

# RECLAMATION

*Managing Water in the West*

Technical Report No. SRH-2011-19

## **Reservoir Area Management Plan for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration**

**Klamath River, Oregon and California  
Mid-Pacific Region**



**U.S. Department of the Interior  
Bureau of Reclamation**

**June 2011**

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.



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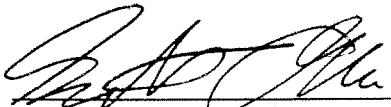
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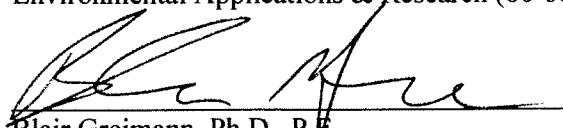
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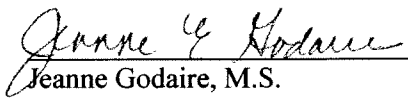
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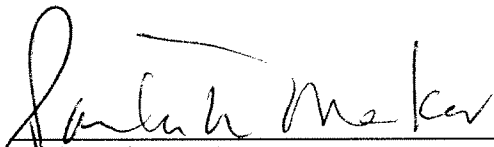
  
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## Executive Summary

PacifiCorp's Klamath River hydroelectric dams have accumulated mineral sediment and organic detritus for decades in four impoundments with a surface area totaling approximately 2,270 acres. If the dams are removed, inundated land will be exposed to surface processes and the areas will require management to meet the intention of the Secretarial Determination and obligations of relevant agreements. This document describes current and anticipated conditions in the reservoir areas after removal of J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate dams on the Klamath River. It also describes the management plan of the three reservoir areas of J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. Copco No. 2 is a relatively small dam located in a steep canyon and there will not be a significant area exposed to surface processes. It does not describe the impacts associated with Dam Removal to the downstream channel and does not detail the simulation of the reservoir drawdown and associated reservoir erosion. More detailed analysis of the surface water hydrology, groundwater hydrology, hydraulic conditions, and sediment transport if the dams were to remain in place (No Action Alternative) and if the dams were to be removed (Dam Removal Alternative) are presented in Reclamation (2011b). The construction aspects of dam removal are presented in Reclamation (2011a).

There will be several stages of reservoir response while the reservoir pool is lowered and after dam removal. Each reservoir has unique characteristics that will result in unique behaviors, but generally, they can be described by a series of seven processes. Each process will operate to various degrees in each reservoir depending on the current deposit thickness, the reservoir geometry, and vegetation types and distribution.

1. Erosion of reservoir deposits during drawdown. The deposits are highly erodible and any significant velocity will wash away the reservoir deposit. Erosion will concentrate where depth is greatest, and old river channels are expected to reestablish. There will be large portions of thin reservoir deposits remaining on the river terraces that are not near the active channel.
2. Slumping of deposit toward river channel due to limited shear strength of deposit and draining of water in the pore spaces of the deposit. Deposit slumping will occur as long as the downslope force of deposit self weight and the force of the draining water exceeds the shear strength of the deposit. Initially, after drawdown the reservoir deposit will have very low shear strength. The slumping of reservoir deposits is expected to be focused around the margins of the channel and limited in scope. The initial slumping process is expected to occur during the drawdown period from January to May under all scenarios.

3. Drying, consolidation, cracking and hardening of reservoir deposit. After the initial slumping and draining of excess water, the deposit will begin to dry as the result of evaporation. The remaining deposits will reduce in volume by approximately 2/3 and the thickness will decrease by about 1/3. Cracks will appear and the deposit will harden significantly. The drying process is expected to occur in the spring or early summer depending upon the balance of rain and evaporation rates. The resistance to erosion will increase markedly during this period, progressing from highly erodible to very resistant to erosion. Because of the cracking, some erosion will continue to occur as the result of gully formation during rainstorms. Erosion is expected during limited rain events and will not continue during other periods.
4. Establishment of herbaceous vegetation in reservoir areas. The reservoir areas will be revegetated with various native herbaceous species (grasses) following drawdown in the spring, allowing plants to take advantage of residual soil moisture and prevent soil surface hardening from impeding establishment. Grasses on upland slopes will serve to stabilize the surface of the deposit and minimize erosion. Herbicides and mechanical control methods will be necessary during this period to manage the growth of invasive species.
5. Erosion of floodplain deposits during subsequent rain storms and high flows. Erosion of floodplain deposits will occur during rainstorms as the rainfall exceeds the infiltration capacity. The erosion process will be focused during the rainstorm event and quickly subside as the infiltration capacity of the soil is no longer exceeded and runoff ceases. High flows in the Klamath River that exceed bank elevations will cause erosion of remaining deposits. This process is mostly dependent upon the storm sequence that occurs during drawdown and in the subsequent years. If the flows during drawdown are relatively low, there will be more deposits remaining along the channel margins and if the flows are high the following year, significant bank widening may occur. If the flows are high during drawdown, very little bank erosion is expected to occur in subsequent years because there will be less deposits remaining near the banks of the river.
6. Establishment of woody species along riparian corridor and from seed source along reservoir rim. Various native woody species will be planted along the channel margins to improve long-term fish habitat and to increase bank stability following drawdown. The establishment of woody species will take several years. Natural recruitment of trees and other woody species from seed sources along the reservoir rim is also expected.
7. Gradual weathering of reservoir deposit due to physical and biological processes. The dried reservoir deposits are relatively resistant to erosion,

but there are many physical, chemical, and biological processes that will begin to break them down and develop soil structure. The weathering process is beneficial and will encourage the establishment of native vegetation.

A multi-disciplinary team developed a list of goals and objectives as stated in Table 1. The goals were written to incorporate the list of interdisciplinary objectives, and to create a framework for articulating, prioritizing, and planning a potentially large and complex suite of projects that may conflict with other objectives. They were organized by time period relative to construction.

Table 1. Compiled goals, objectives, and potential projects for managing the reservoir areas.

<b>Period</b>	<b>Goal</b>	<b>Objective</b>	<b>Potential Project</b>
<i>Pre-construction period:</i>	Control invasive weeds, and eliminate the invasive seed bank.	Reduce and minimize the local sources of invasive weeds.	A weed management program implemented under KBRA and with County involvement
<i>Construction-period: (0 to 1 year)</i>	Natural erosion of reservoir deposits, transport via the river, dispersal in the ocean.	Maximize erosion of reservoir deposits during drawdown	Allow erosion of deposit during reservoir drawdown. Do not stabilize reservoir deposit.
<i>Short-term: (1-5 years after dam removal.)</i>	Limit windblown dust and surface erosion from reservoirs. .	Less than 25% of the reservoir areas will be exposed to erosion.	Active planting of native grasses and other species.*
	Establish native vegetation.*	75% of the reservoir areas will have native vegetation cover.	Active planting of native grasses and other plant species.*
	Control invasive weeds on exposed areas.	Maintain vegetative cover at less than 5% for weed species.	Apply herbicides the first year following dam removal. Monitoring and management of weeds in subsequent years.
	Produce habitat along riparian edges for salmonid smolts.	Establish a Minimum of 400 live shrub or tree species per acre within riparian-bank areas.	Active planting of native shrub and tree species within riparian-bank areas.*

<i>Mid-term: (5-10 years).</i>	Fish habitat within reservoir reaches similar to reaches found u/s or d/s.	Spawning and rearing habitat performing within 25% of similar u/s or d/s habitats.	Passive rehabilitation of riffles and pools. Natural resupply of gravel to reservoir reaches.
<i>Long-term: (10-50 years.)</i>	Establish sustainable riparian and fish habitat	No significant maintenance required to sustain fish habitat	Monitor vegetation growth along riparian corridor. Limit encroachment into riparian corridor.

\* Native and genetically appropriate planting materials from local sources to be used if feasible.

Based upon the stated objectives, a list of potential projects was developed:

1. Passive erosion of sediment during drawdown
2. Weed management around the reservoir areas prior to dam removal;
3. Active re-vegetation of reservoir areas with native grasses immediately after reservoir drawdown;
4. Application of herbicides to further limit invasive species;
5. Planting of woody riparian species along the river banks in the reservoir areas; and
6. Monitoring of vegetation growth and additional planting to ensure objectives are accomplished.

Prior to dam removal, the seed material will need to be cultivated, preferably from local sources. This may need to be initiated several years prior to to obtain sufficient quantities of seed material. An active weed management program in areas above the reservoirs will be initiated several years prior to dam removal. If the invasive species are not controlled above the reservoirs, it may not be possible to produce desirable revegetation within the reservoirs, regardless of the initial success of the revegetation project.

Drawdown will begin at all three reservoirs January 1, 2020 and will be complete by Mid March for all three reservoirs during a median type of water year. Barge hydroseeding of the upland areas will be performed on Copco and Iron Gate reservoir during the drawdown beginning January 1, 2020. Once the reservoirs are drawn down below a specified elevation, the barges will be removed. Ground and aerial based hydroseeding of the remaining reservoirs areas will be performed once drawdown is complete in mid March,. The spring reseeding is expected to be complete by the end of March. If it is a wet year, the hydroseeding at Iron Gate will be delayed because of the possibility of reservoir refilling. Because Copco No. 1 Dam is being notched, there is no risk of reservoir refilling.

In the fall of the same year, herbicides will be applied to the reservoir areas as needed to control invasive species. Fall reseeding of failed upland revegetation



zones will be performed, potentially on an extensive scale. It is assumed that up to 75% of the upland areas will need to be re-vegetated.

In the spring of 2021, the riparian zones will be planted with native riparian woody tree and shrub cuttings and transplants. This will also be the first of four more years of monitoring of the reservoir areas to ensure revegetation success, maintenance of invasive weeds, and, if necessary, revegetation of select areas that have failed and reapplication of herbicides to control invasive species.



# **1 Introduction**

The Klamath Hydroelectric Settlement Agreement (KHSA) was completed in February 2010 for the express purpose of resolving the pending Federal Energy Regulatory Commission (FERC) relicensing proceedings by establishing a process for potential Facilities Removal and operation of the Project until that time. The KHSA addresses the proposed Secretarial Determination whether to proceed with Facilities Removal, defined as the “physical removal of all or part of each of the Facilities to achieve at a minimum a free-flowing condition and volitional fish passage, site remediation and restoration, including previously inundated lands, measures to avoid or minimize adverse downstream impacts, and all associated permitting for such actions.” The Facilities were defined as the “specific hydropower facilities, within the jurisdictional boundary of FERC Project No. 2082: Iron Gate Dam, Copco No. 1 Dam, Copco No. 2 Dam, and J.C. Boyle Dam, and appurtenant works currently licensed to PacifiCorp.” “Decommissioning” was defined as the physical disconnection of the facility from PacifiCorp’s transmission grid, and the removal from a facility of any equipment and personal property that PacifiCorp determines has salvage value.

PacifiCorp’s Klamath River hydroelectric dams have accumulated mineral sediment and organic detritus for decades in four impoundments with a surface area totaling approximately 2,270 acres. The inundated land will be exposed to surface processes if the reservoirs are drawn down and removed, and the areas will require management to meet the intention of the Secretarial Determination and obligations of relevant agreements. This document describes current and anticipated conditions in the reservoir areas after J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate on the Klamath River are removed. It also describes the reservoir management plan of the three reservoir areas of J.C. Boyle Reservoir, Copco Reservoir, and Iron Gate Reservoir. Copco No. 2 is a relatively small dam located in a steep canyon and there will not be a significant area that will be exposed to surface processes. Copco Reservoir in this document will only refer to Copco No. 1 Reservoir in this document. This document does not describe the impacts associated with Dam Removal to the downstream channel and does not detail the simulation of the reservoir drawdown and associated reservoir erosion. More detailed analysis of the surface water hydrology, groundwater hydrology, hydraulic conditions, and sediment transport if the dams were to remain in place (No Action Alternative) and if the dams were to be removed (Dam Removal Alternative) are given in Reclamation (2011b). The detailed engineering plans of dam removal are given in Reclamation (2011a).

The central purpose of this report is to define the reservoir management actions necessary to accomplish defined goals for the reservoir area. The basic outline for this report is:

1. description of the current geomorphic, deposit, and vegetative characteristics of the Klamath reservoirs;

## **1 Introduction**

2. summary of the reservoir conditions after dam removal;
3. statements of the goals and objectives for each discipline area; and
4. project proposals that meet the future conditions goals after dam removal that are sufficiently detailed to allow for cost estimation.
5. preliminary plan of reservoir management activities.

## **2 Setting**

The reservoirs are located in a mid-basin setting between the Basin Range and High Cascades geologic provinces, in various volcanic rock formations. An overview of the Klamath Basin is shown in Figure 2-1. The reservoirs are located downstream of Upper Klamath Lake (UKL) and the most downstream reservoir are located 190 miles upstream from the Pacific Ocean. The slope of the Klamath River upstream from the reservoirs is smaller than the slope downstream from the reservoirs (Figure 2-2). This river profile is generally the opposite in most watersheds, where the headwaters are steeper and the channel flattens downstream.

The reservoirs have stored relatively fine-grained incoming sediment and organic material for decades. Recent bathymetric mapping shows the deposits are relatively uniformly thick throughout the reservoirs and of similar composition. Material properties tests on the deposits show that they are low density, high water content, and low in cohesion and strength. Given these conditions, it is anticipated that the majority of the deposits will mobilize during reservoir drawdown and during winter storms, and the river will quickly regain its former channel (for details, see Reclamation, 2011b).

There are large areas around the reservoir rims currently dominated by invasive weeds. Managing invasive plants is considered critical to meeting many of the management objectives (see Appendix B) for the reservoir areas. Invasive plant will likely overtake the upland areas of the reservoir areas without active site management. Recent germination tests found that viable native seeds of wetland species exist in the reservoir deposits, and that these may establish in the riparian and wetland areas near the river channel. Details of germination analysis are discussed in Section 4.3 of this report.

## 2 Setting

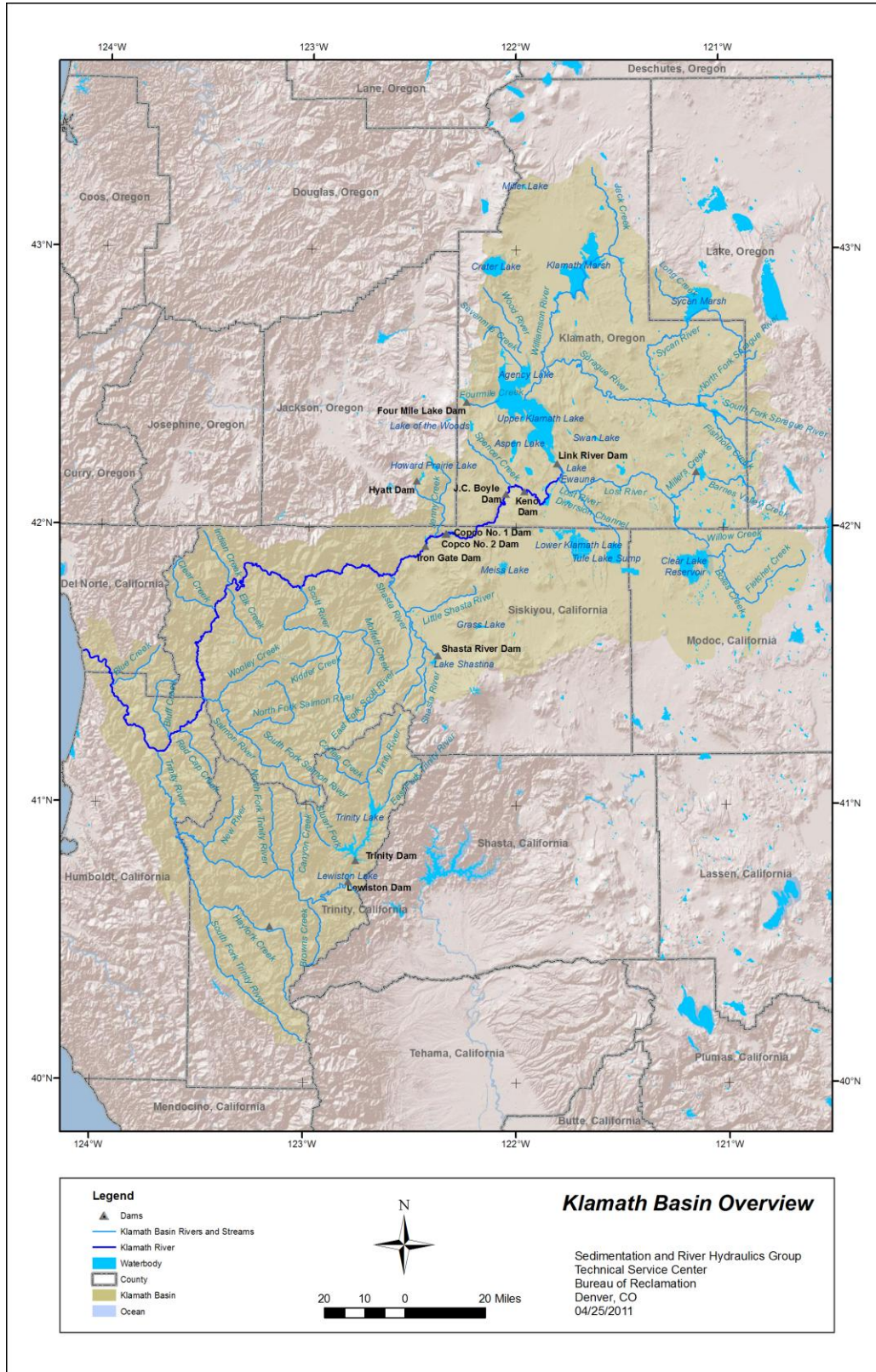


Figure 2-1. Klamath Basin overview.

## 2 Setting

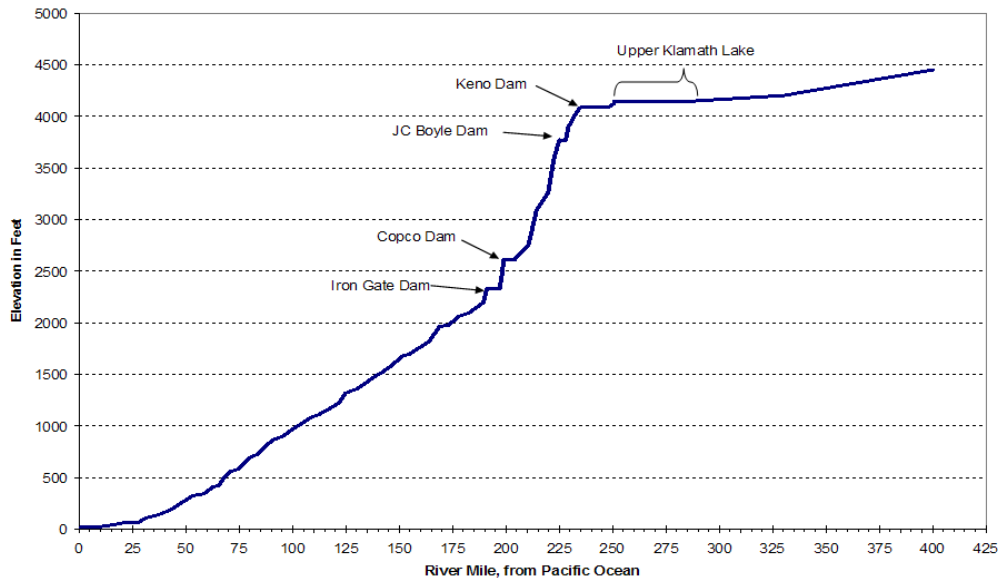


Figure 2-2. Slope of the Klamath River from Upper Klamath Lake to the Pacific Ocean. Note the gentle slope upstream from the reservoirs compared to the slope downstream. This is opposite of most watershed settings and is important context for the production of deposits stored in the reservoirs, as well as the transport of deposits by the river if released upon dam removal.

### 2.1 Geologic Setting

The geomorphic provinces along the Klamath River have a diverse geologic history of formation and deformation. In the upper watershed, from the Klamath Basin headwaters to Iron Gate Dam, the Basin and Range and Modoc Plateau geomorphic provinces have a physiography with subdued relief, low gradient streams, broad basins and many lakes and marshes. The Basin and Range province consists of Miocene age basalts with high permeability and internally drained basins. The ranges are block-faulted with intervening down dropped basins typical of the Basin and Range province in other areas. The Modoc Plateau Province consists of thick sequences of tuffs and basalt flows that form a relatively flat tableland physiography in part of the province. The region was extensively faulted during the late Miocene, forming a series of mountain ranges. Drainage systems were also disrupted, creating lakes in between the ranges. Quaternary age shield volcanoes and cinder cones also are common on the landscape and younger than the extensive basalt flows.

The Lower Klamath Basin, from Iron Gate Dam to the Klamath River mouth, consists of metamorphic and plutonic rocks that have a complex history of metamorphism and volcanism. Geomorphic provinces include the Cascade Range, Klamath Mountains, and Northern Coast Ranges. The Cascade Range Province consists of the Western Cascade and High Cascade volcanics. The western cascade rocks were formed during uplift and folding during the late Eocene to

## **2 Setting**

Pliocene. They include lava flows and pyroclastics and in places interbedded nonmarine and shallow marine sedimentary rocks. The composition of most of the rocks is andesitic, but ranges from olivine basalt to rhyolite. They are underlain by Eocene sedimentary rocks of the Hornbrook Formation or by pre-Cretaceous plutonic and metamorphic basement rocks. The Cretaceous Hornbrook Formation has about a 5,000-ft thickness near the California-Oregon border in the Hornbrook area and consists of conglomerate, sandstone, and siltstone. The High Cascade Range rocks overlie the Western Cascade rocks and are part of a time period of renewed volcanism, in which early flows in the group produced wide spreading flows and small shield volcanoes and fissures, being more basaltic. Later flows became more siliceous in composition, and thus, were more explosive, building large peaks in the Cascade Range.

The Klamath Mountains Province consists of rocks uplifted during the Nevadan orogeny in Late Jurassic time. These rocks are more resistant to weathering, and thus, form a major change from low-relief terrain to high-relief terrain with prominent peaks and ridges along the Klamath River near Cottonwood Creek. Rocks range in age from Ordovician to Late Jurassic and form a series of arcuate belts that are defined on the basis of lithology and have varying degrees of metamorphism. They include the Eastern Klamath belt, central Metamorphic belt, Western Paleozoic and Triassic belt and the Western Jurassic belt. The belts developed as accreted terranes during tectonic episodes of subduction along the continental margin.

Near the mouth of the Klamath River is the Northern Coast Range, which consists of a thick sequence of Mesozoic and Cenozoic sedimentary rocks that were deformed during the Cenozoic. Along the Klamath River, rocks of the Franciscan Formation dominate the landscape and are composed of metasedimentary and metavolcanic rocks as well as mélangé, which form a hummocky landscape due to its tendency to develop landslides.

## **2.2 Geomorphology of the Reservoir Areas**

Aerial photographs, maps, and predam records of land use, and other information were compiled to assess the geomorphic setting of the reservoirs before they were inundated (Reclamation, 2011b). Geomorphology of the reservoir areas is delineated based on historical aerial photography and topographic maps that were rectified by PacifiCorp (2004), Eilers and Gubala, Inc (2003). Predam reservoir photographs were available for Iron Gate and J.C. Boyle reservoirs. A predam topographic map of Copco Reservoir was available in which historical stream channels, wetland areas, springs and side channels were mapped in the reservoir.

### **2.2.1 J.C. Boyle**

At J.C. Boyle Reservoir, pre-dam aerial photography from 1952 shows a flow expansion zone at the upper end of the reservoir where the river exits from a steep, narrow canyon with multiple rapids or riffles visible on the aerial photography. The river flows west, and then turns abruptly to the south as it



## 2 Setting

encounters bedrock and alluvial fan deposits from an unnamed tributary. A large pool is formed at this location and is evident in the bathymetric data collected in the reservoir area. Channel morphology was mostly single thread, with an area of split flow around a semi-vegetated island upstream of the Highway 66 Bridge and a few small side channels in the reach (Figure 2-3). From RM 228 to 226, the river corridor is wide enough to preserve some alluvial surfaces. Spencer Creek enters from the north and forms a large alluvial fan that extends to the river channel with, perhaps, a narrow floodplain surface cut on its edge. The tributary channel was multi-threaded in 1952 and probably supported wetland environments near its confluence with Klamath River. Downstream of Spencer Creek, extensive terrace surfaces less than 5 feet above the river channel were located on the left and right banks. Portions of these surfaces may be unvegetated bars that were modified frequently during larger peak discharges; however, the surfaces appear to be modified in 1952 photography and could not be delineated. It is likely that trees were removed prior to filling of the dam.

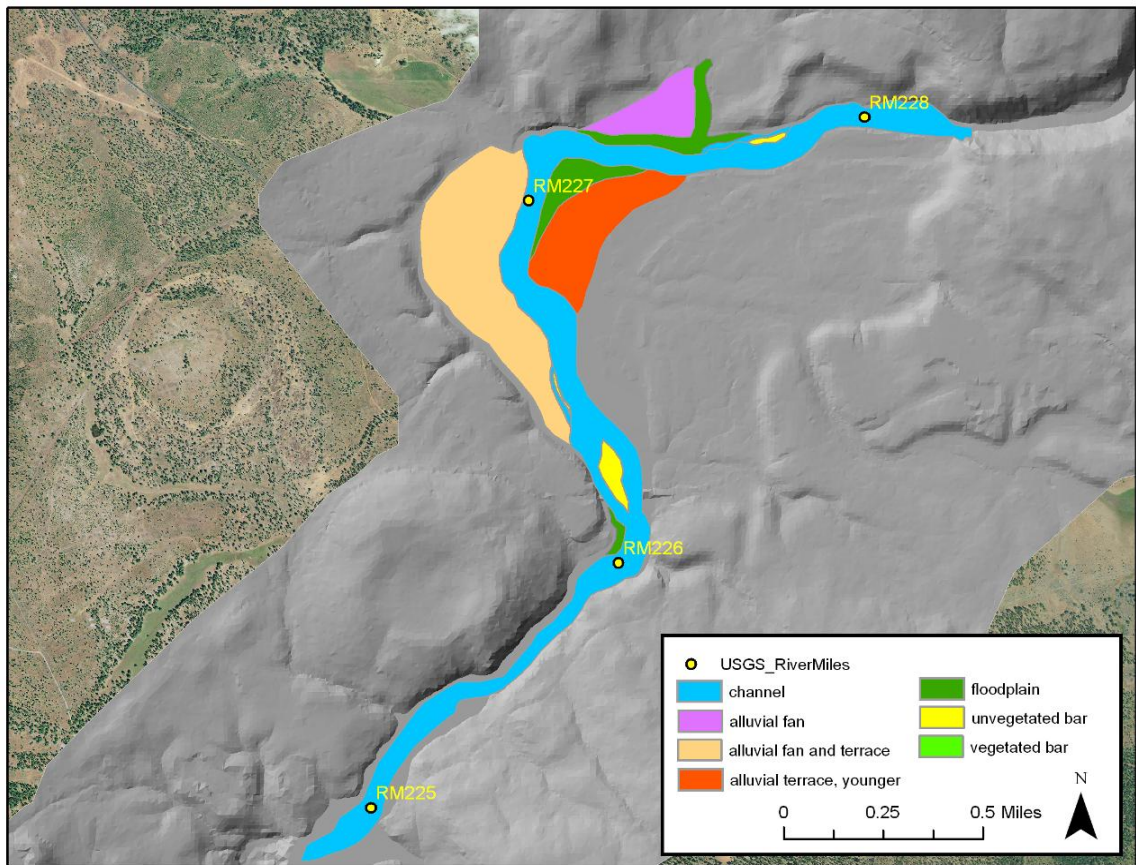


Figure 2-3. Geomorphic map of JC Boyle Reservoir.

### 2.2.2 Copco

Pre-dam geomorphology was interpreted using historical topographic maps of the reservoir area that were developed prior to inundation (see Appendix A). The

## 2 Setting

historical channel through Copco Reservoir consisted of asymmetrical meanders, controlled by bedrock on the outer bends. Deep pools were probably located in these bends; a couple of pools can still be observed in bathymetric data in the SW1/4 of section 27 and in the NW1/4 of section 35. In the upper portion of the reservoir from the high pool to about USGS RM 200, the channel was a mostly single-thread, sinuous channel with broad asymmetrical meanders. Terraces were located along most of the reach, and were mostly 5-10 feet above the river channel, which would correspond to the younger terrace in reaches mapped outside of the reservoir areas. Also, there were areas designated with willow and brush vegetation, which could correspond to either floodplain areas or young alluvial terraces.

Between RM 200 and 199, the channel is more sinuous, perhaps due to the canyon constriction which begins near Copco 1 Dam. In this location, pyroclastic flows blocked the drainage, forming an ancient lake in the vicinity of Copco Reservoir. In this reach, the channel contained a greater number of vegetated islands, some abandoned channel meanders, and wetland or floodplain environments. Most surfaces in the reach were less than 5 feet above the river channel based on historical topography. A few terraces of 5-10 feet and 15-20 feet also exist in the reach, but are more limited in extent. A notable paleochannel, which was abandoned by the Klamath River prior to the historical period, is now partially occupied by Beaver Creek that enters Klamath River from the north. Downstream of RM 199 to the high pool of Iron Gate Reservoir, the Klamath River enters a narrow canyon incised into the pyroclastic deposits of the High Cascade Volcanics; only a few narrow terraces exist in this reach. See Figure 2-4

## 2 Setting

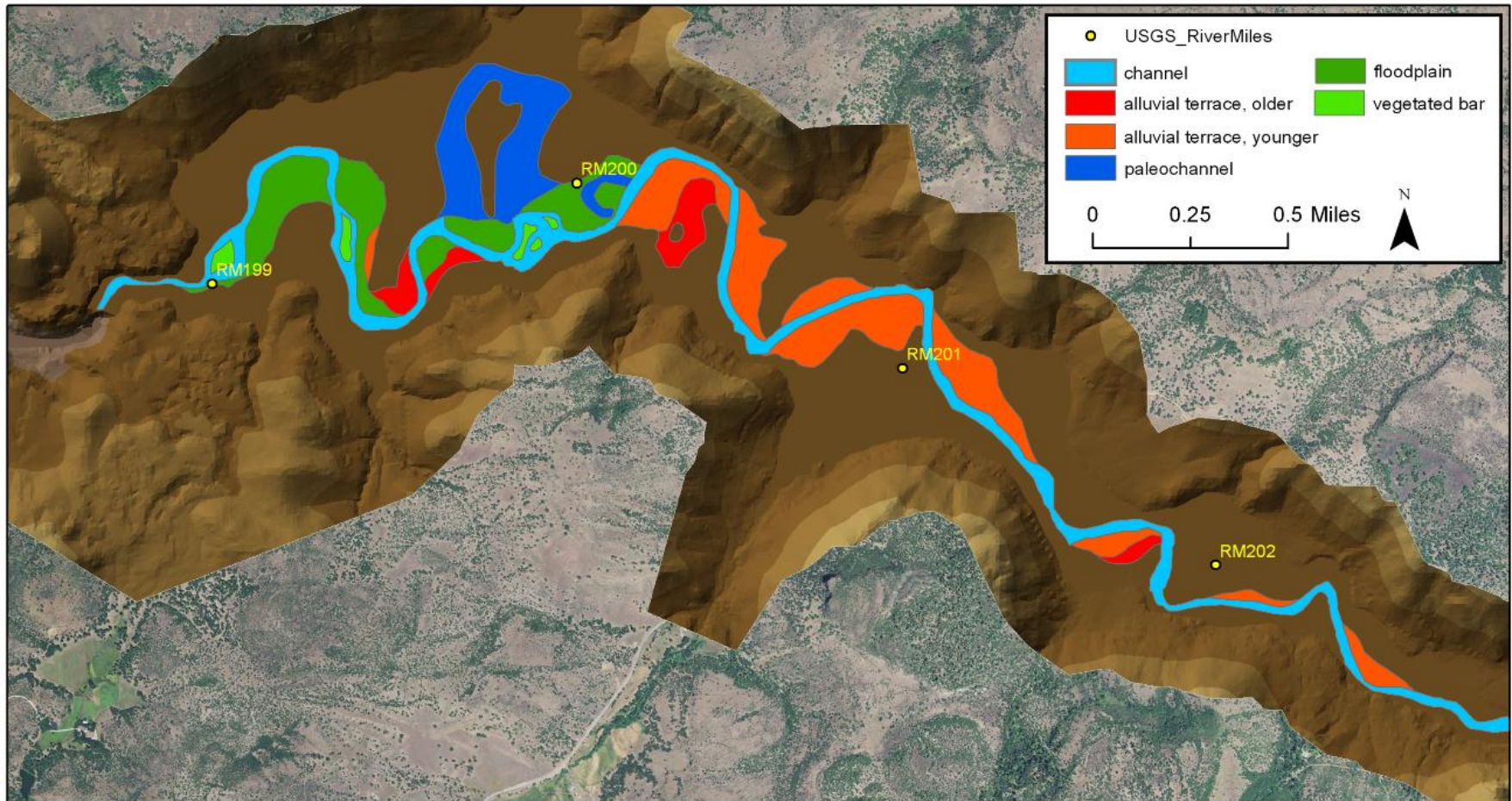


Figure 2-4. Geomorphologic map of Copco Reservoir.



## **2 Setting**

### **2.2.3 Iron Gate**

The reach of the Klamath River through Iron Gate Reservoir consists of a confined bedrock canyon formed in andesite of the Western Cascade Volcanics. Based on 1955 aerial photography and pre-dam topography, terraces were located along the insides of meander bends and near tributary confluences and were typically less than 10 feet above the river channel based on the 10ft contours on the topographic map (Figure 2-5). These surfaces would correspond to younger terraces mapped in adjacent reaches without reservoirs and therefore would consist of an organic-rich, sandy surface horizon with gravelly materials below the surface horizon. Tributaries along this reach had mostly minor alluvial fans at their confluences with the Klamath River, likely indicating that the Klamath River was readily able to erode material deposited by tributaries in the main channel. A few alluvial fans exist that controlled the historical river position along this reach, but these are limited in extent.

Historical channel morphology is single thread with uncommon split flow areas and vegetated islands. A few unvegetated gravel bars are also visible in the 1955 aerial photography. Channel constrictions are located near RM 195 and 196, where large pools are formed behind the narrowed channel. It is likely that bedrock was visible in at least part of the channel bed in these locations. The presence of visible riffles in 1955 aerial photography indicate steeper reaches with higher velocities from RM 194 to RM 192 and from RM 197 to RM 195. Other reaches such as from RM 192 to Iron Gate Dam have riffles located near tributaries or gulches that contribute large sediment to the river, but for the most part likely contained pools or lower velocity sections.

## 2 Setting

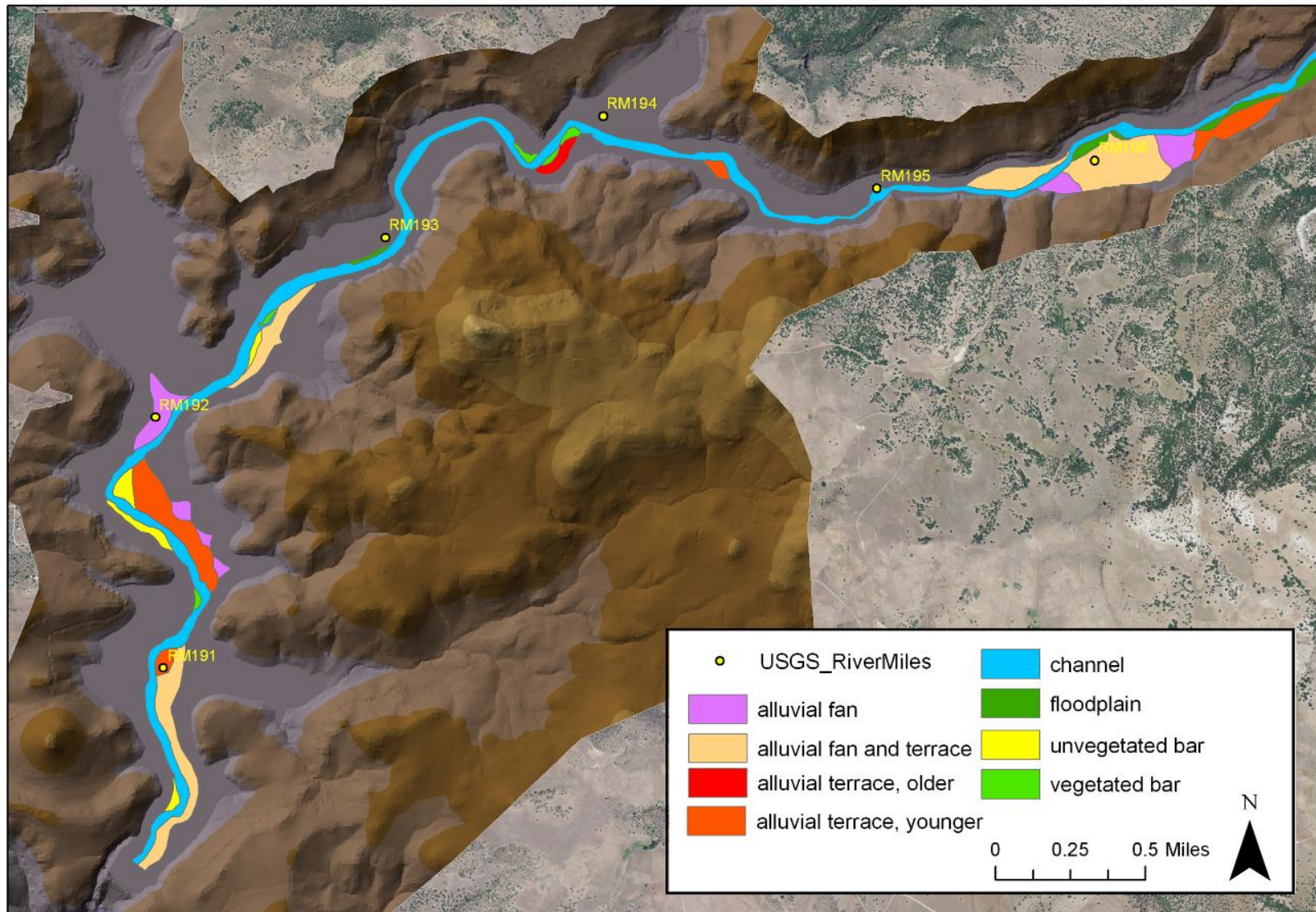


Figure 2-5. Geomorphic map of Iron Gate Reservoir.

### 2.3 Reservoir Deposits

A detailed reservoir investigation is documented in Reclamation (2010) and relevant results are summarized here. Previous reservoir investigations were performed by J.C. Headwaters, Inc. (2003), and Shannon and Wilson (2006).

Deposits in the reservoirs were characterized by soil properties, grain size, desiccation properties, and critical shear stress. The soil properties, including grain size and critical shear stress, were determined from field sampling and laboratory testing.

Field investigations were conducted at J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate dams/reservoirs, and in the Klamath River Estuary including about seven miles upstream from the mouth of the river. Maps of the reservoir and the sample site locations are given at the end of this section in Figure 2-6, Figure 2-7, Figure 2-8 for J.C. Boyle, Copco 1, and Iron Gate reservoir, respectively. Phase 1 of the geologic investigations included in-reservoir drilling to obtain comprehensive suites of samples of reservoir deposits (Qr) behind each dam. There were three main purposes for this work:

1. To collect samples for screening-level analysis of organic and inorganic chemical compounds within the reservoir deposits and, where present, to determine the level and extent of contamination.
2. To collect samples of reservoir deposits to determine a standard suite of physical properties and to collect undisturbed samples for analyses of engineering properties.
3. To help determine the thickness of reservoir deposits throughout all major sections of each reservoir.

The in-reservoir geologic investigations consisted of:

- Barge and boat platforms for Auger Drilling and Sampling
- Barge and boat platforms for Push Tube Sampling
- A boat platform for Vibracore Drilling and Sampling
- A boat platform for Gravity Tube Sampling

Barge and boat-supported drilling/sampling took place at fifty-five locations in J.C. Boyle, Copco No.1, and Iron Gate reservoirs. Sixty-nine samples of reservoir deposits and pre-reservoir sediments were collected for gradation analysis, Atterberg limits, and field moisture content; seventy-three samples were collected for chemical analysis; and nineteen undisturbed samples were collected in Lexan

## **2 Setting**

liners for engineering properties, such as shear strength, testing. In Copco No. 2 Reservoir, boat-supported sampling was performed at sixteen locations, from the dam upstream for about 1,000 feet.

Fine-grained material in all of the reservoirs consisted primarily of Elastic Silt (MH), with lesser amounts of Elastic Silt with Fine Sand. The reservoir deposits are mostly an accumulation of silt-size particles of organic material, such as algae and diatoms, and silt-size particles of rock loosely arranged in an open water-filled structure. Reservoir deposits host a higher percentage of silt, sand, and gravel in the upper reaches of each reservoir. From the upper reaches to several thousand feet downstream, this coarse sediment transitions into sandy elastic silt, and then into elastic silt with trace sand.

Fine-grained material (elastic silt) throughout all the reservoirs has the consistency of pudding. The material captured in the sample tubes was very soft and indented with very light finger pressure. At 6 to 10 feet in the sample tubes, the material firmed up a little. On a microscopic scale, it has an open structure that holds a very high water content. Field moisture of samples of Elastic Silt were frequently 200% to 300% of the sample's dry weight, and ranged up to 700% moisture. Most reservoir material, having this high water content, that remains after the initial stage of dam removal, will take some time to dry out.

Fine-grained reservoir material has a low cohesion and is highly erosive. In each reservoir, fine-grained material was thinnest in the upstream portion of the reservoir and thickest near the dam. Reservoir material was also thin to nonexistent in narrow channels of the reservoirs where water flow was greater than an estimated 2 to 4 miles per hour. This was attributed to the material either remaining in suspension or eroding from the active channel, or both.

These investigations demonstrated that deposition throughout all four reservoirs follows well-understood principals of geology and of fluvio-lacustrine sedimentation. Although the reservoir deposits are predominantly dead algae, geologic investigations did not encounter unusual characteristics or unique depositional environments requiring special consideration or explanations.

Methane gas is currently trapped in deposits behind each dam and this gas will escape during reservoir drawdown. A screening-level determination for all potential contaminants within the reservoir sediments is to be made by Reclamation in separate reports.



## 2 Setting

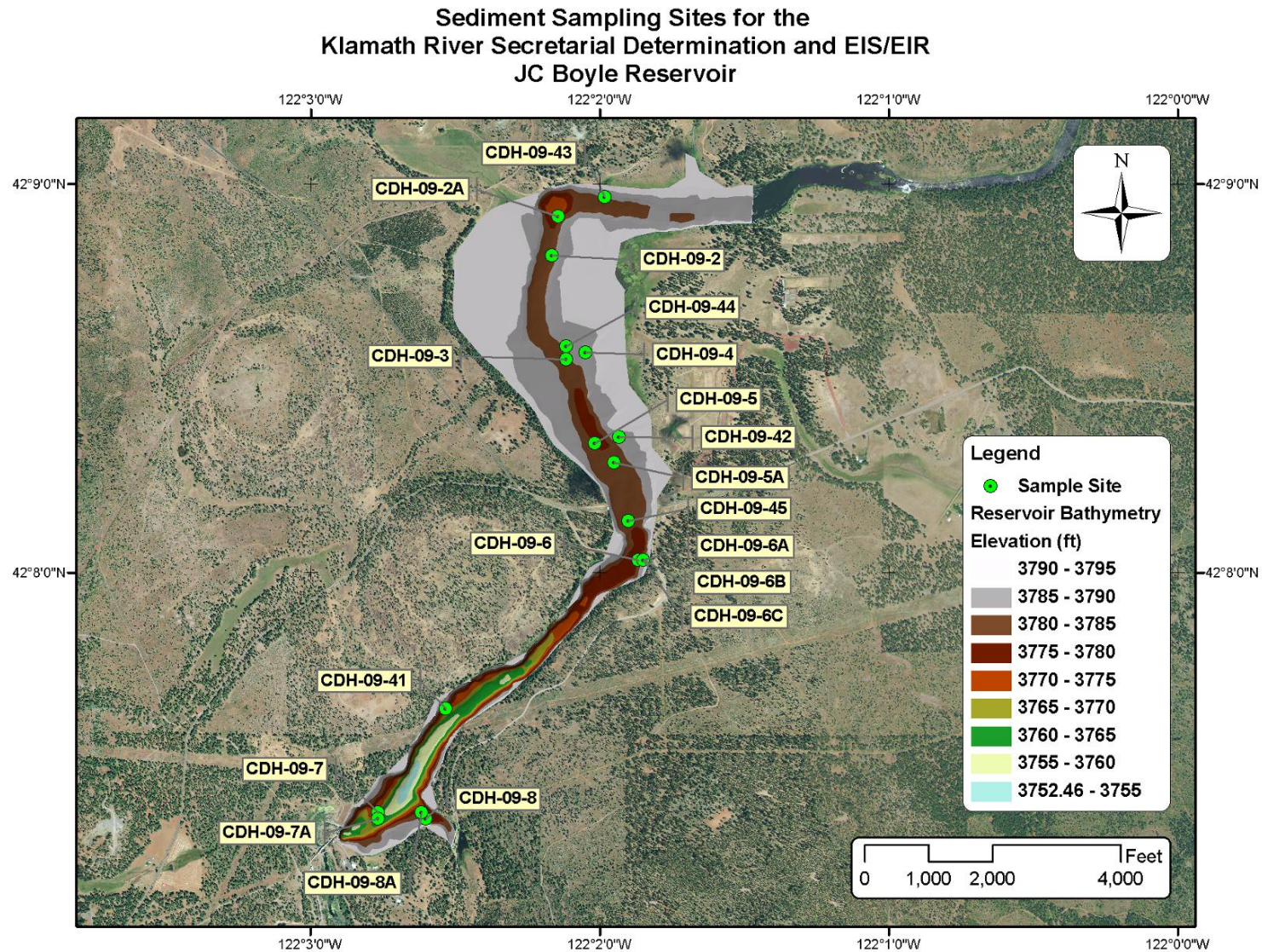


Figure 2-6. Bathymetry of JC Boyle and 2009 Drill Hole Locations.



## 2 Setting

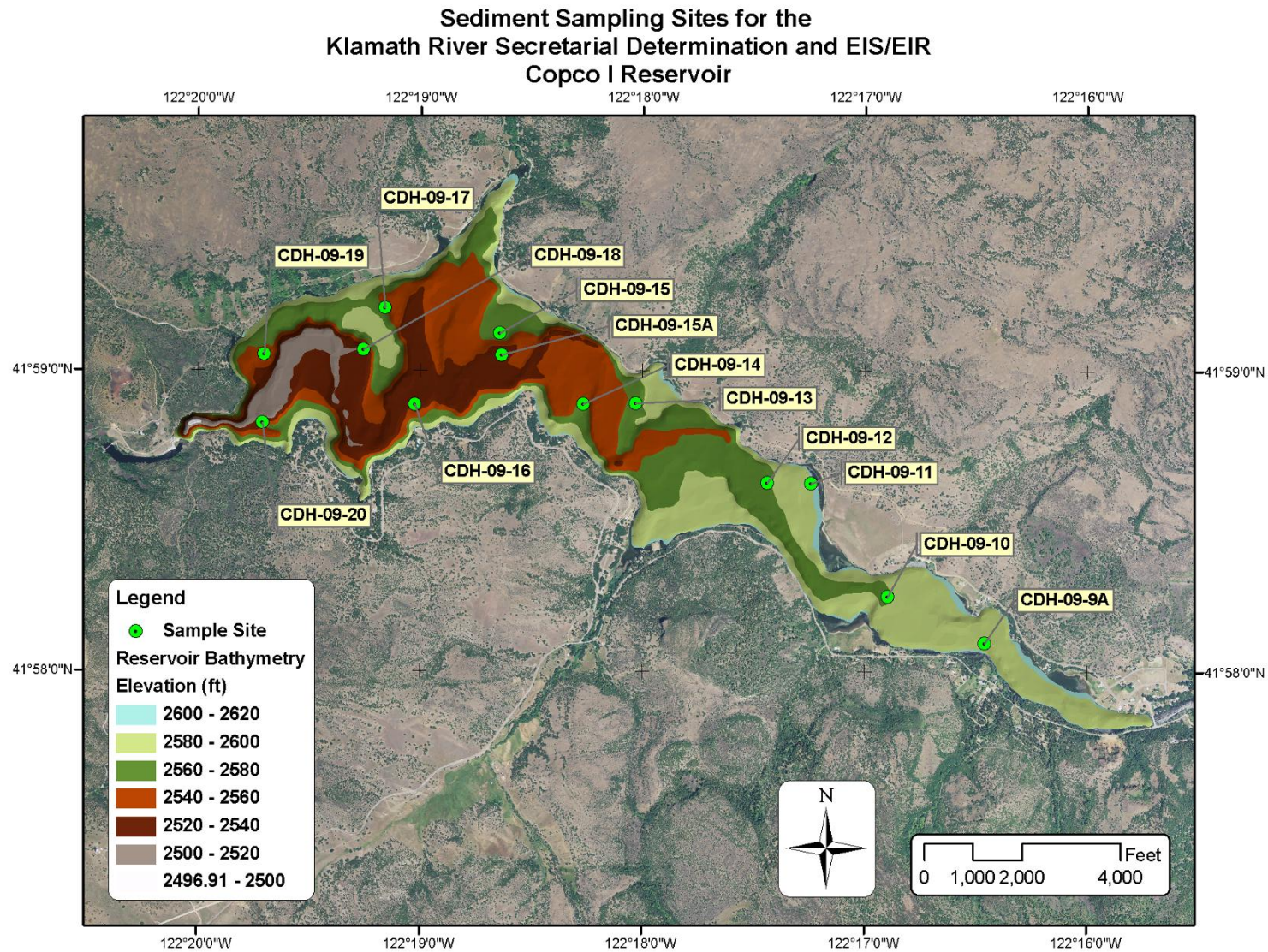


Figure 2-7. Bathymetry of Copco 1 and 2009 Drill Hole Locations.



## 2 Setting

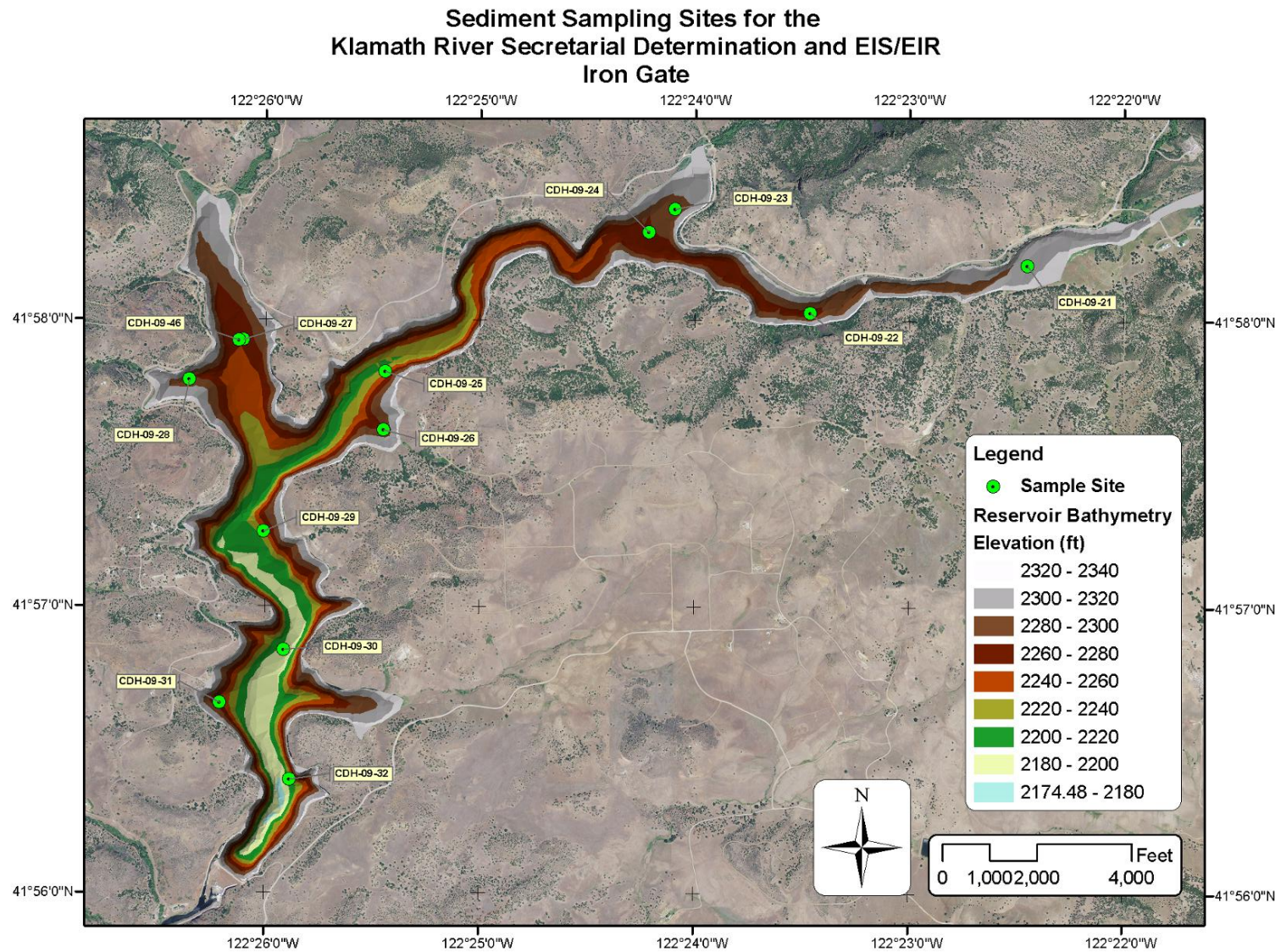


Figure 2-8. Bathymetry of Iron Gate and 2009 Drill Hole Locations.

**2.3.1 Deposit Volume and Thickness**

There were two previous estimates of the reservoir deposit volumes. JC Headwaters, Inc. (2002) performed a bathymetric survey of J.C. Boyle, Copco No. 1, and Iron Gate reservoirs. JC Headwaters, Inc. (2002) then computed the relationships between reservoir water storage volume and water elevation. These were compared against the historical relationships based upon the pre-dam survey of each reservoir. The difference at full pool between the historical storage volume and the current storage volume was assumed to be the volume of deposition. GEC (2006) estimated the deposit volume based on the difference between pre-dam topographic surveys and the bathymetric survey of JC Headwaters, Inc. (2002). The results of the two methods are given in Table 2-1.

Table 2-1. Previous reservoir deposit volume estimates.

	<b>Reservoir deposit (yd<sup>3</sup>)</b>			
<b>Study</b>	<b>J.C. Boyle</b>	<b>Copco No. 1</b>	<b>Copco No. 2</b>	<b>Iron Gate</b>
GEC (2006)	636,000	10,870,000	None	8,767,000
JC Headwaters, Inc. (2003)	22,222	9,629,000	None	4,818,000

Shannon and Wilson (2006a), as part of the GEC 2006 report, collected samples to characterize the physical and chemical properties of the deposits trapped behind the reservoirs. The reservoir deposit thickness was recorded at 26 sites in JC Boyle, Copco 1, and Iron Gate reservoirs.

A limitation of the previous studies is that they relied upon the pre-dam surveys for estimating deposit volumes. At Copco 1, the pre-dam contour interval was 5 ft. At Iron Gate and JC Boyle, the contour interval was 10 ft. The reservoir deposit thicknesses were generally less than 10 ft at Copco, less than 5 ft at Iron Gate and less than 20 ft at JC Boyle. Because the deposit thicknesses were generally on the order of the contour interval, the estimates of the thickness through differencing of surveys are inaccurate. A more direct way to estimate the deposit thicknesses is to rely upon the drill holes, which are direct measurements of the deposit thickness at that location. Given the large sample of bore-holes now available, those data were extrapolated to the entire reservoirs to create deposit thickness maps. More details on the analysis of reservoir volume is found in Reclamation (2011b).

**JC Boyle**

The deposit thickness at JC Boyle was determined by combining deposit sample information with field observations. In the upper portions of the reservoir, little or no deposit was found during drilling except in one bend of the historical stream

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channel. An estimate of the extent of deposition was drawn approximately on the map to encompass the drill holes where the deposit was sampled. It was found that deposition was limited to the historical stream channel.

In the lower portion of the reservoir, the deposit samples were used to determine the thickness. Figure 2-9 shows the map of reservoir thickness and the 2006 (Shannon and Wilson 2006a) and 2009 deposit sample locations. The volume of trapped deposit was estimated to be 990,000 yd<sup>3</sup>. There was considerable uncertainty in this estimate because there were limited samples available where the deposit was the thickest near the dam. It is expected that the uncertainty of the estimate is about +/- 30% or 300,000 yd<sup>3</sup>. This is based upon the difference between the previous (GEC 2006) estimate and ours of about 300,000 yd<sup>3</sup>. Additional drill holes in the areas where significant deposit is present could reduce this uncertainty, although it is not required because it makes little difference in effects upon dam removal.

### **Copco 1**

In order to estimate the deposit thickness throughout Copco 1 and Iron Gate reservoirs, a relationship was found between deposit thickness and position within the reservoir for the collected deposit samples from Shannon and Wilson (2006a) and Reclamation (2010a). For Copco reservoir, 28 samples were used. Details of the regression can be found in Reclamation (2011b).

Using interpolation and mapping techniques, the total volume trapped in Copco 1 reservoir was estimated to be 7.44 million yd<sup>3</sup>. A map of the reservoir thickness is given in Figure 2-10. An estimate of the uncertainty of this volume was computed by multiplying the average error of the regression equation by the area of the reservoir, giving an uncertainty of 1.5 million yd<sup>3</sup>, or 20 %.

### **Iron Gate**

The method for estimating the deposit thickness in Iron Gate Reservoir was similar to that used for Copco 1 Reservoir. A relationship was found between deposit thickness and sample position within the reservoir. Samples were measured by Shannon and Wilson (2006) and Reclamation (2010). For Iron Gate Reservoir, 18 samples were used. Details of the regression can be found in Reclamation (2011b).

The same function was used to fit the data at Iron Gate. The largest difference between the predicted and measured values is 1.7 feet. The average difference is 0.9 feet.

This relationship was applied to the entire reservoir (the extents were based on the area surveyed by JC Headwaters, Inc. (2003)). ArcToolbox raster math functions were used in ArcMap to calculate the deposit thicknesses. Figure 2-11 shows the map of reservoir thicknesses and the locations of the 2009 deposit samples.

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Three areas were modified from the results of the regression function. Any location that produced a negative value was set at zero depth. This occurred in higher elevations around the reservoir edge. The other two areas were where tributaries enter into Iron Gate reservoir from the north and influence deposition. Samples collected in each of these areas were averaged and applied over the approximate area of influence. Jenny Creek is the tributary that enters from the north-east. The average deposit thickness was 6.0 feet. Scotch Creek and Camp Creek enter the reservoir from the north-west. The average deposit thickness in this area is 3.0 feet.

The total volume trapped in Iron Gate reservoir was estimated to be 4.71 million yd<sup>3</sup>. An estimate of the uncertainty of this volume was computed at 1.3 million yd<sup>3</sup> or 29 %.

Table 2-2. Estimated reservoir volumes based upon drill holes (Reclamation, 2011b).

<b>Reservoir</b>	<b># holes 2006</b>	<b># holes 2009</b>	<b># holes Total</b>	<b>Estimated Volume (yd<sup>3</sup>)</b>	<b>Estimated Uncertainty (+/- yd<sup>3</sup>)</b>
JC Boyle	5	26	31	990,000	300,000
Copco I	12	17	29	7,440,000	1,500,000
Copco II	0	0	0	0	
Iron Gate	9	19	28	4,710,000	1,300,000



## 2 Setting

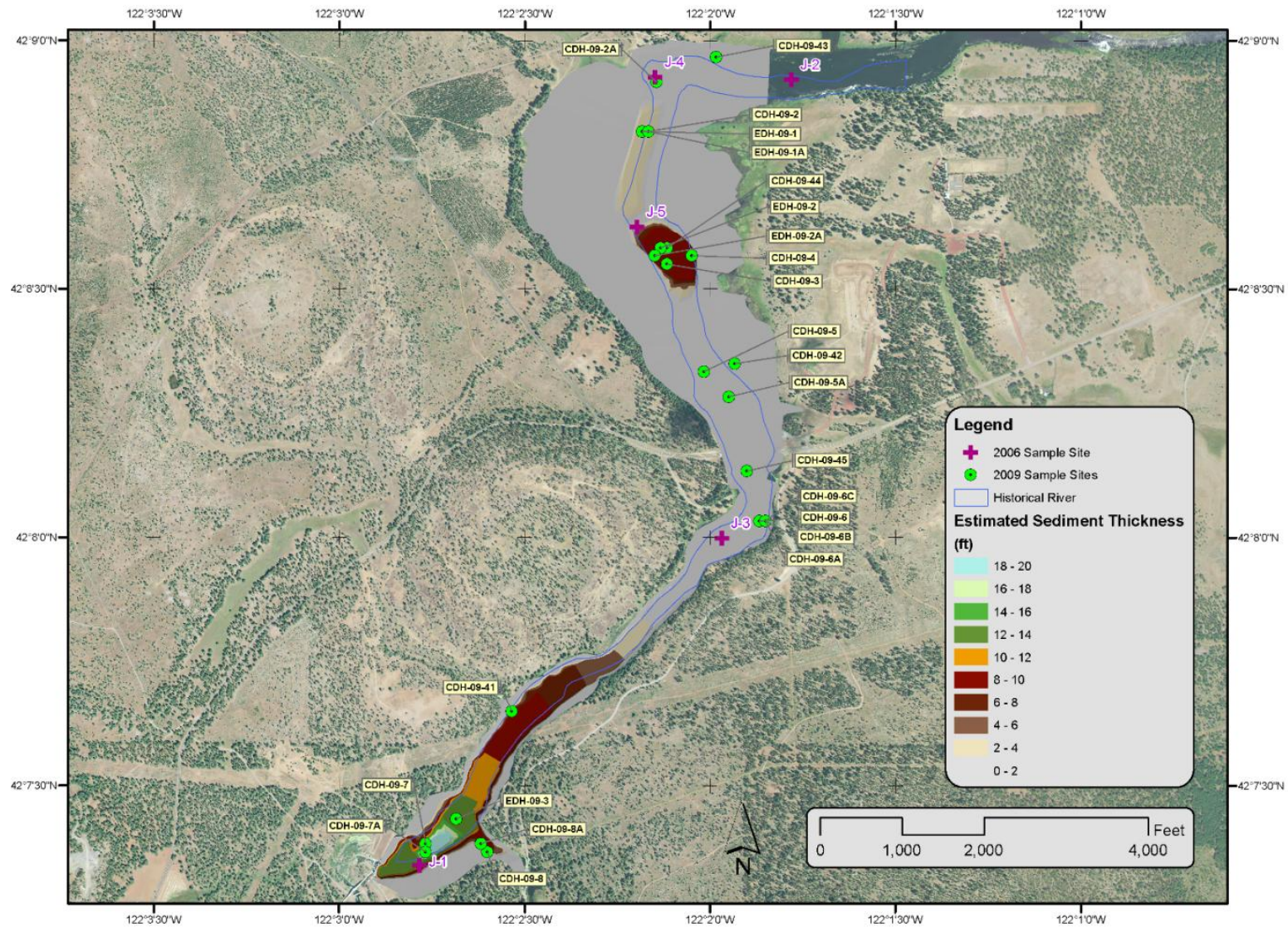


Figure 2-9. JC Boyle Estimated Deposit Thickness and Sample Site Locations.



## 2 Setting

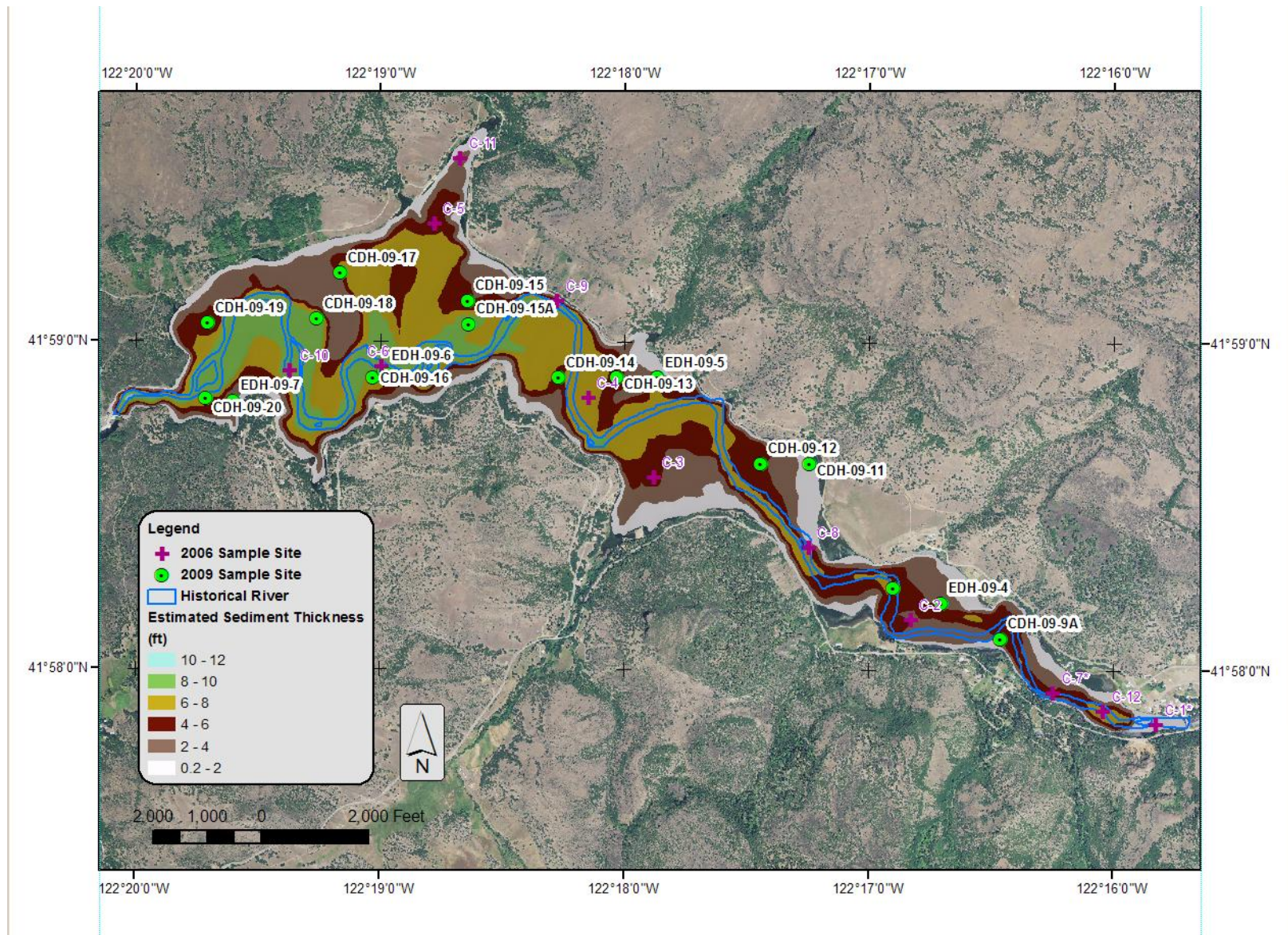


Figure 2-10. Copco 1 Estimated Deposit Thickness and Sample Site Locations.



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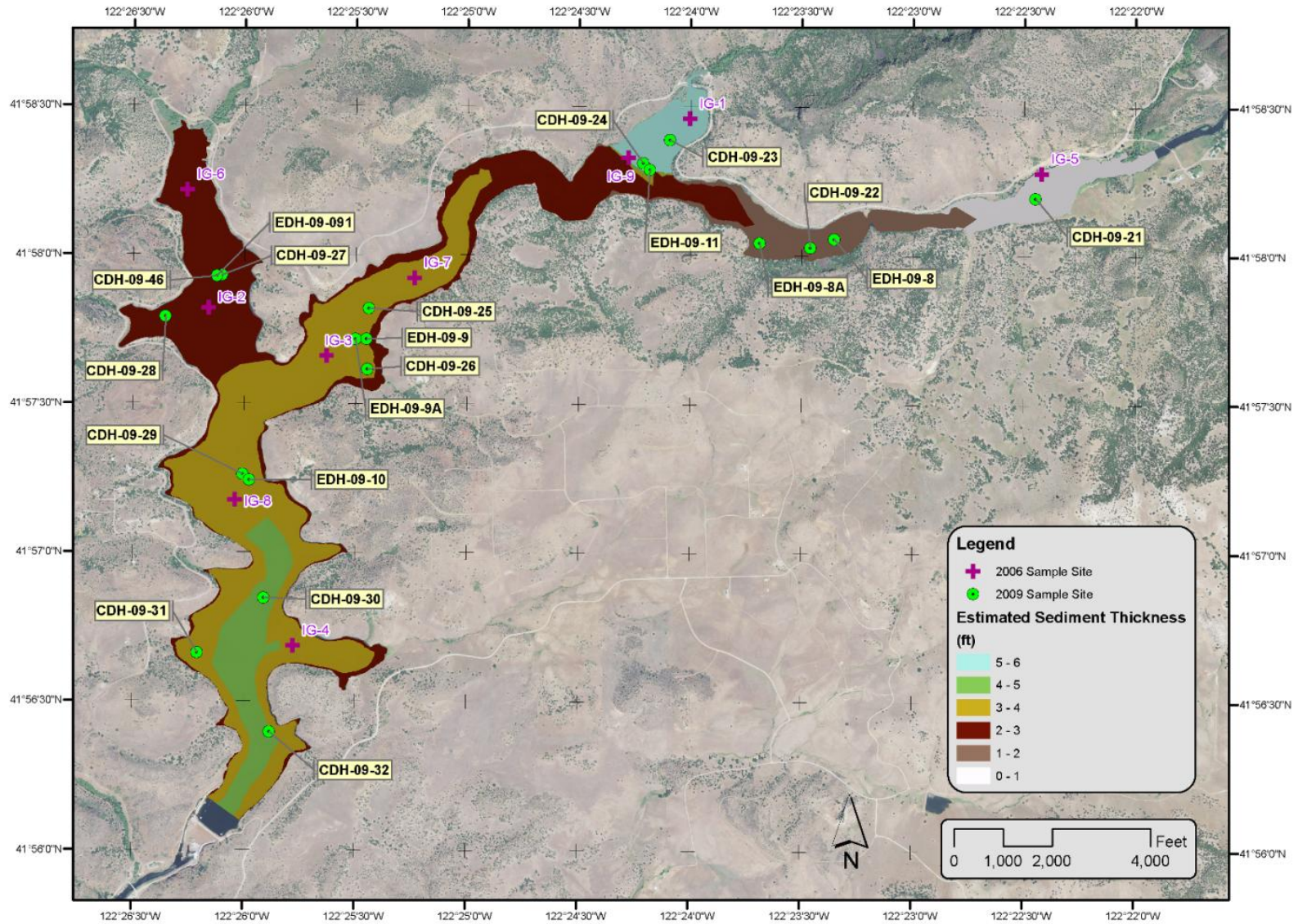


Figure 2-11. Iron Gate Estimated Deposit Thickness and Sample Site Locations.



## 2 Setting

### 2.3.2 Physical Properties

Particle size and basic engineering properties were analyzed on samples from each drill hole and details of the drilling investigation and laboratory analysis are given in Reclamation (2010a). Average properties were computed for the upper and lower sections from each of the reservoir deposits.

Table 2-3. Average physical properties of the reservoir deposit.

	Number samples	Clay %	Silt %	Sand %	Gravel %	LL %	PL %	WC %	$\eta$ %	$\rho_d$ lb/ft <sup>3</sup>
<b>JC Boyle</b>										
Upper Reservoir	12	17.3	26.2	56.5	0.0	45.5	14.7	173	0.82	29.5
Lower Reservoir	17	38.2	49.7	12.1	0.0	173	60.6	345	0.90	16.3
Pre-reservoir	2	3.7	9.5	28.4	58.5	44.9	12.7	23.4	0.38	101
<b>Copco 1</b>										
Upper Reservoir	4	27.9	46.8	25.1	0.2	109.3	49.3	287	0.88	19.2
Lower Reservoir	17	55.8	34.2	10.0	0.0	154.3	59.1	295	0.88	18.7
Pre-reservoir	6	35.6	42.2	22.2	0.0	105.0	41.5	153	0.80	32.6
<b>Iron Gate</b>										
Upper Reservoir	7	35.4	43.1	21.6	0.0	70.9	29.9	192	0.83	27.0
Lower Reservoir	10	60.7	25.5	13.5	0.4	118.7	51.4	276	0.88	19.8
Pre-reservoir	8	33.6	16.9	20.4	29.1	60.6	32.5	37.9	0.50	81.8
Upper Tributary	7	31.8	42.7	25.5	0.0	60.7	22.7	102	0.73	44.4
Lower Tributary	6	61.8	32.0	6.1	0.0	112.2	49.6	284	0.88	19.3
Key: Clay = 0 to 0.005 mm Silt = 0.005 to 0.075 mm Sand = #200 to # 4 sieve Gravel = #4 to 3 inch LL = Liquid limit PL = Plasticity Index $\omega$ = Moisture Content = Weight Water / Weight Solids $\eta$ = porosity $\rho_d$ = dry bulk density										

### 2.3.3 Cohesion and Shear strength

The erosion of the deposit and of the deposit are related to cohesion and shear strength. Strauss (2010) performed direct shear tests on three drill core samples taken from each reservoir, holes EDH-9-3, EDH-9-6, and EDH-9-9A. The measured friction angles were 29.8°, 27.3° and 32.3°, respectively. The measured cohesion values were 1.1, 0.8, and 0.7 lbf/in<sup>2</sup>. Because the material is so soft, it was difficult to obtain accurate shear strength estimates, and Strauss (2010) cautioned that shear strength may be less than measured.

### 2.3.4 Erosive properties

Approximately twelve 5-gallon samples were collected in each reservoir by a 9 inch clam-shell (Ponar) sampler, repacked in the lab, and tested using a jet test device described in Simons et al. (2010). One such sample collected from the Ponar sampler is shown in Figure 2-12. Samples were tested under wet and dry conditions. The effects of drying on erosion resistance and erodibility ( $\tau_c$  and  $k_d$ ) were significant, with reservoir-average values of  $\tau_c$  increasing by at least an order of magnitude. Associated decreases in  $k_d$  also occurred with sample drying, but not to the extent of the increases in critical shear stress. The median value of the erodibility coefficient decreased by about 80%. The average erodibility of the moist reservoir deposit was similar to that of sand, while the average erodibility of the dried deposit was similar to that of gravel or cobbles.



Figure 2-12. Reservoir sample just after release from clamshell sampling device.

### 2.3.5 Consolidation and desiccation

The deposits are primarily water, with an average water content of over 80% by volume. After the reservoir is drawn down, the deposit will dry and decrease in thickness. We performed a simple test of the deposit consolidation by placing wet

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deposit into free draining plastic containers with gravel placed on the bottom (Figure 2.12).

The sample was allowed to dry outside. The initial and final sample thicknesses are given in Table 2.4. The desiccated thickness of the sample was about 60% of the initial. In addition, deep cracks developed in the soil and the sample pulled away from the container edges (Figure 2.13). It was estimated that the volume of the sample decreased by approximately 66%. The porosity changed from 0.82 to approximately 0.46. The dry bulk density increased from  $29.5 \text{ lb/ft}^3$  to approximately  $87 \text{ lb/ft}^3$ . The sample tested was taken from the upper portion of J.C. Boyle Reservoir and has a slightly higher bulk density than the deposit in the lower portions of the three reservoirs. The dry bulk density of the finer material located in the lower parts of the three reservoirs is expected to increase from its existing value of  $16 - 20 \text{ lb/ft}^3$  to between 47 to  $58 \text{ lb/ft}^3$ .

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Table 2-4. Change in thickness after Klamath Reservoir Deposit Desiccated in an Open Air and Freely Draining Container.

Container	Deposit Thickness		
	Initial (in)	Final (in)	% of original
1	7.00	4.25	60
2	7.88	4.63	59
3	4.50	2.75	61



Figure 2-13. Picture of deposit from J.C. Boyle Reservoir immediately after placement



Figure 2-14. Picture of sample from J.C. Boyle after 15 days of air drying.



### **2.4 Reservoir Rim Stability**

PanGeo, Inc. evaluated the stability of hillsides surrounding each reservoir as part of an evaluation of the effects of reservoir lowering in light of the proposed dam removal (PanGeo, 2008). The study had several objectives, one of which was to evaluate the local geology surrounding each reservoir and look for active landsliding and shoreline erosion.

Three landslides were identified along the south rim of Iron Gate reservoir. These ranged from smaller slumps and slides covering a few square miles to larger features that were identified as landslides. The westernmost landslide consisted of a medium size slide along the hillside with a smaller slump near the reservoir level. Two larger scale slides were tentatively identified from a boat reconnaissance but were less definitive upon field reconnaissance in the upland. All features were determined to be inactive and not prone to future landsliding. Two small to medium scale landslides were identified along the north rim of Copco Reservoir, but appeared to be inactive. These were most likely activated by rainfall or groundwater interactions and did not appear to be presently moving. At JC Boyle Reservoir, no landslides were observed in the reservoir area; however, PanGeo, Inc. noted that large scale landslides had been previously identified downstream of the reservoir along the south canyon wall. PanGeo, Inc. also evaluated the potential for subaqueous landslides using bathymetric data in the reservoir areas and found no large scale features that might be related to failure of material in the reservoirs.

Shoreline erosion along the reservoir rims is induced by wave action and most prevalent in areas with less competent deposits, such as volcanoclastic materials and lacustrine deposits. Minimal shoreline erosion is identified at both Iron Gate and JC Boyle reservoirs. At Copco Reservoir, shoreline erosion forms vertical bluffs of up to 20 ft where volcanoclastic deposits are undercut, destabilizing and toppling overlying diatomite deposits into the reservoir. Headward erosion of the bluffs may eventually impact developed areas along the reservoir. Where these deposits are not present, minimal shoreline erosion is observed or expected.

### **2.5 Vegetation Conditions along Reservoir Shorelines**

Existing vegetation along shorelines of the reservoirs (J.C. Boyle, Copco, and Iron Gate) were surveyed in November of 2009 and in July of 2010. Both surveys were conducted by boat with stops on shore for closer examination and identification of species. General vegetation species and community presence were documented with notes, photographs, and GPS points.

#### **2.5.1 November Survey**

The November survey provided limited but useful preliminary data on presence of invasive and native species, including some qualitative distribution information. Sample locations and coordinates were predetermined and navigated to by boat. Available daylight hours and travel limited the number of locations to be sampled,

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as only one day was available for sampling each reservoir; 10 points were sampled at J.C. Boyle and 20 sampled at both Copco and Iron Gate. Photographs and notation on species presence was recorded, but as this survey was conducted during the winter many species were senescent or otherwise unidentifiable.

The November survey indicated the presence of two highly invasive species: Yellow starthistle (*Centaurea solstitialis*) and medusahead (*Taeniatherum caput-medusae*) at Copco and Iron Gate reservoirs. Suppression of invasive weeds is typically a component in revegetation strategies, especially where disturbances occur or new niches are opened, such as with dam removal. The presence and large extent of these two particular species presents further complexities to a post-dam removal management/restoration plan. Lists of typically weedy species noted during the November survey are presented below, although it should be noted that few, if any, were observed in large stands and are likely not problematic, with the exception of Yellow starthistle and medusahead.

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Figure 2-15. November survey: Top: typical state of vegetation during November survey (Copco Reservoir). Bottom: large stand of Yellow Starthistle (Iron Gate Reservoir).

## 2 Setting

Noted weedy species, November survey:

### J.C. Boyle

- Kentucky bluegrass (*Poa pratense*)
- Redstem stork's bill (*Erodium cicutarium*)
- Cheatgrass (*Bromus tectorum*)
- Meadow foxtail (*Alopecurus pratensis*)
- Teasel (*Dipsacus fullonum*)
- Reed canarygrass (*Phalaris arundinacea*)
- Yellow salsify (*Tragopogon dubius*)

### Copco/Iron Gate

- Yellow starthistle (*Centaurea solstitialis*)
- Medusahead (*Taeniatherum caput-medusae*)
- Reed canarygrass (*Phalaris arundinacea*)
- Japanese brome (*Bromus japonicus*)
- Cheatgrass (*Bromus tectorum*)
- Teasel (*Dipsacus fullonum*)
- Curly dock (*Rumex crispus*)

Lack of identifiable features and time constraints limited identification of most native species to those considered significant to revegetation efforts and/or natural succession processes, and only to the genus level. Noted species included those from the genera *Salix* (willows), *Quercus* (oaks), *Artemisia* (sages), and from the family Pinaceae (*Juniperus*, *Abies*, *Pinus*) and Juncaceae (rushes) around all of the reservoirs, although many other forbs, grasses, and woody species were observed.

Mapping data collected in July (presented here) was more representative than the November survey data.

### **2.5.2 July Survey**

The July survey provided a more thorough collection of shoreline data and allowed identification of more of the pre-senescent or flowering species. This survey was also conducted by boat, but at a slow speed (roughly idle) around the entire perimeter with photographs/GPS coordinates recorded approximately once every minute. This provided a more comprehensive assessment of the entire shoreline area and allowed the more prevalent species to be identified and mapped. However, summers are typically very dry in this area and many of the



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cool season grasses and several other species had already senesced by the time the survey was conducted; much of the landscape was brown at this time. Identifiable vegetation was categorized and entered into a GIS database. The maps are shown in Appendix C. This should not be considered an exhaustive survey of every species present. More extensive vegetation surveys of the areas surrounding the reservoirs as well as adjacent river and tributary reaches are recommended to refine potential invasive species and appropriate goals for restorative conditions desired.



Figure 2-16. July survey: Top – yellow starthistle, conifer, rush, and native shrub community at Iron Gate. Bottom – oak, willow, rush, and native shrub vegetation community at Copco.

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Table 2-5. Vegetation categories and abundance:

J.C. Boyle		
CATEGORY	# PTS DETECTED	FREQUENCY
Conifers	90	32%
Assorted native grasses	61	22%
Reed canarygrass	52	19%
Assorted native shrubs	38	14%
Sages	22	8%
Rushes	9	3%
Willows	6	2%
Copco		
CATEGORY	# PTS DETECTED	FREQUENCY
Oaks	161	27%
Assorted native grasses	145	24%
Assorted native shrubs	73	12%
Willows	54	9%
Conifers	49	8%
Yellow starthistle	39	6%
Rushes	29	5%
Reed canarygrass	29	5%
Sages	26	4%
Iron Gate		
CATEGORY	# PTS DETECTED	FREQUENCY
Assorted native grasses	265	25%
Assorted native shrubs	187	17%
Willows	129	12%
Oaks	106	10%
Conifers	106	10%
Yellow starthistle	111	10%
Rushes	81	8%
Sages	77	7%
Reed canarygrass	15	1%

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Vegetation category explanations:

- Oaks: *Quercus* spp., including *Q. kelloggii*, *Q. garryana*, and *Q. chrysolepis*.
- Assorted native grasses: Generally of family Poaceae. It should be noted that medusahead (*Taeniatherum caput-medusae*), a non-native and highly invasive species, often co-occurred with native species at Copco and Iron Gate reservoirs but neither native nor non-native species could be delineated exclusively with the survey protocol used. The results for this category should not be interpreted as solely native grasses.
- Assorted native shrubs: *Ceanothus* spp., *Amelanchier* spp., *Berberis* spp., and others.
- Willows: *Salix* spp.
- Conifers: *Juniperus* spp., *Abies* spp., and *Pinus* spp.
- Yellow starthistle: (*Centaurea solstitialis*)
- Rushes: *Juncus* spp.
- Reed canarygrass: *Phalaris arundinacea*
- Sages: *Artemisia* spp.

### 2.5.3 Discussion

#### J.C. Boyle

The reservoir banks were largely dominated by conifers, especially along the western side of the main reservoir (wider portion north of the Spencer Bridge). The eastern bank of this section of the reservoir was populated with large stands of wetland species such as reed canarygrass and rushes. Along the northern shore, surrounding several tributary/drain confluences, vegetation communities are primarily grassy meadows with many wetland constituents. South of Spencer bridge towards the dam, the reservoir narrows considerably and is surrounded by steep-rocky banks largely populated with woody shrubs. Grasses were often a component of the understory of conifer stands and intermixed with woody shrubs and wetland species. A few willows and sages were observed at J.C. Boyle, mostly in the southern section.

Oaks, yellow starthistle, and medusahead were not found at J.C. Boyle in the course of the survey. Other less weedy species were found, none of which seemed to present serious threats to the native species. The one exception to this may be the large stands of reed canarygrass along the eastern shoreline of the northern section of the reservoir. Although not generally considered an introduced species, non-native cultivars do occur in the United States. The genetic origins of the reed canarygrass in the project area are unknown. Regardless, it is considered by some to be aggressive and/or a nuisance in wet areas, and as beneficial in providing

## **2 Setting**

bank stability, wildlife habitat, and excluding non-native invasive plants by others. Further discussion as to the classification of reed canarygrass as beneficial or undesirable is recommended.

### Copco

Oak trees and scrub were very common amongst the shoreline vegetation at Copco reservoir, and were only sparse in the drier, southern-facing slopes. Other native shrubs and grasses were often observed in the oak and conifer understory as well as in the dry uplands, erosion areas, and mixed in with stands of wetland vegetation. It should be noted that in many cases certain vegetation was thick enough along the margin of the reservoir that any understory or upland species could not be observed and were not recorded. Additionally, many areas along the bank of Copco have experienced significant erosion and thus present a very steep, in some cases vertical, slope from the water up to an elevated terrace above. These steep erosion areas were sparsely vegetated, mostly with weedy forbs, and it was difficult to determine vegetation composition from the viewpoint on the reservoir to the high terrace above. The data presented in the vegetation maps in Appendix C are not an entirely accurate summary of vegetation composition in these areas.

Willows and conifers were relatively sparse and scattered throughout the shoreline areas. The willows were observed to be somewhat clustered in certain areas at the northwest end of the reservoir where a tributary confluences and, along with reed canarygrass and rushes to a lesser extent, in the narrow stretch near the inlet. This is possibly due to an influx of reproductive material from these areas. Conifers did not exhibit any such clustering and were more or less random suggesting parent material originated inland.

Yellow starthistle was only observed growing on the northern side of the reservoir, which corresponds with reports that it prefers slopes with southern aspects. In some areas, primarily the large dry slopes seen as almost uniformly brown on the imagery, yellow starthistle was noted to grow in dense stands that nearly covered the entire visible area uniformly.

### Iron Gate

Native grasses and shrubs were relatively ubiquitous throughout the shoreline areas at Iron Gate reservoir, co-occurring in some of the wetland areas and as understory species in the wooded communities. Willows seemed to occur primarily in the northwest corner of the reservoir coinciding with tributary inlets as well as, to a lesser degree, with the main river inlet to the far-east. Much of the northwest corner consisted of a fringe of willows and rushes with the upland slopes dominated by yellow starthistle and smaller populations of grasses and sagebrush. Oaks were found primarily in the shadier northern facing slopes with



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some exceptions closer to the shoreline. Conifers and sagebrush appeared to be generally random with no apparent preference for slope or moisture regime.

As was found at Copco, yellow starthistle at Iron Gate was observed almost exclusively on slopes with southern exposures. This species was rarely found immediately adjacent to shorelines, which are often dominated by willows, rushes, and assorted mesic/phreatophytic grasses, forbs, and shrubs (not indicated in the map data). It was, however, often observed in relatively close proximity to the shoreline (within approximately 5-10 meters), and highly prolific in dry upland slopes and near roadsides. Rushes seemed to be a common occurrence at the wet perimeter of yellow starthistle dominated slopes, although primarily in association with confluences.

### **2.5.4 Summary**

Existing vegetation along the shoreline and upland of the reservoirs consists of a mix of native and invasive species. Surveys at J.C. Boyle reservoir indicated the areas were dominated by native species and a lack of highly aggressive or troublesome species. Although many native species were also found at Copco and Iron Gate reservoirs, the presence of yellow starthistle and medusahead is an existing management problem, particularly in light of their density and distribution.

It should be emphasized that these results are the result of relatively non-robust surveys over a short period of time. More extensive surveys of flora at the reservoirs, as well as connecting river reaches and tributaries, are recommended to refine the restoration plan. This would provide a better estimation of the presence and distribution of invasive species as well as a more accurate depiction of achievable vegetative conditions by means of active revegetation.

## 2 Setting

## **3 Future Conditions under Dam Removal Alternative**

### **3.1 Predicted Conditions during Drawdown**

There will be significant unavoidable erosion of the reservoir deposits during drawdown. The eroded material will then be transported downstream predominantly in suspension and at the rate of the river flow. These processes were simulated using both one-dimensional (1D) and two-dimensional (2D) sediment transport models. The set up of the models and the results are detailed in Reclamation (2011b). A brief overview of the pertinent results are presented here.

SRH-1D 2.6 was used for 1D sediment transport modeling (Huang and Greimann, 2010). Every water year between 1961 and 2008 was simulated, with a subsequent year, which was long enough for complete drawdown and dam removal, followed by a subsequent year of flow. This generated 48, 2-yr simulations. Three water year scenarios were selected for more detailed analysis corresponding to median, wet, and dry. The dry, median, and wet water years were defined as the 90%, 50%, and 10% exceedance of the March to June flow volume at Keno on the Klamath River. The dry, median, and wet water years were 2001, 1976, and 1984, respectively.

The model was used to assess the volume of material eroded during drawdown and in the subsequent year after dam removal. It also predicted the sediment concentrations downstream of the dams. Several drawdown scenarios were analyzed assuming different maximum drawdown rates, different notching scenarios at Copco 1, and different start times. Details of the deconstruction plan can be found in Reclamation (2011a). The sediment concentration predicted during drawdown and in the subsequent year after drawdown for Scenario 8 (Reclamation, 2011b) is shown in Figure 3-1. Scenario 8 corresponds to the major drawdown of the reservoirs beginning January 1, 2020. It also includes a preliminary drawdown of Copco Reservoir to the spillway elevation beginning November 1, 2019. The results are shown for the approximately median water year (WY) of 1976. Concentrations remain over 1,000 mg/l until early March. By May, the concentrations are approximately 100 mg/l. The volume of erosion is shown in Figure 3-2. For a median water year under Scenario 8, slightly more than 7 million yd<sup>3</sup> of material is expected to be eroded during the first drawdown period. This equates to slightly more than 1/2 of the total deposit deposited behind the dams. There will be less erosion during a dry year and more erosion during a wet year with the amount of erosion from the reservoirs varying from 1/3 to 2/3 of the deposit.

### 3 Future Conditions under Dam Removal Alternative

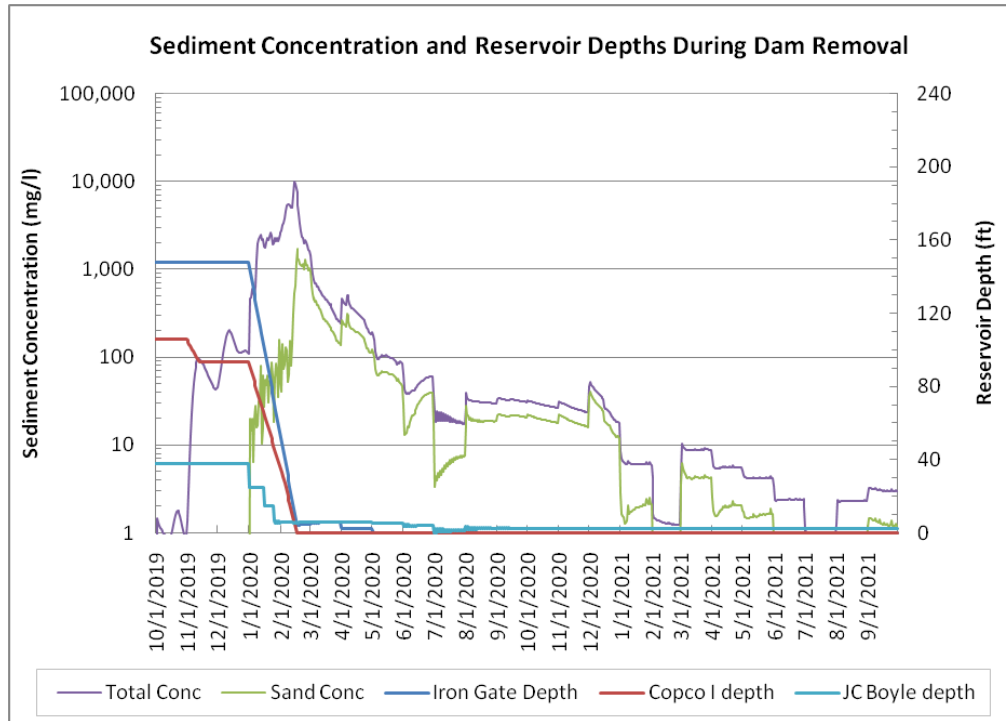


Figure 3-1. Sediment Concentrations predicted Downstream of Iron Gate Reservoir for median year for Scenario 8 (Reclamation 2011).

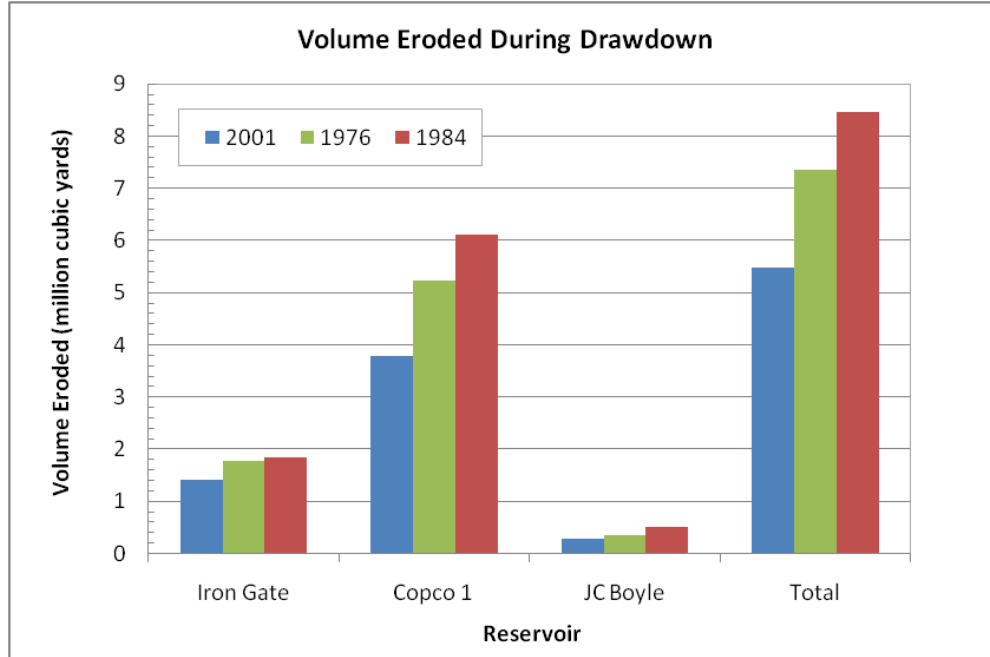


Figure 3-2. Erosion Volumes predicted at JC Boyle, Copco and Iron Gate Reservoirs for Scenario 8 of Reclamation (2011), for Dry (2001), Median (1976) and Wet (1984) water years.



### **3 Future Conditions under Dam Removal Alternative**

SRH-2D version 3, was also used to study the drawdown process of the Copco 1 dam to determine the expected planform of the river channel after drawdown. One-dimensional models such as SRH-1D do not represent lateral variability that can exist in complex channels such as existed in Copco Reservoir prior to its filling. Therefore, a two-dimensional model SRH-2D was used to check the assumptions inherent in the one-dimensional model and provide further insight into the processes that will occur during dam removal. The model predicts the channel incision process as a result of the drawdown, as well as the sediment concentration delivered to the downstream reach under several hydrologic conditions. The planform of river channel in the Copco Reservoir was historically complex and there was some uncertainty as to the evolution of the channel after reservoir drawdown.

Figure 3-3 shows the areas of erosion and deposition within the reservoir. The erosion is focused primarily in the historical stream channel and the pre-dam elevations are attained during dam removal because the reservoir deposits are extremely erodible. There are minor amounts of deposition along the channel banks, generally less than 0.5 ft. The deposition in the model occurs during high flows that inundate the floodplains and deposit small amounts. The 2D model would generally underestimate the erosion along the bankline because it does not include a mechanism to simulate bank erosion or bank collapse. Therefore, in reality, the areas of deposition shown in the figure are expected to be slightly erosional.

### 3 Future Conditions under Dam Removal Alternative

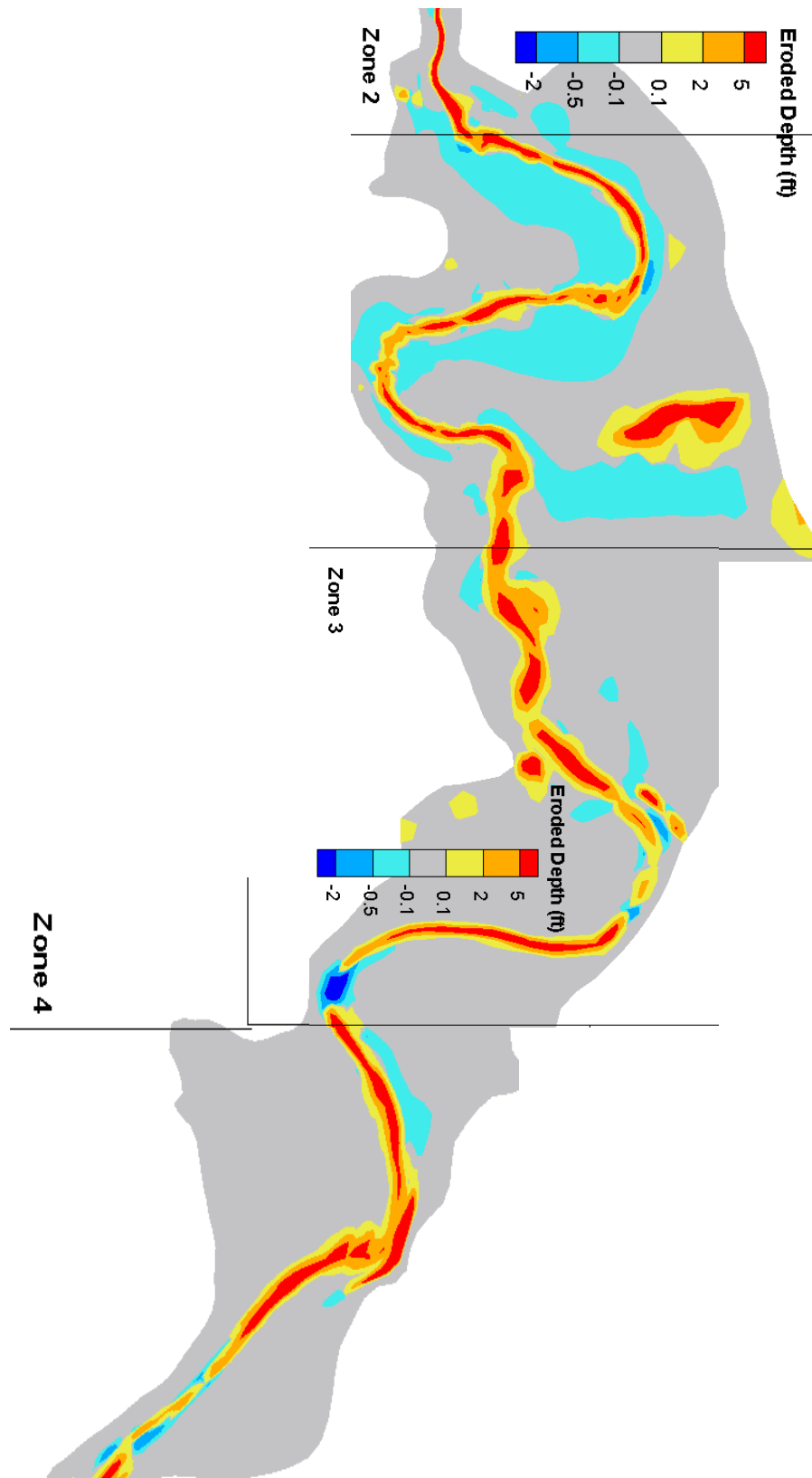


Figure 3-3. SRH-2D predicted erosion/deposition pattern after the drawdown of Copco 1 reservoir under an average water year.

## 3.2 Response of geomorphic and habitat features

There will be several stages of reservoir response while the reservoir pool is lowered and after dam removal. Each reservoir has some unique characteristics that will result in different behaviors but the general behavior of the reservoir areas can be described by a sequence of seven general processes. Each process will operate to various degrees in each reservoir depending on the current deposit thickness, the reservoir geometry, and vegetation types.

1. Erosion of reservoir deposits during drawdown. The drawdown of the reservoirs begins on Jan 1, 2020 and will be complete in dry and median water year types by mid March. Drawdown may take longer under wet water year types and it may be until June before Iron Gate reservoir is completely empty. The process of reservoir deposit erosion during drawdown is simulated as discussed in the previous section. The deposits are highly erodible and any significant velocity will wash away the reservoir deposit. Erosion will concentrate where depth is greatest, and old river channels are expected to be reestablished. There will be large portions of reservoir deposits remaining on the river terraces that are not near the active channel.
2. Slumping of deposit toward river channel due to limited shear strength of deposit and draining of water in the pore spaces of the deposit. Deposit slumping will occur as long as the downslope force of deposit self weight and the force of the draining water exceeds the shear strength of the deposit. Initially, after drawdown the reservoir deposit will have very low shear strength. However, as the excess water drains from the deposit, the deposit will quickly increase in strength. Initial estimates for stable slopes of reservoir deposit would be 10H:1V or about 5 degrees (Stillwater, 2008). The actual stable slope could be significantly higher than this. Laboratory measurements of the deposit drill cores estimated that the friction angle is between 27 and 32 degrees (2H:1V). PanGeo (2008) stated that the aggraded sediments at the edge of the river channel will likely remain stable on a slope of 18 degrees (3H:1V). Therefore, the slumping of reservoir deposits is expected to be focused around the margins of the channel and limited in scope. The initial slumping process is expected to occur during the drawdown period from January to May under all scenarios.
3. Drying, consolidation, cracking and hardening of reservoir deposit. After the initial slumping and draining of excess water, the deposit will begin to dry as the result of evaporation. Figure 2-13 and Figure 2-14 shows the effect of drying the reservoir deposit. The remaining reservoir will reduce in volume by approximately 2/3 and the thickness of the deposit will decrease by about 1/3. Cracks will appear and the deposit will harden

### 3 Future Conditions under Dam Removal Alternative

significantly. The drying process is expected to occur in the spring or early summer depending upon the balance of rain and evaporation rates. The resistance to erosion will increase markedly during this period, progressing from highly erodible to very resistant to erosion. Because of the cracking, some erosion will continue to occur as the result of gully formation during rainstorms. However, the erosion is expected to be limited to rain events and will not continue during other periods.

4. Establishment of herbaceous vegetation in reservoir areas. The reservoir areas will be reseeded with various herbaceous species following drawdown in the spring, allowing seeds to take advantage of residual soil moisture and prevent soil surface hardening from impeding seed germination. The grasses will begin to grow immediately on the exposed reservoir surfaces and begin to stabilize the surface of the deposit. The vegetation growth will minimize the erosion of the surface deposit. Herbicides will be necessary during this period to control the growth of invasive species.
5. Erosion of floodplain deposits during subsequent rain storms and high flows. Erosion of floodplain deposits will occur during rainstorms as the rainfall exceeds the infiltration capacity. The erosion process will be focused during the rainstorm event and quickly subside as the infiltration capacity of the soil is no longer exceeded and runoff ceases. High flows in the Klamath River that exceed bank elevations will cause erosion of remaining deposits. This process is mostly dependent upon the storm sequence that occurs during drawdown and in the subsequent years. If the flows during drawdown are relatively low, there will be more deposits remaining along the channel margins and if the flows are high the following year, significant bank widening may occur. If the flows are high during drawdown, very little bank erosion is expected to occur in subsequent years because there will be less deposits remaining near the banks of the river.
6. Establishment of woody species along riparian corridor and from seed source along reservoir rim. Various woody species will be planted along the channel margins to improve long term fish habitat and to increase bank stability following drawdown. There will also be establishment of trees from seed sources along the reservoir rim. The establishment of woody species will take several years.
7. Gradual weathering of reservoir deposit due to physical and biological processes. The dried reservoir deposits are relatively resistant to erosion, but there are many physical, chemical, and biological processes that will begin to break them down and develop soil structure. The weathering process is beneficial and will encourage the establishment of native vegetation.

### **3 Future Conditions under Dam Removal Alternative**

The general processes are discussed below, specific for each reservoir. See section 4.2 for more detailed information regarding the revegetation plan.

#### **3.2.1 J.C. Boyle**

At J.C. Boyle, the reservoir deposit is thickest in the historical active channel and near the dam. Most of the deposit will be quickly evacuated from the reservoir area. There are two distinct areas of JC Boyle, which are loosely defined as above and below the state highway 66 bridge. Above the bridge, the slope of the historical river channel is significantly less than the slope downstream. In addition, the reservoir is much wider upstream of the bridge than downstream. Downstream of the bridge, there will be little deposit remaining in the reservoir area. The majority of the deposit that remains would be in the small tributary arm near the dam. Upstream of the bridge, there will be reservoir deposit remaining on the floodplain areas. However, it is expected to be only 1 – 2 feet thick. One potential complication to the erosion during the drawdown process is ice formation at J.C. Boyle during the winter months. If the reservoir freezes, the top layer of exposed reservoir deposit could also freeze. This would prevent the slumping process at J.C. Boyle. However, freezing is not expected to be significant at this reservoir because the majority of deposit is located in the active channel that would be eroded before freezing could occur.

An example cross section at JC Boyle is shown in Figure 3-4. The cross section is located upstream of the state highway bridge. The cross section is shown before and after drawdown showing that the erosion is focused in the main channel. After drawdown, there will be minor amounts of consolidation of the floodplain deposit. There is little consolidation of deposit on the floodplain because there are only small amounts of reservoir deposit on these surfaces. Most flow will be confined to the main channel and the upper floodplain terrace will rarely become inundated. The predicted water surface at 1000 cfs and 3000 cfs is shown on the cross section. Herbaceous species will be planted in the spring following drawdown. Conifer species will reestablish on the river terraces as they propagate from the outer edges of the reservoir.

#### **3.2.2 Copco**

Copco Reservoir, the widest of the reservoirs, contains the majority of the deposits. Most of the erosion will be focused in the main channel and significant volumes will remain on the upland terraces. Therefore, the thickness of the remaining terrace deposits will be the greatest at Copco. The pre-dam geomorphology is shown in Figure 2-4. The map shows a few locations where there is split channel flow, tule sloughs areas, and a large abandoned paleochannel. Some of these features will be exposed after dam removal as river flows erode deposit. However, it is possible that reservoir deposits will remain in some of the side channels, particularly if dam removal occurs in a dry year.



### **3 Future Conditions under Dam Removal Alternative**

The paleochannel will be re-occupied by Beaver Creek after dam removal. There are also numerous small springs that originate from the hillsides that will also erode into their previous channels. The erosional processes are expected to occur during the first winter season when the deposit is most erodible. The spring flows are relatively small but continuous and will erode a channel through the soft deposit quickly.

An example cross section at Copco is shown in Figure 3-5. The cross section is located in the wide middle section of the reservoir. River flows erode to the pre-dam surface during the first drawdown. The width of the eroded channel will depend upon the stream flows during drawdown. The figure shows the expected width if the flows during drawdown are relatively high. After drawdown, the remaining deposits will begin to consolidate and decrease in thickness. At Copco, this will be a relatively major process and the thickness of the deposit will decrease up to a few feet. Cracks will appear perhaps to the full thickness of the deposit as it dries. Seeded herbaceous species are expected to germinate after spring revegetation. Woody species will be planted along the river banks and establish over a period of years.

#### **3.2.3 Iron Gate**

The river corridor is relatively narrow throughout the Iron Gate reach and the side slopes of the reservoir area are mostly steeper than 20% with a significant amount of area steeper than 40%. The reservoir deposit at Iron Gate is relatively thin, and the only thicknesses over 5 ft were located in the Jenny Creek delta. There will be little deposit remaining after dam removal and most of the deposit remaining will be less than 3 feet thick. After this deposit consolidates, it is expected to be less than 2 feet thick. The drawdown at Iron Gate is expected to be more rapid than at Copco 1 and this will also cause more reservoir deposit to slump into the channel as the deposits drain off excess water.

An example cross section showing the erosion, consolidation, and vegetation growth at Iron Gate is shown in Figure 3-6. Because the deposit is generally less than four feet thick and much of the deposit will be eroded at Iron Gate, the consolidation process will be relatively less important.

There are fewer alluvial surfaces and the riparian corridor will be much narrower at Iron Gate than Copco. Most of the alluvial surface and riparian areas are located in the Camp Creek/Scotch Creek/Dutch Creek arm of Iron Gate and immediately downstream of their confluence with the Klamath River. These tributaries are heavily vegetated with woody species upstream of Iron Gate Reservoir as documented in PWA (2009) and the tributaries are expected to reestablish a similar riparian and geomorphic condition in the exposed reservoir areas.

### 3 Future Conditions under Dam Removal Alternative

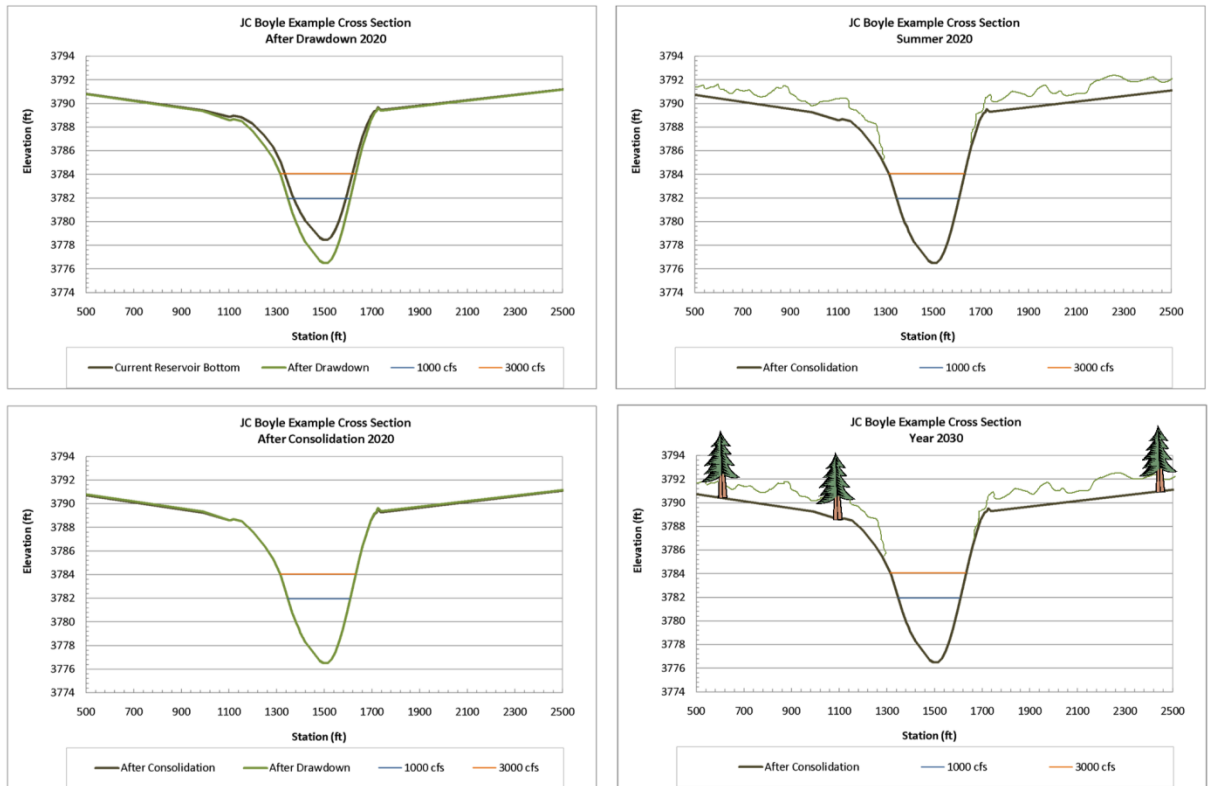


Figure 3-4. Example cross section at JC Boyle Reservoir.



Figure 3-5. Example cross section at Copco Reservoir.

### 3 Future Conditions under Dam Removal Alternative

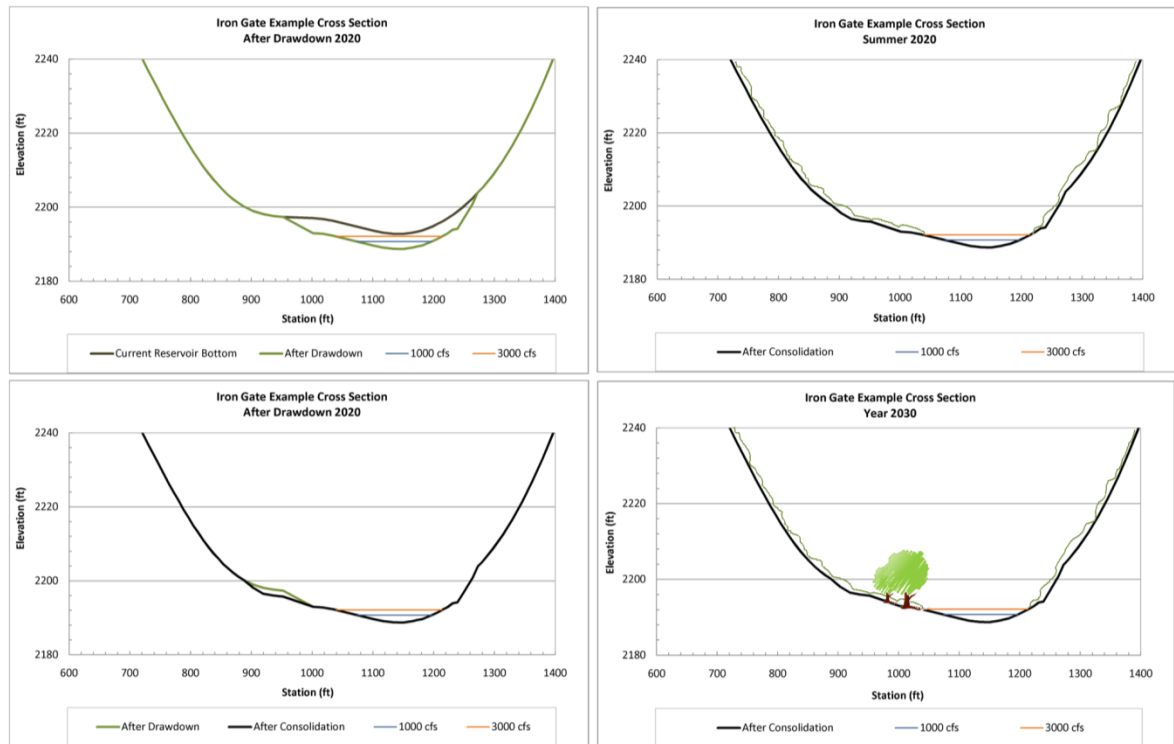


Figure 3-6. Example cross section at Iron Gate Reservoir.

### 3.3 Response of Vegetation

Vegetation response to reservoir drawdown is discussed in light of current vegetation conditions (section 3.3) and a soil seedbank germination study.

#### 3.3.1 Existing vegetation

Existing upland vegetation, including grasses, forbs, shrubs, and trees along banks, upland slopes, and near the reservoir shorelines are predicted to be relatively unchanged. This includes native and invasive species, although it is possible that declining groundwater levels may select for more drought tolerant species and/or invasives. The extent in elevation of existing upland vegetation suggests these species are largely subsistent on precipitation and changes in groundwater levels will likely have minimal impact.

These species are also expected to contribute to the natural succession of the exposed areas after reservoir drawdown, although the degree and timeframe in which this will occur, as well as the composition of species, is uncertain. It is likely that pioneer species colonizing newly exposed areas will be weedy in nature if left to revegetate passively, as is often the case with newly exposed niches or disturbed areas if active measures are not taken.

Vegetation with high moisture requirements (i.e. willows, rushes, and other mesic/wetland species) that exist along the reservoir margins will likely die out as

### **3 Future Conditions under Dam Removal Alternative**

a result of the altered hydrology from reservoir drawdown. These areas will transition to upland communities in most cases, although initial colonization will likely be by weedy and/or non-native species if these are not controlled. Existing hydric vegetation is limited primarily to thin strips along the shorelines and in larger patches along confluences, the only notable exception being a large wetland along the eastern shore of J.C. Boyle reservoir north of Spencer Bridge. Areas near confluences may remain unchanged if the hydrology remains similar to current conditions, and could expand down to the river channel as the tributaries re-connect.

#### **3.3.2 Seedbank study**

Reservoir bottom samples were analyzed for viable reproductive material in the seedbank. This study identified genera and relative density of viable plant seed existing in the reservoir deposit, as well as potential germination after drawdown and implications for active and passive revegetation.

##### Methods

Samples were taken from the reservoir bottom with a Ponar dredge and placed into 5-gallon buckets, each sample filling the bucket roughly half full (2-3 gallons sample size). Sample collection locations were predetermined based on previous drill-hole samples for deposit analyses; GPS coordinates are labeled by drill-hole number (see appendix D). Subsets of the drill-hole sample array were randomly chosen for seedbank analysis; 10 samples were collected from both Copco and Iron Gate reservoirs and 5 from J.C. Boyle.

Samples were transported to greenhouse facilities at the Denver Federal Center for germination analysis. Growing media was first steam-sterilized and placed to a depth of 1.5 inches into 5.25 by 7 inch greenhouse flats with drain holes. Samples were washed through a 70 micron screen to remove fines and concentrate seeds. Material left after screening was mixed with water to create a slurry, which was then spread over the growing media. To maximize germination potential, the layer of slurry was no thicker than 0.2 inches. The proportion of fines in each sample varied considerably, as was the amount of seed and other materials larger than 70 microns. Therefore, multiple flats were sometimes needed for samples with large amounts of slurry in order to retain the 0.2 inch maximum depth. Several flats were left with growing media only and no sample slurry was added in order to verify sterility of the media. Flats were placed in the greenhouse under sprinkler irrigation at approximately 0.1 inches daily and provided with 12 hours of supplemental light. Temperatures were maintained between 70 and 95 °F.

Flats were monitored daily and photographed weekly. Identification and quantification was conducted at 6 weeks after planting, although plants were not yet at a growth stage where they could be keyed out to the species level.

### 3 Future Conditions under Dam Removal Alternative



Figure 3-7. Soil seedbank germination study flats, 6 weeks after planting.

#### Results and Discussion

Control flats did not exhibit any germination, indicating that the media was sufficiently sterile and that any germination seen was indeed from the deposit sample. Germination was variable both by genera present and density, although all genera appeared to be wetland facultative or obligate. This is a general assumption based on the existing wetland genera found around the perimeter of the reservoirs and limited capacity to identify them in the early stages of growth. Results are presented as density by genus for each sample.



### 3 Future Conditions under Dam Removal Alternative

Table 3-1. Genera found in seedbank germination study

GENUS	GENUS NUMBER
<i>Juncus</i>	1
<i>Schoenoplectus</i>	2
<i>Glyceria</i>	3
<i>Lysimachia</i>	4
<i>Typha</i>	5
<i>Polygonum</i>	6
<i>Epilobium</i>	7
<i>Ranunculus</i>	8
<i>Mentha</i>	9
<i>Sisymbrium</i>	10
<i>Aster</i>	11
<i>Veronica</i>	12
<i>Rorippa</i>	13
<i>Alisma</i>	14
<i>Bidens</i>	15
<i>Echinochloa</i>	16

**J.C. Boyle**

DRILL HOLE	GENUS											
	1	2	3	5	6	8	9	10	11	12	15	
CDH-09-2	0	8	2	3	2	5	1	0	0	0	0	
CDH-09-3	0	1	1	2	0	4	0	1	0	0	0	
CDH-09-4	1	5	3	14	1	1	0	2	1	0	0	
EDH-09-1A	0	8	3	0	1	2	0	0	0	0	0	
EDH-09-3	0	0	3	1	0	3	0	2	0	1	1	

### 3 Future Conditions under Dam Removal Alternative

#### Copco

DRILL HOLE	GENUS							
	2	3	5	6	7	8	10	13
CDH-09-9A	3	9	0	0	0	0	3	0
CDH-09-10	1	2	1	0	1	1	0	6
CDH-09-11	0	1	0	0	0	0	0	0
CDH-09-12	0	0	2	1	0	1	0	0
CDH-09-13	0	0	0	0	0	0	0	0
CDH-09-14	0	0	0	0	0	1	0	0
CDH-09-17	0	2	4	0	0	0	0	0
CDH-09-19	0	1	1	1	0	0	0	0
EDH-09-4	0	2	0	0	0	0	0	1
EDH-09-7	0	0	0	0	0	0	0	0

#### Iron Gate

DRILL HOLE	GENUS															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	
CDH-09-22	0	20	0	5	5	0	0	5	0	12	0	2	0	0	1	
CDH-09-23	87	186	18	1	7	1	1	1	0	0	0	0	0	0	0	
CDH-09-24	5	25	2	0	2	0	2	0	0	0	0	0	0	0	0	
CDH-09-26	0	1	5	0	0	0	0	0	0	0	1	0	0	0	0	
CDH-09-28	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	
EDH-09-8A	0	8	3	0	7	0	0	0	1	5	0	0	0	0	2	
EDH-09-9	0	1	3	0	4	0	0	0	0	0	0	0	1	1	2	
EDH-09-10	0	0	0	0	2	0	0	0	0	1	0	0	0	0	0	
EDH-09-11	17	31	0	2	0	0	0	1	0	0	0	0	0	0	0	
EDH-09-091	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	



Figure 3-8. Various seedlings from deposit seedbank germination study, 6 weeks after planting.

### **3 Future Conditions under Dam Removal Alternative**

Results from the seedbank germination study indicate relatively high densities of viable seed material in the reservoir deposit. It is likely that most of the genera identified are wetland adapted because the seeds of these genera typically remain viable in anoxic conditions for extended periods of time, and thus are well suited to persist under constant inundation. Additionally, the samples with the highest germination densities were from locations in relatively close proximity to existing wetlands along the perimeter of the reservoirs.

This suggests that after the reservoirs are drawn down, where hydrologic conditions are conducive to wetland genera there is adequate seed material to vegetate these areas without any further inputs (see section 5.2.1 for predicted wetland acreages). Therefore, active revegetation of wetland areas should not be necessary in order to meet revegetation sub-team goals. It should be noted that the greenhouse study was conducted in somewhat artificial conditions and therefore should not be taken as an absolute surrogate for what will occur in the real world. Actual germination rates of reservoir deposit material after drawdown are unknown and will require further study. For the purposes of determining a cost estimate for revegetation in light of the stated goals, it is deemed adequate at this time to assume it is not necessary to include active revegetation of wetland areas in the current plan.

It should also be noted that although they were unable to be identified to the species level, there is some indication that a few of the genera germinated from the reservoir deposit may be invasive. However, the diversity and density of apparent native genera may be sufficient to compete with invasive species and prevent them from dominating wetland areas and/or creating unacceptable conditions. Regardless of invasive or native composition, wetland areas are expected to restore through natural successional processes which will stabilize deposits and contribute to overall vegetative cover per the goals of the sub-teams. Long term stability and species composition is predicted to mimic those existing along reservoir perimeters and confluences.

Upland and riparian genera were not observed in the seedbank germination flats. This is likely a function of the adaptations for seed survival of these genera as suggested above and/or specific conditions for germination were not present in the greenhouse. Light, temperature, and irrigation regimes in the greenhouse were set to maximize germination potential, but may have favored wetland genera to some degree. This would be particularly evident for survival over the 6 week period, as conditions may have been favorable for germination but not growth/maturation of non-wetland genera. Observations and photographs depict very little seedling mortality after germination, although some did occur. These genera were unable to be fully identified but were largely similar to other genera present in the study that survived, suggesting they may have been wetland genera that were unable to compete for resources, were subject to insect or pathogen damage (of which no evidence was visibly apparent), or conditions were unsuitable for growth and development.

### **3 Future Conditions under Dam Removal Alternative**

Although the presence of viable upland and riparian genera in the soil seedbank cannot be ruled out, it is unlikely that these areas will passively revegetate after reservoir drawdown to the specifications of sub-team goals. The presence and relative proximity of large stands of upland invasive species to shorelines further emphasizes the need for active revegetation activities in order to meet these goals.

#### **3.3.3 Summary**

Existing upland vegetation is expected to remain unchanged and contribute to successional processes on exposed areas after reservoir drawdown. Mesic, phreatophytic, and wetland species currently along the perimeter of the reservoirs are expected to die out due to changes in hydrology; areas near confluences may remain unchanged and or expand to establish along reformed tributaries.

Seedbank analysis indicates relatively high densities of viable wetland vegetation seed present in reservoir deposit, suggesting passive revegetation is feasible for wetland areas after drawdown. Viable upland and riparian seeds were not found in the deposit, possibly due to the growing conditions in the greenhouse, but implies that these areas will require active revegetation.

Ultimately, it is recommended that further studies be conducted regarding viable seed material in the reservoir deposits in order to develop a better understanding of species composition and germination rate under drawdown conditions. This will facilitate a more accurate prediction of passive revegetation of wetland areas, and modifications to future versions of the revegetation plan accordingly.

### **3.4 Rehabilitation of Recreation Sites**

The lands underneath the reservoirs have been designated as Parcel B lands in the Klamath Hydroelectric Settlement Agreement (KHSa). Parcel B lands are intended to be transferred to each of the respective States for future management. It is intended that the transferred Parcel B lands be managed for public interest purposes such as fish and wildlife habitat restoration and enhancement, public education, and public recreational access.

With the exception of the Bureau of Land Management's (BLM) Topsy Campground on J.C. Boyle reservoir, all of the recreation developments on J.C. Boyle reservoir, Copco reservoir and Iron Gate reservoir were constructed and are maintained and operated by PacifiCorp. The PacifiCorp sites are located on lands owned by PacifiCorp and have been designated as Parcel B lands in the KHSa.

Discussions with the states of Oregon and California have indicated they plan to manage these areas for public access and the goals stated in the KHSa. Revegetation of these areas will initially be, at minimum, identical to that performed on the surrounding exposed deposit at each reservoir (see section 5.2.1). While specific plans are not complete, general objectives have been

### **3 Future Conditions under Dam Removal Alternative**

developed for revegetation of the former reservoir lands, which would facilitate recreation use and access and are included in Appendix B.

An assessment was completed in the fall of 2010 of the usefulness of the facilities if the dams were removed. Primary consideration was given to access and proximity to water once the dams are removed and whether the site would likely receive future use in that condition. It was assumed that most of the sites ultimately would be a long distance from the Klamath River channel and would likely not receive much use.

Following is a summary of the results of the assessment. For those sites which will be removed, it is assumed all the improvements will be removed and the site will be put back to a near natural condition. Complete inventories of the facilities to be physically removed and the associated costs are included in the engineering cost estimates in the detailed plan (Reclamation, 2011a).

#### **3.4.1 J.C. Boyle Reservoir**

Developed recreation sites along the J.C. Boyle reservoir include a campground, day use areas, and boat launch. A summary description of the sites is below.

##### Pioneer Park (East and West Units)

Pioneer Park consists of two separate day use areas with picnic tables, fire rings, and portable toilets on the western and eastern shoreline of J.C. Boyle reservoir. Both sites have access from State Road (SR) 66 and are located on either side of the Spencer Bridge.

Without J.C. Boyle Dam, all facilities will be removed.

##### BLM's Topsy Campground

Managed by the BLM, Topsy campground is located on the southeastern shoreline of J.C. Boyle reservoir. It is accessed from the Topsy Grade Road off of SR 66. The site consists of a campground, day use area and boat launch.

Without J.C. Boyle dam, the site will be converted to a river access facility rather than reservoir access. Depending upon the configuration of the river channel, the boat ramp will either be extended to reach the river or it will be removed and replaced. The other facilities will remain.

#### **3.4.2 Copco Reservoir**

Developed recreation sites along the Copco reservoir include a campground, day use areas, and boat launch. A summary description of the sites is below.

##### Mallard Cove



### **3 Future Conditions under Dam Removal Alternative**

Located on the south shore of Copco Reservoir is accessed off the Ager-Beswick Road. The site consists of fill material into the reservoir with a day-use/picnic area and boat launch.

Site restoration following dam removal would require all features to be removed, and the 2.5 acre parking area would be regraded, ripped, and revegetated.

#### Copco Cove

Copco Cove is located on the western shoreline of Copco reservoir, off of Copco Road. The site has a picnic area and a boat launch.

Site restoration following dam removal would require all features to be removed, and the 2.3 acre parking lot would be regraded, ripped, and revegetated.

#### **3.4.3 Iron Gate Reservoir**

Developed recreation sites around Iron Gate reservoir include campgrounds, day use areas, and boat launches. A summary description of the sites is below.

1. Fall Creek
2. Jenny Creek
3. Wanaka Springs
4. Camp Creek
5. Juniper Point
6. Mirror Cove
7. Overlook Point
8. Long Gulch
9. Dutch Creek
10. Iron Gate Hatchery Public Use Area

#### Fall Creek

Fall Creek is located on the far northeast shore of Iron Gate reservoir and is primarily a day use area located along Fall Creek.

Due to its proximity and access to Falls Creek, this site will remain intact and unaltered. There will be no restoration needs.

#### Jenny Creek

Located between Copco Road and Jenny Creek on the northern shoreline of Iron Gate reservoir, the site provides primitive day use and camping opportunities.

Due to its proximity and access to Jenny Creek, this site will remain intact and unaltered. There will be no restoration needs.

#### Wanaka Springs

### **3 Future Conditions under Dam Removal Alternative**

Located on the north shore of Iron Gate reservoir Wanaka Springs is used for day use and camping and has a boat launch. Because of the steep access road, the site is accessed mostly by boat.

Site restoration would include removal of all facilities. The 2 acre parking area and access road would be re-graded and ripped, and revegetated.

#### Camp Creek

Camp Creek is located on Copco Road along the northern shoreline of Iron Gate reservoir. The site accommodates camping, day use and a boat launch.

Site restoration following dam removal would require all facilities to be removed from the site. This would include an estimated 180-foot-long, 16-foot-wide and 8-foot-high earth jetty and approximately 4 acres of parking that would have to be regraded, ripped, and revegetated.

#### Juniper Point

Located on the northwestern shoreline of Iron Gate reservoir the site is accessed from the Copco Road. The site is used for primitive camping and has a boat dock. The access road is very steep.

Site restoration following dam removal would require removal of all of the facilities. Approximately 2 acres of parking would need to be regraded, ripped, revegetated, and about 50 boulders would be buried or removed.

#### Mirror Cove

Mirror Cove is located on the western shore of Iron Gate reservoir. The site has a camping area and a boat launch.

Site restoration following dam removal would require removal of all facilities. Approximately 3 acres of parking would be regraded, ripped, revegetated, and about 120 boulders would be buried or removed.

#### Overlook Point

Located on the western shoreline of Iron Gate reservoir this is a day use site.

Site restoration following dam removal would include removing all facilities. The site and the 800 foot long access road would be regraded, ripped, and revegetated.

#### Long Gulch

Long Gulch is located on the southern shoreline of Iron Gate reservoir and consists of a picnic area and boat launch.

### **3 Future Conditions under Dam Removal Alternative**

Site restoration following dam removal would consist of removal of all facilities and the site and access road would be regraded, ripped, and revegetated.

#### Dutch Creek

Site restoration following dam removal would consist of removal of all facilities and the site would be regraded, ripped, and revegetated.

#### Iron Gate Fish Hatchery Public Use Area

The Iron Gate fish hatchery is located downstream of Iron Gate Dam. There is a day use area adjacent to the fish hatchery and an undeveloped boat launch across the river from the hatchery.

It is expected these facilities will be unaffected by the removal of Iron Gate dam and would remain unchanged.

## 4 Reservoir Area Management Methods

### 4.1 Development of goals and objectives

Potential reservoir management projects were developed through a process of first developing appropriate *Goals and Objectives*. In project development common practice, the terms *goals* and *objectives* are often used interchangeably, but in this document, they represent distinctly different concepts:

- *Goals* are outcome statements that define accomplishments. A goal should efficiently express the intent of a project, serving as the fixed vision to assess all project elements against.
- *Objectives* are statements of measurable actions that support completion of a goal within a specified time frame.

Goals are often not explicit in stating the problems to be addressed; in fact, a suite of problems at varying scales may be addressed by a single goal. Objectives are quantifiable outcomes necessary to achieve a goal, and each goal may contain many objectives. Through the attainment of objectives, progress toward a goal can be measured, and plans for monitoring and adaptive management developed. Ideally, a goal statement will be unambiguous and supported by a stakeholder group representing all the people and institutions with interests in the project. Stream management or restoration goals may not be measurable or quantifiable (this is the role of *objectives*), but rather should provide a guiding image of the intent of the project. Effective goal statements must be developed through consideration of project context, which assesses what is feasible geomorphically and ecologically, what is acceptable socially, and what is sensible economically (Miller and Hobbs 2007). To identify that which is feasible geomorphically and ecologically typically requires a multi-disciplinary team of scientific specialists. To identify that which is acceptable socially and economically requires proper representation of diverse stakeholder interests. Of equal importance are goal statements that acknowledge risks inherent to the project due to scientific uncertainty and natural variability.

While goals articulate a desired end condition, they do not define the actions to be taken. Hence, *objectives* are developed to define the actions necessary to achieve a stated goal. Appropriate criteria for developing objectives follow the acronym SMART:<sup>1</sup>

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<sup>1</sup> SMART is a term that is commonly used in project management training, marketing, and business development. Wikipedia (<http://www.wikipedia.org/>) offers a discussion of the concept and its origins, and states that the term has no clearly documented origin.

#### **4 Reservoir Area Management Methods**

1. **Specific** – objectives are clear, concise statements that specify what you want to achieve.
2. **Measurable** – objectives use parameters that can be measured before and after project implementation.
3. **Achievable** – objectives are geomorphically and ecologically possible.
4. **Relevant** – objectives are clearly related to and support the project goal.
5. **Time-bound** – objectives are bound by a specified time frame.

Objectives developed to meet these stated criteria provide a solid foundation and clear link to project design, as well as to eventual post-project monitoring. Measurable attributes combined with a specific time frame provide the context for post-project appraisal and, where appropriate, adaptive management.

For larger and more complex projects, multiple objectives may overlap or even conflict with one another. Designating primary and secondary objectives is useful in such cases. Secondary objectives should be met only if they do not conflict with primary objectives. In addition, not all objectives may be achieved simultaneously. For example, expanding shallow and protected rearing habitat may increase water temperatures beyond the stated temperature objective. Prioritizing objectives provides greater clarity to project intent and facilitates development of design criteria, as well as post-project monitoring.

As with goals, objectives should not be too prescriptive. Stating objectives too narrowly closes off possible alternatives for meeting the project goals. For example, if the project goal is to increase the number of fish available for harvest, a corresponding objective might be to ‘increase rearing habitat.’ This leads to a prescription that requires instream work as a solution. Modifying the objective to ‘restore geomorphic processes that create and maintain rearing habitat’ is broader and allows for a range of solutions.

Each sub-group of the Technical Management Team for the Secretary’s Determination on Klamath River Dam Removal and Basin Restoration was asked to develop goals for the reservoir landscapes at 5 time steps; pre-construction (-2 – 0), construction (0 – 1), short term (1-5), mid-term (5-10), and long-term (10-50). The goals of the Sub-groups are listed in Appendix B.

### **4.2 Development of potential projects**

The goals of the each subgroup were combined and summarized. In some cases, the goals stated in the Appendix B would better be categorized as objectives and therefore, they were used as objectives when appropriate. The goals and objectives are summarized in Table 4-1. The goals were written to incorporate the list of interdisciplinary objectives, and to create a framework for articulating, prioritizing, and planning a potentially large and complex suite of projects that may conflict with other objectives. The goals and objectives were organized by



#### **4 Reservoir Area Management Methods**

Based upon the stated objectives, a list of potential projects to accomplish the stated objectives was developed:

1. Passive erosion of sediment during drawdown
2. Weed management around the reservoirs areas prior to dam removal;
3. Active re-vegetation of reservoir areas with native grasses immediately after reservoir drawdown;
4. Application of herbicides to further limit invasive species;
5. Planting of woody riparian species along the river banks in the reservoir areas; and
6. Monitoring of vegetation growth and additional planting to ensure objectives are accomplished.

The following sections of this document describe these potential projects except for the first two, passive erosion of sediment during drawdown and active weed management prior to dam removal. The passive erosion of sediment during drawdown was described in Section 3.1. Weed management programs prior to dam removal are currently underway and there are specific projects identified under the KBRA to accomplish weed management around the reservoir areas.

#### 4 Reservoir Area Management Methods

Table 4-1. Compiled goals, objectives, and potential projects for managing the reservoir areas.

<b>Period</b>	<b>Goal</b>	<b>Objective</b>	<b>Potential Project</b>
<i>Pre-construction period:</i>	Control invasive weeds, and eliminate the invasive seed bank.	Reduce and minimize the local sources of invasive weeds.	A weed management program implemented under KBRA and with County involvement
<i>Construction-period: (0 to 1 year)</i>	Natural erosion of reservoir deposits, transport via the river, dispersal in the ocean.	Maximize erosion of reservoir deposits during drawdown	Allow erosion of deposit during reservoir drawdown. Do not stabilize reservoir deposit.
<i>Short-term: (1-5 years after dam removal.)</i>	Limit windblown dust and surface erosion from reservoirs. .	Less than 25% of the reservoir areas will be exposed to erosion.	Active planting of native grasses and other species.*
	Establish native vegetation.*	75% of the reservoir areas will have native vegetation cover.	Active planting of native grasses and other plant species.*
	Control invasive weeds on exposed areas.	Maintain vegetative cover at less than 5% for weed species.	Apply herbicides the first year following dam removal. Monitoring and management of weeds in subsequent years.
	Produce habitat along riparian edges for salmonid smolts.	Establish a Minimum of 400 live shrub or tree species per acre within riparian-bank areas.	Active planting of native shrub and tree species within riparian-bank areas.*
<i>Mid-term: (5-10 years).</i>	Fish habitat within reservoir reaches similar to reaches found u/s or d/s.	Spawning and rearing habitat performing within 25% of similar u/s or d/s habitats.	Passive rehabilitation of riffles and pools. Natural resupply of gravel to reservoir reaches.
<i>Long-term: (10-50 years.)</i>	Establish sustainable riparian and fish habitat	No significant maintenance required to sustain fish habitat	Monitor vegetation growth along riparian corridor. Limit encroachment into riparian corridor.

\* Native and genetically appropriate planting materials from local sources to be used if feasible.

### **4.2.1 Revegetation of reservoir areas**

The revegetation of the reservoir areas presents many challenges and there are many uncertainties related to the dynamics of vegetation establishment after reservoir drawdown. This plan presents a general outline of the revegetation process and recognizes that future work will refine and potentially alter some aspects of this plan. However, the plan should capture all major features and should be complete enough to quantify costs and to understand the potential effectiveness of the revegetation plan. Three different set of assumptions are used to develop most probable low, most probable, and most probable high cost estimates to account for the uncertainty associated with the plan.

Ideally, native grasses and riparian species on exposed reservoir deposit will establish immediately following reservoir drawdown. This will minimize the time the exposed deposits are vulnerable to invasive species, discourage erosion, take advantage of residual moisture for desirable species, and provide valuable habitat in a timely manner. Current scenarios designate initiation of drawdown by January 1<sup>st</sup> and the reservoirs should be completely empty by Mid March under median hydrologic conditions. Under wet conditions, J.C. Boyle and Iron Gate Reservoir may refill partially or fully. Therefore, the exact dates of the re-vegetation are subject to weather conditions and flow forecasts.

Hydroseeding is proposed to establish grasses on the entirety of the exposed reservoir areas after drawdown. For Copco and Iron Gate reservoirs, use of existing and installation of temporary roads will allow areas with relatively low slopes (<20%) to be seeded with ground equipment. Areas not accessible by ground equipment due to terrain, slope, and deposit instability will be conducted with a combination of barge and rotary/fixed-wing aircraft (aerial) for the low and most-probable cost estimates. Hydroseeding from a barge will be accomplished by placing a ground rig on one barge with another barge used to ferry materials from shore. A moveable pier or other engineered method of accessing the supply barge as the water level recedes will also be needed. Barge seeding will only be feasible up to a certain point during the drawdown at which depths are too shallow and/or the current too swift to maneuver the barge effectively (estimated at 2,550 feet elevation for Copco, 2,230 feet for Iron Gate). Installation of a ramp and road access to remove the equipment is also included in the cost estimates. Aerial applications will be used to complete the application of hydromulch once the reservoir elevation is too low for barge seeding. Rotary aircraft will be necessary for precision applications of material near sensitive areas (to be defined pending subsequent reports) and the newly established river channel; fixed wing aircraft may also be used for the remaining areas if more cost effective. Exclusive use of aerial application equipment is used for the high cost estimate for both Copco and Iron Gate reservoirs. The slopes, terrain, scale, and proximity to existing roads at J.C. Boyle reservoir are more conducive to ground-applied hydroseed, although aerial applications are also presented for the most probable high cost estimate. The acreages of each hydroseeding method are given in Table 4-2.

#### **4 Reservoir Area Management Methods**

Hydroseeding of grass species will be applied to the entire exposed area following drawdown. Ideally hydroseeding will be applied as the reservoirs are drawn down (essential if barge seeding is implemented) and, more importantly, before the reservoir deposit desiccates in order to retain residual soil moisture and prevent crust formation.

The establishment rate for hydroseeding can be highly variable. Currently, there are not sufficient data to predict establishment success of grasses from hydroseeding on the exposed reservoir areas after removal of J.C. Boyle, Copco, and Iron Gate dams, although it is likely that the exposed deposit material will pose difficulties in revegetating as it will not immediately possess topsoil characteristics. Additional fall seedings to supplement areas where establishment was unsuccessful from the spring hydroseeding may be necessary and are included as a contingency in the cost estimate. Establishment rate estimates of 25%, 50%, and 75% are used for the low, most probable, and high cost estimates, respectively. Possible causes for establishment failure over the first season could be seed dormancy mechanisms, environmental stresses after germination, herbivory, erosion/movement of the seed and/or mulch, or others. In cases where mulch has moved/degraded or otherwise exposed bare soil, aerial hydroseeding will be used again for the fall re-seeding. In other cases where establishment has failed yet the mulch remains intact, new seed material applications may need to be incorporated in order to re-establish seed/soil contact sufficient for germination. This can be done with ground equipment or by hand with labor crews, depending on the accessibility and terrain. Slopes were used to estimate the proportion of areas likely to lose mulch cover; slopes over 20% were considered to be at higher risk for mulch losses and slopes less than 20% were considered lower risk. The estimated failure rates are assumed to occur homogeneously across the reservoirs; proportionate areas above and below 20% slopes were multiplied by the estimated reseeded coverage to estimate the areas suitable for aerial vs. ground re-seeding in the fall. The assumed areas with various spring establishment rates are given in Table 4-3.

Accelerated establishment of riparian woody species will be conducted by installing pole plantings in the riparian/wetland zone. Although these are critical revegetation areas that will serve to stabilize the river banks and provide habitat for fish and other species, it is impossible to install pole plantings until the reservoirs have been completely drawn down, the new river channel established, and banks stabilized. In addition, labor crews will need access to the riparian zones to install pole plantings, requiring the need for ground (or less preferably river) access to the riparian areas. Planting poles in the spring the year after drawdown will allow the river banks time to establish and shorelines to stabilize, as well as time and suitable substrate for installation of access roads and/or boat ramps. This is also the preferable timing for establishment of woody species poles and transplants.

#### **4 Reservoir Area Management Methods**

Areas predicted to support wetland species will be included in the grass-seeded/pole planted areas for the purposes of the cost estimates. Seed-bank studies have determined a relatively high density and diversity of viable wetland species seed exists in the inundated deposits at all three reservoirs (see Section 3.3). It is assumed that post-drawdown areas with the appropriate hydrology will not support the hydroseeded grasses or pole plantings and will ultimately revert to wetland vegetation without additional inputs. The total acreages of upland and wetland/riparian areas are given in Table 4-4.

Maps of the proposed seeding areas are given in Appendix E. The reservoir is separated into 5 zones:

1. Upland reseeding with ground based hydroseeding equipment
2. Upland reseeding with barge based hydroseeding equipment
3. Upland reseeding with aerial based hydroseeding equipment
4. Wetland/Riparian zones
5. Active Channel

The exact locations of the hydroseeding method are considered preliminary and would be subject to further testing of various methods and an investigation of the logistical problems associated with this effort. In addition, it is assumed that the entire tributary arms of the reservoirs, such as Camp/Dutch and Jenny Creeks at Iron Gate, are hydroseeded. The tributary riparian corridor will also be planted with woody riparian species, but the specific locations of the riparian corridor are not shown in the maps of Appendix E.

#### 4 Reservoir Area Management Methods

Table 4-2. Hydroseeding application method coverage by reservoir and cost-estimate category.

<b>J.C. Boyle</b>		
<b>COST ESTIMATE</b>	<b>APPLICATION METHOD</b>	<b>COVERAGE (acres)</b>
Low	Ground	247
Most Probable	Ground	247
High	Aerial	247
<b>Copco</b>		
<b>COST ESTIMATE</b>	<b>APPLICATION METHOD</b>	<b>COVERAGE (acres)</b>
Low	Ground	420
	Barge	82
	Aerial	300
Most Probable	Ground	420
	Barge	82
	Aerial	300
High	Aerial	802
<b>Iron Gate</b>		
<b>COST ESTIMATE</b>	<b>APPLICATION METHOD</b>	<b>COVERAGE (acres)</b>
Low	Ground	370
	Barge	296
	Aerial	159
Most Probable	Ground	370
	Barge	296
	Aerial	159
High	Aerial	825



#### 4 Reservoir Area Management Methods

Table 4-3. Fall re-seeding coverage (acres) by spring establishment success.

<b>J.C. Boyle</b>			
<b>SLOPE</b>	<b>SPRING SEEDING ESTABLISHMENT</b>		
	<b>75%</b>	<b>50%</b>	<b>25%</b>
< 20%	52	105	157
> 20%	10	19	29

<b>Copco</b>			
<b>SLOPE</b>	<b>SPRING SEEDING ESTABLISHMENT</b>		
	<b>75%</b>	<b>50%</b>	<b>25%</b>
< 20%	170	339	509
> 20%	31	62	93

<b>Iron Gate</b>			
<b>SLOPE</b>	<b>SPRING SEEDING ESTABLISHMENT</b>		
	<b>75%</b>	<b>50%</b>	<b>25%</b>
< 20%	175	349	524
> 20%	32	63	95

Table 4-4. Reservoir revegetation vegetation category coverage.

<b>J.C. Boyle</b>	
<b>CATEGORY</b>	<b>COVERAGE (acres)</b>
Wetland/Riparian	52
Upland	195
Total hydroseeded area	247

<b>Copco</b>	
<b>CATEGORY</b>	<b>COVERAGE (acres)</b>
Wetland/Riparian	170
Upland	632
Total hydroseeded area	802

<b>Iron Gate</b>	
<b>CATEGORY</b>	<b>COVERAGE (acres)</b>
Wetland/Riparian	50
Upland	775
Total hydroseeded area	825

#### **4 Reservoir Area Management Methods**

Species selection, for the purpose of this report, are based on those known to be endemic to the area, expected to establish readily, and meet the goal criteria. It is likely that not all species will actually be suitable for this project; ideally, small-scale studies will be conducted to determine the most effective species selection, seeding rate, timing, and other factors in order to meet the stated goals of the project. For example, the soil types, slopes, aspects, and elevations could be categorized into a manageable number of combinations. Then reference sites representing these categories located near the reservoirs could be selected to perform site specific studies to determine the best species and planting strategies for each category.

Planting material collected on-site (from upland areas around existing reservoirs) to be used as planting material or as nursery stock to generate the required amounts are preferred. Local genotypes are best adapted to thrive and coexist with other species within the revegetation area and will likely have the highest establishment rate. Collections should be conducted in manners that will not detriment the existing populations significantly. In some areas, the existing species populations may be insufficient for harvest and/or nursery production to the scale at which revegetation is desired. Off-site sources may be used to collect supplemental planting materials as needed and permitted. Indigenous genotypes reared by local commercial producers to generate larger amounts of planting material requires advanced planning and should be implemented some time in advance of planting (several years). Time and/or budget constraints may also make it necessary to acquire materials from commercial seed companies or nurseries. This is potentially a less costly source on a per-plant basis but may end up increasing overall costs if establishment success is low or if genotypes are aggressive and suppress natural succession in adjacent areas. Given the scale of the project, it is likely that commercial seed and/or nursery stock sources for planting material may be necessary.

Improved germination of seed material should be investigated and conducted accordingly, regardless of source. This includes scarification, stratification, imbibition, and others.

#### **Grass Seeding**

Grass seed in a hydromulch mixture will be placed over the entire exposed area except for the active channel areas of each reservoir as soon as possible after drawdown. Native cool season grass species common to the Klamath basin typically germinate in the fall to take advantage of winter monsoons. Spring seedings of cool season grasses have also been known to be successful, although generally early plantings (March-April) have greater establishment success than those done in late spring/early summer. Delayed drawdown due to wet weather would push the planting date past this optimum window, although increased soil moisture from such weather may mitigate establishment failure to some degree. This is especially the case if a sufficient layer of mulch can be installed in a timely manner to retain soil moisture.

#### **4 Reservoir Area Management Methods**

Grass seeding rates are presented in Table 4-5 in pounds pure live seed (PLS) per acre. Commercial plant cultivars produced in large-scale are often bred for high germination rates (low dormancy) and seed viability. Locally collected “wild” varieties of plant species often have seed dormancy mechanisms as an adaptation for survival in adverse or catastrophic conditions, and not all seeds produced are viable. In addition, relatively small-scale production and processing methods can incorporate inert materials (chaff, stems, etc.) into the bulk seed, rendering it less than completely “pure”. PLS is the product of the measured purity (%) and germination (%) of bulk seed, and is used in lieu of bulk seed for seeding rates in order to ensure the desired planting density is achieved.

It should be noted that seeding rates are generally toward the higher end of recommended rates from literature sources due to the number of unknown variables affecting successful seeding establishment. Ideally, small-scale and site-specific studies will be conducted to determine the most efficient seeding rate to be incorporated into future revisions of the revegetation plan. In addition, the

In addition to the seed material, wood mulch and tackifier will be added to the hydroseed mix with a water carrier (supplied from the reservoirs/river or tankers). The wood mulch and tackifier will be applied at 2,000 and 120 lbs per acre, respectively, although rates may vary by site conditions and slope.

#### 4 Reservoir Area Management Methods

Table 4-5. Grass seeding rate (PLS) and total pounds PLS – spring planting

<b>J.C. Boyle</b>			
COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	<i>Festuca idahoensis</i>	4	988
Blue wildrye	<i>Elymus glaucus</i>	4	988
Small fescue	<i>Vulpia microstachys</i>	4	988
Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	6	1,482
Sandberg bluegrass	<i>Poa secunda</i>	0.5	124
Spike bentgrass	<i>Agrostis exarata</i>	0.25	62
<b>Copco</b>			
COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	<i>Festuca idahoensis</i>	4	3,208
Blue wildrye	<i>Elymus glaucus</i>	4	3,208
Small fescue	<i>Vulpia microstachys</i>	4	3,208
Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	6	4,812
Sandberg bluegrass	<i>Poa secunda</i>	0.5	401
Spike bentgrass	<i>Agrostis exarata</i>	0.25	201
Western needlegrass	<i>Achnatherum occidentale</i>	4	3,208
California brome	<i>Bromus carinatus</i>	8	6,416
Squirreltail	<i>Elymus elymoides</i>	4	3,208
<b>Iron Gate</b>			
COMMON NAME	SCIENTIFIC NAME	SEEDING RATE	TOTAL POUNDS PLS
Idaho fescue	<i>Festuca idahoensis</i>	4	3,300
Blue wildrye	<i>Elymus glaucus</i>	4	3,300
Small fescue	<i>Vulpia microstachys</i>	4	3,300
Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	6	4,950
Sandberg bluegrass	<i>Poa secunda</i>	0.5	413
Spike bentgrass	<i>Agrostis exarata</i>	0.25	206
Western needlegrass	<i>Achnatherum occidentale</i>	4	3,300
California brome	<i>Bromus carinatus</i>	8	6,600
Squirreltail	<i>Elymus elymoides</i>	4	3,300
<b>Additional Materials</b>			
RESERVOIR	WOOD MULCH (lbs)	TACKIFIER (lbs)	
J.C. Boyle	494,000	29,640	
Copco	1,604,000	96,240	
Iron Gate	1,650,000	99,000	

Species mixes and seeding rates for fall re-seeding are identical to those used in the spring seeding, with the potential addition of incorporation methods for areas where mulch layers persist (Table 4-6). This will require equipment and/or labor crew access to these areas.

#### 4 Reservoir Area Management Methods

Table 4-6. Grass seeding materials for fall re-seeding (total pounds PLS) based upon the spring establishment success.

<b>J.C. Boyle</b>			
COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	247	494	741
Blue wildrye	247	494	741
Small fescue	247	494	741
Bluebunch wheatgrass	371	741	1,112
Sandberg bluegrass	31	62	93
Spike bentgrass	15	31	46
<b>Copco</b>			
COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	802	1,604	2,406
Blue wildrye	802	1,604	2,406
Small fescue	802	1,604	2,406
Bluebunch wheatgrass	1,203	2,406	3,609
Sandberg bluegrass	100	201	301
Spike bentgrass	50	100	150
Western needlegrass	802	1,604	2,406
California brome	1,604	3,208	4,812
Squirreltail	802	1,604	2,406
<b>Iron Gate</b>			
COMMON NAME	SPRING SEEDING ESTABLISHMENT		
	75%	50%	25%
Idaho fescue	825	1,650	2,475
Blue wildrye	825	1,650	2,475
Small fescue	825	1,650	2,475
Bluebunch wheatgrass	1,238	2,475	3,713
Sandberg bluegrass	103	206	309
Spike bentgrass	52	103	155
Western needlegrass	825	1,650	2,475
California brome	1,650	3,300	4,950
Squirreltail	825	1,650	2,475

#### 4 Reservoir Area Management Methods

Additional materials (> 20% slope only)

##### J.C. Boyle

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	19,000	1,140
50%	38,000	2,280
25%	57,000	3,420

##### Copco

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	61,692	3,702
50%	123,385	7,403
25%	185,077	11,105

##### Iron Gate

SPRING ESTABLISHMENT	WOOD MULCH (lbs)	TACKIFIER (lbs)
75%	63,462	3,808
50%	126,923	7,615
25%	190,385	11,423

#### Riparian Planting

Riparian (and wetland) extents were determined using a variety of techniques. These included model assessments based upon reasonable biological parameters and subsequently by comparison to river geomorphologic maps of the reservoirs developed from historical photography.

Initial assessments were determined using two parameters, slope, and height above river. Slopes were derived from bathymetric data adjusted for post dam removal desiccation. Height above river was determined by subtracting a modeled river elevation from the bathymetric elevations. Three initial classes were developed: Wetland, inland riparian, and bank riparian. Inland riparian areas were those with a slope of less than 3%. Potential wetlands were modeled with slopes less than 2% and height less than one foot above the river. Bank riparian was modeled using slope less than 5% and height above river less than 5 feet.

These modeled vegetation extents were then compared to river geomorphology maps and further adjusted. The modeling produced a mosaic of wetland and riparian areas that we determined were more variable than what natural conditions might produce. These areas were combined using mapped terraces and bars as a guide. Wetland or riparian areas disconnected from the river were eliminated. All wetland and riparian areas were combined into one wetland/riparian class, all of which will be treated as riparian for purposes of the cost estimate.

Revegetation species will be native riparian woody tree and shrub cuttings and transplants (seedlings/saplings). Planting densities within the riparian-bank areas



#### **4 Reservoir Area Management Methods**

may be variable, but will be assumed to be at approximately 400, 700, and 1,000 plants per acre for the low, most probable and high scenarios, respectively, on average. Total materials per species are then calculated by estimated proportion desired. The species mix is given in Table 4-7.

Additional materials needed to increase the successful establishment of riparian-bank species include herbivore protection (screens, chemical deterrents) and polymer (transplants only). Herbivore protection is vital to successful establishment of planted cuttings and seedlings, as young plant cuttings and transplants are highly susceptible to mortality from herbivory before root and shoot systems can sufficiently establish and are also often preferred browse material. Addition of polymer (e.g. vermiculite) to soils around seedling transplants can support root development through extensive summer dry periods and increase successful establishment. The quantities necessary for revegetation for each reservoir are given in Table 4-8 and Table 4-9.

Although estimates of groundwater depths and fluctuations are not available, it is expected to be relatively shallow in proximity to the newly established river channel. Riparian species will be planted to a depth at which they will be sub-irrigated by groundwater and/or the capillary fringe; no additional irrigation is expected to be necessary. Further studies are recommended to determine appropriate planting depths for riparian species in light of groundwater levels over extended time periods in order for successful long-term establishment to be obtained.

#### 4 Reservoir Area Management Methods

Table 4-7. Riparian revegetation species and planting proportions

<b>J.C. Boyle</b>			
COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	<i>Salix exigua</i>	Cutting	70%
Arroyo willow	<i>Salix lasiolepis</i>	Cutting	10%
Shining willow	<i>Salix lucida</i>	Cutting	10%
Western serviceberry	<i>Amelanchier alnifolia</i>	Cutting/rhizome	5%
Chokecherry	<i>Prunus virginiana</i>	Transplant	5%
<b>Copco</b>			
COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	<i>Salix exigua</i>	Cutting	60%
Arroyo willow	<i>Salix lasiolepis</i>	Cutting	10%
Shining willow	<i>Salix lucida</i>	Cutting	10%
Three-leaf sumac	<i>Rhus trilobata</i>	Cutting	10%
Western serviceberry	<i>Amelanchier alnifolia</i>	Cutting/rhizome	5%
Chokecherry	<i>Prunus virginiana</i>	Transplant	5%
<b>Iron Gate</b>			
COMMON NAME	SCIENTIFIC NAME	MATERIAL UNIT	PROPORTION
Narrowleaf willow	<i>Salix exigua</i>	Cutting	70%
Arroyo willow	<i>Salix lasiolepis</i>	Cutting	20%
Shining willow	<i>Salix lucida</i>	Cutting	10%

#### 4 Reservoir Area Management Methods

Table 4-8. Riparian species used for revegetation.

<b>J.C. Boyle</b>			
COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	14,560	25,480	36,400
Arroyo willow	2,080	3,640	5,200
Shining willow	2,080	3,640	5,200
Western serviceberry	1,040	1,820	2,600
Chokecherry	1,040	1,820	2,600
<b>Copco</b>			
COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	40,800	71,400	102,000
Arroyo willow	6,800	11,900	17,000
Shining willow	6,800	11,900	17,000
Three-leaf sumac	6,800	11,900	17,000
Western serviceberry	3,400	5,950	8,500
Chokecherry	3,400	5,950	8,500
<b>Iron Gate</b>			
COMMON NAME	COST ESTIMATE SCENARIO		
	LOW	MOST PROBABLE	HIGH
Narrowleaf willow	14,000	24,500	35,000
Arroyo willow	4,000	7,000	10,000
Shining willow	2,000	3,500	5,000

#### 4 Reservoir Area Management Methods

Table 4-9. Additional planting material at each reservoir.

<b>Additional Materials</b>			
<b>J.C. Boyle</b>			
<b>COST ESTIMATE SCENARIO</b>	<b>HERBIVORE SCREENS</b>	<b>CHEMICAL DETERENT (gal)</b>	<b>POLYMER (lbs)</b>
Low	20,800	416	66
Most probable	36,400	728	115
High	52,000	1,040	164
<b>Copco</b>			
<b>COST ESTIMATE SCENARIO</b>	<b>HERBIVORE SCREENS</b>	<b>CHEMICAL DETERENT (gal)</b>	<b>POLYMER (lbs)</b>
Low	68,000	1,360	214
Most probable	119,000	2,380	375
High	170,000	3,400	536
<b>Iron Gate</b>			
<b>COST ESTIMATE SCENARIO</b>	<b>HERBIVORE SCREENS</b>	<b>CHEMICAL DETERENT (gal)</b>	<b>POLYMER (lbs)</b>
Low	20,000	400	0
Most probable	35,000	700	0
High	50,000	1,000	0

#### Wetland Areas

Many sites within the inundated reservoirs are expected to support wetland vegetation more readily than the grass species in the seeding mix. The seed bank germination study indicated a high degree of viability and variability of wetland species seed in the reservoir deposit (see Section 4.3), even after many years or even decades under water. This suggests wetland areas will re-vegetate naturally and relatively quickly where hydrology is favorable, and therefore active revegetation of wetland areas will not be conducted.

### **4.2.2 Control of invasive species**

Several aggressive invasive weed species currently infest areas in relative proximity to the reservoir shorelines. Although hydromulching should theoretically suppress a good degree of weed infestations that would otherwise hinder revegetation efforts, further weed management will likely be necessary. Monitoring and management activities should commence as soon as deposits are stable enough to support application equipment and ground crew activities, as well as prevent chemically treated soils from entering the river. Management should mesh with any ongoing efforts by state, local, or federal agencies in the area prior to dam removal, but will likely involve chemical and mechanical methods.

Herbicides with low soil mobility and/or use rates as well as low toxicity to fish and aquatic organisms are necessary, and should be applied using techniques to avoid drift during application. Glyphosate is one potential herbicide with such characteristics; it is deactivated by soil contact and would not be a pollutant hazard or harm revegetation species. Once grasses are established, spot treatments of post-emergent herbicides will be applied to invasive species within the revegetation areas and may be re-applied the following year if further treatments are necessary. Spot treatments are estimated to be applied over 25%, 50%, and 75% of the total reservoir areas for the low, most probable, and high cost estimates, respectively.

Mechanical control would consist of disking, mowing, and hand-weeding. Limited access and sloping areas will limit disking and mowing to rights of way and possibly some of the flatter terraces, and would need to be combined with chemical treatments to be fully effective. Hand-weeding is highly labor intensive and unpleasant due to the spiny nature of some of the invasive species, but may be the only option to control weeds in sensitive and/or high-priority areas. Estimates of mechanically controlled areas are estimated to be minimal and considered to fall under the contingency budget for the purposes of the cost estimate.

Estimates of chemical treatments in total active ingredient (AI) applied (lbs) are presented in Table 4-10. These estimates are based on 2 lb AI per acre treatments, although actual applications may be spray to wet based on a percent concentration. This is a general guideline for cost estimation purposes and does not indicate the specific herbicide product. Use of herbicides is to be addressed in the Environmental Impact Statement (EIS) and will facilitate further discussion and ultimate determination of herbicides to be used in the revegetation effort.

#### 4 Reservoir Area Management Methods

Table 4-10 .Estimated chemical treatments quantities.

<b>J.C. Boyle</b>		
<b>COST ESTIMATE SCENARIO</b>	<b>TREATED AREA (acres)</b>	<b>TOTAL AI APPLIED (lbs)</b>
Low	62	124
Most probable	124	247
High	185	371
<b>Copco</b>		
<b>COST ESTIMATE SCENARIO</b>	<b>TREATED AREA (acres)</b>	<b>TOTAL AI APPLIED (lbs)</b>
Low	201	401
Most probable	401	802
High	602	1,203
<b>Iron Gate</b>		
<b>COST ESTIMATE SCENARIO</b>	<b>TREATED AREA (acres)</b>	<b>TOTAL AI APPLIED (lbs)</b>
Low	206	413
Most probable	413	825
High	619	1,238



### 4.2.3 Pre and post-revegetation activities

#### Pre-revegetation

As has been implied throughout the document, the revegetation plan presented here is a rough estimation of activities required to revegetate the exposed reservoir deposit in order to meet the stated goals for the purposes of estimating costs for secretarial determination. Many uncertainties still exist and the current plan needs further studies and information to meet these goals. Emphasis is placed on further determination of knowledge gaps and appropriate study in order to formulate a more refined revegetation plan based on site and temporally specific data, and therefore with a greater degree of confidence in its success. Potential information collection topics are presented in Table 4-11.

Table 4-11. Potential topics for investigation to improve future revisions of the revegetation plan.

- Extensive vegetation surveys at reservoirs and adjacent river reaches and tributaries.
- Determination of feasible restorative condition(s) based on current vegetative status in similar local areas.
- Ascertain the potential for successful active and passive establishment of desired species in reservoir deposit: Methods, rates, species, timing, etc.
- Modify planting material requirements based on revised goals, quantities, and availability.
- Coordination with appropriate agencies on immediate and long-term weed management strategies.
- Revise uncertainties with respect to new data and formulate contingency plans.

#### Post-revegetation

Monitoring and maintenance of invasive species will be conducted for a minimum of 4 years following revegetation. This may ultimately be included as part of a larger overall dam removal monitoring program, but for the purpose of cost estimation they are presented here. Development of specific monitoring protocols will be based on the goals of the project. Per the currently stated goals, these would generally include assessment of successful plant establishment and coverage for both desired and invasive species.

Maintenance activities for the vegetation revegetation effort would follow up with appropriate re-seeding/planting, invasive plant management, and other activities as situations arise (e.g. installation of erosion mitigation materials). Actions will be adapted per the monitoring results and amendments to goals on a regular basis. Cost estimates are based on 4 consecutive years of hydroseeding and weed control over 10% of revegetation areas per year.

### **4.3 Summary Schedule of Vegetation Activities**

The overall schedule of the re-vegetation plan is presented in Table 4-12. This time line should be considered as a general guide for the current revegetation schedule. Further small-scale and site-specific studies are recommended to refine the schedule for best possible establishment of revegetation species.

Prior to removal, the seed material will need to be cultivated from preferably local sources. This may need to be started several years prior to dam removal to obtain sufficient quantities of seed material. An active weed management program in the areas above the reservoirs will be initiated several years prior to dam removal. If the invasive species are not controlled above the reservoirs, it may not be possible to control them long term within the reservoirs, regardless of the initial success of the revegetation in the reservoirs.

Drawdown will begin at all three reservoirs will begin January 1, 2020 and will be complete by Mid March for all three reservoirs during a median type of water year. Barge hydroseeding of the upland areas will be performed on Copco and Iron Gate reservoir during the drawdown beginning January 1, 2020. Once the reservoirs are drawdown below a specified elevation, the barges will be removed. Once drawdown is complete in Mid March, truck based and aerial hydroseeding of the remaining reservoirs areas will be performed. The spring reseedling is expected to be complete by the end of March. If it is a wet year, the hydroseeding at Iron Gate will be delayed because of the possibility of reservoir refilling. Because Copco No. 1 Dam is being notched, there is no risk of reservoir refilling.

In the fall of the same year, herbicides will be applied to the reservoirs areas as needed to control invasive species. Fall reseedling of failed upland revegetation zones will be performed, potentially on an extensive scale. It is assumed that up to 75% of the upland areas will need to be re-vegetated.

In the spring of 2021, the riparian zones will be planted with native riparian woody tree and shrub cuttings and transplants. This will also be the first of 4 more years of monitoring of the reservoir areas to ensure revegetation success and, if necessary, revegetation of select areas that have failed and reapplication of herbicides to control invasive species.

#### 4 Reservoir Area Management Methods

Table 4-12. Schedule of re-vegetation activities.

• Several years prior to drawdown	
	<ul style="list-style-type: none"> <li>○ Begin revegetation seed material collection/acquisition/propagation and germination testing</li> <li>○ Control of invasive species in tributary arms and reservoir rims</li> </ul>
• Drawdown initiated	
	○ January 1 <sup>st</sup> , 2020
• Drawdown completion estimates (weather dependent)	
	<ul style="list-style-type: none"> <li>○ J.C. Boyle – February 1<sup>st</sup> to May 1<sup>st</sup></li> <li>○ Copco – March 15<sup>th</sup></li> <li>○ Iron Gate – March 1<sup>st</sup> to May 1<sup>st</sup></li> </ul>
• Immediately following drawdown or as suitable areas are exposed	
	○ Ground, barge and/or aerial hydroseeding - grasses
• Fall of year 1	
	<ul style="list-style-type: none"> <li>○ Re-seeding of failed establishment areas</li> <li>○ Spot applications of herbicide</li> </ul>
• Fall of year 1 to early spring year 2	
	○ Begin revegetation cutting and transplant material collection (from local sources or nurseries)
• Spring to summer, year 2	
	○ Install revegetation cutting and transplant materials in riparian zones
• Years 2 through 5	
	<ul style="list-style-type: none"> <li>○ Monitoring and maintenance</li> <li>○ Revegetation of select areas</li> </ul>

#### **4 Reservoir Area Management Methods**

## 5 References

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## **5 References**

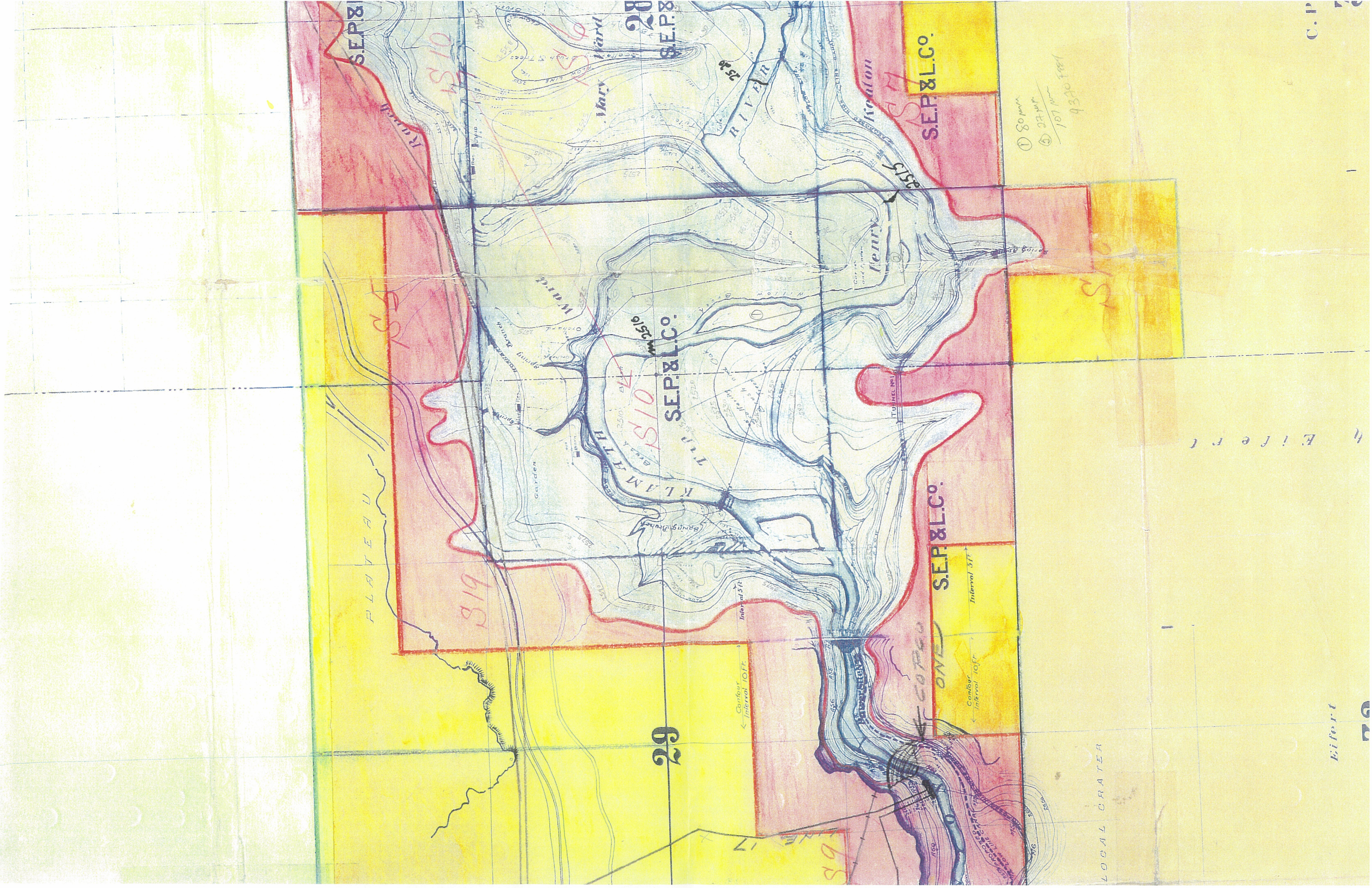
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## **6 Appendix A. Historical Maps of Copco Reservoir**

Figure 6-1. Maps of the pre-dam topography and floodplain features of Copco Reservoir. The maps were from PacifiCorp and the scanned digital maps were provided by Larry Dunsmoor, Senior Aquatics Biologist, The Klamath Tribes, Chiloquin, Oregon.





① 80 m  
② 27 m  
107 m  
930 m

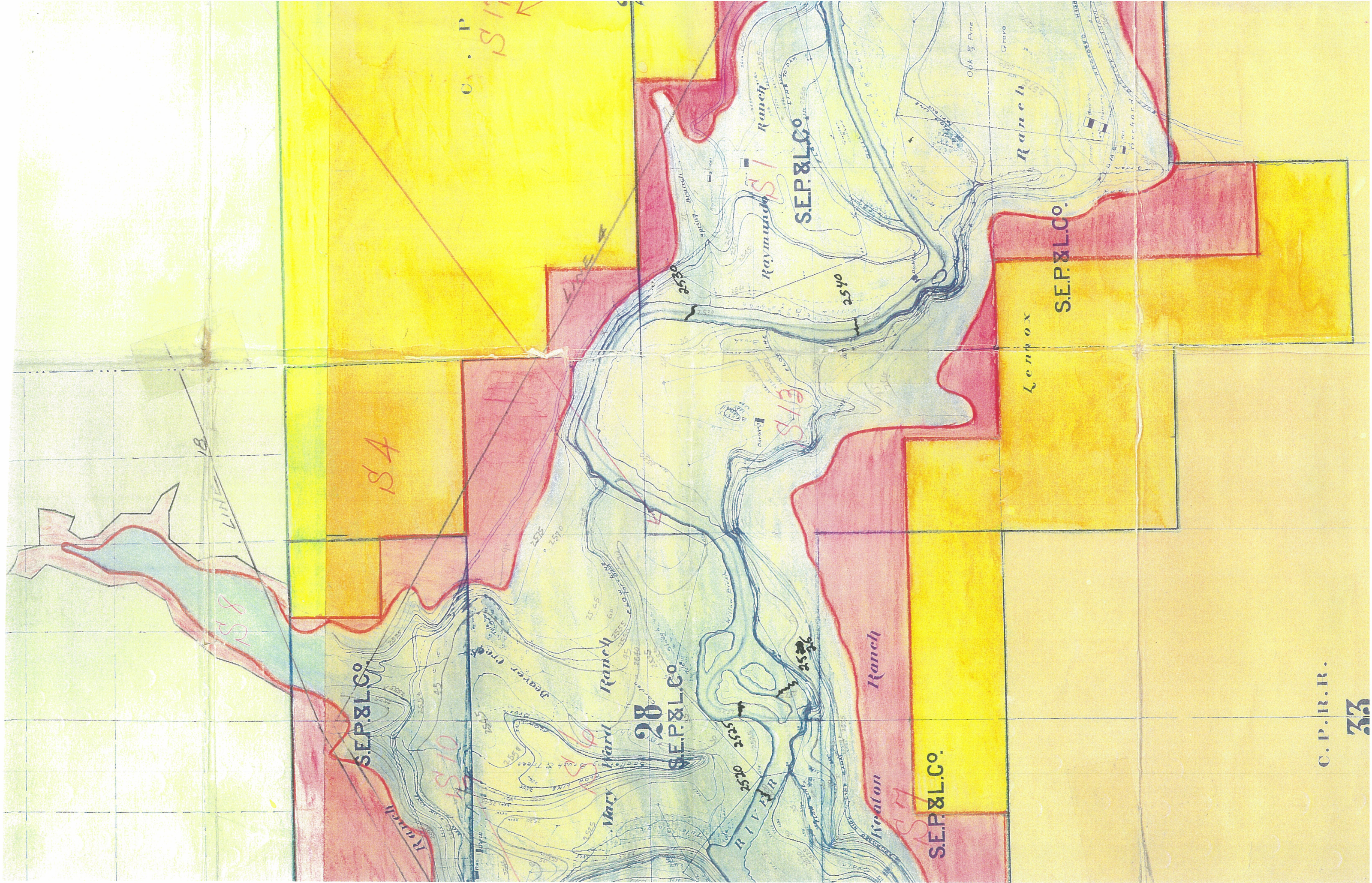
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Power House  
Fall Creek Station  
Power House  
Fall Creek Station  
Power House

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C.P.R.R.

Thomas A. Grubb

S.E.P.&L.CO.

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LAVA FLOW FROM LOCAL CRATERS

S.E.P. & L. Co.



ROAD TWO

LAVA FLOW FROM LOCAL CRATER

S.E.P. & L. Co.

NS19



## **7 Appendix B. Sub-group Goals for Managing the Reservoir Areas**

### **7.1 Engineering/Geomorphology/Construction**

- **Pre-Construction (Year -2 to 0)**
  - Control invasive weeds around reservoirs and nearby upslope areas.
- **Construction (Year 0 to 1)**
  - Allow for maximum natural erosion of reservoir deposits during drawdown and the first year after dam removal,
  - Allow passive vegetation development, while controlling invasive weeds.
- **Short term (Year 1 to 5)**
  - Passive vegetation propagation by native seed sources, enhanced by active stabilization of stream banks with willow and grass plantings.
- **Mid-term (Year 5 to 10)**
  - Weed control as needed to achieve vegetation goals.
- **Long-term (Year 10 to 50)**
  - Allow natural progression of re-vegetation processes

### **7.2 Biology**

- **Short term (Year 1-5)**
  - Reduce the delivery of deposits to background levels to the channel
  - Provide cover for smolt and fry along the channel edges in March to July
- **Mid-term (Year 5-10)**
  - Fully functioning spawning habitat (using similar reaches downstream as models, and looking at substrate, depth, velocity as the key parameters).
- **Long-term (Year 10-50)**
  - Fully functioning off-channel habitats (This may be achieved with enhancement or restoration of back channels, spring headed tributaries, floodplains, etc.)

### **7.3 Water Quality**

- **Construction (Year 0 to 1)**
  - Minimize the impacts of reservoir drawdown on downstream water quality (TSS, DO) through evaluations of dam deconstruction sequencing and seasonal timing.

## **7 Appendix B. Sub-group Goals for Managing the Reservoir Areas**

- Minimize the impacts of organics on downstream water quality by allowing natural hydrologic processes to remove the majority of unstable fine deposits stored behind the dams during the winter and spring months when water quality related issues are generally less sensitive than other times of the year (i.e., flows and deposit concentrations are naturally high in the river).
- Limit exposure and transport of potentially contaminated deposits, if results from the deposit data/interpretive reports indicate contamination is an issue
- **Short-Term and Mid-Term (Year 1 to 10)**
  - Minimize exceedances of Clean Water Act (CWA) standards through accelerated restoration or construction of riparian/wetland areas and BMPs within the reservoir footprint areas or restored free-flowing reaches to benefit water quality (i.e., improved nitrogen and phosphorus assimilation, dissolved oxygen (DO) concentration, reduced water temperature, and reduced deposit delivery).
  - Help minimize nuisance aquatic plant growth (i.e., periphyton and macrophytes) and associated effects on DO and pH by enhancing seasonal flow variability as well as periodic channel bed mobilization and/or deposit scour.
  - Improve nutrient transformations and retention through increased channel complexity that enhances subsurface water exchange, where natural channel morphology allows.
- **Long-Term (Year 10 to 50)**
  - Meet CWA standards by adaptive use of BMPs allowing for stream channel recovery and improved water quality.
  - Within 10 to 20 years, support a well-established riparian zone to provide shading and wetland complexes (where possible) for improved assimilatory capacity of upstream nutrients, resulting in improvement of other water quality parameters such as water temperature and DO.
  - Help minimize nuisance aquatic plant growth (i.e., periphyton and macrophytes) and associated effects on DO and pH by enhancing seasonal flow variability as well as periodic channel bed mobilization and/or deposit scour.

### **7.4 Recreation**

- **Construction (Year 0 to 1)**
  - Minimize impact on recreationists during dam removal operations including:
    - Dust abatement on roads and construction sites
    - Noise and timing of noise near recreation sites
    - Appearance – keep a tidy work site
    - Prevent trespass on private land by the public
- **Short Term (Year 1-5)**



## **7 Appendix B. Sub-group Goals for Managing the Reservoir Areas**

- The primary goal is to prevent or minimize impact to recreation users.
- A functioning main river channel is the highest priority.
- Within two years have 75% ground cover on the formerly inundated reservoir lands to prevent windblown dust and to begin to anchor the new river and perennial stream channels.
- Concentrate treatments for noxious weeds in a zone within ¼ mile of recreation sites, trails, roadways and perennial waterways.
- **Mid-Term (Year 5 to 10)**
  - Continue to prioritize restoration and re-vegetation work along the main Klamath River and perennial side streams where boating and fishing activities will be highest.
  - Within 10 years the predominant ground cover on the previously inundated reservoirs has transitioned to more perennial native vegetation. (we need some assistance in identifying appropriate plant species and materials)
  - Monitor the main river channel banks to identify problem areas that may need additional mechanical or vegetative treatment to reach a stable condition. (do we want to set a threshold like barren eroding banks over “x” high and “y” long particularly in areas with more concentrated recreational activities?). Have plans in place to treat areas that have exceeded the threshold and are not responding.
  - Working in cooperation with the counties, continue to treat noxious weed infestations along recreation sites, trails, roadways and perennial waterways.
- **Long Term (Year 10-50)**
  - Within 20 years have well established appropriate riparian vegetation including woody and herbaceous species in the riparian zones along the main Klamath River channel.
  - Thriving and appropriate vegetative cover on the previously inundated reservoir lands. (Do we need to give % canopy cover or ground cover at this point?)
  - Stable river canyon walls and uplands that will sustain them through future flood events. (See figure 6-18 below from A River Once More: The Klamath River prepared by Phillip Williams and Associates (PWA) April 17, 2009)
  - Working in cooperation with the Counties, continue to treat noxious weed infestations along recreation sites, trails, roadways and perennial waterways.
  - Continue to monitor the main river channel banks to identify problem areas that may need additional mechanical or vegetative treatment to reach a stable condition. Have plans in place to treat areas that have exceeded the threshold and are not responding.

## 7.5 Real Estate

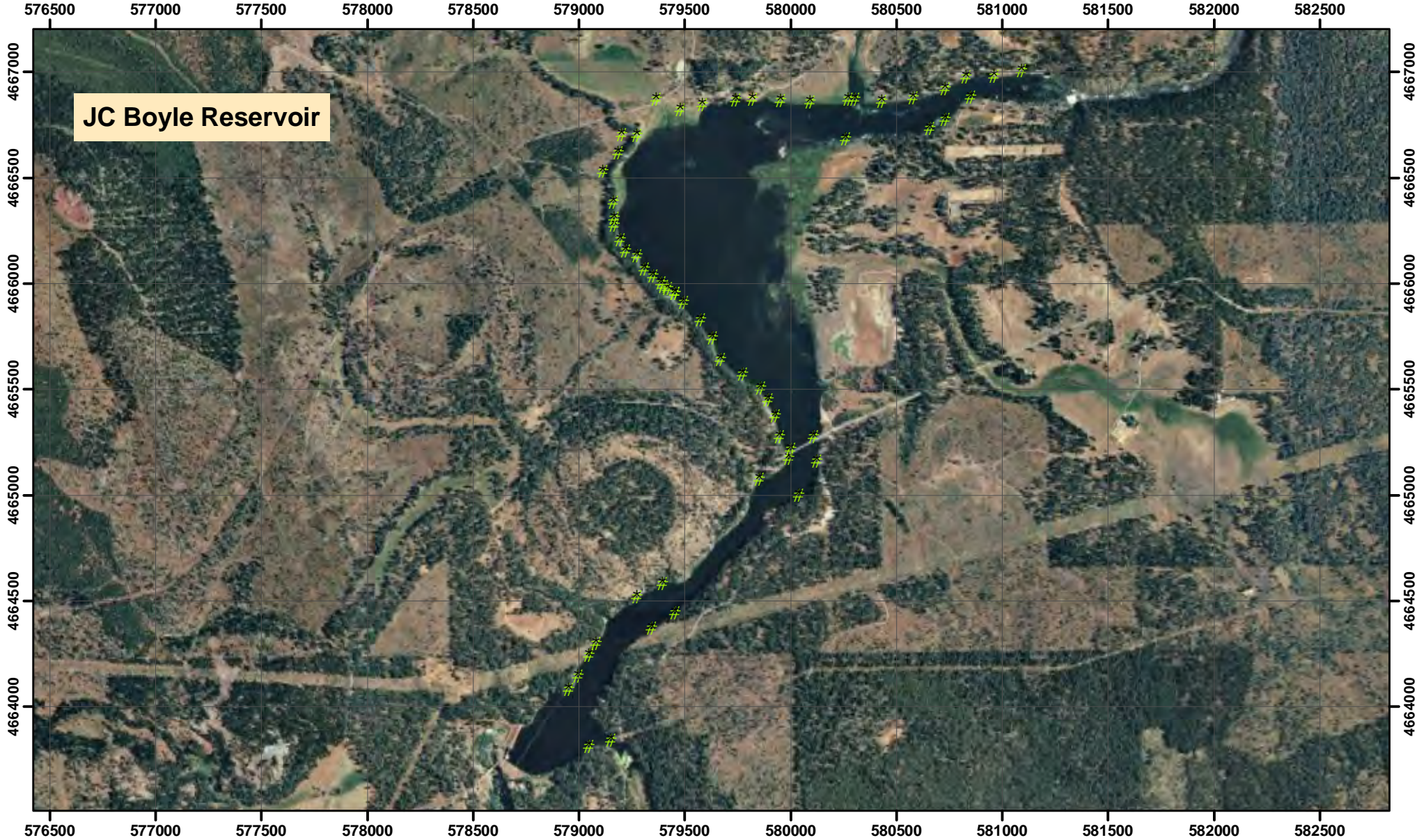
- **During Construction Year (0-1)**
  - Minimize impact on adjacent property owners during dam removal operations including:
    - Dust abatement
    - Odor – minimize duration of odor impacts
    - Noise and timing of noise near residences
    - Appearance – keep a tidy work site
    - Prevent trespass on private land by restoration team members and the public
- **Short Term (Year 1-5)**
  - The primary goal is to prevent or minimize impact on adjacent property owners.
  - Copco Reservoir is the top priority followed by Iron Gate and Topsy Reservoirs.
  - Within two years have 75% ground cover on the formerly inundated reservoir lands to prevent windblown dust onto private lands.
  - Monitor previously inundated lakeshore slopes for potential slope failure on private lands.
  - Quickly look for solutions where slope failure occurs or is predicted to occur on private land and implement them.
  - Concentrate treatments for noxious weeds in a zone within ¼ mile of private lands, along roadways and perennial waterways.
- **Mid Term (Year 5-10)**
  - Continue to prioritize restoration and revegetation work adjacent to private lands around the former Copco Reservoir and along the main Klamath River and perennial side streams.
  - Within 10 years the predominant ground cover on the previously inundated reservoirs has transitioned to a more perennial native vegetation mix.
  - Working in cooperation with the County, continue to treat noxious weed infestations within ½ mile of private lands, and along roadways and perennial waterways.
- **Long Term (Year 10-50)**
  - Within 20 years have well established appropriate riparian vegetation including woody and herbaceous species in the riparian zones along the main Klamath River channel and Beaver, Snackenburg, Milk, Parks Canyon, and Deer Creeks and the unnamed perennial tributary just above the Copco 1 dam on the southside of the existing reservoir.
  - Thriving and appropriate vegetative cover on the previously inundated reservoir lands.

## **7.6 Cultural**

To be determined based upon review of project impacts.



## **8 Appendix C. Existing Vegetation Surveys**



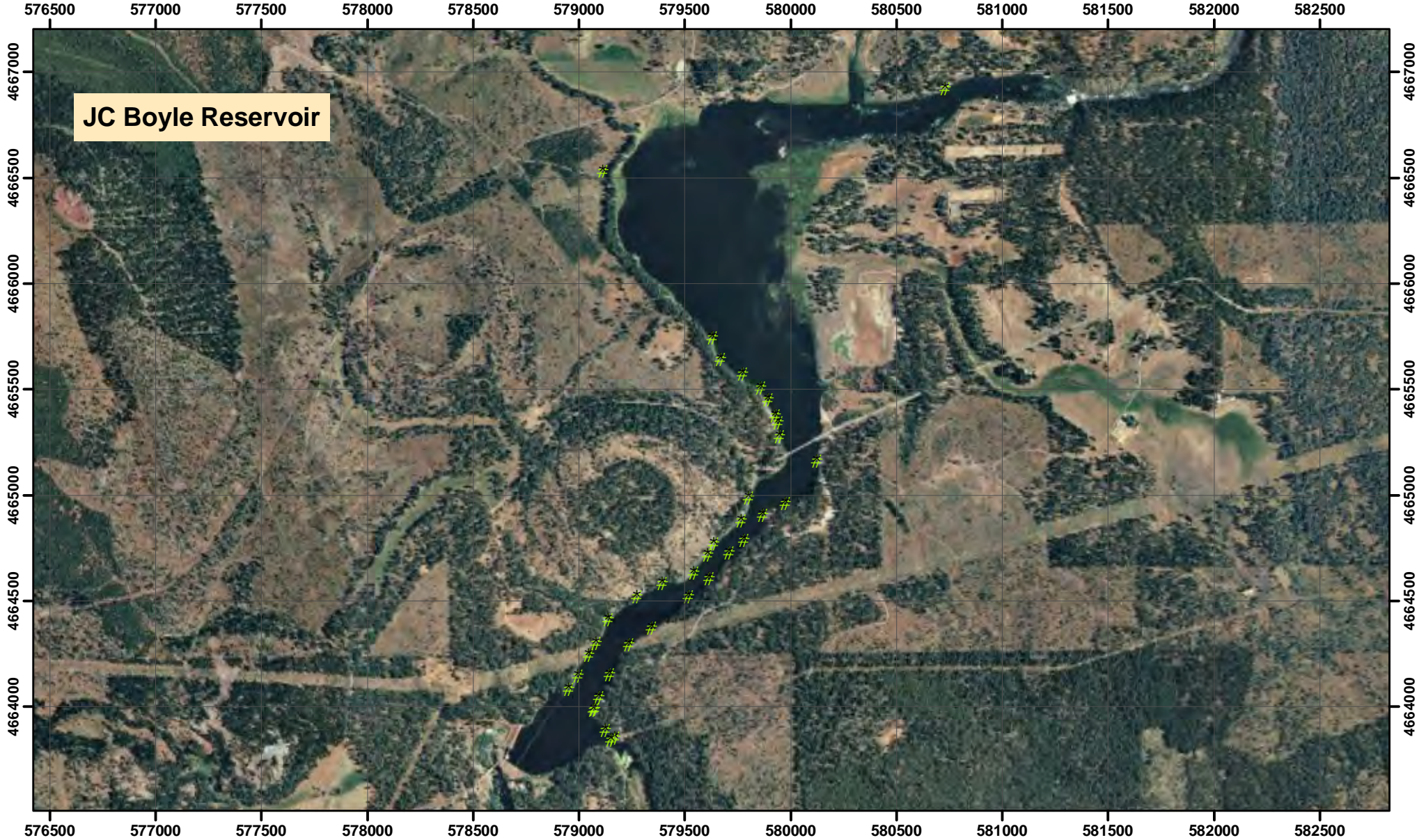
JC Boyle Reservoir



\* Locations of assorted native grasses

Projection UTM  
Datum NAD 83  
Zone 10 N





JC Boyle Reservoir



# Locations of assorted native shrubs

Projection UTM  
Datum NAD 83  
Zone 10 N





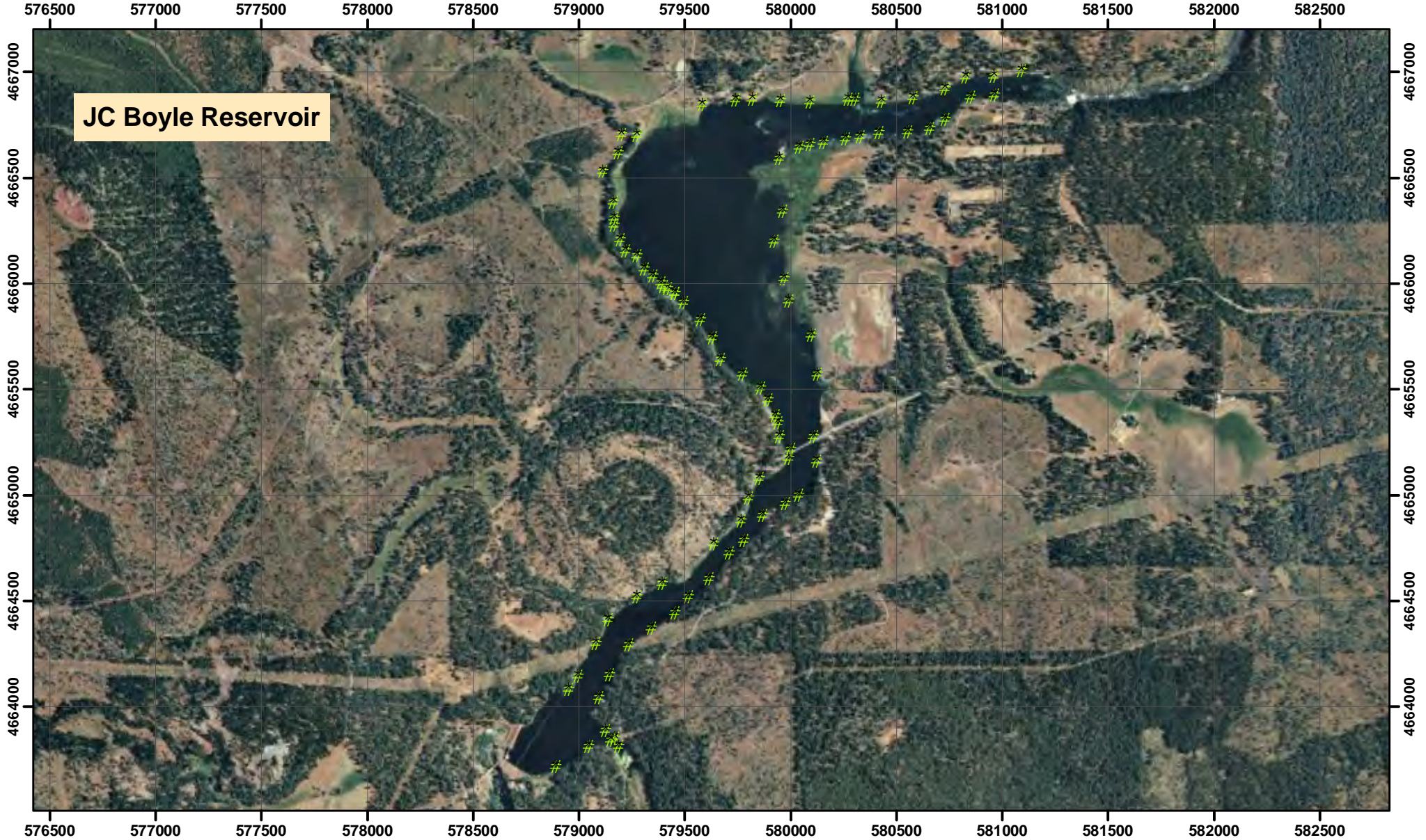
JC Boyle Reservoir



\* Locations of Sagebrush (*Artemisa* spp.)

Projection UTM  
Datum NAD 83  
Zone 10 N





JC Boyle Reservoir



Locations of conifers

Projection UTM  
Datum NAD 83  
Zone 10 N





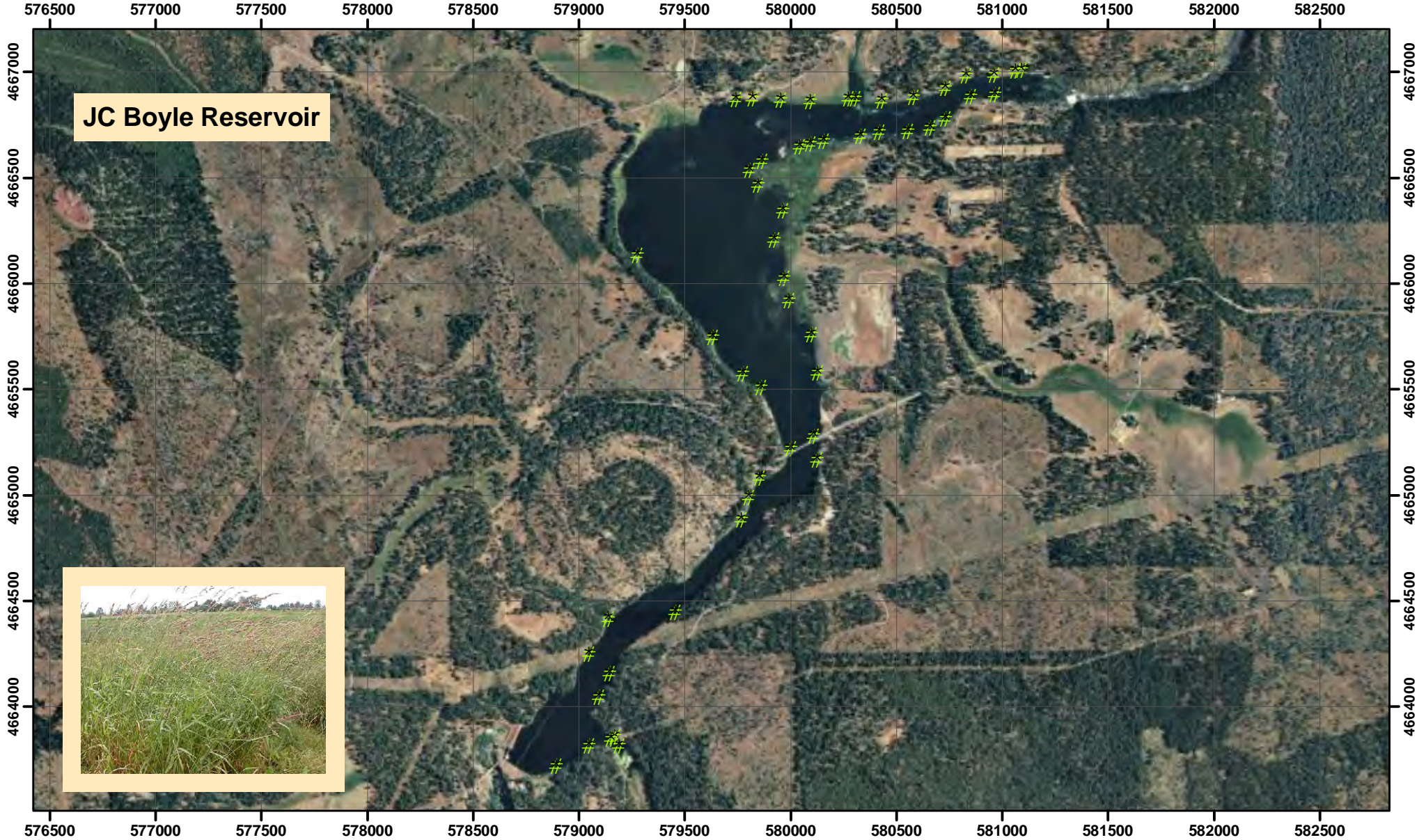
JC Boyle Reservoir



 Locations of Rushes (*Juncus* sp.)

Projection UTM  
Datum NAD 83  
Zone 10 N





JC Boyle Reservoir



Locations of reed canarygrass (*Phalaris arundinacea* L.)

Projection UTM  
Datum NAD 83  
Zone 10 N

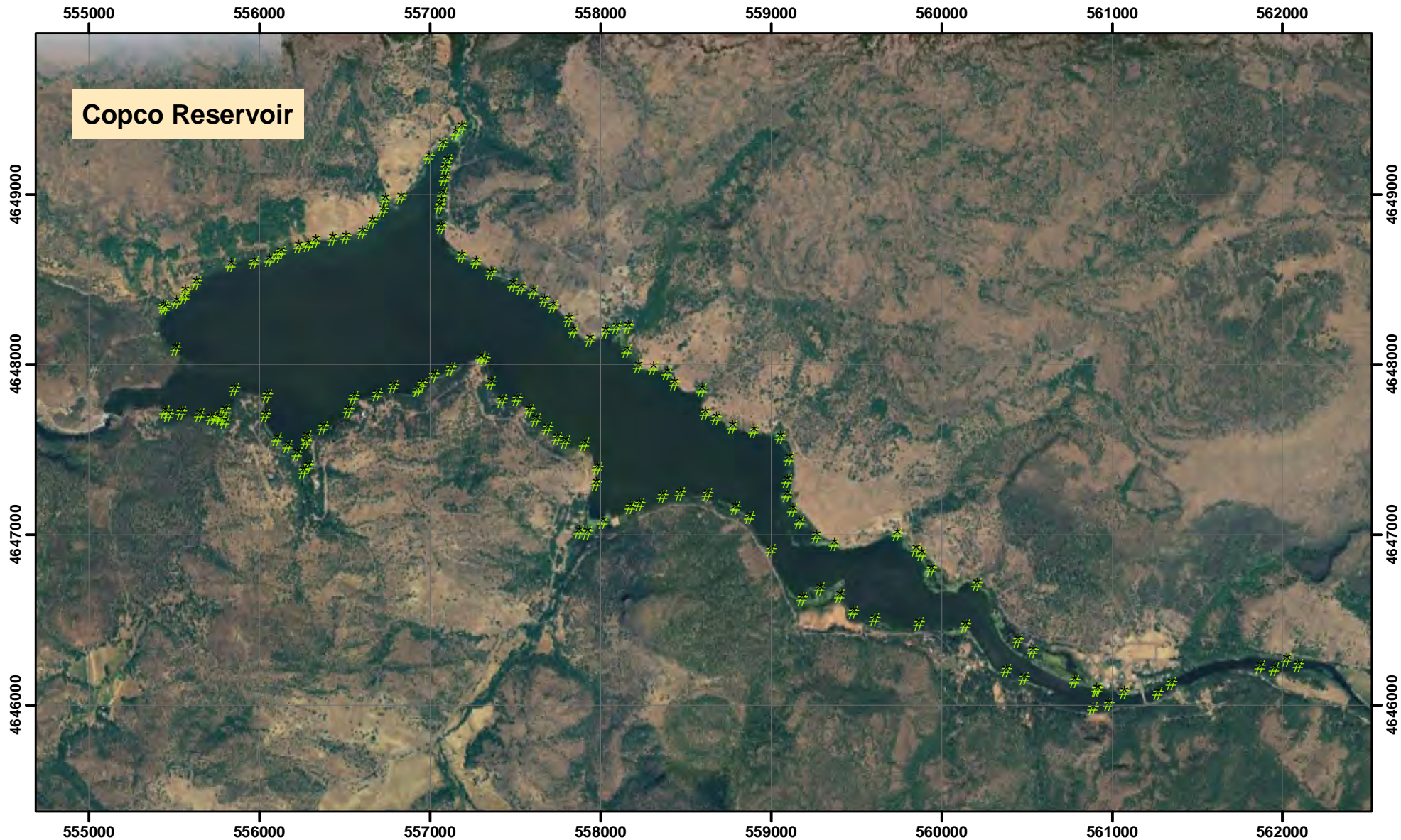




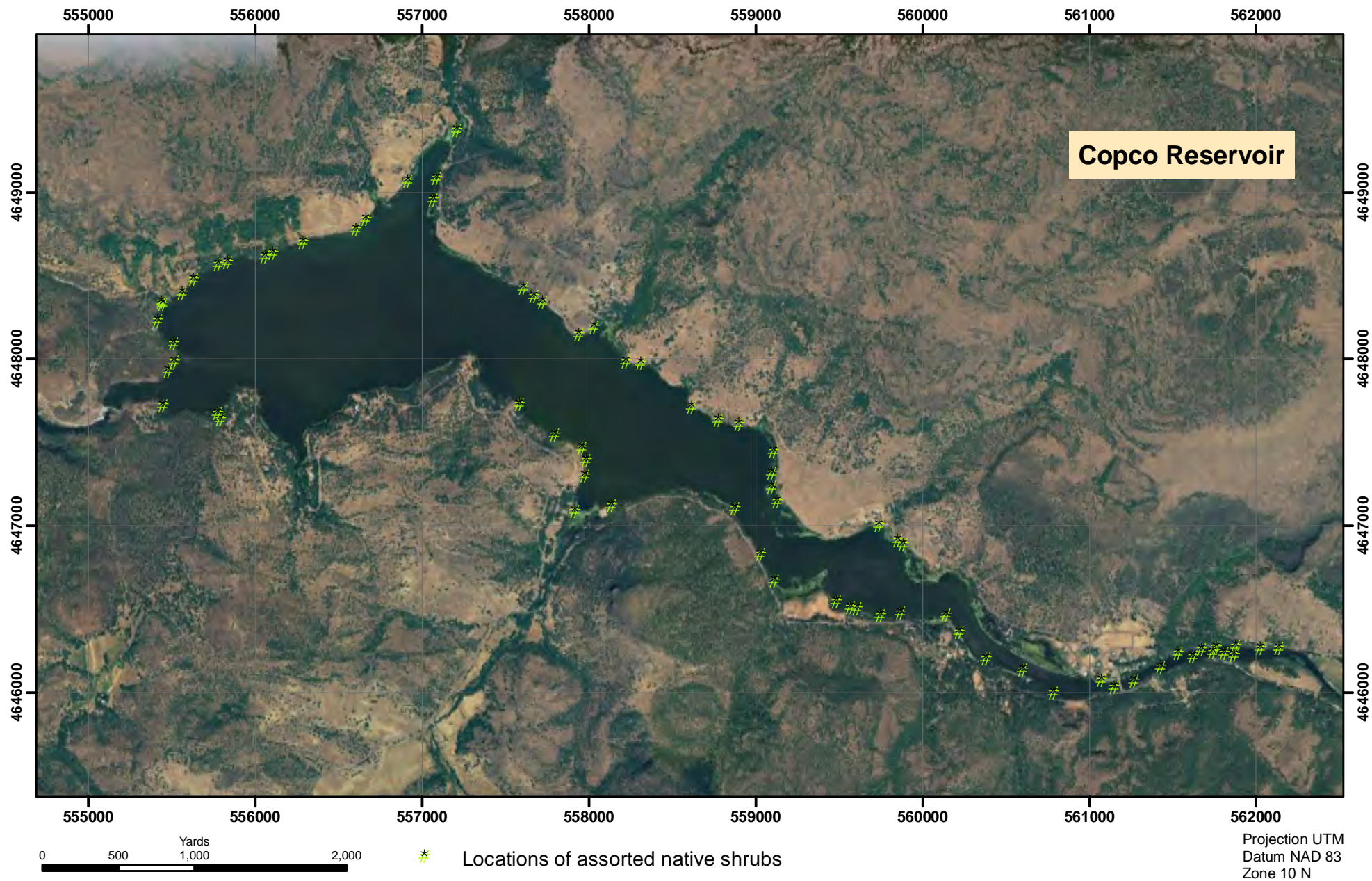
\* Locations of Willow (*Salix* spp.)

Projection UTM  
Datum NAD 83  
Zone 10 N

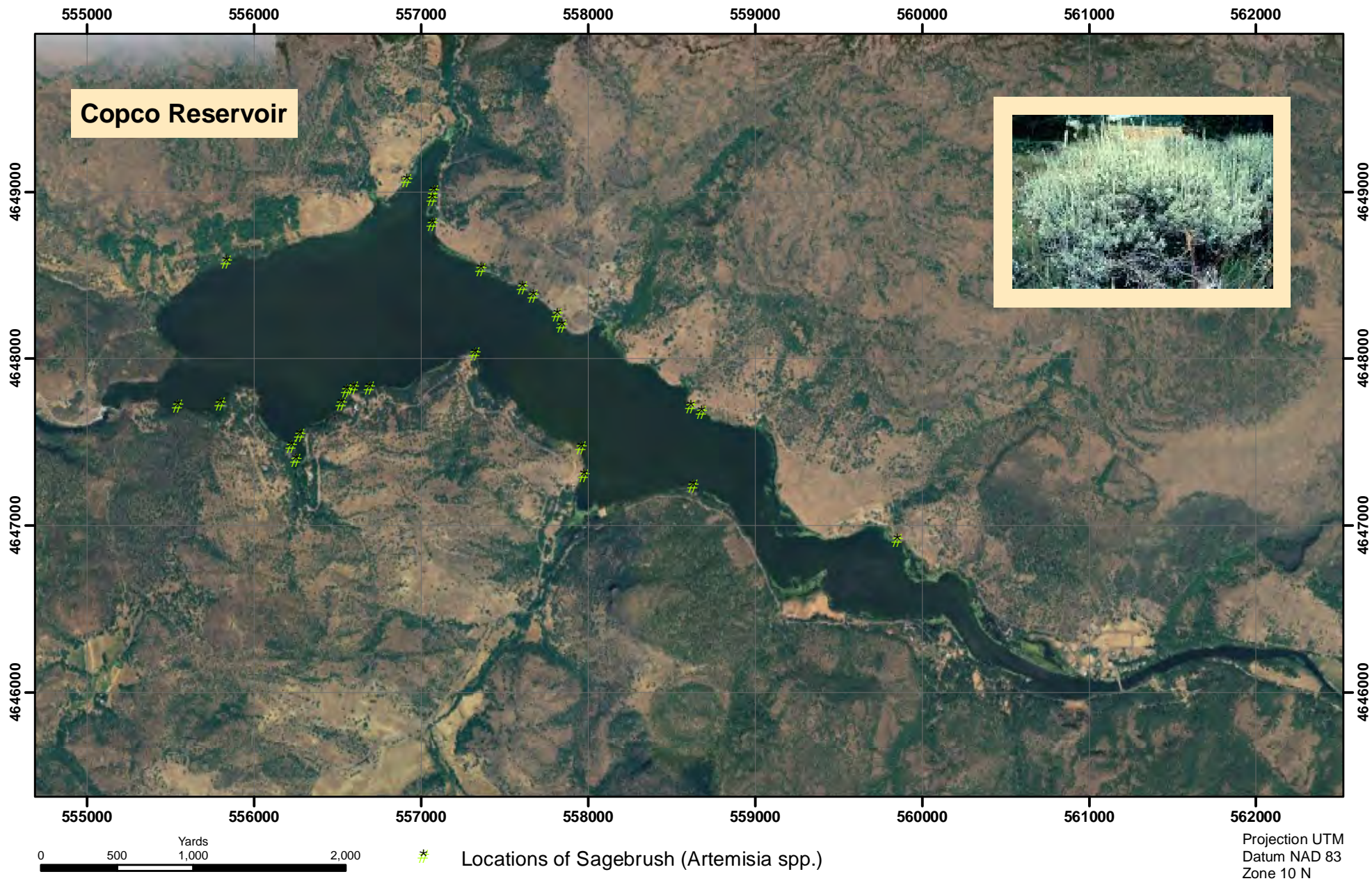




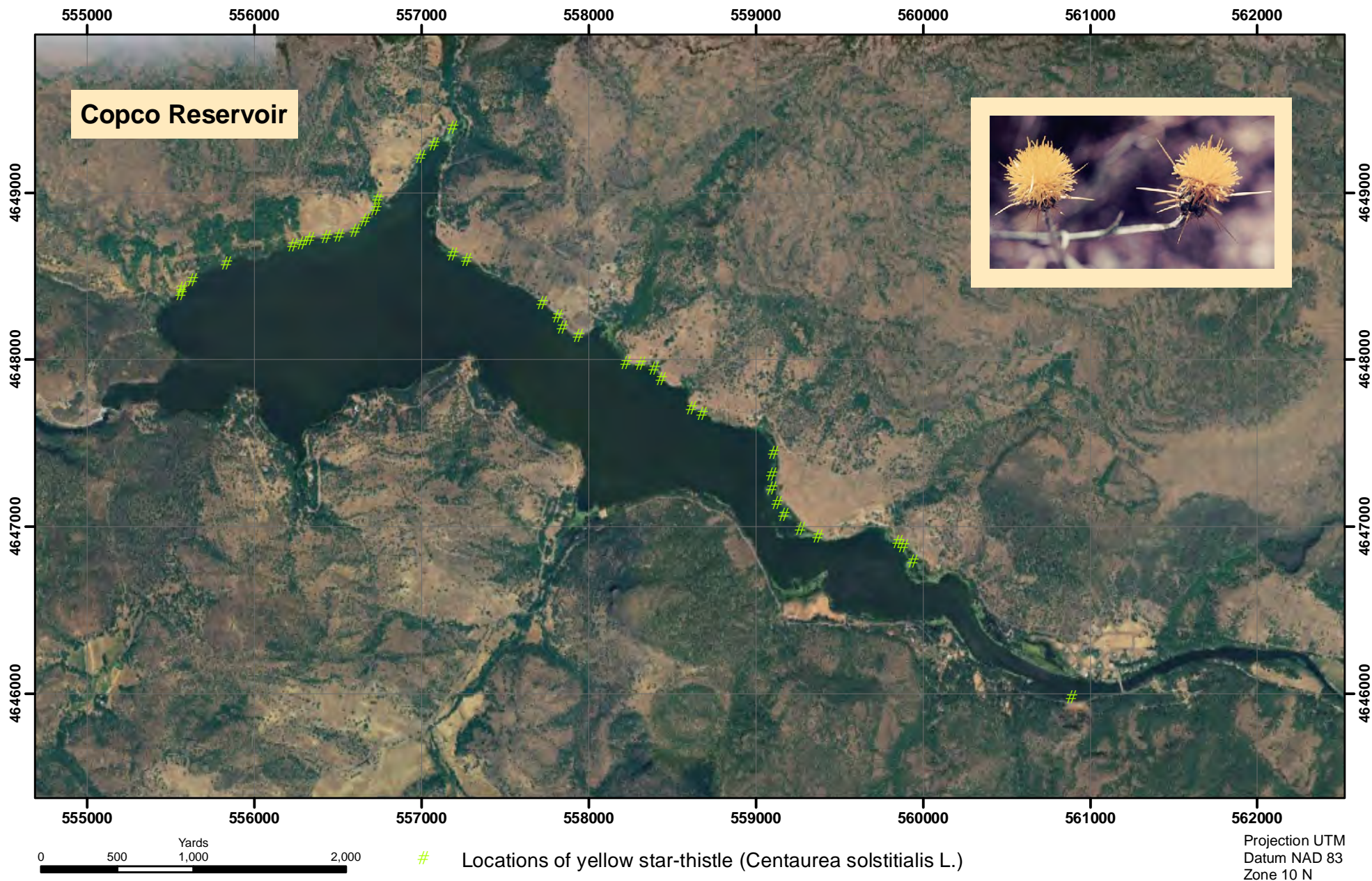




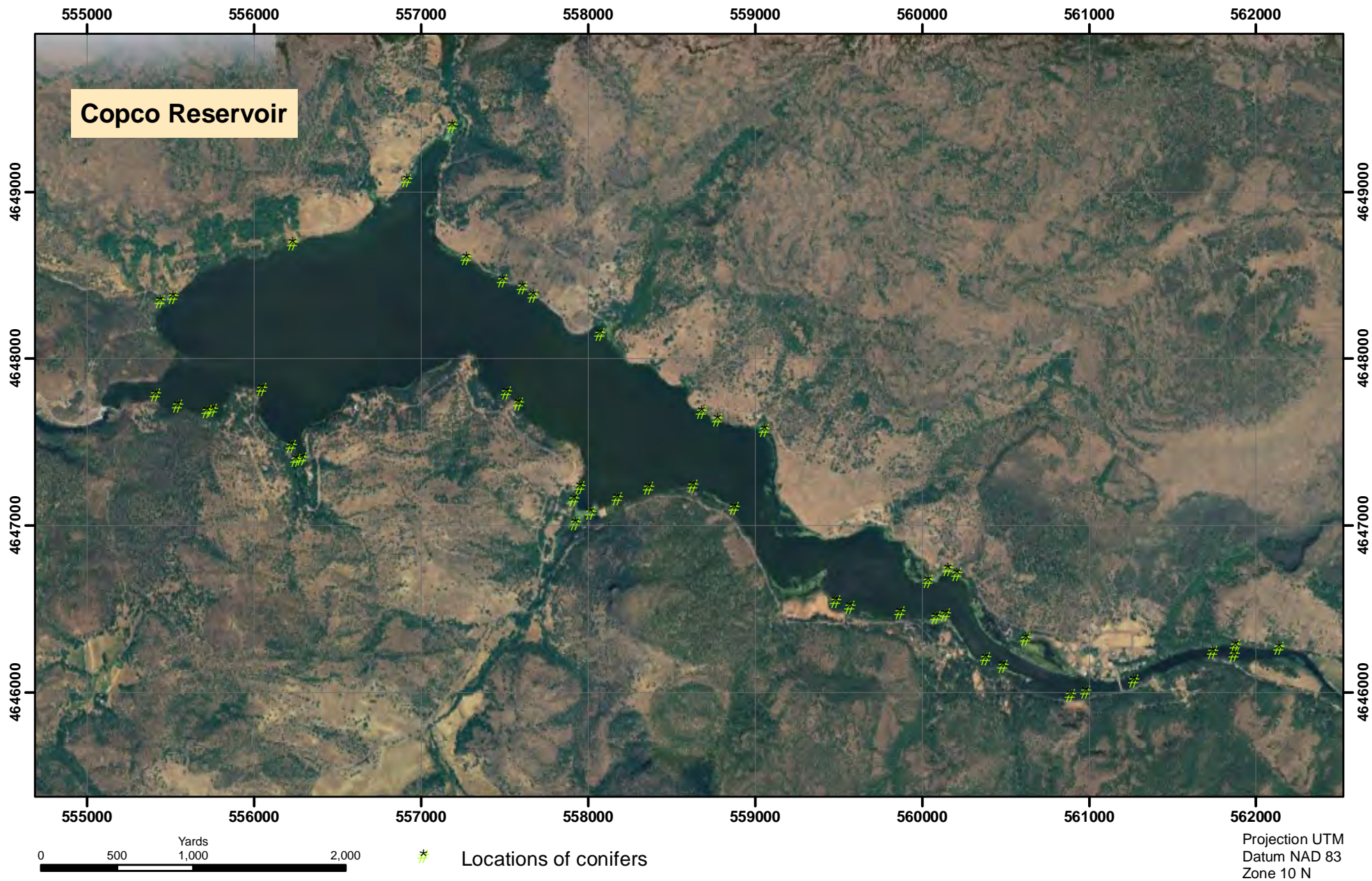




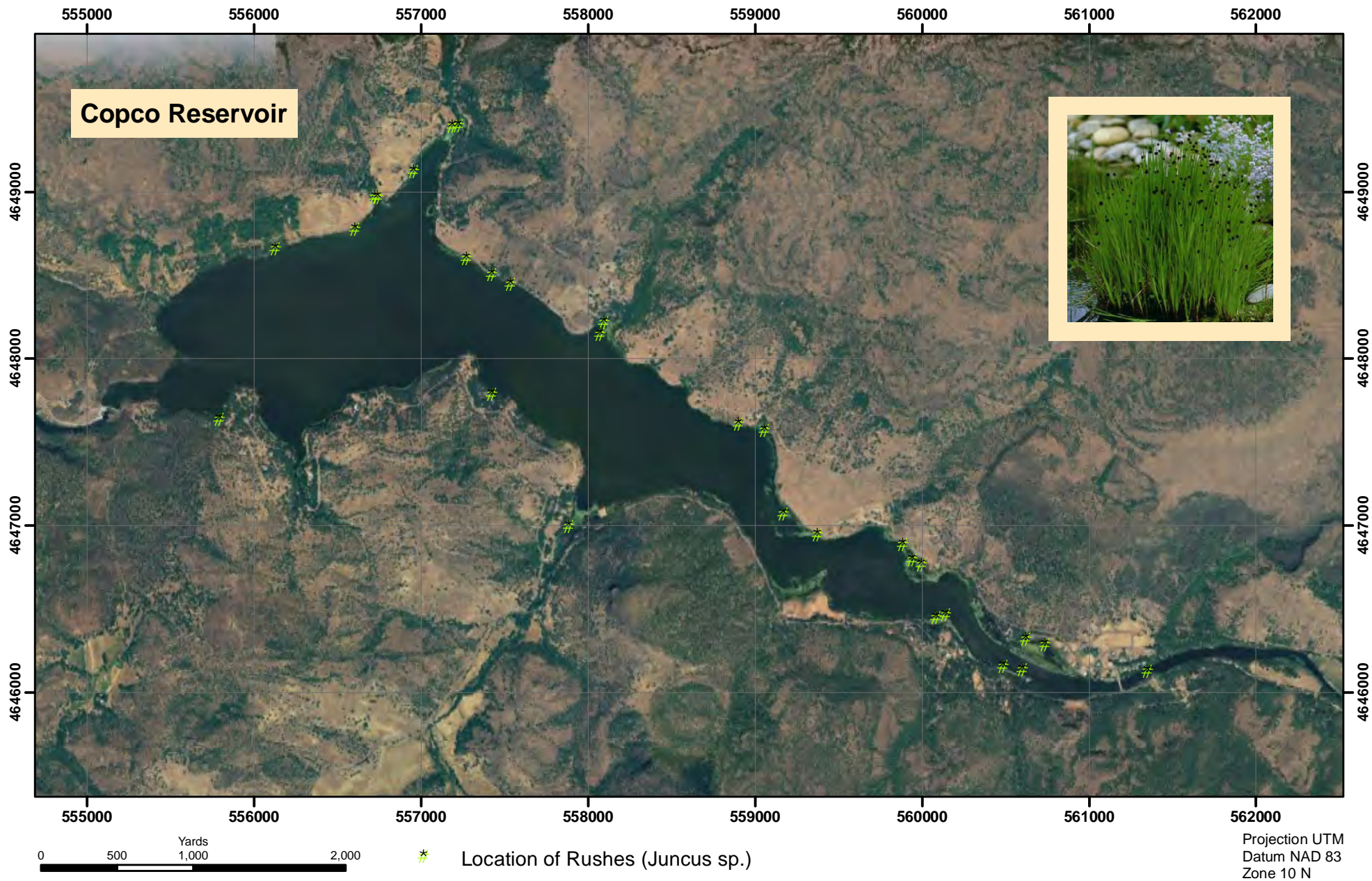




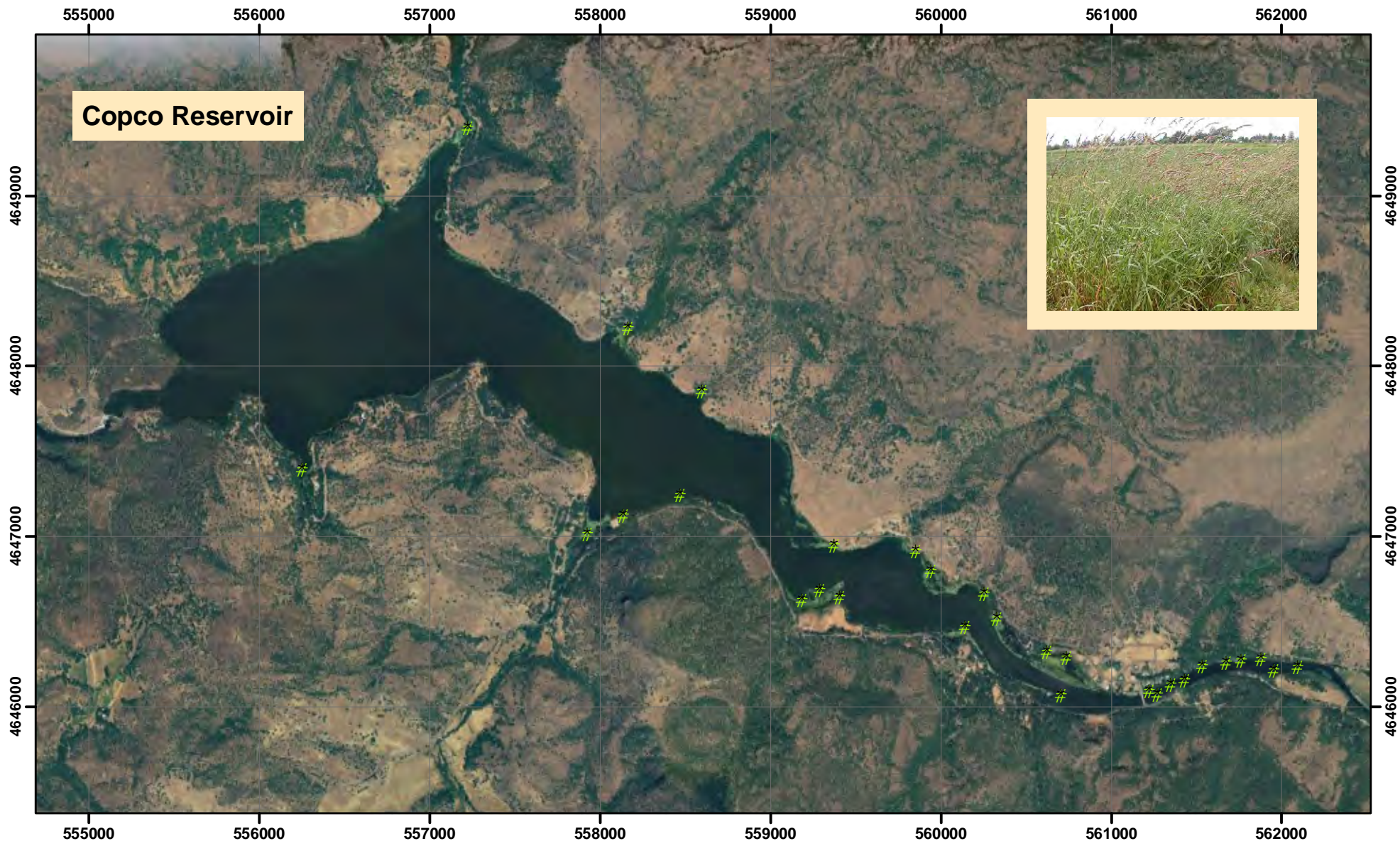




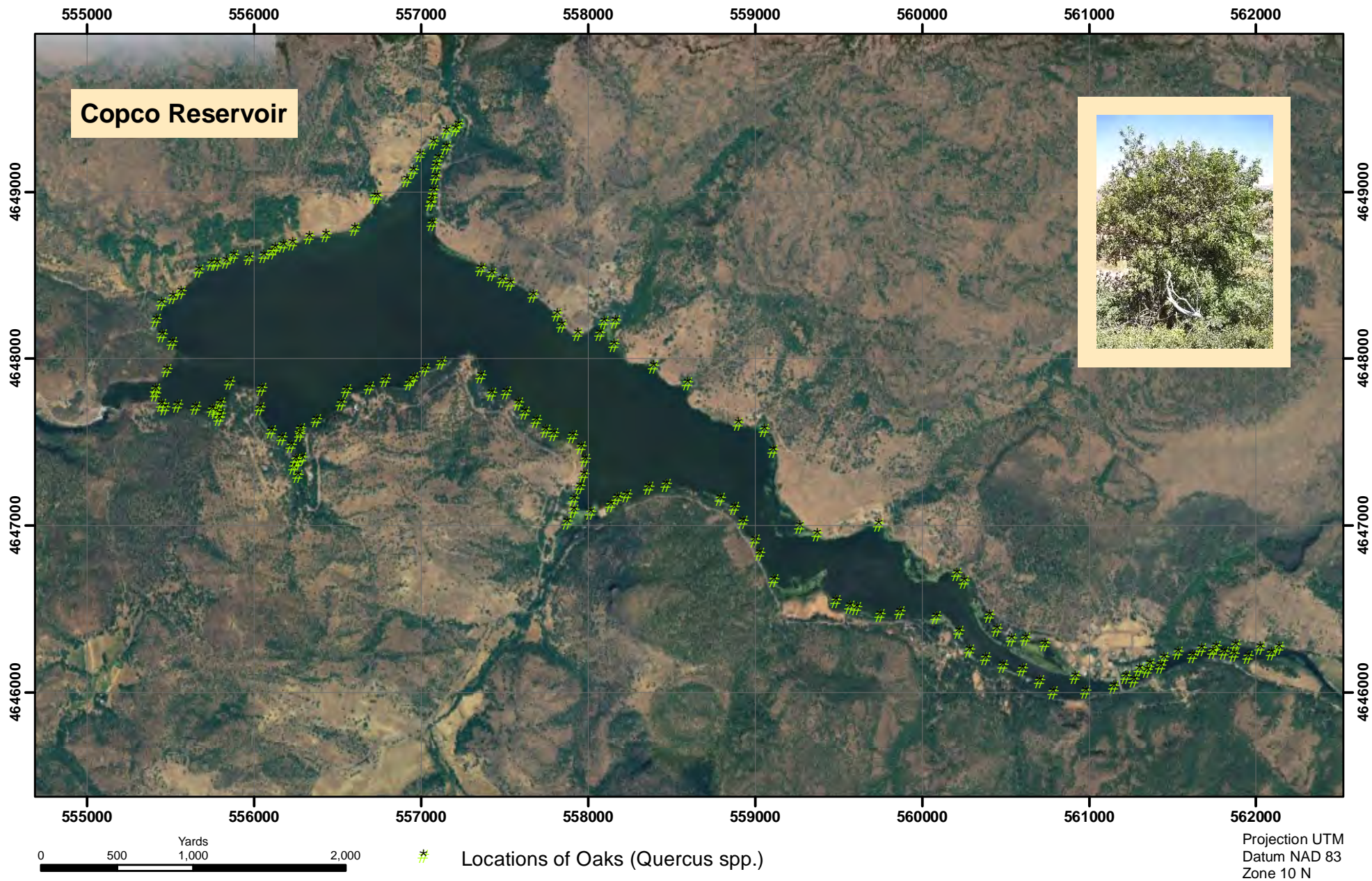




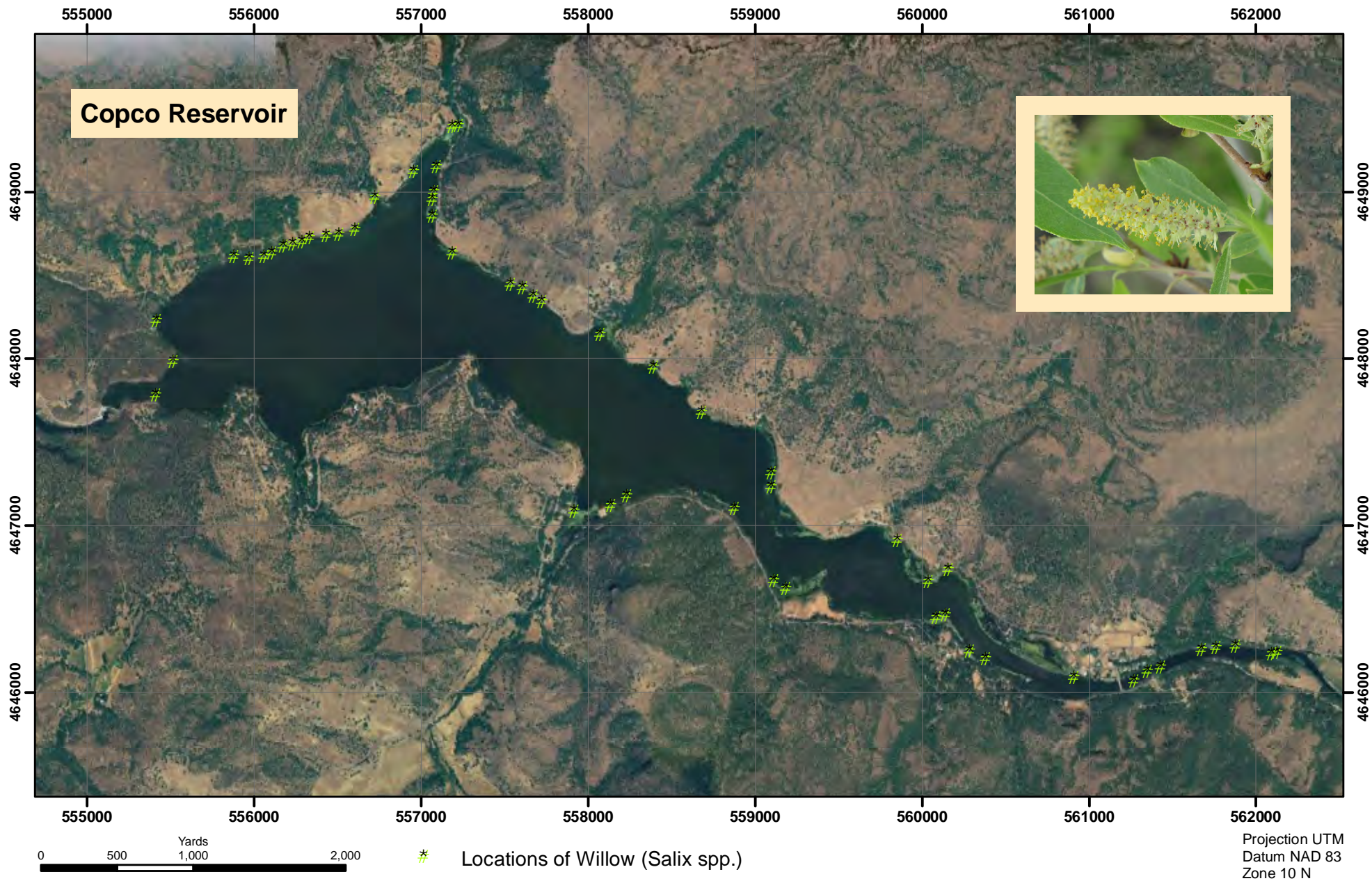




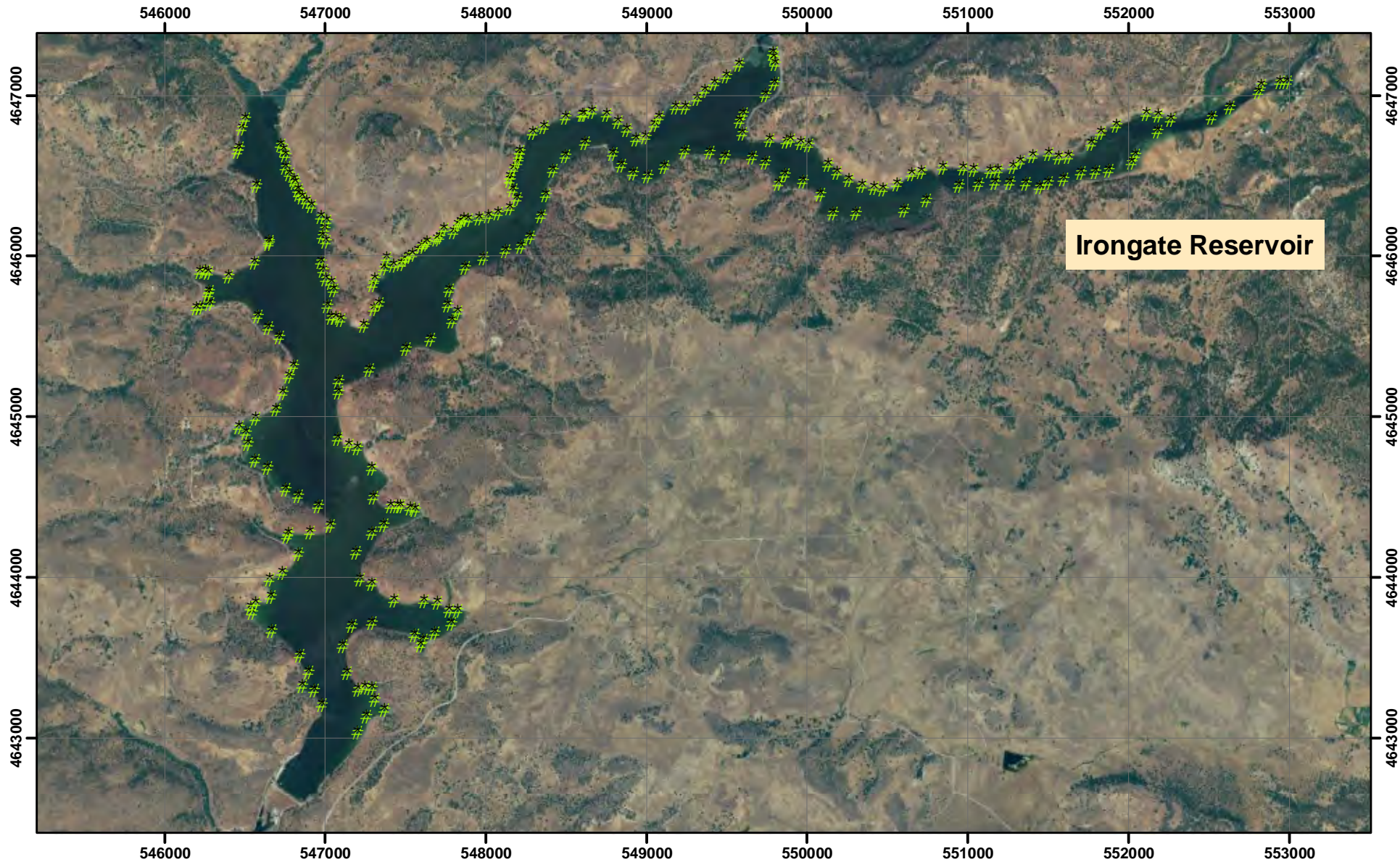




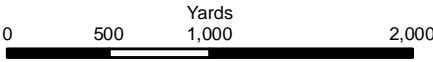








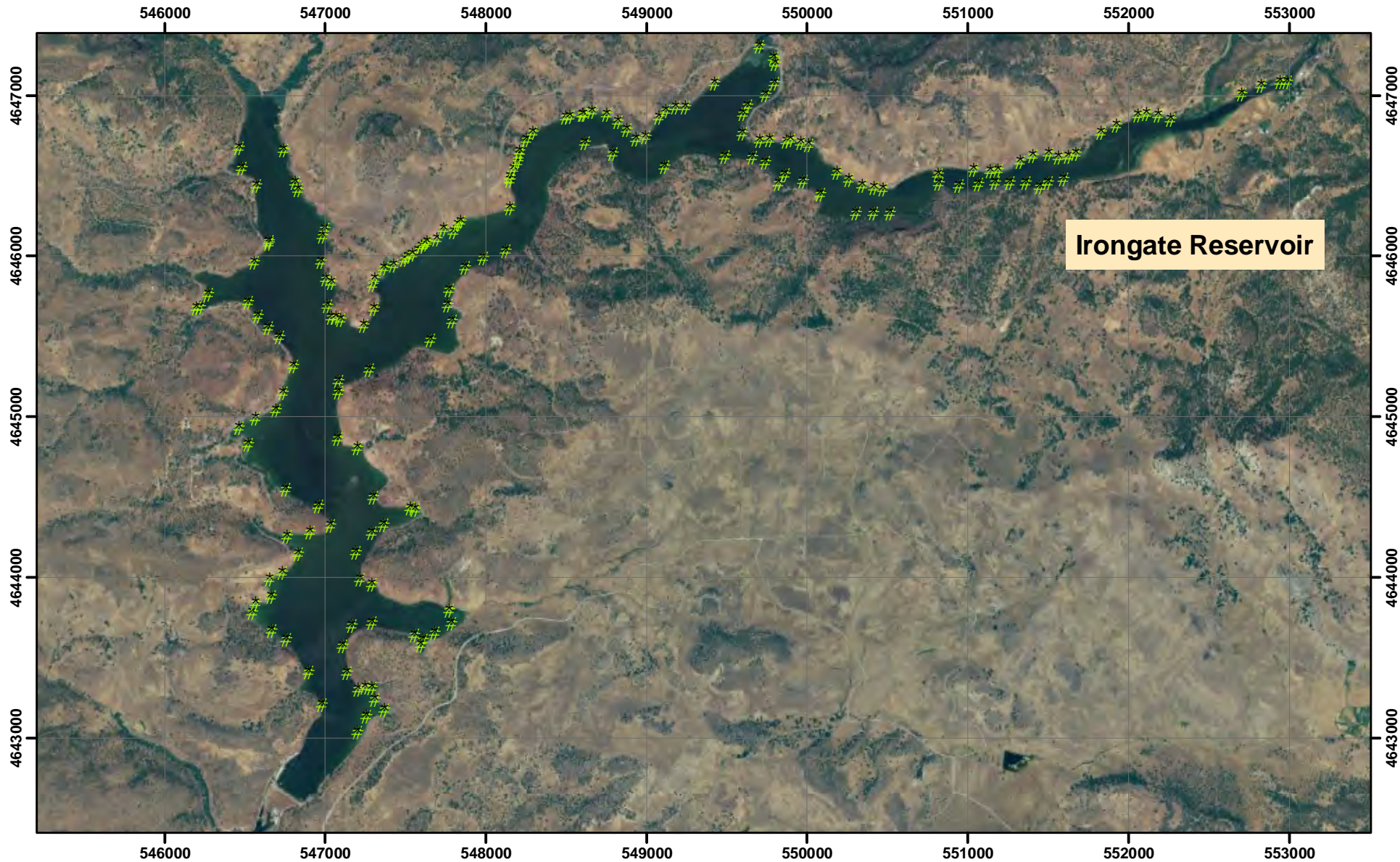
Irongate Reservoir



Locations of assorted native grasses

Projection UTM  
Datum NAD 83  
Zone 10 N





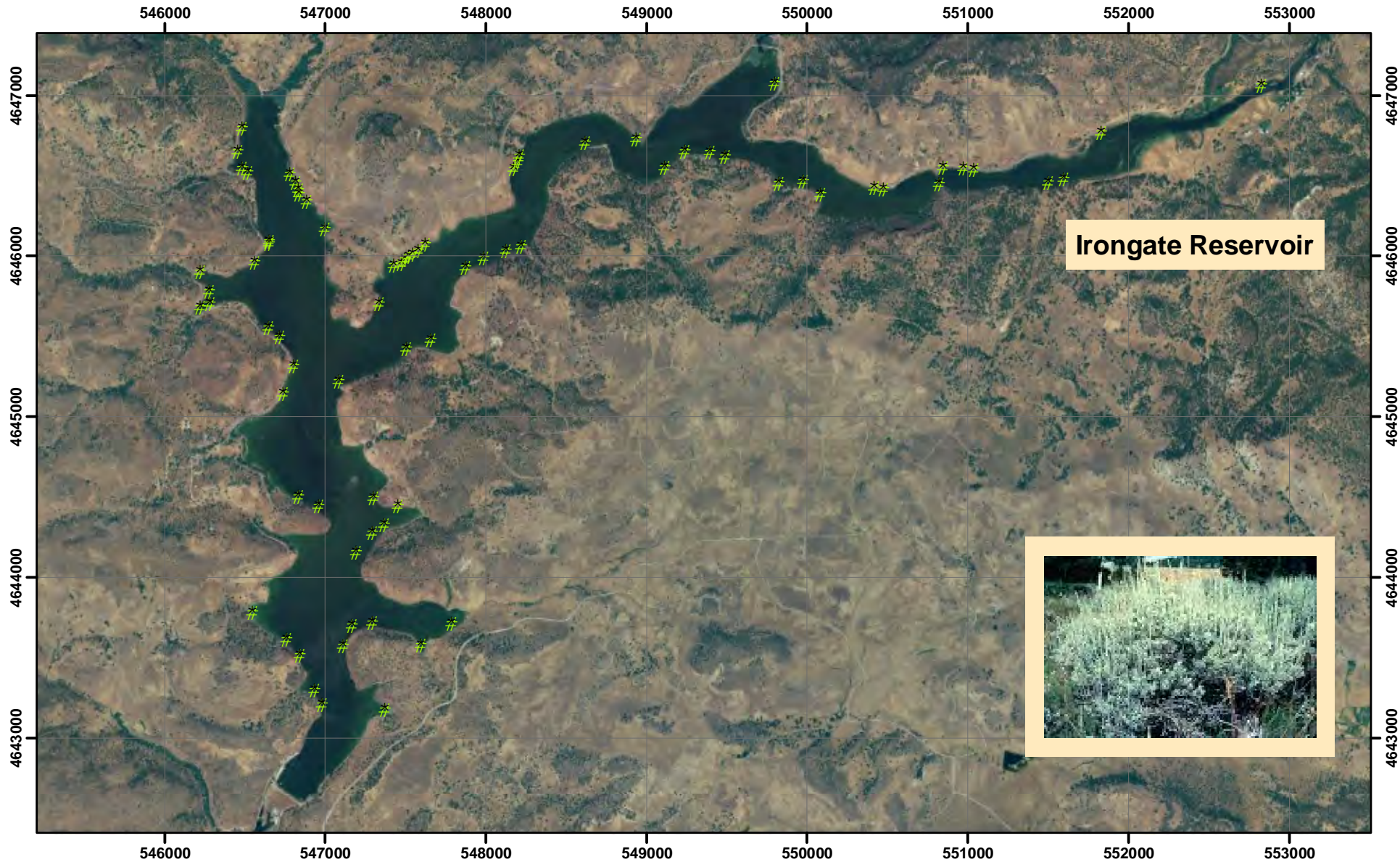
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Yards



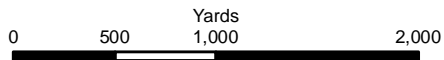
Locations of assorted native shrubs

Projection UTM  
Datum NAD 83  
Zone 10 N





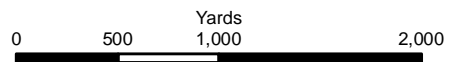
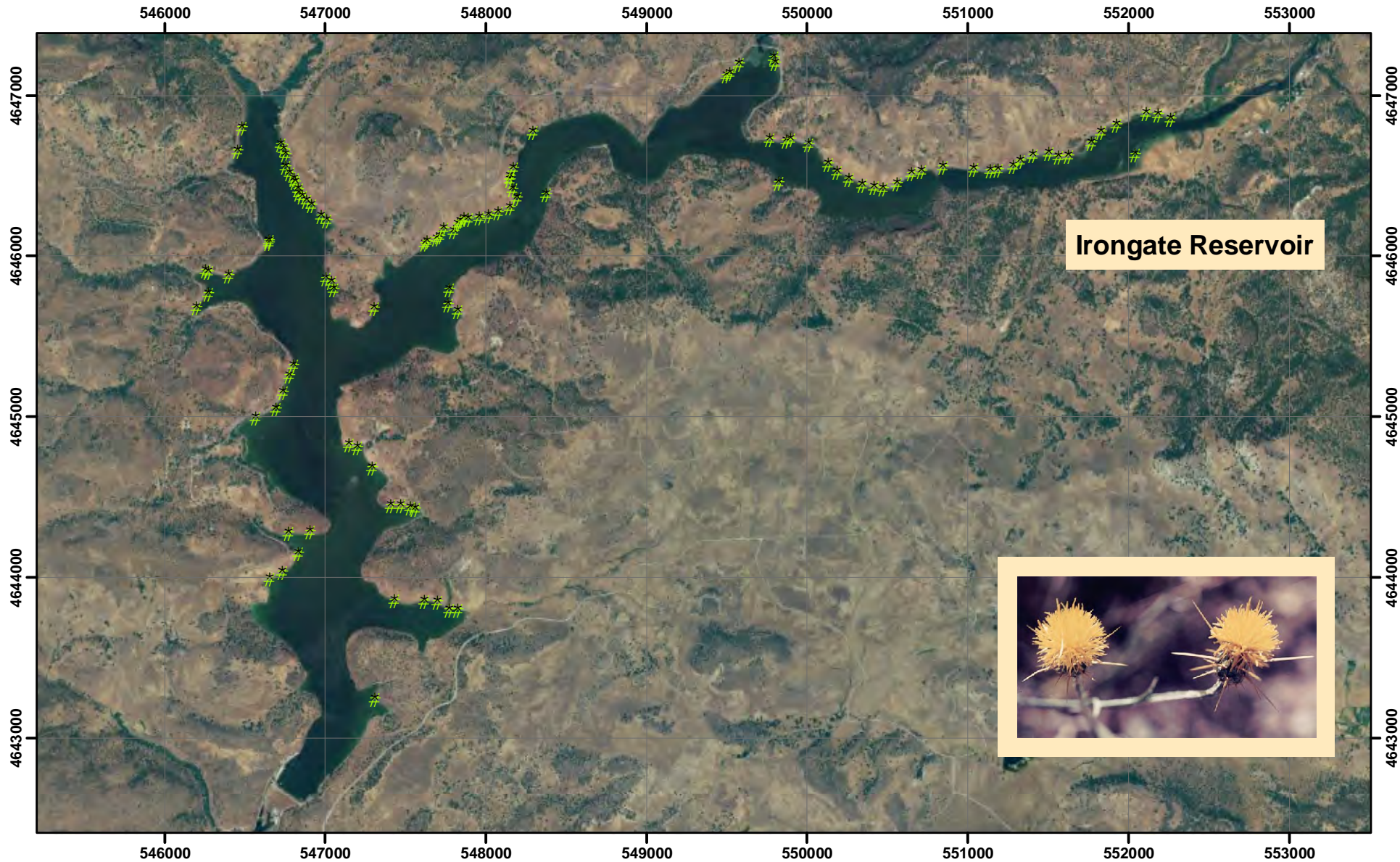
Irongate Reservoir



\* Locations of Sagebrush (*Artemisia* spp.)

Projection UTM  
Datum NAD 83  
Zone 10 N

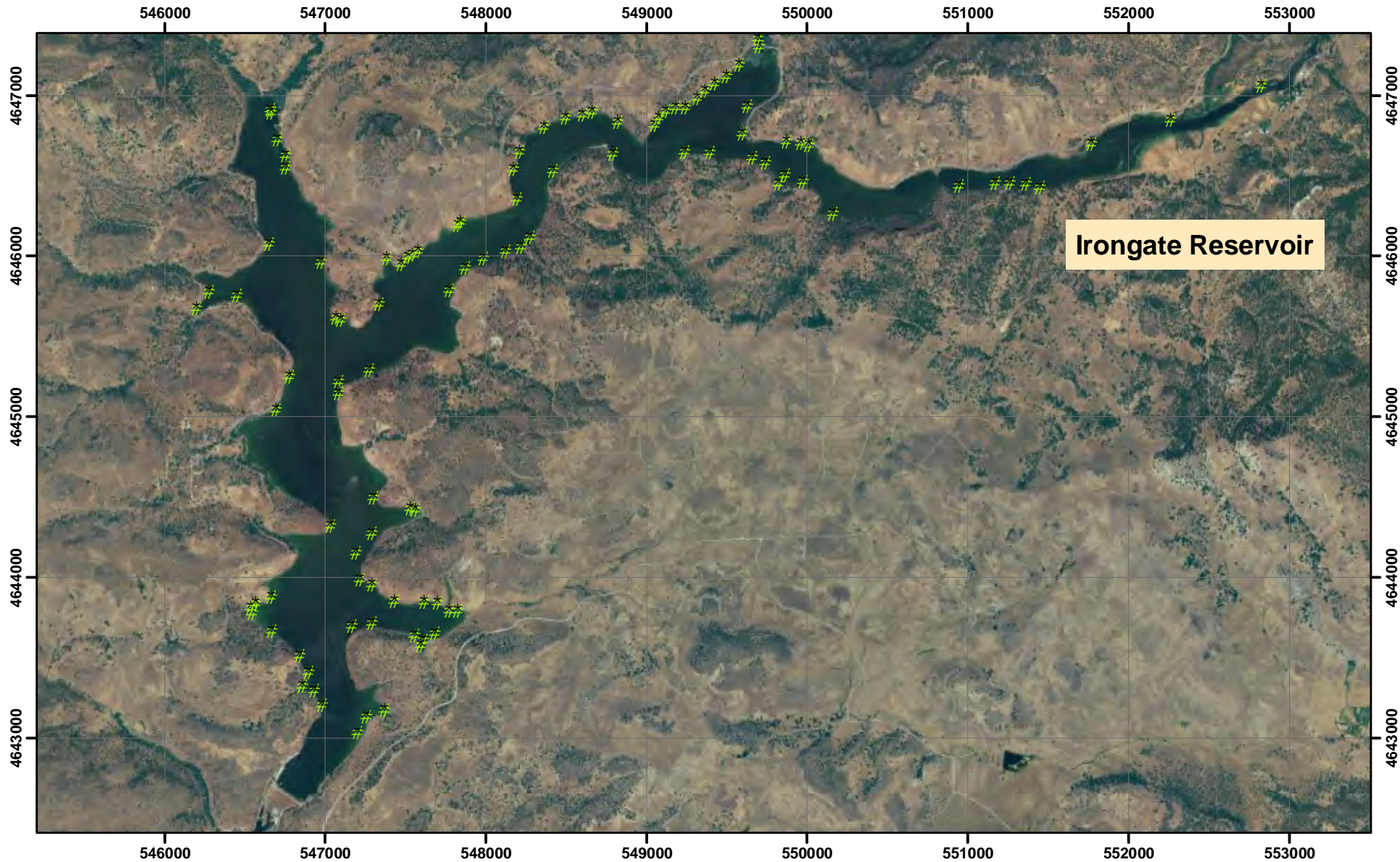




Locations of yellow star-thistle (*Centaurea solstitialis* L.)

Projection UTM  
Datum NAD 83  
Zone 10 N





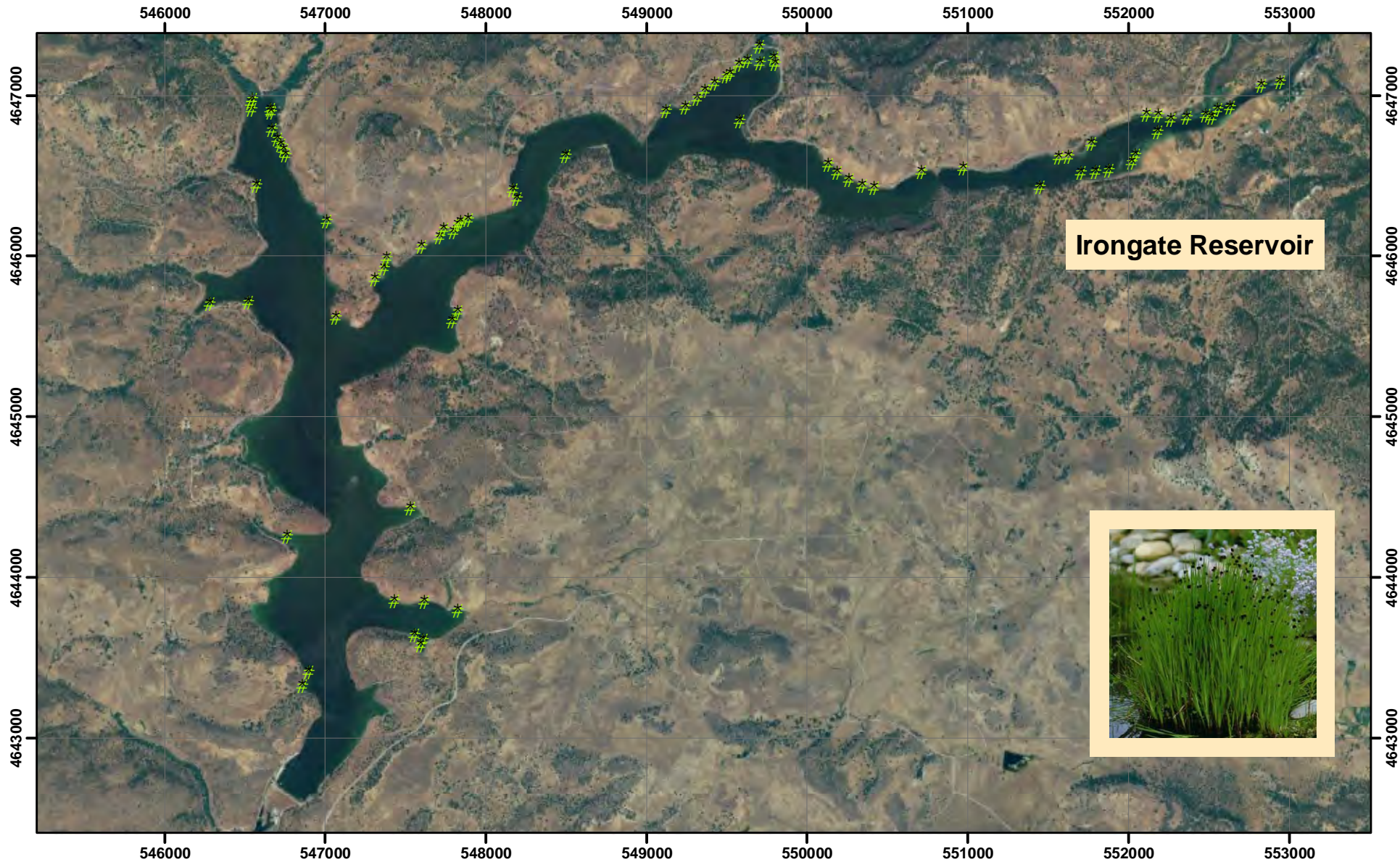
0 500 1,000 2,000  
Yards



Locations of conifers

Projection UTM  
Datum NAD 83  
Zone 10 N



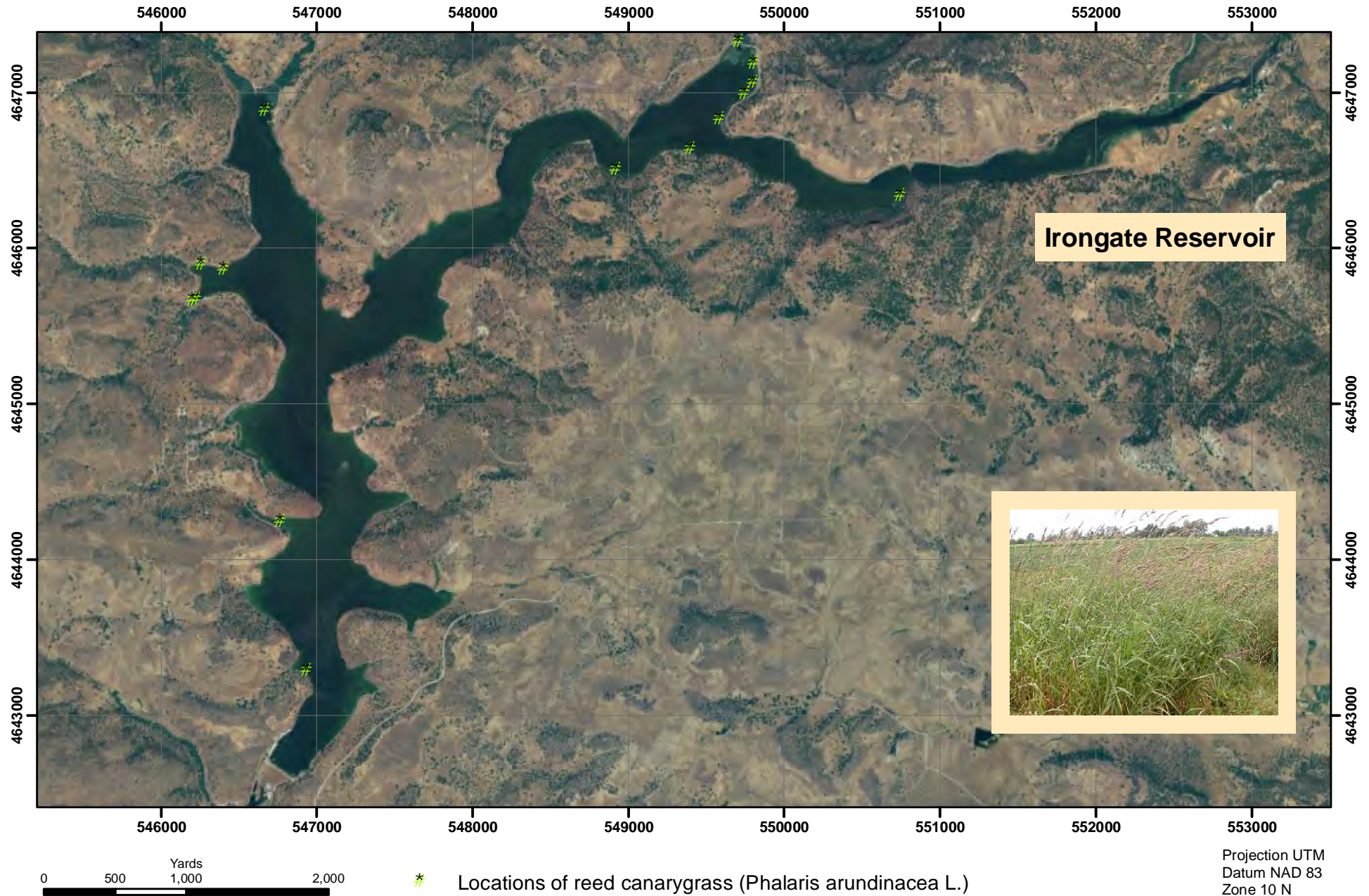


0 500 1,000 2,000  
Yards

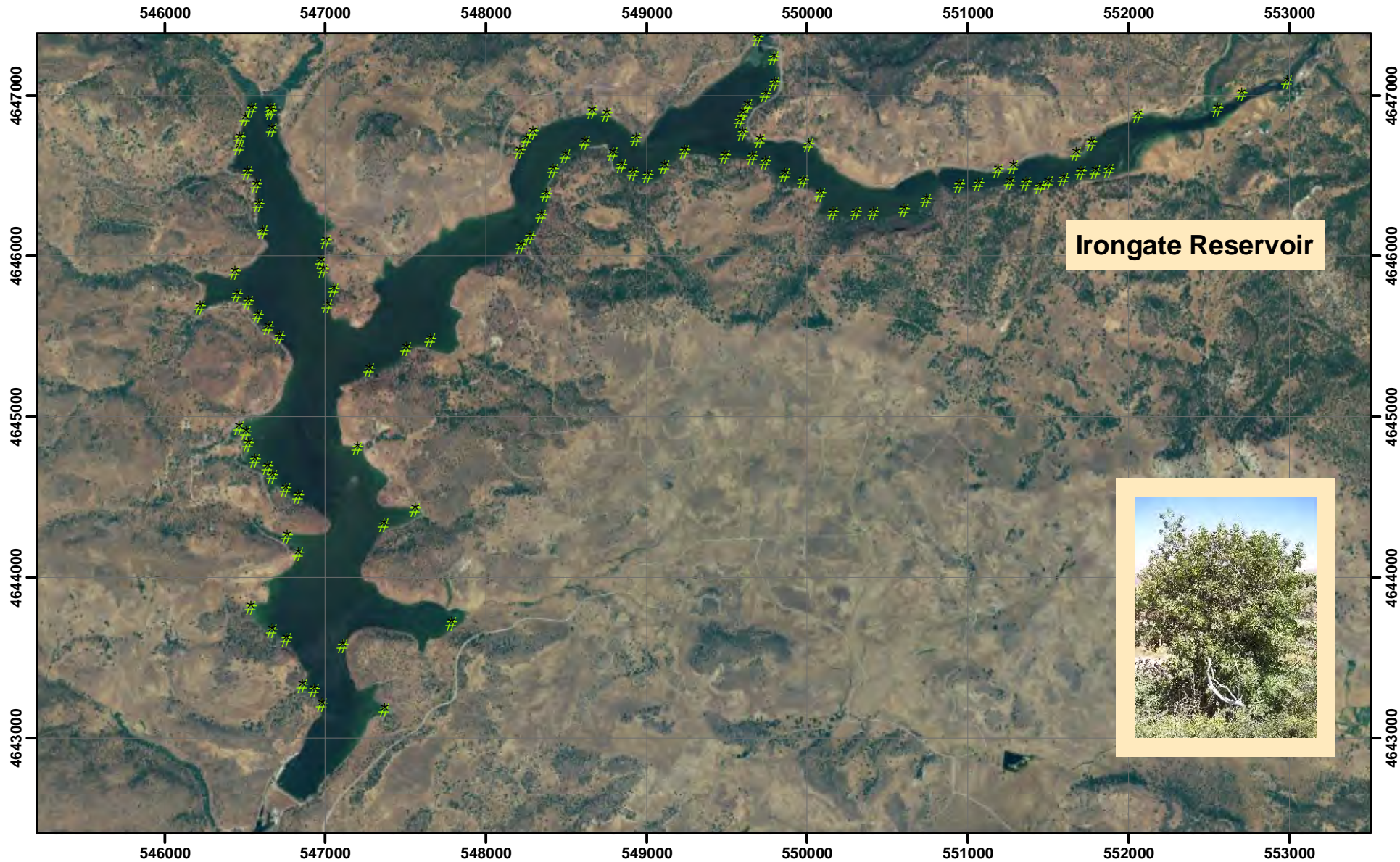
\* Locations of Rushes (*Juncus* sp.)

Projection UTM  
Datum NAD 83  
Zone 10 N

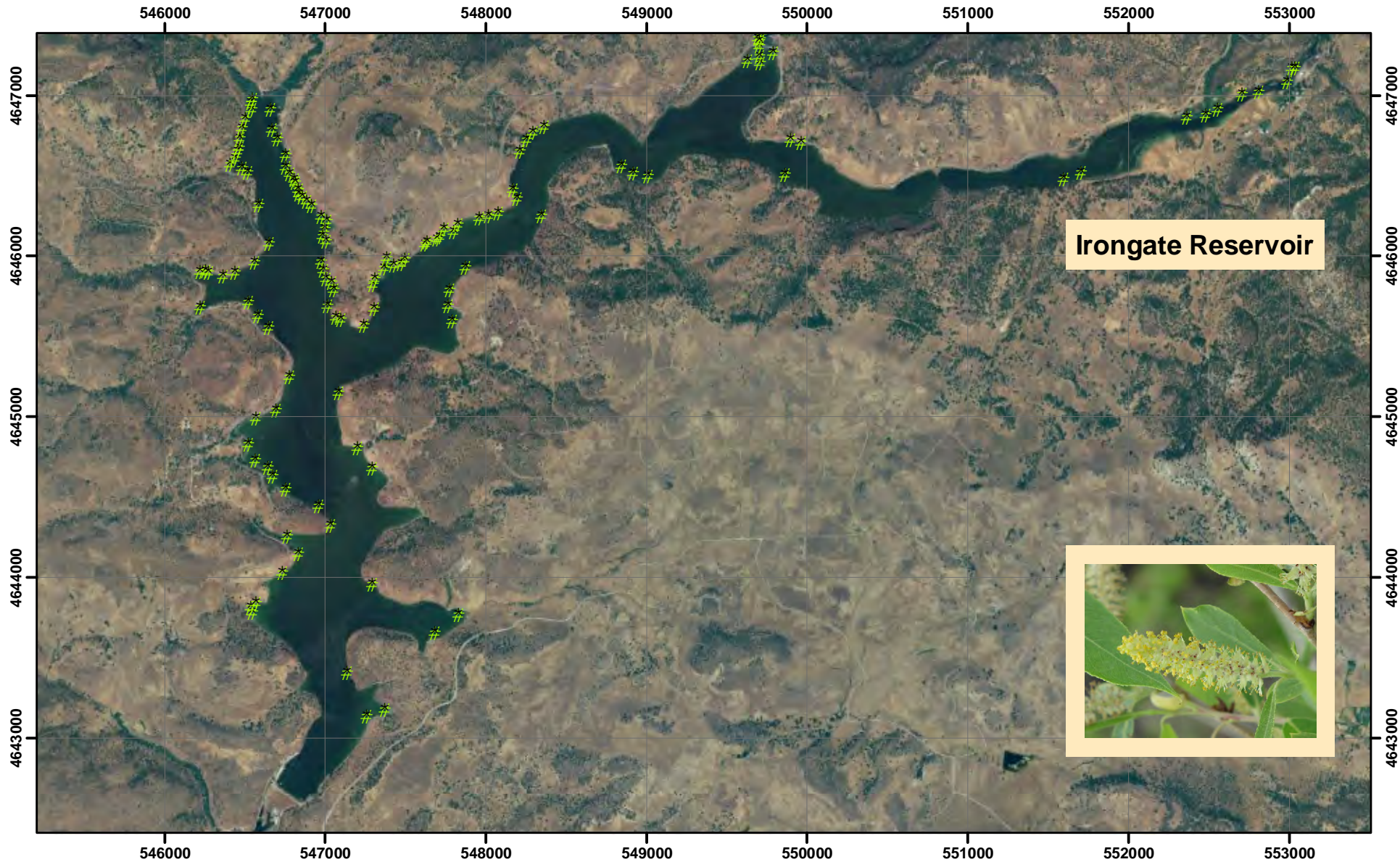












**Irongate Reservoir**



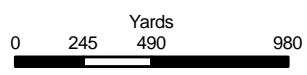
0 500 1,000 2,000  
Yards

 Locations of Willow (*Salix* spp.)

Projection UTM  
Datum NAD 83  
Zone 10 N



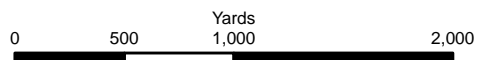
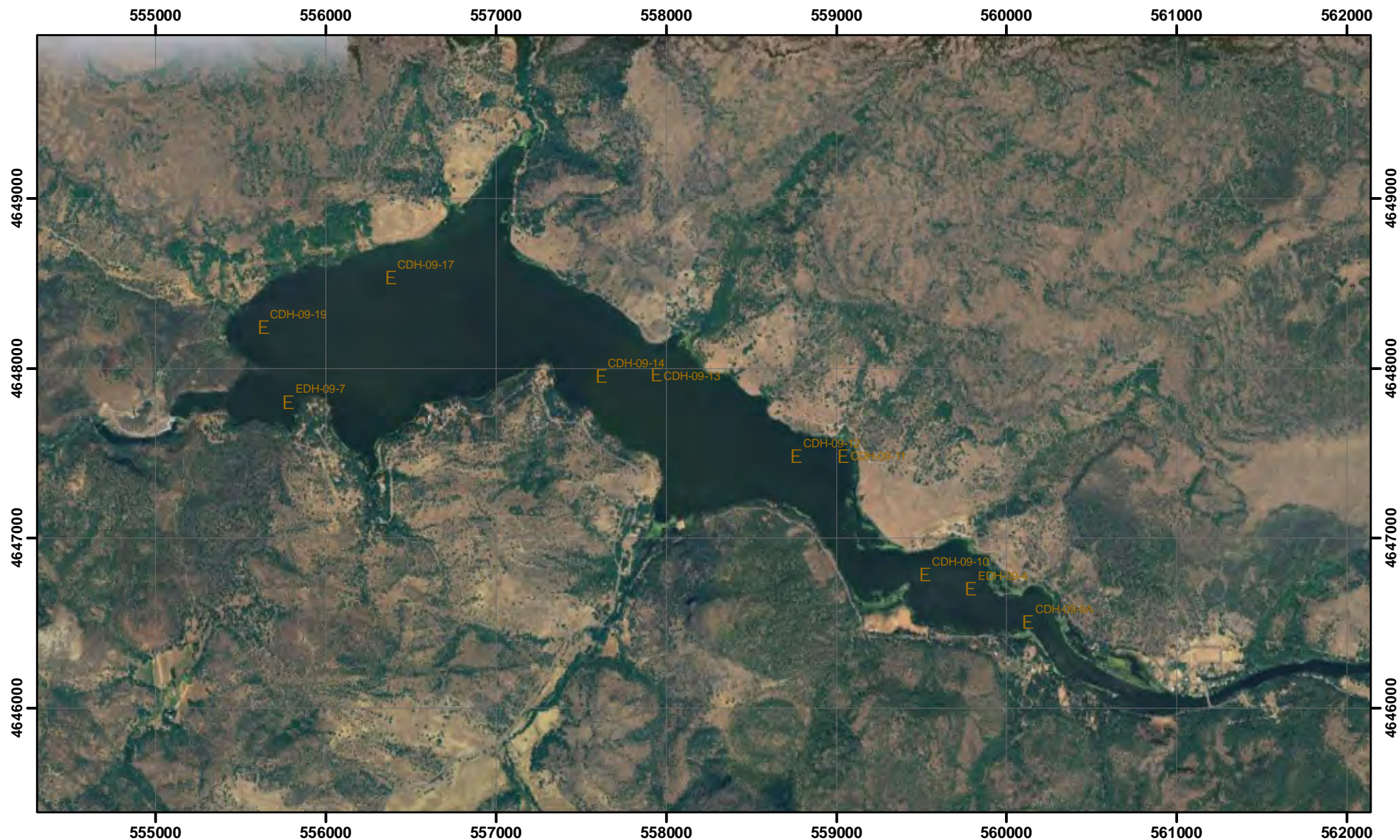
## **9 Appendix D. Seedbank Germination Sample Sites**



E Seedbank Germination Sample Sites

Projection UTM  
Datum NAD 83  
Zone 10 N

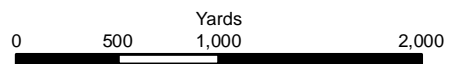
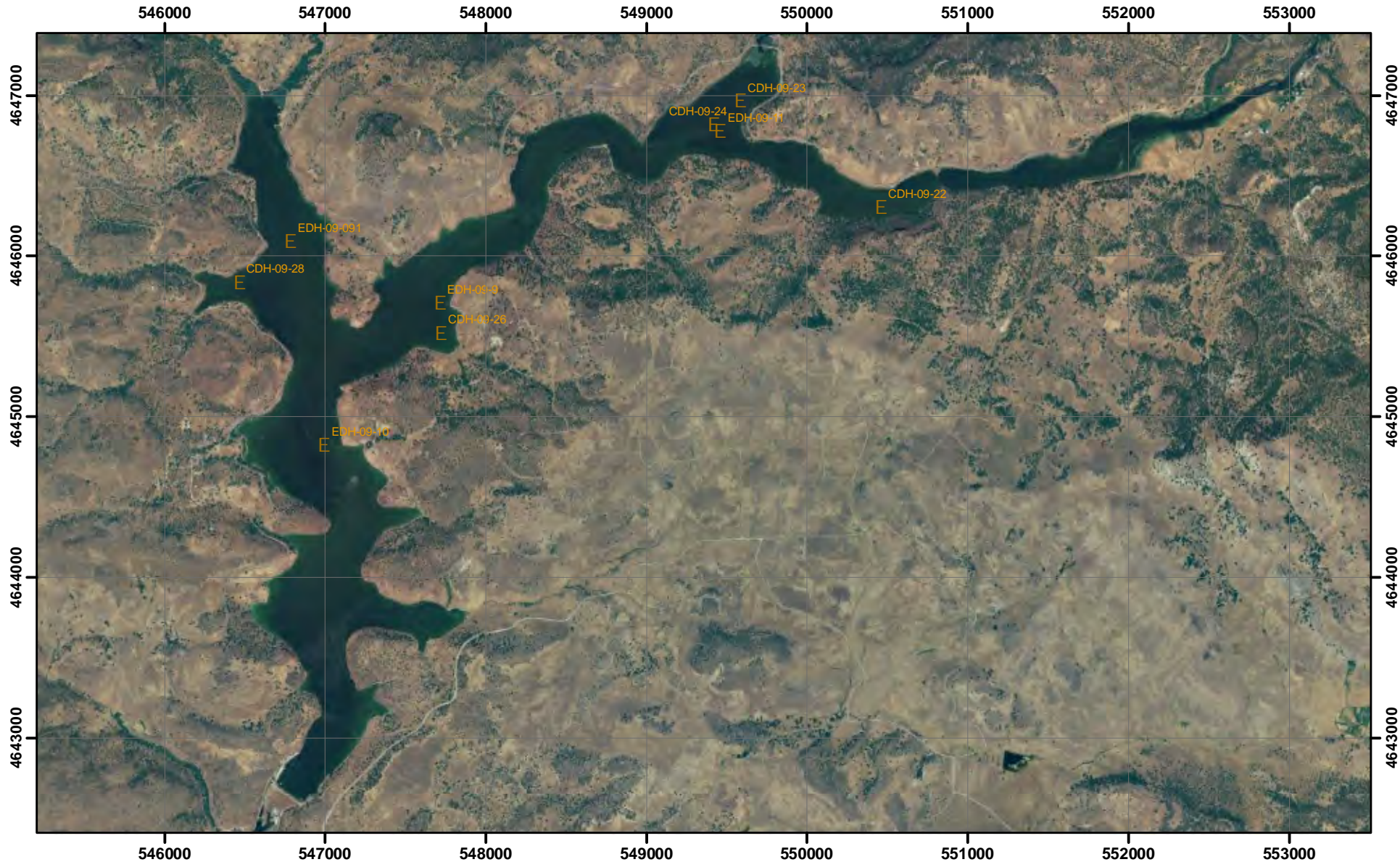




E Seedbank Germination Sample Sites

Projection UTM  
Datum NAD 83  
Zone 10 N





E Seedbank Germination Sample Sites

Projection UTM  
Datum NAD 83  
Zone 10 N



## 10 Appendix E. Re-vegetation Maps

<b>Legend Title</b>	<b>Description</b>
Upland - Ground Access	Upland zone that will be revegetated with a native seed grass mix that will be applied by ground-based hydroseeding equipment
Upland, above XXXX - no Ground Access	Upland zone that will be revegetated with a native seed grass mix that will be applied by barge hydroseeding equipment
Upland, below XXXX - no Ground Access	Upland zone that will be revegetated with a native seed grass mix that will be applied by aerial hydroseeding equipment
Wetland/Riparian	Zone in which native wetland species will passively be allowed to revegetate and in which native riparian trees will be actively planted
Channel	Area that will be active stream channel

\* Native and genetically appropriate planting materials from local sources to be used if feasible.

## 10 Appendix E. Re-vegetation Maps

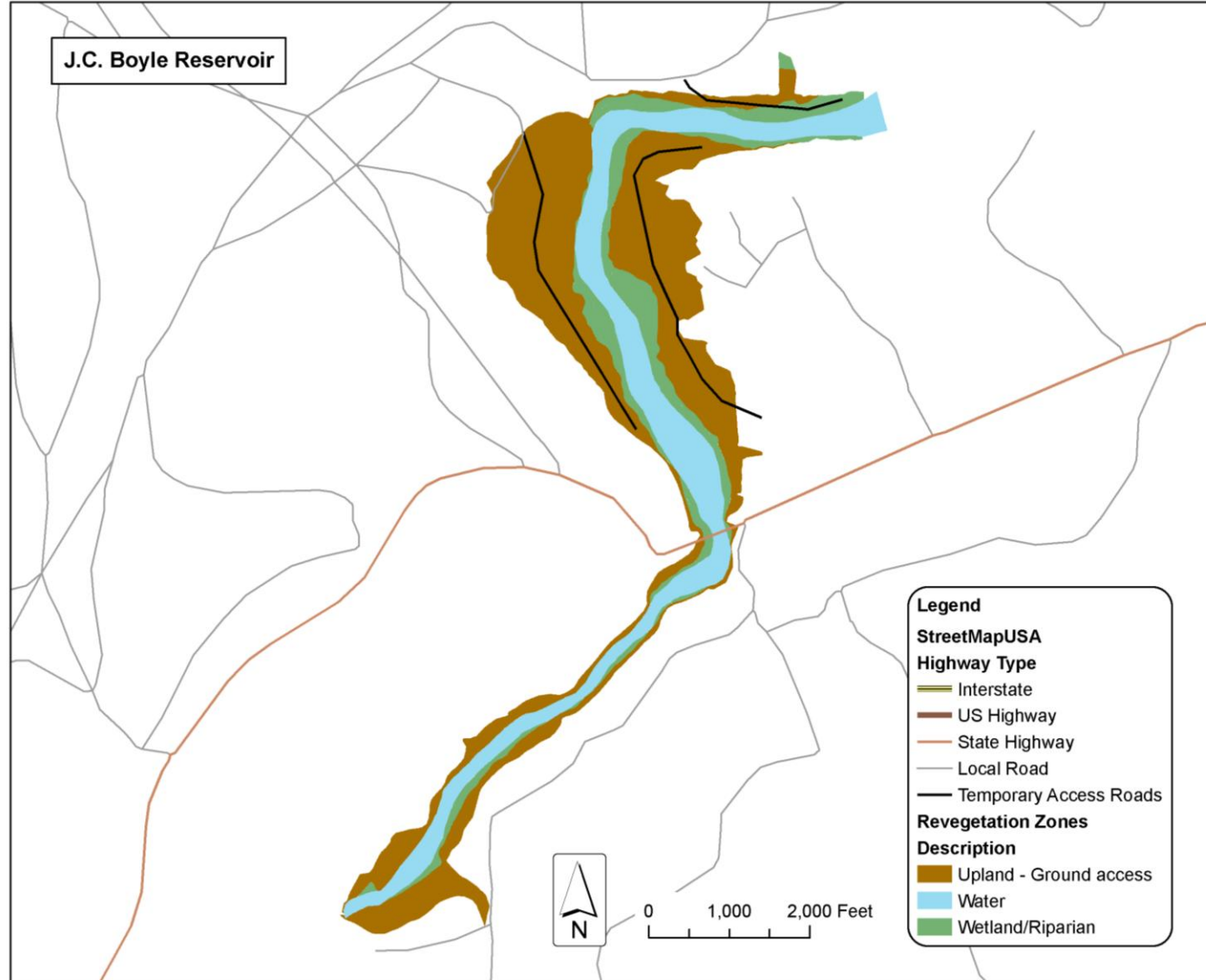


Figure 10-1. Revegetation zones at J.C. Boyle Reservoir.



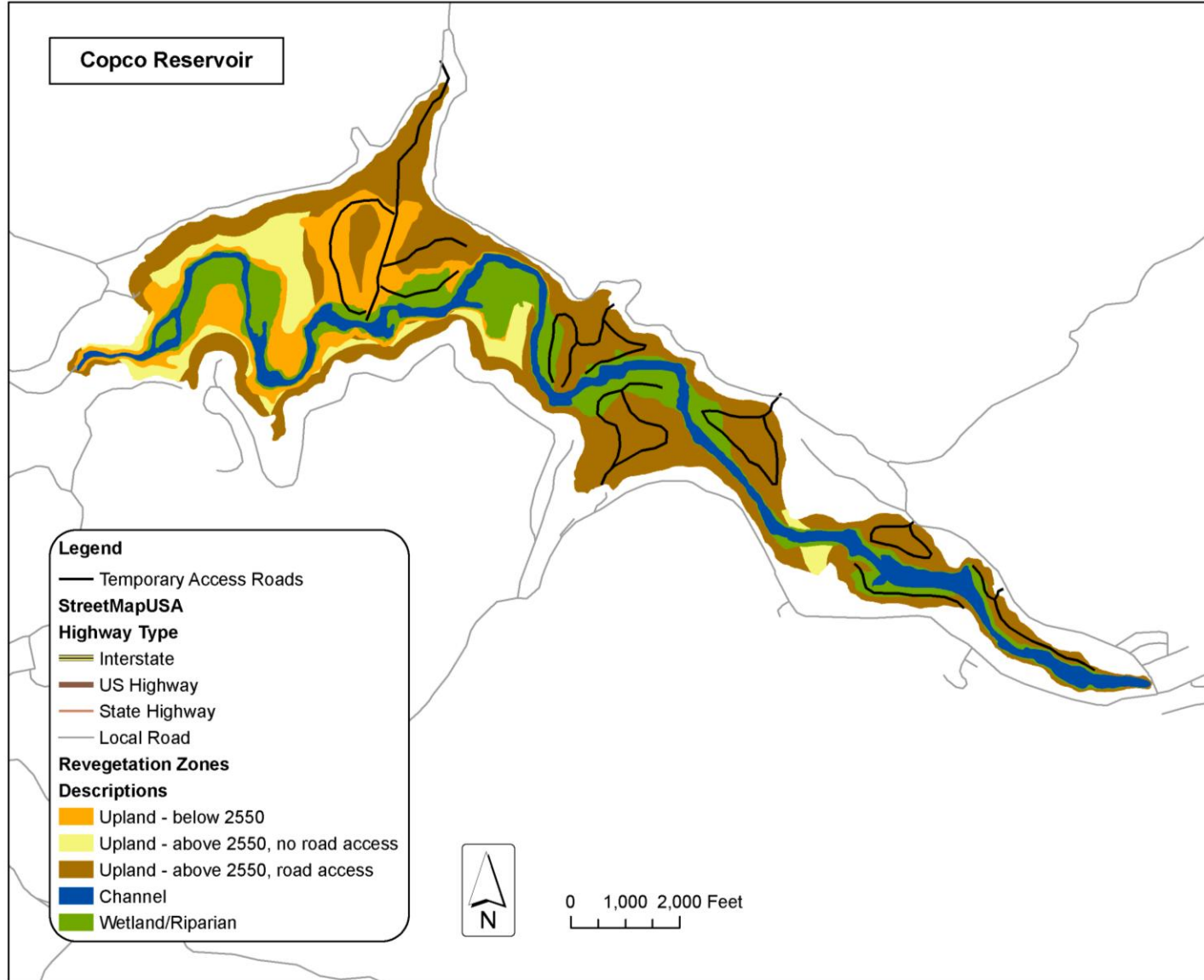


Figure 10-2. Revegetation zones at Copco Reservoir.

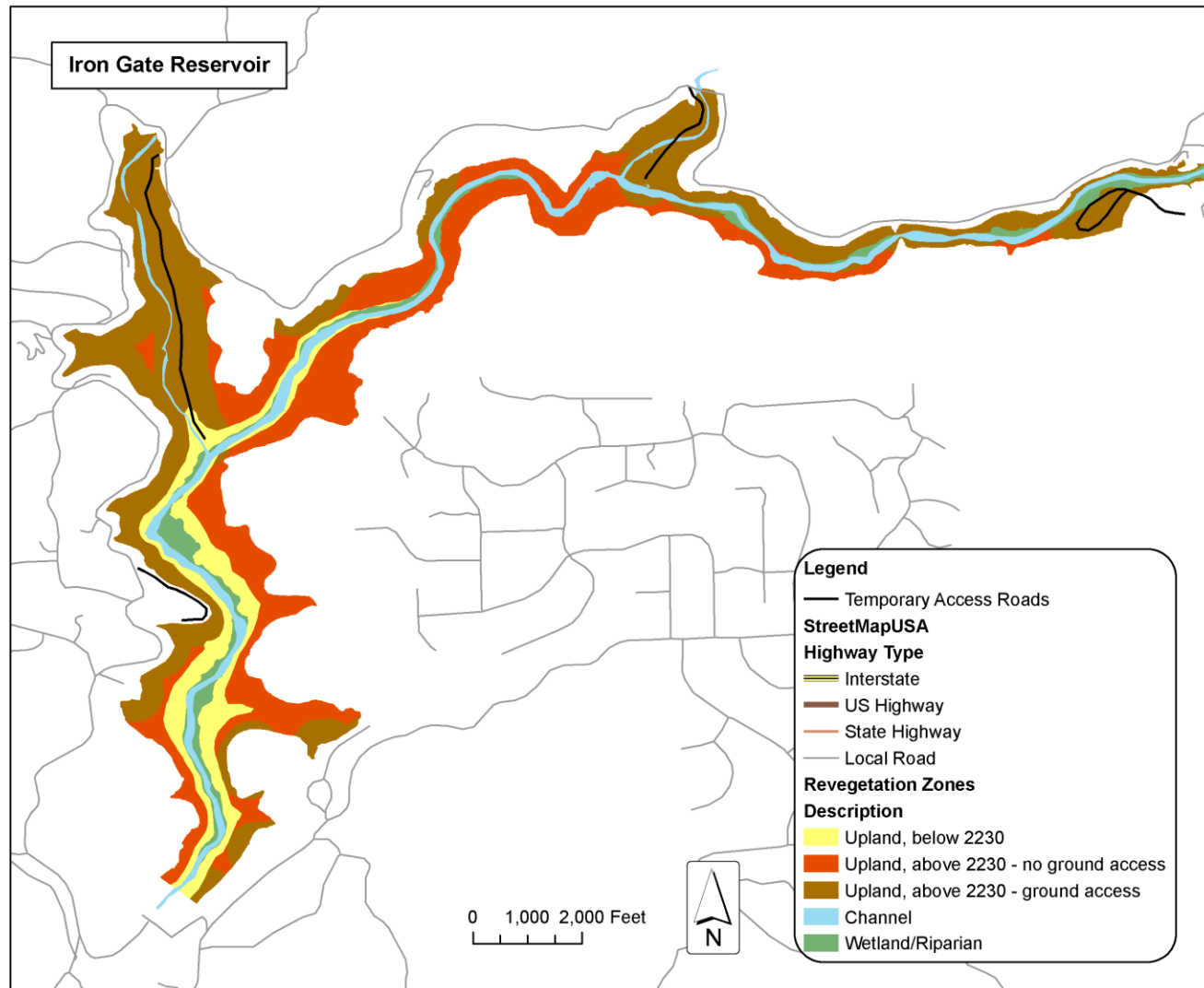


Figure 10-3. Revegetation zones at Iron Gate Reservoir.