would result in short-term minor temporary adverse impacts on northern spotted owl due to construction noise which would be reduced by implementation of BMPs described in *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. These impacts would be between those for Pedestrian Bridge Replacement Alternatives A and B in terms of severity.

### **Cumulative Impacts**

Cumulative adverse impacts from other past, current, and future projects in MWNM include noise and water quality impacts. Phase 1 of the Muir Woods Reservation System caused indirect long-term beneficial impacts to Coho salmon and steelhead by reducing sedimentation and improving water quality. Effects on northern spotted owl are not anticipated from this project. Phase 2 is anticipated to also result in long-term indirect beneficial impacts on Coho salmon and steelhead.

Construction-related sedimentation and temporary disturbance of Redwood Creek from the Muir Woods Road Bridge Replacement Project would result in indirect, short-term adverse impacts on Coho salmon and steelhead. Noise disturbance during construction would result in indirect, short-term adverse impacts to northern spotted owl. The Muir Woods Road Rehabilitation Project and the Muir Woods Water/Wastewater Line Replacement would have similar adverse impacts on threatened and endangered species. However, the Muir Woods Road Rehabilitation Project would also have long-term beneficial impacts on Coho salmon and steelhead by reducing sedimentation in Redwood Creek.

The Muir Woods Sustainable Access Project could result in indirect, short-term impacts on Coho salmon and steelhead from sedimentation and water quality degradation during construction. Construction of the Dipsea Trail footbridge over Redwood Creek, revegetation of disturbed areas, and improvements to stormwater management infrastructure could have direct and indirect, long-term, beneficial impacts on Coho salmon and steelhead as a result of improved water quality and reduced habitat disturbances associated with foot traffic on the Dipsea Trail at the Redwood Creek crossing. Northern spotted owls could potentially be affected by noise and other disturbances associated with construction activities.

Taken as a whole, construction of these projects would have short-term adverse impacts to Coho salmon, steelhead, and northern spotted owls, but would result in long-term benefits to Coho salmon and steelhead. Implementation of project-specific BMPs would reduce the potential for adverse cumulative impacts.

### **Conclusion**

Completing the maximum amount of work for the actions described in the alternatives above would result in short-term adverse effects on Coho salmon and steelhead, which would be reduced by implementation of BMP-1, -2, -4, -5 and BIO-1, -2, -4, and -5 (see Appendix D). These BMPs require measures such as defining the work area and dewatering area, removing fish from the dewatering area, dewatering the work area, implementing measures to reduce equipment impacts, using biodiesel, biological training of workers, and limiting the in-water work window to June 15 to October 31. It would result in a substantial increase in summer and winter rearing habitat for these

species, resulting in a major long-term beneficial impact. This added habitat may increase survival of fry and juvenile Coho salmon and steelhead.

The Proposed Action is not anticipated to substantially increase the amount of fine sediment entering the creek through bank erosion. Detailed long-term observation of spawning habitat within Redwood Creek has not shown burial of spawning gravel from other sediment sources; thus, additional fine sediment is not anticipated to have adverse impacts on downstream spawning habitat. In addition, downstream sedimentation and turbidity will be minimized by restoring and revegetating disturbed banks through implementation of BMP BIO-15 (see Appendix D).

Construction noise impacts on northern spotted owl would be similar to those described in Creek Restoration Alternative 1, with an increase in duration due to implementation of Proposed Action elements. This would result in short-term adverse effects on these species, which would be reduced by implementation of BIO-1, -2, -3, and -6. These measures include biological training of workers; no Proposed Action activities at night, dawn, or dusk; removal of waste; and pre-construction surveys for this species. Long-term impacts to northern spotted owl would be negligible.

## 4.5 Geology: Soils and Bedrock

### ***Methodology and Assumptions***

This analysis considers the impacts of each alternative on geologic resources including: soil removal; soil erosion; potential for mass wasting that would affect soil resources; and the relative disturbance of the project area as compared to existing conditions. Activities that may result in impacts on soils include riprap removal, placement of large woody debris, bridge installation, and rehabilitation or revegetation of disturbed areas. Impacts to geologic resources were assessed by examining soil information and mapping for the project area. For the purposes of this discussion, soil is considered the unconsolidated earth material outside of the immediate stream channel. A stream channel is a more dynamic environment, where mineral and organic material and deposits are found, but these are considered as sediment versus soil. The discussion of instream sediment and geomorphic processes and the potential effects to instream conditions are discussed in Section 4.9, *Water Resources and Hydrologic Processes*.

### ***No Action Alternative***

#### Analysis

Under the No Action Alternative, existing and ongoing recreational use would continue. No riprap would be removed or LWD installed. The four pedestrian bridges would be maintained or replaced in-kind (i.e., same location and similar design, material, and size) at some point in the future; in a worst-case scenario, the replacement would be in response to a bridge failure. During replacement of the pedestrian bridges, impacts would be short-term, direct, and adverse due to construction activities, including ground disturbance and excavation of soils around the bridge. Bridge failure would be anticipated to result in similar but greater impacts due to the uncontrolled nature of the failure.

#### Conclusion

The No Action Alternative would not significantly alter geology, soils, or streambed resources in the project area from existing conditions. However, minor adverse impacts would occur from the presence, maintenance, replacement, and potential failure of existing facilities (e.g., bridges and trails) and visitor use. These impacts would be long-term and would occur throughout MWNM.

## ***Creek Restoration Alternatives***

### **Impacts of Actions Common to all Creek Restoration Alternatives**

#### ***Analysis***

Under all Creek Restoration Alternatives, soils would be stabilized through the revegetation of the creek banks and areas of the forest floor impacted during implementation of the Proposed Action. The proposed actions do not include removal of a segment of riprap (R11) at the base of a steep hillslope to avoid the possibility of hillslope slumping or slides in that location. The proposed actions for LWD also avoid the use of fallen trees on steep hillslopes to avoid potential development of gullies at such locations.

Construction activities necessitate vegetation removal in some areas for channel access and riprap removal. Required equipment and methods vary depending on the location and extent of the construction activities. However, workers and equipment would utilize existing trails and access points to the greatest extent feasible. In addition, gullying and structural instabilities on the existing dirt road segment (i.e., Alice Eastwood Road) would be repaired by the construction crew prior to use (and after use, if needed). These gullies have been identified as a sediment source to Redwood Creek (Pacific Watershed Associates 2002). Repairs to Alice Eastwood Road would take into account that this is a historic road. Potential impacts to soil resources would be avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

#### ***Conclusion***

Planting and revegetation activities have the potential to improve soil resources over the long-term through increasing organic matter in the soil from vegetative litter and duff, encouraging micro-organisms in the soil, and improving the physical soil structure through rooting. Vegetation removal during construction periods would be short-term, direct, and adverse. Maintaining riprap segment R11 would avoid the potential for landslides or slumps in that area. Likewise, not using logs on steep slopes for LWD reduces the potential for adverse impacts to soil resources. Repair of the existing Alice Eastwood Road (dirt road) would be beneficial by reducing erosion.

### **Impacts of Creek Restoration Alternative 1:**

#### ***Analysis***

Actions associated with Creek Restoration Alternative 1 include the installation of approximately 40 to 55 existing downed trees from upland areas into the channel at 19 locations and removal of 1,019 LF of riprap from the banks of Redwood Creek and burial of Phase 1 riprap in the channel. Movement of logs for LWD is planned using the grip-hoist method. As described above, logs on steep slopes have not been selected for use as LWD to avoid potential impacts to soil resources. This would reduce the potential for long-term impacts on soil resources. The grip-hoist method results in one end of the log being dragged along the ground, which would result in a rut along the ground surface where the log is dragged. These ruts would be decompacted and refilled using hand methods described in Section 2.5, *Construction Methods*. Construction activities would result in an increase to minor localized, direct, adverse impacts to soil during construction activities and equipment usage. Potential impacts to soil resources would be further avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

Remnant base rock from a previously removed trail along the top of bank next to riprap segment L10 would be removed to allow better revegetation there for bank stability. An asphalt trail in this area was removed in 2000, but the remnant base rock about 6 inches below the surface has

restricted plant cover despite numerous outplanting events. This would have a beneficial impact on soil resources.

### *Conclusion*

Under Creek Restoration Alternative 1, the impacts on soil resources from LWD placement would be minor and short-term. Removal of remnant base rock would be a minor long-term beneficial impact on soil resources.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 includes actions described in Creek Restoration Alternative 1, as well as an additional 338 LF of riprap removal. Additional riprap removal would be in the vicinity of Cathedral Grove and in the Plaza area. These activities would result in an increase to localized, direct, adverse impacts to soil during construction activities and equipment usage. Potential impacts to soil resources would be avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

Approximately 350 LF of asphalt trail on the top of the left bank at Cathedral Grove would be removed, soils would be decompacted, and the area would be revegetated. Removal and revegetation of impervious or compacted surfaces would increase infiltration rates and reduce the runoff and surface erosion potential of these areas. These activities are considered beneficial.

#### *Conclusion*

In addition to the impacts of Creek Restoration Alternative 1, Creek Restoration Alternative 2 would have greater adverse short-term impacts to soil resources due to a greater use of equipment. The removal of asphalt along the trail and replacement with soil and vegetation planting represents a short-term and long-term benefit in those areas affected.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Creek Restoration Alternative 3 consists of all actions under Creek Restoration Alternative 2, plus installation of three engineered log jams near the Plaza and terracing of the right bank between the channel and the floodplain (Figure 2-3). Implementation of Creek Restoration Alternative 3 would require site grubbing, grading, and off-haul of a significant volume of bank and floodplain material. During site excavation, soils would be exposed and subject to compaction and increased erosion. Graded and disturbed areas would be revegetated. These impacts would be considered short-term, direct and indirect, and adverse. Potential impacts to soil resources would be avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

#### *Conclusion*

Creek Restoration Alternative 3 would have similar impacts as Creek Restoration Alternative 2. Construction activities to implement the terracing on the right bank would be considered a short-term, direct and indirect, adverse impact.

#### Impacts of Creek Restoration Alternative 4:

##### *Analysis*

In addition to the actions described in Creek Restoration Alternative 2, Creek Restoration Alternative 4 would excavate an alcove and add additional woody debris in the footbridge 1.5 area, and would relocate up to 555 LF of two asphalt trail segments which would be replaced with a combination of boardwalk and flexible paving farther from the channel. This action would also remove a small existing footbridge (footbridge 1.5). The former trail alignments would be decompacted, restored and replanted. The relocation of the trail segments would have a long-term, moderately beneficial impact to soil resources by reducing the impervious surface area near the channel thereby reducing erosion by necessitating stormwater runoff travel a greater distance and increasing the likelihood of infiltration before entering surface waters. Potential impacts to soil resources would be avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

##### *Conclusion*

The relocation of asphalt trail farther from the creek would be considered a beneficial long-term impact.

#### Impacts of Creek Restoration Alternative 5:

##### *Analysis*

Creek Restoration Alternative 4 would include all action described in Creek Restoration Alternative 4, plus the left bank terracing described in Creek Restoration Alternative 3.

##### *Conclusion*

In addition to the impacts of Creek Restoration Alternative 4, construction activities to implement the terracing on the right bank would be considered a short-term, direct and indirect, adverse impact.

### ***Pedestrian Bridge Replacement Alternatives***

#### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives:

##### *Analysis*

All Pedestrian Bridge Replacement Alternatives would involve the replacement of the existing bridges with a clear span design across the channel with new abutments farther from the creek. The existing bridge abutments would be removed. Excavation activities to remove the old bridges and construct the new abutments would cause localized, short-term, direct, and adverse impacts on soil resources during bridge construction. Applicable BMPs, listed in Appendix D, would avoid and minimize any potential adverse impacts by reducing areas of disturbance and erosion and limiting potential runoff.

The approaches to Bridges 1 and 4 would be designed to connect the existing trail approaches with the new bridges with only minor trail/grade adjustments.

##### *Conclusion*

Excavation and removal of soil for new bridge abutments/foundations would be relatively minor, adverse, long-term permanent on soil resources. Some short-term, direct and indirect, adverse impacts are associated with construction activities; however, most impacts would be avoided or minimized through the implementation of applicable BMPs (see Appendix D).

### Impacts of Pedestrian Bridge Replacement Alternative A:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative A, spans for Bridges 2 and 3 would be lengthened and designed to pass up to a 25-year peak-discharge event with 15 and 12-inch freeboard at the peak of the arch, respectively (Figures 2-7 and 2-8). Existing abutments would be removed and new abutments would be placed at a distance farther from the creek (Figures 2-7 and 2-8). For Bridge 2, 120 LF of new boardwalk would be installed on the east side of creek and 20 LF of new boardwalk on the west side of the creek, and a small approximately 20- by 20-foot boardwalk gathering area would be built on the east side of the creek. The existing gathering area and asphalt trail alignment at Bridge 2 would be restored. For Bridge 3, approximately 130 LF of existing asphalt trail leading to the east side of the crossing would be relocated and replaced with approximately 160 LF of flexible paving. The approaches to the bridge would require approximately 30 LF of boardwalk on the east side of the creek and approximately 35 LF of boardwalk on the west side of the creek. Soil underlying the previous trail alignments on the east side of the creek would be decompacted, and the area revegetated.

#### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative A would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts would be long-term, direct and indirect, and beneficial by allowing larger flows to pass unimpeded thereby reducing scour around the bridge abutments. Installation of 205 LF (approximately) of boardwalk would replace hardscape (asphalt) trail and be considered a short- and long-term beneficial impact on soil resources by reducing runoff rates.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative B, the spans for Bridges 2 and 3 would be lengthened and designed to pass up to a 100-year peak-discharge event with 13- and 14-inch freeboard at the peak of the arch, respectively (Figures 2-7 and 2-8). Existing abutments would be removed and new abutments would be placed farther from the creek. For Bridge 2, approximately 80 LF of trail segments would be rerouted and replaced with approximately 140 LF of new boardwalk on the east side of the creek and approximately 40 LF of new boardwalk on the west side of creek. For Bridge 3, approximately 130 LF of trail segments would be rerouted and replaced with approximately 160 LF of new flexible paving trail. The approaches to the bridge would require approximately 50 LF of new boardwalk on the east side of the creek and approximately 50 LF of new boardwalk on the west side of creek. The rerouted trail would be pulled back from the channel. The previous trail alignments on the east side of the creek would be restored and revegetated.

#### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative B would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts associated with Pedestrian Bridge Replacement Alternative B would have greater long-term, direct and indirect, beneficial impacts than Pedestrian Bridge Replacement Alternative A since both Bridges 2 and 3 would accommodate 100-year flood flows. In addition, 280 LF (approximately) of boardwalk would be installed replacing hardscape (asphalt) trail and be considered a short- and long-term beneficial impact on soil resources by reducing runoff rates.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative C, the span for Bridge 2 would be lengthened and designed to pass up to a 25-year peak-discharge event with 15-inch freeboard at the peak of the arch and the span for Bridge 3 would be lengthened and designed to pass up to a 100-year peak-discharge event with 14-inch freeboard at the peak of the arch.

#### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative C would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts associated with Pedestrian Bridge Replacement Alternative C would have slightly greater long-term, direct and indirect, beneficial impacts than Pedestrian Bridge Replacement Alternative A, but slightly lower long-term, direct and indirect, beneficial impacts than Pedestrian Bridge Replacement Alternative B. Pedestrian Bridge Replacement Alternative C would replace 240 LF (approximately) of boardwalk would be installed replacing hardscape (asphalt) trail and would be considered a short- and long-term beneficial impact on soil resources by reducing runoff rates.

#### **Cumulative Impacts**

Cumulative adverse impacts from other past, current, and future projects in MWNM include soil removal, soil erosion, and continued sedimentation into Redwood Creek near the Muir Woods Visitors Center, at parking lots, and along Muir Woods Road. As listed in Section 4.1 above, several ongoing and future projects would result in beneficial impacts (i.e., reduced erosion and reduced runoff) of the lower portion of the Proposed project area. Many aspects of the other cumulative effects protect or enhance soil resources and erosion through the elimination of roadside parking in unpaved areas, improved stormwater facilities and infrastructure, installation or replacement of compromised road culverts, realignment or removal of existing dirt trails, and an improved creek crossing at the Dipsea Trail. Implementation of project-specific BMPs would reduce the potential to contribute to any adverse cumulative impacts. In general, construction-related impacts on soil resources would be limited.

#### **Conclusion**

Construction of the various aspects of the Proposed Action would result in soil disturbance and potential for soil erosion. Short-term, adverse impacts from construction would be reduced through revegetation and implementation of erosion control BMPs (see Appendix D), such as BMP-10, restoration of affected pathways (ex. BMP-12), and adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel). Soil erosion from channel migration would be minimized by revegetating disturbed banks per BMP BIO-15 (see Appendix D). Other aspects of the Proposed Action would result in beneficial effects on soils, including the removal of some trail segments and conversion of others to boardwalks.

## **4.6 Visitor Use and Experience**

### ***Methodology and Assumptions***

The analysis of visitor use and experience focused primarily on visitor access to trails and bridges. Aspects of visitor experience relating to views and manmade noise and air pollution from project activities are discussed in more detail in the *Visual Resources*, *Soundscapes*, and *Air Quality* sections, respectively.

## ***Impacts of the No Action Alternative***

### Analysis

To analyze the impacts associated with this alternative, the long-term impacts of taking no action or replacing bridges in-kind were compared to the benefits discussed in the project goals. With no action, in the near term, visitors would continue to experience the monument much as they have since no bridge replacements or trail closures would occur. Over the longer term, visitors may be adversely impacted by experiencing aging bridges (and in a worst-case scenario, bridge failures), and the bridges would ultimately require replacement to ensure public safety, which would have many of the same impacts as the Pedestrian Bridge Replacement Alternatives. Visitors would also experience impacts relating to fish watching and redwood viewing which the Proposed Action seeks to address by improving hydrology and fish habitat within the monument.

### Conclusion

Under the No Action Alternative, no creek improvement or bridge replacement work would be done and no temporary or permanent closure of trails would take place. Adverse impacts to visitor use and experience from construction associated with the Proposed Action, such as trail closures and noise, would be avoided; however, future similar impacts may result from in-kind bridge replacement, maintaining deteriorating bridges, or bridges submerged or damaged during large flow events. Under this alternative, no beneficial impacts to fish watching would be realized in the long term.

## ***Creek Restoration Alternatives***

### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

All creek restoration alternatives include revegetation of any impacted creek banks or areas of forest floor, installation of check dams in a tributary just upstream of Cathedral Grove, and installation of beaver dam analogs. In addition, all alternatives include at a minimum the work discussed for Creek Restoration Alternative 1 whose impacts are discussed below. Visitor use during these activities may be temporarily impacted by the presence, sight, and sound of equipment operating nearby. In the long-term, the restoration activities would preserve and enhance habitat quality and ecosystem resilience, which would beneficially affect user experience. Enhanced Coho habitat and viability would have a beneficial impact on visitors who enjoy fish watching.

#### *Conclusion*

Actions common to all creek restoration alternatives may have short-term adverse impacts on visitor use and experience resulting from the presence, sight, and sound of equipment operating in and near areas used by visitors. The long-term impacts of the actions would be beneficial by protecting and enhancing vegetation and creek function in the area, which are some of the monument's main attractions.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Creek Restoration Alternative 1 involves the removal of riprap upstream of Bridge 1, burial of the Phase 1 portion of this riprap, and the placement of LWD in the channel. Temporary impacts to visitor use and experience would include trail closures while LWD is being moved across sections of trail plus some intermittent trail closures for equipment crossing trails to the channel or to remove

a segment of riprap just upstream of Bridge 2. Some sections of trail may see increased congestion, noise, and unpleasant odors from equipment. During Phase 1 activities, the use of the Alice Eastwood group campground as a staging area may lead to closure of the campground during brief periods of mobilization or demobilization. Alice Eastwood Road from the campground may be periodically closed to pedestrians for safety, but other nearby routes, such as the Fern Creek Trail, will be available. Signs will be placed and updated as needed along trail routes to provide clear information to hikers. BMP-16 and BMP-17 would also be implemented to protect and/or repair the existing Alice Eastwood Road water line and Alice Eastwood Group Camp parking lot from heavy equipment (see Appendix D).

### *Conclusion*

During construction of Creek Restoration Alternative 1, visitor use and experience would be impacted by temporary trail closures and increased congestion, noise, and odors on trails due to the work associated with the movement of LWD into the channel and equipment trips relating to riprap removal and hauling. Signage for alternative routes would be placed during temporary closures to limit use impacts.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 would include all of the actions described in Creek Restoration Alternative 1 as well as riprap removal in the Plaza Area and Cathedral Grove. This alternative also includes the permanent removal of the west section of trail in Cathedral Grove, which would then be inaccessible to visitors.

### *Conclusion*

The permanent removal of the section of trail in Cathedral Grove would not have a major impact on trail continuity or visitor experience in the long term since the main leg of the trail would remain in place and a new trail configuration and gathering area in Cathedral Grove would be planned and implemented as part of a separate process. A minor impact to Visitor Use and Experience would result from the closure of the trail section as a result of changes in flow and loss of sights unique to that section. Compared to Creek Restoration Alternative 1, this alternative would have additional short-term adverse impacts from riprap removal in the Plaza Area; these are discussed in more detail in other sections below.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Creek Restoration Alternative 3 consists of all of the actions and impacts of Creek Restoration Alternative 2, as well as installation of three engineered log jams and terracing of the right bank at or near the Entry Plaza. This work would result in temporary impacts to visitors entering and leaving the monument associated with heavy equipment operating nearby.

### *Conclusion*

In addition to the impacts discussed in Creek Restoration Alternative 2, Creek Restoration Alternative 3 would have temporary adverse impacts on visitor use and experience in the Plaza Area where visitors enter and exit the monument. Because this is a high-traffic area, these impacts are considered moderate. In the long-term, this area would have a more natural appearance and may harbor more watchable wildlife which would be a beneficial impact.

#### Impacts of Creek Restoration Alternative 4:

##### *Analysis*

Creek Restoration Alternative 4 consists of all of the actions and impacts of Creek Restoration Alternative 2 along with additional riprap removal, alcove excavation, and LWD installation that would require modifications to two sections of trail (Figure 2-4). In addition to the roughly 350 LF of trail removed at Cathedral Grove, which this alternative has in common with Alternatives 2, 3 and 5, this alternative would involve the removal and rerouting of up to 440 LF of trail on the right bank near footbridge 1.5. The additional riprap and LWD work would likely proportionally increase related impacts discussed in Alternative 2. The trail modifications would involve replacing sections of trail near the creek with sections farther away, which would alter the visitor experience along those sections.

##### *Conclusion*

In addition to the impacts of Creek Restoration Alternative 2, Creek Restoration Alternative 4 would have proportionally greater temporary impacts relating to equipment usage for riprap, alcove, and LWD work. Minor long-term benefits to visitor use and experience would result from trail modifications.

#### Impacts of Creek Restoration Alternative 5:

##### *Analysis*

Creek Restoration Alternative 5 consists of all of the actions and impacts of Creek Restoration Alternative 4 along with the right bank terracing described in Creek Restoration Alternative 3.

##### *Conclusion*

In addition to the impacts discussed for Creek Restoration Alternative 4, Creek Restoration Alternative 5 would have temporary adverse impacts to visitor use and experience in the Plaza Area, particularly during terracing work. Minor long-term impacts to visitor use and experience would result from changes to trails.

### ***Pedestrian Bridge Replacement Alternatives***

#### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives

##### *Analysis*

The gradient on approaches for all new bridges would be under 5 percent and all trail alterations would meet ABAAS. All bridge alternatives include replacing Bridges 1 and 4 to accommodate a 100-year storm flow. Removal and replacement of each bridge would result in temporary impacts to visitors' options for trail routes and would increase noise levels while work is being done. Bridge 1 is heavily trafficked and enables multiple options for loop routes. Bridge 4 sees less traffic, but provides access to a longer loop option and connects the Redwood Creek Trail to the Hillside Trail and Ben Johnson Trail. Signage for alternate routes and detours would be placed during construction to limit this impact.

##### *Conclusion*

Replacement of Bridges 1 and 4 would have short-term moderate adverse effects on visitor experience from construction activities and closures, but would have long-term beneficial effects from improved facilities.

### Impacts of Pedestrian Bridge Replacement Alternative A:

#### *Analysis*

In addition to activities discussed above, Pedestrian Bridge Replacement Alternative A includes removing and replacing Bridges 2 and 3 and lengthening and elevating them to pass a 25-year storm event. Replacing Bridge 3 would require some trail rerouting with temporary impacts to visitor use during realignment and restoration activities. During removal and replacement activities, noise levels in the area would increase and trail route options would be temporarily impacted.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative A would have temporary impacts on nearby noise levels and visitor access to trail routes during removal and replacement. Once the work is complete, the improved gathering area and bridges would provide long-term beneficial impacts to visitor use and experience.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Like Pedestrian Bridge Replacement Alternative A, Pedestrian Bridge Replacement Alternative B involves replacing Bridges 2 and 3 and rerouting some portions of trail, but bridges would be designed for 100-year storm events, requiring higher and longer bridges and trail connections. This alternative would therefore require increased disturbance and rerouting of existing trails, with temporary impacts to visitor trail route options. Under this alternative, Bridge 2 would require a 10-foot-long guardrail on the boardwalks on each side of the bridge. Long-term beneficial impacts to visitor use and experience would include improved safety and a different visitor experience through a wooded area that is not generally provided on the valley floor. The elimination of an informal gathering area would have a long-term adverse impact.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative B would have temporary impacts on nearby noise levels and trail route options which would be somewhat greater than Pedestrian Bridge Replacement Alternative A. Long-term beneficial impacts would also be greater than Pedestrian Bridge Replacement Alternative A, including improved visitor safety and a broader experience of the monument's habitat types for visitors using the new bridges and sections of trail.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Pedestrian Bridge Replacement Alternative C involves the replacement of Bridge 2 with the same span and trail adjustments as Pedestrian Bridge Replacement Alternative A and Bridge 3 with the same span and trail adjustments as Pedestrian Bridge Replacement Alternative B. Both bridges would improve conveyance of creek flows compared to their current designs, while limiting Bridge 2 to a 25-year flow standard allows for less trail rerouting and the retention of a nearby gathering area that is important to the visitor use.

#### *Conclusion*

Bridge Alternative C would have impacts falling between those of Bridge Alternatives A and B. The removal and construction of bridges would have temporary adverse impacts on visitor use and experience in terms of trail route options and accessibility. Like Pedestrian Bridge Replacement

Alternative A, this alternative would have the long-term beneficial impact of retaining and improving the gathering area near Bridge 2.

### ***Cumulative Impacts***

#### Cumulative Impacts

Phase 2 of the Muir Woods Reservation System, which manages motorized access to the monument (parking and shuttles), will reduce peak visitation levels at MWNM by limiting access and parking for motorized vehicles. Although this project will have an adverse impact on cost to visitors, it expects to provide an overall beneficial impact on visitor experience.

The Muir Woods Road Bridge Replacement Project will replace a bridge on Muir Woods Road near the monument. Access to the monument will be maintained at all times during construction, though minor traffic control delays may have an adverse impact on some visitors traveling to the monument.

The Muir Woods Road Rehabilitation Project will involve repairs and resurfacing work along parts of Muir Woods Road. While access to MWNM will be maintained during construction, visitors to the monument could experience some minor traffic control delays.

The Muir Woods Water/Wastewater Station Line Replacement will involve the rehabilitation of two lift stations in the monument. This work will have beneficial long-term impacts to visitor use and experience by improving potable water and wastewater systems in the monument. With work anticipated to begin in 2017 and be completed in 2018, this project is likely to overlap chronologically with the Proposed Action.

The Muir Woods Sustainable Access Project would involve multiple improvements to the Entry Plaza and several parking lots including the reconfiguration of parking areas, installation of a new pedestrian bridge over Redwood Creek on the Dipsea Trail, relocation of the restroom facilities in the Plaza Area and the addition of a second restroom near the former nursery area, added interpretive media along trails from parking areas, and elimination of some roadside parking. These actions will have short-term adverse impacts on visitor use and experience during construction and implementation and long-term beneficial impacts in terms of improved pedestrian safety, reduced vehicle and pedestrian conflicts, and enhanced transportation efficiency in MWNM.

Cumulative adverse impacts to visitor use and experience from these projects in combination with the action alternatives would result from delays and difficulty in reaching the monument and would be short term. Long-term beneficial impacts include improved experience during arrival and inside the monument with less noise and congestion, and safer roads and bridges along routes in and out of the monument. Any replacement of bridges that overlaps in time with any of the other projects would lead to a minor increase in adverse impacts to visitor use and experience by temporarily creating noise and eliminating trail route options. Work on the Proposed Action is likely to overlap with the Water/Wastewater Station Line Replacement; however, the lift station work will be in an area of the monument that is not heavily trafficked by visitors and is not likely to noticeably increase the amount of construction-related noise, odors, and congestion to which visitors are exposed.

Over the long term, the action alternatives would contribute to the beneficial cumulative impacts to visitor experience that are anticipated to result from the other projects planned for MWNM.

### ***Conclusion***

When considering the maximum amount of work that could occur under the various alternatives, construction would have moderate impacts on visitor use and experience throughout MWNM,

although such impacts would be short term and would be moderated through coordinated construction scheduling, trail rerouting, and signage describing the purpose and benefits of the actions. In the long term the actions would have moderate beneficial impacts on visitor use and experience by improving ecosystem health and climate resilience, as well as wildlife habitat, meaning healthier trees and more wildlife for visitors to experience, while ensuring new bridges fit the monument's historic setting. For some alternatives (e.g., Pedestrian Bridge Replacement Alternative B), the action would offer visitor experiences that are not currently available in the monument.

## 4.7 Transportation

### ***Methodology and Assumptions***

The analysis of transportation impacts focused on potential impacts to:

1. Driving to and from the monument.
2. Parking at the monument.
3. Traffic passing by the monument.
4. Driving and parking in nearby areas that may be impacted by the Proposed Action.

### ***Impacts of the No Action Alternative***

#### Analysis

The Proposed Action involves work on creeks, bridges, and trails inside the monument. Under the No Action alternative, none of these tasks would be undertaken, though some bridges may be replaced in-kind in the future.

#### Conclusion

The No Action Alternative would have a minor adverse short-term impact on transportation when/if bridges are replaced in-kind during construction.

### ***Creek Restoration Alternatives***

#### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

All creek restoration alternatives include revegetation of any impacted creek banks or areas of forest floor and the installation of check dams in a tributary just upstream of Cathedral Grove. In addition, all alternatives include at a minimum the work discussed for Creek Restoration Alternative 1 whose impacts are discussed below. While some equipment and material used during revegetation and check dam construction would be on site already, some materials would be brought in from off site, resulting in additional road traffic.

#### *Conclusion*

Since activities associated with this alternative are temporary and would involve bringing in materials from off site, the actions common to all creek restoration alternatives would have minor short-term adverse impacts on transportation and no long-term impact.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Creek Restoration Alternative 1 involves the removal of approximately 444 CY of riprap, approximately 210 CY of which would be offhauled. Material removed from the banks upstream of Bridge 2 (approximately 234 CY) would be buried in the channel. Material from downstream of Bridge 2 would be loaded at the Plaza Area and hauled to Kent Canyon, other stockpile locations, or a landfill via Muir Woods Road (Figures 2-10 and 2-12). While underway, these activities and associated worker trips would impact parking and transportation in the Plaza Area and increase traffic on Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. The construction crew may improve the dirt section of Alice Eastwood Road prior to use. Alternative 1 would not result in any haul trips during Phase 1. Based on use of 10-CY trucks being approximately 70 percent full, Alternative 1 would result in approximately 30 haul trips during Phase 2.

#### *Conclusion*

During removal and hauling activities, Creek Restoration Alternative 1 would temporarily impact parking and transportation in the Plaza Area and slightly increase traffic on Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. Slower moving trucks and construction equipment may cause minor, short-term delays for vehicles traveling on these roads. Since activities associated with this alternative are temporary, Creek Restoration Alternative 1 would have no long-term impact on transportation.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 involves the removal of approximately 105 CY of riprap (with 33 CY of this total buried in the channel) and 350 LF (approximately 65 CY) of asphalt trail in addition to the work described in Creek Restoration Alternative 1. These materials would be buried or hauled out via the same routes described above and would increase temporary impacts proportionally; another 15 10-CY truck trips during Phase 2 for riprap removal and approximately 65 additional pick-up truck trips to handle removed asphalt during Phase 1 would result.

#### *Conclusion*

During removal and hauling activities, Creek Restoration Alternative 2 would temporarily impact parking and transportation in the Plaza Area and slightly increase traffic on Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. In comparison to Creek Restoration Alternative 1, Creek Restoration Alternative 2 involves the removal of additional riprap and asphalt, and the use of small trucks for asphalt offhaul during Phase 1, and as a result these impacts would be proportionally greater. Since activities associated with this alternative are temporary, Creek Restoration Alternative 2 would have no long-term impact on transportation.

### Impacts of Creek Restoration Alternative 3

#### *Analysis*

Creek Restoration Alternative 3 would involve additional off-hauling of up to 400 CY of floodplain material from near the Entry Plaza in addition to the work described in Creek Restoration Alternative 2. Some of the excavated floodplain material may be reused on site for bank contouring. This alternative would also involve importation of approximately 50 logs for use in engineered log jams near the entry plaza. This would result in approximately 50 additional haul trips compared to Creek Restoration Alternative 2 over the Phase 2 construction period. The additional heavy

equipment use and travel in the Entry Plaza area would increase temporary impacts on parking and transportation in the vicinity.

### *Conclusion*

Compared to Creek Restoration Alternative 1 or 2, which this alternative would supplement, Creek Restoration 3 would produce additional temporary impacts to transportation near the Entry Plaza and on hauling routes.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

In addition to the work described in Creek Restoration Alternative 2, Creek Restoration Alternative 4 would include removal of additional riprap (26 CY of which would be buried in the channel) and up to 555 LF of asphalt trail and importation of materials to construct up to 555 LF of the trail reroutes, resulting in approximately 30 more pick-up truck trips in Phase 1 and 10 more 10-CY truck trips in Phase 2. The additional heavy equipment use and haul trips would slightly increase temporary impacts on parking and transportation in the vicinity.

### *Conclusion*

Compared to Creek Restoration Alternative 1, 2, or 3, Creek Restoration Alternative 4 would produce additional temporary impacts to transportation on hauling routes. It would involve fewer hauling trips than Alternative 3. Since activities associated with this alternative are temporary, Creek Restoration Alternative 4 would have no long-term/permanent impact on transportation.

### Impacts of Creek Restoration Alternative 5:

#### *Analysis*

In addition to work described in Creek Restoration Alternative 4, this alternative includes the floodplain terracing work described in Creek Restoration Alternative 3. Creek Restoration Alternative 5 would involve roughly 30 pick-up trip haul trips during Phase 1 and 100 haul trips during Phase 2. This is more than any of the other alternatives; however, at approximately 110 more trips than Creek Restoration Alternative 1, this averages just 1 to 2 additional hauling trips per day of construction.

### *Conclusion*

Creek Restoration Alternative 5 would have short-term adverse impacts on traffic along hauling routes that would average 1 to 2 more hauling trips per day compared to Creek Restoration Alternative 1.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Actions Common to all Bridge Alternatives:

#### *Analysis*

All bridge alternatives include replacing Bridges 1 and 4. The material from these bridges would be hauled out and transported to a landfill and materials for the new bridges would be imported. Approximately 60 truck trips are anticipated for mobilization, demobilization, in-haul, and off-haul.

### *Conclusion*

Importing bridge construction materials and hauling old bridge material out and transporting it to a landfill would have minor, short-term, adverse impacts on traffic along Alice Eastwood Road,

Panoramic Highway, and Muir Woods Road. The actions common to all bridge alternatives would have no long-term impact on transportation.

#### Impacts of Pedestrian Bridge Replacement Alternative A:

##### *Analysis*

Pedestrian Bridge Replacement Alternative A includes the removal and replacement of Bridges 2 and 3 and some nearby asphalt. This material would be hauled out and transported to a landfill and material for the new bridges would be imported. Approximately 63 truck trips are anticipated for mobilization, demobilization, in-haul, and off-haul.

##### *Conclusion*

Importing construction materials and hauling out old bridge material and transporting it to a landfill would have minor, short-term, adverse impacts on traffic along Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. Pedestrian Bridge Replacement Alternative A would have no long-term impact on transportation.

#### Impacts of Pedestrian Bridge Replacement Alternative B:

##### *Analysis*

Pedestrian Bridge Replacement Alternative B is similar to Pedestrian Bridge Replacement Alternative A, but would require the removal of additional asphalt and importation of additional material for longer bridges. Approximately 67 truck trips are anticipated for mobilization, demobilization, in-haul, and off-haul.

##### *Conclusion*

Importing construction materials and hauling out old bridge material and transporting it to a landfill would have short-term, minor adverse impacts on traffic along Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. These impacts would be proportionally greater than those for Pedestrian Bridge Replacement Alternative A based on the amount of material removed. Pedestrian Bridge Replacement Alternative B would have no long-term impact on transportation.

#### Impacts of Pedestrian Bridge Replacement Alternative C:

##### *Analysis*

Pedestrian Bridge Replacement Alternative C is similar to, and in terms of scale falls between, Alternatives A and B. Approximately 65 truck trips are anticipated for mobilization, demobilization, in-haul, and off-haul.

##### *Conclusion*

Importing construction materials and hauling out old bridge material and transporting it to a landfill would have short-term, minor adverse impacts on traffic along Alice Eastwood Road, Panoramic Highway, and Muir Woods Road. These impacts would be slightly greater than those for Pedestrian Bridge Replacement Alternative A and smaller than those for Pedestrian Bridge Replacement Alternative B based on the amount of material removed. Pedestrian Bridge Replacement Alternative C would have no long-term impact on transportation. Though Alternatives A, B and C vary in size, the number of hauling trips associated with each is anticipated to average less than one per construction day.

### ***Cumulative Impacts***

The Muir Woods Reservation System will decrease the number of motorized vehicles accessing and parking at the monument during peak visitation times, resulting in long-term beneficial impacts on traffic, congestion, and safety along Muir Woods Road.

The Muir Woods Road Bridge Replacement Project will have temporary adverse impacts on Muir Woods Road during construction due to lane closures, causing delays, and the presence of construction crews and long-term beneficial impacts on transportation safety when completed.

The Muir Woods Road Rehabilitation Project will have temporary moderate adverse impacts on traffic on Muir Woods Road during construction and long-term beneficial impacts on transportation safety when completed.

The Muir Woods Water/Wastewater Line Replacement may have temporary minor adverse impacts on traffic on Muir Woods Road during construction due to worker and equipment trips.

The Muir Woods Sustainable Access Project would involve multiple improvements to the Entry Plaza and several parking lots including the reconfiguration of parking areas, installation of a new pedestrian bridge over Redwood Creek on the Dipsea Trail, relocation of the restroom facilities in the Plaza Area, and elimination of some roadside parking. These actions will have temporary adverse impacts on transportation during implementation and beneficial long-term impacts from improved operational efficiency, and reduced conflicts between vehicles and pedestrians.

The action alternatives would involve replacement of bridges which could result in additional cumulative impacts to transportation from delivery or off-hauling of bridge if it were to occur at the same time as one of the projects discussed above. In combination with the action alternatives, these projects would have temporary adverse impacts to transportation at MWNM. This would particularly be the case if project construction overlaps. Combined, the projects would have long-term beneficial impacts on transportation. Work on the Proposed Action is likely to overlap with the Water/Wastewater Station Line Replacement which would increase the scale of construction-related impacts on traffic and parking. Additional adverse impacts to traffic and congestion on Muir Woods Road would result if storage and landfill hauling trips overlap with the Bridge Replacement or Road Rehabilitation projects.

### ***Conclusion***

Completing all of the actions described in the alternatives would result in as much as approximately 290 construction-related offsite hauling trips which would be phased over multiple years and construction periods. Construction activity, worker trips, and hauling trips associated with this work would have adverse, short-term impacts on transportation in, around, and to the monument. Once complete, this work would not have any long-term impacts on transportation.

## **4.8 Wildlife Habitat**

### ***Methodology and Assumptions***

Discussion of habitat for salmonids, northern spotted owl, and marbled murrelet is covered in Section 4.4, *Threatened and Endangered Species*. Impacts on other wildlife habitat are considered below.

## ***No Action Alternative***

### Analysis

Under the No Action Alternative, stream habitat conditions would not be altered. As aquatic invertebrate abundance and family diversity are significantly lower in riprapped portions of Redwood Creek (Kimball and Kondolf 2002), these metrics would remain low. In-kind replacement of pedestrian bridges would result in construction-related noise impacts to habitat used by birds and other wildlife.

### Conclusion

Under the No Action Alternative, impacts on aquatic wildlife habitat would remain adverse and long term. Bridge replacement would result in short-term construction-related adverse impacts on wildlife habitat.

## ***Creek Restoration Alternatives***

### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

The presence of construction equipment and crews would result in noise impacts to habitat used by birds and other wildlife. Implementation of BMPs BIO-8 and -9 would reduce these potential impacts through surveys for nesting birds and woodrat houses and implementation of avoidance and minimization measures (see Appendix D). Installation of grade control could result in temporary impacts to habitat used by California giant salamander and other amphibians. However, installation of grade control would have long-term minor beneficial effects on California giant salamander and other amphibians due to a higher water table in the treatment area. Installation of beaver dam analogs would result in increased low-velocity refugia in Redwood Creek for aquatic wildlife. Revegetation of disturbed areas would have long-term beneficial impacts on wildlife habitat. Implementation of BMP BIO-17 would reduce the potential for impacts from SWD collection on wildlife (see Appendix D).

#### *Conclusion*

Implementation of these actions would result in temporary minor adverse noise and construction impacts to wildlife habitat, but would also result in long-term beneficial impacts to wildlife habitat.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Removal and burial of riprap would result in temporary adverse impacts to aquatic habitat in Redwood Creek due to dewatering and disruption of the channel bed. It would result in long-term beneficial impacts to aquatic habitat due to an increased instream channel sinuosity, expanded cover by streamside vegetation, and a greater allochthonous input of organic matter. The addition of LWD to the channel would result in long-term beneficial impacts to aquatic habitat by increasing cover and complexity. Removal of riprap and installation of LWD is not anticipated to impact wetland habitat. The presence of construction equipment and crews would result in noise impacts to habitat used by birds and other wildlife. Movement of equipment and logs would result in temporary disturbances to the forest floor, which could temporarily adversely impact movement of wildlife. Amphibians may be present underneath the downed logs which would be used for LWD and under downed material along skid/drag routes. Implementation of BMP-6 would reduce

potential impacts on amphibians by searching for and relocating amphibians beneath downed wood disturbed by the proposed actions where feasible (see Appendix D).

### *Conclusion*

Implementation of Creek Restoration Alternative 1 would result in both temporary minor adverse noise and construction impacts to wildlife habitat, but would also result in long-term beneficial impacts to wildlife habitat.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Removal of the additional riprap segments and burial of some of these segments would increase the impacts (both adverse and beneficial) on wildlife habitat as described for Creek Restoration Alternative 1. Removal of the trail segment at Cathedral Grove would increase the amount of forest floor available as wildlife habitat.

### *Conclusion*

Implementation of Creek Restoration Alternative 2 would result in both temporary minor adverse noise and construction impacts to wildlife habitat, but would also result in long-term beneficial impacts to wildlife habitat. The impacts would be proportionally greater compared to the impacts of Creek Restoration Alternative 1.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Under Creek Restoration Alternatives 3, terracing of the right bank in the Entry Plaza area and installation of engineered log jams, would increase the impacts (both adverse and beneficial) on wildlife habitat as described for Creek Restoration Alternative 2. Increased floodplain habitat under this alternative would result in additional short-term construction impacts and additional long-term beneficial impacts on aquatic invertebrate habitat within Redwood Creek.

### *Conclusion*

Implementation of Creek Restoration Alternative 2 would result in both temporary minor adverse noise and construction impacts to wildlife habitat, but would also result in long-term beneficial impacts to wildlife habitat. The impacts would be proportionally greater compared to the impacts of Creek Restoration Alternative 3.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

Under Creek Restoration Alternative 4, removal of the additional riprap segments and burial of some of these segments would have similar but proportionally greater impacts on wildlife habitat as described for Creek Restoration Alternative 2. Construction of the alcove would result in increased aquatic habitat. Trail rerouting could have potential impacts on bat maternity colonies. Heady and Frick (2004) found that bat maternity colonies in tree hollows were not disturbed by humans as long as the entrance to the hollow faces away from the trail. Per BMP BIO-9, bat surveys will be conducted in subsequent phases of trail planning and the trail alignment would be adjusted as needed to be protective of bat maternity colonies (see Appendix D).

### *Conclusion*

Implementation of Creek Restoration Alternative 4 would result in temporary minor adverse noise and construction impacts to wildlife habitat, but would also result in additional long-term beneficial impacts to wildlife habitat compared to Creek Restoration Alternative 2.

#### Impacts of Creek Restoration Alternative 5:

##### *Analysis*

Under Creek Restoration Alternatives 5, impacts to wildlife habitat would be similar to Alternative 4 but with terracing of the right bank in the Entry Plaza area. These actions would proportionally increase impacts (both adverse and beneficial) on wildlife habitat. Increased floodplain habitat under this alternative would result in additional short-term construction impacts and additional long-term beneficial impacts on aquatic invertebrate habitat within Redwood Creek.

### ***Pedestrian Bridge Replacement Alternatives***

#### Impacts of Pedestrian Bridge Replacement Alternative A:

##### *Analysis*

The presence of construction equipment and crews would result in noise impacts to habitat used by birds and other wildlife. Rerouting of the trail for Bridge 3 would result in minor long-term impacts to forest floor habitat, which would be offset by restoration where the existing trail would be removed.

##### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative A would result in short-term adverse impacts on wildlife habitat and minor long-term beneficial impacts on wildlife habitat.

#### Impacts of Pedestrian Bridge Replacement Alternative B:

##### *Analysis*

Impacts under Pedestrian Bridge Replacement Alternative B would be similar to those described for Pedestrian Bridge Replacement Alternative A. However, this alternative would result in increased disturbance because of the increased area of trail rerouting required.

##### *Conclusion*

Implementation of Bridge Alternative B would result in minor short-term adverse impacts on wildlife habitat and minor long-term beneficial impacts on wildlife habitat.

#### Impacts of Pedestrian Bridge Replacement Alternative C:

##### *Analysis*

Impacts under Pedestrian Bridge Replacement Alternative C would be intermediate to those described for Pedestrian Bridge Replacement Alternatives A and B.

##### *Conclusion*

Implementation of Bridge Alternative C would result in minor short-term adverse impacts on wildlife habitat and minor long-term beneficial impacts on wildlife habitat.

### ***Cumulative Impacts***

Combined with past and future planned actions in the vicinity, temporary impacts to wildlife habitat through noise and presence of construction crews could occur. Over the long term, the majority of these projects would improve wildlife habitat in the vicinity of MWMN. Implementation of project-specific BMPs would reduce the potential to contribute to adverse cumulative impacts.

### ***Conclusion***

The combined effects of the implementation of the various actions would be similar to the impacts of each alternative, but with a difference in scale. Collectively, implementation of the Proposed Action would result in increased noise and presence of construction crews, resulting in short-term adverse impacts on wildlife habitat. Improvements to wildlife habitat would also occur, with improved aquatic habitat and greater proportion of boardwalk trails, resulting in greater long-term beneficial impacts to wildlife habitat.

## **4.9 Water Resources and Hydrologic Processes**

This analysis considers the impacts of each alternative on water resources, including water quantity, water quality, and groundwater. This section also focuses on hydrologic and geomorphic (i.e. hydro-geomorphic) impacts within the channels such as effects on creek function; instream features; flooding; sediment erosion, transport and deposition; and changes to bed morphology within the active stream channel. Discussion of soils at the top of the streambanks outside of the active channel are discussed in greater detail above in Section 4.5, *Geology: Soils and Bedrock*. Activities that may result in impacts to water resources and hydro-geomorphic processes include: riprap removal along Redwood Creek; channel bed excavation, burial of riprap, and creation of instream bars and elevated riffles; placement of large woody debris; instream grade control in a tributary; construction of beaver dam analogs; bridge installation; and rehabilitation or revegetation of disturbed areas. Actions which may limit sedimentation and turbidity impacts to water resources include the bank treatments/revegetation (e.g., regraded to a 1V:1.5H slope, covered with erosion control fabric, and aggressively replanted) on new banks where tree roots do not offer adequate bank stability. Impacts were assessed by examining literature on hydrologic and geomorphic processes, and existing studies and mapping for the project area.

### ***No Action Alternative***

#### Analysis

Under the No Action Alternative, visitor usage and the existing trail system and facilities would continue under existing conditions. Asphalt trails located on the historic floodplain near Redwood Creek would not be relocated or removed, thereby continuing to contribute water and sediment to the creek during rain events. Bridges 1, 2, 3, and 4 would be left “as is” or replaced in kind and continue to create hydrologic constrictions and disturbances during high flow events. Existing riprap lining portions of Redwood Creek would likely persist for a significant time period and continue to adversely impact hydrologic and geomorphic processes and floodplain function, including long stretches of channelization/planar bed features, a general inability to trap and store sediment, and little opportunity for the development of undercut banks or side channels that would add system complexity. Therefore, the No Action Alternative would result in direct and indirect, long-term, adverse impacts on surface water, water quality, floodplains, and hydro-geomorphic processes as a result of instream disturbances at bridge crossings, and hardened banks that prevent more natural geomorphic function. The riprap would maintain a sediment production level within MWNM that is below the normal rate observed in the channel downstream of MWNM. Existing

management actions do not pollute groundwater resources or significantly impede groundwater recharge; therefore, there would be no impacts on this resources.

### *Conclusion*

Implementation of the No Action Alternative would not substantially alter water resources or hydro-geomorphic processes in the project area from existing conditions. However, existing facilities, e.g., bridges and riprap, significantly restrict natural hydrologic functions and result in points of hydraulic constriction during high flow periods. The presence of existing facilities result in long-term, direct and indirect, adverse impacts to hydrologic functions of Redwood Creek throughout the project area.

## ***Creek Restoration Alternatives***

### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

Under all Creek Restoration Alternatives, disturbed areas and exposed soils would be stabilized through the revegetation of creek banks and areas of the forest floor impacted during implementation of the Proposed Action. Specific actions to stabilize banks and control erosion are described within each alternative. Revegetation of exposed areas near the creek channel would help stabilize banks and improve the water quality of Redwood Creek during high flow events by reducing turbidity and sediment loads. Impacts from these actions would be long-term, indirect, and beneficial.

Proposed work areas typically have at least a full channel width between the existing bank and an existing trail. This buffer allows for significant erosion to occur before threatening trail integrity. However, if erosion appeared to be extending toward a trail system that is designated as part of the long-term plan, NPS would likely take preventive action to increase bank stability or slow erosion so as to prevent loss of the trail.

In addition, all Creek Restoration Alternatives include the installation of broken pieces of riprap removed during other actions into a series of grade control extending over approximately 150 LF of a small incised tributary on the east side of the creek just upstream of Cathedral Grove. Slash from fallen wood will be added between the grade controls. This would be considered fill in waters of the U.S. The purpose of the grade control is to potentially raise sub-streambed groundwater elevations on a very localized scale, which may help protect instream flows. The grade controls and slash may also capture sediment behind them and help impede the incision which has occurred in this small tributary. This would result in a long-term, direct and indirect, beneficial impact by reducing sediment loads entering the mainstem of Redwood Creek from this source.

Installation of beaver dam analogs under all creek restoration alternatives would alter channel morphology and capture sediment within Redwood Creek. Channel-spanning beaver dam analogs would cause upstream ponding and downstream plunge pools (Bouwes et al. 2016), while non-channel-spanning beaver dam analogs would have smaller effects. Both types of beaver dam analogs would trap sediment. In the long term, these structure are anticipated to aggrade the channel. These features would reduce sediment loads and improve water quality within Redwood Creek.

Construction activities necessitate vegetation removal in some areas for channel access and for exposure and removal of the existing riprap. Required equipment and methods vary depending on the location and extent of the construction activities. However, workers and equipment would utilize existing trails and access points to the greatest extent feasible. BMPs would also be

implemented to further avoid and minimize potential impacts to water resources (see Appendix D). In addition, existing dirt trail segments (i.e., Alice Eastwood Road) showing gulying and structural instabilities will be repaired by the construction crew prior to and/or after use and be considered an indirect beneficial impact.

### *Conclusion*

Planting and revegetation activities have the potential to improve water quality over the long-term by decreasing sheet and rill erosion. Installation of check dams on the adjoining small tributary would result in a long-term, direct and indirect, beneficial impact by reducing sediment loads entering the mainstem of Redwood Creek from this source and slowing continuing downcutting of the drainage. Installation of beaver dam analogs would result in direct and short-term and long-term beneficial impacts to water quality by trapping sediment and aggrading the channel. Vegetation removal during construction periods would be short-term, direct, and adverse. Repair of the existing Alice Eastwood Road (dirt road) would be moderately beneficial by reducing erosion and sedimentation into surface waters. Any short-term, direct and indirect, adverse construction-related impacts to water resources or water quality would be avoided and minimized through implementation of applicable BMPs (see Appendix D).

The impacts of actions common to all Creek Restoration Alternatives would be long-term, indirect, and beneficial through the restoration and revegetation of disturbed or barren areas, stabilization of an incised tributary, and installation of beaver dam analogs.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Actions associated with Creek Restoration Alternative 1 include installing LWD into the channel and removing approximately 1,019 LF of riprap from the banks of Redwood Creek. Approximately 234 CY of rock riprap will be buried for a width of approximately 2-5 feet across the center of the channel over five burial areas ranging from 57 to 220 LF per segment (total of 550 LF of streambed disturbance). Zones of unexcavated, natural streambed areas will be situated between the burial areas to help prevent the development of longitudinal voids as a result of subsurface flow through gaps between the placed riprap. Excavated material displaced by riprap burial and pool excavation will be repurposed to create instream bars and elevated riffle crests. Following construction of bars and reshaping of the channel profile, native material consisting of coarser sediment (e.g., cobble and gravel) would be placed over the streambed surface to better replicate preconstruction conditions, except in deeper pools where coarse material would not be expected naturally.

To reduce potential erosion after riprap removal, about 58 percent of banks will be regraded to a 1V:1:5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have adequate mature root structures and will likely be effective at resisting high rates of erosion, while still providing beneficial stream features. Removing instream riprap would expose the channel banks to more natural geomorphic processes and allow for active channel movement and lateral migration. Following removal of bank armoring and with treatment of those banks that do not have obvious root structures, near-term bank erosion is anticipated to be maintained within no more than 2 to 5 times the natural erosion rate observed downstream (Stillwater Sciences 2004, NHE 2017a). With a natural bank erosion rate at about  $0.015 \text{ m}^3\text{m}^{-1}\text{a}^{-1}$ , an increase of two to five times of the natural rate represents an overall increase in downstream areas of Redwood Creek of about 1 to 5 percent additional sediment, which will be virtually undetectable. The existing condition in MWNM currently produces below normal sediment due to hardened banks (Stillwater Sciences 2004). There may be a short term increase as processes return to a more natural

condition, after which production is expected to be about that of the natural erosion rates downstream.

Several potential erosion processes may occur including: shearing flows initiating toe of bank erosion and promoting outer bend erosion; bank failure caused by flows directly hitting the bank, often caused by deflection from woody debris; bank failure caused by focused eddying and scour related to flow separation downstream of a channel obstruction such as LWD; and mass wasting of banks typically caused by rotational and block slumping following periods of elevated streamflow and bank saturation then followed by flow recession and high bank soil pore water pressure (Stillwater Sciences 2004). However, in general, old-growth forests, including MWNM, typically exhibit relatively low channel migration rates occurring over the scope of hundreds of years, except where flows are deflected in the vicinity of wood jams (Environmental Science Associates 2014; NHE 2017b). Additionally, these erosional processes are anticipated to be substantially reduced by implementation of the bank recontouring and erosion control measures described above. Under Creek Restoration Alternative 1, initial overbank flooding would not be expected to occur substantially more frequently than under existing conditions.

Following riprap removal, the above-mentioned hydro-geomorphic processes may begin to occur during significant streamflow events. The constructed instream bar features will reorganize according to the new channel conditions, which include a less incised channel, more deformable banks, and increased wood load, as would be anticipated in response to natural fluvial and geomorphic processes. Bridges 3 and 2 are immediately downstream of constructed bars and have the highest likelihood of bed change as a result of the action. The likely bed changes include enhancement/expansion of existing bars or formation of new bars. Several sedimentation zones exist between the riprap burial areas and Bridge 1, which mediate sediment transport; thus, no effect is anticipated at Bridge 1. Bridge 4 is upstream of the riprap burial area and will not be affected. With the bank treatments, it is expected that by the time the erosion control fabric has decayed, new bank vegetation will be well established to provide stability to banks. Erosional rates would vary based on localized physical elements of the channel, bed and bank material, hydrodynamic characteristics, and the presence of bedrock, LWD, or established vegetation. In areas where trees or woody shrubs were present, erosional processes would be slowed or redirected in response to developed root systems which increase bank shear strength. Over time, increased bank erosion would generally lead to a wider cross sectional channel area. The enlarged channel width and area would increase channel capacity and enable larger stream flows to be contained in the channel. Increased channel width and channel area would also result in lower flow depth and lower flow velocity for equal-sized discharge events, compared to the pre-project condition. At some point, the increased channel cross-sectional area and relatively lower velocities would in turn result in less erosive conditions along the streambanks and some degree of instream sedimentation as the creek channel adjusts its morphology toward a new dynamic equilibrium form. Restoration of a more natural creek channel condition is one of the goals of the project.

The precise duration of this period of channel adjustment, initiating with moderately increased erosion following riprap removal and continuing through the cycle of channel widening, declining flow velocity and instream deposition is uncertain but would likely operate on the scale of decades. Such a landform adjustment cycle is dependent on many factors including the physical conditions of the channel, woody debris supply to the creek, rainfall and water balance conditions and notably seasonal precipitation amounts and specific event based rainfall amounts and intensities, land use, vegetation and fire conditions in the watershed, etc.

Building on the process described above related to removal of the existing riprap, the Proposed Action's constructed LWD structures may further enhance or amplify these geomorphic processes by creating large debris jams that may potentially redirect flows towards streambanks or create

scour pools through flow eddies. LWD is also anticipated to trap sediment upstream, reducing the downstream effects of sediment. A positive feedback process may occur whereby increased channel lateral movement and erosion in turn leads to more trees falling into the channel, further causing instream blockages and pool scouring. Slack water areas and deeper pools immediately upstream and downstream of these LWD structures also provide opportunities for sediment deposition and storage in the channel. Similar to what is described above, related to channel widening and migration as a result of riprap removal, a new dynamic equilibrium will be achieved that will then slow the channel widening and erosion process caused by increased woody debris in the channel. This is the basic cycle of how streams adjust to their changing environment.

In addition, the placement of riprap within the channel may affect channel geometry and flow pathways if subjected to significant scour. The buried riprap will create a hardened layer or rock lens that prevent downward scour. The buried riprap would not extend the full width of the channel and is not keyed into the bank so as to avoid destabilizing the existing upper bank slopes. While the overall objective of the restoration design is to create a more depositional environment, and thereby not initiate further channel incision or scour, there is still some chance that future incision or scour might occur. If such an erosive or scour condition would occur, such that the channel bed would be exposed down to the level of the buried riprap, then the area along the margins of the buried riprap without riprap (between the streambank and the block of buried riprap) would be vulnerable to erosion as a less resistant area along the streambed. As the project is currently envisioned, this is not a likely scenario, but it is possible as streams are very dynamic environments.

Downward flow would be directed laterally to the edges of the riprap layer and softer, native material would be eroded along the margins of the riprap creating lower flow paths. Under certain conditions, lower flow paths could develop on either side of the riprap. However, this outcome is unlikely since the top of the riprap will be buried at a minimum of 3 feet below the existing streambed surface elevation and pools in Muir Woods are typically less than 2 feet deep, with only 1 in 40 pools measured reaching 3 feet in depth (NHE 2018). Based on existing conditions of Redwood Creek and the projected longitudinal profile of the channel, excavated pools are anticipated to become sediment sinks and not subject to significant scour.

Assessing the magnitude of the expected erosion to occur following removal of the riprap is complex and difficult, owing to the stochastic nature of these types of natural processes. There would be much spatial and temporal variability in the erosive response at different riprap removal locations. Some erosion might occur gradually with moderately sized flows, other locations may erode more substantially as pulsed or episodic events during or after large storms. As described above, over the course of years and decades following the construction of the Proposed Action, it is expected that streambank erosion rates in the project reach will be initially elevated for several years when compared to current conditions, and then gradually decline until the new equilibrium is achieved.

NHE (2017a) conducted an assessment estimating the potential increase in sedimentation following riprap removal based on existing studies (i.e., Stillwater Sciences 2004; NHE 2014 and 2016) and field observations. To determine sedimentation increases following riprap removal, the effects of bank erosion rates on the Redwood Creek sediment budget (as estimated in Stillwater Sciences 2004) were separated and assessed individually following two phases of construction, with Phase 1 removing a maximum of 1,053 LF (321 meters) and Phase 2 a maximum of 748 LF (228 meters) of riprap. The two Phases were analyzed independently of each other. NHE (2017a) estimated an increased erosion rate for a period of approximately 2 to 5 years then, as bank vegetation became more established, a taper off to the estimated natural erosion rate for the Redwood Creek watershed ( $0.015 \text{ m}^3\text{m}^{-1}\text{a}^{-1}$  as cited by Stillwater 2004). The increased

sedimentation of bank erosion in the project area under natural bank conditions from Phase 1 was estimated at 8.2 tonnes per acre ( $\text{ta}^{-1}$ ) and  $5.8 \text{ ta}^{-1}$  following Phase 2. The initial change in sediment production in the lower watershed would be between about 1 to 4 percent higher than under current conditions, but that increase is expected to taper off to about a 1 percent increase as the project area returns to natural erosion rate ( $0.015 \text{ m}^3\text{m}^{-1}\text{a}^{-1}$  as cited in Stillwater Sciences 2004) and shown in Figures 4-1 and 4-2.

In addition to considering the duration and magnitude of the potential erosion impact, another key consideration is the fate of the eroded material. Some of the eroded material would be captured in the project area and stored in pools and depositional features of the created woody debris structures. The remainder of the eroded material will be transported to downstream reaches of Redwood Creek. Material will settle and deposit according to its texture (grain size) compared to the flow energy available to maintain the material in suspension. Certain characteristics of natural fluvial deposits (e.g., imbrication – directional alignment and sorting of particles due to stream flow) that limit entrainment of the subsurface materials cannot be reconstructed. These features are expected to reform after the first sediment mobilizing event (1-2 year flow) occurs. Compared to existing conditions, sediment transport is expected to increase due to: loosening of sorted and consolidated streambed material; changes in cross-sectional area, form, bed surface elevation, and general channel topography; removal of the riprap from the channel banks; and placement of woody debris. These alterations may create zones of higher transport as well as zones of increased sediment storage as sediment in upstream reaches is redistributed to downstream reaches.

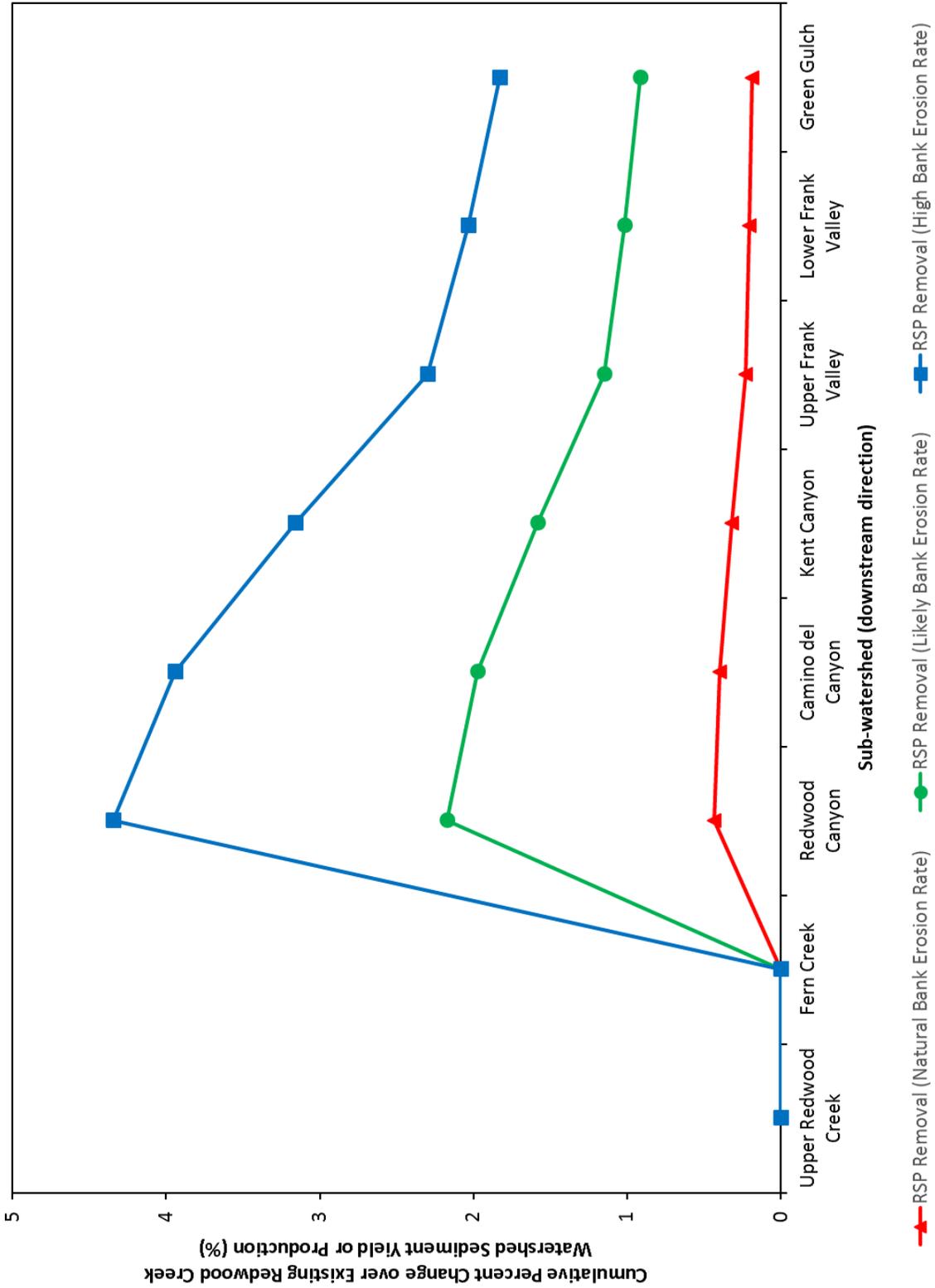


Figure 4-1. Percent change over the existing Redwood Creek watershed sediment budget (SWS, 2004) from natural, likely and high bank erosion rates from rock slope protection removal for Phase 1 of Creek Restoration Actions (figure source, NHE 2017).

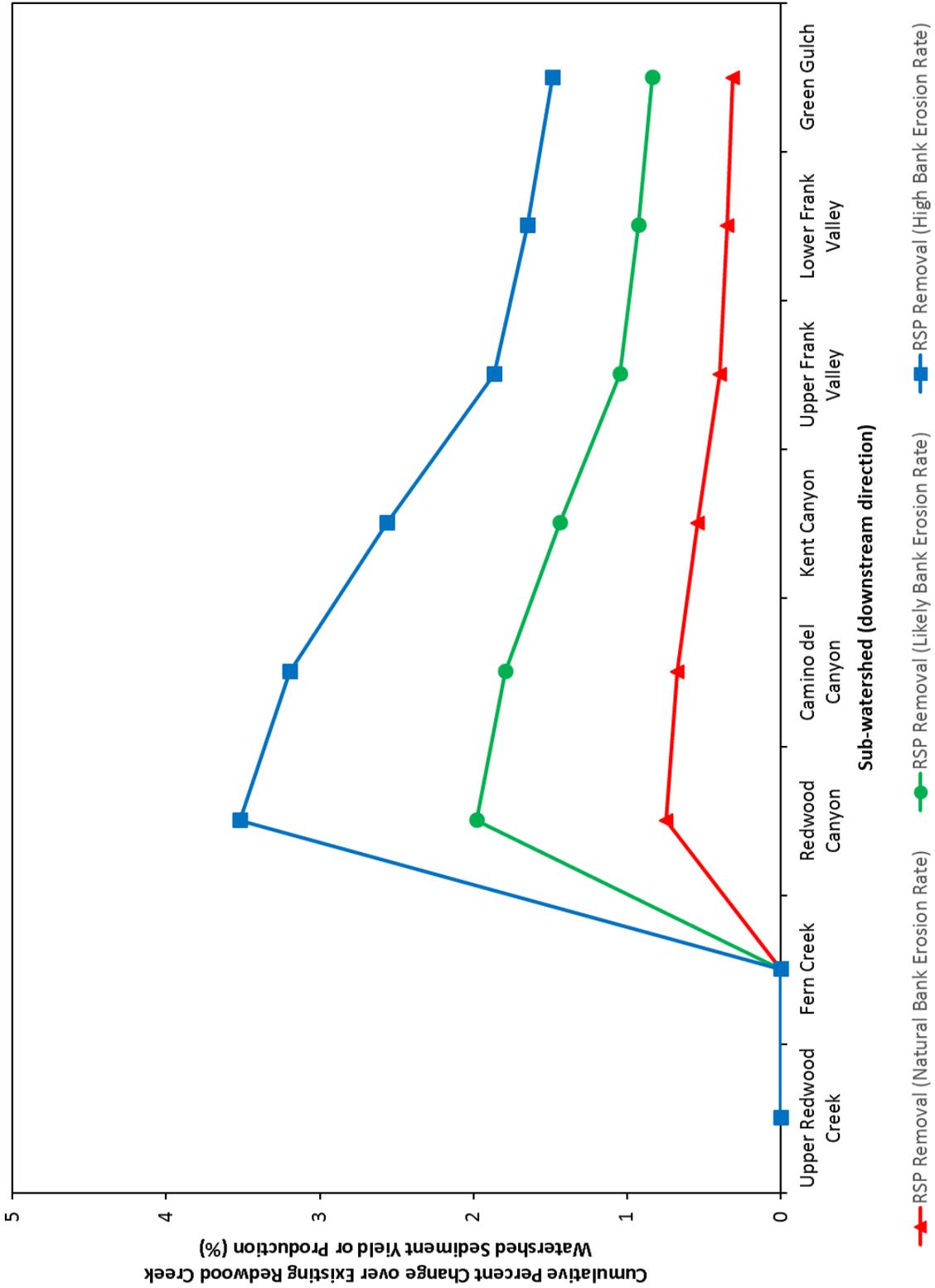


Figure 4-2. Percent change over the existing Redwood Creek watershed sediment budget (SWS, 2004) from natural, likely and high bank erosion rates from rock slope protection removal for Phase 2 of Creek Restoration Actions (figure source, NHE 2017).

The transport and deposition of eroded channel material downstream caused by the removal or riprap, disturbance of the streambed, placement of woody debris structures, and near-term bank treatments, including an increase in turbidity downstream, is considered a short-term and long-term moderate impact of the Proposed Action, given the slight increase of about 1 to 4 percent in the near term and a likely return to less than an additional 1 percent in sediment production over the long-term. The scale of this impact would likely diminish over time as the creek banks can respond naturally via lateral migration, the channels widens, and the system achieves its new dynamic equilibrium. Constructed bar and pools will be reshaped, and new bars and pools will form. Sediment storage is most likely to occur around

new obstructions (e.g. wood), accentuate existing depositional features (e.g. bars), and may temporarily fill created pools. Portions of the channel with planar-bed geometry will likely continue to transport the sediment load with relatively minor change in local relief. Once establishing its new equilibrium, any turbidity generated in the project area would be considered natural and not an anthropogenic source of sediment. However, this process of increased sediment loading to Redwood Creek and return to equilibrium would likely occur over an extended time frame during which transported sediment levels downstream of MWNM could remain at an elevated level of up to an additional 2 percent compared to existing conditions. This restoration of natural processes is considered to be an overall beneficial impact on water resources.

Project actions would result in fill and removal of fill within waters of the U.S., a regulated activity. The addition of LWD would be approximately 2,185 square feet of fill in waters of the U.S. Riprap removal would be considered fill removal of approximately 2,810 square feet within waters of the U.S.

### *Conclusion*

Construction of this alternative would have the potential for short-term minor adverse effects on water quality due to ground disturbance and related erosion, as well as potential for accidental releases of fuels or other construction-related hazardous materials. These effects would be reduced through implementation of BMPs, including erosion control measures and measures to reduce the potential for an accidental spill from construction equipment (see Appendix D).

Over the long term, the restoration of more natural geomorphic processes through riprap removal, LWD installation, creation of riffle-run-pool-glide sequences, instream bars, and other restoration actions would represent a substantial short-term and long-term beneficial effect within the project area, as channel complexity would increase and the channel would migrate, generate pools, trap sediment, develop undercut banks, and exhibit other features commonly found in natural channels.

The anticipated erosion effects of Creek Restoration Alternative 1 would represent a minor, short and long-term adverse impact on water quality, and would have a minor effect on Redwood Creek downstream of the Proposed Action. Impacts would be reduced by bank treatments after implementation to maintain sedimentation rates in the project area at no more than 2 to 5 percent above normal rates downstream in the near term, with long-term rates expected to return to normal rates observed downstream. The project area currently has below normal erosion rates due to the presence of riprap. As conditions normalize after implementation, even the short term increase in sediment would represent, at the worst level in the short term, an estimated 4 percent increase downstream over current elevations, which is most likely not even enough to be measurable. Over time, the expected increase in sediment downstream reaches is expected to be increased by about 1 percent (NHE, 2017a). Therefore the project is not anticipated to result in downstream smothering of spawning areas, filling of instream pools or other adverse effects on instream habitat and water quality (e.g., turbidity). Detailed long-term observation of spawning

habitat within Redwood Creek has not shown burial of spawning gravel from other sediment sources (such as eroding banks) (Mike Reichmuth, NPS, personal observation, Feb. 1, 2017).

In addition to the control of sediment due to bank treatments, impacts would be minimized by staging implementation of the restoration activities into two construction Phases; excavation of pools to reduce flow velocity and encourage deposition; revegetation of banks where riprap has been removed; and/or other appropriate measures to control downstream sediment migration. Impacts to other water quality parameters (e.g., temperature, contaminants, trace metals, nutrients, etc.) would likely be negligible over the long term and would remain comparable to existing levels.

#### Impacts of Creek Restoration Alternative 2:

##### *Analysis*

Creek Restoration Alternative 2 would include all of the actions described in Creek Restoration Alternative 1 as well as an additional 338 LF of riprap removal from the Plaza area and Cathedral Grove. Under this alternative, the same amount of LWD fill in waters of the U.S. would occur as under Creek Restoration Alternative 1. Additional riprap removal would add fill removal of approximately 840 square feet within waters of the U.S. compared to Creek Restoration Alternative 1. To reduce potential erosion after riprap removal, banks will be treated based on conditions at each specific location. Approximately 45 percent of banks are expected to be regraded to a 1V:1.5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have substantial mature root structures behind existing riprap, and since the roots can be very effective at resisting erosion, added treatments are not expected to be needed in those locations. Burial of an additional 33 CY of riprap would occur within a 146 LF burial zone adjacent to Cathedral Grove. Most actions would be conducted as part of Phase 1 activities (mostly upstream of Bridge 3), and about 60 percent of the Phase 1 riprap removal areas would have such bank erosion control, while the rest appear to have adequate root structure.

In addition to the removal of riprap, approximately 350 LF of asphalt trail on the top of the left bank at Cathedral Grove would be removed and revegetated. As discussed above for impacts of actions common to all Creek Restoration Alternatives, removal and revegetation of impervious or compacted surfaces would increase infiltration rates and reduce the runoff and surface erosion potential of these areas. Impacts of removing this segment of impervious asphalt are beneficial, long-term, and indirect.

##### *Conclusion*

In addition to the impacts of Creek Restoration Alternative 1, Creek Restoration Alternative 2 would have slightly greater, but still minor adverse short-term and long-term permanent impacts due to a greater anticipated erosion of upper streambank areas and increased mobilized sediment and turbidity following the removal of riprap, disturbance of 146 LF of streambed for riprap burial, and redistribution of sediment originating from mobilized bedload and constructed instream bars. The removal of asphalt along the trail and replacement with soil and vegetation planting represents a short-term and long-term benefit in those areas affected.

#### Impacts of Creek Restoration Alternative 3:

##### *Analysis*

Creek Restoration Alternative 3 consists of all of the actions and impacts of Creek Restoration Alternative 2, as well as installation of three engineered log jams and terracing of the right bank at near the entry plaza. The right bank downstream of Bridge 1 would be terraced to connect the channel to the historic floodplain (Figure 2-3). This action would help increase the area of inundation along the channel margin under smaller flows and likely reduce the volume of bank

material mobilized and transported downstream during high flow events. Creek Restoration Alternative 3 may likely shorten the duration required for this reach to achieve its geomorphic equilibrium.

Under this alternative, LWD fill in waters of the U.S. would increase approximately 380 square feet compared to Creek Restoration Alternative 2. The same amount of riprap fill removal in waters of the U.S. would occur as under Creek Restoration Alternative 2.

Implementation of Creek Restoration Alternative 3 would require site grubbing, grading, and off-haul of a significant volume of bank and floodplain material. During site excavation, soils would be exposed and subject to increased erosion. Graded and disturbed areas would be revegetated. These impacts would be considered short-term, direct and indirect, and adverse. Potential impacts to water quality would be avoided and minimized through the adherence to permit requirements (e.g., SWPPP, prepared by qualified personnel).

### *Conclusion*

Compared to Creek Restoration Alternative 2, Creek Restoration Alternative 3 would have greater beneficial and adverse short-term and long-term permanent impacts to geomorphology and water quality, due to the additional restoration actions and a somewhat greater, but still minor volume of anticipated erosion and sediment loading into Redwood Creek following the removal of riprap. In addition, Creek Restoration Alternative 3 manually removes instream material that would be subjected to erosion and mobilization and would regrade the right bank to a more gradual angle. These actions would reduce the volume of erodible material and lower the rate of erosion in this reach, as compared to Creek Restoration Alternative 2.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

Creek Restoration Alternative 4 consists of all actions under Creek Restoration Alternative 2, plus removal of an additional 270 LF of riprap, excavation of an alcove and installation of a LWD structure in the footbridge 1.5 area and burial of an additional 26 CY of riprap would occur within a 108 LF burial zone downstream of the Fern Creek confluence. Similar to Creek Restoration Alternative 2, the removal of riprap and installation of LWD would allow for increased bank erosion, the undercutting of the banks, and a resulting increase in creek turbidity and downstream sedimentation. These actions would be an adverse short-term and long-term impacts on water quality. To reduce potential erosion after riprap removal, banks will be treated based on conditions at each specific location. About 45 percent of banks are expected to be regraded to a 1V:1.5H slope, covered with erosion control fabric, and aggressively replanted. Other banks already have substantial mature root structures behind existing riprap, and since the roots can be very effective at resisting erosion, added treatments are not expected to be needed in those locations. Most actions (73 percent of all riprap removal proposed in this alternative) would be conducted as part of Phase 1 activities (mostly upstream of Bridge 3), and about 60 percent of the Phase 1 riprap removal areas would have such bank erosion control, while the rest appear to have adequate existing root structure.

Creek Restoration Alternative 4 would also relocate two asphalt trail segments (up to a total of 555 LF) farther from the channel and would replace them with flexible paving. A small footbridge (footbridge 1.5) would also be removed. The former trail alignment would be decompacted, restored and replanted. The relocation of the trail segments would have a long-term, moderately beneficial impact to water quality by reducing the impervious surface area near the channel and improving infiltration and water quality conditions. Under Creek Restoration Alternative 4, a drainage area at footbridge 1.5 would also be enhanced as an alcove. This alcove would provide an

off-channel, lower energy environment that would capture and store deposited sediment. Impacts with creation of the alcove would be considered a long-term, moderately beneficial impact to water quality.

Under this alternative, LWD fill in waters of the U.S. would increase approximately 70 square feet compared to Creek Restoration Alternative 3. Riprap fill removal in waters of the U.S. would increase approximately 680 square feet compared to Creek Restoration Alternative 3. Trail rerouting near footbridge 1.5 would result in fill of approximately 55 square feet of a tributary to Redwood Creek, but would also result in removal of a trail segment impacting approximately the same area of waters. Creation of the alcove would result in approximately 60 square feet of dredging within waters of the U.S.

### *Conclusion*

The additional impacts of this alternative, both adverse and beneficial, would be similar to those of Creek Restoration Alternative 2; taken on their own, they would be proportionately smaller due to the more limited extent of activity that would be conducted under this alternative. However, because Creek Restoration Alternative 4 would include the actions of Creek Restoration Alternative 1 and an additional 108 LF of streambed disturbance for riprap burial as compared to Creek Restoration Alternative 2, the overall effects (both adverse and beneficial) would be greater. Additionally, the creation of the alcove would be considered a long-term, moderately beneficial impact to water quality.

### Impacts of Creek Restoration Alternative 5:

#### *Analysis*

Creek Restoration Alternative 5 consists of all of the actions and impacts of Creek Restoration Alternative 4 along with the right bank terracing described in Creek Restoration Alternative 3. Under this alternative, LWD fill and riprap fill removal in waters of the U.S. would be the same as in Creek Restoration Alternative 4.

#### *Conclusion*

In addition to the impacts of Creek Restoration Alternative 4, terracing of the right bank between the channel and the floodplain would significantly reduce the volume of mobilized sediment and the adverse short-term and long-term permanent impacts to geomorphic and water quality resources would be significantly less under Creek Restoration Alternative 5 as compared to Creek Restoration Alternative 4.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives:

#### *Analysis*

All Pedestrian Bridge Replacement Alternatives would involve the replacement of the existing bridges with a clear span design with new abutments farther from the creek. The existing bridge abutments would be removed and relocated farther from the creek channel. Excavation activities to remove the old bridges and construct the new bridge and abutments would cause localized, short-term, direct, and adverse impacts on water quality during bridge construction. Applicable BMPs, listed in Appendix D, would avoid and minimize potential adverse impacts by reducing areas of disturbance and erosion and limiting potential runoff and contamination to surface and ground water.

Under all Pedestrian Bridge Replacement Alternatives, Bridges 1 and 4 would be designed to accommodate a 100-year peak-flood flow event with an additional 18 inches of freeboard and require minor increases to bridge span compared to the existing design (Figure 2-6). Bridge 2 and Bridge 3 may be designed for different size storm event(s), as shown in Table 4-1. Currently, Bridge 2 and 3 have the least flood capacity of the four bridges, and are only able to effectively pass the 2-yr peak-flood flow (NHE 2017b). Bridge 1 can effectively pass the 25-year peak-flood flow but is subject to being flooded or submerged during a 50-year or 100-year events (NHE 2017b). Bridge 4 can pass the 2-year, 25-year, and 50-year events but does not pass the 100-year peak-flow event (NHE 2017b).

**Table 4-1.** Flow Capacity for Bridges 1 through 4 under existing, Pedestrian Bridge Replacement Alternative A, Pedestrian Bridge Replacement Alternative B, and Pedestrian Bridge Replacement Alternative C

	Effective Capacity – Existing (peak-flood flow)	Design Capacity – Pedestrian Bridge Replacement Alternative A (peak-flood flow)	Design Capacity – Pedestrian Bridge Replacement Alternative B (peak-flood flow)	Design Capacity – Pedestrian Bridge Replacement Alternative C (peak-flood flow)
Bridge 1	25-year	100-year	100-year	100-year
Bridge 2	2-year	25-year	100-year	25-year
Bridge 3	2-year	25-year	100-year	100-year
Bridge 4	50-year	100-year	100-year	100-year

Source: NHE 2017b

The pedestrian approaches to Bridges 1 and 4 would be designed to connect the existing network of trails with the new bridges. There would be no increase in trail length for these bridges. The removal of the existing bridges would remove fill from Redwood Creek, a water of the U.S. The construction of the new bridges would result in fill in waters of the U.S. that would be similar in size to the fill removed for the existing bridges.

### Conclusion

Excavation and construction of new bridge abutments would have relatively minor, adverse, short-term impacts on surface waters and water quality during construction; however, most impacts would be avoided or minimized through the implementation of applicable BMPs (see Appendix D). Overall, replacement of the bridges would be long-term, direct and indirectly beneficial to water quality and hydrologic resources by allowing larger flows to pass unimpeded under creek crossings. Enlarging the cross-sectional area under the bridges removes potential choke points that can result in scouring and an increase in turbidity.

### Impacts of Pedestrian Bridge Replacement Alternative A:

#### Analysis

Under Pedestrian Bridge Replacement Alternative A, spans for Bridges 2 and 3 would be lengthened and designed to pass a 25-year peak-flood flow event with 15- and 12-inch freeboard at the peak of the arch, respectively (Figure 2-7). For Bridge 2, 120 LF of new boardwalk would be installed on the east side of creek and 20 LF of new boardwalk on the west side of the creek, and a small approximately 20- by 20-foot boardwalk gathering area would be built on the east side of the

creek. The existing gathering area and asphalt trail alignment at Bridge 2 would be restored. For Bridge 3, approximately 130 LF of existing asphalt trail leading to the east side of the crossing would be relocated and replaced with approximately 120 LF of flexible paving. The approaches to the bridge would require approximately 30 LF of boardwalk on the east side of the creek and approximately 35 LF of boardwalk on the west side of the creek. The previous trail alignments on the east side of the creek would be decompacted, and the area revegetated. The removal of the existing bridge abutments would remove fill from Redwood Creek, a water of the U.S. Although ground disturbance and construction of the realigned trails would be considered a short-term, direct, adverse impact, any potential impacts to water quality would be offset through the restoration and revegetation of removed trail segments.

### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative A would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts would be long-term, direct and indirect, and beneficial by allowing larger flows to pass unimpeded thereby reducing scour and lowering water turbidity. Installation of 205 LF (approximately) of boardwalk would replace hardscape (asphalt) trail and be considered a short- and long-term beneficial impact by reducing runoff rates and turbidity of surface waters. Some short-term, direct and indirect, adverse impacts are associated with construction activities; however, most impacts would be avoided or minimized through the implementation of applicable BMPs (see Appendix D).

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative B, the spans for Bridges 2 and 3 would be lengthened and designed to pass a 100-year peak-flood flow event with 14- and 13-inch freeboard at the peak of the arch, respectively (Figure 2-7). For Bridge 2, approximately 80 LF of trail segments would be rerouted and replaced with approximately 140 LF of new boardwalk on the east side of the creek and approximately 40 LF of new boardwalk on the west side of creek. For Bridge 3, approximately 130 LF of trail segments would be rerouted and replaced with approximately 160 LF of new flexible paving trail. The approaches to the bridge would require approximately 50 LF of new boardwalk on the east side of the creek and approximately 50 LF of new boardwalk on the west side of creek. The rerouted trail would be to be pulled back from the channel. The previous trail alignments on the east side of the creek would be restored and revegetated. The removal of the existing bridge abutments would remove fill from Redwood Creek, a water of the U.S. The amount of fill removed would be the same as for Pedestrian Bridge Alternative A.

### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative B would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts would be long-term, direct and indirect, beneficial by allowing 100-year flood flows to pass unimpeded. Pedestrian Bridge Replacement Alternative B has moderately more beneficial impacts than Pedestrian Bridge Replacement Alternative A since Bridges 2 and 3 would allow for larger flows and abutments would be located farther from the center of the channel, thereby reducing scour around the bridge abutments and lowering water turbidity. In addition, 280 LF (approximately) of boardwalk would be installed replacing hardscape (asphalt) trail and be considered a short- and long-term beneficial impact on water resources by reducing runoff rates and turbidity of surface waters.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative C, the span for Bridge 2 would be lengthened and designed to pass up to a 25-year peak-discharge event with 15-inch freeboard at the peak of the arch and the span for Bridge 3 would be lengthened and designed to pass up to a 100-year peak-discharge event with 14-inch freeboard at the peak of the arch. The removal of the existing bridges abutments would remove fill from Redwood Creek, a water of the U.S. The amount of fill removed would be the same as for Pedestrian Bridge Alternatives A and B.

#### *Conclusion*

Impacts under Pedestrian Bridge Replacement Alternative C would be similar to potential impacts discussed above under *Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives*. Overall, impacts associated with Pedestrian Bridge Replacement Alternative C would have slightly greater long-term, direct and indirect, beneficial impacts than Pedestrian Bridge Replacement Alternative A, but slightly lower long-term, direct and indirect, beneficial impacts than Pedestrian Bridge Replacement Alternative B. Pedestrian Bridge Replacement Alternative C would replace 240 LF (approximately) of boardwalk would be installed replacing hardscape (asphalt) trail and be considered a short- and long-term beneficial impact on water resources by reducing runoff rates and turbidity of surface waters.

#### **Cumulative Impacts**

Cumulative adverse impacts from other past, current, and future projects in MWNM include soil removal, soil erosion, and continued sedimentation into Redwood Creek near the Muir Woods Visitors Center, parking lots, and along Muir Woods Road. As listed in Section 4.1 above, the Muir Woods Reservation System, Muir Woods Road Rehabilitation Project, and the Muir Woods Sustainable Access Project all address and reduce disturbance of soils, erosion, sedimentation, and other hardscape-related pollutant loading that degrades the quality of receiving waters. Actions applicable to improving water quality include: revegetation of bare or disturbed areas adjacent to existing facilities; elimination of roadside parking in unpaved areas; installation or repair of culverts; expansion of riparian habitat into previously developed areas; and construction of stormwater treatment facilities for visitor parking areas. Completion of these projects would result in indirect, long-term, beneficial impacts on water resources.

Construction associated with other Muir Woods projects requires some vegetation clearing, excavation, and other ground disturbing activities. This disturbance would expose soils and increase the potential for soil erosion, sedimentation of surrounding water resources, and accidental release of hazardous materials. Ground disturbance during construction could also temporarily alter localized surface water drainage. During construction, impacts on water resources and hydrologic processes would be direct, short-term, and adverse as a result of flow alterations and sediment and pollutant loading.

All of the current and future projects would implement BMPs related to stormwater, sediment and erosion control, and waste management (see Appendix D). Dewatering would be necessary to divert flows around construction activities in the creek. Compliance and implementation of applicable BMPs would help limit erosion and reduce untreated runoff from entering surface waters (see Appendix D). These procedures would avoid and minimize potential impacts to water resources related to construction activities.

The cumulative actions would have adverse effects on water quality and hydrology; however, these effects would be relatively limited and localized compared to the more widespread benefits from

the elimination of ground disturbance and the installation of stormwater management and erosion and sediment control measures. The overall impacts from these cumulative actions would be beneficial. Under the action alternatives, during replacement of the bridges, construction activities and methods would be similar to other cumulative actions and potentially contribute to increased erosion of soils and sedimentation into Redwood Creek. These contributions may be appreciable and result in short-term, direct and indirect, adverse impacts. However, implementation of applicable BMPs would help prevent or limit erosion and reduce untreated runoff from entering surface waters and garner no long-term cumulative impacts (see Appendix D).

In conjunction with other past, current, and future projects in MWNM, the action alternatives associated with the Proposed Action would result in adverse short-term and long-term impact on water quality in and downstream of the Proposed Action. Implementation of the Proposed Action would result in elevated levels of turbidity and downstream sedimentation in Redwood Creek. Many aspects of the other projects protect or enhance water quality through the elimination of roadside parking in unpaved areas, improved stormwater facilities and infrastructure, installation or replacement of compromised road culverts, realignment or removal of existing dirt trails, an improved creek crossing at the Dipsea Trail. In general, construction-related impacts to surface waters and water quality would be relatively minor, adverse, and short-term. Despite increased turbidity, impacts to other water quality parameters (e.g., temperature, contaminants, trace metals, nutrients, etc.) would likely be negligible and remain comparable to existing levels.

### **Conclusion**

Construction activities associated with the Proposed Action would result in short-term impacts to water quality related to ground disturbance and potential erosion, as well as the potential for accidental spills of fuels or other construction-related hazardous materials into the creek. These effects would be eliminated or reduced through use of erosion control and spill prevention BMPs (see Appendix D).

Over the long term, the Proposed Action would result in substantial beneficial effects to geomorphology in the restored area, as a result of the restoration of natural channel processes from installation of LWD, riprap removal, widened bridges, and other proposed actions. These benefits would accrue over a period of decades as the channel migrates, new features form, and it reaches an eventual state of equilibrium.

In addition, the Proposed Action would have minor increases in sediment production due to erosion from removal of riprap, and the subsequent transport of sediment within the restored reach and downstream. Bank treatments to control erosion would reduce levels of sediment released into Redwood Creek. Project features such as the LWD installations, tributary grade control improvements, and natural features such as embedded/exposed tree roots and LWD recruitment over time, would allow for sediment storage within the project area. Increased sediment deposition within the project area would also be expected to occur once the channel widens and flow velocities are reduced, allowing for more sediment to settle out. With proposed bank erosion control treatments, initial erosion is anticipated to be slow and the system would eventually reach a dynamic equilibrium. Over a period of time, the erosion rate would approach natural erosion/sedimentation rates similar to other portions of the Redwood Creek watershed. Actual erosion and sedimentation rates depend on a multitude of factors (e.g., seasonal precipitation amounts and specific event based rainfall amounts and intensities, the physical conditions of the channel, woody debris supply to the creek, land use, vegetation and fire conditions in the watershed, etc.) but would likely be diffused over the course of several years.

Preliminary estimates predict that average rates of bank erosion following proposed actions would be on the order of 2 to 5 times the natural bank erosion rate in the project area and occur for a

period of approximately 5 years, before tapering off to the natural erosion rate as the bank vegetation becomes more established (NHE 2017a). This increase in sedimentation rate represents a 2 to 5 percent increase in the total watershed sediment budget during Phase 1 and a 2 to 4 percent increase during Phase 2 (NHE 2017a). Increases in turbidity would likely be linked to storm and high flow events and would vary in significance based on initial hydrologic conditions, event size and duration, and bank vegetation density and composition. This rate of increase in the watershed is likely virtually imperceptible and minor.

Fate of eroded sediment would also vary widely based on pre- and post-hydrologic and hydraulic conditions of the watershed. In general, the Proposed project area would become a source for sediment with minimal volumes stored within MWNM; most sediment in the project area would be mobilized and transported downstream. Conventional geomorphic principles would project the transport and storage of material (temporary and semi-permanent) in the channel and floodplains downstream of the Proposed project area, such as the lower gradient portions of the creek at Frank Valley, Big Lagoon, and Muir Beach. That said, major improvements to general watershed function and sediment supply and deposition to areas of historic channel incision would be expected over the long term, with improved floodplain connectivity within MWNM resulting in greater long-term beneficial impacts within the project area and downstream.

## 4.10 Vegetation

### *Methodology and Assumptions*

Impacts considered in this analysis include vegetation disturbance from trampling, revegetation of creek banks and disturbed areas on the forest floor, as well as impacts to the overall health of the redwood forest. Existing information on vegetation within MWNM was consulted. No mapping of vegetation or quantification of the area of impacts to vegetation were conducted.

### *No Action Alternative*

#### Analysis

Under the No Action Alternative, riprap would remain in Redwood Creek and the existing pedestrian bridges would be replaced in-kind at some point in the future. Riprap prevents natural channel migration, and channel incision in Redwood Creek has disconnected the stream from its floodplain, reducing the amount of natural disturbance from floods on the adjacent alluvial redwood forest (NHE 2017). Redwood forests are adapted to periodic disturbance, and the incision and lack of channel migration may have affected the redwood forest adjacent to Redwood Creek. In-kind replacement of bridges would likely result in vegetation disturbance in the vicinity of construction. Impacts on special-status or locally rare plants are not anticipated, as it is anticipated that NPS would conduct surveys and implement protective measures prior to in-kind replacement of bridges.

#### Conclusion

Under the No Action Alternative, the health of the alluvial redwood forest would continue to be adversely affected by historic management actions such as the installation of riprap and removal of LWD from Redwood Creek. The replacement of bridges in-kind would not address the issue of passage of LWD through the creek and would result in short-term adverse impacts on vegetation. The No Action Alternative would continue long-term adverse impacts on vegetation in MWNM.

## ***Creek Restoration Alternatives***

### **Impacts of Actions Common to all Creek Restoration Alternatives**

#### ***Analysis***

Revegetation of disturbed areas along banks and the forest floor would reduce the impacts of riprap removal and LWD installation on understory vegetation. Installation of grade control on the incised tributary would result in short-term impacts on understory vegetation due to trampling by construction crews and a narrow route to be used by a small excavator along the tributary. BMP methods to avoid impacts to vegetation would be used (see Appendix D). In addition, plywood or other measures to prevent soil compaction can be used under the equipment. The anticipated increase in water table would result in minor long-term benefits to understory vegetation and adjacent redwoods trees.

#### ***Conclusion***

Revegetation of disturbed areas along banks and the forest floor would reduce the impacts of riprap removal and LWD installation on understory vegetation. Installation of beaver dam analogs in Redwood Creek and grade control on the incised tributary would result in short-term impacts on understory vegetation due to trampling by construction crews. The anticipated increase in water table would result in minor long-term benefits to understory vegetation and adjacent redwood trees.

### **Impacts of Creek Restoration Alternative 1:**

#### ***Analysis***

As noted by Save the Redwoods League, targeted removal of riprap within and addition of LWD to Redwood Creek would improve geomorphic function and natural flooding dynamics within MWNM which would have beneficial effects on the ecological health of the redwood forest (Burns, Pers. Comm. 2016). Save the Redwoods League supports the habitat enhancement actions and describes them as “critical and necessary investment to sustain the ecological health of the coast redwood ecosystem” (Burns et al. 2016). Creek restoration actions that raise the water table and thereby improve water security for redwoods in the park could boost their resilience in the face of expected climate change impacts which include higher temperature and increased aridity (Gonzalez 2016).

Redwood tree root systems influence stream channels that flow through forests (NHE 2017). Redwood trees generally have relatively shallow root systems that can extend over 100 feet from the base of the tree. Roots of multiple trees also intertwine, increasing the stability of these trees during flood events or high winds. Thus, a redwood tree on the bank of a stream channel is far less likely to be toppled from lateral erosion than trees with localized, vertical root systems (NHE 2017). Numerous existing undercut redwoods have persisted at MWNM for at least 15 years since they were last photographed (Shoulders personal observation, 2017).

The altered flow dynamics that are anticipated to result following riprap removal and LWD installation could potentially destabilize redwood trees in the vicinity of the channel. Under Alternative 1, there are approximately 130 trees greater than 1-foot DBH within one channel width (approximately 33 feet) of Redwood Creek within the areas proposed for riprap removal, riprap burial, and LWD installation. The majority of these trees are redwoods. Of these trees, approximately 23 are located between the top of bank and the active channel. Approximately 15 trees are located within the projected long term channel evolution identified by NHE in their 2017 report (NHE 2017). Although these 15 trees are located within project channel evolution zone, as described above redwoods are less likely to be toppled than other tree species. In recent years,

several redwood trees have fallen at MWNM (largely those rooted on steep slopes), but none of the partially undermined redwood trees along the channel have fallen. Even during periods of elevated erosion and channel migration such as prior to the 1930s, there is no documentation that high erosion levels led to increased toppling of old-growth redwoods along Redwood Creek due to channel erosion (NHE 2017).

If one or more of these trees falls into the creek, it would add more beneficial LWD to the creek, as well as creating light gaps that are known to enhance riparian biodiversity as well as enhance redwood regeneration (Lorimer et al. 2009; Van Pelt et al. 2016). Tree fall due to creek movement is a natural disturbance within redwood forests, to which redwood forests are adapted (Lorimer et al. 2009). If the presence of riprap artificially hardening the banks of Redwood Creek has prevented the toppling of adjacent redwoods over the past, this may have been delaying natural processes that would have occurred in the absence of riprap. Within MWNM, current density of trees greater than 0.16-foot DBH is  $430 \pm 31$  individuals (Steers et al. 2014). This is within goals identified for healthy forests on Mt. Tamalpais (Burns et al. 2016). As described by Save the Redwoods League, natural recruitment of riparian redwood trees or other tree species into Redwood Creek is not anticipated to significantly reduce tree density within MWNM (Burns et al. 2016).

Heavy equipment (including a small excavator used for removal of segment R6), movement of logs for LWD, and the presence of construction crews would result in trampling of understory vegetation. These would be short-term adverse impacts to understory vegetation. BMP methods to avoid impacts to vegetation would be used (see Appendix D). In addition, plywood or other measures to prevent soil compaction can be used under the equipment. As described above, disturbed areas would be revegetated as part of the Proposed Action, per BIO-15.

Remnant base rock from a previously removed trail along the top of bank next to riprap segment L10 would be removed to allow better revegetation there for bank stability. An asphalt trail in this area was removed in 2000, but the remnant base rock about 6 inches below the surface has restricted plant cover despite numerous outplanting events. This would have a beneficial impact on understory vegetation.

Implementation of BMP-8 through BMP-13 would reduce the potential for adverse effects on vegetation, including redwoods (see Appendix D). These BMPs include identification of a construction route that minimizes disturbance, placement of protective mats, salvaging of vegetation, decompaction of soil as needed, and potentially padding redwood trunks.

The presence of construction crews and heavy equipment could potentially spread non-native invasive plant species in MWNM. BMP-4 would be implemented to limit the spread of invasive plant species by construction equipment, minimizing this risk. BIO-14 requires the creation of a plant protection plan which would be protective of native plants and would limit the spread of invasive plants. BMP BIO-15 requires the removal of invasive plants in disturbed areas (see Appendix D).

No impacts on rare plants are anticipated because a survey would be conducted prior to any construction activities and protective measures implemented if rare plants were discovered, per BIO-11, -12, and -13 (see Appendix D). These BMPs require a rare plant survey and avoidance and minimization measures for rare plants, if discovered, within 50 feet of proposed actions.

### *Conclusion*

Under Creek Restoration Alternative 1, impacts to the redwood forest would be long term and beneficial. Short-term adverse and beneficial impacts to understory vegetation would occur. No impacts on rare plants are anticipated.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Under Creek Restoration Alternative 2, removal of the additional riprap segments would have similar impacts on vegetation as described for Creek Restoration Alternative 1, with a greater benefit to forest health due to increased opportunities for channel migration associated with additional riprap removal. Trees within one channel width of actions along Redwood Creek would increase by 15. Trees located between the top of bank and active channel near actions would increase by 10 and trees within the projected channel evolution would increase by 6. This would increase the potential for trees to topple into Redwood Creek, although as described in Creek Restoration Alternative 1, this is not anticipated in the short term. Removal of the Cathedral Gove trail segment would reduce compaction to redwood roots and would result in an increased area available for understory vegetation. BMPs indicated in Creek Restoration Alternative 1 would be implemented.

#### *Conclusion*

Under Creek Restoration Alternative 2, impacts to the redwood forest would be long term and beneficial. Short-term adverse impacts to impacts to understory vegetation would occur. No impacts on rare plants are anticipated.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Impacts of Creek Restoration Alternative 3 would be similar to those described for Creek Restoration Alternative 2. This alternative would increase the number of trees within one channel width of actions along Redwood Creek by 7, but no new trees would be within the projected channel migration zone. This action is not anticipated to result in increased likelihood of trees toppling into Redwood Creek compared to Creek Restoration Alternative 2. Additional vegetation impacts would occur with right bank terracing, which may affect five alder trees present in the terracing footprint. Protection of these trees may be possible. BMPs indicated in Creek Restoration Alternative 1 would be implemented.

#### *Conclusion*

Under Creek Restoration Alternative 3, impacts to the redwood forest would be long term and beneficial. Short-term adverse impacts to impacts to understory vegetation and alder trees in the bank terracing area would occur. Long-term beneficial impacts to the riparian forest would occur due to the increase in floodplain habitat. No impacts on rare plants are anticipated. BMPs indicated in Creek Restoration Alternative 1 would be implemented.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

Impacts of Creek Restoration Alternative 4 would be similar to those described for Creek Restoration Alternative 2. This alternative would increase the number of trees within one channel width of actions along Redwood Creek by 9, but no new trees would be within the projected channel migration zone. Additional short-term adverse impacts to understory vegetation would occur with relocation of up to 555 LF of trail. Areas where trails would be removed would be decompacted, restored, and revegetated. BMPs indicated in Creek Restoration Alternative 1 would be implemented.

### *Conclusion*

Under Creek Restoration Alternative 4, impacts to the redwood forest would be long term and beneficial. Additional short-term adverse impacts to understory vegetation would occur due to trail rerouting. No impacts on rare plants are anticipated.

### Impacts of Creek Restoration Alternative 5:

#### *Analysis*

Impacts of Creek Restoration Alternative 5 would be similar to those described for Creek Restoration Alternative 3. Compared with Creek Restoration Alternative 3, this alternative would increase the number of trees within one channel width of actions along Redwood Creek by 7, but no new trees would be within the projected channel migration zone. Additional short-term adverse impacts to understory vegetation would occur with relocation of up to 555 LF of trail. Areas where trails would be removed would be decompacted, restored, and revegetated. BMPs indicated in Creek Restoration Alternative 1 would be implemented.

### *Conclusion*

Under Creek Restoration Alternative 5, impacts to the redwood forest would be long term and beneficial. Short-term adverse impacts to impacts to understory vegetation and alder trees in the bank terracing area would occur. No impacts on rare plants are anticipated.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Pedestrian Bridge Replacement Alternative A:

#### *Analysis*

Under Pedestrian Bridge Replacement Alternative A, the presence of construction equipment and crews would result in limited trampling of understory vegetation. Replacement of portions of the existing trail with boardwalk would reduce compaction of redwood roots, resulting in minor long-term beneficial impacts to redwoods. The rerouting of the existing trail at Bridge 3 and replacement with flexible paving would result in minor, long term adverse impacts to understory vegetation. Implementation of BMP-8 through BMP-14 would reduce the potential for adverse effects on vegetation, including redwoods (see Appendix D). Implementation of BMP BIO-15, which requires revegetation of disturbed areas caused by project work and trail re-routes, would reduce impacts on understory vegetation. These BMPs include identification of a route that minimizes disturbance, placement of protective mats, salvaging of vegetation, decompaction of soil as needed, potentially padding redwood trunks, and creation of a plant protection plan which would be protective of native plants and would limit the spread of invasive plants.

No impacts on rare plants are anticipated because a survey would be conducted prior to any construction activities and protective measures implemented if rare plants were discovered, per BMP BIO-11, -12, and -13 (see Appendix D). These BMPs require a rare plant survey within areas that could potentially be disturbed by proposed actions and avoidance and minimization measures for rare plants, if discovered within 50 feet of proposed actions.

### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative A would result in minor short-term adverse impacts and minor long-term impacts on understory vegetation.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Impacts of Pedestrian Bridge Replacement Alternative B would be similar to impacts described for Pedestrian Bridge Replacement Alternative A. Increased conversion of existing asphalt trail to boardwalk would reduce compaction of redwood roots, resulting in an increase to minor long-term beneficial impacts to redwoods. Revegetation of disturbed areas caused by project work and trail re-routes, would reduce impacts on understory vegetation. BMPs indicated in Pedestrian Bridge Alternative A would be implemented.

#### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative A would result in minor short-term adverse impacts and minor long-term impacts on understory vegetation.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Impacts of Pedestrian Bridge Replacement Alternative C would be intermediate to impacts described for Pedestrian Bridge Replacement Alternative A and B. Revegetation of disturbed areas caused by project work and trail re-routes, would reduce impacts on understory vegetation. BMPs indicated in Pedestrian Bridge Alternative A would be implemented.

#### *Conclusion*

Implementation of Pedestrian Bridge Replacement Alternative C would result in minor short-term adverse impacts and minor long term impacts on understory vegetation.

### ***Cumulative Impacts***

Projects discussed in Section 4.2 such as the Muir Woods Road Bridge Replacement Project, Muir Woods Water/Wastewater Station Line Replacement, and the Muir Woods Sustainable Access Project would affect vegetation in and nearby MWNM. Cumulative adverse impacts from these projects would remove and degrade vegetation in the short term, resulting in short term adverse impacts on vegetation. Some projects, such as the Muir Woods Reservation System project and the Muir Woods Sustainable Access Project, would result in long-term improvements to vegetation conditions in the vicinity, resulting in indirect, long-term, beneficial impacts on vegetation. Implementation of the Creek Restoration or Pedestrian Bridge alternatives would result in minor contributions to short-term adverse impacts on understory vegetation and minor contributions to long-term benefits to the health of the redwood forest.

#### ***Conclusion***

The combined effects of the implementation of the Proposed Action would be similar to the impacts of each alternative, but with a difference in scale. Implementation of the Proposed Action would result in trampling of understory vegetation during construction, a short-term adverse impact. Major improvements to general forest health would be expected over the long term, with improved floodplain connectivity and greater proportion of boardwalk trails, resulting in greater long-term beneficial impacts to the redwood forest. No impacts on rare plants are anticipated.

## 4.11 Visual Resources

### ***Methodology and Assumptions***

The analysis of impacts to visual resources took into consideration potential impacts to views of natural and manmade features. Natural features of particular interest to visitors include redwoods, streams, other vegetation, and wildlife. Historical features in the monument include riprap placed by the CCC in the 1930s.

### ***Impacts of the No Action Alternative***

#### Analysis

The No Action Alternative would leave existing riprap and large downed trees in place. Bridges would either be left or replaced in-kind, and no trail changes would occur.

#### Conclusion

The No Action Alternative would have temporary adverse impacts on visual resources during any future in-kind bridge replacement work. While in-kind bridges would be of similar size and design, new bridges would require guardrails to comply with current safety codes and thus would have minor long-term impacts on visual resources.

### ***Creek Restoration Alternatives***

#### Impacts of Actions Common to all Creek Restoration Alternatives

##### *Analysis*

All creek restoration alternatives include revegetation of any impacted creek banks or areas of forest floor and the installation of grade control in a tributary just upstream of Cathedral Grove. The use of equipment for these actions would create minor, site-specific, short-term impacts to visual resources. Over time, the vegetation would restore the natural character of the restored creek banks. In the long-term, it is likely some beaver dam analogs and/or tributary grade control would be visible from the trail, and these features may improve the water table and health of the surrounding redwood forest ecosystem.

##### *Conclusion*

The actions common to all creek restoration alternatives would have minor, site-specific, short-term adverse impacts to visual resources. Long-term impacts would include a less- channelized, more natural looking stream channel, visible beaver dam analogs and check dams, and possibly beneficial impacts to the viewscape arising from improved ecosystem health and climate resilience.

#### Impacts of Creek Restoration Alternative 1:

##### *Analysis*

Creek Restoration Alternative 1 involves the removal of approximately 1,019 LF of historical riprap, and burial of Phase 1 riprap, all of which is visible from trails in the monument. As part of this alternative, LWD would be moved from nearby locations into the channel. The transport of LWD and removal, burial, and hauling away of riprap would have temporary adverse impacts on visual resources due to the presence of heavy equipment near and on trails. The movement and placement of LWD would create long-lasting changes in views as well. Over time, these actions would result in a more natural appearance to the creek, and improve the health and climate resilience of the local ecosystem, while leaving some historic riprap available for viewing. This

would ultimately lead to improvements to the visual resources relative to the No Action Alternative, a beneficial impact. The placement of erosion control fabric on re-contoured banks would have a short-term minor adverse impact on visual resources, which would fade over time as vegetation covers it.

### *Conclusion*

Equipment operating near and along trails to move LWD and remove and bury riprap and placement of erosion control fabric would have temporary, site-specific, adverse impacts on visual resources. The removal of historic riprap and addition of LWD would have permanent impacts on visual resources and access to specific views, but the overall long-term impact would be beneficial by restoring a more natural character to the creek.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 involves the removal of approximately 338 LF of riprap (in the Entry Plaza Area and near Cathedral Grove) and 350 LF of asphalt trail would be removed from Cathedral Grove in addition to the work described in Creek Restoration Alternative 1. The additional riprap removed near Cathedral Grove would be buried in the channel. The Plaza Area is one of the busiest locations in the monument and offers visitors their initial view of MWNM. The presence of equipment while this work is underway would create a temporary, site-specific, adverse impact to the viewscape. Since some of the riprap being removed is visible from the Plaza Area, some viewers may consider the permanent removal to be an adverse impact. However, in general, the restoration of a more natural character to the creek is considered a long-term beneficial impact.

#### *Conclusion*

The impacts of this alternative would be similar and proportionally greater than those found in Creek Restoration Alternative 1. The removal of a side-section of trail would have permanent impacts on visual resources and access to specific views, but the overall long-term impact would be beneficial by restoring a more natural character to the creek.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Creek Restoration Alternative 3 involves installation of log jams downstream of Bridge 1 and terracing of the right bank in the Entry Plaza Area in addition to the work described in Creek Restoration Alternative 2.

#### *Conclusion*

The impacts of this alternative would be similar to those found in Creek Restoration Alternative 2. Creek Restoration Alternative 3 would have a temporary, site-specific, adverse impact on the viewscape during construction, which would be for a longer period than in Creek Restoration Alternative 2 given the additional work included.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

Creek Restoration Alternative 4 involves the removal of approximately 270 LF of riprap, rerouting of up to 555 LF of trail, and additional LWD in the alcove area, in addition to the work described in Creek Restoration Alternative 2.

### *Conclusion*

The impacts of this alternative would be similar and proportionally greater than those found in Creek Restoration Alternative 2.

### Impacts of Creek Restoration Alternative 5:

#### *Analysis*

Creek Restoration Alternative 5 consists of all of the actions and impacts of Creek Restoration Alternative 4 along with the right bank terracing described in Creek Restoration Alternative 3.

#### *Conclusion*

The impacts of this alternative would be similar and proportionally greater than those found in Creek Restoration Alternative 4.

## ***Pedestrian Bridge Replacement Alternatives***

### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives:

#### *Analysis*

The replacement of Bridges 1 and 4 are actions common to all bridge alternatives. The removal of existing abutments, addition of boardwalk, and replacement of the existing bridges with longer, higher, clear spans with guardrails would impact the sites' visual resources. Under all alternatives, new bridges would be designed to be compatible with the historic setting of MWNM, so the impact should be minor and would be beneficial.

#### *Conclusion*

During removal and replacement, the actions common to all bridge alternatives would have temporary, adverse impacts on visual resources due to the presence of equipment and temporary impacts to vegetation. In the long-term, the actions common to all bridge alternatives would have minor adverse impacts on visual resources due to the addition of boardwalk, as well as longer, higher bridges with guardrails. Long-term minor beneficial impacts to visual resources would occur due to bridge designs compatible with the historic setting.

### Impacts of Pedestrian Bridge Replacement Alternative A:

#### *Analysis*

Pedestrian Bridge Replacement Alternative A involves the removal and replacement of Bridges 2 and 3 with higher, longer, spans that would pass the 25-year flow event. The bridges would have guardrails on the span.

#### *Conclusion*

During removal and replacement of bridges, Pedestrian Bridge Replacement Alternative A would have temporary, adverse impacts on visual resources due to the presence of equipment and impacts to vegetation. In the long-term, Pedestrian Bridge Replacement Alternative A would have minor, adverse impacts to visual resources due to longer, higher spans, and guardrails. However, the bridges would be more consistent with the historic character of the park, which would be beneficial.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Pedestrian Bridge Replacement Alternative B involves the replacement of Bridges 2 and 3 with longer spans than those in Pedestrian Bridge Replacement Alternative A, and the rerouting of some portions of trail. These new trail sections would provide visitors views differing from those typically found along the valley floor. These bridges would also have guardrails on the span, and Bridge 2 would require a 10-foot-long guardrail on each side of the boardwalk approaching the bridge.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative B would have temporary adverse site-specific impacts to visual resources during construction. In the long-term the new bridges would have longer and higher spans with guardrails, which would have a minor adverse impact. This alternative would have more adverse effects on visual resources compared to Pedestrian Bridge Replacement Alternative B. This which would be offset by the bridges being more consistent with the historic character of the park, and by affording more sweeping views compared to existing conditions or Pedestrian Bridge Replacement Alternative A. Rerouting the trail would also have the beneficial impact of providing visitors access to new views.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Pedestrian Bridge Replacement Alternative C involves the replacement of Bridges 2 and 3, though unlike Pedestrian Bridge Replacement Alternative B, only Bridge 3 would be replaced with a span capable of accommodating the 100-year storm with 13 inches of freeboard. Bridge 2 would have the span described under alternative A, and would not have guardrails on the boardwalk. Both bridges would have longer, higher spans with guardrails compared to the no-action alternative.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative C would have temporary adverse site-specific impacts to visual resources during construction. In the long-term, Bridges 2 and 3 would have longer and higher spans with guardrails which would have a minor adverse impact on visual resources. This impact would be intermediate to Pedestrian Bridge Replacement Alternatives A and B. This adverse impact would be offset by the bridge design being more consistent with the historic character of the park compared to existing conditions. Rerouting the trail would also have the beneficial impact of providing visitors access to additional and different views.

### ***Cumulative Impacts***

The cumulative effects of the various projects are first described, and then considered in combination with the Proposed Action. The Muir Woods Reservation System will have minor beneficial long-term impacts on visual resources in the monument by decreasing crowding during peak visitation times and providing visitors with less obstructed views of redwoods, other vegetation, and wildlife.

The Muir Woods Road Bridge Replacement Project will have minor or no long-term impact on visual resources.

The Muir Woods Road Rehabilitation Project and the Muir Woods Water/Wastewater Station Line Replacement will have no long-term impact on visual resources.

The Muir Woods Sustainable Access Project would have long-term beneficial impacts on visual resources around the Plaza Area due to the relocation of the restroom facilities and revegetation work.

Other projects planned or recently completed in the area, in combination with the Proposed Action, would combine to have temporary moderate adverse construction-related impacts. Other projects would have negligible or no long-term impact on visual resources in the monument, with the Proposed Action contributing long-term beneficial impacts, leading to long-term beneficial impacts overall.

### ***Conclusion***

Completing all of the actions described in the alternatives would have moderate adverse impacts on visual resources throughout MWNM during construction. In the long-term, these projects would have moderate, largely beneficial impacts on visual resources by restoring a more natural character to the creek, improving ecosystem health, climate resilience, and wildlife habitat, ensuring new bridges fit the monument's historic setting, and providing more diverse views from the higher bridges and new trail alignments.

## **4.12 Soundscapes**

### ***Methodology and Assumptions***

The soundscapes analysis relied on published studies that detailed the monument's current soundscapes in addition to considering sources of noise related to the Proposed Action that may include:

1. Dewatering pumps and equipment.
2. Haul carts for transporting riprap out of the monument.
3. Cable grip and hoist system and associated heavy equipment to move logs.
4. The use of chainsaws, sledge hammers, and wedges to prepare LWD for installation.
5. Excavators, rock drills, and other equipment used in riprap removal, burial, break-up, and transportation.
6. Equipment and activity associated with the removal and installation of bridges.
7. Equipment and activity associated with the removal of the section of asphalt trail at Cathedral Grove and subsequent soil improvement work.

The types of equipment that will be used for these activities typically produce noise levels of 70 to 85 dBA at a distance of 50 feet which could be perceived as annoyingly loud by visitors, but would not pose a risk of hearing damage over expected periods of exposure (Federal Transit Authority 2006).

Impact severity descriptions took into consideration that many areas of MWNM are typically very quiet in terms of manmade noise sources and that manmade noises have been shown to be a source of irritation for visitors hoping to experience a more peaceful, natural soundscape.

## ***Impacts of the No Action Alternative***

### Analysis

Under the No Action Alternative, no work would be conducted, though some bridges may be replaced in-kind, which would cause adverse construction-related impacts at the time of replacement.

### Conclusion

Any in-kind bridge replacement conducted as part of the No Action Alternative would have short-term temporary adverse impacts on soundscapes during construction. There would be no other noise impacts associated with this alternative.

## ***Creek Restoration Alternatives***

### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

All creek restoration alternatives include revegetation of any impacted creek banks or areas of forest floor, installation of grade control in a tributary just upstream of Cathedral Grove, and installation of beaver dam analogs. These activities would be performed by hand and would generate negligible amounts of noise.

#### *Conclusion*

No impacts to soundscapes are anticipated from these actions.

### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Creek Restoration Alternative 1 involves the removal and burial of Phase 1 portions and hauling out of Phase 2 portions of approximately 1,019 LF of riprap and the relocation of approximately 34 to 50 existing downed trees into the channel. Heavy equipment and dewatering pumps and the breaking of some over-sized rocks would be used to complete this work which would have temporary, adverse impacts on soundscapes. After work is completed, this alternative would not have any long-term impact on soundscapes. Noise-attenuating pumps would be used during dewatering and additional methods of attenuating noise, such as surrounding pumps with rice straw bales, may be employed as well.

#### *Conclusion*

Creek Restoration Alternative 1 would have temporary, moderate, adverse impacts on soundscapes throughout the monument. Once work is complete, it would have no long-term impact.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 involves the removal of approximately 338 LF of riprap (in the Entry Plaza Area and near Cathedral Grove) and 350 LF of asphalt trail would be removed from Cathedral Grove in addition to the work described in Creek Restoration Alternative 1. The additional riprap removed near Cathedral Grove would be buried in the channel. Removal of riprap near the Entry Plaza would require the use of additional dewatering pumps. Materials would be

hailed out via the same routes described earlier and would increase temporary impacts proportionally.

### *Conclusion*

Creek Restoration Alternative 2 would have temporary, moderate, adverse impacts on soundscapes throughout the monument that would be greater than those of Creek Restoration Alternative 1 in proportion to the additional amount of work being proposed. Once work is complete, it would have no long-term impact on soundscapes.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Creek Restoration Alternative 3 involves installation of log jams downstream of Bridge 1 and terracing of the right bank in the Entry Plaza Area in addition to the work described in Creek Restoration Alternative 2. These materials would be hauled out via the same routes described earlier and would increase temporary impacts proportionally. The Plaza is a busy area of MWNM and can have loud crowd noises; however, sound from construction equipment and operations is perceived differently from that of crowds.

### *Conclusion*

Creek Restoration Alternative 3 would have temporary, moderate, adverse impacts on soundscapes throughout the monument that would be greater than those of Creek Restoration Alternative 1 in proportion to the additional amount of work being proposed. Once work is complete, it would have no long-term impact on soundscapes.

### Impacts of Creek Restoration Alternative 4:

#### *Analysis*

Creek Restoration Alternative 4 involves the removal of approximately 270 LF of riprap (of which Phase 1 portions would be buried in the channel), excavation of an alcove, and rerouting of 555 LF of trail in addition to the work described in Creek Restoration Alternative 2. Removal of riprap near the footbridge 1.5 area would require the use of additional dewatering pumps. These materials would be hauled out via the same routes described earlier and would increase temporary impacts proportionally.

### *Conclusion*

Creek Restoration Alternative 4 would have temporary, moderate, adverse impacts on soundscapes throughout the monument that would be greater than those of Creek Restoration Alternative 1 in proportion to the additional amount of work being proposed. Once work is complete, it would have no long-term impact on soundscapes.

### Impacts of Creek Restoration Alternative 5:

#### *Analysis*

Creek Restoration Alternative 5 consists of all of the actions and impacts of Creek Restoration Alternative 4 along with the right bank terracing described in Creek Restoration Alternative 3.

### *Conclusion*

The impacts of this alternative would be similar and proportionally greater than those found in Creek Restoration Alternative 4.

## ***Pedestrian Bridge Replacement Alternatives***

### **Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives:**

#### ***Analysis***

Actions common to all bridge alternatives include removing and replacing Bridges 1 and 4. The use of heavy machinery to remove and haul away the old bridges and walkway debris and to install the new bridges would generate noise for the duration of work activity. The removal and replacement of bridge abutments would generate noise in addition to that described for in-kind bridge replacement under the No Action Alternative.

#### ***Conclusion***

The actions common to all bridge alternatives would create temporary, moderate, adverse impacts for soundscapes in MWNM. No long-term impacts to soundscapes are anticipated from this alternative.

### **Impacts of Pedestrian Bridge Replacement Alternative A:**

#### ***Analysis***

Pedestrian Bridge Replacement Alternative A involves the removal and replacement of Bridges 2 and 3, construction of boardwalk approaches, and rerouting trail segments. The use of heavy machinery to perform this work would generate noise around these sites and along hauling routes for the duration of work activity. Over the long-term, while noise from walking on the boardwalk is possible, such impacts are considered minor.

#### ***Conclusion***

Pedestrian Bridge Replacement Alternative A would create temporary, moderate, adverse impacts for soundscapes in the monument during construction. Long-term adverse impacts to soundscapes are anticipated to be minor due to use of the new boardwalk.

### **Impacts of Pedestrian Bridge Replacement Alternative B:**

#### ***Analysis***

Pedestrian Bridge Replacement Alternative B involves the replacement of Bridges 2 and 3 with longer spans and requires more trail rerouting than Pedestrian Bridge Replacement Alternative A. The use of heavy machinery to perform this work would generate noise around these sites and along hauling routes for the duration of work activity.

#### ***Conclusion***

Pedestrian Bridge Replacement Alternative B would create temporary, moderate, adverse impacts for soundscapes in the monument greater than those of Pedestrian Bridge Replacement Alternative A, in proportion to the amount of work proposed. No long-term impacts to soundscapes are anticipated from this alternative.

### **Impacts of Pedestrian Bridge Replacement Alternative C:**

#### ***Analysis***

Pedestrian Bridge Replacement Alternative C involves the replacement of Bridge 2 with the same span and trail adjustments as Pedestrian Bridge Replacement Alternative A and Bridge 3 with the same span and trail adjustments as Pedestrian Bridge Replacement Alternative B. The use of heavy

machinery to perform this work would generate noise around these sites and along hauling routes for the duration of work activity.

### *Conclusion*

Pedestrian Bridge Replacement Alternative C would create temporary, moderate, adverse impacts for soundscapes in the monument between than those of Pedestrian Bridge Replacement Alternative A and B, in proportion to the amount of work proposed. No long-term impacts to soundscapes are anticipated from this alternative.

### ***Cumulative Impacts***

The cumulative effects of the various projects are first described, and then considered in combination with the Proposed Action. The Muir Woods Reservation System will have long-term beneficial impacts on soundscapes throughout the monument by lowering noise due to a smaller number of visitors and reduced peak vehicular traffic.

The Muir Woods Road Bridge Replacement Project is located south of the monument, but may still have short-term adverse impacts on soundscapes in some areas of the monument during construction. It is not anticipated to have any long-term impacts on soundscapes.

The Muir Woods Road Rehabilitation Project will have short-term adverse impacts on soundscapes during construction and is not anticipated to have any long-term impacts.

The Muir Woods Water/Wastewater Line Replacement work will have short-term adverse impacts on soundscapes during construction and is not anticipated to have any long-term impacts.

The Muir Woods Sustainable Access Project would have short-term adverse impacts on soundscapes during construction and long-term minor beneficial impacts on soundscapes in the Plaza Area by improving operational efficiency and vehicular circulation and shifting vehicular traffic slightly farther away from the entrance. The No Action Alternative may involve in-kind bridge replacement at some future time. This would have an additional short-term adverse impact on soundscapes during construction.

Taken together, with the exception of the Muir Woods Reservation System Project, the projects would combine to create minor to moderate adverse short-term noise impacts as each project is being constructed. This would particularly be the case if project construction overlaps. The Proposed Action is most likely to overlap with the Water/Wastewater Line Replacement which would increase cumulative impacts to soundscapes in the area.

Over the long term, noise impacts would be generally unaffected, with the exception of beneficial impacts related to the reservation system.

### ***Conclusion***

Completing all of the actions described in the alternatives would have moderate, temporary adverse impacts on soundscapes throughout MWNM. After work is completed, these projects are not anticipated to have any major long-term impact on soundscapes.

## **4.13 Air Quality and Greenhouse Gas Emissions**

### ***Methodology and Assumptions***

The air quality and GHG analysis focuses on impacts to air quality and GHG emissions arising from use of trucks, passenger vehicles, and power equipment. Some vehicles and equipment may be powered by gasoline (such as construction worker vehicles), while others may be powered by

diesel, bio-diesel, or vegetable oil. Activities that would result in such emissions include construction worker commutes, delivery of supplies and materials, construction and restoration activities requiring powered equipment, and hauling of waste material such as riprap, bridge materials, and asphalt out of the monument to storage and disposal locations. This would result in emissions of criteria pollutants and toxic air contaminants such as carbon monoxide, particulate matter, hydrocarbons, sulfur oxides, and NO<sub>x</sub>.

Biodiesel will be required for equipment operating in the stream channel; however, trucks transporting material out of MWNM may use standard diesel fuel. In addition to being less toxic to Coho salmon and other aquatic organisms (Khan et al. 2007), biodiesel emissions are often cleaner than traditional diesel in terms of PM, hydrocarbons, smoke, and carbon monoxide, though emissions of carbon dioxide and NO<sub>x</sub> can be higher (Anderson 2012).

Impact severity descriptions took into consideration that visitors to MWNM are typically exposed to, and expecting, relatively “fresh” clean air.

### ***Impacts of the No Action Alternative***

#### Analysis

Under the No Action Alternative, no work would be conducted, though some bridges may be replaced in-kind at some point in the future. Bridge replacement would require vehicles and heavy equipment that would result in air pollutant emissions.

#### Conclusion

The No Action Alternative would have no impact on air quality in the short-term. Any in-kind bridge replacement work would have short-term air quality impacts during construction.

### ***Creek Restoration Alternatives***

#### Impacts of Actions Common to all Creek Restoration Alternatives

#### *Analysis*

All creek restoration alternatives include revegetation of any impacted creek banks or areas of forest floor, the installation of grade control in a tributary just upstream of Cathedral Grove, and installation of beaver dam analogs. Air quality impacts from revegetation, grade control installation, and beaver dam analog installation would be minimal since work will be performed using hand equipment. Beneficial impacts on air quality and climate change from these activities may result from improved long-term carbon dioxide uptake and carbon sequestration associated with planted vegetation and enhanced forest health resulting from improved groundwater elevations.

#### *Conclusion*

The actions common to all creek restoration alternatives would have little or no short-term impacts on air quality and may have minor long-term beneficial impacts on air quality and climate change due to higher rates of carbon dioxide uptake and carbon sequestration compared to the No Action Alternative.

#### Impacts of Creek Restoration Alternative 1:

#### *Analysis*

Creek Restoration Alternative 1 involves the use of various types of heavy equipment and vehicles to deliver materials, move and place LWD, and remove, bury, and haul riprap. While underway, these activities, along with worker trips, would impact air quality in and around the monument.

Operating equipment during the construction period would result in increased vehicle exhaust and emissions of air pollutants and GHGs. Overall, there would be a slight and temporary degradation of local air quality due to emissions from construction equipment. These effects would last only as long as construction occurred. BMPs for reducing air pollutant and GHG emissions would be implemented, such as minimizing idling time of equipment when not in use and using low emission producing equipment when feasible (BMP-15) and maintaining construction equipment in proper working condition (BMP-4) (see Appendix D). Overall, this alternative would not measurably contribute greenhouse gases affecting global climate change.

### *Conclusion*

Creek Restoration Alternative 1 would have short-term adverse impacts on air quality and GHG emissions in and around the MWNM as a result of heavy equipment use, vehicles, and worker trips. Once work is complete, the alternative would have no long-term adverse impact on air quality and climate change. Benefits to local ecosystem health and climate resilience may lead to greater carbon dioxide uptake and sequestration, a beneficial impact.

### Impacts of Creek Restoration Alternative 2:

#### *Analysis*

Creek Restoration Alternative 2 involves the removal of additional riprap, burial of the Phase 1 portion of this riprap, and asphalt trail compared to Creek Restoration Alternative 1. These activities would increase short-term emissions proportionally. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Creek Restoration Alternative 1. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

### *Conclusion*

Creek Restoration Alternative 2 would have temporary, moderate, adverse impacts on air quality and GHG emissions throughout the monument that would be greater than those of Creek Restoration Alternative 1 in proportion to the additional amount of work being proposed. Once work is complete, it would have no long-term adverse impact on air quality. Benefits to local ecosystem health and climate resilience may lead to greater carbon dioxide uptake and sequestration.

### Impacts of Creek Restoration Alternative 3:

#### *Analysis*

Creek Restoration Alternative 3 would involve the same activities as Creek Restoration Alternative 2, with the addition of engineered log jam installation and bank terracing near the Entry Plaza. The additional heavy equipment use and travel in the entry plaza area would increase impacts on air quality compared to Creek Restoration Alternative 2. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Creek Restoration Alternative 1. Overall, this alternative would not measurably contribute greenhouse gases affecting global climate change.

### *Conclusion*

Creek Restoration Alternative 3 would have short-term adverse impacts on air quality in the Plaza Area, lasting longer than those described for Creek Restoration Alternative 2 due to the additional work involved.

#### Impacts of Creek Restoration Alternative 4:

##### *Analysis*

Creek Restoration Alternative 4 involves the removal of additional riprap, burial of the Phase 1 portion of this riprap, and asphalt trail and includes engineered log jam installation compared to Creek Restoration Alternative 3. These activities would increase short-term emissions proportionally. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Creek Restoration Alternative 1. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

##### *Conclusion*

Creek Restoration Alternative 4 would have temporary, moderate, adverse impacts on air quality throughout the monument that would be greater than those of Creek Restoration Alternative 3 in proportion to the additional amount of work being proposed. Once work is complete, the alternative would have no long-term adverse impact on air quality. Benefits to local ecosystem health and climate resilience may lead to greater carbon dioxide uptake and sequestration, a beneficial impact.

#### Impacts of Creek Restoration Alternative 5:

##### *Analysis*

In addition to the activities discussed for Creek Restoration Alternative 4, Creek Restoration Alternative 5 involves terracing the right bank in the Entry Plaza Area. These activities would increase short-term emissions proportionally. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Creek Restoration Alternative 1. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

##### *Conclusion*

Creek Restoration Alternative 5 would have temporary, moderate, adverse impacts on air quality throughout the monument that would be greater than those of Creek Restoration Alternative 4 in proportion to the additional amount of work being proposed. Once work is complete, the alternative would have no long-term adverse impact on air quality. GHG emissions would be minor during construction, and the restoration would have a long-term beneficial effect related to climate change.

### ***Pedestrian Bridge Replacement Alternatives***

#### Impacts of Actions Common to all Pedestrian Bridge Replacement Alternatives

##### *Analysis*

All bridge alternatives include replacing Bridges 1 and 4. The material from these bridges would be hauled out and transported to a landfill and material for new bridge construction would be imported. Powered equipment would be used to dismantle and haul away the existing bridges and to construct the new bridges. Operating equipment during the construction period would result in increased vehicle exhaust and emissions of air pollutants and GHGs. Overall, there would be a slight and temporary degradation of local air quality due to emissions from construction equipment. These effects would last only as long as construction occurred. BMPs for reducing air pollutant and GHG emissions would be implemented, such as minimizing idling time of equipment when not in use and using low emission producing equipment when feasible (BMP-15) and maintaining

construction equipment in proper working condition (BMP-4) (see Appendix D). Overall, these actions would not measurably contribute GHGs affecting global climate change.

### *Conclusion*

The actions common to all bridge alternatives would result in short-term adverse impacts to air quality and emissions of GHGs at the bridge sites and along the haul away routes. No long-term impact to air quality or climate change is anticipated from this work.

### Impacts of Pedestrian Bridge Replacement Alternative A

#### *Analysis*

Pedestrian Bridge Replacement Alternative A includes the removal and replacement of Bridges 2 and 3 and some nearby asphalt. This material would be hauled out and transported to a landfill, and material for replacement bridges would be imported. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Actions Common to all Pedestrian Bridge Replacement Alternatives. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative A would result in short-term adverse impacts to air quality and GHG emissions at the bridge sites and along the haul routes. No long-term impact to air quality or climate change is anticipated from this work.

### Impacts of Pedestrian Bridge Replacement Alternative B:

#### *Analysis*

Pedestrian Bridge Replacement Alternative B is similar to Pedestrian Bridge Replacement Alternative A, but would require the removal of additional asphalt. This material would be hauled out and transported to a landfill. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Actions Common to all Pedestrian Bridge Replacement Alternatives. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative B would result in temporary adverse impacts to air quality and have GHG emissions at the bridge sites and along the haul away routes which would be somewhat greater than Pedestrian Bridge Replacement Alternative A. No long-term impact to air quality or climate change is anticipated from this work.

### Impacts of Pedestrian Bridge Replacement Alternative C:

#### *Analysis*

Pedestrian Bridge Replacement Alternative C would require the removal of additional asphalt than Alternative B but would remove less than Alternative B. This material would be hauled out and transported to a landfill. BMPs for reducing air pollutant and GHG emissions would be implemented as described in Actions Common to all Pedestrian Bridge Replacement Alternatives. Overall, this alternative would not measurably contribute GHGs affecting global climate change.

#### *Conclusion*

Pedestrian Bridge Replacement Alternative C would result in temporary adverse impacts to air quality and have GHG emissions at the bridge sites and along the haul away routes which would be

somewhat greater than Pedestrian Bridge Replacement Alternative A, but less than Alternative B. No long-term impact to air quality or climate change is anticipated from this work.

### ***Cumulative Impacts***

This discussion first focuses on the cumulative impacts of other projects, and then considers these impacts in combination with impacts of the Proposed Action.

The Muir Woods Reservation System will reduce traffic to, and congestion around, MWNM and is likely to have a long-term minor beneficial impact on air quality in the area, as well as reducing GHG emissions.

The Muir Woods Road Bridge Replacement Project and the Muir Woods Road Rehabilitation Project will result in temporary adverse impacts to air quality and emit GHGs during construction; the projects are not anticipated to have any long-term air quality or climate change impacts. These projects are scheduled for 2019 and may overlap.

The Muir Woods Water/Wastewater Line Replacement will result in temporary adverse impacts to air quality and emit GHGs while work is underway and is not anticipated to have any long-term impacts on air quality or climate change.

The Muir Woods Sustainable Access Project would have temporary adverse impacts on air quality and emit GHGs during implementation and would likely have minor long-term beneficial impacts due to improved shuttle and bus circulation.

Any in-kind bridge replacement work would take place at some point in the future and would not be anticipated to meaningfully contribute to any construction-related or operational cumulative impacts.

To the extent that construction of these various projects would overlap, they would combine to create cumulative air quality impacts, and would have combined GHG emissions.

The Proposed Action and the Muir Woods Reservation System will have cumulative long-term beneficial impacts on air quality and climate change in terms of reduced vehicular emissions and greater carbon sequestration.

### ***Conclusion***

Completing all of the actions described in the alternatives would have moderate short-term impacts on air quality and result in GHG emissions at and around MWNM due to construction activity, worker trips, and hauling trips. Once complete, this work would not have any long-term adverse impacts on air quality. The improvements to the local redwood forest ecosystem's health and climate resilience in addition to new areas of vegetation would have beneficial long-term impacts on air quality and climate change in the form of enhanced carbon dioxide uptake and sequestration.

## CONSULTATION AND COORDINATION

### 5.1 Compliance with Agency Consultation Requirements

The following sections describe relevant federal and state consultation requirements and the consultation that has either already been or would be completed for the lead agencies to be in compliance with applicable laws and regulations. Table 5-1 summarizes the regulatory permits, approvals, and consultations that apply to the alternatives being considered as part of the Proposed Action.

#### ***Federal Requirements***

##### Clean Water Act

The Clean Water Act (CWA) is the primary federal legislation governing the protection of surface water. NPS will need to comply with CWA Sections 401 and 404 for both creek restoration and bridge replacement actions.

The authority to implement and oversee most of the programs authorized under the CWA rests with USACE and the State Water Resources Control Board (SWRCB) (through the RWQCBs). USACE, through its regulatory program, administers and enforces CWA Section 404. Under Section 404, a permit is required for the discharge of dredged or fill materials into waters of the U.S., including wetlands. CWA Section 401 requires that an applicant applying for a federal permit to conduct an activity that might result in the discharge of a pollutant to a water of the U.S. obtain a water quality certification (or waiver) verifying that the discharge would not violate state water quality standards. Water quality certifications are issued by RWQCBs in California, with the exception of activities on federal land, in which case the certifications are issued by the USEPA. The Proposed Action would be located within the jurisdiction of the San Francisco RWQCB.

NPS or its designee would prepare applications for permits under CWA Section 404 and water quality certifications under CWA Section 401 from USEPA and/or the San Francisco RWQCB for any actions that require them.

##### Clean Air Act Section 309

Under CAA Section 309, USEPA may review and provide comments on the environmental impacts of major federal actions, such as those that are described in EAs. In the event that USEPA determines the action is “environmentally unsatisfactory,” CAA Section 309 requires USEPA to refer such matters to CEQ (USEPA 2017).

Consistent with CAA Section 309, NPS would notify USEPA during the public review process.

##### Federal Endangered Species Act

ESA provides a program for the conservation of threatened and endangered plants and animals and the habitat in which they live. In accordance with the ESA, USFWS and NMFS have authority over projects that might result in the “take” of a species listed as threatened or endangered. If a project is likely to result in the take of a federally listed species, either an incidental take permit under ESA Section 10(a) or a federal interagency consultation under ESA Section 7 is required.

A list of threatened and endangered species known to occur in the vicinity of the Proposed Action are presented in Section 3.3, Threatened or Endangered Species. NPS, as a federal agency, initiated consultation under Section 7 with the appropriate departments within USFWS and NMFS NPS

initiated informal consultation with the USFWS on August 30, 2017. USFWS was provided a copy of the EA for their review. NPS sought concurrence from USFWS that the Proposed Action may affect, but is not likely to adversely affect, federally listed species under their jurisdiction. NPS received concurrence from USFWS on October 4, 2017.

NPS initiated formal consultation with NMFS on June 30, 2017 regarding listed species under their jurisdiction. NMFS was provided a copy of the EA for their review. A representative from NMFS visited the project site on December 1, 2016. NPS received the biological opinion stating that the Proposed Action is unlikely to jeopardize the continued existence or destroy or adversely modify designated critical habitat of species under their jurisdiction. NPS received an incidental take permit from NMFS on September 20, 2017.

#### Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) ensures that fish and wildlife receive equal consideration with water resources development during planning and construction of federal water projects by requiring that the federal agencies consult with USFWS, NMFS, and the state wildlife resources agency before the waters of any stream or other waterbody are impounded, diverted, deepened, or otherwise controlled or modified. FWCA requires that the views of USFWS and the state agency be considered when evaluating the impacts and determining mitigation needs. NEPA regulations further require that an EA meet the consultation requirements of FWCA (40 CFR 1502.25[a]).

For the Proposed Action, compliance with FWCA requires that NPS coordinate with NMFS, CDFW, and SWRCB. FWCA consultation requirements are being satisfied through the EA process.

#### National Historic Preservation Act

Section 106 of the NHPA 1966 (as amended in 1922) requires federal agencies to evaluate the effects of federal undertakings on historic, archaeological, and cultural resources. Before federal funds can be approved for a particular project and the issuance of any license, any of these effects would be evaluated.

NPS serves as the lead agency for compliance with NHPA for the Proposed Action. To comply with NHPA, NPS must “take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register.” A copy of the Draft EA was sent to the State Historic Preservation Officer requesting review and soliciting input on the Proposed Action. NPS initiated consultation with the State Historic Preservation Officer on March 23, 2017. Consultation will be complete when both NPS and SHPO execute an MOA as required under 36 CFR 800.6 in order to mitigate the adverse effects of this project.

#### Native American Consultation

The regulations for NHPA Section 106 require federal agencies to consult with Native American tribes that attach cultural or religious significance to cultural resources subject to management during the NHPA Section 106 process (36 CFR 800.2). Each federal agency performing an action that constitutes an undertaking as defined in the Section 106 regulations will consult with relevant Native American tribes regarding that undertaking (36 CFR 800.16[y]). NPS initiated consultation with the Federated Indians of Graton Rancheria (Graton Rancheria), March 23, 2017. Consultation will be complete when Graton Rancheria, NPS and SHPO execute an MOA in order to avoid or mitigate any potential adverse effects of this project on Native American resources.

**Table 5-1.** Regulatory Permits, Approvals, and Consultations Relevant to the Proposed Action

Regulatory Agency	Law/Regulation	Purpose	Relevant Activities	Permit/Authorization Type
<b>Federal</b>				
USACE–San Francisco District	CWA Section 404	Regulates placement of dredge and fill materials into waters of the U.S., including wetlands	Removal of riprap, placement of LWD, bank grading and revegetation, terracing, bridge replacement.	Individual or nationwide permits
USEPA	CWA Section 309	Requires USEPA to review and publicly comment on the environmental impacts of major federal actions	Creek restoration and bridge replacement actions.	No permit/authorization issued (only public comments)
USFWS/NMFS	ESA	Consultation with USFWS and NMFS if threatened or endangered species might be affected by the project.	Creek restoration and bridge replacement actions.	ESA Section 7 Consultation.
<b>State</b>				
Regional Water Quality Control Board	CWA Section 401	Water quality certification for placement of dredge and fill materials into waters of the U.S., including wetlands	Removal of riprap, placement of LWD, terracing, bridge replacement.	401 Water Quality Certification is required for federal permits, such as CWA Section 404 Permits
	CWA Section 402	NPDES program, which regulates discharges of pollutants	Creek restoration and bridge replacement actions.	NPDES General Construction Permit
	Porter–Cologne Water Quality Control Act	Regulates discharges of materials to land and protection of beneficial uses of waters of the state	Creek restoration and bridge replacement actions.	Waste Discharge Requirements

Regulatory Agency	Law/Regulation	Purpose	Relevant Activities	Permit/Authorization Type
CDFW	F&G Code Section 1602	Applies to activities that will substantially modify a river, stream, or lake; includes reasonable conditions necessary to protect those resources	Creek restoration and bridge replacement actions.	Streambed Alteration Agreement, if required
	CESA (F&G Code Sections 2080.3, 2080.4, and 2081)	Applies to activities that could result in take of a state-listed threatened or endangered species	Project activities with potential for take of listed species	Incidental Take Permit, if needed
	F&G Code Sections 3503, 3513, 3800, and other sections and subsections	Protection of birds	Project activities with potential for effects on birds	Reflected in other permits (e.g., Streambed Alteration Agreement)
State Historic Preservation Officer; Federated Indians of Graton Rancheria	NHPA Section 106	Consultation with the State Historic Preservation Officer and the Federated Indians of Graton Rancheria, if historic properties, prehistoric archaeological sites, or Native American resources might be affected by the project	Riprap removal and bridge replacement and trail modifications	Consultation will be conducted by NPS

## ***Other Legal Considerations***

### Right-of-Entry Permit

NPS would need to obtain a right-of-entry permit from California State Parks for the use of Alice Eastwood Group Camp as a staging area, as well as for installation of some bridges.

### Porter-Cologne Water Quality Control Act

The Porter-Cologne Water Quality Control Act (Porter-Cologne) established the SWRCB and nine RWQCBs, and gave them authority to regulate the water quality of state waters. Compliance with Porter-Cologne is normally accomplished within the framework of CWA Section 401 compliance.

### California Endangered Species Act

The California Endangered Species Act (CESA) (California Fish and Game Code Section 2050 et. seq.) prohibits the take of listed and candidate (petitioned to be listed) species. For projects that would affect a species that is federally and state listed, compliance with the ESA satisfies CESA if CDFW determines that the federal incidental take authorization is consistent with CESA (California Fish and Game Code Section 2080.1). For projects that would result in take of a state-only listed species, the project proponent must apply for a take permit under California Fish and Game Code Section 2081(b).

## **5.2 Internal Scoping**

A Choosing by Advantages (CBA) meeting was held on January 19, 2017, to discuss the Proposed Action and choose preferred alternatives. Stakeholders and subject matter experts within NPS and the Golden Gate National Parks Conservancy evaluated the advantages of each alternative and chose the preferred alternatives. A secondary CBA meeting was held on February 13, 2017, to confirm the details of the preferred Pedestrian Bridge Replacement Alternative.

## Chapter 6

### LIST OF PREPARERS

Name	Title
<b><i>National Park Service</i></b>	
Carolyn Shoulders	Project Manager, Natural Resource Specialist
Kirsten Holder	Landscape Architect
Tania Pollak	Project Manager, Environmental Planner
Amy Hoke	Historical Landscape Architect
Darren Fong	Aquatic Ecologist
Alison Forrestel	Supervisory Vegetation Ecologist
Bill Merkle	Wildlife Ecologist
Bob Holloway	Section 106 Program Manager
Larry Miranda	NEPA Program Manager
Stephen Skartvedt	GIS Specialist
Peter Gavette	Archeologist
Barnaby Fisher	Trails Supervisor
Mia Monroe	Marin County Community Liaison
Daphne Hatch	Chief of Natural Resources
Brian Aviles	Chief of Planning
Emily Levine	Supervisory Park Ranger
Jerry Scheumann	Chief of Maintenance
Steve Ortega	Environmental Protection Specialist
<b><i>Consultant</i></b>	
Gary Roth	Roth/LaMotte Landscape Architecture
<b><i>Horizon Water and Environment</i></b>	
Michael Stevenson	Principal, Project Manager, QA/QC
Ken Schwarz	Principal, Technical Reviewer
Kevin Fisher	Director of Ecological Services, Technical Reviewer
Janis Offermann	Cultural Resources Practice Leader
Brian Piontek	Associate, Hydrology and Geology
Kara Brunzell	Senior Architectural Historian
Robin Hunter	Deputy Project Manager, Biologist, GIS Analyst
Johnnie Chamberlin	Air Quality, Soundscapes and Visitor Experience
Debra Lilly	Senior Associate, Editor
Linda Littleton	Editor
Paul Glendening	GIS Analyst
Lorrie Jo Williams	Graphic Designer/Editor

## Chapter 7

# REFERENCES

### ***Chapter 1: Purpose and Need***

- Auwaerter, J. and J. Sears. 2006. Historic Resource Study for Muir Woods National Monument: Golden Gate National Recreation Area.
- Fong, D., B. Becker, and M. Reichmuth. 2016. Draft Summary and Analysis of Salmonid Data, Muir Woods National Monument, 1995 to 2015. August.
- National Park Service. 2001. Director's Order 12 Handbook.
2011. Director's Order 12: Conservation Planning, Environmental Impact Analysis, and Decision-Making. Washington, DC.
2014. Final General Management Plan / Environmental Impact Statement for Golden Gate National Recreation Area and Muir Woods National Monument.
- 2015a. National Park Service NEPA Handbook. Available: [www.nps.gov/applications/npspolicy/DOrders.cfm](http://www.nps.gov/applications/npspolicy/DOrders.cfm).
- NHE. *See* Northern Hydrology and Engineering.
- Northern Hydrology and Engineering. 2017. Salmon Habitat Restoration at Muir Woods. Site Analysis, Conceptual Designs and Impact Analysis. August.
- NPS. *See* National Park Service.

### ***Chapter 2: Alternatives***

- California Department of Fish and Game. 2009. Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities. Available: [www.dfg.ca.gov/biogeodata/cnddb/pdfs/protocols\\_for\\_surveying\\_and\\_evaluating\\_impacts.pdf](http://www.dfg.ca.gov/biogeodata/cnddb/pdfs/protocols_for_surveying_and_evaluating_impacts.pdf).
- National Marine Fisheries Service. 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act. June.
- National Park Service. 2006 Management Policies 2006. Available: <http://www.nps.gov/policy/mp2006.pdf>.
2014. Final General Management Plan / Environmental Impact Statement for Golden Gate National Recreation Area and Muir Woods National Monument.

NHE. *See* Northern Hydrology and Engineering.

Northern Hydrology and Engineering. 2017. Salmon Habitat Restoration at Muir Woods. Site Analysis, Conceptual Designs and Impact Analysis. August.

NMFS. *See* National Marine Fisheries Service.

NPS. *See* National Park Service.

Pacific Watershed Associates. 2002. Summary Report, 2000 S.B. 271 Watershed Assessment and Erosion Prevention Planning Project for the Redwood Creek Watershed, Marin County, California, Contract No. P9985121. Prepared for Muir Beach Community Services District, California Dept. of Fish and Game, Marin Municipal Water District and National Park Service.

### **Chapter 3: Affected Environment**

#### **INTRODUCTION**

National Park Service. 2015b. Muir Woods National Monument Reservation System. October.

2016a. Muir Woods National Monument Sustainable Access Project.

#### **CULTURAL RESOURCES**

Auwaerter, J. and J. Sears. 2006. Historic Resource Study for Muir Woods National Monument: Golden Gate National Recreation Area.

Brunzell, K. 2017. Redwood Creek Riprap Assessment.

Gavette, P. 2017. Archeological Survey and Testing For the Salmon Habitat Enhancement and Bridge Replacement Project, Muir Woods National Monument, California. October.

#### **THREATENED OR ENDANGERED SPECIES**

Bustard, D.R. and Narver, D.W., 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). *Journal of the Fisheries Board of Canada*, 32(5), pp.667-680.

California Department of Fish and Game. 2004. Recovery strategy for California Coho salmon. Report to the California Fish and Game Commission. 594 pp.

Ellis, T, and K. Harrigan. 2016. Monitoring northern spotted owls on federal lands in Marin County, California: 2013 report. Natural Resource Report NPS/SFAN/NRR—2016/1180. National Park Service, Fort Collins, Colorado. Available: [http://science.nature.nps.gov/im/units/sfan/monitor/spotted\\_owls.cfm](http://science.nature.nps.gov/im/units/sfan/monitor/spotted_owls.cfm).

- Fong, D., B. Becker, and M. Reichmuth. 2016. Draft Summary and Analysis of Salmonid Data, Muir Woods National Monument, 1995 to 2015. August.
- Forrestel, Alison. 2017. Personal communication with Robin Hunter. E-mail.
- Gardali, T., and G. R. Geupel. 2000. Bird Monitoring in the Muir Woods National Monument: Summary of Results from 1997-1999 and Suggested Long-term Monitoring Plan. Final Report, Cooperative Agreement No. 1443-CA-8140-96-003.
- National Oceanic and Atmospheric Administration. 2012. Final Recovery Plan for Central California Coast Coho salmon Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.
2015. Public Draft Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.
- National Park Service. 2005 Fire Management Plan Final Environmental Impact Statement. Golden Gate National Recreation Area. November.
- Nickelson, T.E., Rodgers, J.D., Johnson, S.L. and Solazzi, M.F., 1992. Seasonal changes in habitat use by juvenile coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences, 49(4), pp.783-789.
- NHE. *See* Northern Hydrology and Engineering.
- Northern Hydrology & Engineering. 2017. Salmon Habitat Restoration at Muir Woods Site Analysis, Conceptual Designs and Impact Analysis. August.
- NOAA. *See* National Oceanic and Atmospheric Administration.
- NPS. *See* National Park Service.
- Press, D., D. Adams, H. Jensen, K. Fehring, W. Merkle, M. Koenen, and L. A. Starcevich. 2010. San Francisco Bay Area Network northern spotted owl monitoring protocol: Version 6.4. Natural Resource Report NPS/SFAN/NRR—2010/245.
- Shirvell, C.S., 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) cover habitat under varying streamflows. Canadian Journal of Fisheries and Aquatic Sciences, 47(5), pp.852-861.
- Shor, A. 2016. Golden Gate National Parks *Phytophthora* Response Plan. Presentation. Sixth Sudden Oak Death Science Symposium. June 23, 2016.
- Smith, J. J. 2001. Distribution and abundance of juvenile Coho and steelhead in Redwood Creek in Fall 2001. Prepared for National Park Service, Golden Gate National Recreation Area. San Francisco, California.
- Stillwater Sciences and Horizon Water and Environment. 2011. Redwood Creek Watershed Assessment. Final Report. Prepared for Golden Gate National Recreation Area. August.

- U.S. Fish and Wildlife Service. 1997. Recovery Plan for the Threatened Marbled Murrelet (*Brachyramphus marmoratus*) in Washington, Oregon, and California. Portland, Oregon. Available: [https://www.fws.gov/arcata/es/birds/mm/m\\_murrelet.html](https://www.fws.gov/arcata/es/birds/mm/m_murrelet.html). Accessed November 14, 2016.
2011. Revised Recovery Plan for the Northern Spotted Owl (*Strix occidentalis caurina*). U.S. Fish and Wildlife Service, Portland, Oregon. xvi + 258 pp.
- USFWS. *See* U.S. Fish and Wildlife Service.
- GEOLOGY: SOILS, BEDROCK, STREAMBEDS**
- Auwaerter, J. and J. Sears. 2006. Historic Resource Study for Muir Woods National Monument, Golden Gate National Recreation Area. Olmsted Center for Landscape Preservation. Boston.
- California Geological Survey. 1991. Geologic Map of the San Francisco-San Jose Quadrangle. Regional Geologic Map No. 5A. 1:250,000 scale. Compiled by D.L. Wagner, E.J. Bortugno, and R.D. McJunkin. Available: <http://www.quake.ca.gov/gmaps/RGM/sfsj/sfsj.html>. Accessed December 23, 2016.
2002. California Geomorphic Provinces. Note 36. Available: [http://www.conservation.ca.gov/cgs/information/publications/cgs\\_notes/note\\_36/Documents/note\\_36.pdf](http://www.conservation.ca.gov/cgs/information/publications/cgs_notes/note_36/Documents/note_36.pdf). Accessed January 31, 2017.
- CGS. *See* California Geological Survey.
- McBride, J., and D. Jacobs. 1978. The History of the Vegetation at Muir Woods National Monument. Prepared for the National Park Service, San Francisco, California.
- National Parks Conservation Association. 2011 Muir Woods National Monument: A Resource Assessment. State of the Parks. 36 pp. Available: [www.nps.gov/muwo/learn/management/upload/State-of-the-Parks-MUWO-by-NPCA.pdf](http://www.nps.gov/muwo/learn/management/upload/State-of-the-Parks-MUWO-by-NPCA.pdf). Accessed October 10, 2016.
- NPCA. *See* National Parks Conservation Association.
- Stillwater Sciences. 2004. Sediment Budget for Redwood Creek Watershed, Marin County, California. Prepared for Golden Gate National Recreation Area, San Francisco, California.
- Stillwater Sciences and Horizon Water and Environment. 2011. Redwood Creek Watershed Assessment. Final Report. Prepared for Golden Gate National Recreation Area. August.
- USDA, NRCS. *See* U.S. Department of Agriculture, Natural Resources Conservation Service.
- U.S. Department of Agriculture, Natural Resources Conservation Service. 2016. Web Soil Survey. Available: <https://websoilsurvey.sc.egov.usda.gov/>. Accessed December 23, 2016.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2017. Soil Education, definition of a soil. Web page. Available [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2\\_054280](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054280). Accessed March 1, 2017.

#### **VISITOR USE AND EXPERIENCE**

National Park Service. 2014. Final General Management Plan / Environmental Impact Statement for Golden Gate National Recreation Area and Muir Woods National Monument.

2015b. Muir Woods National Monument Reservation System. October.

NPS. *See* National Park Service.

#### **TRANSPORTATION**

National Park Service. 2015. Muir Woods National Monument Reservation System. October.

2016a. Muir Woods National Monument Sustainable Access Project.

NPS. *See* National Park Service.

#### **WILDLIFE HABITAT**

California Department of Fish and Wildlife. 2016. California Natural Diversity Data Base (CNDDDB). Online database query. Available: [www.wildlife.ca.gov/Data/CNDDDB](http://www.wildlife.ca.gov/Data/CNDDDB). Accessed December 17, 2016.

CDFW. *See* California Department of Fish and Wildlife.

Environmental Science Associates. 2014 Muir Woods National Monument Redwood Creek Riprap Removal, Channel Migration, and Bridge Replacement Study. Final Report. December.

ESA. *See* Environmental Science Associates.

Fong, D., and J. A. Howell. 2006. Distribution and Abundance of California Giant Salamander (*Dicamptodon ensatus*) and Signal Crayfish (*Pacifastacus leniusculus*) in the Upper Redwood Creek Watershed, Marin County, California. USGS Open-File Report 2006-1066.

Gardali, T., and G. R. Geupel. 2000. Bird Monitoring in the Muir Woods National Monument: Summary of Results from 1997-1999 and Suggested Long-term Monitoring Plan. Final Report, Cooperative Agreement No. 1443-CA-8140-96-003.

Heady, P. A., and W. F. Frick. 2004. Bat Inventory of Muir Woods National Monument, Final Report. Central Coast Bat Research Group.

Kimball, L. C., and G. M. Kondolf. 2002. Analysis of Channel Geomorphology and Habitat Forming Processes for Feasibility Assessment of Rip-Rap Removal, Muir Woods National Monument. Final Report. May.

Stillwater Sciences and Horizon Water and Environment. 2011. Redwood Creek Watershed Assessment. Final Report. Prepared for Golden Gate National Recreation Area. August.

#### **WATER RESOURCES AND HYDROLOGIC PROCESSES**

Coopridge, M. 2004. San Francisco Area Network Preliminary Water Quality Status Report. National Park Service. December. Available: [www.sfnpns.org/download\\_product/1401/0](http://www.sfnpns.org/download_product/1401/0). Accessed October 5, 2016.

Environmental Science Associates. 2014. Muir Woods National Monument Redwood Creek Riprap Removal, Channel Migration, and Bridge Replacement Study. Final Report. December.

ESA. *See* Environmental Science Associates.

FEMA. 2009. Panel 06041C0465D. May 4. <http://msc.fema.gov/portal/>

National Park Service. 2014. Golden Gate National Recreation Area and Muir Woods National Monument Final General Management Plan / Environmental Impact Statement. Available: [parkplanning.nps.gov/document.cfm?parkID=303&projectID=15075&documentID=58777](http://parkplanning.nps.gov/document.cfm?parkID=303&projectID=15075&documentID=58777).

2016b. Stormwater Sampling Summary for Water Years 2015 and 2016 at Muir Woods National Monument. Prepared by Carolyn Shoulders. May.

NHE. *See* Northern Hydrology and Engineering.

Northern Hydrology & Engineering. 2017. Salmon Habitat Restoration at Muir Woods Site Analysis, Conceptual Designs and Impact Analysis. August.

NPCA. *See* National Parks Conservation Association.

NPS. *See* National Park Service.

Ryan, A. 2016. Delineation of Wetlands and “Other Waters” at Redwood Creek and Vicinity, Muir Woods National Monument, Golden Gate National Recreation Area. National Park Service, Marin County, CA. February 2016.

San Francisco Bay Regional Water Quality Control Board 2015. The San Francisco Bay Basin (Region 2) Water Quality Control Plan (Basin Plan). Administrative Law as of March 20, 2015. Available: [http://www.waterboards.ca.gov/sanfranciscobay/basin\\_planning.shtml](http://www.waterboards.ca.gov/sanfranciscobay/basin_planning.shtml). Accessed January 10, 2017.

- Stillwater Sciences. 2004. Sediment Budget for Redwood Creek Watershed, Marin County, California. Prepared for Golden Gate National Recreation Area, San Francisco, California.
- Stillwater Sciences and Horizon Water and Environment. 2011. Redwood Creek Watershed Assessment. Final Report. Prepared for Golden Gate National Recreation Area. August.
- U.S. Geological Survey . 2015. San Rafael Quadrangle, California-Marin County. 7.5-Minute Series.
- 2016a. Stream Stats Database. Available: <https://water.usgs.gov/osw/streamstats/california.html>. Accessed September 29, 2016.
- 2016b. National Water Information System Data for USGS Station 11460151, Redwood CA Hwy 1 Bridge A Muir Beach CA. Available: [waterdata.usgs.gov/nwis/inventory/?site\\_no=11460151&agency\\_cd=USGS](http://waterdata.usgs.gov/nwis/inventory/?site_no=11460151&agency_cd=USGS). Accessed September 29, 2016.
- 2016c. Stormwater Sampling Summary for Water Years 2015 and 2016 at Muir Woods National Monument. Prepared by Carolyn Shoulders. May.USGS. *See* U.S. Geological Survey.
- Wallitner, K. 2016. Freshwater quality monitoring in the San Francisco Bay Area: 2013-2014 biennial report. Natural Resource Report NPS/SFAN/NRR—2016/1188. National Park Service, Fort Collins, Colorado.
- Western Regional Climate Center. 2016. Climate Summary for Muir Woods, California, (046027). Available: [www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6027](http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca6027). Accessed December 5, 2016.
- WRCC. *See* Western Regional Climate Center.
- VEGETATION**
- California Native Plant Society. 2017. Inventory of Rare and Endangered Plants. Available at: [www.rareplants.cnps.org](http://www.rareplants.cnps.org).
- California Oak Mortality Task Force. 2004. Sudden Oak Death Guidelines for Arborists.
- CNPS. *See* California Native Plant Society.
- Davidson, J. M., S. Werres, M. Garbelotto, E. M. Hansen, and D. M. Rizzo. 2003. Sudden oak death and associated diseases caused by *Phytophthora ramorum*. *Plant Health Progress*. doi:10.1094/PHP-2003-0707-01-DG.
- Forrestel, Alison. 2017. Personal communication with Robin Hunter. E-mail.

- Gonzalez, P., J. J. Battles, B. M. Collins, T. Robards, and D. S. Saah. 2015. Aboveground live carbon stock changes of California wildland ecosystems, 2001-2010. *Forest Ecology and Management* 348:68-77.
- Integrated Resource Management Applications. 2005. Certified Species List for Vascular Plants in Muir Woods National Monument. Date Certified: September 28, 2005.
- IRMA. *See* Integrated Resource Management Applications.
- National Park Service. 2016c. A natural resource condition assessment for Golden Gate National Recreation Area. Natural Resource Report. National Park Service, Fort Collins, Colorado.
- NPS. *See* National Park Service.
- Schirokauer, D., T. Keeler-Wolf, J. Menke, and P. van der Leeden. 2003. Point Reyes National Seashore, Golden Gate National Recreation Area, and surrounding wildlands plant community classification and mapping project final report. National Park Service, Point Reyes Station, California, USA.
- Shor, A. 2016. The Golden Gate National Parks *Phytophthora* Response Plan. Presentation at the Sudden Oak Death 6<sup>th</sup> Science Symposium. June 23.
- Steers, R. 2013. Vegetation Resource Surveys in Muir Woods National Monument: Parking Alternatives Project. Results of Vegetation Mapping, Floristic Surveys, and Focused Rare Plant Species Surveys. Prepared for Golden Gate National Recreation Area. July.
- Steers, R., H. Spaulding, and E. Wrubel. 2014. Forest Structure in Muir Woods National Monument, Survey of the Redwood Canyon Old-Growth Forest. U.S. Department of the Interior, National Park Service. Natural Resource Technical Report NPS/SFAN/NRTR—2014/878. May.
- Van Pelt, R., S. C. Sillett, W. A. Kruse, J. A. Freund, and R. D. Kramer. 2016. Emergent crowns and light-use complementarity lead to global maximum biomass and leaf area in *Sequoia sempervirens* forests. *Forest Ecology and Management* 375: 279-308.

#### **VISUAL RESOURCES**

- National Park Service. 2006. Historic Resources Study for Muir Woods National Monument.
- NPS. *See* National Park Service.

#### **SOUNDSCAPES**

- Manning, R., P. Newman, K. Fristrup, D. Stack, and E. Pilcher. 2009. A program of research to support management of visitor-caused noise at Muir Woods National Monument
- U.S. Department of Transportation. 2011. Baseline Ambient Sound Levels in Muir Woods National Monument.

USDOT. *See* U.S. Department of Transportation.

### **AIR QUALITY AND GREENHOUSE GAS EMISSIONS**

BAAQMD. *See* Bay Area Air Quality Management District.

Bay Area Air Quality Management District. 2016. Marin County. Available:  
[www.baaqmd.gov/  
in-your-community/marin-county](http://www.baaqmd.gov/in-your-community/marin-county). Accessed December 12, 2016.

California Air Resources Board. 2016a. California Greenhouse Gas Inventory for 2000-2014 – by Category as Defined in the 2008 Scoping Plan. Available at:  
[www.arb.ca.gov/cc/inventory/  
data/data.htm](http://www.arb.ca.gov/cc/inventory/data/data.htm). Accessed December 15, 2016.

2016b. California Greenhouse Gas Emissions for 2000 to 2014 – Trends of Emissions and Other Indicators (2016 Edition California GHG Emission Inventory). June 17. Available at: [www.arb.ca.gov/cc/inventory/data/data.htm](http://www.arb.ca.gov/cc/inventory/data/data.htm). Accessed December 15, 2016.

CARB. *See* California Air Resources Board.

CEQ. *See* Council on Environmental Quality.

Council on Environmental Quality. 2016. Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews. Available at:  
[www.whitehouse.gov/administration/eop/ceq/initiatives/nepa/ghg-guidance](http://www.whitehouse.gov/administration/eop/ceq/initiatives/nepa/ghg-guidance). Accessed December 15, 2016.

Interagency Monitoring of Protected Visual Environments. 2016. AQRV Summaries. Available at: [vista.cira.colostate.edu/Improve/aqrv-summaries](http://vista.cira.colostate.edu/Improve/aqrv-summaries).

IMPROVE. *See* Interagency Monitoring of Protected Visual Environments.

Sullivan, T. J. 2016. Air quality related values (AQRVs) for San Francisco Bay Area Network (SFAN) parks: Effects from ozone; visibility reducing particles; and atmospheric deposition of acids, nutrients and toxics. Natural Resource Report NPS/SFAN/NRR—2016/1186. National Park Service, Fort Collins, Colorado.

U.S. Environmental Protection Agency. 2016a. California Nonattainment/Maintenance Status for Each County by Year for All Criteria Pollutants, Green Book. Available:  
[www3.epa.gov/airquality/greenbook/anayo\\_ca.html](http://www3.epa.gov/airquality/greenbook/anayo_ca.html). Accessed November 3, 2016.

2016b. General Conformity De Minimis Emission Levels. Available:  
[www.epa.gov/general-conformity/de-minimis-emission-levels](http://www.epa.gov/general-conformity/de-minimis-emission-levels). Accessed November 3, 2016.

2017. Regulations for Greenhouse Gas Emissions from Commercial Trucks and Buses. Available at: [www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-commercial-trucks](http://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-commercial-trucks). Accessed January 9, 2017.

USEPA. See U.S. Environmental Protection Agency.

## **Chapter 4: Environmental Consequences**

### **INTRODUCTION**

County of Marin. 2016. News Release: Road Rehab Plans Rolling on Mount Tam. Restoration of Muir Woods Road to improve access to state & federal lands. October 19. Available: [www.marincounty.org/main/county-press-releases/press-releases/2016/dpw-muirwoodsroad-101916](http://www.marincounty.org/main/county-press-releases/press-releases/2016/dpw-muirwoodsroad-101916).

National Park Service. 2015b. Memorandum of Understanding between National Park Service and County of Marin, Signed June 30, 2015.

2016a. Muir Woods National Monument Sustainable Access Project. Draft Environmental Assessment. November.

NPS. See National Park Service.

### **CULTURAL RESOURCES**

Brunzell, K. 2017. Redwood Creek Riprap Assessment.

Gavette, P. 2017. Archeological Survey and Testing For the Salmon Habitat Enhancement and Bridge Replacement Project, Muir Woods National Monument, California. October.

Haesloop, P., and A. Molinski. 2014. Muir Woods and Dipsea Trail Crossing Footbridge Design Study.

National Park Service. 2007. Draft Cultural Landscapes Inventory (CLI) documentation for Muir Woods National Monument Historic District.

2015b. Muir Woods National Monument Reservation System. October.

### **THREATENED OR ENDANGERED SPECIES**

N. Bouwes, N. Weber, C.E. Jordan, W.C. Saunders, I.A. Tattam, C. Volk, J.M. Wheaton, and M.M. Pollock. 2016. Ecosystem experiment reveals benefits of natural and simulated beaver dams to a threatened population of steelhead (*Oncorhynchus mykiss*). Scientific Reports. 6:28581 | DOI: 10.1038/srep28581

Bustard, D.R. and Narver, D.W., 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Board of Canada, 32(5), pp.667-680.

- Fong, D., B. Becker, and M. Reichmuth. 2016. Draft Summary and Analysis of Salmonid Data, Muir Woods National Monument, 1995 to 2015. August.
- Hartman, G.F., 1965. The role of behavior in the ecology and interaction of underyearling coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Board of Canada, 22(4), pp.1035-1081.
- Lestelle, L. C. 2007. Coho Salmon (*Oncorhynchus kistutch*) Life History Patterns in the Pacific Northwest and California Final Report. Prepared for U.S. Bureau of Reclamation Klamath Area Office.
- Malison, R.L, M.S. Lorang, D.C. Whited, and J.A. Stanford. 2014. Beavers (*Castor canadensis*) influence habitat for juvenile salmon in a large Alaskan river floodplain. Freshwater Biology. 59, 1229–1246.
- NHE. See Northern Hydrology and Engineering.
- Northern Hydrology and Engineering. 2017. Salmon Habitat Restoration at Muir Woods, Site Analysis, Conceptual Designs and Impact Analysis. August.
- Reichmuth, M. Fisheries Biologist, National Park Service. Personal observation communicated to Carolyn Shoulders, National Park Service. Feb. 1, 2017.
- Stillwater Sciences and Horizon Water and Environment. 2011. Redwood Creek Watershed Assessment. Final Report. Prepared for Golden Gate National Recreation Area. August.

#### **GEOLOGY: SOILS, BEDROCK, STREAMBEDS**

- NHE. See Northern Hydrology and Engineering.
- Pacific Watershed Associates. 2002. Summary Report, 2000 S.B. 271 Watershed Assessment and Erosion Prevention Planning Project for the Redwood Creek Watershed, Marin County, California, Contract No. P9985121. Prepared for Muir Beach Community Services District, California Dept. of Fish and Game, Marin Municipal Water District and National Park Service.

#### **WILDLIFE HABITAT**

- Heady, P. A., and W. F. Frick. 2004. Bat Inventory of Muir Woods National Monument, Final Report. Central Coast Bat Research Group.
- Kimball, L. C., and G. M. Kondolf. 2002. Analysis of Channel Geomorphology and Habitat Forming Processes for Feasibility Assessment of Rip-Rap Removal, Muir Woods National Monument. Final Report. May.

#### **WATER RESOURCES AND HYDROLOGIC PROCESSES**

- Environmental Science Associates. 2014. Muir Woods National Monument Redwood Creek Riprap Removal, Channel Migration and Bridge Replacement Study. Prepared for the

National Park Service, Golden Gate National Recreation Area, Division of Natural Resource Management and Science, San Francisco, California.

ESA. *See* Environmental Science Associates.

NHE. *See* Northern Hydrology and Engineering.

Northern Hydrology and Engineering. 2014. Draft Lower Bull Creek Conceptual Design Report, for the Bull Creek Floodplain Design and Conceptual Instream Restoration Plan. Prepared for California State Parks.

2016. Salmon Habitat Restoration at Muir Woods Site Analysis, Conceptual Designs and Impact Analysis. Preliminary Draft Technical Memorandum. Prepared for National Park Service. September 14.

2017a. Preliminary Estimates of Redwood Creek Bank Erosion and Sedimentation from Rock Slope Protection Removal within the Muir Woods National Monument. Technical Memorandum. Prepared for Golden Gate National Recreation Area. February 17.

2017b. Salmon Habitat Restoration at Muir Woods Site Analysis, Conceptual Designs and Impact Analysis. Prepared for National Park Service. August.

Reichmuth, M. Fisheries Biologist, National Park Service. Personal observation communicated to Carolyn Shoulders, National Park Service. Feb. 1, 2017.

Stillwater Sciences. 2004. Sediment Budget for Redwood Creek Watershed, Marin County, California. Prepared for Golden Gate National Recreation Area, San Francisco, California.

## **VEGETATION**

Burns, Emily. 2016. Director of Science and Education, Save the Redwoods League. Letter to Carolyn Shoulders, NPS, on November 4, 2016.

Burns, E., A. Forrestel, and J. Klein. 2016. Coast Redwood (*Sequoia sempervirens*) Forests, In E. Edson, S. Farrell, A. Fish, et al., eds., *Measuring the Health of a Mountain: A Report on Mount Tamalpais' Natural Resources*.

Gonzalez, P. 2016. *Climate Change in the National Parks of the San Francisco Bay Area, California, USA*. July.

Lorimer, C. G., D. J. Porter, M. A. Madej, J. D. Stuart, S. D. Veirs Jr., S. P. Norman, K. L. O'Hara, W. J. Libby. 2009. Presettlement and modern disturbance regimes in coast redwood forests: Implications for the conservation of old-growth stands. *Forest Ecology and Management* 258: 1038-1054.

NHE. *See* Northern Hydrology and Engineering.

Northern Hydrology and Engineering. 2017. Salmon Habitat Restoration at Muir Woods, Site Analysis, Conceptual Designs and Impact Analysis. August.

Shoulders, C. Natural Resource Specialist, National Park Service. Personal observation.

Steers, R., H. Spaulding, and E. Wrubel. 2014. Forest Structure in Muir Woods National Monument, Survey of the Redwood Canyon Old-Growth Forest. U.S. Department of the Interior, National Park Service. Natural Resource Technical Report NPS/SFAN/NRTR—2014/878. May.

Van Pelt, R., S. C. Sillett, W. A. Kruse, J. A. Freund, and R. D. Kramer. 2016. Emergent crowns and light-use complementarity lead to global maximum biomass and leaf area in *Sequoia sempervirens* forests. *Forest Ecology and Management* 375: 279-308.

### **SOUNDSCAPES**

Federal Transit Administration. 2006. Transit Noise and Vibration Impact Assessment. May. FTA-VA-90-1003-06. Available: [www.fta.dot.gov/documents/FTA\\_Noise\\_and\\_Vibration\\_Manual.pdf](http://www.fta.dot.gov/documents/FTA_Noise_and_Vibration_Manual.pdf).

### **AIR QUALITY AND GREENHOUSE GAS EMISSIONS**

Anderson. 2012. Effects of Biodiesel Fuels Use on Vehicle Emissions. *Journal of Sustainable Energy & Environment* 3 (2012): 35-47.

Khan, N., M. A. Warith, and G. Luk. 2007. A comparison of acute toxicity of biodiesel, biodiesel blends, and diesel on aquatic organisms. *Journal of the Air & Waste Management Association* 57(3): 286-296.

### **Chapter 5: Consultation and Coordination**

U.S. Environmental Protection Agency. 2017. EPA Review Process under Section 309 of the Clean Air Act. Available: <https://www.epa.gov/nepa/epa-review-process-under-section-309-clean-air-act>. Accessed March 1, 2017.

# Appendix A

---

## Riprap Condition Report

*This page intentionally left blank*

# Table of Contents

<b>Introduction .....</b>	<b>1</b>
<b>Creek Section Assessments .....</b>	<b>9</b>
Section L1A .....	16
Section R1A.....	18
Section L1B .....	21
Section R1B.....	23
Section R2 .....	26
Section L2 .....	28
Section R3A.....	31
Section R3B.....	34
Section L3 .....	37
Section R4.....	39
Section L4 .....	42
Section R5.....	44
Section L5 .....	46
Section R6.....	49
Section L6 .....	52
Section L7 .....	54
Section L8 .....	59
Section L8.5 .....	61
Section L9 .....	63
Section R7.....	65
Section L10 .....	68
Section R8.....	71
Section L11A .....	75
Section L11B .....	77
Section R9.....	80
Section L12 .....	83
Section R10.....	86
Section R12A.....	90
Section R12B.....	92
Section L16 .....	95

Section L13 .....	98
Section L14 .....	102
Section R11 .....	104
Section L14.5 .....	106
<b>References: .....</b>	<b>107</b>

## List of Tables

<b>Table 1.</b> Riprap segment ratings, with anticipated geomorphic and salmonids effects .....	11
---	----

## List of Figures

<b>Figure 1.</b> Creek Restoration Alternative A. ....	2
<b>Figure 2.</b> Creek Restoration Alternatives B and C. ....	5
<b>Figure 3.</b> Creek Restoration Alternatives D and E. ....	6
<b>Figure 4.</b> Section L1A Condition Assessment. ....	16
<b>Figure 5.</b> Section L1A, center stretch view north-northeast from creek bed, showing tightly placed medium sized rock revetment in fair-good condition behind tree trunks and vegetation.....	17
<b>Figure 6.</b> Section R1A Condition Assessment.....	18
<b>Figure 7.</b> Center-west stretch of Section R1A, view south-southwest from creek bed, showing riprap of medium-sized rocks in good condition beneath vegetation and with trees growing from some areas .....	19
<b>Figure 8.</b> Center-west stretch of Section R1A, view south from creek bed, showing riprap in good condition beneath vegetation and with trees growing from some areas.....	19
<b>Figure 9.</b> Eastern stretch of Section R1A, view south from creek bed, showing larger rocks, some of which are out of place .....	20
<b>Figure 10.</b> Section L1B Condition Assessment. ....	21
<b>Figure 11.</b> Stretch of L1B obscured by vegetation, view northwest from right bank, with large loosely-stacked stones visible left of frame .....	22
<b>Figure 12.</b> Section L1B and boardwalk, view east from right bank, stretch with medium rocks in fair to good condition center frame .....	22
<b>Figure 13.</b> Section R1B Condition Assessment.....	23

<b>Figure 14.</b>	Section R1B and Bridge 1, view southwest from left bank, showing riprap in good condition under bridge and obscured by trees and ferns to the east.....	24
<b>Figure 15.</b>	Detail, Section R1B downstream from Bridge 1, view southwest from left bank.....	24
<b>Figure 16.</b>	Western stretch of Section R1B upstream of Bridge 1, view southwest from Bridge 1, showing riprap in fair condition partially obscured by a tree and other vegetation. ....	25
<b>Figure 17.</b>	Section R2 Condition Assessment.....	26
<b>Figure 18.</b>	Section R2 viewed from left bank, camera facing southwest, showing tightly placed medium-sized rocks in good condition.....	27
<b>Figure 19.</b>	Section R2 viewed from left bank, camera facing west, showing upstream stretch with larger boulders in excellent condition. ....	27
<b>Figure 20.</b>	Section L2 Condition Assessment.....	28
<b>Figure 21.</b>	Central stretch of Section L2, view northwest from right bank, showing riprap in excellent condition beneath ferns and other vegetation. ....	29
<b>Figure 22.</b>	Northwest (upstream) stretch of Section L2, view north from right bank, showing riprap under vegetation and woody debris. ....	29
<b>Figure 23.</b>	Poor condition downstream stretch of Section L2, view east from right bank, showing deteriorating riprap with woody debris, ferns, and other vegetation.....	30
<b>Figure 24.</b>	Section R3A Condition Assessment (east portion).....	31
<b>Figure 25.</b>	Section R3A Condition Assessment (west portion).....	31
<b>Figure 26.</b>	Section R3A from left bank, camera facing east, showing east stretch with 2-4 course riprap in excellent condition.....	32
<b>Figure 27.</b>	Section R3A from left bank with path visible in background, camera facing southwest, showing center-west stretch with 4-5 course riprap in excellent condition with minimal vegetation. ....	33
<b>Figure 28.</b>	West stretch of Section R3A obscured by log jam viewed from left bank, camera facing west, riprap is in good condition beneath vegetation and woody debris. ....	33
<b>Figure 29.</b>	Section R3B Condition Assessment.....	34
<b>Figure 30.</b>	South stretch of Section R3B, view south from creek bed, showing low riprap obscured by ferns and woody debris.....	35
<b>Figure 31.</b>	Detail, Section R3B low rock wall is visible behind woody debris.....	36
<b>Figure 32.</b>	Section L3 Condition Assessment.....	37
<b>Figure 33.</b>	Section L3 seen from right bank, camera facing northeast, showing occasional rocks beneath moss, ferns, and other vegetation. The shape of the bank suggests riprap is in poor condition. ....	38

<b>Figure 34.</b>	Overview of Section L3, camera facing east, showing area slightly to the east of Figure 30 which is also obscured by vegetation but appears to be in fair to poor condition.....	38
<b>Figure 35.</b>	Section R4 Condition Assessment.....	39
<b>Figure 36.</b>	Overview of Section R4, view west, showing displaced riprap beneath fallen logs.....	40
<b>Figure 37.</b>	Detail, Section R4, view south, showing riprap in fair condition with ferns and a tree growing out of it.....	41
<b>Figure 38.</b>	Section L4 Condition Assessment.....	42
<b>Figure 39.</b>	View of Section L4 from right bank, camera facing northeast, showing variable-sized displaced rocks. ....	43
<b>Figure 40.</b>	View of Section L4 from right bank, camera facing north, with little intact riprap in place.....	43
<b>Figure 41.</b>	Section R5 Condition Assessment.....	44
<b>Figure 42.</b>	View of Section R4 with trail in background from left bank, camera facing northwest, showing medium-sized rocks in excellent condition with some light fern growth above. ....	45
<b>Figure 43.</b>	View of Section R4, camera facing southwest, large- and medium-sized rocks in excellent condition below fern growth.....	45
<b>Figure 44.</b>	Section L5 Condition Assessment.....	46
<b>Figure 45.</b>	Portion of Section L5 mostly obscured by woody debris, camera facing north.....	47
<b>Figure 46.</b>	Section L5, from right bank, camera facing northeast, showing woody debris, ferns, and seasonal vegetation with small areas of rock revetment visible left of frame and at center. ....	47
<b>Figure 47.</b>	East end of Section L5 and trail, camera facing east, showing rocks displaced by tree and falling away. ....	48
<b>Figure 48.</b>	Section R6 Condition Assessment.....	49
<b>Figure 49.</b>	South stretch of Section R6, view west from trail showing riprap in excellent condition with some woody debris around it and trees and ferns on top of the bank.....	50
<b>Figure 50.</b>	Center-south stretch of Section R6, view west-southwest showing riprap in clearly visible and in excellent condition with ferns above.....	50
<b>Figure 51.</b>	Center-north stretch of Section R6, showing riprap in good condition to south with area obscured by ferns and other vegetation to north.....	51
<b>Figure 52.</b>	North stretch of Section R6, view west showing riprap in very good condition with small areas of deteriorated or obscured by vegetation at either end. ....	51
<b>Figure 53.</b>	Section L6 Condition Assessment.....	52

<b>Figure 54.</b>	Section L6 from right bank, camera facing northeast, showing riprap in poor condition center frame and otherwise obscured by vegetation. ....	53
<b>Figure 55.</b>	Section L7 Condition Assessment.....	54
<b>Figure 56.</b>	West stretch showing poor condition/obscured stretch left of frame, view northwest from creek bed. ....	55
<b>Figure 57.</b>	Center section, view north-northeast from creek bed, showing well-stacked boulders beneath tree stump, ferns, and the trail.....	55
<b>Figure 58.</b>	Center-east section, view northeast from creek bed showing well-stacked boulders beneath tree stump, ferns, and the trail.....	56
<b>Figure 59.</b>	Overview, east stretch, view east from creek bed, showing riprap in good condition partially obscured by ferns and young trees.....	56
<b>Figure 60.</b>	Overview, view east from creek bed at east end of Section L7, riprap clearly visible below ferns. ....	57
<b>Figure 61.</b>	Detail, eastern stretch where wall has either fallen away or been engulfed in vegetation.....	58
<b>Figure 62.</b>	Section L8 Condition Assessment.....	59
<b>Figure 63.</b>	Section L8, view north from creek bed, showing riprap in good condition with ferns above and some woody debris.....	60
<b>Figure 64.</b>	Section L8 looking east from creek bed, showing medium-sized boulders in good condition with some areas covered by ferns. ....	60
<b>Figure 65.</b>	Section L8.5 Condition Assessment.....	61
<b>Figure 66.</b>	Section L8.5, view north from creek bed, showing heavy seasonal vegetation with what appears to be riprap fallen away in the creek.....	62
<b>Figure 67.</b>	Section L9 Condition Assessment.....	63
<b>Figure 68.</b>	Section L9, view north from creek bed, showing nearly horizontal riprap of small rocks under moss below a vertical creek bank supporting ferns and tree roots. ....	64
<b>Figure 69.</b>	Section L9, view southwest from left bank, showing nearly horizontal riprap of small rocks under moss in foreground. ....	64
<b>Figure 70.</b>	Section R7 Condition Assessment. ....	65
<b>Figure 71.</b>	Overview, northwest stretch of Section R7, view south-southeast from creek bed, showing 2-3 courses of tightly stacked boulders of variable size with ferns and trees above. ....	66
<b>Figure 72.</b>	Detail, northwest stretch, showing 2-3 courses of tightly stacked boulders of variable size with ferns and small amounts of woody debris. ....	66
<b>Figure 73.</b>	Southeast stretch, view southeast from creek bed, well-stacked wall visible center frame behind ferns, small trees, and seasonal vegetation. ....	67
<b>Figure 74.</b>	Section L10 Condition Assessment. ....	68

<b>Figure 75.</b>	West stretch, view north from creek bed, showing riprap in fair condition beneath vegetation. ....	69
<b>Figure 76.</b>	Center stretch, view east from creek bed, showing ferns and small tree grown atop riprap in good condition.....	69
<b>Figure 77.</b>	Center-east stretch, view east-northeast from creek bed, showing riprap in good condition.....	70
<b>Figure 78.</b>	East end showing some displaced boulders with most riprap in good condition beneath light vegetation growth.....	70
<b>Figure 79.</b>	Section R8 Condition Assessment. ....	71
<b>Figure 80.</b>	Section R8 overview, view west from creek bed showing riprap of medium-sized boulders, with smaller rocks fit in to form a relatively solid wall of 3-4 courses, in excellent condition.....	72
<b>Figure 81.</b>	Detail, west stretch, showing riprap in excellent condition with ferns above. ....	73
<b>Figure 82.</b>	Detail, center-west stretch showing riprap in excellent condition with ferns above. ....	73
<b>Figure 83.</b>	Detail showing good-fair condition of east stretch with ferns and vegetation partially obscuring riprap. ....	74
<b>Figure 84.</b>	Section 11A Condition Assessment. ....	75
<b>Figure 85.</b>	West stretch, view north from creek bed, showing riprap in fair-poor condition with ferns partially obscuring.....	76
<b>Figure 86.</b>	East stretch, view north from creek bed, where riprap is missing or completely obscured by ferns and other vegetation. ....	76
<b>Figure 87.</b>	Section L11B Condition Assessment. ....	77
<b>Figure 88.</b>	Downstream stretch of Section L11B looking east from creek bed, showing riprap in very good condition, with tightly stacked medium-sized rocks below fern growth.....	78
<b>Figure 89.</b>	Center stretch of Section L11B, view northeast from creek bed, showing riprap in good condition with some woody debris and heavy moss growth.....	78
<b>Figure 90.</b>	Upstream stretch of Section L11B, view north from right bank, showing riprap not visible possibly due to profusion of moss, ferns, and seasonal vegetation.....	79
<b>Figure 91.</b>	Section R9 Condition Assessment. ....	80
<b>Figure 92.</b>	Overview of Section R9, view southeast from creek bed, showing riprap tightly stacked into 3 to 4 courses that form a nearly upright wall beneath trees, ferns, and other vegetation. ....	81
<b>Figure 93.</b>	Detail, west stretch view south, showing riprap in excellent condition. ....	81

<b>Figure 94.</b>	Detail, east stretch view southeast, showing riprap excellent condition with small collapsed area left of frame and ferns growing above. ....	82
<b>Figure 95.</b>	Section L12 Condition Assessment. ....	83
<b>Figure 96.</b>	Upstream (west) stretch of Section L12 with toe material below riprap wall in good condition, view northeast from creek bed.....	84
<b>Figure 97.</b>	Center stretch of Section L12, view west from creek bed, showing riprap tightly-stacked and in excellent condition.....	84
<b>Figure 98.</b>	Downstream stretch of Section L12, view west from creek bed, showing riprap tightly-stacked and in excellent condition. ....	85
<b>Figure 99.</b>	Section R10 Condition Assessment. ....	86
<b>Figure 100.</b>	Western stretch, view southwest from creek bed with riprap in good condition behind ferns.....	87
<b>Figure 101.</b>	Detail, east stretch, showing tightly stacked wall in excellent condition beneath ferns and some woody debris. ....	87
<b>Figure 102.</b>	Central stretch, view south showing heavy toe material with ferns and woody debris covering riprap that is in excellent condition. ....	88
<b>Figure 103.</b>	View west toward east stretch with large boulder riprap and toe material/check dam.....	89
<b>Figure 104.</b>	Section R12A Condition Assessment. ....	90
<b>Figure 105.</b>	Section R12A left of frame, camera view west from creek bed.....	91
<b>Figure 106.</b>	Section R12B Condition Assessment. ....	92
<b>Figure 107.</b>	Section R12B, camera facing southwest.....	93
<b>Figure 108.</b>	Section R12B, camera facing west.....	93
<b>Figure 109.</b>	Section R12B, camera facing southwest.....	94
<b>Figure 110.</b>	Section L16 Condition Assessment. ....	95
<b>Figure 111.</b>	View upstream with Section L16 at right of frame, camera facing northeast. ....	96
<b>Figure 112.</b>	Section L16 and Redwood Creek Trail, camera facing east. ....	97
<b>Figure 113.</b>	Section L13 Condition Assessment. ....	98
<b>Figure 114.</b>	Overview, Section L13, view east from creek bed, well-stacked western stretch left of frame.....	99
<b>Figure 115.</b>	Western stretch, view northeast from creek bed. ....	99
<b>Figure 116.</b>	Central stretch showing large rocks pushed out by tree roots and small underlayer exposed. ....	100
<b>Figure 117.</b>	Eastern stretch, view east from creek bed. ....	100
<b>Figure 118.</b>	Eastern stretch of Section L13, view west from left bank. ....	101
<b>Figure 119.</b>	Section L14 Condition Assessment (east portion). ....	102

**Figure 120.** Section L14 Condition Assessment (west portion)..... 102

**Figure 121.** Center stretch, Section L14, view northeast from creek bank (photo  
ESA 2014)..... 103

**Figure 122.** Section R11 Condition Assessment. .... 104

**Figure 123.** Section R11, camera facing southeast..... 105

**Figure 124.** Section R11, camera facing east..... 105

**Figure 125.** Section L14.5 Condition Assessment..... 106

**Figure 126.** Section L14.5 and trail, camera facing northeast..... 106

## INTRODUCTION

The National Park Services (NPS) is considering an environmental restoration project on Redwood Creek in Muir Woods National Monument. The project area is a roughly one-mile stretch of creek bed between the vicinity of the monument entrance plaza and Bridge 4. Redwood Creek has approximately 3,500 feet of rock bank armor installed to prevent erosion and meandering. Commonly referred to as riprap, the bank armor was installed by the Civilian Conservation Corps in the 1930s (within the Period of Significance). Although specific characteristics vary, the bank armor is not like typical modern riprap installed for bank protection. Although sloped in most places to follow the shape of the creek bank, in other respects it resembles traditional dry-laid stone walls with irregularly-shaped stones carefully placed and tightly fitted together. The riprap interferes with habitat for the local Coho salmon and steelhead trout populations by preventing natural processes such as channel meandering, floodplain formation, and pool scour. In order to improve riparian habitat for these fish and the overall ecological condition of Redwood Creek, NPS proposes removing between 13 and 18 sections of riprap within the project area. Of the roughly 3570 linear feet of existing historic stone revetment, between 1280 and 2286 feet are targeted for removal. Figures 1 through 3 show visibility of existing riprap (based on data provided by NPS), and which segments are proposed for removal under different project alternatives.



**Figure 1**  
 Creek Restoration Alternative A  
 Sheet 1 of 3

**Riprap**

	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

	Redwood Creek and Tributaries
	Bridge
	trails
	MWNM Boundary

0 75 150 300 Feet



Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project



**Figure 1**  
Creek Restoration Alternative A  
Sheet 2 of 3

**Riprap**

	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

Redwood Creek and Tributaries

Bridge

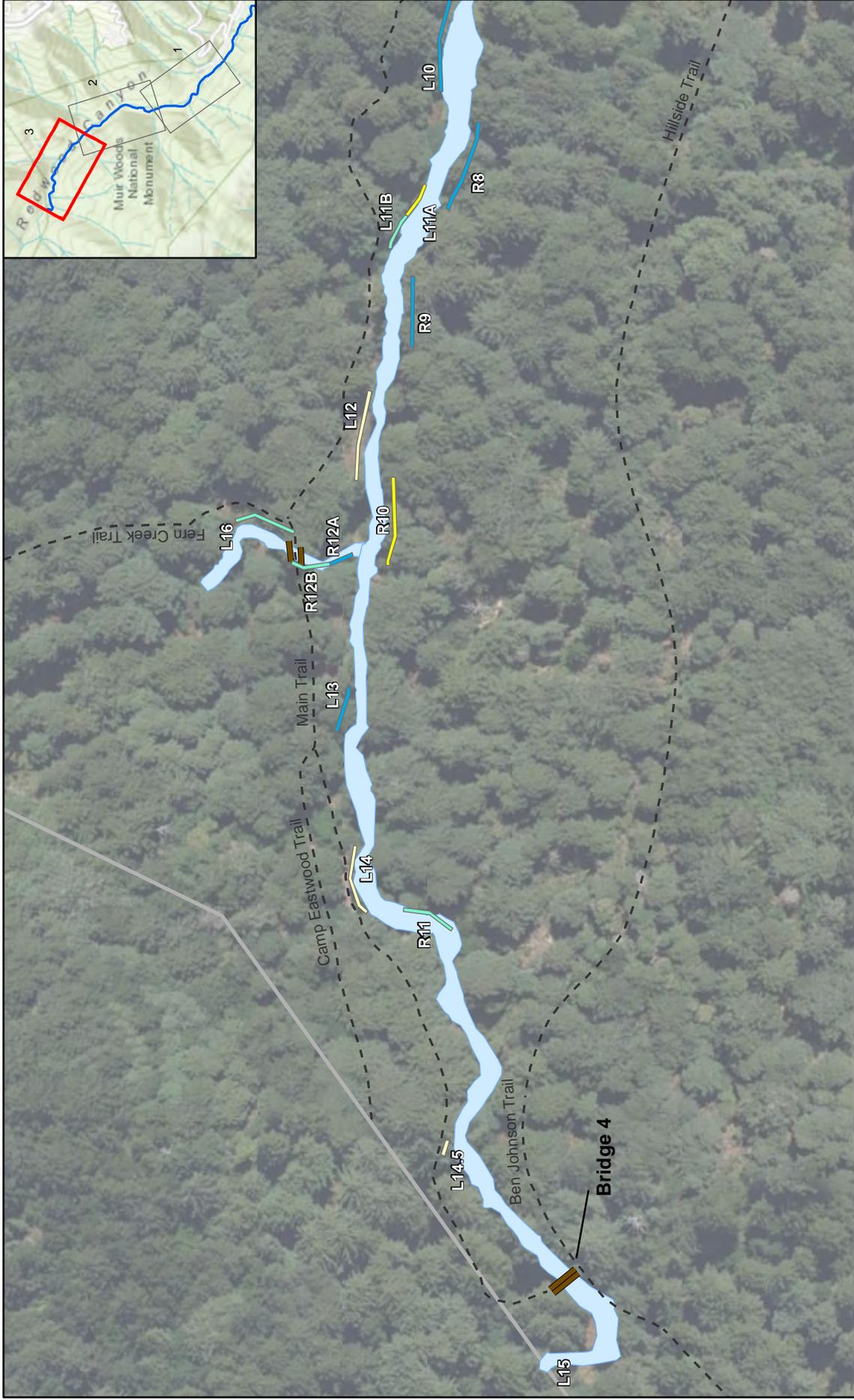
trails

MWNNM Boundary

0 75 150 300 Feet

z

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project



**Figure 1**  
**Creek Restoration Alternative A**  
**Sheet 3 of 3**

**Riprap**

	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

	Redwood Creek and Tributaries
	Bridge
	trails
	MWNM Boundary

0 75 150 300 Feet



Muir Woods National Monument  
 Salmon Habitat Enhancement and  
 Bridge Replacement Project



**Figure 2**  
Creek Restoration Alternatives B and C

**Riprap**

	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

	Redwood Creek and Tributaries
	Bridge
	trails
	MWNM Boundary

0 75 150 300 Feet



Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project



**Figure 3**  
Creek Restoration Alternatives D and E  
Sheet 1 of 3

**Riprap**

	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

**Legend**

	Redwood Creek and Tributaries
	Bridge
	trails
	MWNM Boundary

0 75 150 300 Feet



Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project



**Figure 3**  
Creek Restoration Alternatives D and E  
Sheet 2 of 3

**Riprap**

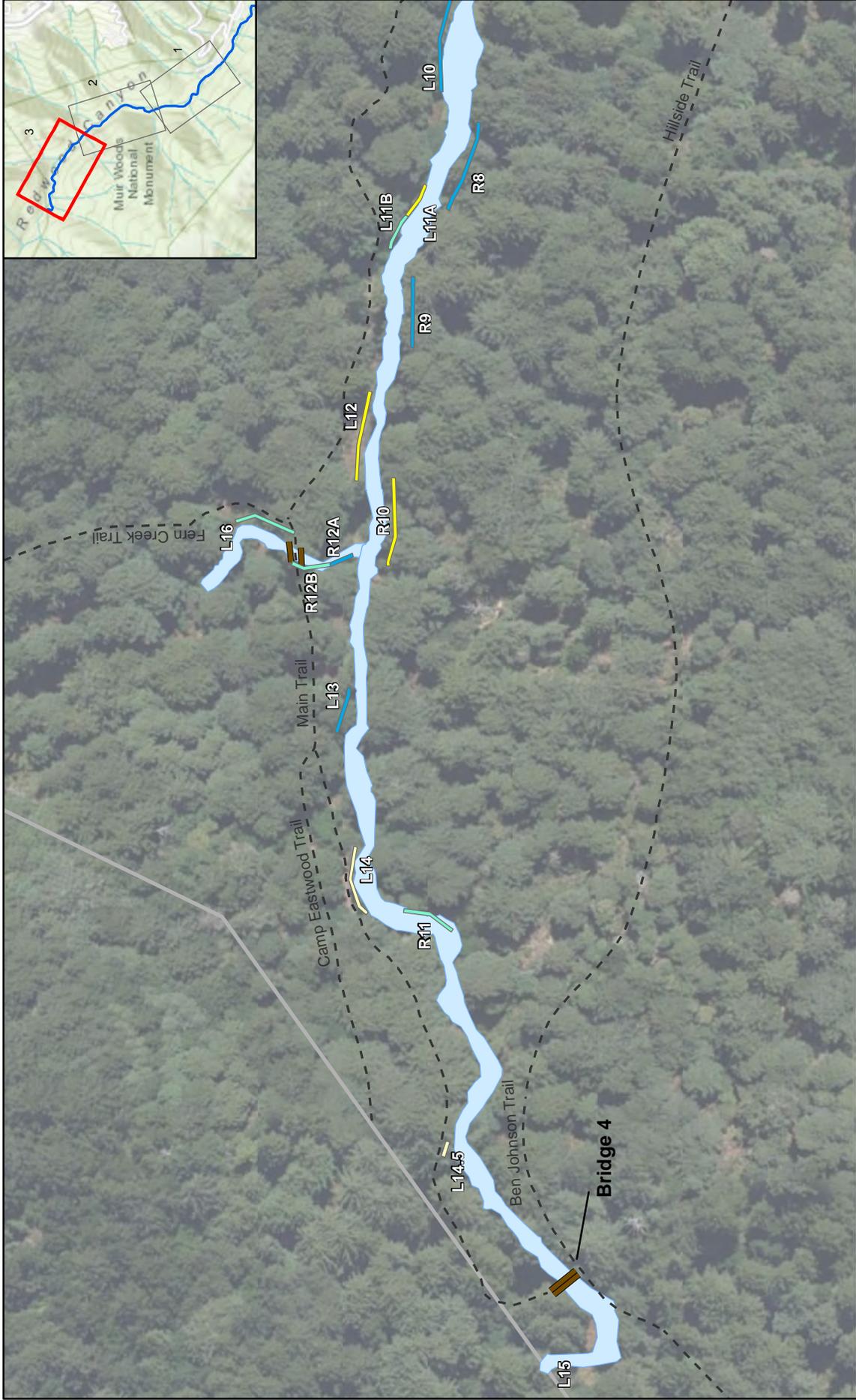
	Visible Remove
	Visible No Action
	Not Visible Remove
	Not Visible No Action

**Legend**

	Redwood Creek and Tributaries
	Bridge
	trails
	MWNM Boundary

0 75 150 300 Feet

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project



**Figure 3**  
Creek Restoration Alternatives D and E  
Sheet 3 of 3

**Riprap**

- Visible Remove
- Visible No Action
- Not Visible Remove
- Not Visible No Action

Redwood Creek and Tributaries

Bridge

trails

MWNM Boundary

0 75 150 300 Feet

Muir Woods National Monument  
Salmon Habitat Enhancement and  
Bridge Replacement Project

## RIPRAP ASSESSMENTS

Horizon Water and Environment Architectural Historian Kara Brunzell performed a field visit to document historic riprap along Redwood Creek on November 10, 2016. Horizon Water and Environmental personnel performed two subsequent field visits in December 2016. Golden Gate National Recreation Area Historical Landscape Architect Amy Hoke walked the Redwood Creek Trail with Kara in order to point out significant features of the cultural landscape along the creek. Kara documented each numbered section of riprap, taking detailed notes on condition and photographs from the creek bank or creek bed as necessary to provide multiple views of the resources.

Letter grades for condition were assigned in the field to each numbered section (where a variety of conditions were present within a single numbered section, multiple grades were utilized). A narrative description of each numbered section is provided below, with condition assessment grades on maps. The sections are described in order, beginning at those closest to the visitor center and working upstream. Photographs with captions illustrate the text and map. Table 1 summarizes visibility, condition, proposed removal, and potential geomorphic and biological effects of removal.

### Condition Assessment Key

A – excellent condition: Intentionally placed, tightly fitted rocks, few or no missing rocks, appears stable.

B – good condition: Intentionally placed rocks range from loosely to tightly fitted, some missing rocks or apparently unstable areas, overall appears stable.

B-/C+ – fair condition: intentionally but loosely stacked rocks or tightly stacked with missing rocks.

C – poor condition: Rocks appear jumbled or randomly stacked, portions missing or fallen into the creek, areas appear unstable.

D – not present or not visible: Section has either fallen away completely or is hidden under vegetation or fully embedded in creek bank.

*This page intentionally left blank*

**Table 1.** Riprap segment ratings, with anticipated geomorphic and salmonids effects

Riprap Section	Condition	Visibility	Removal					Approximate Length (LF)	Geomorphic Effects	Effects on Salmonids
			Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5			
<i>Condition A/B, Visible</i>										
R1A	B-	Visible	no	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>	yes <sup>1</sup>	344	Removing bank armor would allow lateral migration and width adjustment and encourage riffle-pool formation. Due to existing trail on left bank, channel would likely migrate into an area with little woody vegetation. Because of straight reach, channel response anticipated to be minimal.	Small scour pool beneficial to salmonids
R1B	B-	Visible	no	no	no	no	no	66	Removing bank armor would allow lateral migration and width adjustment and encourage riffle-pool formation. Due to existing trail on left bank, channel would likely migrate into an area with little woody vegetation. Because of straight reach, channel response anticipated to be minimal.	None, not being removed.
L2	B	Visible	yes	yes	yes	yes	yes	128	Would allow active meander migration into tree stand with large root masses. High potential for large wood recruitment. Likely to promote deep pool development and undercut banks.	Scour pool and bank erosion beneficial to salmonids.
R5	A	Visible	no	no	no	no	no	135	Active meander migration into tree stands with large root masses. Potential for large wood recruitment. Would create deep pool and undercut banks.	None, not being removed.
R6	A-	Visible	yes	yes	yes	yes	yes	128	Would allow meander migration and channel adjustment. Would create more natural banks and exposed roots. Some potential for large wood recruitment.	Natural banks, exposed roots, and potential LWD recruitment would be beneficial for salmonids.
L7	B-/B	Visible	yes	yes	yes	yes	yes	141	Would allow lateral migration or widening of creek. Limited geomorphic response expected due to straight channel alignment. May undercut trail (6-15 feet laterally from creek) (trail would be removed). Opposite of tributary which may accelerate erosion.	Lateral migration or widening of creek would be beneficial to salmonids. Accelerated erosion would cause downstream water quality issues for salmonids.
R7	A-	Visible	yes	yes	yes	yes	yes	118	May allow sinuosity in a currently straight reach. Would allow lateral migration or widening into a bank with several large root masses. Erosion would expose roots and create overhanging banks. High potential for large wood recruitment.	Overhanging banks and LWD recruitment would be beneficial for salmonids.
L10	B+	Visible	yes	yes	yes	yes	yes	131	Would allow meander migration into a tree stand with large root masses. May create overhanging banks with cover and complexity. High potential for large wood recruitment	Overhanging banks and LWD recruitment would be beneficial for salmonids.
R8	A	Visible	yes	yes	yes	yes	yes	108	Lateral migration or widening would expose roots and create overhanging banks. High potential for large wood recruitment	Overhanging banks and LWD recruitment would be beneficial for salmonids.
L11B	B	Visible	no	no	no	no	no	26	Would allow active meander migration into tree stands with limited root masses. Likely to create deep pool with shaded overhanging banks. Potential for large wood recruitment on downstream end.	None, not being removed.

Riprap Section	Condition	Visibility	Removal					Approximate Length (LF)	Geomorphic Effects	Effects on Salmonids
			Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5			
R9	A-	Visible	yes	yes	yes	yes	82	High potential for channel to migrate or widen into large tree stand, creating overhanging banks, exposed roots and large wood recruitment. Well connected to adjacent floodplain.	Overhanging banks and LWD recruitment would be beneficial for salmonids.	
R12B	B-	Visible	no	no	no	no	26	Reactive confluence scour and deposition processes. High potential for large wood recruitment. Potential erosion near bridge.	None, not being removed.	
L13	B+	Visible	yes	yes	yes	yes	62	Would immediately allow active channel migration into tree stand with large root mass. High potential for large wood recruitment.		
R11	B	Visible	no	no	no	no	49	Would allow active meander migration. May create overhanging banks. May reactivate historic landslide with little large wood. Risk of introducing large volumes of fine sediment with little compensating coarse sediment or wood.	None, not being removed.	
<b>Condition B-/C, Visible</b>										
L1B	C+	Slightly Visible	no	no	no	no	397	Removing bank armor would allow lateral migration and width adjustment and encourage riffle-pool formation. Due to existing trail on left bank, channel would likely migrate into an area with little woody vegetation. Because of straight reach, channel response is expected to be minimal.	None, not being removed.	
R3B	C+	Visible	yes	yes	yes	yes	151	Riprap may be preventing avulsion around log jam – removal may allow process to proceed. Removal would create undercut natural banks with moderate exposure of large tree roots. Removal would disturb existing log jam and pool complex, and riparian area on adjacent bank.	Small scour pool beneficial to salmonids	
R4	C	Visible	yes	yes	yes	yes	13	Would allow lateral migration or widening of channel. Would allow more natural, undercut banks.		
L4	C-	Visible	no	no	no	no	46	Limited benefit for removal since riprap is part of the Bridge 2 abutment and would expose footings of bridge.	None, not being removed.	
L5	B-	Visible	no	no	no	no	79	Would allow lateral migration or widening. Very limited large wood recruitment or shade due to presence of trail in migration zone.	None, not being removed.	
L6	C-	Visible	no	no	no	no	23	Inside of meander bend so limited erosion potential. Limited root mass to expose and limited potential for wood recruitment.	None, not being removed.	
L11A	C-	Visible	yes	yes	yes	yes	59	Would allow active meander migration into tree stands with limited root masses. Likely to create deep pool with shaded overhanging banks. Potential for large wood recruitment on downstream end. May undercut trail at upstream end.		
R12A	C	Visible	yes	yes	yes	yes	39	Reactive confluence scour and deposition processes. High potential for large wood recruitment. Potential erosion near bridge.	LWD recruitment would be beneficial for salmonid habitat.	
L16	C+	Visible	no	no	no	no	72	If removed, limited migration potential due to bridge across Fern Creek.	None, not being removed.	

Riprap Section	Condition	Visibility	Removal					Approximate Length (LF)	Geomorphic Effects	Effects on Salmonids
			Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5			
<b>Condition A/C, Not Visible</b>										
R2	A-	Not Visible	no	no	no	yes	51	Would allow meander migration and natural bank formation. Presence of trail results in no large wood to recruit or tree roots to expose. Could generate large volumes of fine sediment with little benefit.	Removal of trail associate with removal of this section would allow for natural bank formation. Release of fine sediment could have adverse effects downstream.	
R3A	B+	Not Visible	no	no	no	yes	253	Riprap may be preventing avulsion around log jam – removal would allow process to proceed. Removal would create undercut natural banks with moderate exposure of large tree roots. Removal would disturb existing log jam and pool complex, and riparian area on adjacent bank.	Small scour pool beneficial to salmonids	
L3	C-	Not Visible	no	no	no	no	39	If removed, limited lateral migration due to straight alignment and wide channel. Lower potential for large wood recruitment.	None, not being removed.	
L8	C+	Not Visible	no	no	no	no	55	If removed, would allow for lateral migration towards a large tree stand. Improve connectivity with unnamed tributary. If log weir integrated into riprap is removed, 1-2 feet of local bed incision is likely. 23 feet from trail at most likely migration area. May need to smooth tributary transition or rebuild grade control to prevent incision migrating up tributary.	None, not being removed.	
L9	C+	Not Visible	no	no	no	no	23	If removed, would allow for lateral migration towards a large tree stand. Improve connectivity with unnamed tributary. If log weir integrated into riprap is removed, 1-2 feet of local bed incision is likely. 23 feet from trail at most likely migration area. May need to smooth tributary transition or rebuild grade control to prevent incision migrating up tributary.	None, not being removed.	
L12	A-	Not Visible	no	no	no	yes	104	May allow meander migration in an otherwise straight reach. High potential for root exposure and large wood recruitment. Some potential for migration into trail (40 feet from existing bank).	Root exposure and LWD recruitment would create beneficial habitat for salmonids.	
R10	A-	Not Visible	yes	yes	yes	yes	104	High potential for migration or widening into tree stand. Likely to create undercut banks with exposed roots. Limited potential for large wood recruitment. Riprap section is opposite of the Fern Creek confluence, which may promote erosion of bank.	Undercut banks with root exposure would create beneficial habitat for salmonids.	
L14	C-	Not Visible	no	no	no	no	79	If removed, would allow meander migration to occur. Good potential for more natural overhanging banks. Proximity to floodplain terrace reduces migration potential. Low potential for exposed roots and wood recruitment due to presence of trail immediately above bank. Trail is within 3 feet of riprap and likely to be undermined by erosion or bank slumping under no action.	None, not being removed.	

Riprap Section	Condition	Visibility	Removal					Approximate Length (LF)	Geomorphic Effects	Effects on Salmonids	
			Creek Restoration Alternative 1	Creek Restoration Alternative 2	Creek Restoration Alternative 3	Creek Restoration Alternative 4	Creek Restoration Alternative 5				
L14.5	B-	Not Visible	no	no	no	no	no	no	20	If removed, would allow meander migration to occur. Good potential for more natural overhanging banks. Proximity to floodplain terrace reduces migration potential. Low potential for exposed roots and wood recruitment due to presence of trail immediately above bank. Trail is within 3 feet of riprap and likely to be undermined by erosion or bank slumping under no action.	None, not being removed.
<b>Nonexistent Or Very Poor Condition, Not Visible</b>											
L1A	C-	Not Visible	no	yes <sup>2</sup>	yes <sup>2</sup>	yes <sup>2</sup>	yes <sup>2</sup>	yes <sup>2</sup>	151	Would allow lateral migration and width adjustment and encourage riffle-pool formation. Due to existing trail on left bank, channel would likely migrate into an area with little woody vegetation. Because of straight reach, channel response is expected to be minimal.	Riffle-pool formation beneficial to salmonids
L8.5	D	Not Visible	no	no	no	no	no	no	49	If removed, would allow lateral migration towards a large tree stand. Improve connectivity with unnamed tributary. If log weir integrated into riprap is removed, 1-2 feet of local bed incision is likely. 23 feet from trail at most likely migration area. May need to smooth tributary transition or rebuild grade control to prevent incision migrating up tributary.	None, not being removed.
<b>Not Documented (outside of Project Area)</b>											
L15	NA	NA	no	no	no	no	no	no	131	If removed, high potential for exposed roots and large wood recruitment. Lower potential for channel migration in the short-term since large root masses are adjacent to riprap	None, not being removed.

<sup>1</sup>Approximately 112 feet would be removed from the downstream end of this segment

<sup>2</sup> Approximately 98 feet would be removed from this segment

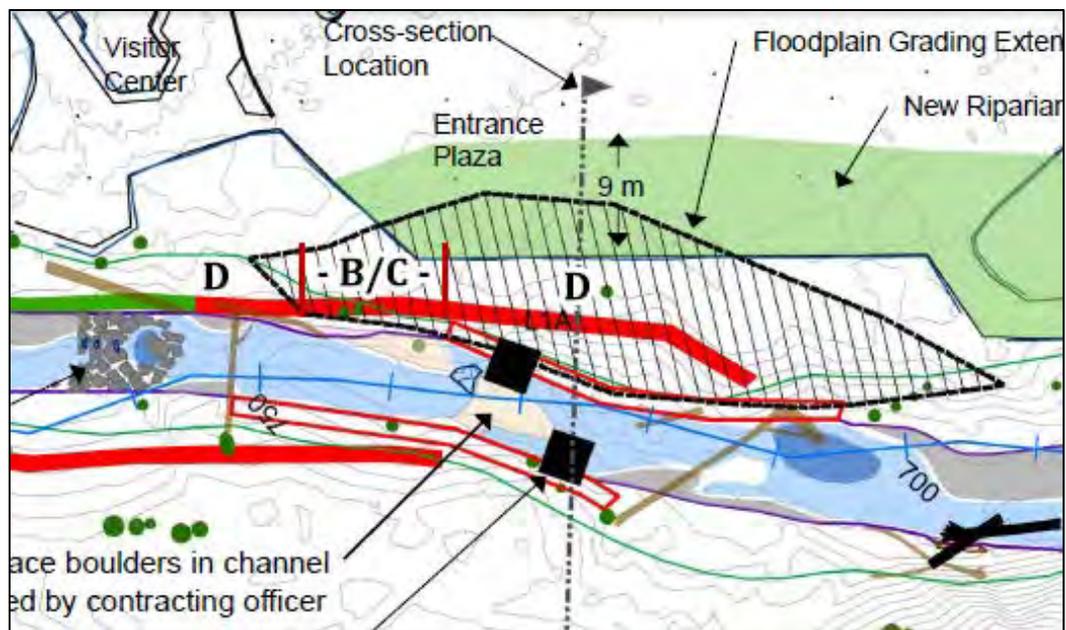
### Riprap Illustration Key

This illustration key provides the symbology used in the following figures. Please note that the removal of some riprap segments has changed since the development of these figures. Table 1 has the correct segments to be removed under each Creek Restoration Alternative.



## Section L1A

Section L1A is located immediately southwest of the Visitor Center and Entrance Plaza (Figure 4). It was previously measured at about 150 feet long and 6 feet high (NHE 2016). In 2000, it was recorded as a well-stacked embedded wall of medium-sized boulders (Peterson 2000). It is not visible from park trails or the Visitor Center. Little of the section was visible from the creek banks and creek bed during the November 2016 field visit. There are medium-sized boulders partially obscured by heavy vegetation in the roughly 30-foot stretch west of center, but plant cover made condition difficult to ascertain (Figure 5). The balance of this Section L1A (a 30 foot stretch to the west and a roughly 90 foot stretch to the east) appears to have been completely engulfed in vegetation and woody debris, although it may have fallen away. The overall condition of Section L1A is poor or not visible. Note: this segment would be removed under alternatives B, C, D, and E.



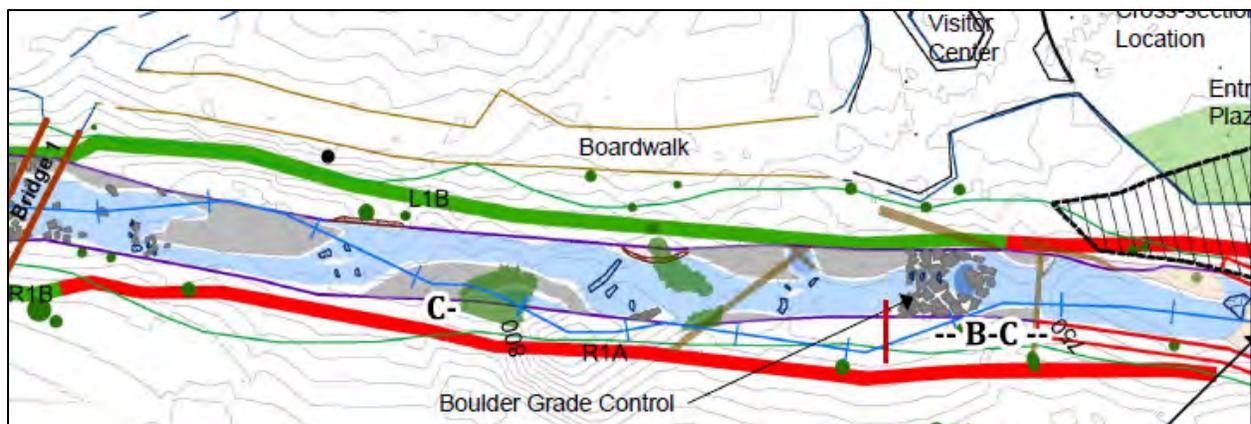
**Figure 4.** Section L1A Condition Assessment



**Figure 5.** Section L1A, center stretch view north-northeast from creek bed, showing tightly placed medium sized rock revetment in fair-good condition behind tree trunks and vegetation

## Section R1A

Section R1A stretches from across the creek from the Entrance Plaza and Section L1A nearly to Bridge 1 (Figure 6). It has been measured at 344 feet long and almost 7 feet high (NHE 2016), consistent with observed conditions in November 2016. In 2000, it was documented as consisting of well-stacked large boulders (Peterson 2000). The section is visible from the Boardwalk. Although the location of this section is observable from the Boardwalk, the creek bank is heavily overgrown with ferns and seasonal vegetation, and only small stretches of its rocks were visible from the creek bank and creek bed in November 2016. The uniform shape of the creek bank, however, indicates the presence of rock retaining walls in fair to good condition (Figures 7-8). The roughly 40-foot eastern stretch slightly more visible and in better condition (Figure 9). Although heavily overgrown, the overall condition of Section R1A is fair to good. Note: this segment would be removed under alternatives B, C, D, and E.



**Figure 6.** Section R1A Condition Assessment



**Figure 7.** Center-west stretch of Section R1A, view south-southwest from creek bed, showing riprap of medium-sized rocks in good condition beneath vegetation and with trees growing from some areas



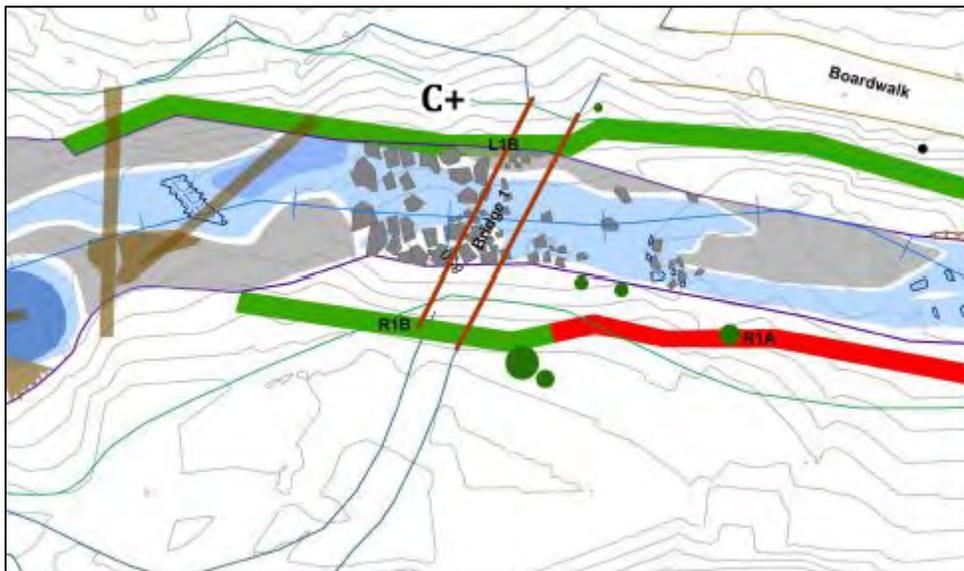
**Figure 8.** Center-west stretch of Section R1A, view south from creek bed, showing riprap in good condition beneath vegetation and with trees growing from some areas



**Figure 9.** Eastern stretch of Section R1A, view south from creek bed, showing larger rocks, some of which are out of place

## Section L1B

Section L1B is located directly adjacent to Section L1A to the northwest and continues upstream under and past Bridge 1, across the stream from most of R1A and all of R1B (Figure 10). It has been measured at roughly 245 feet long and 5.5 feet high (NHE 2016). In 2000, it was documented as consisting largely of boulders that were buried in the bank and not visible (Peterson 2000). These measurements were generally consistent with its observed condition in December 2016, especially toward the west end, which is mostly obscured by vegetation (Figure 11). Very little of the section is visible from park trails. The stretches that are not obscured by vegetation consist of large- and medium-sized rocks and are in relatively good condition (Figure 912). Section L1B is in fair to poor condition overall.



**Figure 10.** Section L1B Condition Assessment.



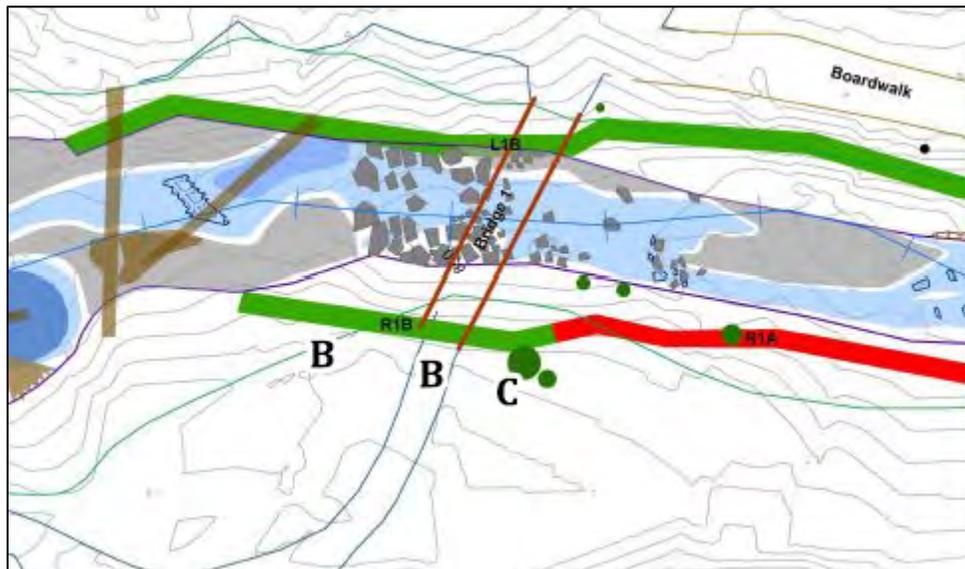
**Figure 11.** Stretch of L1B obscured by vegetation, view northwest from right bank, with large loosely-stacked stones visible left of frame



**Figure 12.** Section L1B and boardwalk, view east from right bank, stretch with medium rocks in fair to good condition center frame

## Section R1B

Section R1B is located across the stream from the northwest end of Section L1B and is continuous with Section R1A, running under and a small distance past Bridge 1 (Figure 13). It has been measured at about 65 feet long (NHE 2016). In 2000, it was documented as being nonexistent and consisting only of exposed soil (Peterson 2000). The December 2016 visit, however, found that, while obscured by vegetation toward the east end, the section consisted of loosely stacked rocks of variable size (Figures 14-15). It is partially visible from park trails. Section R1B is in good condition under and upstream of Bridge 1 (Figure 16) but the downstream (east) end is in poor condition and verging on not visible. Section R1B is in fair to good condition overall.



**Figure 13.** Section R1B Condition Assessment



**Figure 14.** Section R1B and Bridge 1, view southwest from left bank, showing riprap in good condition under bridge and obscured by trees and ferns to the east



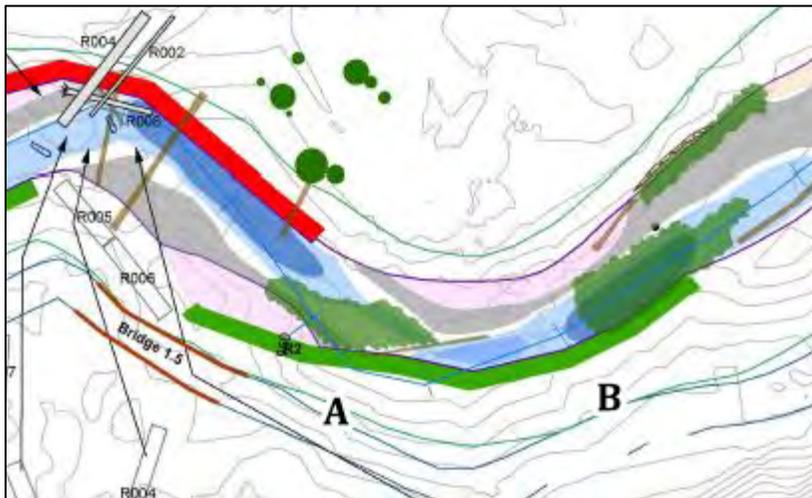
**Figure 15.** Detail, Section R1B downstream from Bridge 1, view southwest from left bank



**Figure 16.** Western stretch of Section R1B upstream of Bridge 1, view southwest from Bridge 1, showing riprap in fair condition partially obscured by a tree and other vegetation

## Section R2

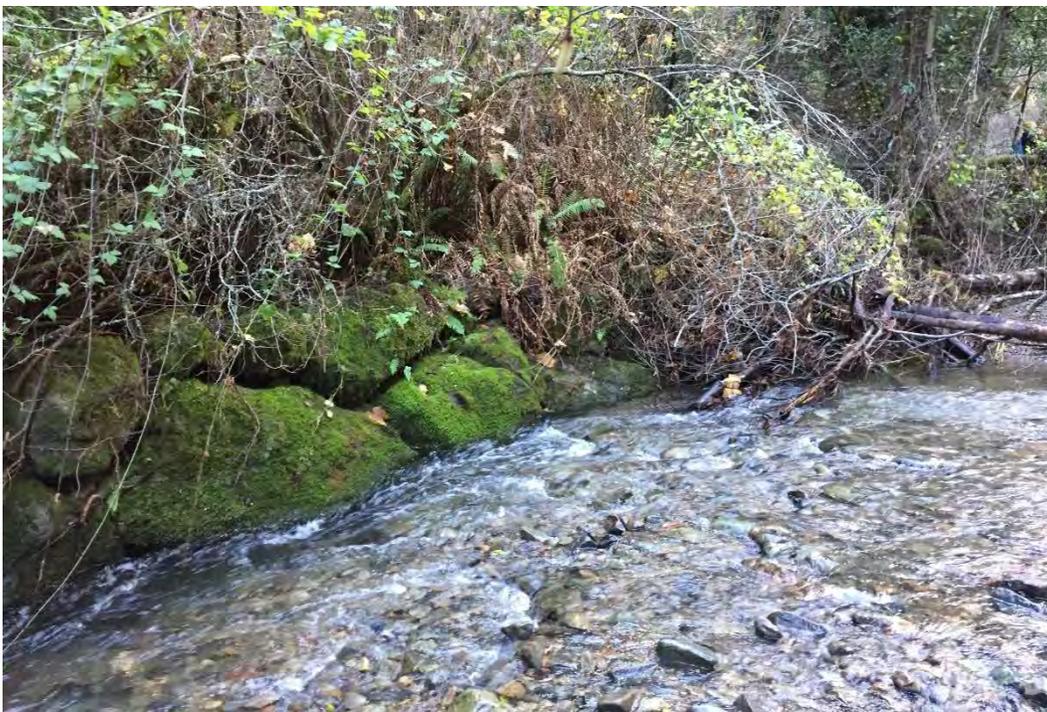
Section R2 wraps around a bend in the creek upstream of Bridge 1 and ends adjacent to Bridge 1.5 to the east (Figure 17). It has been measured at about 165 feet long and 6.5 feet high (NHE 2016). In 2000, it was documented as consisting of a combination of small and large loosely stacked boulders (Peterson 2000). The measurements recorded are mostly consistent with its observed condition in December 2016, although it appears to be more tightly stacked than described in 2000. It is not visible from park trails. Its downstream half is in good condition and consists of tightly-placed medium-sized rocks (Figure 18). Upstream, it is in excellent condition and is also tightly stacked, but is made up of larger boulders (Figure 19). Overall, Section R2 is in very good condition. Note: this segment would be removed under alternatives D, and E.



**Figure 17.** Section R2 Condition Assessment



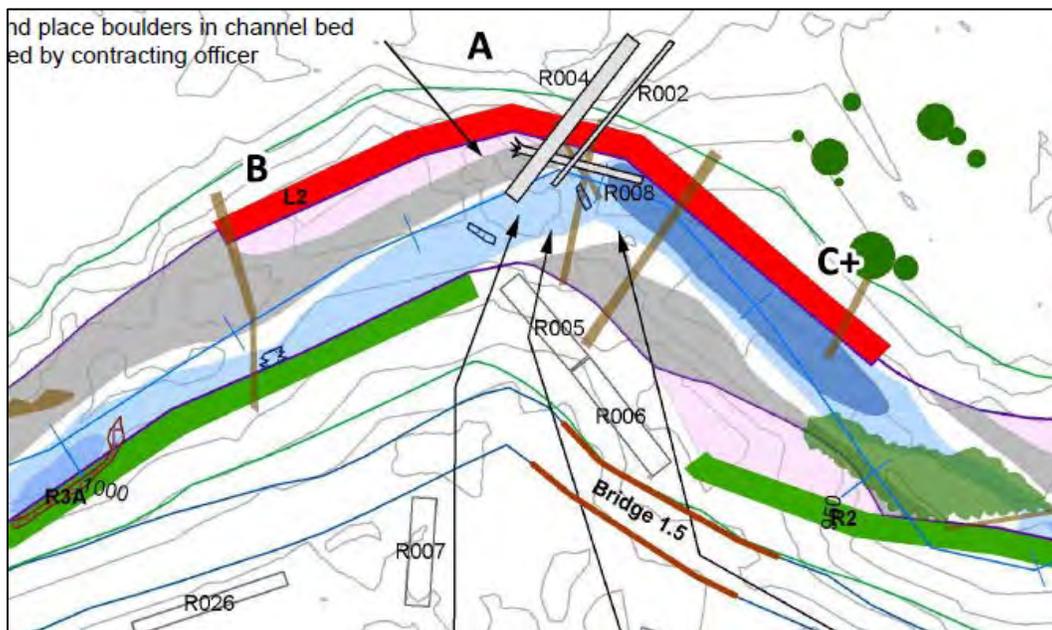
**Figure 18.** Section R2 viewed from left bank, camera facing southwest, showing tightly placed medium-sized rocks in good condition



**Figure 19.** Section R2 viewed from left bank, camera facing west, showing upstream stretch with larger boulders in excellent condition

## Section L2

Section L2 is located at a bend in the creek immediately northwest and upstream of Bridge 1.5 (Figure 20). The U-shaped section has been measured at roughly 128 feet long and 6.5 feet high (NHE 2016). In 2000, it was documented as consisting of large, loosely-stacked boulders, some of which had fallen into the creek (Peterson 2000). The measurements recorded are consistent with its observed condition in November 2016. Its location is visible from park trails. Although its location is visible from park trails, live vegetation on the bank and dry brush and fallen trees in the creek bed make some stretches hard to see, but careful observation shows that the entire section is extant. The 30-foot central stretch is in excellent condition, with intentionally placed large- and medium-sized rocks (Figure 21). The 45-foot stretch upstream of the creek bend is in good condition, while the 45-foot stretch downstream is in fair to poor condition (Figures 22-23). Overall, Section L2 is in good condition.



**Figure 20.** Section L2 Condition Assessment



**Figure 21.** Central stretch of Section L2, view northwest from right bank, showing riprap in excellent condition beneath ferns and other vegetation



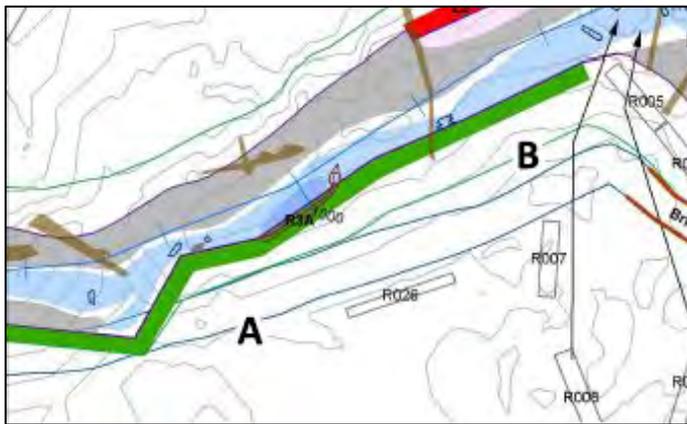
**Figure 22.** Northwest (upstream) stretch of Section L2, view north from right bank, showing riprap under vegetation and woody debris



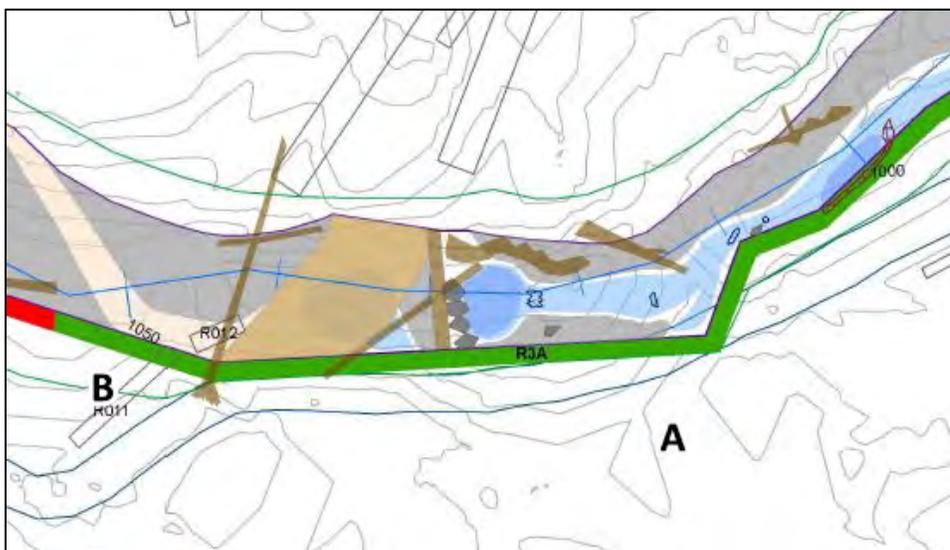
**Figure 23.** Poor condition downstream stretch of Section L2, view east from right bank, showing deteriorating riprap with woody debris, ferns, and other vegetation

## Section R3A

Section R3A begins just north of Bridge 1.5 and continues upstream as far as the part of the right bank across from the Pinchot and Emerson trees (Figures 24-25). It has been measured at about 253 feet long and 4 feet tall (NHE 2016). In 2000, it was documented as a well secured, “embedded wall” of medium-sized boulders (Peterson 2000), which is consistent with observed conditions in December 2016 (Figures 26-27). Vegetation and a log jam at the west end obscured part of the section at the time of the visit (Figure 28). It is not visible from park trails. It consists generally of 4-5 courses, except at the east end. Section R3A is overall in very good condition. Note: this segment would be removed under alternatives D and E.



**Figure 24.** Section R3A Condition Assessment (east portion)



**Figure 25.** Section R3A Condition Assessment (west portion)



**Figure 26.** Section R3A from left bank, camera facing east, showing east stretch with 2-4 course riprap in excellent condition



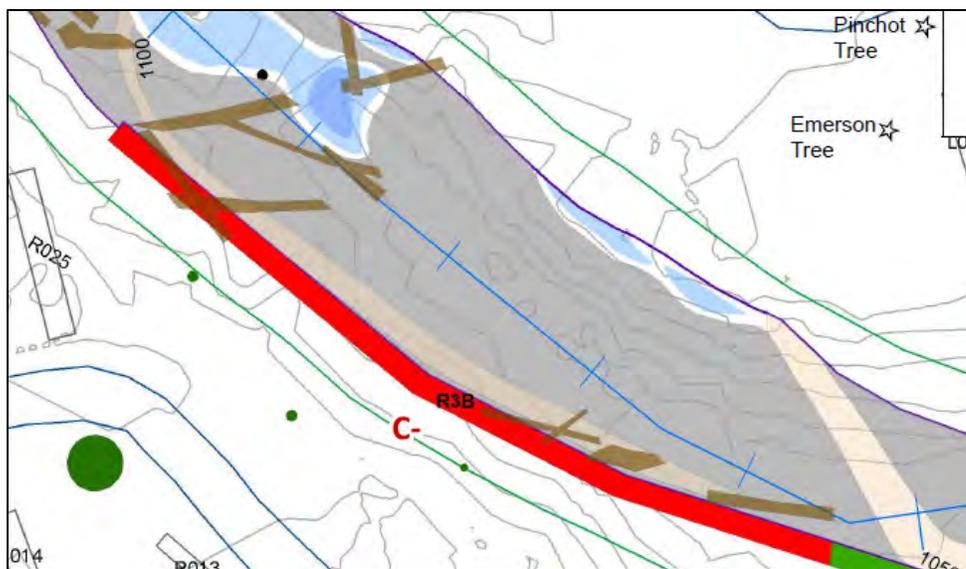
**Figure 27.** Section R3A from left bank with path visible in background, camera facing southwest, showing center-west stretch with 4-5 course riprap in excellent condition with minimal vegetation



**Figure 28.** West stretch of Section R3A obscured by log jam viewed from left bank, camera facing west, riprap is in good condition beneath vegetation and woody debris

## Section R3B

Section R3B is located just across the creek to the west from the Pinchot and Emerson trees (Figure 29). It has been measured at 150 feet long and about 2.5 feet tall (NHE 2016), consistent with observed conditions in November 2016. In 2000, it was documented as disassembled, “non-embedded”, and consisting of a single course of small boulders (Peterson 2000). The section is visible from park trails and the Emerson Tree area. Although the area is visible, heavy seasonal vegetation and woody debris make observation of the section, especially the north stretch, difficult, but there appears to be at least one course of boulders present throughout (Figures 30-31). R3A, which is adjacent to the south and supports the trail, is more visible and consists of at least 2 courses. The overall condition of Section R3B is fair to poor, and it consists of only 1-2 courses in contrast to most sections which have 3 or more courses.



**Figure 29.** Section R3B Condition Assessment



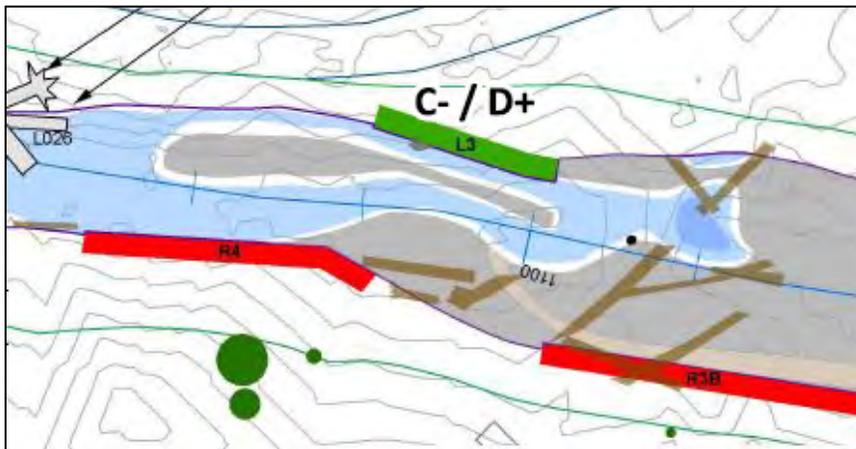
**Figure 30.** South stretch of Section R3B, view south from creek bed, showing low riprap obscured by ferns and woody debris



**Figure 31.** Detail, Section R3B low rock wall is visible behind woody debris

## Section L3

Section L3 is located between Sections R3B and R4, across the creek to the east (Figure 32). It is west of the fork of the Canopy View Trail and Redwood Creek Trail. Section L3 has been measured at about 39 feet long and 4 feet high (NHE 2016). In 2000, it was recorded as a combination of a disassembled, “non-embedded wall,” embedded rocks that did not make up a wall, and rocks fallen into the creek (Peterson 2000). These measurements are consistent with observed conditions in December 2016 (Figures 33-34). The location of Section L3 is not visible from park trails. It is in generally poor condition and much of it is obscured by debris and vegetation or has fallen away.



**Figure 32.** Section L3 Condition Assessment



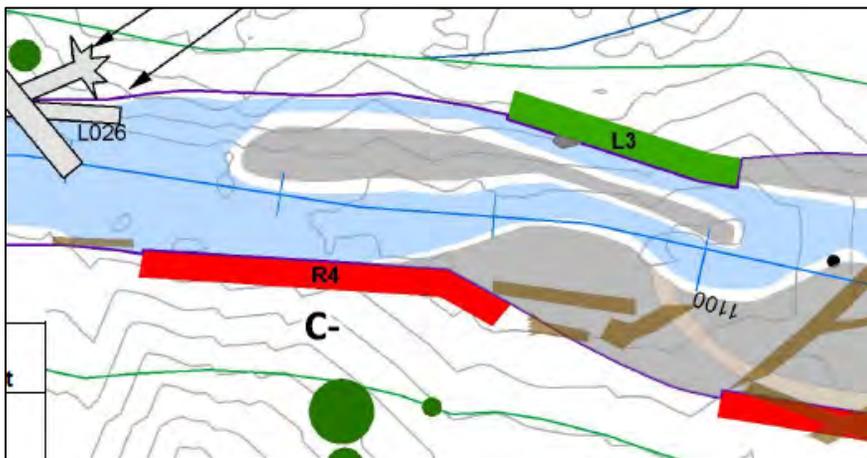
**Figure 33.** Section L3 seen from right bank, camera facing northeast, showing occasional rocks beneath moss, ferns, and other vegetation. The shape of the bank suggests riprap is in poor condition



**Figure 34.** Overview of Section L3, camera facing east, showing area slightly to the east of Figure 30 which is also obscured by vegetation but appears to be in fair to poor condition

## Section R4

Section R4 is located just upstream of R3B and across the creek to the west of where the Canopy View Trail diverges from the main Redwood Creek Trail (Figure 35). This portion of the creek runs north-south in contrast to the general west-east direction. Section R4 has been measured at about 13 feet long and 2.5 feet high (NHE 2016). In 2000, it was recorded as a well-stacked wall of small boulders buried under the bank and not visible (Peterson 2000). However, it appears to be currently visible from park trails as well as the creek bed. The height and length recorded are consistent with observed conditions in November 2016. Section R4's small boulders are now easily visible, and are no longer stacked, but appear piled at random (Figures 36-37). It is completely dry, and at least 20 feet from the current water in the creek. The overall condition of Section R4 is poor.



**Figure 35.** Section R4 Condition Assessment



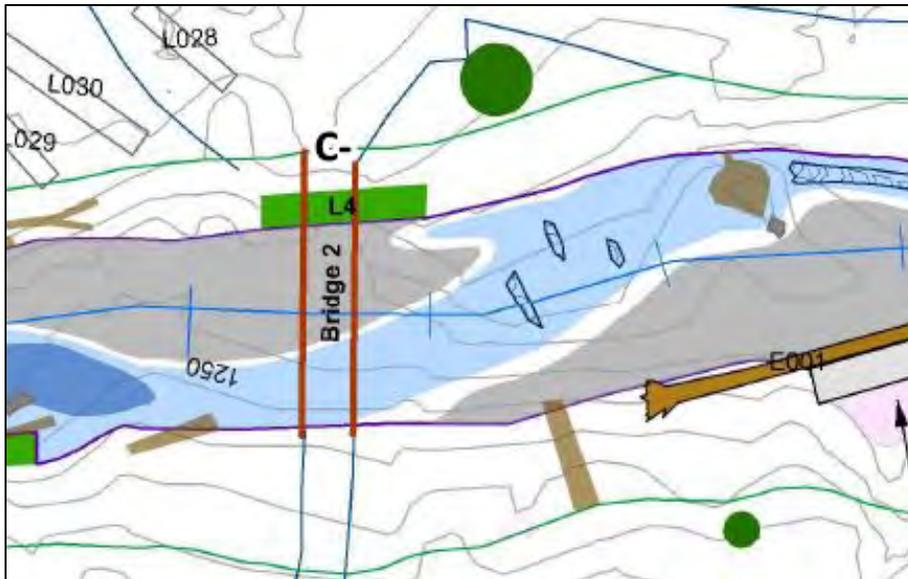
**Figure 36.** Overview of Section R4, view west, showing displaced riprap beneath fallen logs



**Figure 37.** Detail, Section R4, view south, showing riprap in fair condition with ferns and a tree growing out of it

## Section L4

Section L4 is located directly under and at either end of Bridge 2 (Figure 38). It has been measured at roughly 46 feet long and 4 feet tall (NHE 2016). In 2000, it was documented as loosely-stacked, disassembled, and “non-embedded,” (Peterson 2000). Measurements are mostly consistent with observed conditions in December 2016. It consists of rocks that, while mostly small, are variable in size and loosely stacked, and is in poor condition overall (Figures 39-40). It is visible from Bridge 2 and the right bank trail.



**Figure 38.** Section L4 Condition Assessment



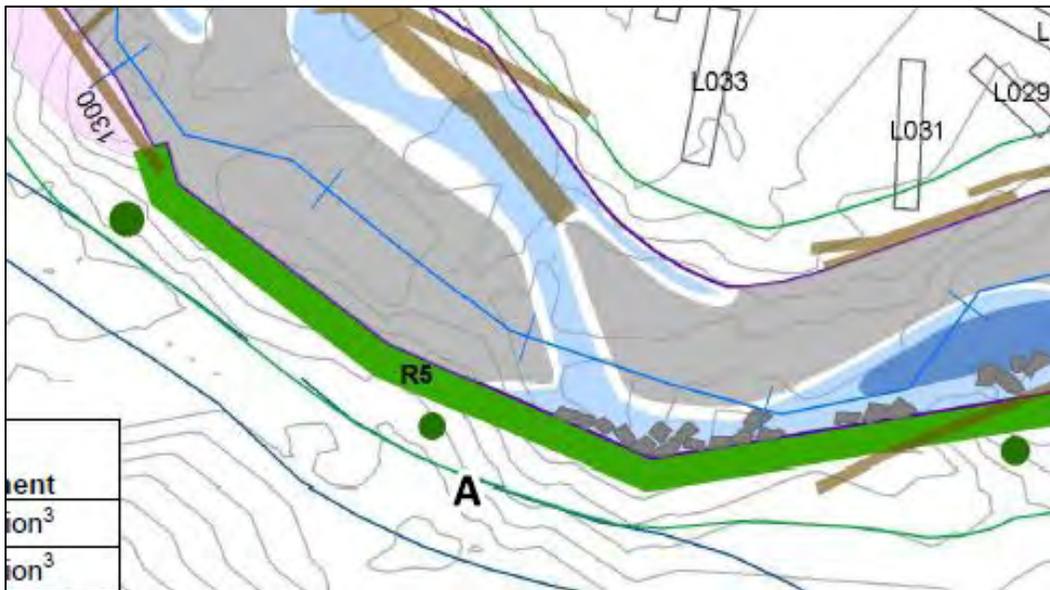
**Figure 39.** View of Section L4 from right bank, camera facing northeast, showing variable-sized displace rocks



**Figure 40.** View of Section L4 from right bank, camera facing north, with little intact riprap in place

## Section R5

Section R5 is located northwest of Bridge 2 and runs along the curve of the creek upstream from the bridge, ending directly west from the start of Section L5 (Figure 41). It has been measured at roughly 135 feet long and just under 7 feet tall (NHE 2016). In 2000, it was documented as a loosely stacked and fallen wall of large boulders (Peterson 2000). However, it appeared tightly stacked and in excellent condition and consisted of small- to medium-sized boulders at the time of the December 2016 field visit (Figures 42-43). The measurements recorded are consistent with field observations in December 2016. It is visible from park trails and in excellent condition overall.



**Figure 41.** Section R5 Condition Assessment



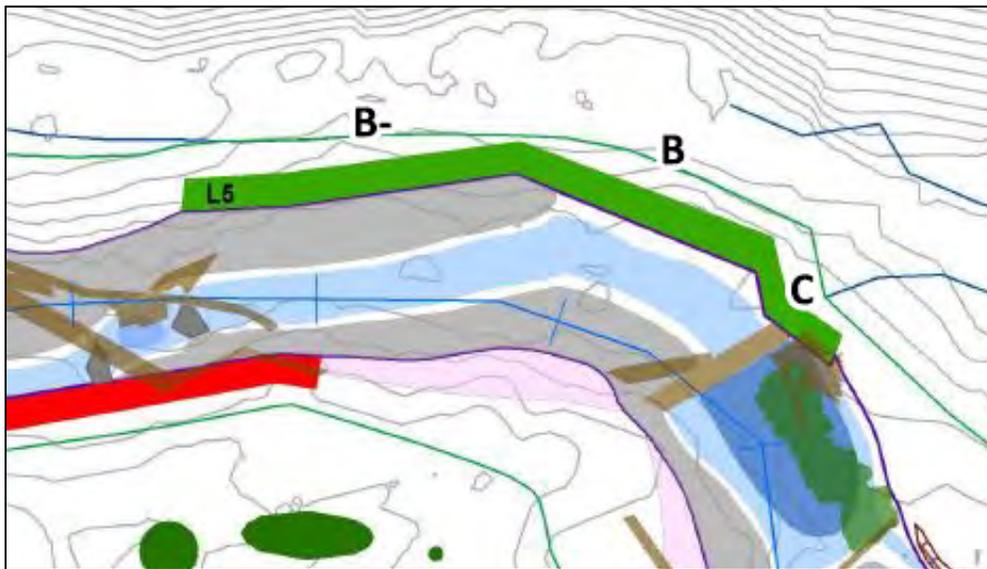
**Figure 42.** View of Section R4 with trail in background from left bank, camera facing northwest, showing medium-sized rocks in excellent condition with some light fern growth above



**Figure 43.** View of Section R4, camera facing southwest, large- and medium-sized rocks in excellent condition below fern growth

## Section L5

Section L5 wraps around the curve where the creek turns and flows north-south upstream of Bridge 2 (Figure 44). It has been measured at roughly 79 feet long and just under 6 feet tall (NHE 2016). In 2000, it was documented as a loosely stacked and “disassembled wall” of medium-sized boulders (Peterson 2000). At the time of the December 2016 visit, parts of the section were obscured by seasonal vegetation and more durable woody debris (Figures 45-46), but visible stretches were consistent with recorded observations. Section L5 is visible from park trails. It is in good condition in the middle and poor condition at the ends (Figure 47). The section overall is in fair to good condition.



**Figure 44.** Section L5 Condition Assessment



**Figure 45.** Portion of Section L5 mostly obscured by woody debris, camera facing north



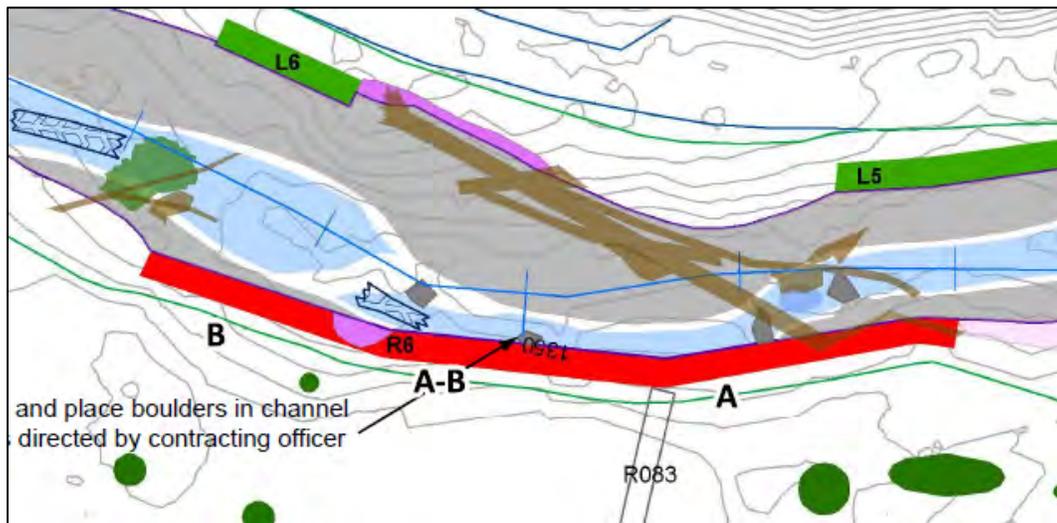
**Figure 46.** Section L5, from right bank, camera facing northeast, showing woody debris, ferns, and seasonal vegetation with small areas of rock revetment visible left of frame and at center



**Figure 47.** East end of Section L5 and trail, camera facing east, showing rocks displaced by tree and falling away

## Section R6

Section R6 is located roughly halfway between Bridge 2 and Bridge 3 along the portion of the creek that runs north-south (Figure 48). It has been measured at roughly 128 feet long and slightly over 7 feet tall (NHE 2016). In 2000, it was documented as a loosely-stacked and fallen wall of large boulders (Peterson 2000). Although there are ferns and trees growing on the top of Section R6, most of the vegetation does not cover the face of the rock wall. It is highly visible from the main Redwood Creek Trail, which is very close to the creek in this area. The measurements recorded are consistent with field observations in November 2016. However its condition is much better than suggested by the previous documentation. The south stretch, about 65 feet long, is in excellent condition (Figure 49). Boulders of varying size are stacked fairly tightly, and are 3-5 courses high. Vegetation obscures some of the center stretch, but it also appears to be in very good condition (Figures 50-51). The north stretch of about 50 feet is in good condition, except for small areas (5-10 feet) where a few boulders have fallen out of place (Figure 52). Section R6 overall is in very good condition. Its condition and craftsmanship are better than many of the other sections targeted for removal.



**Figure 48.** Section R6 Condition Assessment



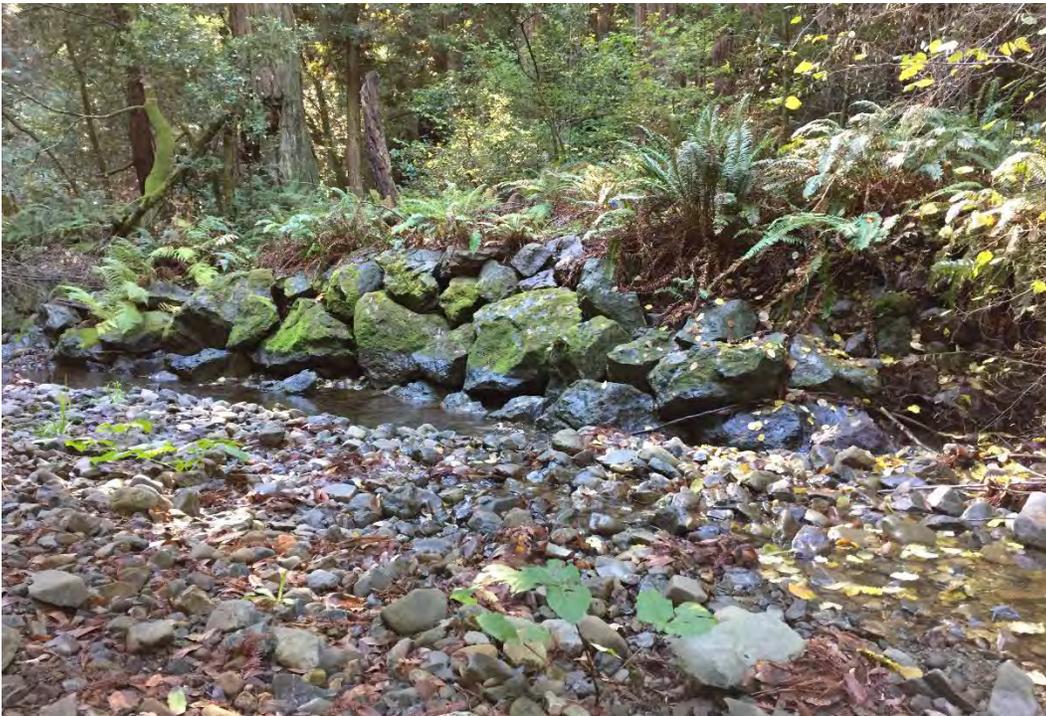
**Figure 49.** South stretch of Section R6, view west from trail showing riprap in excellent condition with some woody debris around it and trees and ferns on top of the bank



**Figure 50.** Center-south stretch of Section R6, view west-southwest showing riprap in clearly visible and in excellent condition with ferns above



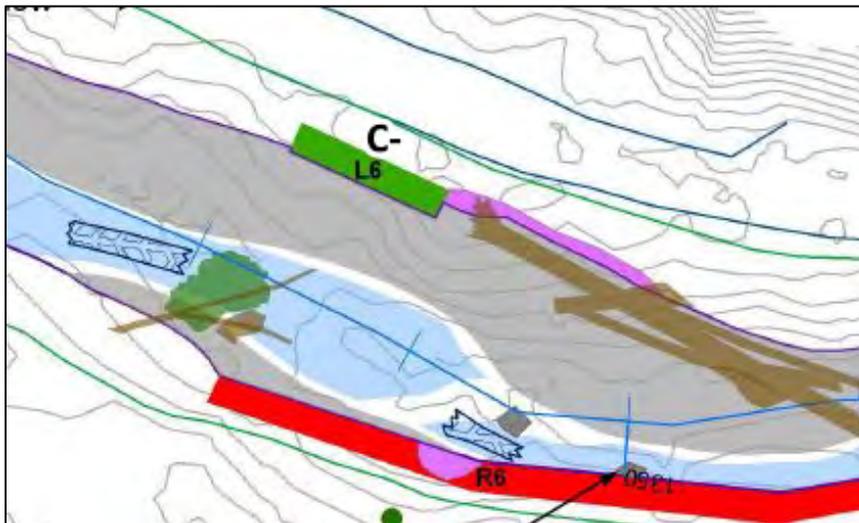
**Figure 51.** Center-north stretch of Section R6, showing riprap in good condition to south with area obscured by ferns and other vegetation to north



**Figure 52.** North stretch of Section R6, view west showing riprap in very good condition with small areas of deteriorated or obscured by vegetation at either end

## Section L6

Section L6 is located directly across the creek from the north end of Section R6 (Figure 53). It has been measured at roughly 23 feet long and just over 7 feet tall (NHE 2016). In 2000, it was documented as a loosely stacked wall of large rocks (Peterson 2000). These measurements were consistent with its observed condition in December 2016; at the time of the field visit, it was partially obscured by woody debris and seasonal vegetation and largely disassembled (Figure 54). Section L6 is visible from park trails. It consists of about 2 courses and is in poor condition.



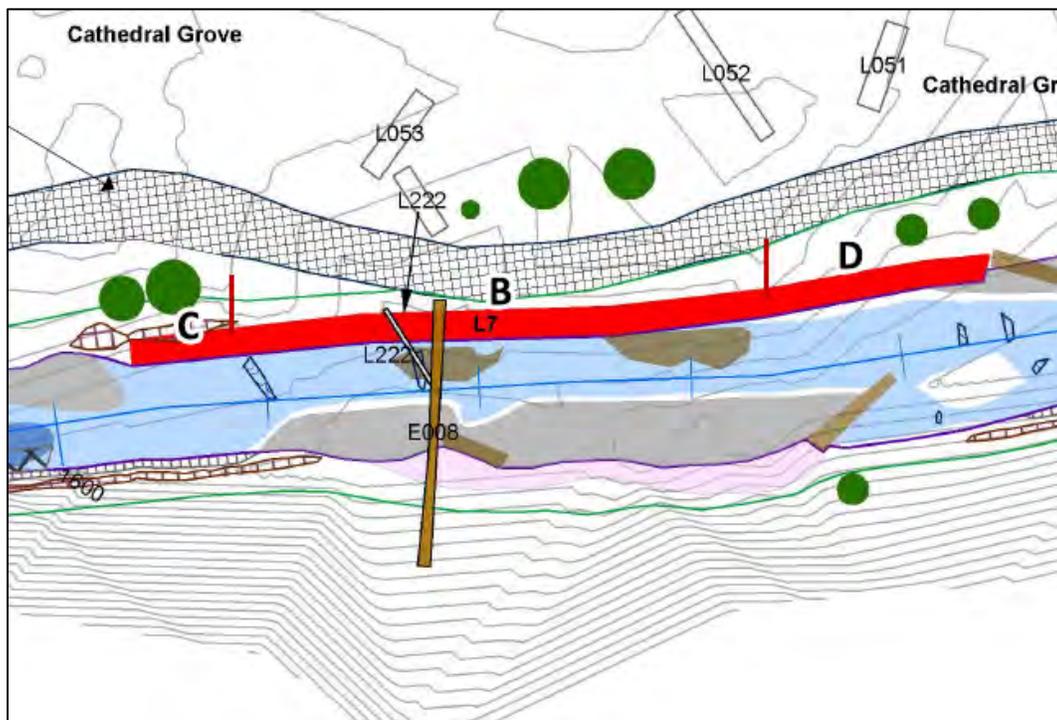
**Figure 53.** Section L6 Condition Assessment



**Figure 54.** Section L6 from right bank, camera facing northeast, showing riprap in poor condition center frame and otherwise obscured by vegetation

## Section L7

Section L7 is located adjacent to Cathedral Grove and supports the western arm of the trail that splits off from Redwood Creek Trail before the grove (Figure 55). It has been measured at about 141 feet long and 5 feet high (NHE 2016). Observed conditions in November 2016 revealed a roughly 110-foot by 5-foot wall. In 2000, it was documented as consisting of medium boulders. The 2000 report called out loosely-stacked, well-stacked, buried, and “embedded non-wall” conditions in the section (Peterson 2000). Although these different conditions must have been observed in different stretches, no details about their specific locations were recorded. The section is visible from the Hillside Trail, although ferns and woody debris partially obscure much of the upper course. Section L7 consists of boulders of variable size with the largest forming the lower course. This results in a wall that is more tapered from bottom to top than most other sections. Roughly 110 feet of its west stretch is in fair to good condition (although rocks are not as carefully fit together as in the most finely wrought sections). Roughly 15 feet at the west end of the section is in fair to poor condition (Figure 56), while the 95 feet at the center are in good condition, with boulders that are clearly stacked intentionally (Figures 57-58). The east 30 feet, as recorded in 2000, has either fallen away or is obscured by vegetation (Figures 59-61). Overall Section L7 is in fair to good condition.



**Figure 55.** Section L7 Condition Assessment



**Figure 56.** West stretch showing poor condition/obscured stretch left of frame, view northwest from creek bed



**Figure 57.** Center section, view north-northeast from creek bed, showing well-stacked boulders beneath tree stump, ferns, and the trail



**Figure 58.** Center-east section, view northeast from creek bed showing well-stacked boulders beneath tree stump, ferns, and the trail



**Figure 59.** Overview, east stretch, view east from creek bed, showing riprap in good condition partially obscured by ferns and young trees



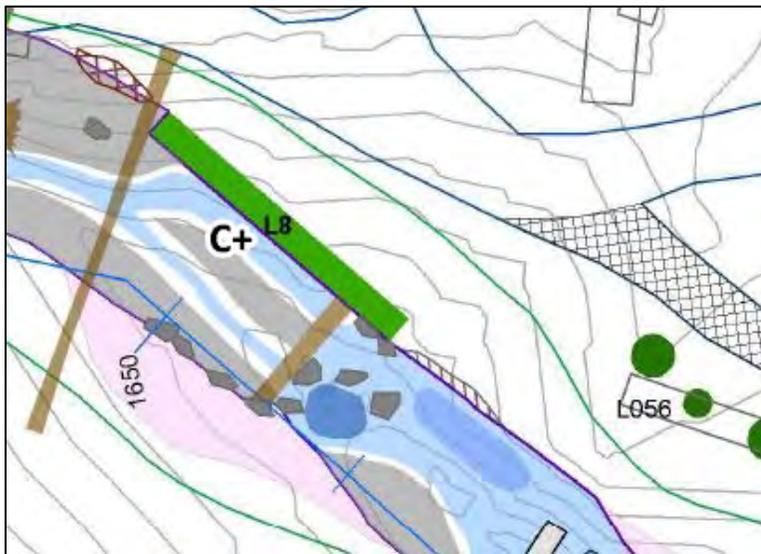
**Figure 60.** Overview, view east from creek bed at east end of Section L7, riprap clearly visible below ferns



**Figure 61.** Detail, eastern stretch where wall has either fallen away or been engulfed in vegetation

## Section L8

Section L8 is located just past the curve in the creek northwest of Cathedral Grove (Figure 62). It has been measured at almost 56 feet long and just under 7 feet tall (NHE 2016). In 2000, it was documented as a combination of loosely stacked wall and “disassembled non-wall,” made of medium-sized boulders that had partly fallen into the creek (Peterson 2000). Previous measurements were consistent with observed conditions at the time of the December 2016 field visit. It consists of loosely-stacked medium-sized boulders (Figures 63-64). The section is not visible from park trails. No disassembled areas were observed. Section L8 is overall in fair condition.



**Figure 62.** Section L8 Condition Assessment



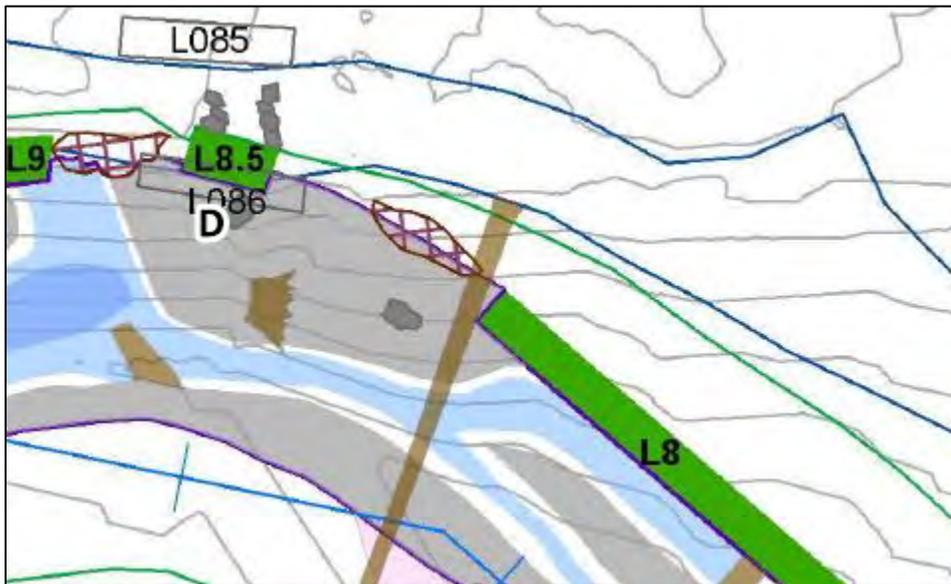
**Figure 63.** Section L8, view north from creek bed, showing riprap in good condition with ferns above and some woody debris



**Figure 64.** Section L8 looking east from creek bed, showing medium-sized boulders in good condition with some areas covered by ferns

## Section L8.5

Section L8.5 is located along where the creek curves towards the east-west and to the north of Section L8 (Figure 65). It has been measured at about 49 feet long (NHE 2016). In 2000, it was documented as consisting of very small boulders, and its categorization as riprap was questioned (Peterson 2000). Its location is not visible from park trails. Very little or no riprap was observed at the time of the December 2016 field visit, although it may be present under heavy fern growth and other vegetation (Figure 66). A tributary was flowing into the creek from the north. Section L8.5 is overall not visible or has fallen away.



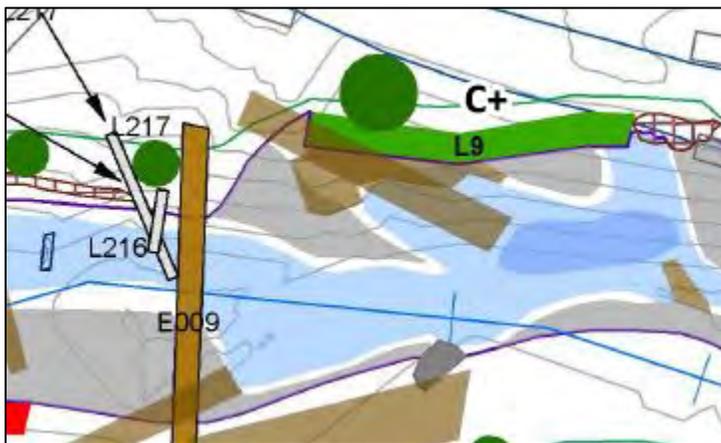
**Figure 65.** Section L8.5 Condition Assessment



**Figure 66.** Section L8.5, view north from creek bed, showing heavy seasonal vegetation with what appears to be riprap fallen away in the creek

## Section L9

Section L9 is located immediately upstream from Section L8.5 (Figure 67). It has been measured at almost 23 feet long and almost 10 feet tall (NHE 2016). In 2000, it was documented as consisting of a combination of loosely stacked wall and “disassembled non-wall” made of medium-sized boulders (Peterson 2000). Measurements were consistent with observed conditions at the time of the December 2016 field visit. Although individual rocks were not directly visible, close inspection of the bank reveals that it consists of small boulders embedded in dirt or covered with moss (Figures 68-69). L9 is much less vertical than other sections, and may have shifted into a more horizontal position over the decades, or may originally have been designed differently than most sections. Its location is not visible from park trails. The section is in fair to poor condition overall.



**Figure 67.** Section L9 Condition Assessment



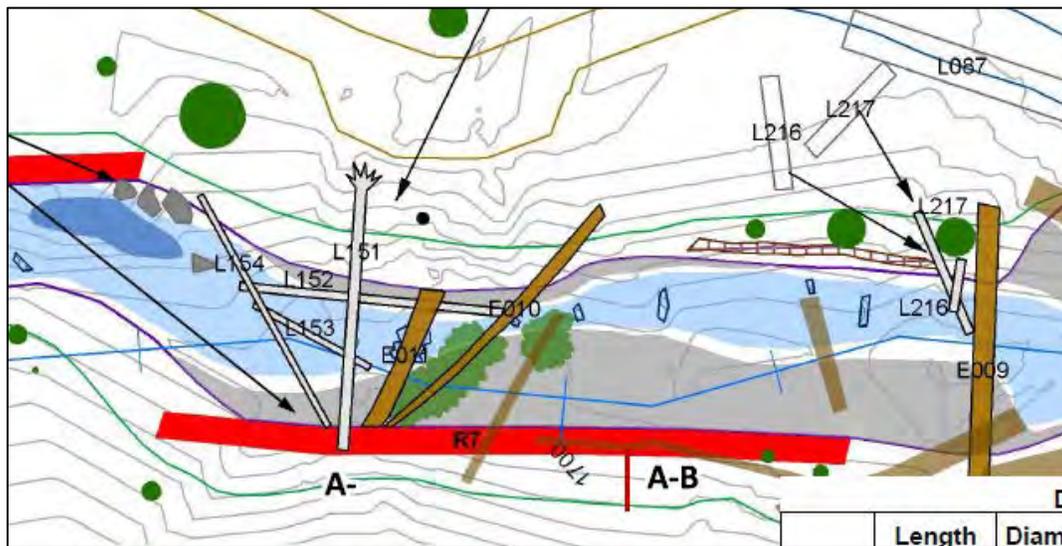
**Figure 68.** Section L9, view north from creek bed, showing nearly horizontal riprap of small rocks under moss below a vertical creek bank supporting ferns and tree roots



**Figure 69.** Section L9, view southwest from left bank, showing nearly horizontal riprap of small rocks under moss in foreground

## Section R7

Section R7 is located across the creek and roughly 150 feet upstream of Cathedral Grove (Figure 70). It was previously measured at about 115 feet long and just under 4 feet high (NHE 2016). The length is consistent with observed dimensions in November 2016, although most of its visible stretches are no more than about 3 feet high. It was documented as a loosely-stacked wall of medium-sized boulders in 2000 (Peterson 2000). The section is visible from the Redwood Creek Trail. Its roughly 60-foot northwest stretch is in very good condition, and consists of 2-3 courses of tightly stacked boulders of variable size (Figures 71-72). The 55-foot southeast stretch is largely obscured by vegetation, but, where visible, consists of carefully placed medium-sized boulders (Figure 73). Overall Section R7 is a low wall in good to very good condition.



**Figure 70.** Section R7 Condition Assessment



**Figure 71.** Overview, northwest stretch of Section R7, view south-southeast from creek bed, showing 2-3 courses of tightly stacked boulders of variable size with ferns and trees above



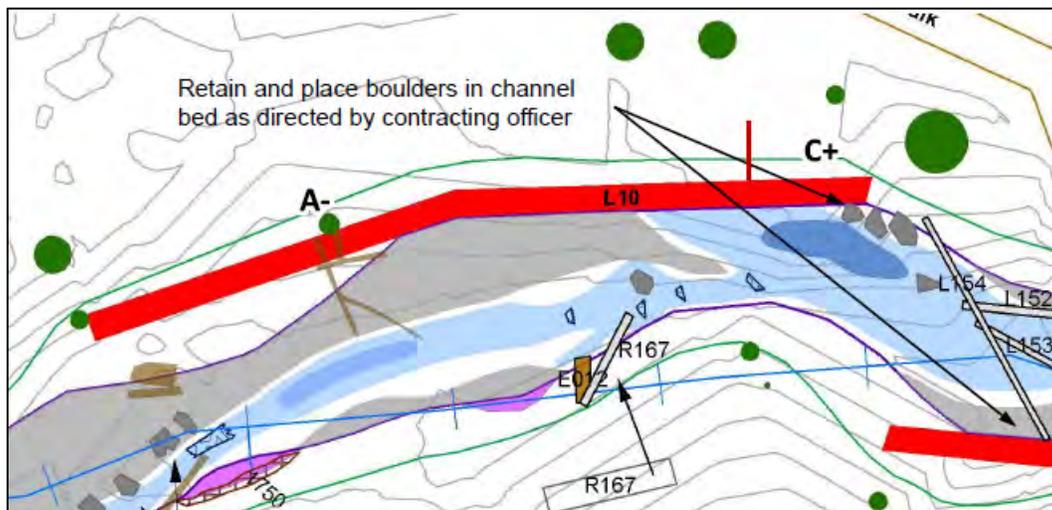
**Figure 72.** Detail, northwest stretch, showing 2-3 courses of tightly stacked boulders of variable size with ferns and small amounts of woody debris



**Figure 73.** Southeast stretch, view southeast from creek bed, well-stacked wall visible center frame behind ferns, small trees, and seasonal vegetation

## Section L10

Section L10 is just across the creek and upstream from Section R7 (Figure 74). It has been measured at about 130 feet long and 5.5 feet tall (NHE 2016), consistent with observed conditions in November 2016. In 2000, it was documented as a well-stacked wall of large boulders (Peterson 2000). Its location is visible from the Hillside Trail. Although partially overgrown with ferns and other vegetation, it remains in excellent condition, with large boulders intentionally placed in 3-4 courses (Figures 75-76). A 30-foot stretch at its eastern end is in poor to fair condition (Figures 77-78). Overall, Section L10 is in good condition. Its condition and craftsmanship make it one of the better sections targeted for removal.



**Figure 74.** Section L10 Condition Assessment



**Figure 75.** West stretch, view north from creek bed, showing riprap in fair condition beneath vegetation



**Figure 76.** Center stretch, view east from creek bed, showing ferns and small tree grown atop riprap in good condition



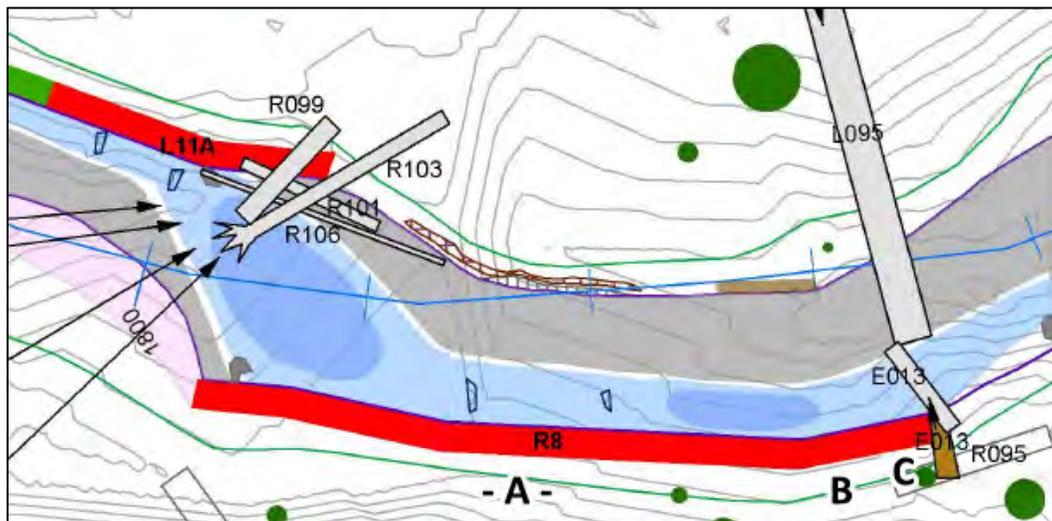
**Figure 77.** Center-east stretch, view east-northeast from creek bed, showing riprap in good condition



**Figure 78.** East end showing some displaced boulders with most riprap in good condition beneath light vegetation growth

## Section R8

Section R8 is located across the creek and upstream from Section L10 (Figure 79). It has been measured at about 110 feet long and 3.5 feet tall (NHE 2016), consistent with observed conditions in November 2016. It was documented in 2000 as a loosely stacked wall of medium boulders. Roughly 80 feet at its west stretch consists of carefully placed and tightly stacked boulders (Peterson 2000). The location of the section is visible from the Redwood Creek Trail. The majority of the section consists of medium-sized boulders, with smaller rocks fit in to form a relatively solid wall of 3-4 courses (Figures 80-82). A small area (roughly 5 feet long) at the east end is in poor condition, with a 15-foot stretch center-east in good condition (Figure 83). The overall condition of Section R8 is excellent. Its condition and craftsmanship make it one of the finest sections targeted for removal.



**Figure 79.** Section R8 Condition Assessment



**Figure 80.** Section R8 overview, view west from creek bed showing riprap of medium-sized boulders, with smaller rocks fit in to form a relatively solid wall of 3-4 courses, in excellent condition



**Figure 81.** Detail, west stretch, showing riprap in excellent condition with ferns above



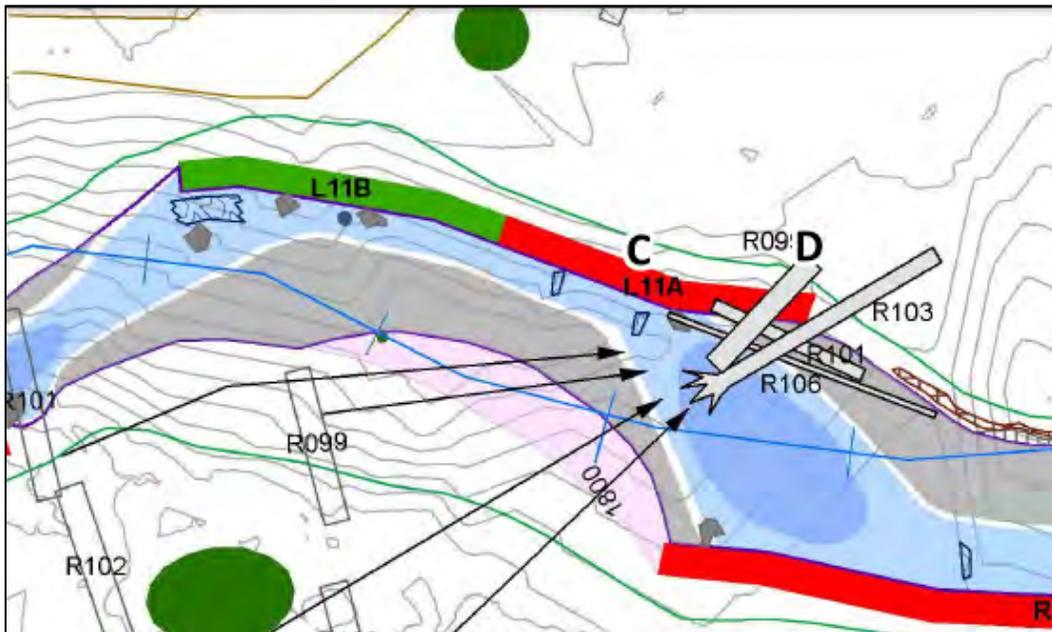
**Figure 82.** Detail, center-west stretch showing riprap in excellent condition with ferns above



**Figure 83.** Detail showing good-fair condition of east stretch with ferns and vegetation partially obscuring riprap

## Section L11A

Section L11A is located across the creek and just upstream from Section R8. It is connected at its west end to Section L11B, which is not slated for removal (Figure 84). It is about 25 feet long, while the adjacent Section L11B is close to 60 feet (NHE 2016). It is just under 6 feet tall (NHE 2016). In 2000, Section L11 was documented as loosely-stacked and “embedded non-wall” of medium-sized rocks (Peterson 2000). No details were recorded to differentiate the west and east stretches of L11. It is visible from the Hillside Trail. The dimensions are consistent with those observed in November 2016, but it is difficult to discern the exact dividing line between L11A and L11B. What appears to be L11A’s west stretch is in fair-poor condition (Figure 85), while the east stretch (about 15 feet long) is completely missing and/or in poor condition (Figure 86). The overall condition of Section L11A is poor.



**Figure 84.** Section 11A Condition Assessment



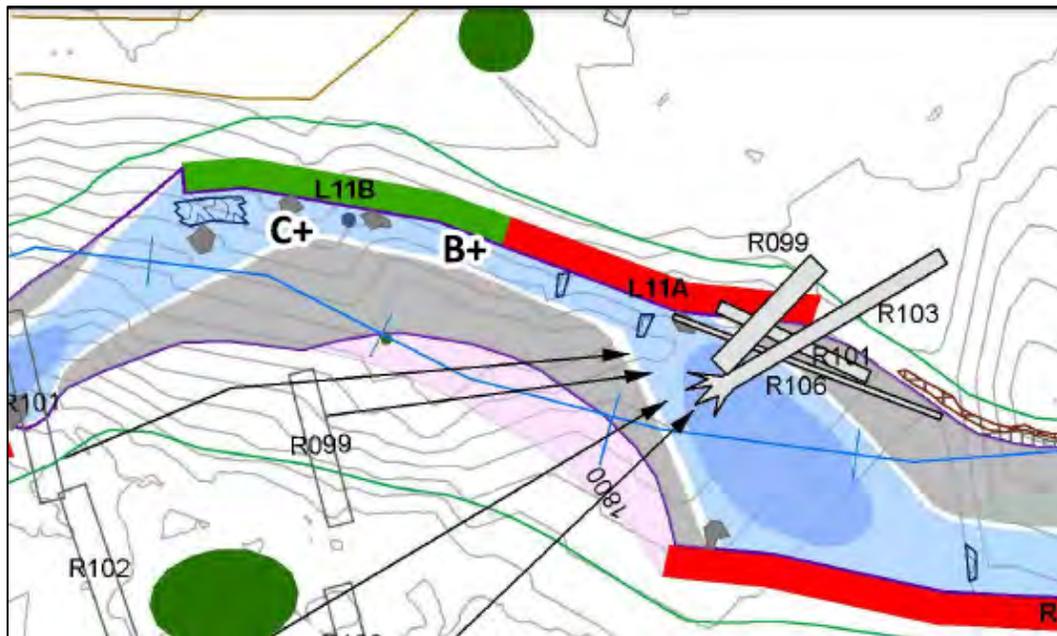
**Figure 85.** West stretch, view north from creek bed, showing riprap in fair-poor condition with ferns partially obscuring



**Figure 86.** East stretch, view north from creek bed, where riprap is missing or completely obscured by ferns and other vegetation

## Section L11B

Section L11B is directly adjacent to and northwest of Section L11A (Figure 87). It has been measured at about 26 feet long and just over 8 feet tall (NHE 2016). In 2000, it was documented as a loosely stacked wall (Peterson 2000). Its length appeared generally consistent with observed conditions at the time of the December 2016 field visit, although it appeared to be only about 5 feet tall. Its location is visible from the Hillside Trail. Its downstream stretch is in very good condition, with tightly stacked medium-sized rocks (Figures 88-89). The upstream stretch may also be in good condition based on the shape of the bank, but it is less visible due to moss, ferns, and seasonal vegetation (Figure 90). Section L11B is in overall good condition.



**Figure 87.** Section L11B Condition Assessment



**Figure 88.** Downstream stretch of Section L11B looking east from creek bed, showing riprap in very good condition, with tightly stacked medium-sized rocks below fern growth



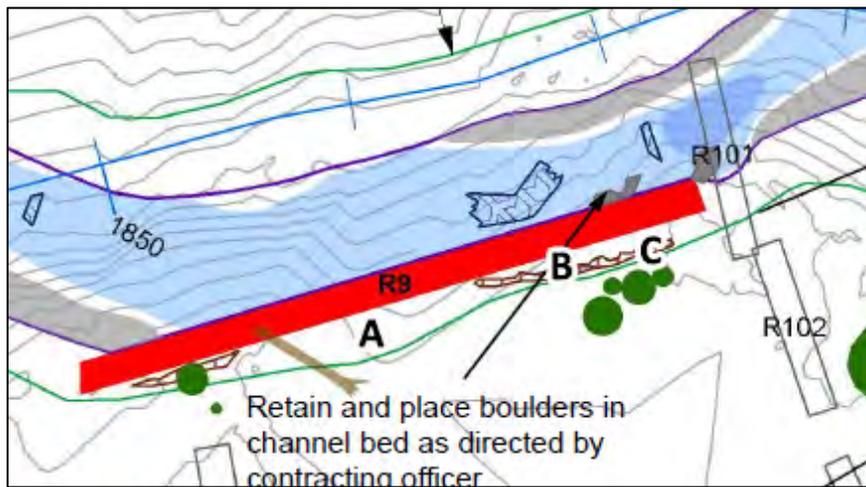
**Figure 89.** Center stretch of Section L11B, view northeast from creek bed, showing riprap in good condition with some woody debris and heavy moss growth



**Figure 90.** Upstream stretch of Section L11B, view north from right bank, showing riprap not visible possibly due to profusion of moss, ferns, and seasonal vegetation

## Section R9

Section R9 is located just across the creek and upstream from Section L11 (Figure 91). It has been measured at roughly 80 feet long and about 6.5 feet tall (NHE 2016). The length is consistent with its observed condition in November 2016, but it appears to be only about 3 feet high. In 2000, the section was documented in two parts, with small and medium boulders recorded in a variety of conditions (Peterson 2000). Its location is visible from the Redwood Creek Trail. Its small and medium boulders are tightly stacked into 3 to 4 courses that form a nearly upright wall (Figure 92). Its roughly 60-foot west stretch is in excellent condition (Figure 93), with some collapsing on the east stretch due to tree root interference (Figure 94). Small areas are obscured by fern growth and seasonal vegetation. The overall condition of Section R9 is excellent. Although small, it is one of the better sections targeted for removal.



**Figure 91.** Section R9 Condition Assessment



**Figure 92.** Overview of Section R9, view southeast from creek bed, showing riprap tightly stacked into 3 to 4 courses that form a nearly upright wall beneath trees, ferns, and other vegetation



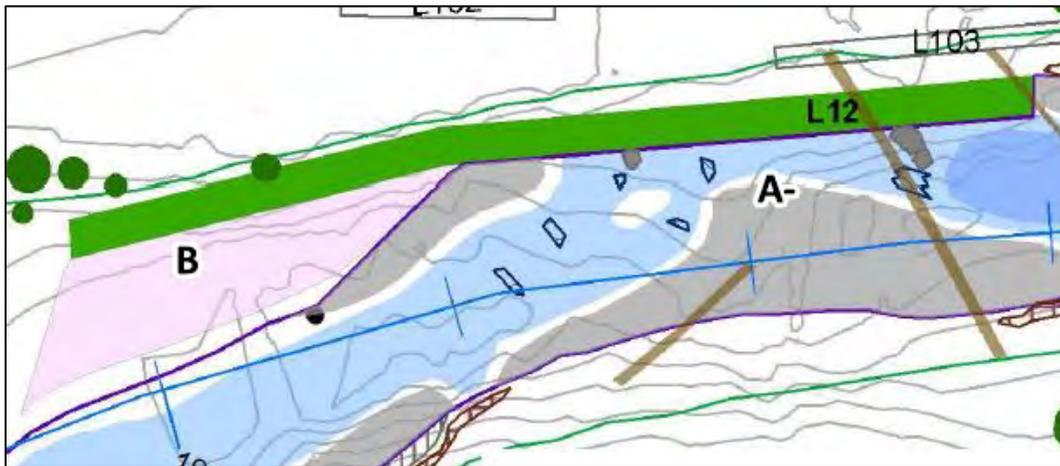
**Figure 93.** Detail, west stretch view south, showing riprap in excellent condition



**Figure 94.** Detail, east stretch view southeast, showing riprap excellent condition with small collapsed area left of frame and ferns growing above

## Section L12

Section L12 is located along the creek to the south of where Fern Creek Trail diverges from the Redwood Creek Trail (Figure 95). It has been measured at almost 105 feet long and about 5 feet tall (NHE 2016). In 2000, it was documented as an embedded wall made of medium and large boulders that was well-secured at some parts (Peterson 2000). Its measured dimensions were consistent with those observed at the time of the December 2016 field visit. Its location is not visible from park trails. It consists of a loosely stacked stretch of medium-large to large boulders at the roughly 30-foot upstream (west) stretch. There is a roughly 6-foot wide strip of embedded toe material in front of this stretch that appears to have been installed along with the riprap (Figure 94). The rocks in the downstream 2/3 of the stretch are the same size range but are tightly-stacked and in excellent condition (Figures 97-98). There is no toe material in front of the 75-foot downstream stretch. Overall Section L12 is in very good condition. Note: this segment would be removed under alternatives D and E.



**Figure 95.** Section L12 Condition Assessment



**Figure 96.** Upstream (west) stretch of Section L12 with toe material below riprap wall in good condition, view northeast from creek bed



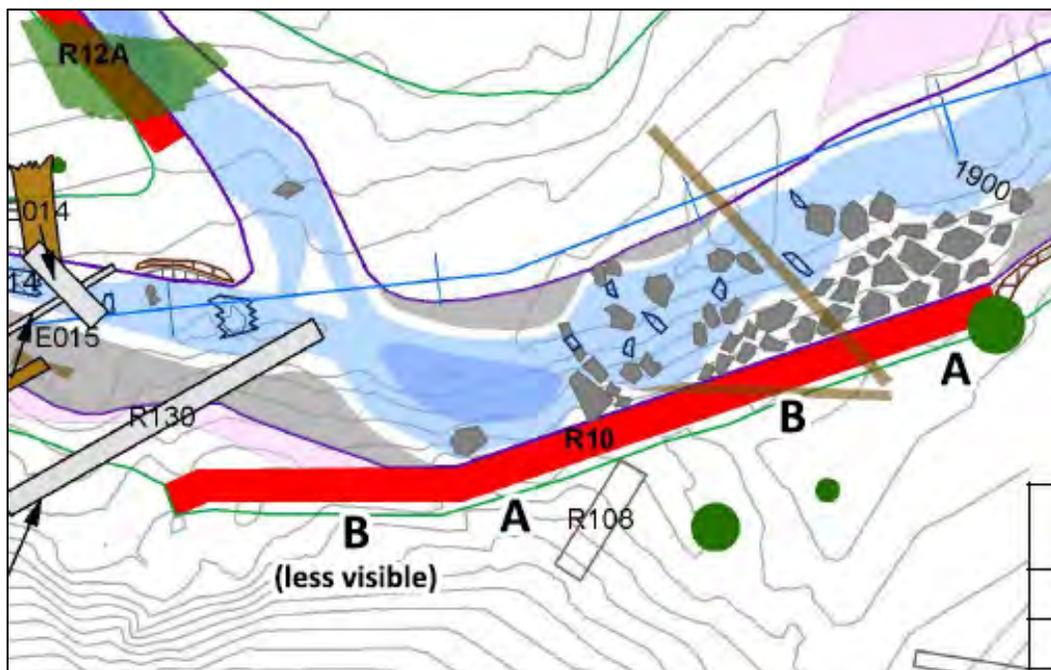
**Figure 97.** Center stretch of Section L12, view west from creek bed, showing riprap tightly-stacked and in excellent condition



**Figure 98.** Downstream stretch of Section L12, view west from creek bed, showing riprap tightly-stacked and in excellent condition

## Section R10

Section R10 is located across the creek from where the Fern Creek Trail diverges from the Redwood Creek Trail (Figure 99). It was measured at roughly 100 feet long and nearly 6 feet tall (NHE 2016), consistent with observed 2016 conditions. In 2000, it was documented as a well-stacked wall of large boulders, and also documented as “fallen” (Peterson 2000). It is not known what where the fallen section was observed. Section R10 is in a location that is not visible from park trails. Its west 25 feet are difficult to see due to heavy fern growth, but close inspection reveals that it appears to be in good condition (Figure 100). The 75-foot east stretch is in excellent condition, except for about 20 feet of good condition at its center (Figure 101). Rocks vary in size, and are tightly fitted into 5 to 6 courses, with the larger boulders on the lowest course. Its eastern 50 feet have a large amount of toe material or a check dam consisting of large boulders in the creek bed adjacent to the section (Figures 102-103). The overall condition of Section R10 is excellent to very good despite being obscured by seasonal and more permanent woody vegetation.



**Figure 99.** Section R10 Condition Assessment



**Figure 100.** Western stretch, view southwest from creek bed with riprap in good condition behind ferns



**Figure 101.** Detail, east stretch, showing tightly stacked wall in excellent condition beneath ferns and some woody debris



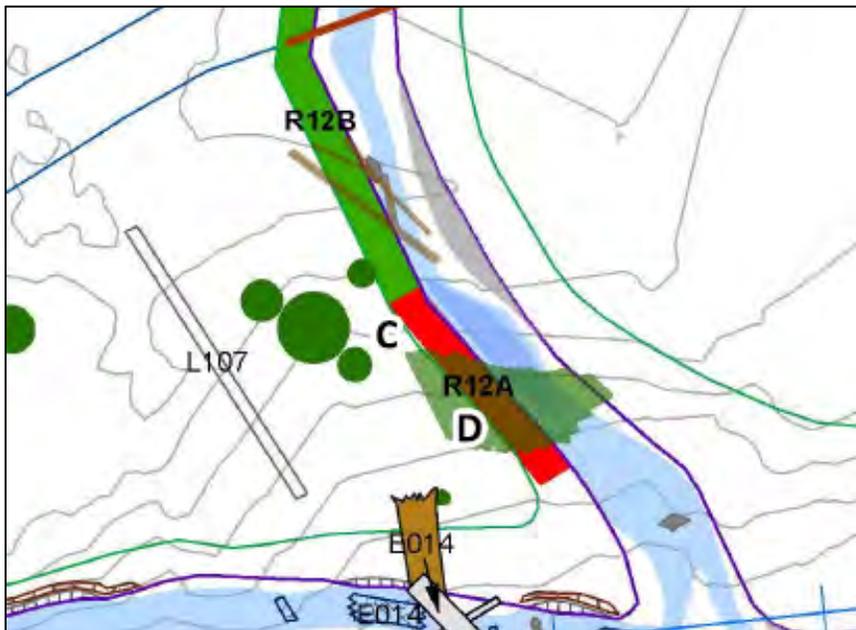
**Figure 102.** Central stretch, view south showing heavy toe material with ferns and woody debris covering riprap that is in excellent condition



**Figure 103.** View west toward east stretch with large boulder riprap and toe material/check dam

## Section R12A

Section R12A is located on Fern Creek just upstream from its confluence with Redwood Creek (Figure 104). It was measured at about 40 feet long and 4 feet high (NHE 2016), consistent with observed conditions in November 2016. In 2000, Section R12A was documented as well- and loosely-stacked large and small rocks (Peterson 2000). It is adjacent to R12B, and the exact dividing line between the sections is difficult to discern. Section R12A is visible from the Redwood Creek Trail. Its north stretch (adjacent to R12B) is in fair condition, but tree roots have apparently destroyed all but this roughly 10-foot stretch (Figure 105). The south stretch is missing or in poor condition. The overall condition of Section R12A is poor.



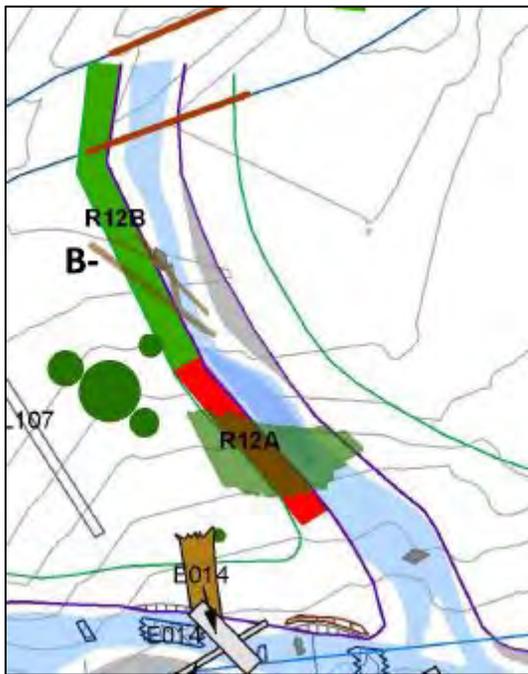
**Figure 104.** Section R12A Condition Assessment



**Figure 105.** Section R12A left of frame, camera view west from creek bed

## Section R12B

Section R12B is located on Fern Creek, north of where it meets Redwood Creek and connected at its south end to Section R12A (Figure 106). It has been measured at almost 43 feet long and just over 4.5 feet tall (NHE 2016). In 2000, it was recorded as a combination of loosely stacked and embedded wall made of small and large boulders, consistent with its observed condition in December 2016 (Figures 107-108) (Peterson 2000). It is visible from park trails. Although difficult to see the rocks because of the bridge over its north end and ferns along the bank, careful inspection shows they are well stacked and medium-sized. Section R12B is in good condition overall.



**Figure 106.** Section R12B Condition Assessment



**Figure 107.** Section R12B, camera facing southwest



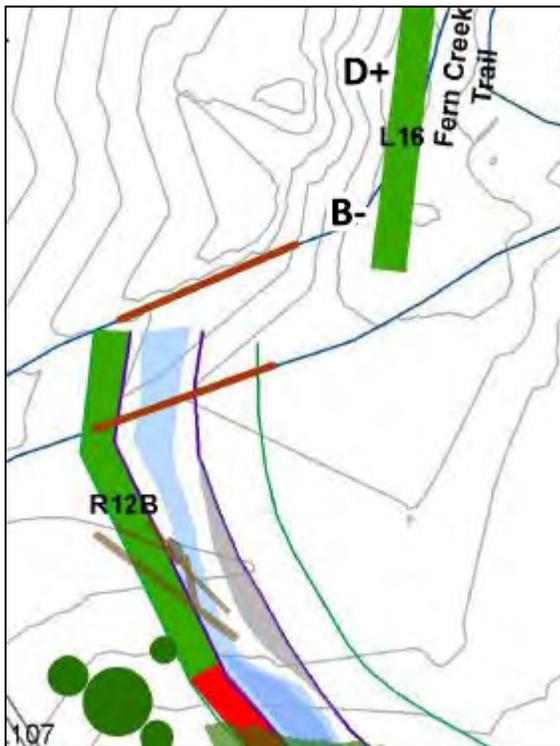
**Figure 108.** Section R12B, camera facing west



**Figure 109.** Section R12B, camera facing southwest

## Section L16

Section L16 is located immediately adjacent, to the northwest, of the fork where Fern Creek Trail splits from the Redwood Creek Trail (Figure 110). It has been measured at roughly 72 feet long and just over 5 feet tall (NHE 2016), consistent with its observed condition in December 2016. In 2000, it was documented as well-secured and embedded, made of a variety of small and large boulders (Peterson 2000). At the time of the December 2016 field visit, it consists of loosely stacked boulders of variable size (Figures 111-112). The eastern stretch is in very poor condition and essentially nonexistent, while the western end is in fair condition. It is visible from park trails and is in overall fair condition.



**Figure 110.** Section L16 Condition Assessment



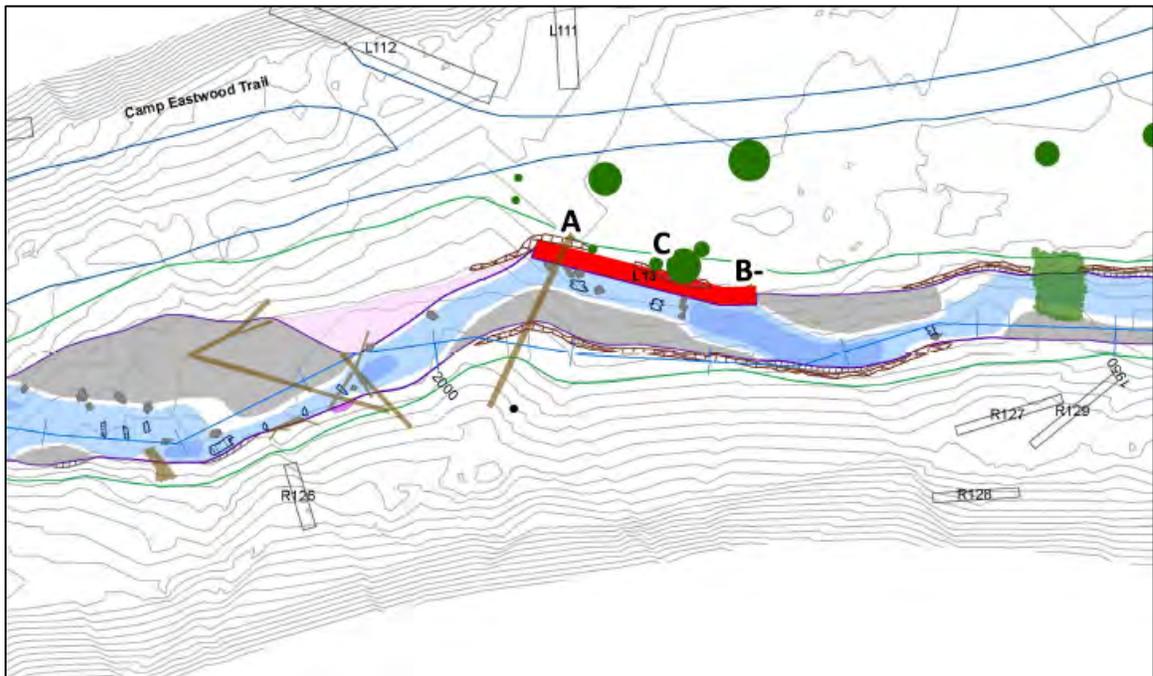
**Figure 111.** View upstream with Section L16 at right of frame, camera facing northeast



**Figure 112.** Section L16 and Redwood Creek Trail, camera facing east

## Section L13

Section L13 is located just southeast of the intersection between Camp Eastwood Trail and Redwood Creek Trail (Figure 113). It was measured at roughly 60 feet long and 5 feet high (NHE 2016), consistent with its observed condition in November 2016. When it was documented in 2000, it was recorded as a loosely stacked wall of medium-sized boulders that had fallen into the creek (Peterson 2000). Overall, the section is a well-stacked wall of medium-sized boulders that have clearly been intentionally placed. The roughly 25-foot western stretch is in excellent condition (Figures 114-115). The 15-foot central section, where tree roots have pushed rocks into the creek, is in poor condition, and the under layer of smaller rocks is visible (Figure 114). The 20-foot eastern stretch is in good condition (Figures 117-118). The overall condition of Section L13 is good. It is visible from Hillside Trail. Its condition and craftsmanship make it one of the finest sections targeted for removal despite the small area of deterioration at its center.



**Figure 113.** Section L13 Condition Assessment



**Figure 114.** Overview, Section L13, view east from creek bed, well-stacked western stretch left of frame



**Figure 115.** Western stretch, view northeast from creek bed



**Figure 116.** Central stretch showing large rocks pushed out by tree roots and smaller rocks used for backfill exposed



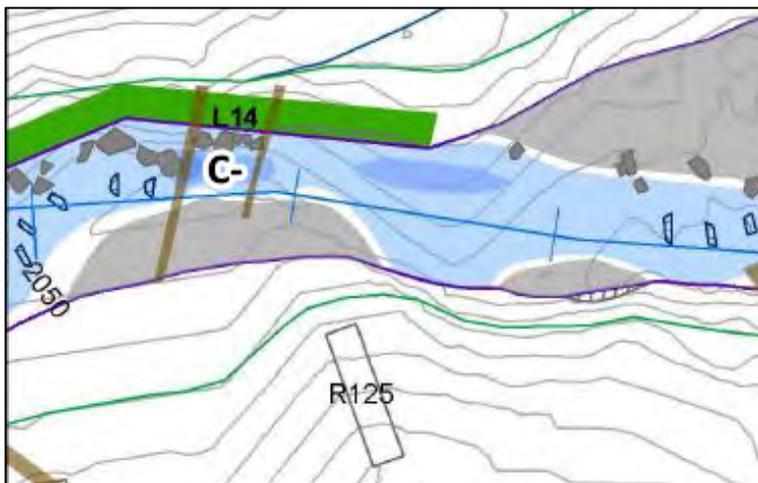
**Figure 117.** Eastern stretch, view east from creek bed



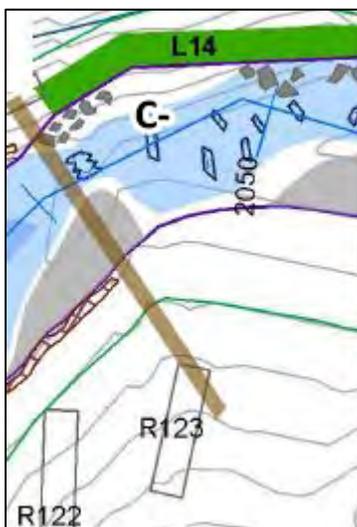
**Figure 118.** Eastern stretch of Section L13, view west from left bank

## Section L14

Section L14 is located west of the start of Camp Eastwood Trail, just east of a bend in the creek (Figures 119-120). It has been measured at almost 79 feet long and around 6 feet high (NHE 2016). In 2000, it was documented as a combination of well-secured embedded wall, loosely stacked wall, “embedded non-wall”, and boulders fallen into the creek, composed of a variety of sizes of boulders ranging from very small to medium (Peterson 2000). It is not visible from park trails and could not be accessed at the time of the December 2016 field visit. However, one photograph of its center stretch was discovered in a 2014 report, which shows jumbled boulders of varying size (ESA 2014) (Figure 121). The larger boulders have fallen into the creek, while some of the smaller stones used for backfill is visible still embedded in the bank. The overall condition of Section L14 appears to be very poor and somewhat unstable.



**Figure 119.** Section L14 Condition Assessment (east portion)



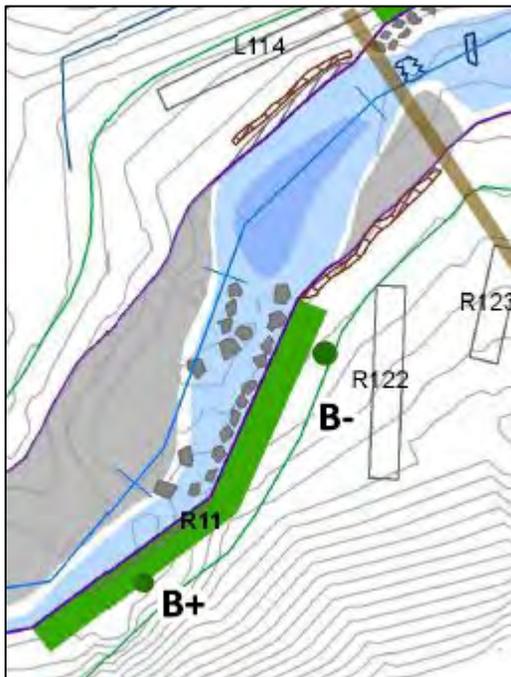
**Figure 120.** Section L14 Condition Assessment (west portion)



**Figure 121.** Center stretch, Section L14, view northeast from creek bank (photo ESA 2014)

## Section R11

Section R11 begins to the southwest of the end of Section L14 and runs alongside most of the short northeast-southwest segment at this part of the creek (Figure 122). It has been measured at roughly 49 feet long (NHE 2016). In 2000, it was documented as a well-secured, “embedded wall” composed of medium-sized and large boulders. These measurements were consistent with the observed condition at the time of the December 2016 field visit (Figures 123-124). It is visible from park trails. The east end is more covered by seasonal and woody vegetation and in worse condition, while the west end is more visible and contains larger rocks. The overall condition of the section is good.



**Figure 122.** Section R11 Condition Assessment



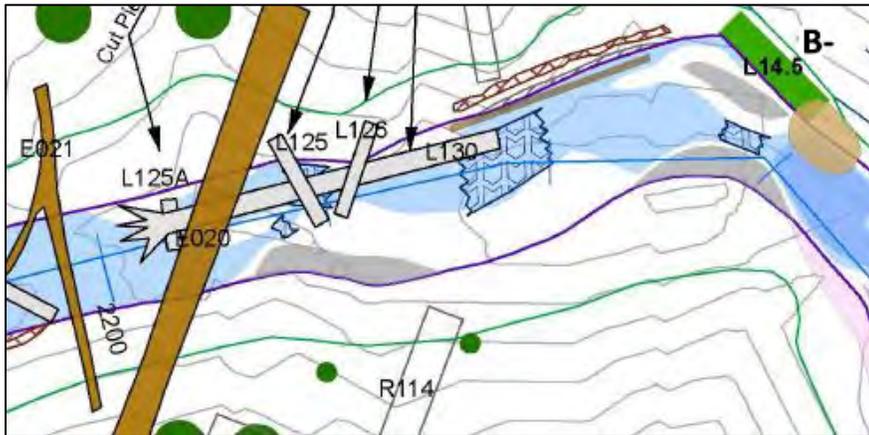
**Figure 123.** Section R11, camera facing southeast



**Figure 124.** Section R11, camera facing east

## Section L14.5

Section L14.5 is located northeast of Bridge 4 at a curve in the creek (Figure 125). It has been measured at just under 20 feet long (NHE 2016), which was consistent with observed conditions at the time of the December 2016 visit. It is not visible from park trails and consists of loosely stacked rocks of variable size that range from large to medium (Figure 126). It is in fair condition.



**Figure 125.** Section L14.5 Condition Assessment



**Figure 126.** Section L14.5 and trail, camera facing northeast

## REFERENCES

- Auwaerter, J. and J. Sears. 2006. Historic Resource Study for Muir Woods National Monument: Golden Gate National Recreation Area.
- Environmental Science Associates & Mark Thomas & Company. 2014. Muir Woods National Monument: Redwood Creek Riprap Removal, Channel Migration, and Bridge Replacement Survey.
- Petersen, B., Rahman, J., Semion, J. Paulson, H., Thurman, S., Xiong, J. and Shoulders, C. 2000. Redwood Creek Riprap Assessment.
- Northern Hydrology & Engineering. 2016. Muir Woods Preliminary Conceptual Design.

*This page intentionally left blank*

# Appendix B

---

## CEQA Checklist

## Appendix B.

# CEQA ENVIRONMENTAL CHECKLIST

This appendix assesses the environmental impacts of the Salmon Habitat Enhancement and Bridge Replacement at MWNM. The environmental impact analysis is based on the environmental checklist provided in Appendix G of the California Environmental Quality Act (CEQA) Guidelines. This checklist has been prepared to support any necessary evaluation of the project pursuant to the California Environmental Quality Act by relevant lead and responsible agencies with discretionary approval authority over some or all of the project. The conclusions in the checklist are supported by information in the body of the Environmental Assessment.

### Environmental Factors Potentially Affected

The environmental factors checked below would potentially be affected by the Proposed Project, as indicated by the checklist on the following pages.

- |   |   |
|---|---|
| <input type="checkbox"/> Aesthetics                         | <input type="checkbox"/> Land Use/Planning                  |
| <input type="checkbox"/> Agriculture and Forestry Resources | <input type="checkbox"/> Mineral Resources                  |
| <input type="checkbox"/> Air Quality                        | <input type="checkbox"/> Noise                              |
| <input type="checkbox"/> Biological Resources               | <input type="checkbox"/> Population/Housing                 |
| <input type="checkbox"/> Cultural Resources                 | <input type="checkbox"/> Public Services                    |
| <input type="checkbox"/> Geology/Soils                      | <input type="checkbox"/> Recreation                         |
| <input type="checkbox"/> Greenhouse Gas Emissions           | <input type="checkbox"/> Transportation/Traffic             |
| <input type="checkbox"/> Hazards and Hazardous Materials    | <input type="checkbox"/> Tribal Cultural Resources          |
| <input type="checkbox"/> Hydrology/Water Quality            | <input type="checkbox"/> Utilities/Service Systems          |
| <input type="checkbox"/> Land Use/Planning                  | <input type="checkbox"/> Mandatory Findings of Significance |

## 1.1 Aesthetics

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Have a substantial adverse effect on a scenic vista?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Substantially damage scenic resources, including, but not limited to trees, rock outcroppings, and historic buildings within a state scenic highway?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. Substantially degrade the existing visual character or quality of the site and its surroundings?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
d. Create a new source of substantial light or glare that would adversely affect daytime or nighttime views in the area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.2 Agriculture and Forestry Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
--	--------------------------------	--	------------------------------	-----------

In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. In determining whether impacts to forest resources, including timberland, are significant environmental effects, lead agencies may refer to information compiled by the California Department of Forestry and Fire Protection regarding the state's inventory of forest land, including the Forest and Range Assessment Project and the Forest Legacy Assessment Project; and forest carbon measurement methodology provided in Forest Protocols adopted by the California Air Resources Board. Would the Project:

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
a. Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program (FMMP) of the California Resources Agency, to nonagricultural use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Conflict with existing zoning for agricultural use, or a Williamson Act contract?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Pub. Res. Code section 12220(g)), timberland (as defined by Pub. Res. Code section 4526), or timberland zoned Timberland Production (as defined by Government Code section 51104(g))?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Result in the loss of forest land or conversion of forest land to non-forest use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. Involve other changes in the existing environment, which, due to their location or nature, could result in conversion of Farmland to nonagricultural use or conversion of forest land to non-forest use?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.3 Air Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
When available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
a. Conflict with or obstruct implementation of the applicable air quality plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
c. Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is a nonattainment area for an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
d. Expose sensitive receptors to substantial pollutant concentrations?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
e. Create objectionable odors affecting a substantial number of people?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

## 1.4 Biological Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
<b>Would the Project:</b>				
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, or regulations, or by the DFG or USFWS?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the CWA (including marshes, vernal pools, and coastal wetlands) through direct removal, filling, hydrological interruption, or other means?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
e. Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f. Conflict with the provisions of an adopted habitat conservation plan (HCP); natural community conservation plan; or other approved local, regional, or state HCP?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.5 Cultural Resources

	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
Would the project:				
a. Cause a substantial adverse change in the significance of a historical resource as defined in Section 15064.5?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Cause a substantial adverse change in the significance of an archaeological resource as defined in Section 15064.5?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Directly or indirectly destroy a unique paleontological resource or site or unique geological feature?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Disturb any human remains, including those interred outside of dedicated cemeteries?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.6 Geology, Soils, and Seismicity

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i. Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ii. Strong seismic ground shaking?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
iii. Seismic-related ground failure, including liquefaction?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
iv. Landslides?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Result in substantial soil erosion or the loss of topsoil?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Be located on a geologic unit or soil that is unstable or that would become unstable as a result of the Project and potentially result in an on-site or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. Have soils incapable of adequately supporting the use of septic tanks or alternative wastewater disposal systems in areas where sewers are not available for the disposal of wastewater?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.7 Greenhouse Gas Emissions

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Generate a net increase in greenhouse gas emissions which may have a significant impact on the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Conflict with a county-adopted climate action plan or another applicable plan, policy or regulation adopted for the purpose of reducing the emissions of greenhouse gases?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.8 Hazards and Hazardous Materials

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Emit hazardous emissions or involve handling hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Be located on a site that is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, create a significant hazard to the public or the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
e. Be located within an airport land use plan area or, where such a plan has not been adopted, be within 2 miles of a public airport or public use airport and result in a safety hazard for people residing or working in the study area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f. Be located within the vicinity of a private airstrip and result in a safety hazard for people residing or working in the study area?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g. Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
h. Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.9 Hydrology and Water Quality

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Violate any water quality standards or waste discharge requirements?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Substantially deplete groundwater supplies or interfere substantially with groundwater recharge, resulting in a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level that would not support existing land uses or planned uses for which permits have been granted)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
c. Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on site or off site?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
d. Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner that would result in flooding on-site or off-site?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
e. Create or contribute runoff water that would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f. Otherwise substantially degrade water quality?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
g. Place housing within a 100-year flood hazard area, as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
h. Place within a 100-year flood hazard area structures that would impede or redirect floodflows?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
i. Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
j. Contribute to inundation by seiche, tsunami, or mudflow?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.10 Land Use and Planning

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Physically divide an established community?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including a general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. Conflict with any applicable habitat conservation plan or natural community conservation plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.11 Mineral Resources

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Result in the loss of availability of a locally important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.12 Noise

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project result in:				
a. Exposure of persons to or generation of noise levels in excess of standards established in a local general plan or noise ordinance or applicable standards of other agencies?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
e. For a project located within an airport land use plan area, or, where such a plan has not been adopted, within 2 miles of a public airport or public-use airport, would the project expose people residing or working in the project site to excessive noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
f. For a project within the vicinity of a private airstrip, would the project expose people residing or working in the project site to excessive noise levels?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.13 Population and Housing

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Induce substantial population growth in an area, either directly (e.g., by proposing new homes and businesses) or indirectly (e.g., through extension of roads or other infrastructure)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Displace a substantial number of existing housing units, necessitating the construction of replacement housing elsewhere?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. Displace a substantial number of people, necessitating the construction of replacement housing elsewhere?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.14 Public Services

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities or a need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times, or other performance objectives for any of the following public services:				
i. Fire protection?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
ii. Police protection?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
iii. Schools?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
iv. Parks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
v. Other public facilities?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.15 Recreation

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
b. Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.16 Transportation/Traffic

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Conflict with an applicable plan, ordinance or policy establishing measures of effectiveness for the performance of the circulation system, taking into account all modes of transportation including mass transit and non-motorized travel and relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
b. Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. Result in inadequate emergency access?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
f. Conflict with adopted policies, plans, or programs regarding public transit, bicycle, or pedestrian facilities, or otherwise decrease the performance or safety of such facilities?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

### 1.17 Tribal Cultural Resources

	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
Would the Project cause a substantial adverse change in the significance of a tribal cultural resource, defined in Pub. Res. Code section 21074 as either a site, feature, place, cultural landscape that is geographically defined in terms of the size and scope of the landscape, sacred place, or object with cultural value to a California Native American tribe, and that is:				
a. Listed or eligible for listing in the California Register of Historical Resources, or in a local	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

register of historical resources as defined in Public Resource Code Section 5020.l(k), or

- |   |                          |                          |                          |                                     |
|---|--------------------------|--------------------------|--------------------------|-------------------------------------|
| <p>b. A resource determined by the lead agency, in its discretion and supported by substantial evidence, to be significant pursuant to criteria set forth in subdivision (c) of Public Resource Code Section 5024.1. In applying the criteria set forth in subdivision (c) of Public Resource Code Section 5024.1. the lead agency shall consider the significance of the resource to a California Native American tribe.</p> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> |
|---|--------------------------|--------------------------|--------------------------|-------------------------------------|

### 1.18 Utilities and Service Systems

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the Project:				
a. Exceed wastewater treatment requirements of the applicable RWQCB?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Require or result in the construction of new water or wastewater treatment facilities or an expansion of existing facilities, the construction of which could cause significant environmental effects?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
c. Require or result in the construction of new stormwater drainage facilities or an expansion of existing facilities, the construction of which could cause significant environmental effects?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
d. Have sufficient water supplies available to serve the Project from existing entitlements and resources, or would new or expanded entitlements be needed?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
e. Result in a determination by the wastewater treatment provider that serves or may serve the Project that it has inadequate capacity to serve the Project's projected demand in addition to the provider's existing commitments?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
f. Be served by a landfill with insufficient permitted capacity to accommodate the Project's solid waste disposal needs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
g. Comply with federal, state, and local statutes and regulations related to solid waste?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
h. Encourage activities that resulted in the use of substantial amounts of fuel or energy, or used these resources in a wasteful manner?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

## 1.19 Mandatory Findings of Significance

	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
a. Does the Project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, substantially reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
b. Does the Project have impacts that are individually limited but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.)	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
c. Does the Project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

*This page intentionally left blank*

# Appendix C

---

## Response to Comments

# Appendix C

## Response to Comments

### 1 Introduction

This Response to Comments has been prepared as a result of public comment from the Draft Environmental Assessment (EA) released for public review and comment from April 3 through May 18, 2017. Responses to substantive comments received from individuals, groups, and regulatory agencies are provided. The changes made in the Final EA do not increase the degree of impact described in the Draft EA.

Ten comment letters were received resulting in 42 substantive comments. These letters and National Park Service (NPS) responses to substantive comments are provided. Comments were received from the Watershed Alliance of Marin, Marin Conservation League, Save Our Seashore, National Marine Fisheries Service, Sierra Club, and unaffiliated individuals.

**PEPC Project ID: 62983, DocumentID: 78726**  
**Correspondence: 1**

**Author Information**

Keep Private: No  
Name: Lonna Richmond  
Organization: Ms.  
Organization Type: I - Unaffiliated Individual  
Address: 45 sunset way  
muir beach, CA 94965  
USA  
E-mail: lomajejan@gmail.com

**Correspondence Information**

Status: New Park Correspondence Log:  
Date Sent: 04/03/2017 Date Received: 04/03/2017  
Number of Signatures: 1 Form Letter: No  
Contains Request(s): No Type: Web Form  
Notes:

**Correspondence Text**

1a

it is hard for me to believe that you are thinking of spending all this money on repairing these aging bridges that not that many people go on, while leaving the road in such disrepair. the people parking alongside the road right above the creek, with their engine oil dripping right into the creek banks, the pollution of so much exhaust enveloping the woods, the braking of the cars and the asbestos particles - well i have to wonder what you people are thinking of. fix the road and put a cap on visitors. these trees are gasping for clean air. you have never spent the time or energy (or money) to evaluate these trees and the ecosystem to see the damage that is being done to them from the constant visitation.

ecosystems have a carrying capacity and you need to spend the money on that and then cap the visits.

don't be so greedy.

sincerely,  
lonna richmond

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 1 of 22

**Public Comment 1                      Letter from Lonna Richmond (April 3, 2017)*****Response to Comment 1a***

Replacement of the deteriorating pedestrian bridges is needed to ensure visitor safety and take advantage of an opportunity to coordinate with improving salmon habitat. This action does not delay work on the other road and parking issues noted by the commenter. As described in Section 4.2, *Cumulative Impacts Analysis Methodology*, planning for several projects to address parking, high numbers of automobiles, road issues, and high visitation levels is well underway. The Muir Woods Reservation System will reduce the number of vehicles parked on the Frank Valley/Muir Woods Road shoulder, as well as reduce peak visitation levels. The Muir Woods Road Rehabilitation Project, a project of Marin County and the Federal Highways Administration, will repair erosion and upgrade drainage systems on Frank Valley and Muir Woods Roads. The Muir Woods Sustainable Access Project will eliminate roadside parking on Muir Woods Road between Conlon Avenue and the Muir Woods Road Bridge and modify parking lots to both coordinate better with the reservation system and improve water quality by upgrading parking lot stormwater drainage infrastructure.

The proposed creek restoration actions will substantially improve the ecosystem function within the boundaries of Muir Woods National Monument (MWNM). There will be more natural creek function, the habitat for salmonids will be improved, more trails will be relocated farther from the top of bank, and over the long run there will be better floodplain connectivity. The redwoods and redwood forest within MWNM have been evaluated in publications such as *The History of the Vegetation of Muir Woods National Monument* (McBride and Jacobs 1979) and *Forest Structure in Muir Woods National Monument: Survey of the Redwood Canyon Old-Growth Forest* (Steers et al. 2014).

**Public Comment 2****Letter from Emily Singh (May 12, 2017)****PEPC Project ID: 62983, DocumentID: 78726****Correspondence: 2****Author Information**

Keep Private: No  
Name: Emily Singh  
Organization:  
Organization Type: I - Unaffiliated Individual  
Address: 3629 Precision Drive  
F247  
Fort Collins, CO 80528  
USA  
E-mail: ecsingh0257@gmail.com

**Correspondence Information**

Status: New Park Correspondence Log:  
Date Sent: 05/12/2017 Date Received: 05/12/2017  
Number of Signatures: 1 Form Letter: No  
Contains Request(s): No Type: Web Form  
Notes:

**Correspondence Text**

2a [ This is my husband and daughter's favorite park. As a family, we fully support the restoration of habitat for the Coho Salmon. Likewise, we also support the bridge restoration that is planned as well. Thank you for being good stewards of our natural resources. We look forward to the next time we are able to spend time in this park.

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 2 of 22

**Public Comment 2**

**Letter from Emily Singh (May 12, 2017)**

***Response to Comment 2a***

Comment noted.

**Public Comment 3**

**Public Meeting Comments from Harry Schulz  
(April 11, 2017)**

**PEPC Project ID: 62983, DocumentID: 78726  
Correspondence: 3**

**Author Information**

Keep Private: No  
Name: Harry Schulz  
Organization: USF Student  
Organization Type: I - Unaffiliated Individual  
Address: NA  
NA, CANA  
USA  
E-mail: ugschulz216@gmail.com

**Correspondence Information**

Status: New Park Correspondence Log:  
Date Sent: Date Received: 04/11/2017  
Number of Signatures: 1 Form Letter: No  
Contains Request(s): No Type: Other  
Notes: Entered from comment card received at public meeting.

**Correspondence Text**

3a  Is there water quality monitoring data available with regard to the proposed project area? (i.e., DO%/mg/2, turbidity, pH, TDS, salinity, sp. cond.) Thanks.

**Public Comment 3****Public Meeting Comments from Harry Schulz  
(April 11, 2017)*****Response to Comment 3a***

Water quality data are provided in Section 3.8, *Water Resources and Hydrologic Processes*. These data include temperature, dissolved oxygen, specific conductance, turbidity, as well as overall chemical analysis. These data were collected from the vicinity of the Proposed Action—Fern Creek and the mainstem of Redwood Creek downstream of the MWNM entrance under the Muir Woods Road bridge. The Fern Creek sampling location is off of the Fern Creek Trail just upstream of the confluence with Redwood Creek.

**Public Comment 4****Letter from Terri Thomas (April 11, 2017)****PEPC Project ID: 62983, DocumentID: 78726****Correspondence: 4****Author Information**

Keep Private: No  
 Name: Terri Thomas  
 Organization:  
 Organization Type: I - Unaffiliated Individual  
 Address: NA  
 NA, CANA  
 USA  
 E-mail: tl2thomas@gmail.com

**Correspondence Information**

Status: New Park Correspondence Log:  
 Date Sent: Date Received: 04/11/2017  
 Number of Signatures: 1 Form Letter: No  
 Contains Request(s): No Type: Other  
 Notes: Entered from comment card received at public meeting

**Correspondence Text**

- 4a  The cumulative impacts section did not adequately analyze the cumulative impacts of 5 sequential years of large work in and adjacent to the creek. This is, of course difficult to know. A monitoring program during all 5 years partnered with an adaptive management approach if a problem occurs would be beneficial. It that is planned please identify it in the FONSI.
- 4b
- 4c  Which 4 - - 5 months are the bridge replacement happening? I didn't see that in the EA. Please include in the FONSI.
- 4d  Carolyn stated the work will happen late summer and fall. The EA says it will happen in fall. Rain generally starts Oct 15(ish). The construction is going to take 8 weeks each year. Please clarify in the FONSI that if will summer and fall or out of rainy season. It is important that the work occur at times that minimize ecological impacts and not at times that are convenient to the large visitor dates.

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 4 of 22

## **Public Comment 4                      Letter from Terri Thomas (April 11, 2017)**

### ***Response to Comment 4a***

Impacts from multiple projects occurring in the vicinity of the Proposed Action during similar time frames are captured under the cumulative impacts analysis in Chapter 4 of the EA. Projects analyzed include the Muir Woods Reservation System, the Muir Woods Road Bridge Replacement Project, the Muir Woods Road Rehabilitation Project, the Muir Woods Water/Wastewater Line Replacement, and the Muir Woods Sustainable Access Project.

Monitoring described in Response to Comment 4b would allow NPS to respond to on-the-ground conditions during and following implementation of the Proposed Action and implement adaptive measures as needed, which would reduce the potential for adverse cumulative impacts and impacts relating to the duration of the Proposed Action. Please see Response to Comment 6d for more information regarding the anticipated phasing and schedule of work. Response to Comment 6g provides information on how visitors would be informed of construction activities, limiting cumulative impacts on visitor experience. Additional information on cumulative sediment impacts is provided in Response to Comment 6f.

The addition of beaver dam analogs to the Proposed Action would help to trap sediment in Redwood Creek and decrease cumulative effects of sedimentation on water quality and salmonid habitat. As described in Response to Comment 5a, the beaver dam analogs would be installed in Phase 1 so their beneficial impacts would begin as soon as possible.

The Proposed Action would result in multiple construction seasons of work within and adjacent to Redwood Creek. The Proposed Action would result in temporary adverse impacts to several resources. The construction of the Proposed Action over several years would result in impacts to threatened and endangered species, visitor use, water quality, and wildlife habitat that are longer in duration than if the Proposed Action were completed across fewer years. However, as described in Response to Comment 5b, logistical constraints related to the work season allowed by resource agencies limits the amount of work that can be completed each season. Response to Comment 5b also describes how the project being spread across multiple construction seasons results in smaller magnitude effects on resources compared to completing the work during a single construction season. The BMPs described in Appendix D of the EA would reduce the potential for adverse impacts. These BMPs have been updated from the Draft EA to be more protective of threatened and endangered species, water quality, and wildlife habitat, based on input from NMFS and USFWS. In addition, NMFS provided a Biological Opinion that the Proposed Action is unlikely to jeopardize the continued existence of CCC steelhead or Coho salmon, or destroy or adversely modify their designated critical habitat (NMFS 2017). Erosion control measures described in the Creek Restoration alternatives would reduce the potential for water quality impacts, as would the implementation of the stormwater pollution prevention plan (SWPPP) described in Response to Comment 4b. Impacts to visitor experience would be spread over several construction seasons, but this approach is much less disruptive than other options such as closing MWNM during construction.

### ***Response to Comment 4b***

Projects in the Redwood Creek Watershed mentioned in the cumulative impacts section will have the required stormwater permits, which require monitoring and reporting. NPS also plans to prepare a monitoring plan before implementation of the Proposed Action in

**Public Comment 4****Letter from Terri Thomas (April 11, 2017)**

coordination with the other projects in the project area. Monitoring is expected to address physical processes, quantity and quality of habitat, and salmonid use. Monitoring during each phase of the Proposed Action would identify unanticipated outcomes; an advantage to the phased construction approach is that corrective measures can be implemented as needed in future phases. In addition, informal observations will be conducted, which could also inform the need for possible adaptive management. Additionally, the project would require permits that would have their own monitoring requirements.

***Response to Comment 4c***

Bridge construction will need to balance construction during dry season, permitted work times below the ordinary high-water line, and avoiding sensitive seasons for birds. Per revised BMP BIO-7, project activities that would raise noise levels above ambient conditions within suitable marbled murrelet breeding habitat would occur outside the core breeding season (March 15 to July 31). During the marbled murrelet's late breeding season (August 1–September 15), these activities will be restricted to the daytime hours from two hours after sunrise to two hours before sunset (avoiding the time periods when marbled murrelets are most sensitive to noise disturbance) (i.e., allows for work during daytime hours). Overall, construction is likely to start in June, consistent with BMPs BIO-4 and BIO-7, and continue through October.

***Response to Comment 4d***

Creek Restoration Alternative work that involves riprap removal or similar work in the channel would occur in late spring, summer, and fall. Per BMP BIO-4, "access and/or construction below ordinary high water will be limited to June 15 to October 31, unless conditions to allow the start of salmon spawning do not occur by October 31 and continued work is approved by or otherwise permitted by regulatory agencies." Such work is anticipated to avoid the rainy season. However, it is possible that some log relocation could occur outside of the window of June 15 to October 31 during periods when it is not rainy. This may be possible because log relocation does not entail use of equipment in the channel, and it mimics a scenario in which a tree falls into the creek.

**Public Comment 5**

**Letter from Laura Chariton, Watershed Alliance of Marin (May 18, 2017)**

**PEPC Project ID: 62983, DocumentID: 78726  
Correspondence: 5**

**Author Information**

Keep Private: No  
Name: Laura Chariton  
Organization: Watershed Alliance of Marin  
Organization Type: I - Unaffiliated Individual  
Address: 446 Panoramic Hwy  
Mill Valley, CA 94941  
USA  
E-mail: laurachariton@comcast.net

**Correspondence Information**

Status: New Park Correspondence Log:  
Date Sent: 05/18/2017 Date Received: 05/18/2017  
Number of Signatures: 1 Form Letter: No  
Contains Request(s): No Type: Web Form  
Notes:

**Correspondence Text**

May 17, 2017

Golden Gate National Recreation Area  
Attn: Muir Woods Salmon/Bridges  
Building 201, Fort Mason  
San Francisco, CA 94123-0022

Dear National Park Service;

5a The Watershed Alliance of Marin is appreciative of the improvements made in the Draft EA to the Muir Woods Salmon Enhancement and Bridge Replacement plan submitted for comments in October 2016. From the original riprap removal and bridge reconstruction project the EA indicates some trail relocations/removals and additional stream and flood plain diversity created - particularly in Alternative 5. This preferred alternative more fully succeeds in achieving the desired goals. Endangered species retention and habitat improvement for coho salmon and steelhead trout are at the core of this project. The dire need to improve conditions for salmonids, as indicated in the coho and steelhead recovery plans, should elevate this project above all others being contemplated in the Redwood Creek watershed. Expediting this project for its benefit to endangered and threatened species should therefore take precedent over projects or occur concurrently, such as the wastewater replacement and pipe relocations as needed.

5b Because of the numerous projects that will be occurring in the Monument - potentially simultaneously - considering park closure for the greatest attention to the project, fish protection and efficiency should be a priority. Accomplishing the project in the shortest time possible is a preference and results in the least amount of dewatering time, impacts from electrofishing and removal, heavy equipment use, etc. While closure is a nuisance for the public in the short term, the results long term will be much better and public acceptance of the need can be communicated and we believe well understood. In addition, visiting Muir Woods while major construction is going on does not advance the goals of the National Park for visitor experience.

5c We also have some suggestions, below:  
The coho salmon are generally in such low numbers and while the triage approach has temporarily bolstered their numbers,

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 5**

**Letter from Laura Chariton, Watershed Alliance of Marin (May 18, 2017)**

5c they are still significantly in jeopardy of extirpation. We do not know if they will return without further dedicated high level response actions that improve habitat in the very near short term.  
 After discussions with National Marine Fisheries Service, it is clear that this project, particularly the in-stream enhancements, may have one of the greatest benefits on salmonid recovery in Redwood Creek through the creation of in-stream diversity and rearing and spawning habitat.

5d As stated in our previous comments, there is justification for removing Bridge 1 and 3 as well as the southwestern trail that connects those bridges, allowing stream migration. Bridge 2 and 4 should remain and be rebuilt.  
 Moving trails out of the flood plain and off the creek should also remain a priority, with maximum removal of trails from creek proximity - allowing riparian vegetative restoration and maximum creek migration.

5e Studies have shown that salmonids are impacted by loud noises. Increased noise from construction, in addition to visitors, should be considered. There are serious concerns that the project, which can only occur during the high visitor season of late summer, would create additional complications and environmental capacity stressors that increase potential for damaging impacts on sensitive species.

5f We have concerns about the restoration implementation contractor and want to be assured that any bidders and heavy equipment operators will have the highest degree of sensitivity and knowledge while working within the creek and riparian zones.

5g For these reasons, including the need for construction storage taking up parking places, it seems that it would be more efficient to close the park, make full use of the parking lots and do the most work in the shortest period to increase the benefit and limit the impacts. Not having to factor in visitor management would save time, money and resources. Closing the Monument and expediting the project will likely result in decreased costs but would be within NPS's mission to protect the resource for future generations. It may be the necessity that the Redwood Creek coho need to stage a better comeback.  
 Thank you for considering our comments and requests.  
 Sincerely,

Laura Chariton, Director, Watershed Alliance of Marin (a 501C3)  
 watermarin.org  
 446 Panoramic Hwy.  
 Mill Valley, CA 94941  
 (415) 234-9007

University Of Maryland, College Park. (2003, February 10). Loud Noise Can Injure Fish Hearing. ScienceDaily. Retrieved May 17, 2017 from [www.sciencedaily.com/releases/2003/02/030210075908.htm](http://www.sciencedaily.com/releases/2003/02/030210075908.htm)

**Public Comment 5****Letter from Laura Chariton, Watershed Alliance of Marin (May 18, 2017)*****Response to Comment 5a***

Section 2.5, *Construction Methods*, has been revised in the Final EA to state that “creek restoration actions would begin in late spring and continue through fall 2018.” This portion of the Proposed Action is a priority, for the reasons the commenter noted, and will likely occur concurrently with other projects within and surrounding MWNM. However, the Proposed Action would still be implemented in two phases, with the second phase conducted several years later when additional funding is expected to be available. Although the first phase of the Proposed Action would mostly be concentrated upstream of Bridge 2 (about half of the project reach), the Phase 1 actions would include installation of beaver dam analogs in the reach between the Plaza and Bridge 2 because these actions are relatively inexpensive and can help achieve short-term benefits before the second phase of the project is implemented.

***Response to Comment 5b***

Closure of MWNM is not anticipated for this Proposed Action, as closure would not substantially reduce impacts, and NPS has an interest in maintaining public access. It would be beneficial to the salmonid population to complete actions as quickly as possible, but there are also logistical constraints to how much can be completed within the limited work window. In fact, if the whole Proposed Action over the mile of channel were implemented in a single construction season during the low-flow period, a greater area of the creek would be impacted at once, since most of the creek would have to be dewatered in the same period. By implementing the work in phases, only a segment of the creek will have to be dewatered at once and fish relocation in each work year will be minimized. The construction periods are dictated by numerous biological seasonal constraints, such as restrictions on when in-stream activities can be conducted and avoiding construction during bird nesting and rainy seasons. Park closure would not shorten or consolidate the construction window. Nevertheless, some park trails will be temporarily closed during construction in order to avoid conflicts with visitors or where construction itself would affect those trails. While the commenter notes that visitation during major construction does negatively impact visitor experience, closure of MWNM for multiple construction seasons would not reduce impacts.

***Response to Comment 5c***

NPS agrees that Coho salmon are in danger of extirpation in Redwood Creek, and agrees that the creek restoration actions would have important benefits to Coho salmon habitat within MWNM.

***Response to Comment 5d***

Bridges 1 and 3 are critical to pedestrian circulation through the monument. Per the General Management Plan (GMP), which is the guiding document for MWNM actions, MWNM is to provide a range of experiences for park visitors (NPS 2014). Bridges 1 and 3 connect to surrounding trail networks and help provide an accessible trail experience and loop options to all users. As stated on page 255 of the GMP, “Rather than continue to concentrate visitation along a main trail, visitors would be encouraged to take different thematic interpretive trails, some new and some existing, to experience different parts of

**Public Comment 5****Letter from Laura Chariton, Watershed Alliance of Marin (May 18, 2017)**

the park." Also, removal of Bridges 1 and 3 would likely double the number of visitors traveling in both directions on the main trail (east side). The User Capacity section of the GMP details visitor capacity indicators and standards developed for management zones within MWNM, with management strategies including "direct visitor flow to other areas and trails" and "redistribute visitor flow and/or reduce use levels" (NPS 2014). Removal of Bridges 1 and 3 and the Bohemian Grove Trail would reduce the management options available to NPS to achieve user capacity standards necessary to manage the monument's resources and experiences.

Of the alternatives considered, the preferred creek restoration alternative (Creek Restoration Alternative 5) provides the maximum amount of trail relocation farther from the creek consistent with the GMP. Furthermore, trails and gathering areas near the creek at bridges 2 and 3 will be re-located farther from the creek and the existing disturbed areas will be revegetated.

***Response to Comment 5e***

As described in Section 2.5, *Construction Methods*, the channel would be dewatered in construction areas. Noise-attenuated diesel pumps would be used for construction, and supplemental noise attenuation such as surrounding the pump with rice straw bales may also be used. Fish would be relocated out of the way of equipment use for many reasons, primarily to protect them from turbid conditions when work is conducted in the channel, but this would also protect them from any impacts of noise and/or vibration from equipment. Fish relocation would be conducted in areas where creek restoration actions involve the use of heavy equipment. Relocation would also be conducted, if necessary, during bridge construction actions where work is either conducted in the channel or if the pile installation methods would cause vibrations. It may be possible to install piles without causing vibrations that would be attenuated through the channel; the specific method would be determined during preparation of construction designs. Noise from construction is not anticipated to cause substantial adverse impacts on salmonids. As described in Section 4.4, *Threatened and Endangered Species*, noise from construction is anticipated to result in direct, short-term impacts on northern spotted owls.

***Response to Comment 5f***

The construction contractor will be required to have prior experience successfully meeting environmental protection requirements while working in sensitive aquatic environments, and prior experience implementing environmental protection requirements while dewatering where listed species are present. Contract specifications will also include an extensive list of environmental protection requirements that will be strictly enforced by NPS-appointed construction managers who will ensure contractors are fulfilling contract-mandated protection measures.

***Response to Comment 5g***

As described in Response to Comment 5b, closure of MWNM is not anticipated as it would not necessarily reduce impacts.

**Public Comment 6****Letter from Kate Powers, Marin Conservation League (May 18, 2017)****PEPC Project ID: 62983, DocumentID: 78726****Correspondence: 6****Author Information**

Keep Private: No  
 Name: Kate Powers  
 Organization: Marin Conservation League  
 Organization Type: I - Unaffiliated Individual  
 Address: 175 N. Redwood  
 Ste 135  
 San Rafael, CA 94903  
 USA  
 E-mail: mcl@marinconservationleague.org

**Correspondence Information**

Status: New Park Correspondence Log:  
 Date Sent: 05/18/2017 Date Received: 05/18/2017  
 Number of Signatures: 1 Form Letter: No  
 Contains Request(s): No Type: Web Form  
 Notes:

**Correspondence Text**

May 18, 2017

Golden Gate National Recreation Area  
 Attn: Muir Woods Salmon/Bridges  
 Building 201, Fort Mason  
 San Francisco, CA 94123-0022

Subject: Salmon Habitat Enhancement &amp; Bridge Replacement Project Environmental Assessment

6a

Marin Conservation League (MCL) appreciates the opportunity to submit comments on the Environmental Assessment (EA) for the subject project in Muir Woods National Monument. The proposed project was identified in the General Management Plan for Golden Gate National Recreation Area and analyzed programmatically in the EIS (NPS 2014). Since that time, National Park Service (NPS) has done detailed study to develop the project, received public comment on the scope of the project and possible alternatives, and prepared an EA. In 2016, MCL submitted scoping comments and raised several concerns for analysis in the EA, discussed below.

After reviewing the proposed action and alternatives analyzed in the Draft EA and conducting a cursory field visit, MCL supports Alternative 5 - the Preferred Alternative - for the habitat enhancement component of the project. For the bridge replacement project component, MCL agrees with the proposal to remove and replace all four pedestrian bridges. Differences among alternatives exist only for Bridges 2 and 3 with respect to flood clearance and trail rerouting; we conclude that selection of Alternative C as the Preferred Alternative is warranted. However, we believe that in the assessments of cumulative impacts, especially under the topics of Water Resources and Hydrology/Geology, and Transportation, the EA understates the significance of impacts that could result from several projects being implemented, possibly simultaneously,

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

## Public Comment 6

## Letter from Kate Powers, Marin Conservation League (May 18, 2017)

6a during the extended, multi-year construction period.

6b Objectives: Re-naturalizing Redwood Creek. We acknowledged in our comments that the National Park Service (NPS) has made huge strides inside the monument to "re-naturalize" the physical environment for the long-term benefit of the redwood forest, such as by directing visitor traffic onto walkways to reduce soil compaction and restore the natural forest understory, and by allowing downed trees and other woody debris and brush to accumulate naturally. Numerous projects have been implemented throughout the Redwood Creek watershed to improve creek habitat in an attempt to restore the coho population to self-sustaining levels. Less has been done inside the monument to re-naturalize the creek except to allow woody debris to accumulate in the creek in recent years, after many decades of clearing. Otherwise, creek flows are constrained by a channel as a consequence of large boulder installed 80 years ago to stabilize creek banks. Along with other factors, this has led to poor habitat conditions for juvenile salmonids. Removing many of the boulders will allow the creek to better connect with its natural flood plain. Introducing more large woody debris into the creek will enhance structural complexity of the habitat for juvenile salmonids seeking refuge from predators. Replacing bridges will help in small measure to release the confined creek, but the more obvious purpose is to replace aging structures for visitor use and to better withstand flood flows.

In sum, the objectives of the preferred project, as described in the EA, are to help to restore natural geomorphic processes where possible, consistent with the need to retain essential infrastructure, and to enhance winter and spring habitat for coho fry and juveniles and summer habitat for juvenile salmonids. MCL supports these objectives, which complement other habitat restoration projects in the watershed.

Alternatives. MCL also suggested in earlier scoping comments that the EA examine an alternative that would remove and not replace Bridges 1 and 3, and remove west side paths, leaving a greater portion of the west side floodplain free of human activity. Under that alternative, Bridge 2 would be replaced for access to the Hillside Trail and Bridge 4 replaced for access to the Ben Johnson Trail. This alternative would allow much of the west side of the canyon to naturalize - that is, become "wild."

6c The EA initially considered this alternative but dismissed it from further analysis (EA, page 2-51), in that it would require major changes in trail alignments, deprive visitors of a loop trail, and eliminate the ability of NPS to disperse large crowds of visitors away from the main trail, one of the purposes of the west side walkway. It would also eliminate NPS' flexibility to close the main trail on occasion due to a hazard, such as a fallen tree. MCL accepts this rationale.

The alternatives for creek restoration retained for analysis in the EA vary in linear feet of rock removal, the number of locations for installing large woody debris, and some special habitat treatments. Given the considerable investment in habitat restoration in other parts of the watershed, and given that the same equipment, material stockpiling, and construction methods would be required for any of the alternatives, MCL recommends that NPS implement the full extent of possible actions, as described in the preferred alternative.

6d Construction Impacts. The project could have significant impacts on the environment during construction, which involves use of major equipment to remove and transport boulders, salvage and place downed trees and other woody debris in the creek, and to remove and replace bridges. In our comments, MCL requested that the EA describe the construction process in detail - the locations for stockpiling of both boulders and logs, staging areas for equipment and materials, construction-related traffic flows, measures to dewater the creek and stabilize banks in the short term, while, at the same time, minimizing disruption to visitors. MCL requested information in the EA on the timing of construction to avoid nesting season of northern spotted owl, for example, and other measures that would be taken to protect wildlife and fish habitats during construction.

The EA provides detailed information on construction logistics, equipment and methods, staging and stockpiling areas, and timing. It appears that the project will take place over four seasons: rock removal in two eight-week phases separated by a year, and bridge replacement in two alternate years in 4-and-a-half- month construction periods, also separated by a year. Thus the entire project will extend over four years: 2018 through 2021. All work will be limited by critical nesting seasons, and work in the creek will be limited to the low flow season.

As "mitigation measures" the EA lists 35 best management practices that will be incorporated into plans and specifications to Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 6****Letter from Kate Powers, Marin Conservation League (May 18, 2017)**

6d minimize disturbance to the creek and control erosion, protect downstream habitats from sedimentation, and limit construction disturbance to sensitive wildlife such as the endangered northern spotted owl. Following construction, it is expected that, over time, natural processes of scour, erosion, and channel widening will interact with revegetated banks and newly-installed large woody debris to reach the dynamic equilibrium of a more natural creek channel.

6e Cumulative Impacts. MCL did not comment on the scope of cumulative impact assessment in our earlier letter but, as other planned projects in the watershed have emerged, this has become a major concern. During the approximate four-year time period anticipated for the salmon habitat enhancement projects, the NPS plans to implement a Muir Woods reservation system, replace water and wastewater infrastructure, make improvements to parking areas and the monument entry, and install a permanent Dipsea bridge. In that same general time frame, the Federal Highway Administration (FHWA) and the county plan to rehabilitate the 2.5-mile-long Muir Woods/Frank Valley Road and replace the bridge, a multi-year process.

The EA discusses the potential for cumulative impacts resulting from the proposed action, concurrent with these other projects. The EA concludes that the long-term beneficial impacts (improvements to traffic congestion and parking; enhanced Redwood Creek water quality and salmonid habitat) will outweigh the potential for adverse short-term, construction-related impacts. Considering the extended time frame for implementation, MCL disagrees that construction-related impacts are "short-term" and therefore not significant, as follows.

6f Water Resources and Hydrology/Geology Cumulative Impacts. The long-term and cumulative intent of all of the projects listed above is to reduce erosion and improve the quality of runoff, and, thereby, habitat conditions, in Redwood Creek - that is, to be beneficial to habitat. In fact, construction of all of these projects will involve vegetation and soil removal, other ground and creek bed disturbance, and soil erosion in varying degree. The EA acknowledges that these construction-related activities would result in elevated levels of turbidity and downstream sedimentation in Redwood Creek. Since other planned projects are intended to enhance water quality, the EA concludes that cumulative construction-related impacts to surface waters and water quality, with implementation of BMPs, would be relatively minor and, although adverse, would be short-term.

MCL believes that sedimentation into the creek under a cumulative scenario could be significant. Construction episodes will occur seasonally over a span of four to five years, allowing limited time for downstream reaches of the creek to "recover" between construction seasons.

In view of the prolonged time frame for implementation of the proposed action, and in combination with other planned projects, MCL recommends that NPS technical staff or a consultant be assigned to monitor activities throughout and following construction periods and report periodically to the public on progress of the project and the effectiveness of BMPs. Project contractors would be required to take corrective action if BMPs were not effective.

6g Transportation Cumulative Impacts. The EA notes that projects such as the reservation system and improved parking and access to the monument will improve traffic conditions. However, over the course of implementing the proposed action along with other planned projects, trucks and equipment and other construction-related vehicles will at various times utilize local roadways, including Panoramic Highway, upper Muir Woods Road, and Frank Valley Road. The roadway rehabilitation and bridge replacement project on Muir Woods/Frank Valley Roads could interfere with other NPS project-generated traffic, with adverse impacts on both visitor and local resident traffic. Although limited to a four to five year period, this would impose a severe hardship especially on local residents if, once again, State Highway 1 were to close temporarily.

For the benefit of both local residents and visitors, MCL recommends that the NPS maintain and post a detailed and constantly updated calendar of construction phases of all projects as they are implemented, with anticipated periods of traffic activity they will generate. For periods of intense construction activity, contract documents should include provision for assigning traffic control.

6h In conclusion, MCL supports this ambitious project that NPS has long contemplated. With effective project erosion controls to limit sediment delivery and turbidity, and through monitoring during and following construction episodes to ensure proper creek functions and other habitat requirements, the relatively short-term construction impacts on the creek system should pay

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 6**

**Letter from Kate Powers, Marin Conservation League (May 18, 2017)**

6h | dividends in the long run by removing or correcting conditions that currently limit survival of juvenile salmonids in Redwood Creek. MCL will continue to follow the progress of NPS activities in Muir Woods and the Redwood Creek watershed.

Sincerely,

Kate Powers, President

Nona Dennis, Chair, Parks & Open Space Committee

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 10 of 22

## **Public Comment 6                      Letter from Kate Powers, Marin Conservation League (May 18, 2017)**

### ***Response to Comment 6a***

Cumulative impacts are addressed in Responses to Comments 6f and 6g.

### ***Response to Comment 6b***

Comment noted.

### ***Response to Comment 6c***

Please see Response to Comment 5d for more information on why removal without replacement of Bridges 1 and 3 was dismissed from further analysis.

### ***Response to Comment 6d***

NPS agrees that Marin Conservation League's assessment of a likely schedule of actions is mostly correct, with all work conducted during low-flow seasons. In general, critical nesting seasons would be avoided, but some construction (particularly of bridges) may occur within the nesting season. Implementation of BMPs BIO-6 through BIO-8 would reduce the potential for impacts on nesting birds. The first phase of the creek restoration action is expected to be conducted in 2018. The full installation of large woody debris (LWD) is likely to be conducted in a second season, expected to be 2019, because the method is slow. The addition in the Final EA of installation of small woody debris structures referred to as beaver dam analogs are expected to be installed in the initial year but modified and added to in subsequent years. NPS expects the beaver dam analogs to offer substantial benefits for low-cost and low-installation impact. The second phase of the creek restoration action is not currently scheduled but could take place in 2021 or 2022 depending on funding availability. The bridges would be installed in two separate years. Please see other responses regarding the overall schedule for actions at Muir Woods, including Responses to Comments 4c and 4d.

### ***Response to Comment 6e***

The Proposed Action and other projects discussed in Section 4.2 *Cumulative Impacts Analysis Methodology*, have been developed to avoid significant cumulative impacts: (a) staggering construction so there would not be high a concentration of impacts in a given time; (b) not allowing actions to be conducted year-round; (c) being responsive to sensitive resources through construction timing and other BMPs, including measures to address erosion/sedimentation from each project during construction. In general, the use of "short-term" in the EA means lasting only as long as the construction phase of the Proposed Action.

### ***Response to Comment 6f***

Please note that the Redwood Creek Watershed Sediment Budget, prepared by Stillwater Sciences in 2004, found that compared to other reaches of Redwood Creek, the project reach through Muir Woods generated an unnaturally low quantity of sediment because of the hardened banks. The enhancement of natural processes in Muir Woods also means that some new bank erosion will occur, thereby creating channel complexity and habitat; but this increase is projected to be within the normal ranges of sediment production observed downstream (Northern Hydrology and Engineering 2017). It is also relevant that the project

**Public Comment 6****Letter from Kate Powers, Marin Conservation League (May 18, 2017)**

reach is incised and currently lacks geomorphic features to trap sediment, but various aspects of the Proposed Action—especially the reintroduction of large wood and the installation of beaver dam analogs—are intended to promote the capture of sediment. This will help the reach recover from incision over the long-term and reconnect with its floodplain. In short, sediment trapping in the project reach will support the goals of the Project. Thus, the focus on sediment reduction from this Project is related to potential construction impacts.

Project-specific BMPs for each project would avoid and reduce sedimentation potentially generated by construction. The Proposed Action could add short-term impacts, but BMPs would be applied during all construction projects to avoid and minimize cumulative impacts. Collectively, projects would have substantial long-term beneficial cumulative effects on water resources. Stormwater permits will be required for some of the projects included in the cumulative impacts section. The SWPPP requires monitoring and reporting and will cover the general construction area for that proposed action, thus the SWPPP monitoring would include work area for the Proposed Action. Corrective actions are, in fact, required as a result of SWPPP monitoring if conditions are not satisfactory. Additionally, as described in Response to Comment 4b, NPS would develop a monitoring plan prior to implementation of the Proposed Action, and water quality would be monitored both during and after construction.

***Response to Comment 6g***

NPS would inform visitors in advance of construction activities via a number of outlets, including the MWNM website, signs, the visitor center, and bus and shuttle drivers. Additionally, NPS would provide consolidated updated information on construction for all projects in MWNM on the NPS and/or MWNM website and other venues as needed. Based on the interest in a calendar of activities, a timeline of construction activities will be posted on the park website. Traffic controls would be in place on Panoramic Highway and other key locations during construction where/when needed. Finally, much of the construction traffic would occur after Labor Day, a time of year when there is less traffic. If an event such as temporary closure of Highway 1 were to occur during such periods, it is likely that traffic plans or schedules would be adapted to minimize impacts on local traffic.

***Response to Comment 6h***

Implementation of erosion control measures outlined in the alternatives, as well as BMP-2, -9, -10, and -11, and BIO-15, would reduce the potential for sedimentation and turbidity. As described in Response to Comment 4b, NPS would develop a monitoring plan prior to implementation of the Proposed Action.

**Public Comment 7**

**Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)**

**PEPC Project ID: 62983, DocumentID: 78726  
Correspondence: 7**

**Author Information**

Keep Private: No  
 Name: Gordon Bennett  
 Organization: Save Our Seashore  
 Organization Type: I - Unaffiliated Individual  
 Address: 40 Sunnyside Dr  
 Inverness, CA 94937  
 USA  
 E-mail: gbatmuirb@aol.com

**Correspondence Information**

Status: New Park Correspondence Log:  
 Date Sent: 05/18/2017 Date Received: 05/18/2017  
 Number of Signatures: 1 Form Letter: No  
 Contains Request(s): No Type: Web Form  
 Notes:

**Correspondence Text**

η η Save Our Seashore η η  
 A 501(c)(3) Charitable Organization (EIN 94-3221625)  
 Founded in 1993  
 to Protect Marin County's Ocean, Coasts, Estuaries, Watersheds and Creeks  
 40 Sunnyside Dr, Inverness, CA 94937 gbatmuirb@aol.com 415-663-1881

May 18, 2017

Re: Salmon Habitat Enhancement and Bridge Replacement Project at Muir Woods  
 Draft Environmental Assessment (dEA)

7a { The above dEA is a contradictory mix: on the one hand, a study of creek restoration actions, which seems well documented and which we support; on the other hand, a study of bridge and trail replacement, which appears to violate the NEPA requirement for a study of reasonable alternatives and which we consequently cannot support. Confounding this deficiency, the dEA employs one set of phrases to describe desired outcomes in its "Need" Section 1.3 while using superficially different phrases to describe the same needed outcomes that it later dismisses in its "Alternatives Considered but Dismissed" Section 2-8.

7b { Tributary Grade Control: The dEA (1-3) describes the need for the Project as "better habitat for survival of fry to the juvenile stage," yet the dEA dismisses an alternative that would address that exactly need. The dEA (2-51) notes, "Some tributaries have grade control at the confluence with the mainstem of Redwood Creek. Actions were considered to remove this grade control to provide better off-channel winter habitat for salmon [aka survival of fry]; however, this action was dismissed because of the risk of inducing further incision...."

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 7****Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)**

7b The dEA is hydrologically correct as stated, but this is a static conclusion that assumes no changes to Redwood Creek despite the dEA's proposals for significant changes. The dEA's proposed channel spanning logs will inevitably act as defacto grade controls and aggrade the mainstem. Tributary incision could then be mitigated and "better habitat for survival of fry to the juvenile stage" could be created. An alternative that removes grade controls on tributaries cannot be dismissed on the basis of the status quo in the mainstem. Instead, the dEA should adopt an alternative for iterative management of tributary grade controls that can respond to opportunities presented by the change in management of the mainstem.

7c Redwood Creek Grade Control: The dEA (1-3) describes the need for the Project as "increase rearing habitat for juvenile salmon by increasing habitat complexity and supporting pool formation... which is important for future visitor experience." Yet the dEA dismisses an alternative that would address those exact needs. The dEA (2-51) notes : "NPS considered an action to install grade control in the Redwood Creek channel... to reactivate the channel with its floodplain [aka increase habitat complexity] and, possibly... to better maintain instream flows during the dry season. This action was dismissed because (it) would require stable, reinforced banks on either side to prevent outflanking by high flows, and no such location was identified... without affecting existing infrastructure (including... trails).

The above dEA statement is hydrologically correct, but this again is a static conclusion that assumes no change to bridges and trails in the Project area. If Bridges 1 and 3 servicing the westside trail were abandoned, then, trails and infrastructure on the eastside (left bank) would not be impacted and it would be possible to "reactivate the channel with its floodplain" on the westside, which would result in increasing habitat complexity and supporting pool formation... which is important for future visitor experience." But once abandonment of Bridges 1 and 3 is dismissed, the dismissal of connecting the creek to its floodplain became a foregone conclusion.

-1-

7d GMP vs dEA: The dEA Pg 2-52 notes, "According to the GMP EIS, the purpose of MWNM "is to preserve the primeval character and ecological integrity of the old-growth redwood forest for scientific values and inspiration" (NPS 2014)." But this GMP purpose is inconsistent with the dEA's dismissal of alternatives that "increase rearing habitat for juvenile salmon" and "reactivate the channel with its floodplain."

The dEA notes, "The GMP does not accommodate the significant change in the landscape that might be expected with a large number of rock grade control structures and extensive bank erosion. Instead, the preferred alternative addresses incision through a long-term approach, by adding wood to significantly increase the sediment storage capacity of the channel and to use angled channel-spanning logs where possible. A moderate approach to reusing some boulders mid-channel will be employed in the preferred alternative without building channel-spanning grade controls." So the dEA appears to assume, without citation, that logs spanning the creek will not create the same significant change in the landscape and extensive bank erosion that rocks spanning the creek will. We believe this is a distinction without a difference. The risk is that by dismissing rock grade controls, the dEA also is dismissing the opportunity to "reactivate the channel with its floodplain" that logs, as well as rocks, would create.

The dEA notes that an alternative connecting the creek with the floodplain by means of channel spanning rock structures was dismissed because (it) would require stable, reinforced banks on either side to prevent outflanking by high flows, and no such location was identified... without affecting existing infrastructure (including... trails). Thus this statement begs the following question.

Given the dEA's presumption that infrastructure (the westside trail) will remain, then what actions will be taken when channel spanning logs create the same high flows as channel spanning rock structures. When those high flows inevitably flank infrastructure, GGNRA will in one year be adding large woody debris and the next year removing it. Such actions would, of course, be needed to protect infrastructure on the eastside, but the dEA fails to study how much effort and money will be needed to protect westside infrastructure that may prove to be a negative to both natural resources and visitor experience. The dEA in essence proposes to loosen the straightjacket that the present rip-rap and bridge abutments impose on

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

## Public Comment 7

Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)

the creek...but only by a little...too little we fear to contribute to material improvements in salmon habitat.

7d

We agree with the dEA that a highly engineered system with multiple channel spanning rock grade controls is not desirable, but we also agree with the dEA that the long term net effect of channel spanning large woody debris will be the same... the mainstem will aggrade and ultimately the grade control on upstream tributaries can be removed. Thus, "no rocks" is not a valid argument as to why connecting the creek to its floodplain (with all its attendant resource benefits) should be dismissed. Ultimately, channel spanning logs (just as channel spanning rocks) would require stable, reinforced banks... to prevent outflanking by high flows... without affecting existing infrastructure (including... trails). But far better to have to deal with this problem on the eastside only.

Visitor Experience - Noise: The dEA continues "The GMP also established a visitor experience goal of fostering "the visitor's deep personal connection to the monument and discovery of the values and enjoyment of the natural environment." Visitors come to experience the immensity of the redwoods, the sights and sounds of nature..." But this GMP purpose is inconsistent with the dEA's dismissal of bridge alternatives that eliminate the westside trail. Visitors on the main eastside trail looking across Redwood Creek do not "experience the immensity of the redwoods, the sights and sounds of nature..." Instead they see the distracting sights and sounds of visitors of the nearby westside trail.

-2-

But The dEA provides no quantitative evidence to back its implied conclusion that the westside loop trail reduces noise and visual distractions. To the contrary, we believe that the westside trail diminishes the ability of visitors to "experience the immensity of the redwoods, the sights and sounds of nature..."

7e

In support of our belief, the GMP EIS (Pg 289 notes): "Given the high levels of use in the woods, including use by families and groups, noise levels and the frequency of human introduced sound can affect the natural soundscape, disrupting wildlife and impacting visitor experience.... Some of the management activities the National Park Service has been employing in relation to this issue have focused on education regarding low-impact practices, including introducing "quiet days" and "quiet zones" within the woods to encourage visitors to voluntarily modify their behavior and better protect the natural soundscape."

But the dEA fails to provide any quantitative data on these management activities, which we believe (due to staffing limitations) are focused on the eastside trail. This results in the westside trail with visitor volume levels that exceed those of the eastside trail, despite lower visitor use.

The dEA continues: "Visitor use and experience at MWNM is influenced by high visitation levels that lead to adverse impacts... Large crowds generate noise and detract from the overall experience in the monument. With the implementation of the first phase of the Reservation System (anticipated in late 2017 or early 2018), days with extremely high daily visitation levels (>4,500) would be minimized or eliminated, visitation would be more evenly distributed over the course of a day, and, numbers of visitors per hour during peak times of the day would be reduced (NPS 2015b). These changes would reduce the effects of crowding on visitors."

This is a correct anticipation of future conditions, but the dEA then justifies its dismissal of alternatives that abandon Bridges 1 and 3 by reference to existing conditions: "The trails in the monument, particularly those between the Entrance Station and Bridges 1 and 2, are heavily-trafficked, especially in the summer months.... Trails on both sides of Redwood Creek also help disperse crowds. The dEA presents no quantitative evidence to support its conclusion that after crowd-reducing effect of the Reservation system, the westside trail would still be needed to "disperse crowds." In fact, the GMP contradicts the dEA claim that "large crowds generate noise," noting that the behavior of the crowd (rather than the sheer size) determines the noise level (e.g. churches are "crowded" but quiet). This fact is the basis for the GMP's reference to "quiet days" and "quiet zones" (rather than reducing the number of visitors) to encourage visitors to voluntarily modify their behavior and better protect the natural soundscape."

7f

Visitor Impacts: The GMP also notes, "The priority resource indicators for Muir Woods National Monument are associated Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

## Public Comment 7

Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)

7f with the issues of informal trails (i.e., trails created by visitors leaving designated trails), evidence of visitor-caused wear or disturbance to the redwood trees, and the amount and distribution of invasive species. The proliferation of informal trails in Muir Woods National Monument is not currently a serious problem because the NPS staff has greatly increased efforts to clearly delineate designated trails (i.e. the boardwalk) and to educate visitors to stay on trails... Roving patrols and other education and enforcement techniques have also been used.

But the dEA fails to note that Bridges 1 and 3 deliver visitors to the westside trail where there is no boardwalk and proportionately "less roving patrols and other education." In essence, the dEA proposes the expenditure of a million dollars to restore two bridges that impact natural resources and deliver visitors where they can most do the most harm both to resources and to other visitors' experience. The dEA Pg 2-52 notes 'Removal of Bridge 1 would likely require major changes... visitor experience in MWNM.' Correct, but we would argue that the change in visitor experience would be for the better.

-3-

7g The dEA also mistakenly notes, "This (westside trail removal) would also eliminate access and unique views around Bohemian Grove on the west side of the creek." Not correct. The alternative that we had suggested in our 10/21/16 scoping letter suggested either a short dead end trail from Bridge 2 to Bohemian Grove or a re-location of Bridge 2 south to more directly connect to Bohemian Grove.

Bridges: The dEA notes, "The trail segment between Bridges 2 and ... provides NPS with management flexibility when trails must be closed to due to hazards such as a tree falling over a trail [and] also helps distribute visitors throughout the woods rather than keeping them all along one trail. Removal of Bridge 3 would result in a major, permanent effects on use patterns and visitor opportunities.... For these reasons, this action was dismissed."

However, as with the dEA statements about Bridge 1, this dEA conclusion is unsupported by any quantitative evidence. We believe, for example, that a tree falling over a trail is an uncommon occurrence that can be quickly remedied and thus does not justify the significant impact of the westside trail to natural resources and visitor experience.

7h Further, this section of the westside trail from Bridge 2 to Bridge 3 is only about 500 feet long. If the comprehensive trail study should find a need for loop trails even after the crowd reduction from the Reservation system, then alternative loop trails could be developed on the eastside. In fact, the dEA Figure 2-9 shows that the east end of the proposed Bridge 3 requires a segment of the eastside trail to be re-routing upslope, with the current streamside location of this segment of trail restored.

On the other hand, if the Bridge 3 were abandoned, yet the proposed upslope trail still built, then the existing eastside trail could be maintained to form a boardwalk loop that could be connected to the existing loop through the nearby Cathedral Grove. This would create an eastside loop trail essentially the same length as the current westside loop trail between Bridges 2 and 3, which would then allow that sensitive area to be restored.

But instead, the EA claims that the GMP does not allow "major" trail realignment and thus proposes Bridge 3 to deliver visitors onto a trail that has no boardwalk, fewer roving patrols and less "other education." And instead of restoring this segment of the westside trail and allowing the bank to erode and the creek to connect to its floodplain, the dEA proposes instead to remove and restore the existing segment of the eastside trail that would necessarily require stable, reinforced banks... to prevent outflanking by high flows. The dEA is restoring the wrong side.

If the "comprehensive trail study" should find a need for loop trails even after the crowd reduction from the Reservation system, then other loop trails could possibly be developed on the eastside. By way of example, the side trail that runs past the café and gift shop is now a dead end that could possibly be extended to loop back to the main trail near the Ocean View trail or possibly even further to the previously mentioned Bridge 3/Cathedral Grove loop. As the dEA notes for the new westside trail proposed for Bridge 3, "This would also provide different visitor experience through a wooded area, which is not generally provided on the valley floor."

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 7****Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)**

7h The dEA concludes, "The GMP supports the use of side trails in the woods in order to avoid concentrating visitors on the main trail. It also encourages the development of thematic interpretive trails to experience different parts of the park. Bridge 1 removal would be more properly considered under a comprehensive trail plan, which is outside the scope of this EA." But our above suggestions for eastside loop trails conform to the GMP, which states, "portions of the main trail and bridges could be relocated to allow for creek and floodplain restoration and improvements to the integrity of the redwood forest ecosystem..."

-4-

7i Summary: Alternatives that could have offered "better habitat for survival of fry to the juvenile stage," and "increase rearing habitat for juvenile salmon by increasing habitat complexity and supporting pool formation" were dismissed in a cascade of logic originating in the assumption that Bridges 1 and 3 have to remain per the GMP.

But as the dEA itself notes on Pg 2-1: "Modifications to trails identified as part of Creek Restoration and Pedestrian Bridge Replacement Alternatives do not represent the full set of possible trail modifications that could benefit channel function." But it is these modifications that should be studied before one million dollars is spent on bridges that (after the Reservation system moderates crowding) may be found to be superfluous and/or destructive to both natural resources and visitor experience.

Once a million dollars has been spent on Bridges 1 and 3, the chance of a comprehensive trail plan concluding that these two bridges are superfluous and/or destructive to both resources and visitor experience is approximately zero. In fact, this study should be done before (not after) Bridges 1 and 3 are green-lighted. Such a study should be a zero-basis comparison of visitor experience with the westside trail blocked off versus with the westside trail in use.

7j Reasonable Alternatives: Luckily, the creek restoration project seems independent of the bridge project, because "restoration actions could begin as early as fall 2017... Bridge construction is scheduled to start in 2019 and 2021 with two bridges removed and replaced each of the construction years" (dEA 2-38). This affords the Project with the opportunity to reconsider dEA Bridge and Trail alternatives presently dismissed from further analysis.

Thus we urge GGNRA to proceed with the dEA suggested creek restoration activities, and to reconstruct Bridges 2 and 4 on schedule in 2019. But in the interim before 2021, before a million dollars is spent on Bridges 1 and 3 and after the Reservation system decreases crowding, do the comprehensive trail study that would enable the NEPA-required analysis of a reasonable range of alternatives.

7k Under the current dEA, the difference between bridge and trail alternatives is trivial. Under all Alternatives, all trails remain substantially the same, all four bridges remain in the same locations and all are the same length. The only difference is that in Alternative A, Bridges 2 and 3 are both nine inches lower than under Alternative 2. IN Preferred Alternative 3, only Bridge 2 is nine inches lower. A nine inch difference in alternatives is not a reasonable range.

In contrast, a comprehensive trail study could consider an alternative that left the bridges and trails in their current location, as the dEA now proposes. Another alternative could be to remove Bridges 1 and 3 and their associated westside trail loop without replacing the loop. A third alternative could be to remove Bridge 1 and 3 and their associated westside loop but replace it with an eastside loop.

Cementing Bridges 1 and 3 in place both literally and figuratively, as the dEA now proposes, would squander a historic opportunity to take a wholly fresh post-Reservation look at Trail and Bridge needs. A much broader range of Bridge and Trail alternatives must be considered to satisfy both the letter and spirit of NEPA.

Sincerely,

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 15 of 22

**Public Comment 7**

**Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)**

Gordon Bennett, SOS President

-5-

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 16 of 22

**Public Comment 7****Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)*****Response to Comment 7a***

One of the purposes of the proposed action is to replace four aging pedestrian bridges that cross Redwood Creek. NPS considered not replacing all bridges based on public comments received during scoping. However, the bridges are a critical infrastructure element to provide visitor circulation through the MWNM as stated in Response to Comment 5d. Replacing the pedestrian bridges allows for an increase in the flood conveyance capacity of the bridges. Although the alternatives considered for pedestrian bridge replacement are in the same location with the same spans, flood conveyance is a crucial aspect of bridge function and the difference in flood conveyance capacity between the alternatives results in a range of reasonable alternatives. The pedestrian bridge alternatives considered are consistent with GMP policies and meet the NEPA requirements for a study of reasonable alternatives (see Response to Comment 7k for more information). As described in the National Park Service NEPA Handbook (NPS 2015), purpose and need set the parameters for determining which alternatives are considered reasonable. Section 1.2 of the Draft EA, *Purpose*, states, “Although some trail realignment or removal may occur as part of the Proposed Action, this document is not intended as a comprehensive master trail plan for MWNM.”

***Response to Comment 7b***

NPS agrees that tributaries represent an opportunity for better juvenile habitat during winter conditions; NPS does not anticipate removing grade control in tributaries in the short run or the long run in order to avoid potential further incision that might further reduce groundwater elevations. Please also see Response to Comment 8a regarding the National Marine Fisheries Service’s (NMFS’s) emphasis that NPS had not adequately considered remedies for incision. In response to both the concern about tributary connection and NMFS’s concern about addressing incision, NPS has added the use of beaver dam analogs to proposed actions. Please see the refinements to the EA section in “*Actions Common to All Creek Restoration Alternatives*”. These small, inexpensive features may target some drainage confluences to help pond water, trap sediment, and create low-velocity refuges. NPS can change these features through time and can make adjustments as needed for fish passage requirements. NPS prefers to work toward connecting tributaries by encouraging aggradation and ponded water instead of anticipating removal of grade control.

***Response to Comment 7c***

The use of rock for grade control would represent a far more engineered approach to creek management. Boulders would be difficult and expensive to alter if undesirable conditions develop, and they would be long-term visible features that are not natural in the channel. NPS supports the goal of grade control, however, and has added the use of beaver dam analogs to supplement large wood to both help trap sediment and achieve other desirable benefits.

***Response to Comment 7d***

Please refer to Response to Comment 5d for information regarding Bridge 3. The essence of this comment is related to reconnecting Redwood Creek with its floodplain. As shown in the

**Public Comment 7****Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)**

new Figure 3-4, lack of floodplain connectivity is an issue within MWNM. NPS has added the new action of beaver dam analogs to supplement the use of LWD to help achieve this (please see Responses to Comments 6d, 7b, and 8d regarding beaver dam analogs). These features will be easier to place than channel-spanning logs or boulders, since the height can be easily adapted as needed for fish passage or to respond to other conditions. The conceptual designs for LWD do not typically include channel-spanning logs but are still expected to help trap sediment. NPS does not think that flooding on trails is a constraint since most trails occur in a natural floodplain. The potential for bank erosion at channel-spanning features is a greater concern where infrastructure occurs on the top of bank. For this reason, NPS understands the interest in removing more trails. However, NPS believes the preferred alternative identifies a broad range of actions that are distributed well geographically in Muir Woods, and the benefits to juvenile salmonids will be substantial even with the existing constraints in the trail system.

***Response to Comment 7e***

Please see Response to Comment 5d regarding Bridges 1 and 3 and trails related to these bridges. The User Capacity section of the GMP details user capacity indicators and standards developed for management zones within MWNM, including an acceptable range of congestion as measured by “people per view” along the trail. Removal of Bridges 1 and 3 and the Bohemian Grove Trail would likely result in an increase of “people per view” on the Main Trail, degrading user experience beyond the accepted standard. This comment is noted and will be considered when the NPS conducts comprehensive trail planning within MWNM. As described in Section 1.2 of the EA, the Proposed Action is not a comprehensive trail planning effort for MWNM. NPS will conduct comprehensive trail planning and related effects on visitor experience in MWNM at a future date as a separate project.

***Response to Comment 7f***

Please see Response to Comment 5d regarding Bridges 1 and 3 and trails related to these bridges. NPS uses several methods to control visitor flow, boardwalk edging, and fences along both sides of the trail are generally successful in keeping visitors on the pathways. NPS interpretive staff conduct walks through MWNM to maintain proper visitor circulation, and make contact with visitors who may be off trail and use this opportunity to provide information on shared stewardship of MWNM natural resources. In addition, NPS is working to update or replace missing signage relevant to staying on the trail and protecting sensitive resources.

***Response to Comment 7g***

The trail network and connectivity of trails encourage visitor flow through the monument. A dead end trail was considered but rejected, because this type of trail can become overcrowded when not connected to the network.

***Response to Comment 7h***

Please see Response to Comment 5d for information regarding the importance of Bridges 1 and 3 and the Bohemian Grove Trail. Creating new loop trails is outside the scope of this EA.

**Public Comment 7****Letter from Gordon Bennett, Save Our Seashore  
(May 18, 2017)*****Response to Comment 7i***

Please see Responses to Comments 5d and 7e.

***Response to Comment 7j***

The bridges are key trail network locations and provide connections to the surrounding trail network. These connections remain necessary. In the future, comprehensive trail planning will be done to determine which trails need to be rerouted, enhanced, removed, or resurfaced as established in the GMP. Trail assessment will also seek to enhance the interpretive opportunities along the trails.

***Response to Comment 7k***

The Pedestrian Bridge Replacement Alternatives are substantially different. While the difference in height is only 9 inches, this difference allows for the conveyance of a 100-year storm flow compared to the 25-year flow. Bridges need replacement to maintain safety for visitors in the woods. Additionally, minimizing impacts is an important part of the proposed action, and significantly changing the location of pedestrian bridges would likely cause more impacts than replacing them at the same location.

**Public Comment 8****Letter from Rick Rogers, National Marine Fisheries Service (May 18, 2017)****PEPC Project ID: 62983, DocumentID: 78726****Correspondence: 8****Author Information**

Keep Private: No  
 Name: Rick Rogers  
 Organization: National Marine Fisheries Service  
 Organization Type: I - Unaffiliated Individual  
 Address: 777 Sonoma Avenue  
 Santa Rosa, CA 95402  
 Santa Rosa, CA 95402  
 USA  
 E-mail: rick.rogers@noaa.gov

**Correspondence Information**

Status: New Park Correspondence Log:  
 Date Sent: 05/18/2017 Date Received: 05/18/2017  
 Number of Signatures: 1 Form Letter: No  
 Contains Request(s): No Type: Web Form  
 Notes:

**Correspondence Text**

Please find below the National Marine Fisheries Service's comments regarding the Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project Draft Environmental Assessment.

• The project intends to remove some of the CCC stone bank liner and add wood to the channel, to improve habitat for salmonids. Lacking a clear problem statement, it is not clear what the project goals are. NMFS' understanding of the problem is that prior channel modifications drained the valley water table by several feet and then stabilized the banks of the deepened channel with large stone bank lining. This has limited the habitat and ecosystem benefits of the reach for most of the last century.

8a

The project as proposed is focused primarily on individual site specific habitat improvements (log structure introductions and removal of rip-rap), and as such lacks reach wide restoration goals and objectives. The habitat improvements will be localized to within the direct influence of the individual site treatments - while not addressing the reach scale problems of incision and sediment evacuation. As stated by NMFS staff during both the December 2015 and December 2016 site visits, a comprehensive reach wide goal of re-aggrading the channel by increasing sediment retention reach-wide, with increasing seasonal water table levels, and re-integrating the channel with the floodplain could be the measurable objectives of the overarching goal of restoring physical processes - for both a reach wide water table and downstream hydraulic response, and an overall reach-wide goal of fish habitat improvement having additional measurable objectives. An overarching goal of restoring alluvial valley physical processes reach-wide within Muir Woods would allow the project to address multiple reach-wide conditions that limit productive habitat forming processes in the valley, and to focus less on individual habitat structures.

Thus, the project description would benefit by explicitly stating an overarching goal of restoring alluvial valley physical processes that will provide multiple benefits and create the conditions to achieve multiple reach wide measurable primary project objectives of:

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 8****Letter from Rick Rogers, National Marine Fisheries Service (May 18, 2017)**

- 1) Re-aggrading the channel by increasing sediment retention reach-wide;
- 2) Increasing seasonal water table levels to benefit instream habitat and downstream summer flows;
- 3) Re-integrating the channel with the floodplain to: increase groundwater recharge; provide winter refuge and rearing habitat; and to decrease in channel high flow velocities.

8a Secondary measurable objectives resulting from attaining primary objectives would address habitat in the following ways:

- 1) Increased depth of pools due to greater mobile sediment depths and subsequent scour, along with increased water table levels.
- 2) Increased frequency of pools and riffle habitat due to restored sediment transport and deposition processes (and added wood structures)
- 3) Increased quantity and quality of spawning gravel habitat (with measurably greater hyporheic flows to benefit egg survival)

8b NMFS understand the desire of the Park to remove the CCC stone work to the extent practical; it is unnatural in this setting. However it could be a valuable resource if re-positioned to facilitate bed aggradation and wood retention. The stone could likely be incorporated in buried elements and foundations and ballast for wood structures, and be unnoticeable. Substantial cost savings as well as project benefits may be possible by re-purposing the stone and not off-hauling it.

8c • NMFS recommends that future river projects, and this project to the extent that it can at this stage of development, take a more structured approach to project development and more fully incorporate early technical assistance. Unquestionably this approach results in better designs and more efficiency and timeliness with the permitting phase of projects. Project development should follow a structured approach such as the SMART approach commonly used in business practice, or as presented in the NMFS RiverRAT tool and book. This approach starts with developing mutually agreed upon goal(s), and measurable objectives, and then develops concept designs that represent feasible alternatives that are evaluated by the measurable objectives. This process delivers a preferred project that the agencies have participated in developing, thus streamlining permitting and funding, and it adds value by including agency technical expertise at the outset instead of in review of proposals. This approach also allows for comparative evaluation of alternatives and potential for a cost vs benefit analysis.

8d • In addition to brush piles, NMFS recommends the Park investigate the use of "beaver dam analogs" as a potential habitat restoration component for aggrading the stream channel.

8e • The Park should adopt and undertake a well thought out monitoring plan to determine the ultimate success of the restoration effort. For example, the California Department of Fish and Wildlife employs a three part process as part of their Fisheries Restoration Grant Program, focusing on project implementation, effectiveness and validation monitoring to gauge the overall success in achieving pre-project goals, and to inform the Department when post-construction remediation or repair is required.

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 18 of 22

**Public Comment 8****Letter from Rick Rogers, National Marine Fisheries Service (May 18, 2017)*****Response to Comment 8a***

Please see changes to the text in the EA regarding goals and objectives and a statement of the conditions at MWNM to incorporate NMFS's suggestions. NPS agrees that incision is a fundamental problem in the existing channel processes. New Figures 3-3 and 3-4 have been added to the Final EA to illustrate this problem. The purpose of the Proposed Action is still to enhance rearing habitat for salmonids, but NPS has incorporated additional actions at NMFS suggestion to both better address incision and provide better habitat.

***Response to Comment 8b***

Some boulders will be reused in the channel, but the volume is too great to reuse most of the boulders in the channel. A few will be used for boulder-formed pools, which provide good habitat for steelhead, and some may be used as ballast.

***Response to Comment 8c***

Comment is noted for future projects. While NPS was not able to incorporate the full range of NMFS suggestion in the Proposed Action, NPS agrees there will be substantial added benefits by incorporating an emphasis on addressing incision and installing beaver dam analogs.

***Response to Comment 8d***

NPS has added the use of beaver dam analogs to the Proposed Action. Please see the refinements to the EA section on *Actions Common to All Creek Restoration Alternatives*.

***Response to Comment 8e***

Please see Responses to Comments 4a and 4b. NPS will prepare a monitoring plan in advance of implementation. This plan is anticipated to include monitoring of physical processes, habitat quality and quantity, and use by salmonids. The plan will likely include topographic surveying at monumented cross-sections to evaluate changes in the bed, banks and pools; periodic channel mapping to show a planview of changes in channel features; flow monitoring to evaluate discharge and water surface elevations in relation to bank height; habitat mapping of features meeting velocity, cover, and depth requirements for suitable juvenile habitat; and winter spawning surveys and summer juvenile surveys.

**Public Comment 9**

**Letter from Alan Carlton, Sierra Club (May 18, 2017)**

**PEPC Project ID: 62983, DocumentID: 78726  
Correspondence: 9**

**Author Information**

Keep Private: No  
 Name: Alan Carlton  
 Organization: Sierra Club  
 Organization Type: I - Unaffiliated Individual  
 Address: 408 Sunset Rd.  
 Alameda , CA 94501  
 USA  
 E-mail: carltonal@yahoo.com

**Correspondence Information**

Status: New Park Correspondence Log:  
 Date Sent: 05/18/2017 Date Received: 05/18/2017  
 Number of Signatures: 1 Form Letter: No  
 Contains Request(s): No Type: Web Form  
 Notes:

**Correspondence Text**

- 9a [ SIERRA CLUB COMMENT ON MUIR WOODS SALMON HABITAT ENHANCEMENT AND BRIDGE REPLACEMENT PROJECT DRAFT ENVIRONMENTAL ASSESSMENT  
 The Sierra Club is appreciative of the improvements made in the Draft EA to the Muir Woods Salmon Enhancement and Bridge Replacement plan submitted for comments in October 2016. From the original riprap removal and bridge reconstruction project the EA includes some trail relocations/removals and additional stream and flood plain diversity created - particularly in Alternative 5. This preferred alternative more fully succeeds in achieving the desired goals, and the Sierra Club supports the preferred alternative.
- 9b [ Endangered species retention and habitat improvement for coho salmon and steelhead trout, are at the core of this project. The dire need to improve conditions for salmonids, as indicated in the coho and steelhead recovery plans, should elevate this project above all others being contemplated in the Redwood Creek watershed. Expediting this project for its benefit to endangered and threatened species should therefore take precedent over other projects or be done concurrently with other projects.
- 9c [ There is justification for removing Bridge 1 and 3 as well as the southwestern trail that connects those bridges, allowing stream migration. Bridge 2 and 4 should remain and be rebuilt.
- 9d [ Moving trails out of the flood plain and off the creek should also remain a priority, with maximum removal of trails from creek proximity. This will allow riparian vegetative restoration and maximum creek migration.
- 9e [ Studies have shown that salmonids are impacted by loud noises. Noise increases from construction in addition to visitors should therefore be considered. We also have concerns about the restoration implementation contracts. All contractors and heavy equipment operators must have the highest degree of sensitivity and knowledge about working within the creek and riparian zones.
- 9f [ ]
- 9g [ The project should be accomplished in the shortest time possible, which will result in the least amount of dewatering time, impacts from electrofishing and removal, heavy equipment use, and other construction impacts.
- 9h [ Recent observations by some Sierra Club Federal Parks Committee members, especially on fee-free days, indicate that too many visitors clearly do not understand that climbing over fences, stepping off the boardwalks, and tramping down plants creating bare earth inside of, or next to, large redwoods will shorten their life span. This is especially true for partially

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

**Public Comment 9**

**Letter from Alan Carlton, Sierra Club (May 18, 2017)**

9h | hollowed out redwoods. There should be more education including on the website, signage on fences in multiple languages, restoration of habitat on visitor created trails, and increased ranger or volunteer presence to educate and enforce good behavior. These actions are essential to protect the Monument from visitors who do not treat the Monument, its habitat, and, by extension, other visitors with respect.

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 20 of 22

**Public Comment 9****Letter from Alan Carlton, Sierra Club (May 18, 2017)*****Response to Comment 9a***

Comment noted.

***Response to Comment 9b***

Please see Responses to Comments 4d and 5a for details on schedule. The first phase of creek restoration action is expected to take place as soon as possible, which will be late spring or summer 2018. While the second phase will take place several years later, NPS expects to be able to install beaver dam analogs in the Phase 2 area of the creek in 2018, thus achieving many of the benefits for juvenile salmonids throughout the project reach as soon as possible. Other projects planned at MWNM are also important and have conducted compliance processes over an extended period, and NPS does not want to delay those projects.

***Response to Comment 9c***

Please see Response to Comment 5d for information regarding the importance of Bridges 1 and 3.

***Response to Comment 9d***

Please see Response to Comment 5d. Trails are being rerouted where riprap can be removed and habitat enhanced. Creek Restoration Alternative 5 (the preferred alternative) includes the maximum rerouting of trails of the alternatives considered.

***Response to Comment 9e***

Please see Response to Comment 5f.

***Response to Comment 9f***

Please see Response to Comment 5g.

***Response to Comment 9g***

In addition to information provided in Responses to Comments 5b and 6d, please note that if all creek actions were conducted in the same season, it would not reduce dewatering areas or periods of dewatering. In fact, it would expand the area of the creek that would be dewatered all at once, since all the work would generally have to be conducted in about the same period starting in late summer. NPS believes that the EA identifies construction methods that have the least impact and allow the work to be conducted as efficiently as possible.

***Response to Comment 9h***

Comment noted. While generally outside of the scope of this Proposed Action, the impacts of off-trail use are a key aspect of ongoing park management. Please see Response to Comment 7f for more information on NPS trail use management.

**Public Comment 10**

**Letter from Mickey Allison (May 22, 2017)**

**PEPC Project ID: 62983, DocumentID: 78726  
Correspondence: 10**

**Author Information**

Keep Private: No  
Name: Mickey Allison  
Organization:  
Organization Type: I - Unaffiliated Individual  
Address: Issaquah Dock  
Sausalito, CA 94965  
USA  
E-mail: mickall1@yahoo.com

**Correspondence Information**

Status: New Park Correspondence Log:  
Date Sent: 05/18/2017 Date Received: 05/22/2017  
Number of Signatures: 1 Form Letter: No  
Contains Request(s): No Type: E-mail  
Notes: Received via email forwarded from goga\_socialmedia\_goga@nps.gov 5/22/17.

Email originally submitted from: mickall1@yahoo.com at /goga/learn/management/staffandoffices.htm (UUID: 387166EA-1DD8-B71B-05E995F7E62F08D4)

Entered by GTR 5/23/17.

**Correspondence Text**

10a  
10b  
MUIR WOODS SALMON HABITAT ENHANCEMENT AND BRIDGE REPLACEMENT PROJECT DRAFT ENVIRONMENTAL ASSESSMENT I fully support the Sierra Club comment that was reached by consensus of members of the Sierra Club Federal Lands Committee. However, I suggested to the committee that the following be added to or after Paragraph 6, Sierra Club comment: The project should be accomplished in the shortest time possible, which will result in the least amount of dewatering time, impacts from electrofishing and removal, heavy equipment use, and other construction impacts. My addition: If there is a question of visitor safety or consensus of both stream rehabilitation and wildlife experts that the project needs to be done in the shortest time period possible, we would hope you would consider the possibility of closure or reduction of visitor numbers. Those objecting felt my addition is outside the scope of comments on the E.A. I respectfully disagree. There is precedent: Closure of Mariposa Grove for restoration, Yosemite N.P., from July 6, 2015 to Fall 2017 <https://www.nps.gov/yose/planyourvisit/mariposagrove.htm> The Mariposa Grove restoration project will restore the grove's dynamic ecology and increase its resilience. As a result of this project, the Mariposa Grove is currently closed and is expected to reopen in fall 2017. The Mariposa Grove is closed, with no vehicle or shuttle access available, from July 6, 2015 until fall 2017. South Entrance and the Wawona Road will remain open. Paragraph 7 is an outgrowth of observations since Fall 2016 by several committee members who visit Muir Woods Monument. However the following are my observations on 2 specific days. I believe they are pertinent and reflect on Visitor Experience that is an important goal to NPS. Re. Veteran's Day, Nov 11, with the goal to make observations for parking lot, water/wastewater, and salmon habitat enhancement scoping comments. I arrived about 8:20 to photograph areas of concern all existing and proposed parking areas, proposed and existing pathways, drainage and culverts off the hillside and the Conlon Creek drainage, etc before walking into Muir Woods Monument, about 9:40, to study the areas of riprap removal and bridge changes. I was carrying a clipboard with photos, diagrams and some text. I was asked questions by many visitors and finally left the Monument around noon. I shared

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

## Public Comment 10

## Letter from Mickey Allison (May 22, 2017)

10b most of the following with Carey Feierabend, Deputy Superintendent GGNRA after the meeting at Tam Valley Community Center on Tuesday, April 11, 2017 1. Somewhere between 12 and 14 groups of 3 to 6 individuals were sitting on benches and bridges picnicking or snacking. I took time to quietly explain why food in the Monument isn't a good idea. Almost every group had scattered crumbs, which they picked up because they thought I might be official. 2. I asked 6 individuals and/or groups to come out of a tree that had relatively large hole and back onto the boardwalk and/or climb back over the fence. I told them the two photo ops (Cathedral Grove creek-side and Bohemian Grove) have "floors" inside them to protect the roots. The ones they were standing in don't. o Cathedral Grove: one individual was standing on a large fallen redwood near his friends inside a tree before the United Nations plaque and 2 other groups off the stream side path. o On the western path, 1 incident between Bridges 1 & 2 and another between Bridges 2 & 3. o The 6th incident just off the boardwalk near Bridge 2. As asked the woman politely twice, and then used my teacher voice to stop a man from joining her and alert the photographer that that action wasn't acceptable. o A 7th instance was a person standing inside the tree circle with the interpretive sign explaining what it is. I explained to all these individuals that redwoods have shallow root systems. 3. I returned to the entry plaza and talked to the Park Conservancy Volunteers. I wrote a note with a short description of my observations, including my name, email and phone number. I never heard back. 4. Three Parks Conservancy volunteers on duty at the window told me that no Ranger was on duty and no one was available for parking enforcement. 5. No visitation count is taken on Fee-Free Days. Might this be a MOU violation? It would be easy for a volunteer to just use a thumb counter volunteer to keep track of visitor numbers. 6. When I drove home via Franks Valley Road and US 1, I saw illegal parking in lots, along the road and also at Muir Beach. On April 16th I arrived with an out of town friend at 8:30. I had forgotten it was also a free day. My observations occurred after a long rainy period. The ground was quite damp: 1. One Ranger on duty near the gathering area. I don't know if this was normal scheduling or if it was in response to my chat with Carey Feierabend. We didn't see the ranger again. 2. Cathedral Grove near the United Nations Plaque: Two adults in same tree hole with a grade school kid on the same large fallen log. I asked them to stop. The two younger children were visibly aware their parents/sibling's actions weren't appropriate. 3. Hillside Trail from Bridge 4 to Bridge 2. Multiple social trails are being created on the uphill side. o The uphill side of a fallen log. An adult, with camera out, was focusing on the end of the log. I could see movement of at least 2 individuals who were trying to hide. o Several slick, well-worn, muddy paths about 8 inches wide trails on the uphill side of the trail have completely smashed the trunk sprouts of redwoods. o Two different individuals at two different places, getting a photo op on the downhill side of the trail. This meant they were standing on the uphill side of a large redwood tree. The wet ground clearly showing multiple sets of foot prints. o There are a few signs asking people to stay on the path. I do not recall seeing any sign pointing out that redwood root systems can be damaged by foot traffic. 4. Once off the Hillside trail, I decided to check out a hollowed redwood just north of a proposed riprap removal section and about 100' Visitor Center side of Bridge 3. A group of young adults was hopping over the fence for a photo op. I yelled out. "Please get out of that tree now." Got a few swear words and a couple of middle fingers, but they complied. We continued over the bridge where I mentioned to two of them that they could have a photo op at the split tree in Cathedral Grove about the middle of the left trail. 5. We continued back toward the Visitor Center to Bridge 2, crossed back to the west side where I showed my friend how the riprap and Bridge 1.5 were going to be removed and searched out the location of the new trail with various small groups of people listening in and asking questions. 6. We did not see the ranger again during our visit over a 1 hour and 45 minute period. I asked a Parks Conservancy Volunteer about putting up signs in areas that people were trampling. The response is that too many signs destroy the visitor experience. I would add one more thing. Perhaps some of the Parks Conservancy Volunteers might enjoy serving part of their duty by taking an hour walk through the Monument. It is good exercise. They would be additional sets of eyes, ears and a voice helping to preserve this special place for future generations. Thank your consideration and for all you do for our Parks and Monuments. Mickey Allison Issaquah Dock, Sausalito, CA  
">

Correspondences - Muir Woods Salmon Habitat Enhancement and Bridge Replacement Project - PEPC ID: 62983

Page 22 of 22

**Public Comment 10**

**Letter from Mickey Allison (May 22, 2017)**

***Response to Comment 10a***

Please see Responses to Comments 5b and 9g. Implementation of the Muir Woods Reservation System, described in EA Section 4.2, *Cumulative Impacts Analysis Methodology*, would reduce visitor numbers in MWNM.

***Response to Comment 10b***

Please see Response to Comment 9h.

## 2 References

- McBride, J., and D. Jacobs. 1978. The History of the Vegetation at Muir Woods National Monument.
- National Marine Fisheries Service. 2017. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Salmon Habitat Enhancement and Pedestrian Bridge Replacement Project at Muir Woods National Monument, Marin County, California. NMFS No.: WCR-2017-7851. September 20, 2017.
- National Park Service. 2014. Golden Gate National Recreation Area Muir Woods National Monument: Final General Management Plan/Environmental Impact Statement.
- \_\_\_\_\_. National Park Service. 2015. National Park Service NEPA Handbook.
- Northern Hydrology and Engineering. 2017. Preliminary Estimates of Redwood Creek Bank Erosion and Sedimentation from Rock Slope Protection Removal within the Muir Woods National Monument. Technical Memorandum. Prepared for Golden Gate National Recreation Area. February 17.
- Steers, R., H. Spaulding, and E. Wrubel. 2014. Forest Structure in Muir Woods National Monument, Survey of the Redwood Canyon Old-Growth Forest. U.S. Department of the Interior, National Park Service. Natural Resource Technical Report NPS/SFAN/NRTR—2014/878. May.

# Appendix D

## Best Management Practices

Table D-1 lists best management practices (BMPs) that would be implemented during construction of the Salmon Habitat Enhancement and Bridge Replacement Project. BMPs required by U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) in the biological opinions for the Project are noted beneath the BMP number.

**Table D-1. Best Management Practices**

Number	BMP Description
<b>Channel Bed BMPs</b>	
BMP-1 (USFWS)	The work zone and the potential area of dewatering will be defined.
BMP-2 (USFWS)	<p>Following implementation of measure BIO-5, the work zone will be dewatered. Dewatering entails setting up a pump and piping along the work zone. The pump must operate continuously. A noise-attenuated diesel pump will be used to reduce noise. Supplemental methods of attenuating noise will be added as necessary, such as surrounding the pump with rice straw bales. All water will be piped to the downstream channel to maintain instream flows there throughout the work.</p> <p>A set of strict BMPs will be implemented to ensure that no turbid water is piped into the channel (or enters the downstream area through other means.) These may include the use of desiltation devices at the terminal end of the discharge pipe, the use of sandbags to disperse the outflow so it does not stir up turbidity, avoiding foot traffic in the intake zone that would stir up turbidity, construction of a cofferdam at the downstream end of the dewatered zone to prevent turbid water from infiltrating upstream, and taking daily turbidity measurements to evaluate effectiveness and modify measure as necessary to eliminate any observed turbidity due to construction activities. If an auxiliary fuel tank is needed for the dewatering pump, NPS will work with the contractor to identify a suitable location and identify site-specific BMPs.</p>
BMP-3a (USFWS)	The small number of existing channel pools will be lined with fabric and then gravel will be placed on top of them. The gravel and fabric will be removed following the completion of construction, re-exposing the pool. This allows the form of the pool to be completely reoccupied after construction.
BMP-3b	Rocks buried in the channel bed will be placed to retain about 3 feet of native bed material at the surface to allow for development of deep pools in the future, with the exception of areas that are dug out for pools. Trenching will be conducted mid-channel at significant distances from the toes of banks and will avoid good pools, existing grade control logs or similar features. Fine bed material will be packed around placed rocks, and with subsurface zones of the natural bed will be placed between segments of buried rock to prevent the development of subsurface voids. Only native, rounded rock will remain at the surface of the bed.
BMP-4 (USFWS)	<p>A. All vehicles and equipment will be kept clean and in proper working order. Excessive build-up of oil and grease will not be accepted.</p> <p>B. NPS through the applicant will maintain all construction equipment to prevent leaks of fuels, lubricants,</p>

Number	BMP Description
	<p>or other fluids. All equipment used for in-channel work will be inspected for leaks each day prior to initiation of work. Action will be taken to prevent or repair leaks, prior to use.</p> <p>C. Incoming equipment will be checked for leaking oil and fluids. Leaking equipment will not be allowed on site. Additionally, equipment and vehicles will be free of soil prior to entering MWNM to avoid the spread of pathogens or invasive species.</p> <p>D. Site staging and storage areas for construction vehicles, equipment, materials, and soils will occur in previously disturbed or paved areas approved by the NPS. These areas will be outside of high visitor use areas and clearly identified in advance of construction.</p> <p>E. No heavy equipment will operate in a live stream.</p> <p>F. No equipment servicing will be done in the channel or immediate floodplain, unless equipment stationed in these locations cannot be readily relocated (i.e., pumps and generators).</p> <p>G. Spill kits will be maintained on site at all times during construction operations and/or staging or fueling of equipment.</p> <p>H. If necessary, all servicing of equipment done at the job site will be conducted in a designated, protected area to reduce threats to water quality from vehicle fluid spills. Designated areas will not directly connect to the ground, surface water, or the storm drain system. The service area will be clearly designated with berms, sandbags, or other barriers. Secondary containment, such as a drain pan, to catch spills or leaks will be used when removing or changing fluids. Fluids will be stored in appropriate containers with covers and properly recycled or disposed of offsite.</p> <p>I. No large fuel storage containers will be allowed. Fuel will be delivered to the site only in pick-up trucks designed for fuel hauling, but it will not be otherwise stored on site. Vehicle and equipment fueling and maintenance operations will be at least 50 feet away from water courses, except at established commercial gas stations or established vehicle maintenance facilities.</p> <p>J. If emergency repairs are required in the field, only those repairs necessary to move equipment to a more secure location will be conducted in the channel or floodplain.</p> <p>K. All on- and off-road vehicles, boots, equipment, and tools must be power washed to remove soil and plant fragments before entering GGNRA property to avoid spreading pathogens or exotic/invasive species. Equipment also must be cleaned when moving between work zones.</p> <p>L. Vehicle and equipment washing can occur on site only as needed to prevent the spread of sediment, pathogens, or exotic/invasive species and only in defined site which would be identified in the SWPPP. No runoff from vehicle or equipment washing is allowed to enter water bodies, including channels and storm drains, without being subjected to adequate filtration (e.g., vegetated buffers, hay wattles or bales, and silt screens).</p>

Number	BMP Description
	<p>M. All boots, equipment, and tools must be disinfected using a 10% bleach solution, 70% isopropyl alcohol, or other NPS-approved disinfectant method prior to entering the site, as well as between work areas, to prevent pathogen spread.</p> <p>N. All tools, equipment, barricades, signs, and surplus materials will be removed from the project area upon completion of the proposed project.</p>
BMP-5 (USFWS)	Biodiesel will be required to the extent possible.
<b>Forest Floor BMPs</b>	
BMP-6 (USFWS)	Where feasible, downed wood slated for movement or in the travel path will be searched to remove and relocate any amphibians (excluding CRLF [ <i>Rana draytonii</i> ]). Worker and visitor safety is a preeminent concern, and searching for and relocating amphibians will not be conducted in instances where safety might be threatened.
BMP-7 (USFWS)	NPS will identify invasive plants, particularly panic veldt grass ( <i>Ehrharta erecta</i> ), within the work and access route areas prior to project implementation. Existing topsoil will also be evaluated for invasive, nonnative plant infestations. A qualified vegetation ecologist or botanist will plan treatments to prevent the spread of invasive species, and implementation of these treatments will be under the supervision of a qualified vegetation ecologist or botanist. The location of invasive species and the treatment plan will be documented in a plant protection plan. The final treatment prior to project implementation will occur close to initiation of project work. Topsoil heavily infested with invasive, nonnative plants will be removed. Non-infested topsoil will be salvaged, stored according to soil conservation guidelines, and replaced once construction is complete. Post-project monitoring and treatment for invasive plant species is expected to be on-going, with treatments at least 2 to 3 times per year for at least two to three years after construction or longer, as long as funding is available.
BMP-8 (USFWS)	Identify a route which avoids understory vegetation where possible and gives sufficient space to redwood trunks.
BMP-9 (USFWS)	Minimize disturbance to vegetation and soils.
BMP-10 (USFWS)	Place protective mats, if necessary, on the haul route to disperse the load.
BMP-11 (USFWS)	Tie back, trim, or remove vegetation (in order of preference) in the route prior to use, and replant after work is completed.

Number	BMP Description
BMP-12 (USFWS)	Evaluate compaction both before and after work and de-compact using hand methods, if needed. Aerate any ground surface temporarily disturbed during construction and replant with native vegetation to reduce compaction and prevent erosion.
BMP-13 (USFWS)	Padding may be wrapped around trunks, if needed, for extra protection in areas where there is a risk of equipment hitting a trunk.
<b>Bridge Construction BMPs</b>	
BMP-14 (USFWS)	Debris from demolition of existing bridges or construction of new bridges will not enter the channel. Bridge construction will follow channel bed BMPs outlined above.
<b>Air Quality and Greenhouse Gas BMPs</b>	
BMP-15 (USFWS)	<p>A. Water all active construction areas with exposed soil surfaces (e.g., parking areas, staging areas, soil piles, graded areas, and unpaved access roads that have not been stabilized with soil binder, mulch, gravel, vegetation or other cover) sufficiently to prevent dust from becoming airborne.</p> <p>B. All trucks transporting soil, sand, or other loose material offsite shall be covered.</p> <p>C. Vehicle speeds on unpaved areas shall be limited to 15 miles per hour.</p> <p>D. Idling time of equipment when not in use will be avoided and low emission producing equipment will be used when feasible.</p>
<b>Alice Eastwood BMPs</b>	
BMP-16	The location of an existing water line along the paved portion of Alice Eastwood Road will be marked prior to use of the road for construction access, as will any existing breaks in the water line. Upon completion of use of Alice Eastwood Road, NPS will repair any breaks in the water line and demonstrate full operation to California State Parks prior to demobilization.
BMP-17	The Alice Eastwood Group Camp parking lot will be protected from heavy equipment impacts through use of protective materials such as plywood or plastic track mats and/or resealed with slurry as needed to restore to as good or better condition after use.
<b>Water Quality BMPs</b>	
BMP-18 (USFWS)	SWPPPs and erosion control BMPs will be developed and implemented to minimize any wind- or water-related erosion and will be in compliance with the requirements of USACE. NPS will include provisions in construction contracts for measures to protect sensitive areas and prevent and minimize stormwater and non-stormwater discharges. Protective measures will include, at a minimum, those listed below.

Number	BMP Description
	<ul style="list-style-type: none"> <li>▪ No discharge of pollutants from vehicle or equipment cleaning will be allowed into any storm drains or water courses.</li> <li>▪ Concrete waste and water from curing operations will be collected in washouts and will be disposed of and not allowed into water courses.</li> <li>▪ Erosion control measures will be implemented that provide for soil stability and prevent movement of soils during rain events (i.e., silt fences and tarps).</li> </ul>
<b>Noise BMPs</b>	
BMP-19 (USFWS)	<p>A. Contractors will ensure that power equipment (vehicles, heavy equipment, and hand equipment such as chainsaws) are equipped with original manufacturer’s sound-control devices. No equipment will be operated with an unmuffled exhaust.</p> <p>B. Except when required for safety or to ensure the integrity of a proposed project component, no work will be conducted on weekends or holidays. The hours specified in the Marin County noise ordinance will be adhered to as general guidance: general construction will be limited to the hours of 7 a.m. to 6 p.m. on Monday through Friday and 9 a.m. to 5 p.m. on Saturdays; loud noise generating equipment operation will be limited to 8 a.m. to 5 p.m. on Monday through Friday.</p> <p>C. Construction equipment will be properly maintained to minimize noise.</p>
<b>Cultural Resources</b>	
CR-1	<p>Deep excavation (including bank terracing and potentially bridge construction) will be monitored by an archeologist who meets the U.S. Secretary of the Interior’s professional qualification standards. If excavation occurs on Alice Eastwood Road or the Alice Eastwood Group Camp, the work will be monitored by an archeologist. Riprap removal and LWD installation will not be monitored by an archeologist.</p>
CR-2	<p>Not all cultural resources are visible on the ground surface. If any cultural resources, such as structural features, unusual amounts of bone or shell, flaked or ground stone artifacts, historic-era artifacts, human remains, or architectural remains, are encountered during any project construction activities, work will be suspended immediately at the location of the find and within an appropriate radius of at least 50 feet, and the NPS archeologist will be notified immediately. The unanticipated discovery will be treated according to the guidelines outlined in 36 CFR 800.13.</p>
CR-3	<p>In the unlikely event that human remains are discovered during construction activities, all work will stop within 50 feet of the discovery, and the NPS archeologist will be contacted immediately. Furthermore, as required by law, the requirements of California Health and Human Safety Code Section 7050.5 will be followed and the Marin County coroner will be notified. If the human remains are determined to be of</p>

Number	BMP Description
	Native American origin, NPS will follow the provisions outlined in the Native American Graves Protection and Repatriation Act (1990).
CR-4	The project prioritizes retaining the most visible segments of CCC rock work. Actions to mitigate the loss of historic fabric may include an interpretive program at MWNM to highlight the work done by the CCC, as well as extensive documentation of historic features adversely affected by the project. In addition, trail features constructed by the CCC throughout Muir Woods will be thoroughly documented and treatment guidelines will be developed to preserve or rehabilitate as warranted and archeological surveys will be conducted to ensure identification of and proper treatment measures for any as-yet unknown resources.
<b>Biological Resources</b>	
BIO-1 (USFWS)	<p>A. All resource protection measures will be clearly state in the construction specifications, and workers will be instructed to avoid conducting activities outside the project area.</p> <p>B. Prior to any construction-related activities, a training session will be required for all contractors, partners, and NPS staff participating in project-related activities in the project area. Training will be conducted by a qualified biologist to familiarize personnel about sensitive resources in the project area. Personnel will be provided with a brief life-history and physical description of Coho salmon, steelhead, northern spotted owl, marbled murrelet, CRLF, and other sensitive wildlife in the area. Training will include staff resource contact information, identification of sensitive resources, the limits of the work area, general BMPs, and appropriate actions to take upon encountering species status species or other wildlife. All attendees will sign an attendance sheet along with their printed name, company or agency, email address, and telephone number.</p> <p>C. Construction zones outside of existing disturbed areas will be delineated with flagging, and all surface disturbances confined to the construction zone;</p>
BIO-2 (USFWS)	No construction activities will occur at night or during dawn or dusk to minimize impacts on wildlife that are most active during these times, such as the northern spotted owl and CRLF. To the maximum extent practicable, earthmoving and construction activities will cease no less than 30 minutes before sunset and will not begin again prior to no less than 30 minutes after sunrise. Except when necessary for driver or pedestrian safety, to the maximum extent practicable, artificial lighting at the project site will be prohibited during the hours of darkness.
BIO-3 (USFWS)	The contractor will be required to keep all waste and contaminants contained and remove them daily from the work site. Wildlife-proof trash receptacles will be used. Uneaten human food and trash attracts crows, ravens, coyotes, and other predators of the CRLF. A litter control program will be instituted at each project site. All workers will ensure their food scraps, paper wrappers, food containers, cans, bottles, and other

Number	BMP Description
<p>BIO-4 (USFWS/NMFS)</p>	<p>trash are deposited in covered or closed trash containers. The trash containers will be removed from the project site at the end of each working day.</p> <p>Access and/or construction below ordinary high water will be limited to June 15 to October 31, unless conditions to allow the start of salmon spawning do not occur by October 31 and continued work is approved by or otherwise permitted by regulatory agencies, to minimize potential adverse effects to salmonid spawning and movement. The actual work window could be adjusted slightly and will depend upon the current water year, creek conditions, and timing of salmonid migrations.</p> <p>NPS will notify NMFS two weeks prior to project construction to allow NMFS personnel the opportunity to view weir construction.</p> <p>NPS and permittee must provide a written report to NMFS by January 15 of the year following construction of the proposed action. The report must be provided to NMFS Santa Rosa Area Office, Attention: Supervisor NMFS CCAO, 777 Sonoma Avenue, Room 325, Santa Rosa, California, 95404-6528. The report must contain, at a minimum, the following information:</p> <ul style="list-style-type: none"> <li>A. Construction-related Activities--The report must include the dates construction began and was completed; a discussion of any unanticipated effects or unanticipated levels of effects on salmonids, a description of any and all measures taken to minimize those unanticipated effects and a statement as to whether or not the unanticipated effects had any effect on ESA-listed fish; the number of salmonids killed or injured during the Project Action; and photographs taken before, during, and after the activity from photo reference points.</li> <li>B. Fish Relocation--The report must include a description of the location from which fish were removed and the release site including photographs; the date and time of the relocation effort; a description of the equipment and methods used to collect, hold, and transport salmonids; the number of fish relocated by species; the number of fish injured or killed by species and a brief narrative of the circumstances surrounding ESA-listed fish injuries or mortalities; and a description of any problems which may have arisen during the relocation activities and a statement as to whether or not the activities had any unforeseen effects.</li> </ul>
<p>BIO-5 (NMFS/USFWS)</p>	<p>In areas to be dewatered, NPS will set up fish exclusion fences at the outer boundaries of the work zone and remove all fish and wildlife from the work zone as described below, although the details may be revised per guidance from NMFS.</p> <ul style="list-style-type: none"> <li>A. All pumps used to divert live stream flow, outside the dewatered work area, will be screened and maintained throughout the construction period to comply with the NMFS Fish Screening Criteria for Anadromous Salmonids (NMFS 2008). Pump intakes will be covered by mesh not larger than 5</li> </ul>

Number	BMP Description
	<p>mm with sufficient area to prevent impingement of fish and intake approach velocities less than 0.2 ft/s and to prevent CRLF from entering the pump system. Pump intakes will be checked periodically to ensure impingement is not occurring.</p> <p>B. The channel will be blocked by placing fine-meshed screens above and below the work area to prevent fish from entering the work area. Exclusion screening will be placed in low velocity areas to minimize impingement. Screening or nets will be oriented so that approach velocities do not exceed 0.2 ft/s (NMFS 2008). Screen mesh diameter will be 3/32-inch. The bottom edge of the net or screen will be secured into the channel bed to prevent fish from passing under the screen. Screens will be checked periodically and cleaned of debris to permit free flow of water.</p> <p>C. Fish Protection Measures:</p> <ul style="list-style-type: none"> <li>i. Fish relocation activities must be performed only by qualified fisheries biologists with experience with fish capture and handling. NPS will ensure that all biologists working on this project be qualified to conduct fish collections in a manner that minimizes all potential risks to salmonids. Electrofishing, if used, will be performed by a qualified biologist and conducted according to the NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (NMFS 2000).</li> <li>ii. A qualified biologist will monitor the construction site during placement and removal of channel diversions and cofferdams to ensure that any harm or loss of salmonids is minimized and documented. The biologist will be on site during all dewatering events to ensure that all listed species are captured, handled, and relocated safely.</li> <li>iii. Captured fish will be handled with extreme care and kept in water to the maximum extent possible during relocation activities. All captured fish will be kept in cool, shaded, aerated water protected from excessive noise, jostling, or overcrowding any time they are not in the stream and fish shall not be removed from this water except when released. To avoid predation, the biologist will have at least two containers and segregate young-of-year fish from larger age-classes and other potential aquatic predators. Captured salmonids will be relocated, as soon as possible, to a suitable instream location in which habitat conditions are present to allow for adequate survival of transported fish and fish already present.</li> <li>iv. If any salmonids are found dead or injured, the biologist shall contact NMFS biologist Rick Rogers by phone immediately at (707) 578-8552 or the NMFS North Central Coast Office at (707) 575-6050. The purpose of the contact is to review the activities resulting in take and to determine if additional protective measures are required. All salmonid mortalities shall be retained, placed in an appropriately-sized sealable plastic bag, labeled with the date and</li> </ul>

Number	BMP Description
	<p>location of collection, fork length measured, and be frozen as soon as possible. Frozen samples will be retained by the biologist until specific instructions are provided by NMFS. The biologist may not transfer biological samples to anyone other than the NMFS North Central Coast Office without obtaining prior written approval from the North Central Coast Office. Any such transfer will be subject to such conditions as NMFS deems appropriate.</p> <p>D. Water shall be released or pumped downstream at an appropriate rate to maintain downstream flows during construction.</p> <p>E. All temporary fill, cofferdams, pumps, pipes and sheet plastic will be removed from the stream upon completion of each project phase, as well as upon project completion in a manner that would allow flow to resume with the least disturbance to the substrate; any clean native gravel used for the cofferdams will be left in the channel to augment available spawning habitat.</p>
<p>BIO-6 (USFWS)</p>	<p>The following measures will be implemented to minimize potential adverse effects to northern spotted owls:</p> <ul style="list-style-type: none"> <li>▪ If construction commences between February 1 and July 31, NPS will conduct pre-construction surveys for northern spotted owls in suitable nesting habitat;</li> <li>▪ If northern spotted owl nests are detected during pre-construction surveys, no work that raises noise levels above ambient background levels at the nest site will be conducted;</li> <li>▪ Within northern spotted owl habitat, disturbance to native trees greater than 10 inches in diameter at breast height will be avoided where feasible.</li> </ul>
<p>BIO-7 (USFWS)</p>	<p>The following measures will be implemented to minimize potential adverse effects to marbled murrelet:</p> <ul style="list-style-type: none"> <li>▪ Project activities (e.g., those that use chain saws or power equipment) that would raise noise levels above ambient conditions within suitable marbled murrelet breeding habitat would occur outside the core breeding season (March 15 to July 31). During the marbled murrelet's late breeding season (August 1 to September 15), these activities will be restricted to the daytime hours from two hours after sunrise to two hours before sunset (avoiding the time periods when marbled murrelets are most sensitive to noise disturbance) (i.e., allows for work during daytime hours).</li> <li>▪ Within marbled murrelet habitat, disturbance to native trees greater than 10 inches in diameter at breast height will be avoided where feasible.</li> </ul>
<p>BIO-8</p>	<p>The following measures will be implemented to minimize potential adverse effects to non-federally listed nesting birds.</p> <ul style="list-style-type: none"> <li>▪ To the extent feasible, vegetation removal would occur outside the landbird nesting season.</li> </ul>

Number	BMP Description
	<ul style="list-style-type: none"> <li>▪ If vegetation clearing or ground disturbing activities commence between March 1 and July 31, a qualified biologist will conduct a survey for nesting birds within 5 days prior to starting work. If a lapse in project-related work of 1 week or longer occurs, another focused survey will be conducted before project work can be initiated. Surveys will cover a minimum of a 1/4-mile radius around the construction area.</li> <li>▪ If nesting birds are found, a buffer will be established around the nest and maintained until the young have fledged. Appropriate buffer widths are 300 feet for non-listed raptors and 100 feet for non-listed passerines. A qualified biologist may identify an alternative buffer based on a site-specific evaluation. Work will not commence within the buffer until fledglings are fully mobile and no longer reliant upon the nest or parental care for survival.</li> </ul>
BIO-9	Prior to project-related activities, a qualified biologist will conduct pre-construction surveys for dusky-footed woodrat ( <i>Neotoma fuscipes</i> ). Identified woodrat houses will be avoided to the maximum extent practicable. If houses are unavoidable, NPS will implement informal NPS protocol of dismantling of woodrat houses.
BIO-10	Prior to determining final trail reroute locations, a qualified bat biologist will conduct surveys of tree hollows adjacent to the proposed new trail location. If bat maternity colonies are detected adjacent to the proposed trail location, the trail location will be designed so the entrance to the hollow does not face the trail.
BIO-11	Within 1 year prior to commencement of ground disturbing activities, a qualified botanist will perform surveys for special-status and locally rare plant species within areas that could potentially be disturbed by the Proposed Action. Floristic surveys will be performed according to the <i>Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities</i> (California Department of Fish and Game 2009 or current version). If special-status or locally rare plants are detected within the construction zone or within a 50-foot radius of the construction zone, NPS will implement BIO-12. Additionally, any invasive plant species within or adjacent to the construction zone will be identified.
BIO-12	If special-status plants are detected within the construction zone or within a 50-foot radius of the construction zone, NPS will adjust the construction footprint or establish an exclusion area to avoid impacts to the plants. Locations of special-status plant populations will be clearly identified in the field by staking, flagging, or fencing prior to the commencement of activities that may cause disturbance. A qualified botanist will determine whether direct and/or indirect impacts will occur. If the botanist determines that impacts will not be completely avoided, BIO-13 will be implemented.

Number	BMP Description
BIO-13	<p>If avoidance is not feasible, NPS will implement measures to minimize the impact on the species. Minimization measures will be evaluated on a case-by-case basis for local rarity and extent of impacts. Minimization measures may include transplanting perennial species, seed collection and dispersal for annual species, and other conservation strategies that will protect the viability of the local population. If minimization measures are implemented, monitoring of plant populations will be conducted by a qualified botanist to assess the mitigation's effectiveness. The performance standard for the mitigation will be no net reduction in the size or viability of the local population.</p>
BIO-14 (USFWS)	<p>NPS will prepare a detailed plant protection plan based on specific areas potentially impacted by any proposed actions. NPS will thoroughly review areas of likely impact in advance and identify either any sensitive species or native species that will be protected or invasive species that will be controlled. Based on the potential impact and the species, a plan will be made to either (a) avoid the area if necessary to the presence of a sensitive species; (b) salvage plants if they are salvageable; (c) trim branches/leaves if the plants will easily resprout; (d) cover with plywood or other protective materials, or (e) other types of activities. Salvaged plants will be removed either immediately before impact or possibly up to 1 month in advance. They will be stored in area where there will be an easy water source (i.e.: such as the former nursery area) and replanted either immediately after work is completed in a specific zone or during the typical winter planting period.</p>
BIO-15 (USFWS)	<p>All areas where vegetation is disturbed by project work, including rip rap removal, log installation, bridge replacement, trail re-routes and access, will be restored following project work with native plants propagated in the park nurseries, and the removal of invasive plants.</p>
BIO-16 (USFWS)	<p>A USFWS-approved biological monitor will be present during implementation of the creek restoration work. The biological monitor will ensure that any unanticipated impacts to natural resources are avoided.</p>
BIO-17	<p>SWD will be collected outside of the bird nesting season (February 1 to July 31). SWD will be collected selectively to avoid removing valuable woody debris in other resource areas.</p>
BIO-18 (USFWS)	<p>The following measures will be implemented to minimize potential adverse effects to CRLF:</p> <ul style="list-style-type: none"> <li>▪ A reconnaissance-level survey for CRLF shall be conducted by a qualified biologist within 48 hours prior to starting work in areas where frogs would be seen if present that provide potentially suitable habitat. In areas where vegetation clearing is needed, surveys will be conducted.</li> <li>▪ If no CRLF are found within the work area during the survey, then the work may proceed. If CRLF are observed, NPS will re-initiate consultation with USFWS to determine appropriate avoidance and minimization measures. Any sightings and/or injuries of CRLF will be reported to USFWS within 24 hours.</li> </ul>

Number	BMP Description
	<ul style="list-style-type: none"> <li>▪ Pipes, conduits, and other materials that could provide shelter for CRLF will be stored above ground level to reduce the potential for animals to climb into the conduits and other materials. Pipes or conduits may be left on ground level if capped at both ends.</li> <li>▪ If a CRLF is observed near the project area during construction activities, all work must stop and the CRLF be allowed to leave the work area on its own volition. NPS will notify USFWS immediately about the finding of any CRLF near the work area, and NPS will reinstate consultation with the USFWS. Work will not resume until USFWS and the USFWS-approved biologist for the proposed project have determined that no CRLF will be harassed, injured, or killed by the proposed project.</li> <li>▪ To prevent inadvertent entrapment of CRLF during construction, steep-walled holes or trenches more than 2 feet deep will be covered at the close of each working day by plywood or similar materials. If this is infeasible, one or more escape ramps will be installed. Before such holes or trenches are filled, they will be thoroughly inspected for trapped animals.</li> <li>▪ Any erosion control materials used shall not entrap animals. Jute mesh, loose, open weave textile fiber netting, burlap or non-banded materials (e.g., rice straw) shall be used for erosion control or other purposes. Tightly woven fabric such as jute should have mesh size &lt;1 cm while loosely woven materials should be &gt; 6 cm to avoid entrapment. No plastic mono-filament matting shall be used for erosion control.</li> <li>▪ To the maximum extent practicable, no construction activities will occur during rain events or within 24-hours following a rain event. Prior to construction activities resuming, a USFWS-approved biologist will inspect the project area and all equipment/materials for the presence of CRLF. The animals will be allowed to move away from the project site of their own volition or be moved by the USFWS-approved biologist.</li> <li>▪ The USFWS-approved biologist(s) will permanently remove any aquatic exotic wildlife species, such as bullfrogs and crayfish from the project site, to the maximum extent possible.</li> </ul>
<p>BMP = best management practice                      CCC = Civilian Conservation Corps                      CRLF = California red-legged frog                      CFR = Code of Federal Regulations                      ESA = Endangered Species Act                      GGNRA = Golden Gate National Recreation Area                      LWD = large woody debris                      MWNM = Muir Woods National Monument</p>	

Number	BMP Description
NMFS = National Marine Fisheries Service	
NPS = National Park Services	
NOAA = National Oceanic and Atmospheric Administration	
SWD = small woody debris	
SWPPP = stormwater pollution prevention plan	
USACE = U.S. Army Corps of Engineers	
USFWS = U.S. Fish and Wildlife Service	

### References:

National Marine Fisheries Service. 2008. Anadromous Salmonid Passage Facility Design. Northwest Region. February.

\_\_\_\_\_. 2017. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Salmon Habitat Enhancement and Pedestrian Bridge Replacement Project at Muir Woods National Monument, Marin County, California. NMFS No.: WCR-2017-7851. September 20, 2017.

