Hydrogeologic Conceptual Model for the Eel River Valley Basin

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Humboldt County Department of Public Works

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Contents

List of Tables

List of Charts

List of Figures

Appendices

1. Hydrogeologic Conceptual Model

1.1 Overview

Descriptive hydrogeologic conceptual models (HCM), based on technical studies and qualified maps (23 CCR § 354.14), are required in Groundwater Sustainability Plans (GSP) to characterize the physical components of the subject basin, as well as describe the occurrence of groundwater and its movement in and out of the basin. The HCM is also the basis for developing the numerical integrated surface water-groundwater model used to simulate current and future basin conditions. This technical memorandum provides a summary, for public review, of the preliminary HCM for the Eel River Valley basin (ERVB), for inclusion in and prior to completion of the Eel River Valley GSP.

Within the ERVB (Figure 1), only a handful of studies have focused on the hydrogeologic conditions of the basin. The understanding of the ERVB as described within this section is primarily developed from a review of these past studies (Ogle 1953; Evenson 1959; U.S. Geological Survey [USGS] 1978), and the work that Humboldt County has completed in response to the Sustainable Groundwater Management Act (SGMA), including the Alternative Plan (2016). New data collection and analysis, along with the development of numerical modeling, is underway and will offer a significant improvement to this current understanding. (Data gaps and important uncertainties relative to the preliminary HCM are discussed in Section 1.9.)

1.2 Geologic Setting

The ERVB is located in a structurally controlled valley within a complex geologic setting, approximately 20 miles north of the Mendocino Triple Junction, where three (3) crustal plates (Gorda, North American, and Pacific plates; see Figure 2) intersect. Northeast-southwest directed compression associated with collision of the Gorda and North American tectonic plates dominates the region. The Gorda plate is actively subducting beneath North America north of Cape Mendocino along the southern portion of the Cascadia Subduction Zone (CSZ). Crustal deformation in the over-riding North American plate associated with the subduction of the Gorda plate is expressed as a 90-kilometer (km) wide fold-and-thrust belt within the accretionary margin of the North American plate (Carver 1987).

A major element of this fold-and-thrust belt is a broad structural downwarp (synclinal fold), referred to as the “Eel River syncline,” coincident with the lower reaches of the Eel River (Figure 3 and Figure 4). The folding affects a series of sedimentary units from the Plio-Pleistocene period referred to as the “Wildcat Group,” as shown on geologic cross-sections in Figure 4. The result is a geologic basin formed in the consolidated basement rocks of the region (Wildcat Group and underlying Franciscan Formation) that fills with large quantities of unconsolidated alluvial deposits from the Eel and Van Duzen rivers, as well as streams flowing from the surrounding uplands. The Eel River has the largest mean annual sediment load of any river on the conterminous U.S. Pacific coast (Meade et al. 1990).

Burdette Ogle initially prepared the most comprehensive and detailed description of the geologic setting of the Eel River Valley area in California Division of Mines Bulletin 164, which includes both mapping and unit descriptions focused on the Eel River Valley area. More recent work by McLaughlin and others (2000) has led to mapping of the broader northern coastal California. The current boundary of the ERVB follows geologic contacts shown on a geologic map by Dibblee (2008), which uses unit names not generally recognized by the local geologic community. Ogle (1953) defined the consolidated rocks of the Wildcat Group; his nomenclature and mapping remain in wide use by local geologists. The Wildcat Group consists of five sedimentary formations—from oldest to youngest: the Pullen, Eel River, Rio Dell, Scotia Bluffs, and Carlotta formations—deposited in the ancestral Eel River basin. The formations represent a shallowing (upward-coarsening) sequence, ranging from inner-shelf, fine-grained sandstone, siltstone, and mudstone (Pullen, Eel River, and Rio Dell formations) to near-shore sands and gravels (Scotia Bluffs and Carlotta formations). This upward coarsening of lithologies represents the transition (regression) from a deep-water offshore environment to a near-shore marine or terrestrial alluvial environment. Wildcat Group units unconformably overlie the regional bedrock material, the Franciscan Complex.

1.2.1 Basin Stratigraphy

Upstream of the Eel River Valley, the Eel and Van Duzen rivers flow in narrow bedrock canyons that empty into the valley at Rio Dell and Alton, respectively. Fluvially-derived alluvium within the valley includes a wide variety of materials, ranging from coarse gravels near active stream channels to fine-grained flood deposits (silts, clays) in floodplain settings far removed from the active channels. Figures 5, 6, and 7 (modified from SHN 2016) show shallow geologic cross-sections highlighting the stratigraphy within the ERVB. The installation, recently completed, of new monitoring wells at 19 locations throughout the ERVB will provide additional stratigraphic resolution. Cross-sections will be amended to include recently installed wells along the alignment and are currently being cross-referenced with the California Department of Water Resources' (DWR) online well completion database. Long-term regional uplift has resulted in the formation of a series of terraces along the valley margins.

1.2.2 Basin Alluvium

Overlying the Wildcat Group in the Eel River Valley is alluvium consisting of gravel, sand, and silt (Ogle 1953). The sediment-rich Eel River and its tributaries flow into the Eel River syncline, depositing a thick section of unconsolidated alluvium over the downwarped Wildcat Group. This accumulation of alluvium, up to 200 feet (ft) thick, consists of a variety of materials, tending to be coarser (sands, gravels) in near proximity to the active river channel and finer (silts, clays) beneath the extensive floodplain upon which agriculture and grazing occur. Evenson (1959) identified an area in the southwest part of the Eel River Valley dominated by fine sediments derived from periodic Eel River floods, as well as fine material washed down from the Wildcat Range upland areas bordering the south side of the ERVB.

1.2.3 Terrace Deposits

Terrace deposits are primarily located near the communities of Fortuna, Rohnerville, and Hydesville, along the Eel and Van Duzen river valleys at elevations ranging between 400 to 600 ft above sea level (Ogle 1953; Dibblee 2008). The most prominent terrace surfaces occur along the northern side of the ERVB, including terraces in Hydesville in the Van Duzen River Valley and the Rohnerville Formation surface (Ogle 1953). The terrace deposits are planar surfaces bounded by mountainous terrain to the north. The Carlotta formation underlies the terrace deposits.

The uplifted terrace deposits and Rohnerville Formation primarily comprise poorly sorted alluvial gravel and sand with small amounts of sandy clay and pebbly clay. Ogle describes the Rohnerville Formation deposits as primarily poorly sorted gravel with lesser amounts of sand, silt, and clay. Boulders up to 1 ft in diameter are common. The terrace sediments have a typical orange-brown or yellow-brown color. The upper few feet of the terrace deposit are made up of silt and clay and usually grades into 6 inches to 1 ft of dark soil (Ogle 1953). The deposits likely age to the Pleistocene with a maximum thickness of approximately 100 ft.

The upper surface of the Rohnerville Formation dips approximately 5 degrees north near Alton, flattens out near Strongs Creek, and dips 1 to 2 degrees south at Fortuna. Along the axis of the Eel River syncline, the surface has been subtly tectonically warped.

Terrace sediments form minor aquifers in the area, which are recharged by precipitation and surface flows from tributary streams. Portions of the terrace sediments are recharge zones for upland Carlotta and the Van Duzen (recharge areas are discussed in Section 1.4.6).

1.2.4 Carlotta Formation

Available information suggests the Carlotta formation underlies most, if not all, of the Eel River Valley, consisting of coarse-grained clastic sediments (i.e., conglomerate), sandstone, and claystone deposited in a near-shore or terrestrial setting during the Plio-Pleistocene period (Ogle 1953). These sediments are difficult to differentiate from the overlying alluvium, and in some places extend up to 4,000 ft below present-day ground surface (Ogle 1953; USGS 1978).

The conglomerate consists of rock fragments ranging in size from boulders of sandstone 8 inches in diameter to fine interstitial sand, silt, and clay. The conglomerate is interbedded with sandstone or claystone. Many outcrops show an iron-oxide coating abundant enough in places to bind the grains together to form a hard resistant rock. Typically, the conglomerate lies in troughs cut 2 ft or more into the claystone. The beds of sandstone and claystone can contain large limbs, trunks, and stumps of carbonized wood. These features represent a change from quiet water, marshy, or mudflat depositional conditions to erosion by stream channeling with concurrent deposition of coarse clastics and woody debris (Ogle 1953). The formation is predominantly overlain by alluvium or terrace deposits.

1.2.5 Geomorphic and Depositional Setting

As we see it today, the geomorphic character of the ERVB is the result of complex and dynamic tectonic and fluvial processes. Compressional forces over millions of years have resulted in a broad tectonic basin (see Figure 4) that receives alluvium from the sediment-laden Eel and Van Duzen rivers. Sea level changes at the coastline associated with glacial cycles have corresponded to significant base level changes as the coastline moves in and out. Rivers incise during periods when sea level has retreated, creating canyons and valleys that are then backfilled with sediment as sea level rises.

The importance of the Eel and Van Duzen river systems to the hydrogeologic character of the ERVB cannot be understated. Together the Eel and Van Duzen watersheds directly supply all of the water for municipal wells, domestic well, industrial and irrigation wells. The sediment transported by these rivers has infilled the lower valley, which over time has created the very aquifers that they currently recharge.

The Eel River is particularly influential on the development of the upper stratigraphy in the lower Eel River Valley. The Eel River watershed is associated with high rainfall in an area with steep slopes underlain by unstable geologic materials. Therefore, sediment loading in the Eel River is exceedingly high, such that alluvial material is readily available to infill any space resulting from ocean base level changes, tectonic land level changes, and deformation associated with the Eel River syncline.

The Eel River currently flows along the eastern and northern margins of the lower valley, but old abandoned channels and river meanders visible throughout the axis of the lower Eel River Valley provide strong geomorphic evidence for the range of past alignments extending as far south as Ferndale (Figure 8). The shallow stratigraphy underlying these abandoned channels reflect a high-energy fluvial environment consisting primarily of course sediments (sands/gravels). In contrast, the smooth, elevated alluvial fan surfaces that have built up from sediment eroded from the Wildcat Range are predominately underlain by fine grained sediments (silts/clays). Ferndale is situated on one of the more prominent fan surfaces associated with Francis Creek drainage.

Flooding is common within the north coast of California, playing an important role in the geomorphic evolution of the main stem river channels, tributaries, and active floodplains. The geologic setting of the ERVB is characterized by steep, unstable slopes influenced by active tectonic processes and high annual rainfall. Significant floods within the Eel and Van Duzen watersheds are often accompanied by channel scour, erosion of riverbanks, and landslide activity. The eroded materials carried by flood waters are either washed out to sea or are redistributed within the river channels lower in the watershed. Aggradation of sediment typically occurs in areas where channels widen and/or where stream gradients are reduced. The coastal floodplain of the Eel River Valley is subject to these processes.

Bedload transport and aggradation within the mainstem channels of the Eel and Van Duzen rivers can change the alignment of the thalweg, fill holes, and generally raise overall channel elevations. Major floods in 1955 and 1964 resulted in substantial geomorphic changes to the channel, adjacent terraces, and tributaries. An aggraded condition, particularly when the materials are coarse, can increase the relative proportion of underflow within the channel and increase the opportunity for sections of the river to flow entirely subsurface. The lower section of the Van Duzen River channel, just before its confluence with the Eel River, often goes dry as water flows through a thick deposit of alluvial material. In Fall 2014, a few hundred yards of the Eel River channel near Fortuna went dry as the surface elevation of the water dropped below the channel surface near a knickpoint.

The impacts of active channel processes within the ERVB, and the effect of the spatial and temporal patterns of erosion and deposition on surface flows, is an important consideration in the development of sustainable criteria for impacts to beneficial uses of surface waters.

1.2.6 Faults within the Basin

The Little Salmon fault is one of the most active fault zones within the on-land fold-and-thrust belt, forming the northern boundary of the ERVB. Since highly sheared fault zone materials often have relatively low hydraulic conductivities, they provide distinct boundary conditions from surrounding geologic formations. Total displacements of up to 7 km and a late Quaternary slip rate as much as 10 to 12 mm per year (mm/yr) have been estimated for the Little Salmon fault zone (Carver 1987; Clarke 1992; McCrory 1996). It is inferred that the Little Salmon fault represents a significant barrier to groundwater flow into the ERVB.

The Goose Lake faults have been mapped along two east-west striking lineaments that offset terraces within the Yager Creek drainage. The lateral extent of these faults is not well understood, but the northern fault trace (geologic evidence of faulting) likely extends towards the west into and potentially through the lower Eel River Valley and eastward across the Yager Creek drainage. Recent geomorphic mapping of the Yager Creek terraces (Samuel Bold personal communication 2021) and paleoseismic work on the more prominent northern fault trace suggests that at least one of these lineaments may be Holocene active (Tyler Ladinsky personal communication 2021).

1.2.7 Basin Boundaries

The ERVB boundary as currently defined by DWR in Bulletin 118 is shown on Figure 1. The ERVB is bounded on the south side by the Wildcat Range, a mountainous area formed by north-dipping sediments of the Wildcat Group in the southern limb of the Eel River syncline. Specifically, the basin encompasses portions of the Wildcat Range underlain by the uppermost, coarse-grained member of the Wildcat Group (the Carlotta formation). The northern side of the ERVB is bounded by the axis of the Table Bluff anticline to the west and the Little Salmon fault to the east. The western edge of the ERVB abuts the estuary where the Eel River flows into the ocean (that is, the saltwater-freshwater interface along the coast). The eastern limit of the ERVB is defined by the extent of the mapped Carlotta formation with some extensions to include the terraces and shallow alluvial materials of the Eel and Van Duzen rivers.

The ERVB bottom is defined by the base of the Carlotta formation, as described by Ogle (Figure 4; Carlotta is depicted in yellow), where it is in contact with the Scotia Bluffs Sandstone and other finer-grained units of the Wildcat Group. The base of the ERVB is not well constrained, as the Carlotta formation is several thousand feet thick in places and exploration of groundwater potential has not penetrated to that depth.

1.3 Soil Characteristics

Soils within the ERVB are derived from weathering processes affecting geologic materials exposed at the ground surface. Soil development and distribution is generally influenced by the nature of the exposed geologic ("parent") material, as well as climatic, vegetative, and topographic factors. Regional groundwater aquifer recharge is directly affected by the soil characteristics that define permeability of the near surface materials. Areas with highly weathered, or clay-rich, soils are generally associated with low permeability, whereas unweathered granular soils are associated with high permeability.

Soil hydrologic groups are assessments of soil infiltration rates determined by the water-transmitting properties of the soil, which are directly related to the relative percentage of clay-to-sand and gravel present. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Geographic Database (SSURGO) is presented in Figure 9 for the mapped hydrologic soil groups. When saturated, the hydraulic conductivity of near surface soils is an indicator of infiltration potential, and therefore groundwater recharge potential from precipitation. Hydrologic soil groups are defined as follows:

- Group A – High Infiltration Rate: water is transmitted freely through the soil; soils typically have less than 10 percent clay and more than 90 percent sand or gravel
- Group B – Moderate Infiltration Rate: water transmission through the soil is unimpeded; soils typically have between 10 and 20 percent clay and 50 to 90 percent sand
- Group C – Slow Infiltration Rate: water transmission through the soil is somewhat restricted; soils typically have between 20 and 40 percent clay and less than 50 percent sand

- Group D – Very Slow Infiltration Rate: water movement through the soil is restricted or very restricted; soils typically have greater than 40 percent clay, less than 50 percent sand

- Groups A/D, B/D, or C/D – Soils are assigned dual hydrologic soil groups where the first letter is for drained areas and the second letter is for undrained areas

The hydrologic soil groups indicated in Figure 9 generally correlate with moderate infiltration rates flanking both the Eel and Van Duzen rivers—including Yager Creek and a large portion of the lower Eel River Valley north of Ferndale—and represent higher sand and gravel content. These moderate infiltration Group B hydrologic soils represent significant aquifer recharge zones, especially when overlying and in direct contact with coarse sand and gravel alluvial packages associated with former river channels.

The soils generally grade from moderate infiltration potential proximal to the river channels to relatively slow infiltration rates in the distal floodplains, elevated marine terraces (Rohnerville, Hydesville, and Table Bluff), and upland slopes surrounding the ERVB.

1.4 Principal Aquifers and Aquitards

Primary water-bearing units within the Basin include the thick sequence of near-surface unconsolidated alluvial deposits that form the lower Eel River Valley and portions of the Van Duzen Valley, and the underlying Carlotta Formation. Minor, localized aquifers are also present within the poorly consolidated sediments that make up the uplifted marine, fluvial and flood-plain terrace sediments (Rohnerville and Hookton formations, Hydesville, Metropolitan, Rio Dell and Scotia terraces).

The contact between the alluvial aquifer and the underlying Carlotta aquifer in the western portion of the ERVB, with two (2) miles of the active Eel River channel, is not entirely understood at this time due to some similarities of material types found in each of the units and a lack of relatively deep wells with screens completed into distinct Carlotta aquifer materials. Well completion reports are often prepared with generalized descriptions of stratigraphy that do not allow for identification of the contact. This uncertainty is not particularly critical in the western portion of the ERVB, as there are very few wells that are believed to extend through the alluvial aquifer into the Carlotta, with the majority of use being shallow sources in the alluvial aquifer.

The eastern half and southern portion of the basin is now understood to have a distinct, relatively thick, fine-grained Carlotta formation aquitard unit underlying the shallow alluvium.

1.4.1 Alluvial Aquifer

The alluvial aquifer within the lower Eel River Valley is the most productive aquifer and, combined with its relatively shallow depths, the most utilized aquifer in the ERVB. The alluvial aquifer is generally defined as the water-bearing units within the relatively young unconsolidated sediments overlying the Carlotta formation. The alluvial aquifer is most prominent within the central portions of the lower Eel River Valley where the thickness is in excess of 260 ft. The alluvial aquifer extends up the Van Duzen River Valley, thinning from approximately 125 ft thick at the confluence with the Eel River to less than 40 ft in the vicinity of the Town of Carlotta.

The physical characteristics of the alluvial aquifer reflect the dynamic tectonic and geomorphic history in the area and are observed to have significant lateral variation. In general, the alluvium is an accumulation of a variety of materials, tending to be coarser (sands, gravels) in areas where the river channels have migrated and finer (silts, clays) in areas where floodplain processes dominate. There are also thick sequences of fine-grained alluvial material along the base of the Wildcat Hills, particularly where major streams have built alluvial fans.

The alluvial aquifer is generally unconfined, though semi-confined conditions can occur where there are particularly thick fine-grained units near the surface.

The surface waters of the Eel and Van Duzen rivers are generally in direct contact and hydraulic communication with the alluvial aquifer. Monitoring of surface and groundwater levels show rapid aquifer response to changes in river levels.

The unconsolidated alluvium is a highly productive aquifer, with supply wells capacities' typically ranging from 400 to 1,200 gallons per minute (GPM), that represents the primary water source for a majority of agricultural wells. Most wells in the alluvial aquifer are less than 100 ft deep and yield relatively high volumes (Evenson 1959).

1.4.2 Carlotta Aquifer

The Carlotta formation consists of an interbedded range of materials, from coarse-grained clastic sediments deposited in a near-shore or terrestrial setting to thick sequences of fine-grained estuarine and bay environments. Based on its texture and regional distribution within the ERVB, the Carlotta aquifer represents a principal aquifer and is often characterized as having dark-grey-to-blue sand and gravel. Groundwater within the unit is generally overlain and confined by a relatively thick and continuous silt and clay aquitard in the eastern half and southern portions of the ERVB. The western and central portions of the ERVB are overlaid by, and grade into, discontinuous silt and clay interbeds, as well as into alluvium and terrace deposits with semi-confined to unconfined conditions.

The Carlotta formation is known to be in excess of 1,500 ft thick (locally as much as 4,000 ft thick per DWR [USGS 1978]) and only the upper part of the Carlotta formation is tapped by water wells. There are likely many different sequences of aquifers at depth within the Carlotta formation coarse-grained sediments, but no studies have been conducted to characterize aquifers deeper than those being used historically and currently. Wells extracting groundwater from the Carlotta formation are predominantly found in upland areas, such as the slopes flanking the northern and southern boundaries of the ERVB, the Ferndale area, and up on the Hydesville/Rohnerville terrace surfaces. Wells completed in the Carlotta aquifer tend to be deeper than the shallow irrigation wells completed in alluvium, often on the order of 200 to 400 ft deep. Some of the wells that intersect the Carlotta formation along the base of the foothills are flowing (artesian) wells.

Based on a review of the DWR Well Completion Report database, in terms of utilization in the ERVB, it is estimated that approximately 40 percent of irrigation wells and 67 percent of domestic wells are drawing from aquifer units within the Carlotta formation. The general locations of these wells are shown in Figure 10. In general, the Carlotta aquifer is not as productive as the alluvial aquifer, so it isn't usually targeted except for areas outside the valley floodplain lowlands.

1.4.3 Aquitards

Virtually all the stratigraphic sections within the ERVB comprise beds of fine-grained sediments, many of which are thick enough and/or of low enough permeability to act as aquitards. Well-defined, laterally continuous aquitards, however, are not typical of the depositional environments in the ERVB alluvium, not laterally continuous, and can be difficult to define with confidence.

The Carlotta formation does have a laterally continuous, prominent aquitard in the eastern half and southern portion of the ERVB that has been identified in this study. This first aquitard represents the uppermost section of Carlotta and underlies the alluvial aquifer, characterized as distinct dark-grey-to-blue silty clay. The Carlotta aquitard, two (2) to three (3) miles up the Van Duzen River near the center of the valley at Hydesville, is approximately 125 ft below the ground surface (bgs), almost 75 ft thick. Near the confluence of the Eel and Van Duzen rivers at Alton, the Carlotta aquitard is 145 feet bgs and almost 20 ft thick. At the Fortuna wellfield just south of Kenmar Road on the east side of the Eel River, the Carlotta aquitard is encountered at 101 ft bgs and almost 30 ft thick.

Wells along the southern to central portion of the ERVB encounter the Carlotta aquitard between 100 and 150 ft bgs; in Ferndale the aquitard is encountered in places within 20 ft of the ground surface and can be greater than 100 ft thick. In the western and central portion of the ERVB, approximately a mile north of Arlynda Corners and a mile south of the active Eel River channel, the aquitard wasn't encountered in a new County monitoring well (MW-14d) installed to a depth of 260 ft.

Groundwater levels in nested County monitoring wells screened in the alluvial aquifer above and separately below the Carlotta aquitard indicate confined groundwater conditions in the Carlotta aquifer. These groundwater levels and aquifer conditions are detailed in both the Water Levels Technical Memorandum (Draft from SHN) and Aquifer Parameters Technical Memorandum (in preparation by GHD).

Additional resolution on the confining conditions within the ERVB aquifers will come from the ongoing analysis of stratigraphy and water levels recorded in the new County monitoring wells that were completed in June 2021.

1.4.4 Aquifer Hydraulic Characteristics

Data regarding the hydraulic characteristics of the aquifers within the ERVB are generally derived from past DWR/USGS reports (1959, 1965, 1978) and the current and previous studies carried out as part of the County's response to SGMA (Alternative Plan 2016, and the ERVB GSP).

The alluvial aquifer is a high production unit that is widely utilized for agricultural irrigation and municipal water. The depth to water (DTW) is generally shallow, with the water table on the order of a few ft to as many as 40 ft bgs. Most wells drawing from the alluvial aquifer are less than 100 ft in depth. Specific well capacities are typically on the order of 20 to 350 GPM per ft of drawdown (Johnson 1978), although they may locally be as high as 600 GPM per foot of drawdown (DWR 1965).

Hydraulic conductivities of the alluvial aquifer, as measured in County wells installed in 2016 and 2021, range from 3 ft per day in the shallow fine-grained sediments west of Ferndale to as high as 420 ft per day in channel alluvium gravels adjacent to the active Eel River channel. Deeper (>125 ft) screened wells in the confined Carlotta aquifer containing silt, sand, and gravel range from 0.3 to 11 ft per day and are detailed in the Aquifer Parameters Technical Memorandum (in preparation by GHD).

1.4.5 Primary Aquifer Use

The primary uses of the ERVB aquifers and vast majority of groundwater pumping is for irrigation of croplands (including permitted and unpermitted cannabis), and to a much lesser extent municipal water supplier extraction, with the remaining uses for non-municipal domestic potable water and non-municipal industrial and commercial purposes (see Table 1 below). A detailed description of groundwater use and water balance are presented in the Water Use Technical Memorandum (GHD, 2021) and the Water Budget Technical Memorandum (GHD, 2021).

Groundwater is pumped from municipal wells, domestic wells, commercial/industrial wells and irrigation wells. These well locations are spread throughout the ERVB. Figure 10 displays the density of these wells throughout the basin. The irrigated lands are pervasive in the ERVB's spatial extent, and the municipal water suppliers are fairly spread out with the remaining minor uses scattered intermittently throughout the entire ERVB.

Table 1. ERVB Groundwater Use by Use Type

Use Type	Municipal	Domestic (non-municipal)	Commercial / Industrial (non-municipal)	Agricultural Irrigation	Cannabis (permitted and non-permitted)	Total
AF/YR	1,733	414	34	10,585	98	12,864
%	13.5%	3.2%	0.3%	82.3%	0.8%	

The shallow, highly productive alluvial aquifer is distinctly separate from the Carlotta aquifer in the eastern half and southern portions of Ferndale out to Centerville. In the western half and the central portion of the ERVB (within approximately one [1] to two [2] miles of the active Eel River channel) the alluvial aquifer grades into undifferentiable portions of the upper Carlotta aquifer, where together these two aquifers supply the vast majority, if not the entirety, of extracted groundwater. Groundwater is pumped from relatively shallow depths, with most of the irrigation wells of known construction completed into less than 100 ft of alluvial sand and gravel packages, with screened intervals starting around 20 ft bgs. The bulk of the ERVB groundwater is used for irrigation pumping (see Chart 1 below) which occurs during a relatively short season of approximately six (6) months, or less, as detailed in the Water Use Technical Memorandum (in preparation by GHD).

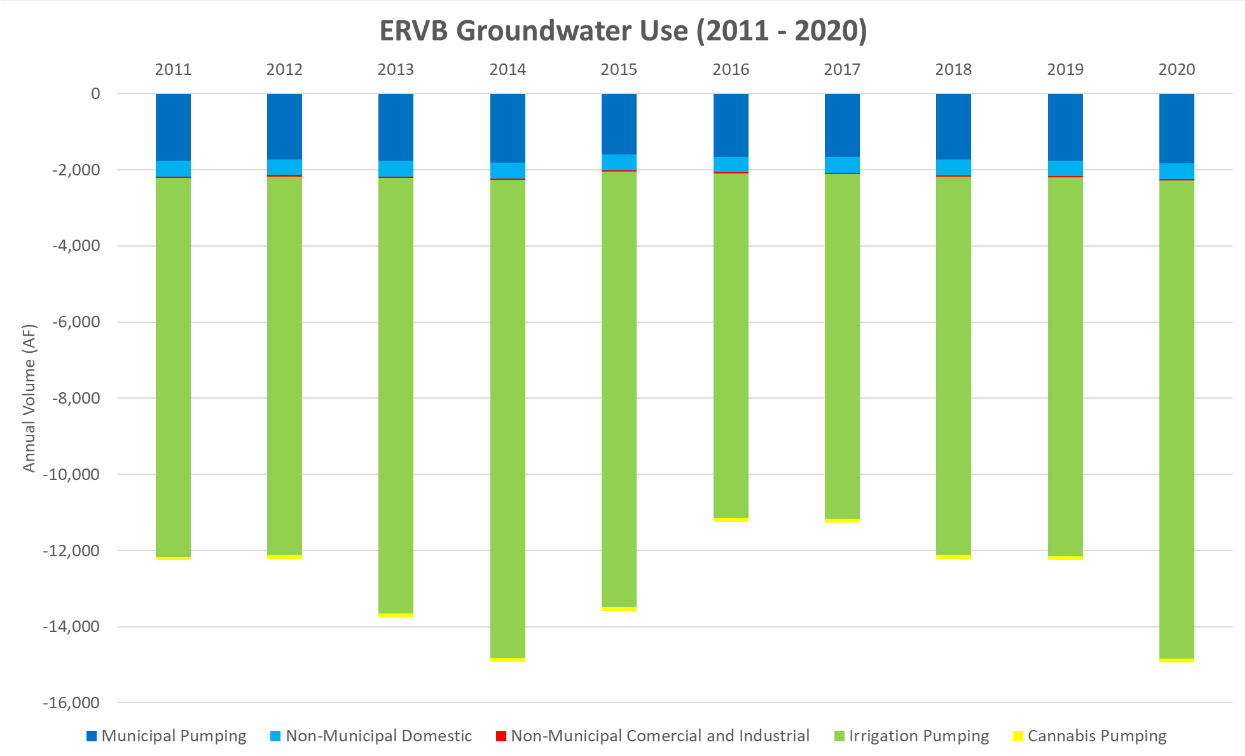

Chart 1. Groundwater Use 2011-2020.

Municipal water supply wells are generally less than 200 ft deep, are fairly spread out, and have relatively deeper screened intervals than irrigation wells. Municipal supply wells serving the Bear River Band of the Rohnerville Rancheria are deeper than 600 ft, as they are located on an upland surface.

Domestic water supply wells for residences are scattered throughout the ERVB and serve the entire rural and suburban populations outside of municipal water districts. The domestic water supply use is the most diverse of all use types in that residential wells are located within the agricultural lowlands in the Eel and Van Duzen river alluvial valleys, as well as in ERVB periphery uplands around fringes of the municipal water suppliers (Ferndale, Table Bluff, Fortuna, Hydesville, Rio Dell, Carlotta), on the fluvial terraces with relatively shallow perched aquifers (Metropolitan, Rio Dell, Scotia, Alton) or underflow directly connected to the rivers, and on the marine terraces.

Although due to the relatively productive nature of the alluvial aquifer, the shallow depth of water extraction is more critical in the western third of the ERVB where the salt water-freshwater interface gets closer to the ground surface near the Pacific Ocean. Available oil and gas exploratory borings from the 1990s and decades earlier indicate a salt-fresh water interphase in the eastern portion of the ERVB around the confluence of the Eel and Van Duzen rivers could be at depths ranging from 600 to 1,000 ft.

The ERVB receives no water from sources outside of the Eel River watershed, such as canals, pipelines, or diversions coming from outside the basin limits. Portions of the upper Eel River watershed surface waters are diverted in Mendocino County at Cape Horn Dam to supply supplemental water for the Russian River system that serves water users in Mendocino, Sonoma and Marin counties.

1.4.6 Aquifer Recharge Areas

Important recharge areas for the ERVB are shown on Figure 11. Primary sources of recharge are associated with the inputs from the river systems and infiltration from rain in the hydrologic soil groups, with relatively higher infiltration rates flanking the active riverbanks and channels. Surface flows from the Eel and Van Duzen rivers recharge the alluvial aquifer within the lower Van Duzen Valley and the lower Eel River Valley, as they are in directly hydrologic connection. Surface water-groundwater monitoring along both the Eel and Van Duzen rivers shows a strong connection with alluvial aquifer levels responding quickly to river level changes. High flows during the wet winter months efficiently feed the shallow alluvial aquifer, particularly on the stretch of river between the confluence with the Van Duzen River and Fernbridge. Secondary streams draining the Wildcat Range south of the ERVB also contribute to alluvial aquifer recharge.

The Carlotta formation aquifer is recharged by a variety of sources. The Van Duzen River and Yager Creek both enter the ERVB from the eastern side and come in direct contact with the underlying Carlotta formation. Where the coarse-grained Carlotta formation intervals come in contact with channel alluvium, opportunities to provide substantial Carlotta aquifer recharge are realized. Additionally, the Carlotta formation is exposed in several upland areas directly surrounding the ERVB, particularly along the southern margin and within the easternmost areas on either side of the Van Duzen Valley. In these areas, tributary streams flowing over the Carlotta formation provide direct surface flow recharge. Secondary aquifers, such as the Hookton formation, the Hydesville and Rohnerville terraces, and alluvial terraces surrounding the ERVB, are similarly recharged by precipitation and/or surface flows of tributary streams.

1.5 General Water Quality

Water quality conditions in the ERVB have been described in past DWR/USGS reports (1959, 1965, 1978). Available online data indicates that groundwater in the ERVB is generally of good quality and suitable for the intended municipal and agricultural uses (Water Quality Technical Memorandum; SHN 2021). Water quality of groundwater emanating from the alluvial aquifer is adequate for irrigation and stock watering and has been used as such for decades.

High concentrations of iron and manganese has been recognized as a natural condition within groundwater of the ERVB (Ogle 1953; Evenson 1959). Raw water sampling for municipal suppliers within the ERVB, as reported in the Safe Drinking Water Information System (SDWIS) online database, indicate that raw water collected by Palmer Creek Community Services District (CSD), Del Oro Water Company, and Loleta CSD regularly have concentrations of iron and magnesium above secondary MCLs (300 ug/L and 50 ug/L, respectively).

Water quality data made available online as part of the California State Water Resources Control Board's online Groundwater Ambient Monitoring and Assessment Program (GAMA), was initially compiled and presented in the 2016 Groundwater Sustainability Plan Alternative (SHN 2016). Fifteen (15) constituents were queried and analyzed in the GAMA database, including aluminum, arsenic, barium, boron, cadmium, chloride, chromium, lead, mercury, nitrate, selenium, silver, sodium, specific conductance, and total dissolved solids (TDS). Six (6) of the 15 constituents had concentration levels that were detected above method detection limits, including arsenic, chloride, nitrate-N, sodium, specific conductance, and TDS. For the six (6) constituents that were selected for further analysis, all datasets in the database were used to provide an assessment of the average concentration for each constituent for each 10-year period of record (decadal averages). None of the detected constituents were found to be above their respective water quality objectives, and analysis of the data trends indicated that there was little to no increase in concentrations in the last 10-year period of record as compared to the entire data set.

As a follow-up to the 2016 work, tabular data were downloaded from GAMA in April 2021 to update the analysis of the 15 constituents initially evaluated. All data available for each constituent for the last 10 years were downloaded and reviewed to identify any specific exceedances during the last decade. All results fell below MCLs except for one (1) TDS result in 2012 and an arsenic result in 2020.

The ERVB was recently identified as a high-priority basin for salts as TDS and nutrients (nitrates) in a 2020 North Coast Regional Water Quality Control Board (NCRWQCB) Staff Report entitled *North Coast Hydrologic Region Salt and Nutrient Management Planning Groundwater Basin Evaluation and*

Prioritization (2020). Sampling results from wells within the ERVB from 2010 to 2020 show exceedances for water quality objectives for nitrates within the central portion of the lower Eel River Valley.

Groundwater quality sampling and testing of a broad suite of analytes was performed within 15 of the County monitoring wells in July 2021. The results from this effort will provide a better baseline of understanding for water quality conditions within the primary aquifers underlying the alluvial flood plains.

1.6 Surface Water Bodies Significant to Basin

The Eel and Van Duzen rivers are the primary surface water bodies within the ERVB. These are large river systems that drain significant areas of northwestern California (Figure 12). The main stem Eel River is dammed near its headwaters in Lake County (far from the ERVB) at Lake Pillsbury (Scott Dam) and some flow is diverted to the Russian River system by way of the diversion at Van Arsdale Reservoir (Cape Horn Dam). Neither the South Fork Eel River nor the Van Duzen River is impounded.

Secondary surface water bodies within the ERVB include the Salt River and Yager, Strongs, Price, Palmer, Howe, and Rohner creeks, along with many other smaller tributaries, generally providing year-round colder freshwater to the Eel and Van Duzen rivers from the upland slopes and watersheds surrounding the ERVB. Additionally, a log pond in Scotia and wastewater treatment facilities in the municipalities of Fortuna and Loleta are minor surface water body sources compared to the primary rivers in the ERVB.

Very little direct surface water extraction of the rivers is used to supply ERVB residents with potable drinking water. Although the quantity of rural creek and spring water may be slightly more significant, it is difficult to estimate due to the remote nature of many of those permitted or unpermitted surface water extraction systems. The surface water quality of the Eel and Van Duzen rivers and ERVB creeks are relatively high and not impacted from commercial or industrial pollutants, and as such provide significant high-quality inflows to ERVB groundwater.

1.7 Hydrogeologic Conceptual Model Data Gaps and Uncertainty

Data gaps within the current HCM include the following:

- The fault zone associated with the Little Salmon fault is complex and the single lineament shown on maps and in cross-sections is a simplification. Similarly, the impacts of secondary faults within the ERVB, such as those of the Goose Lake faults, are not well understood in terms of their lateral extent and impact on some of the younger overlap and alluvial deposits.
- The stratigraphy and aquifer characteristics associated with the Rohnerville and Hydesville terraces are not well known. These areas are unique in their setting but do not play a significant role in water use in the ERVB, and therefore have not been studied in detail. Future studies should consider researching historical water levels and current conditions.
- The stratigraphy within the surficial alluvium is complex. Lateral and vertical stratigraphic variations are the result of a dynamic geologic history influenced by tectonics, sea level fluctuations, and large river systems with high sedimentation rates. The size and configuration of the aquifer(s) associated with the alluvial unit, particularly at depth, are not well understood. Similarly, the continuity of silt/clay layers (aquitards) across the ERVB in the central western third and northern portion is not well understood.

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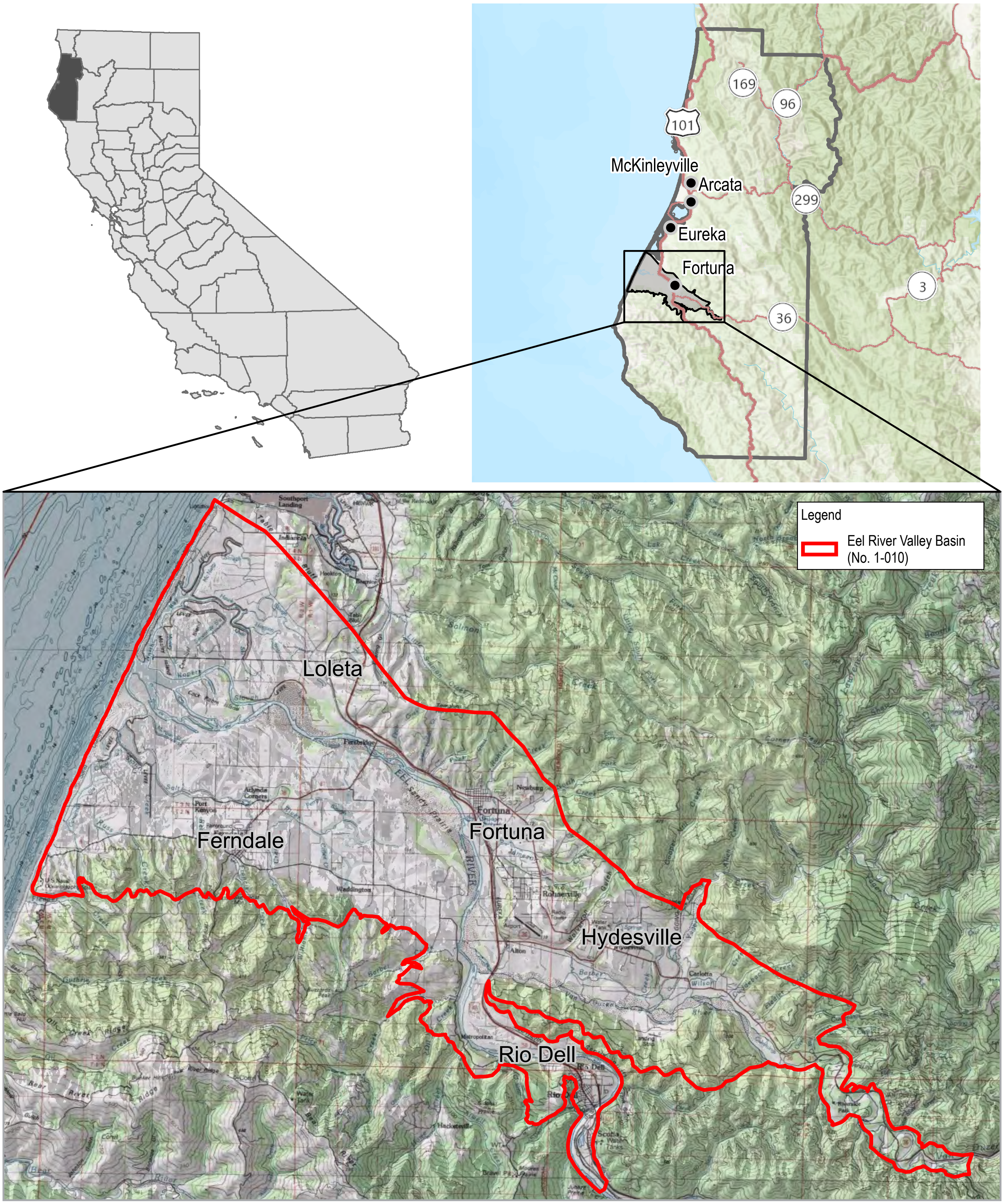
Appendix A Figures



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Eel River Valley Groundwater
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General Basin Vicinity Map

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Revision No. **-**
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FIGURE 1

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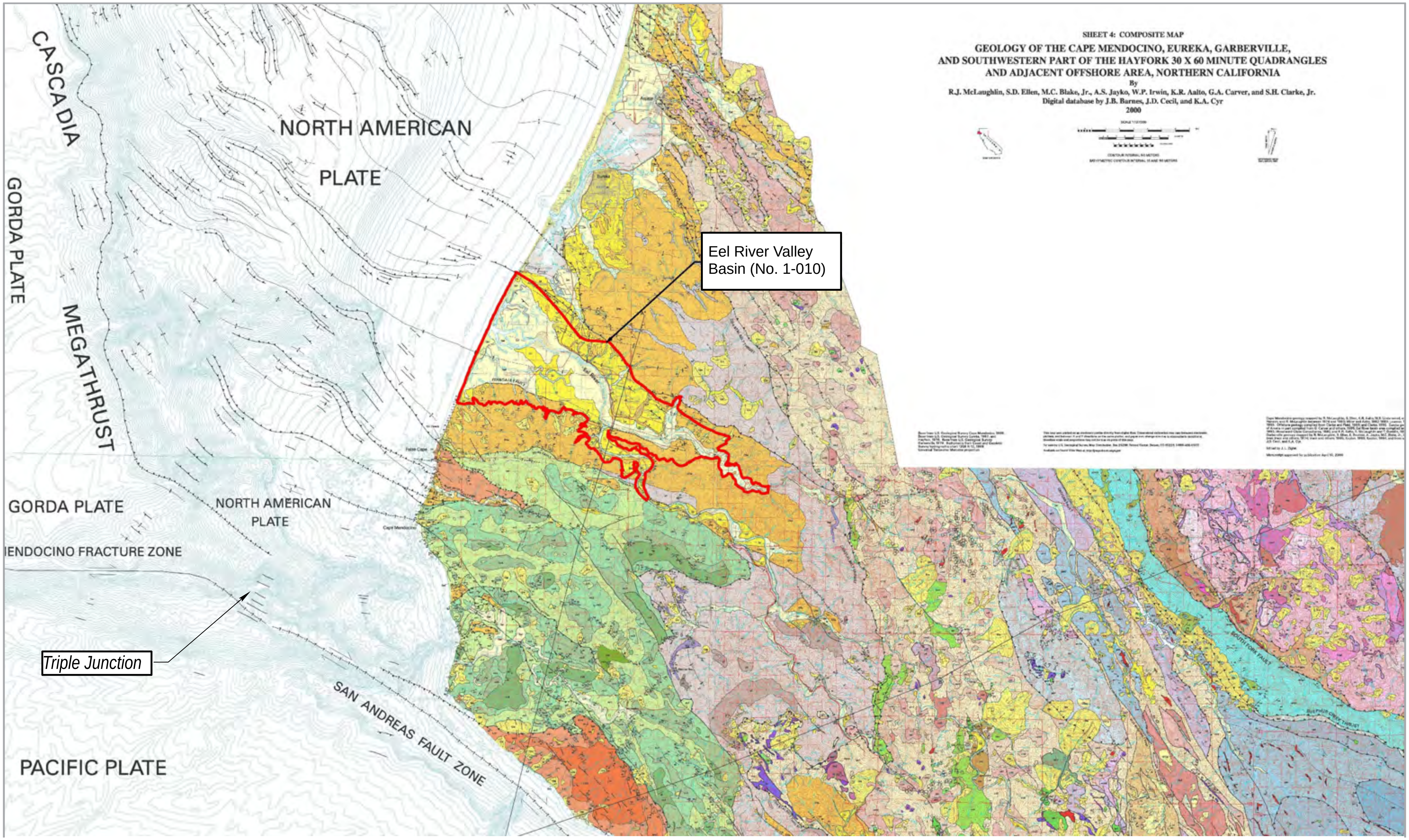

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Geologic Map
(McLaughlin 2002)

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Date August 2021

FIGURE 2

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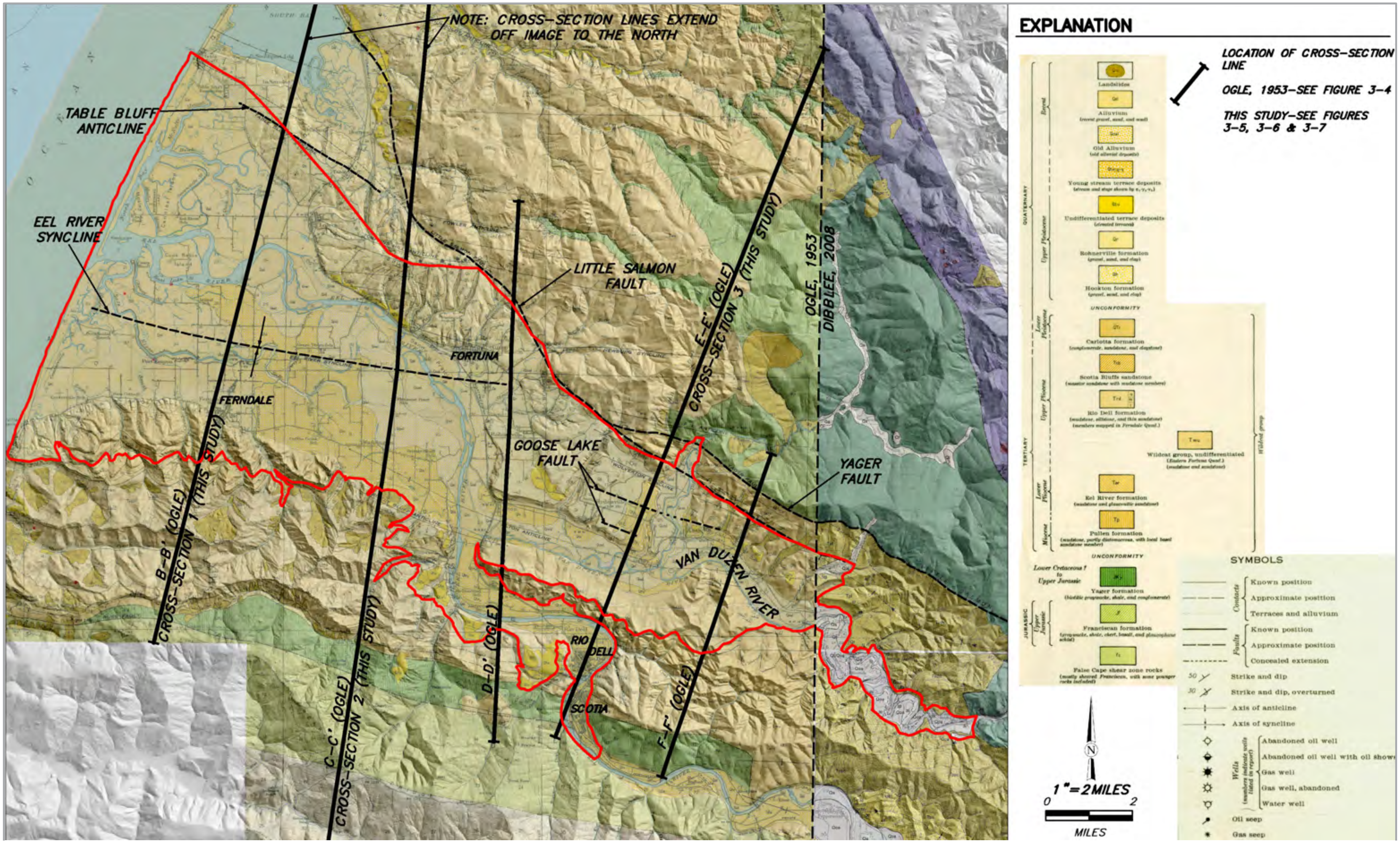

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Geologic Map
(Ogle, 1953; Dibblee, 2008)

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Revision No. -
Date August 2021

FIGURE 3

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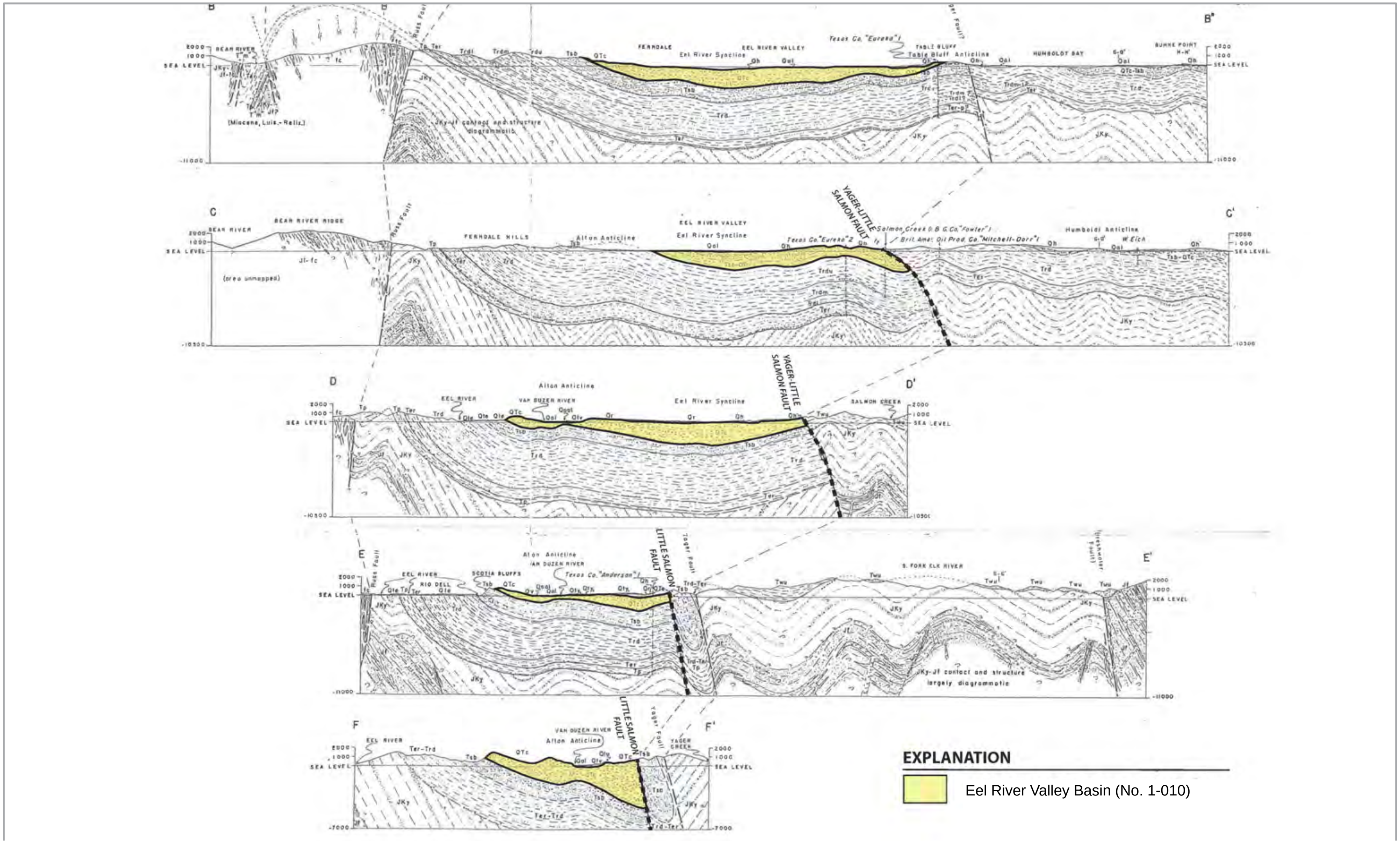

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Revision No. -
Date August 2021

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Geological Cross Sections

FIGURE 4

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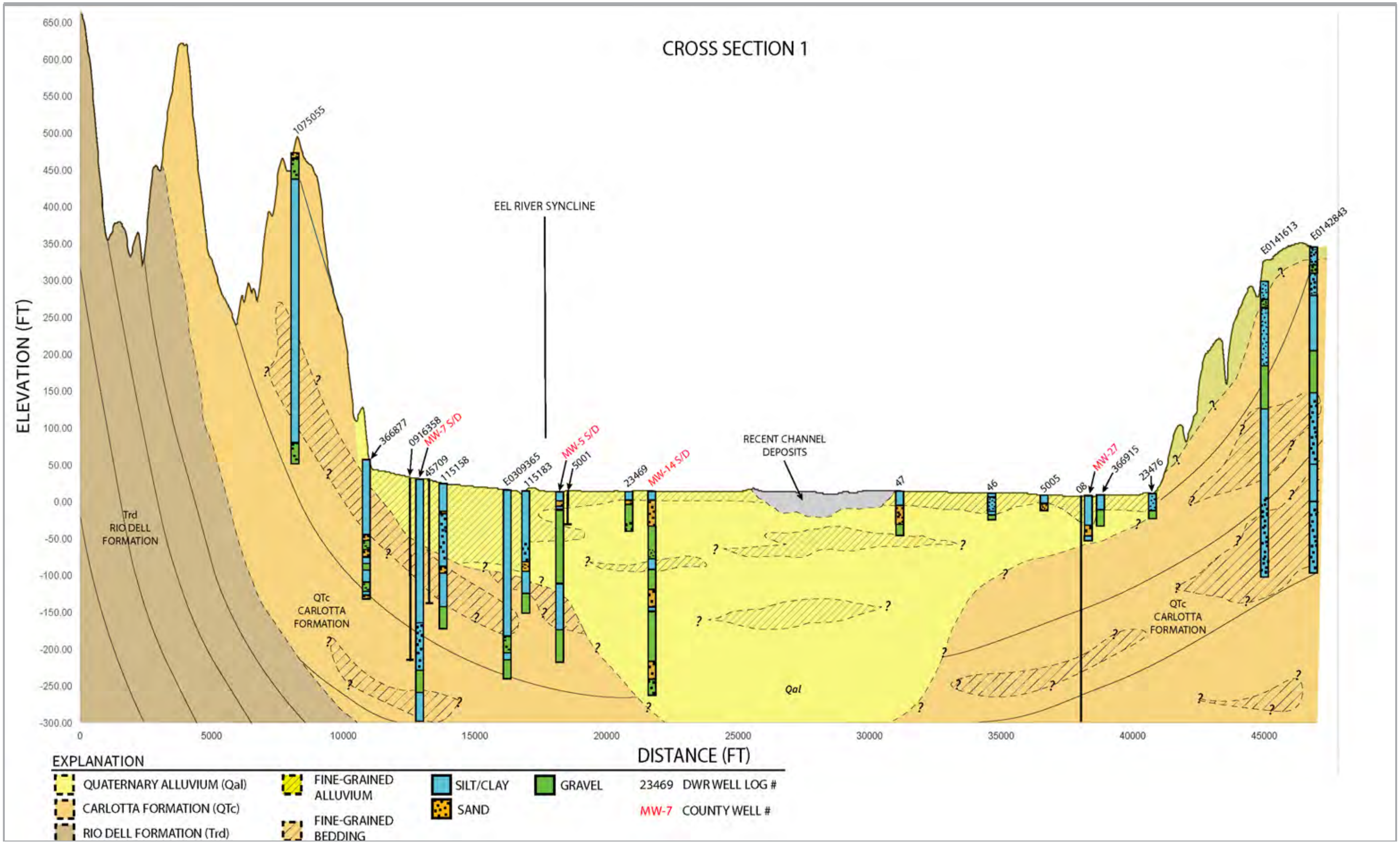

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Project No. **11217388**
Revision No. **-**
Date **August 2021**

Geologic Cross-Section 1

FIGURE 5

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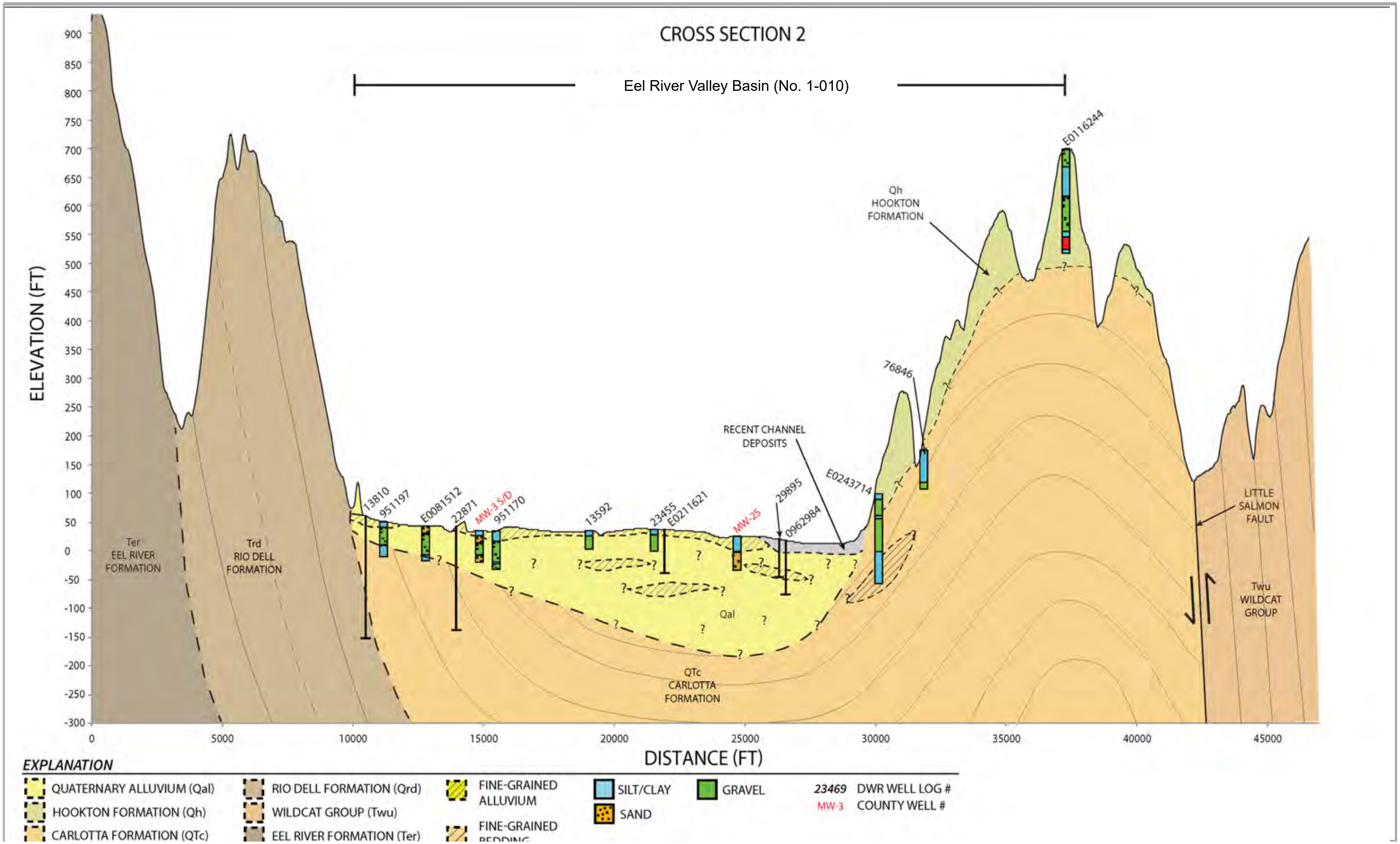

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Sustainability Plan

Project No. **11217388**
Revision No. **-**
Date **August 2021**

Geologic Cross-Section 2

FIGURE 6

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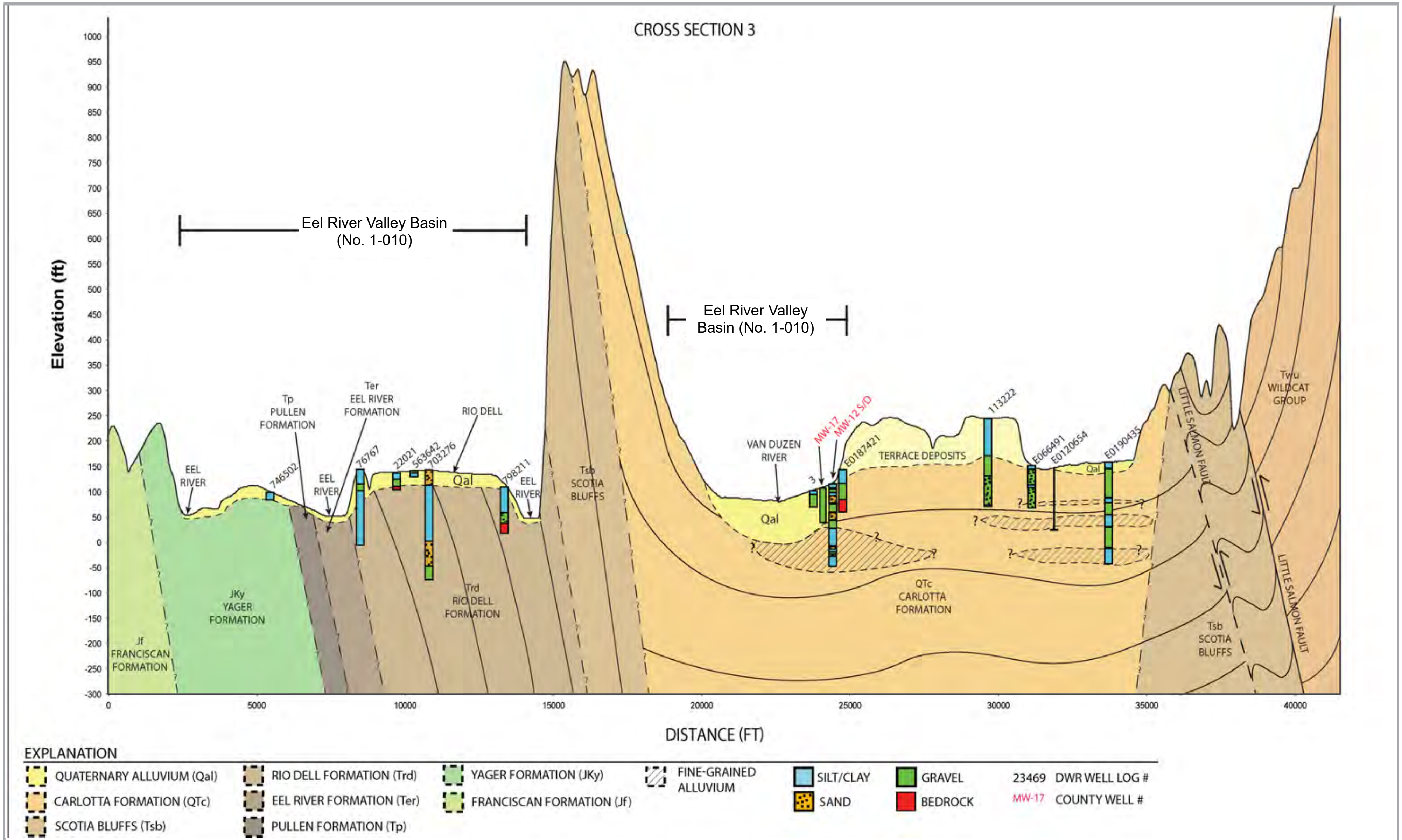

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Revision No. **-**
Date **August 2021**

Geologic Cross-Section 3

FIGURE 7

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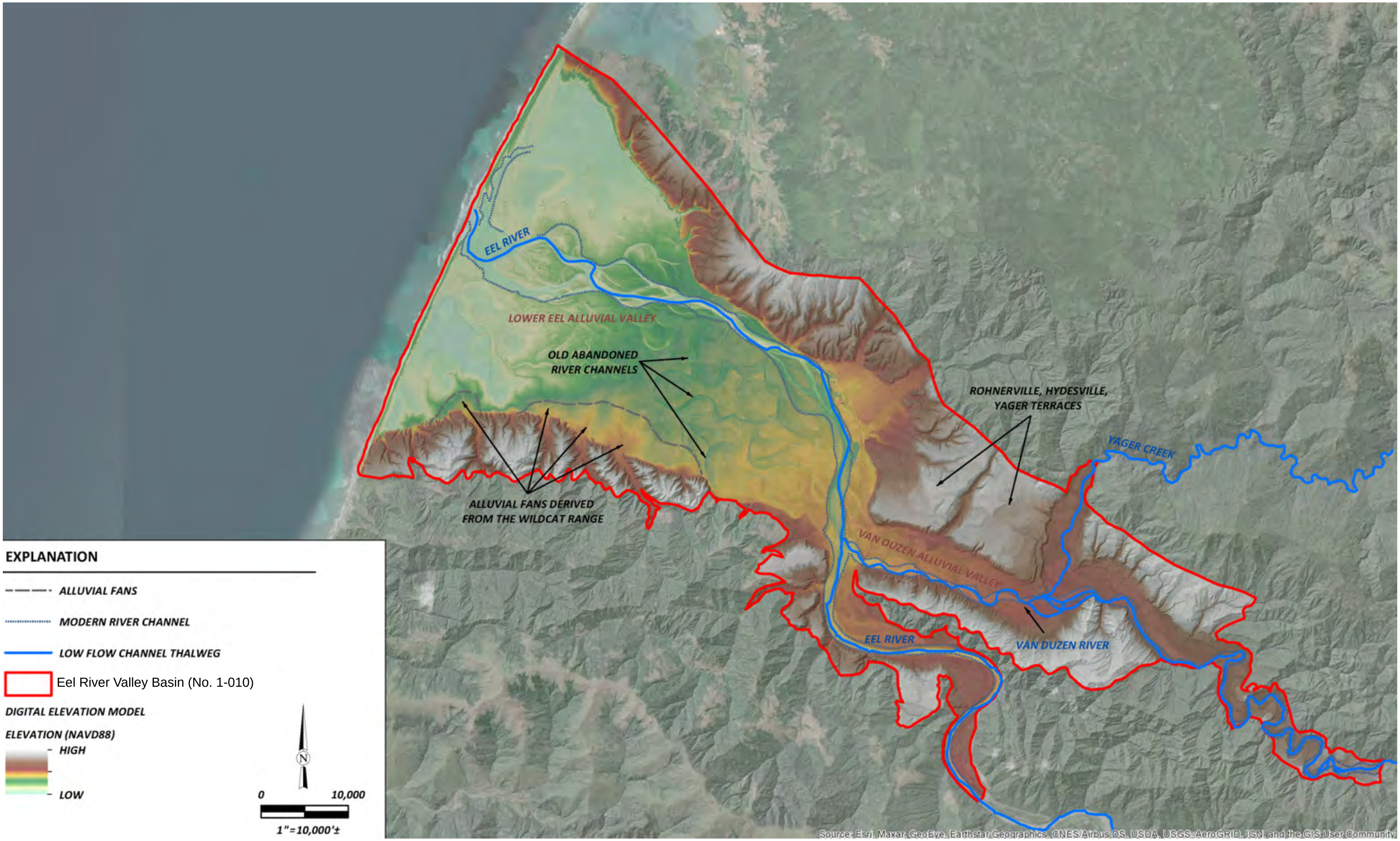

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Revision No. -
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Geomorphology

FIGURE 8

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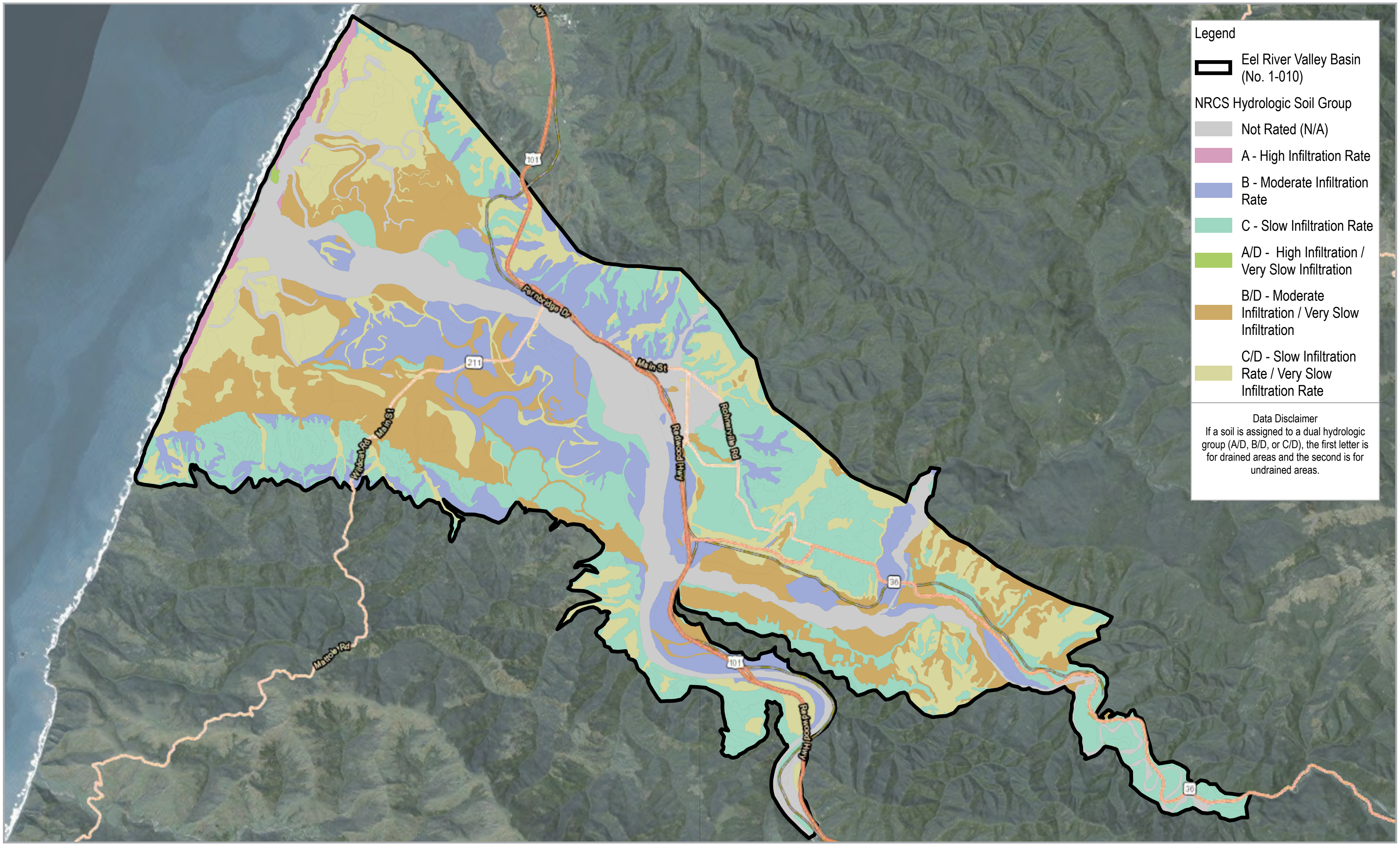

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NRCS Mapping by Hydrologic Soil Group

Project No. **11217388**
Revision No. **-**
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FIGURE 9

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Data source: USDA, Natural Resource Conservation Service, 2021;World Imagery (Clarity): This work is licensed under the Esri Master License Agreement.View Summary | View Terms of UseExport: This layer is not intended to be used to export tiles for offline. Data Collection and Editing: This layer may be used in various ArcGIS apps to support data collection and editing, with the results used internally or shared with others, as described for these use cases.
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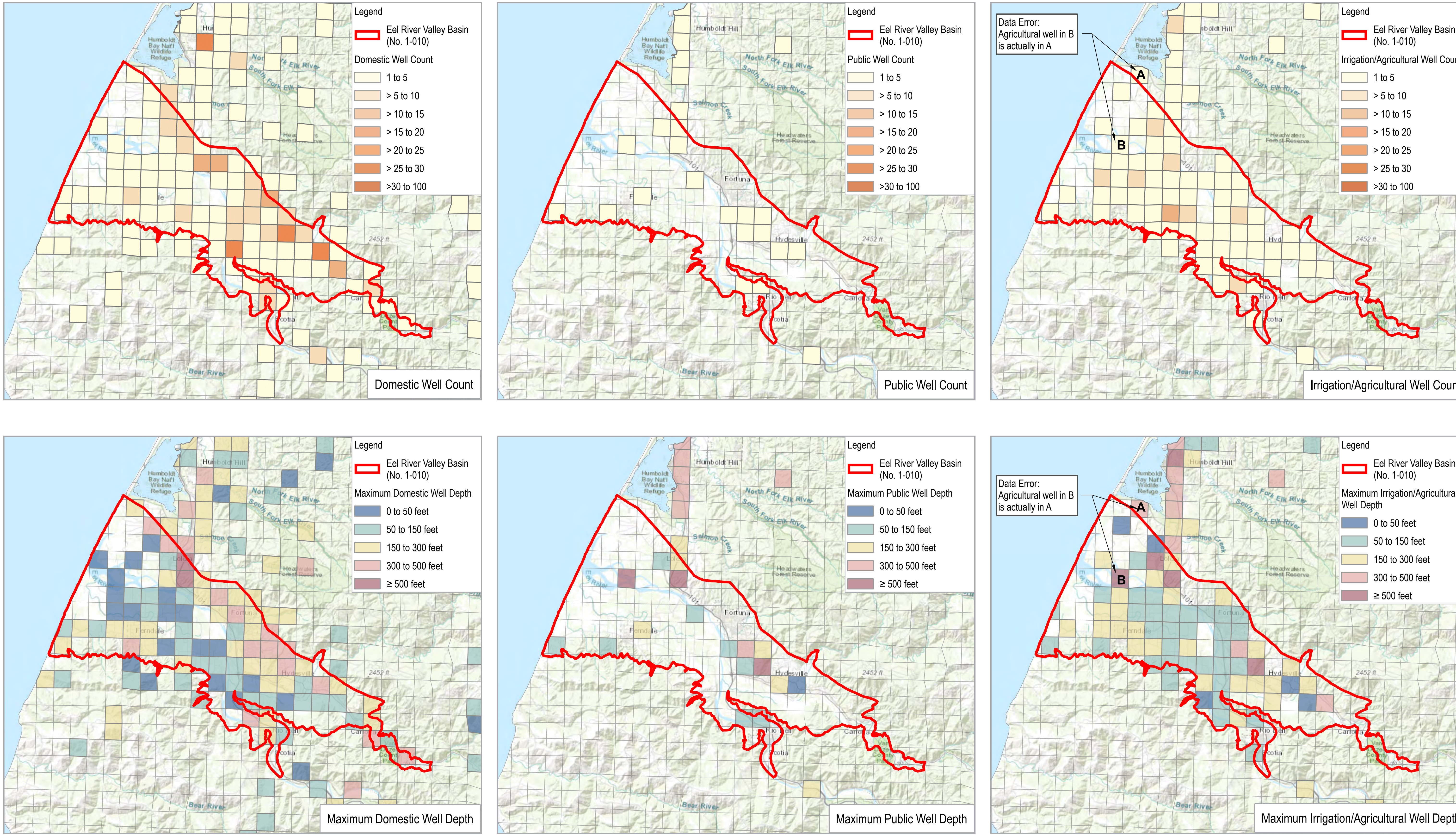

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Project No. **11217388**
Revision No. **-**
Date **August 2021**

Aquifer Use Map

FIGURE 10

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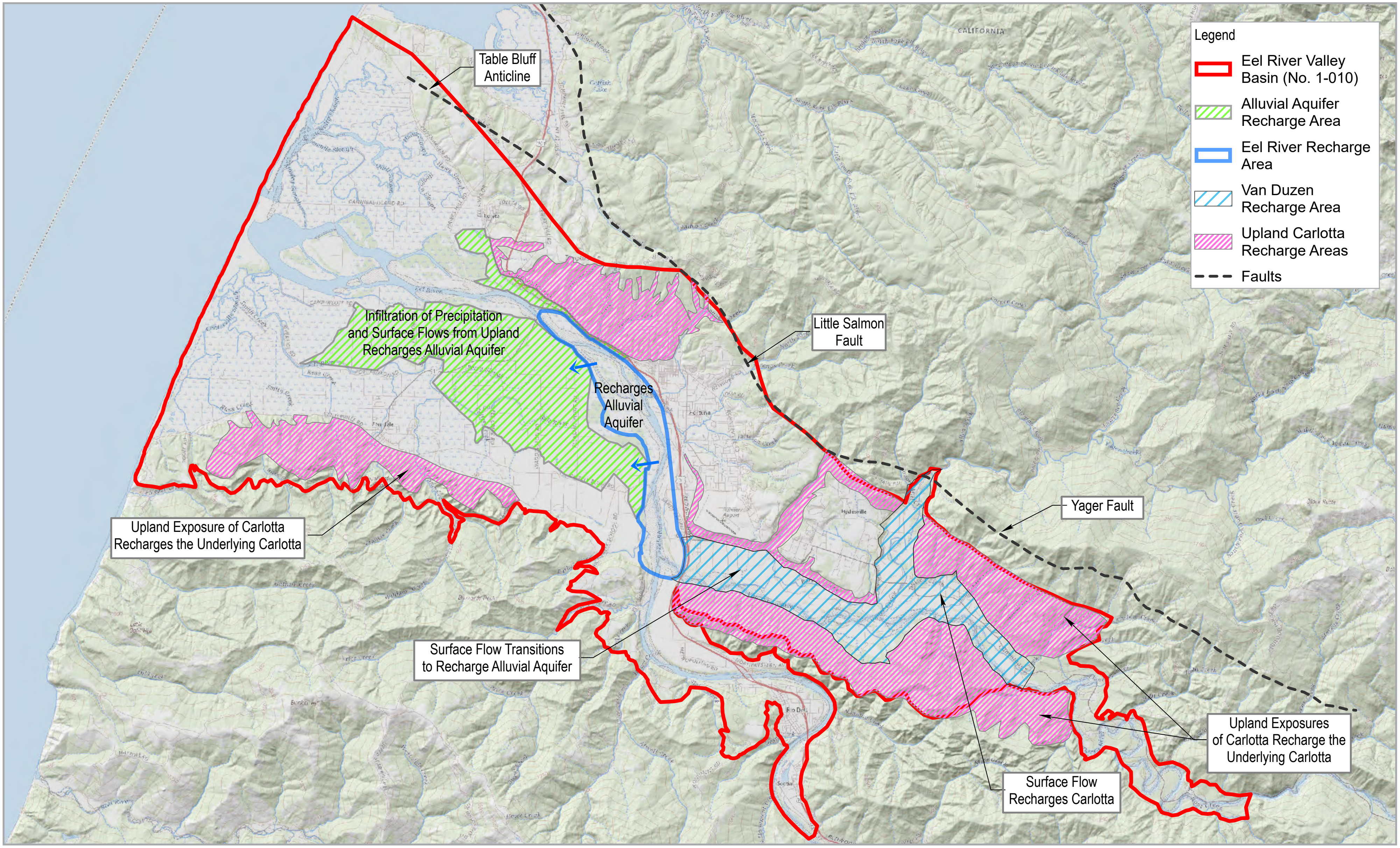

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Eel River Valley Groundwater
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Project No. **11217388**
Revision No. **-**
Date **August 2021**

Important Recharge Areas

FIGURE 11

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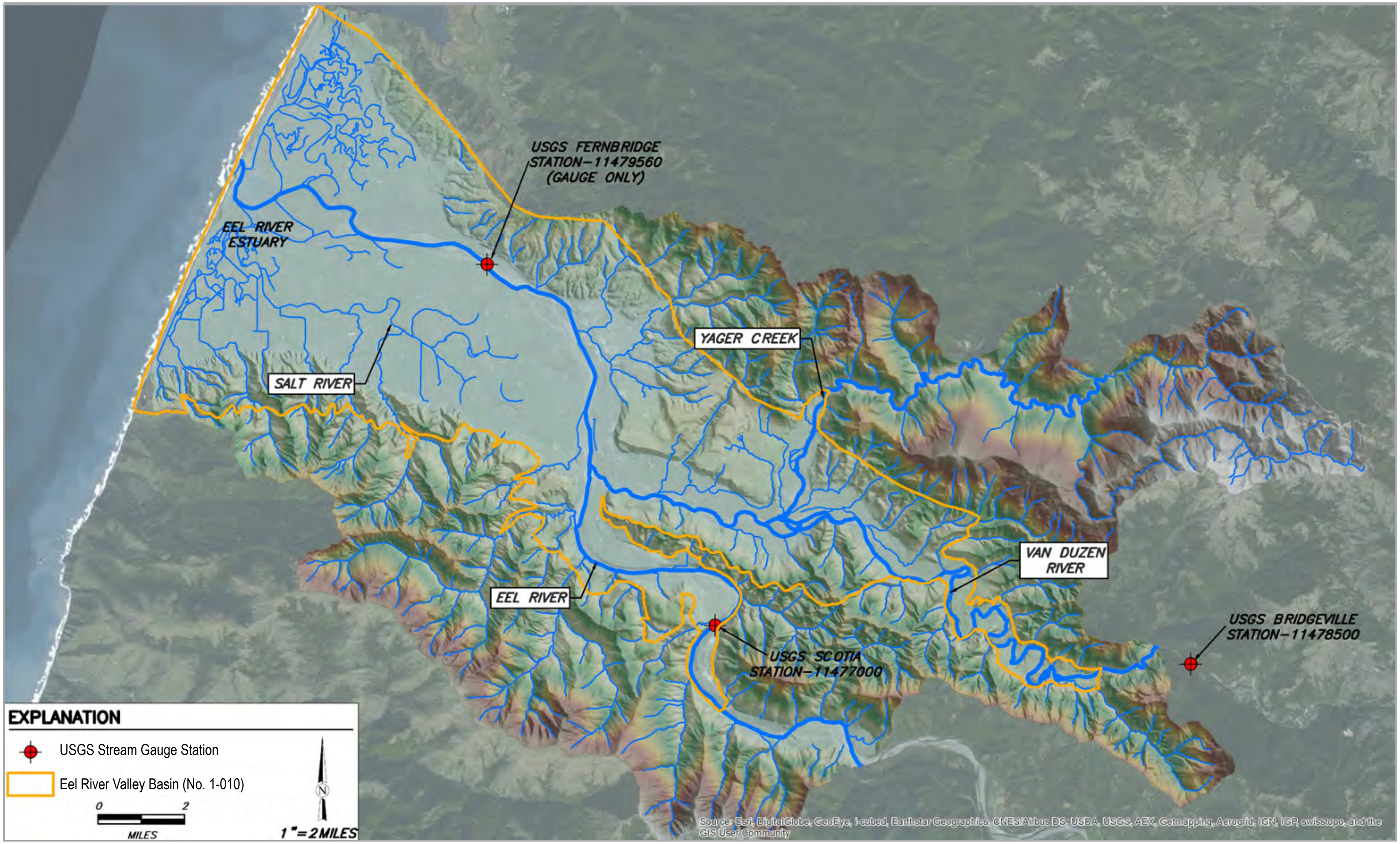

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Eel River Valley Groundwater
Sustainability Plan

Project No. **11217388**
Revision No. **-**
Date **August 2021**

Surface Waters

FIGURE 12

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