UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Klamath River Renewal Corporation	**Project Nos. 14803-001;**
PacifiCorp	**2082-063**

<u>AMENDED APPLICATION FOR SURRENDER OF LICENSE FOR MAJOR PROJECT AND REMOVAL OF PROJECT WORKS</u>

Attachment A-4

Lower Klamath Project Biological Assessment

Appendix C
(Reservoir Area Management Plan)

Biological Assessment

Appendix C – Reservoir Area Management Plan

KLAMATH RIVER RENEWAL CORPORATION

March 2021

Lower Klamath Project
FERC Project No. 14803

Reservoir Area Management Plan

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1.0 Introduction

The Lower Klamath River Project (Lower Klamath Project) (FERC No. 14803) consists of four hydroelectric developments on the Klamath River: J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate (Figure 1-1). Specifically, the reach between J.C. Boyle dam and Iron Gate dam is known as the Hydroelectric Reach. In September of 2016, the Renewal Corporation filed an *Application for Surrender of License for Major Project and Removal of Project Works,* FERC Project Nos. 2082-063 & 14803-001 (License Surrender). The Renewal Corporation filed the License Surrender application as the dam removal entity for the purpose of implementing the Klamath River Hydroelectric Settlement (KHSA). In November of 2020, the Renewal Corporation filed its Definite Decommissioning Plan (DDP) as Exhibits A-1 and A-2 to its amended License Surrender application. The DDP is the Renewal Corporation's comprehensive plan to physically remove the Lower Klamath Project and achieve a free-flowing condition and volitional fish passage, site remediation and restoration, and avoidance of adverse downstream impacts (Proposed Action). The Limits of Work is a geographic area that encompasses dam removal related activities in the Proposed Action and may or may not expand beyond the FERC boundary associated with the Lower Klamath Project.

The Proposed Action includes the deconstruction of the J.C. Boyle Dam and Powerhouse (Figure 1-2), Copco No. 1 Dam and Powerhouse (Figure 1-3), Copco No. 2 Dam and Powerhouse (Figure 1-4), and Iron Gate Dam and Powerhouse (Figure 1-5), as well as associated features. Associated features vary by development, but generally include powerhouse intake structures, embankments, and sidewalls, penstocks and supports, decks, piers, gatehouses, fish ladders and holding facilities, pipes and pipe cradles, spillway gates and structures, diversion control structures, aprons, sills, tailrace channels, footbridges, powerhouse equipment, distribution lines, transmission lines, switchyards, original cofferdam, portions of the Iron Gate Fish Hatchery, residential facilities, and warehouses. Facility removal will be completed within an approximately 20-month period.

This Reservoir Area Management Plan identifies the management measures for the restoration, monitoring, and adaptive management of the lands underlying the Lower Klamath Project reservoirs and surrounding areas, that the Renewal Corporation will implement as part of the Proposed Action. The Renewal Corporation has prepared 16 Management Plans for FERC's review and approval as conditions of a license surrender order. These Management Plans were developed in consultation with federal, state and county governments and tribes.

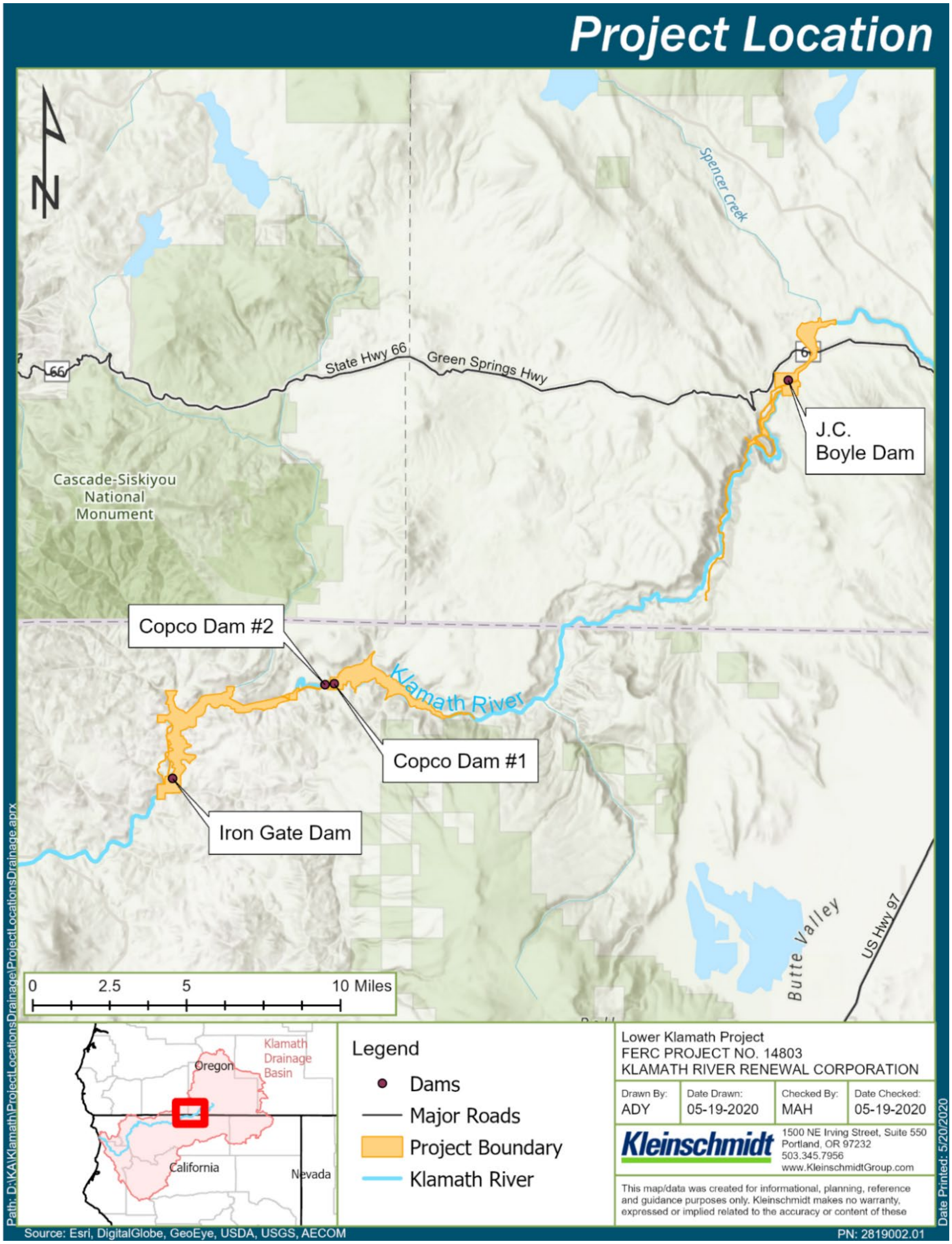


Figure 1-1. Lower Klamath Project Location

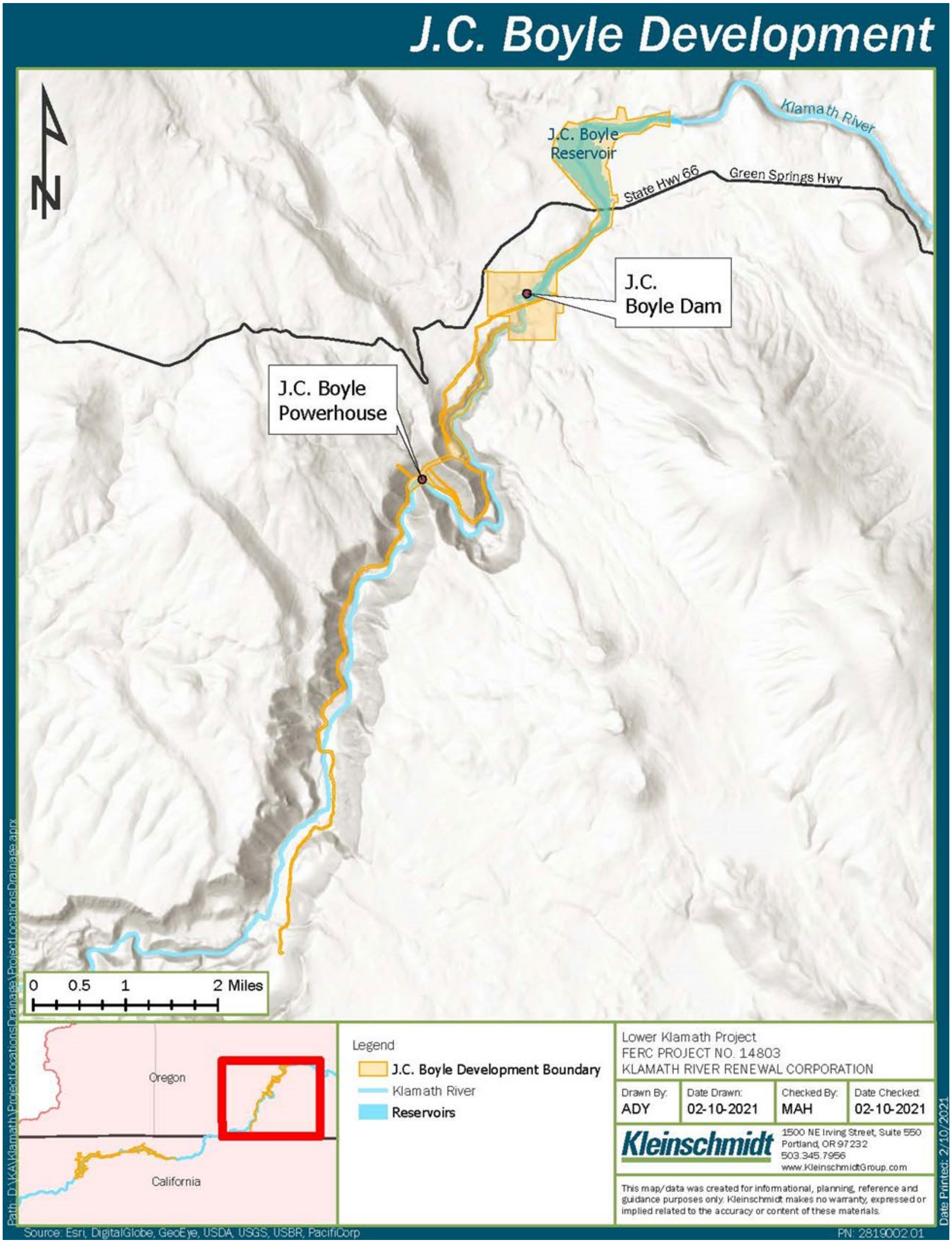


Figure 1-2. J.C. Boyle Development Area

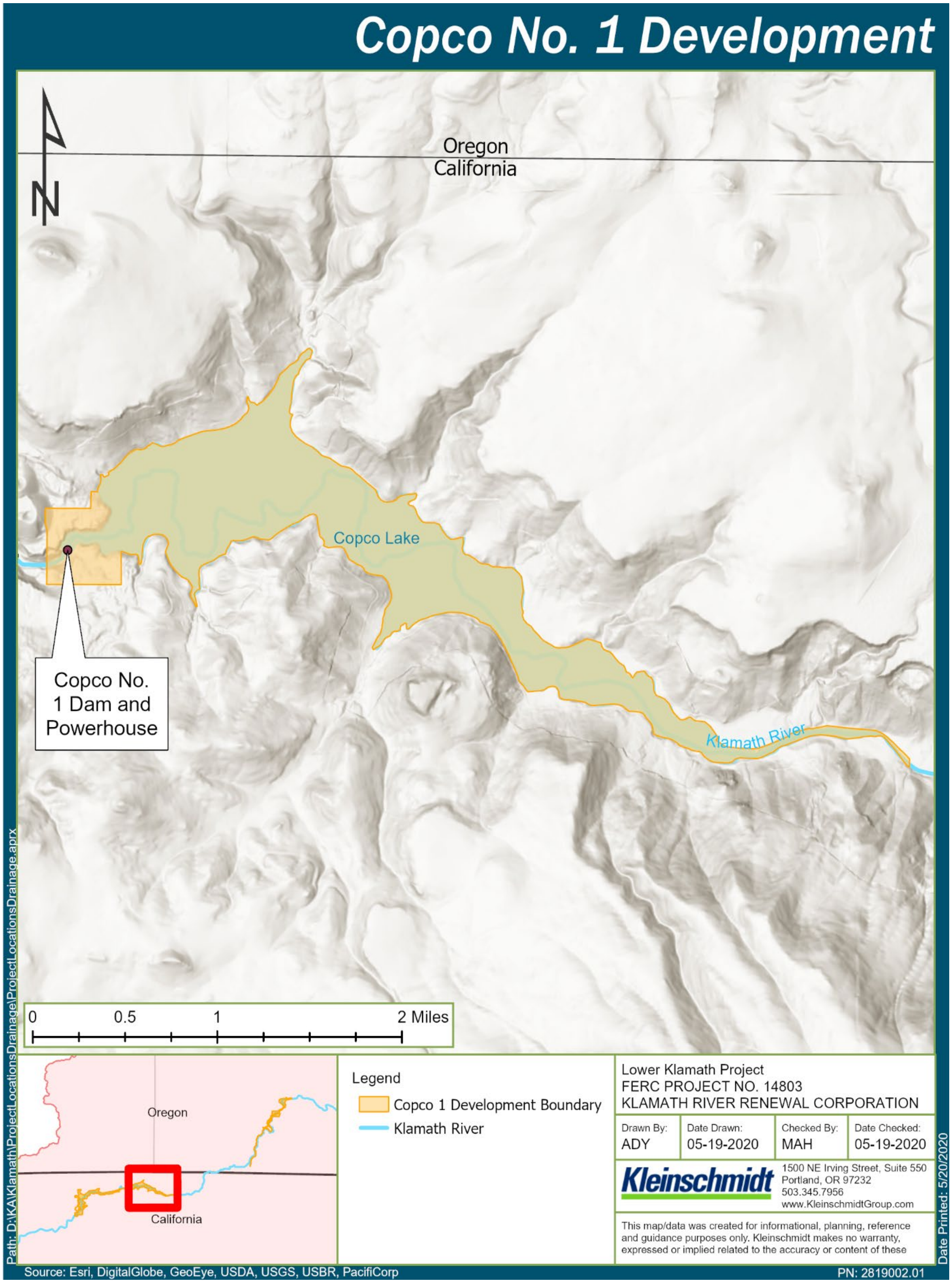


Figure 1-3. Copco No.1 Development Area

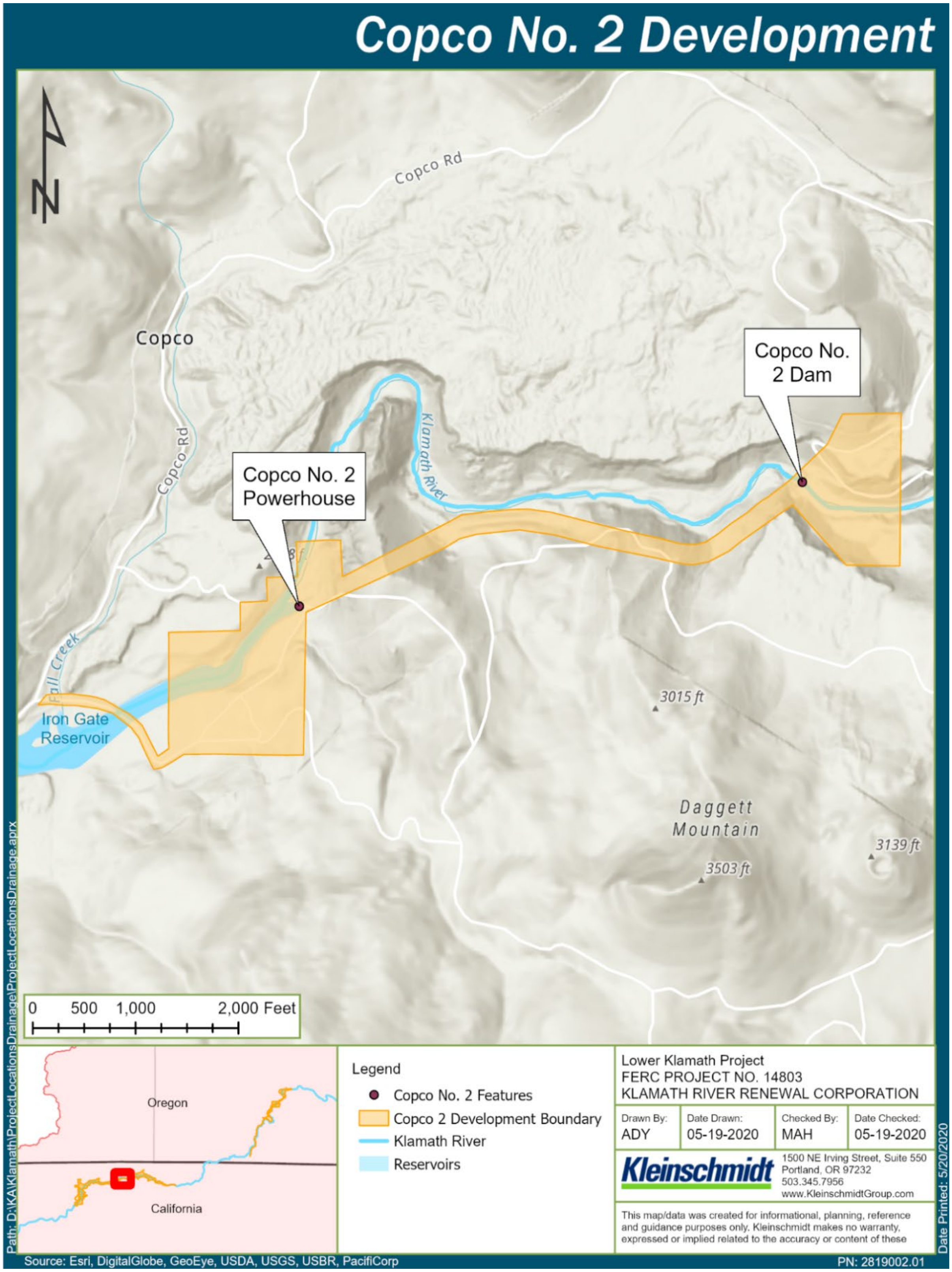


Figure 1-4. Copco No.2 Development Area

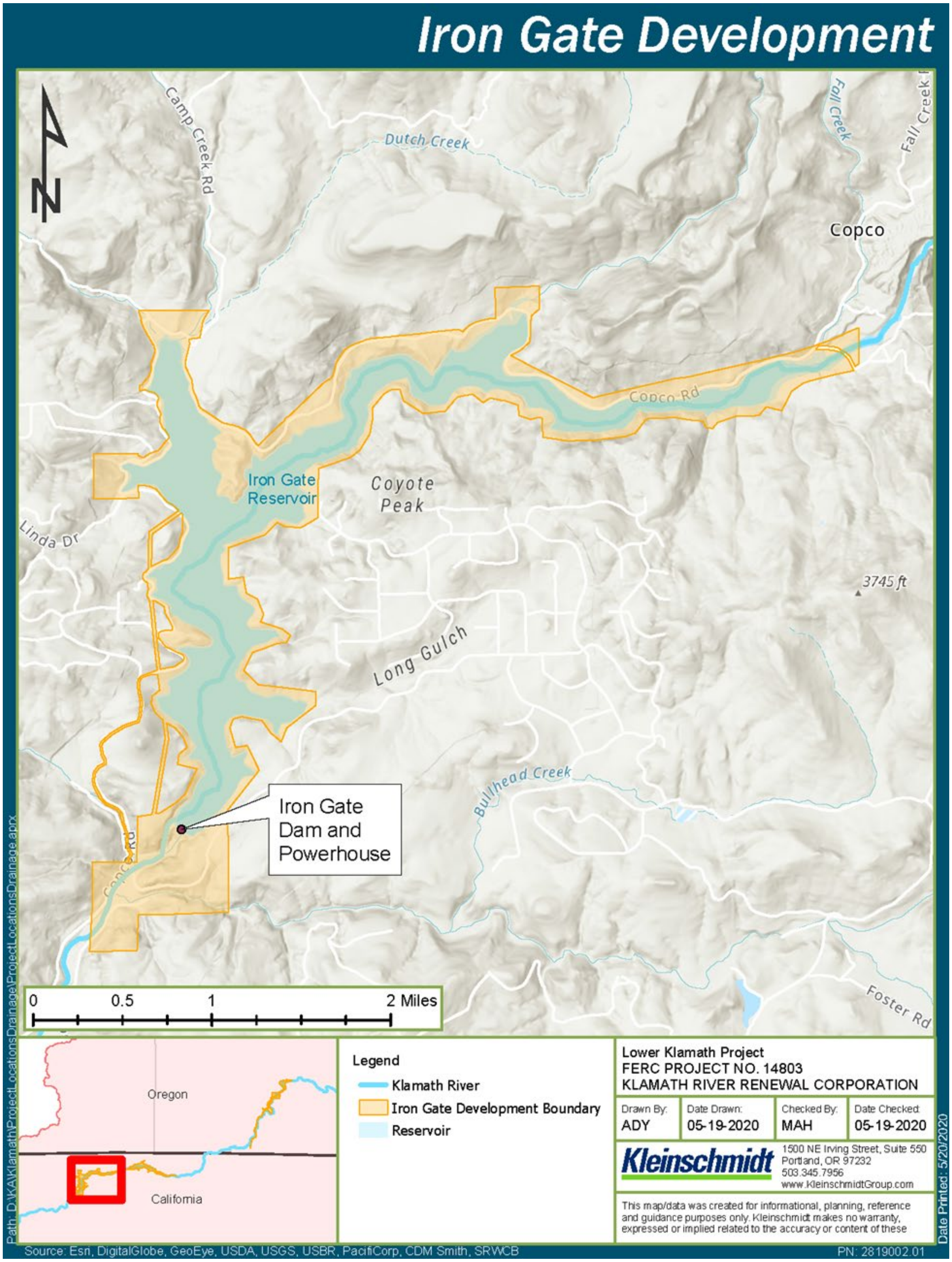


Figure 1-5. Iron Gate Development Area

1.1 Purpose of Reservoir Area Management Plan and Use

As the Renewal Corporation implements the Proposed Action, the currently inundated reservoir areas will become exposed and require restoration and stabilization of bare sediment deposits for long-term water quality and ecological benefits, and restoration of natural river functions and processes. This Plan describes proposed measures for restoration implementation, monitoring, and adaptive management of the exposed reservoir bottoms (and surrounding areas disturbed as part of the Proposed Actions. This Plan defines the restoration elements, establishes restoration performance criteria, and specifies monitoring and adaptive management approaches for river geomorphology and associated riparian and upland revegetation.

The Renewal Corporation will monitor and adaptively manage restoration within the Proposed Action Limits of Work and Restoration (Figure 1-6) where decommissioning, construction, and drawdown actions require restoration, including the reservoir drawdown areas and areas outside the former reservoirs.

The reservoir drawdown areas include restoration (grading, regrading, large wood placement, and revegetation) as shown in the Anticipated Project Activity Areas (Figure 1-7) within the following former reservoir locations: J.C. Boyle Reservoir, Copco No. 1 Reservoir, Copco No. 2 Reservoir, and Iron Gate Reservoir.

Areas outside the reservoirs requiring restoration and monitoring include the following:

- Four (4) hydropower infrastructure demolition areas and associated disposal areas
- transmission line and power pole removal areas
- J.C. Boyle Power Canal demolition area
- Yreka Pipeline replacement area
- Daggett Bridge upgrade area
- Fall Creek fish hatchery upgrade area
- Demolished recreation sites

Regardless of location, the following will also require restoration to approximate pre-existing or surrounding conditions:

- Temporary access road upgrades
- Temporary equipment laydown sites extra work areas

The Renewal Corporation will prepare and submit an Annual Compliance Report within six (6) months of concluding drawdown activities, and annually thereafter by April 1 of each year for as long as the Renewal Corporation has performance obligations under the Reservoir Area Management Plan. The report will be submitted to FERC and will include the following, at a minimum:

1. Monitoring data, including graphical representations, as appropriate
2. Consultation records
3. Narrative interpretation of results
4. Compliance evaluations

Figure 1-6. Limits of Work and Restoration

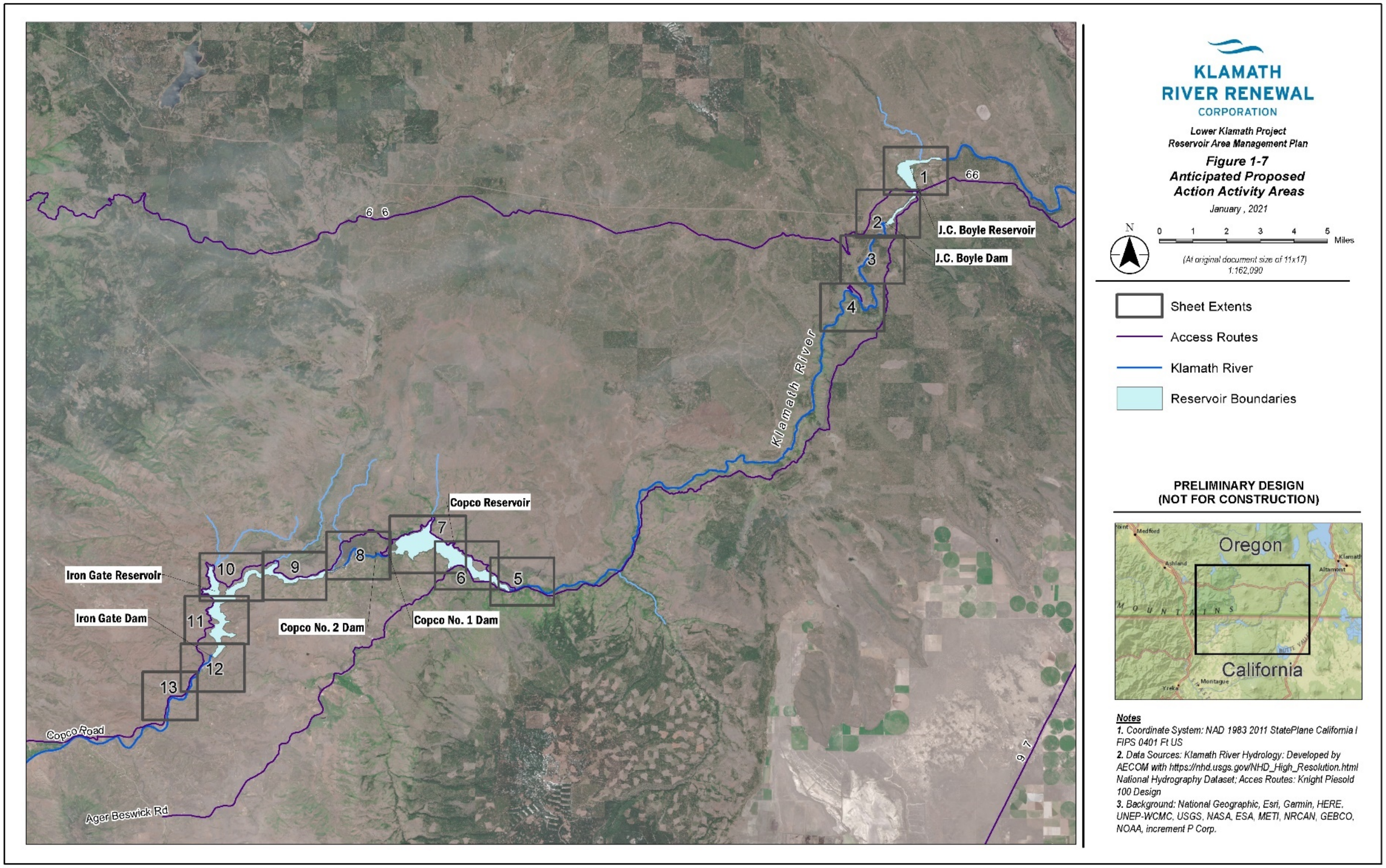


Figure 1-7. Anticipated Proposed Action Activity Areas

Note: Coversheet included herein and mapbook included in Appendix B.

1.2 Organizational Structure

This Reservoir Area Management Plan (2021) replaces all draft versions (2011 and 2018), is informed by regulatory approvals issued to date, and includes 2019-2020 design information.

The remainder of this Plan follows the outline below:

- **Chapter 2:** Regulatory Context, provides context and discusses the management plan regulatory framework and crossover to related management plans.
- **Chapter 3:** Restoration Goals and Objectives, provides context and describes how the Reservoir Area Management Plan is intended to support the overall project goals of restoring volitional fish passage, stabilizing exposed sediment with native vegetation, and enhancing habitat.
- **Chapter 4:** Anticipated Reservoir Conditions After Drawdown provides context and is based on historic information.
- **Chapter 5:** Restoration Measures, summarizes the proposed geomorphology and botanical restoration activities. This chapter of the Reservoir Area Management Plan contains specific measures to be implemented by the Renewal Corporation as part of the Proposed Action.
- **Chapter 6:** Monitoring and Adaptive Management, describing geomorphic and biological monitoring, success criteria, and thresholds for adaptive management and project completion. This chapter of the Reservoir Area Management Plan contains specific measures to be implemented by the Renewal Corporation as part of the Proposed Action.
- **Chapter 7:** Data Management and Reporting. This chapter of the Reservoir Area Management Plan contains specific measures to be implemented by the Renewal Corporation as part of the Proposed Action.
- **Chapter 8:** References

Additionally, to further inform implementation activities, the Reservoir Area Management Plan includes appendices that may be updated to facilitate flexibility throughout the process-based restoration associated with the Proposed Action. These include the following:

- **Appendix A:** Agency Consultation Record
- **Appendix B:** Figures / Detailed Map Books that provide additional detail to the overview figures included in the main body of this Reservoir Area Management Plan.
- **Appendix C:** Best Management Practices
- **Appendix D:** Current and Historic Conditions as a Reference for Restoration
- **Appendix E:** Methodologies for Calculating Anticipated Reservoir Conditions Post-Drawdown
- **Appendix F:** Establishment of Restoration Priorities within the Reservoirs
- **Appendix G:** Geomorphology Monitoring / Adaptive Management Field References
- **Appendix H:** Native Revegetation and Invasive Exotic Vegetation Treatment

- **Appendix I:** Restoration Technical Working Group Members
- **Appendix J:** List of Preparers

Note: Overview figures are included in the main text of this document; and where applicable, detailed map books are included in Appendix B to provide more detail.

2.0 Regulatory Context

The Reservoir Area Management Plan is one of 16 Management Plans implementing the DDP.

Table 2-1. Lower Klamath River Management Plans

1. Aquatic Resources Management Plan	9. Remaining Facilities Plan
2. Construction Management Plan	10. Reservoir Area Management Plan
3. Erosion and Sediment Control Plan	11. Reservoir Drawdown and Diversion Plan
4. Hatchery Management and Operations Plan	12. Sediment Deposit Remediation Plan
5. Health and Safety Plan	13. Terrestrial and Wildlife Management Plan
6. Historic Properties Management Plan	14. Waste Disposal and Hazardous Materials Plan
7. Interim Hydropower Operations Plan	15. Water Quality Monitoring Management Plan
8. Recreation Facilities Plan	16. Water Supply Management Plan

The Reservoir Area Management Plan is intended to facilitate the coordinated implementation of restoration, monitoring, and adaptive management activities. The commitments reflected in the Reservoir Area Management Plan as elements of the Proposed Action are informed by the FERC ALSA (KRRC and PacifiCorp, 2020), the California SWRCB and ODEQ Clean Water Act (CWA) Section 401 Water Quality Certifications (WQCs) (SWRCB, 2020; ODEQ, 2019). The Reservoir Area Management Plan incorporates the material elements from Section 6 (and Appendix H) of 2018 Definite Plan Report (KRRC, 2018), the CDFW Memorandum of Understanding (CDFW, 2020), Oregon Memorandum of Understanding (in development) and comments received by regulatory agency staff on the annotated outline, and to the extent feasible, anticipated conditions of regulatory approval.

2.1 Reservoir Area Management Plan Development

The Renewal Corporation completed development of the Reservoir Area Management Plan in coordination with the Restoration Technical Working Group (RTWG), including representatives from the California SWRCB, North Coast RWQCB, CDFW, ODEQ, Oregon Department of Fish and Wildlife (ODFW), the US Fish and Wildlife Services (USFWS), NMFS and the Karuk and Yurok Tribes. Therefore, the Reservoir Area Management Plan is intended to facilitate compliance with project-specific, restoration-related requirements.

The ALSA contains the DDP, which supersedes the 2018 Definite Plan Report (KRRC and PacifiCorp, 2020). The 2018 Reservoir Area Management Plan was based on the 2018 Definite Plan Report Section 6 (KRRC, 2018). As such, this Reservoir Area Management Plan (2021) supersedes the 2018 Reservoir Area Management Plan relevant for restoration, monitoring, and adaptive management field implementation.

Reservoir Area Management Plan (2021) includes the following contents proposed by the Renewal Corporation in the FERC ALSA:

- Components necessary to implement restoration activities, monitoring, and adaptive management.
- A detailed description of proposed restoration activities and a preliminary map identifying proposed locations for those activities.
- A list of best management practices (BMPs; Appendix C) or other measures addressing invasive weed management, revegetation, floodplain connectivity, and procedures to stabilize and restore the former reservoir area(s) after removal of the dams.
- Performance criteria for evaluating restoration efforts to meet unobstructed stream continuity, fish passage, sediment stability, invasive toxic vegetation abatement, and native vegetation cover establishment.
- Descriptions on the use of native plants to promote soil stabilization, a wetlands presence evaluation (including wetlands in the disposal areas).
- Measures to ensure no net loss of wetland or riparian habitat, floodplain connectivity measures, a monitoring plan for invasive weeds in the restored areas.
- A plan for installation of large woody material and the protection of culturally sensitive plants.
- Monitoring activities using aerial Light Detection and Ranging (LiDAR) reconnaissance surveys to measure sediment stability and estimate the volume of sediment export following the drawdown phases, to be supplemented annually with visual inspections and physical measurements.
- Adaptive management components to ensure that in the event that monitoring results show runoff from exposed embankment areas that causes erosion, sedimentation, or lower water quality, the Renewal Corporation and its contractors would analyze the situation and propose appropriate corrective measures.

ODEQ, WQC Condition 6 “Reservoir Area Management Plan” and California WQC Condition 14 “Restoration Plan” are considered synonymous plans and are incorporated into this Reservoir Area Management Plan.

2.2 Relationship to Other Management Plans

The Reservoir Area Management Plan is supported by elements of other management plans for effective implementation as described in Table 2-2. The geospatial relationship of the Reservoir Area Management Plan to other management plans is depicted in Figure 2-1.

Table 2-2. Management Plans Supporting Elements of the Reservoir Area Management Plan

MANAGEMENT PLAN	NOTES
Reservoir Drawdown and Diversion Plan	This plan manages drawdown, while the Reservoir Area Management Plan informs the associated assisted sediment evacuation measures; these are two (2) interrelated activities.
Aquatic Resources Management Plan	The Tributary-Mainstem Connectivity Plan (TMCP), which is part of the Aquatic Resources Management Plan (ARMP), entails overlapping monitoring and adaptive management activities related to the adaptive removal of reservoir sediment-derived fish passage barriers on key tributaries.
Erosion and Sediment Control Plan (ESCP) and Stormwater Pollution Prevention Plan (SWPPP)	These plans overlap with the Reservoir Area Management Plan in that the goals of both are to effectively stabilize sediments within exposed area post-drawdown and post-deconstruction.
Reservoir Drawdown and Diversion Plan	The Slope Stability Monitoring Plan, which is part of the Reservoir Drawdown and Diversion Plan, focuses on areas near existing infrastructure and generally prescribes proactive measures for site stabilization, which should not conflict with the long-term goals of the Reservoir Area Management Plan.
Recreation Facilities Plan	This plan provides details on site demolition and restoration, the success of which will then be monitored using the methods described in this Reservoir Area Management Plan.

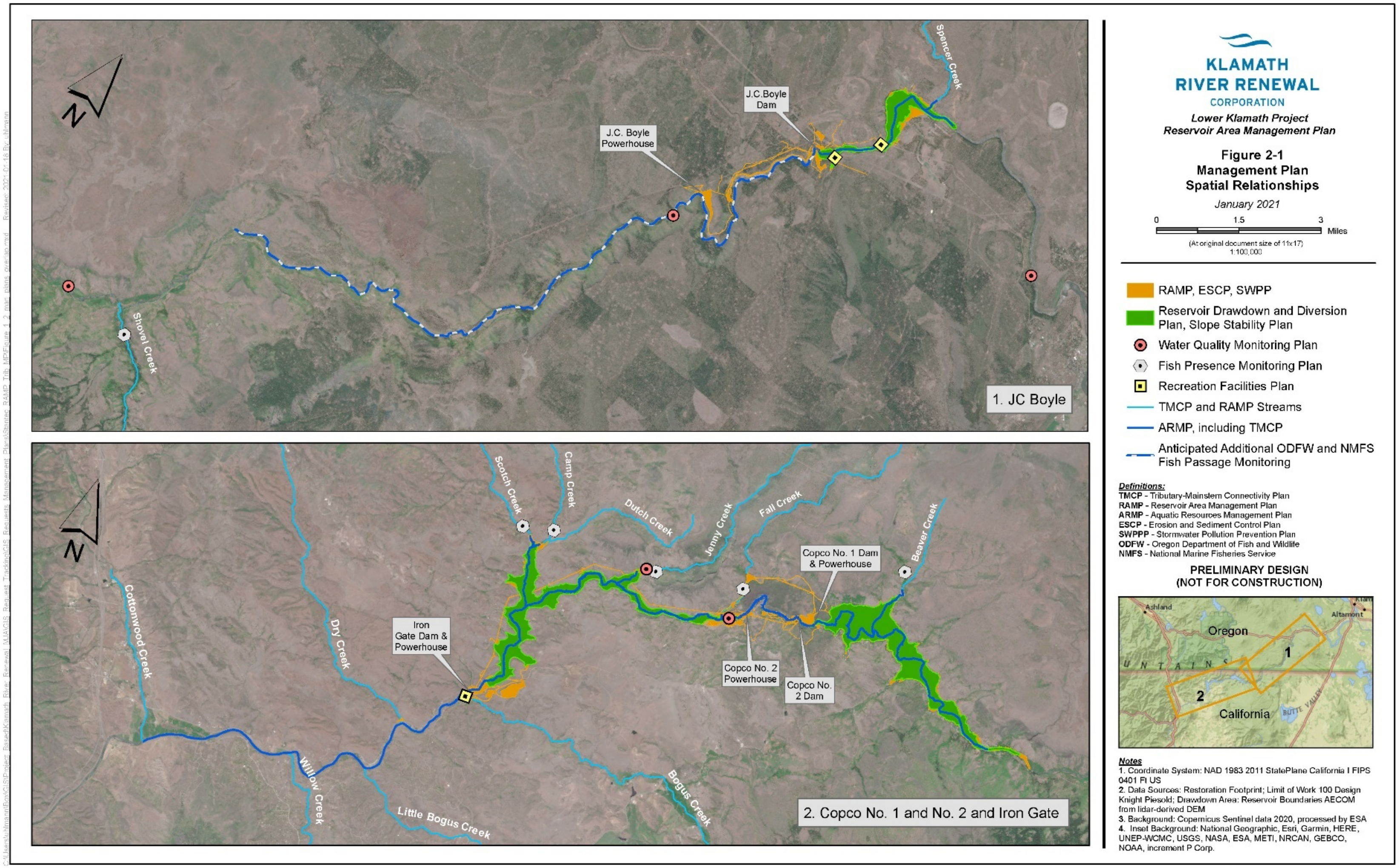
Additional management plan activities will yield data that will inform adaptive management or threshold achievements for the Reservoir Area Management Plan. These include the following:

- The Water Quality Monitoring and Management Plan (WQMP) provides data points to inform potential Reservoir Area Management Plan adaptive management activities. If elevated water quality data is observed, the data will be evaluated to determine the trigger. If the trigger is associated with local slope failures or items covered under the Reservoir Area Management Plan, additional monitoring and adaptive management will be conducted.
- Similarly, monitoring for tributary connectivity and identification of potential reservoir sediment-derived fish passage blockages would likely trigger Reservoir Area Management Plan and Tributary-Mainstem Connection Plan (TMCP) monitoring activities and potentially adaptive management.
- Additionally, if data from the Fish Presence Monitoring Plan indicates fish are present in tributaries within the Reservoir Area Management Plan footprint, that information is positive feedback indicating Reservoir Area Management Plan-related site stabilization in a manner that facilitates volitional fish passage.

Implementation of the Reservoir Area Management Plan may be constrained by sensitive resources areas or temporarily delayed by sensitive resource recovery activities included in the Historic Properties Management Plan (HPMP), the Wildlife and Terrestrial Management Plan provisions for eagle and reptile protection.

Upon receiving the FERC Surrender Order, the Renewal Corporation will develop an environmental exclusion area/permissible work area map to define the seasonal and permanent no work zones associated with the plans listed above. Cultural resource exclusion areas will be contained separately in a confidential map. The Renewal Corporation will provide this information to FERC, ODEQ and SWRCB (as applicable), subject to any confidentially constraints applicable to cultural resources.

Adaptive management actions, depending on their breadth and complexity may entail consultation by the Renewal Corporation with the RTWG as a technical advisory panel. Members of the RTWG are listed in Appendix H. This group has common membership with the tribes and agencies in the Aquatic Technical Work Group (ATWG) which will support coordinated consultation.



Disclaimer: This document has been prepared based on information provided by others as cited in the Notes section. McMillen Jacobs Associates has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated herein as a result. McMillen Jacobs Associates assumes no responsibility for data supplied in electronic format, and the recipient accepts full responsibility for verifying the accuracy and completeness of the data.

Figure 2-1. Management Plan Spatial Relationships

Activities of the Reservoir Area Management Plan are also supported by the general provisions of the following Management Plans :

- Health and Safety Plan
- Construction Management Plan (Traffic Management Subplan)
- Spill Prevention, Control, and Countermeasure Plan
- Waste Disposal and Management Plans
- Hazardous Materials Management Plan
- Fire Management Plan
- Emergency Response Plan

2.3 Limitations

The Reservoir Area Management Plan does not include activities outside of the Limits of Work and Restoration areas (Figure 1-6) or any work beyond five (5) years, unless specifically proposed by the Renewal Corporation and approved by FERC.

3.0 Restoration Goals and Objectives

This Chapter 3 provides a high-level overview of how the Reservoir Area Management Plan will support the overall project goals of restoring volitional fish passage, stabilizing exposed sediment with native vegetation, and enhancing habitat.

The goals and objectives are informed by the current and historic conditions in the Limits of Work which are described in detail in Appendix D. The goals and objectives that are intended to support the overall goals of restoring volitional fish passage, stabilizing exposed sediment with native vegetation, and enhancing habitat, as described in Table 3-1. Multiple planning phase goals have already been accomplished. These include studies vegetation test plot studies to better estimate the post reservoir drawdown vegetation succession. Additional objectives are included based on recent design updates. These include additional restoration activities for fish passage monitoring, per the ODEQ and SWRCB CWA 401 WQCs.

Table 3-1. 2021 Goals, Objectives, and Restoration Activities for Reservoir Restoration Measures

PERIOD	GOAL	OBJECTIVE	RESTORATION MEASURES
Pre-Construction Period	Prepare native plant materials for revegetation.	Collect and propagate native plant seed and grow container plants.	*In Process*. Identify potential seed collection, seed propagation, pole harvest cutting areas, and container plant grow contractors.
			In Process. Perform surveys to identify and map seed collection and pole harvest areas.
			In Process. Prepare seed collection, seed propagation, container plant growing, and pole harvest contract documents.
			In Process. Award and monitor native plant and seed contracts.
			In Process. Develop revegetation contract documents.
	Reduce invasive exotic vegetation (IEV).	Reduce and minimize the local occurrences of IEV.	*Complete*. Gather existing IEV data and perform IEV surveys.
			Complete. Review potential herbicides and potential impact on fish and water quality.
		Implement an IEV management program.	*This Reservoir Area Management Plan.* Create management plan and review with stakeholders.

PERIOD	GOAL	OBJECTIVE	RESTORATION MEASURES
			Complete. Procure local contractor to perform IEV removal.
			Pending. Inspect and monitor IEV removal execution.
	Understand likely evolution of reservoirs post-removal and responses to restoration and reservoir management.	Conduct studies to fill in data gaps from prior planning efforts.	*Completed.* Sample sediment and perform tests to investigate wetting and drying characteristics, plant nutrient availability, and natural revegetation potential.
			Completed. Perform revegetation pilot tests for native seed mixes.
			In Process. Identify reference physical and ecological conditions in tributaries.
Dam removal period (0 to 1 year)	Maximize reservoir area restoration for ecological uplift.	Develop comprehensive restoration plan for post-removal reservoir conditions.	*During drawdown*. Actively promote erosion of reservoir deposits during drawdown; use available techniques such as barge mounted hydraulic monitors or boats (supplemental sediment evacuation).
			Post-drawdown. Modify and enhance site-specific restoration actions based on site conditions after drawdown.
			Identify culturally significant areas that are off limits to disturbance.
			Post-drawdown. Develop final engineering plans for implementation.
	Allow natural erosion and transport of reservoir deposits and dispersal in the ocean.	Maximize erosion of reservoir deposits during drawdown.	*Post-drawdown.* Implement supplemental sediment evacuation activities.
	Evaluate active restoration options (post-removal) for habitat development.	Define locations amenable to site-specific restoration actions.	*Post-drawdown.* Collect new topographic data for basis of restoration design progression
			Post-drawdown. Delineate planting zones.
			Post-drawdown. Install pole cuttings and bare-root trees and shrubs.

PERIOD	GOAL	OBJECTIVE	RESTORATION MEASURES
	Stabilize remaining reservoir sediments.	Initiate native plant revegetation.	*Post-drawdown*. Seeding and establishment of riparian and upland vegetation.
Dam removal period (0 to 1 year) (continued)	Restore volitional fish passage in mainstem and tributaries.	Monitor and rectify any non-natural fish passage barriers.	*Post-drawdown*. Conduct field monitoring of mainstem and tributaries; fix non-natural barriers
			Post-drawdown. Conduct field monitoring of mainstem and tributaries; fix identified non-natural barriers.
	Minimize IEV.	Implement and monitor IEV removal during revegetation.	*Post-drawdown*. Include criteria for IEV removal during revegetation implementation.
			Post-drawdown. Monthly inspections of revegetation areas to verify IEV compliance.
Short-term (1 to 5 years after removal)	Restore natural ecosystem processes.	Continue native plant revegetation, maintenance, and monitoring.	*Post-drawdown*. Monitor establishment and adaptively replace failed pole cuttings, acorns, and container plants.
			Post-drawdown. Maintain irrigation system.
			Re-seed poorly established areas.
	Implement process-based river and tributary restoration actions where applicable.	Work with the river, not against it.	*Post-drawdown*. Assess progress of channel evolution based on natural processes. Implement intervention or construction where is necessary per the adaptive management program described in Chapter 6 of this document.
	Minimize IEV.	Continue IEV monitoring and removal.	*Post-drawdown.* Include criteria for IEV removal during establishment.
			Post-drawdown. Perform monthly inspections to verify IEV removal compliance.
	Restore volitional fish passage in mainstem and tributaries.	Monitor and rectify any non-natural fish passage barriers.	*Post-drawdown.* Conduct field monitoring of mainstem and tributaries, fix non-natural barriers.

PERIOD	GOAL	OBJECTIVE	RESTORATION MEASURES
	Secondary Goal: Promote fish habitat.	Secondary Objective: Increase quantity and quality of in-stream and off-channel habitat for aquatic species.	*Post-drawdown*. Construct in priority tributary areas, in-stream habitat features based on designs that are appropriate for the system.
			Post-drawdown. Construct off-channel wetlands, side channels, and alcoves where appropriate.
			Post-drawdown. Enhance mid-channel gravel bars in priority tributaries.

Anticipated long-term outcomes that are expected to occur as a result of the Proposed Action include the establishment of volitional fish passage and ultimately the restoration of natural ecosystems processes; however, once volitional fish passage and natural ecosystems processes are achieved, continued monitoring and adaptive management will not be required. Natural ecosystem processes are generally described as follows:

- Natural hydrology maintained – river flow unimpeded to artificial impoundments in the Project Area – responds to natural hydrologic conditions
- Sediment transport processes maintained – sediment aggradation and degradation occurs – sediment is transported through the Project Area, enabling sediment transport connection between the Project Area and mainstem Klamath below the former Iron Gate Dam location
- Vegetation recruitment and propagation – the natural recruitment and propagation of native plant species is occurring
- Aquatic fish and invertebrate species occur within the river and perennial tributary features

4.0 Anticipated Reservoir Conditions After Drawdown

This Chapter 4 provides context the expected condition of the reservoir areas post-drawdown.

The Renewal Corporation developed a Reservoir Drawdown and Diversion Plan for the Proposed Action that specifies a four (4)-stage drawdown process for all four (4) reservoirs beginning in January of the drawdown year and extending into June (under 50th percentile water surface levels) as periodic reservoir refilling episodes are expected to occur.

The main physical constraints limiting the extent of restoration actions are difficult construction access and presence of culturally sensitive resources. Application of most restoration actions will depend on the distribution and amount of remaining residual sediment following drawdown in each of the reservoirs, which will directly affect ease of access; however, both the location and thickness of residual sediment remaining in the reservoirs following drawdown is uncertain. Residual sediment depths and locations will vary depending upon river and tributary flows during drawdown and, to a lesser degree, by the effectiveness of supplemental sediment evacuation methods. Final cultural resource evaluations will be performed post-drawdown and may further affect ease of access.

Each reservoir has distinct features and characteristics, so additional information and descriptions of the likely response of the individual reservoir areas are also discussed below for each reservoir. Table 4-1 summarizes miles of river, side channel, and tributary stream and acres of exposed reservoir bottom that are expected to be recovered within each of the reservoirs as a result of the Proposed Action.

Table 4-1. Summary of Mainstem River, Side Channel, Tributaries, and Area Currently Inundated in Each Reservoir

LOCATION	MAINSTEM RIVER LENGTH* (MILES)	SIDE CHANNEL LENGTH* (MILES)	TRIBUTARY LENGTH* (MILES)	NUMBER OF TRIBUTARIES*	INUNDATED RESERVOIR AREA (ACRES)	EXPOSED RESERVOIR AREA (ACRES)
J.C. Boyle	3.3	-	0.2	10	347	222
Copco No. 1 and No. 2	6.9	1.2	1.5	18	972	863
Iron Gate	6.8	-	2.5	52	942	840
Total	17.0	1.2	4.2	80	2,261	1,925

*USFWS 2009

As described in the Reservoir Drawdown and Diversion Plan, J.C. Boyle, Copco No. 1 and No. 2[1], and Iron Gate reservoirs will be drawn down simultaneously, and the accumulated sediment will naturally mobilize and evacuate from the reservoir areas. The accumulated sediment is predominantly silt, clay, and organic material that is more than 80 percent water and highly erodible. BOR (2010) used both one-dimensional (1D) and two-dimensional (2D) sediment transport models to predict likely sediment transport and river conditions in the reservoirs after dam removal.

The assumed post-drawdown reservoir surface is based on the historic bathymetry and updated bathymetric surface datasets as well as the sediment material properties (Appendix E). Those surfaces were used to estimate post-drawdown conditions for the development of the 60 percent restoration design. A description of the anticipated post-drawdown surface that is used as the basis for restoration activity mapping is included herein. Actual reservoir conditions post-drawdown will be updated by the end of the drawdown year and used for the 90 percent and final reservoir restoration designs. Final drawdown is expected to occur by July of the drawdown year, depending on hydrologic conditions in the basin during the drawdown period, and the preliminary restoration map will be updated following completion of final drawdown.

Estimated post-drawdown sediment thickness is less at J.C. Boyle than Copco No. 1 and Iron Gate Reservoirs. Descriptions of anticipated post-drawdown conditions and sediment thicknesses are provided in the following subsections. Actual locations and depths of sediments are expected to vary from those predicted below, as discussed in EPA (2020), due to shifting and re-working of sediments within the reservoirs (EPA, 2020 and BOR and CDFW, 2012).

4.1 J.C. Boyle Reservoir Sediments

For the majority of the J.C. Boyle Reservoir, estimated sediment thickness is less than two (2) feet, with a localized area of thicker sediment reaching upwards of five (5) feet near the confluence of an unnamed tributary. During reservoir sediment testing at J.C. Boyle, sediment decreased in thickness by 40 percent and volume by 66 percent when air dried along with significant crack development (KRRC, 2018). Therefore, a sediment shrinkage factor of 0.4 was applied to sediment thickness data to account for volumetric changes from drying post-drawdown.

Accumulated reservoir sediments are primarily limited to the historical channel and are thickest in the confined canyon reach between Highway 66 and the J.C. Boyle Dam. Lacking alternative flow pathways in the confined lower reach, the river is expected to readily scour out the reservoir sediment down to the bedrock prominent in the historical river channel bed. Narrow but potentially several-feet thick deposits may persist outside the channel banks. The Upstream Reach will be exposed early during drawdown because the water depths are shallow. It is

[1] The Reservoir Drawdown and Diversion Plan includes a proposal to remove Copco No. 2 prior to the drawdown year. It is not expected that early removal of Copco No. 2 would impact sediment evacuation of reservoir areas within of the facility or downstream in the Iron Gate facility.

estimated that the channel here will preferentially erode its historical channel bed and leave the broad (approximately 1,000-ft-wide) deposits on the channel margins relatively intact. Significant slumping of these deposits during drawdown is not expected because of shallow depths (< two [2] ft) and low topographic slopes (< 0.1 ft/ft). These deposits will reduce in height and volume by up to 50 percent as the material dries and consolidates. Water levels in the J.C. Boyle Reservoir are sensitive to river flows because of the small size of the reservoir. As a result, high flow events can inundate and modify the deposits in the period between the onset of drawdown and removal of the dam. A 5-year flow event, for example, will increase reservoir elevations by more than 20 ft during the drawdown period (BOR, 2011b) due to limited flow capacity of the gated spillways or diversion culverts. There are only a few tributaries on these marginal deposits, and some are ephemeral, so the Renewal Corporation expects little subsequent evacuation after removal of the dam. Given the low relief of the Upstream Reach, high flow events will periodically inundate and modify the remnant reservoir surfaces. The modeled 100-year flood inundates nearly the entire Upstream Reach (Figure 5-7 and Appendix D, Figure D-3). It is uncertain if pre-dam bedforms, such as the large mid-channel bar (Appendix D, Figure D-2), will be reestablished post-drawdown.

Canyon Reach is highly confined and will have relatively little upland or floodplain area available for revegetation. This geometry should efficiently evacuate the reservoir sediments, and the coarser pre-dam substrate will be readily exposed and will support revegetation with woody riparian species in some locations. Drawdown in the reach upstream of Highway 66 will expose a large low-gradient area of relatively thin reservoir sediments. The existing reservoir-dependent wetlands in the Upstream Reach, e.g., at the Spencer Creek confluence, may disappear after drawdown, but the seedbank germination study results suggest that wetlands may re-establish naturally, albeit in a new location closer to the historical channel. Sediments at J.C. Boyle contain the lowest amount of clay of the three (3) reservoirs, and they will be best suited for planting of native grassy vegetation and trees (e.g., Douglas fir, ponderosa pine, Oregon white oak) that are currently growing in the reservoir vicinity. Air temperatures at J.C. Boyle typically fluctuate diurnally above and below freezing during the winter months when drawdown is scheduled to occur. As a result, the sediments will drain and dry with warmer daytime temperatures but freeze at night. These conditions, which will persist for months in the upstream reach, will be challenging for young plants, particularly those with shallower root systems. It is estimated that dried sediment thickness will be on the order of approximately one (1) foot thick, so the roots of plants that establish in the sediments will have access to the historical floodplain surface and materials. Sediments and hydrologic conditions in the historical materials may be more suitable for plant establishment, although it is unknown how reservoir inundation may have modified these characteristics.

4.2 Copco No. 1 and No. 2 Reservoir Sediments

Estimated post-drawdown residual sediment thickness at Copco No. 1 reservoir is five (5) to six (6) feet throughout the lower half of the reservoir and decreases to approximately three (3) to four (4) feet in the upper half (KRRC, 2018). The Renewal Corporation expects the reservoir sediments in the sinuous historical channel footprint to erode during drawdown, and large areal extents of residual sediments several feet in thickness will persist on the low-gradient floodplain and upland surfaces of the historical lakebed.

The Renewal Corporation anticipates that reservoir deposits on the low-gradient floodplain and upland surfaces adjacent to the channel in the Downstream Reach (except at the edges of vertical bluffs) will be relatively stable and will not be subject to appreciable slumping or hydraulic erosion. Gradients on these surfaces are typically less than two (2) degrees, as measured from the high-resolution bathymetric data, and are well below even the lowest estimates (six [6] degrees) for the aerial angle of repose for the reservoir sediments.

Larger tributaries, such as Deer Creek and Beaver Creek, will begin to rework their delta deposits and contribute bedload to the mainstem upon aerial exposure. Large-flow events following aerial exposure will increase the amount of sediment reworking by the mainstem and tributaries through repeated cycles of filling and emptying. Copco No. 1 Reservoir sediment thicknesses vary with pre-existing valley topography such that the lower elevation historical channel contains deeper deposits than higher elevation terraces and ancestral lakebed. BOR predicted the spatial patterns of erosion by 2-dimensional (2-D) morphodynamic modeling of Copco Reservoir during drawdown (BOR, 2011b). Erosion more than five (5) ft was concentrated within the sinuous historical channel and in the cut-off meander bend, which will be re-occupied by Beaver Creek following drawdown, but the model predicts nearly zero erosion outside of the historical channel. The model does not simulate fluvial bank erosion or bank failure, nor does it incorporate erosion from tributaries, springs, or concentrated surface runoff from hillslopes; therefore, the spatial extent of modeled erosion is potentially a minimum prediction, and it is likely that more material will naturally evacuate from other areas during drawdown. 2D modeling used the formulation for the erosion rate of fine-grained cohesive sediments and measured parameter values from Simon et al. (2010) to simulate erosion under easier to erode and harder to erode scenarios and is far more sensitive to the modeled hydrology than the variation in the erosion rate parameters. Hard to erode critical shear stress values used were more than an order of magnitude lower and higher than the maximum values measured in the wetting-drying experiments; however, given the large proportion of sediment eroded during the drawdown period and its location in the historical channel, the modeling results do not change with the new shear strength data. Hardened, resistant sediment is more likely located in upland and higher elevation floodplain areas less affected by initial drawdown and erosion by the Klamath River.

Given the high relative elevation, low gradient, and large width of ancestral lakebed and upland surfaces, reservoir deposits two (2) to six (6) ft thick and hundreds of ft in lateral extent may persist at elevations tens of feet above the mainstem active channel post-drawdown. Tributaries and springs may erode these deposits in some places, and the remaining sediments will undergo the physical changes associated with desiccation. Volume reduction during consolidation may lower the surfaces up to 50 percent of the deposit thickness, and the Renewal Corporation expects cracks to form. These cracks may concentrate flow from surface runoff in the future and be foci of subsequent erosion of the deposit by rilling and gullying.

Historical Copco No. 1 valley topography was created by a complex sequence of geologic and geomorphic events; thus a diversity of landforms and materials will be exposed following drawdown. The pre-dam valley relief was high in the Downstream Reach with elevation differences in excess of 50 ft between the channel bed and the higher-elevation, low-gradient ancestral lakebed. These steep, five (5) ft to 50 ft tall banks on the outside banks of the meander bends and the material underlying much of the historical valley bottom are composed of fine-grained and porous diatomite; however, the diatomite, which is mechanically capable of supporting tall vertical bluffs when dry, has been inundated for 100 years, and the pores are likely now filled with water. The effect of saturation on diatomite mechanical strength and the result of dewatering with drawdown are addressed in the Slope Stability Management Plan. Products of a diatomite slope failure, if it occurred, could persist in the valley bottom and potentially alter the course, though probably not dramatically, of the Klamath River away from the historical alignment and cause increased lateral erosion of adjacent diatomite bluffs. The Renewal Corporation expects access by the Klamath River to its historical floodplain to be limited only by the presence of local deposits of residual reservoir sediments along the riverbanks that are not removed during drawdown. Even if floodplain access is locally limited due to accumulated sediment deposits, significant vertical incision into the historical valley floor (i.e. below the reservoir sediment build up layer) is not expected post-drawdown because of the presence of bedrock grade control upstream of Copco No. 1 dam and the relatively coarse gradation of historic riverbed sediments.

Reservoir sediment texture at Copco No. 1 Reservoir is, on average, much finer than that at J.C. Boyle Reservoir and ranges from clay to silty clay loam on a U.S. Department of Agriculture texture triangle, and the size grades from fine texture near the dam to the coarsest texture at the upstream portion of the reservoir (KRRC, 2018). Textural gradations will be reflected in the vegetation palette, which will include a larger proportion of native perennial bunch grasses, trees, and shrubs in the upstream area where coarser, well-aerated soils will be able to support these deep rooting species. Each planting zone species assemblage successfully established in the moist Copco No. 1 sediments and the riparian bank and riparian floodplain species were able to grow in the desiccated samples, albeit with frequent irrigation and moderate temperatures. Air temperatures at Copco No. 1 typically fluctuate diurnally above and below freezing during the winter months when drawdown is scheduled to occur. As a result, the sediments will drain and dry with warmer daytime temperatures but freeze at night, a combination that will be challenging for young plants. Irrigation may not be possible in the ancestral lakebed uplands and many other upland portions of the Copco valley given the large areal extents and distance from surface water sources. Access to the upland areas must be from the road, rather the channel.

Copco No. 2 is primarily a run of the river reservoir and, as a consequence, the combination of periodically unimpeded flows through the reservoir area and the canyon topography have resulted in little sedimentation. As such, little sediment is anticipated in this reservoir.

4.3 Iron Gate Reservoir Sediments

At Iron Gate, sediment thickness is an estimated four (4) to five (5) feet immediately upstream of the dam, decreasing to two (2) to three (3) feet at the upstream extent of the impoundment. At Iron Gate, the Renewal Corporation anticipates the Klamath River to efficiently evacuate the majority of the reservoir sediment because the reservoir deposit layers are thin, the reservoir water depths are large, drawdown will be more rapid, and the historical channel occupied a narrow pre-dam valley with steep adjacent hillslopes (BOR, 2011a). Drawdown of the 2,330-ft elevation reservoir water surface will begin on January 1. It is estimated that Fall Creek (approximately 2,310 ft) will be completely exposed early in the drawdown process, and mobilization of the local deposits at Fall Creek are expected during subsequent storm events. Jenny Creek delta (minimum elevation approximately 2,270 ft) will have full aerial exposure later in the drawdown period and will experience reworking during subsequent high flows; in addition, the Jenny Creek delta has the thickest and coarsest deposits in the Iron Gate Reservoir and will function as a source of bedload to the mainstem. Camp Creek confluence area (elevation approximately 2,230 ft) won't be exposed until late in the drawdown period, although upstream portions of Camp Creek and its tributaries will rework their deposits (maximum sediment thickness five [5] feet) at all stages of drawdown.

Most of the historical roads and the railroad along the Downstream Reach of Iron Gate are not exposed until reservoir levels are below 2,230 ft. Several weeks will likely be required before reservoir sediment has stabilized and the certainty of road stability has been verified. Until that point, the floodplain in the Downstream Reach of Iron Gate and Camp Creek may be inaccessible. Drawdown operation at Iron Gate will be impacted not only by hydrology, but also by releases from Copco and the discharge capacity of the diversion tunnel. Based on updated drawdown modeling described in the Drawdown Diversion Plan, a secondary refilling of the Iron Gate reservoir during the drawdown period is likely. This secondary inundation could persist for days to weeks depending the elevation and magnitude of the event and will potentially re-saturate or erode residual sediments. Fine-grained sediments will be subject to potential breakdown and mobilization from additional cycles of wetting and drying.

Reservoir sediments are not expected to exceed 5 ft in thickness except at the Jenny Creek delta, so the Renewal Corporation expects residual sediment persisting after drawdown to reduce in thickness to less than three (3) ft. Given the relatively more rapid drawdown proposed at Iron Gate and steep side slopes, reservoir deposit erosion from slumping should be more efficient (BOR, 2011a). There are several mapped low relief terraces, fans, and historical floodplains in the valley bottom (particularly in the Downstream Reach) on which larger areal extents of sediment may be stable. The greatest uncertainties relate to the deposit erosion by tributaries, particularly the Camp/Scotch Creek Complex in Mirror Cove. Camp Creek valley is wider relative to the size of the historical tributary channels, and therefore, the Renewal Corporation expects a larger areal extent of sediment relative to the mainstem areas to remain after drawdown. These deposits are only two (2) to three (3) ft thick and will consolidate upon drying.

Challenging access into the Iron Gate Canyon will limit active revegetation and restoration efforts. Sediment texture at Iron Gate Reservoir is the finest of all three (3) reservoirs, with clay content up to 78 percent at the Iron Gate 2 sampling site. Similar to other reservoirs, the sediment textural gradient progresses from finest near the dam to the coarsest at the upstream end of the reservoir and at the Jenny Creek confluence. This gradation will be reflected in the vegetation palette that will include a larger proportion of native perennial bunch grasses, trees, and shrubs in the upstream area where coarser, well-aerated soils will be able to support these deep-rooting species.

5.0 Restoration Measures

This chapter summarizes the measures that the Renewal Corporation will implement to shift the Project reach of the Klamath River from a lentic to a lotic system as reservoirs are replaced by a free-flowing river.

The restoration measures entail work outside and within the reservoirs' current footprints. Actions outside the reservoir footprints primarily entail infrastructure removal, while activities within the current reservoir limits generally concern natural systems. Though exceptions exist, restoration activities outside the reservoirs can be considered direct actions whereby the site is physically returned to a desired state; restoration activities inside the reservoirs, however, are process-based and largely rely on the river to shape the environment with targeted assistance. The Renewal Corporation will focus geomorphic management activities on the dam removal sites and priority (potential fish bearing) tributaries, while actively revegetating the reservoir footprints. The methodology for identifying priority tributaries is summarized in Appendix F.

General restoration activity locations are described in Section 1.1, Purpose and Use. They are located within the Limits of Work (Figure 1-6) and, more specifically, within the estimated project-affected areas depicted in Figure 1-7. Restoration locations have been further delineated within and outside the reservoirs.

The restoration measures described in this chapter are supplemented by monitoring and adaptive management measures. Chapter 6.0 outlines the methods for assessing restoration progress and adaptive management to achieve the fish passage project goal and complete the restoration project. Feedback loops between design and monitoring will govern where and when physical reconstruction of streams takes place.

5.1 Restoration Approach Outside of the Reservoirs

The restoration measures outside of the reservoirs are primarily associated with infrastructure removal or upgrades such as civil structure demolition and associated restoration, electric transmission and distribution line removal and site restoration, recreation area demolition and restoration, temporary staging area restoration, spoil pile restoration, Yreka pipeline replacement restoration, and access road culvert or bridge upgrades and associated restoration. Restoration measures outside the reservoir areas primarily entail regrading to appropriate contours and replanting with native seed mixes or adding hardscape where applicable and are generally categorized as upland restoration or stream crossing restoration.

5.1.1 Upland Restoration Measures

The Renewal Corporation will regrade upland areas, including recontouring to neighboring conditions as applicable. The locations of these areas are depicted in the dam demolition design drawings. The Renewal Corporation will install temporary and permanent sediment and erosion control BMPs per the site-specific Stormwater Pollution Prevention Plan (SWPPP), including revegetation with regionally appropriate upland native seed mixes; see Appendix C for a complete list of BMPs. Specific measures proposed by the Renewal Corporation for upland areas include the following:

- **Disposal sites for placement of embankment or concrete material**: These areas typically include between 10 to 50 ft of fill, and will be graded by the Renewal Corporation to match existing topographic features in the vicinity and will include a cover depth of topsoil material suitable for revegetation where available/appropriate. Some disposal sites will be covered by the Renewal Corporation with coarse rock fill material to provide erosion protection in areas not conducive to vegetation establishment. Native vegetation will be preserved and protected where feasible and will avoid ripping within a distance of twice the canopy diameter from protected tree trunks to protect existing roots. See the Waste Disposal and Hazardous Materials Management plan for disposal site construction.
- **Staging areas and temporary access road areas adjacent to demolition of other work areas**: The majority of these areas are at elevations appropriate for upland planting, although in some cases they include a variety of planting zones. Many of these areas are already compacted to a high degree due to their use. The Renewal Corporation will loosen soil compacted by staging and temporary access road areas adjacent to demolition or other work areas by deep ripping and disking as needed to facilitate seed germination and plant establishment. The Renewal Corporation will preserve and protect native vegetation, where feasible, during active use and revegetation. Ripping, equipment and vehicle parking, or material storage will be avoided to the extent feasible within a distance of twice the canopy diameter from protected tree trunks to protect existing roots.
- **Hydropower infrastructure demolition areas**: The Renewal Corporation will demolish the majority of PacifiCorp buildings and other hydropower infrastructure to be removed. In each former development location, after removal of all demolition debris and man-made materials, the Renewal Corporation will loosen compacted soil in the remaining disturbed areas by deep ripping and disking as needed and restore them to native habitat. These areas occur in a variety of planting zones and will be restored accordingly as described in Appendix H. The Renewal Corporation will preserve and protect existing native vegetation, as feasible and will avoid ripping within a distance of twice the canopy diameter from protected tree trunks to protect existing roots.
- **J.C. Boyle canal demolition area**: The Renewal Corporation will demolish the J.C. Boyle canal along its entire length. Soils in the former canal area will likely be heavily compacted from previous canal construction activities. The Renewal Corporation will loosen compacted soils or position topsoil as needed on top of the canal features to facilitate seed germination and plant establishment. The existing power canal access road on the downslope side of the canal will remain in place post-construction to be used as a hiking trail. See the Remaining Facilities plan for details regarding the J.C. Boyle Canal that will remain.
- **J.C. Boyle spillway scour hole**: The Renewal Corporation will fill the existing spillway and scour hole area with on-site materials. Final grading will be sloped to the adjacent existing grades that naturally drain. The top cover of fill (minimum of 6 ft) will consist of

general fill (E9/E9b) designed to provide final stabilization treatment. See the Waste Disposal and Hazardous Materials Management plan for disposal site (Scour Hole) construction.

Former recreation areas: The Renewal Corporation will remove some of the existing recreation areas around the reservoir rims completely or in part. The demolished recreation areas will restore disturbed former recreation areas to native habitats. Much of the land within these areas is heavily compacted because of the respective areas' uses. The Renewal Corporation will loosen compacted soils in recreation areas associated with the project by deep ripping and disking as needed to facilitate seed germination and plant establishment and will preserve and protect existing native vegetation, as feasible. Deep ripping will be avoided within a distance of twice the canopy diameter from protected tree trunks to protect existing roots). See the Recreation Facilities Plan and Remaining Facilities Plan for additional details. Table 5-1 lists the recreation sites planned for demolition and restoration as part of the Project.

Table 5-1. Recreation Areas

STATE	RESERVOIR	SITE NAME
OR	J.C. Boyle	Pioneer Park East
		Pioneer Park West
		Topsy Campground
CA	Copco No. 1 and No. 2	Mallard Cove
		Copco Cove
	Iron Gate	Fall Creek Day Use Area and Fall Creek Trail
		Overlook Point
		Wanaka Springs Day Use Area
		Jenny Creek Day Use Area and Campground
		Camp Creek Day Use Area and Campground
		Juniper Point Day Use Area and Campground
		Mirror Cove Day Use Area and Campground
		Long Gulch Day Use Area and Campground

5.1.2 Dam Footprints

Following removal of the dams, the Renewal Corporation will configure the Klamath River channel within the former dam footprints to match its pre-dam dimensions as closely as practicable. Pre-dam channel morphology was determined from historical photographs taken prior to and during construction. In general, the Renewal Corporation will achieve pre-dam configurations by matching the post-removal river contours to upstream and downstream contours. Approaches for each dam are described below.

5.1.2.1 J.C. Boyle

The bed of the Klamath River at J.C. Boyle dam was made up of bedrock and large cobble and boulders. During construction, it appears that large material, including boulders and cobble, was pushed out of the footprint with dozers to create direct contact between the embankment and the river bottom. The Renewal Corporation's restoration of the dam footprint will focus on returning the channel to pre-dam conditions. This will be achieved by removing the earthen embankment down to the bedrock channel and reconfiguring the channel to match upstream and downstream contours, and thus, returning the river to its pre-dam condition is largely straight forward.

Restoring the channel to its pre-dam condition will largely achieve the overarching goal of restoring volitional fish passage to the Klamath River. Though there is photographic evidence of boulders and other materials lining the channel bottom, the uncertainty of their presence after dam removal makes it unclear what the texture of the channel bottom will be once the dam is removed. To increase the likelihood of fish passage, fringe roughness elements are included in the channel design to increase roughness near the channel margins, which will reduce near-bank velocity and create pathways for fish to move upstream. Rock comprised of material generated during dam removal activities will be used for fringe roughness and no material will be imported for this purpose.

5.1.2.2 Copco No. 1 and No. 2

Copco No. 1 was constructed on alluvial material, which was excavated approximately 100 ft to accommodate the concrete dam foundation. Since the dam abuts canyon walls on either side of the structure, returning the channel to pre-dam conditions will be largely achieved by removal of the dam itself. The bed will be made up of material suspected to have been removed during its construction, and the bed will match upstream and downstream elevations to recreate a largely consistent slope through the reach. Klamath River channel in the vicinity of Copco No. 2 will largely mimic that of Copco No. 1, by matching existing grades upstream and downstream of the former dam footprint.

5.1.2.3 Iron Gate

Like J.C. Boyle, Iron Gate Dam was constructed on bedrock. Restoration of the Klamath River in the dam footprint will consist of removing the earthen embankment down to the bedrock channel and matching contours upstream and downstream of the dam. The Renewal Corporation will line banks within the footprint with boulders to increase roughness to reduce velocities and to provide seams for fish passage. The Renewal Corporation will us rock comprised of material generated during dam removal activities for fringe roughness and no material will be imported for this purpose.

5.1.3 Infrastructure-Related Restoration

Renewal Corporation will regrade infrastructure-related stream restoration areas, including recontouring to neighboring conditions as applicable. The locations of these areas are depicted in the dam demolition design drawings. The Renewal Corporation will install temporary and permanent sediment and erosion control BMPs per the site-specific SWPPP, including revegetation with regionally appropriate riparian native seed mixes; see Appendix C for a complete list of BMPs. FERC will be notified by the Renewal Corporation when restoration is complete and when the SWPPP conditions are met. A Notice of Coverage (NOC) will be filed with the SWRCB in California and ODEQ in Oregon. Once the SWPPP NOC is filed, no further monitoring will be required.

Additional measures proposed by the Renewal Corporation for restoration locations that are considered infrastructure-related in-water and subject to NPDES compliance-focused restoration include the following:

- **Timber Bridge Removal**: The Renewal Corporation will remove the timber bridge at J.C. Boyle. The Renewal Corporation will regrade the embankments as needed to approximate pre-existing contours . Re regraded slopes will be revegetated with native plants, per the project NPDES permit. Upon completion of this project element, the temporary construction infrastructure will be removed, and the riverbanks will be restored in accordance with the SWPPP.
- **City of Yreka Pipeline Replacement**: By agreement with the City of Yreka, the Renewal Corporation will remove the existing water pipeline from its current elevation. The water pipeline will be replaced by the Renewal Corporation and buried deeper under the re-established mainstem Klamath River. The pipeline will be installed by the Renewal Corporation using open trench methodologies with a cofferdam and temporary river diversion during construction. Upon completion of this work, the cofferdam will be removed, and the riverbanks will be restored in accordance with the SWPPP.
- **Daggett Bridge Replacement:** The Renewal Corporation will replace a culvert and construct a temporary bridge adjacent to Daggett Bridge for construction traffic. Upon completion of this work, the Renewal Corporation will remove the temporary bridge. The riverbanks will be restored in accordance with the SWPPP.
- **Additional Culvert Replacement/Upgrades:** There are several areas where the Renewal Corporation will replace culverts, or construct temporary access roads to facilitate construction traffic. The Fall Creek and Dry Creek culvert replacements are required for construction access. The Camp Creek and Scotch Creek culvert replacements are to promote post-drawdown fish passage. In these areas, once the old culverts are removed and the new access road installed, the areas immediately upstream and downstream of the culverts will be recontoured and revegetated by the Renewal Corporation with native riparian and wetland seed mixes, as appropriate. Upon completion of this work, the Renewal Corporation will remove temporary access roads and restore the riverbanks in accordance with the SWPPP.
- **Historic Bridge Pier Removal:** The Renewal Corporation will remove remnant wooden bridge piers constructed prior to the filling of the J.C. Boyle reservoir. Limited grading will be necessary to provide equipment access and these disturbances will be restored by the Renewal Corporation to match existing, adjacent contours. Upon completion of this work, the Renewal Corporation will remove temporary work structures and restore the riverbanks in accordance with the SWPPP.

- **Long Gulch Culverts Removal:** Historical photos and bathymetric surveys indicate the presence of at least two (2) submerged culverts along Long Gulch upstream of Iron Gate Dam. It appears that these culverts were placed during Iron Gate dam construction and left in place when the reservoir was filled. The Renewal Corporation will remove these culverts, grade the adjacent banks and floodplain to match adjacent contours, and restore the streambanks in accordance with the SWPPP.

5.2 Adaptive Design and Implementation

The restoration measures within the reservoir footprints will follow a feedback loop centered around systematic adaptive design and implementation. Channel response within the mainstem Klamath and priority tributaries will be monitored by the Renewal Corporation following drawdown, and information obtained during the monitoring process will be used by the Renewal Corporation to inform decisions regarding design for active restoration (construction) or continued monitoring of channel response. This process is illustrated in Figure 5-1.

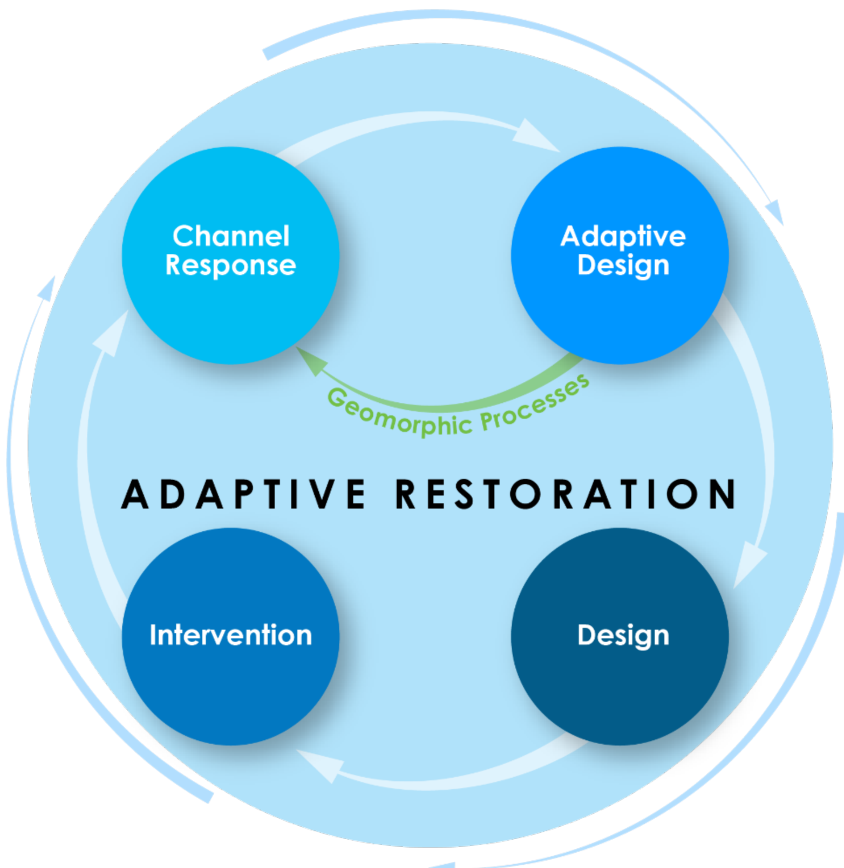


Figure 5-1. Adaptive Design Feedback Loop

Primary restoration actions by the Renewal Corporation for the reservoirs will be the following: (1) reservoir drawdown, (2) sediment evacuation, and (3) dam removal. Additional restoration actions by the Renewal Corporation will be performed to provide volitional fish passage, selectively stabilize residual sediments, and encourage native plant establishment. In addition, supplemental restoration actions by the Renewal Corporation will be taken to enhance aquatic habitat in prioritized locations.

Restoration actions described herein include a tool chest of options to be applied by the Renewal Corporation depending upon post-drawdown conditions and subsequent design. These include the following:

- Implementing measures to encourage sediment evacuation during drawdown.
- Reconstructing a geomorphically appropriate channel through the former dam footprints.
- Selective post-drawdown grading of mainstem near-channel areas and key tributaries as needed to provide volitional fish passage, remove large, unstable residual sediment deposits, and where cost-effective and feasible, improve hydrologic connectivity to off-channel and floodplain areas to establish and sustain native riparian vegetation and enhance aquatic habitat.
- Installing large wood and boulder clusters to enhance habitat.
- Installing willow baffles to provide floodplain roughness and to encourage vegetation establishment and selectively stabilize sediments.
- Revegetating formerly inundated areas primarily through seeding to slow erosion and re-establish native plant communities.
- Selectively planting and irrigating locally salvaged and/or nursery-sourced plants, including wetland sod, willow cuttings, bare root trees and shrubs, and acorns.
- Controlling high-priority IEV prior to, during, and following construction where cost-effective and feasible.
- Fencing select locations to protect restored reservoir areas from trampling and herbivory by cattle and wild horses.

5.2.1 Assisted Sediment Evacuation

A primary objective during the reservoir drawdown period is to maximize natural erosion and evacuation of stored reservoir sediments. This objective has two (2) purposes: (1) to reduce the amount of unnatural, stored sediment remaining on the historical floodplain and reservoir area surfaces and (2) to minimize the potential for future sediment releases in the Klamath River. For a median water year, hydraulic modeling predicted that approximately half of the stored sediment would naturally erode and vacate the reservoir area (BOR, 2011b). Existing sediment in the reservoir area is highly erodible and has a high water content. To further maximize the amount of sediment eroded during drawdown, the Renewal Corporation will use additional manual augmentation during drawdown as described below. The assisted sediment evacuation work window will be limited to January 1-March 15 of the drawdown year.

The Renewal Corporation will use sediment jetting with an air-boat-mounted water jet to maximize stored sediment erosion at the Copco No. 1 and Iron Gate Reservoirs. This approach is not anticipated at the J.C. Boyle Reservoir. Sediment jetting will occur as conditions allow, predicated by hydrologic conditions of the drawdown year, and will be primarily focused on high-priority tributaries and the mainstem channel margins, with work occurring at low-priority tributaries as conditions and time allow. If airboat sediment jetting becomes infeasible due to hydrologic conditions, the Renewal Corporation will mount pump and hose apparatus on side-by-side utility terrain vehicles for land-based applications.

During reservoir drawdown, and if access allows, the Renewal Corporation will grade reservoir sediment to promote evacuation by water flowing the tributaries and mainstem river using machinery such as small excavators. Culturally sensitive areas will be designated by the Renewal Corporation prior to drawdown to ensure that these areas are not entered with machinery. The Renewal Corporation will perform area grading between January 1 and March 15 of the drawdown year and will only grade depositional surface sediment and will not extend below the historical pre-dam ground surface.

Potential assisted sediment evacuation methods rely on flowing water in either the river or a tributary to transport sediment away from the site. Application sites will either be located directly adjacent to or upslope and draining to a tributary and/or the river. Reservoir areas that become exposed and are treated but are not adjacent to flowing water will need to rely on applied water to wash the actively eroded sediment downslope to the reservoir pool. When it meets the reservoir pool, some portion will remain suspended, and some portion will resettle. Similarly, the interface (confluence) where the flowing tributaries and river meet the reservoir will be a place where eroded sediment will resettle, forming a temporary delta. As the reservoir pool lowers, the tributary or river will transport this newly deposited delta sediment as well as incoming sediment from the active sediment evacuation methods being employed upstream or adjacent to the confluence area. Thus, the volume (load) of sediment being eroded and carried downstream in the tributary or river will increase as the reservoir pool lowers and the cumulative volume of sediment from sources upslope and upstream increases.

For optimal sediment evacuation, the sediment eroded from upslope and upstream locations will need to be transported downstream as well as the sediment in the newly formed delta deposits at the confluences with the lowering reservoir pool. Because of this, adequate flows in the tributaries and the river are critical for active sediment evacuation activities. Active measures to increase discharge in the river are infeasible. However, the channels of the tributaries are relatively small and, therefore, pumps and temporary pipelines could be used by the Renewal Corporation to convey reservoir water upstream to the point of maximum reservoir elevation (the location of upstream extent of the aggraded sediment deposits) and discharge that water into the tributary channel. The augmented flow would boost the ability of that tributary to transport sediment downstream to its confluence with the comparatively larger Klamath River where river flows will be sufficient to entrain and transport that sediment out of the reservoir.

Specifically, the Renewal Corporation does not expect that J.C. Boyle will require assisted sediment evacuation due to low sediment thicknesses and valley confinement along the lower reach. The Renewal Corporation does anticipate assisted sediment evacuation for Copco No. 1 and Iron Gate, and planned locations were ranked as primary or secondary. Primary locations are more involved and include a greater focus area, which includes active sediment evacuation along the main channel, riparian/floodplain, and tributary channels. Secondary locations focus on tributary connectivity, and sediment evacuation is confined within the channel. For Copco No.

1, three (3) primary sediment evacuation areas were identified by the Renewal Corporation and include the historic side channel complexes located upstream of Ward's Canyon, the Beaver Creek and Copco No. 1 Unnamed Tributary 2 confluence, and a portion of the Klamath River upstream and downstream of the Deer Creek confluence. Four secondary locations were identified by the Renewal Corporation for Copco No. 1 and include the confluences of Copco No. 1 Unnamed Tributary 1, Raymond Gulch, Spannaus Gulch, and Long Prairie Creek. Three primary evacuation areas were identified the Renewal Corporation for Iron Gate and include the Long Gulch confluence, the Camp Creek confluence, and the Jenny Creek confluence. Iron Gate had three (3) secondary sediment evacuation locations identified and they include the confluences of Long Gulch, Iron Gate Unnamed Tributary 1, and Fall Creek.

5.2.2 Selective Grading

The expanded and connected tributary confluences at the mainstem channel will allow for a range of dynamic geomorphic processes to support resilient habitat structure and fish passage conditions. Select grading will be performed by the Renewal Corporation as needed to do the following:

- Remove unnatural, erosion-resistant deposits that create fish passage barriers (such as the coarse delta deposits at Jenny Creek and the Camp Creek complex)
- Stabilize un-evacuated sediment at vulnerable high-sediment-yield locations

Additional grading might occur at select locations to enhance wetland and/or floodplain connectivity when appropriate.

On the perennial tributaries, the existing riparian vegetation is typically located within a vertical band ranging from one (1) ft to six (6) ft above the channel invert; this serves as a basis for selective grading actions on the priority tributaries. In addition, selective grading may be used by the Renewal Corporation to lay back tributary channel banks (for example, 3H:1V slopes on alternating banks) opportunistically to mimic reference channel geometries and support revegetation. Areas for selective bank grading will be identified and prioritized based on location of other restoration actions and depending on observed and monitored post-drawdown conditions.

5.2.3 Tributary Connectivity

As reservoir water surfaces are lowered during drawdown and beyond, priority tributaries will be further exposed creating longer reaches of free-flowing water conditions (for a discussion of actions related to the connectivity of tributaries outside the reservoir footprints, please see the Tributary Connectivity Management Plan). Newly exposed tributaries will flow over depositional areas of fine sediment that will likely be transported downstream during and following reservoir drawdown; however, some larger sediment and debris may create fish passage barriers or unnatural discontinuities in the longitudinal profile. To rectify this, the Renewal Corporation will use light equipment and manual labor to move materials and enhance access and longitudinal connectivity of the tributaries with the mainstem Klamath River. In addition, the Renewal Corporation may add large wood to tributaries either in the channel or on the floodplain/terrace to promote habitat and complexity and connectivity as further described below. Figure 5-2 shows and example of wood toe installed to increase fringe roughness and improve bank stability.

Another aspect of tributary connectivity is volitional fish passage. Many of the tributaries have road crossings at the reservoir water surface with culverts and stream crossings that do not allow volitional fish passage. Copco Road culverts at Camp Creek and Scotch Creek, as well as the Daggett Road crossing of Fall Creek, will be replaced by the Renewal Corporation to allow fish passage upstream of the roadway. In addition, the Renewal Corporation will remove historical tributary crossings of Long Gulch within the Iron Gate reservoir inundation zone.

5.2.4 Riverbank Stability and Channel Fringe Complexity

Lack of initial roughness along channel margins results in higher than normal near-bank velocity and shear stress. This increase in active channel margin energy negatively affects aquatic species by requiring increased energy for migration and holding while also transporting desired gravels and materials that otherwise form depositional features downstream. Velocity shadows created by bankline complexity (i.e., vegetation, rootwads, etc.), large wood, and boulders create regions of complex hydraulic interactions that provide resting zones, feeding seams, cover, and velocity refugia during high flow (See Figure 5-2). Priority tributary reaches that will benefit from these treatments are typically single thread, where the channel is laterally confined. In addition, bank roughness can improve bank stability and reduce unnatural erosion that degrades water quality. Channel fringe complexity is best improved through the strategic addition of large wood as described in the following section and the establishment of riparian vegetation. Likewise, this restoration technique will not be implemented where it will disrupt natural, process-based channel and floodplain evolution within the reservoir areas.

Figure 5-2. Example of Toe Wood Being Installed to Improve Fringe Complexity
Source: M. Adams, 2017

5.2.4.1 Large Wood Features

The Renewal Corporation will introduce large wood habitat features in high-priority tributaries, primarily to create and support microhabitats for salmonid species. Large wood features provide both short- and long-term habitat enhancement for fish and other aquatic species and provide hydraulic variability and complexity for in-channel areas and floodplains. Large wood features will be installed by the Renewal Corporation along high-priority tributaries for two (2) main functions:

- In-channel habitat enhancement that will provide cover, shade, velocity refuge, and foraging areas for fish and other aquatic species
- In-channel hydraulic complexity, including connectivity with floodplains, providing roughness, and flow guidance to enhance and encourage sediment transport and volitional fish passage

5.2.4.2 Large Wood Feature Design

Large wood feature design and implementation will emulate natural river processes to allow all wood to be dynamic and provide long-term complexity. Further, large wood facilitated geomorphic processes of scour and deposition within and outside of the channel. The Renewal Corporation will strategically place each large wood feature based on post-drawdown topographic and hydraulic conditions. No artificial anchoring will be used by the Renewal Corporation to ballast wood elements. Cultural resources will be evaluated and considered by the Renewal Corporation for specific wood design locations, and any ground placement during implementation activities will be coordinated with cultural specialists or on-site tribal monitors.

The Renewal Corporation will primarily place large wood habitat features in tributaries and will consist of several rootwad logs or trees placed in strategic arrangements or complexes. Helicopter-placed large wood will be installed in the spring and summer of the drawdown year to provide immediate floodplain roughness and promote sediment evacuation. Ground-placed large wood will be installed along the priority restoration tributary channels to provide in-water habitat complexity and promote pool and streambank stability. The Renewal Corporation will implement large wood by using a combination of ground and aerial helicopter methods based on the specific location and post-drawdown conditions. The Renewal Corporation will install wood at various orientations depending on function and may be clustered to increase complexity and diversity. Rootwads are an important component of the structure and when submerged provide complex cover for juvenile salmonids as well as locations for macroinvertebrates and other food sources to reside. Placement and orientation of multiple structures will be used to create areas of flow constriction, direct or turn flow, and to induce scour.

Basic design parameters for large wood structures are listed in Table 5-2. The exact design, architecture, placement locations, and material characteristics for each structure will be determined by the Renewal Corporation based on actual topographic field conditions during and after the reservoir drawdown phase.

Table 5-2. Large Wood Features

PLACEMENT TYPE	TYPE OF WOOD	DIMENSIONS	BALLAST METHOD
Ground Based Placement	Rootwad logs	12-24 in. diameter 35-50 ft in length	natural earth materials or dug into existing bank
Aerial Helicopter Placement	Full Length trees	18-30 in. diameter 50-100 ft in length	None

5.2.4.3 Large Wood Stability

Mobility is defined here as displacement of placed wood by buoyant and hydrodynamic forces. Tolerances for mobility depend on the risk associated with relocation of materials. Factors of safety and other design criteria were derived from guidance from BOR's Large Woody Material Risk Based Design Guidelines, (BOR, 2014). Criteria for resistance to movement are expressed as a combination of target design floods and associated factor of safety. Large wood stability calculations can be found in Appendix G.

There are two (2) main risk considerations for large wood: public safety and property protection. The main public safety concern is boater safety as the Klamath River will be used for whitewater kayaking, rafting, and fishing. While this use will be focused on the mainstem of the Klamath River, rather than the tributaries where large wood will be located, the project area is preliminarily categorized by the Renewal Corporation as a relatively low public safety risk. This risk factor was based on hydraulic modeling and risk assessment of the primary tributaries and their interaction with the mainstem Klamath River. Hydraulic conditions for both the 10-year and 25-year event were compared to the Risk-Based Guidelines (BOR, 2014) and it was determined that the appropriate category for public safety is Low. In addition, the risk of property damage for the project area is also considered ow based on the following conditions:

- Limited number of in-channel structures following dam removal, including existing bridges and future recreational boat docks.
- Limited number of structures located in the floodplain immediately downstream of the dams.
- Future land use of former reservoirs as open space.

The minimum factor of safety and design storm event for large wood stability were selected based on the values recommended by the BOR (2014) – reproduced in Table 5-3.

Table 5-3. Minimum Recommended Factors of Safety from BOR (2014)

PUBLIC SAFETY RISK	PROPERTY DAMAGE RISK	STABILITY DESIGN FLOW CRITERIA	FACTOR OF SAFETY		
			SLIDING	BUOYANCY	ROTATION AND OVERTURNING
High	High	100-year	1.75	2.0	1.75
High	Moderate	50-year	1.5	1.75	1.5
High	Low	25-year	1.5	1.75	1.5
Low	High	100-year	1.75	2.0	1.75
Low	Moderate	25-year	1.5	1.75	1.5
Low	Low	10-year	1.25	1.5	1.25

Source: Table 4, Large Woody Material Risk Based Design Guidelines (BOR, 2014).

Due to the location of the wood placement in the reservoir areas and risk assessment, the recommended design storm event for large wood stability is the 10-year event (Table 5-3). The risk level is categorized as Low for public safety, and therefore, the design factor of safety for the 10-year storm event will be as follows:

- Sliding – 1.25
- Buoyancy – 1.5
- Rotation and Overturning – 1.25

Preliminary stability calculations based on anticipated drawdown characteristics can be found in Table 5-3. The Renewal Corporation will design large wood habitat features to the factor of safety specifications for the 10-year design storm event, but this will be highly dependent on geomorphic evolution trajectory during post-dam removal topography and corresponding hydraulic conditions. Design information based on actual post-drawdown conditions be re-evaluated and refined by the Renewal Corporation to finalize large wood stability calculations. Under larger storm events, the habitat elements may be subject to movement and may shift within the tributary corridor and reservoir area, much like natural wood movement and ecological processes.

5.2.4.4 Large Wood Placement

The Renewal Corporation will place large wood features at high-priority tributaries, particularly focused on the mainstem confluences and adjacent floodplain or off-channel wetlands. The Renewal Corporation will base the location and density of large wood features on post-drawdown topographic and hydraulic conditions. On-site field representatives will define exact geographic locality, arrangement, and architecture of each large wood complex during implementation. Density will be based on field observations and will be consistent with the Southern Oregon Northern California Coast Coho Salmon Recovery Plan (NOAA and NMFS, 2014).

5.2.4.5 Other Habitat Enhancement features

In addition to large wood, the Renewal Corporation will install willow baffles and boulder clusters along the high-priority tributaries. Both features are detailed on Sheet R0804 of the design drawings. Willow baffles are live roughness elements installed on the floodplain to reduce flow velocities and trap fine sediment. Willow baffles are proposed as short-term measures to help stabilize newly exposed channel overbank areas until riparian revegetation establishes. Willow baffles are 'hedges' of willow poles planted perpendicular to the flow direction. The poles are densely planted in trenches that are back-filled with soil and small rock to provide some initial resistance to flow. Willow baffles will be approximately 15 to 30 feet long and should be spaced between 60 to 120 feet apart adjacent to the channel.

The Renewal Corporation will install small clusters of locally sourced, oversized boulders (approximately two [2] to six [6] ft in diameter) at select locations along high-priority tributaries to enhance habitat. The number and size of boulders will vary depending on location and function. Clusters of three (3) to 10 boulders will be used by the Renewal Corporation to break up high-flow fields, encourage site-scale sediment sorting and provide resting for migrating adult anadromous fish. Generally, boulder clusters will be located by the Renewal Corporation with intent of preserving existing riffles or in predicted high velocity areas to provide velocity shelter. Denser boulder fields (up to 12 boulders, depending on tributary size) may be installed adjacent to near-channel wetlands to locally elevate water levels and enhance connectivity.

The Renewal Corporation will place boulder clusters using land-based equipment in readily accessible areas. For the tributaries, boulders will be two (2)- to four (4)-foot diameter sourced on-site. Boulder placement will be staggered downstream, with adequate spacing between boulders to allow flow-through.

5.2.5 Wetlands, Floodplains, and Off-Channel Habitat Features

Incorporating natural features, such as surface undulations, into newly exposed floodplains is a restoration strategy that promotes ecosystem diversity and natural processes. Based on historical pictures, it appears that three (3) main types of floodplain features could be supported on the newly exposed floodplain areas: wetlands, floodplain swales, and side channels. Likewise, floodplain roughness features can be incorporated to further instigate natural processes while enhancing wildlife habitat.

Wetlands are depressional or low-lying features with standing water or saturated soils for a portion of the growing season that are sufficient to support wetland vegetation such as willows, sedges, and rushes. Wetlands provide a wide range of ecological functions such as water quality improvement, flood attenuation, and habitat for both terrestrial and aquatic organisms. Including wetlands in restoration will help address several limiting factors including water quality and lack of habitat diversity for wildlife. Wetland restoration strategies for the reservoir areas include preservation of existing wetlands, hydrologic connection of off-channel wetlands with the river, or creation of new wetlands at lower elevations corresponding to the post-dam removal surfaces and hydrologic regime.

Floodplain swales are small depressional areas incorporated into the floodplain that provide microsites where floodplain vegetation can establish at slightly lower elevations (closer to the water table) than adjacent floodplain surfaces. Floodplain swales also provide storage for flood water and sediment at variable flows, in addition to broadening the range of ecological niches available on the floodplain surface to support different life stages (and behaviors) of plant, bird, amphibian, and many other terrestrial wildlife species. To maximize diversity, floodplain swales vary in size and depth, but do not extend below the anticipated baseflow elevation.

Side channel restoration is a strategy to improve in-stream habitat diversity. Side channels provide off-channel habitat for juvenile rearing and high-flow refugia for other aquatic species. Like floodplains, side channels exchange water, sediment, and nutrients between the main channel and off-channel areas, thus supporting diverse vegetation communities. Side channel restoration strategies include modifying inlet and outlet hydraulics, improving hydraulic complexity with wood structures or realignment, and delivery of water to higher floodplain surfaces.

Floodplain roughness is a technique applied to newly exposed areas where frequent interaction with the river channel is anticipated. In addition, floodplain roughness helps address the initial geomorphic limiting factor on the newly exposed areas—lack of established, stable vegetation. Floodplain roughness also reduces browse pressure by making access more difficult, particularly for geese, which require unobstructed runways for landing and takeoff. Installation of roughness features creates complexity and microsites on new floodplain surfaces to trap and protect seed and other plant propagules and to provide resistance to erosion by reducing velocities and limiting rill formation. Floodplain roughness is created using equipment to roughen the floodplain surface with microtopography and partially bury brush, limbs, and wood in the soil. Microtopography creates variation in the constructed floodplain surface ranging from 0.5 ft above to 0.5 ft below the existing or design floodplain surface. Brush, limbs, and wood in the soil will increase moisture retention, create protective microsites for establishing seed and plants, and promote soil development by introducing organic material. Ultimately, restoration actions should lead to vegetative cover, as illustrated in Figure 5-3**.**

Figure 5-3. Example of Existing Floodplain Features Upstream of Copco No. 1 Reservoir (i.e., Wetland Area)

Source: KRRC, 2018

5.2.6 Wetland Preservation and Restoration

Wetland restoration actions will provide ecological uplift associated with restoration of stream miles and protection of existing reservoir independent wetlands. There are three (3) key types of wetlands in the area, differentiated by their source hydrology (Figure 5-4).

Reservoir Independent Wetlands: Existing wetlands that are not anticipated to be impacted by drawdown are termed "reservoir independent wetlands." These are wetlands that likely have hydrologic inputs separate from the reservoir. If there is restoration enhancement or construction activities in their vicinity of reservoir independent wetlands, the Renewal Corporation will install a 20-ft exclusion fence to avoid impacts (i.e., the placement of dredge or fill material) in these preservation features.

Reservoir Dependent Wetlands: Existing fringe wetlands or wetlands that otherwise are hydrologically connected to the reservoir's pre-drawdown will likely be desiccated over time; however, these areas may opportunistically serve as source materials for wetland creation sites elsewhere. They also may persist. As such, these areas do not require the installation of a 20-ft buffer, but the Renewal Corporation will direct construction activities away from these sites to the extent practicable.

Potential Wetland Creation: The Renewal Corporation will document post-drawdown wetland hydrology conditions using aerial data collection methods to verify/identify depressional features and hillslope seep or spring-fed areas with a high potential for wetland creation. If located within the tributary priority restoration zones, these areas may be graded to enhance the topography and foster wetland hydrology and the survival of hydrophytic vegetation. If these areas are located outside priority tributary restoration zones, they will be delineated by the Renewal Corporation and treated with hydrophytic vegetation as appropriate.

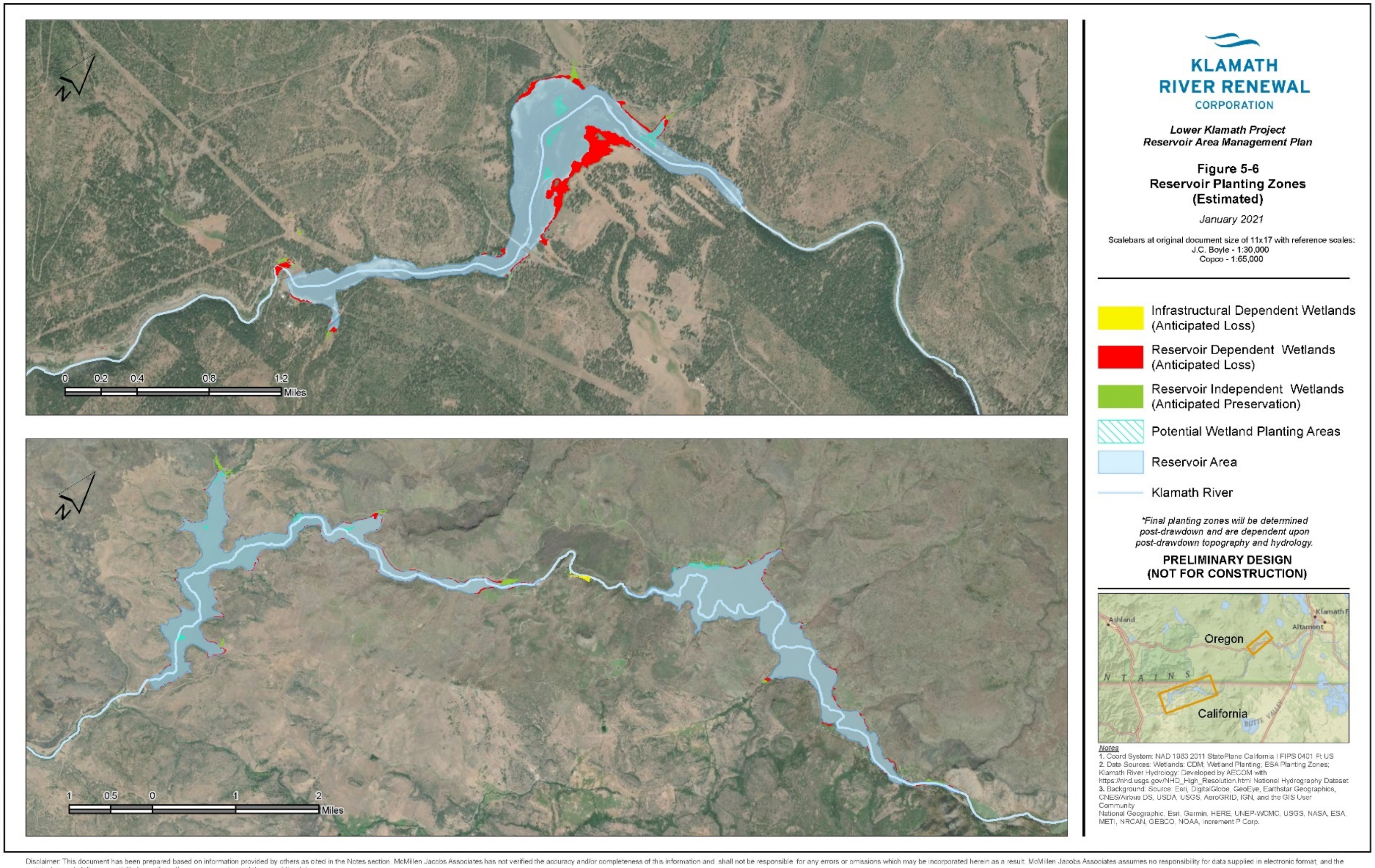


Figure 5-4. Reservoir Planting Zones (Estimated)

5.3 Revegetation

The Renewal Corporation will follow this framework in revegetation design:

- Develop an additive layering system within each broad vegetation community type that (1) sets a matrix condition with seed and then (2) builds upon the matrix condition with supplemental woody species plantings where appropriate.
- Provide flexibility to respond to unfolding field conditions and subtleties in the landscape such as remnant wetland/riparian vegetation, post-drawdown soil conditions, microtopography, soil moisture, seeps, rocky areas, and drainages within each planting zone.
- Create a tool that will support revegetation post-drawdown as well as short- and long-term adaptive management efforts.
- Use inexpensive and robust plant material in the form of seed, cuttings, and bare root stock that are easily transported, establish well in difficult restoration conditions, cost much less per plant than container plants, and reduce the likelihood of spreading pathogens such as phytophthora.
- Plant bare root woody species in dense clusters within the seeded matrix to concentrate resources, increase survival rates via facilitation mechanisms and create island patches of trees and shrubs that will accelerate vegetation structural diversity and community development.
- Use existing adjacent vegetation cover types and post-drawdown topography and soil conditions to guide revegetation efforts.
- Allow for modifications to planting densities within an area while adhering to the total quantity of plant material being installed and managed to better mimic the subtle changes in densities across communities and the strata (tree, shrub, groundcover) within those communities.
- Incorporate salvaged wetland vegetation (sod, plugs or woody vegetation) opportunistically.

The Renewal Corporation will achieve revegetation of the exposed reservoirs through a combination of IEV management, seeding native herbaceous and woody species, planting bare root trees and shrubs and natural recruitment of vegetation.

The Renewal Corporation plans to use irrigation in the Iron Gate and Copco No. 1 newly established riparian areas as needed, and strategically place fencing around high-priority restoration areas.

5.3.1 Plant Material Collection and Propagation

A variety of plant materials will be used to revegetate the reservoirs including:

- Seed
- Bare root plants

- Container plants
  - Herbaceous plugs
  - Woody plants
- Live cuttings
  - Pole cuttings
  - Live-stakes
- Salvaged material
- Natural, native vegetation colonization

Proposed collection and propagation methods for seed and plant material are discussed in Sections 5.3.1.1 through 5.3.1.4.

5.3.1.1 Seed Collection, Propagation, and Storage

Forbs and grass seeds are the foundation of the restoration seed mix. Approximately 32,400 to 90,000 pounds of pure live seed (80 to 100 pure live seeds per square foot [ft^2]) are anticipated to seed the 1,800-acre restoration area twice. Seed weight varies by species; therefore, the number of pounds of pure live seed also varies. For each target species, seeds are collected from sites within the watershed or from an adjacent watershed of similar elevations and are selected to ensure representative genetic variation. Future collections will follow similar guidelines. Collections began in 2018 and continued in 2019 and 2020. Additional collections are planned for the 2021 season and beyond, as needed. The total number and distribution of collection sites varies according to size, density, continuity of populations, and biology of the species sampled, as well as the desired quantity of seed to be obtained. Seed collection as described in the 2018 Definite Plan Report is being employed throughout the collection areas for the Proposed Action. Boundaries for all collection areas are depicted in Figure 5-5. Seeds collected to date are summarized in Appendix H.

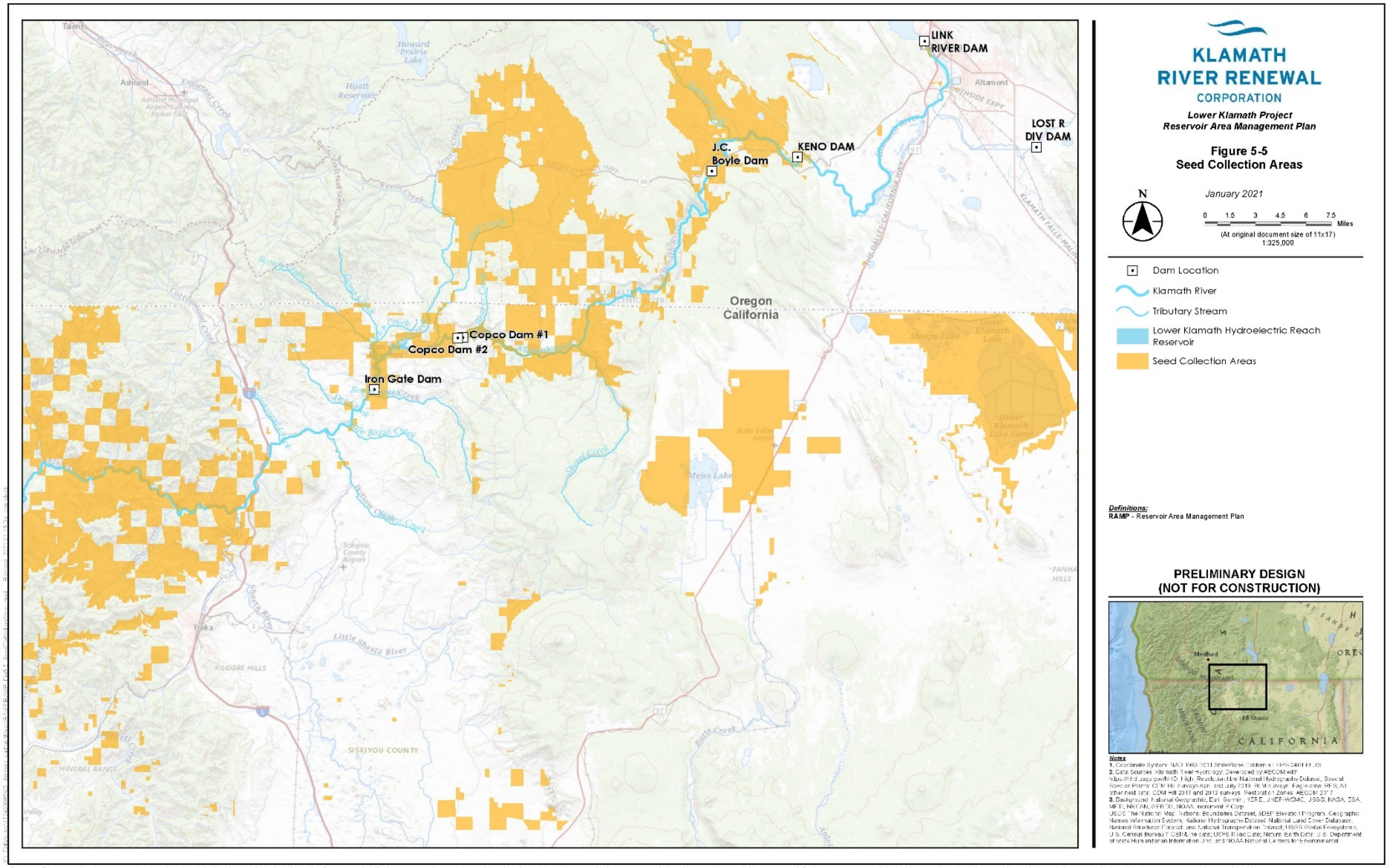


Figure 5-5. Seed Collection Areas

Seed collection methods are tailored to maximize volume of seed collected, depending on the species. Grass seed is harvested by stripping or shaking it off the stem, or by clipping the stem with scissors or small scythes just below the spikelet. Shrub seed is picked or lightly beaten or shaken using a tarp to catch the falling seed. For species that dehisce explosively, the entire inflorescence is cut prior to maturity and allowed to dry in mesh, paper bags, or under netting. Ladders, tree climbing, or light pruning with telescoping pole pruners are used for seed collection from taller shrubs and trees. Collections are conducted in a manner that does not damage existing vegetation or other resources. At least 50 percent of the seed crop at a given site is left intact to allow for natural recruitment and regeneration of the native population. Botanists closely monitor seed maturation to match the timing of seed collection. Collectors made multiple trips to a site to determine when the seed was mature and ready for collecting. Collection throughout the maturation period prevented inadvertent selection for early- or late-maturing genotypes. Field data sheets (Appendix H) have been and will continue to be used to document seed collections.

Genetically appropriate, commercially available seeds were purchased when available, supplementing total number of seeds intended for increase fields to ensure species diversity and to obtain the quantities of seed needed to meet Project goals. Purchases were made from the following growers:

- Silvaseed Company in Roy, Washington
- Bureau of Land Management (Medford, Oregon Office) via Rogue Native Plant Partnership
- BFI Native Seeds in Moses Lake, Washington
- Klamath Siskiyou Native Seeds in Applegate, Oregon
- Local ‘micro-growers’ in the Rogue Valley via Rogue Native Plant Partnership

Wild native seeds collected from the Klamath watershed are the primary source of seed for the Project. This is because such seeds are locally adapted and more likely to survive. The first contracted seed increase fields were established in 2019. Additional fields were established in the winter of 2019 and the fall and winter of 2020, and more fields are contracted for the spring of 2021. Multiple nurseries in the region have been contracted for seed yield increase operations to achieve the target seed quantities for the variety of native species best suited to restoring the former reservoirs. Propagating native species is not a common endeavor, and expertise for each species varies by nursery. Current contracts for seed are expected to produce about a minimum of 43,000 pounds of seed from 28 species, providing enough seed to complete at least two (2) applications at 80 seeds per ft^2 (Appendix H). Nurseries commercially producing seed for this Project include the following:

- BFI Native Seed in Moses Lake, Washington
- S&S Seed in Carpinteria, California
- Hedgerow Farms in Winters, California
- Corvallis Plant Material Center in Corvallis, Oregon
- J. Herbert Stone Nursery in Central Point, Oregon

Many ecologically important species are unsuccessful when grown commercially but can be collected directly from the wild and added to seed mixes. Although the total volume of wild collected seed will be low compared to the volume produced from increase fields, wild collected seed provides important ecologically and culturally significant species to the revegetation project that can be selectively added to seed mixes in strategic locations. *Lomatium* species are particularly important culturally and are known to perform well in seed mixes. Wild collected seed collected to date includes the 25 native species listed in Table 5-4.

Table 5-4. Wild Collected Seed Currently in Storage for the Proposed Action (as of Fall 2020)

SPECIES	COMMON NAME	HABITAT	TYPE
Acmispon americanus	Spanish lotus	Riparian/Wetland	Annual forb
Balsamorhiza deltoidea	deltoid balsamroot	Upland	Perennial Forb
Bidens frondosa	Devil’s beggartick	Riparian/Wetland	Annual forb
Carex nebrascensis	Nebraska segde	Riparian/Wetland	Perennial Sedge
Carex praegracilis	clustered field segde	Riparian/Wetland	Perennial Sedge
Carex simulate	short-beaked sedge	Riparian/Wetland	Perennial Sedge
Carex subbracteata	small bract sedge	Riparian/Wetland	Perennial Sedge
Distichlis spicata	saltgrass	Riparian/Wetland	Perennial Grass
Grindelia nana	Idaho gumweed	Upland	Perennial Forb
Lomatium californicum	California lomatium	Upland	Perennial Forb
Lomatium dissectum	fernleaf biscuitroot	Upland	Perennial Forb
Lomatium macrocarpum	bigseed biscuitroot	Upland	Perennial Forb
Lomatium nudicaule	barestem biscuitroot	Upland	Perennial Forb
Lomatium triternatum	nineleaf biscuitroot	Upland	Perennial Forb
Lupinus albifrons	Silver bush lupine	Upland	Perennial Forb
Lupinus andersonii	Anderson’s lupine	Upland	Perennial Forb
Lupinus latifolius	broadleaf lupine	Upland	Perennial Forb
Monardella odoratissima	Mt mondardella	Upland	Perennial Forb
Penstemon deustus var deustus	hot rock penstemon	Upland	Perennial Forb
Penstemon laetus	Mt blue penstemon	Upland	Perennial Forb
Penstemon speciosus	Royal penstemon	Upland	Perennial Forb
Persicaria amphibia	water smartweed	Riparian/Wetland	Perennial Forb

SPECIES	COMMON NAME	HABITAT	TYPE
Phacelia heterophylla var. *virgate*	varied leaf phacelia	Upland	Perennial Forb
Stipa occidentalis	Lemon's needlegrass	Upland	Perennial Grass
Xanthium strumarium	rough cocklebur	Riparian/Wetland	Perennial Forb

Note: Seed collection began in 2018. Cleaning and testing is in progress for seed collected in 2020.

The seeds will be stored until Proposed Action implementation. Proper storage is imperative to ensure viability as overheating can kill seeds; therefore, excessive heat and temperature fluctuations should be avoided. Prolonged high-moisture environments during storage can promote mold growth and reduce vitality. Seeds are stored at nurseries with adequate, monitored storage facilities to minimize the potential for catastrophic loss due to improper storage. Each of the nurseries follows the University of California, Davis Seed Biotechnology Center guidance that the sum of temperature (degrees Fahrenheit) and relative humidity (percent) should not exceed 100 (U.C. Davis, 2020); commonly known as the "100 rule of thumb." Seed is stored with the following nurseries:

- Sampson Creek Reserve near Ashland, Oregon
- BFI Native Seed in Moses Lake, Washington
- Hedgerow Farms in Winters, California
- Pacific Coast Seed in Tracy, California
- Corvallis Plant Material Center in Corvallis, Oregon

Additional information on seed increase facilities is provided in Appendix H.

5.3.1.2 Native Bare Root Plants

The Renewal Corporation will propagate bare root material (trees, shrubs, and herbaceous) and plant this material into former reservoirs to add woody plant diversity and structure in seeded areas. The Renewal Corporation will prioritize for propagation woody species that are the primary components of the surrounding existing plant communities and are tolerant of clay soils. In addition, direct seeding (i.e., acorns) and containerized root stock will also be used. Seed used to propagate bare root or container plants will be collected from the watershed or adjacent areas to ensure genetic integrity. The Renewal Corporation's production target is 260,000 woody plants from a minimum of 33 species.

Herbaceous species that are difficult to seed will be propagated in small containers. These include wetland species, such as salt grass, and showy species, such as royal penstemon (*Penstemon speciosus*). Rhizomatous species, including showy milkweed (*Asclepias speciosa*), will also be propagated and planted as rhizomes.

Bare root propagation requires one (1) to two (2) years, depending on the species. Many species are ready after one (1) growing season and are shipped in late winter. The first round of bare root plants will be ready to plant immediately after dam removal, maximizing survival rates in the moist sediments; if drawdown period hydrologic conditions permit. Bare root materials will be stored temporarily at facilities close to the dams in a location to be determined. Plants will be removed from shipping bags and stored in mulch piles to keep the root systems moist until planting. Bare roots will be stored a maximum of six (6) weeks.

Bare root plant materials will be tested for *Phytophthora* sp., a plant pathogen detrimental to native plant communities. A minimum of five (5) percent of all bare root material will be tested. Any detections of *Phytophthora* in a particular species will result in removal of all plants of that species (from the same nursery) from the Proposed Action. Exact testing methods are to be determined based on current science and expert recommendations. More information regarding bare root plant collection is provided in Appendix H.

5.3.1.3 Pole Cutting and Live Stake Cutting Collection and Storage

Pole cuttings are a component of the large wood features, willow baffles, mixed willow clusters, and cottonwood clusters. Pole planting should occur after November 20, when plants are dormant. Ideally, live cottonwood and willow pole cuttings are collected after leaves have fallen from donor plants; however, due to construction scheduling and the quantity of pole cuttings necessary for each reservoir, pole collection may occur sooner. Pole cuttings will be collected as close to complete dormancy as feasible. Pole cuttings will be collected from an equal amount of male and female donor plants. Pole cuttings may be purchased from a nursery, from plants growing along the river, or from logs, stumps, or other horticultural methods that produce hardwood poles of the desired species, sex, lengths, and diameter.

Pole cutting diameter is a good proxy of the amount of energy reserves stored in the cutting and desiccation vulnerability. Smaller diameter poles need more poles installed in each planting to ensure that one (1) pole survives, whereas larger diameter poles require fewer poles per planting to ensure survival. Live hardwood pole diameters at the largest end should be 1.5 in. minimum and three (3) in. maximum. Live hardwood poles lengths should be a minimum length of 10 ft..

Following collection, the smaller diameter end of each hardwood pole will be color coded with latex paint to indicate plant species and pole direction, facilitating layout. After pole cuttings are color coded, they will be bundled into groups of 25 and soaked. Each bundle will be prepared with a mixture of diameter ranges and an equal number of male and female poles. Individual bundles will be labeled with an aluminum tag that may indicate the collector(s), species, number of males and female poles (if possible), date and location of collection, the date soaking began and ended, and a unique identification number for tracking the survivorship of poles from each bundle after installation. Poles will be soaked for no more than 16 days and no less than seven (7) days before planting; poles will be submerged approximately two-thirds their length.

In the event that pole cuttings cannot be immediately installed after soaking, poles will be placed in cold storage. Poles can be stored for up to six (6) months (at five [5] degrees Celsius, 41 degrees Fahrenheit) but most repeat the soaking cycle for approximately four (4) to five (5) days prior to installation.

Pole cuttings will be delivered to the revegetation site in tagged bundles of 25 poles, with a minimum of 2,300 pole cuttings being used. Delivery to the jobsite from storage needs to be carefully coordinated to ensure that pole cuttings do not dry out. The best assurance would be to deliver to the site no more poles than can be planted within 24 hours after removal from storage. If daily average air temperatures exceed 27 degrees Celsius (80 degrees Fahrenheit), on-site poles should be temporarily stored in the shade under wet burlap sacks. Poles that are not used in a day should be wrapped in wet burlap sacks and stored in a cool location until the next planting day.

Live-stake cuttings will be used for direct staking into riparian and wetland areas that do not require heavy equipment for planting. Approximately 25,750 live-stakes will be used. Live-stake cutting diameters should be 0.25 in. minimum and one (1) in. maximum. Cutting lengths should be a minimum of 24 or 48 in., depending on application and to be specified by the restoration designer. Management and storage of live-stake cuttings will follow the same methods as for pole cuttings described above.

5.3.1.4 Native Plant Salvage

During reservoir drawdown, the Renewal Corporation will identify for relocation areas of opportunistic salvage of native plants presently around the reservoir rim. Salvageable native plants will be installed immediately to newly exposed wetlands or riparian areas. Wetland sod will be opportunistically salvaged by hand or using heavy equipment. Small woody species (trees and shrubs) may also be salvaged during drawdown.

5.3.2 Planting Strategies and Species

The following subsections describe the Renewal Corporation's proposed methods for seeding and installing woody material, including species that are expected to be planted.

5.3.2.1 Seeding Strategies and Species

The Renewal Corporation's objectives in seeding native herbaceous species include the following:

- Supplement natural revegetation
- Minimize surficial erosion of sediment
- Accelerate vegetation cover
- Minimize nonnative plant establishment

Most of the seeding will be by hand using belly grinders or other manual methods. Seed mixes will be modified for elevation. There will be a minimum of two (2) seeding events with pioneer seeding mixes sown immediately after reservoir drawdown and secondary seed mixes (diversity mixes) being sown in a year or two. Additional seeding may be needed during the maintenance and monitoring period (see Section 6.3, Revegetation Adaptive Management).

Pioneer and diversity seed species are discussed in the following sections; however, the Renewal Corporation will continue to refine species lists based on the following:

- Observed species patterns around all three (3) reservoirs
- Seed availability
- Propagation feasibility
- Likelihood of species to colonize naturally, including the following:
    - Long-distance dispersal ability
    - Presence in the seed bank
    - Seed maturation season

The Renewal Corporation's proposed planting palette differs somewhat between the dam sites, as described in Sections 5.4.6, 5.5.6, and 5.6.6. Estimated planting areas are depicted in Figure 5-6; however, these estimations are based on hydrology estimates from the Yurok Tribe, and the actual planting plan will depend upon post-drawdown conditions.

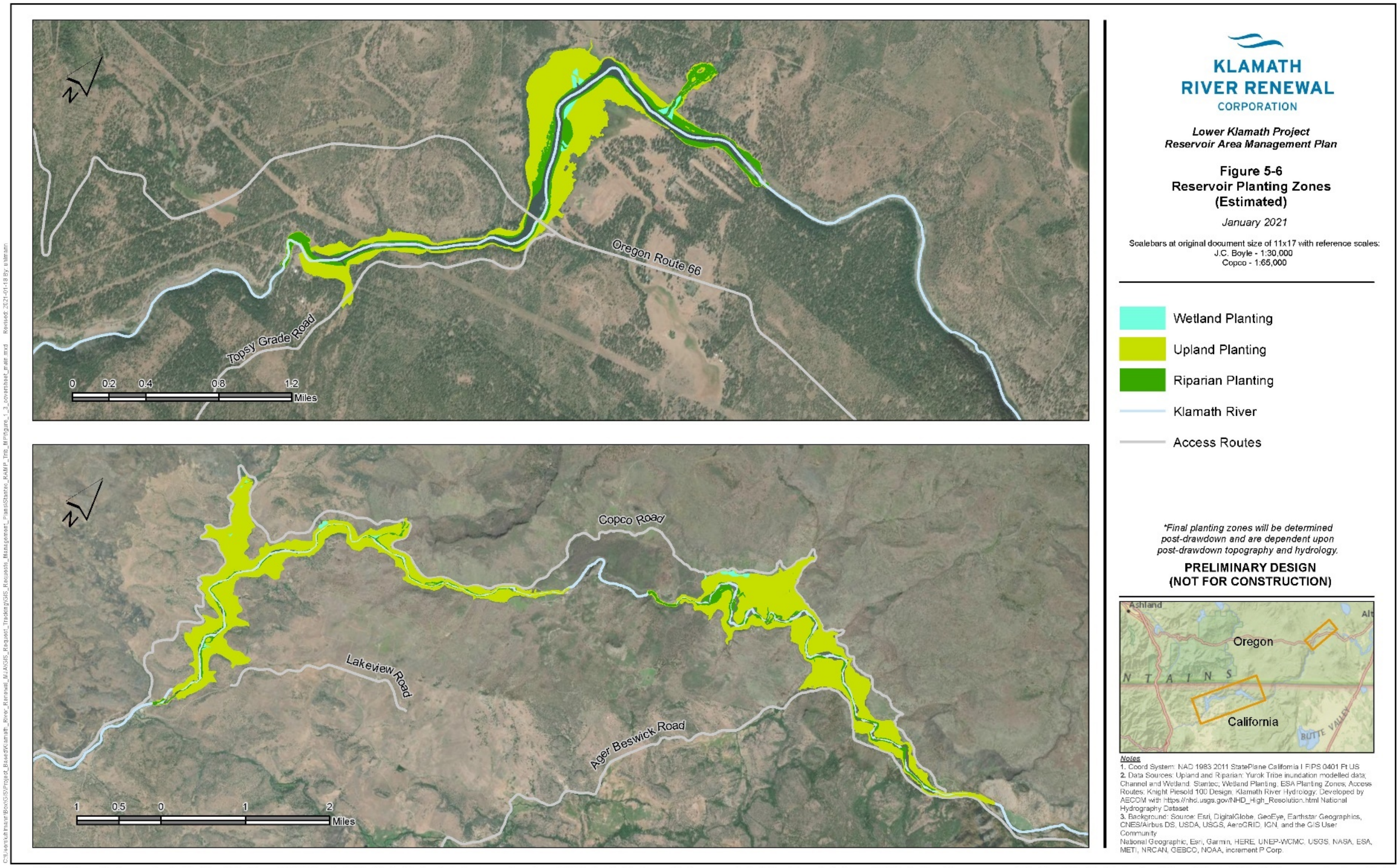


Figure 5-6: Reservoir Planting Zone (Estimated)

Note: Final planting may vary significantly and will be based on post drawdown conditions.

5.3.2.1.1 Pioneer Seed Mixes

The Renewal Corporation will apply two pioneer seed mixes: one (1) for upland areas and one (1) for wetland/riparian areas. The primary function of the pioneer mixes is to break apart the soil crust, begin the development of a more complex soil structure, create pore space for precipitation penetration, support development of the soil microbial ecosystem, and create cover over the soil to prevent erosion and support future plantings. The design criteria prescribes inclusion of up to seven (7) forb species and a minimum of four (4) grass-like species in the pioneer mix. This approach prioritizes using the greatest diversity of species possible for the initial seed mix. High diversity introduced early in plant succession is an important strategy to ensure success in unprecedented ecological conditions. High species diversity and richness provides ecosystem resilience over time. Seeding immediately after dam removal will also ensure good establishment rates because of the residual moisture left behind by reservoir drawdown. Both pioneer seed mixes will be sown immediately after reservoir drawdown before the sediments dry out. Seeds will be applied at a rate of 80 to 100 seeds per ft^2. Actual seed mix species composition, including species percentages, will be determined during final design and will be based on the results of seed collection and production results from seed increase fields.

The Renewal Corporation will apply pioneer seed mixes as soon as practicable following drawdown while the sediment and remaining soil is holding moisture. During the following winter and early spring, over-seeding diversity mixes are proposed to add to species diversity where needed and seed areas that performed poorly during the first summer. Seed will be broadcast by hand, from helicopters and/or other mechanical seeding methods (i.e., all-terrain vehicle-mounted seeders) in areas difficult to access on foot. Proposed species for, respectively, the upland and riparian pioneer seed mixes are provided in Tables 5-5 and 5-6, respectively.

Table 5-5. Species List for the Upland Pioneer Seed Mixes

SPECIES	COMMON NAME
Achillea millefolium	common yarrow
Amsinckia menziesii	Menzies' fiddleneck
Bromus carinatus	California brome
Croton setigerus	turkey mullein
Drymocallis glandulosa	sticky cinquefoil
Elymus elymoides	squirreltail
Elymus glaucus	blue wildrye
Elymus spicatus	blue bunch wheat grass
Eriophyllum lanatum	Oregon sunshine
Eschscholzia californica	California poppy

SPECIES	COMMON NAME
Festuca idahoensis spp. roemeri	Roemer's fescue
Grindelia camporum	great valley gumweed
Koeleria macrantha	June grass
Lupinus microcarpus var. densiflorus	chick lupine
Lupinus microcarpus var. microcarpus	valley lupine
Mentzelia laevicaulis	smoothstem blazingstar
Penstemon roezlii	Rozel's penstemon
Penstemon speciosus	royal penstemon
Poa secunda	Sandberg's bluegrass
Solidago elongata	Cascade goldenrod
Stipa lemmonii	Lemmon's needlegrass
Trichostema lanceolatum	Vinegarweed

Note: The list and ratios of species will be modified by reservoir and depend on final seed production results.

Table 5-6. Species List for the Riparian Pioneer Seed Mixes

SPECIES	COMMON NAME
Artemisia douglasiana	California mugwort
Deschampsia cespitosa	California hairgrass
Drymocallis glandulosa	sticky cinquefoil
Elymus cinereus	great basin wildrye
Elymus glaucus	blue wildrye
Elymus triticoides	creeping wildrye
Grindelia camporum	great valley gumweed
Hordeum brachyantherum	meadow barley
Hordeum jubatum	foxtail barley
Trichostema lanceolatum	vinegarweed

Note: The list and ratios of species will be modified by reservoir and depend on final seed production results.

5.3.2.1.2 Diversity Seed Mixes

The Renewal Corporation will undertake a second round of seeding designed to add species diversity, reseed areas not meeting success criteria, and seed areas impacted by construction in the summer and fall of 2023. Wild collected seed will be selectively added to the base mix of species used in the pioneer mix. Anticipated species to be included in diversity mixes are provided in Tables 5-7 and Table 5-8. The diversity seed applied at a given reservoir will be tailored to include species local to that reservoir (see site-specific discussions in in Sections 5.4.6, 5.5.6, and 5.6.6). These mixes will incorporate more perennial, forb, and woody species as well as additional sedge and rush species (Table 5-7). The diversity mixes will be seeded in the fall of 2023 and early spring of 2024, depending on species availability from seed increase fields and weather conditions. When the application window for these two (2) mixes approaches, the landscape will have had at least one (1) season to respond to the drawdown, and managers will be able to identify pioneer seed success and failures, natural regeneration patterns, and emerging habitat zones for appropriate application locations. This will allow for a more strategic (i.e., adjusting seeds per ft^2 as needed) and successful application of seed mixes that are more expensive and in limited supply. Areas identified with dense vegetation that is not native or has low diversity may be prepped prior to seeding to ensure that open ground and sunlight are available. Surface preparations will include tilling or other surface roughening and/or mowing tall vegetation.

Table 5-7. Potential Riparian/Wetland Species for Diversity Seed Mixes

SPECIES	COMMON NAME	LIFEFORM	SEED STATUS
Acmispon americanus	Spanish lotus	Annual forb	Stored (PCS)
Bidens frondosa	Devil's beggarticks	Annual forb	Stored (HRF, CPMC)
Carex nebrascensis	Nebraska sedge	Perennial sedge	Stored (CPMC)
Carex praegracilis	clustered field sedge	Perennial sedge	Stored (CPMC)
Carex simulata	short beaked sedge	Perennial sedge	Stored (CPMC)
Deschampsia danthonioides	annual hairgrass	Annual grass	Stored (HRF)
Erythranthe guttata	yellow monkey flower	Annual/Perennial forb	To be collected
Hordeum depressum	Alkali barley	Annual grass	To be collected
Juncus occidentalis	western rush	Perennial rush	Stored (HRF)
Kyhosia bolanderi	Bolander's tarweed	Perennial forb	To be collected
Muhlenbergia richardsonis	mat muhly	Perennial grass	To be collected
Paspalum distichum	Knotgrass	Perennial grass	To be collected
Persicaria amphibia	water smartweed	Perennial forb	Stored (CPMC)

SPECIES	COMMON NAME	LIFEFORM	SEED STATUS
Sidalcea oregana	Oregon checkermallow	Perennial forb	To be collected
Stipa lemmonii	Lemmon's needlegrass	Perennial grass	Stored (HRF)
Trifolium willdenovii	Tomcat clover	Annual forb	To be collected
Xanthium strumarium	Cocklebur	Annual forb	Stored (HRF, CPMC)

Notes:
CPMC = Corvallis Plant Material Center, Oregon
HRF = Hedgerow Farms in Winters, California

Table 5-8. Potential Upland Species for the Diversity Seed Mixes

SPECIES	COMMON NAME	LIFEFORM	SEED STATUS
Amsinckia menziesii	Menzies' fiddleneck	Annual forb	To be collected
Acmispon americanus	Spanish lotus	Annual forb	Stored (CPMC)
Angelica arguta	Lyall's angelica	Perennial forb	To be collected
Artemisia tridentata	big sagebrush	Shrub	Stored (JHS)
Danthonia californica	California oatgrass	Perennial grass	To be collected
Ericameria nauseosa	Rabbitbrush	Shrub	To be collected
Festuca microstachys	small fescue	Annual grass	To be collected
Grindelia nana	Idaho gumweed	Perennial forb	Stored (RNPP)
Lomatium macrocarpum	bigseed biscuitroot	Perennial forb	Stored (RNPP)
Lomatium nudicaule	barestem biscuitroot	Perennial forb	Stored (RNPP)
Lomatium triternatum	nineleaf biscuitroot	Perennial forb	Stored (RNPP)
Monardella odoratissima	mountain mondardella	Perennial forb	Stored (RNPP)
Penstemon deustus	rock penstemon	Perennial forb	Stored (RNPP)
Perideridia bolanderi	Bolander's yampah	Perennial forb	Stored (RNPP)
Phacelia heterophylla var. virgata	varied leaf phacelia	Perennial forb	Stored (RNPP)
Poa secunda	Sandberg's bluegrass	Perennial grass	To be collected
Stipa lemmonii	Lemmon's needlegrass	Perennial grass	Stored (CPMC)
Stipa occidentalis	western needlegrass	Perennial grass	To be collected

Note:
CPMC = Corvallis Plant Material Center, Oregon
JHS = J. Herbert Stone Nursery, Oregon
RNNP = Rogue Native Plant Partnership, Oregon

Exact composition of species mixes will vary and the Renewal Corporation will continue to refine the composition based on the following:

- Observed species patterns around all three (3) reservoirs (see Sections 5.4.6, 5.5.6, and 5.6.6)
- Seed availability
- Propagation feasibility
- Likelihood of species to colonize naturally, including the following:
    - Long-distance dispersal ability
    - Presence in the seed bank
    - Seed maturation season

5.3.2.1.3 Mulching

Where application is feasible, the Renewal Corporation will apply native straw mulch or sterile wheat mulch as a seeding mulch on bare soils and exposed sediment. The Renewal Corporation's outdoor seed germination tests found that the straw mulch greatly improved germination and survival of seedlings (RFI RES-08). The study suggested that the mulch served two (2) key purposes: it retained surface soil moisture and it offered the seedlings thermal protection from below-freezing nighttime temperatures.

Straw mulch is commonly used to aid in germination and protect exposed soils in many types of seeding and erosion control applications. The risk of applying straw mulch is that the straw may contain unwanted weed seeds. The native straw mulch will be procured in advance to monitor for the presence of weedy species. The native straw mulch or sterile wheat straw mulch will be applied with the pioneer seed mix after drawdown in select areas. During subsequent years, the widespread use of straw mulch will not be necessary. Straw mulch can be used as an adaptive management technique in areas that show poor coverage and require reseeding.

The Renewal Corporation is also considering using other types of mulch such as wood chips or shavings and pine needle shavings for adaptive management of strategic locations.

5.3.2.1.4 Irrigation

The Renewal Corporation will install irrigation systems as needed in the riparian areas of Iron Gate (approximately 109 acres) and Copco No. 1 (approximately 98 acres) to increase likelihood of seeding success, facilitate establishment of native vegetation, and promote stabilization of the floodplain of the Klamath River and its tributaries within the Project Area post-drawdown. Additional areas will receive supplemental irrigation, with primary focus on south facing slopes with lower soil moisture, as needed to meet vegetative success criteria and achieve sediment stabilization. Wide-scale irrigation use is not anticipated for any parts of the Limits of Work/Restoration after the drawdown year. Water used for irrigation will be pumped directly from the Klamath River or tributaries, with diversion points being determined at a later time as needed. Water rights will be obtained by the Renewal Corporation, and diversions will comply with all local permitting conditions.

5.3.2.2 Woody Species Planting Strategies and Species

The Renewal Corporation will plant native woody species to supplement natural and seeded vegetation, enhance slope stability, accelerate succession of trees and shrubs, and provide habitat for fauna. The majority of bare roots and container plants will be installed immediately following drawdown, if possible. Trees and shrubs will be planted in distinct clusters (facilitation patches), with specifications outlined in an annual planting plan. Planting in dense clusters, as opposed to spreading out the plants, lowers the density per acre and is preferred because high density patches more closely mimic early plant successional patterns. This will increase overall survival rates of plants due to facilitation mechanisms common to ecosystems in extreme climates (Callaway, 1995).

As with seed source (Section 5.3.1.1), the proposed planting palette for trees and shrubs will vary based on availability and tailored to each reservoir (see Sections 5.4.6, 5.5.6, and 5.6.6). Proposed species that may be used are listed in Table 5-9. Additional native woody species may be considered based on data collected from reference sites.

Table 5-9. Native Tree and Shrub Species Palette for Restoration Sites

SCIENTIFIC NAME	COMMON NAME	STRATA
Acer macrophyllum	bigleaf maple	Tree Layer
Alnus rhombifolia	white alder	Tree Layer
Amelanchier alnifolia	western serviceberry	Tree Layer
Amelanchier utahensis	Utah serviceberry	Shrub Layer
Artemisia tridentata	big sagebrush	Shrub Layer
Berberis aquifolium	Oregon grape	Shrub Layer
Calocedrus decurrens	incense cedar	Tree Layer
Ceanothus cuneatus	buckbrush	Shrub Layer
Ceanothus integerrimus	deerbrush	Shrub Layer
Ericameria nauseosus	rubbery rabbitbrush	Shrub Layer
Cornus glabrata	smooth dogwood	Shrub Layer
Cornus sericea	red-osier dogwood	Shrub Layer
Ericameria bloomeri	rabbitbush	Shrub Layer
Fraxinus latifolia	Oregon ash	Tree Layer
Juniperus occidentalis	western juniper	Tree Layer
Lonicera interrupta	chaparral honeysuckle	Shrub Layer
Philadelphus lewisii	Lewis' mock orange	Shrub Layer
Physocarpus capitatus	ninebark	Shrub Layer
Pinus contorta var. marrayana	lodgepole pine	Tree Layer
Pinus lambertiana	sugar pine	Tree layer

SCIENTIFIC NAME	COMMON NAME	STRATA
Pinus ponderosa	ponderosa pine	Tree Layer
Prunus emarginata	bitter cherry	Tree Layer
Prunus subcordata	Klamath plum	Tree Layer
Prunus virginiana	chokecherry	Tree Layer
Pseudotsuga menziesii	Douglas-fir	Tree Layer
Purshia tridentata	antelope bitterbrush	Shrub Layer
Quercus garryana	Oregon white oak	Tree Layer
Quercus kelloggii	California black oak	Tree Layer
Rhus trilobata	skunkbush sumac	Shrub Layer
Ribes cereum	wax currant	Shrub Layer
Ribes velutinum	desert gooseberry	Shrub Layer
Rosa gymnocarpa	dwarf rose	Shrub Layer
Rosa woodsii	wood rose	Shrub Layer
Salix exigua	coyote willow	Tree Layer
Salix lasiolepis	arroyo willow	Tree Layer
Salix lucida ssp. lasiandra	shining willow	Tree Layer
Sambucus nigra	blue elderberry	Shrub Layer
Spiraea douglasii	rose spirea	Shrub Layer
Symphoricarpos albus	common snowberry	Shrub Layer

See Section 5.3.2.1.4 for a discussion of irrigation.

5.3.2.2.1 Fencing

The Renewal Corporation will make strategic use of temporary fencing at priority tributary restoration sites to prevent browsing of newly planted vegetation. This use of fencing is constrained by construction access, flooding, and cost-effectiveness. Fencing installation will need to be modified in some locations based on topography and obstructions (e.g., steep slopes, rocks, trees). Where feasible, exclusion zones will be created around each of the proposed restoration areas rather than protecting individual plants with tubes. Fencing is intended to exclude cows and horses. The only fencing currently contemplated is fencing of priority tributary sites; fencing of stream crossing areas will be minimized.

The Renewal Corporation will install taller fencing to protect against deer and other native herbivores if herbivory becomes a management problem. The Renewal Corporation is not proposing taller fencing at this time but will investigate such fencing as an adaptive management practice if it observes unacceptable levels of herbivory by deer.

5.3.3 Invasive Exotic Vegetation (IEV) Management

Non-native plant species currently are common in the area and are expected to recolonize disturbed areas following dam removal. Many non-native species provide beneficial habitat elements for wildlife species in the vicinity. Others may provide less benefit but are not priorities for removal either because of their low ecological impact or difficulty to contain. A number of non-native species are considered to be detrimental and are medium to high priorities for control or removal by regulatory agencies. These species are referred to here as IEV.

Dam removal will create large areas devoid of vegetation, providing opportunities for IEV to colonize and attain dominance. Post-drawdown reservoir footprints are particularly susceptible to invasion by IEV. If left unchecked, invasive species establishing in the former reservoir areas will degrade potential salmon habitat by dispersing propagules (seeds, rhizomes) downstream. Managing IEV will be a concern at all three (3) reservoir areas. Iron Gate, and to some extent Copco No. 1, will be particularly challenging as those areas have the most aggressive and widespread existing IEV coverage adjacent to the Project boundaries.

The IEV management period covers pre-dam removal (2021-2022) and the dam removal and restoration phase (2023-2024). IEV management will be completed annually in early season and late season implementation phases, as necessary, to maximize IEV treatment effectiveness for specific plant species. The post-restoration period from 2024 to 2029 will be managed under a forthcoming, IEV management strategy (to be produced in 2024 and updated annually) and based on the status and abundance of IEV in 2024.

5.3.3.1 Existing IEV Populations and Species Prioritization

PacifiCorp document IEV in the lower Klamath River watershed in 2002-2003 (PacifiCorp, 2004). The Renewal Corporation revisited PacifiCorp's documentation of IEV in 2017 and 2018 (KRRC, 2018). Existing IEV coverage ranges from approximately 16 percent at J.C. Boyle to 19 percent at Copco No. 1 and 75 percent at Iron Gate. The Renewal Corporation developed a prioritized target list of 52 invasive species based on data collected during field studies in 2018 (KRRC, 2018) and modified the IEV priority list to reflect 2019 agency ratings (Tables 5-10 and 5-11). The Renewal Corporation will continue to adaptively manage the priority list as conditions on-the-ground and agency priorities change. Of the 52 species of concern identified on the priority list, only 22 were present in the latest survey by the Renewal Corporation 2018. Fourteen of the 22 species have been identified as high or medium priority for treatment (see Table 5-10), with eight (8) being low treatment priority species (Table 5-11).

Table 5-10. Medium and High Treatment Priority IEV Species

SCIENTIFIC NAME	COMMON NAME	PRIORITY	TOTAL OBS	CONTROL OPPORTUNITY	
				ERADICATION	CONTAINMENT
Onopordum acanthium	Scotch thistle	High	2	High	-

SCIENTIFIC NAME	COMMON NAME	PRIORITY	TOTAL OBS	CONTROL OPPORTUNITY	
				ERADICATION	CONTAINMENT
Centaurea diffusa	diffuse knapweed	High	1	High	-
Acroptilon repens	Russian knapweed	High	1	High	-
Linaria dalmatica	Dalmatian toadflax	High	1	High	-
Isatis tinctorial	dyer's woad	Medium	1	High	-
Bromus madritensis ssp. rubens	foxtail brome	Medium	4	High	-
Foeniculum vulgare	fennel	Medium	2	High	-
Xanthium spinosum	spiny clotbur	Medium	1	High	-
Rubus armeniacus	Himalayan blackberry	Medium	54	Moderate	Moderate
Bromus tectorum	cheatgrass	Medium	185	Low	High
Centaurea solstitialis	yellow starthistle	Medium	107	Low	High
Dipsacus fullonum	teasel	Medium		Low	High
Elymus caput-medusae	medusahead	Medium		Low	High
Phalaris arundinacea	reed canarygrass	Medium		Low	High

Table 5-11. Low Treatment Priority IEV Species

SCIENTIFIC NAME	COMMON NAME	PRIORITY	TOTAL OBS	CONTROL OPPORTUNITY	
				ERADICATION	CONTAINMENT
Brassica nigra	Black mustard	Low	4	High	-
Bromus diandrus	ripgut grass	Low	4	High	-
Cirsium arvense	Canada thistle	Low	5	High	-
Conium maculatum	poison hemlock	Low	9	High	-
Festuca arundinacea	tall fescue	Low	9	High	-
Hypericum perforatum	St. John's wort	Low	2	High	-
Lepidium draba	hoary cress	Low	53	Moderate	Low

SCIENTIFIC NAME	COMMON NAME	PRIORITY	TOTAL OBS	CONTROL OPPORTUNITY	
				ERADICATION	CONTAINMENT
Cirsium vulgare	bull thistle	Low	93	Low	Low

5.3.3.2 IEV Control Methods, Including Targeted Use of Exclusion Fencing

The Renewal Corporation will implement two (2) primary strategies for IEV treatment: eradication and containment. Species to be contained are those that are ubiquitous on the landscape, those in close proximity to all restoration areas, and those that cannot be realistically eradicated or contained for long periods, including cheatgrass (*Bromus tectorum*), medusahead (*Elymus caput-medusae*), and yellow starthistle (*Centaurea solstitialis*). The strategies were determined for each species and were based on abundance on the landscape and the cost-effectiveness of treatments. Treatments will be adaptively managed through a robust quantitative monitoring program.

Treatments will require a combination of methods including mechanical (grubbing, mowing) and chemical. Chemical treatments will be minimized and used only on species that are not effectively treated mechanically.

IEV identified in the Project Limits of Work (Figure 1-6) were individually evaluated to determine effective control methods using federal, state, and local recommendations (i.e., California Invasive Plant Council Management guidelines). The following control methods are proposed to be used for IEV control:

1. Grubbing (hand pulling) is effective for controlling small IEV infestations, emerging infestations, or infestations at the fringes of a large patch. Grubbing (hand pulling) is typically more effective on annual species and species that are not rhizomatous but can be used for perennial species if the populations are small and/or young. Grubbing will be done with hand tools such as Pulaskis, shovels, or other digging tools. Efforts will be made to minimize soil disturbance when possible. Large patches of *Rubus armeniacus* may be grubbed using large equipment (i.e., excavators) during construction activities when possible.
2. Mowing or cutting (using weed trimmers and mowers) for invasive annuals will be employed as a containment strategy to reduce production in biennials and perennials, exhaust the nutrient reserves, and reduce plant vigor, as well as decrease the buildup of thatch. Mowing is considered an effective containment strategy for the most abundant IEV species (*Bromus tectorum, Centaurea solstitialis, Dipsacus follunum,* and *Elymus caput-medusae*) (DiTomaso et al., 2013) and will only be employed in areas with extensive, near-monoculture stands of IEV to avoid mowing native species. For this to be effective, mowing must be repeated two [2] to three [3] times during the growing season for three (3) or more years to be effective (DiTomaso et al., 2013). A buffer of 50 to 100 ft mowed regularly should prevent seed dispersal into the reservoirs after

drawdown because these species all disperse seed short distances in the wind (DiTomaso et al., 2013).

   a. Mowing will primarily be accomplished with string trimmers. Large rocks, steep terrain, and other features on the landscape preclude the effective use of tractor-based mowers. Trimmers can handle the terrain better and presents less risk of sparking wildfire. Trimmers will also allow for the preservation of important native species such as *Lupinus argenteus* and woody shrubs within the mowed area, providing residual vegetation capable of seeding into the mowed areas.

3. Solarization may be used only in areas where there are small patches of invasive vegetation (i.e., reed canarygrass). Solarization will be accomplished using thick, non-translucent black plastic or other heavy duty weed fabric capable of smothering a population and blocking all sunlight.
4. Herbicides will be used for species that are not suited to mechanical removal techniques. Only herbicides that have been approved for use by the Bureau of Land Management, CDFW, ODFW, Regional Water Quality Control Boards, USFWS and NMFS in both California and Oregon, and the Renewal Corporation and Native American Tribes, will be considered. Herbicides will be applied in fall, winter, and early spring and will be rotated when possible to reduce herbicide resistance. Spot spraying, the primary method that we will employ on this Project, is used for species-specific control. All herbicides are applied according to label specifications and by a California Licensed Qualified Applicator and approved by the U.S. Environmental Protection Agency (EPA). Herbicides will only be used to control species not suited to mechanical removal methods. Application timing and locations will be designed to minimize chemical contamination of waterways. When necessary, populations that are close to water will be treated with AquaNeat®, the only herbicide identified for use on IEV near water. AquaNeat® is an herbicide designed for use in aquatic environments and is approved by EPA for use in or near water.

   Herbicides recommended for treatment include the following:

   a. Glyophosate (Roundup®, Roundup Pro®, AquaNeat®)
   b. Aminopyralid (Milestone®)
   c. Chlorosulfuron (Telar®)
   d. Aminocyclopyrachlor + chlorosulfuron (Perspective®)
   e. Triclopyr (Garlon 3A®)
   f. Imazapyr (Habitat®, Arsenal ®, Stalker®, others)
   g. Dicamba (Banvel®, Clarity®)

   This list is not comprehensive. As new information becomes available on recommended treatment, additional herbicides may be added. Any new herbicides and/or surfactants proposed will be provided to the pertinent agencies prior to use. Glyphosate is generally only effective for the season that it is applied for perennial or woody species, and it is non-selective, affecting all vegetation in the area of treatment. This can create significant bare ground for new weeds to colonize. Application of this herbicide will be formulated to minimize impacts to native plants and will be mostly employed as a spot treatment for small populations. Bare ground that is created by all herbicide use will be seeded and/or planted with native species within a year. Additional IEV control methods that may be employed include the following:

a. Tilling and disking is an agricultural weed eradication method in solid stands of invasive species, in order to disrupt and bury the plant or to separate the root from the plant after soil dries out to have the largest impact. This method will be employed only in level heavily infested areas where erosion is not a concern and culturally significant resources are not expected. If used, seeding of pioneer as well as native species will follow the tilling/disc event to promote native growth to outcompete the invasive species. This method will be best employed on areas outside the reservoirs that are impacted by deconstruction activities.
b. Grazing may be used for control of invasive vegetation palatable for cattle, sheep and goats and the timing, quantity and will select the type of livestock to address different invasive species.

Proposed treatments for the 52 identified IEV species are provided in Table 5-12.

Table 5-12. Proposed Treatments for IEV Species Known to Occur or That May Occur, in the Project Area

SPECIES	PRIORITY	PRIMARY	SECONDARY	ADDITIONAL
Onopordum acanthium	High	Grub	Aminopyralid	Glyphosate
Centaurea diffusa	High	Grub	Aminopyralid	Glyphosate
Acroptilon repens	High	Grub	Aminopyralid	-
Linaria dalmatica	High	Grub	Aminopyralid + chlorosulfuron	Glyphosate
Isatis tinctoria	Medium	Grub	Aminopyralid + chlorosulfuron	-
Bromus madritensis ssp. *rubens*	Medium	Grub/Mow	Glyphosate	Aminopyralid
Foeniculum vulgare	Medium	Chop	Glyphosate	-
Xanthium spinosum	Medium	Grub	Will not use herbicide	
Rubus americanus	Medium	Mow/Grub	Glyphosate	Triclopyr
Bromus tectorum	Medium	Mow	Glyphosate	Aminopyralid
Centaurea solstitialis	Medium	Mow	Glyphosate	Aminopyralid
Dipascus fullonum	Medium	Mow	Aminopyralid	-
Elymus caput-med	Medium	Mow	Glyphosate	Aminopyralid
Phalaris arundinacea	Medium	Mow	Glyphosate	Solarization

SPECIES	PRIORITY	PRIMARY	SECONDARY	ADDITIONAL
Brassica nigra	Low	Mow/Grub	Will not use herbicide	
Bromus diandrus	Low	Mow/Grub	Glyphosate	Aminopyralid
Cirsium arvense	Low	Mow/Grub	Aminopyralid	-
Conium maculatum	Low	Mow/Grub	Glyphosate	-
Festuca arundinacea	Low	Mow/Grub	Glyphosate	Imazapyr
Hypericum perforatum	Low	Mow/Grub	Aminopyralid	Glyphosate
Lepidium draba	Low	Mow/Grub	Chlorosulfuron	Glyphosate
Cirsium vulgare	Low	Mow/Grub	Will not use herbicide	
WATCH LIST				
Centaurea virgata ssp. *squar*	High	Mow/Grub	Aminopyralid	Glyphosate
Euphorbia esula	High	Mow/Grub	Aminopyralid + chlorosulfuron	-
Onopordum tauricum	High	Mow/Grub	Aminopyralid	Glyphosate
Carduus acanthoides	High	Mow/Grub	Will not use herbicide	
Carduus nutans	High	Mow/Grub	Will not use herbicide	
Centaurea stoebe ssp. *micr*	High	Mow/Grub	Aminopyralid	Glyphosate
Cytisus scoparius	High	Mow/Grub	Will not use herbicide	
Lepidium latifolium	High	Mow/Grub	Chlorosulfuron	Glyphosate
Lythrum salicaria	High	Mow/Grub	Triclopyr	-
Fallopia japonica	High	Mow/Grub	Imazapyr	Glyphosate
Sonchus arvensis	High	Mow/Grub	Glyphosate	-
Tamarix parviflora	High	Mow/Grub	Imazapyr	Triclopyr
Anchusa officinalis	Medium	Mow/Grub	TBD	-
Cirsium ochrocentrum	Medium	Mow/Grub	Will not use herbicide	
Convolvulus arvensis	Medium	Mow/Grub	Glyphosate	Imazapyr
Crupina vulgaris	Medium	Mow/Grub	Will not use herbicide	
Halogeton glomeratus	Medium	Mow/Grub	Will not use herbicide	
Linaria vulgaris	Medium	Mow/Grub	Aminopyralid + chlorosulfuron	Glyphosate
Salvia aethiopis	Medium	Mow/Grub	Glyphosate	Aminopyralid

SPECIES	PRIORITY	PRIMARY	SECONDARY	ADDITIONAL
Tribulus terrestris	Medium	Mow/Grub	Dicamba	Glyphosate
Aegilops cylindrica	Low	Mow/Grub	Will not use herbicide	
Avena barbata	Low	Mow/Grub	Will not use herbicide	
Hirschfeldia incana	Low	Mow/Grub	Will not use herbicide	
Hordeum murinum	Low	Mow/Grub	Will not use herbicide	
Leucanthemum vulgare	Low	Mow/Grub	Will not use herbicide	
Marrubium vulgare	Low	Mow/Grub	Will not use herbicide	
Mentha pulegium	Low	Mow/Grub	Will not use herbicide	
Persicaria wallichii	Low	Mow/Grub	Will not use herbicide	

IEV treatment will require a multi-year approach to ensure that containment or eradication goals are achieved. Treatment will begin during pre-drawdown site preparation activities, will continue through demolition, and will extend two (2) to three (3) years post-drawdown and into the monitoring period. Although total eradication or prevention of IEV in the reservoirs is not possible, the strategy will be to minimize IEV presence during the crucial native plant establishment phase, providing desirable native vegetation a competitive advantage for several years.

The strategies for controlling IEV will differ for each revegetation period. Prior to dam removal, restoration staff will work at the watershed scale to eradicate and contain established populations to limit the opportunity for propagules to disperse into the dewatered reservoirs (Von Holle and Simberloff, 2005). Highest priority sites for IEV control will be the future access points and staging areas. The Renewal Corporation will establish a 50- to 100-foot buffer around all future staging areas. This buffer will be eradicated of all IEV species and will be maintained IEV-free during the lifespan of these temporary access sites. During demolition, work at the watershed scale will continue, but the priority will shift to evaluating and eradicating pioneering populations of IEV in the newly exposed areas within the former reservoir footprints. Eradicating pioneering populations within the reservoirs will be the highest priority during and after dam removal (Moody and Mack, 1988). Preventing inadvertent introductions of IEV can be achieved by focusing management on roads and access points to the reservoirs. New trails and roads established in the dewatered reservoirs will be major pathways for moving invasive plants (seeds and roots). Therefore, we will maintain a 50-ft buffer free of IEV around access trails and roads during and after dam demolition.

After dam removal, the Renewal Corporation will focus its efforts on preventing introductions of IEV by initiating an Early Detection and Rapid Response (EDRR) program in the exposed reservoirs. Wildlife will disperse seed long distances from the unmanaged areas into fenced and unfenced exposed reservoir areas by tracking seed on their hooves and paws. The EDRR program will be designed to eradicate IEV populations originating from seed tracked into the area. EDRR elements include the following:

1. Crews will be trained to identify IEV species in their seedling forms.
2. Reservoir footprints will be thoroughly surveyed annually on the ground using Geographic Information System (GIS) portable units.
3. Patterns of infestations will be assessed to inform adaptive management.
4. Seed sources outside of the Project Area may need additional control efforts based on infestation patterns.
5. Populations will be removed mechanically while seedlings are small.
6. All restoration staff will be educated and trained, including dam removal contractors, fisheries biologists, etc.
7. A public awareness campaign will be implemented using educational flyers highlighting priority IEV species.
8. Disposal units (i.e., garbage cans) for mechanically removed IEV will be well labeled and placed at all staging areas to facilitate and encourage removal by all Project staff.

The Renewal Corporation will remove IEV in accordance with all federal, state, and local laws.

The Renewal Corporation will employ the following BMPs to limit the spread of invasive species to the extent practicable during removal efforts (see Appendix C for a complete list of BMPs):

1. Maintain 50-ft-wide buffer free of IEV species around access roads and trails.
2. Thoroughly clean clothing and gear following site visits.
3. Check clothing and gear for soil, seeds, and plant materials.
4. Inspect and clean equipment upon entering and exiting the Project Area.
5. Inspect and clean vehicles upon entering and exiting the Project Area.
6. Train staff, including contractors, on weed identification and methods to avoid the unintentional spread of invasive plants.
7. Manage vegetation using methods that reduce the spread of invasive species and encourage desirable vegetation.

The Renewal Corporation will closely monitor movement of people and equipment conducting restoration in an effort to ensure that human activities do not introduce IEV seed. IEV cleaning stations at each staging area will include vehicle washing and boot cleaning facilities. Fencing can prevent seed from entering the reservoirs from cattle movements. The Renewal Corporation does expect wildlife capable of jumping over fencing to move seed into restoration sites.

5.4 J.C. Boyle Site-Specific Restoration

Figure 5-7 depicts an overview map of the reservoir area with proposed priority restoration locations. The map also indicates the probable post-removal location of the Klamath River, water inundation limits for the anticipated 2-year and 100-year flood events.

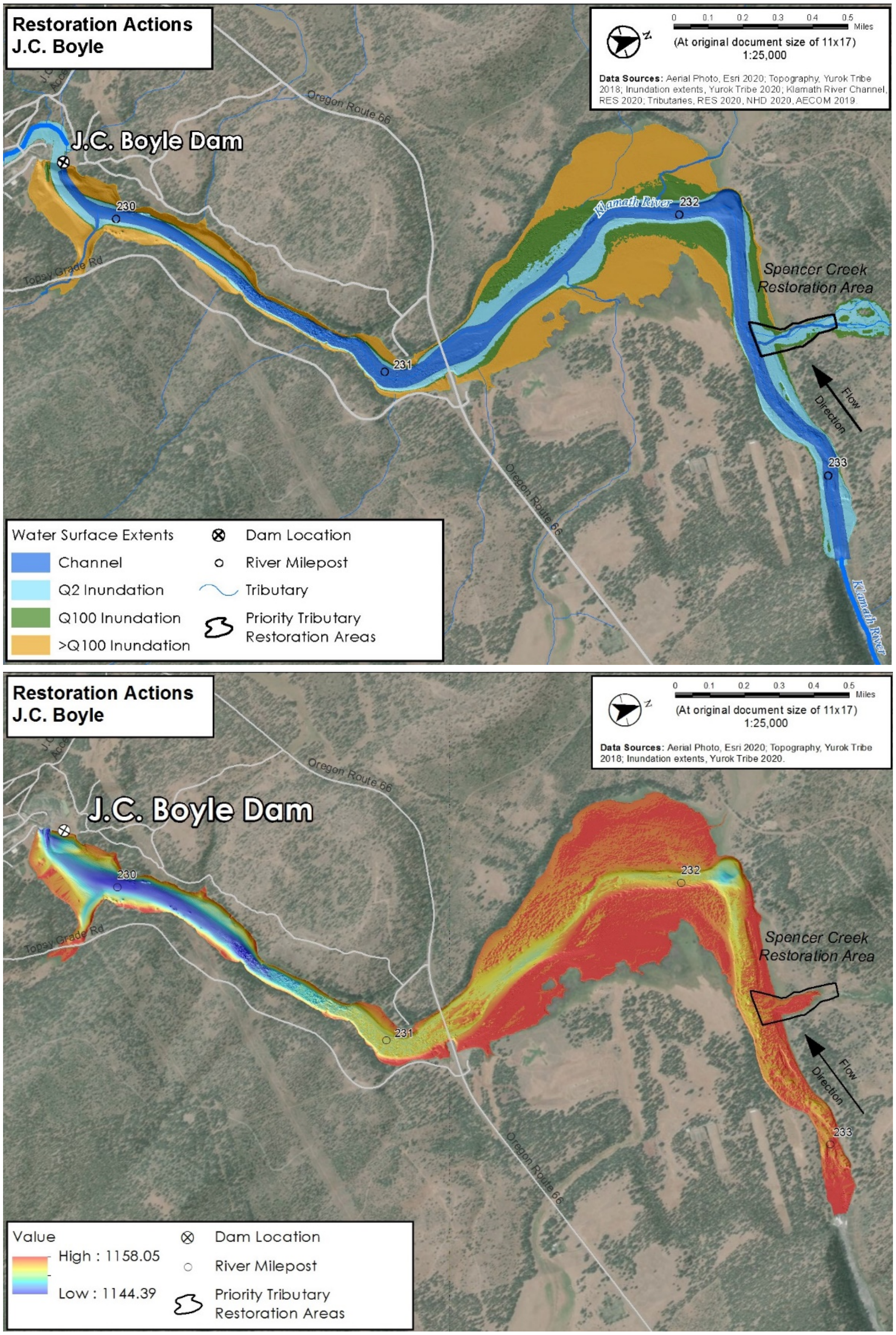


Figure 5-7. Maps of Estimated Klamath River Centerline, Tributaries, and Locations of Potential Restoration Actions in J.C. Boyle

J.C. Boyle Reservoir area topography with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context (Yurok Tribe 2020 estimation).

5.4.1 Assisted Sediment Evacuation

The Renewal Corporation does not propose assisted sediment evacuation activities at the J.C. Boyle Facility.

5.4.2 Major Tributaries

5.4.2.1 Spencer Creek

The Renewal Corporation expects to limit restoration of Spencer Creek to minor profile adjustment at or near its confluence with the Klamath River. Sediment composition at the confluence is expected to be coarser than other locations throughout the Spencer Creek restoration reach; thus, it is plausible that during a low-flow year, mechanical means of sediment removal may be necessary. Under normal water years, sediment might be self-evacuated by flow in Spencer Creek. Design considerations for Spencer Creek will focus on removing observed passage barriers and providing a restored channel with stable planform, profile, and cross-section while promoting frequent floodplain access commensurate with the geomorphometry of the portion of Spencer Creek just upstream of the reservoir footprint.

5.4.3 Selective Grading

The Renewal Corporation does not expect to perform selective grading in the vicinity of Spencer Creek given the shallow residual sediment depths within the J.C. Boyle reservoir.

5.4.4 Tributary Connectivity, Bank Stability, and Channel Fringe Complexity

The Renewal Corporation will improve Spencer Creek, as a priority tributary restoration site, through restoration construction. The proposed improvements will be designed to maintain tributary connectivity and bank stability and incorporate channel fringe complexity and habitat enhancement into the design approach as described in Section 5.2, Adaptive Design and Implementation. The Renewal Corporation will utilize grading at the priority tributary restoration site to remove remaining reservoir sediments and create channels with connected floodplains to spread flow and reduce in-channel stream power and to minimize incision potential post-restoration construction to maintain volitional passage (see Section 5.2.3, Tributary Connectivity).

5.4.5 Wetlands, Floodplains, and Off-Channel Habitat Features

The Renewal Corporation will improve Spencer Creek through restoration actions to reconnect floodplains, improve off-channel habitat features, and enhance wetlands (see Section 5.2.5, Wetlands, Floodplains, and Off-Channel Habitat Features). Pre-dam photographs and adjacent topography suggest that there is the potential for the conversion of floodplains to wetlands over time through the continued influence of riverine hydrology and the establishment of wetland plants.

5.4.6 Revegetation and Initial IEV Management

Surveys of J.C. Boyle in 2009 and 2010 (KRRC, 2018) found that J.C. Boyle reservoir banks were largely dominated by conifers, especially along the river-right side of the main reservoir (wider portion north of the Highway 66) while the river-left bank was populated with large stands of wetland species such as reed canarygrass and rushes (note, river-right and river-left designations are in reference to looking in the downstream direction) (BOR, 2011a). Confluences of tributaries in the Upper Reach primarily supported grassy meadows with many wetland constituents. Between the Highway 66 Bridge and the dam, the reservoir narrows considerably and is surrounded by steep, rocky banks largely populated with woody shrubs. Grasses were common in the understory of conifer stands, intermixed with woody shrubs and wetland species. A few willows and sages were observed, primary in the southern section. Large stands of reed canarygrass were observed along the eastern shoreline of the northern section of the reservoir (BOR, 2011a). Based on field observations by the Yurok Tribe and other biologists, the five (5) most common IEV species include, in order of total acreage are cheatgrass, teasel, reed canarygrass, medusa head, and yellow starthistle. The Renewal Corporation will manage these IEV species primarily through mowing (see Section 5.3.2.2). (IEV Control Methods, Including Targeted Use of Exclusion Fencing), while employing other monitoring and adaptive management, as described in Section 6.3, Revegetation Adaptive Management.

The Renewal Corporation will use the following revegetation methods for J.C. Boyle:

- Seeding approximately 248 acres with pioneer upland mix with straw mulch
- Seeding approximately 248 acres with upland diversity mix
- Salvaged wetland transplant (approximately 0.52 acre)
- Bare root herbaceous (approximately 4,460 individuals)
- Cuttings (approximately 5,270 individuals)
- Pole cuttings (approximately 120 individuals)
- Bare root shrubs (approximately 29,029 individuals)
- Bare root trees (approximately 4,700 individuals)

Seeding and planting at J.C. Boyle will follow methods outlined in Section 5.3.2, Planting Strategies and Species.

The Renewal Corporation will select a suitable planting palette for the J.C. Boyle site, including native species that occur in the vicinity. The proposed palette is provided in Tables 5-13 and 5-14. Additional species may be considered based on reference site data collected.

Table 5-13. Riparian Species Suitable for Planting in the J.C. Boyle Reservoir Post-Dam Removal

SPECIES	TYPE	PROPAGULE
Calocedrus decurrens	Tree	Bare root
Cornus sericea	Shrub	Bare root, live-stake
Fraxinus latifolia	Tree	Bare root
Philadelphus lewisii	Shrub	Bare root
Pinus ponderosa	Tree	Bare root
Prunus virginiana	Shrub	Bare root
Pseudotsuga menziesii	Tree	Bare root
Salix exigua	Shrub	Live-stake
Salix lasiolepis	Shrub	Live-stake
Salix lucida ssp. lasiandra	Shrub	Live-stake
Spiraea douglasii	Shrub	Bare root, live-stake
Symphoricarpos albus	Shrub	Bare root, live-stake

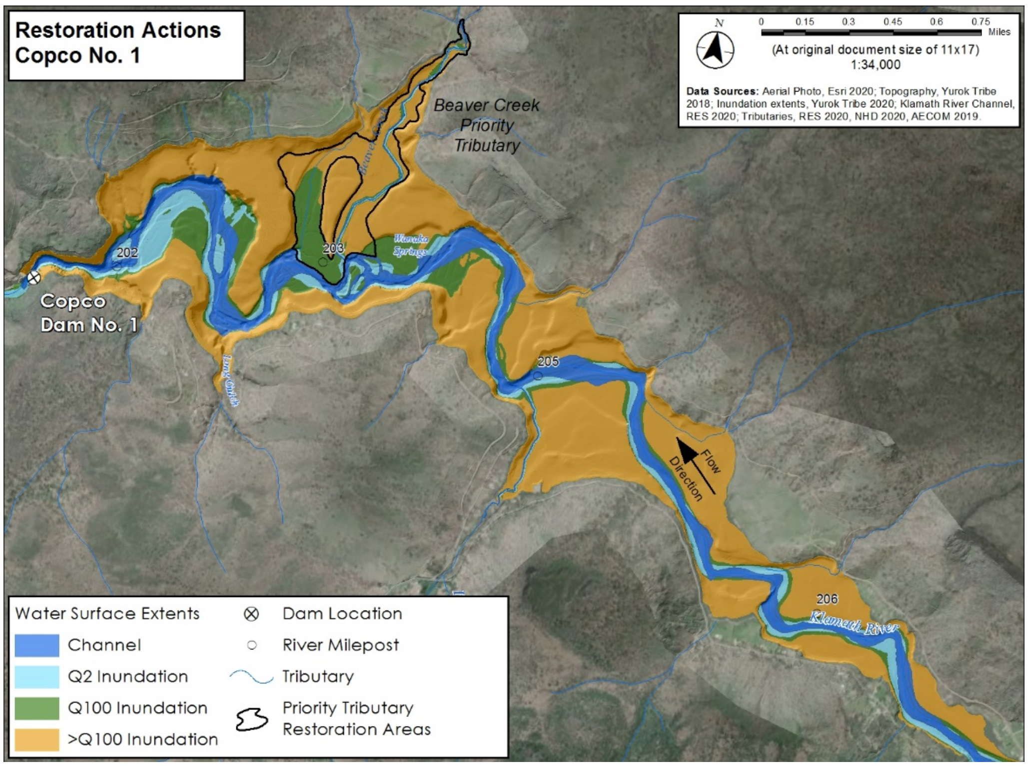
Table 5-14. Upland Native Woody Species Suitable for Planting in the J.C. Boyle Reservoir Post-Dam Removal

SPECIES	TYPE	PROPAGULE
Abies concolor	Tree	Bare root
Amelanchier alnifolia	Shrub	Bare root
Artemisia tridentata	Shrub	Bare root
Berberis aquifolium	Shrub	Bare root
Calocedrus decurrens	Tree	Bare root
Cercocarpus betuloides	Shrub	Bare root
Ericameria bloomeri	Shrub	Bare root, Seed
Ericameria nauseosa	Shrub	Bare root, Seed
Philadelphus lewisii	Shrub	Bare root
Pinus contorta var latifolia	Tree	Bare root
Pinus lambertiana	Tree	Bare root
Pinus ponderosa	Tree	Bare root
Prunus subcordata	Shrub	Bare root
Prunus virginiana	Shrub	Bare root
Pseudotsuga menziesii	Tree	Bare root
Purshia tridentata	Shrub	Bare root
Ribes cerneum	Shrub	Bare root
Ribes velutinum	Shrub	Bare root
Sambucus nigra	Shrub	Bare root

The Renewal Corporation does not expect to employ irrigation at J.C. Boyle. Approximately 2,300 linear feet of fencing will be installed, primarily at the priority tributary restoration sites (Figure 5-7 through Figure 5-9).

5.5 Copco No. 1 Reservoir Site-specific Restoration

This section describes restoration activities that are unique to Copco No. 1 Reservoir. These approaches are either in addition or in place of activities described in Section 5.2, Adaptive Design and Implementation. Priority tributary restoration work is limited to Beaver Creek. Most of the length of Long Prairie Creek is unreachable for anadromous fish due to a steep reach that is likely to be a natural passage barrier at RM 0.2. Based on this analysis, Long Prairie Creek is considered a low-priority tributary. Figure 5-8 provides an overview map of the reservoir area with proposed priority restoration locations.



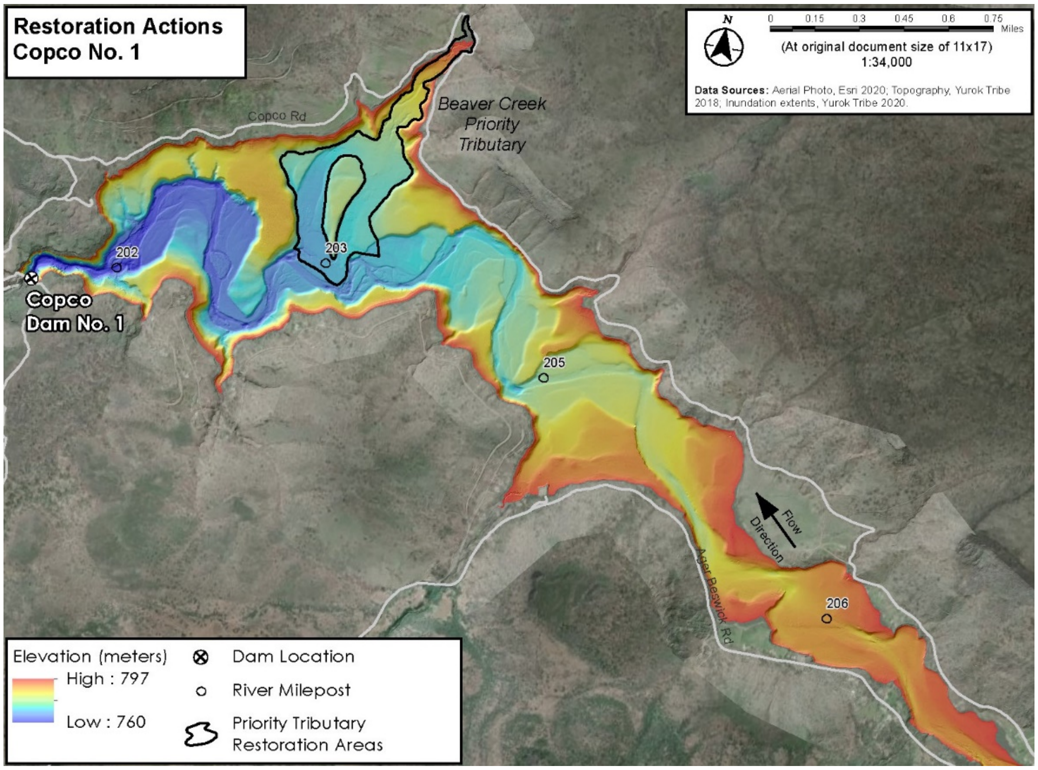


Figure 5-8. Maps (upper and lower) of Estimated Klamath River Centerline, Tributaries, and Locations of Potential Restoration Actions in Copco No. 1 Reservoir

Copco No. 1 Reservoir area topography with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context (Yurok Tribe 2020 estimation).

5.5.1 Assisted Sediment Evacuation

Following drawdown, the Renewal Corporation will perform assisted sediment evacuation activities to promote removal of stored reservoir sediments within the Copco No. 1 Reservoir Area as described in Section 5.2.1, Assisted Sediment Evacuation. In addition to tributary sites within the reservoir area, side channel complexes throughout the reservoir footprint will be the focus of assisted sediment evacuation (Figure 5-8).

5.5.2 Major Tributaries

5.5.2.1 Beaver Creek

As with other primary tributaries, the restoration work on Beaver Creek will focus on preserving fish passage from the confluence with the Klamath River upstream beyond the limits of the reservoir footprint. Historical topographic information suggests that the alignment of Beaver Creek has occupied one (1) segment or the other of an abandoned Klamath River meander. The strategy for Beaver Creek will be to allow geomorphic processes to create the preferred pathway for Beaver Creek; whichever direction the path follows will be monitored, and interventions to preserve fish passage will be initiated as needed. Furthermore, the lower extents of Beaver Creek may comprise single or multiple threads.

5.5.3 Selective Grading

The priority tributary restoration area at Beaver Creek will likely require additional selective grading to promote process-based restoration and recovery of the tributary.

5.5.4 Tributary Connectivity, Bank Stability, and Channel Fringe Complexity

The Renewal Corporation will improve Beaver Creek, as a priority tributary restoration site, through restoration construction that maintains tributary connectivity and bank stability and incorporates channel fringe complexity and habitat enhancement into the design approach as described in Section 5.2, Adaptive Design and Restoration Activities. Grading will be used at the priority tributary restoration site to remove remaining reservoir sediments and create channels with connected floodplains to spread flow and reduce in-channel stream power and minimize incision potential post-restoration construction to maintain volitional passage (see Section 5.2.3, Tributary Connectivity).

5.5.5 Wetlands, Floodplains, and Off-channel Habitat Features

The Renewal Corporation will improve the spring-fed floodplain/wetland complex in the Copco No. 1 Reservoir area along with Beaver Creek through restoration actions to reconnect floodplains, improve off-channel habitat features and enhance wetlands (see Section 5.2.5, Wetlands, Floodplains, and Off-Channel Habitat Features).

5.5.6 Revegetation and Initial IEV Management

Based on surveys of Copco No.1 and Copco No.2 in 2009 and 2010 (KRRC, 2018), the Renewal Corporation found that oak trees and scrub were very common amongst the shoreline vegetation, occurring more sparsely on drier, southern-facing slopes. Yellow pine was scattered fairly uniformly. Other native shrubs and grasses were often observed in the oak and conifer understory as well as in the dry uplands and erosion areas and mixed in with stands of wetland vegetation. Eroded banks were sparsely vegetated, primarily with weedy forbs. Willows and conifers were scattered along the shoreline, somewhat clustered in certain areas at the northwest end of the reservoir at tributary confluence, along with reed canarygrass and rushes to a lesser extent. Yellow starthistle was observed growing on the northern side of the reservoir, appearing to be a near monoculture on dry slopes (BOR, 2011a). Based on field observations by the Yurok Tribe and other biologists, the warmer, drier conditions and surrounding land uses at the Copco No. 1 reservoir support a different proportion of IEV species than J.C. Boyle, with the top five in order of acreage being: yellow starthistle, medusa head, Himalayan blackberry, reed canary grass, and teasel. The Renewal Corporation proposes to manage these species in accordance with methods outlined in in Section 5.3.3.2. IEV Control Methods, Including Targeted Use of Exclusion Fencing, with monitoring and adaptive management, as described in Chapter 6.0, Monitoring and Adaptive Management.

Proposed revegetation methods for Copco include the following:

- Seeding approximately 845 acres with pioneer upland mix with straw mulch
- Seeding approximately 845 acres with upland diversity mix

- Salvaged wetland transplant (approximately 0.04 acre)
- Bare root herbaceous (approximately 5,890 individuals)
- Cuttings (approximately 8,600 individuals)
- Pole cuttings (approximately 1,770 individuals)
- Bare root shrubs (approximately 99,300 individuals)
- Bare root trees (approximately 5,780 individuals)

The Renewal Corporation's proposed seeding and planting at Copco will follow methods outlined in Section 5.3.2, Planting Strategies and Species, and Section 5.3.3, Invasive Exotic Vegetation (IEV) Management. The planting palette at Copco will be selected to be suitable for the site, including native species that occur in the vicinity. Proposed palette is provided in Tables 5-15 and 5-16. Additional native woody species may be considered based on reference site data collected.

Table 5-15. Riparian Woody Species Suitable to Planting in the Copco Reservoir Post-Dam Removal

SPECIES	TYPE	PROPAGULE
Acer macrophyllum	Tree	Bare root
Alnus rhombifolia	Tree	Bare root
Berberis aquifolium	Shrub	Bare root
Cornus glabrata	Shrub	Bare root, live-stake
Cornus sericea	Shrub	Bare root, live-stake
Fraxinus latifolia	Tree	Bare root
Philadelphus lewisii	Shrub	Bare root
Physocarpus capitatus	Shrub	Bare root
Pinus ponderosa	Tree	Bare root
Prunus virginiana	Shrub	Bare root
Pseudotsuga menziesii	Tree	Bare root
Salix exigua	Shrub	Live-stake
Salix lasiolepis	Shrub	Live-stake
Salix lucida ssp. lasiandra	Shrub	Live-stake
Spiraea douglasii	Shrub	Bare root, live-stake
Symphoricarpos albus	Shrub	Bare root, live-stake

TABLE 5-16. UPLAND NATIVE WOODY SPECIES SUITABLE FOR PLANTING IN THE COPCO RESERVOIR POST-DAM REMOVAL

SPECIES	TYPE	PROPAGULE
Amelanchier utahensis	Shrub	Bare root
Berberis aquifolium	Shrub	Bare root
Calocedrus decurrens	Tree	Bare root
Ceanothus cuneatus	Shrub	Bare root
Ceanothus integerrimus	Shrub	Bare root
Cercocarpus betuloides	Shrub	Bare root
Ericameria nauseosa	Shrub	Bare root, Seed
Juniperus occidentalis	Tree	Bare root, container
Lonicera interrupta	Shrub	Bare root
Philadelphus lewisii	Shrub	Bare root
Pinus ponderosa	Tree	Bare root
Prunus subcordata	Shrub	Bare root
Pseudotsuga menziesii	Tree	Bare root
Purshia tridentata	Shrub	Bare root
Quercus garryana	Tree	Container, acorn
Quercus kelloggii	Tree	Container, acorn
Rhus aromatica	Shrub	Bare root
Ribes velutinum	Shrub	Bare root
Sambucus nigra	Shrub	Bare root

The Renewal Corporation anticipates mid-channel islands within the Klamath River in the Copco No. 1 reach based on review of historical mapping and high-resolution bathymetric data. The Renewal Corporation will seed these islands with either the upland or wetland/riparian mix depending upon elevation above channel. Additional planting may be added where access is possible.

The Renewal Corporation may utilize irrigation to promote success of newly established riparian areas, covering approximately 98 acres. Approximately 14,600 linear feet of fencing will be installed.

5.6 Iron Gate Site-Specific Restoration Activities

This section describes restoration activities that are unique to Iron Gate Reservoir. These approaches are either in addition to or in place of activities described in Section 5.2 (Adaptive Design and Implementation). Figure 5-9 provides an overview map of the reservoir area with proposed priority restoration locations.

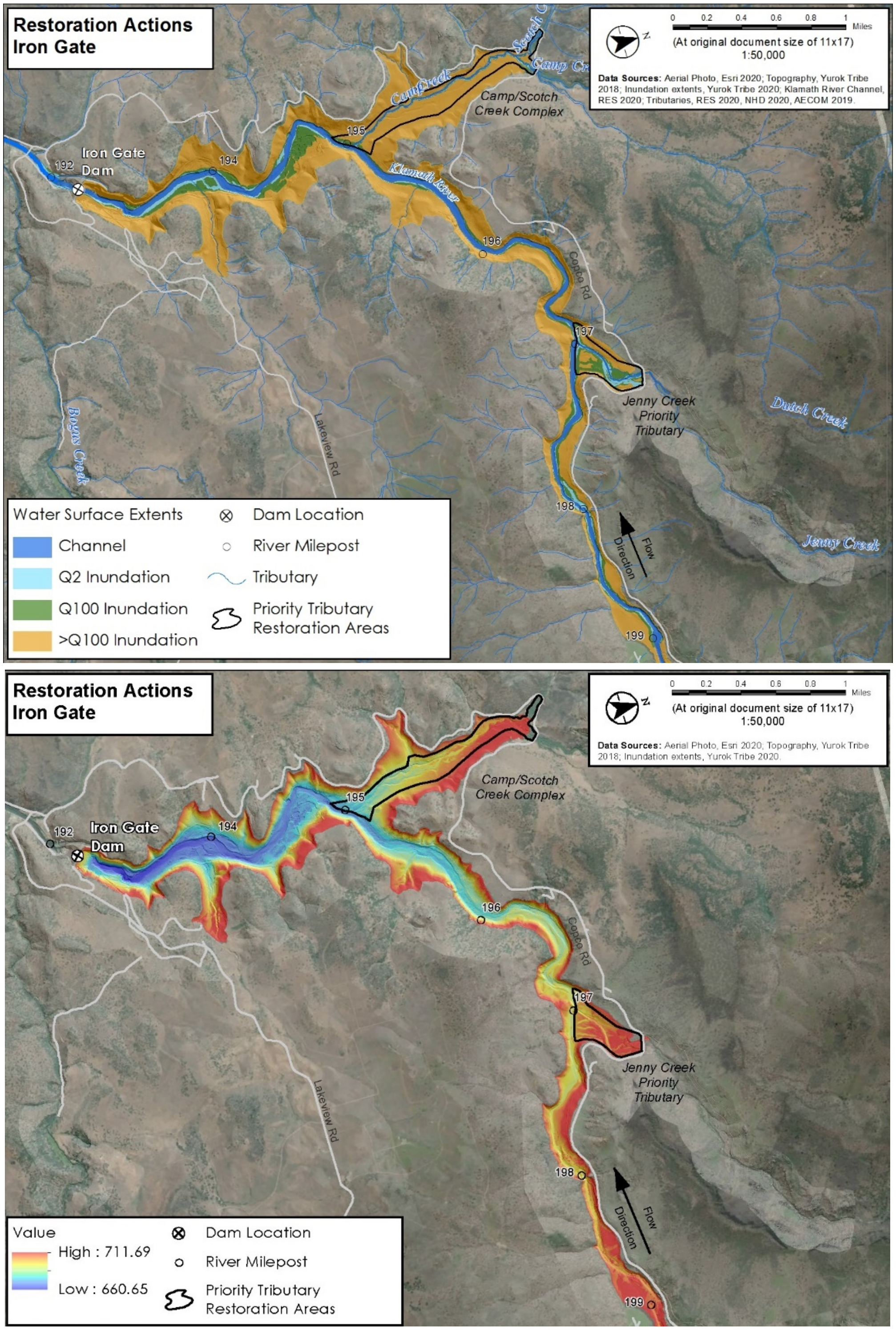


Figure 5-9. Maps (upper and lower) of Estimated Klamath River Centerline, Tributaries, and Locations of Potential Restoration Actions in Iron Gate Reservoir

Iron Gate Reservoir area topography with flood inundation extents for the 2-year (Q2) and 100-year (Q100) floods are shown for context (Yurok Tribe 2020 estimation)

5.6.1 Assisted Sediment Evacuation

Following drawdown, the Renewal Corporation will perform assisted sediment evacuation activities to promote removal of stored reservoir sediments within the Iron Gate Reservoir Area as described in Section 5.2.1, Assisted Sediment Evacuation. In addition to tributary sites within the reservoir area, historic side channel complexes will be the focus of assisted sediment evacuation (Figure 5-9).

5.6.2 Major Tributaries

5.6.2.1 Jenny Creek

Restoration activities for Jenny Creek are expected to address volitional fish passage through deltaic sediments at the upstream limits of the reservoir footprint as well as passage continuity through reservoir sediments at the confluence with the Klamath River. Adaptive design strategy will follow the procedure described in Section 6.2, Geomorphology Management, but there is a high likelihood that physical manipulation of sediments will be required in the upstream section of the reach.

5.6.2.2 Camp Creek

Restoration for Camp Creek will be similar to the approach outlined for Jenny Creek Sediments that do not evacuate during drawdown will be physically removed during the year following dam removal as part of the restoration activities. In Camp Creek there is a potential for multi-thread channel at the downstream end based on bathymetric mapping. The channels will be monitored as described in Section 6.2, Geomorphology Management, and as described in Chapter 4.0, restoration activities will focus on establishing and maintaining volitional fish passage.

5.6.2.3 Scotch Creek

Restoration for Scotch Creek will be similar to the approach outlined for Jenny Creek. Sediments that do not evacuate during drawdown will be physically removed during the year following dam removal as part of the restoration activities. At Scotch Creek it will be important to promote confluence stability with Camp Creek. The channel will be monitored as described in Section 6.2, Geomorphology Management, and as described in Chapter 3.0, Restoration Goals and Objectives, restoration activities will focus on establishing and maintaining volitional fish passage.

5.6.2.4 Long Gulch

Though not listed as a Major Tributary, Long Gulch will require targeted work following dam removal. Several culverts believed to have been placed during original dam construction are submerged in Long Gulch. Restoration activities along Long Gulch are expected to consist of the removal of these culverts, reconstruction of the banks to approximate adjacent contours, and revegetation.

5.6.3 Selective Grading

Following drawdown, the Renewal Corporation will perform assisted sediment evacuation activities to remove stored reservoir sediments within the Iron Gate Reservoir Area as described in Section 5.2.1, Assisted Sediment Evacuation. It is expected that additional grading will be required to remove sediments making up the deltas at Camp, Scotch and Jenny Creeks.

5.6.4 Tributary Connectivity, Bank Stability, and Channel Fringe Complexity

The Renewal Corporation will improve Jenny Creek and the Camp/Scotch Creek Complex, as priority tributary restoration sites, through restoration construction that maintains tributary connectivity and bank stability and incorporates channel fringe complexity and habitat enhancement into the design approach as described in Section 5.2, Adaptive Design and Implementation. The Renewal Corporation will use grading at the priority tributary restorations sites to remove remaining reservoir sediments and create channels with connected floodplains to spread flow and reduce in-channel stream power and to minimize incision potential post-restoration construction to maintain volitional passage (see Section 5.2.3, Tributary Connectivity).

5.6.5 Wetlands, Floodplains, and Off-channel Habitat Features

The Renewal Corporation will improve Wanaka Springs in the Iron Gate Reservoir area along with Jenny Creek and the Camp/Scotch Creek Complex through restoration actions to reconnect floodplains, improve off-channel habitat features, and enhance wetlands (see Section 5.2.5, Wetlands, Floodplains, and Off-Channel Habitat Features).

5.6.6 Revegetation and Initial IEV Management

Based on surveys of Iron Gate in 2009 and 2010 (KRRC, 2018), the Renewal Corporation found native grasses and shrubs commonly occurring along the shoreline area of Iron Gate, co-occurring in some of the wetland areas and as understory species in the wooded communities (BOR, 2011a). Willows and rushes were observed to dominate the river-right side of the reservoir at tributary inlets, with willows to a lesser degree at the main river inlet on the river-left (looking downstream) side. Upland slopes were dominated by yellow starthistle and smaller populations of grasses and sagebrush. Oaks were observed on the shadier northern facing slopes, occasionally scattered closer to the shoreline. Conifers and sagebrush did not appear to be associated with specific slope or moisture regimes. Yellow starthistle at Iron Gate was primary observed on southern-facing slopes, with rushes being common at the wet perimeter of slopes, primarily at stream confluences (BOR, 2011a). The Iron Gate area is the restoration area most affected by yellow starthistle, with nearly one hundred acres impacted. Based on field observations by the Yurok Tribe and other biologists, the top five (5) IEV species at Iron Gate include: yellow starthistle, medusa head, teasel, cheatgrass, and Himalayan blackberry. These areas will likely be best managed by mowing (in accordance with methods outlined in Section 5.3.3.2. IEV Control Methods, Including Targeted Use of Exclusion Fencing), with monitoring and adaptive management employed, as described in Chapter 6.0, Monitoring and Adaptive Management.

The Renewal Corporation will use the following revegetation methods for Iron Gate:

- Seeding approximately 874 acres with pioneer upland mix with straw mulch
- Seeding approximately 874 acres with upland diversity mix
- Salvaged wetland transplant (approximately 0.08 acre)
- Bare root herbaceous (approximately 3,560 individuals)
- Cuttings (approximately 11,880 individuals)
- Pole cuttings (approximately 410 individuals)
- Bare root shrubs (approximately 99,859 individuals)
- Bare root trees (approximately 5,740 individuals)

In seeding and planting at Iron Gate, the Renewal Corporation will follow methods outlined in Section 5.3.2, Planting Strategies and Species.

The Renewal Corporation will select a suitable planting palette for Iron Gate , including native species that occur in the vicinity. The proposed palette is provided in Tables 5-17 and 5-18. Additional native woody species may be considered based on reference site data collected.

Table 5-17. Riparian Woody Species Suitable to Planting in the Iron Gate Reservoir Post-Dam Removal

SPECIES	TYPE	PROPAGULE
Acer macrophyllum	Tree	Bare root
Alnus rhombifolia	Tree	Bare root
Berberis aquifolium	Shrub	Bare root
Cornus glabrata	Shrub	Bare root, live-stake
Cornus sericea	Shrub	Bare root, live-stake
Fraxinus latifolia	Tree	Bare root
Philadelphus lewisii	Shrub	Bare root
Physocarpus capitatus	Shrub	Bare root
Pinus ponderosa	Tree	Bare root
Prunus virginiana	Shrub	Bare root
Pseudotsuga menziesii	Tree	Bare root
Salix exigua	Shrub	Live-stake
Salix lasiolepis	Shrub	Live-stake
Salix lucida ssp. lasiandra	Shrub	Live-stake
Spiraea douglasii	Shrub	Bare root, live-stake
Symphoricarpos albus	Shrub	Bare root, live-stake

Table 5-18. Upland Native Woody Species Suitable for Planting in the Iron Gate Reservoir Post-Dam Removal

SPECIES	TYPE	PROPAGULE
Amelanchier utahensis	Shrub	Bare root
Berberis aquifolium	Shrub	Bare root
Ceanothus cuneatus	Shrub	Bare root
Ceanothus integerrimus	Shrub	Bare root
Cercocarpus betuloides	Shrub	Bare root
Ericameria nauseosa	Shrub	Bare root, Seed
Juniperus occidentalis	Tree	Bare root, container
Lonicera interrupta	Shrub	Bare root
Philadelphus lewisii	Shrub	Bare root
Pinus ponderosa	Tree	Bare root
Prunus subcordata	Shrub	Bare root
Purshia tridentata	Shrub	Bare root
Quercus garryana	Tree	Container, acorn
Quercus kelloggii	Tree	Container, acorn
Rhus aromatica	Shrub	Bare root
Ribes velutinum	Shrub	Bare root
Sambucus nigra	Shrub	Bare root

The Renewal Corporation may use irrigation to promote success of newly established riparian areas, covering approximately 109 acres of restored habitat. Approximately 14,600 linear feet of fencing will be installed in the vicinity of priority tributaries.

5.7 Schedule of Construction and Restoration

This section summarizes the schedule for construction and restoration activities based on current design reports. Tables 5-19 through 5-22 summarize the work activity schedules for each of the reservoirs and related work areas, based on the Renewal Corporation's implementation schedule in Appendix I of the 100 percent Design Report. A summary of Road, Culvert and Bridge improvements and schedule are presented in the Construction Management Plan. In general, the pre-drawdown dam removal activities will occur in mid- to late 2022, with drawdown commencing in 2023. The remainder of the deconstruction activities occur in 2023, with volitional fish passage targeted for October 2023. Active restoration (tributary connectivity, recontouring, creating habitat complexity and flood plain connection, and revegetation) will begin in 2023 as the reservoir levels lower and continue through to the end of 2024.

The dam and infrastructure removal schedules are based on the current 100 percent design; whereas the revegetation and priority tributary restoration schedule is based on the current reservoir restoration 60 percent design. The reservoir restoration design will be updated from 60 to 90 percent and final design after the reservoir areas respond and evolve under post-drawdown conditions during the drawdown year.

Table 5-19. J.C. Boyle Work Activities

DESCRIPTION	EXPECTED START	EXPECTED FINISH
Pre-Drawdown Work	Oct 2022	Nov 2022
Drawdown	Jan 2023	Jan 2023
Transmission / Distribution Work	Apr 2023	May 2023
Power Canal Removal	Apr 2023	Aug 2023
Powerhouse and Penstock Removal	Apr 2023	Sept 2023
Intake Structure Removal	May 2023	Oct 2023
Embankment Removal	May 2023	Oct 2023
Embankment Breach	Sept 2023	Sept 2023
Volitional Fish Passage	Sept 2023	Sept 2023
Restoration	Jan 2023	Sept 2024

Table 5-20. Copco No. 1 Work Activities

DESCRIPTION	EXPECTED START	EXPECTED FINISH
Construction Access	May 2022	Oct 2022
Pre-Drawdown Work	May 2022	Nov 2022
Drawdown	Jan 2023	Jul 2023
Transmission / Distribution Work	Apr 2023	May 2023
Dam Removal	Apr 2023	Oct 2023
Powerhouse and Penstock Removal	Apr 2023	May 2023
Volitional Fish Passage	Oct 2023	Oct 2023
Restoration	Jan 2023	Sep 2024

Table 5-21. Copco No. 2 Work Activities

DESCRIPTION	EXPECTED START	EXPECTED FINISH
Construction Access	May 2022	Aug 2022
Initial Dam Removal	Jul 2022	Sep 2022
Dam Removal	Aug 2022	Oct 2022
Transmission / Distribution Work	Jun 2023	May 2023

DESCRIPTION	EXPECTED START	EXPECTED FINISH
Powerhouse and Penstock Removal	June 2023	July 2023
Wood-Stave Penstock Removal	Apr 2023	May 2023
Volitional Fish Passage	Oct 2023	Oct 2023
Restoration	Jan 2023	Sep 2024

Table 5-22. Iron Gate Work Activities

DESCRIPTION	EXPECTED START	EXPECTED FINISH
Construction Access	May 2022	Aug 2022
Pre-Drawdown Modifications	Aug 2022	Nov 2022
Drawdown	Jan 2023	Oct 2023
Transmission / Distribution Work	Apr 2023	May 2023
Powerhouse / Penstock / Fish Facility Removal	June 2023	Aug 2023
Embankment Removal	Apr 2023	Nov 2023
Embankment Breach	Oct 2023	Nov 2023
Volitional Fish Passage	Nov 2023	Nov 2023
Restoration	Jan 2023	Sep 2024

6.0 Monitoring and Adaptive Management

This chapter describes the Renewal Corporation's geomorphic and biological monitoring, success criteria, and thresholds for adaptive management and project completion. The Renewal Corporation will implement these measures as part of the Proposed Action. These measures are summarized in Tables: 6-1 - Monitoring Decision Pathway, 6-2 - Restoration Approach and Key Monitoring Metrics of Proposed Action, 6-5 - Monitoring Timeline and Criteria Achievement, 6-6 - Monitoring Success Criteria, 6-7 - Post-Dam Removal Fish Passage Monitoring, 6-8 - Summary of Desktop and Field Fish Passage Evaluation Components, 6-9 - Example Monitoring Results that Trigger Proposed Adaptive Management Frameworks, and 6-10 - Fish Passage Adaptive Management Interventions below.

Restoration of natural rivers is an evolving science and requires building in mechanisms to deal with uncertainty. Adaptive management is a comprehensive approach to natural resource management activities where feedback between observation and corrective action is emphasized to address uncertainty, as illustrated in the CDFW adaptive management diagram in Figure 6-1. Through this structured effort, a decision-making framework allows the monitoring metrics for the Proposed Action to be interpreted and to take corrective actions as necessary. Likewise, monitoring the Proposed Action provides the data necessary for tracking ecosystem health; for evaluating progress towards restoration goals and objectives (i.e., performance measures); and for evaluating and updating problem statements, goals and objectives, conceptual models, and restoration actions.

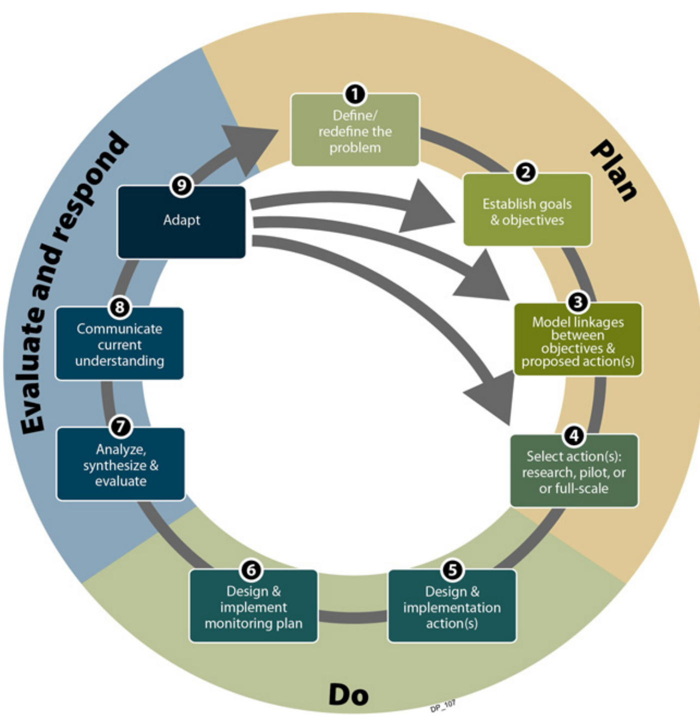


Figure 6-1. CDFW Adaptive Management Diagram

Source: CDFW, 2012 as cited in KRRC, 2018).

The framework for making decisions and actions is based on monitoring of Proposed Action metrics (Table 6-1). Inherent in the decision-making framework is the idea of increasing effort when issues are present and decreasing effort when monitoring metrics are achieved and/or when the trajectory of recovery is on track. Since the Proposed Action is founded on process-based restoration, time is required for the intended ecological uplift to be achieved, and the long-term monitoring and adaptive management plan must be flexible, address issues that arise, and take advantage of opportunities that may not be apparent at the onset of the restoration process.

Table 6-1. Monitoring Decision Pathway

CONCLUSION CATEGORIES	DECISIONS AND ACTIONS
Conclusion 1 – Proposed Action is meeting objectives based on values of qualitative and/or quantitative monitoring metrics.	• Evaluate the monitoring program (continue, reduce, or eliminate some metrics and/or geographic areas if stop-monitoring success criteria is achieved [see Table 6-5])
Conclusion 2 – Proposed Action is trending towards objectives based on values of qualitative and/or quantitative monitoring metrics.	• Evaluate the monitoring program (continue, reduce, eliminate some metrics)
Conclusion 3 – Proposed Action is not meeting (or trending away from) objectives based on monitoring values of performance criteria.	• Evaluate causes through quantitative monitoring approaches • Confer with RTWG to assess the monitoring program to evaluate whether appropriate data are being collected to assess and evaluate causes • Evaluate whether performance criteria metrics are appropriate, and propose new criteria as necessary • Develop a plan to address problems • Implement the plan and monitor results

6.1 Management Overview

This monitoring and adaptive management plan addresses measures proposed in the Reservoir Area Management Plan. The monitoring plan is focused on physical site characteristics including revegetation and geomorphological elements that are required by permits and that will be used to indicate ecological uplift as described in Section 6.2, Geomorphology Management, and Section 6.3, Revegetation Adaptive Management.

The Renewal Corporation’s management of restoration project elements is divided into riparian and upland revegetation, IEV control, residual reservoir sediment stability, priority tributary restoration, process-based restoration of the Klamath River, and dam footprint restorations. While the overall goal of the Proposed Action is to create a free-flowing Klamath River and tributaries, the restoration approach varies by Reservoir Area Management Plan Component as described in Table 6-2. For instance, restoration of the five (5) priority tributaries involve assisted sediment evacuation, run-of-the-river operation, and restoration plan implementation followed by monitoring and adaptive management.

The intent of construction interventions at the priority tributary sites is to advance the stream evolutionary clock to achieve favorable site conditions following initial establishment without having to wait for natural processes to stabilize the sites over a longer period of time. Following initial establishment, monitoring and adaptive management activities will rely on a process-based approach. On the other hand, restoration of the Klamath River relies on a process-based approach without the same level of construction intervention that is planned for the priority tributary sites. Both approaches are contrasted with dam footprint restorations that rely on construction interventions to create threshold channels that are designed to be stable over the range of flows anticipated at the sites and support fish passage. The key monitoring metrics are summarized in Table 6-2. These key metrics guide monitoring and adaptive management and are tied to the goals of the Proposed Action.

Table 6-2. Restoration Approach and Key Monitoring Metrics

RESERVOIR AREA MANAGEMENT PLAN COMPONENT	INITIAL ESTABLISHMENT	RESTORATION APPROACH	KEY MONITORING METRICS
Riparian and Upland Revegetation	Begin immediately following drawdown – Mulching, Native Seed, Bare Root, Live Stakes, Plugs	Revegetation	% Native plant cover
IEV Management	Begin pre drawdown - Mechanical, Chemical, and Fencing	Removal/control of IEV	% IEV Vegetation
Residual Reservoir Sediment Stability	Begin immediately following drawdown – Mulching, Native Seed, Bare Root, Live Stakes, Plugs	Revegetation – Residual reservoir sediment stabilization	% Native plant cover and Residual Reservoir Sediments Stability based on remote sensing surface measurements and water quality feedback data

RESERVOIR AREA MANAGEMENT PLAN COMPONENT	INITIAL ESTABLISHMENT	RESTORATION APPROACH	KEY MONITORING METRICS
Priority Tributaries	Assisted Sediment Evacuation (2023), Run-of-the-River Operation (2023–2024), Restoration Plan Implementation (2024)	Restoration construction to reconnect floodplains, spread energy and achieve favorable conditions, including fish passage, followed by monitoring and adaptive management to achieve favorable post-dam removal outcomes based on process-based restoration and stream evolution	Revegetation success, floodplain connection, and volitional fish passage
Klamath River	Run-of-the-River Operation (2023–2024) and Revegetation	Process-based restoration through monitoring and adaptive management	Revegetation success and volitional fish passage
Dam Footprints	Run-of-the-River Operation (2023–2024), Demolition, Threshold Design Construction	Threshold channel construction following drawdown	Threshold based channel design is stable, and volitional fish passage is maintained as demonstrated by fish presence monitoring

6.1.1 Monitoring and Management Approach

Monitoring associated with restoration of the reservoir areas is designed to measure progress toward achieving the project goals, inform potential adaptive management needs, and provide feedback into river and reservoir area conditions to evaluate whether sites are trending towards or away from achieving the goals of the Proposed Action. Physical site characteristics have been identified by the Renewal Corporation as appropriate monitoring metrics using standard field techniques to produce data compatible with standard protocols derived from previously developed dam removal monitoring and adaptive management plans as described in the following sections.

6.1.2 Baseline Monitoring Conditions

During initial establishment of reservoir areas, the Renewal Corporation will use a combination of survey techniques, including photo points, ground based survey, and aerial topographic data capture, to finalize priority tributary restoration designs and to set initial conditions for monitoring and adaptive management (Table 6-3). The Renewal Corporation will begin revegetation at the site immediately following drawdown. Drawdown in turn sets the stage for dam removal and run-of-the-river operation. Dam footprint restoration is planned for 2023 and priority tributary restoration efforts are planned in 2023 and 2024.

Table 6-3. Initial Establishment Measures to Set Baseline Monitoring Conditions

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	INITIAL ESTABLISHMENT ACTIONS			
	2023		2024	
Riparian and Upland Revegetation[3]	DD[1]	Mulching, Native Seed, Bare Root, Live Stakes, Plugs	Run of the River[2]	Mulching, Native Seed, Bare Root, Live Stakes, Plugs
IEV Management[4]	DD	Mechanical, Chemical, and Fencing	Run of the River	Mechanical, Chemical, and Fencing
Reservoir Areas	DD	Mulching, Native Seed, Bare Root, Live Stakes, Plugs	Run of the River	Mulching, Native Seed, Bare Root, Live Stakes, Plugs
Priority Tributary Restoration	DD	Assisted sediment evacuation	Run of the River	Restoration Construction if needed at sites following Geomorphic Assessment
Klamath River	DD	Residual Reservoir Sediment management to maintain volitional fish passage	Run of the River	Residual Reservoir Sediment management to maintain volitional fish passage
Dam Footprint Restorations	DD	Dam Removal	Run of the River	Management to maintain volitional fish passage

Notes:
1. DD -Drawdown of the Lower Klamath Project reach reservoirs to facilitate dam removal and restoration activities.
2. Run of the River – Run of the river refers to the post dam removal operation condition of the Lower Klamath Hydroelectric Reach unimpeded by dam structures that impound the river and create reservoirs. Run-of-the-river operation is used as a process-based restoration tool to facilitate residual reservoir sediment evacuation and begin the conversion from lotic to lentic and riparian environments.
3. Initial establish of riparian and upland vegetation will occur over a 2-year period following drawdown (2023 – 2024)
4. IEV Management activities begin pre-drawdown

Table 6-4. presents critical data gathering for both priority tributary restoration design development and monitoring during the 2023 to 2024 drawdown and run-of-the-river time period. are presented in Data gathering is incremental because the reservoir areas are still underwater until drawdown and dam removal is achieved, and priority tributary restoration design progresses to final design from the current 60 percent design phase. Following drawdown and assisted sediment evacuation at the priority tributary restoration sites, the Renewal Corporation will use aerial data capture methods and ground-based survey to inform design progression. The Renewal Corporation will verify priority tributary restoration site intervention approaches post-drawdown. The scale and intensity of construction and/or continuation of passive process-based restoration will be based on post-dam removal site conditions.

Table 6-4. Data Gathering Methods for Design and Monitoring

DATA GATHERING	2023		2024		
	DRAWDOWN	DAM REMOVAL	RUN OF THE RIVER/VOLITIONAL FISH PASSAGE		
Design	Aerial Topographic Data Capture to update baseline surface data	Aerial Topographic Data Capture supplemented with ground-based survey for construction sites	Restoration Design Completion where appropriate and/or Process Based Restoration Monitoring and adaptive management	Continued Aerial Topographic Data Capture and ground-based survey to support Design and Construction	Continuation of Process Based Restoration Monitoring and Adaptive Management where indicated
Monitoring	Aerial and Ground Based Photography to record post-drawdown condition	Establish revegetation monitoring plots for native plant establishment and IEV control. Establish Permanent Ground Photo Points for construction sites	Aerial and Ground Based Photography to record post-drawdown condition evolution and revegetation success	Continue data collection at permanent Ground Photo Points for construction sites	Aerial Topographic Data Capture and monitoring profiles and cross-sections for construction site As-Builts

The Renewal Corporation will complete additional data gathering following run of the river operation and construction completion to confirm the as-built restoration condition and to set the baseline for monitoring and adaptive management. Pre-drawdown topographic data for the Proposed Action is based on the 2018 baseline bathymetry, which is stored at www.opentopography.org. The open topography website is open to the public and will serve as the baseline data hub for topography and bathymetry. Baseline data can be downloaded at https://opentopography.org/news/klamath-river-renewal-project-data-access-through-opentopography and https://doi.org/10.5069/G9DN436N.

The Renewal Corporation will modify the 2018 baseline data set following drawdown, dam removal, and run-of-the-river operation as the Proposed Action progresses. In this way, baseline data will evolve as the site changes and will be used to inform design, monitoring, and adaptive management.

6.1.3 Monitoring Timeline

Reservoir Area Management Plan components, monitoring elements, initial monitoring timeline per component, and success for concluding monitoring are presented in Table 6-5. The monitoring approach is adaptable based on the feedback loop of achieving monitoring metrics or trending towards positive outcomes (Figure 6-1). The monitoring timeline in Table 6-5 is anticipated to be five (5) years. Within this context, monitoring elements may be removed if end-of-monitoring success criteria are achieved, and/or the approach may be modified if the monitoring program is not appropriately informing restoration trajectories.

Table 6-5. Monitoring Timeline and Criteria Achievement

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	MONITORING TIMELINE[1]	CRITERIA MET[2]
Riparian and Upland Revegetation	Native Vegetation	Two (2) years of implementation period monitoring (2023 – 2024), follow by maximum five (5)-year term (2025 – 2029)	When (1) success criteria are achieved or (2) after five years of monitoring, whichever is earlier
IEV Management	% IEV Vegetation	Two (2) years of implementation period monitoring (2023 – 2024), follow by maximum five (5)-year term (2025 – 2029)	When (1) success criteria are achieved or (2) after five years of monitoring, whichever is earlier
Reservoir Areas	Sediment Stability	Maximum five (5)-year term (2023 – 2028)	When (1) success criteria are achieved or (2) after five years of monitoring, whichever is earlier
Priority Tributaries	Fish Passage	Maximum five (5)-year term (2023 – 2028)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier
	Bank Stability	Maximum five (5)-year term (2025 – 2029)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	MONITORING TIMELINE[1]	CRITERIA MET[2]
	Floodplain Connectivity	Maximum five (5)-year term (2025 – 2029)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier
	Floodplain Roughness	Maximum five (5)-year term (2025 – 2029)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier
	Channel Fringe Complexity	Maximum five (5)-year term (2025 – 2029)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier
Klamath River	Fish Passage	Maximum five (5)-year term (2023 – 2028)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier
Dam Footprints	Fish Passage	Maximum five (5)-year term (2023 – 2028)	When (1) success criteria achieved for two years with two bankfull[3] or larger flow events or (2) after five years of monitoring, whichever is earlier

Notes:
1. Monitoring elements that begin following drawdown (fish passage and sediment stability) are estimated to begin in July 2023 and will end in July of 2028. Fish passage at dam footprints will be evaluated immediately following completion of dam removal activities. Priority Tributary monitoring will be delayed until October 2024 to allow for design and construction activities to complete and will end in October of 2029. Riparian and upland revegetation establishment will begin immediately following drawdown for a 2-year period (2023- 2024), with monitoring beginning in 2025 and ending in 2029. IEV management begins pre-drawdown (2021-2022) and continues through the dam removal and restoration phase (2023-2024) followed by a 5-year monitoring period also ending in 2029.
2. If monitoring success criteria is achieved (Table 6-6) in one (1) geographic area based on the *Criteria Met* description (Table 6-5), it will be recommended for removal from further monitoring activities. Renewal Corporation will notify applicable regulatory agencies, report that performance criteria have been met, and request permission to stop monitoring.
3. **Bankfull Definition** From a traditional geomorphic perspective, bankfull is defined as the point of incipient flooding whereby flow accesses its floodplain in alluvial channels. It is generally observable in the field as break in slope as the bank transitions to a flatter surface at the floodplain as one moves away from the stream centerline. However, in actively incising, adjusting, or non-alluvial channels this break in slope can be difficult to perceive, and bankfull may be difficult to discern based on physical characteristics of the channel so it must be determined based on other characteristics. As many of the tributaries to the Klamath River within the footprints of the reservoir are expected to undergo cycles of adjustment as residual sediments are mobilized and transported downstream, this circumstance is likely to apply, and thus, other means may be required to determine if bankfull flows have occurred. For the primary tributaries, the determination of whether or not flow has

exceeded the bankfull discharge will be based first on bankfull indicators where present. In the absence of bankfull indicators, RES will consult bankfull indicators that can be observed on the channel upstream of the reservoir footprint, and if flow exceeds the threshold signified by those indicators, it will be concluded that the bankfull discharge was exceeded within the tributary as well.

6.1.4 Monitoring Success Criteria

Revegetation and geomorphic success criteria for monitoring elements are described for each Reservoir Area Management Plan component in Table 6-6. The Reservoir Area Management Plan components include native plant establishment, nonnative species management, reservoir areas, priority tributary restoration sites, mainstem Klamath River restoration, and dam footprint restoration.

The revegetation success criteria for native plant establishment is based on a comparison to reference site conditions (to be established and approved prior to drawdown) and has success criteria considerations for upland versus riparian and for species richness, tree and shrub density, and vegetative cover. The IEV management has upland and riparian considerations and is tied to nonnative vegetation relative frequency. Please refer to Section 6.3.1, Success Criteria, for the revegetation success criteria over the monitoring period.

Table 6-6. Monitoring Success Criteria

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	SUCCESS CRITERIA
Native Plant Establishment	% Native plant cover	Species richness, Tree and shrub density, vegetation cover
IEV Frequency	% IEV Vegetation	IEV relative frequency
Reservoir Areas	Sediment Stability	Residual reservoir sediments exhibit stability as demonstrated by digital surface comparisons and revegetation success

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	SUCCESS CRITERIA
Priority Tributaries	Fish Passage	Water surface elevation drops caused by discontinuity in residual reservoir sediments do not preclude fish passage.
	Bank Stability	Constructed banks critical to restoration goals are stable. Erosion indicators are beneficial to goals and continue evolution towards a positive outcome.
	Floodplain Connectivity	Regular inundation of floodplains is achieved. Excessive aggradation and/or degradation is not present in channel or floodplain surfaces.
	Floodplain Roughness	Revegetation of floodplain surface along with large wood elements and willow baffles are producing roughness in alignment with plan.
	Channel Fringe Complexity	Channel fringe complexity features (pools, large wood, overhanging banks) are present and accessible to species.
Klamath River	Fish Passage	Water surface elevation drops caused by discontinuity in residual reservoir sediments do not preclude fish passage.
Dam Footprints	Fish Passage	Threshold channel design is functioning and is passable to target fish species.

6.2 Geomorphology Management

This section focuses on the proposed geomorphology management of the reservoir and dam footprint areas. Geomorphology refers to the study of landforms, their processes, form, and sediments, and how interactions with erosive forces like water, wind, and ice change landforms. In addition, and critically important to the success of the Proposed Action , is the role of vegetation in stabilizing sediments, river, and streambanks, and in adding roughness to floodplain surfaces. The Renewal Corporation's revegetation adaptive management is addressed in Section 6.3, Revegetation Adaptive Management. Tracking the evolutionary trajectory of the reservoir landscape as the Proposed Action progresses through initial establishment and into monitoring and adaptive management requires qualitative and quantitative monitoring measures as well as a common language to communicate channel evolution.

6.2.1 Geomorphological Communication

The Renewal Corporation has adopted the Stream Evolution Triangle (SET) (Figure 6-2) developed by Castro and Thorne (Castro and Thorne, 2019) as the conceptual model for communicating riverine geomorphology for the Project. The Castro and Thorne report can be found in Appendix G-1. The SET will be used by the Renewal Corporation to communicate the geomorphic state of restoration sites based on stream evolution by indicating site condition relative to dominant process which include hydrology, geology, and biology. Geomorphic site condition will then be tracked over time during subsequent phases noting trends during monitoring activities to plot stream evolution trajectories over time. If the trend at a site is diverging from desirable outcomes, then the Renewal Corporation will consider adaptive measures. This approach is illustrated in Figure 6-3 for the Camp/Scotch Creek Complex, which is a priority tributary restoration site.

The Camp/Scotch Creek Complex stream channels may exhibit a Stage 6 channel form following drawdown with reservoir sediments occupying the pre-dam channel as indicated by the yellow #1 circle in Figure 6-3. Following assisted sediment evacuation and run of the river operation the sediment will be evacuated the stream will move to a Stage 3 channel, with incision as indicated by the yellow #2 circle on Figure 6-3. The yellow #3 circle in Figure 6-3 represents the post-restoration construction trajectory and a positive endpoint for the site. Following construction, the biological components, namely native vegetation, will not be fully established, and therefore the site will be trending towards position 3 but will need successful revegetation to get there. Critical to putting the channel on the path towards Stage 8 is correcting the incision that will be present once reservoir sediments are evacuated. The Renewal Corporation will accomplish this by constructing channels connected to floodplains that are capable of transmitting flow and sediment without further incision. For the Camp/Scotch Creek example, the Renewal Corporation will use monitoring and adaptive management to keep the site on track towards a favorable endpoint. Monitoring use of the SET is demonstrated in Figure 6-4 where the Wychus Creek Stage 0 restoration is depicted.

In the Wychus Creek example, the pre-construction stage is geology dominated with an incised channel, little vegetative interaction, and insufficient hydrology to inundate floodplains and promote channel evolution (Figure 6-4 (a)). During construction, the incised channel is filled, large wood is used to spread energy and inhibit a single thread channel from reforming and the site is revegetated. This construction intervention moves the channel from a geology dominated Stage 2 to a hydrology dominated Stage 6 (Figure 6-4 (b)). Rapid revegetation success over the first-year post-construction due to successfully elevating the groundwater table moves the site towards a biology dominated Stage 0 (Figure 6-4 (c)). The Renewal Corporation will use fixed photo points, aerial data capture, and handheld photography to enable stream evolution monitoring and reporting like the Wychus Creek example. In cases where the trajectory is not trending as anticipated or desired, a conceptual analysis using the SET, as in the example presented for the Camp /Scotch Creek Complex, will be applied by the Renewal Corporation along with quantitative monitoring measures to evaluate causes and corrective actions and to communicate approach as appropriate.

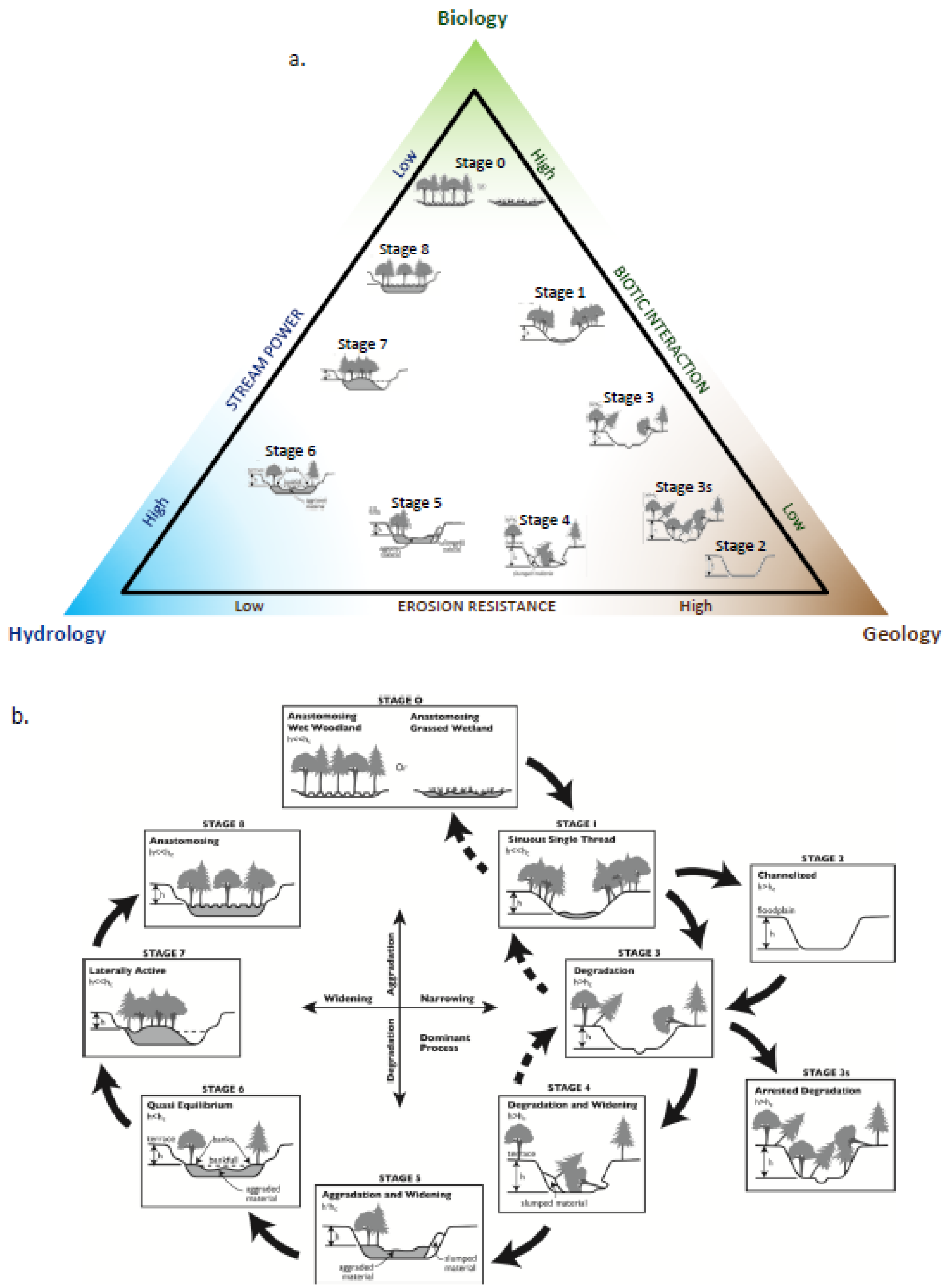


Figure 6-2. Stream Evolution Triangle
(a) SET with Stages of Stream Evolution (Cluer and Thorne, 2013), (b) Stream Evolution Model (Cluer and Thorne, 2014)

Source: Castro and Thorne, 2019

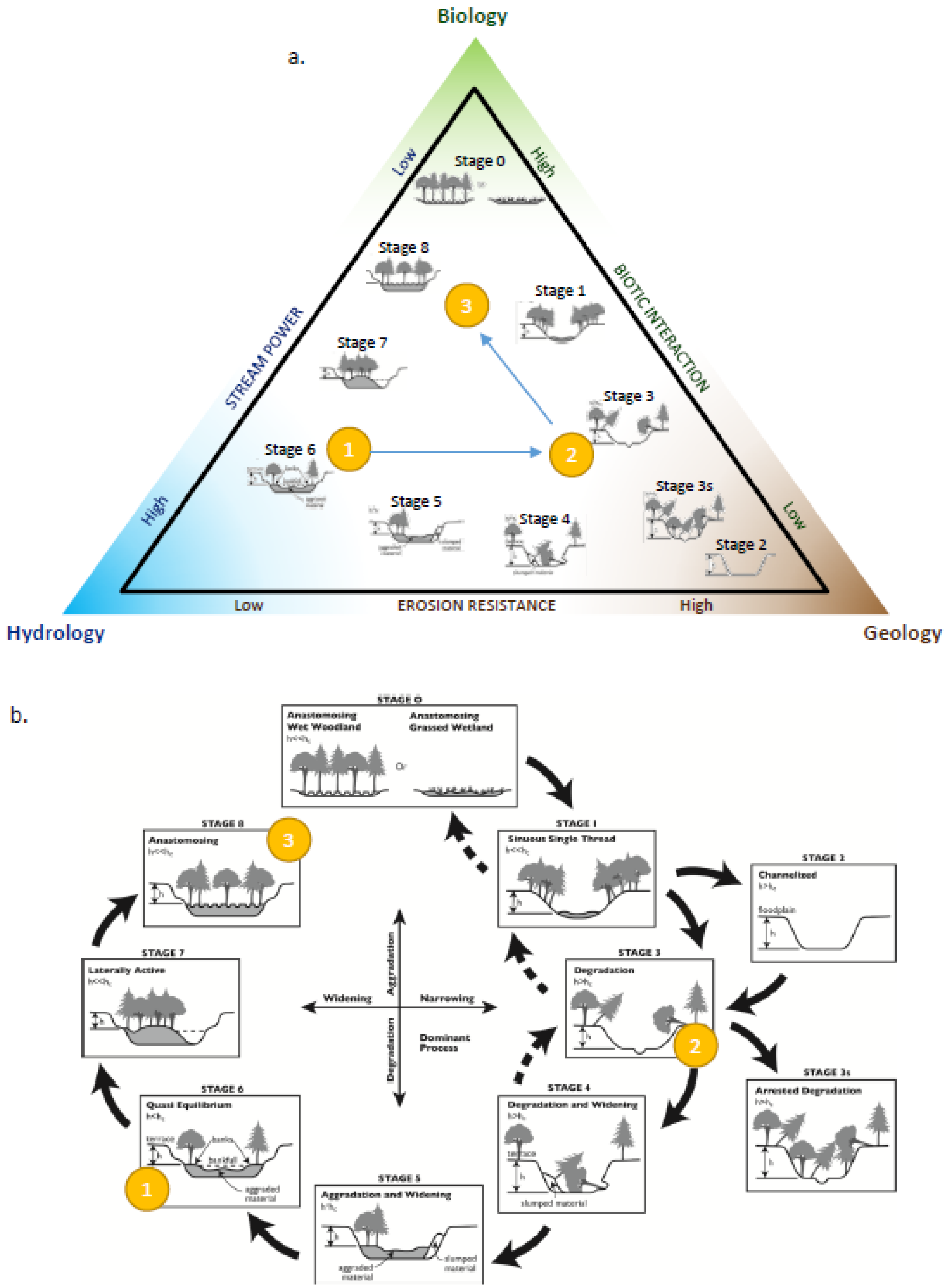


Figure 6-3. Stream Evolution Triangle Example for Camp/ Scotch Creek Complex Starting with Post-Drawdown (1), Following Assisted Sediment Evacuation and Run-of-the-River Operation (2), and Post -Construction Implementation (3)

Source: Castro and Thorne, 2019

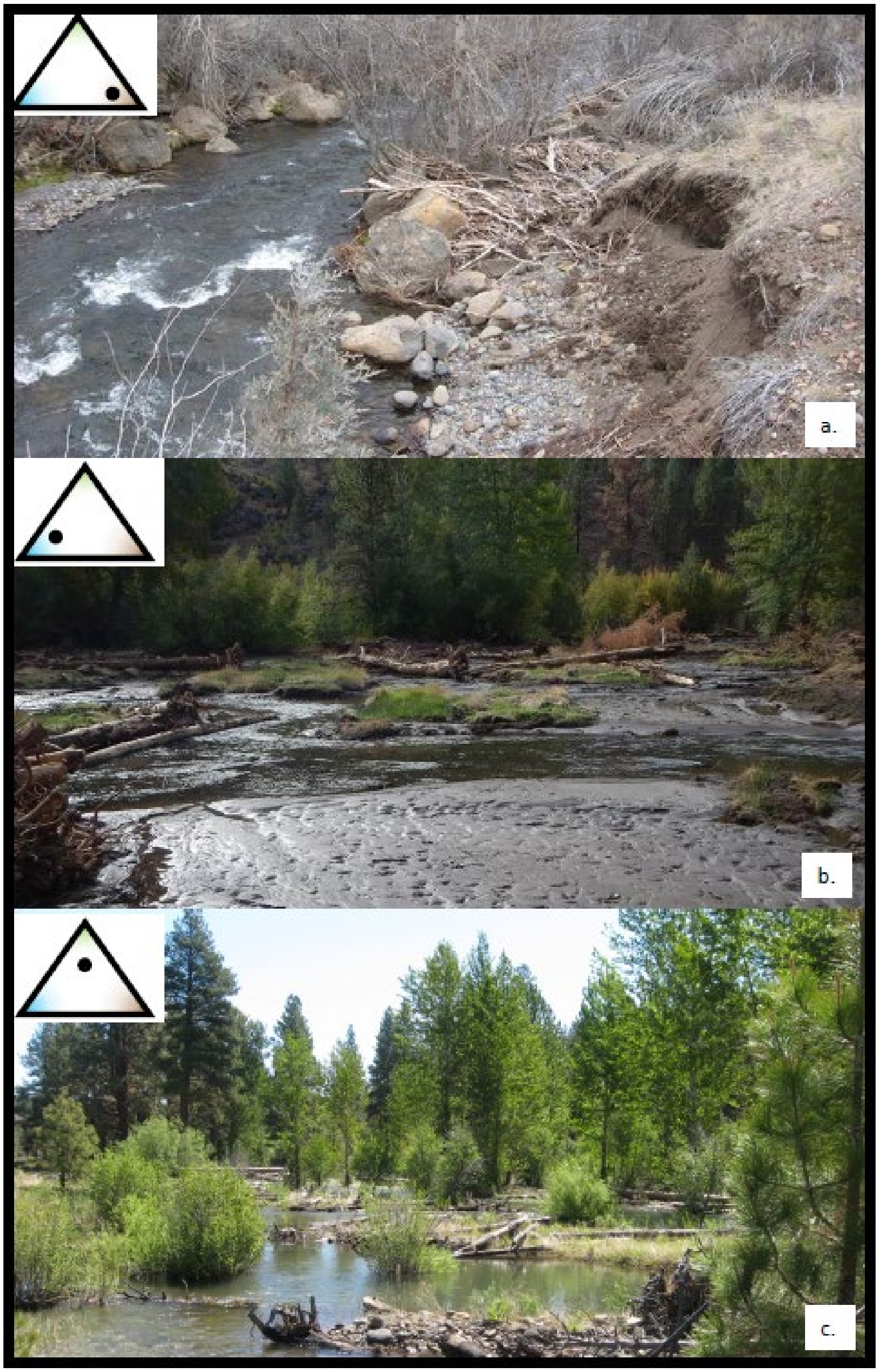


Figure 6-4. Stream Evolution Triangle Example
(a) Representing Pre-Implementation, (b) Immediately Following Restoration Construction, and (c) One (1)-Year Following Construction

Source: Castro and Thorne, 2019

6.2.2 Success Criteria

Geomorphic success criteria for monitoring elements are described for each Reservoir Area Management Plan component in Table 6-6. Reservoir Area Management Plan components include reservoir areas, priority tributary restoration sites, mainstem Klamath River restoration, and dam footprint restoration.

6.2.3 Monitoring Methods

Reservoir Area Management Plan geomorphology monitoring methods are focused on fish passage, headcut migration, and residual reservoir sediment stability as described in Sections 6.2.4 to 6.2.8.

6.2.4 Fish Passage Monitoring

Fish passage monitoring for the Proposed Action is described in Section 6.2.5, Reservoir Area Management Plan Fish Passage Monitoring Area, and Section 6.2.6, Fish Passage Monitoring Schedule. Fish passage monitoring is also described in the TMCP for the TMCP Monitoring Area. Refer to Figure 6-5 for a graphical depiction of fish passage monitoring requirements for the Proposed Action. Both Reservoir Area Management Plan and TMCP documents rely on Section 6.2.7, Headcut Migration Monitoring, for potential fish passage barrier identification and evaluation.

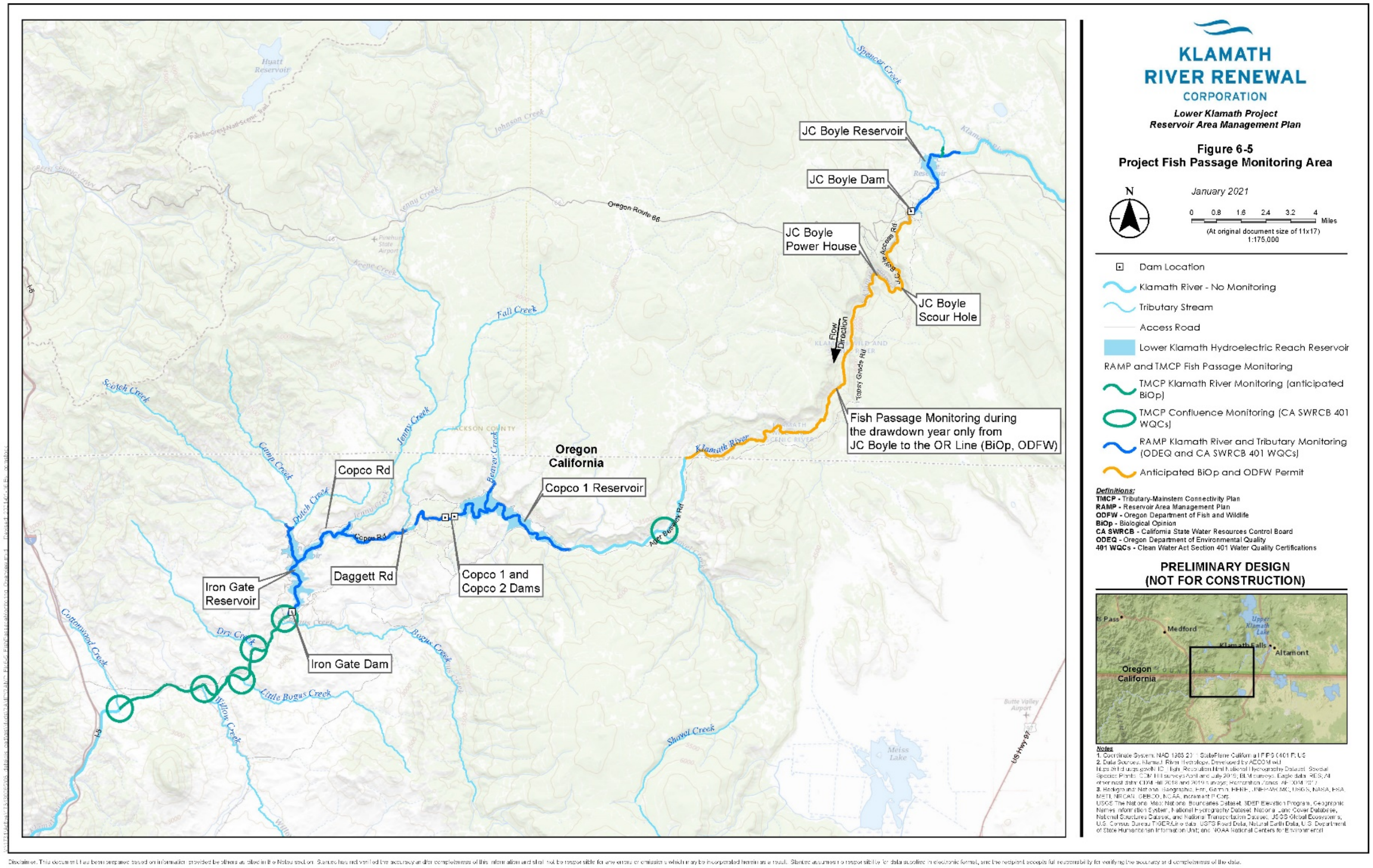


Figure 6-5. Project Fish Passage Monitoring Area

Fish passage monitoring in the Reservoir Area Management Plan is within the Lower Klamath Hydroelectric Reach and includes the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Reservoirs and dam footprints, whereas TMCP monitoring is from the downstream side of the Iron Gate Dam footprint to Cottonwood Creek and at the confluence of Shovel Creek with the Klamath River.

In addition to the fish passage monitoring areas covered in the Reservoir Area Management Plan and TMCP, the Klamath River downstream from J.C. Boyle Dam to the Oregon State Line will also be surveyed in accordance with the anticipated conditions of NMFS's Biological Opinion (Figure 6-5).

6.2.5 Reservoir Area Management Plan Fish Passage Monitoring Area

The Reservoir Area Management Plan fish passage monitoring area (Figure 6-6) is within the Lower Klamath Hydroelectric Reach and includes the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Reservoirs and dam footprints. Map boxes 1 through 4 in Figure 6-6 reference the map book in Appendix B, Figure B-5, which is intended for field-based monitoring activities for the Reservoir Area Management Plan.

Fish passage monitoring and associated adaptive management activities in the Reservoir Area Management Plan and TMCP are focused on fish passage impediments caused by anthropogenic features including residual reservoir sediments and infrastructure. The Reservoir Area Management Plan volitional fish passage monitoring will be conducted by the Renewal Corporation on the mainstem Klamath River:

- In the Hydroelectric Reach (i.e., within the former J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate Reservoir areas)
- At and immediately downstream of the former dam footprints of J.C. Boyle Dam, Copco No. 1 Dam, Copco No. 2 Dam, and Iron Gate Dam (i.e., restored channel footprint)
- At any temporary and/or permanent road stream crossings associated with dam removal activities within the Reservoir Area Management Plan fish passage monitoring area

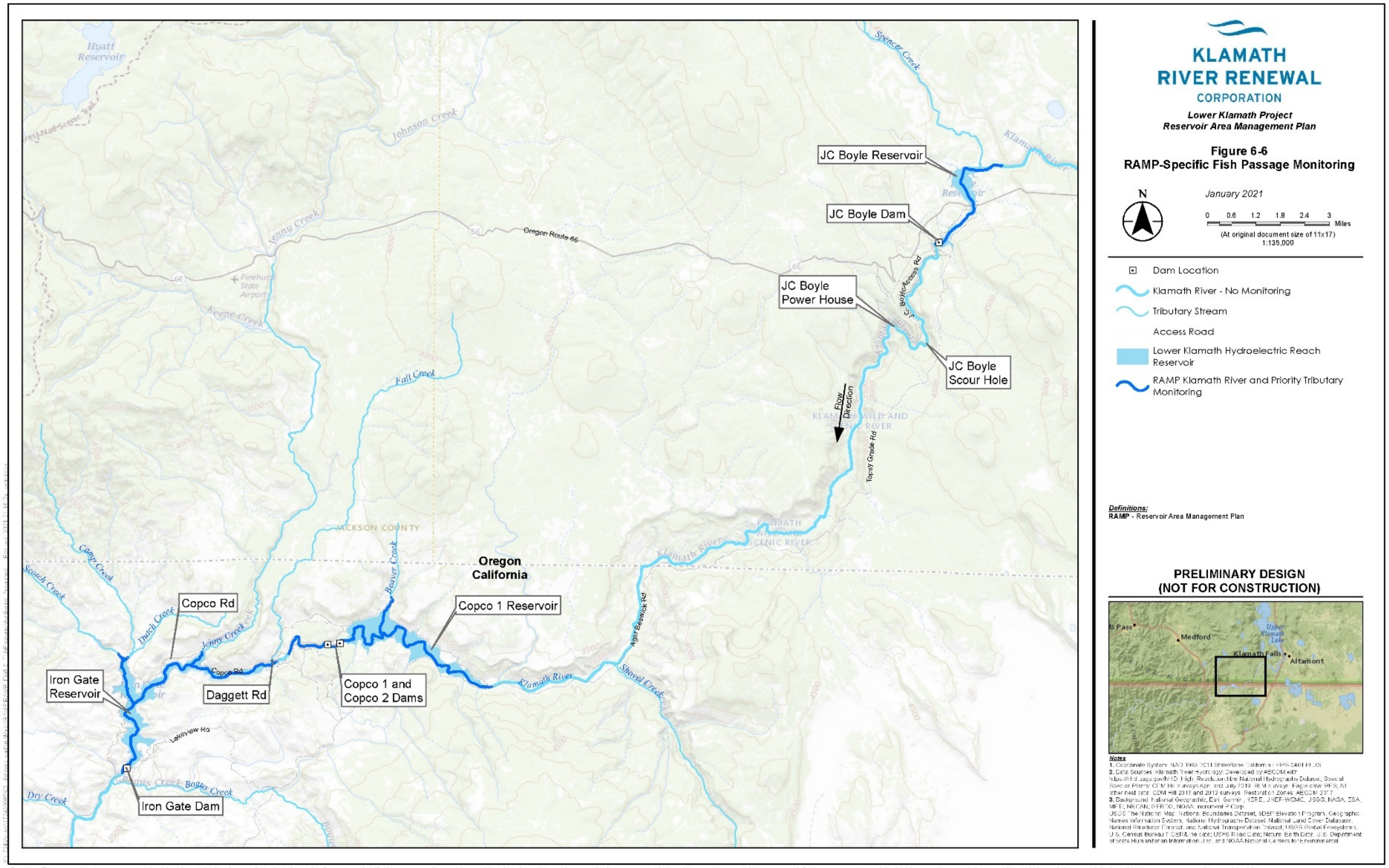


Figure 6-6. Reservoir Area Management Plan-Specific Fish Passage Monitoring Area

Additionally, the Renewal Corporation will monitor fish-bearing streams (i.e., fish-bearing tributaries) upstream of the former Iron Gate Dam. These tributaries were selected based on having historical or potential habitat for adult salmonids (Huntington, 2006). These include the following:

- The lower reach of Spencer Creek near the confluence of Spencer Creek and the Klamath River
- Approximately 1.1 miles of lower Beaver Creek, from Copco Road to the confluence of Beaver Creek and the Klamath River
- The lower 400 feet of Fall Creek, from Daggett Road to the confluence of Fall Creek and the Klamath River
- Approximately 0.5 mile of lower Jenny Creek, from approximately 500 feet upstream of Copco Road to the confluence of Jenny Creek and the Klamath River
- Approximately 1.25 miles of the lower Camp/Scotch Creek Complex, from Copco Road to the confluence of Camp/Dutch Creek and the Klamath River

Collectively, the areas defined above are the Reservoir Area Management Plan Fish Passage Monitoring Areas (Figure 6-5).

6.2.6 Fish Passage Monitoring Schedule

The Renewal Corporation's fish passage monitoring schedules are presented in Table 6-7 for both Reservoir Area Management Plan and TMCP for easy reference. During the drawdown year (2023) and following year (2024), the Renewal Corporation will monitor after the wet season, which corresponds to a seasonal window and flow period characteristic of native migratory fish movement, and again in early fall. For the remainder of the fish passage monitoring period (2025–2028) the Renewal Corporation will monitor annually, after the wet season. Additional monitoring events will be conducted following a 5-year or greater flow event if it occurs prior to the criteria achievement specifications presented in Table 6-5.

Table 6-7. Post-Dam Removal Fish Passage Monitoring

YEAR	SURVEY PERIOD	LOCATION	MANAGEMENT PLAN RESPONSIBILITY
Drawdown Year	Spring	TMCP Monitoring Area[1] and Spencer Creek	TMCP
	Post-Final Drawdown	Reservoir Area Management Plan Fish Passage Monitoring Areas[2] and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
	Post-Final Drawdown	J.C. Boyle Dam to Oregon State Line	BO

YEAR	SURVEY PERIOD	LOCATION	MANAGEMENT PLAN RESPONSIBILITY
	Fall	Reservoir Area Management Plan Fish Passage Monitoring Areas and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
All Fish Passage Monitoring Years	Additional monitoring event will be conducted following a 5-year or greater flow event if it occurs prior to criteria achievement as described in Table 6-5.[3]	Reservoir Area Management Plan Fish Passage Monitoring Areas and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
2024	After wet season	Reservoir Area Management Plan Fish Passage Monitoring Areas and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
	Fall	Reservoir Area Management Plan Fish Passage Monitoring Areas and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
2025	After wet season	Reservoir Area Management Plan Fish Passage Monitoring Areas and TMCP Monitoring Area	Reservoir Area Management Plan and TMCP
2026	After wet season	Reservoir Area Management Plan Fish Passage Monitoring Areas	Reservoir Area Management Plan
2027	After wet season	Reservoir Area Management Plan Fish Passage Monitoring Areas	Reservoir Area Management Plan
2028	After wet season	Reservoir Area Management Plan Fish Passage Monitoring Areas	Reservoir Area Management Plan

Note:
1. TMCP Monitoring Area = Five tributary confluences in the 8-mile reach from Iron Gate Dam (RM 193.1) to Cottonwood Creek (RM 185.1) and Shovel Creek Confluence (RM 210.4)
2. Reservoir Area Management Plan Fish Passage Monitoring Areas – Defined in Section 7.2.5
3. 5-year Flow Event of 10,895 cfs or greater on the Klamath River recorded at the USGS Klamath River Below Iron Gate Dam CA gage (#11516530)

6.2.6.1 Desktop versus Field Survey, Agency Notification, and Reporting

The Renewal Corporation will undertake fish passage monitoring through a combination of desktop and field review processes as described in Section 6.2.7, Headcut Migration Monitoring. The reference to survey period in Table 6-7 refers to a scheduled desktop evaluation. If the desktop evaluation of a potential fish passage barrier is inconclusive, or a potential barrier warrants adaptive management, field investigations will be conducted by the Renewal Corporation, and FERC and agency staff will be notified two (2) weeks prior to field surveys to allow the opportunity to participate in the monitoring effort. Monitoring will be led by qualified professional(s) who will assess barriers to volitional fish passage.

6.2.6.2 Anthropogenic Debris

The Renewal Corporation will remove human-made structures within the Fish Passage Monitoring Area that are visible within channel beds and present as potential fish passage barriers. These structures present potential fish passage barriers if they cause greater than a six (6)-in. discontinuity in water surface elevation (WSE) in the Oregon or twelve (12) in. discontinuity in WSE in California.

6.2.6.3 Natural Barriers

The Renewal Corporation will not remove any natural barriers consisting of non-residual reservoir sediments, bedrock, and other pre-dam channel elements, such as woody debris and boulders.

6.2.7 Headcut Migration Monitoring

Discontinuities in the channel bed due to uneven evacuation of sediments may lead to temporary headcuts that could act as a barrier to fish migration. Depending on the nature of the residual sediment and subsequent flows experienced, such headcuts may be short-lived and/or not likely to pose a sustained threat to fish passage or long-term habitat function. The Renewal Corporation will apply the following methods for evaluating and removing residual reservoir sediment headcuts that result in water surface elevation drops of six (6) in. (Oregon) and twelve (12) in. (California)[2].

6.2.7.1 Qualitative/Desktop Monitoring Methods

The Renewal Corporation will begin qualitative desktop monitoring immediately after drawdown (2023) and will continue through 2028. The Renewal Corporation's qualitative desktop monitoring will include monitoring and evaluation of all headcut features within the fish passage monitoring area using topographic data and aerial imagery as described in Section 6.2.7.2, Identification, and will be conducted by qualified professional staff. The Renewal Corporation's qualitative desktop monitoring will allow for in-season adaptive management of headcut features and communication of potential fish passage issues. The Renewal Corporation's qualitative desktop monitoring assessment will include the identification of headcuts that are potential barriers to fish passage and the evaluation of substrate, stability, and upstream fish presence.

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[2] The 6 in. discontinuity monitoring in Oregon may be refined in coordination with ODFW and ODEQ.

6.2.7.2 Identification

Given the spatial scale of the fish passage monitoring area, the Renewal Corporation will implement aerial data collection technologies to identify and evaluate potential fish passage barriers. Aerial data collection may include the following within the fish passage monitoring area:

- Low-elevation, geolocated oblique aerial video along the mainstem of the Klamath River and tributaries where fish passage monitoring is required. Video should be flown at a low elevation from downstream to upstream so that headcuts generating a change in WSE greater than six (6) in. in Oregon and twelve (12) in. in the California can be remotely identified.
- High-resolution orthorectified aerial imagery.
- Bare earth digital terrain model developed from aerial topographic data collection technologies.

The Renewal Corporation will collect aerial data for the fish passage monitoring area according to the schedule outlined in Table 6-7. All three data sets will be collected concurrently such that headcuts will be cross-identified between data sources. If the results of the desktop evaluation are inconclusive, the Renewal Corporation will conduct a site investigation, if required. The Renewal Corporation's desktop and any required field programs include the evaluation of physical and biological components. Subsequently, desktop and any required field programs will be completed by a multi-disciplinary team of qualified personnel. A fluvial geomorphologist or stream restoration engineer with experience in evaluating headcut migration will evaluate the physical components of the headcuts. An ecologist or fisheries biologist with experience in evaluating fish passage barriers will evaluate the biological components of the headcuts.

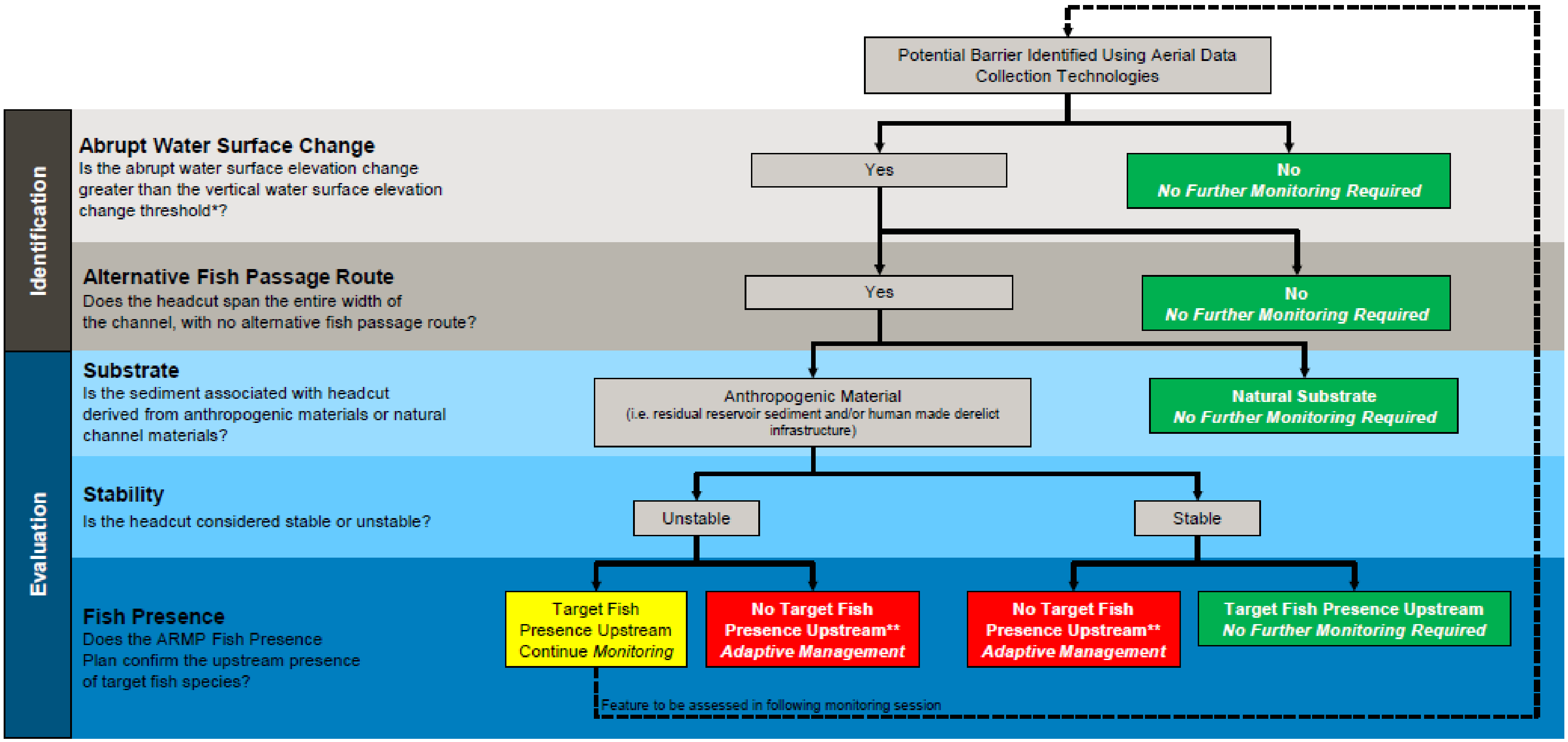
The first step in the mapping process is to review aerial data to identify and map the locations of headcuts within the fish passage monitoring area that have the potential to meet the following criteria:

- Abrupt water surface elevation changes greater than twelve (12) in. (California) and six (6) in. (Oregon); and
- Span the width of the channel, with no alternative fish passage route.

Upon the Renewal Corporation's completion of feature identification, the identified headcuts will be assigned a unique identifier such that their location and morphology can be monitored over time. Furthermore, a detailed desktop evaluation will be completed by the Renewal Corporation for each identified headcut feature as described below. Features that do not meet both the WSE change and channel width spanning criteria will not undergo further evaluation, as outlined in the identification component of the headcut evaluation framework in Figure 6-7.

6.2.7.3 Evaluation

The Renewal Corporation will evaluate identified headcuts that are potential barriers to fish passage to determine the need for future monitoring and/or adaptive management. Utilization of the headcut evaluation framework in Figure 6-7 will provide a systematic and repeatable evaluation of each potential barrier. The evaluation component of the framework separates potential barriers into those resulting from residual reservoir sediments and potential barriers arising from natural processes. The Renewal Corporation will undertake further evaluation if the barrier is anthropogenic in origin to assess whether it is stable or unstable over time. The Renewal Corporation will not correct natural barriers (those composed of materials other than residual reservoir sediments or dam infrastructure). The Renewal Corporation will evaluate potential barriers that are determined to be unstable with no fish presence above them (or fish presence/absence upstream is unconfirmed) for adaptive management interventions as described in Section 6.2.9, Adaptive Management. The Renewal Corporation will reassess potential barriers that are determined to be unstable with fish presence above them in the following monitoring year. The Renewal Corporation will evaluate potential barriers that exhibit stability with no fish presence above them for adaptive management interventions as described in Section 6.2.9, Adaptive Management. On the other hand, fish presence above a stable barrier will remove it from further monitoring activities.



* Abrupt water surface elevation changes greater than six inches in the Oregon portion of monitoring area and twelve inches in the California portion of the monitoring area.

** Adaptive management will be required if target fish presence/absence upstream is unconfirmed. Project adaptive management begins with a field-based review of the potential barrier and coordination with the RTWG to determine next steps (see Section 7.0)

Figure 6-7. Headcut Evaluation Framework

6.2.7.4 Substrate

The fish passage monitoring and associated adaptive management activities in the Reservoir Area Management Plan are focused on fish passage impediments caused by anthropogenic features including residual reservoir sediments and infrastructure. The Renewal Corporation will undertake a substrate evaluation to evaluate whether sediment associated with a potential fish passage barrier headcut is derived from anthropogenic materials or natural channel materials.

Anthropogenic materials include but are not limited to the following:

- residual reservoir sediments
- remnant infrastructure

Natural channel materials include but are not limited to the following:

- channel substrate with a gradation consistent with the pre-dam channel substrate, excluding imported or placed material
- colluvial and/or alluvial material supplied to the Reservoir Area Management Plan area from natural process occurring within the upstream watershed during the period of monitoring
- beaver dams
- Woody debris exposed within the residual reservoir sediments or supplied to the Reservoir Area Management Plan area from the upstream watershed

The desktop analysis will include a comparison of the headcut substrate composition to the composition of natural and anthropogenic materials. To support the categorization of substrate as anthropogenic or natural it may be necessary to compare the existing channel elevation to the pre-dam channel elevation. If the headcut is founded on natural channel materials then no further monitoring is required as indicated in Figure 6-7.

6.2.7.5 Stability

Following dam removal, downcutting and headcut migration is expected and desired to evacuate residual reservoir sediments within the reservoir area. In general, the rates of reservoir sediment erosion and headcut migration are expected to decay exponentially over time, until the pre-dam surface is reached (BOR, 2016). There may be instances where headcut migration is arrested as a result of incision intersecting erosion resistant material (e.g., large woody debris, firm reservoir deposits, remnant infrastructure); however, time and/or increased river flow may reinitiate headcut migration. The headcut migration process described above can be expected to occur within the mainstem of the Klamath River as well as tributary channels that enter the reservoir and flow through residual reservoir sediments.

The Renewal Corporation's headcut stability monitoring will include the following steps to evaluate potential effects of headcuts on fish passage within the fish passage monitoring area:

- Estimate annual migration distance based on relative position; and
- Review the flow record on the mainstem of the Klamath to evaluate the number of flow events exceeding the bankfull discharge within the monitoring year (see bankfull definition in Section 6.1.3, Table 6-5, Note 3).

The headcut is considered stable for the purpose of this monitoring protocol if both of the following statements are true:

- Planform position has remained stationary relative to previous two (2) monitoring years
- The hydrologic record indicates that the headcut has twice endured a discharge equal to or larger than the bankfull discharge within the previous two (2) monitoring years

If either of the above statements is false, then the feature cannot be categorized as stable. The Renewal Corporation will deem unstable features that do not meet these criteria (see Figure 6-7).

6.2.7.6 Fish Presence

Headcut migration has the potential to act as an impediment to fish migration. Because of multiple variables, including flow regime, channel morphology, sediment transport, and fish migration timing and despite the presence of an apparent barrier, fish presence upstream is still possible. Therefore, if the Renewal Corporation's fisheries investigations (ARMP Fish Presence Plan) confirm upstream target fish presence, this information will be used by the Renewal Corporation (Figure 6-7) to assess next steps based on the stability evaluation above. If the fisheries investigations neither confirms the presence or absence of target fish species upstream, the Renewal Corporation will implement adaptive management.

6.2.7.7 Quantitative / Field Monitoring Methods

If the desktop monitoring process is inconclusive, the barrier assessment approach may shift to field monitoring methods to complete the headcut evaluation. The Renewal Corporation's field monitoring methods may include the following:

- Longitudinal survey of the water surface profile to confirm magnitude of the drop. Details on the longitudinal profile survey are provided in Section 6.2.3, Monitoring Methods
- Field assessment to confirm whether headcuts span the width of the channel, with no alternative fish passage path

- Substrate characterization using visual observations, Wolman pebble count, or grab samples where appropriate
- Additional fish presence/absence surveys upstream of the headcut

If field-based data gathering is required to support the headcut evaluation, the relevant sections of the following references will be used by the Renewal Corporation to guide the effort:

- **Wadeable Streams:** A watercourse is considered wadable if it is less than one (1) meter deep for at least half the length of the site. Site investigations for wadeable streams will adhere to the relevant sections of the EPA Field Operations Manual for Wadeable Streams (EPA, 2013a).
- **Non-Wadeable Streams**: Site investigations for non-wadeable streams will adhere to the relevant sections of the EPA Field Operations Manual for Non-Wadeable Streams (EPA, 2013b).

6.2.7.8 Summary of Headcut Monitoring Methods

Headcut migration monitoring is to assess potential impacts to volitional fish passage within the fish passage monitoring area. The Renewal Corporation's monitoring program is designed to inform the fish passage monitoring project element and is summarized in Table 6-8.

Table 6-8. Summary of Desktop and Field Fish Passage Evaluation Components

HEADCUT EVALUATION STAGE	DESKTOP EVALUATION COMPONENTS	FIELD EVALUATION COMPONENTS *
Identification	• Identify headcuts generating a change in WSE greater than six (6) in. in Oregon and twelve (12) in. in California and span the width of the channel, with no alternative fish passage path • Assign each potential barrier a unique identifier	• Longitudinal profile survey to confirm if WSE change exceeds six (6) inches in Oregon and twelve (12) in.in California • Field confirmation that the barrier spans the width of the channel, with no alternative fish passage path
Substrate	• Characterization of headcut substrate to confirm if it is consistent with the residual reservoir sediment, restored reach substrate, or with natural channel substrate • Confirm the presence of remnant anthropogenic structures	• Field characterization of headcut substrate (e.g., visual observation, pebble count, grab sample)
Stability	• Estimate annual migration distance based on relative position • Review flow record to evaluate the number of flow events exceeding the bankfull discharge within the monitoring year	• Field observations by a qualified river scientist to confirm stability of the headcut
Fish Presence	• Refer to findings of fisheries investigation to evaluate the presence/absence of fish upstream of the headcut	• Completion of additional fisheries investigations to evaluate the presence or absence of fish upstream of the headcut

Notes:
* Implementation of a field evaluation component is only required if the results of the desktop evaluation are inconclusive. Field evaluation only required to address data gaps in the desktop evaluation (i.e., completion of all field evaluation components is only required if all desktop evaluation components are inconclusive).
**The vertical step threshold will be adjusted from six (6) in. to twelve (12) in. if agreed to by ODFW and ODEQ

6.2.7.9 Subsequent Measures

Upon completion of the evaluation, the Renewal Corporation will determine the need for continued monitoring, adaptive management, or if no further monitoring is required. A summary of action items for each determination is provided below:

- **Continued monitoring**: Continue monitoring to the end of the monitoring period.

- **Adaptive management**: If a site requires adaptive management intervention which includes field based data gathering because desktop analysis was inconclusive or to address a significant adaptive management intervention (Section 1216.2.9.5), notification will be provided to RTWG approximately (2) weeks prior to scheduled field work activities
- **No further monitoring required:** Success criteria have been achieved, and no further monitoring is required for the feature

6.2.8 Geomorphological and Residual Reservoir Sediment Stability Monitoring

The Renewal Corporation will annually monitor geomorphological and residual reservoir sediment stability by qualified professional(s) to assess the stability of the priority tributaries and the residual reservoir sediments within the reservoir areas. The Renewal Corporation will use qualitative and quantitative monitoring methods to evaluate the stability of the priority tributaries and the residual reservoir sediments within the reservoir areas as discussed in the following sections. Additionally, the Renewal Corporation will complete an interpretation of the qualitative and quantitative observations annually to estimate the patterns and trends of geomorphological adjustment. The results of this interpretation will be used by the Renewal Corporation to evaluate each site's position within the SET (Section 6.2.1, Geomorphological Communication). Positioning each site within the SET will provide context to any adaptive management decisions and facilitate consistent geomorphological communication.

6.2.8.1 Qualitative Assessment

This section defines the Renewal Corporation's qualitative monitoring methods to assess geomorphic restoration success through monitoring. Qualitative monitoring shall be completed by the Renewal Corporation following the wet season and include the following:

- **Rapid Geomorphological Assessment**: Rapid geomorphological assessment (RGA) includes an evaluation of bed morphology, substrate composition, bank stability, riparian vegetation, and geomorphological stability (i.e. aggradation and degradation). In order to provide a systematic and repeatable evaluation of each site, field forms were developed to support the RGA (Appendix G). The RGA also includes the collection of photographs to document the channel morphology, floodplain condition, and vegetation establishment. Attempts will be made to collect photographs from the same location and looking in the same direction, during subsequent monitoring visits such that photographic comparisons can be made over time.
  Monitoring element(s) supported: bank stability, floodplain connectivity, floodplain roughness, and channel fringe complexity.
- **Residual Reservoir Sediment Stability Assessment**: Residual reservoir sediment stability assessment includes the use of digital aerial data capture technologies and the creation of digital terrain models (DTM) that can be compared through surface subtraction to evaluate changes in residual reservoir sediments

over time. Project baseline DTM (Section 7.1.2, Initial Establishment) will be updated over time to represent site conditions as the Proposed Action progresses and to support monitoring and adaptive management activities.
Monitoring element(s) supported: residual reservoir sediment stability

6.2.8.2 Quantitative Assessment

This section defines the quantitative monitoring methods the Renewal Corporation will use to assess geomorphological restoration success through monitoring. The Renewal Corporation will only conduct quantitative monitoring surveys on restored priority tributaries to evaluate the success of the restoration construction. When quantitative monitoring reveals issues with the success of restoration elements, follow-up monitoring and/or adaptive management will be triggered. The Renewal Corporation will complete the following quantitative methods following the wet season:

- **Longitudinal Profile:** Longitudinal profile refers to the elevations of the thalweg of the watercourse. The longitudinal profile will consist of thalweg, water surface, and bankfull indicators where appropriate. The Renewal Corporation's comparison of the channel profile between monitoring years will support the Renewal Corporation's evaluation of channel change over time. Natural watercourses may demonstrate slight vertical adjustments over time, but there should be no significant channel bottom lowering (degradation) or raising (aggradation). The Renewal Corporation's longitudinal profile surveys will support the assessment of the bank stability and floodplain connectivity monitoring elements. The survey will also support the assessment of drop heights in support of the fish passage monitoring element, if required.
  Monitoring element(s) supported: bank stability (if required), floodplain connectivity (if required), fish passage (if required)
- **Dimension**: The Renewal Corporation will monitor channel dimension through monumented annual cross-sectional surveys. The Renewal Corporation will survey geometry to monitor any changes in channel geometry (e.g., cross-sectional area, bankfull width, bankfull depth etc.) and floodplain dimension. The Renewal Corporation's cross-sectional surveys will support bank stability and floodplain connectivity monitoring elements.
  Monitoring element(s) supported: bank stability, floodplain connectivity

When quantitative monitoring reveals issues with the success of restoration elements follow-up monitoring and/or adaptive management will be triggered.

6.2.8.3 Field Protocols

In order to provide a systematic and repeatable quantitative evaluation of each site is completed, quantitative assessment field protocols the Renewal Corporation will adhere to the relevant sections of the EPA Field Operations Manual for Wadeable Streams (EPA, 2013a). Additionally, geomorphological processes and formations tend to be more visible after large flow events, before a river system has been able to re-establish equilibrium.

The Renewal Corporation will Conduct assessments after high water has receded following a larger storm event to balance safety with ease of observation.

6.2.9 Adaptive Management

The adaptive management framework allows the monitoring elements to be interpreted and to take adaptive management actions when necessary to achieve the goals of the Proposed Action.

6.2.9.1 Triggers

Examples monitoring results that trigger the Renewal Corporation's adaptive management interventions are presented in Table 6-9 for Reservoir Area Management Plan Components and Monitoring Elements.

Table 6-9. Example Monitoring Results that Trigger Adaptive Management Frameworks

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	EXAMPLE MONITORING RESULT	ADAPTIVE MANAGEMENT
Reservoir Areas	Sediment Stability	Remaining reservoir sediments exhibit active erosion and vegetation is not producing stability.	Revegetation maintenance and hand work to address water sources contributing to rill formation.
Priority Tributaries	Fish Passage	Water surface elevation drops caused by discontinuity in residual reservoir sediments may preclude fish passage.	May conduct long profile survey, continue to monitor, assess severity, and evaluate need for physical interventions.
	Bank Stability	Constructed banks critical to restoration goals exhibit instability and erosion indicators indicate evolution towards a negative outcome.	May conduct long profile survey, continue to monitor, assess severity, and evaluate need for physical interventions.
	Floodplain Connectivity	Regular inundation of floodplains is not achieved. Excessive degradation is present in channel surface.	May conduct long profile survey, continue to monitor, assess severity, and evaluate need for physical interventions based on entrenchment ratio and SET trend.
	Floodplain Roughness	Revegetation of floodplain surface is not producing	Revegetation maintenance and hand work to address roughness elements.

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	EXAMPLE MONITORING RESULT	ADAPTIVE MANAGEMENT
		roughness in alignment with plan.	
	Channel Fringe Complexity	Channel fringe complexity features are not present and/or are inaccessible to species.	Assess lacking complexity elements to fish passage. May conduct long profile survey to assess incision processes.
Klamath River	Fish Passage	Water surface elevation drops caused by discontinuity in residual reservoir sediments may preclude fish passage.	May conduct long profile survey, continue to monitor, assess severity, and evaluate need for physical interventions.
Dam Footprints	Fish Passage	Threshold channel design is not functioning as intended and may not be passable to target fish species.	Revisit design and assess required adaptive management interventions to maintain threshold design and fish passage.

6.2.9.2 Example of Adaptive Management Measures

If volitional fish passage or geomorphological and residual reservoir sediment monitoring indicate that the success criteria outlined in Section 6.3.1, Success Criteria, are not being met, adaptive management may be required. The following list provides examples of specific proposed adaptive management measures that may be implemented by the Renewal Corporation:

- Bank stabilization using bioengineering, channel grading, and/or appropriately dimensioned stone
- Increase stability through targeted revegetation efforts
- Additional assessment and/or data collection (i.e., bathymetric survey)
- Channel bed stabilization using large wood and/or appropriately dimensioned stone
- Implementation of riparian plantings
- Supplementary sediment grading and stabilization

6.2.9.3 Adaptive Measures and Changing Circumstances

The Renewal Corporation will develop a plan to address unanticipated fish passage barriers (an amended plan) if any of the following occur: (1) natural disasters or other force majeure events (defined as events beyond the control of the entities removing the dams and providing habitat restoration services), (2) sediment evacuation or other assumptions are incorrect, or (3) other unforeseen circumstances result in more fish passage barriers than anticipated. Any amended plan will be adaptive, flexible, and responsive to changing natural conditions without imposing obligations that are more burdensome than anticipated (i.e., materially the same as what would have been required had both of the following circumstances taken place: (1) the event described above never occurred, and (2) the assumptions used by the Renewal Corporation were correct).

6.2.9.4 Minor and Significant Fish Passage Barrier Intervention

As detailed in Table 6-10, adaptive management interventions are considered minor and maintenance-oriented, requiring hand tools, or significant requiring mobilization of powered equipment and in-water work zone isolation. If extreme conditions require a revaluation of objectives, the Renewal Corporation will convene the RTWG (Appendix I) and strategize next steps (Section 6.2.9, Adaptive Management).

Table 6-10. Fish Passage Adaptive Management Interventions

RESERVOIR AREA MANAGEMENT PLAN COMPONENTS	MONITORING ELEMENT	MINOR INTERVENTIONS	SIGNIFICANT INTERVENTIONS	REVALUATE OBJECTIVES
Priority Tributary, Klamath River, Dam Footprints	Fish Passage	Maintenance Oriented – Hand Work – No Stream Isolation Required	Mobilization of Excavation Equipment – Stream Isolation may be Required	Sustained Drought, Extreme Weather, Incorrect Assumptions

The Renewal Corporation will monitor volitional fish passage at variable frequencies depending on the season and year (see Table 6-7). The Renewal Corporation will remedy obstructions that limit fish passage through appropriate manual or mechanical means necessary to address obstructions. Example removal methods include removing sediment using hand tools or hydraulic equipment. The Renewal Corporation will redistribute removed gravels and large woody debris within the channel in a manner that will avoid future headcut formation. The Renewal Corporation will place removed fine sediments on the adjacent floodplain or uplands and stabilize by using appropriate revegetation methods. The removal effort seek to provide volitional passage for adult and juvenile Chinook salmon, Coho salmon, steelhead, and Pacific lamprey.

Differentiation between minor and significant interventions is based on the scale of the issue encountered, inherent risk to aquatic species, the need to mobilize powered excavation equipment to the site or the ability to remedy with less impactful hand approaches, and in-water work zone isolation requirements (Table 6-10). The Renewal Corporation will coordinate with the RTWD for all significant barrier interventions.

In the event that data gathering is required to support significant interventions on the mainstem Klamath River, the relevant sections of the EPA Field Operations Manual for Non-Wadeable Streams (EPA, 2013b) will be used by the Renewal Corporation to guide the effort. In the event that data gathering is required to support significant interventions on priority tributaries, the relevant sections of the EPA Field Operations Manual for Wadeable Streams (EPA, 2013a) will be used by the Renewal Corporation to guide the effort

6.2.9.5 Communication Process for Significant Interventions

The Renewal Corporation will use the monitoring program evaluate if adaptive management is required. In the event that a significant adaptive management intervention (Section 6.2.9.4, Minor and Significant Fish Passage Barrier Intervention) is required, RTWG and/or ATWG members will be notified and provided with the location of the issue, photographs, and characteristics, as well as assessed type and severity. Based on the type and severity of the issue, the Renewal Corporation will take the following actions during the monitoring period:

- RTWG/ATWG members will be notified to confer on the need for corrective actions
- Hand tools will be used for minor interventions
- Mechanical equipment will be used for major interventions
- Continued monitoring will potentially occur to evaluate if natural hydrology correction will occur, and no direct intervention will be required

Notifications will be provided to RTWG/ATWG members approximately (2) weeks prior to field activities or 24 hours in advance of emergency interventions.

6.2.9.6 In-Water Work BMPs for Significant Interventions

Significant adaptive management interventions involve in-water work and the need for work zone isolation measures. The Renewal Corporation will implement the following BMPs for significant interventions that require in-water work (see Appendix C for a complete list of BMPs):

1. ATWG will be notified a minimum of 48-hours before start of work.
2. Unless under the guidance of ATWG, in-water work activities will occur during the in-water work window, expected to be June 15 to October 31.
3. A biologist will evaluate the in-water habitat to determine if salmonids or protected fish occur in the limits of work.
    a. If salmonid or protected fish are or are assumed to be present in the in-water work area, fish rescue, relocation, and exclusion will occur under the direction of a qualified fisheries biologist.
        i. General conditions for fish capture and relocation activities: Exclusion will include the use of block nets, or similar, to isolate the work area from fish access. The fisheries biologist will evaluate the upstream and downstream extent of the fish exclusion and relocation efforts, which will be based on the minimal amount of

wetted channel where salmonids may experience potential injury or mortality from the in-water activity. Fish relocation will be performed using seine nets, dip nets, and/or electrofishing as determined appropriate and effective by the fisheries biologist. The duration and extent of fish relocation actions will be determined by the fisheries biologist. Once the work area is determined to be cleared of salmonids, in-water work activities will be cleared to begin.

1. Electrofishing: All electrofishing will be conducted in accordance with the NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (NOAA and NMFS, 2000).
2. Salmonid Handling and Relocation: National Oceanic and Atmospheric Administration (NOAA) Restoration Center's Programmatic Approach to ESA/EFH Consultation Streamlining for Fisheries Habitat Restoration Projects (NOAA and NMFS, 2017), Section 2.4.1.E – Guidelines for Relocation of Salmonids, will guide relocation work.

b. If no salmonids or protected fish occur in the work area, a biologist will monitor the in-water work actions to ensure that there is no change in conditions that would require fish exclusion or relocation. The biologist will document and report the completion of the in-water work activity to NMFS as described below.

4. Disturbance to existing riparian vegetation and channel banks will be minimized to the extent feasible to complete the required restoration or maintenance action.
5. In the tributary restoration areas, flow diversion around the work area will be used if channel bed adjustments are required.
6. The use or storage of petroleum-powered equipment shall be accomplished in a manner to prevent the potential release of petroleum materials into waters of the state.
7. Areas for fuel storage, refueling, and servicing of construction equipment will be located in an upland location.
8. Oil absorbent and spill containment materials will be on site when mechanical equipment is in operation within 100 ft of the proposed watercourse crossings. If a spill occurs, no additional work shall commence in-channel until the following occurs: (1) the mechanical equipment is inspected by the Renewal Corporation contractor, and the leak has been repaired; (2) the spill has been contained; and (3) ATWG is contacted and have evaluated the impacts of the spill.
9. Invasive species control measures will be followed to minimize potential transport of aquatic invasive species.
10. Documentation and Reporting: Photographs of the in-water work location, summary of actions including any fish relocation, and notification of completion of the in-water work will be provided to ATWG within one (1) week of the completion of in-water work.

6.3 Revegetation Adaptive Management

The first two (2) years after dam removal (2023-2024) are critical to vegetation establishment, because plants that establish early have a strong impact on the trajectory of vegetation succession. Survival of established species will be highest in the first two (2) years due to the residual moisture left behind in the sediments after reservoir drawdown. Therefore, important species (i.e., oaks) will be introduced by the Renewal Corporation during this period. Establishment of native vegetation at the early stages of succession will also decrease the colonization and spread of IEV. The Renewal Corporation will quantitively and qualitatively monitor during the first two (2) years, with implementation of adaptive management where appropriate. IEV management will be completed annually in early season and late season implementation phases, as necessary, to maximize IEV treatment effectiveness for specific plant species. A five (5)-year maintenance period (2025-2029) will follow this two (2)-year vegetation establishment period. The Renewal Corporation will continue quantitative monitoring for the entire five (5)-year maintenance and monitoring period.

6.3.1 Success Criteria

Success criteria for the Proposed Action provide targets to evaluate the progression of vegetation development in the reservoirs with the goal of creating viable self-sustaining native plant communities in riparian and upland habitats. The Renewal Corporation's annual monitoring of the restoration areas will evaluate if revegetation is progressing along a trajectory compliant with the success criteria.

The Renewal Corporation is proposing four (4) criteria designed to evaluate revegetation success in the former reservoirs after dam removal: (1) relative vegetation cover, (2) plant diversity, (3) number of surviving trees and shrubs per acre, and (4) invasive exotic vegetation cover. These criteria are standard practice for restoration projects. Dam removal revegetation is unique and differs in several ways from other restoration projects. To account for the unique conditions, the Renewal Corporation modified the criteria. These criteria are based on previous dam removal monitoring programs. The criteria establish targets for the following vegetation characteristics.

- Species richness
- Tree and shrub density
- Vegetation cover
- IEV relative frequency

The criteria are separated into dry upland criteria and riparian/wetland criteria. The proposed vegetation success criteria for species richness, vegetation cover, tree and shrub density and nonnative vegetation frequency applies to both landforms. The Renewal Corporation's criteria targets are a percentage of reference sites. For example, the upland species richness target in Year 1 is 50 percent the species richness as measured in adjacent reference upland plant communities.

The Renewal Corporation will assess all of the success criteria using quantitative monitoring methods. The Renewal Corporation will establish randomly distributed permanent plots in all three (3) reservoirs and monitor annually beginning in 2025 (Year 1) after implementation is complete and re-survey annually until 2029 (Year 5). The Renewal Corporation will evaluate the results of annual monitoring to determine if success criteria are being met. If criteria are not meeting targets, adaptive management and remedial actions may be needed.

The Renewal Corporation will not consider naturally occurring species separately in the data. All species present, planted, seeded, or natural will be treated equally for all success criteria. The Renewal Corporation will make determinations of naturally recruited species versus planted by comparing data to plots located in control areas left unseeded and unplanted in the reservoir footprints.

6.3.1.1 Species Richness

Species richness is an assessment of the number of species present in a given area. Species richness is preferable to the related species diversity metric because species diversity in early successional communities is very fleeting and not representative of the eventual community that will develop. Species richness is the number of species present in a given ecosystem. Species diversity combines the number of species with abundance measurements. Species richness provides a better measure of ecosystem resilience, which is not provided by diversity metrics. For restoration, particularly in light of climate change, ecosystem resilience is critical to a newly restored site. Species diversity in primary series tend to be low because early plant communities are often dominated by only a few species for a few years before giving way to longer-lived species. Ocular cover estimates, typically used to determine species diversity, are subjected to surveyor observation variability over time. Species richness records all species present, which is a less subjective metric that provides insight into the presence of important long-lived species that might be under-represented using diversity assessments. Species richness data are efficient and cost-effective to collect and can be used to determine abundance (diversity) on a landscape scale.

The Renewal Corporation’s species richness criteria is based on percentage of species richness monitored in reference target plant communities (Table 6-11). Over time, species richness will increase as a result of planting and natural recruitment. Moist riparian habitats are expected to develop more rapidly than drier upland habitats. Riparian habitats will be immediately connected to intact upstream riparian communities that provide moisture, seed, and vegetative propagules critical to habitat development.

Table 6-11. Species Richness Success Criteria

HABITAT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Upland	50%	55%	60%	65%	70%
Riparian	50%	60%	70%	80%	85%

Note: The targets are a percent of the species richness observed in appropriate reference communities.

6.3.1.2 Tree and Shrub Density

Trees and shrubs provide important structural features in upland and riparian habitats. Target densities will be achieved by planting bare root plants, seeding (i.e., *Ericameria nauseosa* and *Quercus* species) and natural recruitment from surrounding seed sources. The Renewal Corporation's field botanists will not differentiate between natural and planted trees and shrubs; all woody plants present in the plots will be treated equally. These data will allow the Renewal Corporation's field staff to assess species performance in the sediments to focus maintenance activities on planting species that exhibit tolerance to the unique environmental conditions. These data also provide a species richness and diversity metric for woody plants.

The Renewal Corporation will base tree and shrub density on a percentage of densities observed in target plant communities (Table 6-12). The Renewal Corporation expects that riparian areas will support densities close to reference conditions more quickly than in drier upland sites.

Table 6-12. Tree and Shrub Density Success Criteria

HABITAT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Upland	50%	55%	60%	65%	70%
Riparian	50%	60%	70%	80%	85%

Note: The targets are a percent of the density of trees and shrubs observed in appropriate reference communities.

6.3.1.3 Vegetation Cover

The Renewal Corporation's criteria for vegetation cover is based on the percentage of vegetation cover observed in target plant communities (Table 6-13). Vegetation cover includes herbaceous and woody species and is calculated as the inverse of bare ground encountered along line-intercepts. In riparian/wetland areas, primary succession can result in rapid cover of vegetation, which can be accelerated by irrigation. The Renewal Corporation expects upland vegetation cover to be slow to reach targets because dry, primary successional surfaces devoid of vegetation take time to develop. For example, it is not anticipated that oak trees will develop significant cover in only seven (7) years. A progression of increasing cover is expected annually after Year 1.

Table 6-13. Vegetation Cover Success Criteria

HABITAT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Upland	15%	25%	45%	60%	80%
Riparian	40%	50%	60%	70%	80%

Note: The targets are a percent of the vegetation cover observed in appropriate reference communities.

6.3.1.4 IEV/Non-Native Vegetation Relative Frequency

Typically, ocular cover data are used to assess abundance of non-native species. An alternative abundance measurement is frequency. Frequency is measured using presence/absence plots. Relative frequency calculates the percentage of all nonnative plants present relative to native species. This method is quicker and repeatable, with low observer variability compared to ocular cover estimates. During monitoring events, vegetation frequency data collection will treat all non-native species equally (IEV are not weighted differently - see Section 5.3.3 for discussion of non-native plants versus IEV).

The Renewal Corporation’s proposed seeding is designed to significantly reduce the abundance of non-native vegetation that initially establishes; however, the Renewal Corporation expects a relatively slow increase in the frequency of non-native vegetation. Although this is not ideal, it is based on the conditions in the surrounding landscape – all three (3) reservoirs are surrounded by significant populations of non-native species. Non-native vegetation frequency success criteria take this into account, with non-native vegetation frequency criteria increasing each year (Table 6-14).

Table 6-14. Non-Native Vegetation Frequency Success Criteria

HABITAT	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Upland	25%	40%	55%	70%	90%
Riparian	25%	40%	55%	70%	90%

Note: The targets are a percent of the total non-native vegetation relative frequency observed in appropriate reference communities. All IEV species occurrence will be included in non-native vegetation data collection; high priority IEV species will be eradicated upon observation, following occurrence frequency notation.

The Renewal Corporation’s IEV management strategy (as discussed in section 5.3.3) outlines measures to make a concerted effort to contain highly invasive species and does not focus on all non-native species. High-priority IEV will not be tolerated in the non-native vegetation frequency plots and will also be monitored separately outside the plots to contain occurrences within the reservoir footprints. Randomly located, quantitative plots, such as those used to measure non-native vegetation frequency, are excellent at determining large-scale patterns of relative abundance but are not designed for effective early detection and rapid response to IEV.

6.3.2 Monitoring Methods

The Renewal Corporation will use the qualitative and quantitative monitoring methods discussed in this section.

6.3.2.1 Qualitative Monitoring Methods

The Renewal Corporation's qualitative monitoring will begin immediately after dam removal in 2023 and will continue annually through 2029. The Renewal Corporation's qualitative monitoring includes regular site inspections of all plantings and seeded areas conducted by professional botanists and ecologists. The Renewal Corporation's qualitative inspections allow for in-season adaptive management of vegetation and will inform project managers of the progress of vegetation development. The Renewal Corporation will establish landscape-scale photo points in 2023 following drawdown to represent the overall response of vegetation. During the maintenance and monitoring period, the Renewal Corporation will establish photo points at all monitoring plots and will be repeated annually.

6.3.2.2 Quantitative Monitoring Methods

The Renewal Corporation will monitor success criteria using quantitative vegetation surveys in permanent plots randomly located with the reservoir footprints and stratified by landform (riparian or upland) and treatment (i.e., seeded only, planted and seeded, or unmanaged). Each plot will survey for all four (4) success criteria and will consist of a line-intercept and a 100-square-meter (m^2) (approximately 1,076 ft^2) plot. In uplands, the plots will be larger to ensure that tree and shrub densities are accurately measured. The final size and dimensions (shape) for these plots will be determined by reference sites in adjacent areas.

6.3.2.2.1 Monitoring Methods

Observational setup at each location shall consist of three (3) elements, a 20-meter line-intercept transect, and a 100-m^2 plot (larger plots will be required in uplands and dimensions may differ in wetland/riparian areas) and multiple 80-square-centimeter plots. Bare ground, the cover of woody plants (to species, all canopy layers included), and the total cover of herbaceous plants (not identified to species) will be measured along the line-intercept transect. Within each 100-m^2 plot, all plant species will be identified to species (for measure of species richness), and all trees and shrubs will be counted by species (for measure of tree and shrub density criterion). Within each plot, a minimum of ten 80-square-centimeter quadrats (more may be needed in larger plots) will be located along either side of the line-intercept and sampled for rooted plant frequency (nonnative frequency criterion).

The Renewal Corporation will survey plots once annually during late spring/early summer to ensure that annual species are well represented in the data. Many native and nonnative annual species are prevalent in the surrounding plant communities, and these species senesce in the hot summers, when they are difficult to identify.

6.3.2.2.2 Reference Sites

The Renewal Corporation will survey plots in adjacent upland and riparian reference sites in the spring and summer prior to dam removal (2022) to establish a baseline for the criteria. Although site conditions within the reservoir footprints are expected to be unique, the Renewal Corporation's success criteria are designed to focus more on vegetation structural characteristics as appropriate targets for revegetation. The field monitoring team will sample multiple plant communities in the uplands around the reservoirs and locate appropriate tributary and mainstem riparian habitats for sampling. The Renewal Corporation will survey multiple plots (a minimum of nine [9] per vegetation type), and use the mean value for each vegetation characteristic to establish specific target numbers for all four (4) criteria to meet. For example, if the mean number of species identified in uplands is 32, 50 percent of 32 (16) will be the target species richness value for uplands in Year 2.

6.3.2.2.3 Control Plots within the Reservoir Footprints

The Renewal Corporation will leave areas within the reservoir footprints unseeded and unplanted (control areas) to provide additional reference conditions to managed areas. Control areas will be small, limited to a few acres in areas away from residential viewpoints. The Renewal Corporation will treat these control sites for IEV. The Renewal Corporation will establish plots in the control areas to provide additional reference conditions and to adaptively manage the revegetation project and expectations. If necessary, the Renewal Corporation will use data from control areas to reassess the success criteria in consultation with appropriate agencies if traditional reference sites are not proving informative to vegetation development.

6.3.3 Adaptive Management for Vegetation

6.3.3.1 Maintenance Activities

If the monitoring data determined that the success criteria outlined above are not being met, the Renewal Corporation will take the following actions:

1. Determine the cause of the problem. Appropriate staff, including but not limited to, restoration ecologists, botanists, soil scientists, hydrologists, and geomorphologists, will assess environmental conditions and submit a report to the Project management team.
2. Success criteria will be re-evaluated by comparing plot data to control sites. Results will be summarized and submitted to the appropriate regulatory agencies for review.

3. If necessary, remedial measures based on problem determination will be proposed and submitted to the regulatory agencies for approval prior to implementation.

Remedial actions implemented by the Renewal Corporation will be monitored to determine whether they are successful. The maintenance period begins in Year 3 post-dam removal (2025). The Renewal Corporation will use data from the first two (2) years to develop the five (5) year maintenance plan. Maintenance will focus on meeting success criteria and managing IEV species within the reservoir footprints.

Several options are available to provide successful revegetation during the maintenance period including reseeding, replanting, irrigation, and IEV control. The Renewal Corporation's additional revegetation actions may include mulching, compost or other natural nutrient additives, and herbivore fencing.

6.3.3.1.1 Reseeding

The Renewal Corporation will consider reseeding areas that are not performing up to standard (i.e., low cover, low richness or high IEV abundance) with species proven to succeed in the unique environmental conditions (fine sediments). The Renewal Corporation will use data from control plots and plots in managed sites to determine species patterns that are successful, and seed may be wild-collected to sow into trouble sites. New seed increase contracts or genetically appropriate native seed materials may be necessary to seed large areas during the maintenance period.

6.3.3.1.2 Plant Replacement

The Renewal Corporation will consider replanting if tree and stem densities do not meet the target numbers defined in the success criteria. Species selected for replanting will be based on native species proven to tolerate the unique environmental conditions in the reservoir footprints based on data collected in the first two (2) years.

6.3.3.1.3 Irrigation

Irrigation may be a remedial action at sites with facilitation patches of trees and shrubs. The Renewal Corporation will consider the location and irrigation methodology needed during the maintenance period.

6.3.3.1.4 IEV Management

The management of IEV species is critical to successful revegetation. Long term management will be dependent on how the sites evolve and will be based on data from a few years of monitoring. As such adaptive IEV management will likely be re-assessed by the Renewal Corporation three or four years post-drawdown.

7.0 Data Management and Reporting

The Renewal Corporation will manage compliance planning and documentation for the Reservoir Area Management Plan and concurrent management plans discussed in Section 2.2, Relationship to Other Management Plans (Crosswalk to facilitate collaboration, communication, and knowledge access between the Renewal Corporation's contractors, agencies, and stakeholders.

The Renewal Corporation will prepare and submit an Annual Compliance Report within six (6) months of concluding drawdown activities, and annually thereafter by April 1 of each year for as long as the Renewal Corporation has performance obligations under the Reservoir Area Management Plan. The report will be submitted to FERC and will include the following, at a minimum:

1. Monitoring data, including graphical representations, as appropriate
2. Consultation records
3. Narrative interpretation of results
4. Adaptive Management
5. Compliance evaluations

8.0 References

Brownell, N.F., Kier, W.M., and Reber, M.L. 1999. Historical and Current Presence and Absence of Coho Salmon (Oncorhynchus kisutch) in the Northern California Portion of the Southern Oregon-Northern California Evolutionary Significant Unit.

California Department of Fish and Game (CDFG). 2010. California Salmonid Stream Habitat Restoration Manual. 4th Edition. Available online at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=22660. Accessed January 2021.

CDFG. 2012. Adaptive Management Conceptual Model. Available online at: https://www.dfg.ca.gov/erp/adaptive_management.asp. Accessed January 2021.

California State Water Resources Control Board (SWRCB). 2018. Draft Environmental Impact Report for the Lower Klamath Project License Surrender, Volume I. December 2018. Available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/lower_klamath_ferc14803_deir.html

SWRCB. 2020. Water Quality Certification for the Klamath River Renewal Corporation Lower Klamath Project License Surrender Federal Energy Regulatory Commission Project No. 14803. April 7, 2020. Available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_final_wqc_7april2020.pdf

Callaway, R.M. 1995. Positive interactions among plants. The Botanical Review 61:306–340.

Castro, J.M. and Thorne, C.R. 2019. The Stream Evolution Triangle: Integrating Geology, Hydrology, and Biology. March 26, 2019. Available online at: https://onlinelibrary.wiley.com/doi/full/10.1002/rra.3421. Accessed January 2021.

Close, D., Docker, M., Dunne, T., and Ruggerone, G. 2010. Scientific Assessment of Two Dam Removal Alternatives on Lamprey. January 14, 2020. Available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_final_wqc_7april2020.pdf. Accessed January 2021.

Cluer, B., and Thorne, C. 2013. A Stream Evolution Model Integrating Habitat and Ecosystem Benefits. Available online at: https://onlinelibrary.wiley.com/doi/abs/10.1002/rra.2631

Department of the Interior, U. S. Department of Commerce, National Marine Fisheries Service (DOI, USDC, and NMFS). 2007. Magnuson-Stevens Reauthorization Act Klamath River Coho Salmon Recovery Plan. July 10, 2020. Available online at: https://repository.library.noaa.gov/view/noaa/17378. Accessed January 2021

DiTomaso, J.M. and G.B. Kyser. 2013. Weed Control in Natural Areas of the Western United States. Weed Research and Information Center, University of California, 599 pages.

EPA, 2020. Determination regarding Sediment Quality Data for removal of J.C. Boyle, Copco 1 and 2, and Iron Gate Dams on the Lower Klamath River. Memo dated 8/20/20

Federal Energy Regulatory Commission (FERC). 2018. Order Amending License and Deferring Consideration of Transfer Application FERC Project Nos. 2082-062 and 14803-000. March 15, 2018. Available online at: https://www.ferc.gov/sites/default/files/2020-04/H-2.pdf. Accessed January 2021.

Graham Matthews & Associates (GMA), 2003. Evaluation of Tributary Sediment Yields for the PacifiCorp Klamath Project Based on Delta Deposits. Appendix 6B.

Hamilton, J.B., G.L. Curtis, S.M. Snedaker, and D.K. White 2005. Distribution of Anadromous Fishes in the Upper Klamath River Watershed Prior to Hydropower Dams – A Synthesis of the Historical Evidence. Available online at: https://fisheries.org/docs/fisheries_magazine_archive/fisheries_3004.pdf. Accessed January 2021.

Hamilton, J., R. Quinones, D. Rondorf, K. Schultz, J. Simondet, S. Stressor. 2010. Biological Synthesis for the Secretarial Determination on Potential Removal of the Lower Four Dams on the Klamath River. Prepared by the Biological Subgroup. Draft May 27, 2010.

Hamilton, J. B., D. W. Rondorf, W. T. Tinniswood, R. J. Leary, T. Mayer, C. Gavette, and L. A. Casal, 2016. The persistence and characteristics of Chinook salmon migrations to the upper Klamath River prior to exclusion by dams. OHQ 117: 326–377.

Hammond, P.E., 1983. Volcanic formations along the Klamath River near Copco Lake. California Geology.

Huntington, C.W. 2006. Estimates of Anadromous Fish Runs above the Site of Iron Gate Dam. January 15, 2006. Available online at: http://www.klamathbasincrisis.org/settlement/documents/Huntington%282006%29-FishEstimatesUpdate.pdf. Accessed January 2021.

Klamath River Renewal Corporation (KRRC). 2018. Definite Plan for the Lower Klamath Project (also known as the 2018 Definite Plan Report). June 2018. Available online at: http://www.klamathrenewal.org/definite-plan/. Accessed January 2021.

KRRC and PacifiCorp. 2020. Amended Application for Surrender of License for Major Project and Removal of Project Works and Request for Expedited Review; FERC Project Nos. 14803-001 and 2082-063. November 17.

Montgomery. D. R., and J. M. Buffington. 1998. Channel processes, classification, and response in R. J. Naiman and R. E. Bilby (eds.), River Ecology and Management: Lessons from the Pacific Coastal Ecoregion. Springer, New York, NY. Pages 13-42

Moody, M.E. and R.N. Mack. 1988. Controlling the spread of plant invasions: the importance of nascent foci. Journal of Applied Ecology. 25: 1009-1021.

National Oceanic and Atmospheric Administration and National Marine Fisheries Service (NOAA and NMFS). 2000. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act. June 2000. Available online at: https://www.arlis.org/docs/vol1/230935595.pdf. Accessed January 2021.

NMFS. 2017. Klamath River Basin Report to Congress. Available online at: http://www.westcoast.fisheries.noaa.gov/klamath/salmon_management.html.

NOAA. 2017. The National Oceanic and Atmospheric Administration Restoration Center's Programmatic Approach to ESA/EFH Consultation Streamlining for Fisheries Habitat Restoration Projects.

Oregon Department of Environmental Quality (ODEQ). 2019. Clean Water Act Section 401 Certification for the Klamath River Renewal Corporation Lower Klamath Project License Surrender (FERC No. 14803), Klamath County, Oregon. September 7, 2018. Available online at: https://www.oregon.gov/deq/FilterDocs/ferc14803final.pdf. Accessed January 2021.

PacifiCorp. 2004. Environmental Report. Final License Application, Volume 2, Exhibit E. Klamath Hydroelectric Project (FERC Project No. 2082). February 2004. Available online at: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/klamath-river/relicensing/klamath-final-license-application/Exhibit_E_Table_of_Contents_Introduction_and_General_Description.pdf. Accessed January 2021.

Philip Williams & Associates (PWA). 2009. A River Once More: Restoring the Klamath River following Removal of the Iron Gate, Copco, and J.C. Boyle Dams. December 2008.

River Design Group (RDG). 2018a. River Design Group's field notes from 2/5/18 Fall Creek survey.

RDG. 2018b. River Design Group's field notes from 3/28/18 Jenny Creek survey.

RDG. 2019, unpublished. Fish passage structure inventory. Shared via personal communication.

Simon, A., Thomas, R.E. and Bell, R.B., 2010. Erodibility Characteristics of Bottom Deposits from Three Klamath River Reservoirs, California and Oregon. USDA-ARS National Sedimentation Laboratory, Oxford, MS.

U.S. Environmental Protection Agency (EPA). 2013a. National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Wadeable. EPA-841-B-12-009b. May 2013. Available online at: https://www.epa.gov/sites/production/files/2016-04/documents/nrsa1314_fom_wadeable_version1_20130501.pdf. Accessed January 2021.

USEPA. 2013b. National Rivers and Streams Assessment 2013-2014: Field Operations Manual – Non-Wadeable. EPA-841-B-12-009a. May 2013

U.S. Bureau of Reclamation (BOR). 2010. Klamath River Sediment Sampling Program Phase 1 – Geologic Investigations Volume 1 of 2.

USBOR. 2011a. Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-19.

USBOR. 2011b. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02.

USBOR. 2014. Reclamation – Managing Water in the West. Pacific Northwest Region Resource & Technical Services Large Woody Material Risk Based Design Guidelines. September 2014. Available online at: https://www.usbr.gov/pn/fcrps/documents/lwm.pdf. Accessed January 2021.

USBOR. 2016. Reclamation – Managing Water in the West. Dam Removal Analysis Guidelines for Sediment – Version 1, Technical Report No. SRH-2016-38. September 2016. Available online at: Reservoir Sediment Analysis (usbr.gov)https://usbr.gov/tsc/techreferences/mands/mands-pdfs/DamRemovalAnalysisGuidelinesForSediment_09-2016_508.pdf. Accessed January 2021.

US Bureau of Reclamation (BOR) and California Department of Fish and Wildlife (CDFW) 2012. Facilities Removal Final Environmental Impact Statement/Environmental Impact Report. December.

U.S. Geological Survey (USGS). 2019. StreamStats. Available online at: https://streamstats.usgs.gov/ss/. Accessed January 2021.

University of California, Davis (U.C. Davis). 2020. Seed Storage/Conservation. Seed Biotechnology Center. Available online at: http://sbc.ucdavis.edu/About_US/Seed_Biotechnologies/Seed_Storage_Conservation/#

Von Holle, B, and D Simberloff. 2005. Ecological resistance to biological invasion overwhelmed by propagule pressure. Ecology. 86(12): 3212- 3218.

Appendix A

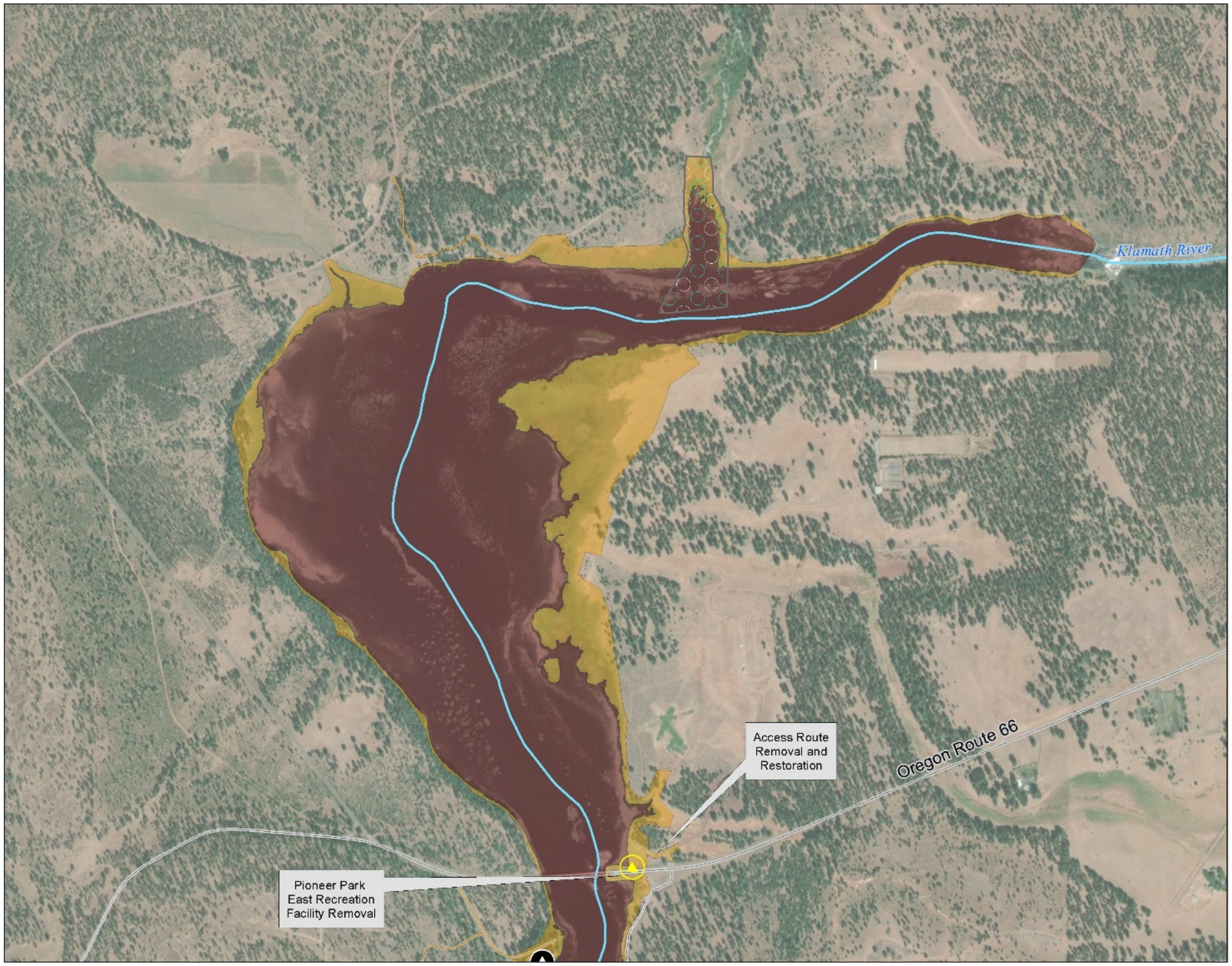
Consultation Record

Consultation Record

Reservoir Area Management Plan			
Agency	**Date of Agency Plan Submittal**	**Agency Comments Received Date**	**Date of Call to Resolve Agency Comments**
National Marine Fisheries Service	January 27, 2021	February 8, 2021	Pending
United Stated Fish and Wildlife Service	January 27, 2021	February 8, 2021	Pending
California State Water Resources Control Board	January 25, 2021	Pending	Pending
California Department of Water Resources	January 25, 2021	Pending	Pending
California North Coast Regional Water Quality and Control Board	January 25, 2021	Pending	Pending
California Department of Fish and Wildlife	January 25, 2021	February 8, 2021	Pending
California Department of Water Resources	January 25, 2021	Pending	Pending
Karuk Tribe	January 25, 2021	Pending	Pending
Yurok Tribe	January 25, 2021	Pending	Pending
Oregon Department of Environmental Quality	January 25, 2021	Pending	Pending
Oregon Department of Fish and Wildlife	January 25, 2021	Pending	Pending

Appendix B

Figures / Detailed Map Books



KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
Reservoir Area Management Plan

Figure B. 1-7
Anticipated Proposed Action Activity Areas

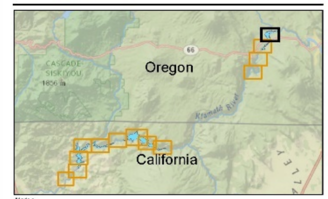
January 2021

N

0 500 1,000 1,500 Feet
(At original document size of 11x17)
1:9,830

Maximum Limits of Restoration
Restoration Drawdown Area
Priority Tributary Restoration Areas
Access Routes
Recreation Sites to Modify
Recreation Sites to Remove
Klamath River
Streams

PRELIMINARY DESIGN
(NOT FOR CONSTRUCTION)



Notes
1. Coordinate System: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US
2. Data Sources: Access Routes: Knight Piesold 100 Design; Disposal Sites: Knight Piesold 100 Design; Staging Areas: CDM and McMillen Jacobs to reflect Knight Piesold 100 Design; Tributary Restoration Areas: Stantec; Klamath River: Developed by AECOM with https://nhd.usgs.gov/NHD_High_Resolution.html National Hydrography Dataset
3. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

Sheet 1 of 13

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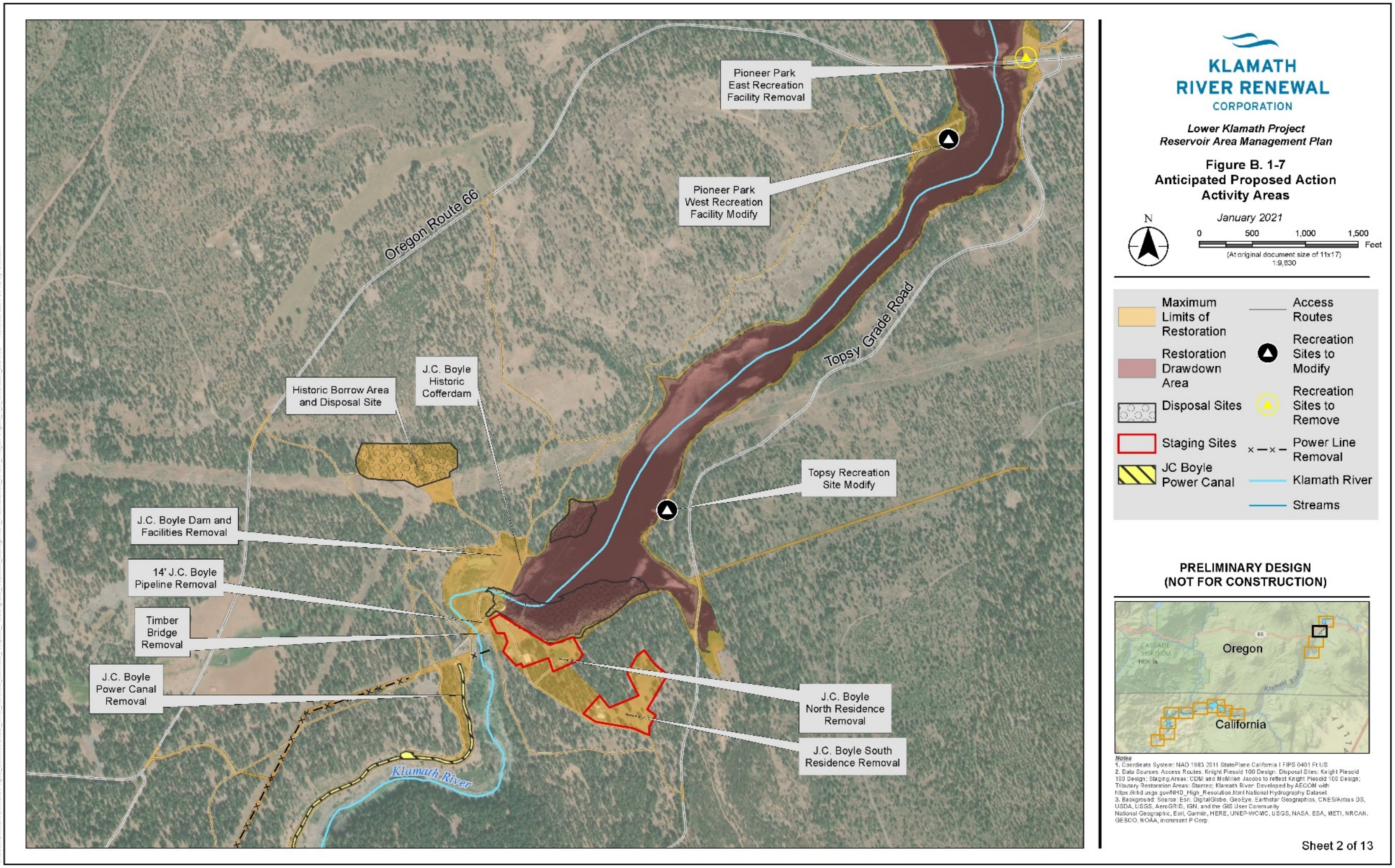
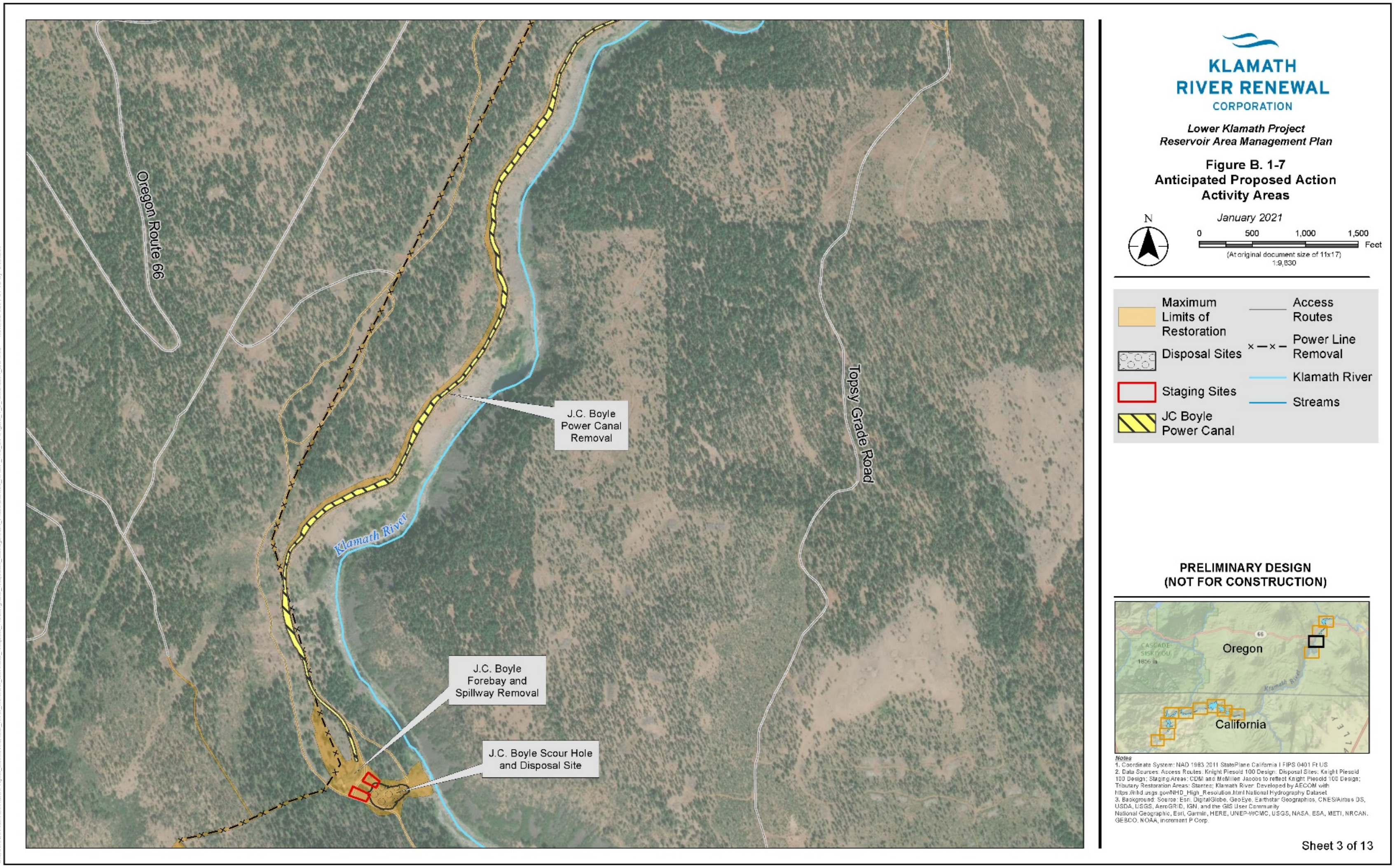

Pioneer Park East Recreation Facility Removal
Pioneer Park West Recreation Facility Modify
Oregon Route 66
Topsy Grade Road
Historic Borrow Area and Disposal Site
J.C. Boyle Historic Cofferdam
Topsy Recreation Site Modify
J.C. Boyle Dam and Facilities Removal
14' J.C. Boyle Pipeline Removal
Timber Bridge Removal
J.C. Boyle Power Canal Removal
J.C. Boyle North Residence Removal
J.C. Boyle South Residence Removal
Klamath River
KLAMATH RIVER RENEWAL CORPORATION
Lower Klamath Project
Reservoir Area Management Plan
Figure B. 1-7
Anticipated Proposed Action Activity Areas
January 2021
N
0 500 1,000 1,500 Feet
(At original document size of 11x17)
1:9,830
Maximum Limits of Restoration
Restoration Drawdown Area
Disposal Sites
Staging Sites
JC Boyle Power Canal
Access Routes
Recreation Sites to Modify
Recreation Sites to Remove
Power Line Removal
Klamath River
Streams
PRELIMINARY DESIGN
(NOT FOR CONSTRUCTION)
Oregon
California
Notes
1. Coordinate System: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US
2. Data Sources: Access Routes: Knight Piesold 100 Design: Disposal Sites: Knight Piesold 100 Design; Staging Areas: CDM and McMillen Jacobs to reflect Knight Piesold 100 Design; Tributary Restoration Areas: Stantec; Klamath River: Developed by AECOM with https://nhd.usgs.gov/NHD_High_Resolution.html National Hydrography Dataset
3. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Sheet 2 of 13



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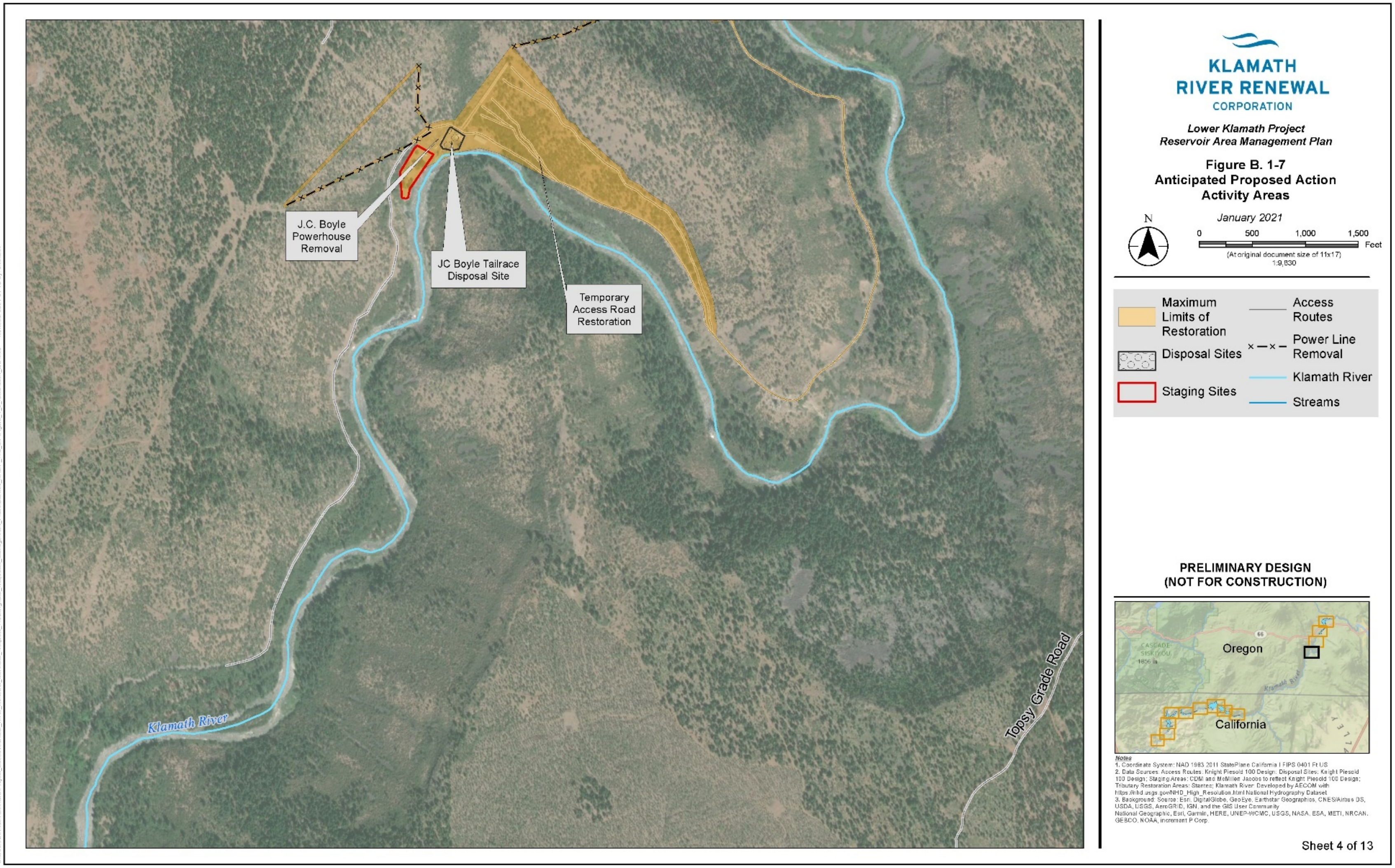

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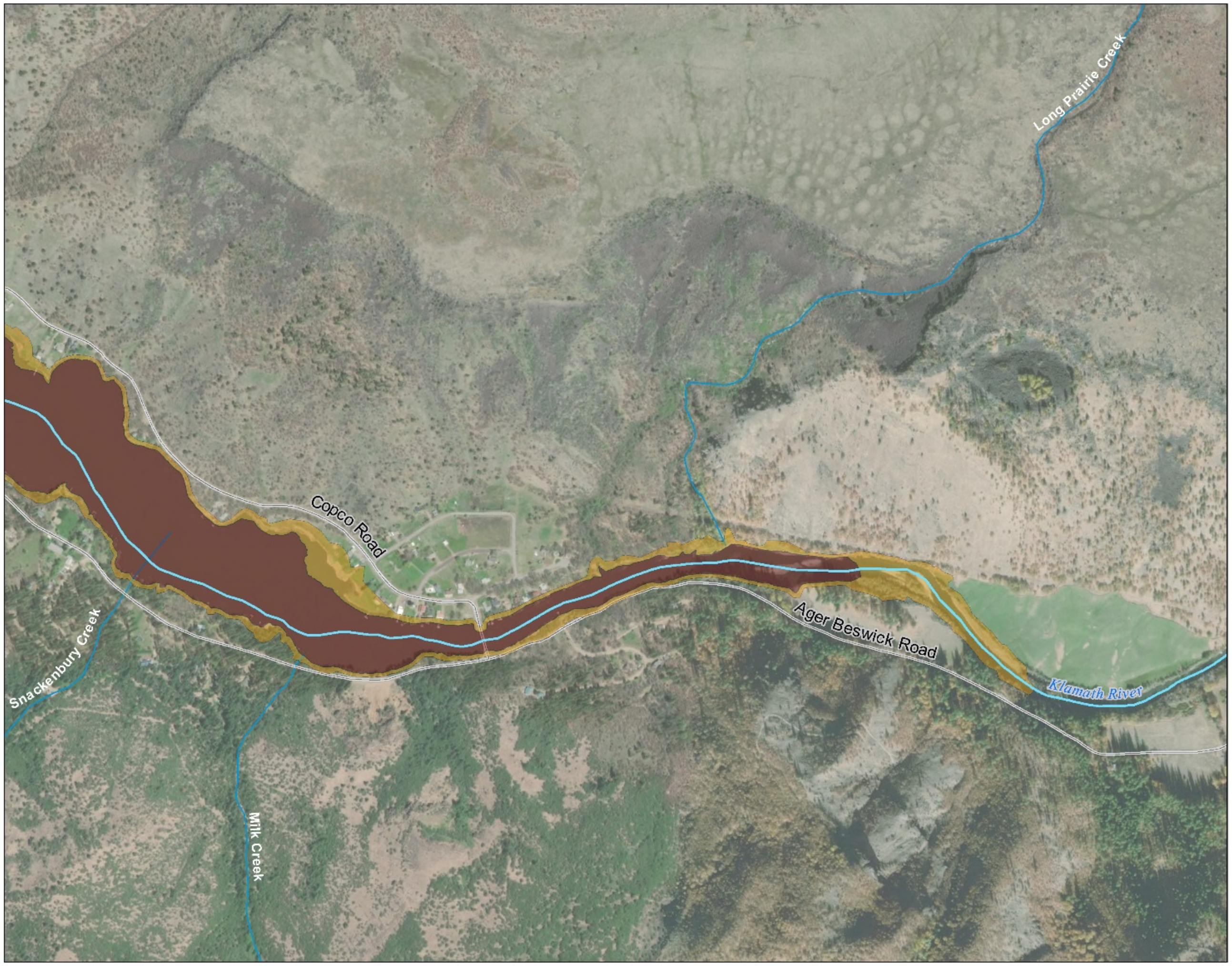

KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
Reservoir Area Management Plan

Figure B. 1-7
Anticipated Proposed Action Activity Areas

January 2021

PRELIMINARY DESIGN
(NOT FOR CONSTRUCTION)

Notes
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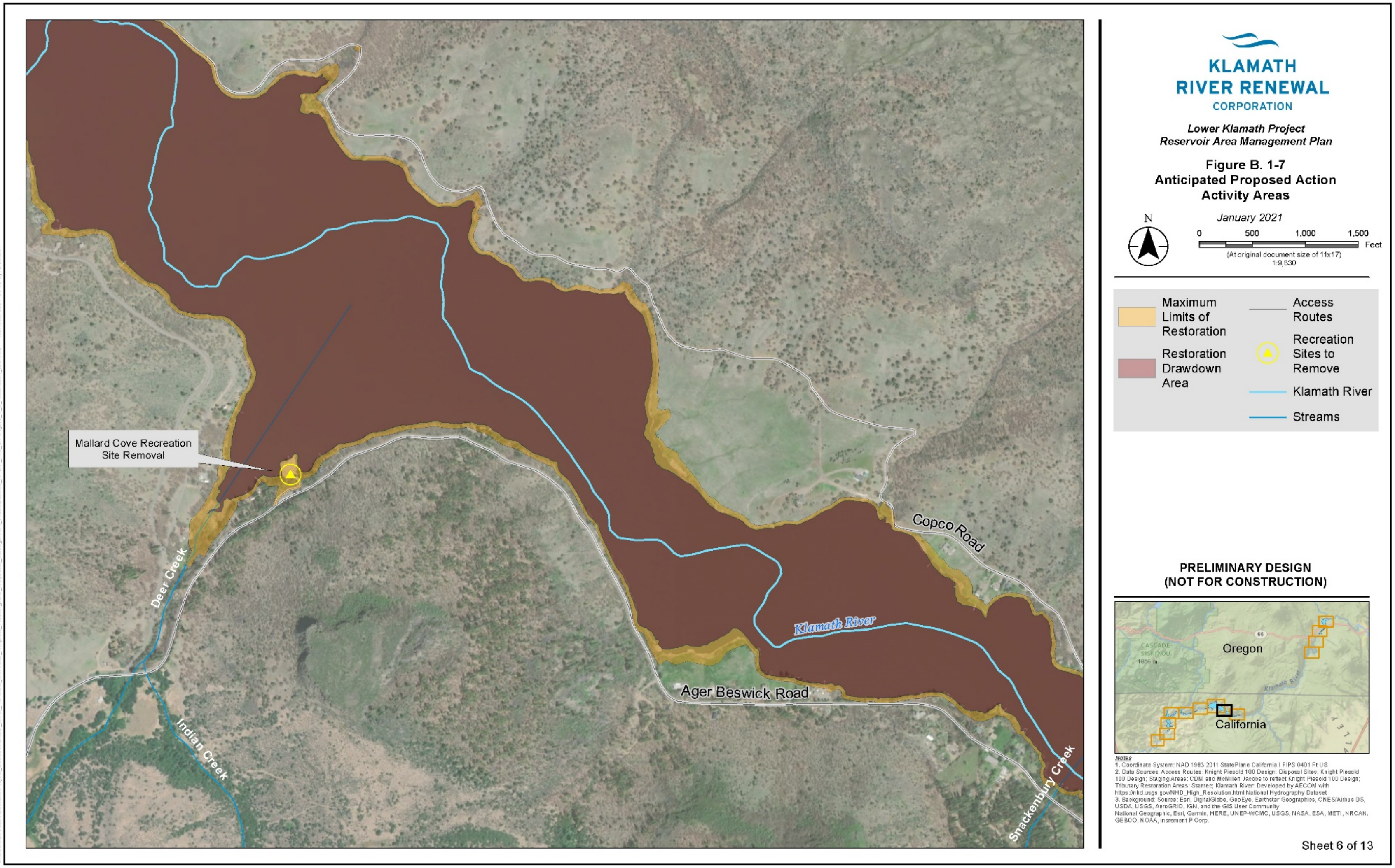
Mallard Cove Recreation Site Removal
Deer Creek
Indian Creek
Klamath River
Copco Road
Ager Beswick Road
Snackenbury Creek
KLAMATH RIVER RENEWAL CORPORATION
Lower Klamath Project
Reservoir Area Management Plan
Figure B. 1-7
Anticipated Proposed Action Activity Areas
January 2021
N
0 500 1,000 1,500 Feet
(At original document size of 11x17)
1:9,830
Maximum Limits of Restoration
Restoration Drawdown Area
Access Routes
Recreation Sites to Remove
Klamath River
Streams
PRELIMINARY DESIGN
(NOT FOR CONSTRUCTION)
Oregon
California
Notes
1. Coordinate System: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US
2. Data Sources: Access Routes: Knight Piesold 100 Design; Disposal Sites: Knight Piesold 100 Design; Staging Areas: CDM and McMillen Jacobs to reflect Knight Piesold 100 Design; Tributary Restoration Areas: Stantec; Klamath River: Developed by AECOM with https://nhd.usgs.gov/NHD_High_Resolution.html National Hydrography Dataset
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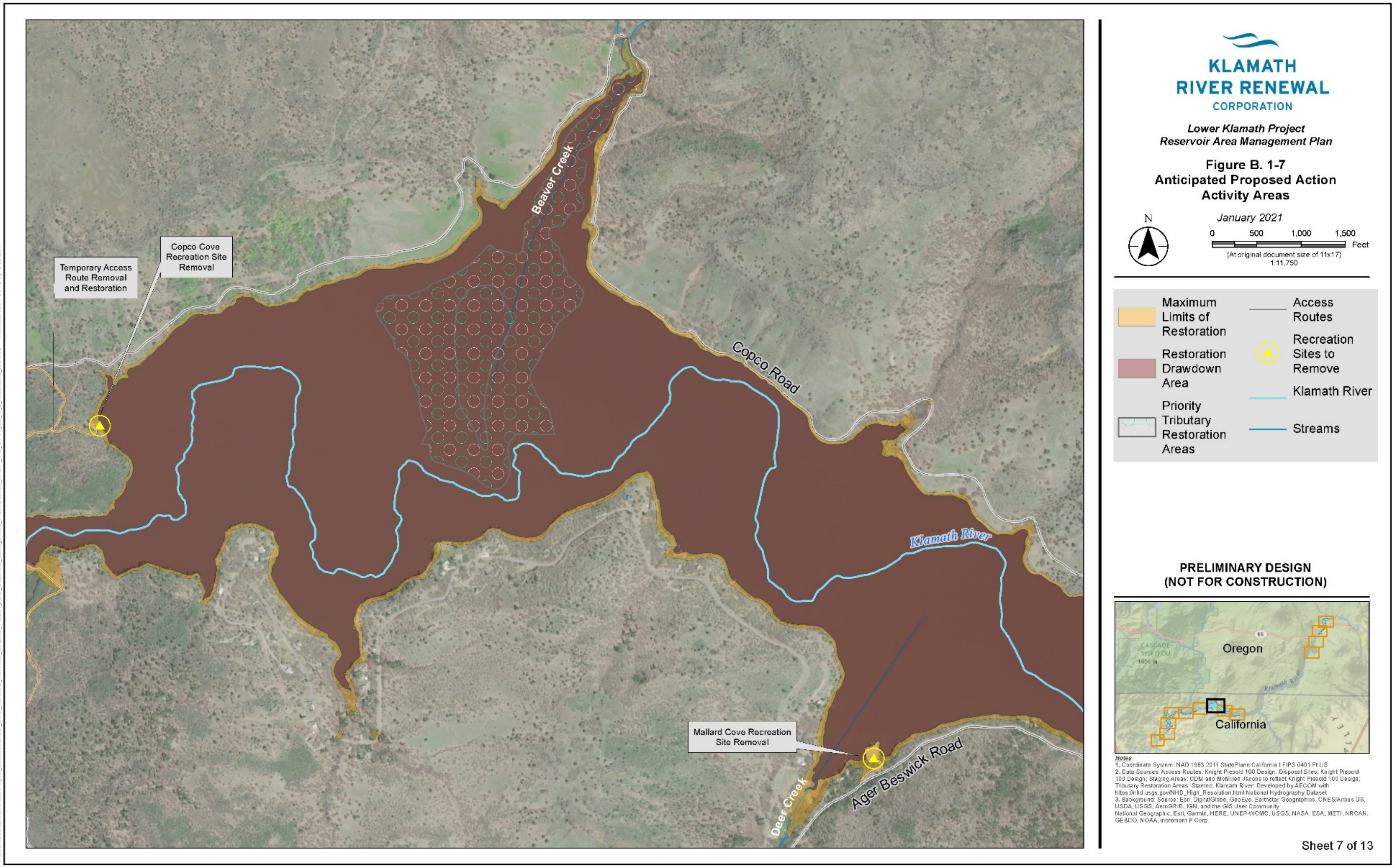
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Sheet 6 of 13



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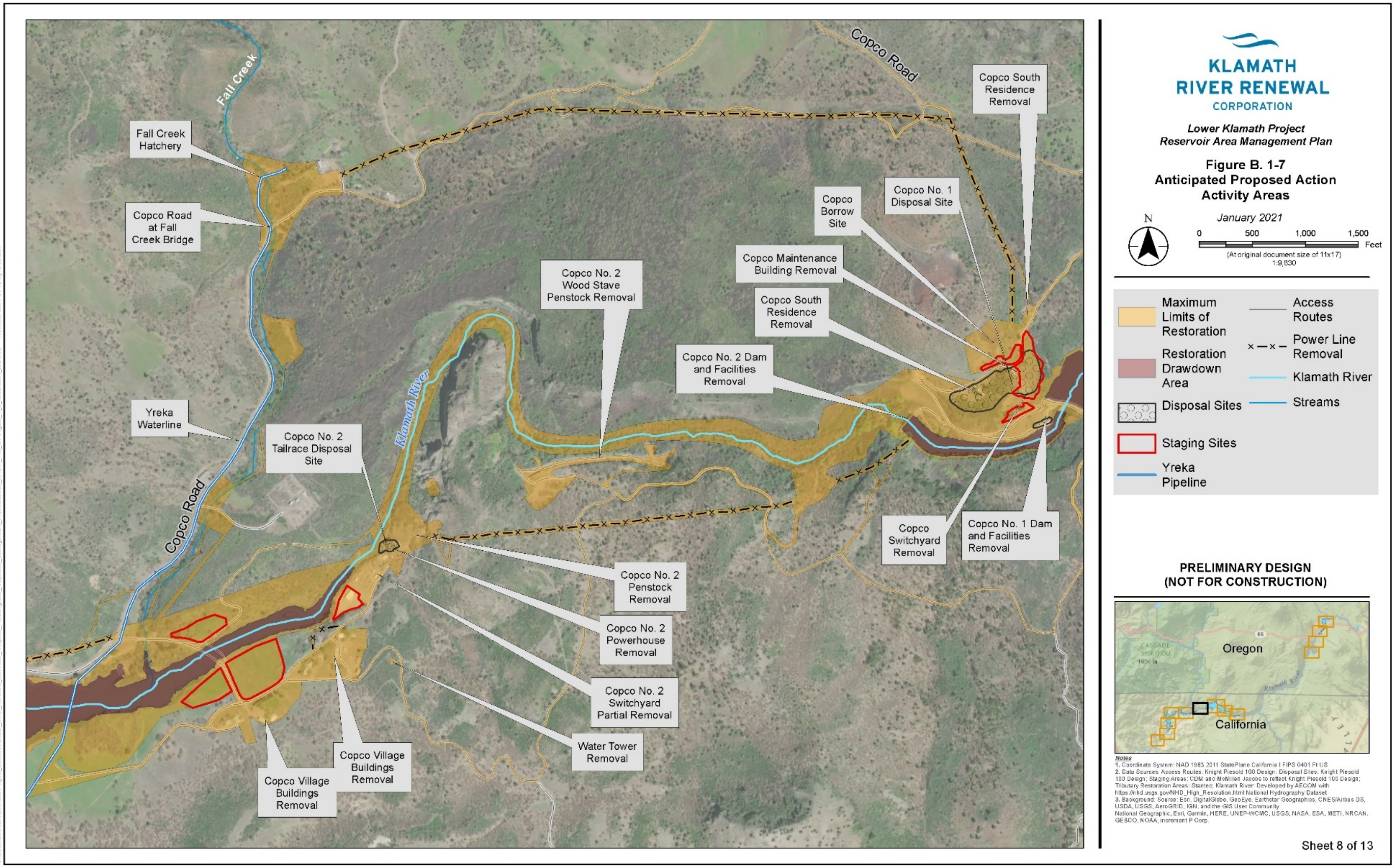

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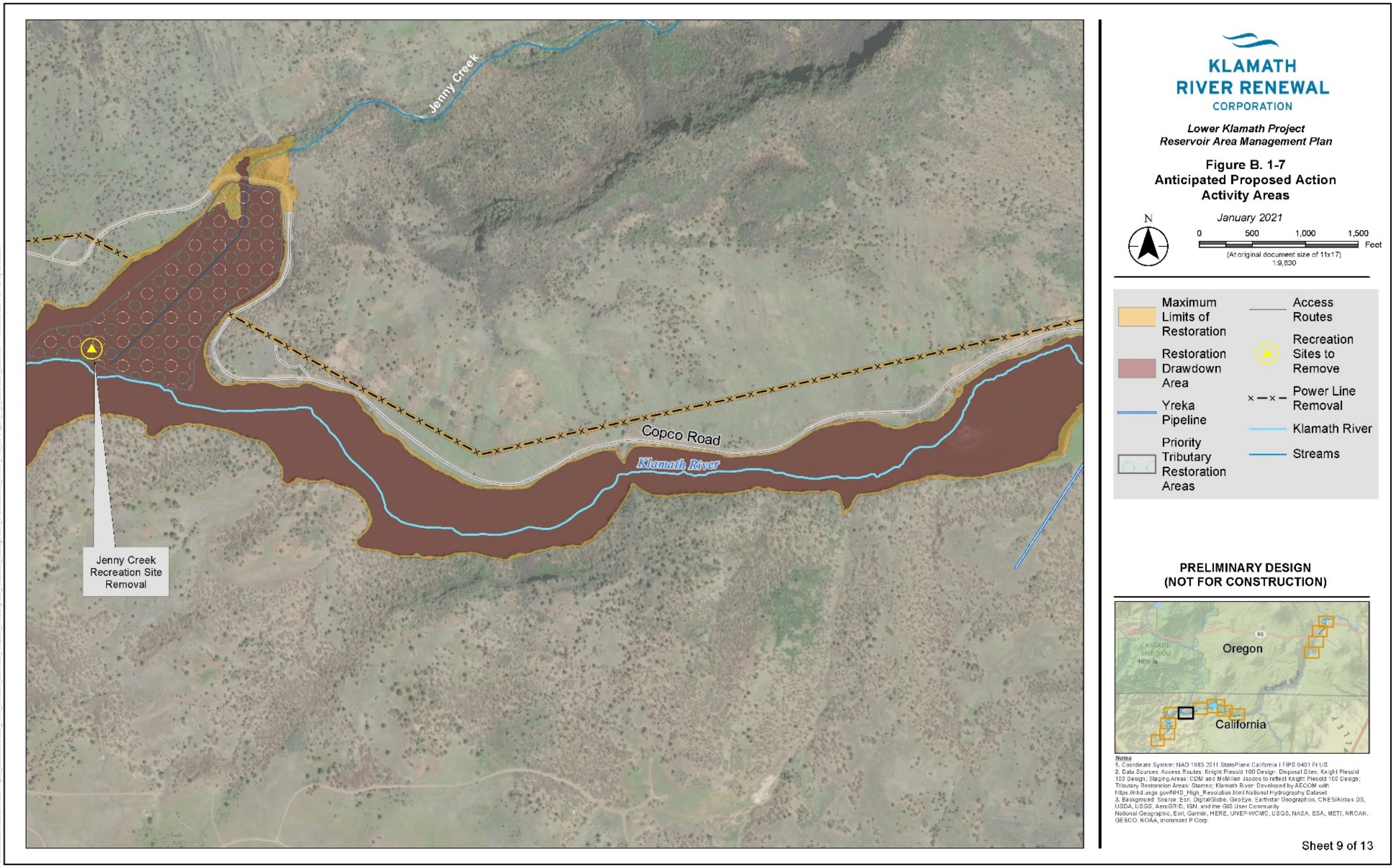

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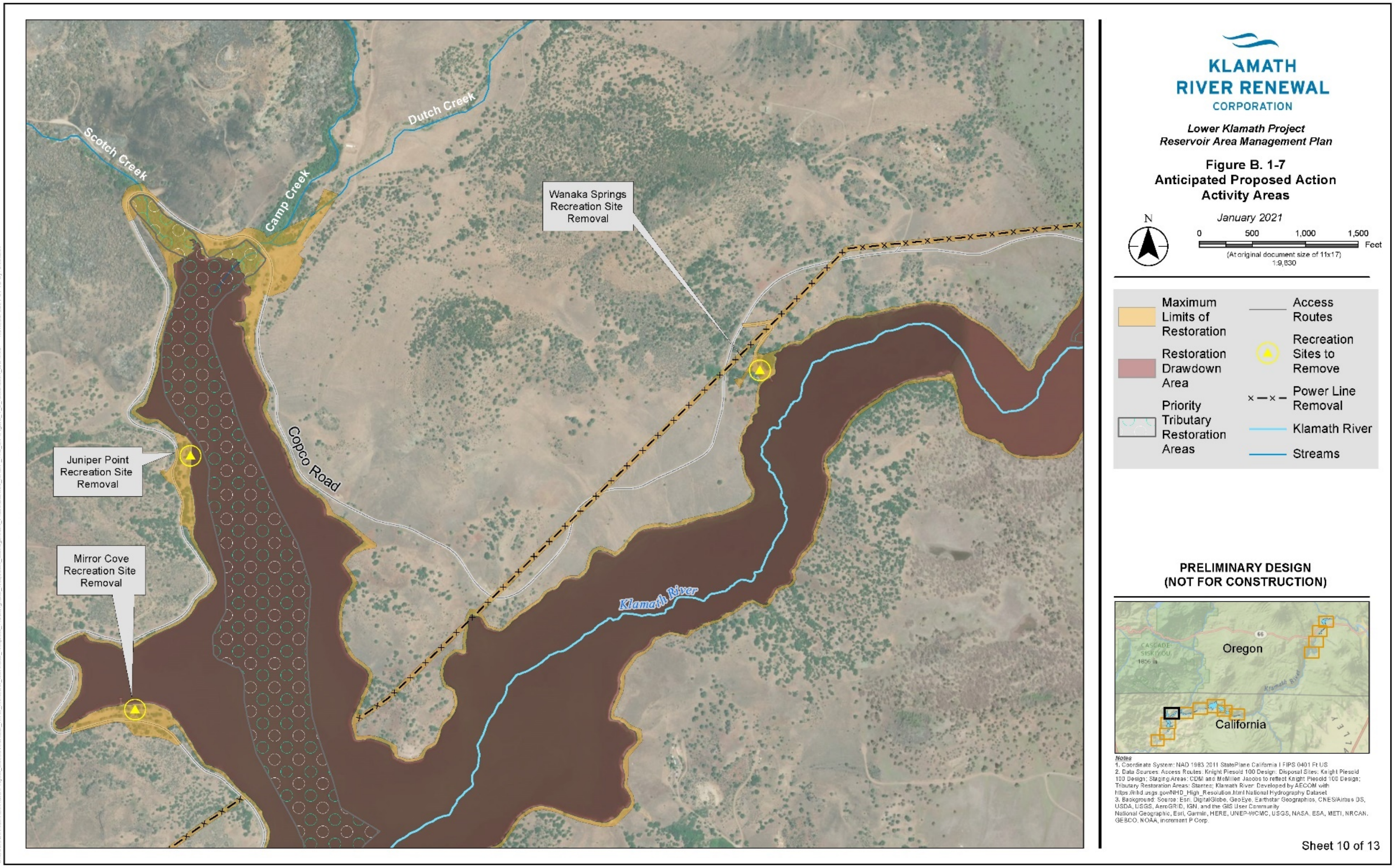

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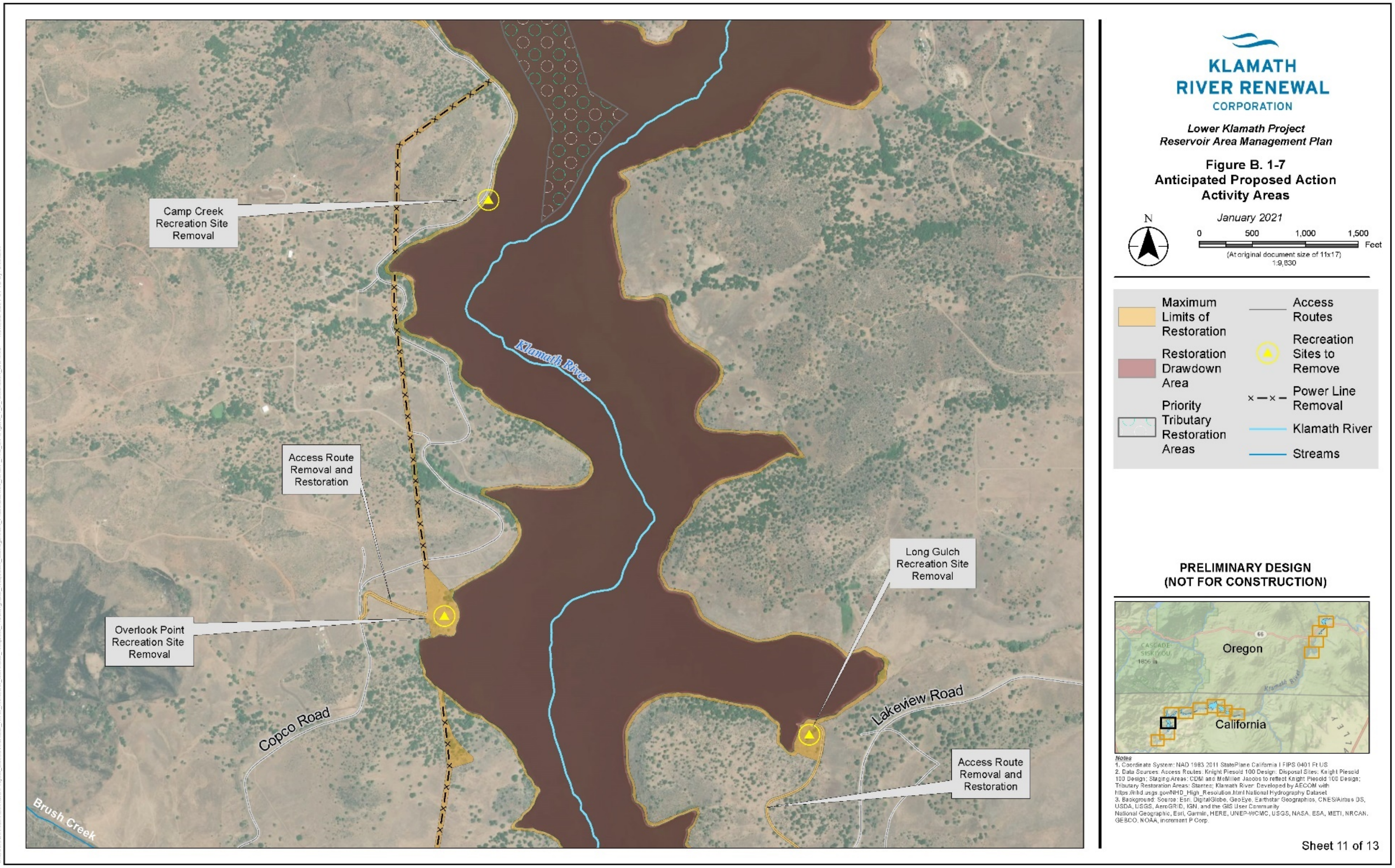

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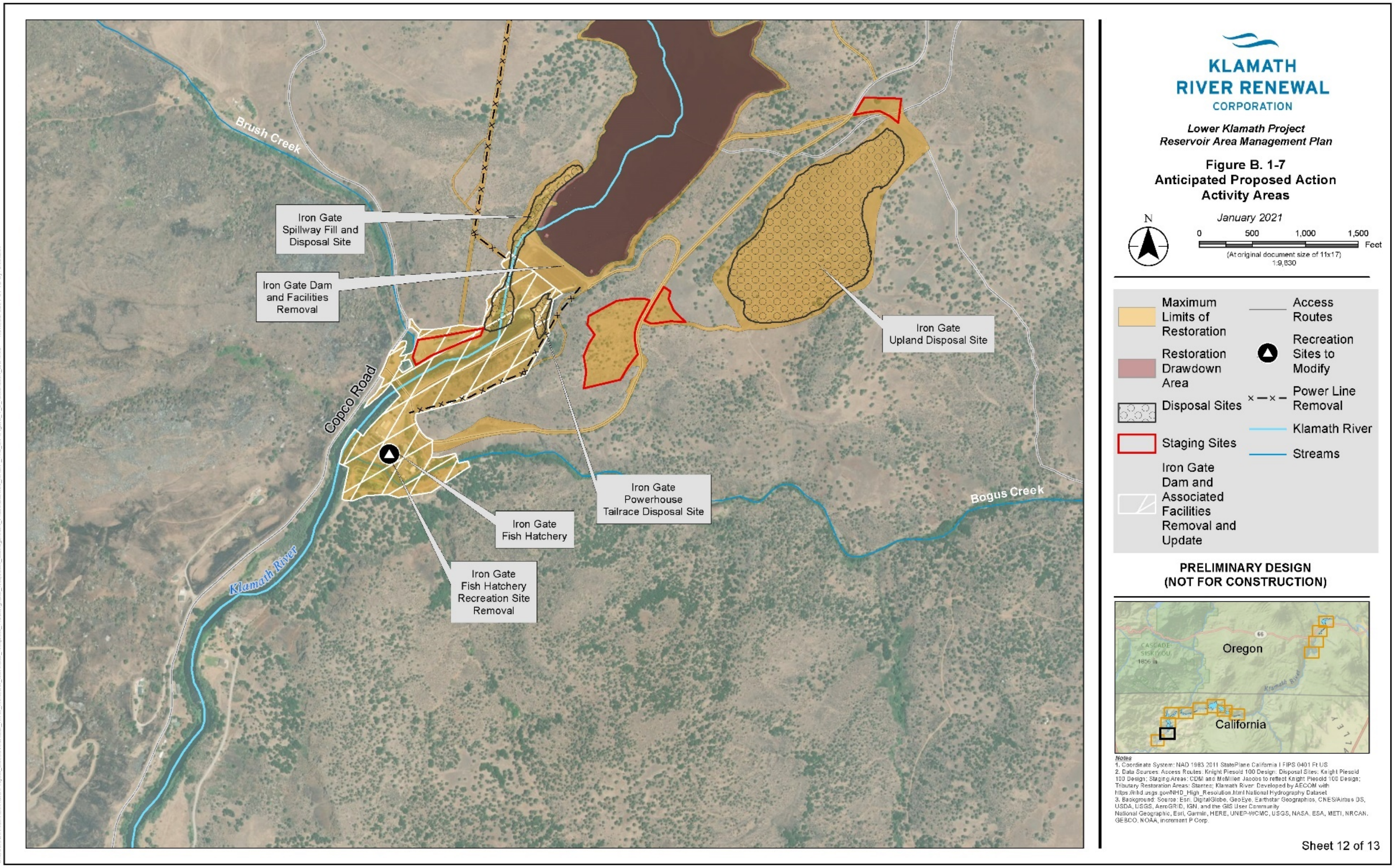

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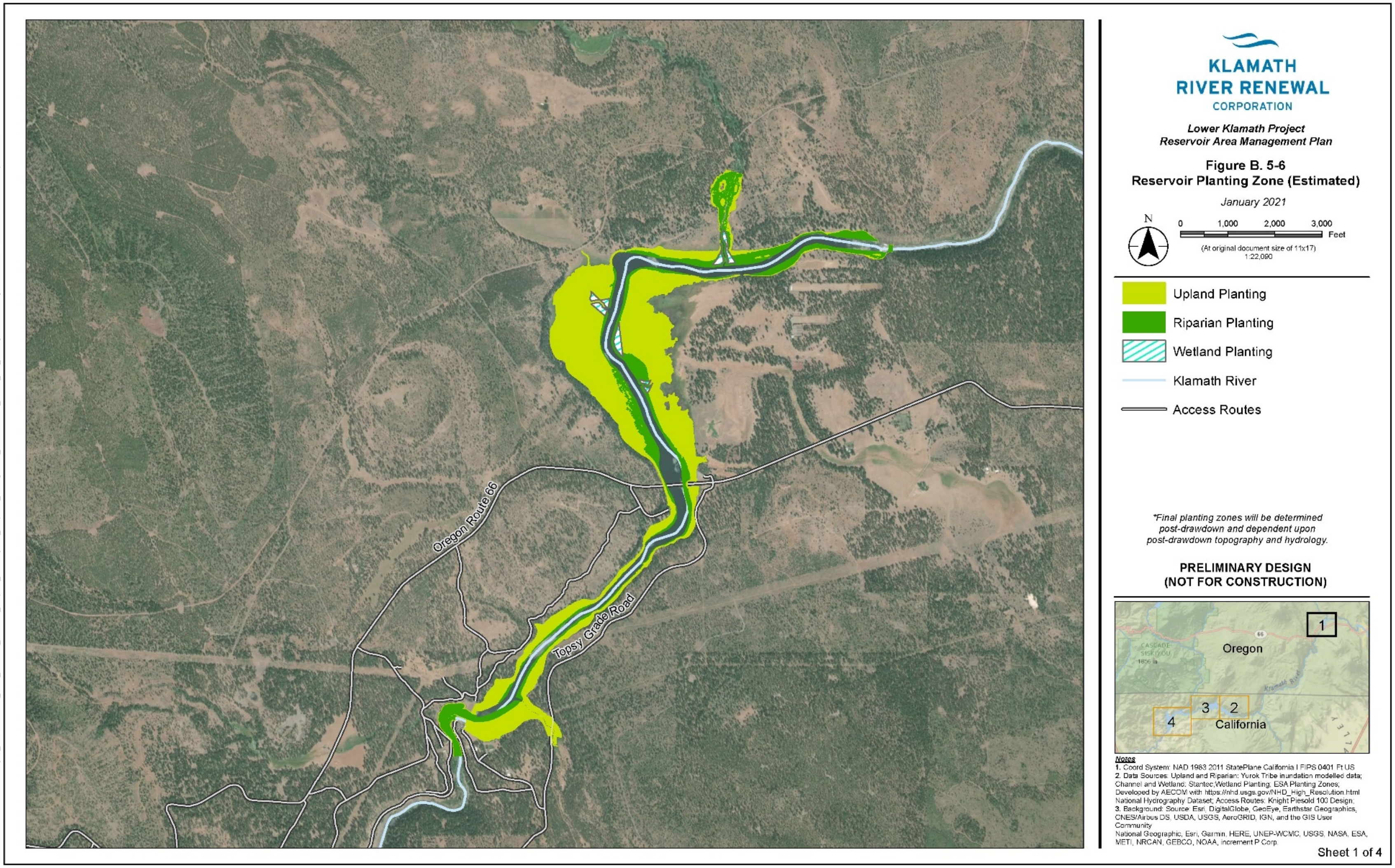

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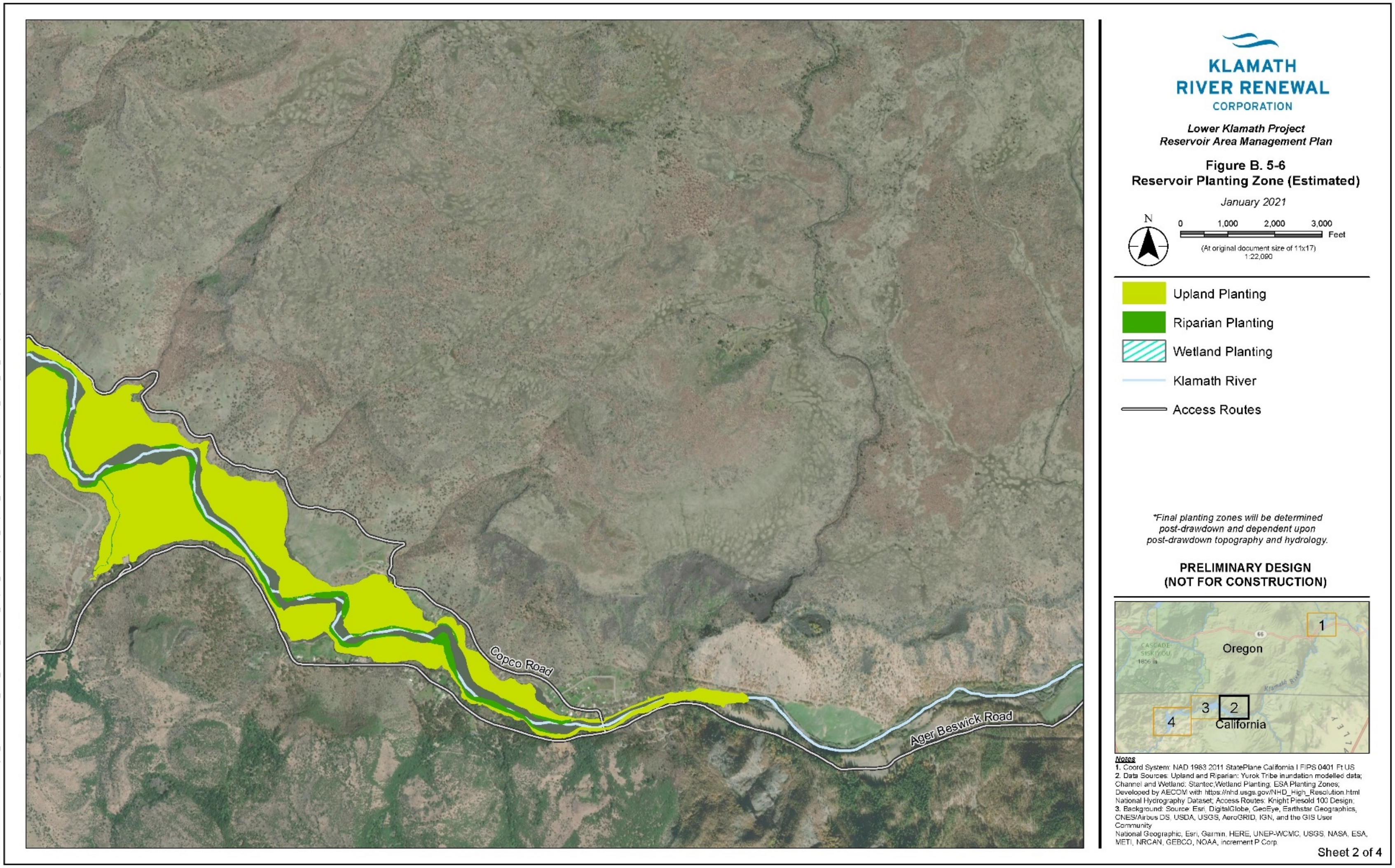
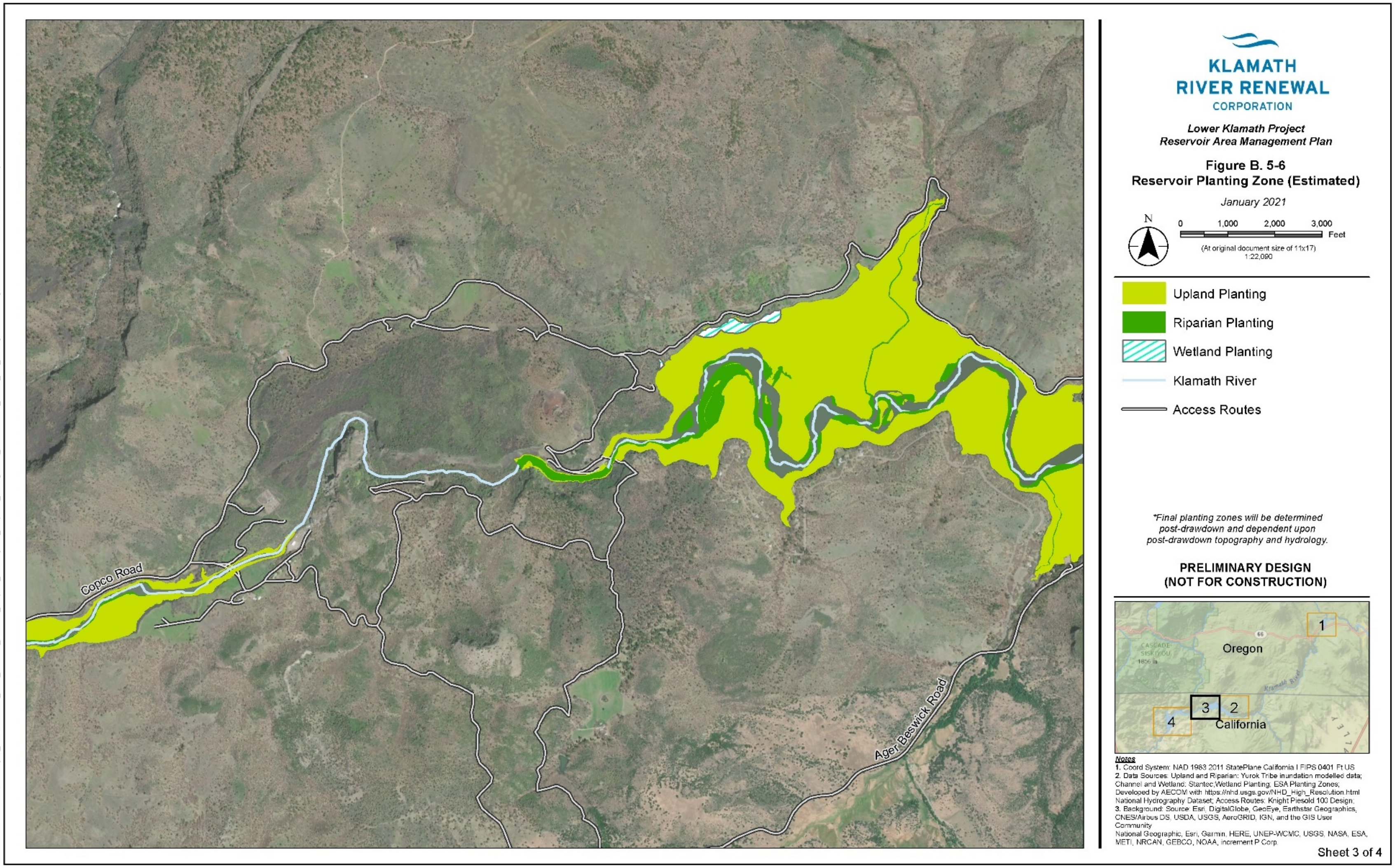

KLAMATH
RIVER RENEWAL
CORPORATION
Lower Klamath Project
Reservoir Area Management Plan
Figure B. 5-6
Reservoir Planting Zone (Estimated)
January 2021
N
0
1,000
2,000
3,000
Feet
(At original document size of 11x17)
1:22,090
Upland Planting
Riparian Planting
Wetland Planting
Klamath River
Access Routes
*Final planting zones will be determined
post-drawdown and dependent upon
post-drawdown topography and hydrology.
PRELIMINARY DESIGN
(NOT FOR CONSTRUCTION)
Copco Road
Ager Beswick Road
Oregon
California
1
2
3
4
Notes
1. Coord System: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US
2. Data Sources: Upland and Riparian: Yurok Tribe inundation modelled data; Channel and Wetland: Stantec;Wetland Planting: ESA Planting Zones; Developed by AECOM with https://nhd.usgs.gov/NHD_High_Resolution.html National Hydrography Dataset; Access Routes: Knight Piesold 100 Design;
3. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.
Sheet 2 of 4



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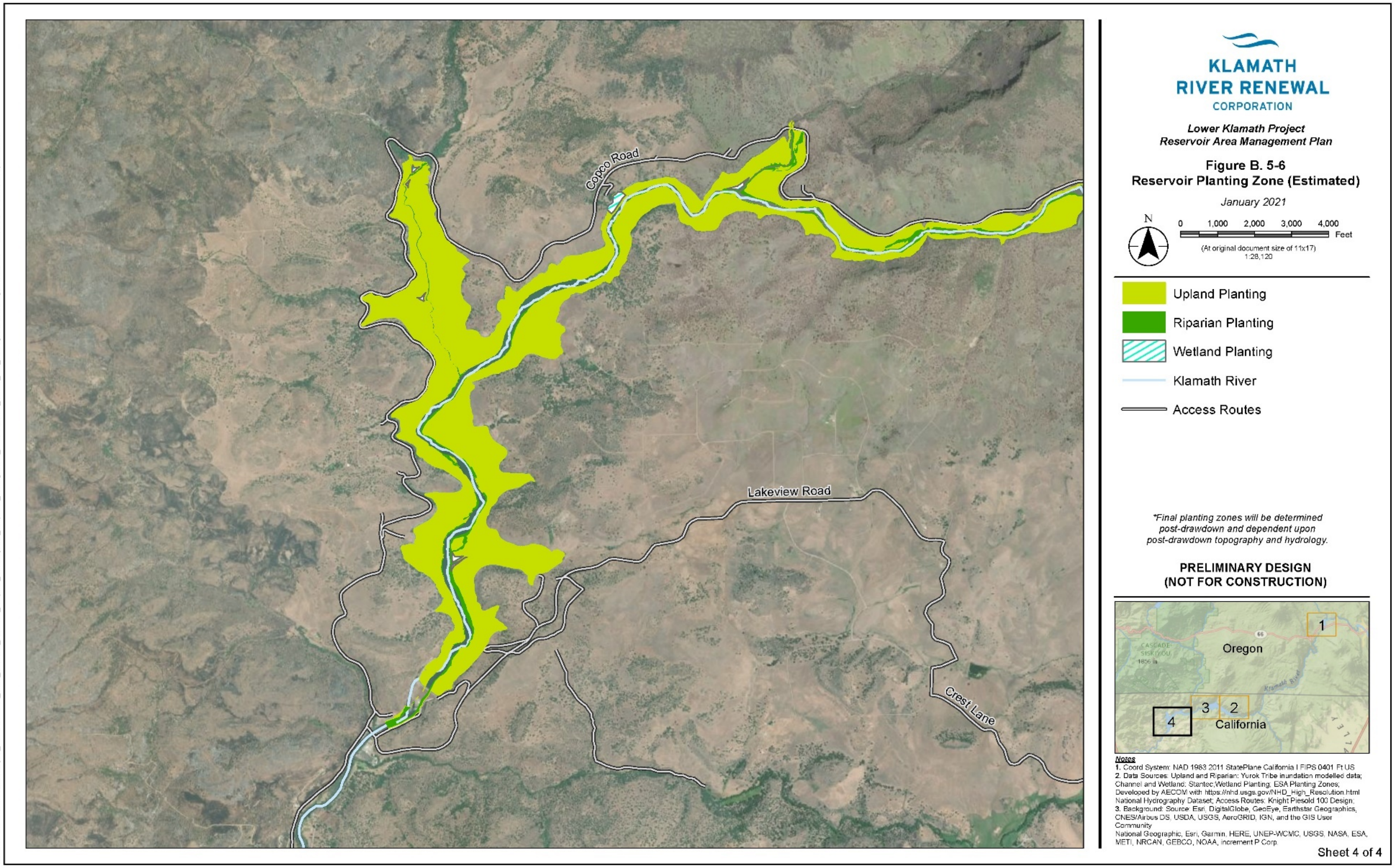

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Appendix C

Best Management Practices

Table C-1 below provides a categorized list of Best Management Practice (BMP) measures as discussed throughout the RAMP and associated management plans. Table C-2 provides a summary of herbicide application buffers for applications near water resources (adapted from the 2021 Biological Assessment).

Table C-1. Best Management Practices (BMPs)

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
Upland Restoration Measures	Disposal sites for placement of embankment or concrete material	These areas typically include between 10 to 50 ft of fill, and will be graded by the Renewal Corporation to match existing topographic features in the vicinity and will include a cover depth of topsoil material suitable for revegetation where available/appropriate. Some disposal sites will be covered by the Renewal Corporation with coarse rock fill material to provide erosion protection in areas not conducive to vegetation establishment. Native vegetation will be preserved and protected where feasible and will avoid ripping within a distance of twice the canopy diameter from protected tree trunks to protect existing roots. See the Waste Disposal and Hazardous Materials Management plan for disposal site construction.
Upland Restoration Measures	Staging areas and temporary access road areas adjacent to demolition of other work areas	The majority of these areas are at elevations appropriate for upland planting, although in some cases they include a variety of planting zones. Many of these areas are already compacted to a high degree due to their use. The Renewal Corporation will loosen soil compacted by staging and temporary access road areas adjacent to demolition or other work areas by deep ripping and disking as needed to facilitate seed germination and plant establishment. The Renewal Corporation will preserve and protect native vegetation, where feasible, during active use and revegetation. Ripping, equipment and vehicle parking, or material storage will be avoided to the extent feasible within a distance of twice the canopy diameter from protected tree trunks to protect existing roots.

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
Upland Restoration Measures	Hydropower infrastructure demolition areas	The Renewal Corporation will demolish the majority of PacifiCorp buildings and other hydropower infrastructure to be removed. In each former development location, after removal of all demolition debris and man-made materials, the Renewal Corporation will loosen compacted soil in the remaining disturbed areas by deep ripping and disking as needed and restore them to native habitat. These areas occur in a variety of planting zones and will be restored accordingly as described in Appendix H. The Renewal Corporation will preserve and protect existing native vegetation, as feasible and will avoid ripping within a distance of twice the canopy diameter from protected tree trunks to protect existing roots.
Upland Restoration Measures	J.C. Boyle canal demolition area	The Renewal Corporation will demolish the J.C. Boyle canal along its entire length. Soils in the former canal area will likely be heavily compacted from previous canal construction activities. The Renewal Corporation will loosen compacted soils or position topsoil as needed on top of the canal features to facilitate seed germination and plant establishment. The existing power canal access road on the downslope side of the canal will remain in place post-construction to be used as a hiking trail. See the Remaining Facilities plan for details regarding the J.C. Boyle Canal that will remain.
Upland Restoration Measures	J.C. Boyle spillway scour hole	The Renewal Corporation will fill the existing spillway and scour hole area with on-site materials. Final grading will be sloped to the adjacent existing grades that naturally drain. The top cover of fill (minimum of 6 ft) will consist of general fill (E9/E9b) designed to provide final stabilization treatment. See the Waste Disposal and Hazardous Materials Management plan for disposal site (Scour Hole) construction.
Upland Restoration Measures	Former recreation areas	The Renewal Corporation will remove some of the existing recreation areas around the reservoir rims completely or in part. The demolished recreation areas will restore disturbed former recreation areas to native habitats. Much of the land within these areas is heavily compacted because of the respective areas' uses. The Renewal Corporation will loosen compacted soils in recreation areas associated with the project by deep ripping and disking as needed to facilitate seed germination and plant establishment and will preserve and protect existing native vegetation, as feasible. Deep ripping will be avoided within a distance of twice the canopy diameter from protected tree trunks to protect existing roots). See the Recreation Facilities Plan and Remaining Facilities Plan for additional details.

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
Infrastructure-Related Restoration	Timber Bridge Removal	The Renewal Corporation will remove the timber bridge at J.C. Boyle. The Renewal Corporation will regrade the embankments as needed to approximate pre-existing contours . Re regraded slopes will be revegetated with native plants, per the project NPDES permit. Upon completion of this project element, the temporary construction infrastructure will be removed, and the riverbanks will be restored in accordance with the SWPPP.
Infrastructure-Related Restoration	City of Yreka Pipeline Replacement	By agreement with the City of Yreka, the Renewal Corporation will remove the existing water pipeline from its current elevation. The water pipeline will be replaced by the Renewal Corporation and buried deeper under the re-established mainstem Klamath River. The pipeline will be installed by the Renewal Corporation using open trench methodologies with a cofferdam and temporary river diversion during construction. Upon completion of this work, the cofferdam will be removed, and the riverbanks will be restored in accordance with the SWPPP.
Infrastructure-Related Restoration	Daggett Bridge Replacement	The Renewal Corporation will replace a culvert and construct a temporary bridge adjacent to Daggett Bridge for construction traffic. Upon completion of this work, the Renewal Corporation will remove the temporary bridge. The riverbanks will be restored in accordance with the SWPPP.
Infrastructure-Related Restoration	Additional Culvert Replacement/Upgrades	There are several areas where the Renewal Corporation will replace culverts, or construct temporary access roads to facilitate construction traffic. The Fall Creek and Dry Creek culvert replacements are required for construction access. The Camp Creek and Scotch Creek culvert replacements are to promote post-drawdown fish passage. In these areas, once the old culverts are removed and the new access road installed, the areas immediately upstream and downstream of the culverts will be recontoured and revegetated by the Renewal Corporation with native riparian and wetland seed mixes, as appropriate. Upon completion of this work, the Renewal Corporation will remove temporary access roads and restore the riverbanks in accordance with the SWPPP.

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
Infrastructure-Related Restoration	Historic Bridge Pier Removal	The Renewal Corporation will remove remnant wooden bridge piers constructed prior to the filling of the J.C. Boyle reservoir. Limited grading will be necessary to provide equipment access and these disturbances will be restored by the Renewal Corporation to match existing, adjacent contours. Upon completion of this work, the Renewal Corporation will remove temporary work structures and restore the riverbanks in accordance with the SWPPP.
Infrastructure-Related Restoration	Long Gulch Culverts Removal	Historical photos and bathymetric surveys indicate the presence of at least two (2) submerged culverts along Long Gulch upstream of Iron Gate Dam. It appears that these culverts were placed during Iron Gate dam construction and left in place when the reservoir was filled. The Renewal Corporation will remove these culverts, grade the adjacent banks and floodplain to match adjacent contours, and restore the streambanks in accordance with the SWPPP.
Limiting spread of invasive species		1. Maintain 50-ft-wide buffer free of IEV species around access roads and trails. 2. Thoroughly clean clothing and gear following site visits. 3. Check clothing and gear for soil, seeds, and plant materials. 4. Inspect and clean equipment upon entering and exiting the Project Area. 5. Inspect and clean vehicles upon entering and exiting the Project Area. 6. Train staff, including contractors, on weed identification and methods to avoid the unintentional spread of invasive plants. 7. Manage vegetation using methods that reduce the spread of invasive species and encourage desirable vegetation.
In-Water Work		1. ATWG will be notified a minimum of 48-hours before start of work. 2. Unless under the guidance of ATWG, in-water work activities will occur during the in-water work window, expected to be June 15 to October 31. 3. A biologist will evaluate the in-water habitat to determine if salmonids or protected fish occur in the limits of work. a. If salmonid or protected fish are or are assumed to be present in the in-water work area, fish rescue, relocation, and exclusion will occur under the direction of a qualified fisheries biologist. i. General conditions for fish capture and relocation activities: Exclusion will include the use of block nets, or similar, to isolate the work area from fish access. The fisheries biologist will evaluate the upstream and downstream extent of the fish exclusion and relocation efforts, which will be based

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
		on the minimal amount of wetted channel where salmonids may experience potential injury or mortality from the in-water activity. Fish relocation will be performed using seine nets, dip nets, and/or electrofishing as determined appropriate and effective by the fisheries biologist. The duration and extent of fish relocation actions will be determined by the fisheries biologist. Once the work area is determined to be cleared of salmonids, in-water work activities will be cleared to begin. • Electrofishing: All electrofishing will be conducted in accordance with the NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (NOAA and NMFS, 2000). • Salmonid Handling and Relocation: National Oceanic and Atmospheric Administration (NOAA) Restoration Center's Programmatic Approach to ESA/EFH Consultation Streamlining for Fisheries Habitat Restoration Projects (NOAA and NMFS, 2017), Section 2.4.1.E – Guidelines for Relocation of Salmonids, will guide relocation work. b. If no salmonids or protected fish occur in the work area, a biologist will monitor the in-water work actions to ensure that there is no change in conditions that would require fish exclusion or relocation. The biologist will document and report the completion of the in-water work activity to NMFS as described below. 4. Disturbance to existing riparian vegetation and channel banks will be minimized to the extent feasible to complete the required restoration or maintenance action. 5. In the tributary restoration areas, flow diversion around the work area will be used if channel bed adjustments are required. 6. The use or storage of petroleum-powered equipment shall be accomplished in a manner to prevent the potential release of petroleum materials into waters of the state. 7. Areas for fuel storage, refueling, and servicing of construction equipment will be located in an upland location. 8. Oil absorbent and spill containment materials will be on site when mechanical equipment is in operation within 100 ft of the proposed watercourse crossings. If a spill occurs, no additional work shall commence in-channel until the following occurs: (1) the mechanical equipment is inspected by the Renewal Corporation

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
		contractor, and the leak has been repaired; (2) the spill has been contained; and (3) ATWG is contacted and have evaluated the impacts of the spill. 9. Invasive species control measures will be followed to minimize potential transport of aquatic invasive species. 10. Documentation and Reporting: Photographs of the in-water work location, summary of actions including any fish relocation, and notification of completion of the in-water work will be provided to ATWG within one (1) week of the completion of in-water work.
Herbicide Application	General	1. Use herbicides only in an integrated weed or vegetation management context, and only when other non-chemical methods are unsuccessful. 2. Treat only the minimum area necessary for effective control. 3. Implement an herbicide safety/spill response plan to reduce the likelihood of spills, misapplication, reduce potential for unsafe practices, and to take remedial actions in the event of spills. 4. Apply the least amount of herbicide needed to achieve the desired result. 5. Follow herbicide product label for use and storage. 6. Mix herbicides more than 150 feet from any natural waterbody to minimize the risk of an accidental discharge. Place impervious material beneath mixing areas in such a manner as to contain any spills associated with mixing/refilling. Wash spray tanks further than 300 feet away from surface water. Check that all hauling and application equipment is free from leaks and operating as intended. 7. Have trained applicators apply herbicides under direct supervision of a Qualified Applicator Licensee (Oregon and California applicator license). 8. Use only United States Environmental Protection Agency (EPA)-approved herbicides and follow product label directions and "advisory" statements. 9. Consider surrounding land use before assigning aerial spraying as a treatment method and avoid aerial spraying near agricultural or densely populated areas. 10. Comply with herbicide-free buffer zones to ensure that drift will not affect crops or nearby residents/landowners. 11. Post treated areas and specify reentry or rest times, if appropriate. 12. Notify adjacent landowners prior to treatment. 13. Keep a copy of Material Safety Data Sheets (MSDSs) at work sites. 14. Keep records of each application, including the active ingredient, formulation, application rate, date, time, and location.

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
		15. Consider site characteristics, environmental conditions, and application equipment to minimize damage to non-target vegetation. 16. Turn off applied treatments at the completion of spray runs and during turns to start another spray run. 17. Refer to the herbicide product label when planning revegetation to ensure that subsequent vegetation would not be injured following application of the herbicide. 18. Clean off-road vehicles to remove seeds.
Herbicide Application	Herbicide Adjuvants and Carriers	1. When recommended by the label, an approved aquatic surfactant would be used to improve uptake. When aquatic herbicides are required, the only surfactants and adjuvants permitted are those allowed for use on aquatic sites, as listed by the Washington State Department of Ecology: http://www.ecy.wa.gov/programs/wq/pesticides/regpesticides.html. (Oregon Department of Agriculture also often recommends this list for aquatic site applications). 2. The surfactants R-11, POEA, and herbicides that contain POEA (e.g., Roundup) will not be used. 3. Herbicide carriers (solvents) are limited to water or specifically labeled vegetable oil.
Herbicide Application	Herbicide Application Methods	1. Broadcast spraying using booms mounted on ground-based vehicles, with the following restrictions: a. Do not broadcast spray within 100 feet of open water when wind velocity exceeds 5 miles per hour (mph). b. Do not broadcast spray when wind velocity exceeds 10 mph. c. Do not spray if precipitation is occurring or is imminent (within 24 hours). d. Do not spray if air turbulence is sufficient to affect the normal spray pattern. 2. Spot spraying with hand-held nozzles attached to backpack tanks or vehicles and hand-pumped sprayers to apply herbicide directly onto small patches or individual plants 3. Hand and selective application through wicking and wiping, basal bark, frill (“hack and squirt”), stem injection, or cut-stump applications 4. Dyes or colorants, (e.g., Hi-Light, Dynamark) will be used as needed to assist in treatment assurance and minimize over-spraying within 100 feet of live water.

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
Herbicide Application	Minimization of Herbicide Drift, Leaching, and Runoff	1. Do not spray when wind speeds exceed 10 miles per hour to reduce the likelihood of spray/dust drift. Winds of 2 mph or less are indicative of air inversions. The applicator must confirm the absence of an inversion before proceeding with the application whenever the wind speed is 2 mph or less. 2. Be aware of wind directions and potential for herbicides to affect aquatic habitat area downwind. 3. Keep boom or spray as low as possible to reduce wind effects. 4. Avoid or minimize drift by using appropriate equipment and settings (e.g., nozzle selection, adjusting pressure, drift reduction agents). Select proper application equipment (e.g., spray equipment that produces 200- to 800-micron-diameter droplets [spray droplets of 100 microns or less are most prone to drift]). 5. Follow herbicide label directions for maximum daytime temperature permitted (some types of herbicides volatilize in hot temperatures). 6. Do not spray during periods of adverse weather conditions (snow or rain imminent, fog, etc.). Wind and other weather data will be monitored and reported for all pesticide applicator reports. 7. Herbicides shall not be applied when the soil is saturated or when a precipitation event likely to produce direct runoff to fish-bearing waters from a treated site is forecasted by National Oceanic and Atmospheric Administration National Weather Service or other similar forecasting service within 48 hours following application. Soil-activated herbicides can be applied as long as label is followed. Do not conduct any applications during periods of heavy rainfall. 8. Minimize treatments in areas where herbicide runoff is likely, such as steep slopes when heavy rainfall is expected. 9. Minimize use of herbicides that have high soil mobility, particularly in areas where soil properties increase the potential for mobility. 10. Do not apply granular herbicides on slopes of more than 15 percent where there is the possibility of runoff carrying the granules into non-target areas. 11. Plan to treat between weather fronts (calms) and at appropriate time of day to avoid high winds that increase water movements, and to avoid potential stormwater runoff and water turbidity.
Herbicide Application	Protection of Aquatic Resources	1. Obtain National Pollutant Discharge Elimination System (NPDES) permit from California Environmental Protection Agency (CalEPA) and Oregon Department of Environmental Quality (ODEQ).

CATEGORY	AREA OR SPECIFIC TASK	BMP MEASURES
		2. Use local historical weather data to choose the month of treatment. Considering the phenology of the target species, schedule treatments based on the condition of the water body and existing water quality conditions. 3. Review hydrogeologic maps of proposed treatment areas. Note depths to groundwater and areas of shallow groundwater and areas of surface water and groundwater interaction. Minimize treating areas with high risk for groundwater contamination. 4. Minimize the potential effects to surface water quality and quantity by stabilizing terrestrial areas as quickly as possible following treatment. 5. Minimize treatments near fish-bearing water bodies during periods when fish are in life stages most sensitive to the herbicide(s) used, and use spot treatments rather than broadcast or aerial treatments. 6. For treatment of aquatic vegetation: 1) treat only that portion of the aquatic system necessary to achieve acceptable vegetation management, 2) use the appropriate application method to minimize the potential for injury to desirable vegetation and aquatic organisms, and 3) follow water use restrictions presented on the herbicide label.
Herbicide Application	Herbicide Buffer Distances	Table C-2 below provides the no-application buffers to be observed during herbicide applications. Herbicide applications based on a combination of approved herbicides will use the most conservative buffer for any herbicide included. Buffer widths are measured as map distance perpendicular to the bankfull for streams, the upland boundary for wetlands, or the upper bank for roadside ditches.
Stormwater Pollution Prevention		See the Stormwater Pollution Prevention Plan for BMPs associated with stormwater sediment runoff.
Spill Prevention and Control		See Spill Prevention, Control and Countermeasure Plan for BMPs associated with spill prevention and control.
Waste Disposal		See Waste Disposal Management Plan for BMPs associated with hazardous materials.

Table C-2. No-Application Buffer Widths in Feet for Herbicide Application by Stream Type and Application Method

HERBICIDE	PERENNIAL STREAMS AND WETLANDS, AND INTERMITTENT STREAMS AND ROADSIDE DITCHES WITH FLOWING OR STANDING WATER PRESENT			DRY INTERMITTENT STREAMS DRY INTERMITTENT WETLANDS DRY ROADSIDE DITCHES		
	BROADCAST SPRAYING	SPOT SPRAYING	HAND SELECTIVE	BROADCAST SPRAYING	SPOT SPRAYING	HAND SELECTIVE
LABELED FOR AQUATIC USE						
Aquatic Glyphosate	100	Waterline	Waterline	50	0	0
Aquatic Imazapyr	100	Waterline	Waterline	50	0	0
LOW RISK TO AQUATIC ORGANISMS						
Dicamba	100	15	15	50	0	0
Metsulfuron-methyl	100	15	Bankfull elevation	50	0	0

Appendix D

Current and Historic Conditions as a Reference for Restoration

Project Area and General Project Features

The Lower Klamath Project (Project) is located along the Klamath River in Klamath County, Oregon (J.C. Boyle), and Siskiyou County, California (Copco No.1, Copco No.2 and Iron Gate Dam). The Klamath River originates at the base of the Cascade Mountains in the Oregon desert and flows 254 river miles (RM) through southern Oregon and Northern California to the Pacific Ocean near the town of Requa, California. The figures in Chapters 1 and 2 of the Reservoir Area Management Plan depict the limits of work/restoration.

The four (4) dams, powerhouses, and associated facilities slated for removal and site restoration are described below in the Development Context subsections. These descriptions include an overview of the existing facilities in 2020 for orientation during restoration and monitoring activities. In addition, this section includes a description of historic, pre-dam conditions to provide context for restoration activities in the Historical Context/Restoration Potential subsections. An understanding of pre-dam conditions within the reservoir footprints is necessary to develop appropriate and effective restoration objectives to meet the restoration goals of volitional fish passage, sediment stabilization through revegetation, and habitat enhancement. Restoration objectives described later in this document have been tailored to promote the return of the reservoir footprints to as close to the pre-dam condition as possible.

Hydropower development descriptions in this section are primarily derived from the *Environmental Report. Final License Application, Klamath Hydroelectric Project (FERC Project No. 2082)* (PacifiCorp, 2004). Information in the historical context/restoration potential sections for each dam and reservoir was derived from the Definite Plan Report (KRRC, 2018), and the Amended License Surrender Application.

J.C. Boyle Development Context

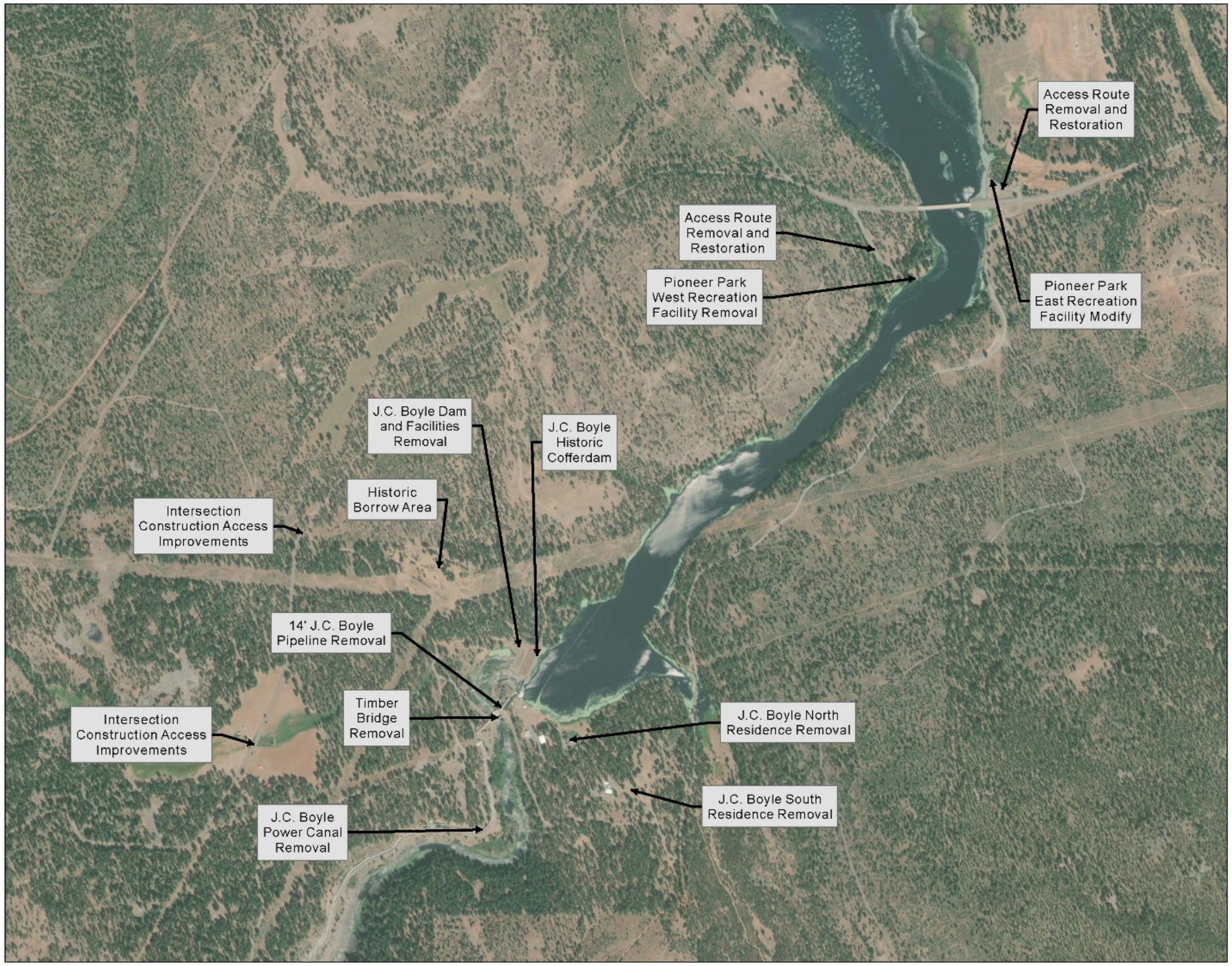
J.C. Boyle Hydroelectric Facility was constructed from 1957 to 1958 and is located at approximately RM 226.0 in Oregon. Major components of the J.C. Boyle Facility include the following:

- A reservoir of approximately 3,200-acre-feet capacity at a reservoir elevation of 3,796.7 feet (ft)
- A 68-ft-high combination earth fill and concrete gravity dam that spans approximately 700 ft in length
- A three (3)-bay gated spillway with 36-ft-wide bays
- Two low-level diversion culverts with concrete stoplogs
- A power intake structure and a fish ladder at the intake
- A water conveyance system made up of a 600-ft syphon and pipeline, a 2.2-mile-long concrete power canal, a 1,600-ft-long low-pressure tunnel and two (2) 950-ft-long surface mounted high-pressure steel penstocks
- An eroded scour hole downstream of the forebay structure
- A two (2) turbine, at-surface 98-megawatt (MW) powerhouse and a tailrace channel

- A switchyard, substation, and transmission lines

Recreation facilities at J.C. Boyle include the Topsy Campground and boat launch, Pioneer Park east and west units and boat launches, Spring Island whitewater boating launch, and numerous dispersed shoreline recreations sites.

The J.C. Boyle facilities slated for removal and restoration are depicted in Figure D-1.



KLAMATH RIVER RENEWAL CORPORATION

Lower Klamath Project
Reservoir Area Management Plan

Figure D - 1
J.C. Boyle
Features Slated for Removal and Site Restoration

J.C. Boyle Dam and Facilities Area

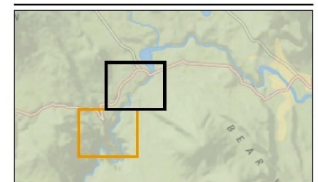
January 2021

N

0 400 800 1,200 1,600 Feet

(At original document size of 11x17) 1:12,000

PRELIMINARY DESIGN (NOT FOR CONSTRUCTION)



Notes
1. Coordinate System: NAD 1983 2011 StatePlane California I FIPS 0401 Ft US
2. Data Sources: Feature Locarions: Digitized locations from Knight Piesold 90 Design General Arrangement.
3. Background: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
National Geographic, Esri, Garmin, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp.

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Figure D-1. Site Reference – J.C. Boyle Dam Features Slated for Removal and Site Restoration (Page 1) Upper Reservoir (Page 2) Lower Reservoir

J.C. Boyle Historical Context/Restoration Potential

Prior to inundation by the J.C. Boyle Dam, the Klamath River had two (2) distinct reaches, a wider Upstream Reach that includes a floodplain/sand bar area, and a narrower more sediment deprived Canyon Reach. Highway 66 Bridge is considered the division between the two (2) reaches (Figure D-2), per the Definite Plan Report (KRRC, 2018).

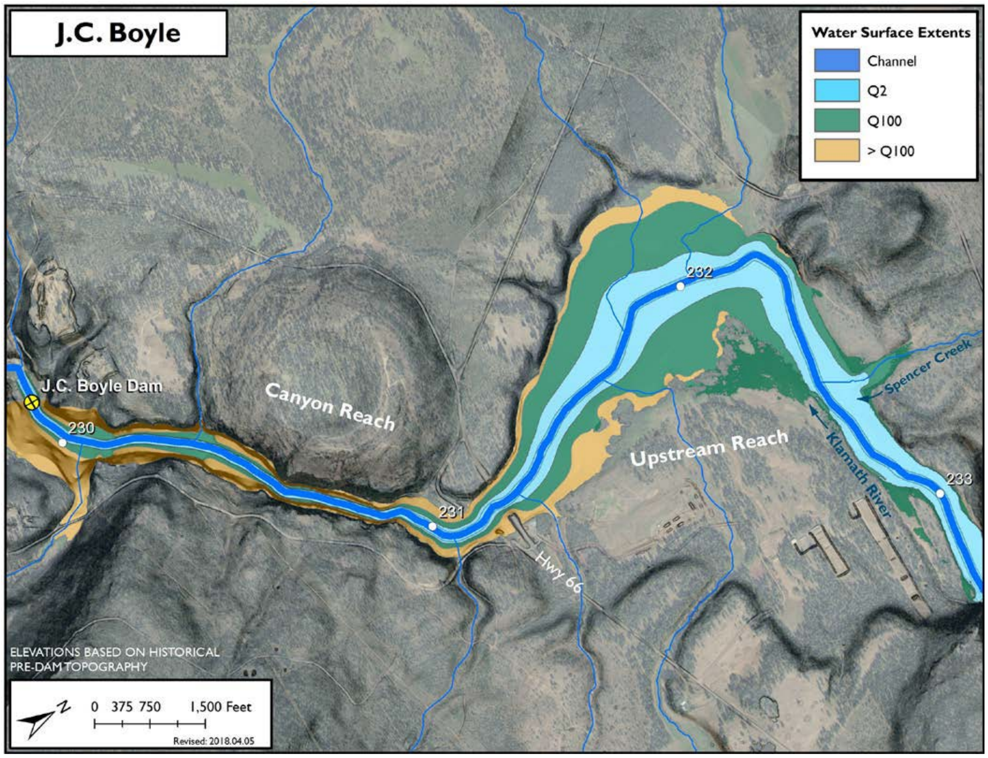

Figure D-2. Estimated Historic River Conditions of J.C. Boyle Reservoir

Source: KRRC, 2018

Note: Slopeshades are of bare earth LiDAR overlaid with aerial imagery and historical topography of J.C. Boyle Reservoir area with estimated flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods. Reach designations and river miles are noted.

In the Upstream Reach, the Klamath River actively modified its channel as suggested by the extensive mapped floodplains and the vegetated and unvegetated bars, including a large semi-vegetated, mid-channel bar upstream of the Highway 66 Bridge (Figure D-3). The majority of the existing reservoir was shallowly inundated during high flows as a result of the low floodplain gradient and the small bank heights of the historical river. Wetland conditions were likely supported in Spencer Creek, which had a multi-threaded distributary character in its lower sections.

In the Canyon Reach, the Klamath River was historically incised several tens to hundreds of feet into the surrounding volcanic bedrock to form a deep, narrow valley (Figure D-4). The narrow valley contained limited space for sediment storage, and, accordingly, there are no mapped historical geomorphic features (BOR, 2011). The Klamath River was single threaded with significant exposures of bedrock on the riverbed and banks that limited channel adjustment.

There is little evidence of bedform development, and most in-channel sediment visible in historical photographs is boulder- or cobble-sized. Two (2)-year and 100-year flood extents were estimated to be narrow, demonstrating the confined nature of the Canyon Reach (KRRC, 2018).

Figure D-3. Historic Aerial Photograph of J.C. Boyle Reservoir Area (1952) Prior to Dam Construction

Source: KRRC, 2018

Note: Highway 66 bridge crosses the Klamath River in this location. Flow is top to bottom. Photograph is oriented north-up. Dam location is out of frame at the bottom left.

Figure D-4. View Looking Upstream at Location Where J.C. Boyle Dam Was Constructed in 1957

Source: KRRC, 2018

Note: View of historical vegetation and rocky, volcanic, slightly incised geomorphology.

Copco No. 1 and No. 2 Development Context

Copco No. 1 hydroelectric facility was constructed from 1911 to 1922 and is located at RM 202.2 in Siskiyou County, California. The site is approximately 25 miles east of the Interstate 5 Highway. The facility is accessed by the public Copco Road. Major components of the Copco No. 1 facility include the following:

- A reservoir of 40,700-acre-feet capacity at a reservoir elevation of 2,611 ft
- A 133-ft-high (maximum height) 410-ft-long concrete arch dam
- A 224-ft-long ogee crest overflow spillway controlled with thirteen spillway gates
- An abandoned and concrete-plugged diversion tunnel and concrete inlet control structure
- A power intake structure and surface mounted steel penstocks
- An at-surface two-unit 22-MW powerhouse
- A switchyard, substation, and transmission lines

Recreation facilities associated with the Copco No. 1 Reservoir included Mallard and Copco Cove with boat launches.

Copco No. 2 hydroelectric facility was constructed from 1924 to 1925 and is located between RM 201.8 and RM 200.3 in Siskiyou County, California. Copco No. 2 dam is approximately 25 miles east of the Interstate 5 Highway and is approximately 1,600 ft downstream of the Copco No. 1 dam. The facility is accessed by the public Copco Road. Major components of the Copco No. 2 facility include the following:

- A reservoir of 58-acre-feet capacity at a reservoir elevation of 2,486.5 ft
- A 32-ft-high concrete gravity diversion dam and a 100-ft-long earth fill embankment section at the right abutment
- A 145-ft-long overflow spillway with five (5) 26-by-11-ft radial gates
- An intake and 5,215-ft-long water conveyance system with a 2,400-ft concrete lined tunnel, 1,345-ft wood-stave penstock, a second 1,095 ft of concrete lined tunnel, and two (2) surface mounted high pressure steel penstocks approximately 375 ft long.
- An at-surface two (2)-unit 27-MW powerhouse with a capacity of 2,676 cubic feet per second at a net head of 140 ft.
- A switchyard, substation, and transmission lines.

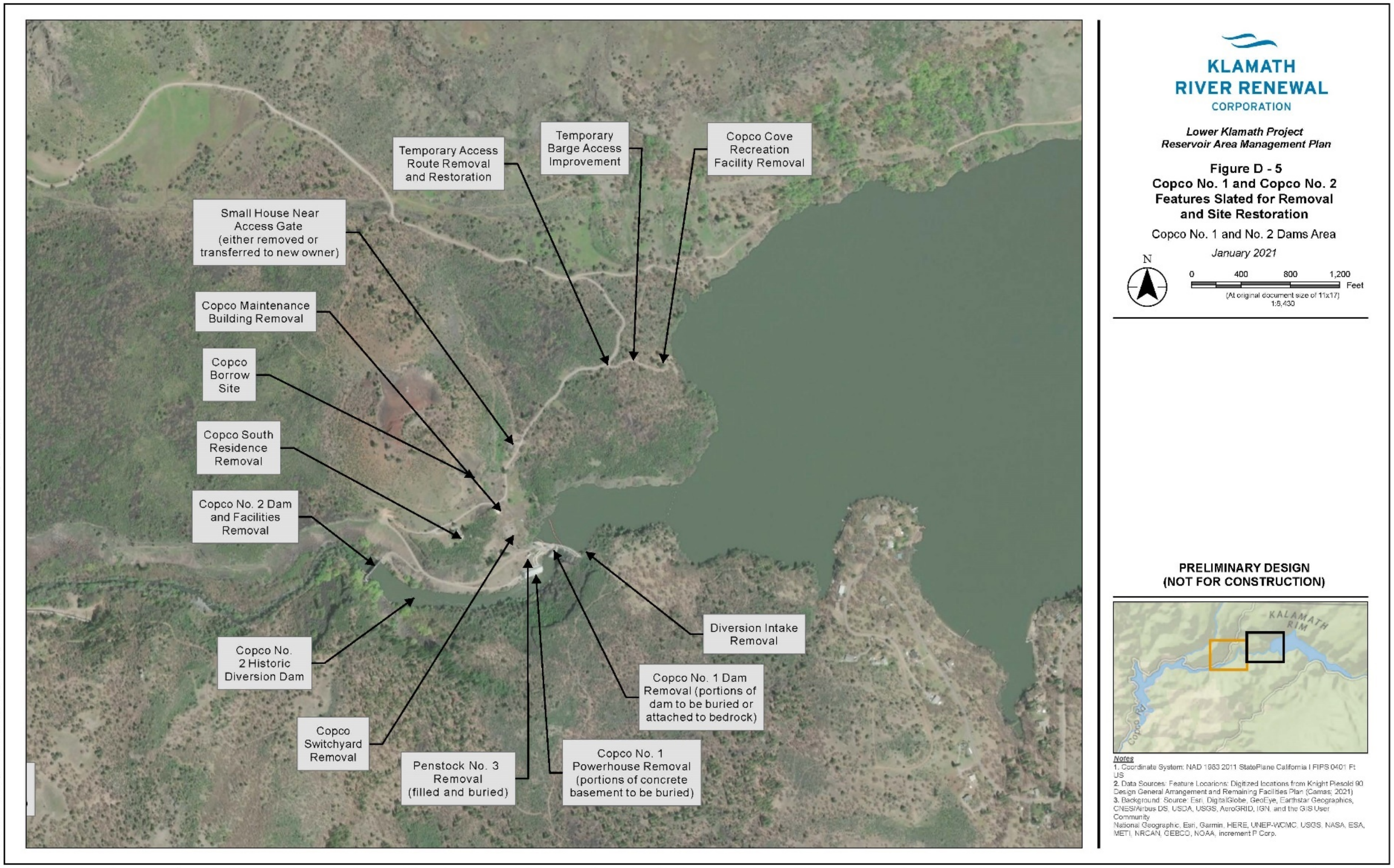

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Figure D-5. Site Reference – Copco No.1 and No. 2 Features Slated for Removal and Site Restoration (Page 1) Lower Reservoir (Page 2) Upper Reservoir

Copco Historical Context/Restoration Potential

Historically, the Klamath River within the Copco No. 1 and No. 2 reach was a meandering, bedrock river inset within lithified fluvio-lacustrine bedrock. The historical valley bottom was relatively wide compared to reaches of the Klamath River downstream of the dam (e.g., historical Iron Gate Reservoir valley) and upstream of the reservoir. The wide and flat valley morphology was the result of aggradation caused by the damming of the ancestral Klamath River by the Copco basalt, a 140,000-year-old lava flow (Hammond, 1983, as referenced in KRRC, 2018). These lava flows created an ancestral lake approximately 130 ft deep at its maximum (35 to 40 ft above modern lake level) that occupied approximately five (5) miles of the Copco valley upstream of RM 202. (KRRC, 2018)

The Klamath River incised into the ancestral lakebed after the lava dam was breached and formed the bedrock meandering valley visible in the historical pre-dam topography. This pre-dam topography was characterized by the flat ancestral lake bed, which is perched up to 50 ft above the historical channel, and asymmetric channel-valley cross-sections, which comprise steep to vertical diatomite banks on the outsides of bend and more gradual alluvium-draped slip-off slopes on the insides of the meanders, morphology indicative of vertical and lateral erosion proceeding in tandem. The grade of the historical Klamath River in the reservoir area appeared to be controlled by bedrock outcrops, likely the Copco basalt, at the narrow entrance to the canyon reach where the dams were constructed (locally known as Ward's Canyon), several hundred feet upstream of the Copco No. 1 Dam location (Figure D-6). (KRRC, 2018)

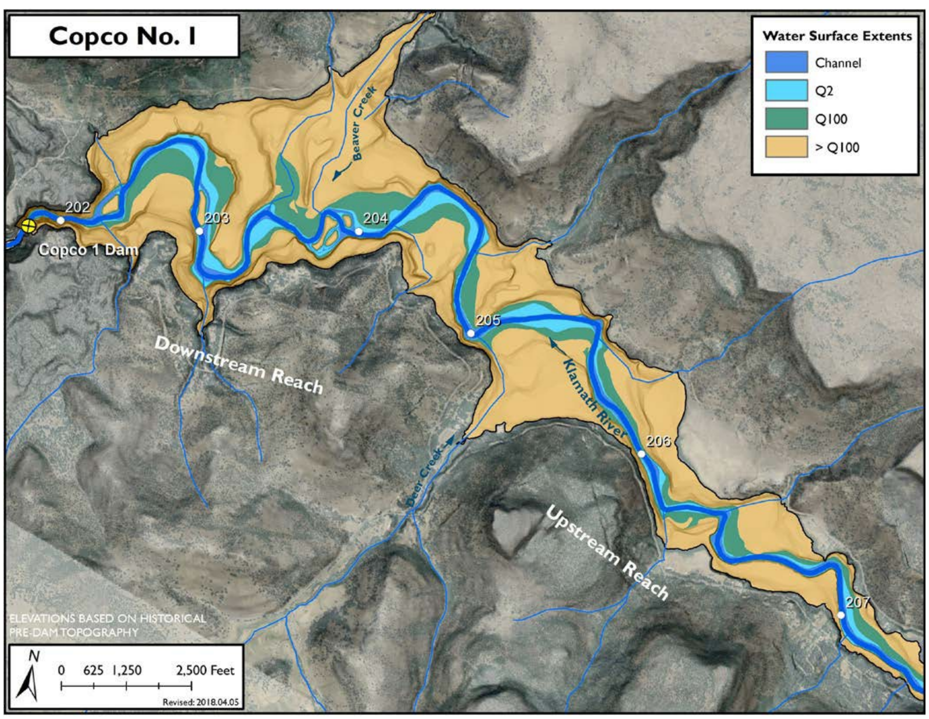

Figure D-6. Estimated Historic River Conditions

Source: KRRC, 2018

Note: Slopeshades are of bare earth LiDAR overlaid with aerial imagery and historical, pre-dam topography of Copco Reservoir area with estimated flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods.

The historical channel was inundating and modifying its narrow floodplain and eroding its diatomite riverbanks as evidenced by the mapped flood inundation boundaries and the presence of a large cut-off meander loop of the mainstem Klamath River occupied by historical Beaver Creek at the time of dam construction. Swales, side channels, remnant meanders, and additional floodplain complexity are noted on the 1906 topographic map (Figure D-7) and visible in the bathymetry. The large aerial extent of the reservoir that is not inundated by the Q100 demonstrates the degree of valley confinement in the reach. (Figure D-6)

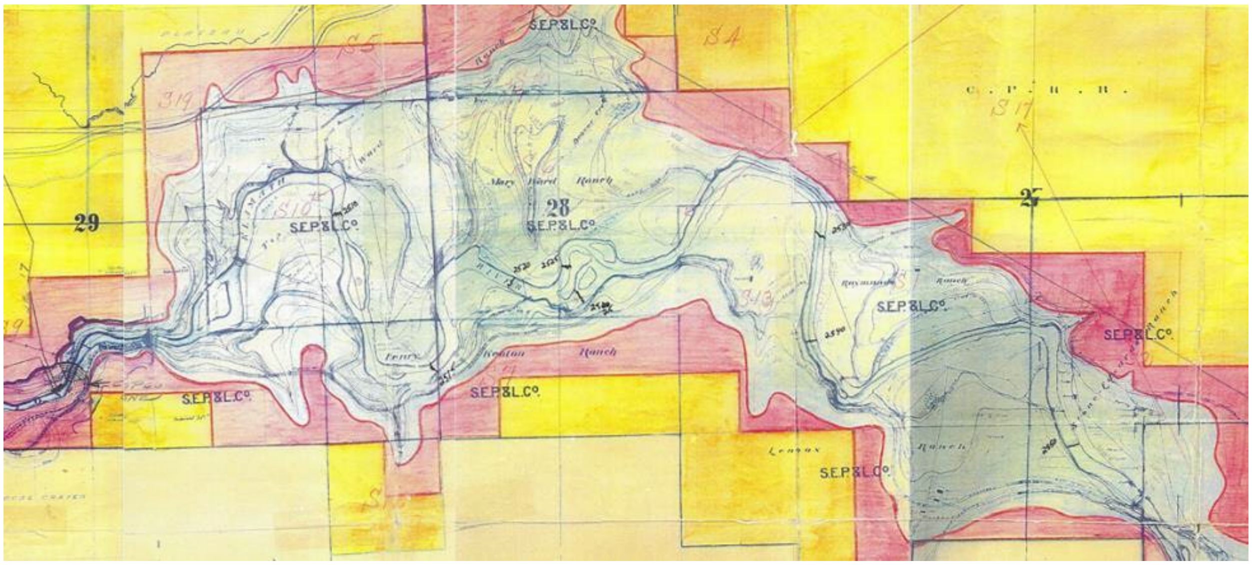

Figure D-7. Topographic Survey from 1906 Survey of Copco Lake Area

Source: KRRC, 2018

The valley bottom was inhabited by humans prior to dam construction, and orchards and ranchlands covered much of the land surface with evidence of widespread land clearing. Oak, juniper, and pine groves are visible in historical pre-dam photographs (Figure D-8) and marked on the topographic survey maps (Figure D-7). Riparian vegetation along the mainstem, tributaries, smaller side channels, and floodplain swales primarily consisted of willows, tule, and brush. Upland vegetation was a mix of oak, pine, juniper, and fir. Prior to dam construction, it appears that the valley bottom was cleared of larger trees (e.g., pine) for agricultural purposes.

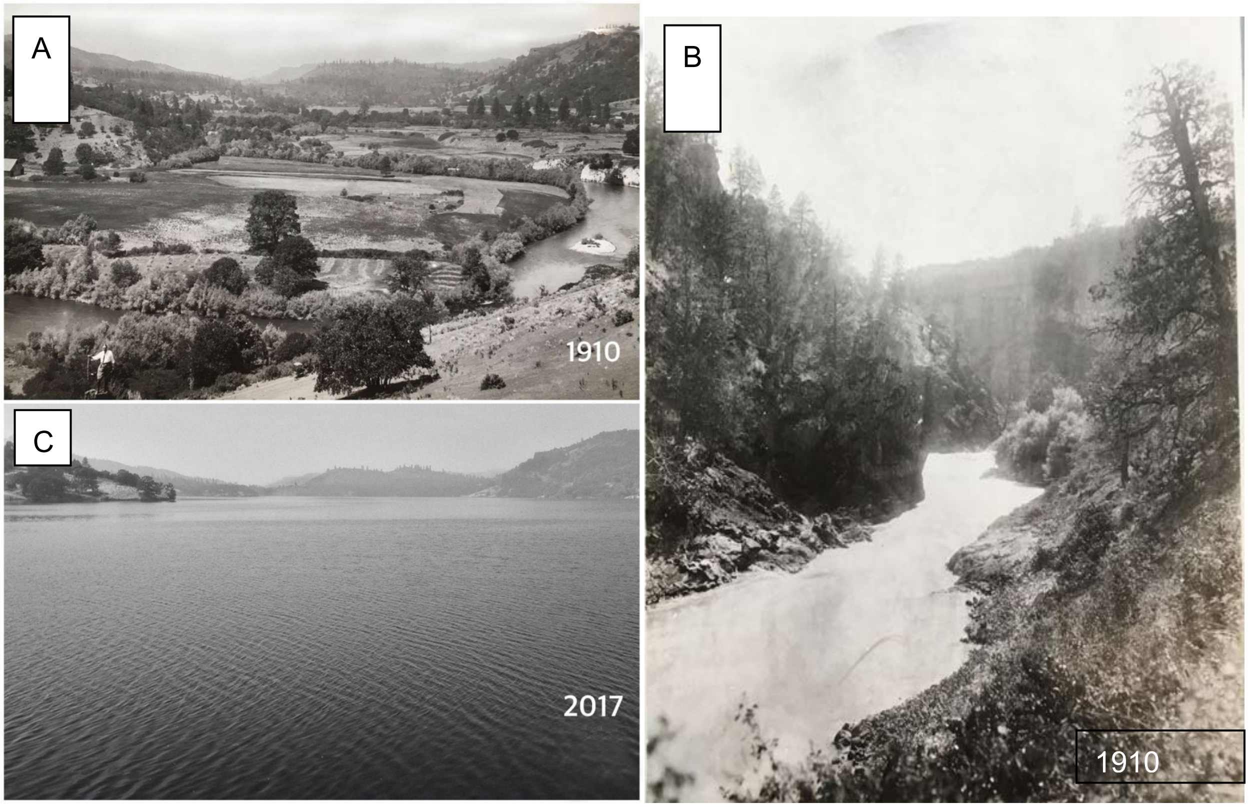

Figure D-8. Historical Photographs of Copco Lake Area, 1910 and 2017

Source: KRRC, 2018

Note: (A) Photo from 1910, prior to Copco No. 1 dam construction showing existing vegetation and land use in the reservoir area. Bedrock/valley fill is exposed in the right bank. A sequence of two mapped alluvial terraces are located on river left in the center of the photograph . (B) Ward Canyon looking upstream in the Klamath River prior to dam Construction. (C) Copco No. 2 conditions in 2017.

Iron Gate Development Context

Iron Gate hydroelectric facility was constructed from 1960 to 1962 and is located at RM 193.1 in California. The site is located approximately 10 miles east of the Interstate 5 Highway. The facility is accessed by the public Copco Road. Major components of the Iron Gate facility include the following:

- A reservoir of 54,714-acre-feet capacity at a reservoir elevation of 2,331.3 ft
- A 189-ft-high, 740-ft-long earth fill embankment dam
- A sheet pile wall at the dam crest to increase reservoir flood attenuation capacity
- A 727-ft-long side channel flip-bucket spillway
- A diversion tunnel that functions as a low-level outlet
- A power intake structure and steel penstock
- An at-surface single unit 18-MW powerhouse
- A switchyard, substation, and transmission lines
- Various fish related pipes, a fish ladder, and six (6) collection ponds that support operations of the Iron Gate Hatchery

The Iron Gate hydroelectric development features (Figure D-9) are scheduled for removal in 2023, pending regulatory approvals. Upon removal, the development sites and former reservoir footprints are to be graded as applicable, revegetated as appropriate, monitored, and potentially adaptively managed in accordance with the 2021 Reservoir Area Management Plan (Chapters 5.0 and 6.0).

Recreation facilities at Iron Gate include the Fall Creek day-use area and boat launch, campgrounds, and other boat launch areas and dispersed shoreline sites.

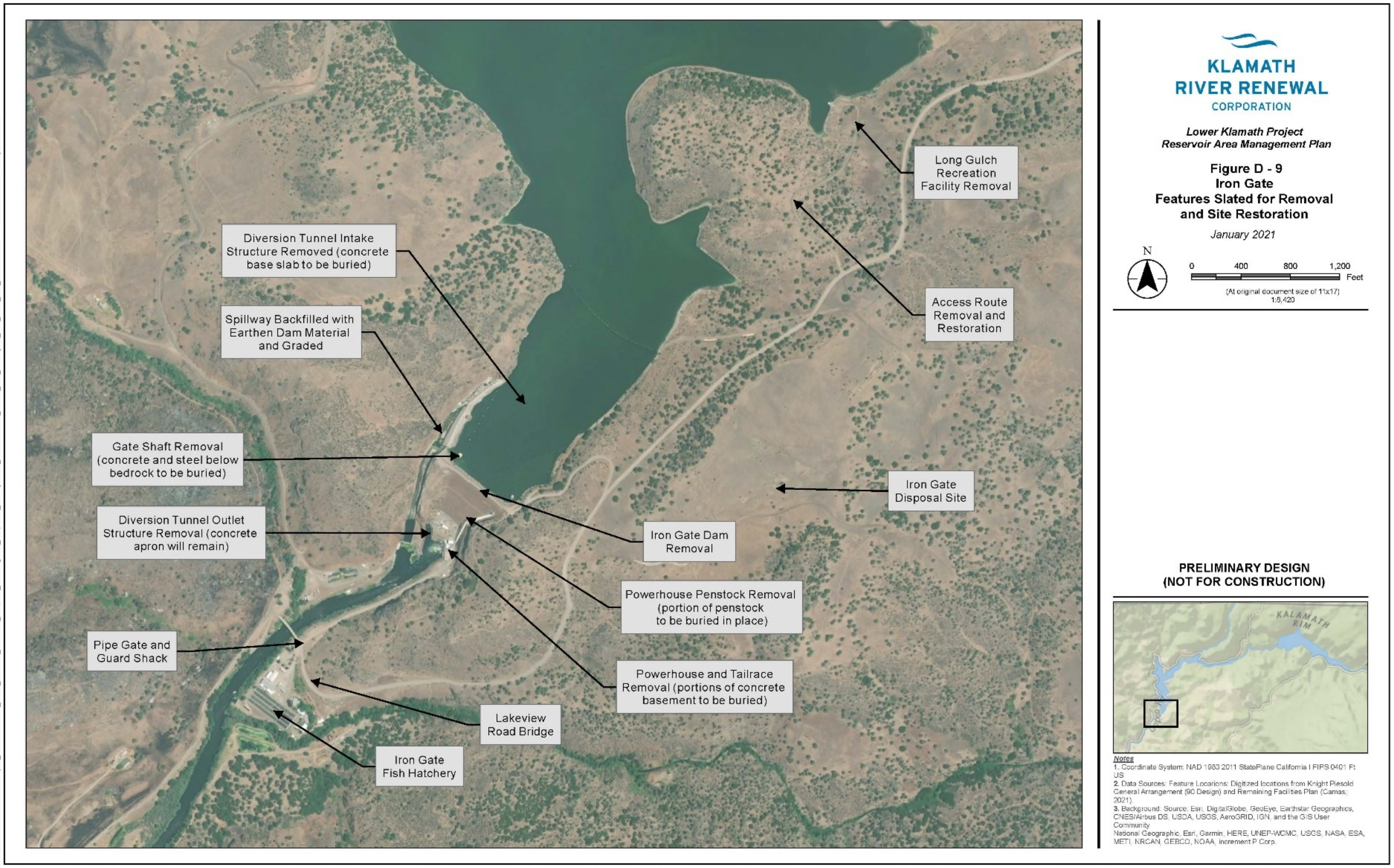

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Figure D-9: Site Reference – Iron Gate Features Slated for Removal and Site Restoration

Iron Gate Historical Conditions/Restoration Potential

In the Iron Gate Reservoir area, prior to dam construction, the Klamath River was a single-thread channel with low- to moderate-sinuosity that occupied a deep, narrow, and symmetric valley incised into a complex set of intrusive rock, Tertiary age volcaniclastic rocks, and younger basaltic and andesitic lava flows that outcrop in many of the ridges adjacent to the channel (KRRC, 2018). Much of the channel bed was composed of coarse sediment that was sourced from adjacent hillslopes and bedrock exposures and formed rapids in the steep reach. Physical geomorphic conditions (e.g., cross-sectional geometry and channel dimensions) in the Iron Gate reach were relatively uniform longitudinally, except locally at tributary junctions. Several larger tributaries (Fall Creek, Jenny Creek, and Camp Creek) contributed appreciable sediment to the mainstem, and mapped geomorphic features were coincident with the confluences (BOR, 2011). For example, in the downstream reach, Camp Creek, likely contributed a considerable amount of sediment to the mainstem (BOR, 2010), and there was a large alluvial fan at the historical confluence . These geomorphic features were longitudinally extensive but typically limited to one (1) to two (2) channel widths in lateral extent due to the confined nature of the valley. Rapids were visible in photos at several locations coincident with the wider 100-year floodplains depicted in Figure C-10. Anthropogenic disturbance, including mining and road construction, is visible in the bathymetry on the river-left floodplains at RM 194 and RM 195 and Figure C-10 shows estimated pre-dam conditions upstream of the Iron Gate dam.

Prior to dam construction, upland vegetation consisted of grasses with dominant tree species of oak and juniper. Tree concentrations were sparse on southern aspects and considerably thicker on northern aspects and in tributary valleys. A narrow band of willows, tule, and other species lined the riparian zone. Iron Gate dam was constructed using a bypass tunnel to dewater the dam construction zone, an area with relatively steep slopes and sparse vegetation (Figure D-10). The channel and floodplain were narrow and topographically confined as indicated by the relatively narrow flood width extents (Figure D-11).

Figure D-10. View Looking Upstream at Site of Iron Gate Dam during Construction and Showing Reservoir Area

Source: KRRC, 2018

Note: Photo from initial Iron Gate Dam Construction, shows Cofferdam and bypass tunnel.

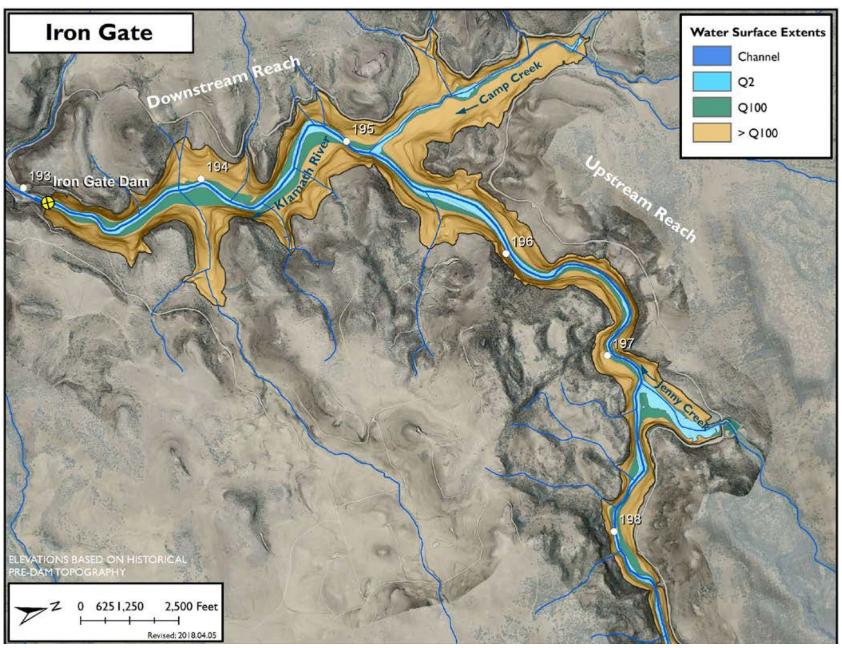

Figure D-11. Estimated Historic River Conditions Based on Historical Topography with Flood Inundation Estimations

Source: KRRC, 2018

Note: Slopeshades are of bare earth LiDAR overlaid with aerial imagery and historical topography of Iron Gate Reservoir area with estimated flood inundation boundaries for the 2-year (Q2) and 100-year (Q100) floods (Definite Plan Report, 2018).

References

Klamath River Renewal Corporation (KRRC). 2018. *Definite Plan for the Lower Klamath Project* (also known as the 2018 Definite Plan Report). June 2018. Available online at: http://www.klamathrenewal.org/definite-plan/

PacifiCorp. 2004. *Environmental Report. Final License Application, Volume 2, Exhibit E. Klamath Hydroelectric Project (FERC Project No. 2082)*. February 2004. Available online at: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/hydro/klamath-river/relicensing/klamath-final-license-application/Exhibit_E_Table_of_Contents_Introduction_and_General_Description.pdf

U.S. Bureau of Reclamation (BOR). 2010. *Klamath River Sediment Sampling Program Phase 1 – Geologic Investigations Volume 1 of 2*.

USBOR. 2011. *Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration.* Technical Report No. SRH-2011-19.

Appendix E

Methodologies for Calculating Anticipated Reservoir Conditions Post-Drawdown

Methodologies for Calculating Anticipated Reservoir Conditions Post-Drawdown

While acknowledging high uncertainty, there is still a need to approximate post-drawdown topography to quantify probable earthwork volumes and to aid in selecting active sediment evacuation locations. The process for estimating the post-drawdown topography is summarized below and described in the following sections:

11. Identify and analyze historic topographic data and existing bathymetric data to approximate probable channel alignments and channel sizes
12. Estimate sediment thicknesses using past sediment coring studies
13. Make reasonable assumptions to how the sediment will respond to dewatering based on past sediment analyses of each reservoir

E.1 Available Topographic Data

Historical topographic maps were used to provide the pre-dam elevation baseline for the reservoir areas. The Iron Gate drawings were dated January 29, 1957; Copco Reservoir drawings were dated August 12, 1940; and J.C. Boyle Reservoir drawings were dated March 30, 1963. These maps were digitized by AECOM and provided digitally as a Tagged Image Format (TIF) to the project team.

In 2018, topographic and bathymetric data was collected for the reservoirs by GMA Hydrology, Inc. for AECOM. This data combined Light Detection and Ranging (LiDAR), bathymetric LiDAR, multibeam, sweep and Global Navigational Satellite System (GNSS) real-time kinematic (RTK) collected data to develop topographic information for the inundated and exposed portions of the reservoir. The project team received this data and converted the 2.6-foot (ft) grid digital elevation model (DEM) into a 1 ft grid DEM.

Initially, it was thought that these two surfaces could be used to determine sediment thicknesses within each reservoir; however, it was determined that the analyses would not be accurate. This is because, when the surfaces were compared, there were significant portions of the historic topographic data above the 2018 data for all three (3) reservoirs. With the 2018 data being the most current and most accurate, it was determined that the historic topography of the inundated areas was faulty. Therefore, the historic topography was not used in developing the post-drawdown surface.

E.2 Sediment Thickness Estimation

Without pre-dam topography to compare the 2018 bathymetric data to, past sediment studies were used to estimate sediment thicknesses. In 2011, BOR published *Hydrology, Hydraulics, and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration*. The study developed a multivariate regression equation to estimate sediment thickness based on historic and current sediment coring data. The results were published in the report that contained isoline sediment depth figures (Figures 5-35, 5-36, and 5-37) for each reservoir. Those figures were georeferenced, and the isolines were digitized.

A comparison of the total sediment volumes published in the report, and the sediment volumes generated from the digitized isolines are provided in Table E.1.

Table E.1 Comparison of Sediment Volumes

	Volume of Sediment (cubic yards)		
Source	**J.C. Boyle**	**Iron Gate**	**Copco**
Reclamation (2011)	1,000,000	4,710,000	7,440,000
Digitized Isolines	932,000	4,517,189	6,760,000

E.3 Post-Drawdown Surface

Assumptions were made about how the sediment would respond to dewatering to develop the anticipated post-drawdown surfaces. These assumptions were based past sediment analyses and typical responses of natural sediment evacuation from previous dam removal projects. The first major assumption made was that all sediment within the vertical extents of all active channels would naturally evacuate. The second assumption made is that the Klamath River and its tributaries would occupy approximately the same alignment as they historically occupied. These alignments and channel widths were based on historic photos, apparent depressions in the 2018 bathymetric data, and regional geomorphic curves for bankfull width. The third assumption made was that all sediment confined within steep and narrow valleys would naturally evacuate. For example, the sediment contained within the steep and confined fluvial valley of the downstream extents of the J.C. Boyle Reservoir was assumed to all naturally evacuate. The final two assumptions were based on sediment studies that focused on angle of repose and the drying and shrinking of sediments. It was assumed that the sediment would initially dry and shrink by 40 percent, and sheer cliffs would fall to an angle of repose of 10V:1H. The angle of repose was applied from the estimated top of banks and extended outward until it daylighted to the shrunk sediment surface.

The combination of these assumptions with both the sediment depth surface and the 2018 bathymetric data was used to generate the anticipated post-drawdown surface.

Appendix F

Establishment of Restoration Priorities within the Reservoirs

Restoration Priorities

Restoration priorities are driven by the primary Project goals of volitional fish passage, residual sediment stabilization, native plant establishment, and the secondary goal of enhancing native fish habitat. Priorities also considered the challenging natural environment for plant establishment, including variable soil quality, low rainfall, high summer temperatures, and competition from invasive species. From this, the following four (4) restoration tiers were identified:

- **1st Tier – Klamath River.** The highest Project priority is providing volitional fish passage on the Klamath River. This will be achieved through the primary habitat restoration actions (drawdown, sediment evacuation, and dam removal). Mainstem habitat connectivity is important for re-establishing natural distributions of anadromous salmonids and Pacific lamprey in the Klamath River Basin. Fish passage will be promoted by reconstructing a fish-passable and geomorphically appropriate channel through the footprints of the former dams. In addition, any anthropogenic structures in the river channel, either known or uncovered post-drawdown, will be removed. Additional measures may be taken to opportunistically encourage floodplain benches and channel complexity where post-drawdown conditions, access, time, and budget allow. Generally, the restoration approach for the Klamath River is to restore natural processes so that the river and associated habitats can recover without significant intervention (process-based restoration).
- **2nd Tier – Perennial Tributaries.** The secondary priority is perennial tributaries, particularly at the tributary confluences with the Klamath River and where tributaries have formed deltas around the reservoir rim. Tributaries and tributary mouths tend to be highly used habitats by anadromous salmonids and Pacific lamprey. Tributaries can support several life stages necessary for anadromous salmonids to complete their life history, including spawning, egg incubation, juvenile rearing, and overwintering. Tributary mouths provide habitat for anadromous salmonids originating in the tributary, as well as adults and juveniles during migration and rearing. Because tributaries are expected to have lower suspended sediment loads than the mainstem as it adjusts to its restored condition, tributary mouths may also be particularly important refugia habitat for salmonids and Pacific lamprey in the first few years following drawdown. Restoration prioritization of tributaries is discussed in detail in Selection of Restoration Activities at Tributaries and Confluences.
- **3rd Tier – Natural Springs.** Natural springs and seeps are water sources that can be used to create wetlands, add channel complexity by supporting spring-fed alcoves or side channels, and widen riparian areas. Appropriate planting and focused, minor grading can add complexity and connectivity to ecosystems associated with the river and springs. Expanded and revegetated areas serve as seed sources for passive restoration in adjacent areas, provide critical functions in terms of refugia and foraging for terrestrial species, and improve potential biological productivity for a range of species, including aquatic organisms.

- **4th Tier – Intermittent and Ephemeral Tributaries.** Although perennial tributaries are the highest priority, there are selected intermittent tributaries that may provide non-natal juvenile rearing refuge habitat. If access and budget allow, restoration actions may address connectivity at the mainstem confluence of the larger intermittent tributaries to provide expanded habitat and/or increased biological productivity.

These tiers were applied to each reservoir to identify high- and low-priority restoration areas. The resulting areas are those with the greatest opportunity to enhance habitat value through direct actions, such as grading and installing enhancement features. Areas outside of restoration areas will be restored more passively, primarily through native seeding and selective planting.

Restoration Opportunities: J.C. Boyle

While the lower reach of J.C. Boyle is confined, the less confined upper reach presents more restoration opportunity. Given the relatively low sediment deposition in J.C. Boyle, little intervention is anticipated to be needed to reconnect with Klamath River with adjacent habitats. Active restoration in the J.C. Boyle Reservoir is limited to Spencer Creek, a fish-bearing, perennial stream. Spencer Creek was identified for restoration actions in the 2018 Definite Plan Report (Appendix H, Figure 5.1; KRRC 2018) and remains a priority tributary for restoration. The three (3) unnamed tributaries, which were identified for active grading in the 2018 Definite Plan Report (Sites 1 to 3), are anticipated to recover through natural processes augmented by active revegetation and IEV controls. Specific restoration activities in the J.C. Boyle Reservoir are described in Restoration Opportunities: J.C. Boyle.

Spencer Creek extends for approximately 13 miles above its confluence with the mainstem Klamath River and has perennial flow. No stretches within the longitudinal profile exceed the gradient and length for natural fish passage barriers. With the exception of a short stretch of step-pools in the first mile of the creek, the lower six (6) miles are primarily characterized by riffle-pool bedforms. After that, the streambed slope steepens, and the estimated channel type becomes primarily step-pool.

Fall-run Chinook salmon and steelhead trout were present on Spencer Creek prior to dam construction (Hamilton et al., 2005). The Klamath River upstream limit for Coho salmon and Pacific lamprey is believed to have extended at least to Spencer Creek, which has suitable habitat for Coho salmon (Hamilton et al., 2005; NOAA and NMFS, 2014; DOI, USDC, and NMFS, 2007). Additionally, Huntington (2006) suggests that approximately 13 miles of Spencer Creek are “potential anadromous fish habitat.” Based on this analysis, Spencer Creek is considered a high-priority tributary.

The revegetation approach at J.C. Boyle Reservoir will be similar to other reservoirs; however, the seed mix and planting palettes will be adjusted to reflect its higher elevation, shallower reservoir depth, and different plant communities around the reservoir. IEV control will be implemented before the restoration implementation begins. Spencer Creek, which drains into the reservoir, will serve as a reference site for the revegetation portion of the restoration.

Because of the striking topographical contrast between the two (2) reaches of the reservoir, there will be a large difference in the revegetation approach. The Upstream Reach above the Highway 66 bridge has mostly gentle slopes and includes large and broad riparian floodplains that will have favorable hydrology for riparian and wetland habitat restoration, while the Canyon Reach downstream of the bridge passes through a narrow rocky gorge with minimal restoration opportunities.

Canyon Reach will not be able to support much vegetation because the bedrock riverbed and the constricting rock wall bank conditions will result in high water velocities, expedited removal of any fine sediment, and very little suitable growing substrate along the narrow banks. Revegetation will be implemented by seeding only areas with suitable growing substrate.

Restoration Opportunities: Copco No.1 and Copco No.2

Copco No. 1 Reservoir is the reservoir with the highest restoration potential based on its wider, less confined valley and meandering mainstem. Copco No. 1 has restoration opportunity areas along the mainstem as well as key tributaries. The two (2) main restoration areas targeted for restoration on Copco No. 1 (Appendix H, Figure 5.4; KRRC 2018) are the Beaver Creek Complex, an intermittent stream with historic fish presence, and a spring-fed floodplain and wetland complex made up of natural springs to receive wetland planting. One of the six (6) sites identified for active grading in the 2018 Definite Plan Report for Copco No. 1, Site 2, is included in the above priorities. Site 1, the historic side channel complex on the mainstem, is a focus area for assisted sediment evacuation during drawdown. Sites 3 through 6 are considered lower priority and therefore will not be targeted for restoration actions. In addition, the following intermittent tributaries identified in the 2018 Definite Plan Report are considered low priority: Deer/Indian Creek, Raymond Gulch, Unnamed Copco No. 1 Tributary, Spannaus Gulch, Snackenbury Creek, Unnamed Copco No. 1 Tributary. Long Prairie Creek at the upstream end of Copco No. 1 is also a low-priority tributary, though it was not included in the 2018 Definite Plan Report. Specific restoration activities in the Copco No. 1 Reservoir are described in Restoration Opportunities: Copco No. 1 and Copco No. 2.

Revegetation at Copco No. 1 and Copco No. 2 will have seed mixes and planting pallets that reflect lower elevation and potentially deeper reservoir sediment than JC Boyle. IEV control will be initiated before the restoration implementation begins.

Restoration Opportunities: Iron Gate

Iron Gate Reservoir is located in a relatively confined valley with little to no pre-dam floodplain connectivity, so restoration opportunities are primarily focused on the larger tributaries. The three (3) main restoration areas on Iron Gate are Jenny Creek, the Camp/Scotch Creek Complex, and Wanaka Springs. Jenny Creek and the Camp Creek Complex are identified for active grading in the 2018 Definite Plan Report (Appendix H, Figure 5-7). The 2018 Definite Plan Report also included Unnamed Tributary 1 and Long Gulch (Site 1; KRRC 2018), which are considered low priority for restoration. Wanaka Springs is not included in the 2018 Definite Plan Report but has been included above to be consistent with approach of prioritizing natural wetlands and seeps. Fall Creek, at the upstream end of the Iron Gate Reservoir; and Bogus

Creek, located downstream of Iron Gate Dam were not included in the 2018 Definite Plan Report and therefore are not considered high-priority restoration areas; however, regulatory agencies have noted that mainstem connectivity at these tributary confluences is important. The mouths of these creeks will be monitored following drawdown, and residual sediment will be removed as needed for fish passage. Specific restoration activities in the J.C. Boyle reservoir are described in Restoration Opportunities: J.C. Boyle.

The longest of the studied tributaries, Jenny Creek is perennial and extends for 22.3 miles upstream of its confluence with Iron Gate Reservoir. The lower 3.5 miles are primarily made up of step-pool bedforms, and the next 16 miles upstream are at a gentler slope before the gradient steepens again towards the headwaters. Though Jenny Creek does not have reaches that meet the length and gradient criteria for a natural passage barrier as described above, field notes indicate that falls located two (2) miles from the present reservoir limit are a natural passage barrier (RDG, 2018b). There is also a low-head dam located approximately 1.1 miles upstream of Copco Road Jenny Creek Bridge that is a man-made fish passage barrier. In addition, a series of cascades in the first mile upstream from the existing reservoir limit may be an obstacle at low-flow conditions (RDG, 2018b). Spawning habitat may be limited, as the visible substrate mostly consisted of boulders (RDG, 2018b). According to PWA (2009), of the studied creeks, Jenny Creek has the greatest potential to provide quality anadromous fish habitat. More specifically, Jenny Creek has resident rainbow trout and contains suitable rearing habitat for Coho (DOI, USDC, and NMFS, 2007), and about one (1) mile of the creek is considered "accessible habitat" to Pacific lamprey (Hamilton et al., 2010, as cited in Close et al., 2010). Based on this analysis, Jenny Creek was considered a high-priority tributary.

Dutch and Camp Creeks are intermittent according to the Department of the Interior (DOI), the U.S. Department of Commerce (USDC), and NMFS (2007) (and consistent with recent field observations). Camp Creek is characterized by multiple channels and developed riparian vegetation at its mouth, transitioning to riffle-pool and plane-bed bedform for the lower 1.5 miles. Moving upstream, the bedform then becomes considerably more varied, spanning all classes from regime to cascade until its upstream extent at RM 8.6. The Dutch-Camp Creek confluence occurs at Camp Creek RM 1.3. Dutch Creek extends for about 3.7 miles upstream of the confluence and varies in classification largely between riffle-pool and step-pool.

Camp Creek is documented to have been habitat for *Oncorhynchus mykiss* (Hamilton et al., 2005, 2016). Coho salmon have also been observed in Camp Creek, which is believed to provide natal rearing habitat (NOAA and NMFS, 2014). Additionally, steelhead are known to occur in the Oregon portion of Camp Creek. In fact, along with Fall Creek and Jenny Creek, the Camp/Dutch Creek Complex is named in the PWA study (2009) as one (1) of the three (3) tributaries to Iron Gate that may have provided "high quality" salmonid habitat, in this case particularly for spawning and non-natal rearing. It is currently unknown whether the culvert under Copco Road near Iron Gate Reservoir is passable (RDG, 2019). This culvert is being replaced with a larger, fish passable crossing as described in Restoration Priorities. Based on this analysis, Camp/Dutch Creek Complex was considered a high-priority tributary.

Scotch Creek is an intermittent stream that empties into the Iron Gate Reservoir at a cove on the northern side near the mouth of the Camp/Dutch Creek Complex. Scotch Creek is 8.4 miles long and flows into the post-dam course of Camp Creek approximately 1.2 miles upstream of where Camp Creek confluences with the Klamath River mainstem. The slope analysis for Scotch Creek suggests no one (1) bedform type is dominant in the lower three (3) miles of the creek. The upper six (6) miles predominantly consist of step-pools with cascades toward the headwaters; a natural passage barrier occurs at RM 5.0. Historically, steelhead trout were observed in Scotch Creek (Hamilton et al., 2005) and *Oncorhynchus mykiss* currently reside in this reach. It may also be suitable rearing habitat for Coho salmon (DOI, BOR, and NMFS, 2007). It is currently unknown whether the culvert under Copco Road near Iron Gate Reservoir is passable (RDG, 2019). This culvert is being replaced with a larger, fish passable crossing as described in Restoration Priorities. Based on this analysis and due to its connectivity with Camp and Dutch Creeks, Scotch Creek was considered a high-priority tributary.

Long Gulch is 2.8 miles long and flows into the eastern side of Iron Gate Reservoir. It is primarily made up of estimated step-pool bedform through the first 2.8 miles, after which the gradient rises steeply toward its headwaters. An existing culvert presents an unnatural fish passage barrier at approximately at RM 0.7 (450 ft upstream of the reservoir rim). In addition, a natural passage barrier based on length and gradient criteria is located at RM 2.6. Currently, Long Gulch suffers from high turbidity and poor water quality due to cattle grazing (PWA, 2009). There is an existing wetland seep along the north bank of Long Gulch that currently daylights into the Iron Gate reservoir; this wetland should be re-connected to Long Gulch following drawdown. Long Gulch also contains two (2) submerged culvert crossings that will be removed within the reservoir area. Based on this analysis, Long Gulch was considered a low-priority tributary that will receive select structure removal actions.

Fall Creek is located approximately 10.5 miles upstream of Iron Gate Dam and flows into the Klamath River from the north. Fall Creek’s watershed is 15 square miles (USGS, 2019) and discharges into the upstream, north side of Iron Gate Reservoir. Fall Creek’s flow is perennial (DOI, BOR, and NMFS, 2007). Fall Creek has a moderately steep to steep gradient for approximately its first mile and a steep gradient for the next approximately 1.5 miles. A culvert 100 feet upstream of the mouth at Daggett Road is considered a passage barrier (particularly for juvenile fish) (RDG, 2018a). This culvert is being replaced with a larger, fish passable crossing as described in Restoration Priorities. Approximately one (1) mile upstream of the mouth, the steep, natural falls represent the upper limit of passage for all fish life stages. The Draft EIR for the Lower Klamath Project License Surrender further identified Fall Creek as one (1) of four (4) “primary tributary habitat[s] available for salmonids,” along with Jenny, Shovel, and Spencer Creeks (SWRCB, 2018). Coho spawning was observed in Fall Creek in the past (DOI, USDC, and NMFS, 2007), and about 1.2 miles of the creek were identified as “accessible habitat” for Pacific lamprey (Hamilton et al., 2010, as cited in Close et al., 2010).

Fall Creek Hatchery is located on Fall Creek approximately 2,000 feet upstream of its confluence with the Klamath River. Fish rearing and production at Fall Creek Hatchery ceased in 2003 (KRRC, 2018); however, the Fall Creek Hatchery will be rehabilitated as part of the Project. Although Fall Creek was not included in the 2018 Definite Plan Report, it is included in this analysis because the Fall Creek Hatchery will become operational prior to dam removal. While Fall Creek is considered a high-priority tributary because of the hatchery and presence of suitable habitat, it is a low priority for active restoration under the Project, and direct restoration actions will be limited to providing connectivity at its confluence with the Klamath River.

Revegetation at Iron Gate have seed mixes and planting pallets that reflect lower elevation and potentially deeper reservoir sediment than JC Boyle. IEV control will be initiated before the restoration implementation begins.

Selection of Restoration Activities at Tributaries and Confluences

This section describes how various tributaries to the three (3) reservoirs have been prioritized for restoration actions and then discusses the specific restoration actions for the tributaries, including grading and large wood and riparian planting.

Table F-1 provides a summary of restoration actions.

Table F-1. Summary of Restoration Actions by Area

RESTORATION AREA	ASSISTED SEDIMENT EVACUATION DURING DRAWDOWN	SELECTIVE GRADING	HABITAT ENHANCEMENT FEATURES	RIPARIAN PLANTING (AVERAGE WIDTH)	OTHER
J.C. BOYLE RESERVOIR					
Klamath River		Stabilize unnatural sediment deposits, as needed		50-ft wide along mainstem	Fish passable channel at dam; remove former crossing
Spencer Creek	Focus Area		Large wood, willow baffles, boulder clusters	30-ft wide	
COPCO NO. 1 AND NO.2 RESERVOIRS					
Klamath River (entire length)		Stabilize unnatural sediment deposits, as needed;		50-ft wide along mainstem	Fish passable channel at dam

RESTORATION AREA	ASSISTED SEDIMENT EVACUATION DURING DRAWDOWN	SELECTIVE GRADING	HABITAT ENHANCEMENT FEATURES	RIPARIAN PLANTING (AVERAGE WIDTH)	OTHER
Klamath River – Historic Side Channel Complex	Focus Area	Spot grading to reconnect side channel		50-ft wide along mainstem	
Spring-fed Wetlands					Wetland planting
Beaver Creek	Focus Area	Spot grading along entire reach for connectivity	Large wood, willow baffles, boulder clusters	30-ft wide	
IRON GATE RESERVOIR					
Klamath River		Stabilize unnatural sediment deposits, as needed		50-ft wide along mainstem	Fish passable channel at dam;
Jenny Creek	Focus Area	Excavate delta at reservoir rim	Large wood, willow baffles, boulder clusters	30-ft wide	
Camp/Scotch Creek Complex (Includes Dutch, Scotch Creeks and Unnamed Camp 1 and 2)	Focus Area	Excavate delta at reservoir rim; selectively along channel length	Large wood, willow baffles, boulder clusters	30-ft wide	
Wanaka Springs					Wetland planting
Long Gulch				30-ft wide	Remove remnant crossing(s); Wetland planting at seep

Note: This table lists restoration actions primarily focused on enhancing aquatic habitats. Quantity and locations of habitat enhancement features will vary. Other actions to enhance upland habitats within the reservoir footprints include seeding, planting, irrigation and associated exclusion fencing and IEV management activities.

In addition to the sites listed above, low priority tributaries will receive riparian seeding/planting and be graded if needed for mainstem connectivity. Low priority tributaries include the following:

- Iron Gate Reservoir – Long Gulch, Unnamed Iron Gate Tributary 1, Fall Creek
- Copco No. 1 Reservoir – Raymond Gulch, Unnamed Copco1 Tributary, Spannaus Gulch, Snackenbury Creek, Unnamed Copco No. 2 Tributary and Long Prairie Creek
- J.C. Boyle Reservoir – Unnamed J.C. Boyle tributaries 1, 2, and 3

In addition, Fall and Bogus Creeks located in the vicinity of Iron Gate Reservoir may I also have blockage removed if needed (for connectivity at the confluence only).

Prioritization of Tributaries

The five (5) high-priority tributaries and/or tributary complexes(Figure F-1) identified as restoration areas in Section 0, Restoration Priorities, (Spencer Creek, Beaver Creek, Jenny Creek, Scotch Creek, and Camp Creek) were selected based on the following factors:

- Watershed size and flow regime (perennial or intermittent)
- Historic presence of salmon and/or steelhead
- Potential future incisions risk
- Channel type, including presence of suitable spawning and rearing habitat and/or natural fish passage barriers

These five (5) tributaries are considered to have the highest potential to support target fish species based on the factors above. These tributaries were identified by evaluating and prioritizing the 10 largest tributaries identified in the Definite Plan Report. (Note that Long Gulch, which only has a 1.4-square-mile watershed area but has features of interest (e.g., historic crossings and seep), was also included. Below we present the analysis for future incision risk and channel slope analysis, followed by a brief discussion of each tributary.

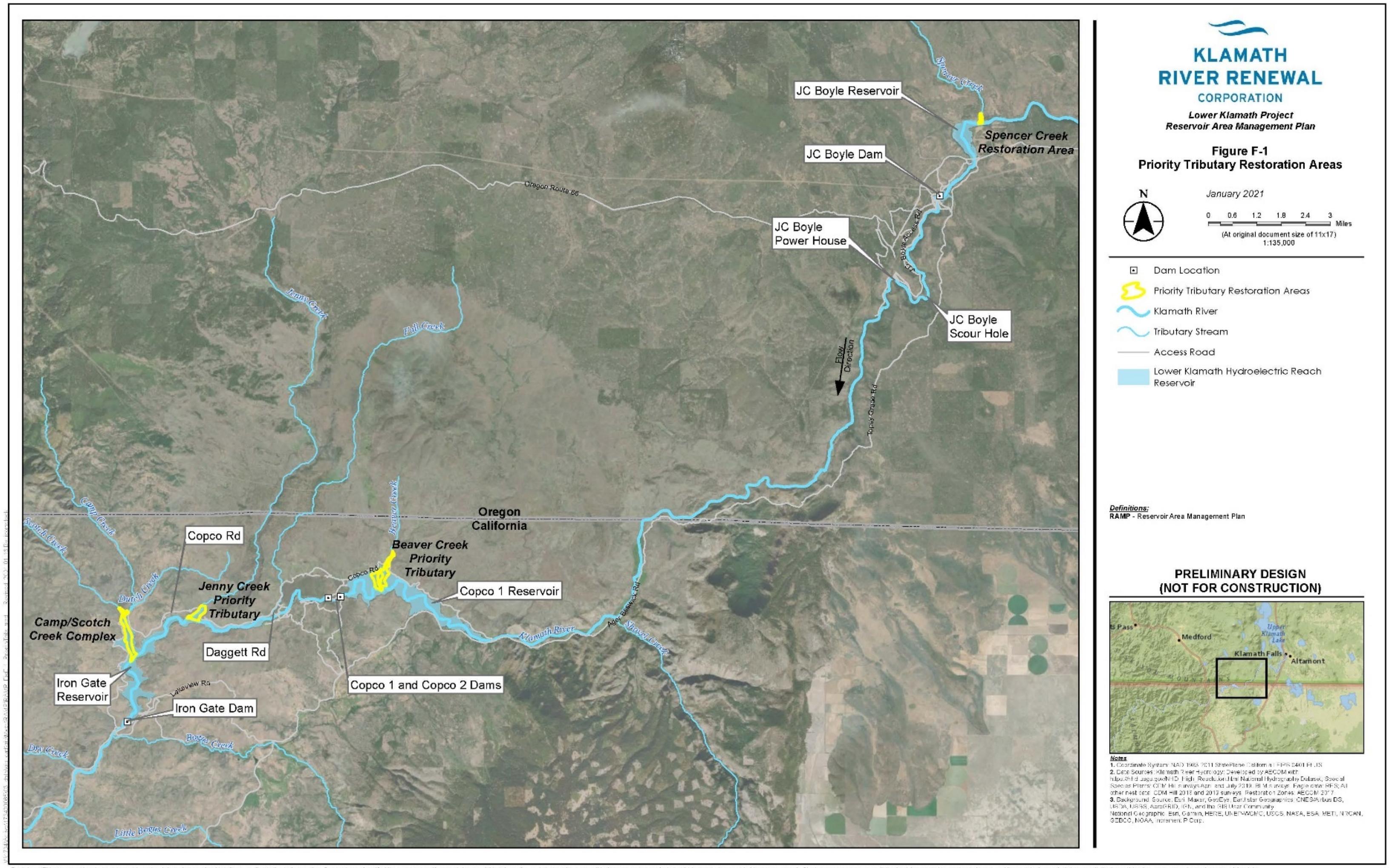

Figure F-1: Priority Tributaries for Restoration Actions

Tributary Incision Risk Assessment

Differential incision is a potential fish passage risk for tributary channels that have developed sedimentary deltas at the reservoir rim. Preferential erosion of the finer, unvegetated sediment below the reservoir level but not the coarser, well vegetated sediment deposited above the water line could result in headcuts that form barriers to fish migration, as well as degraded, deeply incised channels that offer limited fish habitat benefit. This incision risk was previously studied (GMA, 2003) for the four (4) tributaries considered especially important either for potential fisheries or for sediment delivery to the mainstem of the Klamath River: Camp/Scotch Creek Complex and Jenny Creeks on Iron Gate, Beaver Creek on Copco No. 1, and Spencer Creek on J.C. Boyle. The study included surveying the portions of the deltas above and below the reservoirs that formed when each tributary was inundated and comparing them with the pre-dam topography (estimated using historic maps). Based on these comparisons it appears that the existing channels in the Camp/Scotch Creek Complex are up to 16 ft higher than the historic channels due to sediment that has been deposited in the alluvial fans. The difference in channel elevation for the deltas at Jenny and Spencer Creeks, while smaller at two [2] to four [4] ft deep, could still present an incision risk.

Above the reservoir level, the delta sediment is quite coarse and well vegetated, creating a relatively erosion-resistant surface. Below the reservoir level, the alluvial fan sediment is unvegetated and while coarser than the sediment in the main body of the reservoirs, is likely finer and more erodible than the material immediately upstream. Hence, a possible condition soon after the reservoirs are drawn down is for tributary channels with thick alluvial deposits such as the Camp/Scotch Creek Complex to incise in the finer sediment immediately below reservoir level and then for the incision to be arrested by the coarser sediment or road crossings upstream. This may create the potential for “hanging” tributaries with knickpoints (which could be potential fish passage barriers) at the transitions between incision and bed stability.

It appears that the GMA Hydrology (GMA) 2003 study was focused on the tributaries where incision was most likely to be a risk. The remaining tributaries do not appear to have deposited deltas as thick as the Camp/Scotch Creek Complex, and hence are assumed to have a lower risk of headcuts developing.

The recommended design approach for Scotch, Camp, and Jenny Creeks is to actively remove sediment from the deltas during and after drawdown, including some coarse delta sediment that is now above the reservoir water level. Spencer Creek is not included in this approach because of its thinner sediment and because of culturally sensitive sites that constrain excavation. The goal of sediment removal in this area is to prevent partial incision from creating headcuts that impede fish migration, as well as to restore a wider floodplain along the tributaries than would otherwise emerge, with side slopes that are gentle enough to support planting of riparian trees. The channel invert will be excavated down to the historic invert, assuming that this is identifiable as the boundary between overlying gravel and sand and underlying boulders and cobble. Sediment removal may be achieved by hydraulic methods during drawdown (e.g., jetting, boat waking) or by earth-moving equipment following drawdown.

Channel Type and Fish Passage Analysis

During preliminary design documentation of the 16 tributaries identified in the Definite Plan Report was reviewed. Of these, 11 tributaries with either fish habitat potential or larger watersheds were further analyzed to assess channel slope, from which potential natural fish passage barriers and habitat type were inferred. (Note that the following six [6] tributaries from the Definite Plan Report (KRRC 2018) were not included in the slope analysis due to their smaller watershed size [less than three (3) square miles]: Unnamed Iron Gate 1, Spannaus Gulch, Raymond Gulch, Unnamed Copco No. 1, Snackenbury Creek, and Unnamed J.C. Boyle 1).

Channel slope was used to infer channel bedform using the Montgomery-Buffington classification scheme (1998). We recognize that parameters in addition to slope are used to classify channels in the Montgomery-Buffington scheme, and that in a sediment-limited watershed channel type may shift towards steeper classes than those indicated using slope alone, but this provided an efficient desktop method to quickly evaluate a large length of tributaries. Calculated slopes were also used to evaluate whether the tributary slopes likely constituted natural barriers for fish passage, and this was cross-referenced against field notes and a literature review of historic fish presence.

Stantec Consulting Services Inc. (Stantec) provided station-elevation data for key tributaries from the estimated post-drawdown surface to just above the current water line of each reservoir. These were tied into profiles cut from 2013 U.S. Geological Survey Digital Elevation Models for the upstream portion of key tributaries. These datasets were resampled at uniform 25-foot intervals to calculate gradients for the Montgomery-Buffington classification.

Table F-2 shows the different slopes used to assign Montgomery-Buffington channel type, overlain with a compilation of published gradient limits on fish passage for various salmonid species (recognizing that fish passage limitations are naturally variable and affected by other factors such as hydrology and the length and hydraulic properties of the reach in question).

Table F-2: Montgomery-Buffington Stream Classification and Fish Passage Criteria

BED SLOPE	CHANNEL TYPE (MONTGOMERY-BUFFINGTON)	LIMITS OF COHO AND CHINOOK SALMON USAGE	LIMITS OF ADULT STEELHEAD USAGE
<0.1%	Regime	0-7% usable for migration, spawning and rearing[1]	0-12% usable for migration, spawning and rearing[1]
0.1- 2%	Riffle-pool		
1- 2%	Riffle-pool to plane-bed overlap		
1- 3%	Plane-bed		

BED SLOPE	CHANNEL TYPE (MONTGOMERY-BUFFINGTON)	LIMITS OF COHO AND CHINOOK SALMON USAGE	LIMITS OF ADULT STEELHEAD USAGE
3-10%	Step- pool	>8% to 10% gradients for more than 1,000 feet are natural barriers to migration[2] Gradients from 7-16% are potentially passable[1]	
10-30%	Cascade	>16% for more than 525 feet are natural barriers to migration[1] >20% for >30 feet are also impassable[3]	12-20% used for migration but not rearing/spawning. >20% for more than 525 feet are natural barriers to migration[1]
>30%	Colluvial	Impassable	Impassable

Sources:

1. Washington Department of Fish and Wildlife (WDFW): Fish Passage Inventory, Assessment, and Prioritization Manual (WDFW, 2019).
2. California Department of Fish and Game (CDFG): California Salmonid Stream Habitat Restoration Manual, Section IX (CDFG 2004).
3. Oregon Department of Forestry (ODF) rules: cited in “Inventory of Barriers to Fish Passage in California’s Coastal Watersheds” (Coastal Conservancy, 2004; page 1 Appendix A).

Most published limits of salmonid migration fall within the cascade class. While short, 30-ft segments of greater than 20 percent slope are considered impassable, the topographic data were not of fine enough resolution to allow for analysis on that scale. Instead, the following discussion considers a reach impassable if the stream slope is greater than 16 percent on average for a length of 525 ft. The data were smoothed by taking a moving average of slope values over a sliding window of 525 ft. This analytical approach was supplemented with field notes and literature review. The results are summarized in Table F-3.

Prioritization Summary

A summary of tributary characteristics, results of analyses discussed above, and the final prioritization of the eleven largest tributaries is presented in Table F-3 followed by a brief discussion of each. Based on this analysis, each tributary was classified as high- or low-priority for restoration actions, defined as follows:

- **High-Priority:** Restoration activities planned along the tributary to remove reservoir sediment, facilitate fish passage, and/or enhance habitat.
- **Low-Priority:** The only intervention planned is minor grading at the mainstem confluence if needed for connectivity.

Note that there are six (6) additional tributaries identified in the Definite Plan Report (KRRC, 2018) that are not listed in Table F-3 due to their smaller watershed size (less than three [3] square miles). These six (6) tributaries are also considered low-priority: Unnamed Iron Gate 1, Spannaus Gulch, Raymond Gulch, unnamed Copco No. 1, Snackenbury Creek and unnamed J.C. Boyle 1.

Table F-3: Characteristics of Key Tributaries

TRIBUTARY	RESERVOIR	APPROX. WATERSHED AREA (ACRES)[1]	Q2 (CFS)[1]	FLOW REGIME	HISTORICAL FISH PRESENCE[2]	LIMIT OF ANADROMY	POTENTIAL BARRIER	INCISION POTENTIAL AT RESERVOIR RIM	PRIORITY
Spencer Creek	J.C. Boyle	54,500	N/A	Perennial[3]	Chinook salmon, Coho salmon, Pacific lamprey, steelhead trout	None	N/A	No	High
Long Prairie Creek	Copco No. 1	26,600	187	Perennial, TBD[4]	N/A	RM 0.2	Steep gradient	N/A	Low
Beaver Creek	Copco No. 1	3,600	42.2	Intermittent[3]	Coho salmon[9]	RM 1.5	Steep gradient	N/A	High
Jenny Creek	Iron Gate	134,700	927 (1,400)	Perennial[3]	Chinook salmon, Coho salmon	RM 0-1 at low flows	Falls[5]	Yes	High
Dutch/ Camp Creek	Iron Gate	12,700	126	Intermittent[8]	Chinook salmon, Coho salmon, steelhead trout	RM 6.6 on Camp Creek None on Dutch Creek	Steep gradient	Yes	High
Scotch Creek	Iron Gate	11,500	115	Intermittent	Steelhead trout	RM 5.0	Steep gradient	Yes	High
Fall Creek	Iron Gate	9,600	82.2	Perennial[3]	Chinook salmon, Coho salmon, Pacific lamprey, steelhead trout	RM 0.1 RM 1.0	Culvert[6] Steep gradient	N/A	Low
Long Gulch	Iron Gate	900	11.1	Intermittent[7]	N/A	RM 2.6	Steep gradient	N/A	Low

Notes:

1. USGS, 2019
2. Hamilton et al., 2005, unless otherwise noted
3. DOI, USDC, and NMFS, 2007.
4. RDG 2018b.
5. RDG, 2019, Fish Passage Structure INVENTORY.
6. PWA, 2009.
7. Intermittent according to DOI, USDC, and NMFS, 2007 and recent field observation (October 2019); perennial according to PWA, 2009.
8. Brownell et al., 1999
9. Flow $(Q)_2$ for Jenny creek estimated as 1400 cfs based on preliminary analysis by Knight Piesold
10. RM = River mile as measured upstream from estimated mainstem confluence

Appendix G

Geomorphology Monitoring / Adaptive Management Field References

Appendix G-1: Castro and Thorne 2019

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RESEARCH ARTICLE

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The stream evolution triangle: Integrating geology, hydrology, and biology

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Abstract

The foundations of river restoration science rest comfortably in the fields of geology, hydrology, and engineering, and yet, the impetus for many, if not most, stream restoration projects is biological recovery. Although Lane's stream balance equation from the mid-1950s captured the dynamic equilibrium between the amount of stream flow, the slope of the channel, and the amount and calibre of sediment, it completely ignored biology. Similarly, most of the stream classification systems used in river restoration design today do not explicitly include biology as a primary driver of stream form and process. To address this omission, we cast biology as an equal partner with geology and hydrology, forming a triumvirate that governs stream morphology and evolution. To represent this, we have created the stream evolution triangle, a conceptual model that explicitly accounts for the influences of geology, hydrology, and biology. Recognition of biology as a driver leads to improved understanding of reach-scale morphology and the dynamic response mechanisms responsible for stream evolution and adjustment following natural or anthropogenic disturbance, including stream restoration. Our aim in creating the stream evolution triangle is not to exclude or supersede existing stream classifications and evolutionary models but to provide a broader "thinking space" within which they can be framed and reconsidered, thus facilitating thought outside of the alluvial box.

KEYWORDS

channel evolution model (CEM), conceptual model, fluvial geomorphology, river restoration, stream evolution model (SEM), stream classification

1 | INTRODUCTION

The stream evolution triangle (SET) is a conceptual model that blends long-established principles of fluvial geomorphology with results emerging from recent research revealing the high degree to which biological agents affect stream processes and systems (Atkinson, Allen, Davis, & Nickerson, 2018; McCluney et al., 2014). Conceptual models are useful when attempting to integrate information from natural science disciplines in order to understand complex systems (Fortuin, van Koppen, & Leemans, 2011) and are consequently well-suited to fluvial systems. With the SET, we attempt to create a conceptual space inclusive enough to represent wide ranges of process drivers, stream forms, and evolutionary pathways but simple enough to allow for creative thinking and rapid evaluation of both established and new ideas (Jackson, Trebitz, & Cottingham, 2000).

In common with existing stream classifications (e.g., Leopold & Wolman, 1957; Montgomery & Buffington, 1993; Rosgen, 1996; Schumm, 1985 [Figure 1]) and evolution models (e.g., Cluer & Thorne, meaningful patterns, based on measures of similarity and difference (Naiman, Lonzarich, Beechie, & Ralph, 1992). With respect to process response, the balance between hydrology and geology is implicit to the basal axis of the SET, along which the influence of biology is minimal. This accords with Lane's balance (Lane, 1955), which represents alluvial channel stability solely as a function of stream power (hydrology) and sediment supply/calibre (geology).

Physics-based stream classification has advanced our understanding of river form and process, and its application has proven useful in the contexts of river engineering, management, and restoration. However, a limitation of conventional stream classifications is the perception that there is a finite number of enduring stable stream types that change only in response to an extreme event or a step change in one of the controlling variables. This can lead to an erroneous conclusion that a stream of a designated type will not, and perhaps should not, change through time.

Channel and stream evolution models (CEMs or SEMs) provide an alternative to morphological classifications in that they characterise streams in terms of patterns and trends of adjustment, rather than stasis (Cluer & Thorne, 2014; Schumm et al., 1984; Simon & Hupp, 1986). Although useful for describing and understanding temporal and spatial sequences of change, existing evolutionary models also rely on physics-based arguments and explanations, eschewing consideration of the influence of biological agents in conditioning, let alone driving morphological change. In this context, the SEM represented an advance over earlier CEMs in that it associates the range and value of ecosystem benefits provided by an incised stream with its stage of evolution. However, the SEM still frames ecosystem functions as being dependent on the morphological outcomes of fluvial processes, rather than representing biology as an evolutionary driver in its own right.

In summary, existing stream classifications and evolutionary models start with the premise that river form results from physical interactions between the flow regime, sediment regime, and channel boundary materials. In the SET, we cast biology as an equal partner with geology and hydrology, forming a triumvirate that governs stream morphology, drives morphological adjustment, and steers the sequential path along which disturbed streams evolve. Further, the SET recognises that the form, function, and evolutionary trajectory of a stream may be dominated by a single driver, a pair of drivers, or (more usually) some combination of all three, depending on its catchment, landscape, and management contexts.

2 | FOUNDATIONS

The SET depicts the relative influences of geology, hydrology, and biology on stream form and process (Figure 1). Triangular representations of three characteristics or traits are well established in natural science and are known as ternary or triangle plots or diagrams (Flemming, 2000; Frohlich, 1992). Hence, the SET can appropriately be described as a ternary diagram.

Stream types may be differentiated in the SET depending on where they plot in terms of the relative influences of geology, hydrology, and biology. Streams with one predominant driver will plot close to that corner of the triangle. Streams with codominant drivers, such as island-braided streams controlled by biology and hydrology, will plot midway along the axis connecting those drivers. Conversely, if all three drivers have equal influence, a stream plots near the centre of the triangle. It follows that in terms of stream classification, the space within this ternary diagram represents a wide range of driver-defined process domains and associated stream types and evolutionary trends. It further follows that when there is a change in the relative influences of the high-level drivers, this alters the plotting position, reflecting a shift in process domain that initiates a responsive adjustment in stream form along a new evolutionary path.

Stream responses may be relatively simple and short lived or complex and long-lasting, depending on the magnitude and duration of the causal change in one or more of the drivers. For example, a flood event temporarily increases the influence of hydrology, shifting the plotting position towards the "hydrology" corner. The relative influences of geology and/or biology must decrease, because the three relative influences must sum to 100%. After a flood, the influence of hydrology returns to its pre-event value, and the plotting position shifts away from the hydrology corner.

The potential for more complex responses to disturbance can be illustrated by the impacts of a drought. If the drought is short lived, the plotting position shifts away from the hydrology corner, increasing the relative influences of geology and/or biology. When the drought ends, the influence of hydrology returns to its pre-event value, and the plotting position shifts back towards the hydrology corner. However, if the drought is severe, it not only may reduce river flows but also may stress riverine ecosystems—thus diminishing the influence of biology as well as hydrology. When an event directly affects multiple drivers, adjustments to changes in their relative influences become more difficult to evaluate and predict. Also, stream adjustments to an event impacting more than one driver will likely be protracted, nonlinear, and morphologically complex.

3 | UNDERSTANDING THE DRIVERS AND THEIR INFLUENCES

Geology is a process driver because highly erosion-resistant boundary materials, such as intact bedrock, coarse colluvium, strongly cohesive clays, or cemented sediments, limit the capacity of a stream to adjust its geometry, at least over multidecadal timescales. But erosion resistance is just one of numerous ways that geological influences on stream form and process can be represented (Figure 2a).

The decreasing influence of geology can also be characterised using bands that grade from "source," through "transport," to "response" (Montgomery & Buffington, 1993; Figure 2b). In source reaches, primary erosion supplies weathered rock and colluvium to the fluvial system. These reaches are nonalluvial and insensitive to disturbance. In transport reaches, sediment loads are limited by the supply of sediment from local and upstream sources. This makes them more sensitive to disturbance than source reaches but less sensitive

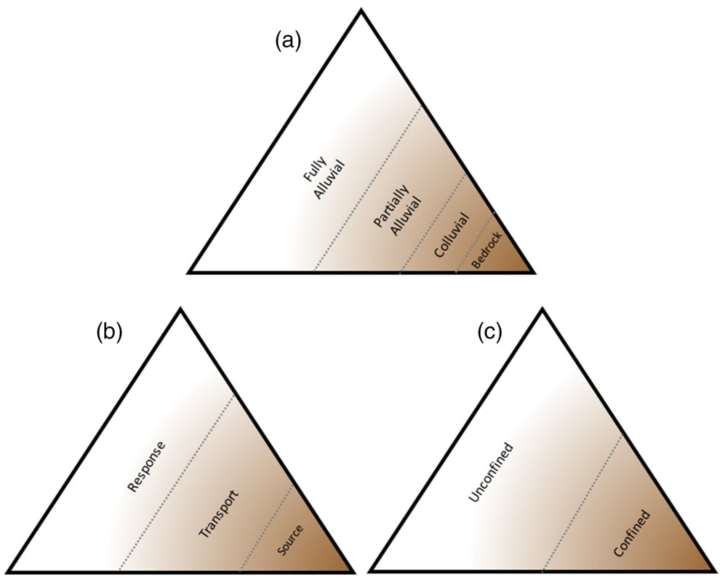

FIGURE 2 Examples of decreasing influence of geology with distance from the "geology" corner of the stream evolution triangle [Colour figure can be viewed at wileyonlinelibrary.com]

than fully alluvial response reaches, where sediment loads are limited only by the capacity of the stream to transport alluvium.

The importance of valley confinement is highlighted by Fryirs, Wheaton, and Brierley (2016). Streams vary from those that are geologically "confined" within narrow valleys to those that are "unconfined" because they flow through wide valleys with space for development of streams with meandering, braiding, or anastomosing planforms (Figure 2c). When an alluvial stream is channelised, incised, and/or stabilised by river engineering, process–response mechanisms are distorted, and morphological outcomes artificially mimic those of geological confinement. Consequently, in the SET, the impact of constructing nonerodible structures is to shift the plotting positions of naturally alluvial or partially alluvial streams towards the "geology" corner of the triangle.

Geologically controlled and artificially stabilised channels are relatively simple, typically featuring rectangular, trapezoidal, or triangular cross sections, with longitudinal slopes dictated by landscape gradients, and single-thread planforms that follow faults, lineaments, narrow valleys, or anthropogenically fixed courses. These streams are resilient to fluvially driven, morphological change even when subjected to extreme hydrological events. They are also insensitive to changes in the associated biological communities. Consequently, streams that plot close to the geology corner of the SET are relatively unresponsive to disturbance, and their morphologies are persistent—at least over steady (Schumm & Lichty, 1965) and human timescales. Even in such geologically controlled streams, heavy wood loading can result in more complex morphologies and habitats, which could move these streams towards the biology corner.

Hydrology is a process driver because it is energy imparted to the landscape by flowing water that powers fluvial processes. Channel dimensions scale on stream discharge, and thus, the relative influence of hydrology is often dominant in very large rivers, generally tending to diminish as stream size decreases. However, all aspects of the flow regime affect the influence of hydrology on stream form and function (including flow frequency, magnitude, seasonality, and duration), and particular attributes and combinations of attributes act to intensify or weaken the influence of hydrology. Hence, there are multiple ways other than the discharge magnitude to characterise how the influence of hydrology increases with proximity to the hydrology corner.

The influence of hydrology is amplified in arid areas where mean annual discharge is low but morphological effectiveness is high due to storm-dominated, flashy flows (Skidmore et al., 2011). For example, the Gila River in the Sonora Desert was observed to widen by a factor of 20 during a single flood event, with the impacts of that single storm persisting for half a century (Burkham, 1972). Hence, the Gila River would plot close to the hydrology corner in the SET despite its relatively low mean annual flow. At the other end of the flow variability, spectra are spring-fed streams with nearly flat annual hydrographs, such as the Deschutes River, Oregon, whose channel has changed little over centuries (O'Connor, Grant, Curran, & Fassnacht, 1999). Between these extremes, flow regimes range from those in basins subject to rain-on-snow flood events, through rivers characterised by low-intensity, long-duration rainfall and runoff from frontal depressions to high-alpine, snow-fed streams that rarely experience rainfall at all (Figure 3a).

The natural flow regimes of many streams and rivers have been purposefully or inadvertently altered by catchment and water

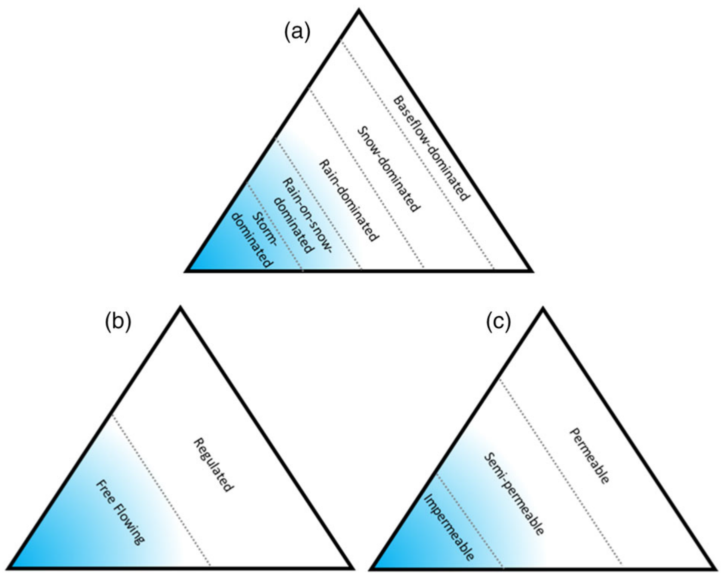

FIGURE 3 Examples of decreasing influence of hydrology with distance from the "hydrology" corner of the stream evolution triangle [Colour figure can be viewed at wileyonlinelibrary.com]

resource development, with impacts that may either truncate or magnify the influence of hydrology. For example, using dams and diversion channels to reduce natural flow, variability shifts the plotting positions of regulated rivers away from the hydrology corner (Figure 3b). Conversely, urbanisation that significantly increases the proportion of the catchment that is impermeable has been shown to increase flows and flashiness, shifting affected streams closer to the hydrology corner (Figure 3c).

Hydrologically dominated and unregulated streams are more responsive to fluvially driven, morphological change because hydrology drives channel adjustments, whereas geology and biology generally resist them. Due to their alluvial nature and lack of biological control, hydrologically dominated streams are temporally variable and complex, typically featuring braided channels with mobile beds and high width-to-depth ratios. Hydrologically dominated streams are also sensitive to changes in the associated biological communities through, for example, colonisation of bars by woody vegetation (Bertoldi et al., 2015). Consequently, streams that plot close to the hydrology corner are more responsive to disturbance than those near the geology corner, and their morphologies are transient and changeable over steady (Schumm & Lichty, 1965) and human timescales.

Biology is a process driver because energy imparted to the landscape by organisms drives biogeomorphic processes as well as modifying fluvial processes. The effectiveness of biology as a process driver has long been recognised through, for example, the statistically significant impact of dense, woody bank vegetation on the stable widths of gravel-bed rivers (Hey & Thorne, 1986). Evidence of the influence of vegetation on river form also comes from the sedimentary record, where concordance has been shown between the appearance and spread of trees in fluvial landscapes during the Devonian and Carboniferous periods (between about 300 and 420 million years ago), and planform transitions from sheet braided to meandering and then anastomosed (Davies & Gibling, 2010). Conversely, a close association between the disappearance of vegetation and planform metamorphosis was demonstrated by a switch from meandering to braiding in South African rivers when vegetation was eliminated during the Permian–Triassic extinction, about 250 million years ago (Ward, Montgomery, & Smith, 2000).

The morphological impacts of vegetation have received considerable attention and clearly demonstrate one way in which biology affects river forms and processes. In the SET, the influence of vegetation can be represented by plotting streams with riparian zones colonised by wetland obligate species near the apex because there is frequent and close interaction between vegetation and the stream. However, streams surrounded by upland vegetation species plot closer to the base because such vegetation rarely, if ever, interacts directly with stream flows (Figure 4a).

Upland species may still, indirectly, affect stream processes having been recruited by the stream through lateral erosion and/or gravity-induced, mass failure. This is the case because although live vegetation (including standing trees) significantly influences stream forms and functions, a considerable body of research establishes that trees continue to impact fluvial processes even after their demise, in the form of large wood pieces and log jams (Abbe & Montgomery, 1996). Indeed, reintroduction of large wood and construction of engineered log jams have become staple actions in modern river

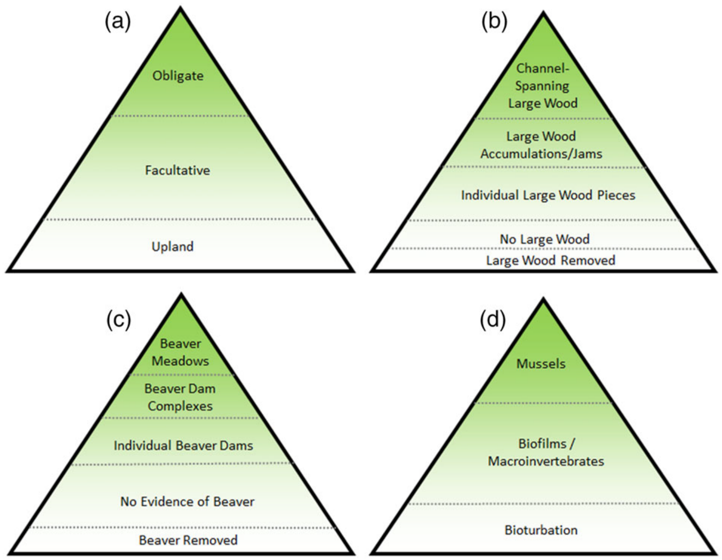

FIGURE 4 Example of decreasing influence of biology with distance from the "biology" corner of the stream evolution triangle expressed through (a) riparian vegetation by wetland indicator status rating (Lichvar, Melvin, Butterwick, & Kirchner, 2012; obligate = almost always occurs in wetlands; facultative = occurs in wetlands and nonwetlands; upland = almost never occurs in wetlands), (b) presence and abundance of large wood, (c) presence and relative dam building activity of beaver; and (d) biologically induced bed stability or instability [Colour figure can be viewed at wileyonlinelibrary.com]

restoration. This is a testimony to the influence of large wood on channel morphology, channel-forming processes, and channel–floodplain connectivity (Abbe & Montgomery, 1996; Gurnell, 2012). It follows that the influence of biology can also be characterised in terms of the relative size and spatial organisation of large wood or, indeed, its absence or removal (Figure 4b).

Biological influence is, obviously, exerted by animals as well as plants. Historically, beavers were endemic to most of North America (*Castor canadensis*) and Europe (*Castor fibre*), and their effects on hydrology, hydraulics, sediment dynamics, morphology, and floodplain connectivity are known to have been pervasive (Pollock, Lewallen, Woodruff, Jordan, & Castro, 2017). In areas characterised by beaver occupation and dam building, valley morphology is often described as a "beaver meadow," indicating the intensity of geomorphic change resulting from beaver activity (Polvi & Wohl, 2012). When beavers were driven towards extinction during the late 19th century, their removal often resulted in channel degradation, disconnection from the floodplain, lowering of groundwater tables, and impoverished stream ecologies that are only now starting to recover in response to restoration projects that increasingly include beaver reintroduction or recolonisation (Pollock et al., 2017; Figure 4c).

Although the morpho-dynamic influences of large animals like beaver and wolves (Polvi & Wohl, 2012) are well known, it is easy to underappreciate the impacts of very small animals, especially when their habitats are masked. Yet recent research has established that benthic life also affects riverine processes, particularly through its impact on bed mobility. For example, colonisation of a stream by freshwater mussels (*Unionoida*) and/or macroinvertebrates such as caddisfly (*Trichoptera*) can significantly reduce bed mobility compared with that of uncolonised stream beds formed in otherwise equivalent sediments (Zimmerman & de Szalay, 2007). Conversely, bioturbation by crustaceans such as crayfish (*Astacoidea* and *Parastacoidea*) or by spawning salmon (*Onchorynchus* spp.) can increase bed mobility by disrupting the surface armour in gravel-bed rivers (DeVries, 2012; Harvey et al., 2011). It follows that the influence of biology can be characterised in the SET on the basis of the presence, abundance, and health of benthic life (Figure 4d) as well as that of riparian vegetation and mammals.

4 | MORPHO-DYNAMIC DOMAINS, STREAM CLASSIFICATION, AND STREAM EVOLUTION

4.1 | Morpho-dynamic domains

The influence axes of the process drivers describe morpho-dynamic domains within the SET, which are zones characterised by particular combinations of relative geological, hydrological, and biological influence. Because the axes are not scaled or rigidly defined and because the influences are relative, the SET can accommodate a wide range of stream classifications and evolutionary models, thus providing a flexible, conceptual "thinking space" within which to evaluate not only current channel forms but also sensitivity to disturbance, past trends of change, and possible future trajectories of adjustment. However, attempting to map the morpho-dynamic domains within the SET and populate them with typical examples, a priori would risk closing down, or at least constraining, the thinking space we seek to create. Accepting this, there is still a case for making that space a little less abstract by including here three examples of rivers that illustrate morpho-dynamic domains associated with the corners of the triangle.

An archetypal example of a stream naturally controlled by geology is the Colorado River within the Grand Canyon. In addition to being laterally constrained, the river is also hydrologically emaciated as it is regulated by multiple upstream dams. Also, the influence of biology is muted because vegetation on the floor of the canyon is sparse. Accordingly, this reach of the Colorado River plots in the geology corner of the SET (Figure 5a).

The Rakaia River, New Zealand, rises in the Southern Alps before draining across the broad expanse of the Canterbury Plains. In its middle reach, the Rakaia is geologically unconstrained, and its flow regime features highly variable discharges, including great floods driven by rainstorm, snowmelt, and rain-on-snow events. Sediment loads are high, deriving from rapid erosion in the headwater basins. Consequently, the middle reach of the Rakaia plots in the hydrology corner of the SET (Figure 5b).

The Rio Negro is a tributary to the River Amazon. Globally, it is the seventh largest river by discharge, and its lower course has created a

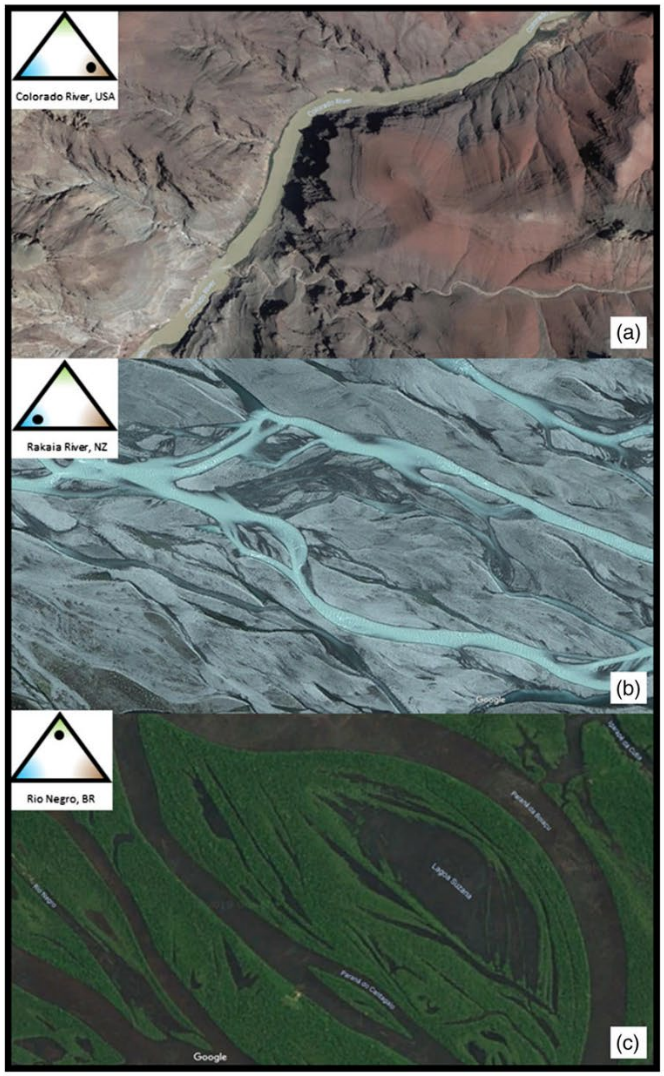

FIGURE 5 Archetypal examples of world rivers representing the three corners of the stream evolution triangle. Images from Google Maps [Colour figure can be viewed at wileyonlinelibrary.com]

continuous riparian corridor that is up to 30-km wide. On the basis of its discharge, it might be expected that the Rio Negro would plot in the hydrology corner of the SET. However, the sediment load of the Rio Negro is disproportionately small, and its planform is anastomosed, featuring an intricate network of anabranches bordered by islands and floodplains that are densely vegetated by obligate and facultative wetland species (Figure 5c). On the basis of these attributes and despite its huge discharge, form and process in the lower Rio Negro are dominated by biology, and hence, it plots at the apex of the SET.

4.2 | Stream classification

Morpho-dynamic domains within the SET have associated characteristic stream morphologies that are conventionally classified as particular channel types. In this context, the SET is able to accommodate a wide range of existing stream classifications, including those of Schumm (1985; Figure 1) and Rosgen (1996; Figure 6), which rely on physical attributes such as slope, bed material, number of channels, sinuosity, width-to-depth ratio, and confinement. Plotting these classifications in the SET provides new insights because plotting position associates stream types with the relative influences of all three process drivers. Generally, ease of adjustment decreases with proximity to any corner of the triangle, as the influence of one driver becomes controlling and, hence, the stream type becomes more persistent.

For example, in the geology corner, the morphologies of bedrock channels are highly resilient to change because their boundaries are fixed, at least over timescales of decades to centuries. In the hydrology corner, the wide, braided subchannels of alluvial rivers with abundant runoff, mobile sediments, and little or no vegetation adjust constantly, but the braided planform persists through time. Near the apex, where the influences of hydrology and geology are muted and the life of the river predominates, flows are slower, boundaries are erosion resistant, and the multiple channels are relatively small, making anastomosed planforms resilient to disturbance. In contrast, closer to the centre of the triangle, the relative influences of geology, hydrology, and biology are finely balanced. In this region of the SET, frequent adjustments to stream processes are intrinsic to the single-thread–meandering morphologies that predominate.

What the SET adds to existing classifications is explicit recognition that, when affected by multiple drivers, a stream's morphology adjusts constantly in response to fluctuations in their relative influences. In the SET, morphology and ease of adjustment are both indivisibly tied to the relative influences of the process drivers, conditioning the stream system's susceptibility or resilience to change, and its capacity for recovery or relaxation following major disturbance.

4.3 | Evolutionary pathways

Morpho-dynamic domains within the SET also have associated characteristic stream evolution stages and trajectories that occur in response to various types of disturbance. Consequently, the SET provides a

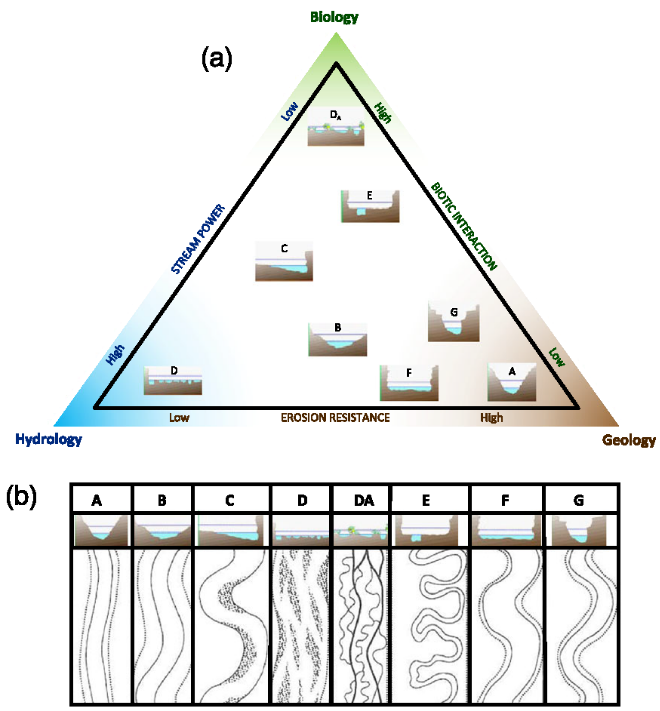

FIGURE 6 (a) Stream evolution triangle with example classification system (Rosgen, 1996); (b) Rosgen Stream Classification System (modified from Rosgen, 1996) [Colour figure can be viewed at wileyonlinelibrary.com]

suitable template for plotting the stages in channel and stream evolution models, such as that of Cluer and Thorne (2014; Figure 7).

In the original CEMs, morphological adjustments are represented as a linear sequence, whereas in the later SEM, the sequence is represented as being cyclical. Although both linear and cyclical behaviours are observed in nature, it is rare for a single site to follow the precise sequence of evolutionary stages envisaged in either the CEMs or the SEM. The advantage of plotting evolutionary stages within the SET is that this highlights the possibility of a stream following other evolutionary pathways, depending on how the relative influences of the process drivers vary through time and space during postdisturbance evolution.

In the SEM, an evolving stream passes rapidly through some evolutionary stages although it may linger in others (Cluer & Thorne, 2014). The SET captures this temporal variability because the plotting positions for different stages indicate not only their morphological form and function but also, through their proximity to a corner or the centre of the triangle, their ease of change, which governs how long an evolving stream spends in a particular evolutionary stage.

Finally, even in rapidly evolving systems, it is unusual for a given site to complete the eight-stage SEM cycle, because this requires at least a decade of undisturbed, incremental evolution and, more often than not, the cycle is interrupted, advanced, or reversed by subsequent disturbances or complex responses in the fluvial system (see Zheng, Thorne, Wu, & Han, 2017). Although the SEM's evolutionary pathway does plot coherently in the SET (Figure 7), it is no longer prescribed deterministically. In the SET, channel morphologies and evolutionary pathways are emergent properties, charted on the basis of changes in the relative influences of the high-level drivers and morphological susceptibility or resilience to change. Consequently, although some evolutionary trends are more probable than others, as in nature, a disturbed stream's evolutionary path is not predetermined. In this regard, uncertainty stemming from natural variability is inherent to the SET.

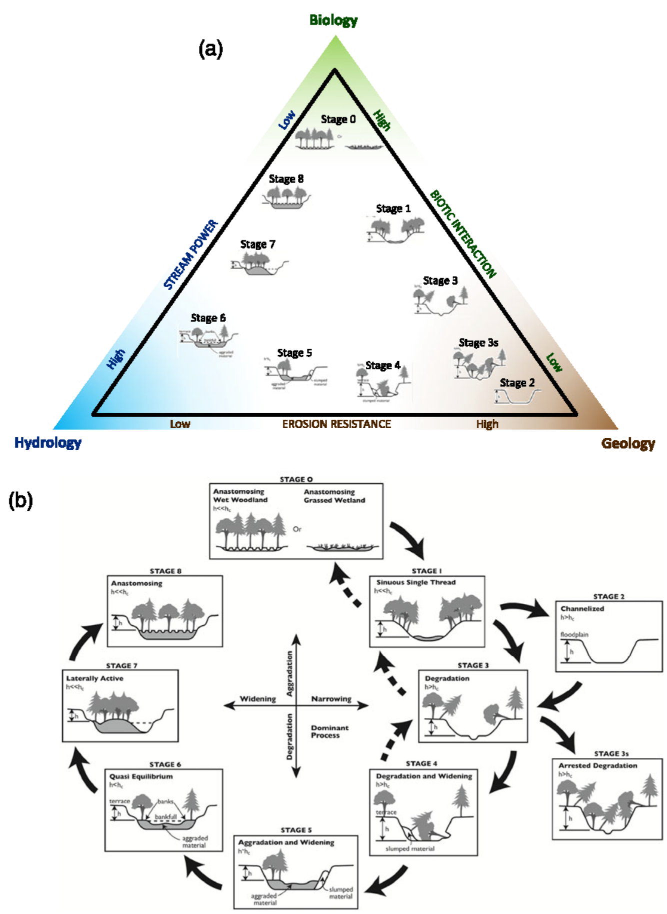

FIGURE 7 (a) Stream evolution triangle with stages of stream evolution (Cluer & Thorne, 2014); (b) stream evolution model (Cluer & Thorne, 2014) [Colour figure can be viewed at wileyonlinelibrary.com]

5 | STREAM DISTURBANCE, RESPONSE, AND RECOVERY

Fluvial geomorphology has long recognised that disturbance may result from a variety of natural events or human actions that affect catchment runoff, sediment yield, or the channel's dimensions, geometry, and resistance to flow and erosion (Knighton, 1998). In river science and management, the significance of disturbance resulting from changes to catchment, floodplain, riparian, and in-channel vegetation has been widely appreciated for decades (Thorne, Soar, Skinner, Sear, & Newson, 2010). More recently, disturbances that affect longitudinal and/or lateral connectivity in the fluvial system are receiving increasing attention (Wohl et al., 2018), whereas the importance to river forms and processes of changes to catchment, stream, and aquatic ecology is now accepted (Atkinson et al., 2018).

The SET reveals that for postdisturbance recovery to be robust and enduring, some degree of biological uplift is essential and re-establishment of a healthy and functional ecosystem (represented by migration upwards of plotting position in the SET) depends on the rate of recolonisation compared with the frequency of physical or biological disturbance (Shafroth, Stromberg, & Patten, 2002). The SET can aid understanding in both the impact of a disturbance and recovery at the reach and system scales, because it represents causal relationships between changes in the process drivers (and hence SET-defined, morpho-dynamic domains) and the types of disturbance, morphological response, and evolutionary trajectory that result. In this context,

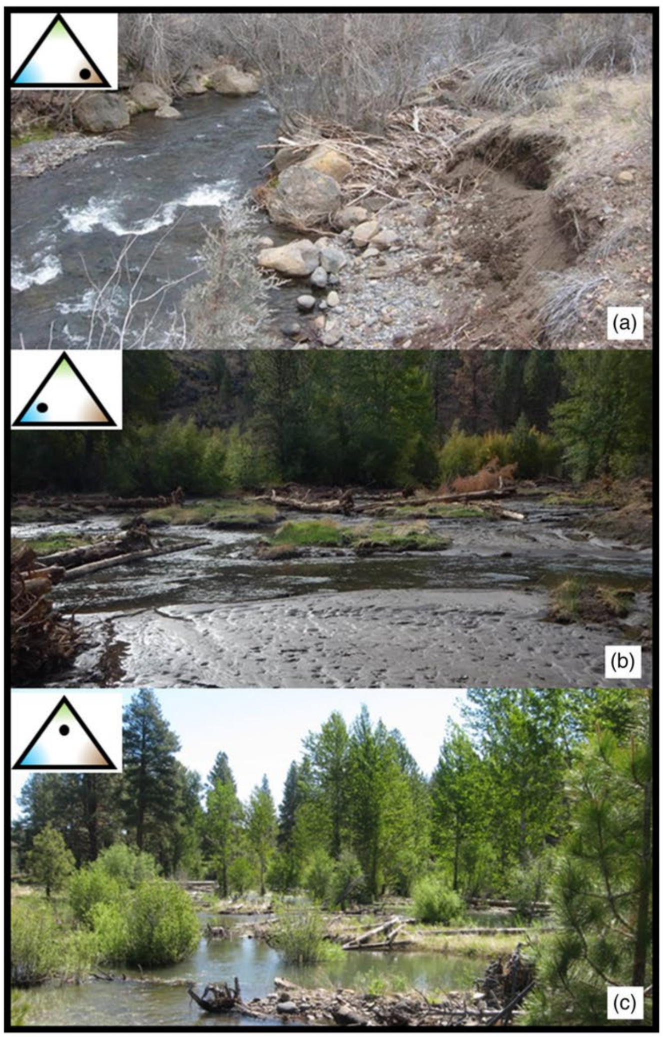

FIGURE 8 Whychus Creek, Oregon, restoration project phases over 1 year. Photos courtesy of Paul Powers [Colour figure can be viewed at wileyonlinelibrary.com]

restoration of disturbed streams should facilitate either recovery to the predisturbed condition or evolution towards a new, dynamically metastable morphology. Either pathway involves biological uplift. What restoration should avoid is locking an actively evolving stream into an artificially stable configuration using engineered structures.

If disturbance is simple and limited to one driver, such as hydrology, recovery may be relatively straightforward and even predictable using physics-based theories of complex response in alluvial systems (Hey, 1979). However, the SET illustrates that when a "game changing" natural or human disturbance triggers changes in process domains dominated by biology (through, for example, species extinctions or ecosystem collapse), profound changes in relative influence and major shifts of plotting position in the SET result. This indicates that natural recovery will be slow, convoluted, and functionally indeterminate, unless assisted by appropriate and well-designed river restoration.

That recovery to the predisturbance condition can be achieved through resetting the floodplain, and channel network is illustrated by a restoration project on Whychus Creek, Oregon. Prior to restoration, the postdisturbance-incised channel was vertically and laterally stable, plotting near the geology corner (Figure 8a). Filling the incised channel reconnected the stream to its floodplain, initially moving the system close to the hydrology corner (Figure 8b). Subsequent bar and floodplain recolonisation by wetland and riparian vegetation then shifted Whychus Creek towards the biology corner (Figure 8c), following a path close to the hydrology–biology side of the triangle.

6 | CONCLUSIONS

A conceptual model provides a space within which complex systems with unpredictable relationships and indeterminate outcomes can be assessed and evaluated to help elucidate potential trajectories of change and scenarios for possible future conditions. Conceptual models are "thinking tools," and the best outcome of a conceptual model is not a precise answer but deeper thinking. According to Fortuin et al. (2011), conceptual models help to "structure, retrieve, and construct knowledge, which thereby substantially improves the learning process."

In this spirit, the SET reframes physics-based fluvial geomorphology to acknowledge and explicitly account for the power of biology as a process driver. The SET's flexibility and inclusiveness are its greatest assets because the aim is not to constrain or supersede conventional wisdom but to expand and support thinking outside of the alluvial box when studying, managing, engineering, and restoring stream systems.

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REFERENCES

Abbe, T. B., & Montgomery, D. R. (1996). Large woody debris jams, channel hydraulics and habitat formation in large rivers. *Regulated Rivers: Research & Management*, *12*, 201–221. https://doi.org/10.1002/(SICI)1099-1646(199603)12:2/3<201::AID-RRR390>3.0.CO;2-A

Atkinson, C. L., Allen, D. C., Davis, L., & Nickerson, Z. L. (2018). Incorporating ecogeomorphic feedbacks to better understand resiliency in streams: A review and directions forward. *Geomorphology*, *305*, 123–140. https://doi.org/10.1016/j.geomorph.2017.07.016

Bertoldi, W., Welber, M., Gurnell, A. M., Mao, L., Comiti, F., & Tal, M. (2015). Physical modelling of the combined effect of vegetation and wood on river morphology. *Geomorphology*, *246*, 178–187. https://doi.org/10.1016/j.geomorph.2015.05.038

Burkham, D. E. (1972). Channel changes of the Gila River in Safford Valley, Arizona, 1846–1970, *Geological Survey Professional Paper 655-G*, Washington D.C.: US Government Printing Office.

Cluer, B. L., & Thorne, C. R. (2014). A stream evolution model integrating habitat and ecosystem benefits. *River Research and Applications*, *30*(2), 135–154.

Davies, N. S., & Gibling, M. R. (2010). Cambrian to Devonian evolution of alluvial systems: The sedimentological impact of the earliest land plants. *Earth-Science Reviews*, *98*, 171–200. https://doi.org/10.1016/j.earscirev.2009.11.002

DeVries, P. (2012). Salmonid influences on rivers: A geomorphic fish tail. *Geomorphology*, *157–158*, 66–74.

Flemming, B. W. (2000). A revised textural classification of gravel-free muddy sediments on the basis of ternary diagrams. *Continental Shelf Research*, *20*, 1125–1137. https://doi.org/10.1016/S0278-4343(00)00015-7

Fortuin, K. P. J., van Koppen, C. S. A., & Leemans, R. (2011). The value of conceptual models in coping with complexity and interdisciplinarity in environmental sciences education. *Bioscience*, *61*(10), 802–814. https://doi.org/10.1525/bio.2011.61.10.10

Frohlich, C. (1992). Triangle diagrams: Ternary graphs to display similarity and diversity of earthquake focal mechanisms. *Physics of the Earth and Planetary Interiors*, *75*, 193–198. https://doi.org/10.1016/0031-9201(92)90130-N

Fryirs, K. A., Wheaton, J. M., & Brierley, G. J. (2016). An approach for measuring confinement and assessing the influence of valley setting on river forms and processes. *Earth Surface Processes and Landforms*, *41*(5), 701–710.

Gurnell, A. (2012). Fluvial geomorphology: Wood and river landscapes. *Nature Geoscience*, *5*(2), 93–94. https://doi.org/10.1038/ngeo1382

Harvey, G. L., Moorhouse, T., Clifford, N. J., Henshaw, A., Johnson, M., MacDonald, D. W., … Rice, S. (2011). Evaluating the role of invasive aquatic species as drivers of sediment-related river management problems: The case of the signal crayfish (*Pacifastacus leniusculus*). *Progress* *in Physical Geography*, *35*(4), 517–533. https://doi.org/10.1177/0309133311409092

Hey, R. D. (1979). Dynamic process-response model of river channel development. *Earth Surface Processes*, *4*(1), 59–72. https://doi.org/10.1002/esp.3290040106

Hey, R. D., & Thorne, C. R. (1986). Stable channels with mobile gravel beds. *Journal of Hydraulic Engineering, American Society of Civil Engineers*, *112*(8), 671–689. https://doi.org/10.1061/(ASCE)0733-9429(1986)112:8(671)

Hickin, E. J. (1984). Vegetation and river channel dynamics. *Canadian Geographer/Le Géographe Canadien*, *28*(2), 111–126. https://doi.org/10.1111/j.1541-0064.1984.tb00779.x

Jackson, L. J., Trebitz, A. S., & Cottingham, K. L. (2000). An introduction to the practice of ecological modelling. *Bioscience*, *50*(8), 694–706. https://doi.org/10.1641/0006-3568(2000)050[0694:AITTPO]2.0.CO;2

Knighton, D. (1998). *Fluvial forms and processes: A new perspective*. London: Routledge.

Lane, E. W. (1955). Design of stable channels, *Transactions of the American Society of Civil Engineers*, Paper No. 2776, 1234–1279.

Leopold, L. B., & Wolman, M. G. (1957). River channel patterns: Braided, meandering, and straight. In *Geological Survey Professional Paper 282-B*. Washington, D.C.: US Government Printing Office.

Lichvar, R. W., Melvin, N. C., Butterwick, M. L., & Kirchner, W. N. (2012). National wetland plant list indicator rating definitions, Report ERDC/CRREL TN-12-1, Hanover New Hampshire: US Army Corps of Engineers, Engineer Research and Development Center.

McCluney, K. E., Poff, N. L., Palmer, M. A., Thorp, J. H., Poole, G. C., Williams, B. S., … Baron, J. S. (2014). Riverine macrosystems ecology: Sensitivity, resistance, and resilience of whole river basins with human alterations. *Frontiers in Ecology and the Environment*, *12*(1), 48–58. https://doi.org/10.1890/120367

Montgomery, D. (1999). Process domains and the river continuum. *Journal of the American Water Resources Association*, *35*(2), 397–410. https://doi.org/10.1111/j.1752-1688.1999.tb03598.x

Montgomery, D., & Buffington, J. (1993). Channel classification, prediction of channel response, and assessment of channel condition, report TFW-SH10-93-002 for the SHAMW committee of the Washington state timber/fish/wildlife agreement, Seattle WA: University of Washington, 84 p.

Naiman, R. J., Lonzarich, D. G., Beechie, T. J., & Ralph, S. C. (1992). General principles of classification and the assessment of conservation potential in rivers. In P. J. Boon, P. Calow, & G. E. Petts (Eds.), *River conservation and management*. New York: John Wiley and Sons.

O'Connor, J. E., Grant, G. E., Curran, J. H., & Fassnacht, H. (1999). Geomorphology of the Deschutes River below the Pelton Round Butte Dam Complex, Oregon. *Report issued by Portland General Electric*, Portland, Oregon.

Pollock, M. M., Lewallen, G. M., Woodruff, K., Jordan, C. E., & Castro, J. M. (Eds.) (2017). The beaver restoration guidebook: Working with beaver to restore streams, wetlands, and floodplains. Version 2.0. United States Fish and Wildlife Service, Portland, Oregon, 189 pp. Online at: http://www.fws.gov/oregonfwo/ToolsForLandowners/RiverScience/Beaver.asp

Polvi, L. E., & Wohl, E. (2012). The beaver meadow complex revisited: The role of beavers in post-glacial floodplain development. *Earth Surface Processes and Landforms*, *37*, 332–346. https://doi.org/10.1002/esp.2261

Rosgen, D. L. (1996). *Applied river morphology*. Pagosa Springs, Colorado: Wildland Hydrology.

Schumm, S. A. (1985). Patterns of alluvial rivers. *Annual Review of Earth and Planetary Sciences*, *13*, 5–27. https://doi.org/10.1146/annurev.ea.13.050185.000253

Schumm, S. A., Harvey, M. D., & Watson, C. C. (1984). *Incised channels: Morphology, dynamics, and control*. Littleton, CO.: Water Resources Publications.

Schumm, S. A., & Lichty, R. W. (1965). Time, space and causality in geomorphology. *American Journal of Science*, *263*, 110–119. https://doi.org/10.2475/ajs.263.2.110

Shafroth, P. B., Stromberg, J. C., & Patten, D. T. (2002). Riparian vegetation response to altered disturbance and stress regimes. *Ecological Applications*, *12*(1), 107–123. https://doi.org/10.1890/1051-0761(2002)012[0107:RVRTAD]2.0.CO;2

Simon, A., & Hupp, C. R. (1986). Geomorphic and vegetative recovery processes along modified Tennessee streams: An interdisciplinary approach to disturbed fluvial systems. *Forest Hydrology and Watershed Management*, *IAHS-AISH Publ.167*.

Skidmore, P. B., Thorne, C. R., Cluer, B. L., Pess, G. R., Castro, J. M., Beechie, T. J., & Shea C. C. (2011). Science base and tools for evaluating stream engineering, Management and Restoration Proposals, *NOAA Technical Memorandum NMFS-NWFSC-112*, Springfield, VA: NOAA National Technical Information Service, 253p. Available via http://www.nwfsc.noaa.gov

Thorne, C. R., Soar, P. J., Skinner, K. S., Sear, D. A., & Newson, M. D. (2010). Investigating, characterising and managing river sediment dynamics. In D. A. Sear, M. D. Newson, & C. R. Thorne (Eds.), *Guidebook of applied fluvial geomorphology* (pp. 120–195). London: Thomas Telford. https://doi.org/10.1680/gafg.34846.0004

Ward, P. D., Montgomery, D., & Smith, R. (2000). Altered river morphology in South Africa related to the Permian-Triassic extinction. *Science*, *289*, 1740–1743. https://doi.org/10.1126/science.289.5485.1740

Wohl, E., Brierley, G., Cadol, D., Coulthard, T. J., Covino, T., Fryirs, K. A., … Meitzen, K. M. (2018). Connectivity as an emergent property of geomorphic systems. *Earth Surface Processes and Landforms*, published online. https://doi.org/10.1002/esp.4434, *44*, 4–26.

Zheng, S., Thorne, C. R., Wu, B. S., & Han, S. (2017). Application of the stream evolution model to a volcanically disturbed river: The North Fork Toutle River, Washington state, USA. *River Research and Applications*, *33*(6), 937–948.

Zimmerman, F., & de Szalay, F. A. (2007). Influence of unionid mussels (*Mollusca*: *Unionidae*) on sediment stability: An artificial stream study. *Fundamental and Applied Limnology*, *168*(4), 299–306. https://doi.org/10.1127/1863-9135/2007/0168-0299

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Appendix G-2: Rapid Geomorphic Assessment (RGA) Field Forms

RAPID GEOMORPHOLOGICAL ASSESSMENT (RGA)
FIELD FORM

Stream Name	Observers	Date
Reach Name	Weather over past 2-5 days (No of days precip/average daytime temp.)	Weather (Temp, Precipitation)
Upstream Reach Boundary	Downstream Reach Boundary	Flow Conditions

MORPHOLOGY ☐ Typical Photo Captured

Increasing particle size & gradient

☐	Bedrock	Lack alluvial bed. Some material in scour holes temporarily
☐	Cascade	No pools. Turbulent flow over large protruding grains
☐	Step-Pool	vertical steps and pools present
☐	Plane-Bed	Featureless bed. Homogeneous habitat
☐	Riffle-Pool	Alternating riffles and pools
☐	Dune-Ripple	bed mobile at most stages, dune-forms
☐	Multi-Thread	Multiple channel in lowlands

Average Bankfull Width (ft): ________

SUBSTRATE ☐ Typical Photo Captured

	Estimated Relative Abundance			
	>50% Mostly	30-50% Some	15-30% Little	1-15% Few
Bedrock	☐	☐	☐	☐
Boulder (>256 mm)	☐	☐	☐	☐
Cobble (64-256 mm)	☐	☐	☐	☐
Gravel (2-64 mm)	☐	☐	☐	☐
Sand (0.6-2 mm)	☐	☐	☐	☐
Fines (<0.6 mm)	☐	☐	☐	☐

RIPARIAN VEGETATION ☐ Typical Photo Captured

	Left Riparian Corridor	Right Riparian Corridor
Average Riparian Width (ft)		
	_______	_______
Estimated Relative Abundance		
Cover Type: Tree	_____ %	_____ %
Shrub	_____ %	_____ %
Herbaceous	_____ %	_____ %
Bare	_____ %	_____ %

Estimated relative abundance should add up to 100%

NOTES

BANK STABILITY ☐ Typical Photo Captured

Based on USDA Stream Visual Assessment Protocol, 2009*

	Banks are stable; protected by roots of natural vegetation, wood, and rock No excessive erosion or bank failures	Banks are moderately stable, protected by roots of natural vegetation, wood, or rock or a combination of materials Evidence of erosion or bank failures, some with reestablishment of vegetation	Banks are moderately un-stable; very little protection of banks by roots of natural wood, vegetation, or rock Excessive bank erosion or active bank failures	Banks are unstable; no bank protection with roots, wood, rock, or vegetation Numerous active bank failures
Left Bank	10 9	8 7 6	5 4 3	2 1 0
Right Bank	10 9	8 7 6	5 4 3	2 1 0

* USDA, 2009. Stream Visual Assessment Protocol Version 2. National Biology Handbook, Subpart B - Conservation Planning, United States Department of Agriculture Natural Resources Conservation Service

RAPID GEOMORPHOLOGICAL ASSESSMENT (RGA) FIELD FORM

CHANNEL FRINGE COMPLEXITY

Developed from: USDA 2009* and Ode et al. 2016**

Within the reach, observe the approximate abundance of different habitat features that provide diverse and complex habitat for fish along the channel margins. Only features that are within the stream's bankfull channel should be considered. Typical habitat features along the channel margins include the items outlined in the table below

Habitat features along channel margins	Abundance			
	Absent 0%	Sparse 1-10%	Moderate 10-40%	Heavy > 40%
Logs, large wood	0	1	2	3
Small wood accumulations	0	1	2	3
Overhanging vegetation	0	1	2	3
Live tree and/or shrub roots	0	1	2	3
Undercut banks	0	1	2	3
Aquatic vegetation	0	1	2	3
Small boulder clusters	0	1	2	3
Large boulders	0	1	2	3
Connected off-channel habitats	0	1	2	3
Other	0	1	2	3

Note: the sum of the percentages of the different features does not necessarily need to equal 100%

Channel Fringe Complexity = Sum of all abundance scores = ______

(Sums greater than 10 shall be assigned a channel fringe complexity of 10)

Habitat Features - Descriptions

- **Logs, large wood**—fallen trees or parts of trees that are submerged in the water and large enough to remain during normal flows
- **Small wood accumulations**—submerged accumulations of small wood pieces, twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity as the debris moves within the reach
- **Overhanging vegetation**—tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade and cover
- **Live tree and/or shrub roots**—roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface
- **Undercut banks**—water-scoured areas extending horizontally beneath the surface of the bank by at least 6 inches, forming underwater pockets used by fish for hiding and thermal cover
- **Aquatic vegetation** - emergent, submerged, or floating leaf aquatic plants thick enough to serve as cover
- **Small boulder clusters**—groups of 2 or more smaller rocks (>10 and <20 inches in diameter) interspersed relatively close together in the channel
- **Large boulders**—submerged or partially submerged large rocks (>20 inches in diameter)
- **Connected off-channel habitats**—side channels, flood plain wetlands, backwaters, alcoves etc. Features must be hydraulically connected to the mainstem under low or moderate flows
- **Other** — locally important habitat features

NOTES:

* USDA, 2009. Stream Visual Assessment Protocol Version 2. National Biology Handbook, Subpart B - Conservation Planning, United States Department of Agriculture Natural Resources Conservation Service

** Ode, P.R., A.E., Fetscher, and L.B. Busse. 2016. Standard Operating Procedures for the Collection of Field Data for Bioassessments of California Wadeable Streams: Benthic Macroinvertebrates, Algae, and Physical Habitat. California State Water Resources Control Board Surface Water Ambient Monitoring Program (SWAMP) Bioassessment SOP 004

RAPID GEOMORPHOLOGICAL ASSESSMENT (RGA) FIELD FORM

FLOODPLAIN ROUGHNESS Typical photo captured ☐

Based on USDA Stream Visual Assessment Protocol, 2009*

Part 1 - Impact of Large Woody Debris (LWD) on Floodplain (F.P.) Hydraulic Roughness

	LWD within the F.P. significantly increases hydraulic roughness and Majority of the LWD within the F.P. is expected to remain in-situ until veg. establishment	LWD within the F.P. significantly increases hydraulic roughness and Majority of the LWD within the F.P. has the potential to mobilize prior to veg. establishment	LWD within the F.P. moderately increases hydraulic roughness and Majority of the LWD within the F.P. is expected to remain in-situ until veg. establishment	LWD within the F.P. moderately increases hydraulic roughness and Majority of the LWD within the F.P. has the potential to mobilize prior to veg. establishment	No LWD within the F.P. or LWD within the F.P. has minimal or no impact on hydraulic roughness
LWD Roughness	4	3	2	1	0

Part 2 - Impact of Vegetation (Veg.) on Floodplain Hydraulic Roughness

Natural plant community covers the entire riparian planting zone and is generally contiguous throughout the reach	Natural plant community covers more than 1/2 to 2/3 of riparian planting zone and is generally contiguous throughout the reach and Vegetation gaps do not exceed 10% of the estimated length of the stream	Natural plant community covers more than at least 1/2 of riparian planting zone and Vegetation gaps do not exceed 30% of the length of the stream	Natural plant community covers more than 1/4 of riparian planting zone and Vegetation gaps exceed 30% of the length of the stream	Natural plant community covers less than 1/4 of riparian planting zone and Vegetation gaps exceed 30% of the length of the stream
Veg. Roughness 10 9	8 7	6 5	4 3 2	1 0

Floodplain Roughness = LWD Roughness + Veg. Roughness = ______ (Sums greater than 10 shall be assigned a F.P. roughness of 10)

FLOODPLAIN CONNECTIVITY Typical photo captured ☐

Based on USDA Stream Visual Assessment Protocol, 2009*
Buffington
Thorne

Valley Configuration Frequency of F.P Inundation	Fully Un-Confined / Largely Un-Confined and Active channel and floodplain are connected throughout reach and flooded multiple times per year	Largely Unconfined and Floods up to bankfull discharge retained in-channel. Larger floods spill into floodplain	Partially Confined and Active channel appears to be connected to the floodplain, with infrequent inundation	Largely Confined and Active channel appears to be disconnected from the floodplain, with infrequent inundation	Largely Confined / Fully Confined and Wide range of flood flows contained within active channel with very infrequent or no inundation
F.P. Connectivity	10 9	8 7	6 5	4 3 2	1 0

* USDA, 2009. Stream Visual Assessment Protocol Version 2. National Biology Handbook, Subpart B - Conservation Planning, United States Department of Agriculture Natural Resources Conservation Service

RAPID GEOMORPHOLOGICAL ASSESSMENT (RGA) FIELD FORM

INDICATORS OF DEGREDATION, AGGRADATION, AND STABILITY

Based on USDA Stream Visual Assessment Protocol, 2009*

Degradation

- ☐ Terraces (abandoned floodplains)
- ☐ perched channels or tributaries
- ☐ headcuts and knickpoints
- ☐ exposed pipe crossings
- ☐ suspended culvert outfalls and ditches
- ☐ undercut bridge pier
- ☐ exposed tree roots
- ☐ leaning trees
- ☐ narrow/deep channel
- ☐ banks undercut on both sides of riffles
- ☐ armored channel bed
- ☐ hydrophytic vegetation located high on bank
- ☐ failed revetments due to undercutting
- ☐ compacted channel bed
- ☐ Cut face on bar forms
- ☐ Channel worn into undisturbed overburden/bedrock

Aggradation

- ☐ Buried structures (e.g. culverts and outfalls)
- ☐ reduced bridge clearance
- ☐ Presence of midchannel bars
- ☐ outlet of tributaries buried in sediment
- ☐ sediment deposition in floodplain
- ☐ buried vegetation
- ☐ channel bed above the floodplain elevation (perched)
- ☐ Significant backwater in tributaries
- ☐ Uniform sediment deposition across the channel
- ☐ hydrophobic vegetation located low on bank or dead in floodplain
- ☐ unvegetated point bars
- ☐ Large uncompacted point bars
- ☐ rills or remnant channels in riparian areas
- ☐ coarse material in riffles embedded
- ☐ poor longitudinal sorting of bed materials

Stable

- ☐ Vegetated bars and banks
- ☐ Limited bank erosion
- ☐ evidence of frequent overbank flows
- ☐ algae growth on substrate
- ☐ No exposed pipeline crossings, bridge footings, or abutments
- ☐ roots or large trees anchored in soil
- ☐ Older bridges, culverts, and outfalls with invert at or near grade
- ☐ Mouth of tributaries at or near existing main stem stream grade

STREAM EVOLUTION TRIANGLE

From Castro and Thorne, 2019

SET Stages - Indicate location on SET triangle

0 - **Anastomosing:** dynamically meta-stable network of ana branching channels with vegetated islands

1 - **Sinuous:** Stable and laterally active. Sediment sorting and transfer

2 - **Channelized:** Re-sectioned land drainage, flood control, or navigation channels

3 - **Degrading:** incising and abandoning its floodplain. Banks stable geotechnically

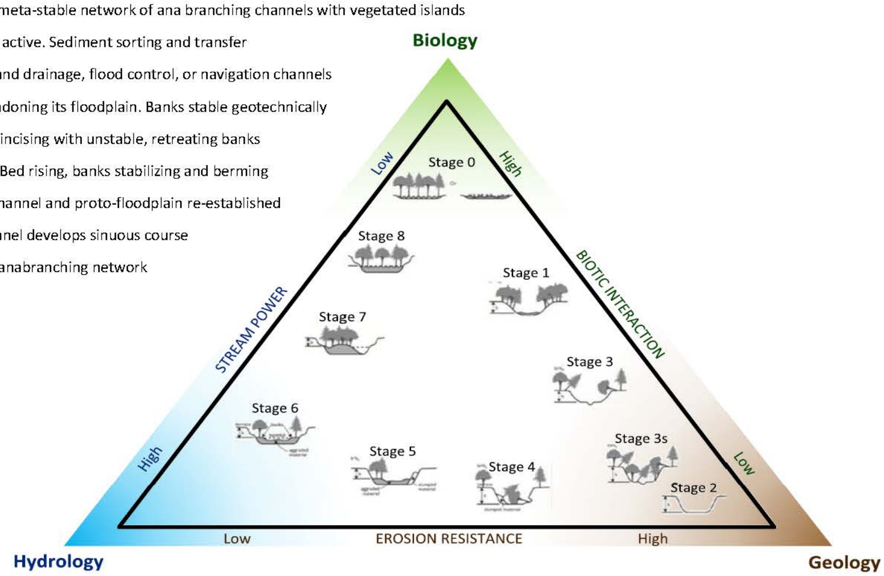
4 - **Degradation and Widening:** incising with unstable, retreating banks

5 - **Aggradation and Widening:** Bed rising, banks stabilizing and berming

6 - **Quasi-Equilibrium:** regime channel and proto-floodplain re-established

7 - **Laterally active:** regime channel develops sinuous course

8 - **Anastomosing:** meta-stable anabranching network



* USDA, 2009. Stream Visual Assessment Protocol Version 2. National Biology Handbook, Subpart B - Conservation Planning, United States Department of Agriculture Natural Resources Conservation Service

** Castro, J.M. and Thorne, C.R. 2019. The Stream Evolution Triangle: Integrating Geology, Hydrology, and Biology

RAPID GEOMORPHOLOGICAL ASSESSMENT (RGA) FIELD FORM

FIELD MAP AND NOTES

Appendix H

Native Revegetation and Invasive Exotic Vegetation

Appendix H-1: Success Criteria Monitoring Protocols

Klamath Revegetation Project

Permanent scientific vegetation plot surveys will be conducted annually for five years beginning the first spring (2025) after the implementation period to determine progress toward success criteria in the Klamath Reservoirs after dam removal. The surveys will provide qualitative scientific data for unbiased analysis assessing the progress of vegetation development in the newly exposed reservoirs. Data will be compared to data collected from reference plots from surrounding vegetation communities to determine success criteria progress and will be compared to plots located in areas within the reservoirs left unseeded and unplanted to determine the effectiveness of seeding and planting on vegetation development.

Qualitative Survey Layout

Qualitative surveys will be conducted in nested line-intercept plots located on reservoir transects within dewatered habitats exposed by dam removal. Transects will begin at the former shoreline and extend to and end at the river. Nested line-intercept plots will provide managers with data designed to detect changes over time and will consist of four surveys. The data will be used to address the following revegetation success criteria;

- Species richness is increasing over time and meeting success criteria targets
- Cover of vegetation is increasing over time and meeting success criteria targets
- Native woody species densities are increasing over time and meeting success criteria targets
- Native plants are more abundant than non-native plant species and are meeting success criteria targets

Reservoir Transects

Permanent transects beginning on the original reservoir shorelines and eventually extending perpendicular to the river will be established beginning in 2022 during dam removal. Permanent plots (nested line-intercept plots) will be located along each reservoir transect. The beginning of reservoir transects will be marked on prominent features along the former shoreline area to simplify relocation. Markers will be aluminum tags with the transect number nailed into a live tree, large stump, large woody debris or another prominent feature.

- Transects perpendicular to the river will run through all zones of the reservoirs (upland, wetlands, riparian).
- Permanent plots will be established at random distances along the reservoir transect.

Some plot locations may need to be adjusted to ensure they are located fully within planted areas or specific habitat type.

Reservoir transect locations were determined by generating 60 random points along the pre-removal reservoir rim contours. Each point was reviewed in ARCMAP to determine if the location is acceptable. Further reasons for rejection may be determined with a field visit.

- Reasons for rejection:
  - Steep slopes (slopes >45 degrees)
  - Center of river, stream or creek
  - Large woody debris obstructions that cannot be safely crossed or other obstacle to establishing a transect

Plots must be a minimum of 20 meters apart along a transect, UNLESS there is an abrupt change to a different zones or treatment (planted, seeded, wetland feature, etc.). For example, if an upland plot ends and a wetland begins less than 20 meters away, then it is ok to begin the next plot within the wetland less than 20 meters from the previous plot.

Reservoir Transect Numbering System

Reservoir transects will begin with the letter of the reservoir (I for Iron Gate, C for Copco or J for J.C. Boyle) followed by the number of the transect (Example C22). Transect numbers will be generated in ArcGIS based on the position in the firing order. Since many of the ArcMap points may be rejected, transect numbers may not be sequential.

Nested Line-Intercept Plots

Permanent plots will be a combination of four surveys and will be referred to as “nested line-intercept plots” (Table H-1). The first survey will be a 20-meter line-intercept transect that will measure changes over time in vegetation cover (bare ground). Each transect will be surrounded by a 5 by 20 meter plot extending 2.5 meters perpendicular to the line-intercept. Within this plot, all species present will be recorded to determine species richness, and a woody plant tally will survey all woody species greater than 30 centimeters (cm) tall, noting whether the stems are alive or dead, to determine woody plant density and mortality rates. The woody tally will provide management with mortality statistics and woody plant density measurements. Along the line-intercept, 80-square-centimeter (cm^2) plots will be established to determine the frequency of native and nonnative species.

Table H-1. Surveys Conducted in the Permanent Nested Line-Intercept Plots

SURVEY	SURVEY DIMENSIONS	PURPOSE
Line-intercept transect	20 meter line	Measure cover of vegetation cover (bare ground) over time
Species list	100 square meter (m^2)	Provides overview of species richness over time
Woody plant tally	100 m^2 (or smaller if necessary)	Measures the abundance of woody plants >30 cm over time and measures mortality.
Rooted sub-frequency quadrats	Ten 80cm^2 plots located along the line-intercept	Measures native and non-native species frequency

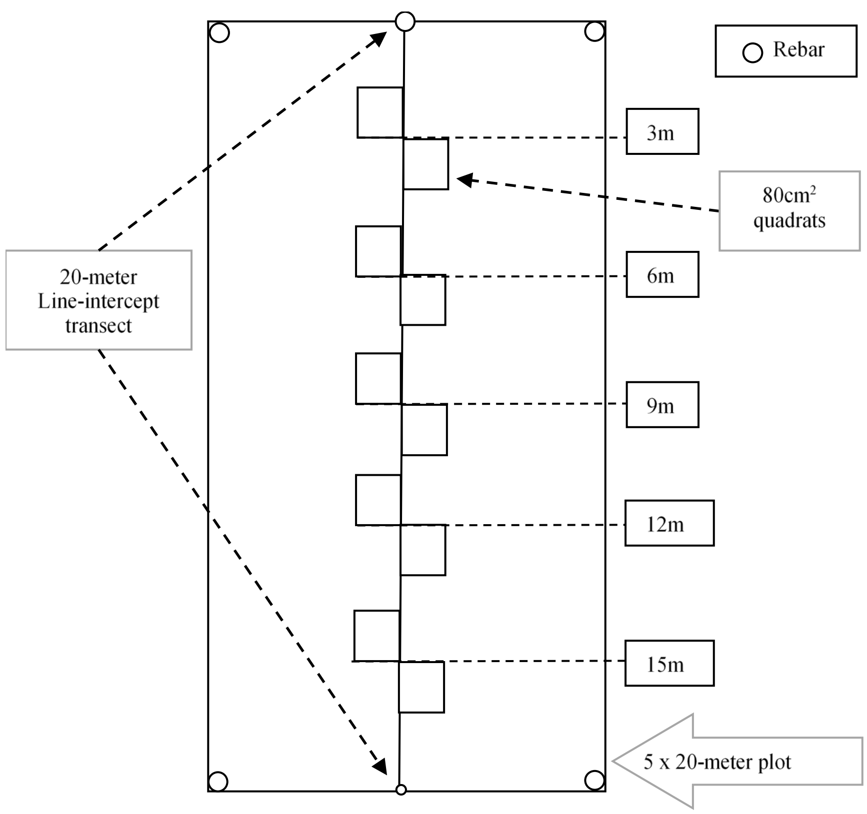


Figure H-1. Layout of Permanent Nested Line-Intercept Plots

Permanent Plot Numbering System

The nested line-intercept plot numbering system will be four (4) characters determined by the reservoir and transect number followed by the plot number as determined by the sequence along the transect. For example, the third plot on transect 05 in Copco reservoir will be numbered C05-3.

Line-Intercept Transect

A primary objective of the revegetation project is to ensure that the amount of vegetation cover in the dewatered reservoirs increases over time and approximates reference plots in the surrounding plant communities. Permanent line-intercept transects 20 meters long will be established and surveyed annually. The line-intercept transects will measure the cover of bare-ground, large woody debris, woody plants (by species), and herbaceous plants (not to species). The total cover of vegetation will be determined by the subtracting the total cover of bare ground 20 meters. This method ensures that the total cover of vegetation does not exceed 20 meters, which could result from the multiple layers of cover provided by woody species and the cover beneath the trees and shrubs provided by the understory.

Locating the Line-Intercept Transect

The beginning of each line-intercept transect will be located at pre-determined random points along the reservoir transect generated by the technical lead in ArcGIS prior to field visits. The 20-meter line must fall entirely within a single habitat type and treatment. The final locations of the intercept transect may need to be adjusted by the monitoring crew based on field conditions. Reasons for rejecting or moving a line-intercept location are as follows:

- Line-intercept follows along a watercourse for more than 10 percent of the length.
- Unsafe conditions due to unusually steep terrain, large unstable woody debris, etc.
- The line-intercept crosses through more than one habitat type or treatment.

Nested Line-Intercept Establishment Form

After locating the beginning of the line-intercept, record a Global Positioning System (GPS) point using the data dictionary provided in the GPS unit.

Field Procedure for Line-Intercept Transects

- Install 4-foot rebar at start of the line and record GPS point.

Cap the rebar with plastic protective cap.

- Measure the slope to determine if any slope corrections are needed to adjust the length (Table H-1).
- Anchor the measuring meter tape to the rebar at the transect start and end point.

The line should be taut, do not allow vegetation to deflect the alignment of the tape.

The line should be as close to the ground as possible.

Stretch tape out 20 meters perpendicular the Klamath river along the reservoir transect azimuth.

- Install 4-foot rebar and plastic protective cap at end of line-intercept transect.
- Take photos looking down the transect—both directions
- Begin survey at the start of the measuring tape (0 cm) and work down the transect line.

Stay on the north side of the line.

Position yourself directly above the line.

Use a plumb-bob or decimeter tape when measuring along tape that is elevated off the ground.

- Measure the start and end point of the following categories along the tape:

Bare-ground (BG)

Large woody debris (LWD)

- Defined as wood ≥ 10 cm diameter

Herbaceous plants (HERB)

- Any herbaceous vascular plants including grasses, forbs, ferns, etc.
- The measurement is of foliar cover of the vertical projection of exposed leaf area. The cover would equal the shadow cast if the sun was directly overhead.

Small openings in the canopy or overlap within the plant are excluded.

Species identification is not necessary for this category.

If a plant is dead, DO NOT record the cover as herbaceous. Instead, consider dead herbaceous plants as bare ground, since a new plant can grow in that space.

However, if the plant is senesced but alive (i.e., it is late in the summer or early fall) OR the dead plant was an annual (i.e., *Deschampsia*), count the plant in the herbaceous category.

Woody plants by species

- Trees and shrubs should be identified to species.
- Include canopy of trees overhead IN ADDITION to whatever cover category under the canopy (important when close to forest edge or in 2-3 year old alder/willow/cottonwood).
- Exclude gaps in the canopy less than 5 cm (2 inches/5 cm).
- Include leaves and stems as canopy.
- Canopies of multiple woody species that overlapped one another are measured separately. You may have to move overstory plants to see what canopy cover of different species is underneath.
- Canopies of the same species that overlap one another are not measured separately (ignore the overlap).
- Ignore cover that extends beyond the end of the tape.
- Ignore intersections along the transect that are **<1 cm**.

Nested 5-by-20-Meter (100 m²) Plot

Extending 2.5 meters in both directions perpendicular to the line-intercept, a 100 m^2 plot will be established. Within this plot, a species list will be created and a woody plant survey will be recorded.. Please take a photo of the entire plot.

Field procedures for establishing and surveying the 5-by-20-meter plot

- Position the corners of the plot 2.5 meters perpendicular to both ends of the line-intercept plot.
- Mark each corner with rebar and cap with protective plastic caps.
- Square the corners to ensure that the plot will be a true rectangle and that all sides are equal.
- Stretch meter tape around the four outer corners to mark the plot boundaries.

Table H-2: Slope Correction Factors

% SLOPE	SLOPE	METERS
10 – 17	6-9	5.05
18 – 22	10-12	5.10
23 – 26	13-14	5.15
27 – 30	15-16	5.20
31 – 33	17-18	5.25
34 – 37	19-20	5.30
38 – 39	21	5.35
40 – 42	22-23	5.40
43 – 44	24	5.45
45 – 47	25	5.50
48 – 49	26	5.55
50 – 52	27	5.60
53 – 54	28	5.65
55 – 56	29	5.70
57 – 58	30	5.75
59 – 61	31	5.80

Species List

List all species within the 5-by-20-meter plot. The species list is organized by lifeform (woody plant, forb, graminoid, and ferns and allies). Bryophytes are not listed. Nativity will be determined using Calflora, the *Jepson Manual: Vascular Plants of California Second Edition*, and *Flora of the Pacific Northwest: An Illustrated Manual*, second edition.

Field Procedure for Species List

Identify all species present in the plot.

Includes woody plants, forbs, graminoids and ferns and their allies. Minimize walking inside the plot for this survey. If walking within the plot is necessary, try and walk on bare-ground, rocks or woody debris. Remember, these plots are meant to be re-surveyed annually for up to 5 years, so stepping on a woody plant or killing a seedling will have a significant impact on the data.

Woody Plant Tally

Within the 100-m^2 plot, count all woody plants by species and size class.

Field Procedure for Woody Tally Plots

- Tally all living woody plants by species and size class.
- Tally all dead woody plants on a separate line on the data sheet. Note species if possible.

Rooted Sub-Quadrat Frequency

Along the line intercept, ten 80-cm^2 plots will be established and surveyed to determine the frequency of native and non-native species. Each two 80-m^2 quadrats will be constructed of polyvinyl chloride and used for this survey. The quadrats will be established perpendicular to the line-intercept at five locations that are 3 meters apart on either side of the line, beginning at the 3 meters mark on the line-intercept (Figure 1). A species list will be recorded within each quadrat. The ten plots will be combined, and each species will be given a score of 1-10 based on presence or absence recorded within each quadrat. For example, if *Elymus elymoides* (ELYELY) is present in 3 out of the 10 quadrats, then it would have a score of 3 for that entire nested line-intercept plot. **Photos will be taken of each quadrat from above**. It is important to take the picture at an oblique angle, so surveyors should use a two-step ladder if necessary and it is safe to do so (steep slopes may make this infeasible).

Field Procedure for Root Sub-Quadrat Frequency Plots

- Place quadrat perpendicular to the measuring tape along the line-intercept at 3-meter intervals (Figure 1).
- Take a photo of the plot while the quadrat is in place.
- Identify all plants rooted in the entire quadrat to species only (we will no longer identify the stage of growth).

Exclude plants that are not rooted within the quadrats – cover extending into the quadrat from adjacent rooted plants do not count.

Appendix H-2: IEV Monitoring Protocols

Revegetation

Monitoring the reservoir footprints for invasive exotic vegetation (IEV) presence is critical to successful treatment and prevention. This monitoring protocol is not necessarily meant to be qualitative; it is primarily designed to ensure early detection and rapid response to IEV species establishing in the former reservoirs after dam removal. The data will be assessed during the growing season and used to develop a strategy for immediate treatment. The data provided in this survey is more detailed than traditional qualitative data that attempt to assess IEV abundance on the landscape and has been used for qualitative assessments (Woodward et al., 2011).

These surveys will be complemented by incidental observations of IEV populations in the former reservoirs by other staff or by the general public.

Reservoir IEV Surveys

IEV spatial surveys will be conducted twice annually, once in spring and once in the summer. A team of 2-4 biologists will survey all reservoir areas with field Global Positioning System (GPS) units and record any populations encountered. Data dictionaries in each unit will be filled out at each IEV location. The data dictionary will provide critical information on species abundance, phenology, distance to water, and any treatment of the population that may have occurred at the location. No hard copy data sheets will be used for this survey.

Survey Protocols

- While traveling within the reservoir footprints where no IEV are present surveyor will record the path traveled using the GPS units (line feature).
- When IEV are encountered, a GPS point (not polygon) will be recorded.
- Separate points will be taken for each species encountered at each location.
- Each point represents what is visible within 30 meters of the point location for each species encountered.

Surveyor will scout area before recording point to ensure the point location best represents the center of the population(s) encountered.

Metadata

- Date

Date that the point was recorded in the field

- Species

Full scientific name of the IEV species encountered. This data field will be a pick list to avoid misspellings or other data entry mistakes.

- Surveyor

Person recording the point with the GPS unit

- Num_pop

Number of population clusters visible within 30 meters within 30 meters of point

- Tot_num

Total number of plants within all clusters visible within 30 meters of point

- GrosAreaM2

Estimated area (square meters) containing IEV clusters or plants

- Perc_cov

Estimated percent cover of IEV within the gross area

- Phenology

Pick list identifying the phenology at time of survey

Emerging

Flowering – early

Flowering – late

Fruiting – early

Fruiting – late

Senescing

- DistToH2O

Distance in meters to nearest open water

- Treatment

Pick list of treatment applied at time of survey

Mechanical removal

Herbicide application

Flower removal

Fruit removal

- Herbicide

Herbicide product applied if applicable

- Surfactant

Surfactant used if applicable

- Comments

Any notes about observations

- Northing

UTM N – can be determined in post processing of data

- Easting

UTM E – can be determined in post processing of data

- RES

Reservoir

References

Woodward A.C., C. Torgersen, J. Chenoweth, K. Beirne and S.A. Acker. 2011. Predicting spread of invasive exotic plants into de-watered reservoirs following dam removal on the Elwha River, Olympic National Park, Washington. U.S. Geological Survey Open-File Report 2011-1048, 64p.

Appendix H-3: Data Analysis Protocols

Revegetation

Success Criteria Data Analysis Protocols

Data from the permanent scientific vegetation plot surveys will analyzed annually to determine the trajectory of vegetation development as outlined in the success criteria and to direct adaptive management during the maintenance and monitoring period. Data will be entered into an Access database specifically designed for the Project. Queries in Access will be designed to export tables for input into R software for statistical computing. All analyses will be performed using the latest version of R Studio. Key packages used will be vegan (Oksanen et al., 2018), labdsv (Roberts, 2016) and indicspecies (De Cáceres and Legendre, 2009).

Quantitative data analysis will focus on five response variables: cover of vegetation, species composition, species richness, relative frequency of invasive exotic vegetation (IEV), and density of woody plants. Although species composition is not included in any success criteria, it will help to guide adaptive management during the maintenance and monitoring phase. Vegetation cover is calculated as an inverse to bare ground at each line-intercept. IEV relative frequency is calculated as the frequency of IEV plants as a proportion of the total frequency of all plants rooted in the 80 square centimeter (cm^2) plots.

For quantitative analyses, univariate responses (bare ground, IEV frequency, species richness, and density of woody plants) will be expressed as Euclidean distance matrices. The covers of woody species and herbaceous plants will not be analyzed as response variables but will provide insight into the type of vegetation cover (i.e., herbaceous or woody) in the various treatments that presumably cause reductions in bare ground. Multivariate responses (i.e., species composition) will be expressed as a Bray-Curtis dissimilarity matrix.

Statistical analyses will primarily be conducted using permutational multivariate analysis of variance (PERMANOVA; Anderson, 2001) with $\alpha = 0.05$ and 9,999 permutations to determine statistical significance of the resulting pseudo-F -statistics (Legendre and Legendre, 2012). The potential explanatory variables in all models will be geographic location of plot (Universal Transverse Mercator [UTM] coordinates), distance to reservoir edge, restoration condition (reference plot or reservoir restoration plot), whether the plot was planted (yes, no), or seeded (yes, no). We may also include irrigation as an explanatory variable. UTM coordinates will be included as the first terms in all models to account for possible spatial autocorrelation. We will test for the main effects of treatments, (seeding, planting) and compare mean values to the mean values collected at reference plots for each success criteria. We expect statistically significant differences between reference and restoration plots since the success criteria targets are a percentage of reference and not expected to be the same. Means will be calculated for all response variables within all habitat types and compared to the means collected at reference plots to track progress towards success criteria. We will use the control plots within the reservoir footprints (unseeded and unplanted areas) to determine if planting and seeding provides statistically significant differences in response variables.

Non-metric multidimensional scaling (NMDS) ordination will be used to visualize differences in composition of all species between restoration conditions and habitat types within the reservoir footprints. Although species composition is not included in the success criteria, NMDS analyses using composition can point out important differences in plot type for adaptive management purposes. The NMDS solutions will be calculated using three (3) dimensions with 500 iterations and 100 random starting configurations. Separate ordinations were conducted for all plants and for woody plants. The fit of the NMDS ordination was evaluated by plotting the original dissimilarities against the Euclidean ordination distances in Shepard plots.

Indicator Species Analysis (ISA) will be applied to the compositional matrix (all plants) to identify species strongly associated treatments (seeded and/or planted compared to unplanted and/or unseeded and to reference plots). ISA will be performed using multi-level pattern analysis (De Cáceres et al., 2010), allowing species to be indicators of individual combinations of treatment and restoration condition or habitat type (i.e. riparian or upland). The Indicator Value (IV) of each species will be calculated as the product of the species' relative abundance and relative frequency within each group. IVs will be tested for statistical significance using 10,000 permutations. We will focus our attention on species with IV ≥ 0.5 and $p \leq 0.05$. Determining indicator species can assist with future planting efforts. For example, seeded or planted species that are revealed to be indicators at certain sites are likely to be excellent performers in the restoration conditions and can be used to plant sites not performing well or in control areas that are failing to revegetate naturally.

IEV Monitoring Data Analysis Protocol

Data points collected using field Global Positioning System (GPS) units of all IEV populations within the reservoir footprints collected outside of the permanent plots will be combined and summarized during the growing season to direct treatments. Each treatment will receive a GPS data point recording treatment information (i.e., date, treatment method, etc.). At the end of the summer, all data of treatments and IEV locations will be totaled and summarized by species and reservoir. Data each year will be compared to previous years within each reservoir footprint. We expect a slow increase of some IEV populations within the first few years before native vegetation is well established and treatment efficacy is refined to manage the specific conditions encountered in the unique environment created by dam removal (Chenoweth et al., in prep).

References

Anderson, M.J. 2001. A new method for non-parametric multivariate analysis of variance. *Austral Ecology*. 26: 32-46

Chenoweth, J., S. Acker, M. McHenry, David W. Allen. in prep. *Elwha River Restoration Project: Revegetation Report 2011-2018*. NPS Natural Resource Report, U.S. Dept of the Interior.

De Cáceres, M., P. Legendre. 2009. Associations between species and groups of sites: indices and statistical inference. Ecology, URL http://sites.google.com/site/miqueldecaceres/

De Cáceres, M., P. Legendre, M. Moretti. 2010. Improving indicator species analysis by combining groups of sites. *Oikos*. 119: 1674-1684

Legendre, P., and L. Legendre. 2012. *Numerical Ecology*. 3rd English edition. Elsevier. Amsterdam, The Netherlands.

Oksanen, J., F. Guillaume Blanchet, M. Friendly, R. Kindt, P. Legendre, D. McGlinn, P.R. Minchin, R.B. O'Hara, G.L. Simpson, P. Solymos, H. Henry, H. Stevens, E. Szoecs, and H. Wagner. 2018. vegan: Community Ecology Package. R package version 2.4-6. https://CRAN.R-project.org/package=vegan

Roberts, D.W. 2016. labdsv: Ordination and Multivariate Analysis for Ecology. R package version 1.8-0. https://CRAN.R-project.org/package=labdsv

Appendix H-4: Data Sheets

Klamath Revegetation Monitoring
Line-Intercept Data From

version 12/2/20

Reservoir: ________________ Zone: _____________ Treatment: ___________ Plot No. ___ ___ ___ ___-___ ___ Date: M__ __ D __ __ Y __ __ __ __

Crew: ____ page ___

notes:	Category				Woody Species									
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End

Entered by _______________date __/__/____

Klamath Revegetation Monitoring
Line-Intercept Data From

version 12/2/20

Reservoir: ________________ Zone: _____________ Treatment: ___________ Plot No. ___ ___ ___ ___-___ ___ Date: M__ __ D __ __ Y __ __ __ __

Crew: ____ page ___

notes:	Category				Woody Species									
	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End	Start	End

Entered by ________________date __/__/____

Klamath Revegetation Monitoring
Rooted Quadrat Frequency

version 12/03/20

Reservoir: ________________ Habitat: _____________ Treatment: ___________ Plot No. ___ ___ ___-___ ___

Crew: ____ Date: M__ __ D __ __ Y __ __ __ __

Page ___ of ____

Quadrat	Species

Quadrat	Species

Entered by _______________date __/__/____

Klamath Revegetation Monitoring
Rooted Quadrat Frequency

version 12/03/20

Reservoir: ________________ Habitat: _____________ Treatment: ___________ Plot No. ___ ___ ___-___ ___

Crew: ____ Date: M__ __ D __ __ Y __ __ __ __

Page ___ of ____

Quadrat	Species

Quadrat	Species

Entered by _______________date __/__/____

Klamath Revegetation Monitoring
Woody Plant Tally

version 12/2/20

Reservoir: ________________ Zone: _____________ Treatment: ___________ Plot No. ___ ___ ___-___ ___

Crew: ____ Date: M__ __ D __ __ Y __ __ __ __

Species	TALLY			Species	TALLY		
	Size class	Live	Dead		Size class	Live	Dead

Notes (i.e. healthy, drought stress, discoloration, etc):

Entered by _______________date __/__/____

Klamath Revegetation Monitoring
Woody Plant Tally

version 12/2/20

Reservoir: ________________ Zone: _____________ Treatment: ___________ Plot No. ___ ___ ___-___ ___

Crew: ____ Date: M__ __ D __ __ Y __ __ __ __

Species	TALLY		
	Size class	Live	Dead

Species	TALLY		
	Size class	Live	Dead

Notes (i.e. healthy, drought stress, discoloration, etc):

Entered by _______________date __/__/____

Appendix H-5: Seed Contracts and Seed Production Summary

Table H-5.1 Native Vegetation Seed Contracts and Seed Production Summary

Species	Contract Status	Contract Type	Vendor	Seed source	2020 harvest (actua)	2021 harvest (est)	2022 harvest (est)	seeds/lb	Total lbs (est)	Total seeds estimated	Storage Location
Achillea millifolium	Current	Custom field	BFI	2018 Wild collect, PCS	200	200	0	2,790,000	**400**	**1,116,000,000**	BFI
Achillea millifolium	Proposed	Custom field	BFI	2018 Wild collect, PCS	0	200	200	2,790,000	**400**	**1,116,000,000**	BFI
Amsinckia menziesii	Current	Custom field	HRF	2020 Wild collect, Yurok	0	200	0	156,766	**200**	**31,353,200**	HRF
Amsinckia menziesii	Current	Custom field	HRF	2020 Wild collect, Yurok	0	0	200	156,766	**200**	**31,353,200**	HRF
Amsinckia menziesii	Verbal	Custom field	JHS	BLM Medford	0	25	0	156,766	**25**	**3,919,150**	JHS
Artemisia douglasiana	Current	Custom field	BFI	2018 Wild collect, PCS	100	100	0	340,000	**200**	**68,000,000**	BFI
Bromus carinatus	Current	Commercial	BFI	Burnt Creek	7,230	5,354	0	80,000	**12,584**	**1,006,720,000**	BFI
Croton setigerus	Current	Custom field	HRF	2019 Wild collect, Yurok	96.9	0	0	52,060	**96.9**	**5,044,614**	HRF
Croton setigerus	Current	Custom field	HRF	2020 Wild collect, Yurok	0	45	0	52,060	**45**	**2,342,700**	HRF
Deschampsia cespitosa	Current	Custom field	BFI	2019 Wild collect, Yurok	0	95	95	2,500,000	**190**	**475,000,000**	BFI
Drymocallis glandulosa	Current	Custom field	BFI	2018 Wild collect, PCS	0	22	0	1,135,000	**22**	**24,970,000**	BFI
Elymus cinereus	Current	Custom field	BFI	2018 Wild collect, PCS	675	625	0	130,000	**1,300**	**169,000,000**	BFI
Elymus elymoides	Current	Commercial	BFI	Norcross Klamath	3,500	2,082	0	165,836	**5,582**	**925,696,552**	BFI
Elymus elymoides	Proposed	Commercial	BFI	Norcross Klamath	0	0	3,000	165,836	**3,000**	**497,508,000**	BFI
Elymus glaucus	Current	Custom field	BFI	2018 Wild collect, PCS	3,000	1,800	0	110,000	**4,800**	**528,000,000**	BFI
Elymus glaucus	Current	Custom field	BFI	2018 Wild collect, PCS	0	600	600	110,000	**1,200**	**132,000,000**	BFI
Elymus spicatus	Current	Custom field	BFI	2020 wild collect, Yurok & BFI (Agate Desert)	0	700	700	130,488	**1,400**	**182,683,200**	BFI
Elymus triticoides	Current	Custom field	BFI	2018 Wild collect, PCS	680	80	0	51,000	**760**	**38,760,000**	BFI
Eriophyllum lanatum	Current	Custom field	BFI	2019 Wild collect, Yurok	0	130	0	1,306,077	**130**	**169,790,010**	BFI
Eriophyllum lanatum	Proposed	Custom field	BFI	2020 Wild collect, Yurok	0	100	400	1,306,077	**500**	**653,038,500**	BFI
Eriophyllum lanatum	Current	Custom field	CPMC	2019 Wild collect, Yurok	0	25	65	1,306,077	**90**	**117,546,930**	CPMC
Eschscholzia californica	Current	Commercial	HRF	Lodoga Hills, Colusa Co	0	400	400	234,000	**800**	**187,200,000**	HRF
Euthamia occidentalis	Current	Custom field	BFI	2018 Wild collect, PCS	200	200	0	2,500,000	**400**	**1,000,000,000**	BFI
Festuca idahoensis spp *roemeri*	Current	Commercial	BFI	Ashland Cascades, BFI	209	833	0	450,000	**1,042**	**468,900,000**	BFI
Festuca idahoensis spp *roemeri*	Proposed	Commercial	BFI	Ashland Cascades, BFI	0	0	1,000	450,000	**1,000**	**450,000,000**	BFI
Grindelia camporum	Current	Custom field	S&S	2018 Wild collect, PCS	1,300	0	0	132,000	**1,300**	**171,600,000**	CPMC
Horderum brachyantherum	Current	Commercial	HRF	Santa Rosa, Sonoma Co, HRF	0	500	0	85,000	**500**	**42,500,000**	HRF
Hordeum jubatum	Current	Custom field	HRF	2019 Wild collect, Yurok	35	40	0	129,500	**75**	**9,699,550**	HRF
Koeleria macrantha	Proposed	Commercial	BFI	Medford Roundtop, BFI	0	500	500	1,592,721	**1,000**	**1,592,721,000**	BFI
Lupinus microcarpus var *densiflorus*	Current	Custom field	HRF	2020 Wild collect, Yurok	0	55	0	13,529	**55**	**744,095**	HRF
Lupinus microcarpus var *densiflorus*	Current	Custom field	HRF	2020 Wild collect, Yurok	0	0	440	13,529	**440**	**5,952,760**	HRF
Lupinus microcarpus var *microcarpus*	Current	Custom field	HRF	BLM Medford (two sources)	0	55	0	13,529	**55**	**744,095**	HRF
Mentzelia laevicaulis	Proposed	Custom field	BFI	2020 Wild collect, Yurok	0	300	300	400,960	**600**	**240,576,000**	BFI
Penstemon roezlii	Current	Commercial	BFI	Box O	283	165	0	650,000	**448**	**291,200,000**	BFI
Penstemon speciosus	Proposed	Custom field	JHS	2020 Wild collect, Yurok	0	2	8	445,879	**10**	**4,458,790**	JHS
Poa secunda	Current	Commercial	BFI	Fremont 5850	1,400	417	0	912,500	**1,817**	**1,658,012,500**	BFI
Solidago elongata	Current	Custom field	BFI	2018 Wild collect, PCS	93	220	0	4,600,000	**313**	**1,439,800,000**	BFI
Stipa lemmonii	Proposed	Custom field	JHS	2020 Wild collect, Yurok & BLM Medford	0	40	800	108,474	**840**	**91,118,328**	JHS
Trichostema lanceolatum	Completed	Custom field	S&S	2018 Wild collect, PCS	116	0	0	126,400	**116**	**14,662,400**	CPMC
				TOTALS	**19,118**	**16,110**	**8,708**		**43,936**	**14,964,615,574**	

Table H-5.2 Wild Collected Seed Inventory

Species	Lot #	Collection year	Seed Source	Collector	Seeds per lb	Clean seed weight (bulk lbs)	Approximate # Pure live seed	Storage location	Seed plan	Notes
Acmispon americanus	KP1002	2018	Klamath watershed	PCS	75,750	1.300	63,753	CPMC	Propagate into plugs or directly added to seed mixes	
Amelanchier utahensis	YT20-AMEUTA-IG	2020	Iron Gate/Copco area	YT	40,542	0.111	4,500	JHS	To be sown for bare root production	
Artemisia tridentata	KP1049A	2018	Klamath watershed	PCS	1,382,732	150.000	18,708,364	JHS	To be sown for bare root production	
Artemisia tridentata	KP1049B	2018	Klamath watershed	PCS	1,382,732	116.000	19,055,153	JHS	To be sown for bare root production	
Balmsamerhiza deltoidea	YT20-BALDEL	2020	Klamath watershed	YT	39,185	0.552	16,220	RNPP	Seed to be directly added to upland seed mixes	
Berberis aquifolium	YT20-BERAQU-IG	2020	Iron Gate/Copco area	YT	43,846	0.699	18,077	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Berberis aquifolium	YT20-BERAQU-JCB	2020	JC Boyle area	YT	43,846	0.847	21,911	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Bidens frondosa	KP1005	2018	Klamath watershed	PCS	195,300	12.900	2,159,856	CPMC	Propagate into plugs or directly added to seed mixes	
Bidens frondosa	KP1005A	2018	Klamath watershed	PCS	195,300	4.610	611,956	CPMC	Propagate into plugs or directly added to seed mixes	
Carex nebrascensis	KP1007	2018	Klamath watershed	PCS	534,100	1.250	98,541	CPMC	Propagate into plugs or directly added to seed mixes	
Carex nebrascensis	KP1007A	2018	Klamath watershed	PCS	534,100	0.650	62,629	CPMC	Propagate into plugs or directly added to seed mixes	
Carex praegracilis	KP1009	2018	Klamath watershed	PCS	664,900	2.760	1,553,065	CPMC	Propagate into plugs or directly added to seed mixes	
Carex simulata	KP1044	2018	Klamath watershed	PCS	1,043,000	1.400	464,782	CPMC	Propagate into plugs or directly added to seed mixes	
Carex simulata	KP1044A	2018	Klamath watershed	PCS	1,043,000	0.880	409,540	CPMC	Propagate into plugs or directly added to seed mixes	
Carex utriculata	KP1045	2018	Klamath watershed	PCS	360,000	3.950	1,422,000	CPMC	Propagate into plugs or directly added to seed mixes	
Ceanothus cuneatus	YT20-CEACUN-IG	2020	Iron Gate/Copco area	YT	58,171	0.853	40,688	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Ceanothus integerrimus	YT20-CEAINT-IG	2020	Iron Gate/Copco area	YT	102,523	0.103	7,075	JHS	To be sown for bare root production	
Cercocarpus betuloides	YT20-CERBET-IG	2020	Iron Gate/Copco area	YT	19,786	1.750	24,930	JHS	To be sown for bare root production	
Cercocarpus betuloides	YT20-CERBET-JCB	2020	JC Boyle area	YT	19,786	1.075	15,314	JHS	To be sown for bare root production	
Cornus glabrata	YT20-CORGLA-IG	2020	Iron Gate/Copco area	YT	18,628	0.447	6,416	JHS	To be sown for bare root production	
Cornus sericea	YT20-CORSER-JCB	2020	JC Boyle area	YT	18,628	1.848	26,507	JHS	To be sown for bare root production	
Distichlis spicata	KP1014	2018	Klamath watershed	PCS	520,000	8.130	292,127	CPMC	Propagate into plugs or directly added to seed mixes	
Ericameria bloomeri	YT20-ERIBLO-JCB	2020	JC Boyle area	YT	693,000	0.619	38,693	JHS	To be sown for bare root production	
Ericameria nauseosa	YT20-ERINAU-IG	2020	Iron Gate/Copco area	YT	621,749	0.077	47,564	JHS	To be sown for bare root production	
Ericameria nauseosa	YT20-ERINAU-JCB	2020	JC Boyle area	YT	621,749	2.474	1,538,207	JHS	To be sown for bare root production	
Fraxinus latifolius	YT20-FRALAT-IG	2020	Iron Gate/Copco area	YT	12,601	2.280	10,918	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Grindelia nana	YT20-GRINAN	2020	Iron Gate/Copco area	YT	128,000	17.340	2,219,520	RNPP	Seed to be directly added to upland seed mixes	
Hordeum brachyantherum	KP1022	2018	Klamath watershed	PCS	85,000	0.250	12,822	CPMC	Establish seed increase field or propagate into plugs	
Juniperus occidentalis	YT20-JUNOCC-IG	2020	Iron Gate/Copco area	YT	13,642	0.547	2,985	JHS	To be sown for bare root production	
Lomatium species	YT20-LOMsp	2020	Klamath watershed	YT		8.800	0	RNPP	Seed to be directly added to upland seed mixes	
Lonicera interrupta	YT20-LONINT-IG	2020	Iron Gate/Copco area	YT	263,932	0.074	14,315	JHS	To be sown for bare root production	
Lupinus albifrons	YT20-LUPALB	2020	Iron Gate/Copco area	YT	9,100	0.413	3,754	RNPP	Seed to be directly added to upland seed mixes	
Lupinus albifrons	YT20-LUPALB-GC	2020	Ashland, OR (2100 ft)	YT	9,100		0	RNPP	Seed to be directly added to upland seed mixes	Not yet cleaned
Lupinus andersonii	YT20-LUPAND	2020	JC Boyle area	YT	18,000		0	RNPP	Seed to be directly added to upland seed mixes	Not yet cleaned
Monardella odoratissima	YT20-MONODO	2020	Iron Gate/Copco area	YT	600,000	0.289	173,280	RNPP	Seed to be directly added to upland seed mixes	
Penstemon deustus	YT20-PENDEU	2020	Klamath watershed	YT	3,376,508	2.467	666,280	RNPP	Seed to be directly added to upland seed mixes	
Penstemon laetus	YT20-PENLAE	2020	Klamath watershed	YT		0.212	0	RNPP	Seed to be directly added to upland seed mixes	Unk seeds per pound
Penstemon speciosus	YT20-PENSPE	2020	Iron Gate/Copco area	YT	633,006	4.936	2,186,996	RNPP	Propagate into plugs or directly added to seed mixes	
Persicaria amphibia	KP1046	2018	Klamath watershed	PCS		0.520	0	CPMC	Propagate into plugs or directly added to seed mixes	Unk seeds per pound
Phacelia heterophylla	YT20-PHAHET	2020	Klamath watershed	YT	559,172	0.000	0	RNPP	Establish seed increase field or propagate into plugs	Not yet cleaned
Philadelphus lewisii	YT20-PHILEW-IG	2020	Iron Gate/Copco area	YT	5,462,404	0.000	0	FCN	To be sown for bare root production	Not yet cleaned
Philadelphus lewisii	YT20-PHILEW-JCB	2020	JC Boyle area	YT	5,462,404	0.000	0	FCN	To be sown for bare root production	Not yet cleaned
Physocarpus capitatus	YT20-PHYCAP-IG	2020	Iron Gate/Copco area	YT	499,763	0.000	0	FCN	To be sown for bare root production	Not yet cleaned
Pinus contorta var. murryana	Seed Zone 681	2017	Klamath Co, 4,500 ft	SS	117,000	1.000	114,660	JHS	To be sown for bare root production	98% viability, 2017 test
Pinus ponderosa	Seed Zone 721	2014	Klamath watershed, 4,500 ft	SS	12,000	1.000	11,280	JHS	To be sown for bare root production	94% viability, 2014 test
Prunus subcordata	YT20-PRUSUB-IG	2020	Iron Gate/Copco area	YT	797	15.680	9,998	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Prunus subcordata	YT20-PRUSUB-JCB	2020	JC Boyle area	YT	797	1.011	645	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Prunus virginiana	YT20-PRUVIR-IG	2020	Iron Gate/Copco area	YT	10,267	3.460	26,998	JHS	To be sown for bare root production	
Prunus virginiana	YT20-PRUVIR-JCB	2020	JC Boyle area	YT	10,267	0.621	4,846	JHS	To be sown for bare root production	
Pseudotsuga menziesii	Seed Zone 512	2017	Josephine Co, 1,500 ft	SS	29,233	1.000	29,233	JHS	To be sown for bare root production	77% viability, 2017 test
Pseudotsuga menziesii	Seed Zone 502	2017	Jackson Co, 4,000 ft	SS	29,233	1.000	29,233	JHS	To be sown for bare root production	79% viability, 2017 test
Purshia tridentata	YT20-PURTRI-IG	2020	Iron Gate/Copco area	YT	27,233	0.483	8,420	JHS	To be sown for bare root production	

Table H-5.2 Wild Collected Seed Inventory, con't.

Species	Lot #	Collection year	Seed Source	Collector	Seeds per lb	Clean seed weight (bulk lbs)	Approximate # Pure live seed	Storage location	Seed plan	Notes
Purshia tridentata	YT20-PURTRI-JCB	2020	JC Boyle area	YT	27,233	0.063	1,098	JHS	To be sown for bare root production	
Quercus garryana	YT20-QUEGAR-IG	2020	Iron Gate/Copco area	YT	85	95.356	6,079	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Quercus kellogii	YT20-QUEKEL-IG	2020	Ashland, OR (2100 ft)	YT	80	22.344	1,341	JHS	Sown at JHS, fall of 2020 for 2yr bare root production	
Rhus aromatica	YT20-RHUARO-IG	2020	Iron Gate/Copco area	YT	19,082	1.514	20,512	JHS	To be sown for bare root production	
Ribes cereum	YT20-RIBCER-JCB	2020	JC Boyle area	YT	334,019	0.078	19,615	JHS	To be sown for bare root production	
Ribes velutinum	YT20-RIBVEL-IG	2020	Iron Gate/Copco area	YT	136,000	0.141	18,344	JHS	To be sown for bare root production	
Ribes velutinum	YT20-RIBVEL-JCB	2020	JC Boyle area	YT	136,000	0.007	953	JHS	To be sown for bare root production	
Rosa woodsii	YT20-ROSWOO-IG	2020	Iron Gate/Copco area	YT	58,839	0.025	1,015	JHS	In stratification for spring 2021 sow, 2 yr bare root	
Rosa woodsii	YT20-ROSWOO-JCB	2020	JC Boyle area	YT	58,839	0.379	15,387	JHS	In stratification for spring 2021 sow, 2 yr bare root	
Sambucus nigra	YT20-SAMNIG-IG	2020	Iron Gate/Copco area	YT	171,959	0.017	2,325	JHS	To be sown for bare root production	Not yet cleaned
Sambucus nigra	YT20-SAMNIG-JCB	2020	JC Boyle area	YT	171,959	0.113	15,531	JHS	To be sown for bare root production	Not yet cleaned
Spiraea douglasii	YT20-SPIDOU-JCB	2020	JC Boyle area	YT	15,482,292	0.374	1,621,306	JHS	To be sown for bare root production	
Stipa occidentalis	YT20-STIOCC	2020	Iron Gate/Copco area	YT	151,700	0.300	4,105	RNPP	Seed to be directly added to upland seed mixes	Only partially clean
Symphoricarpos albus	YT20-SYMALB-IG	2020	Iron Gate/Copco area	YT	69,326	0.000	0	FCN	To be sown for bare root production	Not yet cleaned
Symphoricarpos albus	YT20-SYMALB-JCB	2020	JC Boyle area	YT	69,326	0.000	0	FCN	To be sown for bare root production	Not yet cleaned
					TOTALS	499.377	53,961,662			

CPMC: Corvallis Plant Material Center, Corvallis, OR
FNC: Fourth Corner Nursery, Bellingham, WA
HRF: Hedgerow Farms, Winters, CA
JHS: J Herbert Stone Nursery, Central Point, OR
RNPP: Rogue Native Plant Partnership, Sampson Creek Reserve, Ashland, OR

Appendix H-6: Bare Root Plant Summary and Production Plan

Table H-6.1: Bare Root Plant Summary and Production Plan - 2020

Species	Reservoir	Seed status	Proposed Vendor	2023 number	2024 number	TOTAL number	Bare root or Container	Sowing Date	Min age of bare root	Max age of bare root	Notes
Abies concolor	JC Boyle	To be collected 2021	JHS	500	0	500	77/170 Styro	Spring 2022	1	3	
Acer macrophyllum	Iron Gate/Copco	To be collected 2021	JHS	0	0	0	Bareroot	Fall 2021	1	1	
Alnus rhombifolia	Iron Gate/Copco	To be collected 2021	JHS	600	700	1,300	Bareroot	Spring 2022	1	1	
Amelanchier alnifolia	JC Boyle	To be collected 2021	JHS	300	200	500	Bareroot	Fall 2021	1	2	
Amelanchier utahensis	Iron Gate/Copco	Sown fall 2020	JHS	3,350	2,650	6,000	Bareroot	Fall 2021	1	2	
Artemesia tridentata	JC Boyle	Collected 2018, stored at JHS	JHS	2,500	1,500	4,000	Bareroot	Spring 2022	1	1	
Berberis aquifolium	Iron Gate/Copco	Sown fall 2020	JHS	400	2,600	3,000	Bareroot	Spring 2022	2	3	
Berberis aquifolium	JC Boyle	Sown fall 2020	JHS	0	500	500	Bareroot	Spring 2022	2	3	
Calocedrus decurrens	Iron Gate/Copco	To be collected 2021	JHS	600	0	600	Bareroot	Spring 2022	1	2	
Calocedrus decurrens	JC Boyle	To be collected 2021	JHS	1,000	300	1,300	Bareroot	Spring 2022	1	2	
Ceanothus cuneatus	Iron Gate/Copco	Sown fall 2020	JHS	15,000	15,000	30,000	Bareroot	Fall 2021	1	2	
Ceanothus integerrimus	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	4,000	18,000	22,000	Bareroot	Spring 2022	1	1	

Table H-6.1: Bare Root Plant Summary and Production Plan - 2020

Species	Reservoir	Seed status	Proposed Vendor	2023 number	2024 number	TOTAL number	Bare root or Container	Sowing Date	Min age of bare root	Max age of bare root	Notes
Cercocarpus betuloides	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	9,100	5,900	15,000	Bareroot	Spring 2022	1	2	
Cercocarpus betuloides	JC Boyle	Collected 2020, stored at JHS	JHS	700	300	1,000	Bareroot	Spring 2022	1	2	
Cornus glabrata	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	1,500	1,500	3,000	Bareroot	Spring 2022	1	1	
Cornus sericea	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	250	250	500	Bareroot	Spring 2022	1	1	
Ericameria nauseosa	Iron Gate/Copco	Collected 2020, more needed	JHS	12,000	6,000	18,000	Bareroot	Spring 2022	1	2	
Ericameria nauseosa	JC Boyle	Collected 2020, stored at JHS	JHS	2,000	1,000	3,000	Bareroot	Spring 2022	1	2	
Ericameria bloomeri	JC Boyle	Collected 2020, stored at JHS	JHS	1,500	0	1,500	Bareroot	Spring 2022	1	2	
Fraxiunus latifolia	Iron Gate/Copco	Sown fall 2020	JHS	700	1,800	2,500	Bareroot	Fall 2020	1	2	
Fraxiunus latifolia	JC Boyle	To be collected 2021	JHS	350	150	500	Bareroot	Fall 2021	1	2	
Juniperus occidentalis	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	0	800	2,600	Bareroot	TBD	2	3	
Lonicera interrupta	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	1,700	6,800	8,500	Bareroot	Spring 2022	1	2	
Pinus contorta var latifolia	JC Boyle	Purchased 2020, stored at JHS	JHS	1,000	500	1,500	Bareroot or 77/170	Spring 2022	2	3	

Table H-6.1: Bare Root Plant Summary and Production Plan - 2020

Species	Reservoir	Seed status	Proposed Vendor	2023 number	2024 number	TOTAL number	Bare root or Container	Sowing Date	Min age of bare root	Max age of bare root	Notes
Pinus ponderosa	Iron Gate/Copco	To be collected 2021	JHS	1,500	1,700	3,200	Bareroot	Spring 2022	1	2	
Pinus ponderosa	JC Boyle	Purchased 2020, stored at JHS	JHS	2,600	1,600	4,200	Bareroot	Spring 2022	1	2	
Prunus subcordata	Iron Gate/Copco	Sown fall 2020	JHS	5,900	3,100	9,000	Bareroot	Fall 2021	1	2	
Prunus subcordata	JC Boyle	Sown fall 2020	JHS	750	750	1,500	Bareroot	Fall 2021	1	2	
Prunus virginiana	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	1,000	1,500	2,500	Bareroot	Fall 2021	1	1	
Prunus virginiana	JC Boyle	Collected 2020, stored at JHS	JHS	600	400	1,000	Bareroot	Fall 2021	1	1	
Pseudotsuga menziesii	Iron Gate/Copco	Purchased 2020, stored at JHS	JHS	800	600	1,400	Bareroot	Spring 2022	1	2	
Pseudotsuga menziesii	JC Boyle	Purchased 2020, stored at JHS	JHS	800	300	1,100	Bareroot	Spring 2022	1	2	
Purshia tridentata	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	8,200	5,800	14,000	Bareroot	Spring 2022	1	2	
Purshia tridentata	JC Boyle	Collected 2020, stored at JHS	JHS	2,500	1,500	4,000	Bareroot	Spring 2022	1	2	
Quercus garryana	Iron Gate/Copco	Sown fall 2020	JHS	0	2,500	2,500	MT2510 pot	Fall 2020	2	3	
Quercus kelloggii	Iron Gate/Copco	Sown fall 2020	JHS	0	900	900	MT2510 pot	Fall 2020	2	3	

Table H-6.1: Bare Root Plant Summary and Production Plan - 2020

Species	Reservoir	Seed status	Proposed Vendor	2023 number	2024 number	TOTAL number	Bare root or Container	Sowing Date	Min age of bare root	Max age of bare root	Notes
Rhus aromatica	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	15,800	10,200	26,000	Bareroot	TBD	1	2	
Ribes cereum	JC Boyle	Collected 2020, stored at JHS	JHS	300	200	500	Bareroot	Spring 2022	1	2	
Ribes velutinum	Iron Gate/Copco	Collected 2020, stored at JHS	JHS	10,800	7,200	18,000	Bareroot	Spring 2022	1	2	
Ribes velutinum	JC Boyle	Collected 2020, stored at JHS	JHS	1,500	500	2,000	Bareroot	Spring 2022	1	2	
Rosa woodsii	Iron Gate/Copco	In strat to be sown spring 2021	JHS	500	500	1,000	Bareroot	Fall 2020	1	2	Requires long winter strat
Rosa woodsii	JC Boyle	In strat to be sown spring 2021	JHS	500	500	1,000	Bareroot	Fall 2020	1	2	Requires long winter strat
Spiraea douglasii	Iron Gate/Copco	To be collected 2021	JHS	600	2,900	3,500	Bareroot	Spring 2022	1	2	
Spiraea douglasii	JC Boyle	Collected 2020, stored at JHS	JHS	700	300	1,000	Bareroot	Spring 2022	1	2	
Philadephus lewisii	Iron Gate/Copco	Collected 2020, stored at FCN	FCN	9,000	1,000	10,000	Bareroot	Spring 2022	1	2	
Philadephus lewisii	JC Boyle	Collected 2020, stored at FCN	FCN	2,250	0	2,250	Bareroot	Spring 2022	1	2	
Physocarpus capitatus	Iron Gate/Copco	Collected 2020, stored at FCN	FCN	1,200	800	2,000	Bareroot	Spring 2022	1	2	
Sambucus nigra	Iron Gate/Copco	Collected 2020, stored at FCN	FCN	0	3,500	3,500	Bareroot	Summer 2021	2	3	Requires long summer strat

Table H-6.1: Bare Root Plant Summary and Production Plan - 2020

Species	Reservoir	Seed status	Proposed Vendor	2023 number	2024 number	TOTAL number	Bare root or Container	Sowing Date	Min age of bare root	Max age of bare root	Notes
Sambucus nigra	JC Boyle	Collected 2020, stored at FCN	FCN	0	500	500	Bareroot	Summer 2021	2	3	Requires long summer strat
Symphoricarpos albus	Iron Gate/Copco	Collected 2020, stored at FCN	FCN	0	3,000	3,000	Bareroot	Summer 2021	2	3	Requires long summer strat
Symphoricarpos albus	JC Boyle	Collected 2020, stored at FCN	FCN	0	1,000	1,000	Bareroot	Summer 2021	2	3	Requires long summer strat
			TOTALS	126,850	119,200	247,850					

Appendix H-7: Nurseries, Seed Cleaners, and Seed Collectors

Table H-7.1 Nurseries, Seed Cleaners, and Seed Collectors

NURSERY	CONTACT	CITY/STATE	FACILITY TYPE	STATUS
Forth Corner Nursery	Dylan Levy-Boyd	Bellingham, WA	Private nursery	No contract yet but seed has been provided to them
J. Herbert Stone Nursery	John Justin or Andrew Colyer	Central Point, OR	USFS facility that only contacts with tribes or other government agencies (local, state or federal)	No contract yet but propagation underway
BFI Native Seed	Matthew Benson	Moses Lake, WA	Private nursery	Active contracts – 2019-2022
Hedgerow Farms	Patrick Reynolds	Winters CA	Private nursery	Active contracts – 2020-2022
Corvallis Plant Material Center	Amy Bartow	Corvallis, OR	USDA facility that only contracts with tribes or other gov entities	They will be storing seed and have a 0.5 acre field in production at no cost
S&S Seeds	Jody Miller	Carpinteria, CA	Private nursery	Currently cleaning seeds from 2020. No contract beyond this year.
Pacific Coast Seed	David Gilpin	Tracy, CA	Private nursery	Remaining seeds collected November 2020. No future contracts.
Bend Seed Extractory	Kayla Herriman	Bend, OR	USFS facility (can only contract with tribes or other government agencies) – seed cleaners, no storage	Provides services as needed

NURSERY	CONTACT	CITY/STATE	FACILITY TYPE	STATUS
Rogue Native Plant Partnership	Kathryn Prive	Southern Oregon	Not a nursery. Seed cleaners, provide connections with local small-scale seed providers and store seed at their facility	Provides services as needed
Siskiyou Biosurvey	Greg Carey	Eagle Point, OR	Botany consultation and seed collection	Provides services as needed

Appendix I

Restoration Technical Work Group

The purpose of the RTWG is to provide agency, tribal, and stakeholder input to inform development of the Reservoir Area Management Plan, final restoration designs, adaptive management strategies, and other restoration-focused actions.

Restoration Technical Work Group Members

- Renewal Corporation Team
    - McMillen Jacobs
    - Camas, LLC
    - RES
    - Stantec Consulting Services Inc.
- Agencies
    - California Department of Fish and Wildlife
    - National Oceanic and Atmospheric Administration
    - Oregon Department of Environmental Quality
    - Oregon Department of Fish and Wildlife
    - Regional Water Quality Control Board
    - State Water Resources Control Board
    - United States Fish and Wildlife Service
- Tribes
    - The Karuk Tribe
    - The Yurok Tribe

Appendix J

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