3.13 Paleontologic Resources

This section of the EIR analyzes the potential impacts of the Proposed Project on paleontologic resources.

3.13.1 Area of Analysis

The Area of Analysis for paleontologic resources includes the region within and adjacent to the Klamath River 100-year floodplain, in Siskiyou, Humboldt, and Del Norte counties, from the Oregon-California state line to the Klamath River's mouth near Requa, CA (Figure 3.13-1).

The Area of Analysis is defined to be within 1,000 feet of the FEMA Flood Zones A and AE. For areas of the Klamath River that do not have FEMA Flood Zone designation, the Area of Analysis is defined to within 3,000 feet of the National Hydrography Dataset Klamath River centerline. For the area upstream of Iron Gate Dam, the Area of Analysis is defined to be within a five-mile buffer of the National Hydrography Dataset Klamath River centerline.

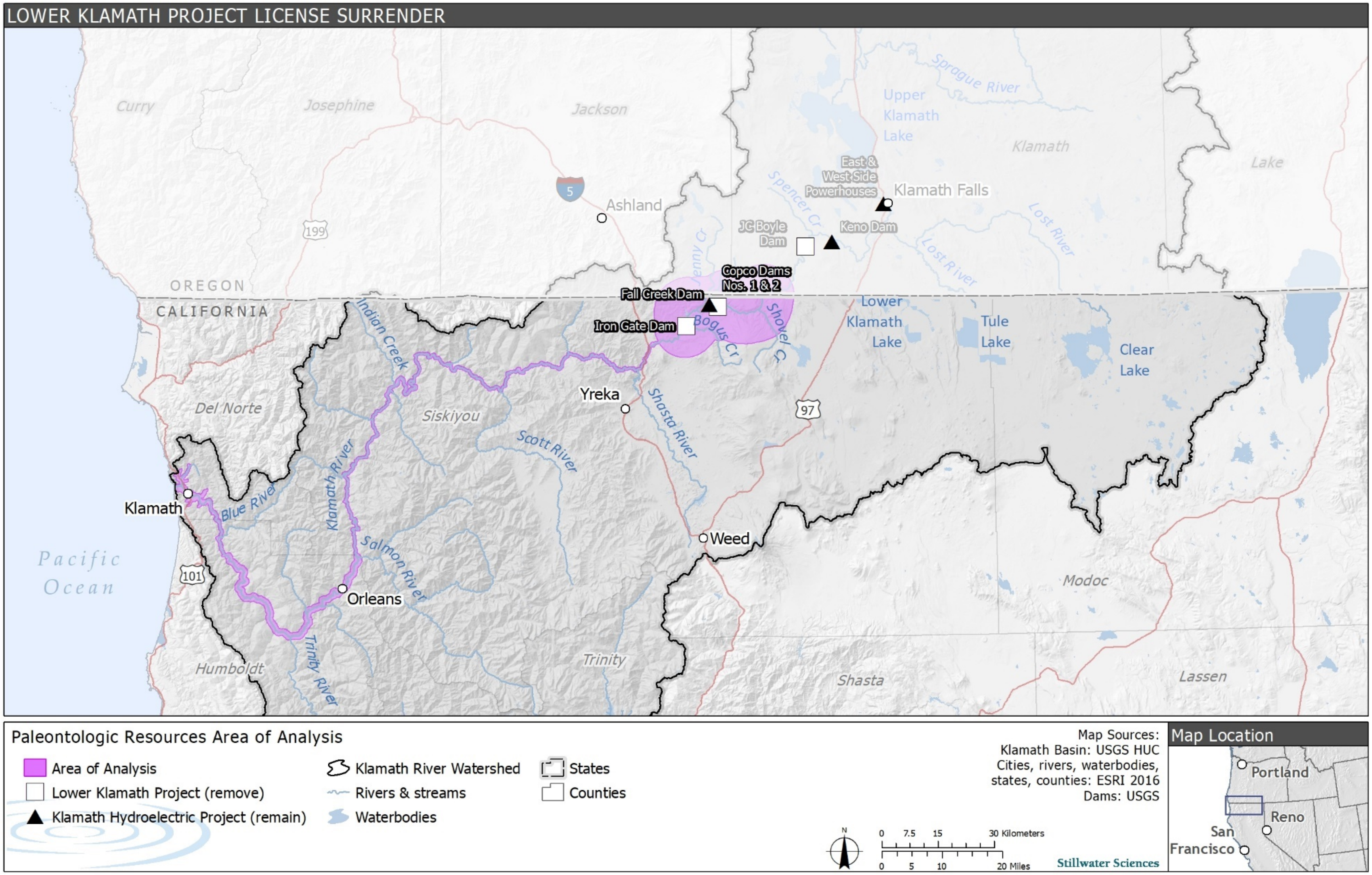

Figure 3.13-1. Area of Analysis for Paleontologic Resources.

3.13.2 Environmental Setting

The Klamath River passes through four main regional rock types that dominate the geology and which span the Mesozoic and Cenozoic eras. The four main rock types include metamorphic, igneous (volcanic), fluvial sedimentary, and marine sedimentary (Figure 3.11-2). Metamorphic rocks are rocks that have changed into different rock types due to changes in temperature and pressure. Sometimes rocks that have fossils in them become sufficiently metamorphosed that the fossils no longer exist. Igneous volcanic rocks are rocks that are formed as a process related to volcanic eruptions, so generally these types of rocks do not contain fossils. Though, sometimes volcanic deposits can entomb organisms during deposition, thus preserving these organisms which can later turn into fossils. Fluvial sedimentary rocks are rocks formed from river sediments. Marine sedimentary rocks are rocks formed from sediments in the ocean.

While the majority of bedrock deposits within the Area of Analysis for paleontologic resources are not fossil-bearing units, exceptions include an unnamed diatomite deposit along the shores of Copco No. 1 Reservoir and the Hornbrook Formation (USGS 1983, Elliot 1971). Additional details about the regional geologic framework are presented in Section 3.11.2.1 *Regional Geology*.

3.13.2.1 Bedrock Geology

The eastern portion of the Klamath Basin (the Cascade Range Geomorphic Province, approximately east of U.S. Interstate 5; Figure 3.11-1) is underlain by Tertiary and Quaternary volcanic rocks (Wagner and Saucedo 1987). These rocks generally do not contain fossils. To the west, in the Klamath Mountains and Coast Ranges Geomorphic Provinces, the Klamath Basin is underlain by Paleozoic and Mesozoic metasedimentary (metamorphic) and igneous rocks (Wagner and Saucedo 1987, Irwin 1994, Delattre and Rosinski 2012, Ernst 2015). The igneous rocks lack fossils and the metasedimentary rocks have been deformed sufficiently to destroy fossils; accordingly, no fossils have been documented in these rocks. There are also mapped Quaternary fluvial[159] deposits, discontinuously, along the entire Klamath River (Hotz 1967, 1977; Wagner and Saucedo 1987; Delattre and Rosinski 2012), as well as diatomite deposits along the banks of Copco No. 1 Reservoir (USGS 1983). While these fluvial deposits may contain fossils, no fossils have been documented to exist in the Area of Analysis for paleontologic resources.

The Late Cretaceous Hornbrook Formation (Hornbrook Formation) is mapped at the boundary between the Cascade Range and Klamath Mountains geomorphic provinces, 2 of California’s 11 geomorphic provinces (Peck et al. 1956, Elliot 1971, Nilsen et al. 1983, Nilsen 1984, Sliter et al. 1984, Nilsen 1993, Irwin 1994, Nilsen 1994, Elliot 2007, Surpless 2015). The Cascade Range Geomorphic Province is the region from northern California into southwestern Canada where topographic forms are dominated by the volcanism associated with the Cascades volcanoes. The Klamath Mountains Geomorphic Province is a region in northwestern California and southwestern Oregon where the landforms and topography are controlled by uplifted ancient subduction zone and igneous (plutonic) rocks. Plutonic rocks are igneous rocks that formed beneath the surface of the Earth. Hornbrook Formation rocks are composed of marine and non-

[159] Quaternary refers to the Quaternary Period, a time range between 2.56 million years ago and extends to today. Fluvial refers to sediments deposited as a result of processes associated with rivers.

marine sedimentary rocks formed between 100 and 66 million years ago, but possibly as early as 113 million years ago (Surpless 2015). Nilsen et al. (1983), along with previous mappers, documented that many of the subunits within the Hornbrook Formation have fossils including mollusks, ammonites, foraminifers, plant fossils, and paleosols.

3.13.2.2 Paleontologic Resources

Two mapped geologic units that contain paleontologic resources are present within the Area of Analysis: (1) the unnamed diatomite deposit at Copco No. 1 Reservoir; and (2) the Hornbrook Formation. The diatomite deposit is determined to be of Low Paleontologic Potential because these fossil diatoms (algae): 1) do not occur in association with significant vertebrate fossils; 2) are not rare; and 3) it is not thought that the distribution of fossils and fossil species has a significant spatial variation. The fossils in the Hornbrook Formation are documented to include megafossils (e.g., Gastropoda) and microfossils (e.g., Foraminifera), but it is not known if the fossil abundance varies spatially within this geologic unit.

The Klamath River cuts across the Hornbrook Formation in the region of Hornbrook, California, along approximately three river miles (Figure 3.13-2). The different sub-units within the Hornbrook Formation are listed relative to Geologic Symbol (symbology on the map), Unit Description (rock type), and Fossil Description (absence/presence; fossil types) in Table 3.13-1. All Hornbrook Formation units are within the Area of Analysis for paleontologic resources, but some of these mapped units are separated from the active channel by Quaternary Alluvium. Many of the fossil sampling locations are along Blue Gulch and Klamathon Road, south of Hornbrook, California (Nilsen 1993). Fossil biostratigraphy[160] was used to provide age control for the stratigraphic correlation of geologic units in the region of Hornbrook, California, along with geologic units elsewhere in northern California (Sliter et al. 1984). Type sections (unique and identifiable sedimentary stratigraphic sections) for each sub-unit in the Hornbrook Formation are located outside of the Area of Analysis (Nilsen 1993).

[160] Fossil biostratigraphy is the ability to date the age of rock formations based on the presence of fossils.

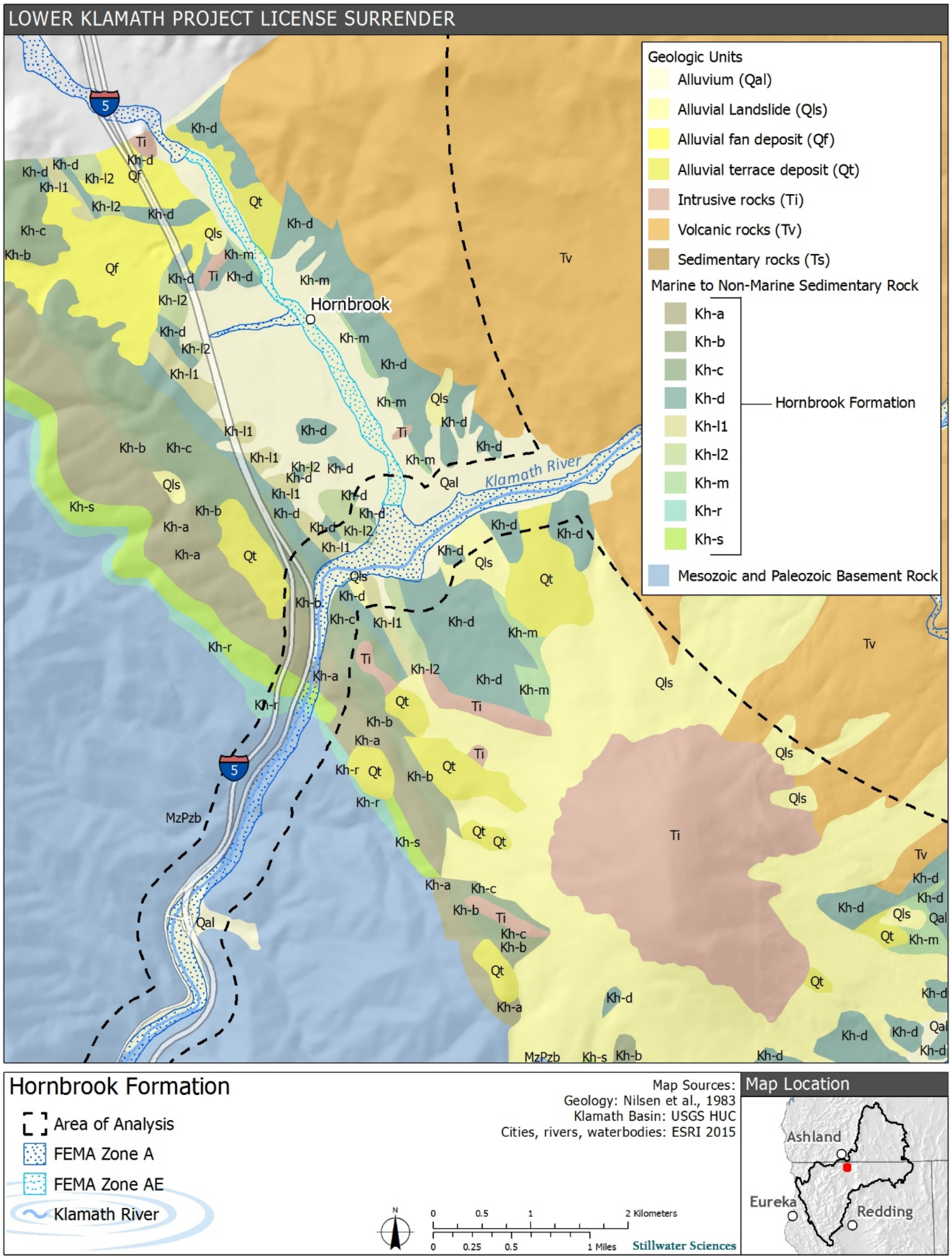

Figure 3.13-2. Late Cretaceous Hornbrook Formation mapped along the Klamath River (Nilsen et al. 1983). Hornbrook Formation unit descriptions are presented in Table 3.13-1.

The Hornbrook Formation is exposed in road cuts along Klamathon Road and the Old Hornbrook Highway in the region of Hornbrook, California. These outcrops include subunits IKh-d, Kh-l1, and Kh-l2.

Table 3.13-1. Hornbrook Formation Geologic Unit and Fossil Descriptions.

Geologic Symbol	Unit Description	Fossil Description
Kh-a	Marine Sandstone with local conglomerate; hummocky cross strata in upper part	Molluscan fossils
Kh-b	Marine siltstone with some mudstone and very fine-grained sandstone; local coal beds	Molluscan fossils
Kh-c	Marine sandstone and conglomerate with thin interbeds of shale	Unfossiliferous
Kh-d	Marine shale, mudstone, and thin-bedded, fine-grained sandstone	Ammonites and foraminifers
Kh-l1	Very fine- to fine-grained lens of hummocky cross stratified marine sandstone; lower unit	Molluscan fossils
Kh-l2	Very fine- to fine-grained lens of hummocky cross stratified marine sandstone; upper unit	Molluscan fossils
Kh-m	Thick bed of marine turbidite sandstone	—
Kh-r	Nonmarine conglomerate, sandstone, pebbly mudstone, and siltstone; locally a basal breccia	Plant fossils, paleosols
Kh-s	Marine conglomeratic sandstone characterized by large-scale trough cross strata	Molluscan fossils

3.13.3 Significance Criteria

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

- Result in the destruction of any High Potential Paleontologic Resources, as defined in Table 3.13-2 and discussed further below.
- Result in substantial adverse effects on any High Potential Paleontologic Resources, as defined further below.

In general, destruction of High Potential Paleontologic Resources includes the physical demolition, relocation, or alteration of the paleontologic resource that would alter or remove the factors that are the basis for determining the significance of the paleontologic resource. These factors include taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data uniquely related to the paleontologic resource. See definitions for, and an explanation of, these terms below.

In general, a substantial adverse effect on High Potential Paleontologic Resources is defined as a loss of fossils or their surrounding material contributing to the potential loss of taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic information. An explanation of each of these types of paleontologic information and the definition of substantial adverse effect specific to that type of information is provided below. While the below definitions are provided for examples of fossils from organisms' bodies, they also apply to trace fossils (fossils of a burrow, boring, feces, footprint, track, or some other physical evidence of life preserved in the rock record), as well as the material surrounding fossils and trace fossils.

- Taxonomic information includes the hierarchical classification of biological organisms (e.g., genus, species). A substantial adverse effect on taxonomic information would occur if rocks with fossils or their surrounding material that included significant taxonomic information were destroyed, such as fossils that had body parts with geometry that helped identify those species in a specific taxonomic way.
- Phylogenetic information describes how an extant species (one that no longer exists) may relate to other species in an evolutionary way (i.e., the "family tree" of the different species). A substantial adverse effect on phylogenetic information would occur if rocks with fossils or their surrounding material that included significant phylogenetic information were destroyed, such as fossils that have physical features that tie that species to other species in the "family tree" with the physical development of that species' physical form.
- Paleoecologic information inferred from the fossil related to the climate at time of deposition A substantial adverse effect on paleoecologic information would occur if rocks with fossils or their surrounding material that included significant paleoecologic information were destroyed, such as pollen, isotope, or other information that can be used as a proxy for the prehistoric climate.
- Taphonomic information describes how the organism(s) had been modified prior to fossilization (e.g., the erosion or modification of the shapes or forms of the pre-fossilized materials as they were transported in a landslide, tsunami, river flow or some other process). A substantial adverse effect on taphonomic information would occur if rocks with fossils or their surrounding material that included significant taphonomic information were destroyed, such as a fossil that had been modified by some physical process prior to fossilization, especially if that process is linked to some physical behavior of the organism or some physical process related to where the organism existed.
- Biochronologic information describes where fossils fit into the geologic time scale. A substantial adverse effect on biochronologic information would occur if rocks with fossils or their surrounding material that included significant biochronologic information were destroyed, such as if there is some chronologic information that linked the species with rocks of a particular age or age range.
- Stratigraphic information describes the layering of geologic materials with time, including information about superposition[161]). A substantial adverse impact on stratigraphic information would occur if rocks with fossils or their surrounding material that included significant stratigraphic information were destroyed, such as information about overlying or underlying geologic, biologic, or chemical data or trends in data.

[161] Superposition refers to a sedimentary deposit that is on top of another sedimentary deposit, the deposit on top is "superposed" over the lower sedimentary deposit. The superposed deposit is therefore younger than the underlying deposit.

3.13.4 Impacts Analysis Approach

Paleontologic resources are defined as any fossilized remains, traces, or imprints of organisms, preserved in or on the Earth's crust, that are of paleontologic interest and that provide information about the history of life on Earth. The Society of Vertebrate Paleontology published the "Standard Guidelines for the Assessment and Mitigation of Adverse Impacts to Nonrenewable Paleontological Resources" and this guide, updated in 2010, was developed to help evaluate the potential of destroying paleontologic resources during construction projects. These guidelines include an: "(a) assessment of the potential for land to contain significant paleontologic resources which could be directly or indirectly impacted, damaged, or destroyed by proposed development and (b) formulation and implementation of measures to mitigate these adverse impacts, including permanent preservation of the site and/or permanent preservation of salvaged fossils along with all contextual data in established institutions" (SVP 2010). These guidelines provide criteria for designating the potential paleontologic sensitivity of a site, along with the corresponding recommended mitigation measures required for high, moderate, or low potential for containing significant paleontologic resources (Table 3.13-2, SVP 2010).

Paleontologic potential consists of both: (a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and (b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units that contain potentially datable organic remains older than late Holocene, including deposits associated with animal nests or middens, and rock units that may contain new vertebrate deposits, traces, or trackways are also classified as having high potential.

Significant nonrenewable paleontologic resources are fossils and fossiliferous deposits (rocks with fossils or fossil traces) here defined as consisting of identifiable vertebrate fossils, large or small, uncommon invertebrate, plant, and trace fossils, and other data that provide taphonomic, taxonomic, phylogenetic, paleoecologic, stratigraphic, and/or biochronologic information. Paleontologic resources are considered to be older than recorded human history and/or older than middle Holocene (i.e., older than about 5,000 radiocarbon years), as outlined in the Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources (SVP 2010). In other words, significant nonrenewable paleontologic resources include vertebrate fossils and their taphonomic and environmental indicators, along with invertebrate or botanical fossils in association with a vertebrate assemblage, or plant or invertebrate fossils that are defined as significant by a qualified vertebrate paleontologist[162]. In addition, if invertebrate, plant, or trace fossils are known to have an association with a significant vertebrate fossil

[162] Based on the SVP (2010), a qualified vertebrate paleontologist is a practicing scientist who is recognized in the paleontological community as a professional and can demonstrate familiarity and proficiency with paleontology in a stratigraphic context. A paleontological Principal Investigator shall have the equivalent of the following qualifications: (1) a graduate degree in paleontology or geology, and/or a publication record in peer reviewed journals; and demonstrated competence in field techniques, preparation, identification, curation, and reporting in the state or geologic province in which the project occurs. An advanced degree is less important than demonstrated competence and regional experience; (2) at least two full years professional experience as assistant to a Project Paleontologist with administration and project management experience; supported by a list of projects and referral contacts;(3) proficiency in recognizing fossils in the field and determining their significance; (4) expertise in local geology, stratigraphy, and biostratigraphy; and (5) experience collecting vertebrate fossils in the field.

and those invertebrate, plant, or trace fossils are present in a given rock, then there are potentially more of the significant fossil found in those rocks.

Of the various ways that nonrenewable paleontologic resources could be harmed, which includes excavation using heavy equipment, the fossil bearing geologic units in the Area of Analysis are exposed in regions that have exposure to river flows and could be harmed by erosion and undercutting. It is possible that river flows would be sufficiently large to erode the fossil bearing bedrock, undercutting this bedrock, leading to slope failure. If this were to happen, nonrenewable paleontologic resources could be harmed by the destruction of these outcrops through erosion and slope failure (landslides). Because the Hornbrook Formation is classified with a Low Paleontologic Potential, it was not evaluate further.

Table 3.13-2. Paleontologic Potential (SVP 2010).

Paleontologic Potential	Definition
High	Rock units from which vertebrate or significant invertebrate, plant, or trace fossils have been recovered are considered to have a high potential for containing additional significant paleontologic resources. Rocks units classified as having high potential for producing paleontologic resources include, but are not limited to, sedimentary formations and some volcaniclastic formations (e.g., ashes or tephras), and some low-grade metamorphic rocks which contain significant paleontologic resources anywhere within their geographical extent, and sedimentary rock units temporally or lithologically suitable for the preservation of fossils (e.g., middle Holocene and older, fine-grained fluvial sandstones, argillaceous and carbonate-rich paleosols, cross-bedded point bar sandstones, fine-grained marine sandstones, etc.). Paleontologic potential consists of both (a) the potential for yielding abundant or significant vertebrate fossils or for yielding a few significant fossils, large or small, vertebrate, invertebrate, plant, or trace fossils and (b) the importance of recovered evidence for new and significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. Rock units which contain potentially datable organic remains older than late Holocene, including deposits associated with animal nests or middens, and rock units which may contain new vertebrate deposits, traces, or trackways are also classified as having high potential.
Undetermined	Rock units for which little information is available concerning their paleontologic content, geologic age, and depositional environment are considered to have undetermined potential. Further study is necessary to determine if these rock units have high or low potential to contain significant paleontologic resources. A field survey by a qualified professional paleontologist (see “definitions” section in this document) to specifically determine the paleontologic resource potential of these rock units is required before a paleontologic resource impact mitigation program can be developed. In cases where no subsurface data are available, paleontologic potential can sometimes be determined by strategically located excavations into subsurface stratigraphy.
Low	Reports in the paleontologic literature or field surveys by a qualified professional paleontologist may allow determination that some rock units have low potential for yielding significant fossils. Such rock units will be poorly represented by fossil specimens in institutional collections, or based on general scientific consensus only preserve fossils in rare circumstances and the presence of fossils is the exception not the rule, e.g., basalt flows or recent colluvium. Rock units with low potential typically will not require impact mitigation measures to protect fossils.
No	Some rock units have no potential to contain significant paleontologic resources, for instance high-grade metamorphic rocks (such as gneisses and schists) and plutonic igneous rocks (such as granites and diorites). Rock units with no potential require no protection nor impact mitigation measures relative to paleontologic resources.

The Paleontologic Potential was determined for each geologic unit within the paleontologic resources Area of Analysis using existing geologic and paleontologic peer review literature and data from the USGS, University of California Museum of Paleontology database (UCMP 2017), and geologic and paleontologic professional societies. Relevant geologic maps (Nilsen et al. 1983, Wagner and Saucedo 1987) were georeferenced and digitized, and a reconnaissance field survey was conducted on August 22, 2017 to evaluate the likelihood that mapped geologic units are exposed or otherwise could be impacted by the Proposed Project.

The following sources were assessed to determine the scope of existing local policies relevant to the Proposed Project:

- Siskiyou County General Plan (Siskiyou County 1980):
  - Land Use Policy 41.12 (Siskiyou County 1997)
  - The Conservation Element (Siskiyou County 1973), Archaeology, Objective F

The aforementioned policy (and objective) are stated in generalized terms, consistent with their overall intent to protect paleontologic resources. By focusing on the potential for impacts to paleontologic resources within the paleontologic resources Area of Analysis, consideration of the more general local policy listed above is inherently addressed by the specific, individual analyses presented in Section 3.13.5 *[Paleontologic Resources] Potential Impacts and Mitigation*.

3.13.5 Potential Impacts and Mitigation

Potential Impact 3.13-1 The Proposed Project could result in substantial adverse effects on, or destruction of, High Potential Paleontologic Resources through exposure or slope failure.

An on-site evaluation was conducted August 22, 2017, to evaluate the potential for exposure of paleontologic resources in the Area of Analysis. In the region of Hornbrook, CA, the Hornbrook Formation is exposed in road cuts along Klamathon Road and the Old Hornbrook Highway, in the form of partially lithified and fully lithified rock[163]. Based on observations of the Klamath River cutbank from the Old Hornbrook Highway and along Klamathon Road, the Hornbrook Formation bedrock is not presently exposed along the north bank of the Klamath River in this region. The banks of the river in this area are well vegetated and, downstream of the end of the Old Hornbrook Highway, they are armored by materials that form the road base for U.S. Interstate 5.

Under the Proposed Project, there are two scenarios that could result in erosion of the Hornbrook Formation along the Klamath River, which could impact paleontologic resources contained within the river banks. First, if as a result of dam removal, the river were to downcut (incise) upstream of the contact between the Mesozoic to Paleozoic bedrock and the Hornbrook Formation, this could lead to undercutting of the northern bank of the Klamath River and an over-steepened cutbank, possibly leading to erosion and slope failure within the Hornbrook Formation. Second, if as a result of dam removal, the Klamath River were to migrate laterally northwards on the outer bend of the river just south of Hornbrook (the same region discussed in the first scenario), the lateral migration could also possibly result in erosion and slope failure of the Hornbrook

[163] Lithified means the material has transformed from sediment to sedimentary rock.

Formation. However, the base level (e.g., the lowest level to that erosion can happen due to running water) of the river in the region of Hornbrook is controlled downstream by Mesozoic to Paleozoic basement rock and this base level control pre-dated the installation of any dams, including the Lower Klamath Project, on the Klamath River.

The evaluation of river flow rates, and the potential for bank erosion during drawdown downstream of the Lower Klamath Project dams, is documented in the geology (Potential Impact 3.11-6) and flood hydrology sections (Section 3.6.5 *[Flood Hydrology] Potential Impacts and Mitigation*). The KBRA expired on December 31, 2015 due to a lack of Congressional authorization, and the 2016 Amended KHSA, under which dam removal is currently proposed, does not involve a connected action. Consequently, this CEQA analysis considers the potential effects of dam removal using Klamath River flows as defined by the NMFS and USFWS 2013 Joint Biological Opinion (2013 BiOp) (NMFS and USFWS 2013a), which is currently the standard to which the USBR Klamath Irrigation Project operates. The 2013 BiOp operations requirements and court-ordered flushing flows would determine how instream flows through the Lower Klamath Project and releases from Iron Gate Dam are managed (NMFS and USFWS 2013, U.S. District Court 2017c). A summary of the hydrology information used in this EIR is provided in Section 3.1.6 *Summary of Available Hydrology Information for the Proposed Project* and potential impacts of reservoir drawdown on flood hydrology is addressed in Section 3.6.5 *[Flood Hydrology] Potential Impacts and Mitigation*. The proposed drawdown rates for each of the four dams are similar in magnitude to historical flow rates and discharge statistics for these reservoirs. Flow rates downstream of the dams are not anticipated to exceed substantially median historical rates. In other words, discharges during drawdown would be similar to, or less than, the seasonal 10-year flood rates of discharge.

Based on the analysis of Potential Impact 3.11-6, there could be bank erosion and slope failures in the lower river, but the magnitude of this bank erosion will not be substantial given that the flow rates will be similar or lower than flow rates during the operation of the Lower Klamath Project dams. Thus, there is a low likelihood that changes to river discharge under the Proposed Project would lead to downcutting or erosion of the Hornbrook Formation to a greater degree than existed prior to the construction of facilities associated with the creation of the Lower Klamath Project.

The different sub-units of the Hornbrook Formation are mapped in continuous to discontinuous regions surrounding and beyond the Area of Analysis for paleontologic resources. The fossils mapped by previous researchers were found in regions within and outside the Area of Analysis (Peck et al. 1956, Nilsen et al. 1983, Sliter et al. 1984), but fossils used at type sections[164] to correlate geologic units in the Hornbrook Formation are mapped outside of the Area of Analysis. The fossils contained within the Hornbrook Formation are not vertebrates nor do they contain significant taxonomic, phylogenetic, paleoecologic, taphonomic, biochronologic, or stratigraphic data. While there have been identified plant fossils in some Hornbrook Formation subunits, they are not considered to be associated stratigraphically within a given vertebrate assemblage. Considering these factors, the Hornbrook Formation is interpreted to be of Low Paleontologic Potential.

[164] Type sections as defined in Section 3.13.2.2 *Paleontologic Resources*

Overall, given that there is a low likelihood that changes to river discharge under the Proposed Project would lead to additional downcutting or erosion of the Hornbrook Formation and the formation's Low Paleontologic Potential, there would be no impact to paleontologic resources due to implementation of the Proposed Project.

Significance

No significant impact

3.13.6 References

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