3.7 Groundwater

This section describes the potential effects of the Proposed Project on groundwater levels, recharge, and availability. Potential effects of the Proposed Project related to water quality are described in Section 3.2 *Water Quality* and potential effects related to geology are described in Section 3.11 *Geology and Soils*.

Multiple comments were received during the NOP public scoping process relating to groundwater (Appendix A). These comments were primarily concerned with the potential effects of dam and reservoir removal on groundwater wells adjacent to the Lower Klamath Project reservoirs. Examples of specific concerns include the potential for groundwater levels to lower and/or well production to diminish. See Appendix A for further summary of the groundwater comments received during the NOP public scoping process, as well as the individual comments themselves.

3.7.1 Area of Analysis

The Area of Analysis for groundwater impacts includes the area within 2.5 miles of Copco No. 1, Copco No. 2, and Iron Gate reservoirs (Figure 3.7-1), which encompasses the area immediately adjacent to the reservoirs where the likelihood of groundwater well impacts due to the Proposed Project is greatest, as well as areas further from the reservoirs where regional groundwater flow data are generally available (Figure 3.7-2). The Area of Analysis lies within Siskiyou County, California and portions of Jackson and Klamath counties, Oregon. Portions of the Area of Analysis within Oregon are considered to the extent that they are likely to influence potential impacts to groundwater resources in California, rather than for potential impacts in Oregon.

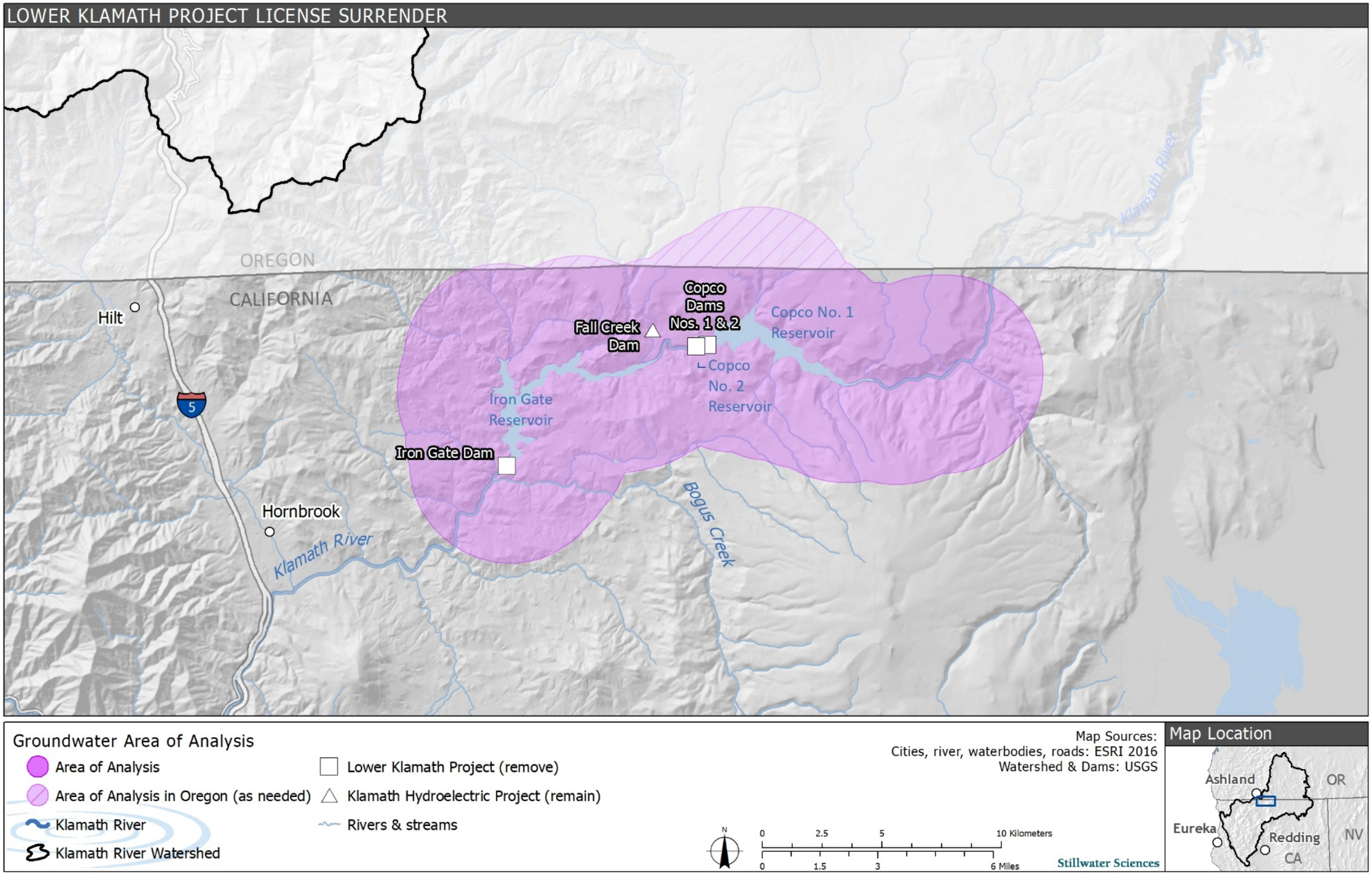

Figure 3.7-1. Groundwater Area of Analysis.

3.7.2 Environmental Setting

This section provides a description of the environmental setting for groundwater resources, including a brief overview of regional groundwater conditions and more specific groundwater information in the Area of Analysis.

3.7.2.1 Regional Groundwater Conditions

There are limited groundwater well data to support characterization of regional groundwater conditions in the Area of Analysis. Gannett et al. (2007) completed the most recent and comprehensive attempt to estimate the groundwater level gradients and flow patterns within the regional area upstream and downstream from each of the four Lower Klamath Project reservoirs. Figure 3.7-2 shows a generalized groundwater flow map for the Hydroelectric Reach of the Klamath Basin (i.e., from Iron Gate Reservoir to Upper Klamath Lake) and portions of the Lower Klamath Basin. Figure 3.7-2 suggests that the regional groundwater flow patterns along the Klamath River downstream from Keno Dam are generally from the higher elevations (upland areas, mountain ranges, hills, etc.) toward the Klamath River, and from Keno Dam toward Iron Gate Dam (USBR 2011). Figure 3.7-2 shows a very steep groundwater head gradient between Keno Dam and J.C. Boyle Reservoir. This steep head gradient suggests the presence of a groundwater barrier and is also roughly correlative with the mapped trace of the Sky Lakes fault zone (Personius et al. 2003). A groundwater barrier at this location implies that the groundwater system upstream of Keno Dam is separate from the groundwater system downstream of Keno Dam.

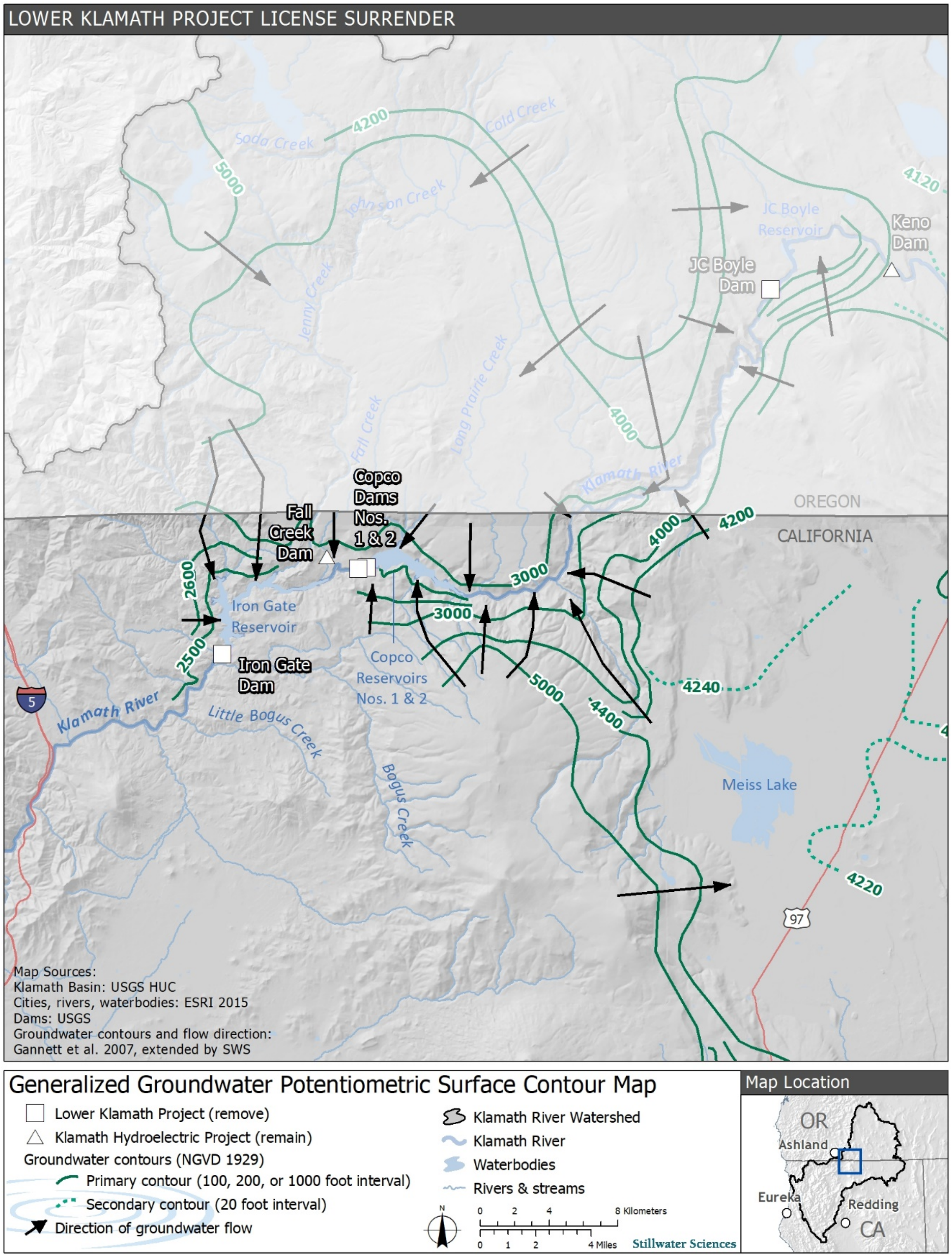

Figure 3.7-2. Regional Groundwater Map (modified from Gannett et al. 2007).

Closer to the Lower Klamath Project Reservoirs but still at the regional scale, USBR (2012) reviewed the area around the Iron Gate and Copco No. 1 reservoirs on USGS topographic 7½-minute quadrangle maps (Iron Gate and Copco No. 1 Quadrangles). Numerous springs, where groundwater discharges to the surface, occur in the area surrounding Iron Gate Reservoir. These springs occur at elevations from less than 50 feet to more than 300 feet above the reservoir level (USBR 2012). The maps also show springs around Copco No. 1 and Copco No. 2 reservoirs. These springs are similarly less than 50 feet to more than 800 feet above the reservoir levels (USBR 2012). The USGS maps also indicate a number of the small drainages that empty into Copco No. 1 Reservoir possess a spring at the headwater of the drainage, again at elevations hundreds of feet above reservoir surface water levels. The presence of numerous groundwater springs in the Area of Analysis indicates that regional conditions support a groundwater table that is near the ground surface, and also suggests that local groundwater systems are not likely to be receiving water directly from the reservoirs (USBR 2012). That is, at the regional scale, water discharging from groundwater springs in the Area of Analysis is not likely to be reservoir water (USBR 2012). Local groundwater conditions (i.e., immediately adjacent to the Lower Klamath Project reservoirs) are discussed in detail in Section 3.7.2.2 *Local Groundwater Conditions*.

Sources of Groundwater in the Area of Analysis

At the regional scale, groundwater in the Area of Analysis is likely fed by the infiltration of surface water and by precipitation and subsequent percolation through the sub-surface soil and bedrock units (Gannett et al. 2007). In the absence of barriers to vertical flow, surface water infiltration is a common source of recharge to groundwater systems. Rivers, lakes and other surface water bodies are common sources of site-specific infiltration recharge. Aerial precipitation is more of a dispersed source of infiltration recharge. As Figure 3.7-2 shows, at a regional scale, groundwater flows into the Area of Analysis from upland areas toward the Klamath River and the Lower Klamath Project reservoirs. Given a regional groundwater flow direction toward the river and reservoirs in the groundwater Area of Analysis (Figure 3.7-2), it is generally assumed that groundwater levels are supported by the regional groundwater system (USBR 2012).

At the local scale, wells immediately adjacent (potentially extending up to a mile from the reservoirs under certain conditions) to the reservoirs are more likely influenced by local site-specific variability in subsurface porosity and permeability. Where current groundwater levels in wells immediately adjacent to a reservoir are above the reservoir water surface elevation (e.g., at Iron Gate Reservoir), river and reservoir reaches are more likely to be receiving water from the regional groundwater system. In locations where current groundwater levels immediately adjacent to a reservoir are below the reservoir water surface elevation (e.g., at Copco No. 1 Reservoir), river and reservoir reaches may be receiving groundwater from the reservoir (USBR 2012). Given the existing data from local groundwater wells, these interpretations provide the best available conceptual characterization of regional and local groundwater resources in the Area of Analysis. Local groundwater conditions (i.e., immediately adjacent to the Lower Klamath Project reservoirs) in the Area of Analysis are discussed in more detail in Section 3.7.2.2 *Local Groundwater Conditions*.

Further upstream, a spring complex approximately one mile downstream of J.C. Boyle Dam contributes substantial flow to the Klamath River (Gannett et al. 2007). The water discharging at this site likely originates from the regional groundwater system, which, as described above, is generally near the ground surface. The flows could also be influenced by seepage from the reservoir that is flowing around or under J.C. Boyle Dam and coming to the surface at the spring site. It is likely that the flows from this spring complex are influenced by both the regional groundwater system as well as leakage from the reservoir (USBR 2012).

Groundwater Sinks in Area of Analysis

Features that cause a loss of groundwater from the groundwater system are called groundwater “sinks.” In areas where surface water levels are lower than the adjacent groundwater level, groundwater can discharge to the surface water (e.g., rivers, streams, and reservoirs), making a groundwater sink. At a regional scale, Gannett et al. (2007) estimate that groundwater flow patterns move toward the Klamath River in the Area of Analysis (Figure 3.7-2). The USGS estimates an average groundwater discharge (sink) of 92 cfs for the reach from the J.C. Boyle Powerhouse downstream to Iron Gate Dam. Based on gage data and changes in reservoir storage, these estimates are calculated for the length of each of these reaches and may include some un-gaged tributary inflows.

Groundwater pumping is also a typical groundwater sink in the Area of Analysis. Domestic and limited irrigation are the primary uses of pumped groundwater in the Area of Analysis. Most domestic wells around the reservoirs are likely seasonal residences (i.e., owner’s official address is different than the well location address) and are not expected to be a major groundwater sink in the Area of Analysis (USBR 2012). Average well yields in Siskiyou County, California are just over 19 gpm (USBR 2012). Based on completion dates on well logs for Siskiyou County, an average of five new wells per year have been installed in the Proposed Project area since 1963 (USBR 2012).

3.7.2.2 Local Groundwater Conditions

The California Department of Water Resources (DWR) *Bulletin 118 – Interim Update 2016, California’s Groundwater,* delineates groundwater basins and sub-basins throughout the State. The Area of Analysis for the Proposed Project does not fall within one of these delineated basins. The area is defined as a “groundwater source area” by the DWR. A “groundwater source area” is defined as “rocks that are significant in terms of being a local groundwater source, but do not fit the [typical] category of basin or sub-basin” (DWR 2003). The Klamath River from the Oregon-California state line to downstream from Iron Gate Dam is a predominantly non-alluvial river flowing through mountainous terrain. Downstream from Iron Gate Dam, and for most of the river’s length to the Pacific Ocean, the river maintains a relatively steep, high-energy, coarse-grained channel frequently confined by bedrock. Section 3.11.2.2 *Geomorphology* describes channel reach geomorphology for the Klamath River in the Area of Analysis and in downstream areas.

USBR (2012) obtained and reviewed groundwater well information from the California DWR and Oregon Water Resources Department (WRD) databases to identify well logs for known domestic and irrigation wells within several miles upstream and downstream from the Lower Klamath Project. Roughly 83 percent of the logs (300 out of 360 logs) included sufficient detail to locate the wells relative to the reservoirs. Of the 300 logs for which reasonable coordinate data could be determined, only 47 wells were within 2.5 miles of one or more of the three reservoirs within California, 25 near Iron Gate Reservoir and 22 near Copco No. 1 and Copco No. 2 reservoirs (USBR 2012).

Using the local topography, reservoir bathymetry, and lithologic descriptions on the well logs, representative cross-sections through the reservoirs and adjacent lands were drawn such that each cross-section intersected at least one known well location. Each cross-section displays the topography, water surface elevation of the reservoir, well log ID, abbreviated well log lithology, and the static water level in the well. Cross-sections aid in understanding the spatial relationship between surface waters, potential water-bearing lithologic units, and groundwater aquifers. The water-bearing units in each well are presented in summary tables for each reservoir (Tables 3.7-1 and 3.7-2).

Copco No. 1 and Copco No. 2 Reservoirs

As described in Section 3.11 *Geology and Soils*, Copco No. 1 and Copco No. 2 reservoirs are located at the contact between the Western Cascade Volcanics and the High Cascade Volcanics geologic provinces. The Western Cascade Volcanics is faulted and intruded by basaltic dikes. Its composition of stratified rocks with low to high permeability results in discrete aquifer units. Based upon the generally shallow depth of known groundwater wells, the groundwater near Copco No. 1 and Copco No. 2 reservoirs is likely from the permeable aquifer units of the High Cascade province or the upper water-bearing units of the Western Cascade province.

The California DWR well database identifies 22 wells within 2.5 miles of Copco No. 1 and Copco No. 2 reservoirs. Figure 3.7-3 shows the locations of the wells. The construction details for these wells are outlined in Appendix L. Five cross-sections that intersected at least one of the 22 wells were developed. Figure 3.7-3 shows the locations of these cross-sections. Figures 3.7-4 through 3.7-8 show the cross-sections and abbreviated descriptions are given in Table 3.7-1. The well parameters used to develop the cross-sections are summarized in Table 3.7-2.

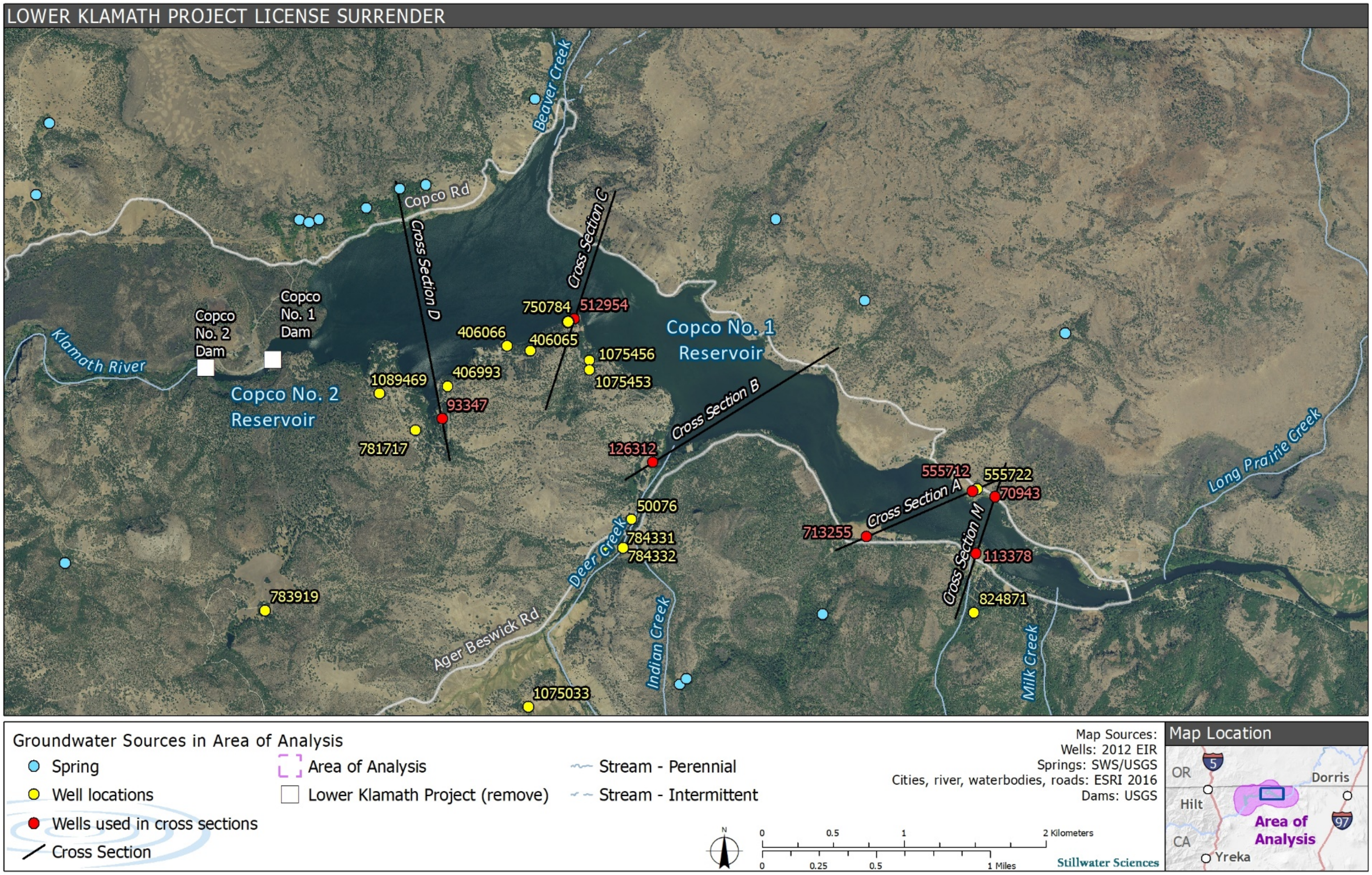

Figure 3.7-3. Locatable Wells within 2.5 Miles of Copco No. 1 and Copco No. 2 Reservoirs and Cross-section Locations. Adapted from USBR 2012.

Table 3.7-1. Abbreviations Used to Characterize Well Logs in Cross-sections.

Material	SDST	Sandstone
	CLST	Claystone
	BRNST	Brownstone
	GRST	Graystone
	SH	Shale
	CGLT	Conglomerate
	BDRK	Bedrock
	SPTN	Serpentine
	SLT	Silt
	MDST	Mudstone
Color	brn	Brown
	lt	Light
	grn	Green
	dk	Dark
	brnsh	Brownish
	grnsh	Greenish
	blk	Black
Other	decomp'd	Decomposed
	fract'd	Fractured
	interm't	Intermittent
	crs	Coarse
	am't	Amount
	med	Medium
	lgr	Large
	sm	Small
	comp'd	Compacted
	N/R	No recovery, no log, or illegible log

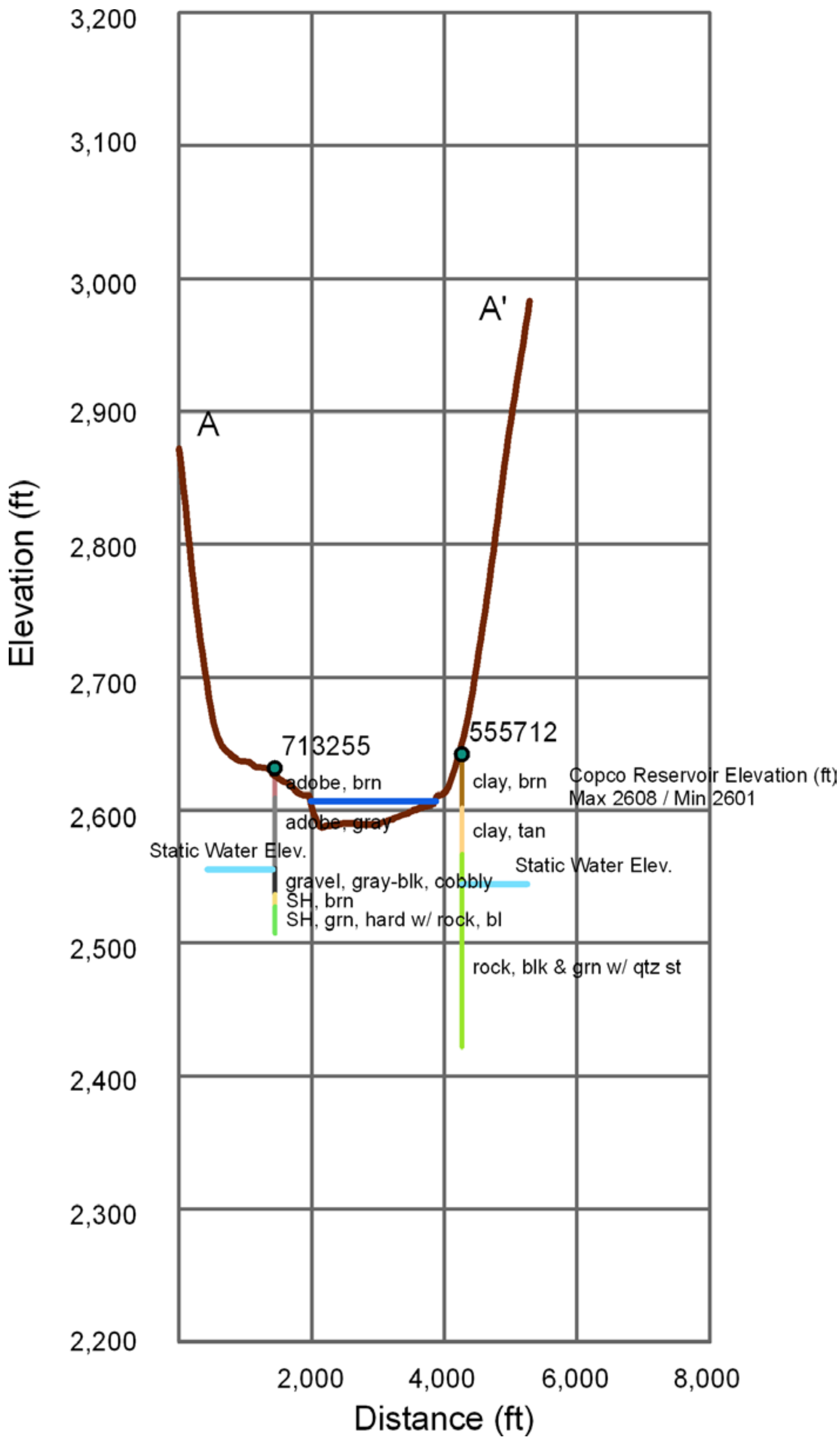

Figure 3.7-4. Copco No. 1 Reservoir, Cross-Section A-A' Depicting Groundwater Elevations and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

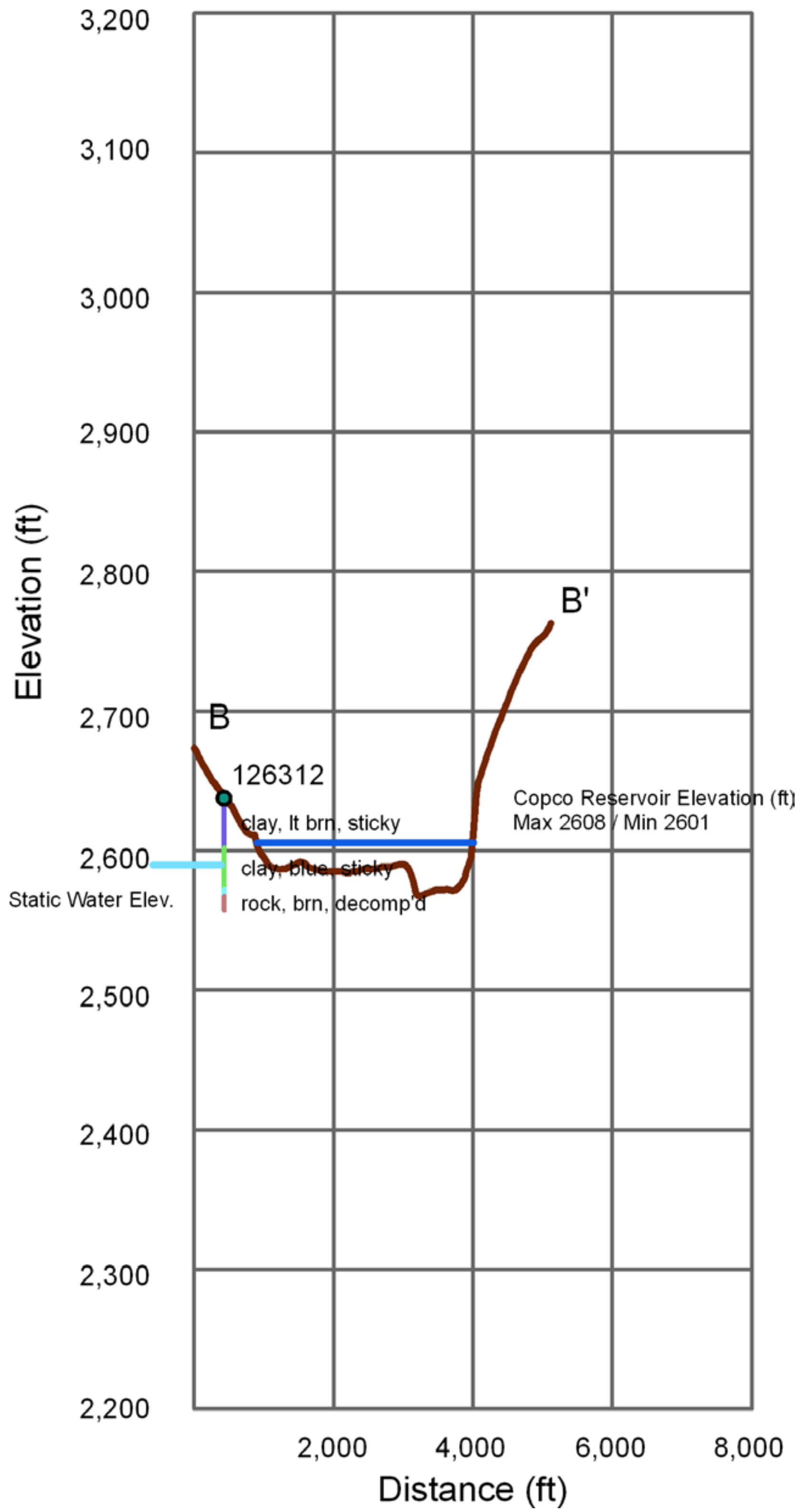

Figure 3.7-5. Copco No. 1 Reservoir, Cross-Section B-B' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

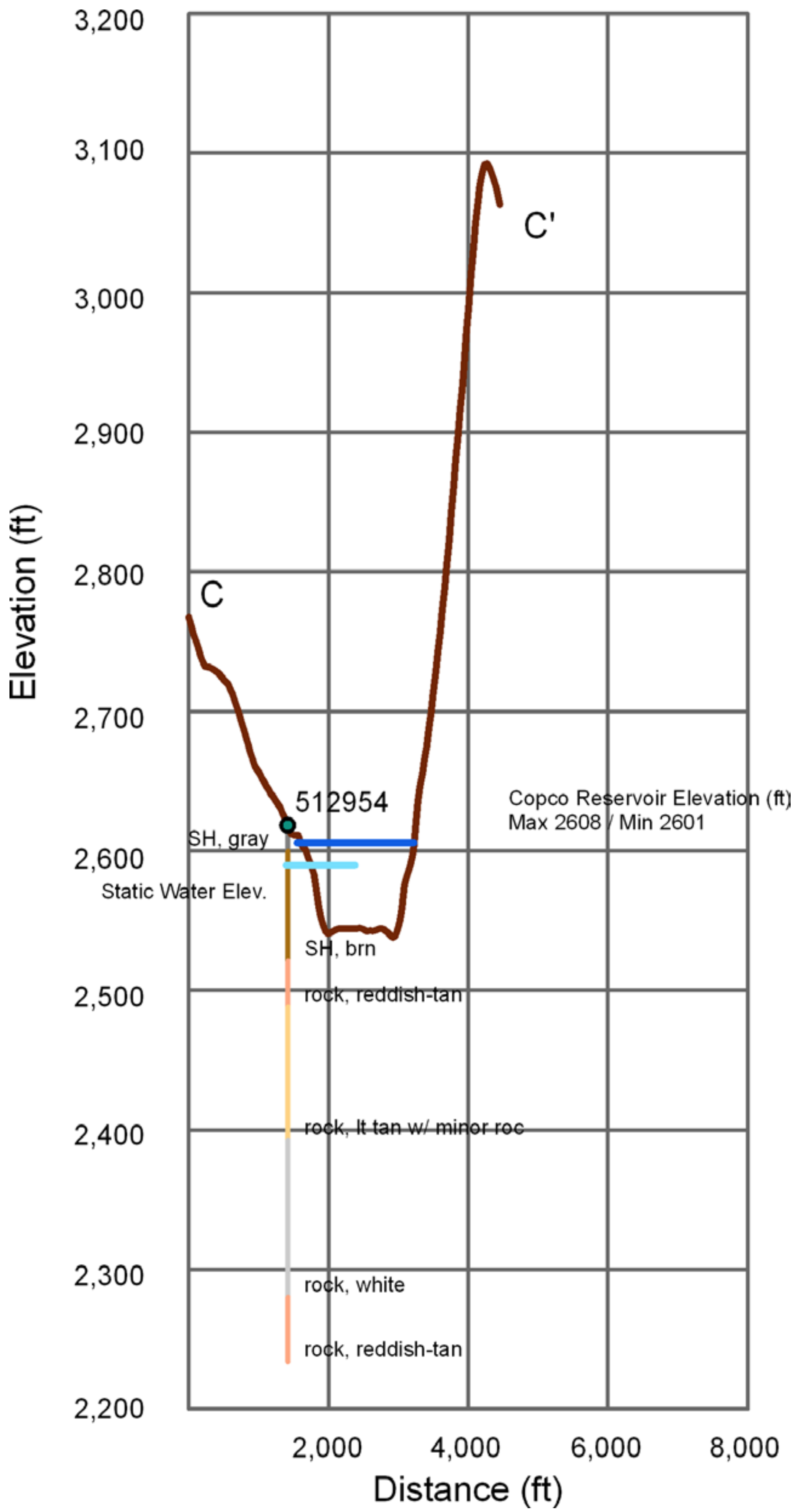

Figure 3.7-6. Copco No. 1 Reservoir, Cross-Section C-C' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

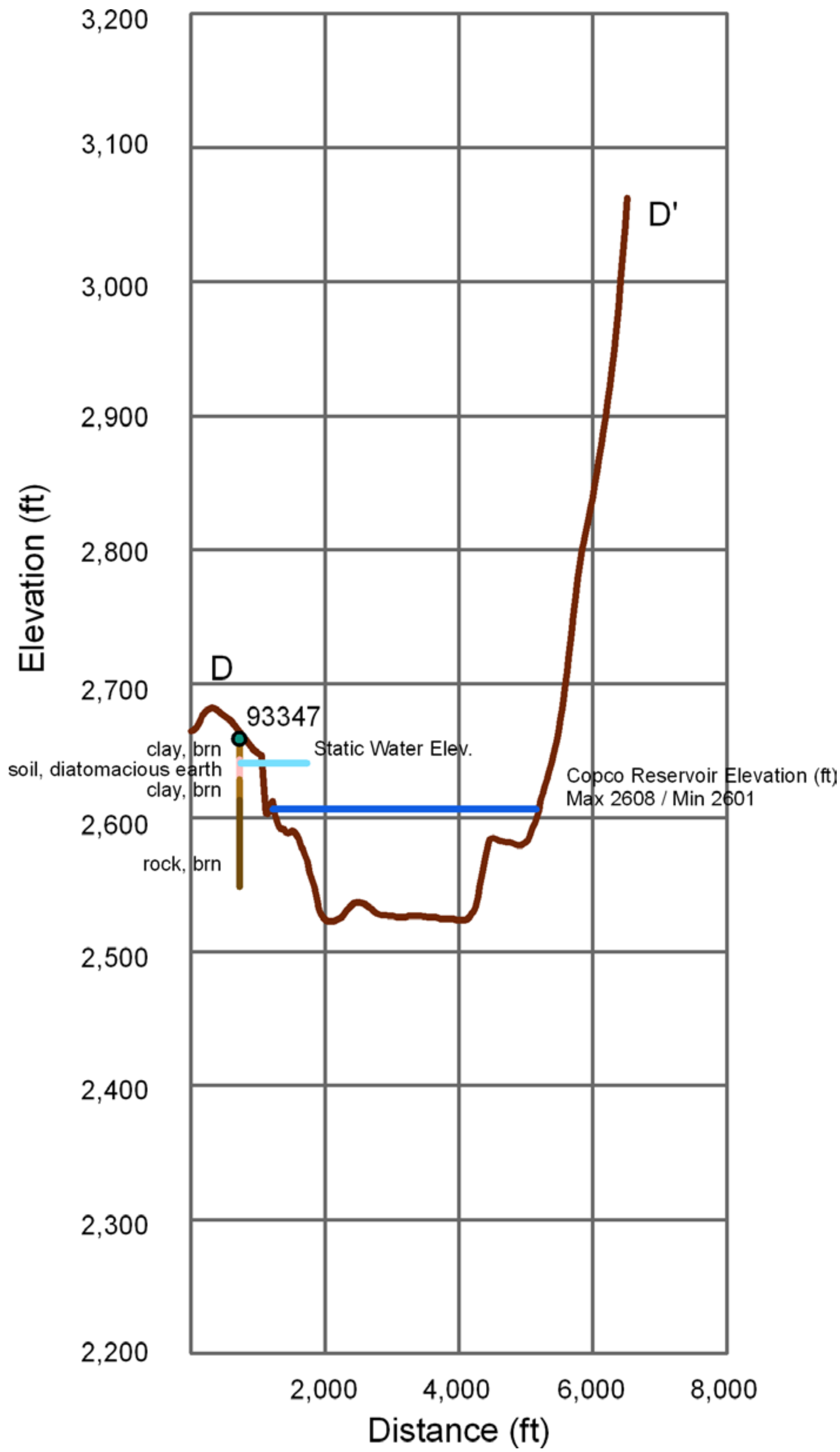

Figure 3.7-7. Copco No. 1 Reservoir, Cross-Section D-D' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

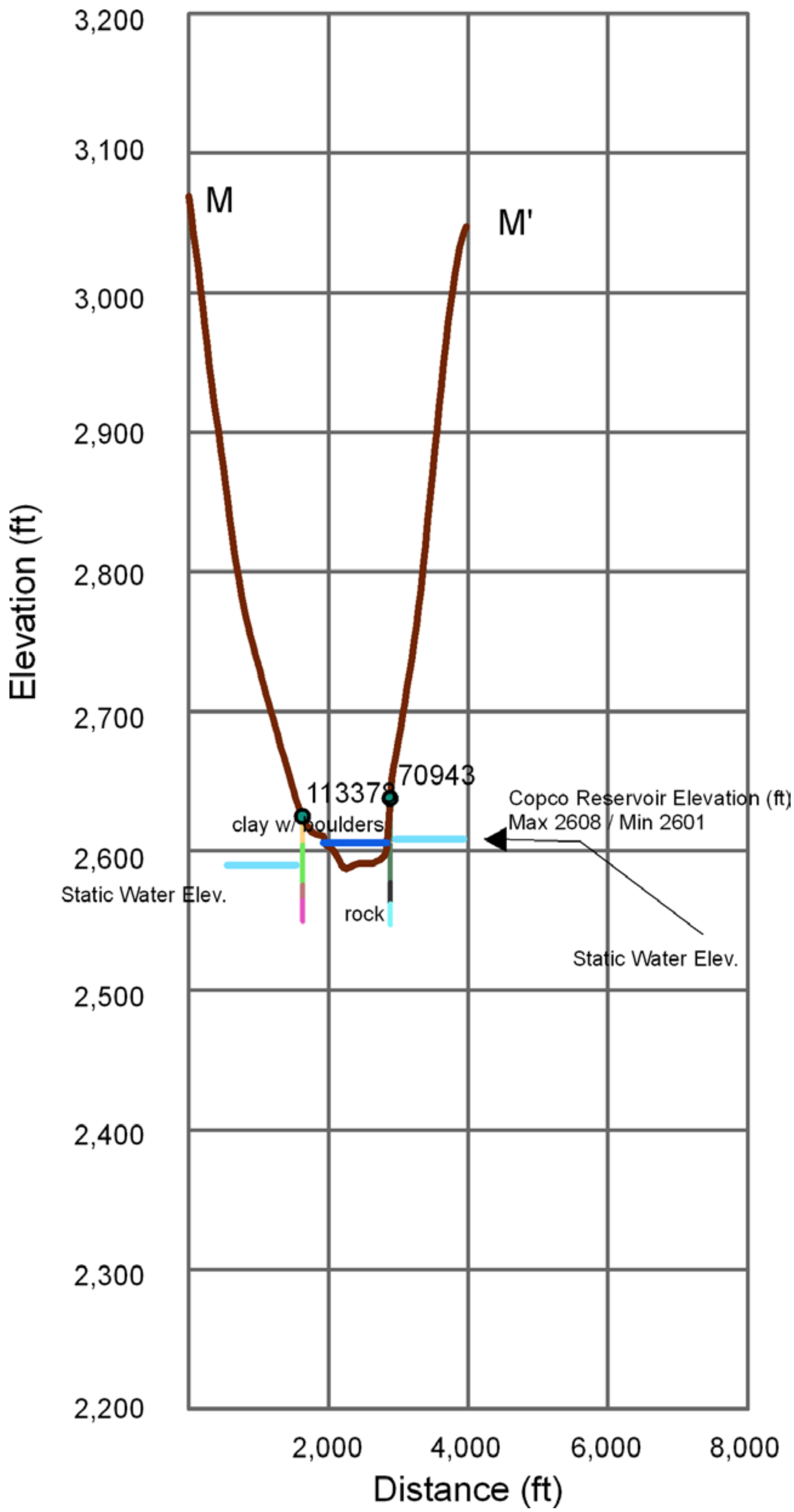

Figure 3.7-8. Copco No. 1 Reservoir, Cross-Section M-M' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

Table 3.7-2. Well Parameters for Copco No. 1 and Copco No. 2 Reservoir Wells used in Cross-sections A, B, C, D, and M.

Well ID[2]	Drill Date	Well Diameter (in)	Depth to Top of Perforated Zone or Bottom of Surface Casing in an Open Well (ft)	Depth to Bottom of Perforated Zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
93347	8/5/1975	6	45 [3]	Open	110	N/R	20	15	D	N/R	Rock, 45- to 110-foot bgs; Elevation 2,608
126312	7/14/1976	6.625	63	83	83	55	10	40	B	2,597	Tight blue cemented sand, 55- to 70-foot bgs; Brown decomposed rock, 70- to 80-foot bgs; Elevation 2.582
512954	10/14/1998	6	75	225	384	N/R	2	50	C	2,566	Reddish tan rock, lighter tan rock, white rock, reddish tan rock; Elevation 2,541
555712	9/30/1994	6	100	120	220	N/R	15	80	A	2,597	Black/green rock w/quartz stringers, 100- to 120-foot bgs; Elevation 2,544
713255	7/19/1999	6	104 [3]	Open	124	N/R	30	60	A	2,565	Hard green and black rock, 104- to 124-foot bgs; Elevation 2,521
113378	08/01/1965	8	16	75	75	49	25	40	M	2,597	Small boulders, 49- to 60-foot bgs; Elevation 2,588
70943	06/20/1964	4.5	70	84	90	32	N/R	15	M	2,608	Gravel, 32- to 33-foot bgs; Elevation 2,591

Source: Adapted from USBR 2010 and USBR 2012.

Notes:

[1] Reservoir stage is 2,602 feet AMSL; river bed elevation at the dam is 2,493 feet AMSL.

[2] All wells listed as domestic supply wells.

[3] Depth to the bottom of the surface casing or sanitary seal in holes/wells that are open

Key:

AMSL: above mean sea level
bgs: below ground surface
in: inches
ft: feet
gpm: gallons per minute
N/R: Data not recorded

The data for the wells in the cross-sections indicate that the water-bearing units and static water levels are above the bottom of the reservoir. All except one of the wells near Copco No. 1 and Copco No. 2 reservoirs have static water levels that are below the reservoir stage but above the river bed elevation at the dam site. Similarly, all the wells except one have elevations for the top of the water-bearing unit below the reservoir stage and above the river bed elevation at the dam site. The two exceptions are two different wells. The top of the water-bearing unit was not identified on the log for some wells. In this case, the elevation at which water was first encountered in the drilling is used as a substitute for the top of the water-bearing unit.

The average static water level for all wells less than 300 feet from Copco No. 1 and 2 reservoirs is 2,591 feet while the average static water level for all wells more than 400 feet from the reservoir is 2,680 feet (USBR 2012). These levels suggest that there is inward groundwater flow near the reservoir (i.e., groundwater is flowing toward the reservoir). As groundwater is flowing toward the reservoir, water level in Copco No. 1 Reservoir is not expected to have a significant lateral influence on local groundwater levels (USBR 2012).

Iron Gate Reservoir

Like Copco No. 1 and Copco No. 2 reservoirs, Iron Gate Reservoir overlies units of the Western Cascade Volcanics geologic province, which has been faulted and intruded by basaltic dikes (Hammond 1983). Specific groundwater well data provides the best understanding of the occurrence of groundwater in the vicinity of Iron Gate Reservoir.

The identification of wells in the vicinity of Iron Gate Reservoir followed the same methods as for Copco No. 1 and Copco No. 2 reservoirs. The California DWR well database identifies 25 wells within 2.5 miles of Iron Gate Reservoir. Figures 3.7-9 and 3.7-10 show the locations of the wells. The construction details for these wells are outlined in Appendix L. Three cross-sections that intersected at least one of the 25 wells were developed. Figures 3.7-9 and 3.7-10 show the locations of these cross-sections. Figures 3.7-11 through 3.7-13 show the cross-sections. The well parameters used to develop the cross-sections are summarized in Table 3.7-3.

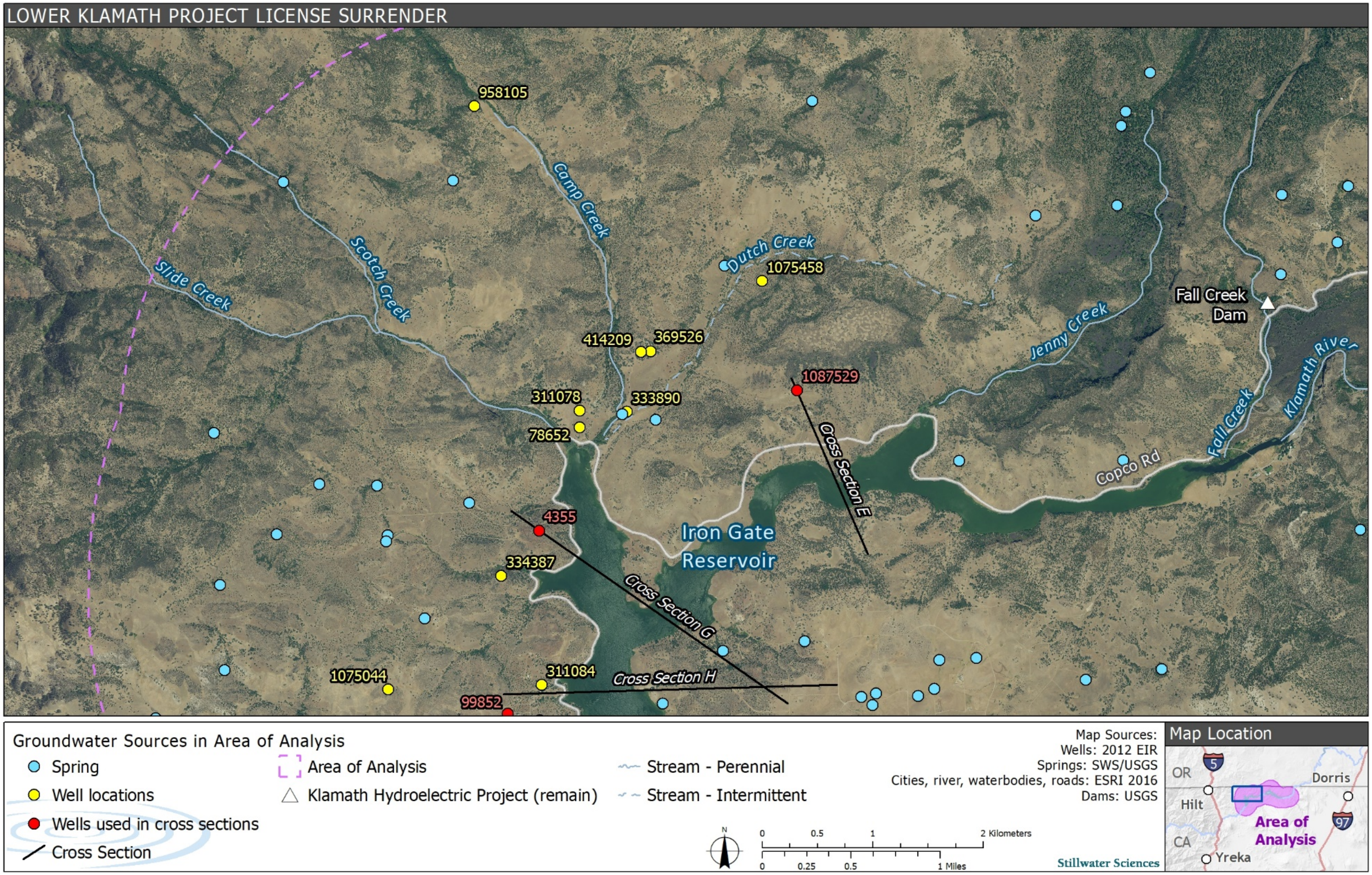

Figure 3.7-9. Locatable Wells within 2.5 Miles of Iron Gate Reservoir and Cross-section Locations. Adapted from USBR 2012.

Figure 3.7-10. Locatable Wells within 2.5 Miles of Iron Gate Reservoir and Cross-section Locations. Adapted from USBR 2012.

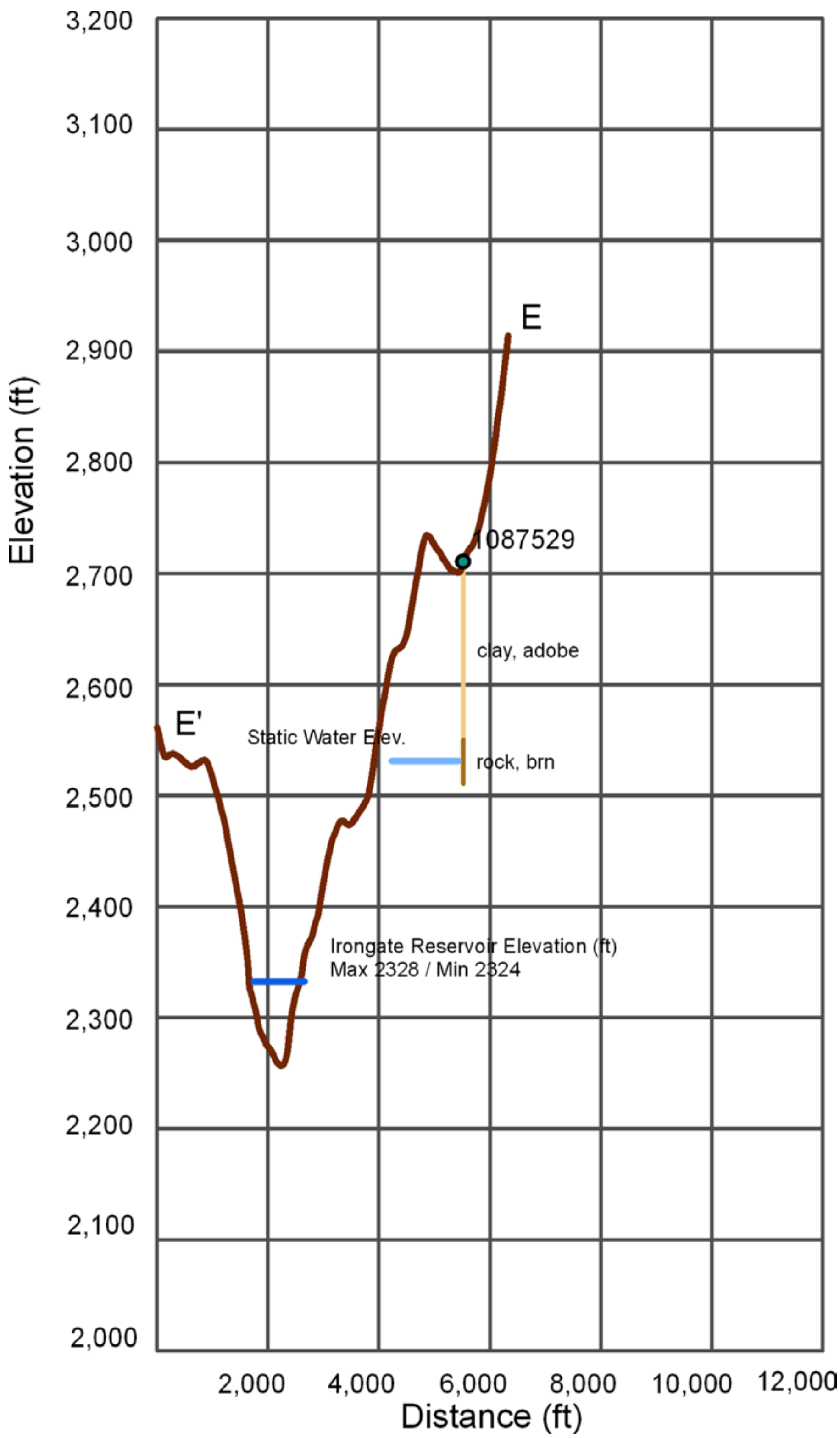

Figure 3.7-11. Iron Gate Reservoir, Cross-Section E-E' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

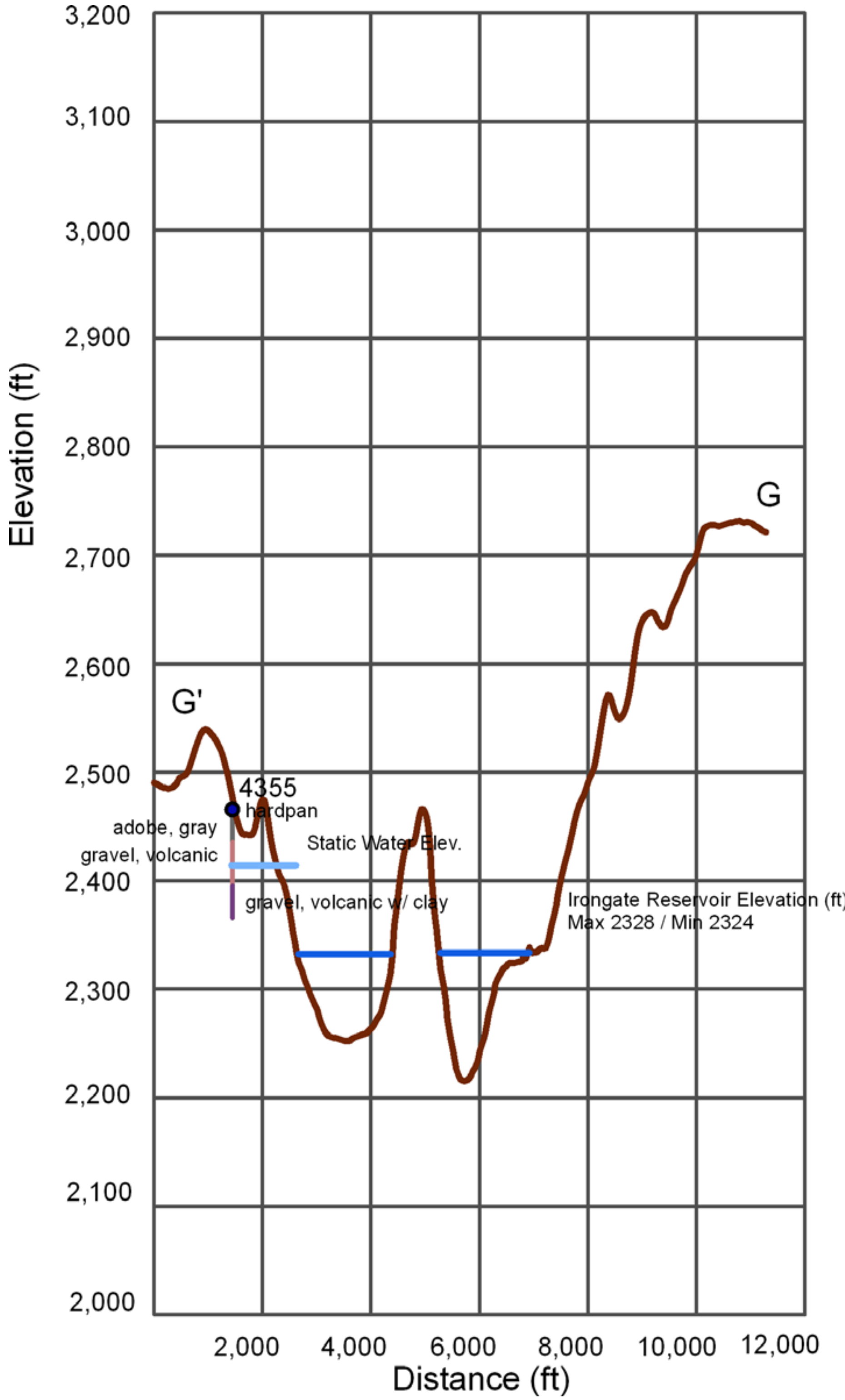

Figure 3.7-12. Iron Gate Reservoir, Cross-Section G-G' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

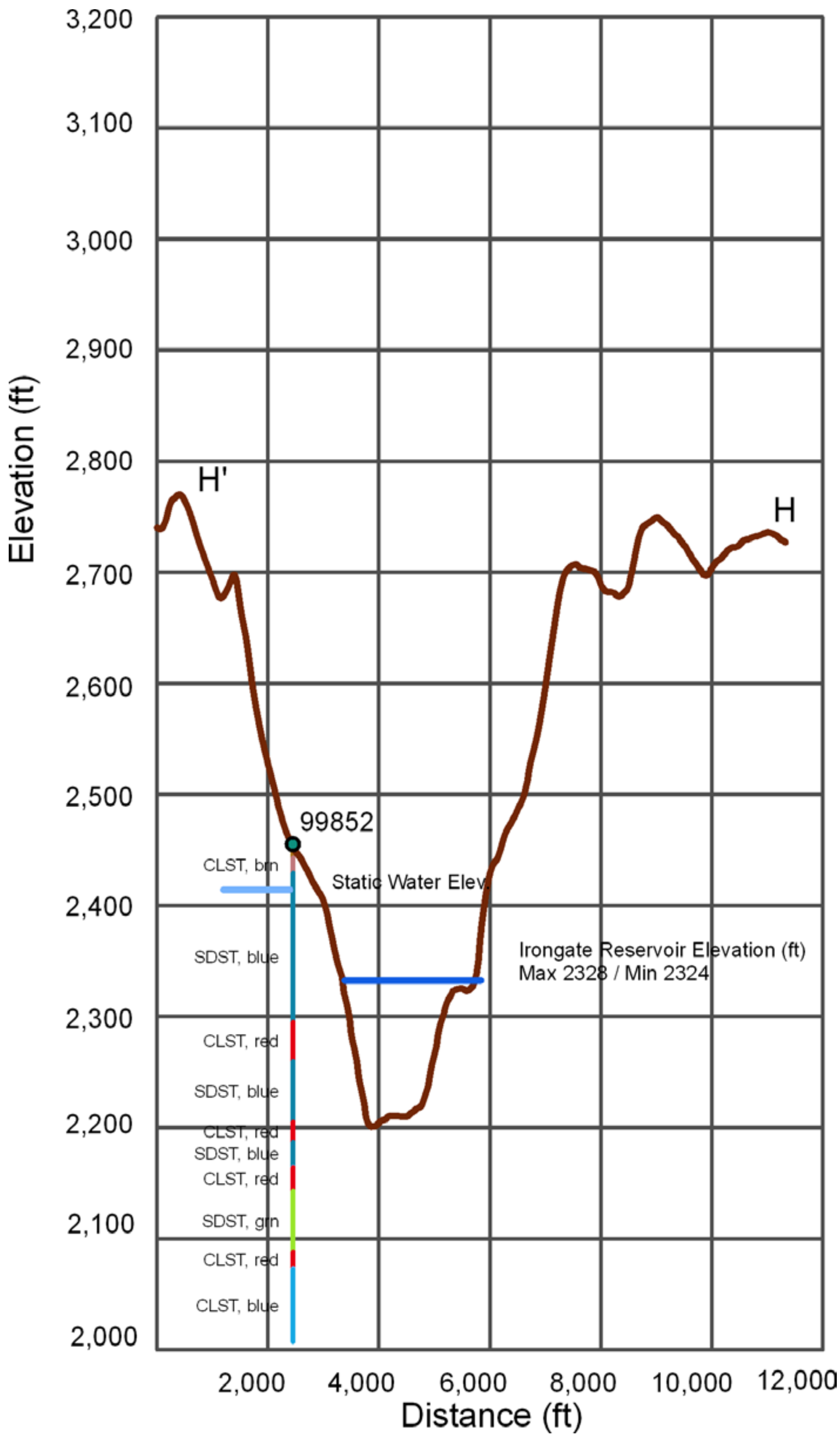

Figure 3.7-13. Iron Gate Reservoir, Cross-Section H-H' Depicting Groundwater Conditions and Stratigraphy Characterized in Wells. 20x vertical exaggeration. Dark blue line shows the elevation of Copco No. 1 Reservoir surface water and light blue line shows the static elevation of groundwater. Adapted from USBR 2012.

Table 3.7-3. Well Parameters for Iron Gate Reservoir[1] Wells used in Cross-sections E, G, and H.

Well ID[2]	Drill Date	Well Diameter (in)	Depth to Top of Perforated Zone or Bottom of Surface Casing in an Open Well[3] (ft)	Depth to Bottom of Perforated Zone (ft)	Depth of Well (ft)	Depth to 1st Water (ft)	Pumping Rate (gpm)	Depth to Static Water (ft)	Located on Cross-section	Static Water Elevation (ft)	Water-Bearing Unit and Top Elevation (ft)
4355	6/14/1966	8	12	70	100	30	10	50	G	2,424	Volcanic gravels, 30- to 700-foot bgs; Elevation 2,444
99852	9/1/1981	6.625	30	Open	500	191	5	150	H	2,563	Blue sandstone from 195- to 250-foot bgs; Elevation 2,518
1087529	5/1/2004	8	100	200	200	180	25	N/R	E	N/R	Brown rock, 160- to 200-foot bgs; Elevation 2, 532

Source: Adapted from USBR 2010 and USBR 2012.
Notes:
[1] Reservoir stage is 2,328 feet AMSL; river bed elevation at the dam is 2,165 feet AMSL.
[2] Wells 24272 and 29830 are domestic supply wells. Well 1087529 is listed as a domestic/irrigation well.
[3] Depth to the bottom of the surface casing or sanitary seal in holes/wells that are open
Key:
AMSL: above mean sea level
bgs: below ground surface
in: inches
ft: feet
gpm: gallons per minute

The well data show that the static water level (when recorded) is above the reservoir stage with only two exceptions (wells 781723 and 99834). The static water level for all but one of the wells (well 781723) is also above the elevation of the river bed at the dam site. The data in Appendix L show that the estimated elevation of the top of the water bearing unit (recorded on 13 of the 25 logs) is above the reservoir stage in 10 of the 13 wells. The top of the water-bearing unit is between the reservoir stage and the reservoir bottom in two wells. The top of the water-bearing unit is below the reservoir bottom in only one well (781723).

Wells further away from Iron Gate Reservoir have higher static water levels and generally higher top of water-bearing unit elevations than wells closer to the reservoir. These elevations indicate groundwater flow direction is toward the reservoir and is consistent with regional groundwater gradients (Figure 3.7-2). Wells within 2,000 feet of the reservoir have static water levels very close or above the reservoir stage (with one exception, well 334387) indicating a potential flow direction toward the reservoir. The current well dataset cannot determine conclusively whether Iron Gate Reservoir has any vertically downward or horizontal seepage (USBR 2012).

In summary, based on review of topographic and geologic maps, the Area of Analysis is underlain by permeable and porous rocks of the High Cascade and Western Cascade Provinces, and it contains abundant groundwater springs. Existing information indicates that while regional groundwater flow in the Area of Analysis is toward the Lower Klamath Project reservoirs, local (i.e., immediately adjacent to the reservoirs) groundwater levels exhibit site-specific variability, with the majority of wells exhibiting water levels above reservoir stage (i.e., groundwater flow toward the reservoir) and a small number of groundwater wells immediately adjacent to Copco No.1 Reservoir exhibiting water levels below the reservoir stage (i.e., potential groundwater flow from the reservoir toward the well).

3.7.3 Significance Criteria

Criteria for determining significant impacts on groundwater are based upon Appendix G of the CEQA Guidelines (California Code of Regulations title 14, section 15000 et seq.) and professional judgment. Effects on groundwater are considered significant if the Proposed Project would result in:

- A substantial decrease of groundwater resources or substantial interference with groundwater recharge, lowering the local groundwater table level so that the production rate of existing nearby wells (i.e., within 2.5 miles of Copco No. 1, Copco No. 2, and Iron Gate reservoirs, see Section 3.7.1 *Area of Analysis*) would drop to an amount that would not support existing uses or planned uses for which permits have been granted.
- Substantially interfering with groundwater levels or groundwater recharge so there would be changes to groundwater/surface water interactions that would adversely affect surface water conditions or related resources.

This EIR does not analyze the potential for land subsidence due to groundwater aquifer collapse because the rock types in the Area of Analysis are not susceptible to collapse. Land subsidence caused by aquifer collapse can be caused by many processes such as the dewatering of fine grained materials (i.e., clays) or collapse of the structure of an aquifer (i.e., through over pumping, dissolution, or piping). The Area of Analysis does not contain areas underlain by extensive clay deposits, so it is not anticipated that the Proposed Project would cause land subsidence (Wagner and Saucedo 1987).

3.7.4 Impacts Analysis Approach

The groundwater impact analysis compares the potential effects of the Proposed Project to existing conditions. This analysis used the groundwater information presented in Section 3.7.2 *Environmental Setting* to evaluate potential effects on existing wells and on groundwater's influence on surface water resources in the Area of Analysis.

The analysis of potential or possible impacts to local wells from the Proposed Project is predicated on the conceptual model that in order to be impacted, the water-bearing unit that each well taps must be hydraulically connected to the reservoir—either by having the water-bearing stratigraphic unit exposed at the ground surface (i.e., daylight) within the reservoir walls or being hydraulically connected to the reservoir through a series of permeable layers between the reservoir and the water-bearing unit. Under the Proposed Project, removal of the Lower Klamath Project reservoirs has the potential to impact water levels in groundwater wells in the Area of Analysis. Other researchers have found that potential groundwater impacts to wells associated with dam removal are strongly controlled by local hydrogeologic characteristics and vary on a site-by-site basis (Berthelote 2013 and Tullos et al. 2016). Furthermore, peer-reviewed published literature addressing groundwater changes resulting from dam removal is extremely limited (Tullos et al. 2016). USBR (2012) concluded that based on local hydrogeologic conditions and well completion reports, potential impacts to groundwater wells in the Area of Analysis likely would only extend up to 0.5 mile from the Lower Klamath Project reservoirs.

The potential for impacts to the wells is further predicated on the relative elevation differences between the static water level in the well(s) and the water surface elevation of the reservoir. Specifically, if the water-bearing unit being tapped by any given well is hydraulically connected to a reservoir, then the static water level in the well should be similar or close to the water surface elevation in the reservoir. If the static water level is higher or lower than the reservoir level, and the water-bearing unit is not exposed along the reservoir walls, then it is likely that the water-bearing unit is reflecting a regional or local aquifer system influence in addition to, or in place of, the reservoir. If the water-bearing unit itself is entirely above the reservoir water levels, or it is substantially deeper (more than three or four intervening impermeable units) than the lowest portion of the reservoir, then it would be unlikely that the water-bearing unit would be in hydraulic connection with the reservoir. It should be noted that the static water level in a well can vary from year to year based on preceding hydrologic conditions (i.e., climatic cycles, wet years vs. dry years).

The following existing local plan is relevant to the Proposed Project:

- Siskiyou County General Plan (Siskiyou County 1980)
    - Chapter 3 Land Use Policies
        - Water Quality Policies: 17.

The aforementioned policy is stated in generalized terms, consistent with its overall intent to protect groundwater resources. By focusing on the potential for impacts to specific groundwater resources within the groundwater Area of Analysis, consideration of the more general local policy listed above is inherently addressed by the specific, individual analyses presented in Section 3.7.5 *[Groundwater] Potential Impacts and Mitigation*, below.

3.7.5 Potential Impacts and Mitigation

Potential Impact 3.7-1 Groundwater levels in existing wells adjacent to the reservoirs could decline in response to the decrease in reservoir surface-water elevations if the dams, and therefore reservoirs, are removed.

The water-bearing units from which most of the existing domestic and/or irrigation wells pump have one of three relationships to the hydroelectric reach: (a) below the elevation of the original river channel, (b) exposed along reservoir walls, or (c) above the reservoir stage. This analysis provides the reasonable inferences regarding the hydraulic connection between these water-bearing units and the reservoirs, as the paucity of measured data precludes more detailed analysis.

The location, underlying hydrogeologic conditions (i.e., how groundwater moves through underlying sediment and rock), and construction characteristics for a groundwater well can influence the potential impact of reservoir removal on well water levels. Some of the water-bearing units tapped by existing domestic and/or irrigation wells (approximately 27 of the 47 wells within the Area of Analysis) lie above the reservoir water surface elevations and are at elevations similar to those of mapped springs. These springs are likely fed by the same water-bearing units supplying the wells and therefore water levels in the wells are not expected to be significantly impacted by the removal of the reservoirs. Domestic and irrigation wells that pump from water-bearing units that are directly connected to the reservoirs (approximately 13 wells) would likely be affected by reservoir removal and the impacts could be significant. Wells that tap water-bearing units below the bottom of the reservoir (approximately 6 wells) are assumed to be maintained by regional groundwater flow patterns that would continue to “sink” toward the restored Klamath River and its alluvial floodplain. Consequently, those wells are unlikely to be affected by the removal of the reservoirs. Ultimately, however, the potential impacts at specific wells would also depend upon local hydrogeologic conditions at the well site location and the well construction characteristics.

Because of limited existing well location data, there could be additional domestic or irrigation wells in water-bearing units that intercept the reservoirs. There are existing domestic and irrigation groundwater wells that could not be reliably located based on the information in the Oregon WRD or California DWR water well databases. In addition to the non-locatable wells in the databases, real estate information suggests the potential for some additional wells. The real estate information presented in the Dam Removal Real Estate Evaluation Report prepared by the DOI in 2011 lists 1,467 potentially impacted parcels near the Copco No. 1, Copco No. 2, and Iron Gate reservoirs. Of those 1,467 parcels, 12 percent (176 parcels) are listed as improved and 88 percent (1,291 parcels) are shown as vacant (Bender Rosenthal, Inc. 2011). The extent of improvements on the 12 percent of parcels is not known. However, it is possible that improvements may have included installation of a groundwater well for domestic and/or irrigation supplies.

In light of the likely connectivity of some wells’ water source with the reservoir, and in light of data gaps, it is possible that removal of the reservoir would cause a substantial decrease of groundwater levels and a corresponding decrease in production rates in existing wells to a degree that interferes with existing or planned uses. This would be a significant impact.

However, the Proposed Project includes implementation of the Groundwater Well Management Plan, as described in Section 2.7.8.7 *Groundwater Well Management Plan* and in Appendix B: *Definite Plan*. The Groundwater Well Management Plan is intended to identify groundwater wells that may be adversely impacted following dam removal and reservoir drawdown and provide sufficient monitoring to understand the effects, if any, on groundwater levels and quality. The Well Management Plan would further identify short and long-term measures to address and mitigate any supply impairments encountered.

Under the Groundwater Well Management Plan, baseline conditions would be determined by monitoring sentinel wells within 2.5 miles of the reservoirs, and ideally within 0.25 miles of the reservoirs. Sentinel wells would include those belonging to volunteer landowners, or if an insufficient number of well owners volunteer to participate in the groundwater monitoring activity, a minimum of ten wells around the three reservoirs on PacifiCorp's Parcel B lands (tentatively, up to four monitoring wells each at Iron Gate and Copco No. 1 reservoirs, and two wells at J.C. Boyle Reservoir). Sentinel wells belonging to participating landowners and any monitoring wells installed by the KRRC would be monitored pre-, during, and post-dam removal to identify seasonal fluctuations in groundwater levels and any groundwater level changes resulting from reservoir removal. Sentinel wells would also be monitored for general water quality parameters including pH, conductivity, and major anions and cations. The KRRC would monitor sentinel wells monthly for a minimum of one year prior to dam removal and monthly for up to one year following dam removal, or until such time that groundwater levels and general water quality parameters have stabilized (no discernable water level declines or changes in quality over a four-month period) or they mirror baseline conditions (Appendix B: *Definite Plan*).

Under the Groundwater Well Management Plan, if groundwater levels in existing wells adjacent to the Lower Klamath Project reservoirs are found to be substantially depleted following dam removal, such that production rates drop to levels that do not support designated domestic or irrigation uses, the KRRC would undertake measures to return the production rates of the affected domestic or irrigation groundwater supply wells to conditions existing prior to dam removal. Short-term measures would include actions providing temporary water supplies until long-term measures such as motor replacement, well deepening, or full well replacement are identified and implemented. The regional and local groundwater pattern of groundwater flow toward the Lower Klamath Project reservoirs suggests that the measures in the Groundwater Well Management Plan would be successful in completely mitigating the identified potential impacts. Because successful implementation of the proposed short-term and long-term measures would return production rates of any affected domestic or irrigation groundwater supply wells to conditions existing prior to dam removal, there would be no significant impact on groundwater levels in existing wells adjacent to the reservoirs.

The State Water Board has issued a draft water quality certification[136] which sets forth monitoring and reporting requirements for groundwater wells surrounding the Lower Klamath Project reservoirs as part of Condition 14.

Significance

No significant impact

Potential Impact 3.7-2 The Proposed Project could interfere with groundwater recharge and adversely affect surface water conditions in the Klamath River.

Because of the underlying geology, removal of the Lower Klamath Project reservoirs is not expected to interfere with groundwater recharge that could potentially affect surface water flows in the Klamath River. Sometimes, removing reservoirs from an area can result in percolation of less surface water to the underlying groundwater aquifers. However, as discussed in Section 3.7.2 *Environmental Setting* the reservoirs generally lie within rock valleys where groundwater recharge is expected to be low. Gannett et al. (2007) concluded that the Klamath River reaches in the Area of Analysis are gaining reaches (i.e., groundwater discharges to the stream). This assessment and the characteristics of the rock surrounding the reservoirs suggest that any surface water that may have infiltrated to groundwater aquifers under the reservoirs would likely discharge back to the river just downstream from the impoundments, rather than increasing aquifer storage. Therefore, there would be a less than significant impact on groundwater recharge and the resulting groundwater/surface water interactions due to the Proposed Project.

Significance

No significant impact

3.7.6 References

Bender Rosenthal, Inc. 2011. Dam Removal Real Estate Evaluation Report for U.S. Department of the Interior, Bureau of Land Management and Bureau of Reclamation, March 22, 2011. Available at: https://klamathrestoration.gov/sites/klamathrestoration.gov/files/Real%20Estate%20Evaluation%20Report_final.pdf

Berthelote, A. R. 2013. Forecasting groundwater responses to dam removal. Doctoral dissertation. University of Montana, Missoula, Montana.

DWR (California Department of Water Resources). 2016. California's Groundwater: Bulletin 118 – Interim update 2016. https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118

Gannett, M. W., K. E. Lite, Jr., J. L. La Marche, B. J. Fisher, and D. J. Polette. 2007. Ground-water hydrology of the Upper Klamath Basin, Oregon and California. U.S. Geological Survey Scientific Investigations Report 2007-5050. Version 1.1. Available at: http://pubs.usgs.gov/sir/2007/5050/. April 2010 revision.

[136] The State Water Board's draft water quality certification is available online at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/water_quality_cert/docs/lower_klamath_ferc14803/lkp_dwqc.pdf (Accessed December 19, 2018).

Hammond, P. 1983. Volcanic formations along the Klamath River near Copco Lake. California Geology Publication, California Division of Mines and Geology. ISSN 0026 4555.

Personius, S. F., R. L. Dart, L. A. Bradley, and K. M. Haller. 2003. Map and data for quaternary faults and folds in Oregon. U.S. Geological Survey Open-File Report 03-095. Version 1.1. http://pubs.usgs.gov/of/2003/ofr-03-095/.

Siskiyou County. 1980. Siskiyou County General Plan Land Use and Circulation Element.

Tullos, D. D., M. J. Collins, J. R. Bellmore, J. A. Bounty, P. J. Connolly, P. B. Shafroth, and A. C. Wilcox. 2016. Synthesis of common management concerns associated with dam removal. Journal of the American Water Resources Association 52: 1,179–1,206 .

USBR (Bureau of Reclamation). 2010. E-mail communication with California Department of Water Resources re: well log information for Siskiyou County. April-May 2010.

USBR. 2011. Irrigated Agriculture Economics Technical Report. Bureau of Reclamation, Technical Service Center, Resource Management and Economics Group. Denver, Colorado. https://klamathrestoration.gov/sites/klamathrestoration.gov/files/2013%20Updates/Econ%20Studies%20/k.Irrigated%20Ag_8-17-2012%20(accessible).pdf

USBR. 2012. Hydrology, Hydraulics and Sediment Transport Studies for the Secretary's Determination on Klamath River Dam Removal and Basin Restoration. Technical Report No. SRH-2011-02. Prepared for Mid-Pacific Region, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Wagner, D. L., and G. J. Saucedo. 1987. Geologic map of the Weed quadrangle, California: California Division of Mines and Geology, regional geologic map series, map 4A, scale 1:250,000.