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8.7 GEOMORPHOLOGY ENVIRONMENTAL EFFECTS

This section describes potential impacts to channel geomorphology (sediment supply, channel geometry/sediment conditions, and large woody debris) and shoreline erosion (reservoirs and diversion pools) under the Proposed Action for the Middle Fork American River Project (MFP or Project). Section 4.0 – Proposed Action (including Tables 4-4, 4-5, and 4-6) provides a description of routine operation and maintenance activities to be implemented under the Proposed Action compared to the No-Action Alternative. Appendix A – Modified or New Facilities Construction Activities and Concept Designs includes a detailed description of facility modification and construction activities, as well as avoidance and protection (AP) measures to enhance the protection of channel conditions and reservoir shoreline conditions.

Potential impacts to geomorphology have been identified based on changes in Project operations, changes in routine Project maintenance activities, and modification of existing or construction of new Project facilities. Specifically, potential impacts on channel geomorphology include the accumulation of fine sediments in gravels and pools, and channel aggradation. Potential impacts also include shoreline erosion in diversion pools and reservoirs. Impacts to geomorphology are evaluated as follows:

- Potential impacts on channel geomorphology in the bypass and peaking reaches from changes in Project operations affecting:
    - Sediment supply;
    - Channel geometry and sediment conditions; and
    - Large woody debris supply and transport.
- Potential impacts on reservoir and diversion pool shoreline erosion from changes in Project operations affecting:
    - Water surface elevation (WSE) fluctuations.
- Potential impacts from existing facility modifications and construction of new facilities on:
    - Channel geomorphology; and
    - Shoreline erosion.

Potential impacts to geology and soils, including soil erosion from non-routine recreation facility activities and construction projects, local topography, and soil contamination are provided in Section 8.2 – Geology and Soils Environmental Effects.

A description of potential impacts to geomorphology resources resulting from implementation of the Proposed Action, considering AP and enhancement measures along the bypass and peaking reaches and reservoir and diversion pool shorelines, is provided below. A conclusion of impacts to geomorphology under the Proposed Action including any unavoidable adverse effects is presented at the end of this section.

8.7.1 Channel Geomorphology

The Proposed Action specifies modifications to facilities and sediment management activities potentially affecting sediment supply to the small bypass streams downstream of the diversions and the river reaches downstream of the medium dams (Sediment Management Plan [SMP] [PCWA 2011a; Supporting Document (SD) A]). The Proposed Action also specifies new instream flows, including environmental pulse flows that potentially affect channel geometry and sediment conditions in the bypass and peaking reaches (Instream Flow and Reservoir Minimum Pool Measure [IFRM] [PCWA 2011b; SD A]). The Proposed Action may also potentially affect large woody debris supply and transport. The following describes each of these potential MFP effects.

8.7.1.1 Sediment Supply

Under the Proposed Action, the sediment supply in small bypass streams downstream of the diversion dams (Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek diversions) will be affected by small diversion infrastructure modifications (Duncan Creek, North Fork Long Canyon Creek, and South Fork Long Canyon Creek diversions). Sediment supply in the rivers below the medium sized reservoirs (Middle Fork Interbay and Ralston Afterbay) will be affected by sediment augmentation. The Proposed Action restores sediment supply to the reaches downstream of the small diversions and improves sediment supply to the reaches downstream of the medium dams and is an enhancement compared to the No-Action Alternative, as described in further detail below.

Small Diversion Infrastructure Modifications

Installation of self-cleaning wedge-wire screens at the Duncan Creek, South Fork Long Canyon Creek, and North Fork Long Canyon Creek diversion dams under the Proposed Action allows bedload material and fine sediments, including gravel-sized material, to be naturally transported past the diversion facilities during high-flow events. An estimate of the annual amount of material, including gravels, which will be transported downstream of the facilities during high flows is shown in Table 8.7-1. Between 374–622 cubic yards of spawning gravel (8–64 mm) is estimated to be transported per year in the small streams, depending on location. Under the No-Action Alternative, this sediment would be captured and removed from streams. The increase in sediment supply under the Proposed Action will provide long-term channel geomorphology and aquatic and riparian ecosystem benefits to the small bypass streams.

Sediment Augmentation

In the Middle Fork American River downstream of Middle Fork Interbay and Ralston Afterbay dams, a portion of sediment removed during periodic sediment management activities will be placed downstream of the dams in the sediment augmentation areas under the Proposed Action (Table 8.7-1). The sediment will consist primarily of gravels and small cobbles (less than 7 inches) with a limited amount of finer sediments. These sediments will be placed within the high-water channel to allow subsequent high-flow events to transport the material naturally downstream. The two augmentation areas in the Middle Fork American River, downstream of Middle Fork Interbay Dam have an approximate capacity for 10,000–16,000 cubic yards of sediment. The two augmentation areas below Ralston Afterbay Dam (Junction Bar and Indian Bar) have an approximate capacity for 60,000 cubic yards of sediment. Sediments will be placed at the augmentation areas following the first sediment management activities at Middle Fork Interbay and Ralston Afterbay and will be periodically replenished as sediment is transported downstream.

Sediment augmentation areas will be monitored and managed under the Proposed Action to enhance natural transport and to avoid any potential adverse local effects of augmentation on the channel or water quality downstream (PCWA 2011b; SD A). Sediment transport monitoring will be implemented as part of the SMP to characterize the amount of sediment mobilized from the augmentation areas and any potential build-up of coarse boulders or sediments adjacent to the low flow channel. If armoring or aggradation is observed next to the low flow channel, then those sediments will be removed and transported to an approved disposal area (Section 4.0 for description of disposal areas). If a substantial amount of sediment has been mobilized from an augmentation area based on monitoring, then the sediment will be replenished. Re-grading may also be scheduled to facilitate sediment transport during subsequent high-flow events. PCWA will also monitor pool sediment conditions after sediment augmentation activities in the Middle Fork American River below Middle Fork Interbay and Ralston Afterbay as part of the SMP. Turbidity monitoring and AP measures will address any potential effects resulting from implementation of sediment management activities including potential effects to water quality (including, turbidity, erosion, sedimentation, or hazardous materials) and biological resources (including riparian habitats and special-status plants and wildlife species). The potential effects to water quality are described in Section 8.4 – Water Quality Environmental Effects. The potential effects to biological resources are discussed in Section 8.5 – Fish and Aquatic Resources Environmental Effects; Section 8.6 – Botanical and Wildlife Resources Environmental Effects; and Section 8.8 – Riparian Resources Environmental Effects.

Prior to implementation of sediment management activities, PCWA will consult with resource agencies and obtain appropriate permits. This may include a California Department of Fish and Game (CDFG) Streambed Alteration Agreement, United States Army Corps of Engineers (USACE) Section 404 Permit, Regional Water Quality Control Board (RWQCB) 401 Certification, United States Department of Agriculture-Forest Service (USDA-FS) Road Use Permit, USDA-FS Special Use Authorization, etc. In addition, PCWA anticipates that preparation of a project-specific Water Quality Protection Plan (WQPP) will be a condition of the State Water Resources Control Board (State Water Board) 401 Certification. PCWA will develop a WQPP in consultation with the State Water Board prior to commencement of any construction activities.

8.7.1.2 Channel Geometry and Sediment Conditions

In the absence of sediment transporting flows, sediments (including fines) may accumulate in pools and spawning gravels, potentially degrading aquatic and riparian habitat. Under existing conditions (No-Action Alternative), the fine sediment volume in pools was very low (less than 8% and often much less) (Table 8.7-2 and Section 7.7 Geomorphology Affected Environment, Table 7.7-7). Fine sediment in spawning gravels was also very low in all river reaches and was consistent with high successful fish spawning (Section 7.7 Geomorphology Affected Environment, Table 7.7-8).

Sediment accumulation may also cause a change in channel morphology in the absence of high magnitude, infrequent flows that maintain the channel by scouring the banks and channel bed, including emerging vegetation and some established vegetation. Smaller cross-sectional areas and aggradation (berm development) may result if riparian encroachment also occurs. Under existing conditions (No-Action Alternative), the results of the geomorphology and riparian studies indicated that the channel/sediment conditions in the bypass and peaking reaches are being maintained by the current flow regime (AQ 9 – Geomorphology Technical Study Report [TSR] – 2008 [AQ 9 – TSR] [PCWA 2011c; SD B] and AQ 10 – Riparian Resources TSR [AQ 10 – TSR] [PCWA 2011d; SD B]). The bypass and peaking reaches have limited adjustability, and no berm or new bank development was observed.

The Proposed Action includes environmental pulse flows and modifications to facilities (Hell Hole Reservoir Seasonal Storage Increase Improvement, small diversion structure modifications) that could potentially affect the frequency of high magnitude scouring flows and, to a lesser extent, initiation of motion flows (gravels). These potential effects are described below.

Initiation of Motion and Scouring Flows

The Proposed Action specifies (schedules) pulse flows developed to provide for initiation of motion (gravels), in addition to other benefits, (AQ 9 – TSR [PCWA 2011c; SD B]) in wet and above normal water year types in the bypass river reaches (PCWA 2007b; SD A). Pulse flows are anticipated to occur approximately 50% of the time based on the period of record. The exception is the Rubicon River where infrastructure constraints limit the magnitude of flow that can be released.

To analyze the frequency of high magnitude infrequent "scouring" flows, the number of days/years the impaired 5-year recurrence flow[1] occurred under the Proposed Action

[1] The 5-year recurrence interval flow (Q5) was selected to represent a flow that would scour the channel. Based on the results of the relicensing studies (AQ 1 – Instream Flow TSR [PCWA 2011e; SD B]; AQ 9 – TSR [PCWA 2011c; SD B]; and AQ 10 –TSR [PCWA 2011d; SD B]), the Q5 flow for each reach is estimated to be able to mobilize the channel bed (McBain and Trush 1997; Schmidt and Potyondy 2004) and exceed bankfull elevations. The Q5 flow is also within the range of high flows that are typically associated with large-scale cottonwood and willow regeneration in the literature (i.e., Mahoney and Rood 1998).

and the No-Action Alternative were compared (1975–2007). A similar analysis was conducted to evaluate the frequency of initiation of motion under the Proposed Action and No-Action Alternative. In the small bypass streams, both the No-Action Alternative (historical hydrology) and the Existing License Conditions (model runs) were compared to the Proposed Action. This was done because the historical hydrology is not the best representation of how the small diversions would be operated in the future under the No-Action Alternative[2]. Rather, the Existing License Conditions are the best representation of how the No-Action Alternative would be operated in the future. The effects of the Proposed Action on the frequency of scouring flows and initiation of gravel motion are summarized below.

- Middle Fork American River and Rubicon River
    - **Scouring Flows:** The Proposed Action maintains/schedules a similar frequency of scouring flows that have historically occurred in the No-Action Alternative (Table 8.7-3a).
    - **Initiation of Motion:** The Proposed Action maintains/schedules a similar frequency of initiation of motion flows that have historically occurred in the No-Action Alternative (Table 8.7-4a).
- Duncan, North Fork Long Canyon, South Fork Long Canyon, and Long Canyon creeks
    - **Scouring Flows:** The frequency (number of years and total number of days) of scouring flows under the Proposed Action and the Existing License Conditions are similar. Compared to the No-Action Alternative (historical hydrology), scouring flows occur at the same or slightly less frequency (1 less year) compared to the Proposed Action. However, fewer total number of days of scouring flows are provided under the Proposed Action compared to the No-Action Alternative (historical hydrology) (1–6 fewer days over the period of record, depending on the reach) (Table 8.7-3b).
    - **Initiation of Motion:** The total number of days and number of years for initiation of motion flows typically increases substantially (1.7 to 8.9 times more days and 1.3 to 2 times more years, depending on the reach) under the Proposed Action compared to Existing License Conditions (Table 8.7-4b). However, compared to the No-Action Alternative (historical hydrology), the frequency of initiation of gravel motion flows is less (fewer days and years). For example, the number of days of initiation motion in the Proposed Action is

[2] See Section 8.0 Environmental Effects of the Proposed Action for more details regarding the historical hydrology in the small streams. Historic diversions in the small streams were reduced compared to those allowed in the Existing License Conditions due to debris maintenance problems at the intake screens. In the future, debris maintenance would not be an issue under the No-Action Alternative due to the small diversion modifications that would occur.

50–80% of days and 79–94% of years, depending on the reach, in the No-Action Alternative.

Therefore, the frequency of high flows that will scour and initiate gravel motion in the small bypass streams is less under the Proposed Action compared to historical conditions (No-Action Alternative), but the frequency of these flows (number of days and years) under the Proposed Action is much greater than would occur in the future under the No-Action Alternative (Existing License Conditions). The frequency under the Proposed Action is sufficient to maintain the channel geometry and low fine sediment content in pools and spawning gravels equivalent to the historical hydrology (No-Action Alternative) for the following reasons:

- Fine sediment supply is low throughout the system (Section 7.7 Geomorphology Affected Environment); and

- The frequency of "scouring" and initiation of gravel motion flows in the small streams (days and years) under the Proposed Action is similar to that which has been occurring in the larger rivers (Middle Fork American and Rubicon rivers) under historical conditions (No-Action Alternative) (Tables 8.7-3a–b and 8.7-4a-b) and the frequency of flow events has maintained fine sediment at low levels (Table 8.7-2; and Section 7.7 Geomorphology Affected Environment, Tables 7.7-7, and 7.7-8).

In the peaking reach, pulse flows are not specified in the Proposed Action because naturally high flow events from unimpaired river inflows (North Fork of the Middle Fork American River and North Fork American River) and tributaries provide high-flow events (scouring and spring flows). These flows maintain low sediment concentrations in pools and spawning gravels (PCWA 2011c), which will continue to be maintained under the Proposed Action.

The Geomorphology/Riparian Monitoring Plan (GRMP) (PCWA 2011f; SD A) in the Proposed Action includes monitoring of channel and sediment conditions, including channel geometry (channel width, berm development), bank erosion, and fine sediment in pools in the bypass and peaking reaches. A Geomorphology/Riparian Monitoring Report summarizing the data collected each monitoring period will be prepared by PCWA and distributed to the USDA-FS, State Water Board, and CDFG for review and comment. Based on the results of the monitoring and/or comments received during the review process, PCWA and the agencies may call a meeting to discuss the results.

Bank Erosion

Changes in the Proposed Action potentially could affect bank erosion in the bypass and peaking reach streams. Bank erosion along the bypass and peaking reaches is low under existing conditions, and hillslope processes are the primary sources of sediments (Section 7.7 Geomorphology Affected Environment and AQ 9 – TSR [PCWA 2011c; SD B]). This is in part due to the type of channels present in the vicinity of the MFP. The majority of the bypass reaches are confined within narrow, fluvially dissected V-shaped valleys with frequent bedrock and boulder exposures. The valley walls are typically comprised of exposed bedrock near the toe of the hillslope/bankfull channel interface. Although the peaking reach is an alluvial channel, lateral shifts in channel planform appear to occur infrequently, as few were observed in a comparison of historic and recent aerial photography (PCWA 2006). In addition, sediment delivery from bank erosion was considerably less compared to mass wasting sources (i.e., debris slides) (Table 7.7-2).

In the larger bypass and peaking reaches, the Middle Fork American River and Rubicon River, the Proposed Action maintains/schedules a similar frequency of high-flow events (scouring flows and gravel initiation of motion flows) as historically occurred under the No-Action Alternative (Tables 8.7-3a and 8.7-4a). Therefore, bank erosion will remain low under the Proposed Action similar to the No-Action Alternative. In the small bypass streams, the frequency of scouring flows and gravel initiation of motion flows under the Proposed Action is greater than that which will occur under Existing License Conditions, but is less than historical conditions (Tables 8.7-3b and 8.7-4b). As a result, bank erosion will remain low under the Proposed Action similar to the No-Action Alternative.

8.7.1.3 Large Woody Debris Supply and Transport

In the large bypass and peaking reaches, the supply and transport of large woody debris is expected to be maintained under the Proposed Action. Maintenance activities and the frequency of high-flow events will remain the same as under the No-Action Alternative. In the small bypass streams, the infrastructure modifications of the small diversions (described above) will allow woody debris, which is trapped within the diversion pool under the No-Action Alternative, to be transported downstream under the Proposed Action. In addition, as part of the SMP, post construction effectiveness monitoring will be conducted at the small diversions once the diversion modifications have been completed to document the ability of structures to pass large woody debris. Effectiveness monitoring will be accomplished by making visual observations and photo documentation once the impoundment is full of sediment to verify the movement of large woody debris placed downstream of the diversion during contingency sediment activities and large woody debris movement over the wedge-wire screen (i.e., verify that structure is not an impediment to large woody debris movement). A report summarizing the data collected each monitoring period will be prepared by PCWA and distributed to the USDA-FS, State Water Board, and CDFG for review and comment. Based on the results of the monitoring and/or comments received during the review process, PCWA and the agencies may call a meeting to discuss the results.

8.7.2 Reservoir and Diversion Pool Shoreline Erosion

Under the Proposed Action, changes in reservoir WSEs and modification of the small stream diversions have the potential to affect shoreline erosion. The following identifies potential effects of the Proposed Action on shoreline erosion.

8.7.2.1 Large Reservoir Shorelines

French Meadows Reservoir

Under the Proposed Action and No-Action Alternative, normal operating WSEs at French Meadows Reservoir will be very similar (Appendix C2c). The overall potential for shoreline erosion is low because the reservoir is surrounded by rock outcrops with steep slopes, the banks consist primarily of granitic and volcanic rock, and the soils are derived from the weathering of the rock. The shorelines are primarily comprised of large substrates that are highly resistant to any erosion (Section 7.7, Geomorphology Affected Environment).

Hell Hole Reservoir

At Hell Hole Reservoir, changes in operations under the Proposed Action, after construction of the new 6-foot-high crest gates on the existing Hell Hole Dam Spillway, have the potential to increase shoreline erosion caused by wave action between about 4,630 feet mean sea level (msl) (the current maximum normal operating WSE) and 4,636 feet msl. This area will be inundated more frequently compared to the No-Action Alternative. Under the No-Action Alternative, the reservoir WSEs only exceed 4,630 feet msl maximum normal operation elevation during spill events (average 1.5 feet higher, 4,631.5 feet msl during spill events). Water surface elevation traces under the Proposed Action and the No-Action Alternative are shown in Appendix C2c.

The majority of the shoreline around Hell Hole Reservoir is resistant to erosion. It is surrounded by rock outcrops with steep slopes, with very little soil development on steep slopes that border the reservoir shoreline. Large portions of the shoreline are bedrock or boulder-sized materials that are highly resistant to any erosion. Most of the material that would be subject to erosion is decomposed granitic material that is comprised of coarse sands found in small, interspersed pockets along bedrock joints and fractures, or coarse sands intermixed with glacial (in moraines) gravel and cobble deposits on steep slopes (Section 7.7, Geomorphology Affected Environment).

To evaluate the potential affects of changes in WSEs on the amount of sediment susceptible to shoreline erosion, the length of potentially erodible shoreline and the volume of potentially erodible sediment were calculated (refer to AQ – 9 TSR [PCWA 2011c; SD B]). Based on this analysis, about 20% of the 11-mile shoreline is susceptible to potential erosion. Conservatively assuming an average 1-foot depth of erodible materials, the volume of potentially erodible sediments under the Proposed Action is about 2,600 cubic yards, which is a very small amount of sediment volume relative to the entire volume of the reservoir. At full pool, Hell Hole Reservoir has a gross storage capacity of 207,590 acre-feet, which is equivalent to 335,000,000 cubic yards of storage volume. The 2,600 cubic yards of potentially erodible sediments represent 0.0009% of the reservoir storage volume, and therefore, effects of the Proposed Action on the amount of additional sediment due to shoreline erosion will be negligible.

8.7.2.2 Medium Reservoir Shorelines

Normal operating reservoir WSEs will not change at Middle Fork Interbay and Ralston Afterbay under the Proposed Action compared to the No-Action Alternative. Ralston Afterbay and Middle Fork Interbay are surrounded by rock outcrops with steep side slopes, and the shorelines are comprised of large substrates that are highly resistant to erosion. Therefore, there will be no change in shoreline erosion potential under the Proposed Action.

8.7.2.3 Diversion Pool Shorelines

Under the Proposed Action, the small diversion dams will be modified into self-cleaning, stream-bottom intakes and sediment will be transported downstream during high flows. The top (crest) of the sloped wedge-wire screen will be 1.3 to 3.1 feet higher than the existing dam, depending on the facility (Figures DC 4, NF 4, and SF 4 in Section 4.0 – Proposed Action, Appendix A). The existing diversion pools will aggrade with sediment to near the top of the wedge-wire screen, and the resulting diversion pools will be shallower and more riverine. The area footprint of the new diversion pools will remain approximately similar to the existing diversion pools; but the water surface of the new diversion pools will be 1.3 to 3.1 feet higher; and therefore, effects to shoreline erosion will be negligible.

8.7.3 Existing Facility Modifications and Construction of New Facilities

Implementation of the Hell Hole Reservoir Seasonal Storage Increase Improvement, small diversion modifications, and outlet works modifications could potentially affect channel geomorphology and reservoir shorelines. However, construction associated with these projects will not affect stream channel geomorphology or reservoir shorelines, except for the Hell Hole Dam Outlet Works. This project includes re-contouring the Rubicon River downstream of the outlet works (approximately 650 feet) so that environmental pulse flows can be released without damaging the road or powerhouse (PCWA 2011a; SD A). The channel will be deepened and widened to accommodate flows up to approximately 600 cubic feet per second. Measures to protect soils and to address potential erosion during construction activities are described in Section 8.2, Geology and Soils Environmental Effects. The changes in channel geometry are very localized, will not adversely affect the downstream reaches of the Rubicon River, and will allow for the release of flows that will have long-term benefits to the aquatic and riparian ecosystems in the Rubicon River.

8.7.4 Conclusion—Geomorphology

The Proposed Action specifies modifications to MFP operations and maintenance, and includes implementation of construction activities that could affect geomorphology resources. These changes under the Proposed Action will maintain/enhance geomorphic conditions by:

- Restoring more natural sediment supply and transport in the bypass reaches;

- Preserving or restoring high magnitude flows (scouring flows and initiation of motion flows) in the bypass and peaking reaches;
- Providing frequency of scouring and initiation of motion flows in the small bypass streams sufficient to maintain channel geometry and low fine sediment concentrations (Section 8.7.1.2);
- Maintaining stream bank and reservoir/ diversion pool shoreline erosion at very low levels; and
- Conducting periodic monitoring of resource condition and agency consultation over the term of the license to:
    - Document channel geometry (channel width, berm development), bank erosion, and fine sediment in pools in the bypass and peaking reaches (PCWA 2011f; SD A) and
    - Document sediment transport at augmentation areas and pool sediment conditions after sediment augmentation activities.

8.7.5 Unavoidable Adverse Effects

There are no unavoidable adverse effects to channel geomorphology or stream bank or reservoir/diversion pool shoreline erosion under the Proposed Action.

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TABLES

8.7-1. Summary of Historic Sediment Removal Activities at MFP Diversion Pools and Medium Reservoirs (through 2009)[1].

Year	Month[2]	Loose, Uncompacted Volume of Sediment Removed (cubic yds)
Duncan Creek Diversion Pool (period of record 1997-2009)		
1988	-	Sediment removal occurred in this year, however, no information on the volume of sediment removed is available
1998	Aug	4,500
2007	Sept	1,570
Total		**6,070**
Frequency of Sediment Removal Activities: 3 times between 1988-2009 (22 years)		**once every 7.3 years**
Volume Removed per Maintenance Activity[2]		**3,035 cubic yards**
Average Annual Volume Removed		**416 cubic yards/year**
Average Annual Spawning Gravel Volume Removed		**148 cubic yards/year**
North Fork Long Canyon Creek Diversion Pool (period of record 1980-2009)		
1980	-	Sediment removal occurred in these years, however, no information on the volume of sediment removed is available
1982	-	
1986	-	
1988	-	
1990	-	
1992	-	
1995	-	
1997	-	1,600
2004	Sept	400
2006	Sept	1,370
Total		**3,370**
Frequency of Sediment Removal Activities: 10 times between 1980-2009 (30 years)		**once every 3 years**
Average Volume Removed per Maintenance Activity[2]		**1,123 cubic yards**
Average Annual Volume Removed		**374 cubic yards/year**
Average Annual Spawning Gravel Volume Removed		**75 cubic yards/year**
South Fork Long Canyon Creek Diversion Pool (period of record 1980-2009)		
1980	-	Sediment removal occurred in these years, however, no information on the volume of sediment removed is available
1982	-	
1986	-	
1988	-	
1995	-	
1997	-	2,500
2006	Sept	2,850
Total		**5,350**
Frequency of Sediment Removal Activities: 7 times between 1980-2009 (30 years)		**once every 4.3 years**
Average Volume Removed per Maintenance Activity[2]		**2,675 cubic yards**
Average Annual Volume Removed		**622 cubic yards/year**
Average Annual Spawning Gravel Volume Removed		**386 cubic yards/year**
Middle Fork Interbay (period of record 1987-2009)		
1987	Oct	25,000
1988	Oct	35,000
1997	Feb	16,000
2000	Oct	68,000
Total		**144,000**
Frequency of Sediment Removal Activities: 4 times between 1987-2009 (23 years)		**once every 5.8 years**
Average Volume Removed per Maintenance Activity[2]		**36,000 cubic yards**
Average Annual Volume Removed		**6,207 cubic yards/year**
Average Annual Spawning Gravel Volume Removed		**1,303 cubic yards/year**

Table 8.7-1. Summary of Historic Sediment Removal Activities at MFP Diversion Pools and Medium Reservoirs (through 2009) (continued).[1]

Year	Month[2]	Loose, Uncompacted Volume of Sediment Removed (cubic yds)
Ralston Afterbay (period of record 1969-2009)		
1969	-	Sediment removal occurred in this year, however, no information on the volume of sediment removed is available
1981	Oct	10,000
1984	Oct	13,000
1985	Oct	12,000
1986	Mar	45,000
1986	Oct	80,000
1989	Oct	35,000
1994	Sept	77,000
1997	Feb	65,000
2002	Oct	101,000[3]
Total		**438,000**
Frequency of Sediment Removal Activities: 10 times between 1969-2009 (41 years)		**once every 4.6 years**
Average Volume Removed per Maintenance Activity[2]		**48,667 cubic yards**
Average Annual Volume Removed		**10,580 cubic yards/year**
Average Annual Spawning Gravel Volume Removed		**2,645 cubic yards/year**

[1]Source: AQ 9 – Geomorphology TSR (PCWA 2011c; SD B).

[2]Includes only the years with known sediment volumes.

[3]Volume equals 45,000 cubic yards compacted, in-place sediment at Indian Bar; and 29,000 cubic yards compacted, in-place sediment at Ralston Ridge.

Table 8.7-2. Summary Results from V* Studies Conducted in 2006 and 2007.

Stream	Calculated V* 2006				Calculated V* 2007			
	Minimum	Maximum	Weighted 2006 V*	Number of Pools	Minimum	Maximum	Weighted 2007 V*	Number of Pools
Duncan Creek								
Duncan Creek					0.000	0.005	0.0002	10
Middle Fork American River (MFAR)								
French Meadows Reservoir to Middle Fork Interbay	0.020	0.030	0.027	2	0.000	0.071	0.003	15
Middle Fork Interbay to Ralston Afterbay	0.003	0.070	0.025	6	0.000	<0.001	0.000	3
Below Ralston Afterbay					0.0003	0.071	0.002	8
Rubicon River								
Hell Hole Reservoir to South Fork Rubicon River					0.000	0.023	0.005	9
South Fork Rubicon River to Ralston Afterbay					0.000	0.081	0.019	17
Rubicon at Ralston Afterbay	NA	NA	0.030	1				
Long Canyon Creek								
North Fork Long Canyon Creek (NFLC)					0.000	0.025	0.004	10
South Fork Long Canyon Creek (SFLC)					0.000	0.007	0.002	10
Long Canyon Creek (LCC)					0.000	<0.001	0.000	9
Comparison Stream								
North Fork American River (NFAR)					0.000	0.020	0.010	5
North Fork of the Middle Fork American River (NFMF)	0.030	0.070	0.046	3				

Note that two different V* studies were performed: a quantitative V* assessment performed in 2006 immediately following the Ralston Ridge Fire, but prior to the runoff period; and, a visual V* estimation assessment performed in 2007. The quantitative V* analysis of fine sediment was conducted in 12 pools along the Middle Fork American and Rubicon rivers above Ralston Afterbay in the fall of 2006 using the methodology developed by the USDA-FS (Lisle and Hilton 1991, 1992; Hilton and Lisle 1993). Therefore, a calculated V* is available using either 2006 or 2007 data for most streams. In two sections of the MFAR, the calculated V* is available for both years.

Table 8.7-3a. Total Number of Days that Scouring Flows Occur under the Proposed Action and No-Action Alternative in Large Bypass Streams.[1]

Site/Release Location	Flow (cfs)	Water Year Type	Proposed Action				No-Action Alternative[2]			
			Total # of Days	Average # of Days[3]	Scour Year Average # of Days[4]	Number of Years[5]	Total # of Days	Average # of Days[3]	Event Year Average # of Days[4]	Number of Years[5]
Large Bypass Streams										
Middle Fork American River below French Meadows Dam										
MF44.7	632	Wet	32	3	5	6 / 10	22	2	4	6 / 10
		Abv Normal	6	1	6	1 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**38**	**---**	**---**	**7 / 33**	**22**	**---**	**---**	**6 / 33**
MF36.2	1,758	Wet	14	1	3	5 / 10	21	2	4	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**14**	**---**	**---**	**5 / 33**	**21**	**---**	**---**	**6 / 33**
Middle Fork American River below Middle Fork Interbay Dam										
MF26.2	2,970	Wet	17	2	3	6 / 10	18	2	3	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**17**	**---**	**---**	**6 / 33**	**18**	**---**	**---**	**6 / 33**

Table 8.7-3a. Total Number of Days that Scouring Flows Occur under the Proposed Action and No-Action Alternative in Large Bypass Streams (continued).[1]

Site/Release Location	Flow (cfs)	Water Year Type	Proposed Action				No-Action Alternative[2]			
			Total # of Days	Average # of Days[3]	Scour Year Average # of Days[4]	Number of Years[5]	Total # of Days	Average # of Days[3]	Event Year Average # of Days[4]	Number of Years[5]
Large Bypass Streams (continued)										
Rubicon River below Hell Hole Dam										
R25.7	1,922	Wet	14	1	3	5 / 10	13	1	3	5 / 10
		Abv Normal	1	0	1	1 / 6	1	0	1	1 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**15**	**---**	**---**	**6 / 33**	**14**	**---**	**---**	**6 / 33**
R20.9	4,479	Wet	19	2	3	7 / 10	16	2	3	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**19**	**---**	**---**	**7 / 33**	**16**	**---**	**---**	**6 / 33**
R3.5	11,341	Wet	15	2	3	6 / 10	15	2	3	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**15**	**---**	**---**	**6 / 33**	**15**	**---**	**---**	**6 / 33**

Table 8.7-3a. Total Number of Days that Scouring Flows Occur under the Proposed Action and No-Action Alternative in Large Bypass Streams (continued).[1]

Site/Release Location	Flow (cfs)	Water Year Type	Proposed Action				No-Action Alternative[2]			
			Total # of Days	Average # of Days[3]	Scour Year Average # of Days[4]	Number of Years[5]	Total # of Days	Average # of Days[3]	Event Year Average # of Days[4]	Number of Years[5]
Large Bypass Streams (continued)										
Middle Fork American River below Ralston Afterbay										
MF14.1	19,789	Wet	18	2	3	7 / 10	19	2	3	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**18**	**---**	**---**	**7 / 33**	**19**	**---**	**---**	**6 / 33**
MF4.8	20,241	Wet	18	2	3	7 / 10	19	2	3	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**18**	**---**	**---**	**7 / 33**	**19**	**---**	**---**	**6 / 33**

[1]For this analysis, a 'scouring flow' was a flow that exceeded the impaired Q5 (5-year recurrence interval) flow.

[2]No-Action Alternative = Historical hydrology (1975–2007).

[3]Total number of scour days / number of years in water year type.

[4]Total number of scour days / number of years with scour events in water year type.

[5]Number of years with scour events / total number of years in water year type.

Table 8.7-3b. Total Number of Days that Scouring Flows Occur under the Proposed Action, No-Action Alternative, and Existing License Conditions in Small Bypass Streams.[1]

Site/Release Location	Flow (cfs)	Water Year Type	Proposed Action				No-Action Alternative[2]				Existing License Conditions[3]			
			Total # of Days	Average # of Days[4]	Scour Year Average # of Days[5]	Number of Years[6]	Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]	Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]
Small Bypass Streams														
Duncan Creek	774	Wet	9	1	2	5 / 10	14	1	3	5 / 10	9	1	2	5 / 10
		Abv Normal	0	0	0	0 / 6	1	0	1	1 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**9**	**---**	**---**	**5 / 33**	**15**	**---**	**---**	**6 / 33**	**9**	**---**	**---**	**5 / 33**
North Fork Long Canyon Creek	225	Wet	12	1	2	5 / 10	16	2	3	6 / 10	11	1	2	5 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**12**	**---**	**---**	**5 / 33**	**16**	**---**	**---**	**6 / 33**	**11**	**---**	**---**	**5 / 33**
South Fork Long Canyon Creek	396	Wet	10	1	2	5 / 10	16	2	3	6 / 10	9	1	2	5 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**10**	**---**	**---**	**5 / 33**	**16**	**---**	**---**	**6 / 33**	**9**	**---**	**---**	**5 / 33**
Long Canyon Creek	1,144	Wet	14	1	2	6 / 10	15	2	3	6 / 10	14	1	2	6 / 10
		Abv Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**14**	**---**	**---**	**6 / 33**	**15**	**---**	**---**	**6 / 33**	**14**	**---**	**---**	**6 / 33**

[1]For this analysis, a 'scouring flow' was a flow that exceeded the impaired Q5 (5-year recurrence interval) flow.

[2]No-Action Alternative = Historical hydrology (1975-2007).

[3]Existing License Conditions = Operations model run using existing FERC license conditions and current demand.

[4]Total number of scour days / number of years in water year type.

[5]Total number of scour days / number of years with scour events in water year type.

[6]Number of years with scour events / total number of years in water year type.

Table 8.7-4a. Average Number of Days Initiation of Motion (gravels) that Occur by Water Year Type under the Proposed Action and No-Action Alternative in Large Bypass Streams.[1]

Site/ Release Location	Gravel Initiation of Motion (cfs)[2]	Water Year Type	Proposed Action				No-Action Alternative[3]			
			Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]	Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]
Large Bypass Streams										
Middle Fork American River below French Meadows Dam										
MF44.7	343	Wet	151	15	15	10 / 10	107	11	13	8 / 10
		Abv Normal	31	5	5	6 / 6	24	4	12	2 / 6
		Blw Normal	7	1	4	2 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**189**	**---**	**---**	**18 / 33**	**131**	**---**	**---**	**10 / 33**
MF36.2	702	Wet	117	12	12	10 / 10	179	18	18	10 / 10
		Abv Normal	23	4	5	5 / 6	9	2	2	4 / 6
		Blw Normal	1	0	1	1 / 6	2	0	2	1 / 6
		Dry	0	0	0	0 / 5	2	0	1	2 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**141**	**---**	**---**	**16 / 33**	**192**	**---**	**---**	**17 / 33**
Middle Fork American River below Middle Fork Interbay Dam										
MF26.2	532	Wet	466	47	47	10 / 10	493	49	49	10 / 10
		Abv Normal	47	8	8	6 / 6	15	3	3	6 / 6
		Blw Normal	4	1	2	2 / 6	0	0	0	0 / 6
		Dry	1	0	1	1 / 5	4	1	2	2 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**518**	**---**	**---**	**19 / 33**	**512**	**---**	**---**	**18 / 33**

Table 8.7-4a. Average Number of Days Initiation of Motion (gravels) that Occur by Water Year Type under the Proposed Action and No-Action Alternative in Large Bypass Streams (continued).[1]

Site/ Release Location	Gravel Initiation of Motion (cfs)[2]	Water Year Type	Proposed Action				No-Action Alternative[3]			
			Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]	Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]
Large Bypass Streams (continued)										
Rubicon River below Hell Hole Dam										
R25.7	500	Wet	176	18	18	10 / 10	192	19	21	9 / 10
		Abv Normal	17	3	17	1 / 6	14	2	14	1 / 6
		Blw Normal	0	0	0	0 / 6	2	0	2	1 / 6
		Dry	0	0	0	0 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**193**	**---**	**---**	**11 / 33**	**208**	**---**	**---**	**11 / 33**
R20.9	678	Wet	255	26	26	10 / 10	281	28	28	10 / 10
		Abv Normal	27	5	5	5 / 6	22	4	4	5 / 6
		Blw Normal	1	0	1	1 / 6	1	0	1	1 / 6
		Dry	1	0	1	1 / 5	1	0	1	1 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**284**	**---**	**---**	**17 / 33**	**305**	**---**	**---**	**17 / 33**
R3.5	2,198	Wet	183	18	18	10 / 10	201	20	20	10 / 10
		Abv Normal	22	4	4	6 / 6	22	4	4	6 / 6
		Blw Normal	1	0	1	1 / 6	1	0	1	1 / 6
		Dry	1	0	1	1 / 5	1	0	1	1 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**207**	**---**	**---**	**18 / 33**	**225**	**---**	**---**	**18 / 33**

Table 8.7-4a. Average Number of Days Initiation of Motion (gravels) that Occur by Water Year Type under the Proposed Action and No-Action Alternative in Large Bypass Streams (continued).[1]

Site/ Release Location	Gravel Initiation of Motion (cfs)[2]	Water Year Type	Proposed Action				No-Action Alternative[3]			
			Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]	Total # of Days	Average # of Days[4]	Event Year Average # of Days[5]	Number of Years[6]
Large Bypass Streams (continued)										
Middle Fork American River below Ralston Afterbay										
MF14.1	6,674	Wet	125	13	13	10 / 10	110	11	11	10 / 10
		Abv Normal	11	2	2	6 / 6	9	2	2	6 / 6
		Blw Normal	1	0	1	1 / 6	1	0	1	1 / 6
		Dry	1	0	1	1 / 5	1	0	1	1 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**138**	**---**	**---**	**18 / 33**	**121**	**---**	**---**	**18 / 33**
MF4.8	6,797	Wet	126	13	13	10 / 10	110	11	11	10 / 10
		Abv Normal	11	2	2	6 / 6	9	2	2	6 / 6
		Blw Normal	1	0	1	1 / 6	1	0	1	1 / 6
		Dry	1	0	1	1 / 5	1	0	1	1 / 5
		Total	0	0	0	0 / 6	0	0	0	0 / 6
		Critical	**139**	**---**	**---**	**18 / 33**	**121**	**---**	**---**	**18 / 33**

[1]See AQ 1- TSR, Table G-1 (PCWA 2011e).

[2] Flow required to initiate motion of 25% of the gravel substrate.

[3]No-Action Alternative = Historical hydrology (1975–2007).

[4]Total number of event days / number of years in water year type.

[5]Total number of event days / number of years with events in water year type.

[6]Number of years with events / total number of years in water year type.

Table 8.7-4b. Average Number of Days Initiation of Motion (gravels) Occurs by Water Year Type under the Proposed Action, No-Action Alternative, and Existing License Conditions in Small Bypass Streams.[1]

Site/ Release Location	Gravel Initiation of Motion (cfs)[2]	Water Year Type	Proposed Action				No-Action Alternative[3]				Existing License Conditions[4]			
			Total # of Days	Average # of Days[5]	Event Year Average # of Days[6]	Number of Years[7]	Total # of Days	Average # of Days[5]	Event Year Average # of Days[6]	Number of Years[7]	Total # of Days	Average # of Days[5]	Event Year Average # of Days[6]	Number of Years[7]
Small Bypass Streams														
Duncan Creek	149	Wet	97	10	10	10 / 10	128	13	13	10 / 10	35	4	4	10 / 10
		Abv Normal	24	4	5	5 / 6	14	2	4	4 / 6	3	1	3	1 / 6
		Blw Normal	1	0	1	1 / 6	3	1	2	2 / 6	1	0	1	1 / 6
		Dry	1	0	1	1 / 5	1	0	1	2 / 5	1	0	1	1 / 5
		Critical	0	0	0	0 / 6	0	0	0	1 / 6	0	0	0	0 / 6
		Total	**123**	**---**	**---**	**17 / 33**	**146**	**---**	**---**	**19 / 33**	**40**	**---**	**---**	**13 / 33**
North Fork Long Canyon Creek	29	Wet	172	17	19	9 / 10	401	40	45	9 / 10	47	5	6	8 / 10
		Abv Normal	25	4	4	6 / 6	5	1	2	3 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	6	1	2	4 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	3	1	2	2 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	1	0	1	1 / 6	0	0	0	0 / 6
		Total	**197**	**---**	**---**	**15 / 33**	**416**	**---**	**---**	**19 / 33**	**47**	**---**	**---**	**8 / 33**
South Fork Long Canyon Creek	40	Wet	301	30	30	10 / 10	490	49	54	9 / 10	44	4	6	8 / 10
		Abv Normal	91	15	15	6 / 6	13	2	7	2 / 6	0	0	0	0 / 6
		Blw Normal	0	0	0	0 / 6	7	1	2	4 / 6	0	0	0	0 / 6
		Dry	0	0	0	0 / 5	2	0	2	1 / 5	0	0	0	0 / 5
		Critical	0	0	0	0 / 6	1	0	1	1 / 6	0	0	0	0 / 6
		Total	**392**	**---**	**---**	**16 / 33**	**513**	**---**	**---**	**17 / 33**	**44**	**---**	**---**	**8 / 33**
Long Canyon Creek	197	Wet	164	16	16	10 / 10	278	28	28	10 / 10	92	9	9	10 / 10
		Abv Normal	21	4	5	4 / 6	20	3	4	5 / 6	18	3	4	5 / 6
		Blw Normal	4	1	4	1 / 6	4	1	4	1 / 6	4	1	4	1 / 6
		Dry	1	0	1	1 / 5	2	0	1	2 / 5	1	0	1	2 / 5
		Critical	0	0	0	0 / 6	0	0	0	0 / 6	0	0	0	0 / 6
		Total	**190**	**---**	**---**	**16 / 33**	**304**	**---**	**---**	**18 / 33**	**115**	**---**	**---**	**18 / 33**

[1]See AQ 1- TSR, Table G-1 (PCWA 2011e).

[2] Flow required to initiate motion of 25% of the gravel substrate.

[3]No-Action Alternative = Historical hydrology (1975 –2007).

[4]Existing License Conditions = Operations model run using existing FERC license conditions and current demand.

[5]Total number of event days / number of years in water year type.

[6]Total number of event days / number of years with events in water year type.

[7]Number of years with events / total number of years in water year type.