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List of Acronyms

ac-ft	acre-feet
CDC	California Department of Conservation
CFR	Code of Federal Regulations
cfs	cubic feet per second
Commission	Federal Energy Regulatory Commission
FERC	Federal Energy Regulatory Commission
msl	mean sea level
NRCS	Natural Resource Conservation Service
Project	Kaweah Project
RM	river mile
SCE	Southern California Edison Company
SNP	Sequoia National Park
USACE	United States Army Corps of Engineers
Watershed	Kaweah River Watershed

3.7 GEOLOGY AND SOILS

This section describes the geology and soils in the vicinity of the Kaweah Project (Project) and surrounding area. The Federal Energy Regulatory Commission's (FERC or Commission) content requirements for this report are specified in Title 18 of the Code of Federal Regulations (CFR) Chapter I § 5.6(d)(3)(ii).

As required, this section provides: (1) a description of the geologic setting in the vicinity of the Project, including a description of the bedrock lithology, structural and glacial features, unconsolidated deposits, and mineral resources; (2) a description of the soils in the vicinity of the Project, including factors pertaining to soil movement and erodibility; and (3) a description of the shorelines and streambanks associated with the Project. In addition, this section identifies Project facilities or operations that are known to or may cause erosion and instability. The information presented in this section focuses on those aspects of the geologic environment that are pertinent to hydropower facilities and/or may affect stream conditions. Additional related information is included in Section 3.8 Geomorphology.

3.7.1 Information Sources

This section was prepared utilizing existing information available in the following maps and documents:

- Environmental Assessment, Kaweah Project FERC Project No. 298-000 (FERC 1991);
- Evaluation of Geologic and Soils Conditions, Kaweah Hydroelectric Project, (Sholes 1989);
- Fault Activity Map of California, California Department of Conservation (CDC 2010a);
- Geology of California (Norris R. and Webb, R. 1990);
- Geologic Map of California (CDC 2010b);
- Glacial Reconnaissance of Sequoia National Park (SNP) California (Matthes 1959);
- Limits of Tahoe glaciation in Sequoia and Kings Canyon National Parks, California (Moore and Mack 2008);
- Terminus Reservoir Geology, Paleontology, Flora & Fauna, Archaeology, History (Berryman, et al. 1966);
- United States Department of Agriculture – Natural Resource Conservation Service (NRCS) for soils information (NRCS 2015); and
- United States Army Corps of Engineers (USACE) Kaweah River Investigation (USACE 1996).

3.7.2 Geologic Setting

The Project is situated along the western slope of the Sierra Nevada, at elevations ranging from about 2,585 feet above mean sea level (msl) at the Kaweah No. 1 Diversion Dam to 921 feet above msl at the Kaweah No. 2 Powerhouse. The upper Kaweah River Watershed (Watershed) is characterized by steep canyons with narrow "V-shaped" valley bottoms and steep, deeply-incised channels. The lower Watershed is characterized by rolling foothills with wider "U-shaped" valley bottoms and lower gradient and wider channels (floodplains). Topography in the Watershed is shown on Map 3.7-1.

3.7.2.1 Bedrock Lithology

The Watershed primarily consists of mixed Cretaceous (Upper Mesozoic) granites and granodiorites of the Sierra Nevada batholith that intruded coherent older masses of Mesozoic metasedimentary and metavolcanic rocks. Quaternary till and talus and recent alluvium are the principal surficial deposits. A basic geologic time scale is provided in Table 3.7-1 for reference.

As shown on Map 3.7-2, the Cretaceous granites underlying the Project facilities primarily consist of granodiorite. Small bodies of mafic intrusive igneous rocks, mainly gabbro, are also present. The Mesozoic metasedimentary and metavolcanic rocks are expressed as large generally elongated roof pendants, mapped as perodotite. Contacts between the granitic and metamorphic rocks are deeply dipping. The roof pendants trend northwest, reflecting the orientation of bedding and foliation within the metamorphic bodies (Sholes 1989).

All of the Project facilities overlie granitic rock. Bedrock outcrops occur in scattered locations; in a few areas, outcrops comprise up to 50% or more of the ground surface. Weathering of the granitic rock is variable; in some areas the bedrock is completely decomposed to depths of 20 feet or more (FERC 1991)

3.7.2.2 Seismicity

The Project is situated in an area with low historic seismicity. There are no known active faults[1] or fault zones in the immediate vicinity of the Project. In addition, there are no Alquist-Priolo Earthquake Fault Zones[2] identified in the Project vicinity (CDC 2015).

The nearest known active fault is the Kern Canyon Fault, a northeast-southwest trending fault that extends from the mouth of the Kern River Canyon, through Lake Isabella and Kernville, through the SNP, terminating near Harrison Pass, approximately 32 miles east

[1] The California Department of Conservation (CDC) defines an "Active Fault Zone" as an area of related faults that have exhibited surface displacement within the last 11,000 years.

[2] The Alquist-Priolo Earthquake Fault Zoning Act was passed into law following the 1971 San Fernando earthquake. The intent of the Act is to ensure public safety by prohibiting the siting of most structures for human occupancy across traces of active faults that constitute a potential hazard to structures from surface faulting or fault creep.

of the community of Three Rivers. Recent USACE field studies determined that the Kern Canyon Fault is active and capable of producing a 7.5-magnitude earthquake. The last movement on the Kern Canyon Fault appears to have occurred during the past 2,500 to 4,000 years, with an average interval between large earthquakes of about 3,200 years (USACE 2012). A moderate to large earthquake on this fault would likely produce ground shaking in the Project vicinity.

3.7.2.3 Structural Features

There are very few structural features in the vicinity of the Project, primarily because the area is relatively inactive. The most prominent structural features are the roof pendants that occur in the Watershed. These features consist of older rocks stratigraphically positioned on top of younger intrusive rocks.

Massive, rounded, granitic domes that are typical of the Sierra Nevada occur in the Watershed. The most prominent of these is Moro Rock which is located in the SNP, between the Marble and Middle forks of the Kaweah River.

At least four caverns have been formed in the marble and limestone deposits in the Watershed. None are large, but all contain limestone cave features such as stalactites, stalagmites, and pillars (Norris and Webb 1990). The largest and most popular is Crystal Cove near the Giant Forest in the SNP.

3.7.2.4 Glacial Features

The Sierra Nevada was glaciated several times during the Pleistocene Period. Glacial events modified the topography of the Watershed by forming wider, U-shaped valleys, particularly in the upper portions of the Watershed. Glaciers in the Kaweah Watershed were not extensive and terminated at approximately 6,100 feet, 5,100 feet, and 6,200 feet in the Marble, Middle, and East forks of the Kaweah River, respectively (Moore and Mack 2008).

Glacial deposits (moraines and till) have been mapped in the upper portions of the Watershed. The most prominent glacial deposit is located on the Marble Fork Kaweah River upstream of the Marble Fork Diversion Dam, where Highway 198 crosses the river (Map 3.7-2). Erosion of glacial deposits, such as till and moraines tend to contribute gravel-sized sediment to the streambeds downstream.

3.7.2.5 Unconsolidated Sediments

Aside from glacial deposits, unconsolidated sediments in the Watershed are generally limited to surface soils, and recent alluvium deposited in the stream and river courses and associated terraces. As shown on Map 3.7-2, a relatively large deposit of unconsolidated and semi-consolidated Quaternary alluvium is present in the vicinity of Three Rivers, extending along the North Fork Kaweah River and the Kaweah River to the upper end of Lake Kaweah.

3.7.2.6 Mineral Resources

Historic and current mining activity in the Watershed is shown on Map 3.7-3. As indicated, with the exception of one uranium prospect located near the Kaweah No. 1 Diversion Dam, there are no known historic or active mines located within the FERC Project boundary or the immediate vicinity. The only active mine in the vicinity of the Project is a crushed stone mining operation located due south of the community of Three Rivers (Map 3.7-3).

As indicated by the absence of productive mines, mineral resources in the Watershed are relatively limited, which is typical in areas dominated by granitic rock. As shown on Map 3.7-3, a variety of minerals have been identified in the Watershed, but only a few deposits have produced active mines. Deposits of lead were identified on the divide between the North Fork Kaweah River and the Middle Fork Kaweah River, but not in concentrations that could be economically mined. Tungsten was historically mined along the North Fork Kaweah River and the South Fork Kaweah River, southeast of Three Rivers. These northwest-southeast trending lead deposits appear to occur along or near the contact between the younger granitic and older metamorphic rocks (Map 3.7-2).

Silver and galena (a lead ore) were historically mined in the Mineral King Valley, which is located in the SNP at the headwaters of the East Fork Kaweah River, approximately 20 miles southeast of the community of Three Rivers. Silver was first discovered in the Mineral King Valley in 1872. Mining continued between 1873 and 1882, but these operations ceased when the ore was found to be difficult to smelt profitably (SCE 1992a).

Extensive deposits of limestone occur near Three Rivers along the South Fork Kaweah River, and on the Middle, Marble and East forks of the Kaweah River in the SNP. These deposits were mined historically but are not currently active.

3.7.3 Soils

Soils found within 0.5 mile of Project facilities and associated bypass reaches are shown on Map 3.7-4. Descriptions of each soil shown on the map, including taxonomy, parent rock, vegetation and erodibility (K Factor) are summarized in Table 3.7-2, organized by the soil codes identified on Map 3.7-4. Table 3.7-3 summarizes the soil types that underlie each Project facility, organized by development. The information is based entirely on detailed soil information developed by the NRCS (NRCS 2015).

In general, the soils shown on Map 3.7-4 can be classified into two categories as follows, based primarily on factors that pertain to the parent material from which the soil is derived:

- Soils formed on granitic bedrock are moderately deep and moderately coarse-grained. These soils are subject to erosion, particularly when devoid of vegetated cover (USACE 1996).

- Soils formed on metamorphic and volcanic bedrock are shallow, well-drained, slightly acidic, rocky, and medium-textured. These soils are relatively stable and well-vegetated.

As indicated on the map and tables, most of soils within 0.5 mile of the East Fork Kaweah River and within 0.5 mile of the Kaweah River, including the soils underlying the Project facilities, were formed on granitic bedrock, meaning they are moderately deep and moderately coarse-grained and are subject to erosion, particularly when devoid of vegetated cover. The excessively well-drained nature of the soils can make revegetation difficult, especially on steeper slopes. Soils derived from metasedimentary rocks do not occur in the immediate vicinity of the Project or within 0.5 mile of a Project facility, but they do occur downstream near Three Rivers. Minor deposits of alluvium (stream deposits) and colluvium (material moved by gravity) occur at scattered locations throughout the area, primarily within the active stream channels and terraces.

One of the parameters used by the NRCS in assessing the susceptibility of a soil to erosion is the K factor. This factor assesses the susceptibility of the soil to sheet and rill erosion and is dependent upon the percentages of clay, silt, sand, and organic matter in the soil. In general, soils with low K factors are less susceptible to erosion and soils with high K factors are more susceptible to erosion. The K factor for each of the soil types in the vicinity of the Project are provided on Tables 3.7-2 and 3.7-3. As indicated, K values for the soils underlying Project facilities range from 0.15 to 0.37, meaning they have low to moderate susceptibility to erosion when there is minimal vegetative cover. Areas with good vegetative cover would have a lower overall potential for erosion.

3.7.4 Shorelines and Streambanks

This section describes the shorelines associated with the Project, including potential erosion issues. A description of the channel conditions in the river reaches downstream of the Project diversion dams is provided in Section 3.8 Geomorphology.

3.7.4.1 Shorelines

The Project has limited storage capacity and is operated in a run-of-river mode. Aside from the small pools formed behind the diversion dams, the only impoundments associated with the Project are the forebays located above the three Project powerhouses at or near the terminus of the flowlines, which are described as follows:

- The Kaweah No. 1 Forebay consists of a 24-foot diameter steel forebay tank with an overflow spillway chute and a capacity of 0.18 acre-feet (ac-ft). Water enters the forebay from the Kaweah No. 1 Flowline and exits via the Kaweah No. 1 Penstock.
- The Kaweah No. 2 Forebay is an enlargement of the Kaweah No. 2 Flowline. The forebay extends for a distance of 180 feet and has a cross section 13-feet wide by 14-feet deep and a capacity of 0.75 ac-ft. From the forebay, flow is conveyed to the Kaweah No. 2 Powerhouse through the Kaweah No. 2 Penstock.

- The Kaweah No. 3 Forebay is an embankment forebay with a capacity of approximately 11 ac-ft. A concrete-lined spillway near the upstream end of the forebay discharges into a drainage channel which connects to the Kaweah No. 3 Penstock.

The potential for shoreline erosion at Project diversion pools and forebays is discussed in the following subsections.

Shoreline Erosion

The Kaweah No. 1 and Kaweah No. 2 diversion dams are situated in granitic bedrock. Therefore, there is very minimal potential for erosion in the immediate vicinity of the dams or along the perimeters of small pools formed behind the diversion pools. In addition, the bedrock/large boulder channels upstream of the diversion pools have little potential for erosion. No erosion was observed at these locations during field visits conducted in 2015.

Kaweah No. 1 Forebay is a 24-foot diameter steel tank and the Kaweah No. 2 and No. 3 forebays are lined with concrete. Therefore, there is no potential for shoreline erosion at these facilities.

3.7.5 Erosion Associated with Project Facilities

In general, the Project facilities are well-maintained and the surrounding landscape is relatively stable. Very little erosion is present on natural slopes. Potential erosion issues are primarily limited to the operation and maintenance of Project roads and Project flowlines, as discussed in the following subsections.

3.7.5.1 Project Roads

Twenty-nine access roads (totaling 9.31 miles) and 14 trails (totaling 0.27 mile) are used for routine operation and maintenance of the Project. These roads and trails are described in detail in Section 2.0 Project Description.

Most of these roads and trails are unpaved and therefore susceptible to erosion. Moderate erosion occurs where concentrated runoff from roads or other graded areas has been directed down natural slopes. To minimize erosion, Southern California Edison Company (SCE) regrades the roads and maintains adjacent ditches annually (FERC 1991). In addition, water bars and berms have been installed to keep runoff controlled and directed into culverts and downdrains (FERC 1991).

During the previous relicensing effort, active erosion was identified along specific sections of the Mineral King Road that had the potential to undercut the support legs of adjacent the Kaweah No. 1 Flowline (SCE 1992b; FERC 1999). SCE has since addressed this issue as required in the Erosion Protection and Remediation Plan discussed in Section 3.7.6.

3.7.5.2 Flowlines

The flowlines are narrow and essentially contour the hillsides, so there are limited areas of cut and fill that could be subject to erosion or slope instability (FERC 1991). Slope runoff above the flowlines is channeled through culverts and overflow chutes. The largest of these are the forebay spillway channels discussed above.

Breaks in the flowlines have the potential to cause erosion. Historically, these breaks caused substantial erosion, creating gullies and channels up to 40 feet wide and 10 to 15 feet deep. These channels have since been revegetated by native grasses and scattered brush. As discussed below, in 1992, SCE implemented a plan to limit the potential for erosion from flowline breaks. The plan specified actions that were to be implemented in the event of a break, including shutting off the flow within two hours (Sholes 1989; SCE 1992b).

3.7.5.3 Forebays

When a powerhouse unit trips, water in the flowlines spills at the forebays into adjacent drainages, which are generally very steep. Periodic spills have occurred into these drainages for decades. These spills generally last for less than a day. The locations of the spill drainages are shown on Maps 3.7-5 and 3.7-6, and a general description of each is provided below. This description is based on observations made during a site visit conducted on July 1, 2015.

<u>Kaweah No. 1 Forebay Spill Channel</u>

Overflow from the Kaweah No. 1 Forebay Tank is directed through a spill chute into a channel located adjacent to the penstock. This channel is very steep and heavily vegetated. Erosion in this channel has not yet been assessed.

<u>Kaweah No. 2 Forebay Spill Channels</u>

At the Kaweah No. 2 Forebay, up to 87 cubic feet per second (cfs) can spill into three concrete-lined spillways, which discharge into natural drainages. These three drainages are shown on Map 3.7-5.

The primary spill drainage is located adjacent to the forebay and receives spill flows up to 40 cfs. The drainage is approximately 0.23-mile long and flows into the Kaweah No. 2 Tailrace. Figure 3.7-1a shows the primary drainage on July 1, 2015 with approximately 10 cfs of water. The other two spill drainages are located along the flowline (Map 3.7-5), and receive spills up to 47 cfs. These two smaller drainages converge approximately 220 feet downslope and then continue downslope to the Kaweah River, discharging approximately 0.16 mile upstream of the Kaweah No. 2 Powerhouse. The upper sections of the three drainages are very steep, with slopes exceeding 50%.

The three drainages show evidence of incision through the decomposed granite to the underlying granitic bedrock. As shown on Figure 3.7-1b, the upper portion of the main spill drainage has been incised up to 20 feet. Most of the vertical erosion occurred several decades ago based on the size of the alder trees currently established along the channel margins. The side slopes of the upper sections of the drainages are generally comprised of bedrock or coarse boulders or decomposed granite, with relatively minimal vegetative cover. On-going instability occurs in portions of the drainages where decomposed granite is exposed, and the channel is deeply incised, particularly in the upper portions of the drainages (Figure 3.7-1c). The other bedrock or large boulder sections are stable (e.g., Figure 3.7-1d). The lower portions of the drainages are lower gradient and well vegetated, which reduces the erosion potential.

Kaweah No. 3 Forebay Spill Channel

At Kaweah No. 3 Forebay, up to 97 cfs of flow can spill into an approximate 75-foot long concrete-lined spillway chute that begins at the upstream end of the forebay. The chute discharges into an adjacent drainage that flows approximately 0.3 mile downslope into the Kaweah River (Map 3.7-6). Spills occur periodically and generally last for less than a day. Photographs of the upper portion of the drainage and the top of the spill chute are shown in Figure 3.7-2a. As shown in the figures, the drainage is very narrow and steep (approximately 38% gradient), and is primarily comprised of large boulders and is well vegetated (Figures 3.7-2 b-d). The large substrate that acts as rip-rap and well-vegetated side slopes limit the potential for down cutting and erosion of the side slopes. At the confluence with the Kaweah River, the drainage is vegetated, with no large sediment deposits at the margins of the channel (Figure 3.7-2e).

3.7.6 Current Erosion Management

SCE prepared an Erosion Protection and Remediation Plan in association with the previous relicensing effort. License Article 401 approved the Erosion Protection and Remediation Plan. The plan was subsequently revised and FERC approved the revised plan in an Order issued January 19, 1993. In addition to addressing specific erosion issues that were identified during the previous relicensing effort, the plan includes erosion protection measures that SCE is required to implement in the event of a future flowline break. Implementation of the measures outlined in this plan has substantially reduced the potential for erosion and other forms of instability associated with the Project.

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TABLES

Table 3.7-1. Simplified Geologic Time Scale.*

Eon	Era	Period	Years Before Present (MYA = Million Years Ago)
Phanerozoic (542.0 mya to present)	**Cenozoic (65.5 mya to present)**	**Quaternary** Holocene Pleistocene	**2.6 mya to present** 11,700 yrs to present 2.588 mya to 11,700 yrs
		Tertiary	**65.5 to 2.6 mya**
	Mesozoic (251.0 to 65.5 mya)	**Cretaceous**	**145.5 to 65.5 mya**
		Jurassic	**199.6 to 145.5 mya**
		Triassic	**251.0 to 199.6 mya**
	Paleozoic (542.0 to 251.0 mya)	**Permian**	**299.0 to 251.0 mya**
		Carboniferous	**359.2 to 299.0 mya**
		Devonian	**416.0 to 359.2 mya**
		Silurian	**443.7 to 416.0 mya**
		Ordovician	**488.3 to 443.7 mya**
		Cambrian	**542.0 to 488.3 mya**
Precambrian			

*Adapted from Geologic Time Scale, University of California Museum of Paleontology (http://www.ucmp.berkeley.edu/help/timeform.php)

Table 3.7-2. Description of Soils Within 0.5 Mile of the Kaweah Project Facilities, Organized by Soil Code.

Code (Corresponds to Map 3.7-4)	Association	Soil Description	Slope	Taxonomy	Parent Rock	Erosion K Factor[1]	Vegetation
102	Auberry sandy loam	deep, well drained soils that formed in material weathered from intrusive, acid igneous rocks	15 to 30 percent slope	Fine-loamy, mixed, semiactive, thermic Ultic Haploxeralfs	intrusive acid igneous rocks, principally quartz diorite or grandiorite	0.24	woodland grass, annual grasses and forbes, and brush
103	Auberry sandy loam	deep, well drained soils that formed in material weathered from intrusive, acid igneous rocks	30 to 50 percent slope	Fine-loamy, mixed, semiactive, thermic Ultic Haploxeralfs	intrusive acid igneous rocks, principally quartz diorite or grandiorite	0.24	woodland grass, annual grasses and forbes, and brush
105	Blasingame sandy loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	9 to 15 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
106	Blasingame sandy loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	15 to 30 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
107	Blasingame sandy loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
108	Blasingame rock outcrop complex	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	9 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
116	Cieneba-Rock	very shallow and shallow, somewhat excessively drained soils that formed in material weathered from granitic rock	15 to 75 percent slope	Loamy, mixed, superactive, nonacid, thermic, shallow Typic Xerorthents	granite and other rocks of similar texture and composition	0.24	chaparral and chemise with widely spread foothill pine or oak tree, small area of thin annual grasses and weeds
118	Coarsegold loam	moderately deep, well drained soils that formed from weathered schist	15 to 30 percent slope	Fine-loamy, mixed, superactive, thermic Mollic Haploxeralfs	metasedimentary rocks of mica schist, quartz, gneiss or quartzite	0.28	chaparral composed of chamise, scrub oak, birchleaf mountain mahogany, eastern manzanita, cupleaf ceanothus, and yucca Open Area: ground cover of cheatgrass, wild oats and other annual grasses and weeds
119	Coarsegold loam	moderately deep, well drained soils that formed from weathered schist	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Mollic Haploxeralfs	metasedimentary rocks of mica schist, quartz, gneiss or quartzite	0.28	chaparral composed of chamise, scrub oak, birchleaf mountain mahogany, eastern manzanita, cupleaf ceanothus, and yucca Open Area: ground cover of cheatgrass, wild oats and other annual grasses and weeds
123	Crouch-Rock outcrop complex	deep, well drained soils that formed in material weathered from granitic rock	15 to 50 percent slope	Coarse-loamy, mixed, superactive, mesic Ultic Haploxerolls	igneous (granitic) rocks	-	annual grasses and forbs with open stands of timber at higher elevations
128	Fallbrook sandy loam	deep, well drained soils that formed in material weathered from granitic rocks	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	material weathered from granite and closely related granitic rocks	0.28	annual grasses and forbs with considerable chaparral, chamise, flattop buckwheat and other shrubs
130	Friant-Rock outcrop complex	shallow, well drained soils that formed in material weathered from mica schist, quartz schist and gneiss	15 to 75 percent slope	Loamy, mixed, superactive, thermic Lithic Haploxerolls	residuum weathered from mica schist, quartz schist, and gneiss	0.28	buckwheat, chaparral, and naturalized grasses and forbs
136	Holland loam	very deep, well drained soils that formed in material weathered from granitic rock	15 to 30 percent slope	Fine-loamy, mixed, semiactive, mesic Ultic Haploxeralfs	granitic rocks	0.24	semi-dense stands of ponderosa pine and incense cedar with some white fir, sugar pine, black or canyon live oak with an understory of bear clover and manzanita
137	Holland loam	very deep, well drained soils that formed in material weathered from granitic rock	30 to 50 percent slope	Fine-loamy, mixed, semiactive, mesic Ultic Haploxeralfs	granitic rocks	0.24	semi-dense stands of ponderosa pine and incense cedar with some white fir, sugar pine, black or canyon live oak with an understory of bear clover and manzanita
138	Holland-Rock outcrop complex	very deep, well drained soils that formed in material weathered from granitic rock	15 to 50 percent slope	Fine-loamy, mixed, semiactive, mesic Ultic Haploxeralfs	granitic rocks		semi-dense stands of ponderosa pine and incense cedar with some white fir, sugar pine, black or canyon live oak with an understory of bear clover and manzanita
140	Honcut sandy loam	very deep, well drained soils that formed in moderately coarse textured alluvium from basic igneous and granitic rocks	2 to 5 percent slope	Coarse-loamy, mixed, superactive, nonacid, thermic Typic Xerorthents	alluvium dominantly from basic rocks but are derived from acid igneous rocks in some places	0.2	open parklike areas of annual grasses, herbs and scattered oaks
142	Las Posas loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	15 to 30 percent slope	Fine, smectitic, thermic Typic Rhodoxeralfs	material weathered from basic igneous rocks	0.37	annual grasses, forbs, and broadleaf chaparral
143	Las Posas loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	30 to 50 percent slope	Fine, smectitic, thermic Typic Rhodoxeralfs	material weathered from basic igneous rocks	0.37	annual grasses, forbs, and broadleaf chaparral
151	Riverwash	-	-	-	-	-	-
152	Rock outcrop	-	-	-	-	-	-
160	Sheephead-Rock outcrop complex	shallow, somewhat excessively drained soils that formed in material weathered from mica, schist, gneiss, or granite	15 to 75 percent slope	Loamy, mixed, superactive, mesic, shallow Entic Ultic Haploxerolls	material weathered from granitic rocks	0.17	mainly chaparral but in the lower rainfall area it is scrub oak, pinyon pine, and digger pine

Table 3.7-2. Description of Soils Within 0.5 Mile of the Kaweah Project Facilities, Organized by Soil Code.

Code (Corresponds to Map 3.7-4)	Association	Soil Description	Slope	Taxonomy	Parent Rock	Erosion K Factor[1]	Vegetation
164	Tujunga sand	very deep, somewhat excessively drained soils that formed in alluvium from granitic sources		Mixed, thermic Typic Xeropsamments	alluvium weathered from granitic sources or similar	0.02	Uncultivated areas have a cover of shrubs, annual grasses and forbs. In urban areas ornamentals and turf-grass are common
165	Vista coarse sandy loam	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	9 to 15 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
166	Vista coarse sandy loam	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	15 to 30 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
167	Vista coarse sandy loam	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	30 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
168	Vista-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks, 9 to 15 percent slope	9 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
169	Walong sandy loam	moderately deep, well drained soils that formed in material weathered from granitic rocks	15 to 30 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerolls	material weathered from granite	0.2	annual grasses, blue oaks, and live oaks
171	Walong-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from granitic rocks	15 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerolls	material weathered from granite	0.15	annual grasses, blue oaks, and live oaks
173	Wyman loam	deep, well drained soils that formed in alluvium from andesitic and basaltic rocks	2 to 5 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	alluvium originating from andesitic and basaltic rocks	0.37	annual grasses and herbs with a few scattered oaks
175	Xerofluvents	-	-	-	-	-	-
178	Water	-	-	-	-	-	-

Data Source: USDA NRCS Official Soil Series Descriptions (OSDs) https://soilseries.sc.egov.usda.gov/osdnamequery.asp

[1] The K factor assesses the susceptibility of soil to sheet and rill erosion and is dependent upon the percentages of clay, silt, sand, and organic matter in the soil. In general, soils with low K factors are less susceptible to erosion and soils with high K factors are more susceptible to erosion.

Table 3.7-3. Description of Soils Underlying the Kaweah Project Facilities, Organized by Development.

Project Facility	Code (Corresponds to Map 3.7-4)	Association	Soil Description	Slope	Taxonomy	Parent Rock	Erosion K Factor[1]	Vegetation
Kaweah No. 1 Development								
Kaweah No 1 Diversion Dam Kaweah No. 1 Flowline	128	Fallbrook sandy loam	deep, well drained soils that formed in material weathered from granitic rocks	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	material weathered from granite and closely related granitic rocks	0.28	annual grasses and forbs with considerable chaparral, chamise, flattop buckwheat and other shrubs
Kaweah No. 1 Flowline	152	Rock outcrop	-	-	-	-	-	-
Kaweah No. 1 Flowline Kaweah No. 1 Forebay Tank Kaweah No. 1 Penstock Kaweah No. 1 Powerhouse	171	Walong-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from granitic rocks	15 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerolls	material weathered from granite	0.15	annual grasses, blue oaks, and live oaks
Kaweah No. 2 Development								
Kaweah No. 2 Diversion Dam	107	Blasingame sandy loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
Kaweah No. 2 Powerhouse	108	Blasingame rock outcrop complex	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	9 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
Kaweah No. 2 Flowline	116	Cieneba-Rock	very shallow and shallow, somewhat excessively drained soils that formed in material weathered from granitic rock	15 to 75 percent slope	Loamy, mixed, superactive, nonacid, thermic, shallow Typic Xerorthents	granite and other rocks of similar texture and composition	0.24	chaparral and chemise with widely spread foothill pine or oak tree, small area of thin annual grasses and weeds
Kaweah No. 2 Flowline	166	Vista coarse sandy loam	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	15 to 30 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
Kaweah No. 2 Flowline Kaweah No. 2 Forebay Kaweah No. 2 Powerhouse	168	Vista-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	9 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
Kaweah No. 3 Development								
Kaweah No. 3 Flowline Kaweah No. 3 Forebay	160	Sheephead-Rock outcrop complex	shallow, somewhat excessively drained soils that formed in material weathered from mica, schist, gneiss, or granite	15 to 75 percent slope	Loamy, mixed, superactive, mesic, shallow Entic Ultic Haploxerolls	material weathered from granitic rocks	0.17	mainly chaparral but in the lower rainfall area it is scrub oak, pinyon pine, and digger pine
Kaweah No. 3 Powerhouse	107	Blasingame sandy loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	30 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
Transmission Line								
Transmission Line	108	Blasingame rock outcrop complex	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	9 to 50 percent slope	Fine-loamy, mixed, superactive, thermic Typic Haploxeralfs	gabbrodiorite and other basic igneous rocks	0.24	annual grasses and forbs with some shrubs and blue oak trees
Transmission Line	116	Cieneba-Rock	very shallow and shallow, somewhat excessively drained soils that formed in material weathered from granitic rock	15 to 75 percent slope	Loamy, mixed, superactive, nonacid, thermic, shallow Typic Xerorthents	granite and other rocks of similar texture and composition	0.24	chaparral and chemise with widely spread foothill pine or oak tree, small area of thin annual grasses and weeds
Transmission Line	143	Las Posas loam	moderately deep, well drained soils that formed in material weathered from basic igneous rocks	30 to 50 percent slope	Fine, smectitic, thermic Typic Rhodoxeralfs	material weathered from basic igneous rocks	0.37	annual grasses, forbs, and broadleaf chaparral
Transmission Line	166	Vista coarse sandy loam	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	15 to 30 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
Transmission Line	168	Vista-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from decomposed granitic rocks	9 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerepts	material weathered from decomposed granite and other closely related rocks	0.15	annual grasses and forbs and such shrubs as California sagebrush, scrub oak, lilac, chamise, sumac, and flattop buckwheat
Transmission Line	171	Walong-Rock outcrop complex	moderately deep, well drained soils that formed in material weathered from granitic rock	15 to 50 percent slope	Coarse-loamy, mixed, superactive, thermic Typic Haploxerolls	material weathered from granite	0.2	annual grasses, blue oaks, and live oaks

Data Source: USDA NRCS Official Soil Series Descriptions (OSDs) https://soilseries.sc.egov.usda.gov/osdnamequery.asp

[1]The K factor assesses the susceptibility of soil to sheet and rill erosion and is dependent upon the percentages of clay, silt, sand, and organic matter in the soil. In general, soils with low K factors are less susceptible to erosion and soils with high K factors are more susceptible to erosion.

FIGURES

Figure 3.7-1a-d. Representative Photographs of the Spill Drainages Associated with the Kaweah No. 2 Forebay.

a. View of Kaweah No. 2 main spill drainage on July 1, 2015. Flow is approximately 10 cfs.

b. Representative photograph of a down cut section in the Kaweah No. 2 main spill drainage.

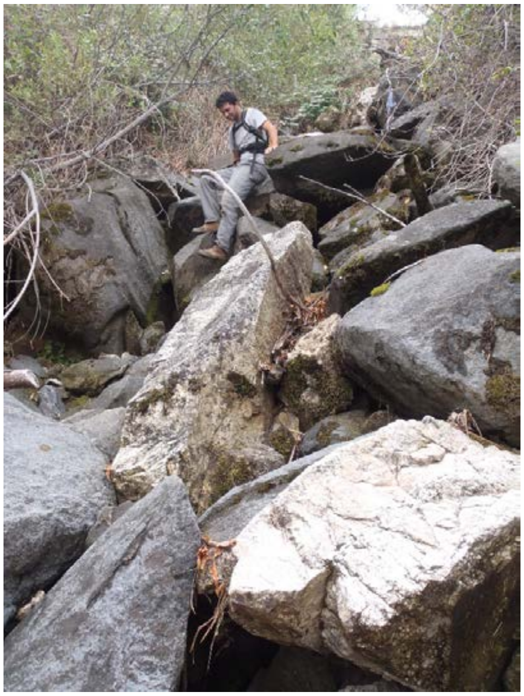
Figure 3.7-1a-d. Representative Photographs of the Spill Drainages Associated with the Kaweah No. 2 Forebay (continued).

c. Recent erosion on the side slope of the Kaweah No. 2 main spill drainage, near the top of the drainage.

d. Representative photograph of a stable section of the Kaweah No. 2 drainage #2.

Figure 3.7-2a-e. Representative Photographs of the Spill Drainage Associated with the Kaweah No. 3 Forebay.

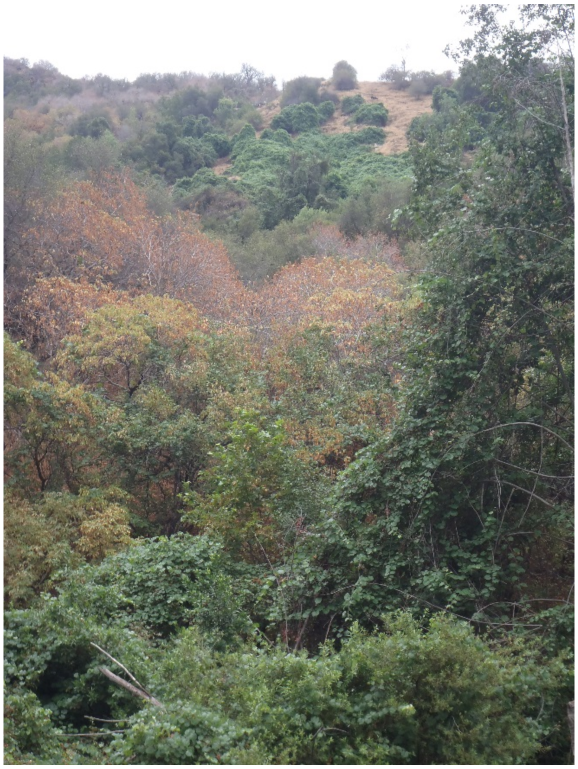
a. Representative photograph of the upper portion of the Kaweah No. 3 spill drainage, showing the end of the spill chute.



b. Representative section Kaweah No. 3 spill drainage, illustrating the steep, bedrock/boulder nature of this drainage.

Figure 3.7-2a-e. Representative Photographs of the Spill Drainage Associated with the Kaweah No. 3 Forebay (continued).

c. Representative section of the Kaweah No. 3 spill drainage showing boulders along the side slopes of the drainage.

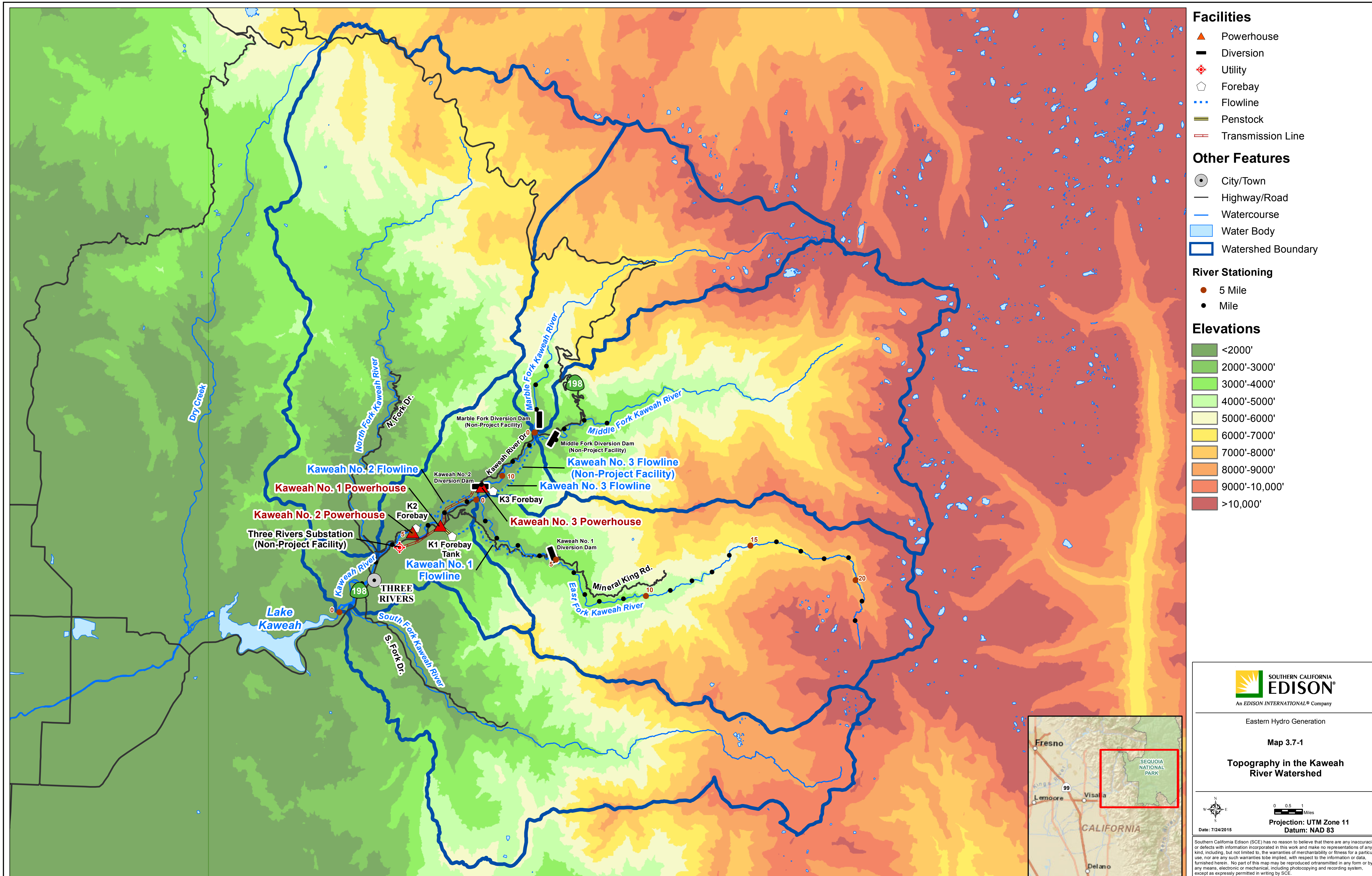


d. View of the Kaweah No. 3 spill drainage from the bottom.

Figure 3.7-2a-e. Representative Photographs of the Spill Drainage Associated with the Kaweah No. 3 Forebay (continued).

e. Outlet of the Kaweah No. 3 spill drainage at the Kaweah River

MAPS



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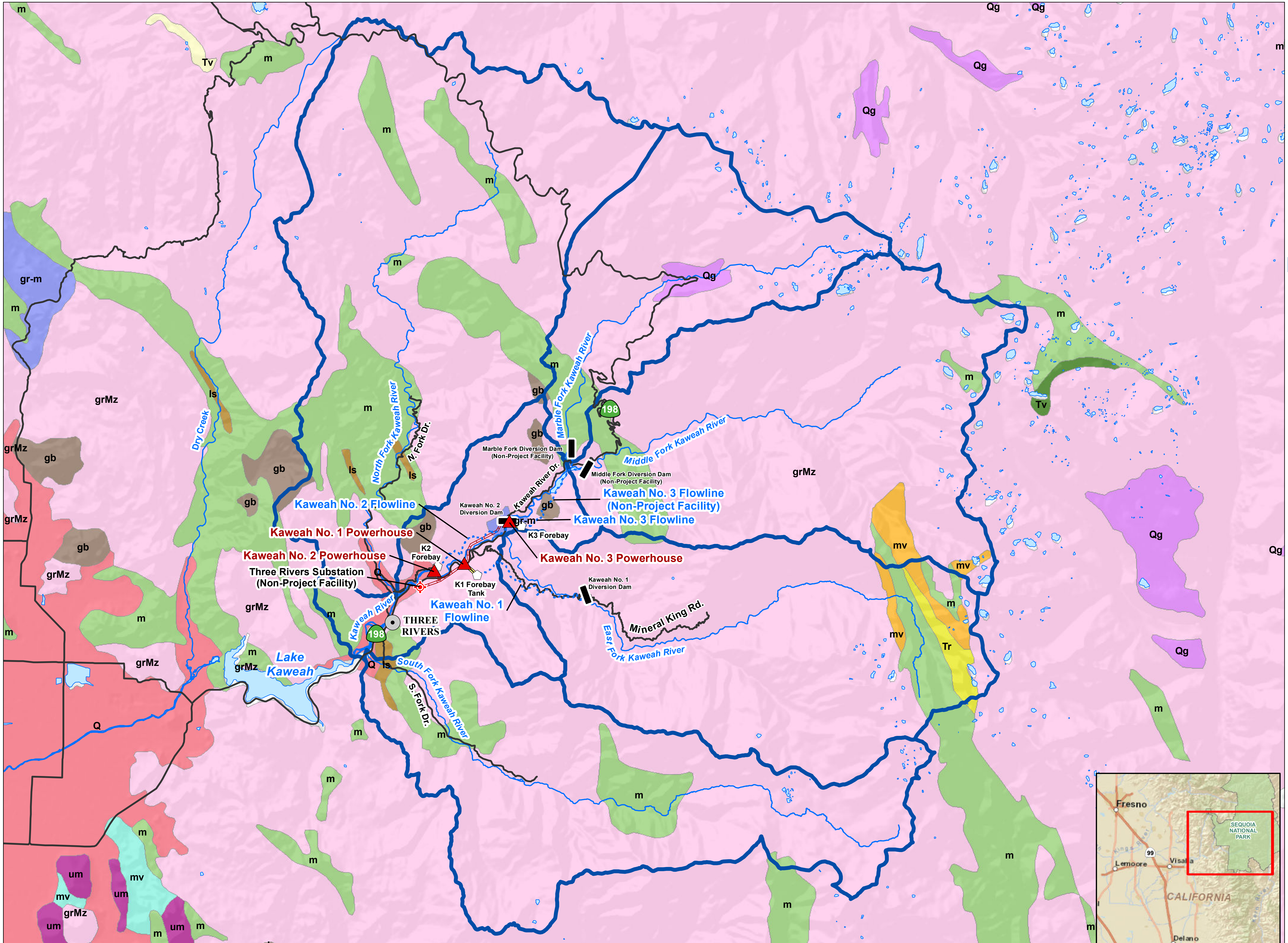

Facilities

- Powerhouse
- Diversion
- Utility
- Forebay
- Flowline
- Penstock
- Transmission Line

Other Features

- City/Town
- Highway/Road
- Watercourse
- Water Body
- Watershed Boundary

Geologic Rock Types

Cenozoic

- Q alluvium
- Qg glacial drift
- Tr sandstone
- Tv rhyolite
- Tv tephrite (basanite)

Mesozoic

- grMz granodiorite
- gb gabbro
- gr-m plutonic rock (phaneritic)
- ls limestone
- m peridotite

Paleozoic

- mv schist
- mv basalt
- um intermediate volcanic rock

Source: California Geologic Survey Data, 2005

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Map 3.7-2

Geologic Formations in the Kaweah River Watershed

0 0.5 1 Miles

Projection: UTM Zone 11
Datum: NAD 83

Date: 7/24/2015

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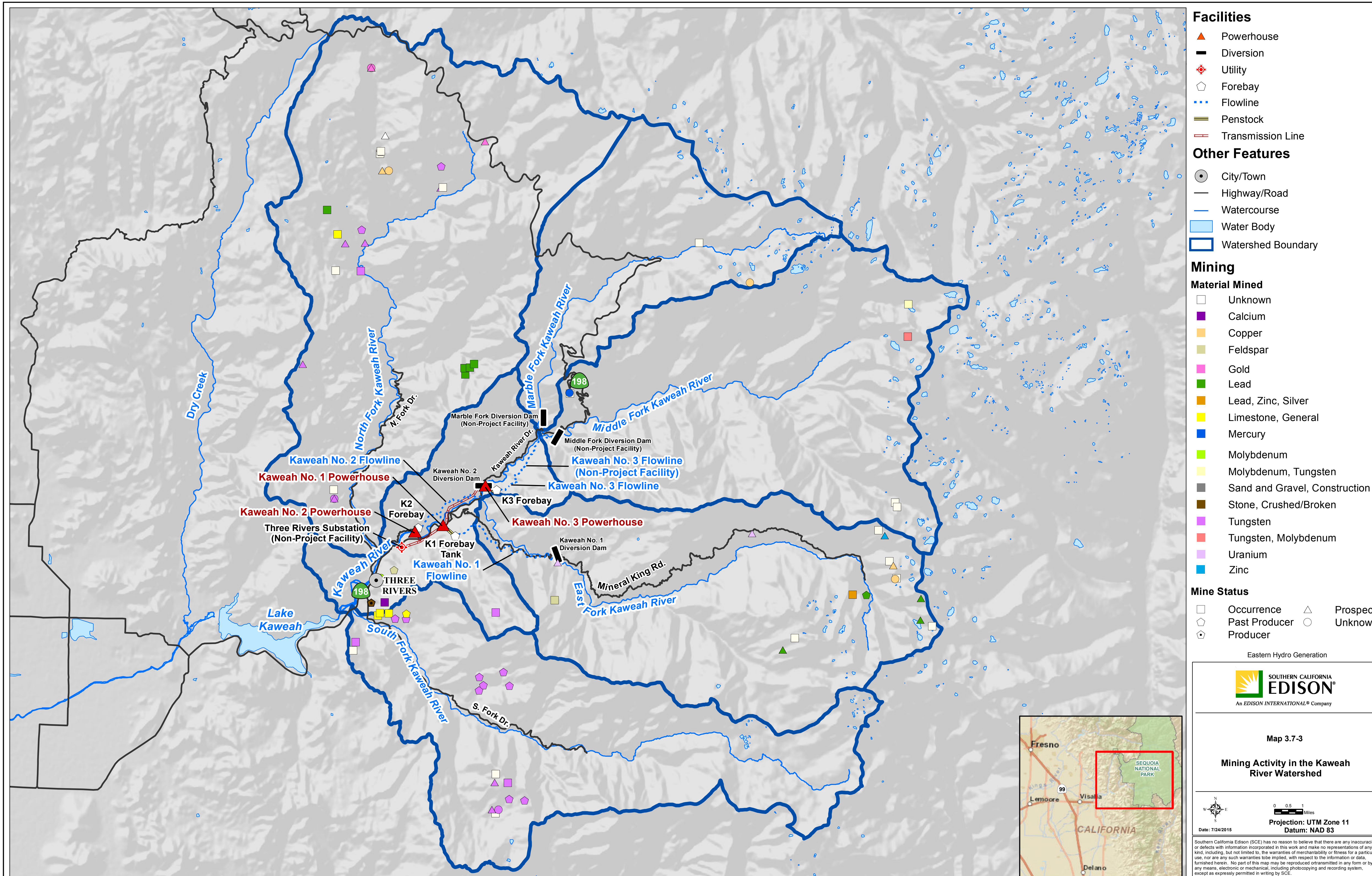

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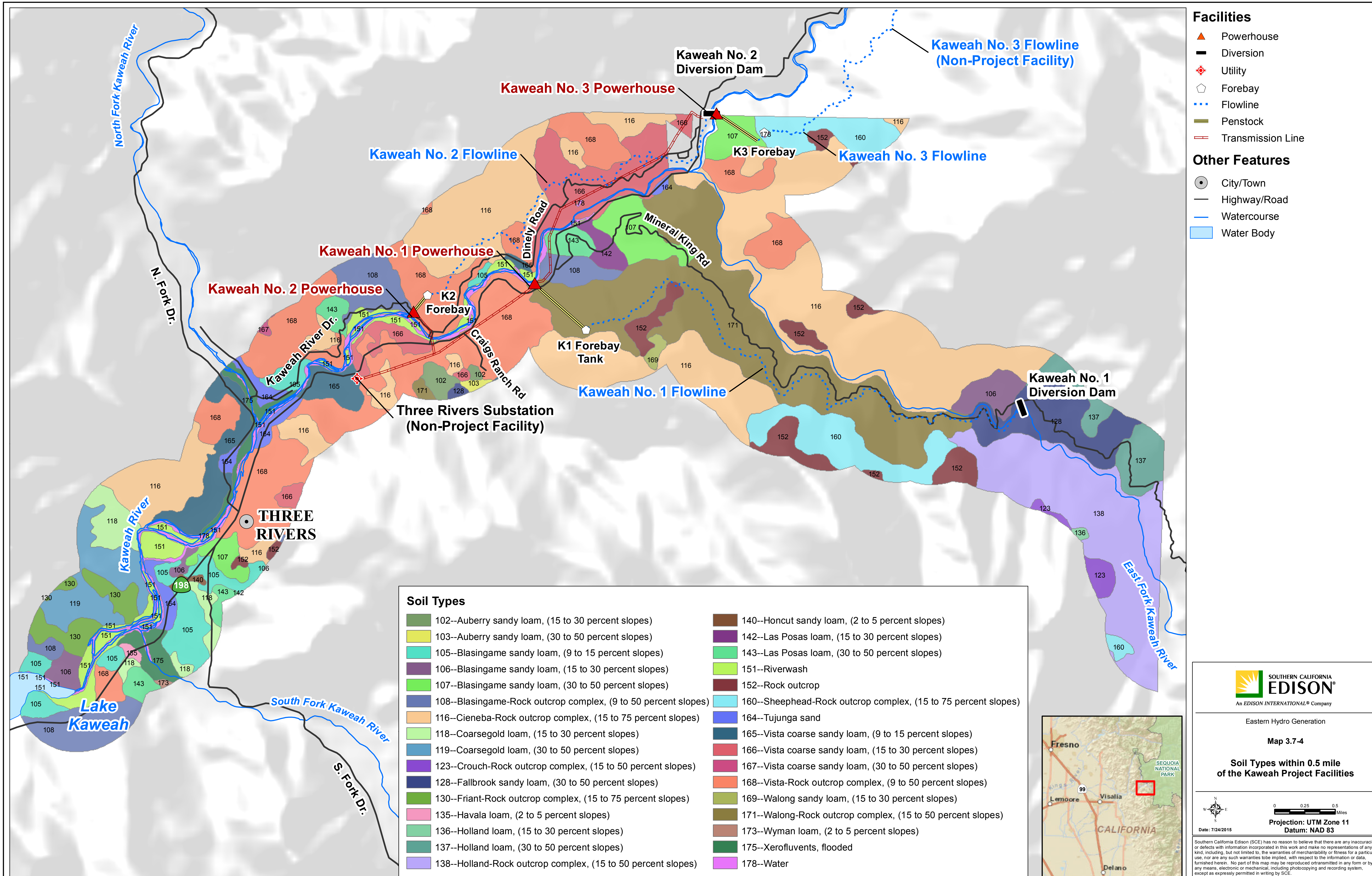

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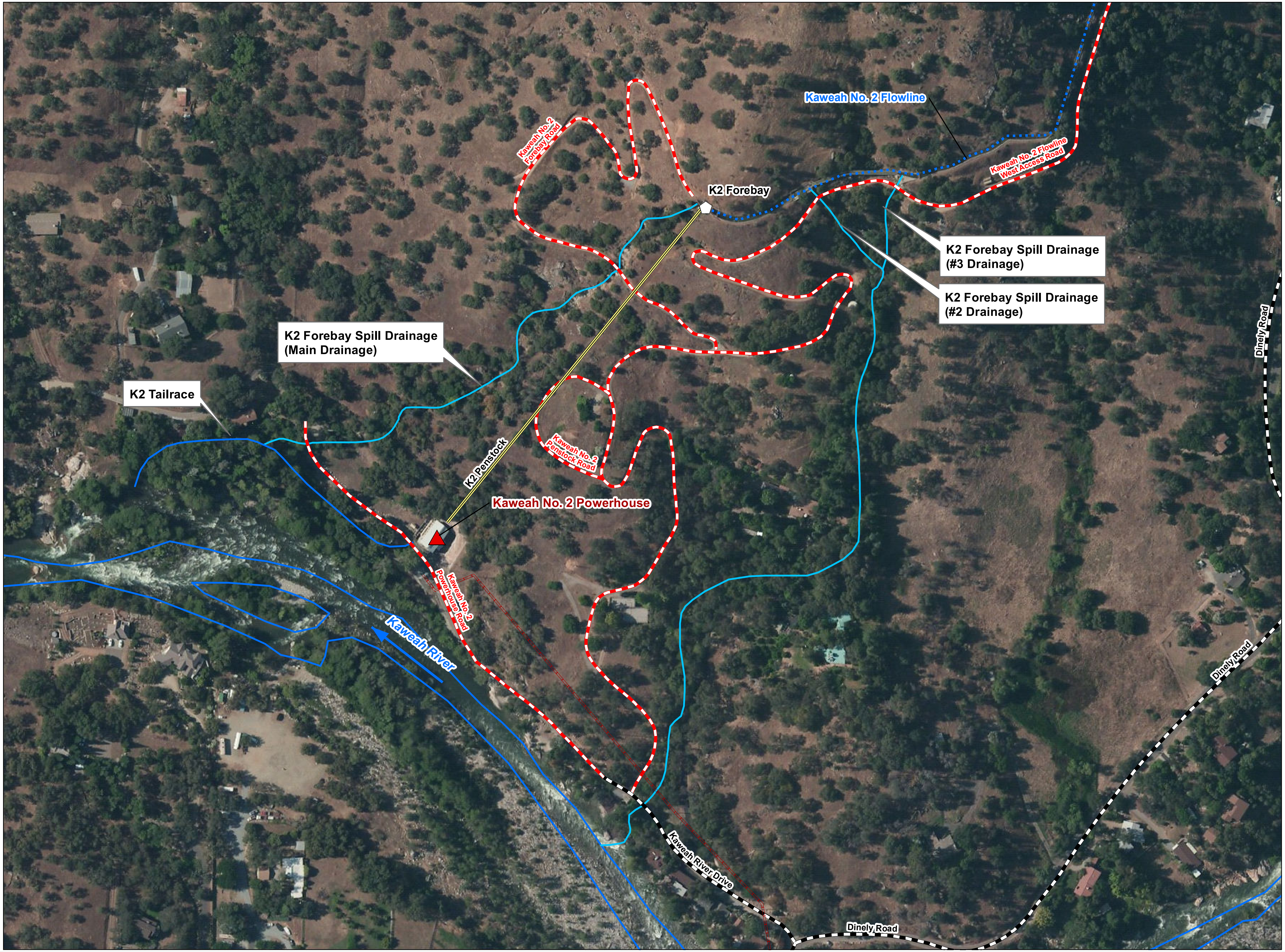

Facilities

- Powerhouse
- Diversion
- Dam
- Utility
- Forebay
- Flowline
- Penstock
- Transmission Line

Other Features

- City/Town
- Project Road
- Non-Project Road
- Watercourse
- Water Body

Survey Features

- K2 Forebay Spill Drainage

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Map 3.7-5

Kaweah No. 2 Forebay Spill Drainages

0 50 100 200 Feet

Date: 7/28/2015

Projection: UTM Zone 11
Datum: NAD 83

Facilities

- Powerhouse
- Diversion
- Dam
- Utility
- Forebay
- Flowline
- Penstock
- Transmission Line

Other Features

- City/Town
- Project Road
- River/Stream
- Water Body

Survey Features

- K3 Forebay Spill Drainage

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Map 3.7-6

Kaweah No. 3 Forebay Spill Drainage

N W E S

0 50 100 200 Feet

Projection: UTM Zone 11
Datum: NAD 83

Date: 7/23/2015