

PUBLIC DRAFT

Sutter Subbasin GSP Amendment

Chapter 5: Basin Setting

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Sutter Subbasin GSAs

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- Appendix 5-E: Wells from DWR Database, Specific Capacities, and Estimated T and K Values
- Appendix 5-F: C2VSimFG-Sutter Model Report
- Appendix 5-G: AEM Data Reprocessing

Acronyms

AEM	Aerial Electromagnetic Survey
AF	acre-feet
AFY	acre-feet per year
AZ	Aquifer zone
bgs	below ground surface
CDFW	California Department of Fish and Wildlife
CEC	constituents of emerging concern
Delta	Sacramento-San Joaquin River Delta
DTSC	Department of Toxic Substances Control
DWR	California Department of Water Resources
ETc	crop evapotranspiration
ft bgs	feet below the ground surface
GAMA	Groundwater Ambient Monitoring and Assessment
GDE	groundwater dependent ecosystem
gpm	gallons per minute
GQTMWP	Groundwater Quality Trend Monitoring Work Plan
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeologic Conceptual Model
HVA	Hydrogeological Vulnerable Area
ILRP	Irrigated Lands Regulatory Program
MAF	million acre-feet
MCL	Maximum Contaminant Level
mg/L	milligrams per liter
MSL	mean sea level
MTBE	methyl-tert-butyl ether
MW	monitoring well
NASA JPL	National Aeronautics and Space Administration Jet Propulsion Laboratory

NCCAG	National Communities Commonly Associated with Groundwater
NPL	National Priorities List
PFAS	per- and polyfluoroalkyl substances
PFOS	perfluorooctanesulfonic acid
SAGBI	Soil Agricultural Groundwater Banking Index
SDWIS	State Drinking Water Information System
SGMA	Sustainable Groundwater Management Act
SMCL	Secondary Maximum Contaminant Level
SVWQC	Sacramento Valley Water Quality Coalition
SWRCB	State Water Resources Control Board
T	transmissivity
TAF	thousand acre-feet
TDS	total dissolved solids
TNC	The Nature Conservancy
µg/L	micrograms per liter
µmhos/cm	micro mhos per centimeter
µS/cm	microSiemens per centimeter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WY	Water Year

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5. BASIN SETTING

The Basin Setting chapter contains three sections as follows:

- **Hydrogeological Conceptual Model** – The Hydrogeologic Conceptual Model (HCM) section (**Section 5.1**) provides the geologic and hydrogeologic information needed to understand how water moves through the Sutter Subbasin. This section includes information about geologic formations, aquifers, structural features, and topography.
- **Groundwater Conditions** – The Groundwater Conditions section (**Section 5.2**) describes historic groundwater conditions in the Sutter Subbasin, including data from January 1, 2015 to current conditions. Groundwater trends, groundwater levels, hydrographs, contour maps, estimated change in groundwater storage, groundwater quality issues, land subsidence, identification of interconnected surface water systems over historic conditions through present day are presented in this section. Identification of groundwater dependent ecosystems within the Sutter Subbasin is also presented in this section.
- **Water Budget** – The Water Budget section (**Section 5.3**) describes the data used to develop the required historic water budget, current water budget, and projected water budgets. This section also discusses how the water budgets were calculated as well as the sustainable yield estimate for the Sutter Subbasin.

The Basin Setting chapter serves as a basis for defining and assessing reasonable sustainable management criteria and projects and management actions. This chapter addresses required elements of the GSP Emergency Regulations Article 5. Plan Contents, Subarticle 2. Basin Setting (§354.12 – 354.18). Management areas were not established for this GSP and therefore are not addressed herein (GSP Emergency Regulations §354.20).

5.1 Hydrogeologic Conceptual Model

This section describes the HCM for the Sutter Groundwater Subbasin (Sutter Subbasin or Subbasin) in accordance with Section 354.14 of the Groundwater Sustainability Plan (GSP) Emergency Regulations. The HCM is a “big picture” framework that represents (and visualizes) the current understanding of the general physical characteristics related to regional hydrology, land use, geology and geologic structure, water quality, principal aquifers, and principal aquitards of the basin setting. The HCM also provides the context for developing water budgets, mathematical (analytical or numerical) models, and monitoring networks, and provides a tool for stakeholder outreach and communication. Specific objectives of the HCM are to:

- Provide the information necessary to evaluate sustainability within the Sutter Subbasin with regards to the six sustainability indicators.

- Provide the framework and information needed to conduct additional analyses for GSP preparation, such as development of water budget, construction of mathematical (analytical or numerical) models, and development of monitoring systems and management actions and projects.
- Develop an understanding and description of the Sutter Subbasin, specifically the structural and physical characteristics that control the flow, storage, and quality of surface and groundwater.
- Identify data gaps towards evaluation of sustainability indicators that will be used to develop investigations and data collection programs during the implementation period of the GSP.

The HCM presented in this GSP provides the current understanding of water movement and water quality through the Sutter Subbasin based on currently available public information as well as the Sutter Subbasin Alternative Plan (GEI, 2016). Updates to the HCM should be conducted as new information is obtained to ensure that sustainability of the Subbasin is maintained.

For this GSP, data supporting development of the HCM are available to the public from a variety of local, State, and federal agencies, as well as from non-governmental entities. The data presented herein were compiled from numerous studies conducted in the Subbasin. Information from several online databases that support ongoing monitoring and development of groundwater resources within the Sutter Subbasin and throughout California was amassed, evaluated, and reconfigured in support of the HCM. The following subsections present the information as outlined in the GSP Regulations.

5.1.1 Regional Geologic Setting (Reg. 354.14(b)(1))

GSP Regulations state that the HCM shall include a description of the regional and structural setting of the basin, including the immediate surrounding area, as necessary for geologic consistency. **Figure 5-1** shows the geologic map of the Sutter Subbasin.

5.1.1.1 Regional Setting and Physiography

The Sutter Subbasin is located within the Sacramento Valley Groundwater Basin (Basin Number 5-021), a large depression bounded by the Sierra Nevada to the east and the Coast Ranges to the west. Topography is generally flat along the Sacramento River Valley with elevations ranging from 80 feet above mean sea level (MSL) in the northeast corner to 20 feet above MSL in the south. The Sutter Buttes, located in the northern portion of the Subbasin, rise over 2,000 feet above the surrounding valley floor and are the only prominent topographic feature in the Subbasin. **Figure 5-2** shows the topography of the Sutter Subbasin.

Soil characteristics play a major role in cropping patterns and farming practices and influence the retention and infiltration of water and nutrients/pesticides through the subsurface. Clay and clay loam are the dominant soil type and are poorly to very poorly drained. Well drained loam to sandy loam soils may be present near the rivers.

Hydrologic grouping of the soil types and their distribution are provided in **Figure 5-3**. About 70 percent of soils in the Subbasin are characterized as having slow to very slow infiltration.

5.1.1.2 Geologic History

The Sutter Subbasin lies within the Sacramento Valley Groundwater Basin - a north-south trending structural trough filled with a sequence of westward-dipping sedimentary and volcanic deposits. These deposits exhibit a regional transition from older marine depositional environments to younger continent depositional environments (DWR, 1978).

The Sutter Subbasin also includes a local geologic complexity associated with the Sutter Buttes. In the northern and central portions of the Sutter Subbasin, volcanic activity and related uplift modified the regional stratigraphic sequence and resulted in the deposition and deformation of volcanic and volcanoclastic sediments around the Sutter Buttes. These sediments primarily consist of gravel, sand, silt, clay, volcanic ash, and other volcanoclastic deposits that form a fan-like apron around the perimeter of the Sutter Buttes (Hausback et al., 2011; Springhorn et al., 2008).

Deformation associated with the evolution of the valley trough and with emplacement of the Sutter Buttes produced the structural features that influence groundwater occurrence and movement in the Subbasin, including the Willows Fault and the localized doming and tilting of strata near the Buttes. These features are described in **Section 5.1.1.4**. The stratigraphic units deposited within this framework are described below.

5.1.1.3 Geologic Formations and Stratigraphy

Relevant stratigraphic units dip west below the basin and exhibit a regional transition from older marine depositional environments to younger continent depositional environments (DWR, 1978). Younger continental deposits, including alluvial fan, stream channel, and floodplain deposits, comprise most of the freshwater aquifer system in the Sacramento Valley. In the Sutter Subbasin, these deposits include formations associated with the Sacramento, Feather, and Yuba River systems, as well as older continental deposits that are laterally continuous across adjacent subbasins. Sediments are primarily composed of interbedded gravel, sand, silt, and clay, with groundwater generally present in the more permeable, coarse-grained intervals (Bertoldi et al., 1991; Williamson et al., 1989). Older marine and transitional deposits underlie portions of the Sacramento Valley and generally contain poorer water quality, including brackish groundwater at greater depths (Berkstresser, 1973). Because the geologic formations vary in thickness, extent, and depositional character across the Subbasin, particularly in the vicinity of the Sutter Buttes, the relationship between individual formations and the aquifer zones varies spatially, as discussed in **Section 5.1.3.2**.

The Sutter Buttes are comprised of two formations, the Andesitic Ramparts and the Rhyolitic Rampart. Previous investigations evaluated the extent of the Ramparts using surface geologic mapping, oil and gas well logs, and drilling logs. Based on these investigations, the Ramparts vary laterally and are estimated to extend 10 miles to the north, five miles to the south, five miles to the east, and four miles to the west of the Sutter Buttes. Information on the igneous formations associated with the Sutter Buttes was provided during a coordination meeting between the Sutter Subbasin GSAs and DWR staff.

The Sutter Subbasin aquifer system includes the Holocene Alluvium, Modesto, Riverbank, Turlock Lake, Laguna, Sutter Buttes Rampart, and Sutter Formations in the northern subbasin; and the Holocene Alluvium, Modesto, Riverbank, Laguna, and Sutter Formations in the southern subbasin. The subsurface extent of the Sutter Buttes Rampart formation defines the approximate boundary between the north and south subbasins and is shown in **Figure 5-1**. Unconfined and semiconfined conditions exist within the units. This leaky aquifer system has resulted in varied hydraulic connectivity between different depth zones in different areas of the Subbasin.

The stratigraphic units identified in the Subbasin, based on a synthesis of regional geologic mapping (Helley and Harwood, 1985; Harwood and Helley, 1987), the Alternative Plan (GEI, 2016), and recent coordination meeting information, are summarized in the table below and are described sequentially from the shallowest (Holocene) to the deepest (Miocene) units. This table provides the authoritative list of stratigraphic units for the principal aquifer framework; the formation-by-formation narrative that follows provides supporting detail.

Both water-bearing and non-water-bearing formations underlie the Sutter Subbasin. As described in various reports from the 1960s through the present, the Sutter Subbasin aquifer system is comprised of continental deposits of Quaternary (Recent) to Late Tertiary (Miocene) age. The identified stratigraphic units are described sequentially in **Table 5-1**, ranging from Holocene (shallower) to Miocene (deeper).

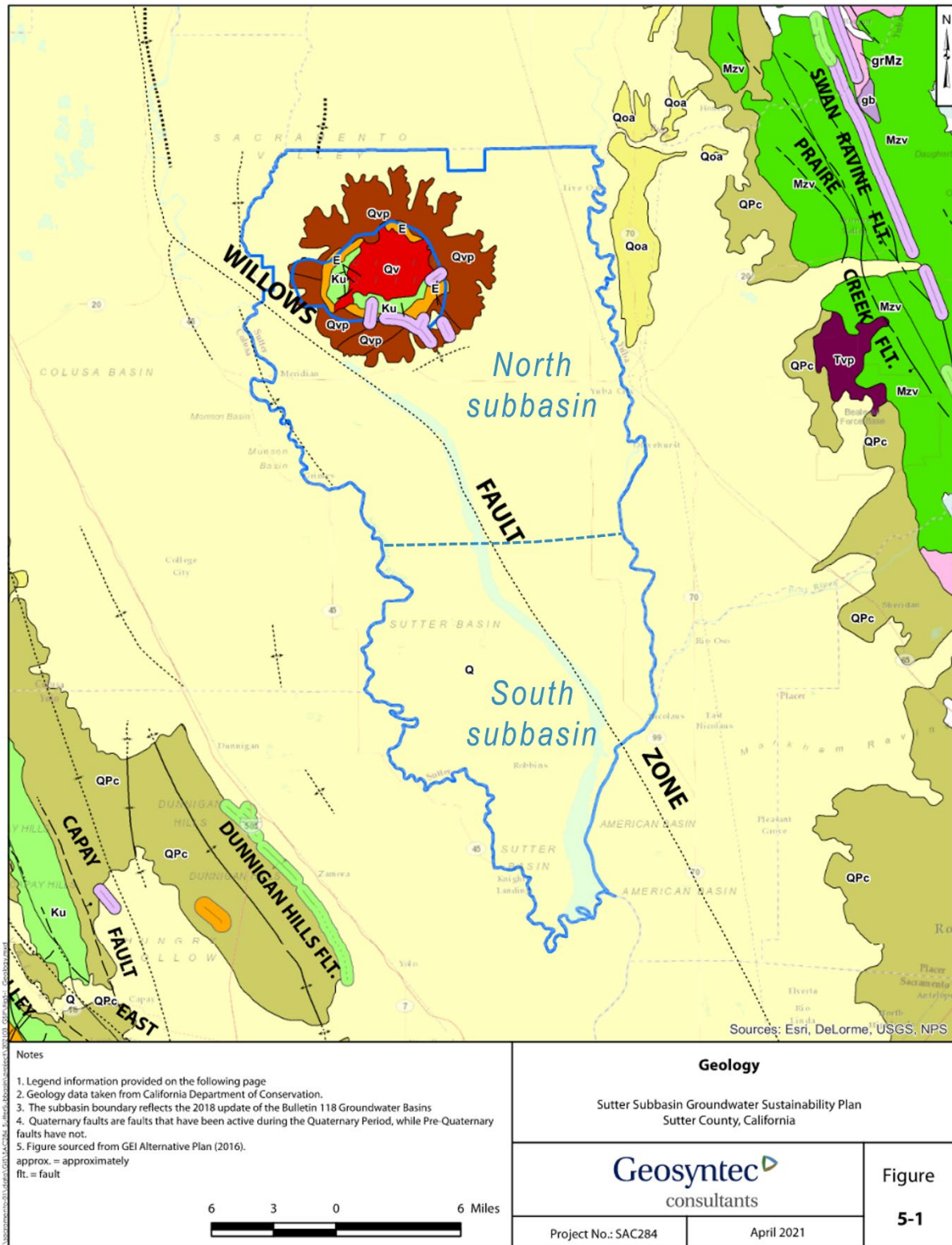


Figure 5-1. Surface Geology, Sutter Subbasin



Figure 5-1. Surface Geology, Sutter Subbasin (continued)

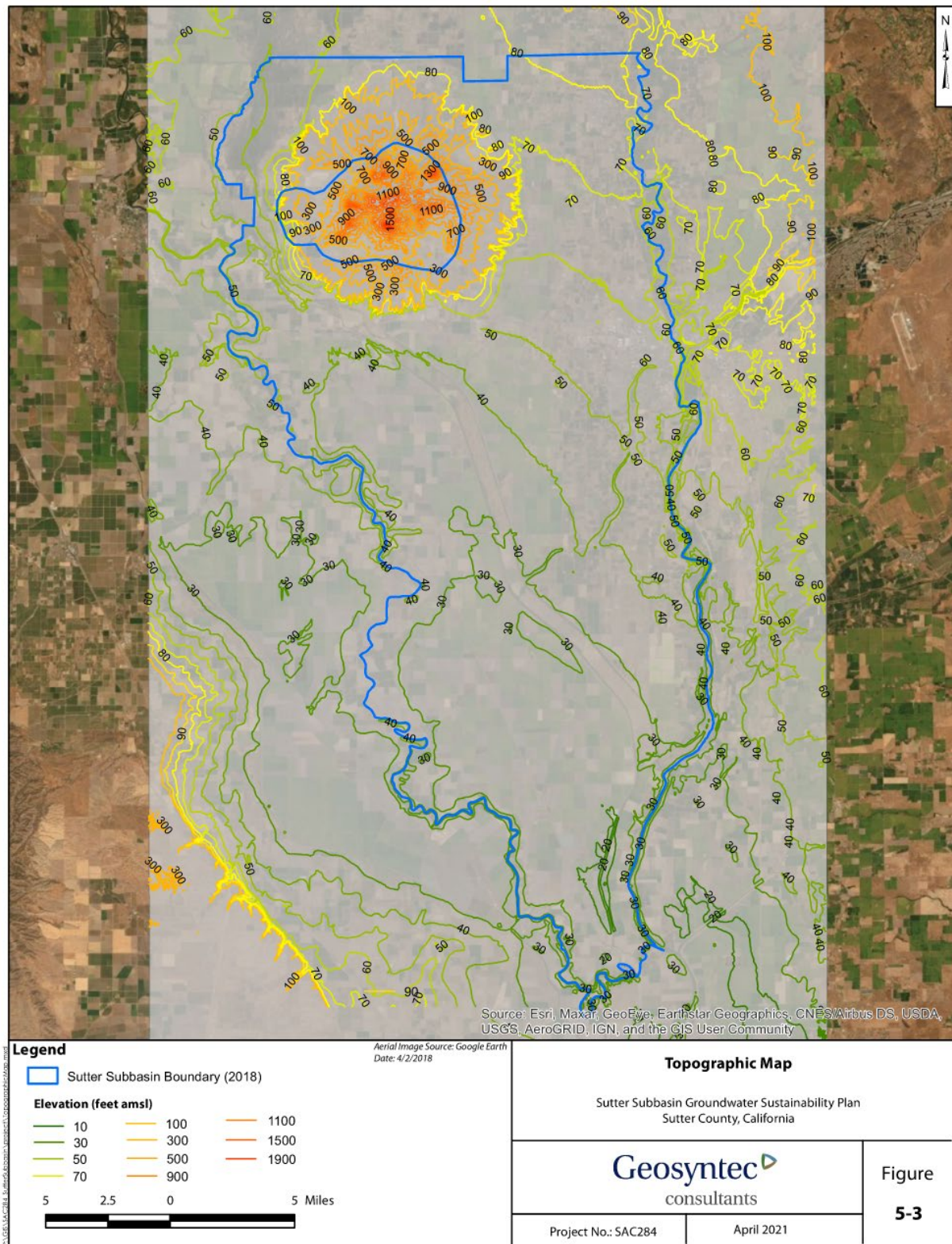


Figure 5-2. Topographic Map, Sutter Subbasin

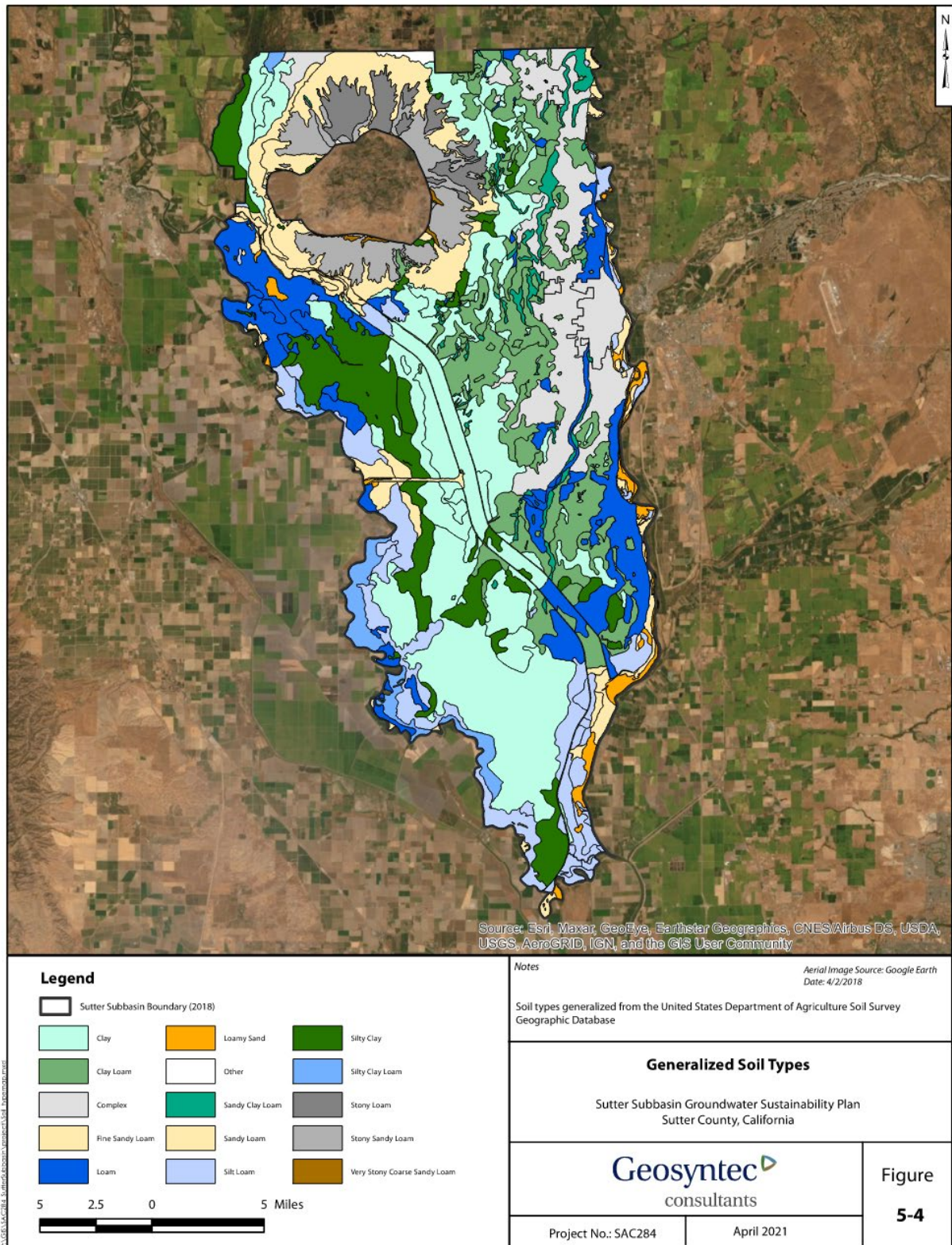


Figure 5-3. Generalized Soil Types, Sutter Subbasin

Table 5-1. Identified Stratigraphic Units in Sutter Subbasin

Geologic Epoch	Primary Formation Name	Member or Equivalent Units	Description	Hydrogeologic Characteristics – North subbasin	Hydrogeologic Characteristics – South subbasin	Geographic Extent
Holocene - Pleistocene	Alluvial Deposits	<ul style="list-style-type: none">Holocene AlluviumModestoRiverbank	<ul style="list-style-type: none">Coarse sand and gravel along present and historical stream channels of the Yuba, Feather and Sacramento Rivers.Where coarse-grained, these deposits are highly permeable and form the shallow portion of the principal aquifer.Thicknesses are variable but may be up to 100 feet near major stream channels.	<ul style="list-style-type: none">Water-bearing; high porosity and permeability where coarse-grained.Generally unconfined.Upper 50 ft. characterized as the Shallow Aquifer; deeper portion characterized as AZ-1 (see 5.1.3.2)		<ul style="list-style-type: none">Present across the Subbasin at or near ground surface
Pleistocene	Turlock Lake Formation	<ul style="list-style-type: none">Upper Turlock LakeLower Turlock Lake	<ul style="list-style-type: none">Alluvial fan deposits composed of loosely consolidated gravel, sand, silt, and clay.Lenticular beds with decreasing thickness and grain size with increasing distance from the Yuba River and Sierra Nevada foothills.Hardpan and/or claypan soils may locally reduce vertical permeability and contribute to semiconfined conditions in the Lower Turlock Lake unit.Estimated thickness of 70 feet.	<ul style="list-style-type: none">Upper Turlock Lake is water-bearing (fan sand and gravel).Upper unit characterized as AZ-1.Lower Turlock Lake unit hardpan/claypan forms the shallower low-permeability zone (semi-confining).Variable porosity/permeability.	<ul style="list-style-type: none">Not present	<ul style="list-style-type: none">A semi-continuous unit situated in the northern and central portions of the Subbasin
Pleistocene	Laguna Formation	<ul style="list-style-type: none">Not differentiated	<ul style="list-style-type: none">Lacustrine and continental deposits consisting of compacted sand, silt, and clay with hardpan in near-surface soils.Low to moderate permeability, with groundwater present in more permeable sandy intervals.Thickness is variable; averaging approximately 300 feet but is estimated to be up to 1,000 feet along the valley axis.	<ul style="list-style-type: none">Aquifer where overlying Sutter Buttes Rampart; characterized as AZ-2A.Water-bearing in sandy intervals; low to moderate permeability overall.	<ul style="list-style-type: none">Aquifer with multiple confining layersWater-bearing in sandy intervals; low to moderate permeability overall.Upper water-bearing intervals associated with AZ-2B.Lower water-bearing intervals associated with AZ-3.	<ul style="list-style-type: none">Present across the Subbasin, but depth and thickness vary laterally. The Laguna Formation may occur within more than one aquifer zone interval depending on location.
Pleistocene	Sutter Buttes Rampart	<ul style="list-style-type: none">Andesitic RampartRhyolitic Rampart	<ul style="list-style-type: none">Volcanic and volcanoclastic deposits associated with the Sutter Buttes, including gravel, sand, silt, clay, and volcanic ash.Reflects multiple stages of volcanic activity, deposition, and erosion around the Sutter Buttes.Thickness is variable; averaging approximately 400 feet but can be up to 600 feet thick in closer proximity to the Sutter Buttes.	<ul style="list-style-type: none">Local aquitard (~50 ft. thick) overlying aquifer zone AZ-3.Permeability highly variable.	<ul style="list-style-type: none">Not present	<ul style="list-style-type: none">Laterally variable and associated solely within the north and central portions of the Subbasin near the Sutter Buttes.Previous investigations indicate that Rampart units form an apron around the Buttes and extend several miles from the center of the Sutter Buttes.

Geologic Epoch	Primary Formation Name	Member or Equivalent Units	Description	Hydrogeologic Characteristics – North subbasin	Hydrogeologic Characteristics – South subbasin	Geographic Extent
Miocene-Pliocene	Sutter Formation	<ul style="list-style-type: none">TuscanMehrtenValley SpringsUpper Princeton Valley Fill	<ul style="list-style-type: none">Informally named stratigraphic unit used in the Sutter Subbasin to describe deeper continental and volcanoclastic deposits where regional formation boundaries are complex.Includes alluvial–fluvial deposits and volcanoclastic deposits interbedded with basaltic or andesitic materials.Permeable intervals include gray to black, well-sorted fluvial andesitic sand and gravel lenses; lower permeability layers include clay, silt, and tuff-breccia that create semi-confined to confined conditions.Thickness ranges from approximately 200 feet to over 1,000 feet along the axis of the valley.	<ul style="list-style-type: none">Deepest freshwater-bearing unit; water-bearing in well-sorted sand and gravel lenses.Interbedded clay, silt, and tuff-breccia create semi-confined to confined conditions.Characterized as AZ-3 with overlying Sutter Buttes Rampart and Laguna Formations	<ul style="list-style-type: none">Deepest freshwater-bearing unit; water-bearing in well-sorted sand and gravel lenses.Interbedded clay, silt, and tuff-breccia create semi-confined to confined conditions.Characterized as AZ-3 with lower parts of the overlying Laguna Formations	<ul style="list-style-type: none">Present across the Subbasin below the Sutter Buttes Ramparts in the northern and central portions of the Subbasin and below the Laguna Formation in the southern portion of the Subbasin.
Miocene-Pliocene	Lovejoy Basalt	<ul style="list-style-type: none">Not differentiated	<ul style="list-style-type: none">Basaltic lava flows associated with the broader Valley Springs volcanic sequence.A relatively low-permeability unit where unfractured, although fractured zones may locally transmit groundwater.	<ul style="list-style-type: none">Aquitard; generally non-water-bearing.Low-permeability basaltic lava where unfractured.Fractured zones may locally transmit groundwater.Not a productive aquifer.		<ul style="list-style-type: none">Present across the Subbasin below the Sutter Formation
Miocene	lone Formation	<ul style="list-style-type: none">Not differentiated	<ul style="list-style-type: none">Continental deposits that are part of the broader Sacramento Valley fill sequence and includes gravels, sand, silt, clay, and tuffaceous sediments.Groundwater quality and permeability are variable, and the formation generally occurs below the base of freshwater-bearing formations.	<ul style="list-style-type: none">Aquitard; generally non-water-bearing.Low-permeability basaltic lava where unfractured.Fractured zones may locally transmit groundwater.Not a productive aquifer.		<ul style="list-style-type: none">Present across the Subbasin below the Lovejoy Basalt
Miocene	Capay Formation	<ul style="list-style-type: none">Not differentiated	<ul style="list-style-type: none">Marine to transitional marine–continental deposits representing early valley fill.This formation includes fine-grained deposits and tuff-breccias and is generally associated with poorer water quality compared to the overlying freshwater-bearing formations.	<ul style="list-style-type: none">Non-water-bearing (marine).Fine-grained; poorer water quality.Below the base of freshwater and excluded from the principal aquifer; effectively a basal confining unit.		<ul style="list-style-type: none">Present across the Subbasin below the lone Formation

Alluvial deposits are present across the Subbasin at or near ground surface and contain coarse sand and gravel deposited from the present-day Yuba, Feather, and Sacramento Rivers. Alluvial deposits are up to 100 feet thick and coarse-grained near riverbeds (Harwood and Helley, 1987) and decrease in thickness and grain size further from riverbeds. These sediments are highly permeable and provide areas where groundwater can be recharged. Wells in these areas can yield from 2,000 to 4,000 gallons per minute (gpm; DWR, 2006). Alluvial deposits consist of the Holocene Alluvium, Modesto Formation, and Riverbank Formation:

- **Holocene Alluvium** is characterized by unconsolidated sediments deposited during the Holocene epoch, primarily by the Yuba, Feather and Sacramento Rivers. This formation is characterized by loose to moderately compacted, fine to medium sand, silt and clay that may be interbedded with older alluvium.
- The **Modesto** Formation is characterized mostly by gravels, cobbles, and sand with some silt and clay. GEI (2016) designated sediments representing this formation from the ground surface to about 70 to 120 feet below ground surface (bgs) just to the west of Yuba City, near SEWD MW-1, and indicated the formation is thicker to the south and thins to the north with beds that are generally flat-lying.
- The **Riverbank** Formation underlies the Modesto Formation and contains silts and clays with 10- to 20-foot-thick sand and gravel layers. The sand and gravel beds of the Riverbank Formation are thinner and less laterally extensive than those of the overlying Modesto Formation. Similar to the Modesto Formation, the Riverbank Formation is thicker to the south, and thins closer to the Sutter Buttes, with beds that are generally flat (GEI, 2016).

The **Turlock Lake Formation** is a mixed aquifer/local aquitard roughly 70 feet thick. The Upper Turlock Lake unit is water-bearing and contains loosely consolidated gravel, sand, silt, and clay. The lower unit includes hardpan/claypan soils that locally reduce vertical permeability and contribute to semiconfined conditions.

The **Laguna** Formation occurs above the **Sutter Buttes Rampart** and is unconformably overlain by the Upper Turlock Formation in the northern and central portions of the Subbasin, and by the Riverbank Formation in the southern portion of the Subbasin. The formation consists of sandy gravel channel facies, sandy channel facies, and sandy clay to clay floodplain facies (Blair et al., 1991). The Alternative Plan placed the Nomlaki Tuff Member, an upper Pliocene, white, pumice-rich, water-lain vitric tuff, as the base of the Laguna Formation, consistent with Busacca et al. (1989). As cited in Blair et al. (1991), others have placed the Nomlaki Tuff as the top of the Mehrten or Tuscan Formations. Blair et al. (1991) isolated this unit as a formal formation because it is easily identifiable in drilling samples and separates the Laguna Formation from the underlying volcanic rich sediments of the Mehrten and Tuscan Formations. The Laguna Formation

thickness ranges in the Subbasin region from around 80 feet to up to 1,000 feet along the valley axis.

The **Sutter Buttes Rampart** geologic unit is present in the north-central portion of the Subbasin and reflects multiple stages of volcanic activity, deposition, and erosion around the Sutter Buttes. This unit contains volcanic debris shed off the Sutter Buttes in a radial pattern. The volcanic debris consists of gravel, sand, silt, clay, and volcanic ash. Thickness averages approximately 400 feet but can be up to 600 feet thick in closer proximity to the Sutter Buttes. The gamma log signature of the Sutter Butte Rampart has a recognizable and correlative “kick,” which is more distinct near the Sutter Buttes. Few wells in the area use this formation for water supply.

The **Sutter Formation** is an informally named stratigraphic unit used in the Sutter Subbasin to describe deeper continental and volcanoclastic deposits where regional formation boundaries are complex. It includes alluvial–fluvial deposits and volcanoclastic deposits interbedded with basaltic or andesitic materials. Thickness ranges from approximately 200 feet to over 1,000 feet along the axis of the valley. Permeable intervals include gray to black, well-sorted fluvial andesitic sand and gravel lenses; lower permeability layers include clay, silt, and tuff-breccia that create semi-confined to confined conditions. The Sutter Formation encompasses regionally recognized units that are difficult to differentiate in the Subbasin subsurface - the Tuscan, Mehrten, Valley Springs, and Upper Princeton Valley Formations:

- The **Mehrten** Formation and its stratigraphic correlative to the north **Tuscan** Formation consist of purple volcanic debris-flow deposits and interbedded water-lain fluvial deposits rich in volcanic detritus but also containing Sierran crystalline basement-derived clasts and rare tuff beds (Blair et al., 1991). The occurrence of both channel-lain, clast supported, gravel-facies and interbedded volcanic rich debris flows in these formations suggests that debris flows, probably related to volcanic events, episodically choked the ancestral river systems in the area.
- The **Valley Springs** Formation of the Sierra Nevada, located greater than 2,000 feet deep in the Sacramento Valley or found shallower near the eastern margin of the valley, consists of tan, white, and green rhyolitic fragments and is the equivalent to the Princeton Valley Fill defined by Springhorn (2008). The Valley Springs Formation was originally included in the Lone Formation as the “clay rock or tuff,” the highest of three subdivisions of the Lone (United States Geological Survey [USGS], 2007). Bartow (1992) recognized the fundamental lithologic difference between the Lone proper and the “clay rock and tuff,” and noted that the two units are separated by a disconformity. The Valley Springs Formation was formally defined by Gale et al. (1939) from a type section near the town of Valley Springs in Calaveras County.
- The Alternative Plan has interpreted the presence of a unit referred to as the **Upper Princeton Valley Formation**. As defined by Redwine (1972), the

Princeton Submarine Valley System is a morphological feature of the ancestral Sacramento River Basin and contains the geologic formations described below. For example, the lone Formation is used by Redwine (1972) to separate the lower and upper Princeton Valley fills, and the Lovejoy Basalt is interpreted to represent the rimrock of the upper Princeton Valley Fill. As stated above, the Sutter Formation has also been designated to consist of several of these units. For this GSP, the nomenclature of Upper Princeton Valley Formation or Fill is not used unless referring to the morphological feature defined by Redwine (1972).

The **Lovejoy Basalt** contains basaltic lava flows associated with the broader Valley Springs volcanic sequence. It is generally low-permeability where unfractured, although fractured zones may locally transmit groundwater.

The **lone Formation** contains continental deposits of gravel, sand, silt, clay, and tuffaceous sediments that are part of the broader Sacramento Valley fill sequence. Groundwater quality and permeability are variable, and the formation generally occurs below the base of freshwater-bearing formations.

The **Capay Formation** contains marine to transitional marine-continental deposits representing early valley fill. It includes fine-grained deposits and tuff-breccias and is generally associated with poorer water quality compared to the overlying freshwater-bearing formations.

Upper Cretaceous marine formations underlie the freshwater-bearing units across the Subbasin and are the source of natural gas produced in the region; the locations of gas exploration borings and wells, which provide deep subsurface control for the Subbasin, are shown in **Figure 5-4**. One of these units, the Starsky Sands, is not exposed at ground surface but is projected to be in contact with the freshwater aquifer within the Sutter Subbasin. All of the formations and sediments described above are underlain by igneous rocks associated with the Sutter Buttes, or by igneous and metamorphic basement rocks.

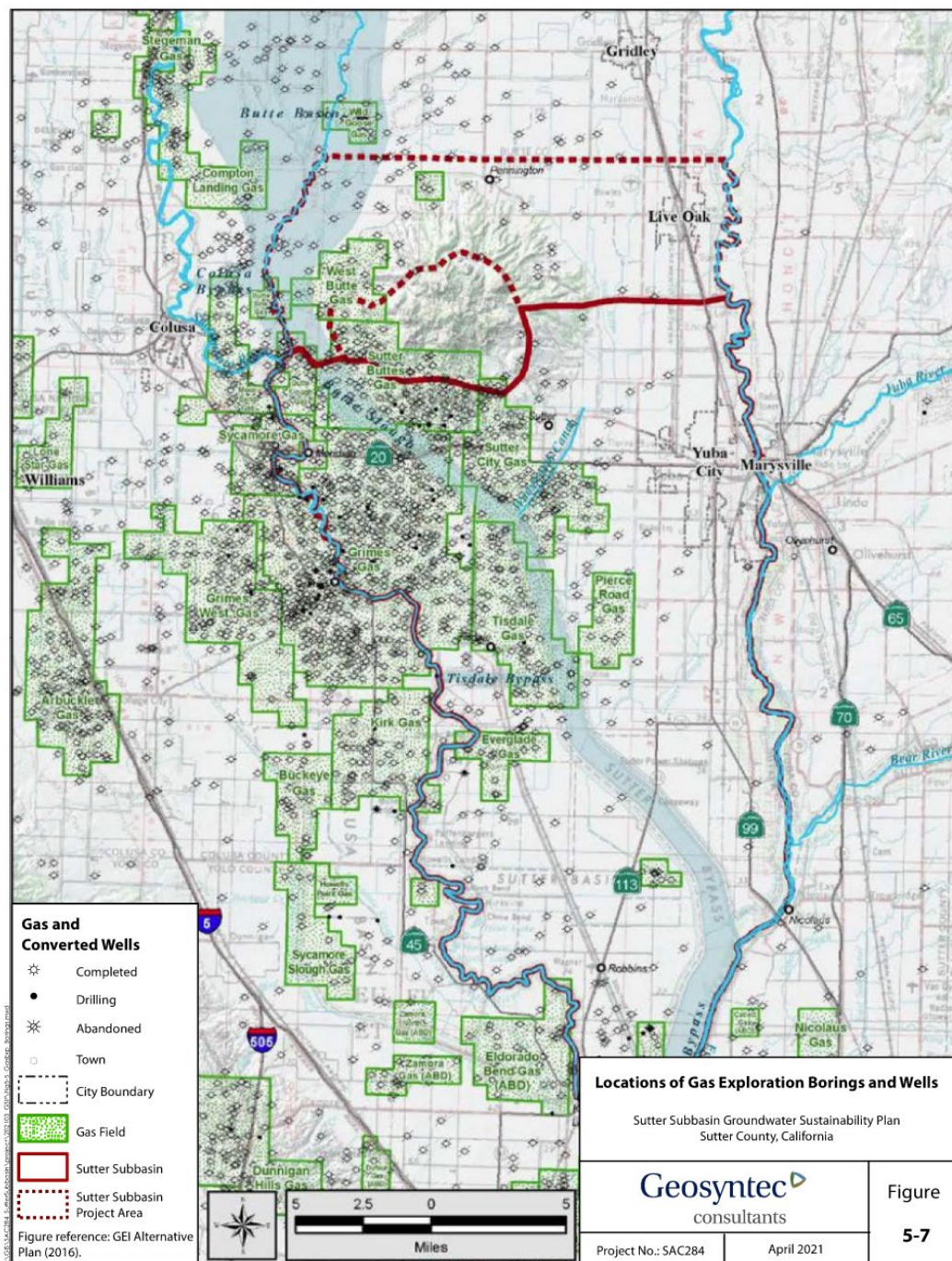


Figure 5-4. Gas Exploration Borings and Wells Locations¹

¹ Figure sourced from Sutter Subbasin Alternative Plan (GEI, December 2016), reflecting basin boundaries as of Alternative Plan development. A Basin Boundary Modification Request was approved by DWR in 2019 consolidating the East Butte Subbasin ("Sutter Subbasin Project Area") with the Sutter Subbasin as well as minor jurisdictional boundary modifications. Such boundary modifications have not resulted in material changes that would alter understanding of basin conditions.

5.1.1.4 Faults and Structural Features (Reg. 354.14(b)(2), (b)(4))

Two structural features directly or indirectly affect groundwater flow in the Subbasin: (1) the Sutter Buttes and (2) the Willows Fault. The Sutter Buttes impacts the Subbasin's groundwater flow by separating or limiting the direct hydraulic connection between different aquifer zones, resulting in groundwater flow patterns that are more localized and less interconnected across the butte area. Additionally, due to its impermeable nature, the Sutter Buttes reduces direct recharge from precipitation into the underlying aquifer system. As such, the buttes focus or deflect recharge toward the valley flows and alluvial deposits along the Subbasin's rivers and streams, where recharge primarily occurs.

The Willows Fault is the primary fault structure within Sutter County. The fault was discovered in the 1950s during the development of a nearby gas field and lies to the southwest and west of the Sutter Buttes. The fault is active and northwest-trending with a 74 degree or steeper dip to the northeast and exhibits approximately 1,610-feet of reverse displacement, indicating the ground east of the fault has moved up relative to the west side (Redwine, 1972). The Willows Fault enters into Sutter County from Colusa County, southwest of the Sutter Buttes, and extends to the southeast portion of the Subbasin towards Sacramento, presumably following the boundary between the ophiolite basement of the west and the Sierran basement to the east (Harwood and Helley, 1987). **Figure 5-5** presents a cross-section developed by Harwood and Helley (1987) showing offset of the Willows Fault within the Subbasin. One primary concern with the Willows Fault is how it may affect groundwater flow in the Sutter Subbasin. In one way, the fault can act as a conduit for the movement of groundwater between the Sutter Subbasin and the adjoining subbasins. In others, the fault can act as a barrier, blocking the lateral movement of groundwater. In all, the fault can change groundwater flow direction due to the orientation and dip of the fault. As shown in Bulletin 118-6, *Evaluation of Ground Water Resources: Sacramento Valley*, the base of freshwater rises close to 400 feet below the ground surface in the area of the Sutter Buttes (DWR, 1978); this could potentially result in connate marine water underlying the base of freshwater to move upward along the fault zone.

5.1.1.5 Geologic Profiles

Geologic profiles (cross-sections) are discussed and presented to illustrate the relationships and distribution of the formations and coarse-grained sediments that constitute principal aquifers. The locations of these profiles are shown in **Figure 5-6**.

East-west geologic profiles (Springhorn, 2008) across the northern Subbasin boundary and along the Sutter and Butte County lines where inflow to the Subbasin occurs are provided in **Figure 5-7** and **Figure 5-8**. **Figure 5-9** shows a regional north-south profile. **Figure 5-10** shows a regional east-west profile. **Appendix 5-A** contains the well logs used to create these geologic profiles. **Appendix 5-G** contains cross-sections resulting from the reprocessing of the DWR's aerial electromagnetic (AEM) survey data.

In addition to these geologic profiles, geotechnical investigations (to depths of up to 140 feet) have been performed along significant portions of the Feather and Sacramento River levees, along the east and west sides of the Subbasin. Profiles were developed along the Sutter Bypass levees, located in the central portion of the basin. The investigations show sediment types where groundwater and surface water interactions occur, and where the river (bathometric elevations) incised partially or entirely through coarse-grained sediments that make up the shallow aquifer zone. They also show where slurry walls have been constructed and where they are planned. **Appendices 5-B** through **5-D** provide these geologic profiles for each of the rivers and the bypass. These sections do not contain a breakout of the geologic formations but in general, depending upon the location, would include Alluvium, Modesto, Riverbank, and Turlock Lake Formation.

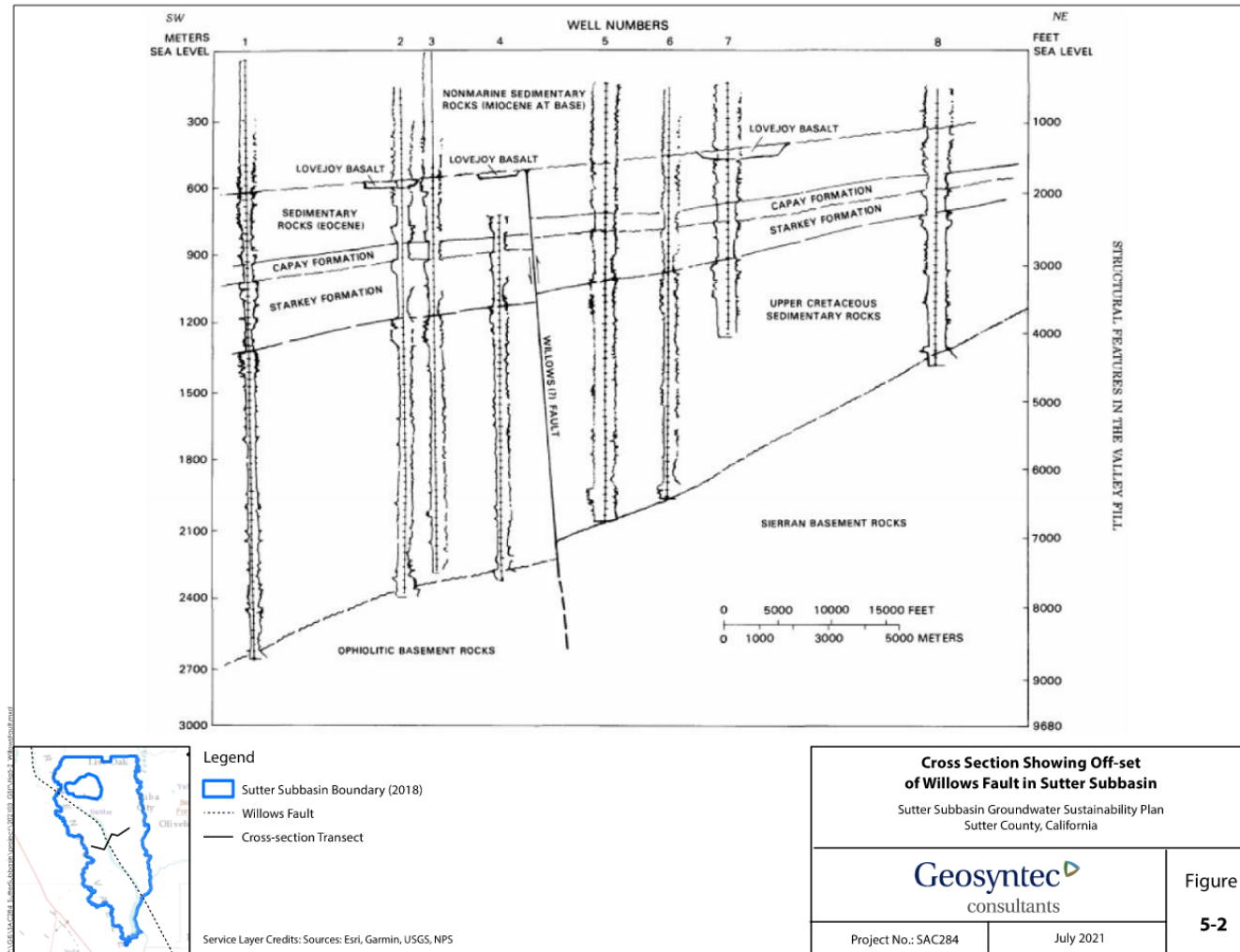


Figure 5-5. Willows Fault Cross-Section

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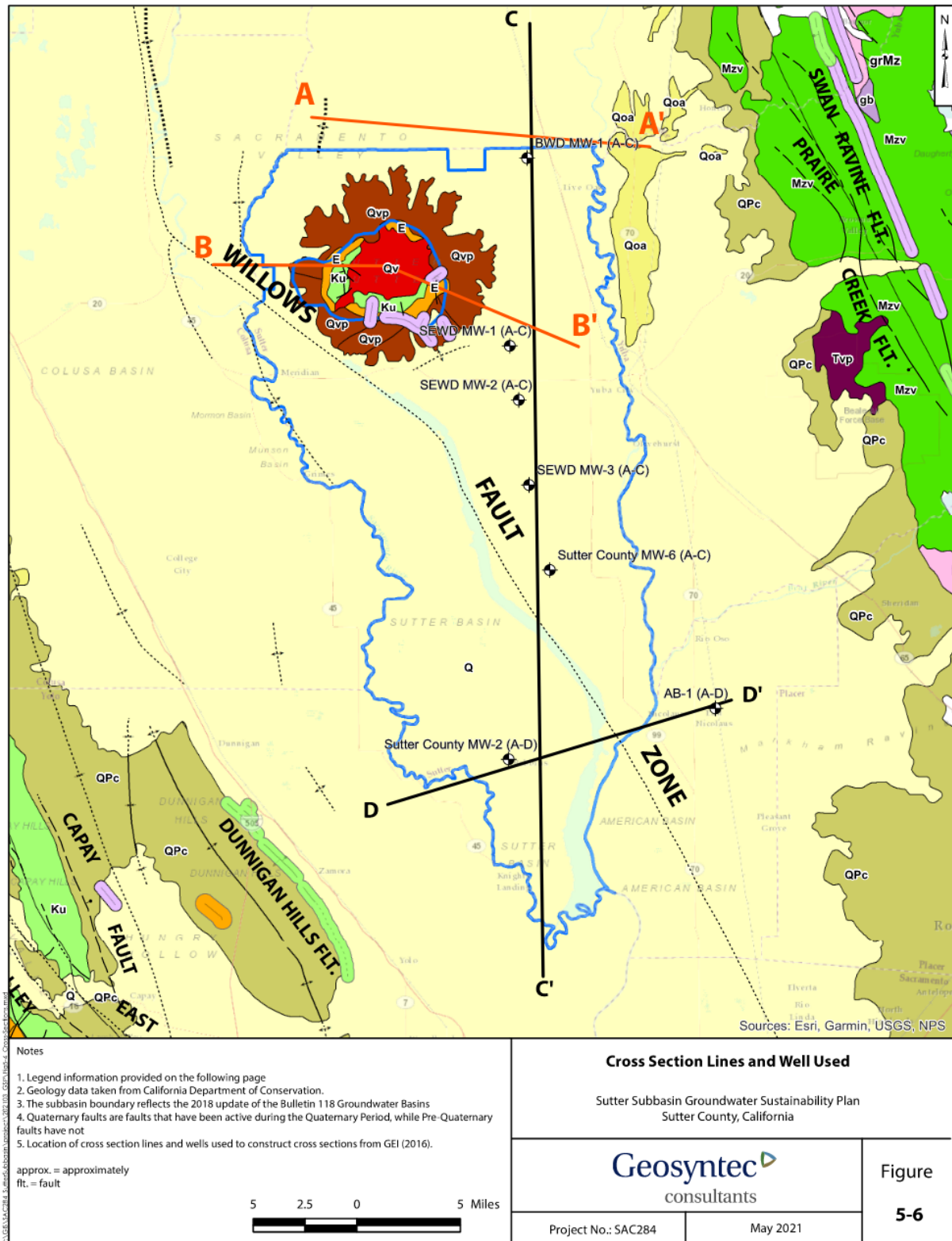


Figure 5-6. Cross-Section Lines and Well Boring Locations

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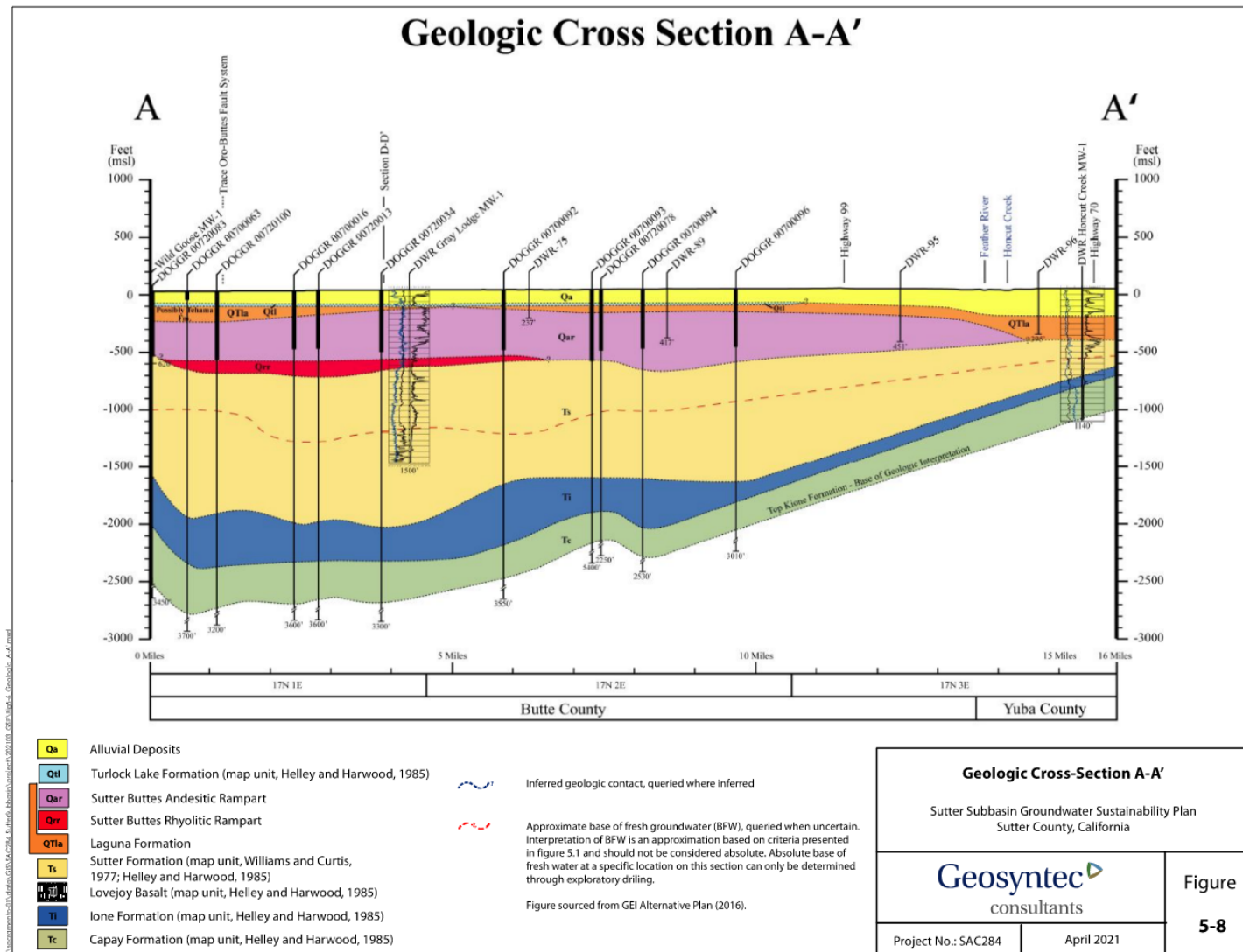


Figure 5-7. Geologic Cross-Section A-A'

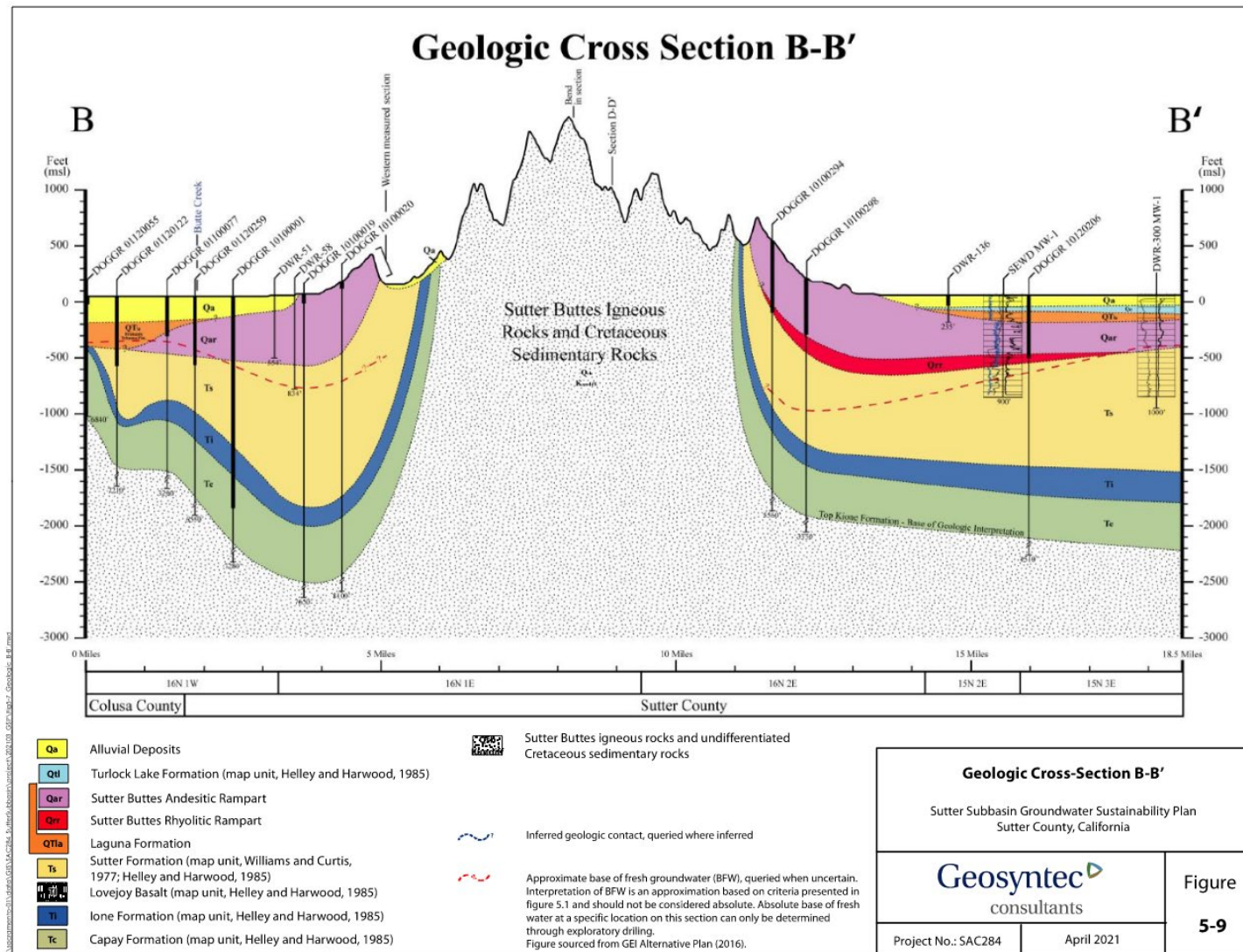


Figure 5-8. Geologic Cross-Section B-B'

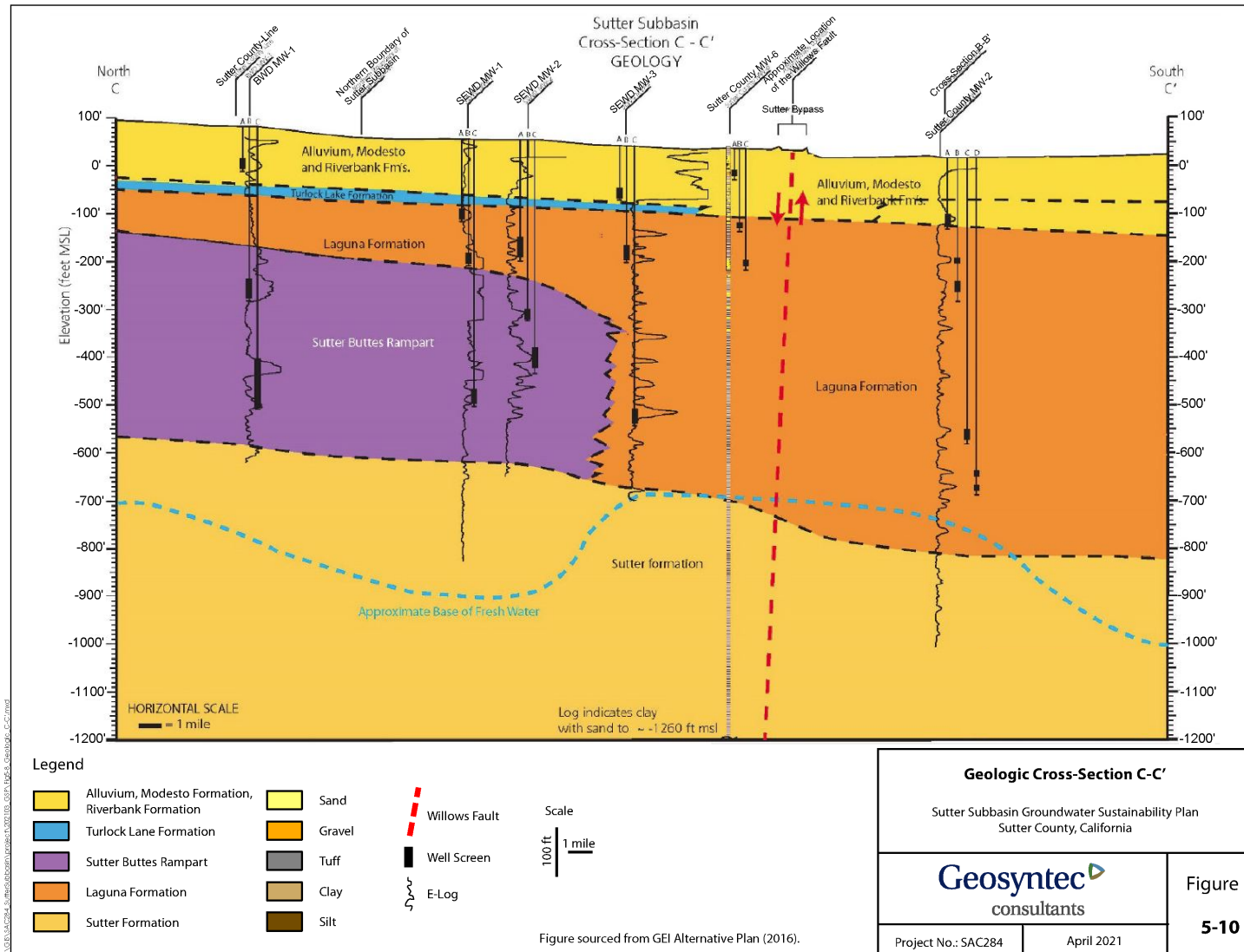
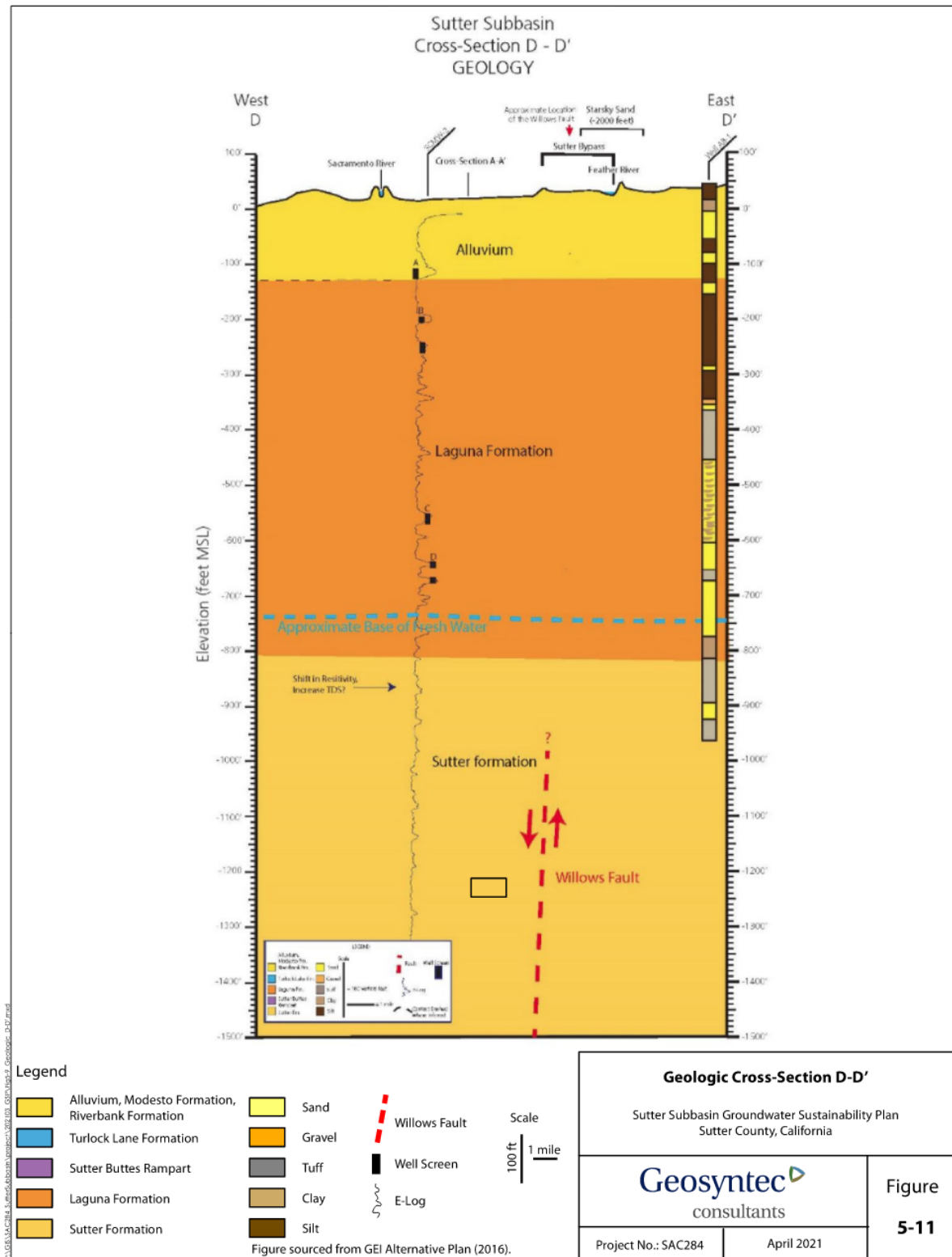


Figure 5-9. Geologic Cross-Section C-C'

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**Figure 5-10. Geologic Cross-Section D-D'**

5.1.2 Basin Geometry and Boundaries

5.1.2.1 Lateral Basin Boundaries (Reg. 354.14(b)(2))

The lateral boundaries of the Sutter Subbasin are defined on the north by the confluence of Butte Creek and the Sacramento River and the Sutter Buttes, on the west by the Sacramento River, on the south by the confluence of the Sacramento River and the Sutter Bypass, and on the east by the Feather River (DWR, 2006). The hydrologic rationale for these boundaries is that the rivers are, or may be, coincidental with groundwater divides (boundary zones of either converging or diverging groundwater flow) and the low-permeability Sutter Buttes rampart creates a barrier to groundwater flow at their contact with the alluvial sediments in the Subbasin.

The modified Subbasin extents have been defined as the jurisdictional boundaries of Sutter County such that:

- The northern subbasin boundary is the County boundary between Sutter and Butte Counties, except for the portion of the Biggs-West Gridley Water District GSA that is within Sutter County, and the County boundary between Sutter and Yuba Counties, except for the portion of the Yuba County Water Agency GSA that is within Sutter County.
- The eastern boundary is the County boundary between Sutter and Yuba Counties.
- The southern boundary is the Boundary between the Sutter Subbasin and the North American Subbasin within Sutter County coincident with the South Yuba Subbasin.
- The western boundary is the County boundary between Sutter and Colusa Counties except for the portion of the RD1004 GSA that is within Sutter County (as requested in adjacent modification requests).

5.1.2.2 Definable Bottom of Basin (Reg. 354.14(b)(3))

The vertical extent of the Sutter Subbasin is generally defined as the base of groundwater that can also be chemically defined as the base of freshwater. Berkstresser (1973) defines the base of freshwater in the Sacramento Valley as fresh water characterized by an electrical conductivity measurement of less than 3,000 micromhos or approximately 2,000 milligrams per liter (mg/L) total dissolved solids (TDS) (**Figure 5-11**). The physical base of the Sutter Subbasin is the basement complex, a continuation of the Sierra Nevada fault block that has been tilted towards the southwest (Curtin, 1971). The approximate bottom of the basin is also illustrated in the geologic cross sections discussed in **Section 5.1.1.5**.

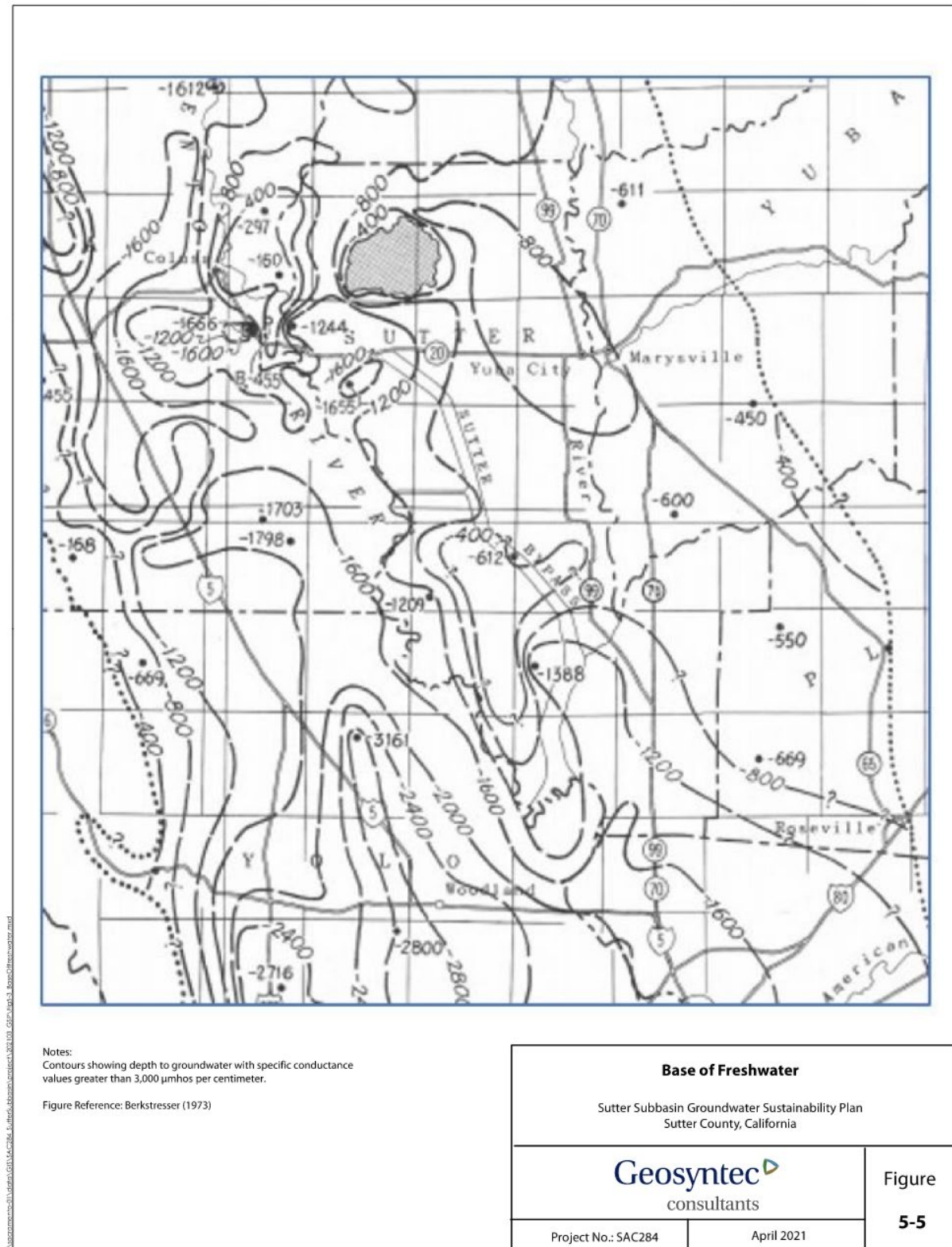


Figure 5-11. Base of Freshwater (Berkstresser, 1973)

5.1.3 Regional Hydrogeology (Reg. 354.14(b)(4))

5.1.3.1 Principal Aquifers and Aquitards

The Sutter Subbasin is underlain by one principal aquifer composed of freshwater-bearing continental deposits of Quaternary and late Tertiary age. These deposits include alluvial, lacustrine, and volcanic materials that vary in thickness, permeability, and degree of confinement across the Subbasin. The cumulative thickness of the deposits that comprise the principal aquifer generally increases from the eastern boundary of the Sutter Subbasin toward the valley axis and western boundary.

As described in this GSP Amendment, the principal aquifer is defined as the aquifer system occurring above the base of freshwater previously determined in the Subbasin (Berkstresser, 1973). The base of freshwater is the lowest vertical extent of the Subbasin's and GSAs' managed groundwater system. Groundwater below this base of freshwater is generally brackish and unsuitable for potable or agricultural use without treatment; as such, geologic units below the base of freshwater are not considered part of the Sutter Subbasin's principal aquifer.

5.1.3.2 Aquifer Zone Framework

The principal aquifer is described using aquifer zones that represent hydrostratigraphic and management intervals within the Subbasin. These aquifer zones are also used to support groundwater level monitoring and applicable sustainable management criteria. The aquifer zones are not intended to represent laterally continuous, formation-bound aquifers across the entire Subbasin. This framework is based on the stratigraphic units described in **Section 5.1.1.3**, low permeability intervals, well construction information, and groundwater level responses observed in multi-completion wells. Because the geologic formations vary spatially, particularly near the Sutter Buttes, the relationship between individual formations and aquifer zones vary by location. As a result, the GSP Amendment uses aquifer zones as intervals within the principal aquifer that vary spatially across the Subbasin, rather than as separate aquifers or fixed formation-based units.

Figure 5-12 and **Figure 5-13** provide hydrostratigraphic cross-sections constructed as part of the Alternative Plan that illustrate the vertical and lateral extent of each of the aquifer zones interpreted from the geology, electric log responses, groundwater levels, and water quality.

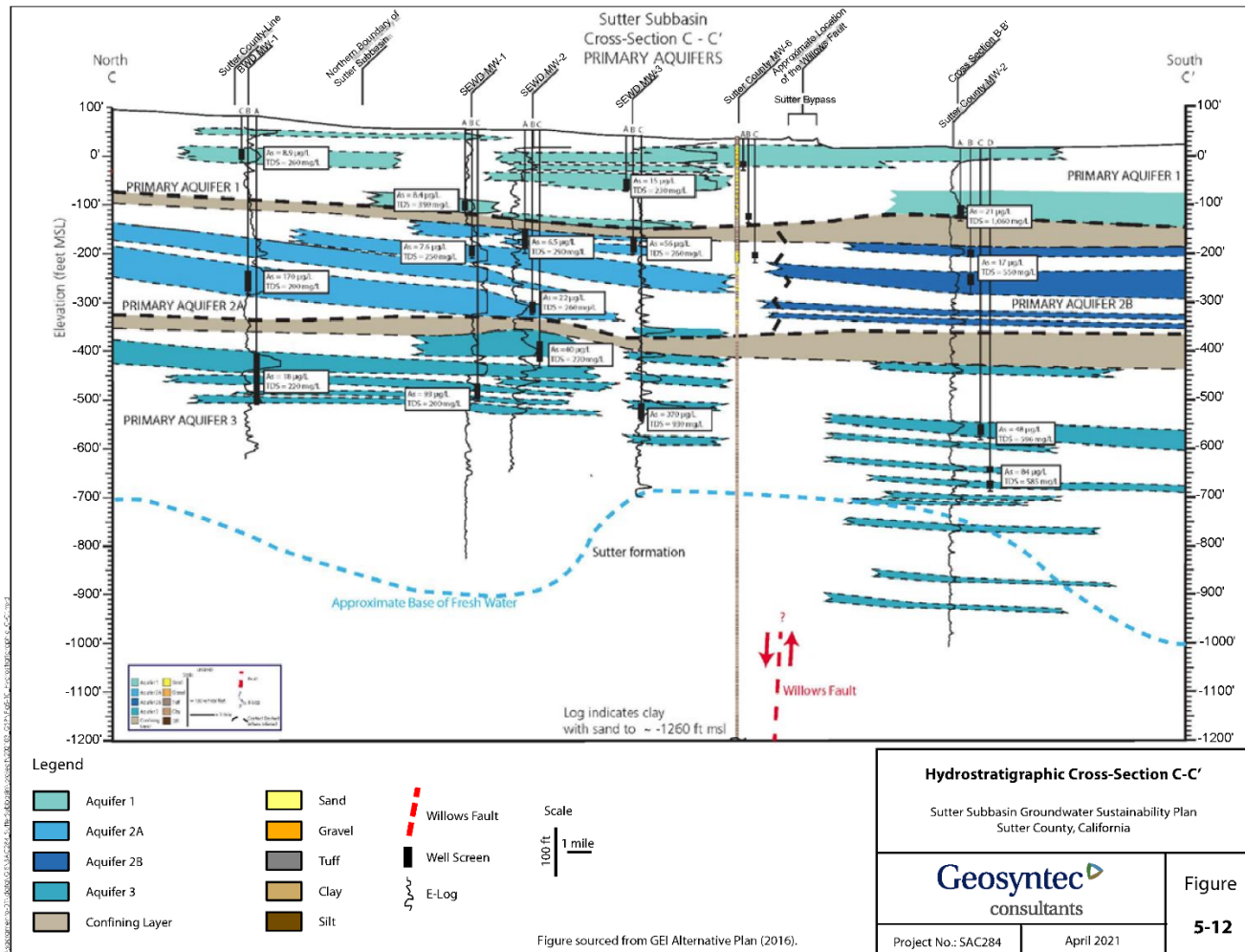


Figure 5-12. Hydrostratigraphic Cross-Section C-C'¹

¹ Some geologic formations that comprise AZ-3, including the Sutter Formation, may continue below the base of fresh water. Where these formations extend below this boundary, the deeper portions are considered part of the regional geologic framework but are not included in the principal aquifer managed by the GSAs. Therefore, the base of fresh water, rather than the base of any individual geologic formation, defines the bottom of the Subbasin for GSP implementation.

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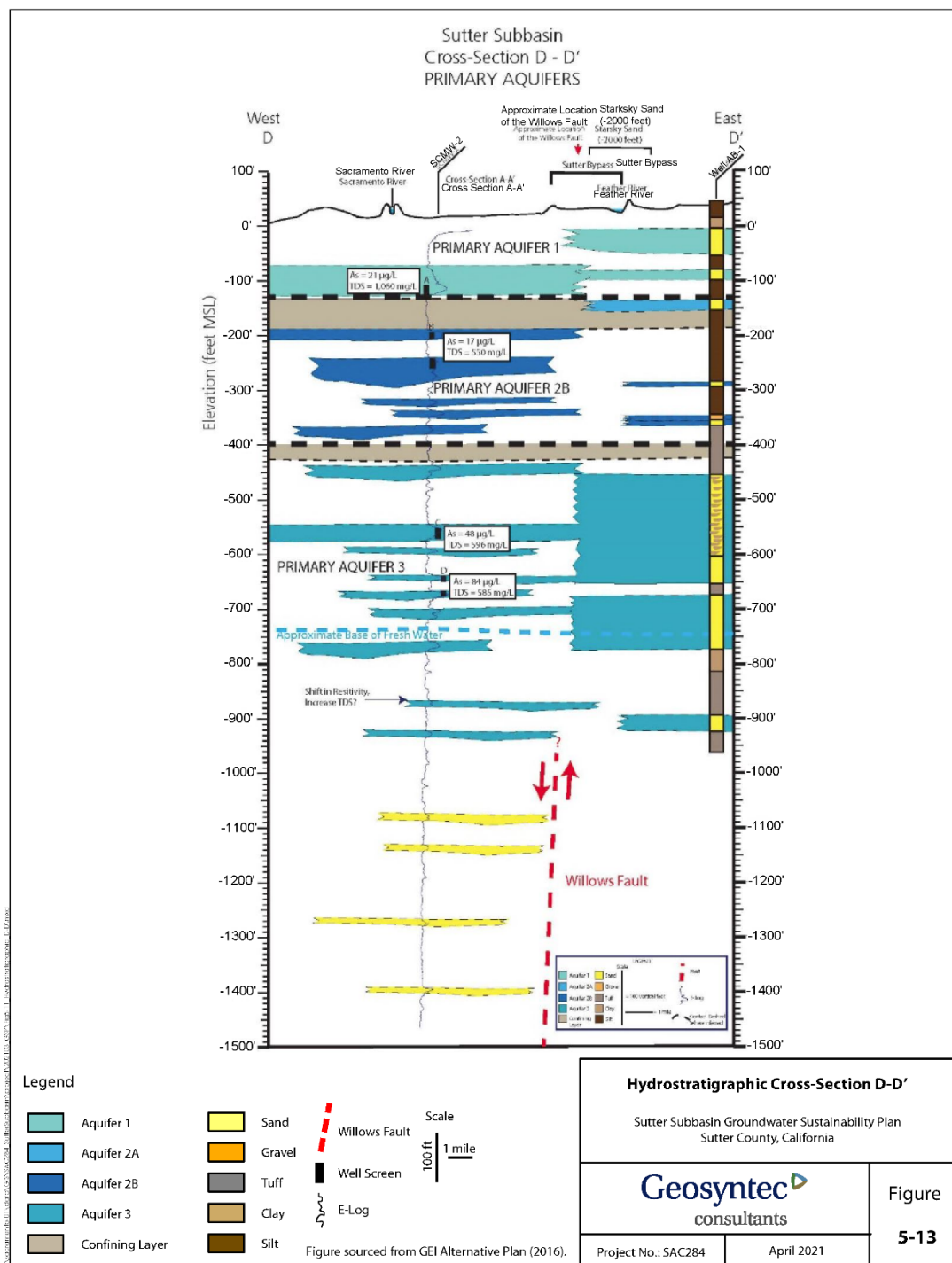


Figure 5-13. Hydrostratigraphic Cross-Section D-D'¹

¹ Some geologic formations that comprise AZ-3, including the Sutter Formation, may continue below the base of freshwater. Where these formations extend below this boundary, the deeper portions are considered part of the regional geologic framework but are not included in the principal aquifer managed by the GSAs. Therefore, the base of freshwater, rather than the base of any individual geologic formation, defines the bottom of the Subbasin for GSP implementation.

The principal aquifer can be grouped into four zones: the Shallow Aquifer Zone, Aquifer Zone 1 (AZ-1), Aquifer Zone 2 (AZ-2), and Aquifer Zone 3 (AZ-3). The Shallow Aquifer Zone is delineated separately from the AZ-1 system and is considered to be the upper 50 feet of the principal aquifer. While the Shallow Zone is not hydraulically separate from AZ-1, this zone was defined separately as it is most likely connected to interconnected surface water (ISW) bodies. Additionally, AZ-2 may be further defined as AZ-2A and AZ-2B where applicable to reflect local hydrostratigraphy differences associated with the Sutter Buttes Rampart. Each aquifer zone (except the Shallow Aquifer Zone) is separated by a low permeability layer comprised of fine-grained intervals consisting of silt, clay, hardpan, tuff-breccia, and other lower-permeability materials that occur throughout the principal aquifer. These low permeability intervals locally impede vertical groundwater flow and contribute to semiconfined or confined conditions. However, available data and information do not support the presence of laterally continuous aquitards that separate the Subbasin into multiple principal aquifers.

As noted above, the Shallow Aquifer Zone is considered to be the upper 50 feet of the principal aquifer (surface to 50 feet below the ground surface [ft bgs]). This zone was established to assess and monitor for impacts related to interconnected surface water and groundwater dependent ecosystems (GDEs).

AZ-1 is considered to extend from 50 to 150 ft bgs and generally represents the shallow portion of the principal aquifer. AZ-1 is composed of alluvial, stream channel, and floodplain deposits. In the northern and central portions of the Subbasin, AZ-1 is approximately 150 feet thick and is comprised of Alluvial Deposits and the Upper Turlock Lake Formation (Helley and Harwood, 1985). In the southern portion of the Subbasin, AZ-1 is approximately 100 feet thick and solely comprised of Alluvial (flood plain) Deposits (Olmsted and Davis, 1961) but could be thicker near the Feather and Sacramento Rivers.

AZ-1 and AZ-2A/-B are separated by the shallower of two low permeability zones present within the Subbasin. This low permeability zone is present across the Subbasin at varying degrees of confinement and does not represent a continuous aquitard. In the northern and central portions of the Subbasin, this low permeability zone is primarily associated with the Lower Turlock Lake unit and approximately 50 feet thick. In the southern portion of the Subbasin, the low permeability zone is associated with the Laguna Formation and approximately 20 feet thick.

AZ-2 is considered to extend from 150 to 400 ft bgs corresponding to the intermediate portion of the principal aquifer and, depending on location within the Subbasin, includes the Laguna Formation and/or the Sutter Buttes Rampart. In the northern and central portions of the Subbasin, AZ-2A is used where the Sutter Buttes Rampart is present in the principal aquifer and underlies the Laguna Formation. In AZ-2A, the Laguna Formation is approximately 200 feet thick, and the Sutter Buttes Rampart are 50 or more feet thick. Away from the Sutter Buttes in the southern portion of the Subbasin,

AZ-2B is delineated where the principal aquifer is solely within the Laguna Formation and is approximately 200 to 300 feet thick (Helley and Harwood, 1985).

AZ-2A/B and AZ-3 are separated by the deeper of the two low permeability zones within the Subbasin. Similar to the shallower low permeability zone, it is present across the Subbasin at varying degrees of confinement and does not represent a continuous aquitard. In the northern and central portions of the Subbasin, this low permeability zone is primarily associated with the Sutter Buttes Rampart and could be approximately 50 feet thick or more. In the southern portion of the Subbasin, the low permeability zone is associated with the Laguna Formation and has been estimated to range in thickness from 180 feet (Helley and Harwood, 1985) to 1,000 feet (Olmsted and Davis, 1961).

AZ-3 is considered to extend from 400 ft gs to the base of freshwater and represents the deepest portion of the principal aquifer and includes the deeper sections of the Laguna Formation, Sutter Buttes Rampart where present, and the Sutter Formation. In the northern and central portions of the Subbasin, AZ-3 is comprised of the three previous formations. Farther south, where the Sutter Buttes Rampart is absent, AZ-3 contains only the Laguna and Sutter Formations. The thickness and depth of the formations within AZ-3 vary across the Subbasin due to changes in depositional environment, formation extent, and the influence of the Sutter Buttes.

The base of freshwater defines the bottom of the Subbasin. As a result of the depth to the base of freshwater varying across the Subbasin, the lower extent of AZ-3 also varies spatially. In general, the greatest depths to the base of fresh water are in the central trough area in the Sacramento Valley, where the synclinal trough is deepest. In general, the base of freshwater ranges from -400 to -1,200 feet mean sea level (DWR, 1978).

Some geologic formations that comprise AZ-3, including the Sutter Formation, may continue below the base of freshwater. Where these formations extend below this boundary, the deeper portions are considered part of the regional geologic framework but are not included in the principal aquifer managed by the GSAs. Therefore, the base of freshwater, rather than the base of any individual geologic formation, defines the bottom of the Subbasin for GSP implementation

5.1.3.3 Aquifer Interactions

Groundwater level data from multi-completion wells were reviewed to evaluate whether the aquifer zone framework is consistent with observed hydraulic responses across the Subbasin. Hydrographs from multi-completion wells show that the degree of connection between aquifer zones varies spatially. In some areas, groundwater levels in AZ-2 and AZ-3 respond similarly while AZ-1 may show a different response, suggesting greater separation between the shallow and deeper portions of the aquifer system. In other areas, groundwater levels across multiple aquifer zones show similar responses, indicating greater hydraulic connection. These observed differences support the interpretation that the Subbasin contains one laterally and vertically heterogeneous

principal aquifer system with variable aquifer zones, rather than separate principal aquifers.

Figure 5-14 shows the location of multi-completion monitoring wells (MWs) around the Subbasin, including:

- Butte Water District (BWD) MW-1
- Flood MW-1
- Sutter Extension Water District (SEWD) MW-1
- SEWD MW-2
- SEWD MW-3
- Sutter Mutual Water Company (SMWC) MW-1
- Sutter County (Sutter) MW-1
- Sutter MW-2
- Sutter MW-3
- Sutter MW-4
- Sutter MW-6

Nine of these wells are equipped with pressure transducers and record water levels hourly. The following summarizes an assessment of the hydrographs for these monitoring wells. **Figure 5-15** through **Figure 5-21** provide hydrographs for each of the MWs listed above. For each of these hydrographs, AZ-1 hydrographs are in green, AZ-2 in blue, and AZ-3 in red. Where a nested well has two screens within the same aquifer zone, the deeper well hydrograph is dashed.

The hydrographs from these monitoring wells indicate that the vertical hydraulic relationships between aquifer zones varies across the Subbasin. This variability is consistent with the Subbasin's complex geologic setting and supports the presence of two laterally extensive, low permeability zones within the principal aquifer. As observed in the hydrographs, these low permeability zones vary in thickness, continuity, and hydraulic connectivity across the Subbasin and may be locally interrupted, merged, or less distinct where affected by changes in depositional environments.

In the northern portion of the Subbasin, BWD MW-1 (**Figure 5-15**) shows similar groundwater level fluctuations in AZ-2 and AZ-3 in response to pumping, while AZ-1 shows little to no response, suggesting some separation between the shallow and deeper portions of the aquifer at that location. However, at Sutter County MW-3 (**Figure 5-16**), south-southeast of BWD MW-1, groundwater levels in all three aquifer zones show a more coordinated response suggesting greater vertical hydraulic connection and less confining conditions. These differences indicate that the low-permeability intervals are not uniformly expressed near the Sutter Buttes, where uplift and deformation have modified the regional stratigraphic sequence.

In the central portion of the Subbasin, hydrographs for SEWD MW-1 (**Figure 5-17**), SEWD MW-2 (**Figure 5-18**), SEWD MW-3 (**Figure 5-19**), Sutter County MW-1 (**Figure 5-20**), Sutter County MW-6 (**Figure 5-21**), and SMWC MW-1 (**Figure 5-22**) show mixed

but related responses between aquifer zones. In several wells, AZ-2 and AZ-3 exhibit similar groundwater levels or similar seasonal responses, while AZ-1 may occur at a higher groundwater elevation or show a more limited response. These patterns suggest that the aquifer zones are hydraulically connected to varying degrees, but that low permeability intervals locally influence vertical gradients and groundwater level responses. The relationship between zones also appears to vary from east to west, consistent with changes in alluvial fan deposits and proximity to the Sutter Buttes.

At the southern end of the Subbasin, groundwater-level responses in the aquifer zones at monitoring wells Sutter County MW-2 (**Figure 5-23**), Sutter County MW-4 (**Figure 5-24**), and Flood MW-1 (**Figure 5-25**) are generally reflective of one another, but AZ-3 commonly behaves differently than AZ-1 and AZ-2. This pattern is consistent with a more layered depositional environment farther from the Sutter Buttes, where the low permeability intervals are more distinguishable and more likely to separate AZ-3 from AZ-1 and AZ-2.

The hydrograph observations are also generally consistent with aerial electromagnetic (AEM) survey interpretations presented in **Appendix 5-G**, which indicate deformation and merging of strata near the Sutter Buttes, more distinguishable layering farther south, and alluvial fan deposits along the eastern side of the Subbasin. Accordingly, the low permeability intervals are best understood as laterally variable hydrostratigraphic features within the principal aquifer system, rather than continuous aquitards that define separate principal aquifers.

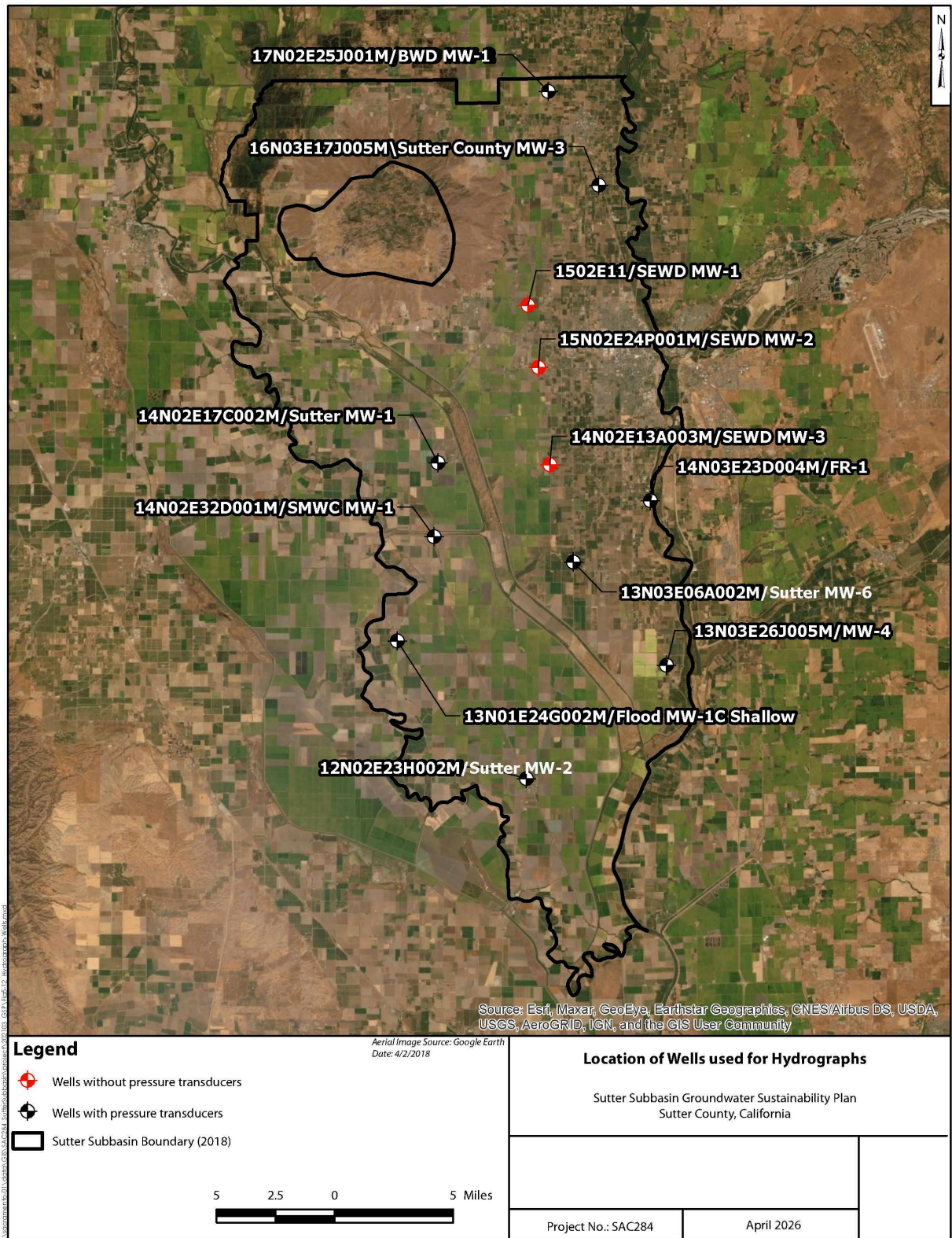


Figure 5-14. Location of Wells Used for Hydrographs

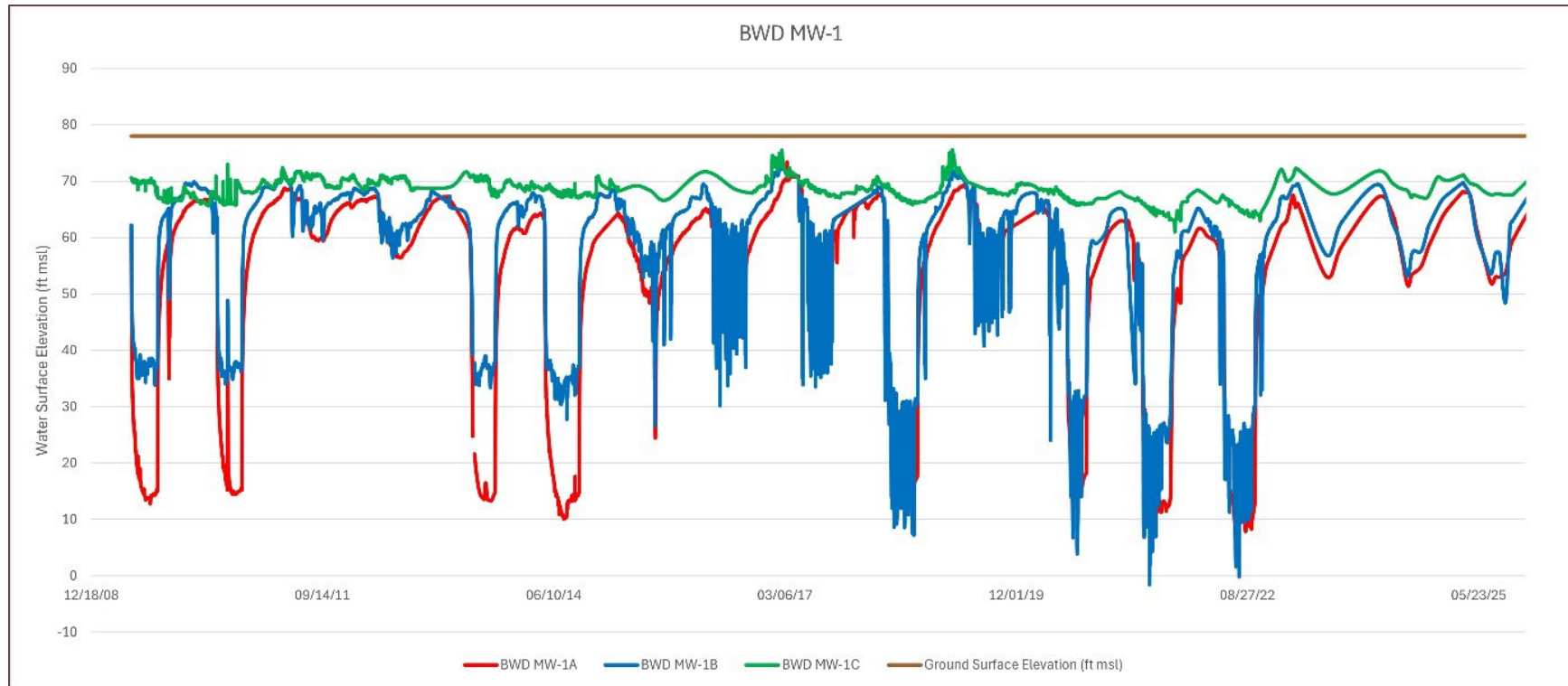


Figure 5-15. Butte Water District MW-1 Hydrograph

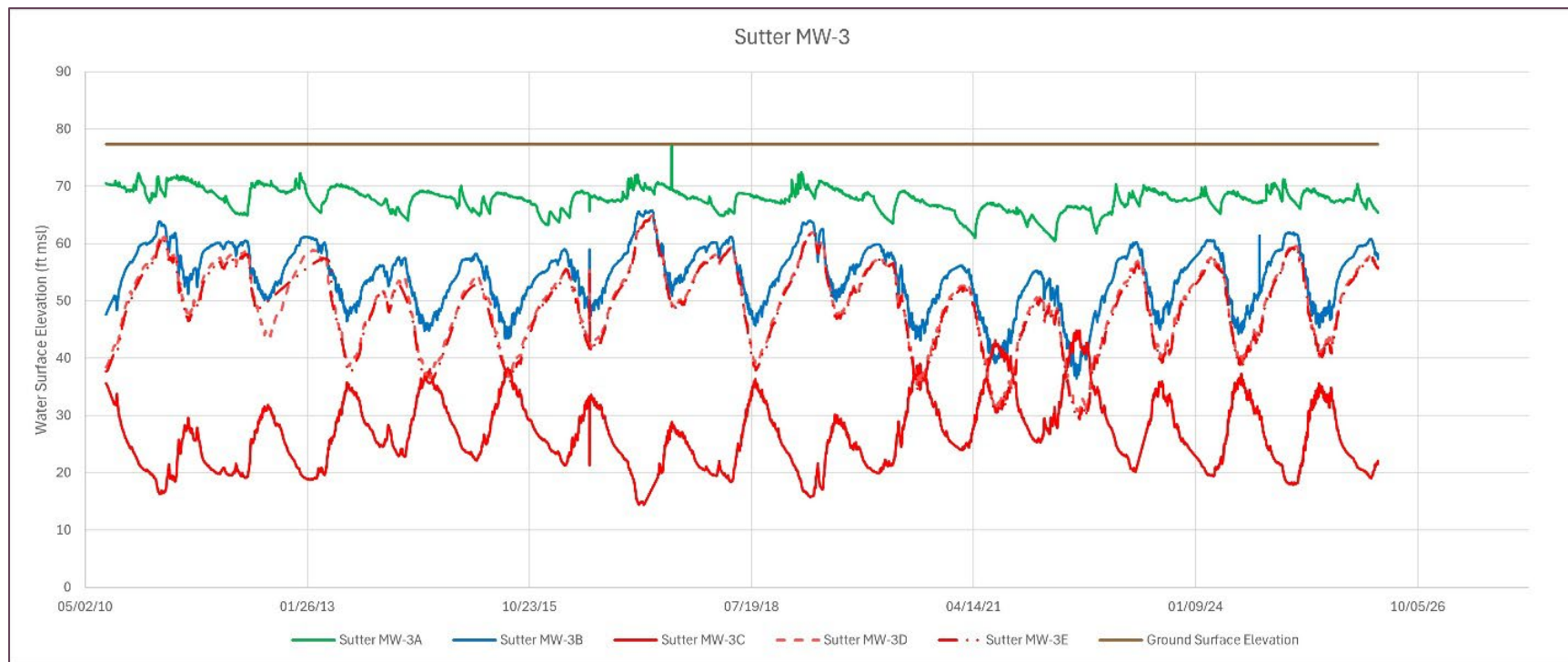


Figure 5-16. Sutter County MW-3 Hydrograph



Figure 5-17. Sutter Extension Water District MW-1 Hydrograph

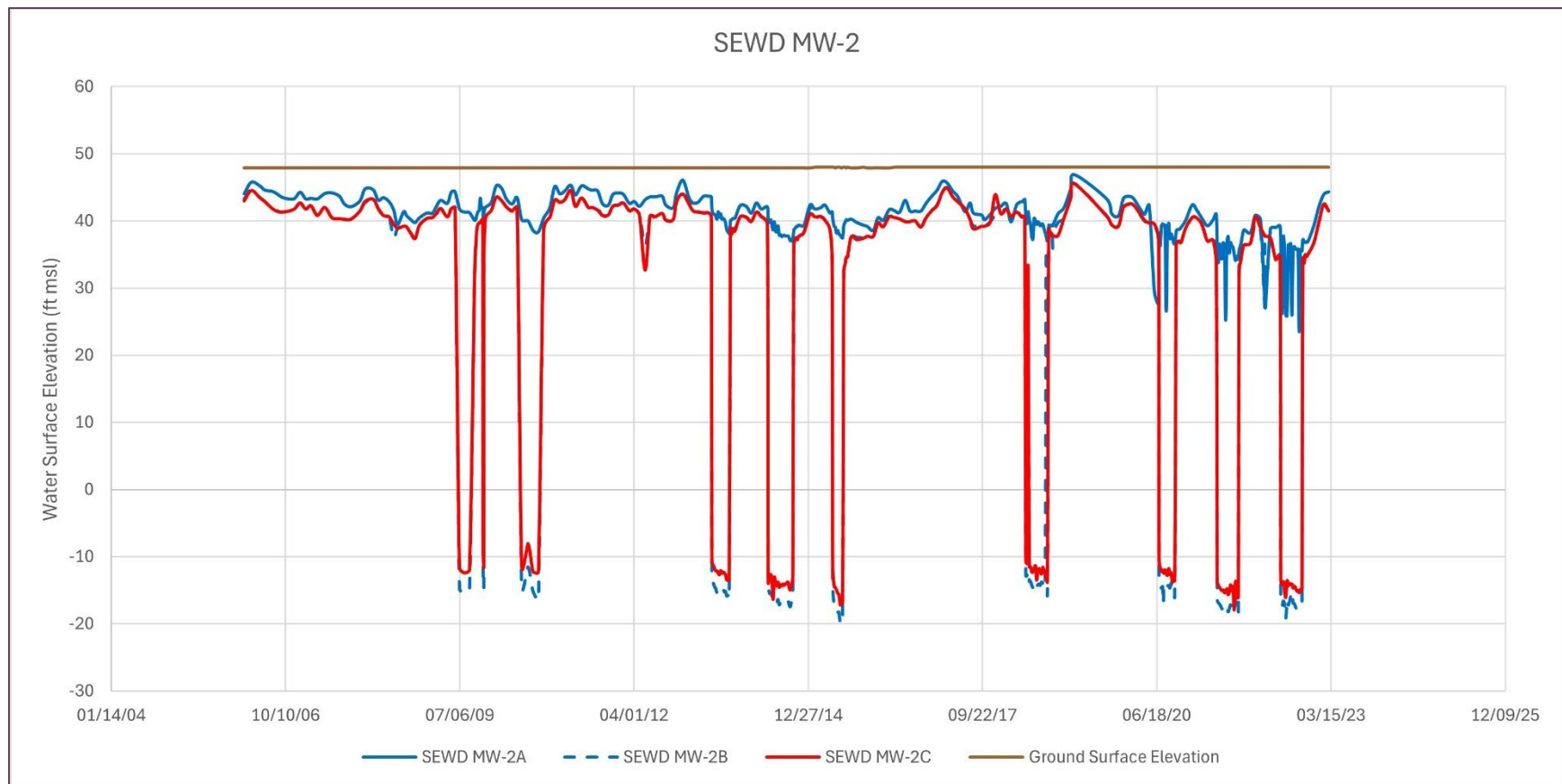


Figure 5-18. Sutter Extension Water District MW-2 Hydrograph



Figure 5-19. Sutter Extension Water District MW-3 Hydrograph

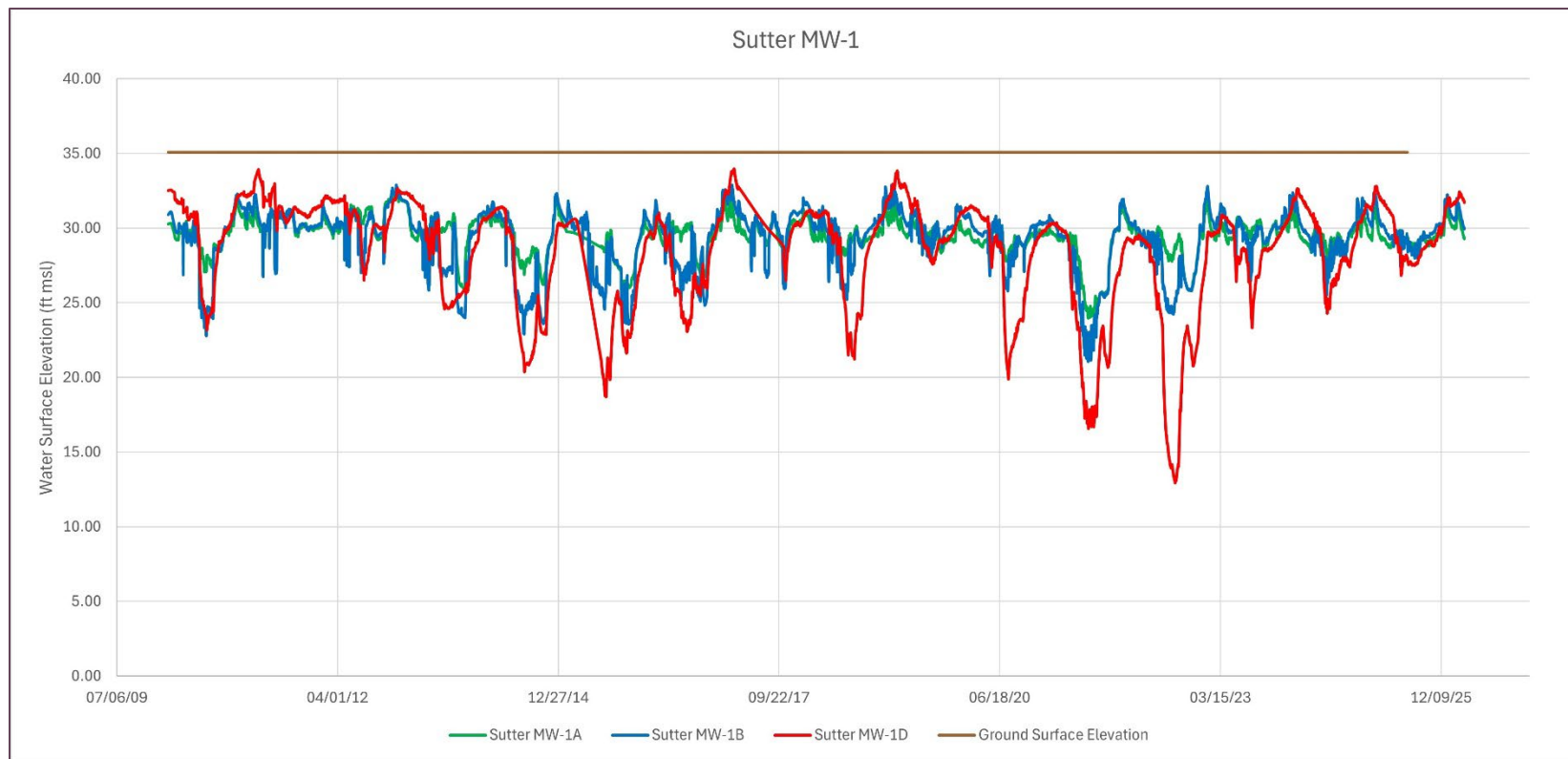


Figure 5-20. Sutter County MW-1 Hydrograph

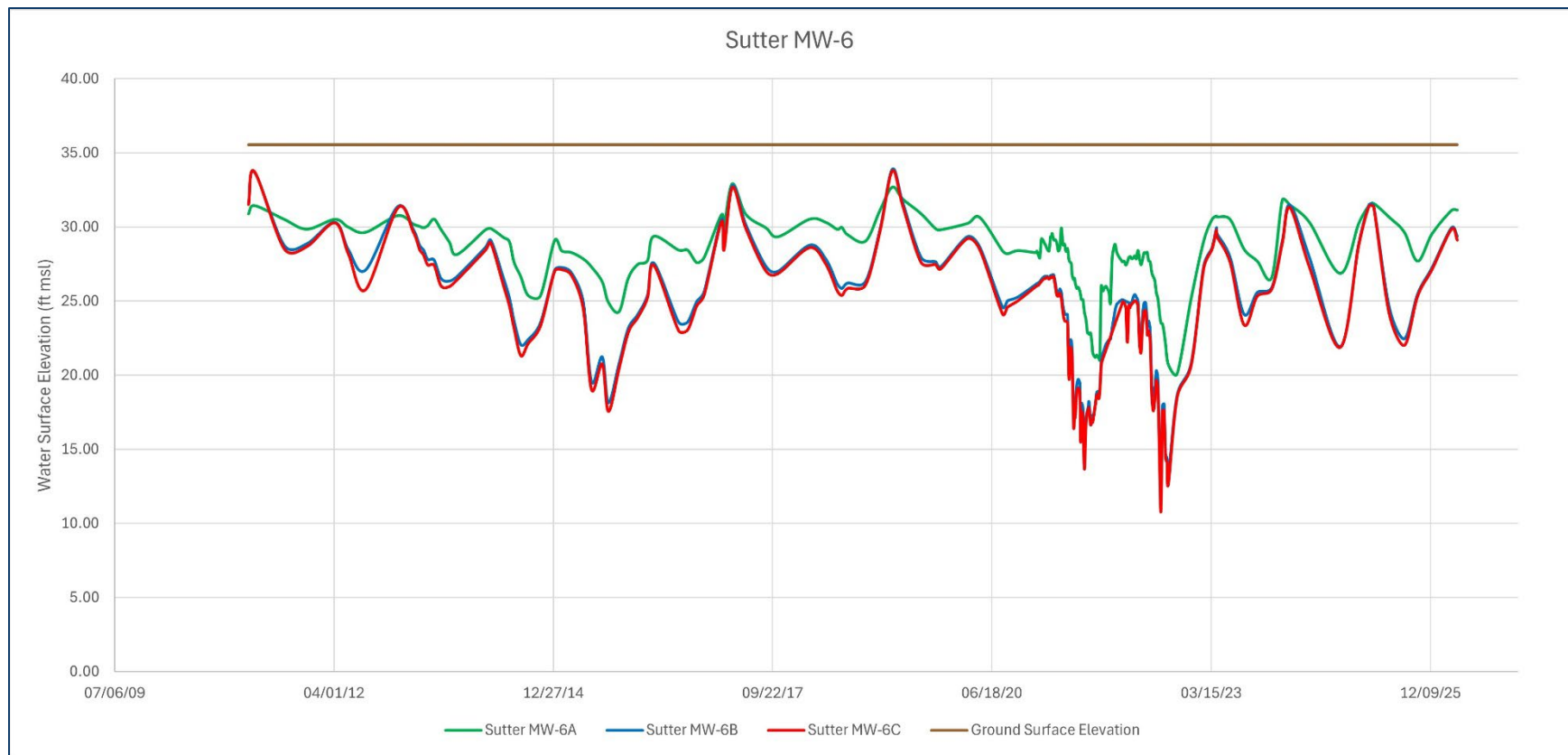


Figure 5-21. Sutter County MW-6 Hydrograph

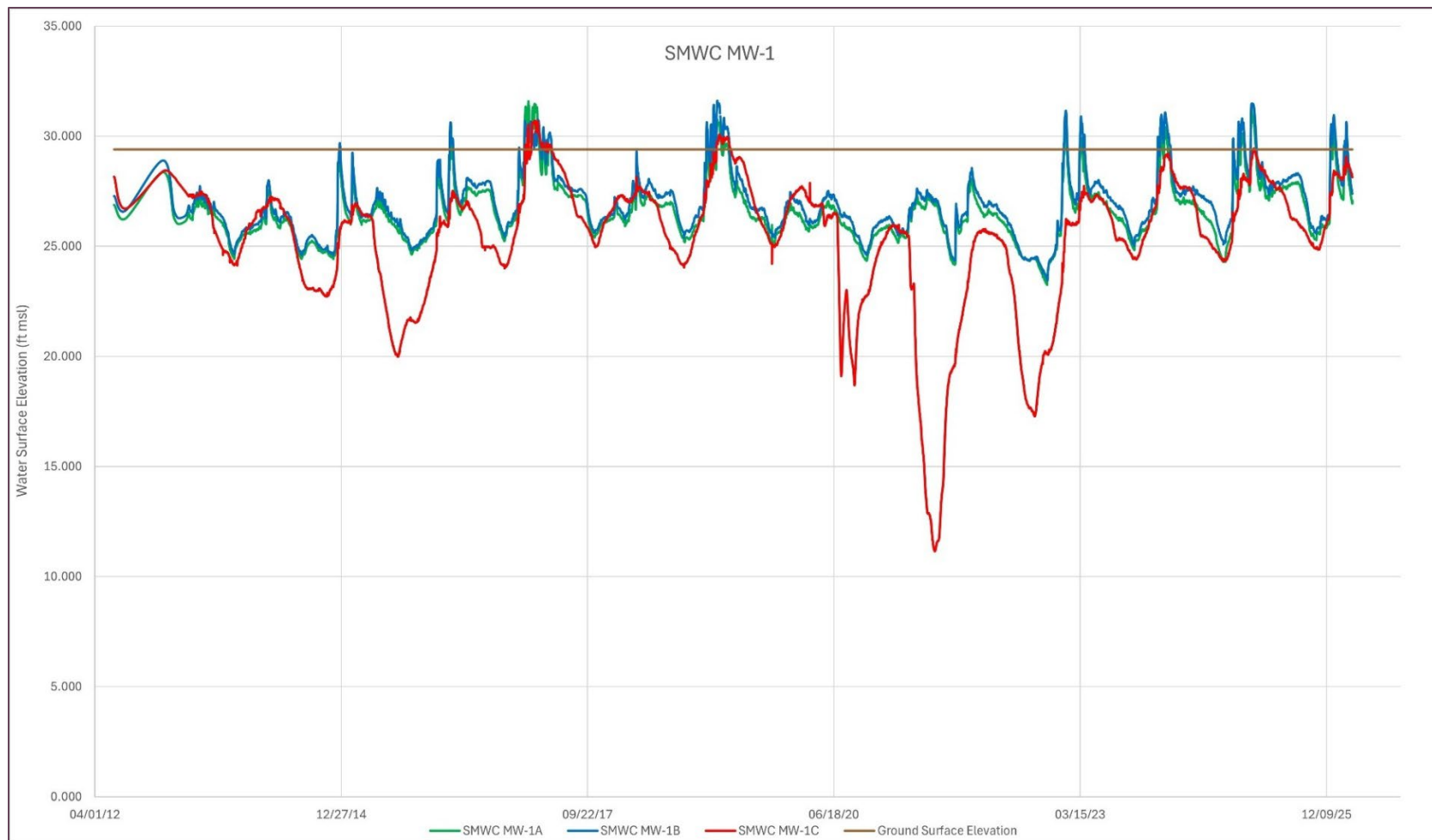


Figure 5-22. Sutter Mutual Water Company MW-1 Hydrograph

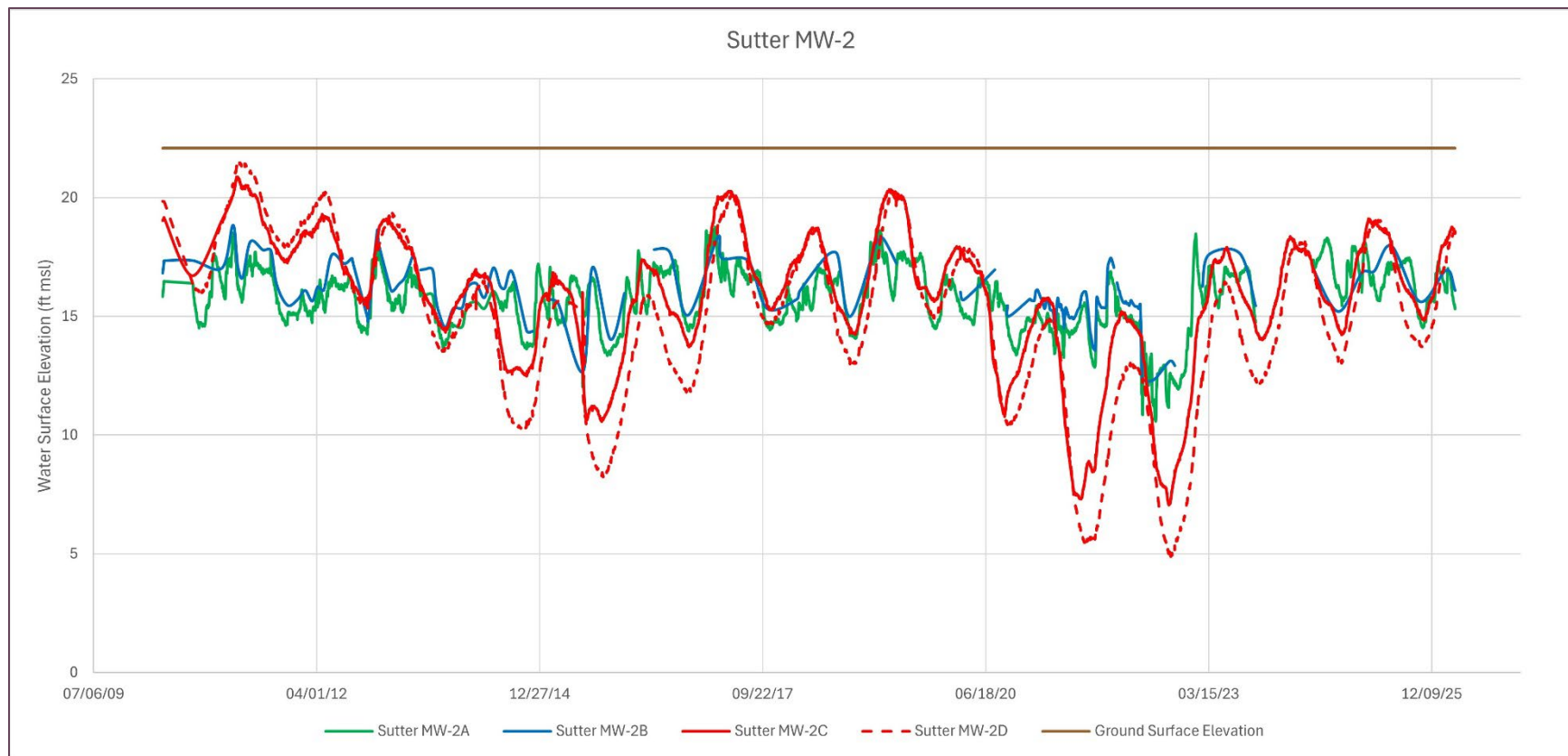


Figure 5-23. Sutter County MW-2 Hydrograph

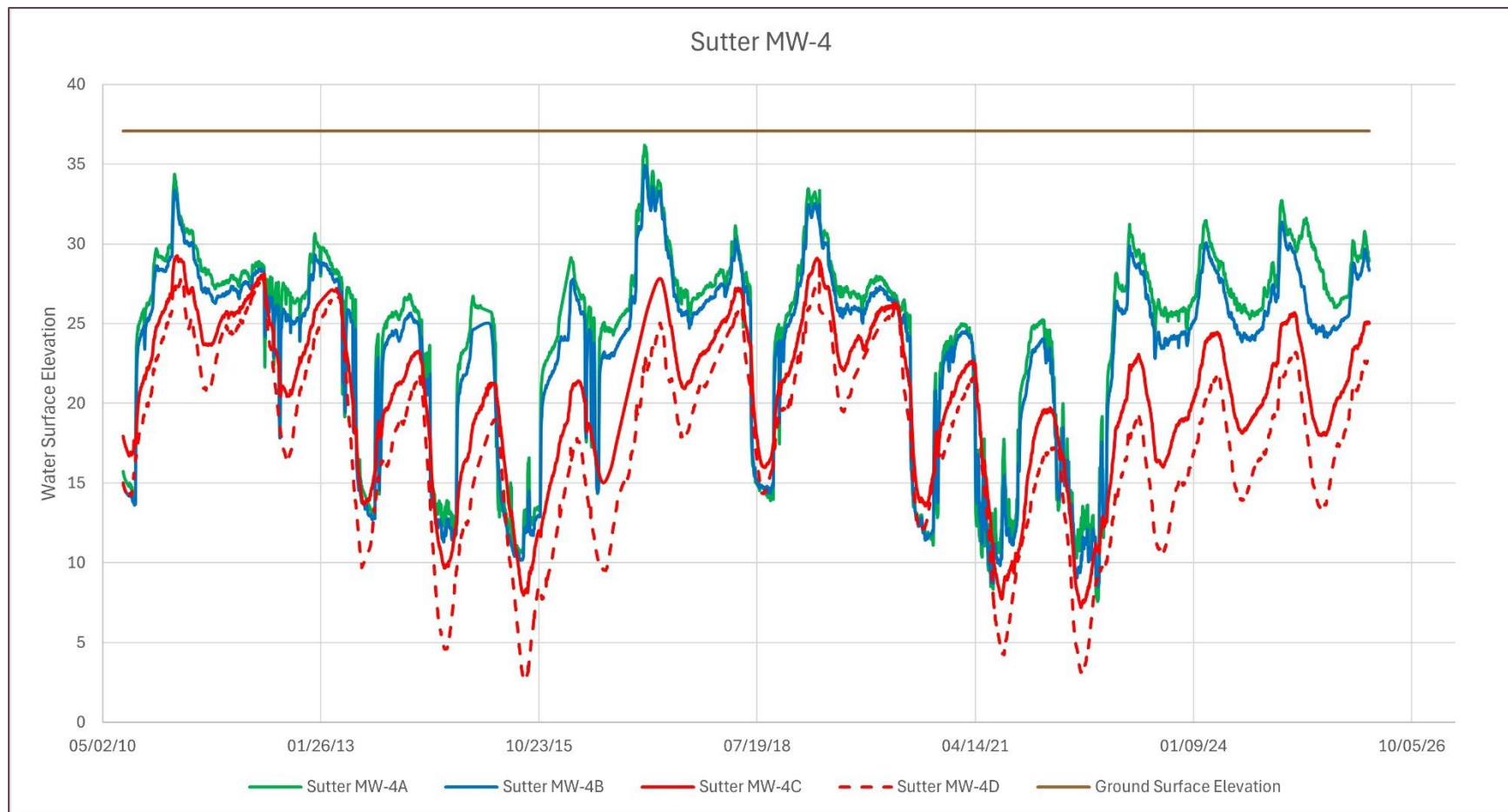


Figure 5-24. Sutter County MW-4 Hydrograph

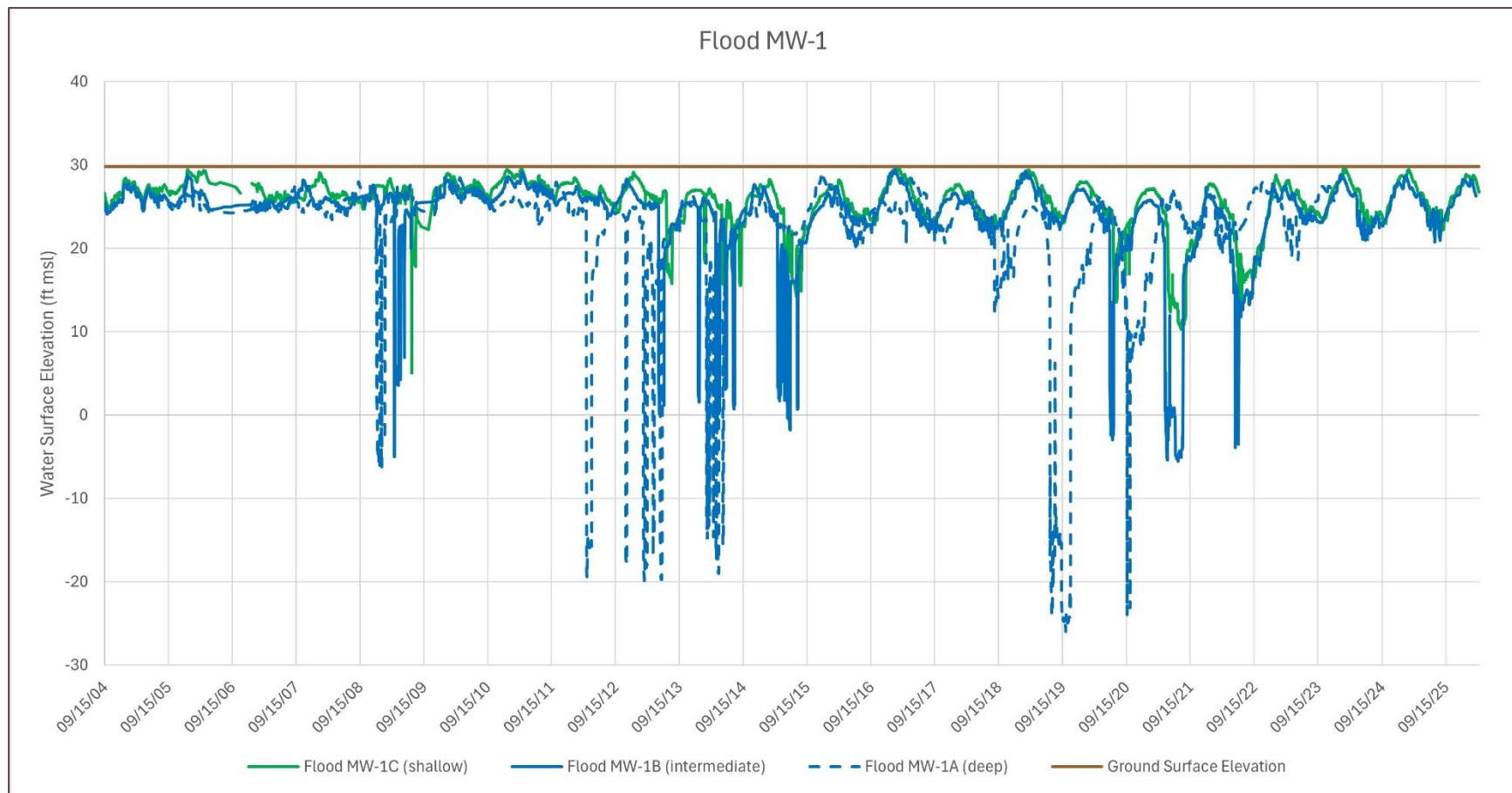


Figure 5-25. Flood MW-1 Hydrograph

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5.1.3.4 Physical Properties of Aquifers and Aquitards

Limited aquifer tests with observation wells are available to provide reliable estimates of the aquifer characteristics. The aquifer tests available were conducted in 2007 for SEWD Wells #1 and #2 (GEI, 2016). The results of these tests are summarized in **Table 5-2**.

Table 5-2. Aquifer Zone Hydraulic Characteristics from Aquifer Tests, Sutter Subbasin

Aquifer Zone	Transmissivity (ft ² /day)	Specific Yield or Storativity (unitless)	Source
AZ-1	N/A	N/A	N/A
AZ-2	N/A	N/A	N/A
AZ-3	7,619 to 8,957	0.000556 to 0.000898	SEWD, Well #1, 2007
	7,352 to 8,556	0.00108 to 0.000978	SEWD, Well #2, 2007

N/A = No aquifer tests available. ft²/day = square feet per day.

To provide an additional assessment of aquifer properties in the basin, transmissivity (T) values were calculated using an empirical equation where T is calculated by multiplying the specific capacity by an assumed value estimated using the Theis equation. The multiplying factor can be based on unconfined or confined assumptions. As a general rule, T in units of gallons per day per foot (gpd/ft) is calculated by multiplying the specific capacity by 2,000 for a confined aquifer and by 1,500 for an unconfined aquifer (Driscoll, 1986). Specific capacities were obtained from data downloaded from DWR's Well Completion Report Map Application for well completion reports¹. The well completion reports include data for pumping rates and total drawdowns if reported.

Appendix 5-E includes the data downloaded from DWR's well completion report database for the Sutter Subbasin, along with calculated T values using the empirical formulas stated above (units of T converted to square feet per day [ft²/day]). As seen in this table, calculated specific capacities ranged from 0.45 to 189 gallons per minute per foot of drawdown (gpm/ft) with an average value of about 19 gpm/ft. This table also separates calculations by aquifer zones based on completed depths and estimates hydraulic conductivity (K) values using average thickness of each of aquifer zones, as discussed in **Section 5.1.3.2**. **Table 5-3** summarizes the results of calculations for T and K using the empirical equation for specific capacities.

¹ Well completion reports obtained from DWR's Well Completion Report Map Application (<https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>)

Table 5-3. Summary of Calculated T and K Values

Aquifer Zone	# of Records	Min T Value (ft ² /day)	Max T Value (ft ² /day)	Average T Value (ft ² /day)	Min K Value (ft/day) ³	Max K Value (ft/day)	Average K Value (ft/day)
1 ¹	58	90	14,964	1,975	1	100	13
2 ²	71	141	50,501	6,407	1	230	30
3 ²	10	1,205	16,825	9,303	5	76	42

ft/day = feet per day.

¹ Uses empirical value for unconfined aquifer, multiplies specific capacity by 1,500 for units of gpd/ft. See Appendix 5-E for range of calculated specific capacities.

² Uses empirical value for confined aquifer, multiplies specific capacity by 2,000 for units of gpd/ft. See Appendix 5-E for range of calculated specific capacities.

³ K Values calculated using aquifer zone thickness of 150 feet for AZ-1 and 220 feet for AZ-2 and AZ-3.

As shown in **Table 5-4**, the average K value for each aquifer zone is consistent with well sorted sands and gravels. Typically, T values of less than 100 ft²/day will supply only enough water for domestic wells or other low-yield purposes. In wells with T values greater than 1,300 ft²/day, the production yields are typically sufficient for industrial, municipal, or irrigation use.

Table 5-4. Hydraulic Conductivity Values of Common Aquifer Materials (Modified from Bear, 1972)

K Values in units of feet per day (ft/day)	Aquifer Quality	Typical Aquifer Material
100,000	Good	Well Sorted Gravel
10,000	Good	Well Sorted Gravel
1,000	Good	Well Sorted Sand or Sand and Gravel
100	Good	Well Sorted Sand or Sand and Gravel
10	Good	Well Sorted Sand or Sand and Gravel
1	Poor	Very Fine Sand
0.1	Poor	Very Fine Sand
0.01	Poor	Very Fine Sand
0.001	Poor	Very Fine Sand
0.0001	None	Clay
0.00001	None	Clay

5.1.3.5 General Water Quality of Principal Aquifers

Groundwater quality was evaluated in the Alternative Plan, in the Sutter County Groundwater Management Plan (Wood Rodgers, 2012), and during the preparation of the Rice Coalition Groundwater Assessment Report (CH2MHill, 2016). The Alternative Plan utilized available data and developed water quality profiles for three general depths that broadly correspond to the aquifer zones defined in this GSP. For the Alternative Plan, AZ-1 extends to 150 feet bgs (Shallow AZ not defined in Alternative Plan), AZ-2 to 400 feet bgs, and AZ-3 to greater than 400 feet bgs. This water quality compilation is a composite of sampling events that span almost 40 years and includes data from DWR, the USGS Shallow Rice, Shallow Domestic, and the Groundwater Ambient Monitoring and Assessment Program (GAMA) well networks. To support these data, this GSP also assessed data from DWR's Water Data Library located at <https://wdl.water.ca.gov/waterdatalibrary/WaterQualityDataLib.aspx> for wells completed in all aquifer zones across the Sutter Subbasin. Many of these wells are nested wells with separate screen zones within each aquifer zone. The location of the wells used for this assessment are provided in **Figure 5-26** and well construction details for these wells are provided in **Table 5-5**.

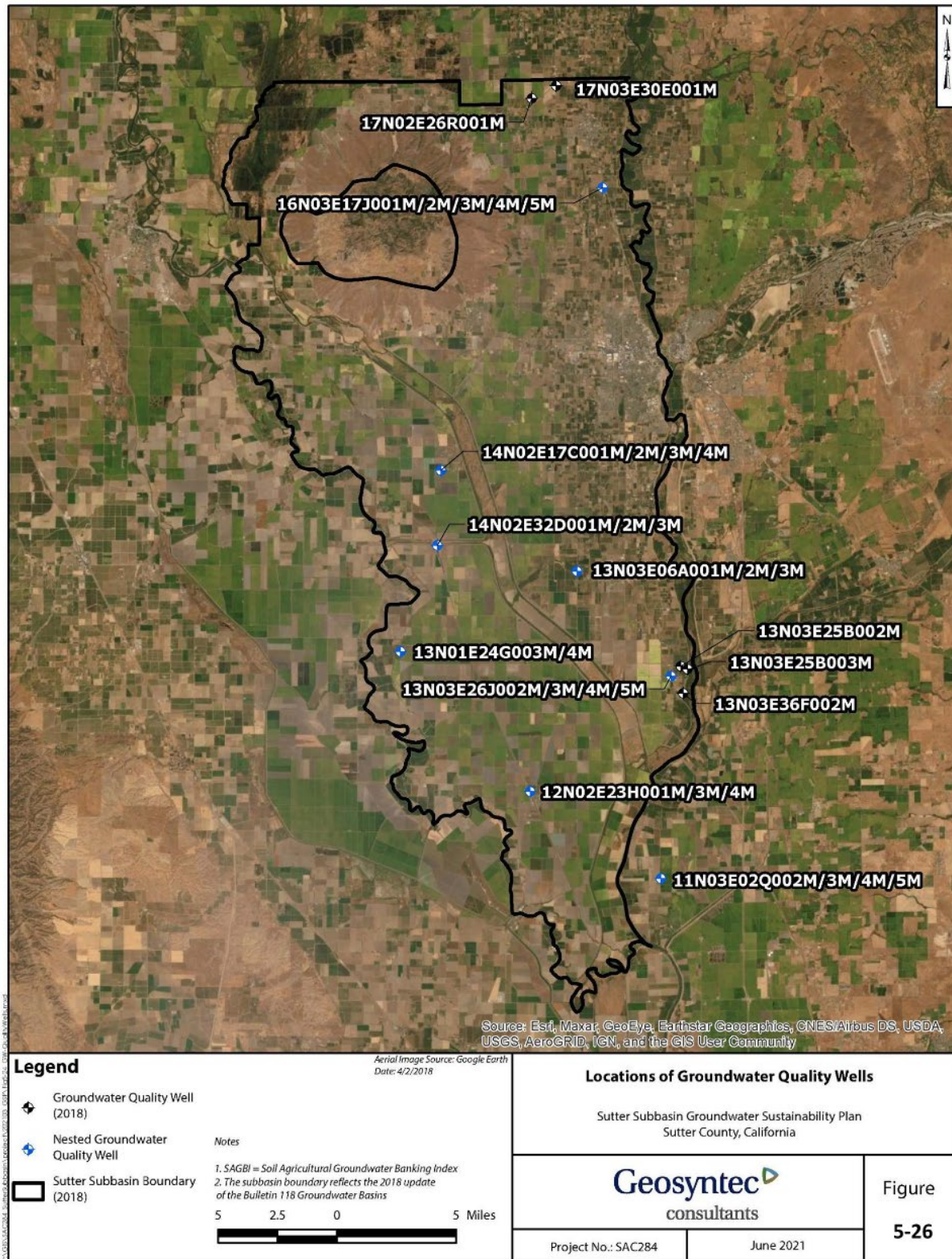


Figure 5-26. Locations of Groundwater Quality Wells

Table 5-5. Well Construction Details for Wells with Water Quality Information

Well ID	Latitude	Longitude	Total Depth	Screen Interval	Aquifer Zone
12N02E23H001M	38.8761	-121.709	150	120-140	1
12N02E23H003M	38.8761	-121.709	600	570-590	3
12N02E23H004M	38.8761	-121.709	705	655-695	3
16N03E17J001M	39.2394	-121.651	85	65-75	1
16N03E17J004M	39.2394	-121.651	615	595-605	3
16N03E17J005M	39.2394	-121.651	785	765-775	3
16N03E17J002M	39.2394	-121.651	315	285-305	2
16N03E17J003M	39.2394	-121.651	430	400-420	2
13N03E26J002M	38.945159	-121.599	175	145-165	1
13N03E26J003M	38.945159	-121.599	445	425-435	2
13N03E26J004M	38.945159	-121.599	610	590-600	3
13N03E26J005M	38.945159	-121.599	1005	985-995	3
11N03E02Q002M	38.823236	-121.6076	170	130-160	1
11N03E02Q003M	38.823236	-121.6076	675	655-675	3
11N03E02Q004M	38.823236	-121.6076	930	910-920	3
11N03E02Q005M	38.823236	-121.6076	1225	1205-1215	3
13N01E24G003M	38.9605	-121.81	160	130-160	1
13N01E24G004M	38.9605	-121.81	100	70-90	1
14N02E32D001M	39.024429	-121.781	64	34-54	1
14N02E32D002M	39.024429	-121.781	210	170-200	1
14N02E32D003M	39.024429	-121.781	500	460-490	3
13N03E06A001M	39.008641	-121.672	65	45-55	1
13N03E06A002M	39.008641	-121.672	175	155-165	1
13N03E06A003M	39.008641	-121.672	265	245-255	2
14N02E17C001M	39.0696	-121.778	60	30-50	1
14N02E17C002M	39.0696	-121.778	245	205-235	2
14N02E17C003M	39.0696	-121.778	425	395-415	2
14N02E17C004M	39.0696	-121.778	755	725-745	3
17N02E26R001M	39.2935	-121.706	601	279-601	2 and 3
17N03E30E001M	39.3012	-121.687	610	263-610	2 and 3
13N03E25B002M	38.951044	-121.5913	248	148-168	1
13N03E36F002M	38.934758	-121.5896	365	160-170	1
13N03E25B003M	38.9494	-121.5863	200	115-200	1

California Code of Regulations Title 22 establishes water quality standards for drinking water contaminants. A primary maximum contaminant level (MCL) or secondary MCL (SMCL) is defined for a variety of parameters. The Alternative Plan identified several constituents within the Sutter Subbasin that exceed these standards for drinking water, the highest beneficial use category. Although groundwater quality in the Sutter Subbasin is generally sufficient to meet beneficial uses, these constituents of concern are either currently impacting groundwater use or have the potential to impact it in the future. Depending on the water quality constituent, the source may be anthropogenic in origin or naturally occurring, and the issue may be widespread or localized. The primary naturally-occurring water quality constituents of concern are arsenic, boron, salinity, iron, and manganese. Primary water constituents detected related to human activity include salinity, nitrates, and various point-source contaminants.

The sections herein provide information on the historical and current groundwater quality conditions starting with the general water quality within the Sutter Subbasin followed by trends for specific constituents, including:

- Arsenic
- Boron
- Salinity
- Nitrate
- Iron and manganese
- Point-source contamination, which includes petroleum hydrocarbons, solvents, and emerging contaminants

For the purposes of this GSP, comparing parameter concentrations to their MCL or SMCL is used as the basis for describing groundwater quality concerns in the Sutter Subbasin. Comparisons to the MCL or SMCL must be considered in context, as the measured concentrations represent raw water that may be treated or blended prior to delivery to meet the standard or may not be used for potable uses.

As stated above, several nested monitoring wells, along with irrigation wells with longer screens, within the Subbasin have been monitored for general water quality issues since 2009 by DWR (see **Figure 5-26** for location and **Table 5-5** for well construction details). The nested wells sampled by DWR have separate well screens within each of the three aquifer zones discussed in **Section 5.1.3.2**, allowing an overall assessment of general water quality changes with depth across the Sutter Subbasin. **Table 5-6** summarizes the general chemical parameters collected from each of these wells.

To assess general chemical trends within the Sutter Subbasin, the cations (metals such as calcium and sodium) and anions (such as chloride and sulfate) were plotted on a piper diagram. A piper diagram is a graphical representation of the chemistry of a water sample or samples. As shown in **Figure 5-27**, piper diagrams are a combination cation triangle (lower left) and anion triangle (lower right) that lie on a common baseline. A

diamond shape is placed between them. Information that can be assessed from this diagram includes water type. **Figure 5-27** was developed by USGS (presentation from <http://inside.mines.edu/~epoeter/GW/18WaterChem2/WaterChem2pdf.pdf>) that lists general interpretations for specific water types.

Figure 5-28 presents the piper diagram constructed from the groundwater quality data available for the wells listed in **Table 5-6**. As seen in this figure and listed in **Table 5-6**, water types reported for these samples include magnesium (Mg) – bicarbonate (HCO_3), sodium (Na)-chloride (Cl), and Na-HCO_3 . The Mg-HCO_3 is similar to the calcium (Ca) HCO_3 water type and is typical of shallow fresh groundwaters. The Na-Cl water type is typical of marine or ancient groundwaters, but anthropogenic sources could also change waters to this type. The Na-HCO_3 water type is typical of groundwaters that have been in contact with aquifer materials for a longer time period and are influenced by ion exchange processes.

Figure 5-29 through **Figure 5-31** shows the water types reported for each of the aquifer zones at each nested well location. As seen in **Figure 5-29**, within the shallow aquifer zone, AZ-1, the northern to central part of the Subbasin is characterized by Mg-HCO_3 waters that suggests shallow fresh groundwater. From the central part to the southern area of the Sutter Subbasin, water types are classified by Na-HCO_3 and Na-Cl waters. These water types suggest these areas are influenced by ion exchange processes (Na-HCO_3) or typical of marine or ancient groundwaters (Na-Cl). For the shallow groundwater zone, the Na-Cl water type is more likely the result of interactions with agricultural practices within the area. As discussed below for salinity, the wells classified as Na-Cl in the shallow aquifer zone also have total dissolved solids (TDS) reported at values greater than 1,000 milligrams per liter (mg/L), whereas the other wells in the shallow zone with different water types have TDS values below 1,000 mg/L. For AZ-2, water types (**Figure 5-30**) in the northern to central part of the Sutter Subbasin are Na-HCO_3 , indicative of influence from ion exchange processes. Water types for the central to southern part of the Sutter Subbasin are Na-Cl, suggesting influence from marine or ancient groundwaters or anthropogenic sources. As discussed below for salinity, except for one well screened near the boundary with AZ-1 (06A003M), the TDS values with Na-Cl values are below 1,000 mg/L. All the wells completed within AZ-3 or deeper (screens deeper than 700 feet bgs) have reported water types of Na-Cl (**Figure 5-31**), suggesting influence from marine or ancient groundwaters. As discussed in **Section 5.1.2.2**, the base of fresh water is encountered between approximately 700 feet bgs to 1,000 feet bgs (or -400 to -1,200 feet mean sea level) across the basin. The only well in AZ-3 with reported TDS values above 1,000 mg/L (02Q003M) is screened near this boundary. Only the deepest well screened below AZ-3 (02Q005M – 1,215 feet bgs) had TDS values below 1,000 mg/L.

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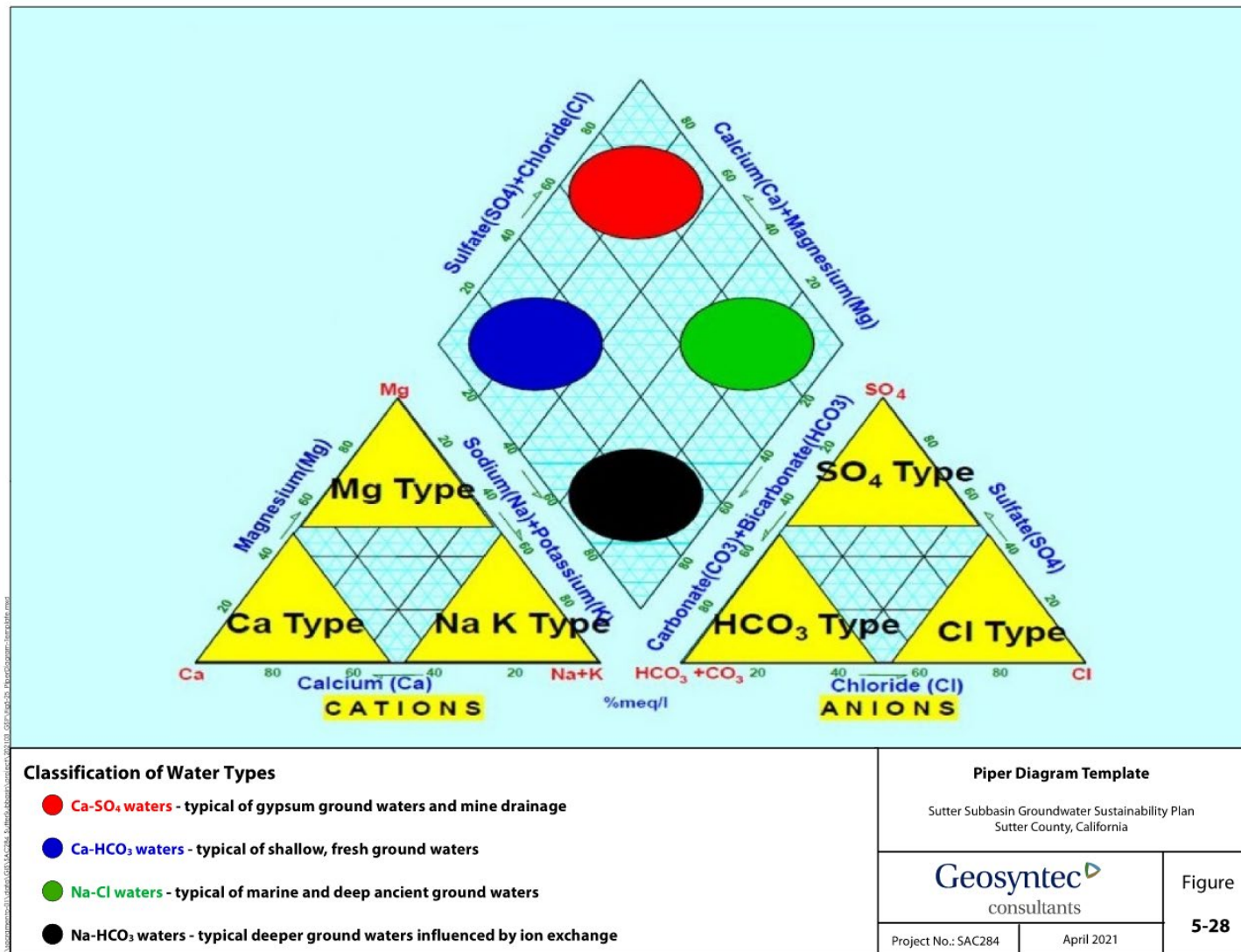


Figure 5-27. Piper Diagram Template

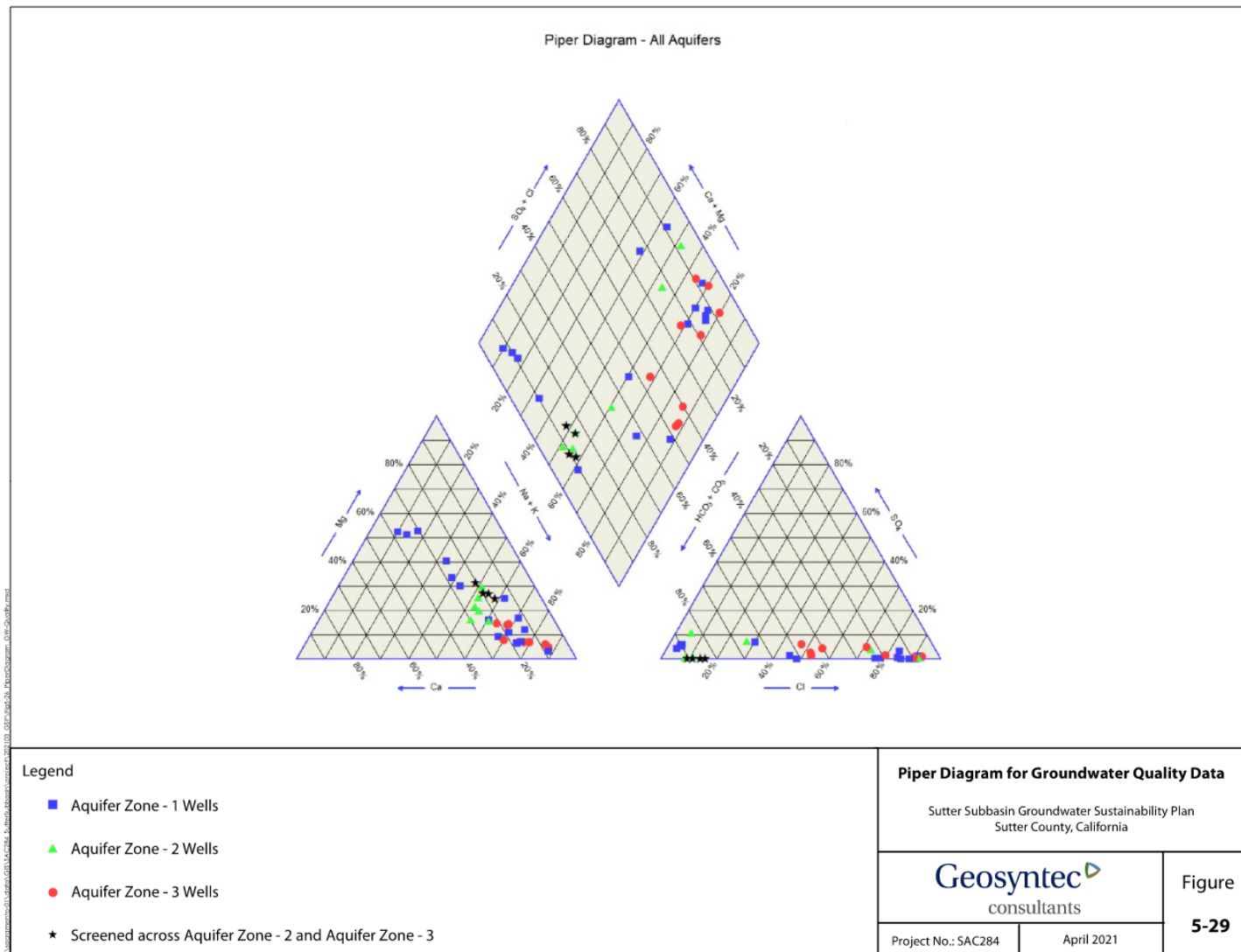


Figure 5-28. Piper Diagram for Water Quality Data by Aquifer Zone

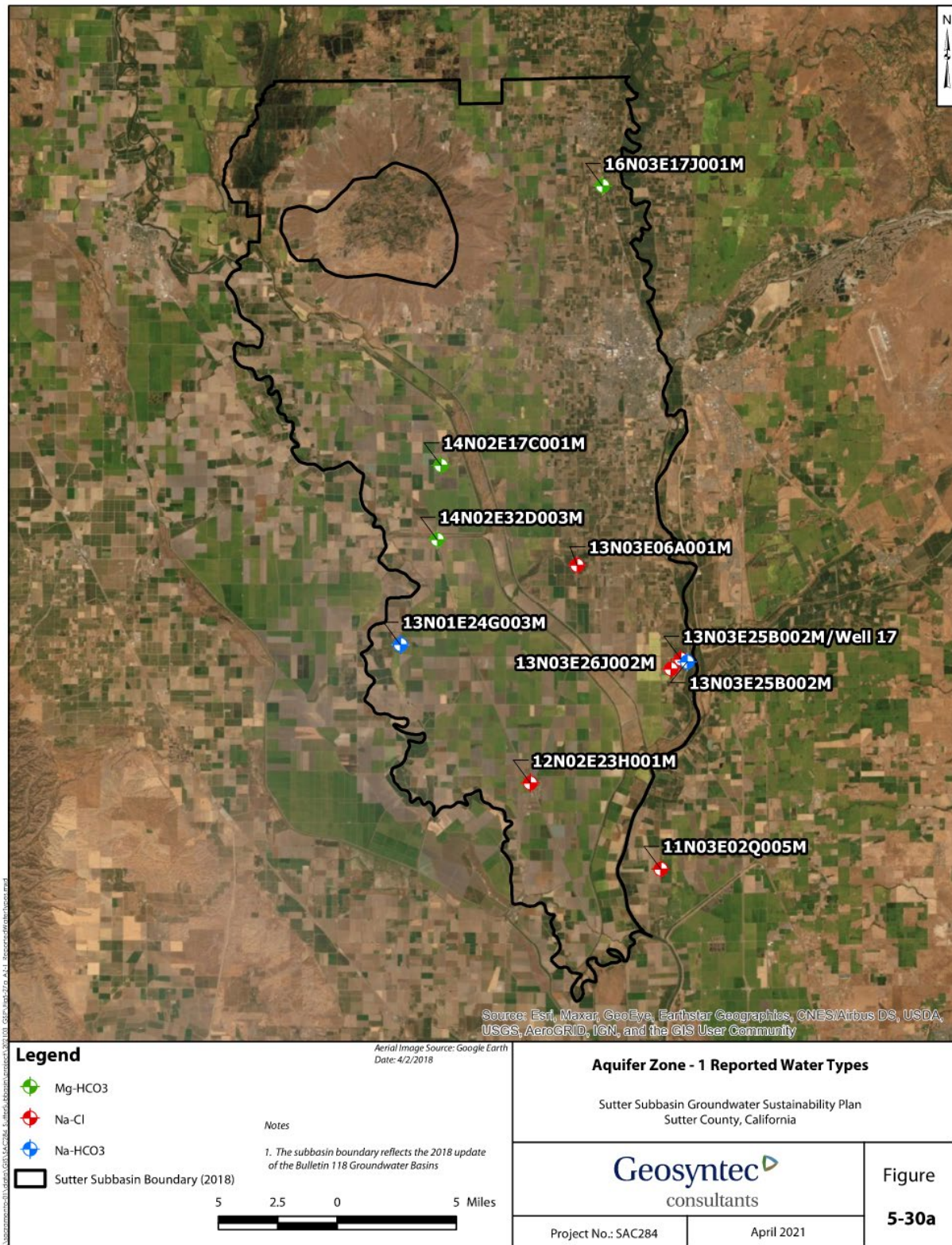


Figure 5-29. Aquifer Zone-1 Reported Water Types

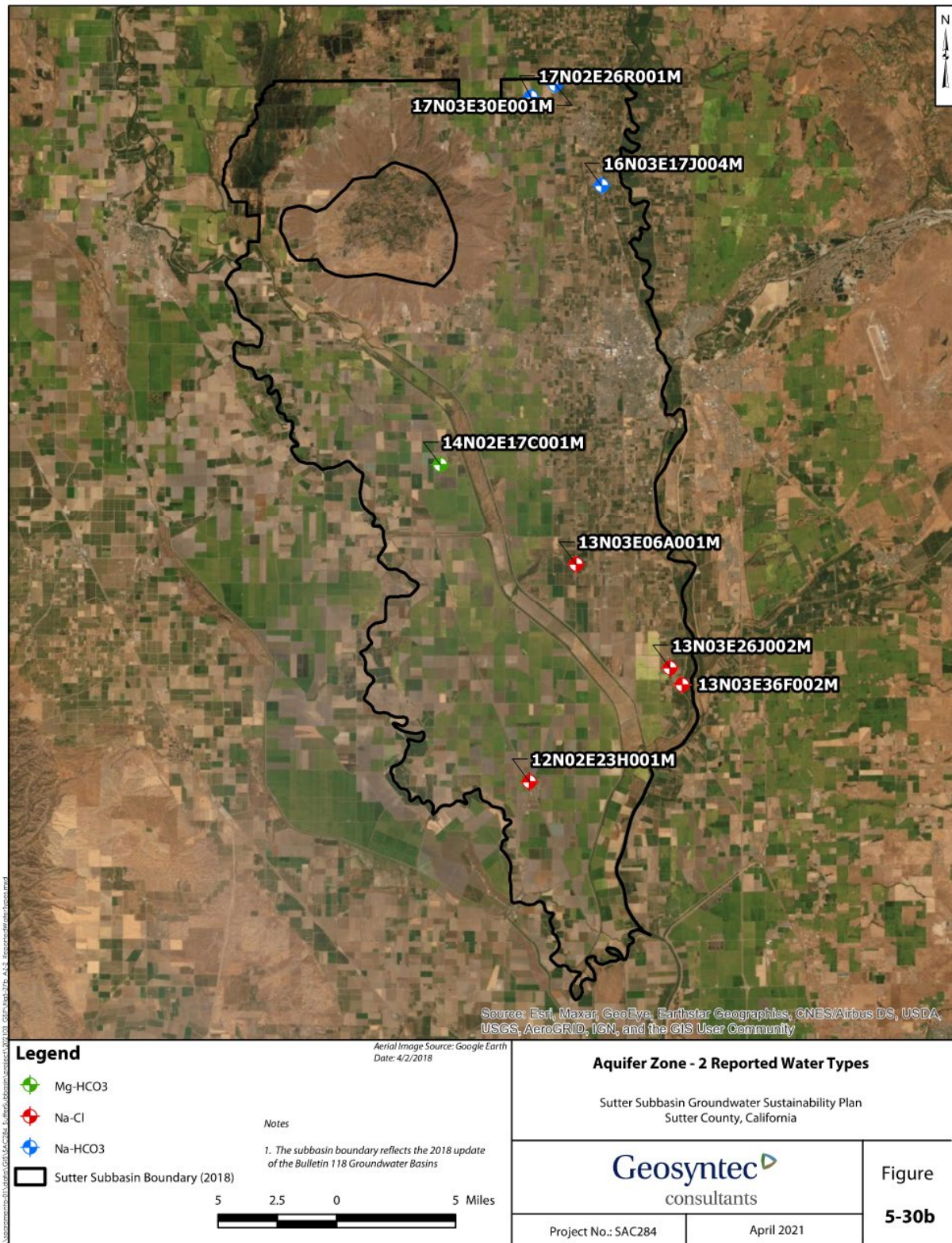


Figure 5-30. Aquifer Zone-2 Reported Water Types

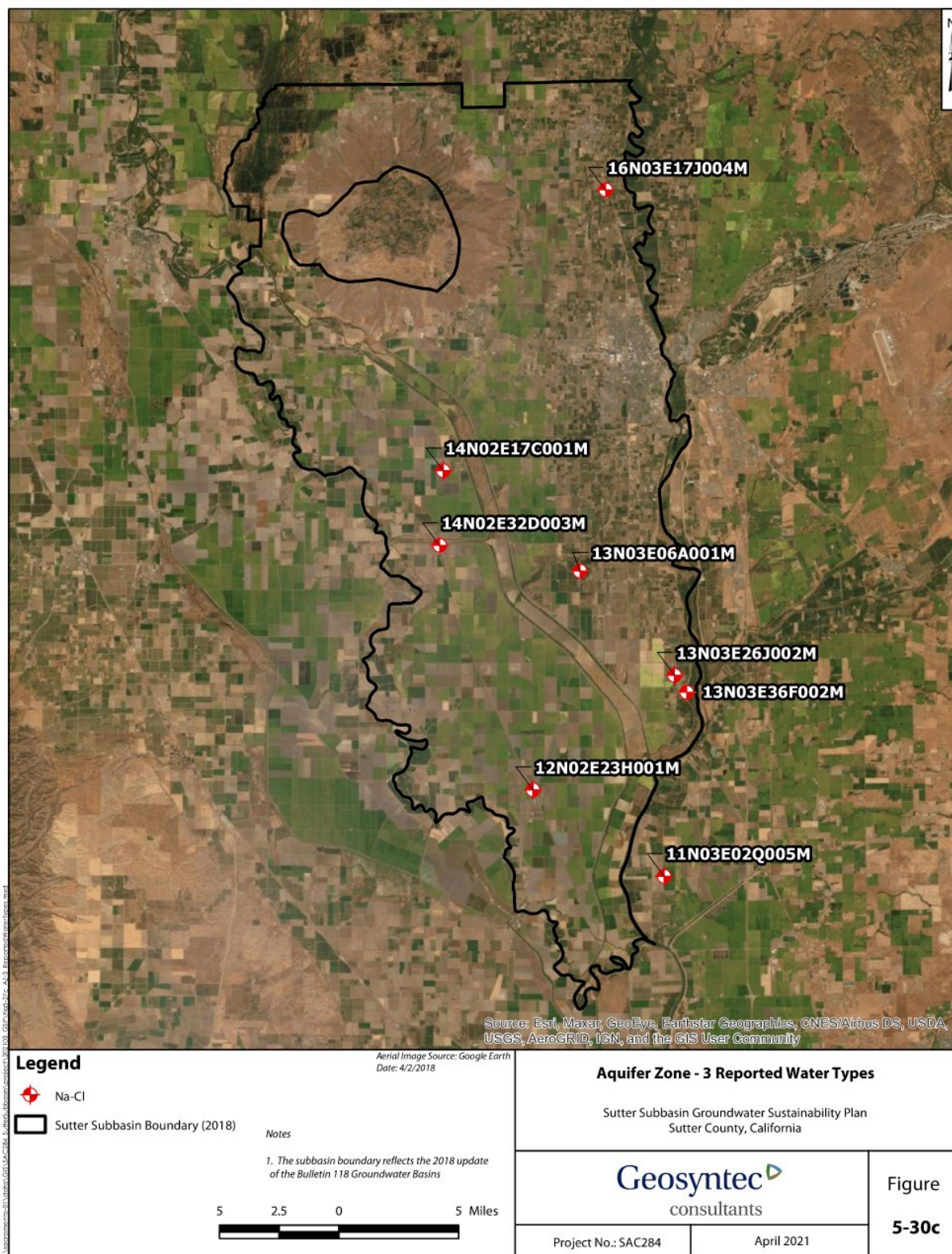


Figure 5-31. Aquifer Zone-3 Reported Water Types

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Table 5-6. Summary of Water Quality Data Used for General Chemical Analysis

Well ID	Sample Date	Boron (mg/L)	Total Alkalinity (mg/L)	Arsenic (mg/L)	Calcium (mg/L)	Chloride (mg/L)	Specific Conductance (µS/cm)	Iron (mg/L)	Magnesium (mg/L)	Manganese (mg/L)	Nitrate (mg/L)	Potassium (mg/L)	Sodium (mg/L)	TDS (mg/L)	Sulfate (mg/L)	pH	Temperature (Degrees C)
12N02E23H001M	5/18/2010	0.8	198	0.021	44	517	1938	0.008	37	0.154	<0.1	3.7	290	1060	2	7.54	18.80
12N02E23H003M	5/18/2010	0.8	209	0.048	13	151	922	0.021	5	0.073	<0.1	4.2	173	596	26	8.23	21.50
12N02E23H004M	5/18/2010	0.9	194	0.084	15	191	1004	0.032	7	0.088	<0.1	6.1	185	585	20	8.05	20.60
16N03E17J004M	8/12/2010	0.5	134	0.09	19	111	625	0.038	9	0.191	<0.1	5.5	81	386	4	7.69	20.84
16N03E17J005M	8/12/2010	1.8	108	0.013	65	488	1801	0.036	14	0.194	<0.1	12	309	1060	24	7.64	20.42
13N03E26J002M	8/12/2010	0.9	120	0.006	63	472	1728	<0.005	22	0.155	<0.1	26.2	256	951	5	8.91	20.25
13N03E26J003M	8/12/2010	0.7	157	0.008	88	355	1528	0.01	28	0.178	0.3	9.2	178	901	23	7.77	20.22
13N03E26J004M	8/12/2010	1.4	141	0.007	10	116	691	0.01	3	0.042	<0.1	3	126	403	8	8.39	20.90
13N03E26J005M	8/12/2010	2.4	109	0.012	70	920	3229	0.038	22	0.16	<0.2	11.9	483	1850	8	7.38	20.67
16N03E17J001M	8/12/2010	<0.1	70	0.002	13	2	150	<0.005	11	<0.005	3.8	<0.5	4	115	3	7.37	19.75
16N03E17J002M	8/12/2010	0.3	132	0.201	12	9	278	<0.005	11	0.329	<0.1	3.7	35	210	<1	7.39	20.04
16N03E17J003M	8/12/2010	0.3	143	0.101	17	13	310	0.039	8	0.145	<0.1	4	41	225	1	7.78	20.47
11N03E02Q002M	3/9/2011	0.3	327	0.02	55	198	1262	0.18	23	0.242	<0.1	3.1	163	716	9	8.05	18.40
11N03E02Q003M	3/9/2011	0.4	112	0.014	125	951	3279	0.062	30	0.289	<0.1	7.3	416	1880	15	8.07	19.40
11N03E02Q004M	3/9/2011	0.5	95	0.012	129	1040	3515	0.029	28	0.151	<0.1	9.2	473	2160	14	8.03	19.20
11N03E02Q005M	3/9/2011	0.5	124	0.014	38	369	1508	0.075	10	0.198	<0.1	4.6	218	866	9	8.02	18.50
13N01E24G003M	9/12/2012	0.1	112	0.011	7	4	250	0.047	8	0.07	<0.1	1.3	37	189	6	7.28	18.64
13N01E24G004M	9/12/2012	0.3	341	0.013	42	12	692	0.974	39	0.039	0.1	2.1	60	428	22	7.15	18.66
14N02E32D003M	6/20/2012	0.5	169	0.022	49	355	1502	0.021	25	0.254	0.1	11.3	221	874	32	7.67	22.13
14N02E32D002M	6/20/2012	0.3	245	0.008	20	84	784	0.184	12	0.161	<0.1	5.1	139	496	26	7.21	21.90
14N02E32D001M	6/20/2012	<0.1	276	0.006	46	11	566	<0.005	41	0.271	<0.1	2.1	20	318	15	7.18	23.87
13N03E06A001M	3/9/2011	0.3	260	0.009	117	606	2461	0.06	85	0.775	<0.1	2.6	186	1370	2	7.27	18.10
13N03E06A002M	3/9/2011	0.5	134	0.01	154	1000	3501	0.082	106	1.17	<0.1	7.6	286	2200	<1	7.18	18.40
13N03E06A003M	3/9/2011	0.7	130	0.023	148	1110	3803	0.137	99	1.42	<0.1	15.4	386	2290	<1	7.28	19.10
14N02E17C001M	3/17/2010	<0.1	408	0.011	57	16	797	<0.005	60	0.125	7	2.1	36	492	26	7.27	19.50
14N02E17C002M	3/17/2010	0.1	143	0.026	18	7	328	<0.005	9	0.074	<0.1	3.1	41	231	17	6.99	20.30
14N02E17C003M	3/17/2010	0.2	122	0.03	18	36	380	<0.005	7	0.029	0.1	3.8	51	228	12	6.78	20.30
14N02E17C004M	3/17/2010	0.7	142	0.017	127	994	3337	0.026	53	0.573	<0.333	27.7	431	2100	9	5.86	20.70
17N02E26R001M	6/17/2009	0.2	119	0.127	12	14	264	0.0161	11	0.228	1.1	4.4	30	201	<1	7.10	21.50
17N02E26R001M	9/23/2009	0.2	118	0.134	12	16	278	0.06	10	0.00022	1.1	4.2	35	202	<1	7.02	22.10
17N03E30E001M	6/17/2009	0.2	121	0.0681	10	9	250	0.0064	9	0.212	0.4	4.4	33	191	<1	7.20	21.50
17N03E30E001M	9/23/2009	0.3	120	0.0686	10	11	265	0.0318	9	0.192	0.4	4.3	38	197	<1	7.30	21.80
13N03E25B002M	8/26/2009	2.2	120	0.007	78	673	2519	0.064	17	0.574	<0.1	7.5	369	1510	<1	7.65	19.80
13N03E36F002M	8/26/2009	2.2	148	0.01	64	632	2246	0.078	17	0.451	<0.1	6.3	344	1290	<1	7.59	20.50
13N03E25B003M	8/26/2009	1.4	146	0.005	9	98	606	0.05	2	0.074	<0.1	2.1	107	361	<1	8.17	19.00

µS/cm – micro-Siemens per centimeter

Degrees C – Degrees Celsius

mg/L – milligrams per liter

TDS – Total dissolved solids

See Table 5-5 for well construction details

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Boron

Boron is a naturally occurring element and is commonly found in alluvial sediments derived from volcanic sources such as the Sutter Buttes Rampart, Mehrten, and Tuscan Formations that make up the intermediate and deep aquifer zones. High concentrations of boron can also be associated with old marine deposits that are known to exist within the basin (USGS, 2011). An MCL has not been established for drinking water, but a Notification Level of 1 mg/L has been established.

Figure 5-32 provides a cross plot of boron versus depth of the bottom of screen interval for the wells shown in **Figure 5-26**. As seen in this figure, most reported boron values are below the 1 mg/L value. However, four wells from AZ-1 (17J005M, 25B002M, 36F002M, and 25B003M) and two wells from AZ-3 (26J004M and 26J005M) are above the Notification Level of 1 mg/L. The two AZ-3 locations are located adjacent to the Feather River in the northern part of the Sutter Subbasin. The four AZ-1 wells are located adjacent to the Feather River in the southern part of the Sutter Subbasin.

Figure 5-33 displays the boron concentration distribution by aquifer zone as presented in the Alternative Plan. For these figures, developed as part of the Groundwater Management Plan for the Subbasin (Wood Rodgers, 2012), AZ-1 extends from 0 to 150 feet bgs, AZ-2 extends from 150 to 400 feet bgs, and AZ-3 covers depths from greater than 400 feet bgs. As shown in this figure, boron concentrations in the Sutter Subbasin are generally acceptable, except for some deeper wells which likely encounter more marine sediments. Boron concentrations were not monitored as part of the Rice Coalition Groundwater Assessment Report.

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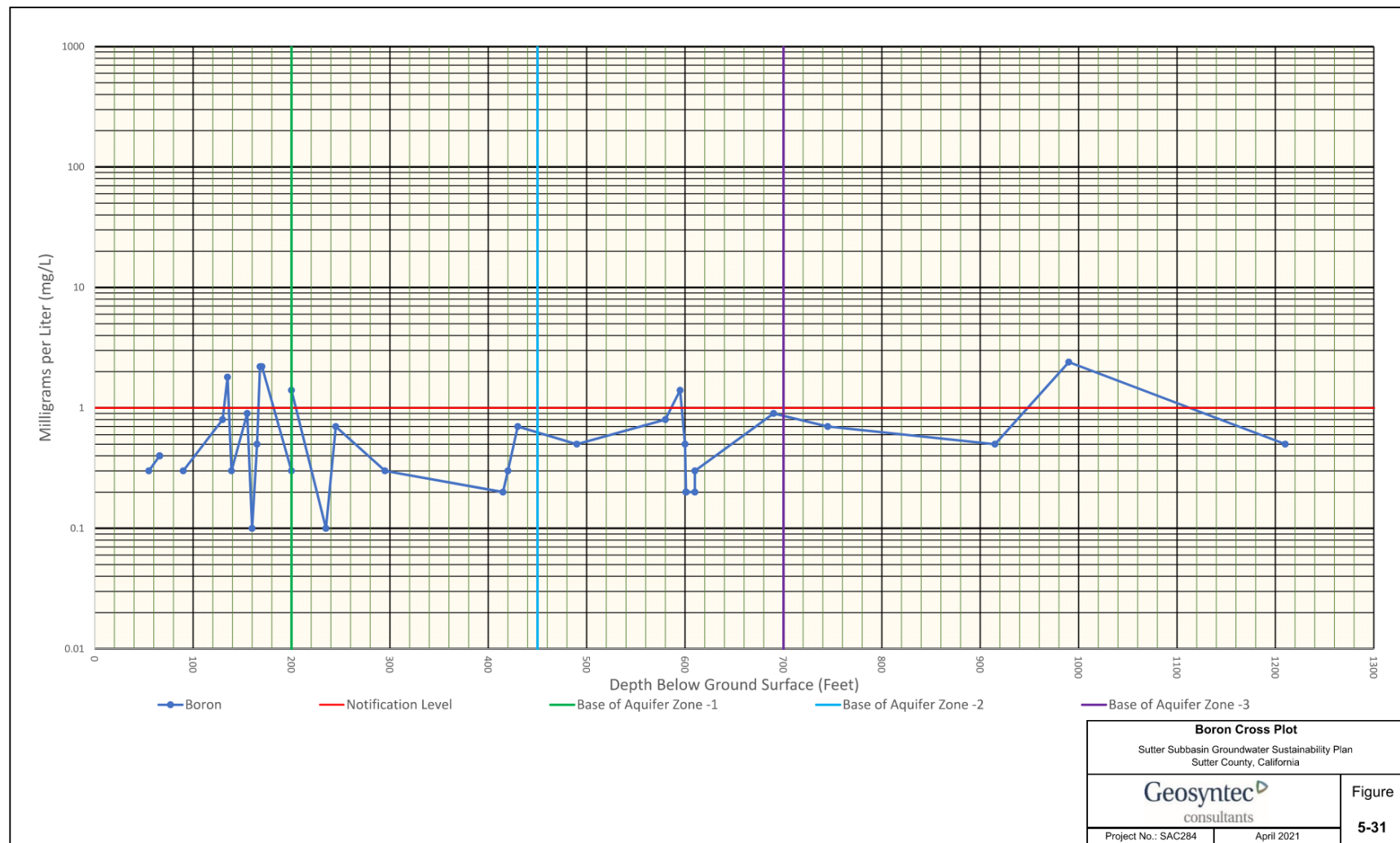


Figure 5-32. Boron Cross Plot

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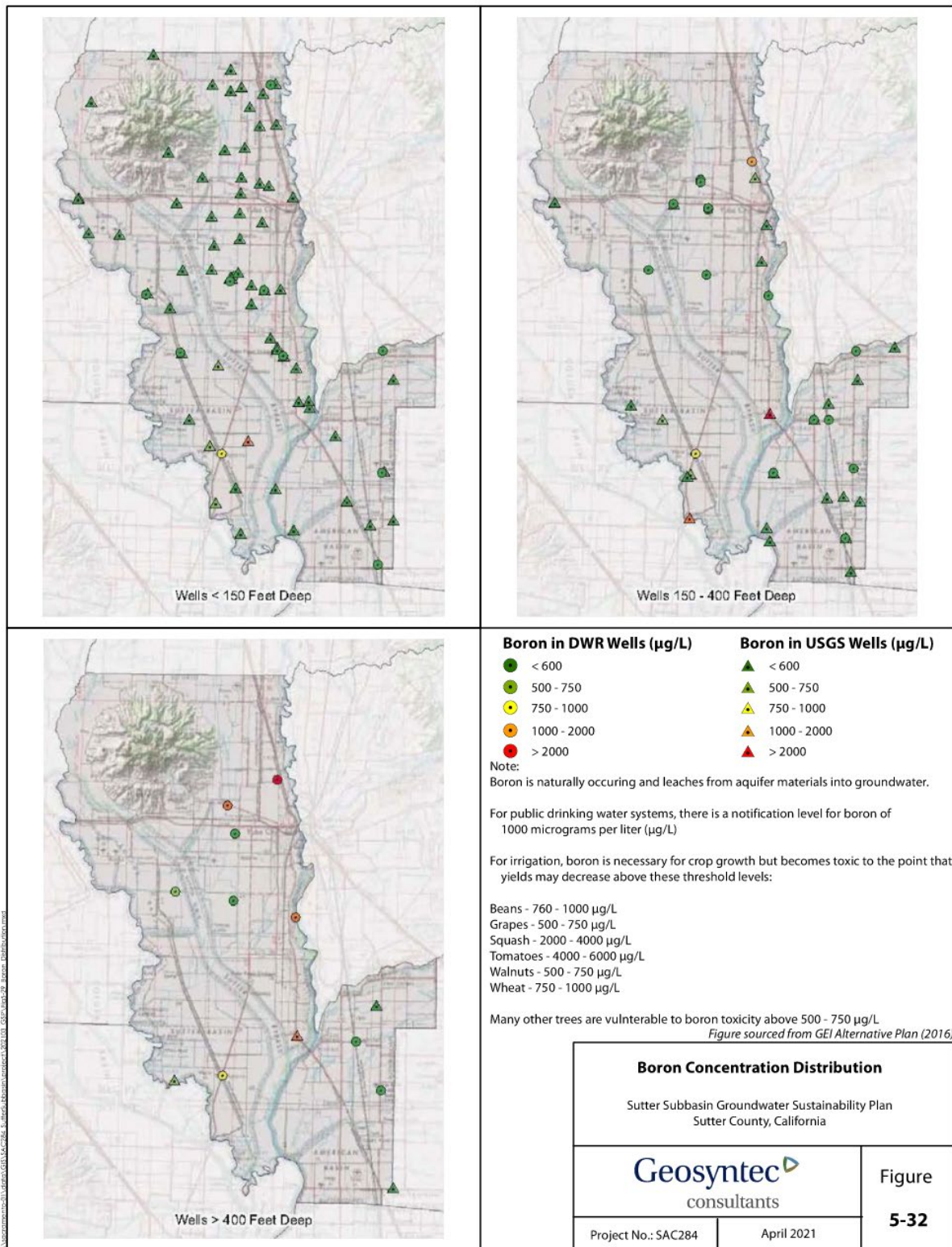


Figure 5-33. Boron Concentration Distribution by Aquifer Zone, Sutter Subbasin

Arsenic

Arsenic is a naturally occurring element commonly found in alluvial sediments derived from volcanic sources such as the Sutter Buttes Rampart, Mehrten, and Tuscan Formations that make up the intermediate and deep aquifer zones. The oxidation-reduction (redox) state of water can affect which compounds are present in that water. Water with chemistry indicating oxidizing chemical reactions is referred to as oxic; water with chemistry indicating reducing chemical reactions is referred to as anoxic. The elevated levels of arsenic within the Sutter Subbasin are most likely the result of the sediments being in contact with groundwaters under reduced conditions that have been correlated with elevated arsenic concentrations in the Sacramento Valley (USGS, 2001). As indicated in USGS (1984), reducing conditions in the Sutter Subbasin most likely produce higher concentrations of arsenic, manganese, and iron. These same conditions reduced nitrate concentrations, probably reflecting denitrification reactions.

Because of the origin of the sediments, arsenic at elevated concentrations is detected throughout the Sutter Subbasin and much of the northern Central Valley. Although oxidation-reduction data were not available for groundwater samples assessed for this GSP, USGS (2011) states that groundwater in the Quaternary alluvium along the Sacramento River and in the Delta commonly has low dissolved oxygen content that reflect reducing conditions. As indicated in the Alternative Plan, arsenic is not a component of materials applied to farmland. The primary MCL for arsenic is 10 micrograms per liter ($\mu\text{g/L}$).

Figure 5-34 provides a cross plot of arsenic versus depth of the bottom of screen interval for the well for the wells shown in **Figure 5-26**. As seen in this figure, the majority of reported arsenic values are above the MCL of 10 $\mu\text{g/L}$. The highest levels are reported for wells screened from about 300 feet bgs to 420 feet bgs (AZ-2) and 600 feet bgs to 700 feet bgs (AZ-3).

Figure 5-35 displays the arsenic distribution in the Sutter Subbasin and **Figure 5-36** shows the distribution by aquifer zone as presented in the Alternative Plan. Arsenic concentrations presented in **Figure 5-35** and **Figure 5-36** are from the USGS Rice Wells, Shallow Domestic Wells and from GAMA Well networks, as presented in the Rice Coalition Groundwater Assessment Report (CH2MHill, 2016). The GAMA well network was used to focus on the deeper portions of the aquifer. These figures divide AZ-1 through AZ-3 as described for boron.

As seen in these figures, arsenic concentrations vary in the shallow aquifer. Most (50 percent) of the locations show arsenic between half the MCL and the MCL and several locations (29 percent) exceed the MCL. Typically, arsenic concentrations increase with depth, in the intermediate and deep aquifer zones, with concentrations exceeding the MCL. Several locations show concentrations are below the MCL along the eastern side of the Sutter Subbasin.

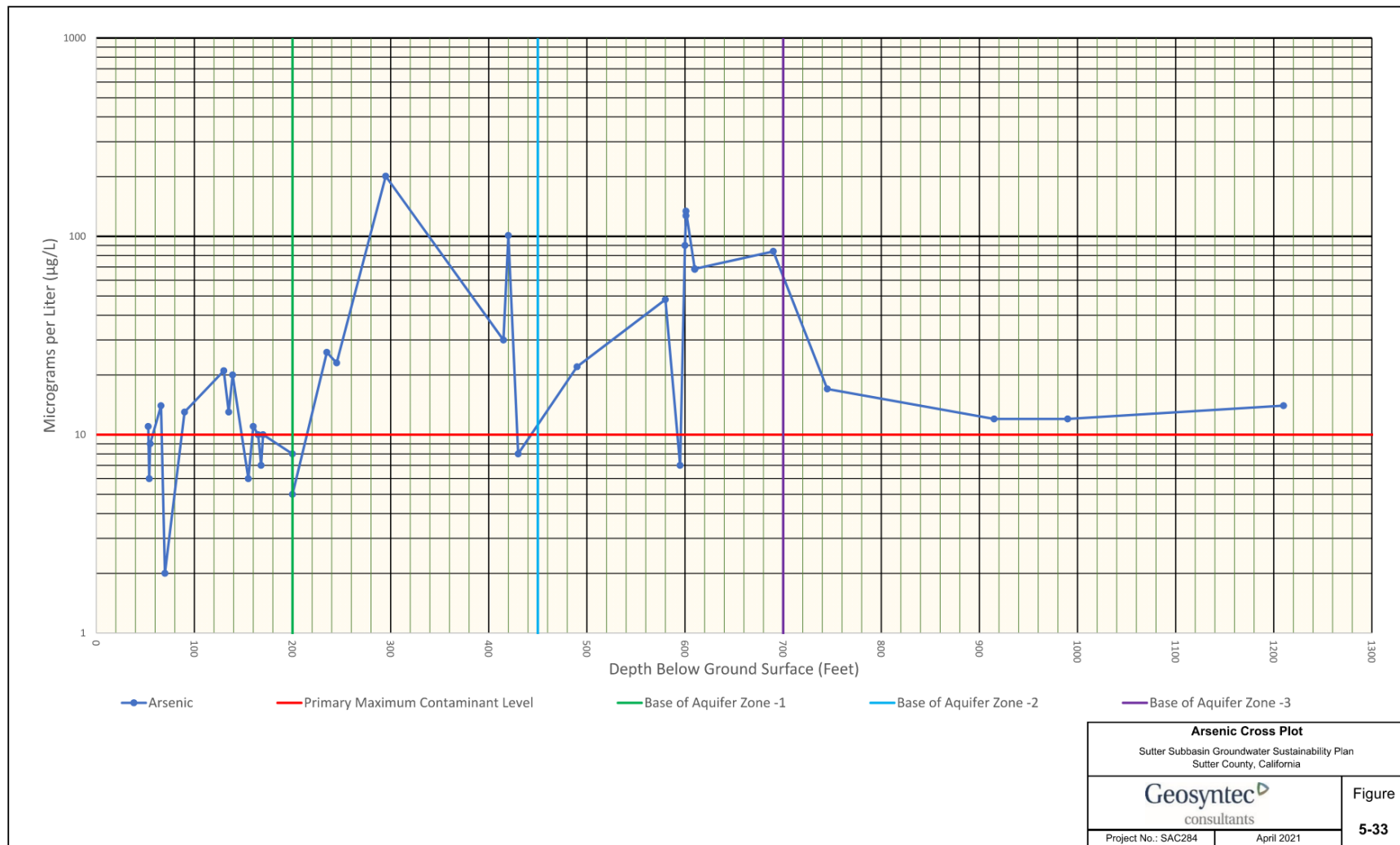


Figure 5-34. Arsenic Cross Plot

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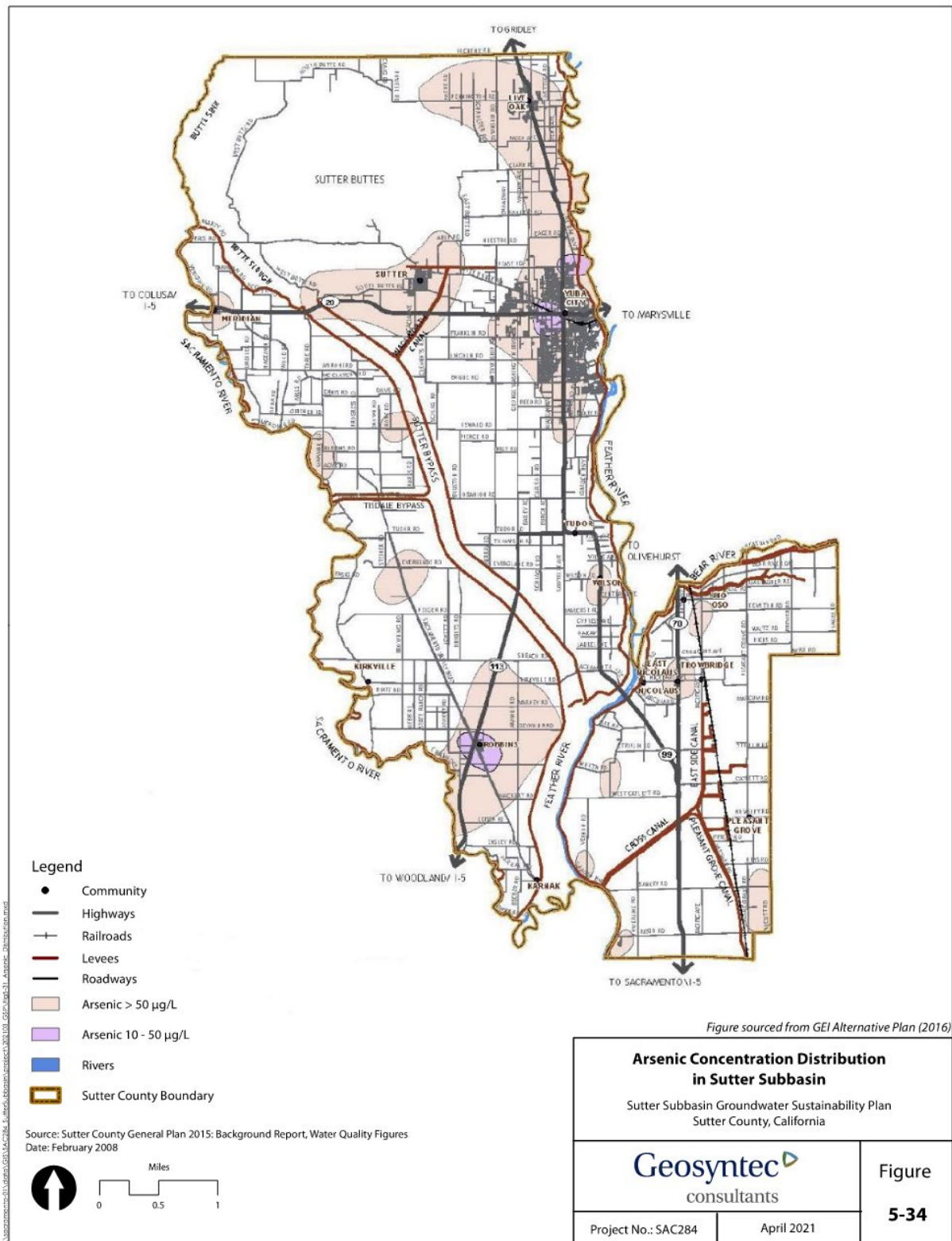


Figure 5-35. Arsenic Concentration Distribution, Sutter Subbasin

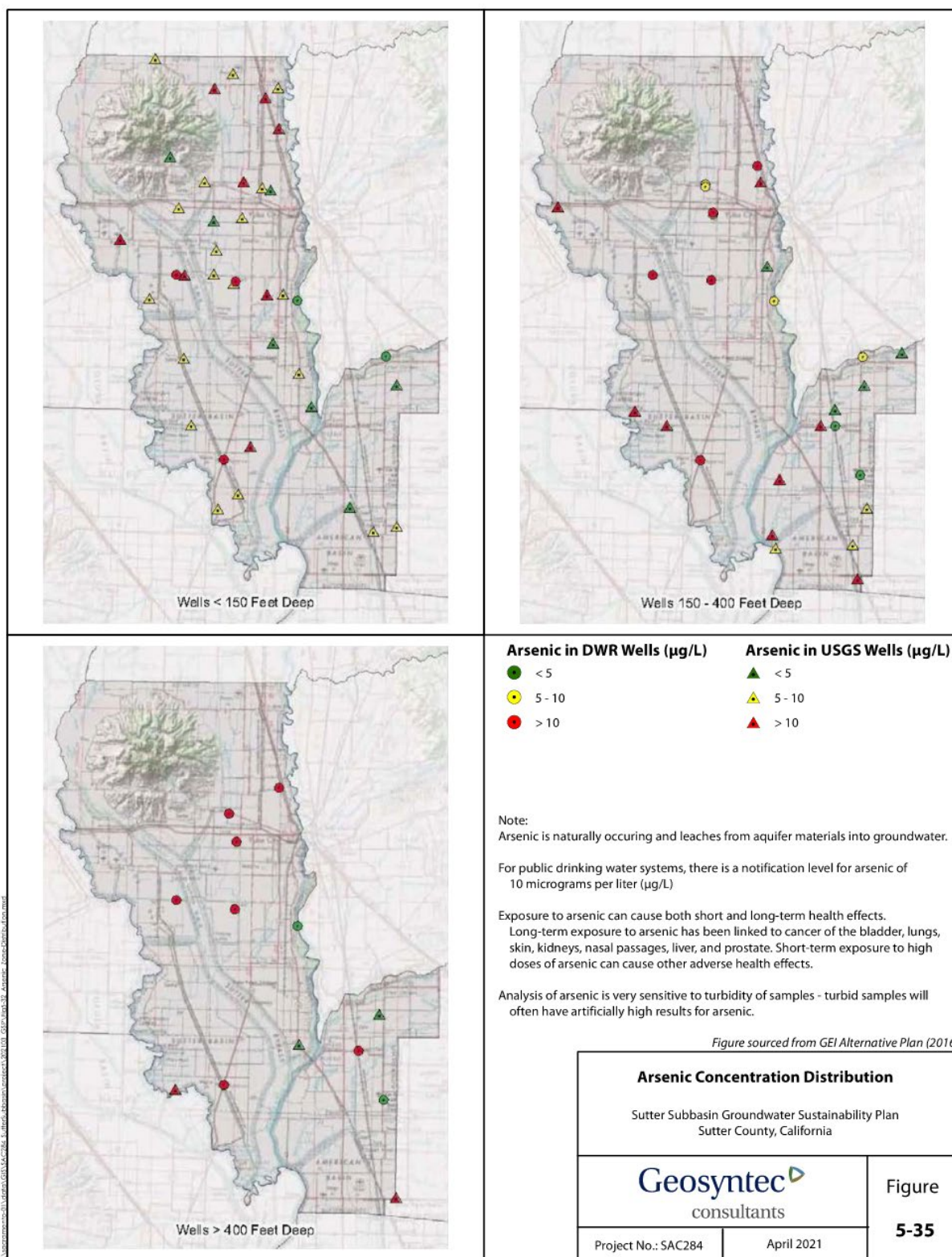


Figure 5-36. Arsenic Concentration Distribution by Aquifer Zone, Sutter Subbasin

Salinity

Salinity in groundwater is often caused by the dissolution of soluble minerals, the presence of seawater deposited with marine sediments, in particular geologic formations and/or the presence of mineral springs. The USGS (1984) indicated that a major source of salinity within the Sutter Subbasin is thought to be connate marine water moving upward along fault zones created when Sutter Buttes was emplaced.

Salinity can be assessed using different parameters, including specific conductance, TDS, and chloride. Specific conductance or electrical conductivity is a measure of how effectively water will conduct electricity. When soluble salts dissolve in water, the resulting ions behave as conductors. Therefore, specific conductance provides an indirect measurement of the amount of dissolved solids (salts). This parameter is reported in microSiemens per centimeter ($\mu\text{S}/\text{cm}$) or the equivalent unit micro mhos per centimeter ($\mu\text{mhos}/\text{cm}$). Chloride is often used to identify saline water and can be representative of where high specific conductance water is present.

The recommended SMCL for specific conductance is 900 $\mu\text{S}/\text{cm}$, with an upper SMCL of 1,600 $\mu\text{S}/\text{cm}$ and short-term secondary MCL of 2,200 $\mu\text{S}/\text{cm}$. The corresponding TDS SMCLs are 500 mg/L, 1,000 mg/L, and 1,500 mg/L. Constituent concentrations lower than the recommended SMCL (500 mg/L for TDS) are desirable for a higher degree of consumer acceptance. Constituent concentrations ranging to the Upper SMCL are acceptable if it is neither reasonable nor feasible to provide more suitable waters. Constituent concentrations ranging to the short-term SMCL are acceptable only for existing community water systems on a temporary basis pending construction of treatment facilities or development of acceptable new water sources. The SMCL for chloride is 250 mg/L.

Figure 5-37 provides cross plots of specific conductance, TDS, and chloride versus depth of the bottom of screen interval for the wells shown in **Figure 5-26**. As seen in this figure, high salinity values exist from about 50 feet bgs to 245 feet bgs and from below 700 feet bgs. Wells completed between 300 feet bgs and 700 feet bgs have reported specific conductance and TDS values below their respective upper SMCL, although the two wells between 430 feet and 490 feet bgs have chloride values above the SMCL.

Figure 5-38 presents the distribution of specific conductance by aquifer zone as divided in the Alternative Plan. As seen in this figure, specific conductance values in the shallow aquifer zone in the northern half of the Sutter Subbasin are mostly below the SMCL. Elevated values of specific conductance are near to and/or exceed the recommended SMCL in the shallow aquifer between the Feather and Sacramento Rivers, in the intermediate aquifer at one location, and at two locations in the deep aquifer. The Alternative Plan stated that it is unclear why elevated specific conductance occurs in the shallow aquifer zone (which suggests an agricultural source), but because nitrate concentrations do not correlate with areas of elevated specific conductance, the salinity

does not appear to be related to agriculture. However, as previously discussed, the existence of reducing conditions in the shallow zone could result in lower levels of nitrate due to denitrification suggesting that the high salinity values in the shallow zone are from agricultural sources. In groundwater below 700 feet, the poor water quality is likely due to the underlying marine sediments being in direct contact with the deeper aquifer zones and potentially due to faults that have created pathways that allow water from the older marine sediment to migrate upward (USGS, 1984).

The Rice Coalition Groundwater Assessment Report (CH2MHill, 2016) also assessed trends in salinity across the Subbasin using trends in TDS. **Figure 5-39** is a snapshot of Figure 5-5 from CH2MHill (2016) showing trends of TDS within the Sutter Subbasin. As shown in this figure, several areas show increasing trends in salinity across the Subbasin, although many of these areas are still below the upper SMCL of 1,000 mg/L.

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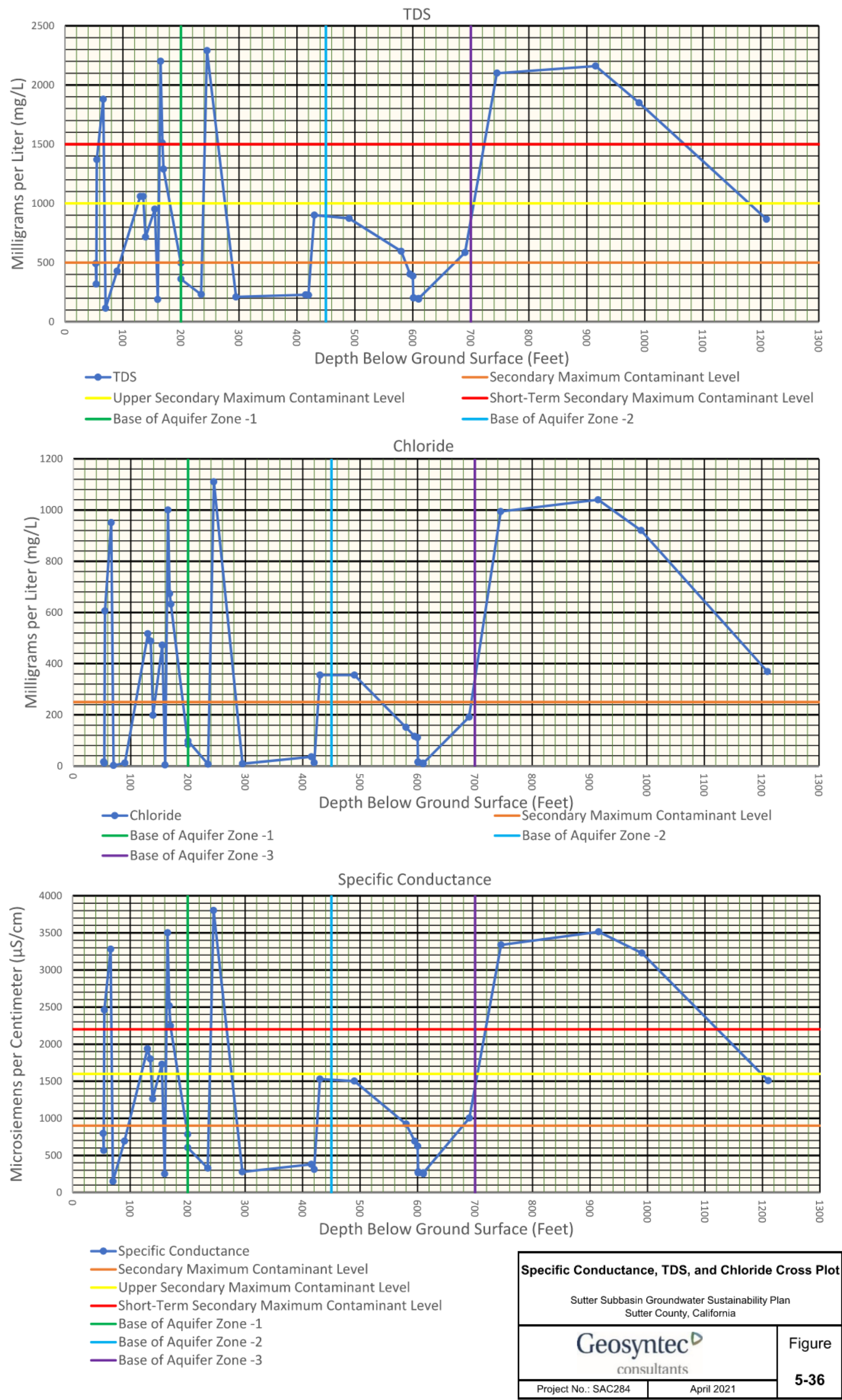


Figure 5-37. Specific Conductance, TDS, and Chloride Cross Plot

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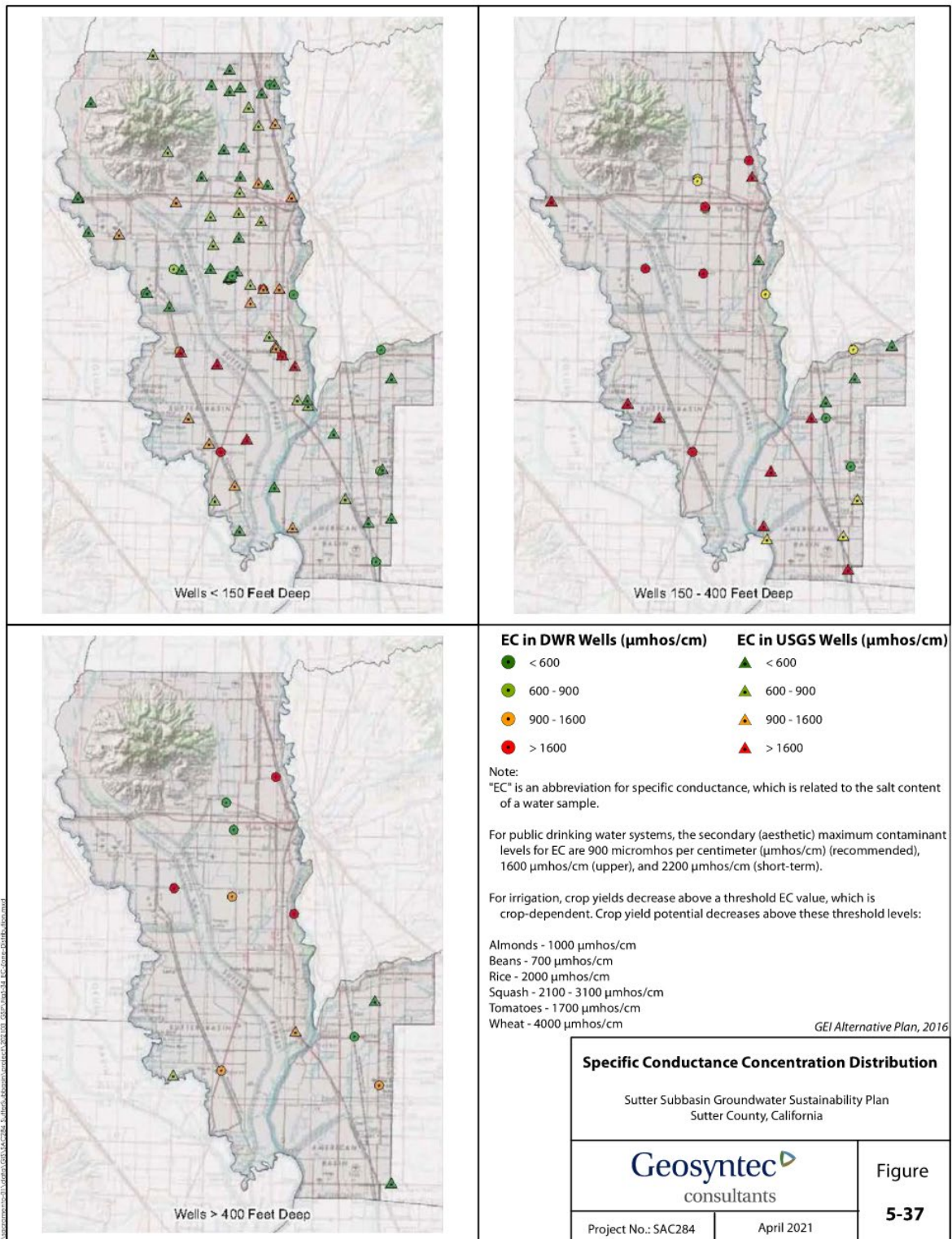


Figure 5-38. Specific Conductance Concentration Distribution by Aquifer Zone, Sutter Subbasin

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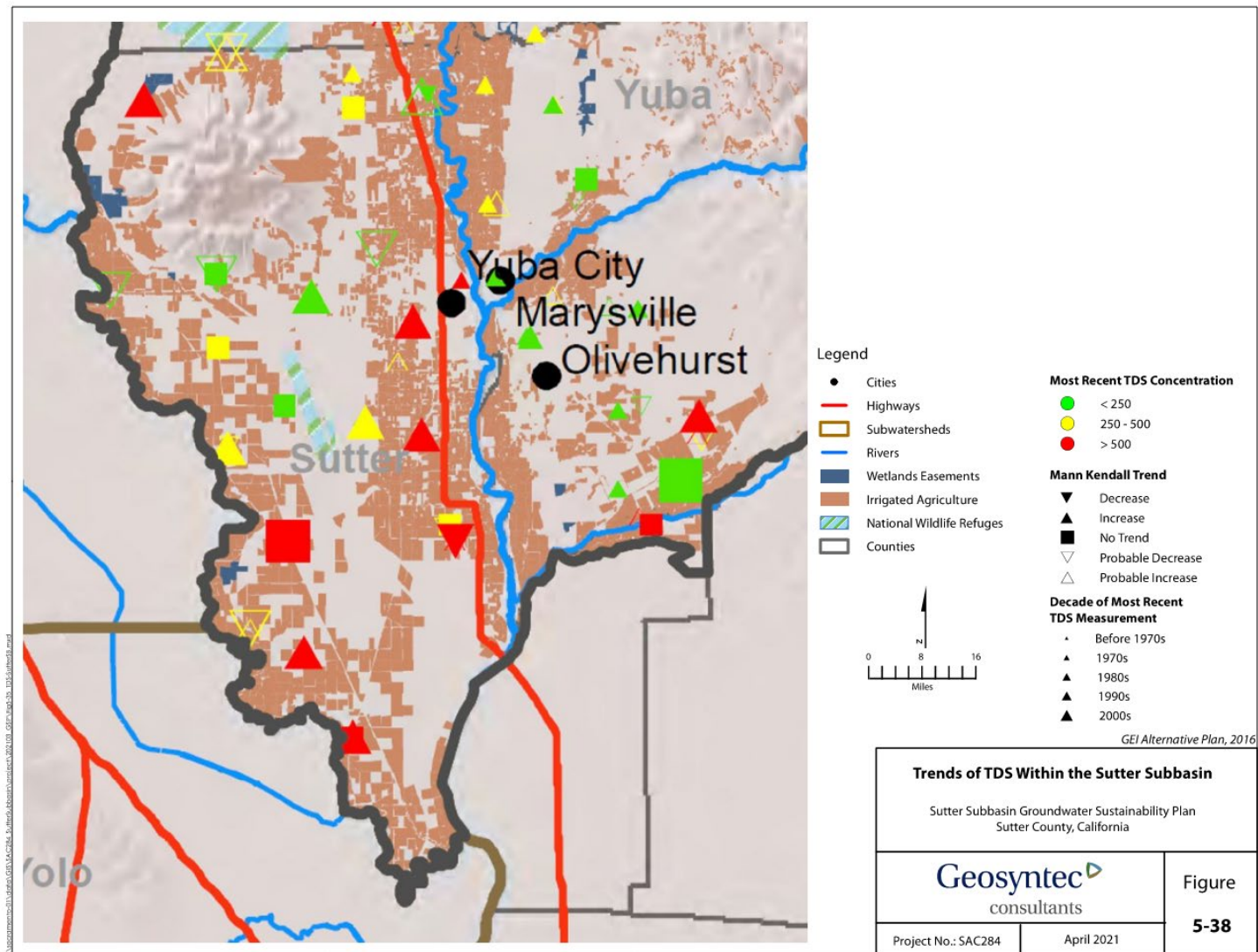


Figure 5-39. TDS Trends, Sutter Subbasin

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Nitrate

Nitrogen is present in water bodies in the following forms that are measured to characterize water quality: nitrate (NO_3), ammonia (NH_3), and organic (Total Kjeldahl nitrogen [TKN] minus NH_3). The sum of the concentration of these compounds is referred to as total nitrogen. The primary drinking water MCL for nitrate (as nitrate) is 45 mg/L.

Nitrogen is of particular concern when assessing water quality impacts from agriculture as it is frequently applied as fertilizer. Nitrate concentrations at or exceeding 3 mg/L are generally thought to be caused by anthropogenic sources. Nitrate can occur naturally in groundwater from leaching of soils or bedrock. Nitrate does not generally react with soil particles or sediment and tends to move with groundwater due to its high solubility in water and its generally stable condition. Ammonia is less mobile and is subject to sorption and conversion to nitrate under oxidized conditions (USGS, 2001).

Anthropogenic groundwater nitrate sources include synthetic fertilizer, animal manure (including poultry facilities), wastewater treatment plant effluent and biosolids, and septic systems (Esser et al., 2003).

Figure 5-40 provides the cross plot of nitrate versus depth of the bottom of screen interval for the wells shown in **Figure 5-26**. As seen in this figure, all the reported nitrate values are significantly below the MCL of 45 mg/L.

Figure 5-41 shows the distribution of nitrate across the Sutter Subbasin by aquifer zone as presented in the Alternative Plan. Near the Sutter Buttes and Yuba City, nitrate concentrations in several wells in the shallow aquifer (less than 150 feet) exceed the MCL. Some of these populated areas have septic systems that might be the source of the nitrate. Concentrations in the shallow aquifer in the southern portion of the Sutter Subbasin are below the MCL. Concentrations in the intermediate and deep aquifer zones are also below the MCL.

The Alternative Plan further stated that eighty-four percent of the USGS Rice Wells' (CH2MHill, 2016) samples had nitrate concentrations below 3 mg/L, which is the level generally considered to be indicative of potential impacts by human activities. Therefore, this report states that nitrate levels in these wells are likely to be naturally occurring. However, as indicated in USGS (1984), reducing conditions in the Sutter Subbasin most likely produce higher concentrations of arsenic, manganese, and iron, whereas these conditions reduced nitrate concentrations probably reflecting denitrification reactions. As such, even these lower nitrate levels in these areas could be the result of anthropogenic sources.

The Rice Coalition Groundwater Assessment Report (CH2MHill, 2016) also assessed trends in nitrate across the Subbasin. **Figure 5-42** is a snapshot of Figure 5-3 from CH2MHill (2016) showing trends of nitrate within the Sutter Subbasin. As shown in this

figure, several areas within the central portion of the Subbasin show increasing trends in nitrate concentration, although many of these areas are below the MCL of 45 mg/L.

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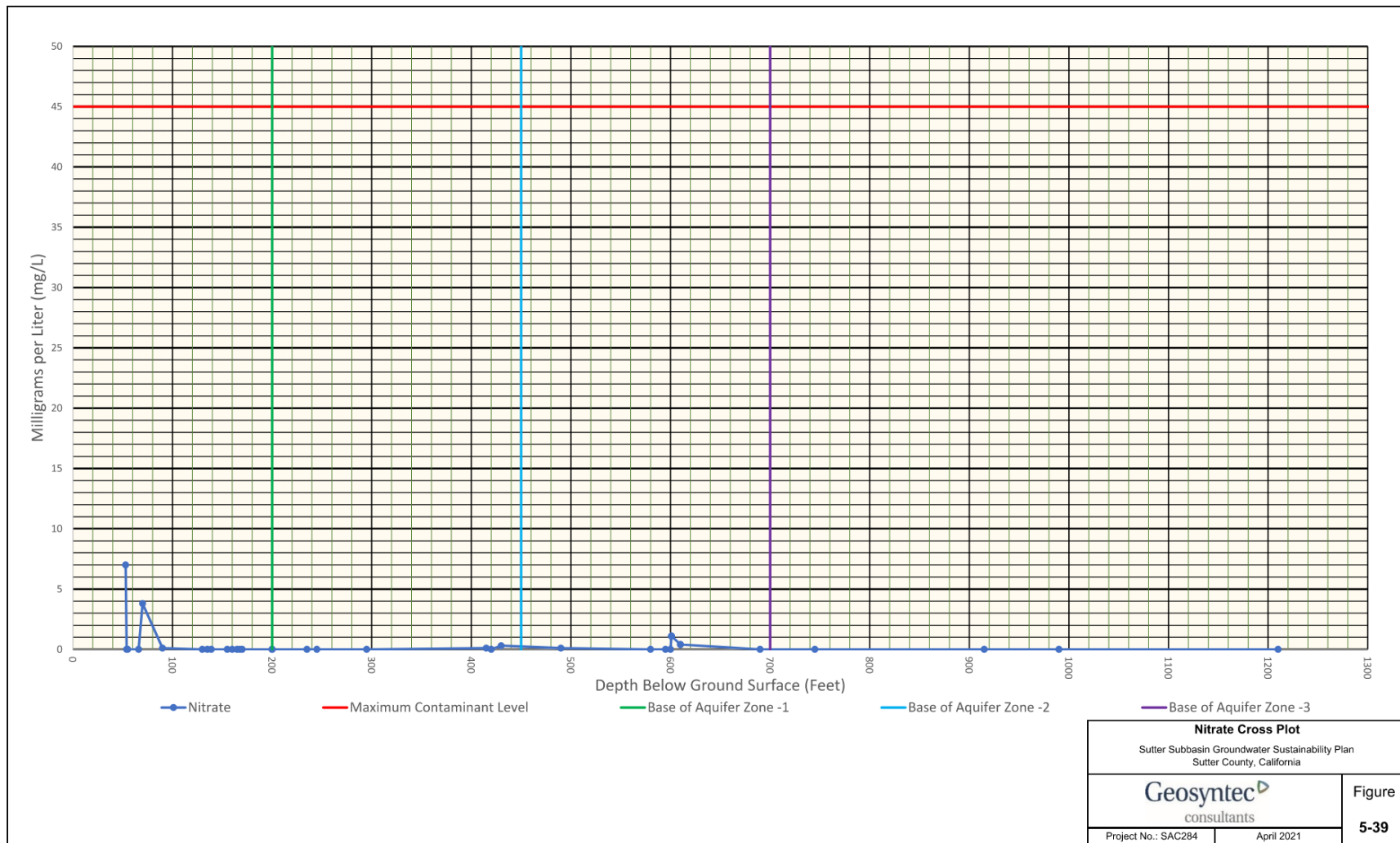


Figure 5-40. Nitrate Cross Plot

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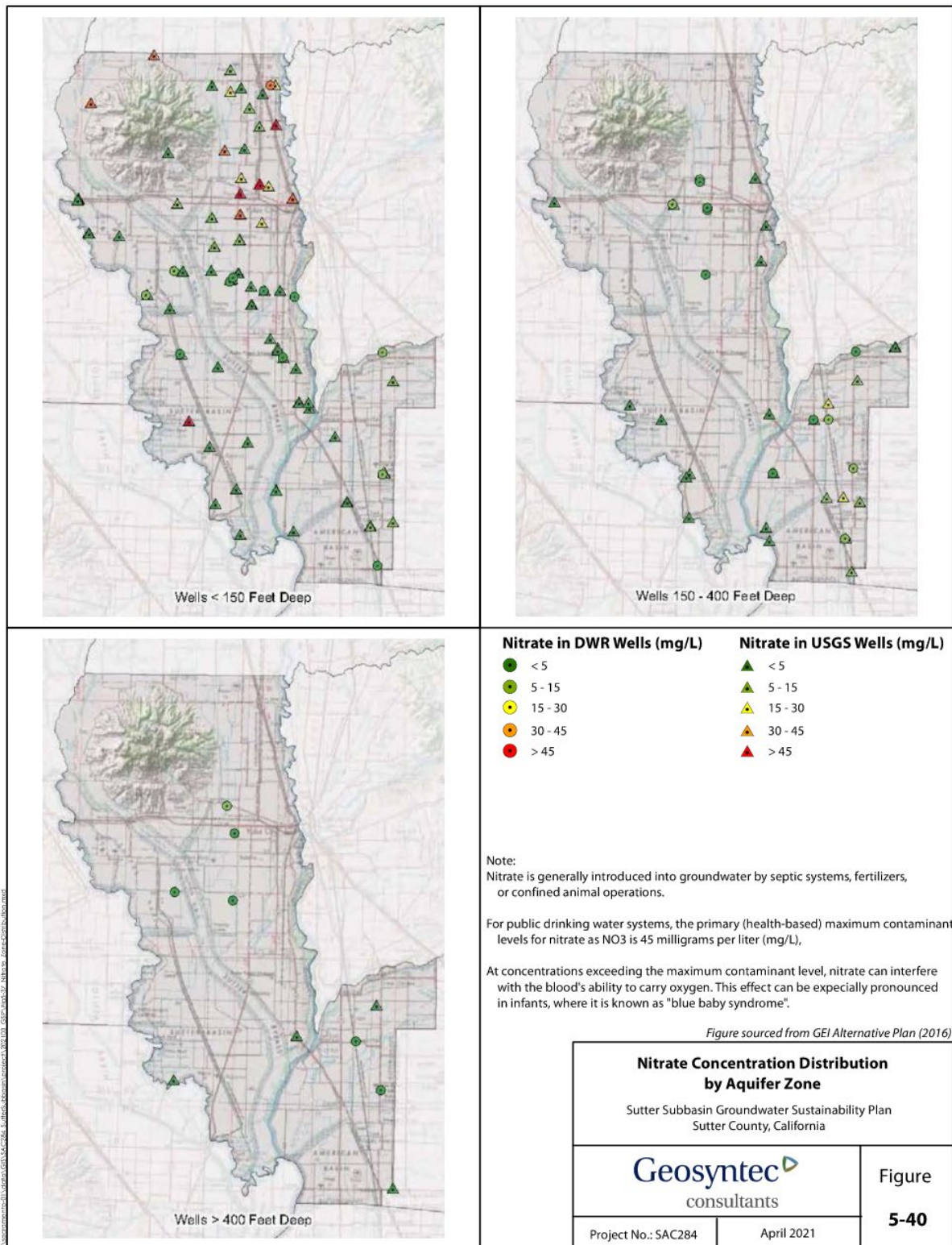


Figure 5-41. Nitrate Concentration Distribution by Aquifer Zone, Sutter Subbasin

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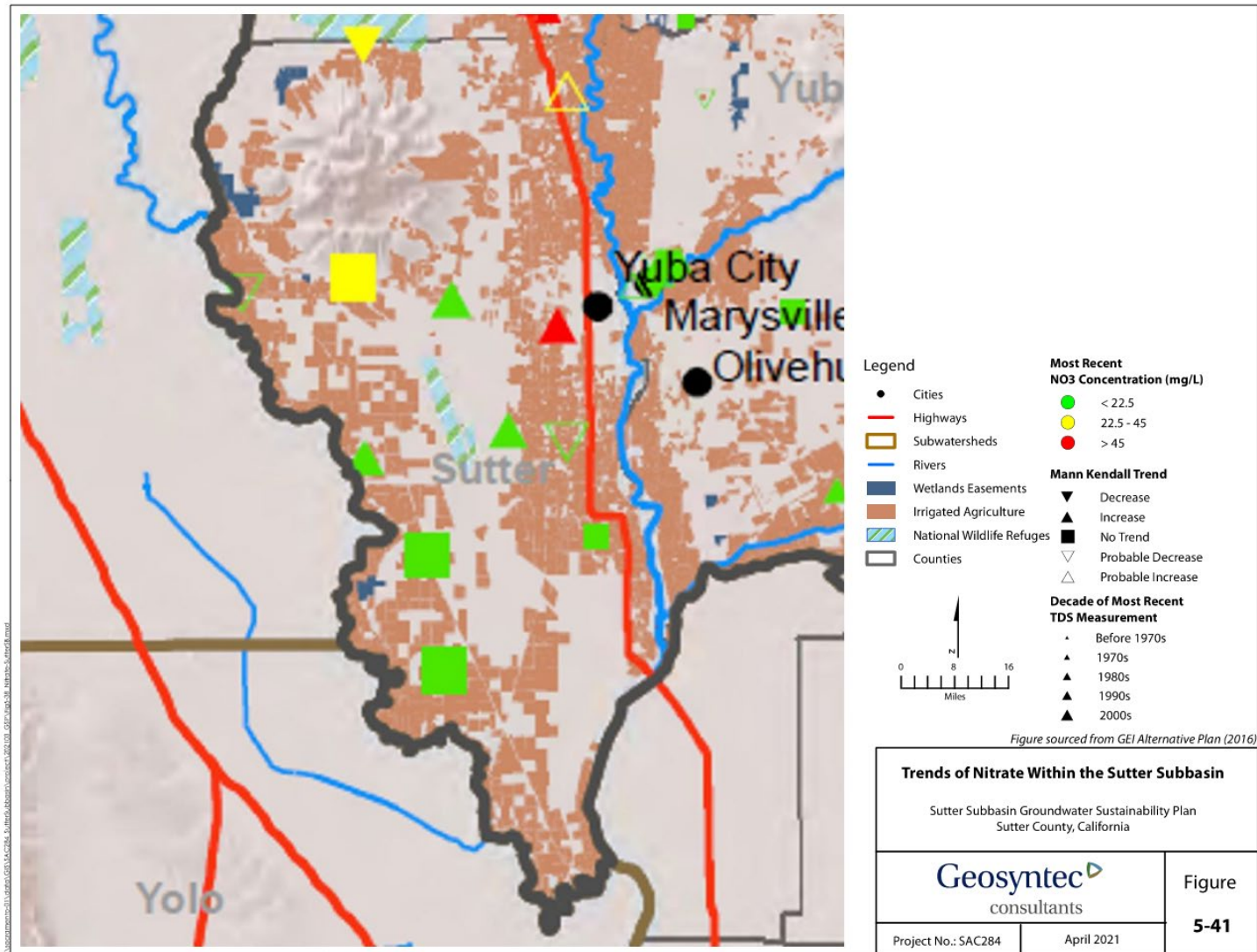


Figure 5-42. Nitrate Trends, Sutter Subbasin

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Iron and Manganese

Iron and manganese are naturally occurring elements in rocks and minerals and the dissolution of these materials can mobilize them into groundwater. These minerals are commonly associated with volcanic derived sediments that form the Sutter Buttes Rampart, Mehrten, and Tuscan Formations. The SMCL for iron is 0.3 mg/L and for manganese is 0.05 µg/L.

Figure 5-43 provides the cross plots for iron and manganese versus depth of the bottom of screen interval for the wells shown in **Figure 5-26**. As seen in this figure, only one well completed at 90 feet bgs (24G004M, **Figure 5-26**) had a reported iron concentration above the SMCL whereas almost all the wells had reported manganese levels above the SMCL. The highest reported manganese levels were within the upper 250 feet. USGS (1984) indicated that reducing conditions in the Sutter Subbasin most likely produce higher concentrations of iron and manganese, and the USGS (2011) has reported that groundwater in the Quaternary alluvium along the Sacramento River and in the Delta commonly has low dissolved oxygen content that reflect reducing conditions.

Figure 5-44 shows the manganese distribution by aquifer zones as presented in the Alternative Plan. As seen in this figure, manganese concentrations in the shallow aquifer are typically below the SMCL in the northern portion of the County, but in the southern half, concentrations typically exceed the SMCL; this trend is consistent with the USGS (2011) report that reducing conditions exist in this area. Manganese concentrations in the deeper aquifer zones typically exceed the SMCL, but there are some occurrences where their concentrations are below the MCL. There are no data (oxidation-reduction potential or dissolved oxygen) to indicate if reducing conditions exist in these areas, but high concentrations of manganese especially above 1 mg/L are indicative of reducing conditions.

Iron concentrations were not monitored as part of the Rice Coalition Groundwater Assessment Report and a figure showing iron distribution by aquifer zones was not included in the Assessment Report. However, **Figure 5-45** shows the iron distribution across the Subbasin as presented in the Alternative Plan and shows elevated iron concentrations above the SMCL in areas along the Feather and American Rivers reported to have reducing conditions (USGS, 2011).

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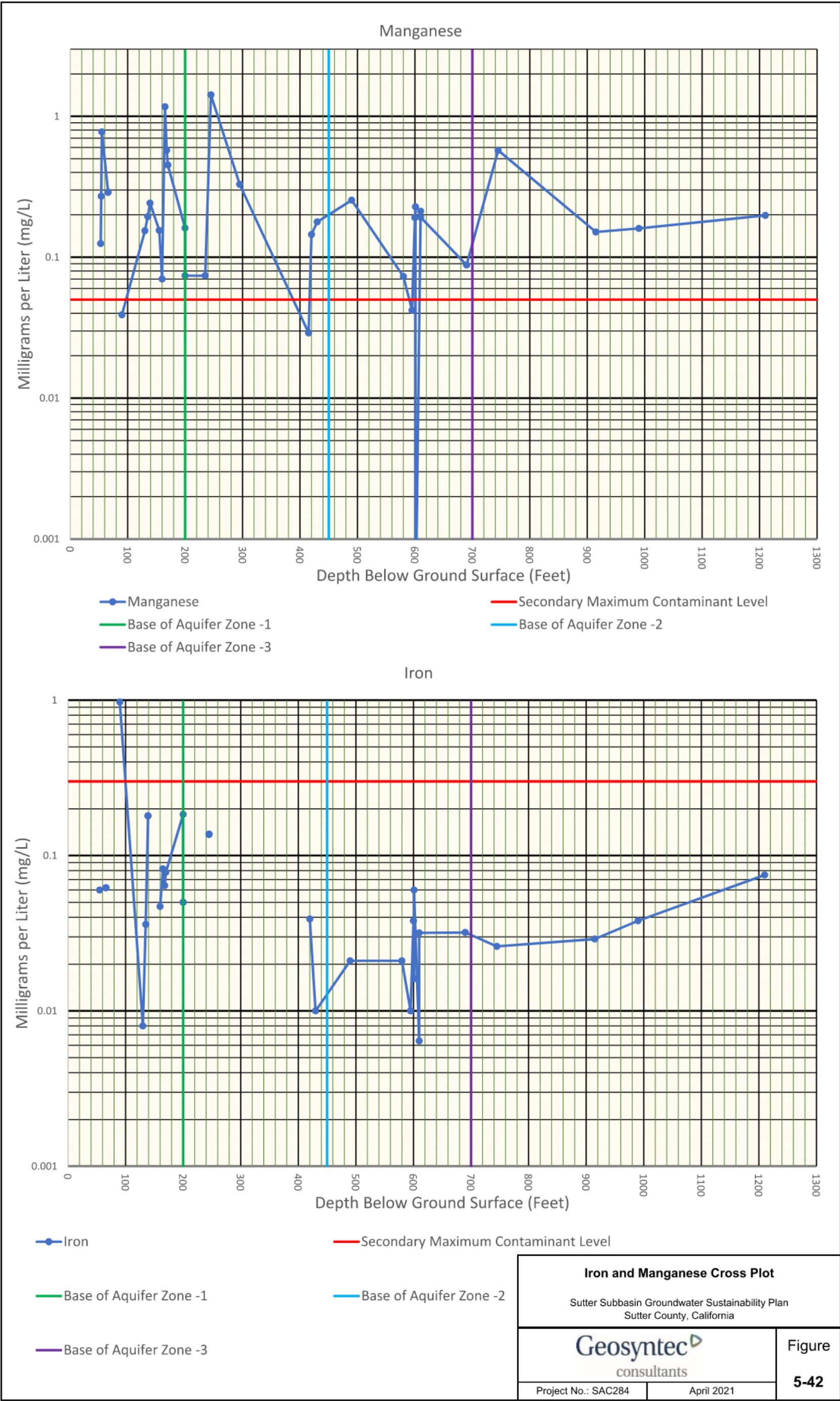


Figure 5-43. Iron and Manganese Cross Plot

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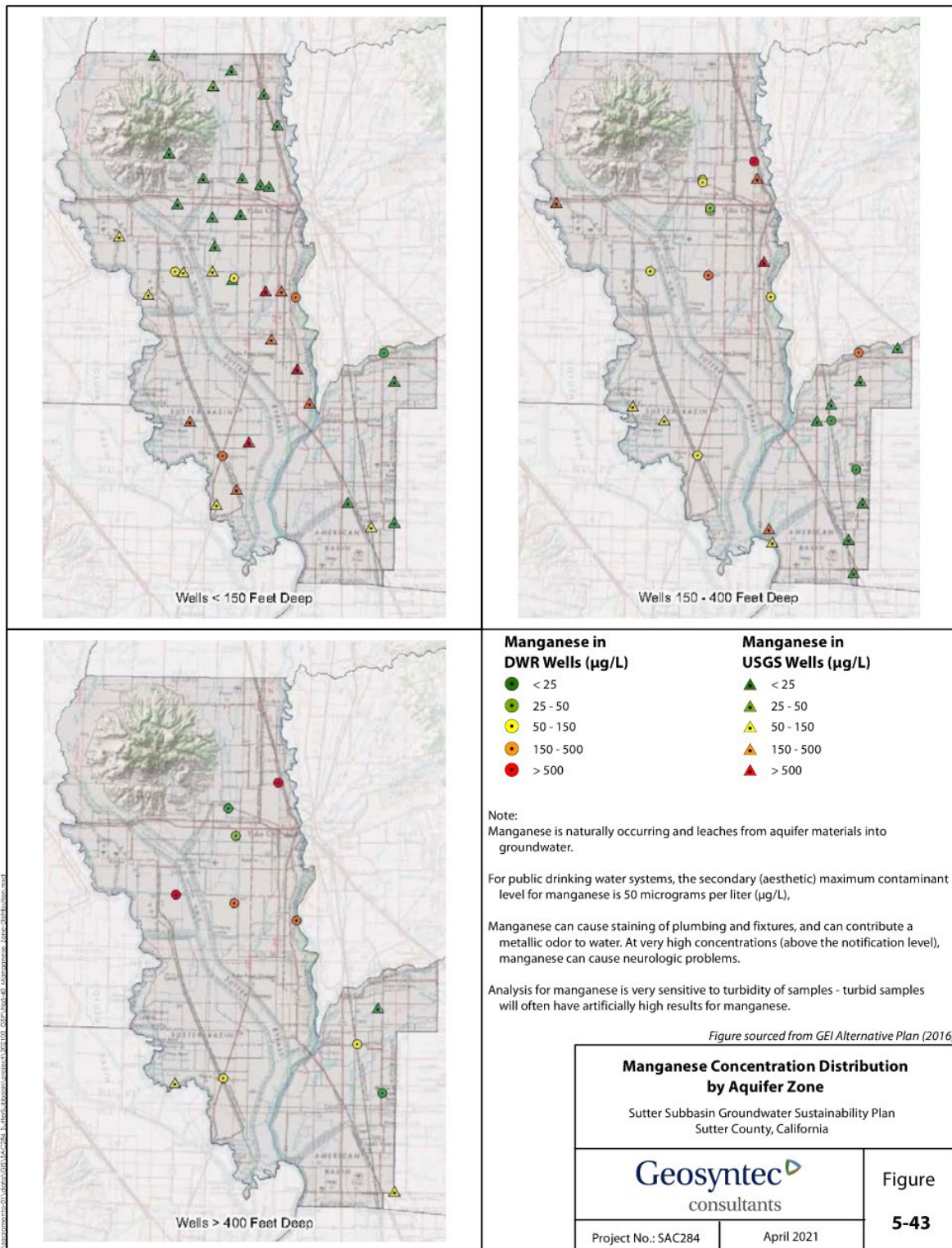


Figure 5-44. Manganese Concentration Distribution by Aquifer Zone, Sutter Subbasin

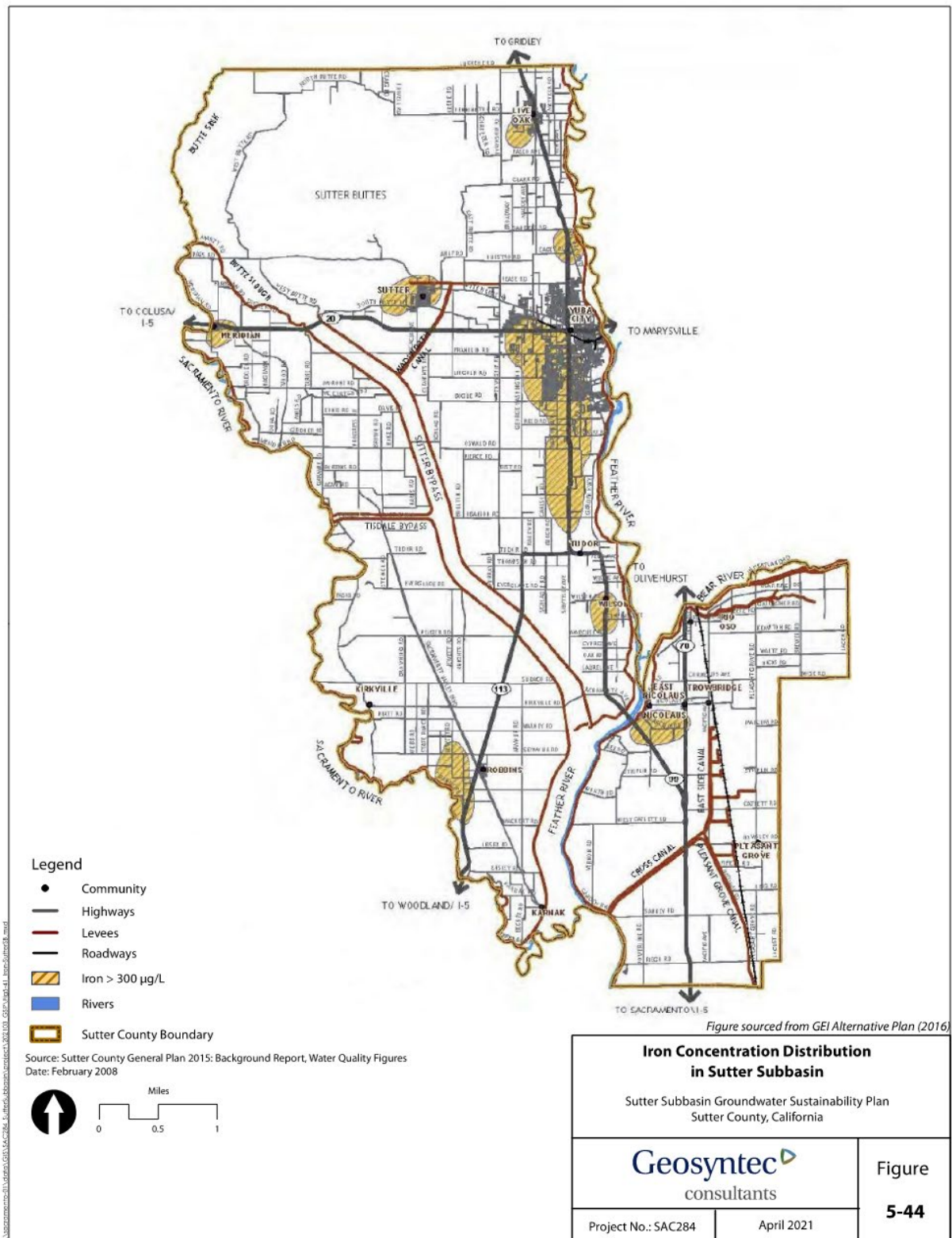


Figure 5-45. Iron Concentration Distribution, Sutter Subbasin

Point Sources

The goal of groundwater quality management under SGMA is to supplement information available from other sources with data targeted to assist GSAs in the Sutter Subbasin to comply with the requirements of SGMA. Development of groundwater quality-related sustainable management criteria for the Sutter Subbasin is not intended to duplicate or supplant the goals and objectives of ongoing programs including those by the USGS Rice, Shallow Domestic, and GAMA well programs, Sacramento Valley Water Quality Coalition (SVWQC), and the State Drinking Water Information System (SDWIS).

Because irrigated agriculture is the predominant land use in the Sutter Subbasin, monitoring of the groundwater quality data developed through the Groundwater Quality Trend Monitoring Work Plan (GQTMWP) being implemented by the SVWQC for compliance with the Central Valley Regional Board's Irrigated Lands Regulatory Program (ILRP) will be an important source of information to GSAs in the Subbasin. Pesticides are included in this program as well as part of the Rice Coalition Groundwater Assessment program.

Among the contaminants that may affect groundwater conditions in the future are chemicals of emerging concern (CECs). These are contaminants having toxicities not previously recognized, which may have the potential to cause adverse effects to public health or the environment and are found to be building up in the environment or to be accumulating in humans or wildlife. CECs such as perfluorooctanesulfonic acid (PFOS) and per- and polyfluoroalkyl substances (PFAS) will not be monitored under the groundwater quality monitoring program established for SGMA. However, GSAs will have access to data on CECs collected by other agencies and will be attentive to the effect the presence of CECs may have on groundwater management in specific locations.

The SGMA regulations require that GSPs describe locations, identified by regulatory agencies, where groundwater quality has been degraded due to industrial and commercial activity. Locations of impacted groundwater were identified by reviewing information available on the State Water Resources Control Board GeoTracker/GAMA website, the California Department of Toxic Substances Control (DTSC) EnviroStor website, and the Environmental Protection Agency's (USEPA) National Priorities List (NPL). Cases that have been closed by the supervisory agency are not considered.

Figure 5-46 and **Figure 5-47** provides the locations of active sites listed in California's GeoTracker/GAMA and EnviroStor databases, respectively, that could potentially impact groundwater in the Sutter Subbasin. Links to each of these databases that also include locations of National Priorities List or "Superfund" sites are as follows:

- EnviroStor - <https://www.envirostor.dtsc.ca.gov/public/>
- GeoTracker/GAMA - <https://geotracker.waterboards.ca.gov/>

As shown in **Figure 5-46**, 22 open Geotracker sites and **Figure 5-47** shows four active EnviroStor sites in the Sutter Subbasin. **Table 5-7** lists the information available for open GeoTracker sites and **Table 5-8** includes information for active EnviroStor sites.

Under SGMA, GSAs are only responsible for groundwater quality issues related to pumping. Other programs and agencies are responsible for enforcing groundwater quality violations for sites located in the Subbasin. However, GSAs will coordinate with these other agencies if water quality degradation is associated with groundwater pumping.

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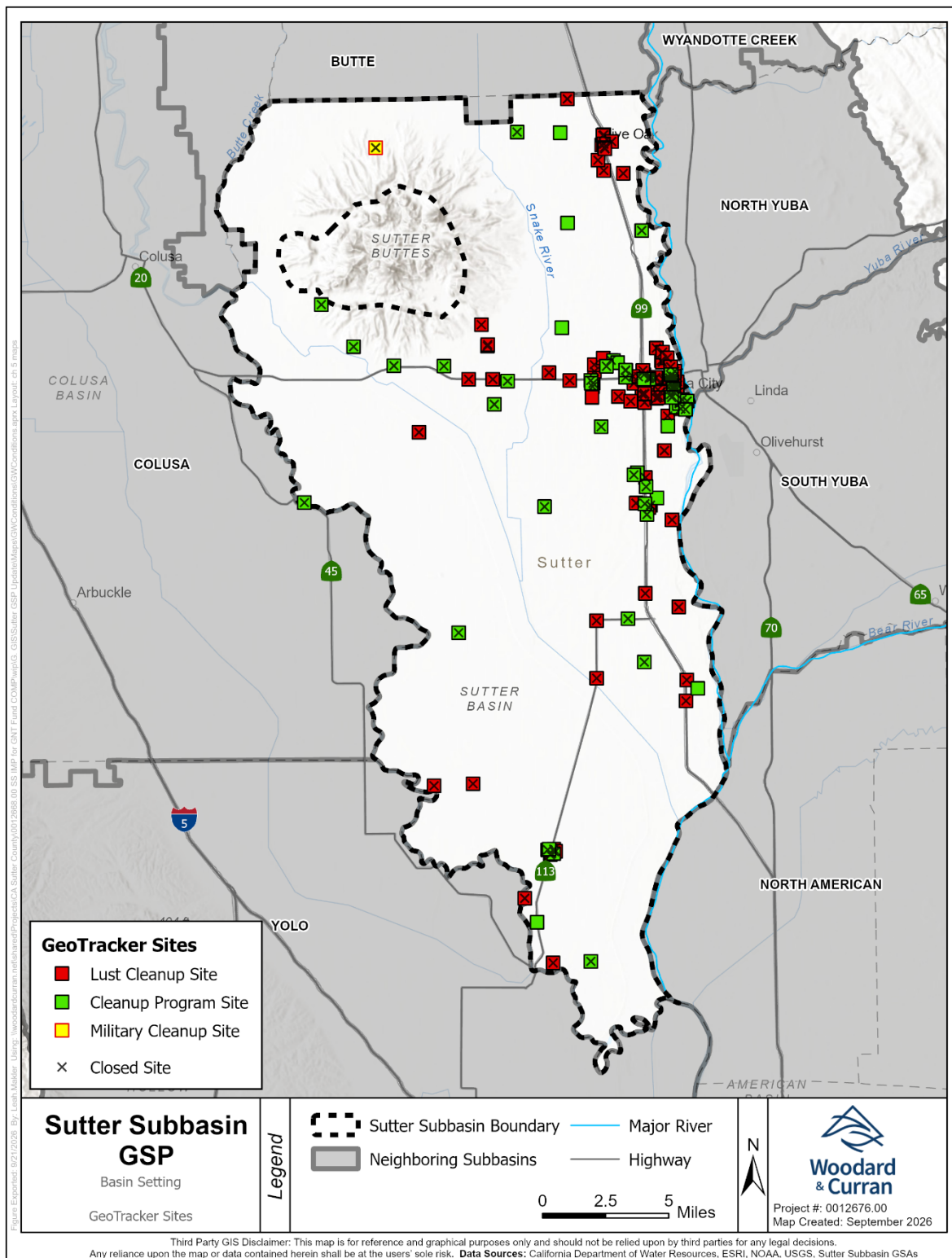


Figure 5-46. GeoTracker Sites, Sutter Subbasin

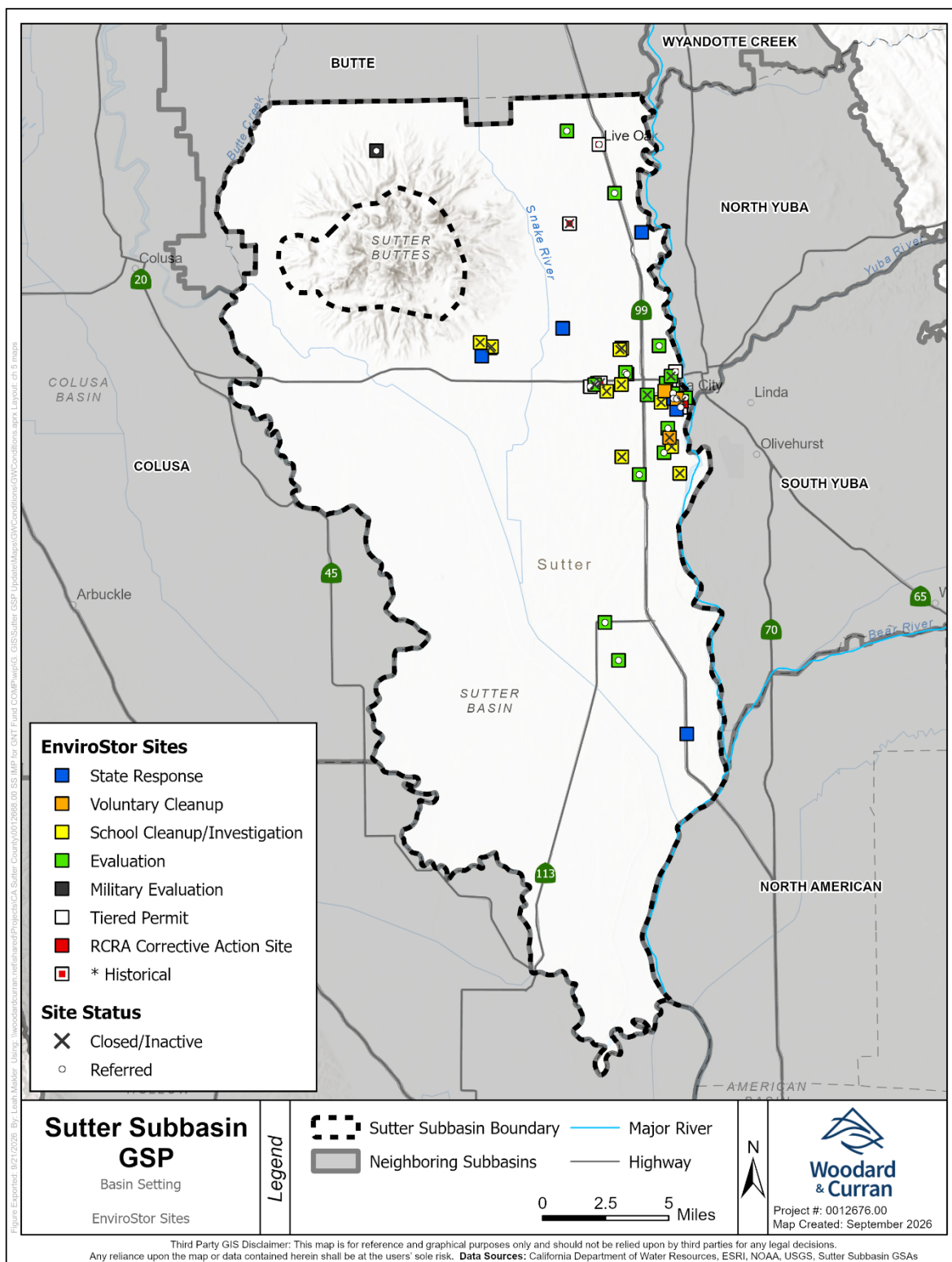


Figure 5-47. Active EnviroStor Sites, Sutter Subbasin

Table 5-7. Open GeoTracker Sites, Sutter Subbasin

Site Name	Site Type	Status	Address	City	Latitude	Longitude
442 B Street	Cleanup Program Site	Open - Site Assessment	442 B Street	Yuba City	39.1333	-121.61257
AAA Salvage Yard	Cleanup Program Site	Open - Inactive	3094 North Township Road	Yuba City	39.17126132	-121.6940117
Bob's Flying Service	Cleanup Program Site	Open - Inactive	20510 Highway 113	Knights Landing	38.830045586415686	-121.7184907
Bonanza Seed Co.	Cleanup Program Site	Open - Inactive	3818 Railroad Ave.	Yuba City	39.07267333	-121.625746
Bowles Flying Service	Cleanup Program Site	Open - Inactive	10600 Township Road	Live Oak	39.283185911840036	-121.6932499
Costa Property	Cleanup Program Site	Open - Inactive	1716 Elmer Road	Yuba City	39.15198252	-121.6563374
Crop Production Services, Yuba City	Cleanup Program Site	Open - Site Assessment	928 Garden Hwy	Yuba City	39.11382945	-121.6168928
Custom Chrome & Bumper Company	Cleanup Program Site	Open - Inactive	335 Garden Highway	Yuba City	39.12458414	-121.6104641
Diesel Repair Facility	Cleanup Program Site	Open - Inactive	2035 Butte House Rd	Yuba City	39.15069	-121.653248
Efuel Yuba City	LUST Cleanup Site	Open - Site Assessment	740 N George Washington Blvd	Yuba City	39.13714152	-121.6722011
John Taylor Fertilizers - Yuba City	Cleanup Program Site	OPEN - Verification Monitoring	900 North George Washington Blvd	Yuba City	39.139117000000013	-121.672975
Morf Contaminated Site (M.A.D.) Sutter Co.	Cleanup Program Site	Open - Inactive	925 Market St	Yuba City	39.1434119	-121.6139014
Puregro	Cleanup Program Site	OPEN - Assessment & Interim Remedial Action	4900 Del Monte Ave	Robbins	38.86930099	-121.7056203
Quick-n-Shop	LUST Cleanup Site	Open - Remediation	2590 Butte House Rd	Yuba City	39.153436722351913	-121.6638633
Sumitomo Property (Uyemoto Ranch)	Cleanup Program Site	Open - Inactive	1469 Stewart Road	Yuba City	39.08732772	-121.6398823
Sutter Butte Dusters Inc.	Cleanup Program Site	Open - Inactive	4080 Clark Road	Live Oak	39.23136184	-121.6886875
Sutter Co Agri Dept	Cleanup Program Site	Open - Inactive	Central Ave.	Yuba City	38.962977	-121.597791
Sutter Co Agri Dept	Cleanup Program Site	Open - Inactive	Central Ave.	Yuba City	38.962977	-121.597791
Unknown	Cleanup Program Site	Open - Inactive	Gray Avenue	Yuba City	39.14102847	-121.6302609
Valley Pump	LUST Cleanup Site	Open - Site Assessment	464 N. George Washington Blvd	Yuba City	39.13098995	-121.6725508
Wagner Aviation	Cleanup Program Site	Open - Inactive	17690 CA-113	Robbins	38.871873249804381	-121.7088968
Zelie's Cleaners	Cleanup Program Site	Open - Remediation	1222 Colusa Avenue	Yuba City	39.141059	-121.634054

Table 5-8. Active EnviroStor Sites, Sutter Subbasin

Site / Facility Name	EnviroStor ID	California Department of Toxic Substances Control (DTSC) Site Type	DTSC Status	Address	City	Latitude	Longitude
Butler Cleaners	60003905	Evaluation	Active	778 Plumas Street	Yuba City	39.13957004017497	-121.6176935
Custom Chrome and Bumper	51340009	State Response	Active	335 Garden Highway	Yuba City	39.124472	-121.610301
Onstott Dusters Inc	51070014	Evaluation	Active	Highway 113, 1.5 miles north of Knights Landing	Knights Landing	38.81716215	-121.714358567428
Union Pacific Railroad Right-of-Way Yuba City	60000621	Voluntary Cleanup	Active	Railroad Right-of-Way from Boyd Street to Harter Parkway	Yuba City	39.13502219193255	-121.6188603

5.1.4 Primary Uses of Each Aquifer (Reg. 354.14(b)(4)(E))

Groundwater in the Sutter Subbasin is used primarily for agricultural (irrigation) supply, with smaller volumes used for urban/municipal and domestic supply, and for managed wetlands. In Water Year (WY) 2025, total groundwater extraction in the Subbasin was approximately 119,400 acre-feet (AF), of which approximately 108,600 AF (about 91 percent) was used for agricultural supply, 8,800 AF for urban supply, 1,800 AF for managed wetlands, and 200 AF for industrial supply (DWR, 2026b). Groundwater is used conjunctively with surface water delivered by the Subbasin's water districts; total water use in WY 2025 was approximately 864,000 AF, of which surface water supplied approximately 665,100 AF and groundwater approximately 119,400 AF (DWR, 2026b).

5.1.5 Recharge and Discharge

5.1.5.1 Groundwater Recharge Areas

Groundwater recharge to the Subbasin occurs from various areas within and outside of the Subbasin. The location of groundwater recharge areas is based on groundwater flow contours and geologic profiles. Groundwater contours and flow directions are discussed in detail in **Section 5.2**. For those areas outside of the Subbasin, the recharge areas are discussed in the narrative but not shown on the maps.

5.1.5.2 Recharge Areas Outside of the Subbasin

Groundwater contours show recharge to the Subbasin occurs predominantly in the northern and eastern portions of the Subbasin. Recharge areas present in the North Yuba and Butte Subbasins would contribute groundwater to the connected principal aquifer of the Sutter Subbasin. The amount of subsurface inflow to the Sutter Subbasin from these recharge areas outside of the Subbasin is presented in **Section 5.3**.

5.1.5.3 Recharge Areas Inside of the Subbasin

Shallow aquifer zones throughout the Subbasin area are recharged by creeks, rivers, and applied water. **Figure 5-48** shows the Soil Agricultural Groundwater Banking Index (SAGBI) map of the Subbasin. This index provides a composite evaluation of soil suitability to accommodate groundwater recharge while maintaining healthy soils, crops, and a clean groundwater supply. The SAGBI is based on five major factors that are critical to successful agricultural groundwater banking: deep percolation, root zone residence time, topography, chemical limitations, and soil surface condition. As shown in **Figure 5-48**, most soils across the Sutter Subbasin are rated as poor to very poor for accommodating groundwater recharge. Areas that are rated as moderately good to good are located around the Sutter Buttes and adjacent to the Feather River on the east and the Sacramento River on the west.

Aquifer Recharge Potential (ARP) maps produced by California's Groundwater Basin Characterization Program are a screening tool to identify locations with relatively higher

potential for managed aquifer recharge (DWR SGMO, 2025). Managed aquifer recharge (MAR) is a common conjunctive use management strategy where water is intentionally infiltrated from land surface or directly injected into an aquifer for replenishment, later extraction, or long-term water resource management. MAR goals considered in ARP mapping include groundwater recharge into shallow portions of the aquifer to support shallow well water supply, habitat rehabilitation, or flood mitigation and recharge into deeper portions of the aquifer to support deep water supply or subsidence mitigation. ARP maps can be used by water managers, planners, and modelers at a high level for planning MAR opportunities and programs.

Figure 5-49 shows potential for infiltration from the land surface through the native soil layer into a shallow portion of the aquifer, or Shallow (Natural) ARP map. The Shallow (Natural) ARP map type represents recharge opportunities in the shallow zone (less than 50 feet deep) that could capture excess water and infiltrate that water quickly into the ground. The objectives of recharging in the Shallow (Natural) zone would be to mitigate downstream flood impacts by quickly recharging water to support shallow domestic wells and ecosystems reliant on shallow groundwater. ARP values range from 0 to 6 (light to dark blue) with higher ARP values corresponding to locations with higher recharge potential. Within the Sutter Subbasin, shallow natural recharge potential is generally low, with a rank number of 3 or less, with the exception of small areas up to a rank number of 4 around the Sutter Buttes and isolated areas around the Sacramento and Feather Rivers.

Figure 5-50 shows potential for infiltration through the land surface to deeper portions of the aquifer via pathways dominated by coarse grained materials through the native soil layer, or Deep Preferential Pathways (Natural) ARP map. Deep Preferential Pathways (Natural) represents flow paths to the deep aquifer that can be assessed from the surface through a soil layer. This ARP map may be helpful to local agencies who are considering purchasing land or building recharge facilities since it identifies where recharge could be conducted during a regular water year. It highlights pathways that contain a high concentration of coarse-grained material that serve as fast-draining, high volume pathways that connect to a deep aquifer. ARP values range from 0 to 6 (light to dark blue) with higher ARP values corresponding to locations with higher recharge potential. Within the Sutter Subbasin, deep recharge potential is generally low with a rank number of 3 or less and similar spatial patterns observed to the shallow zone.

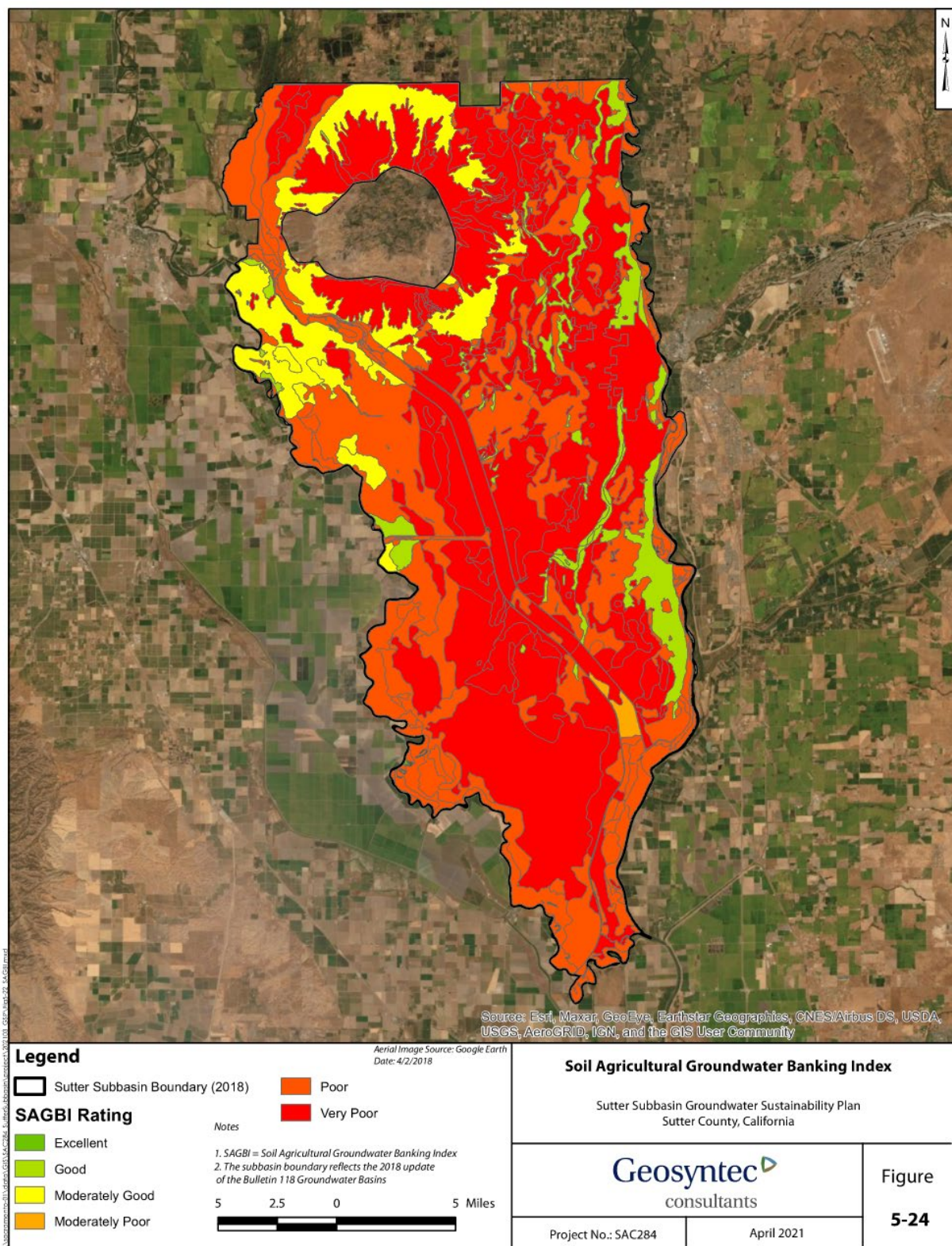


Figure 5-48. SAGBI Map, Sutter Subbasin

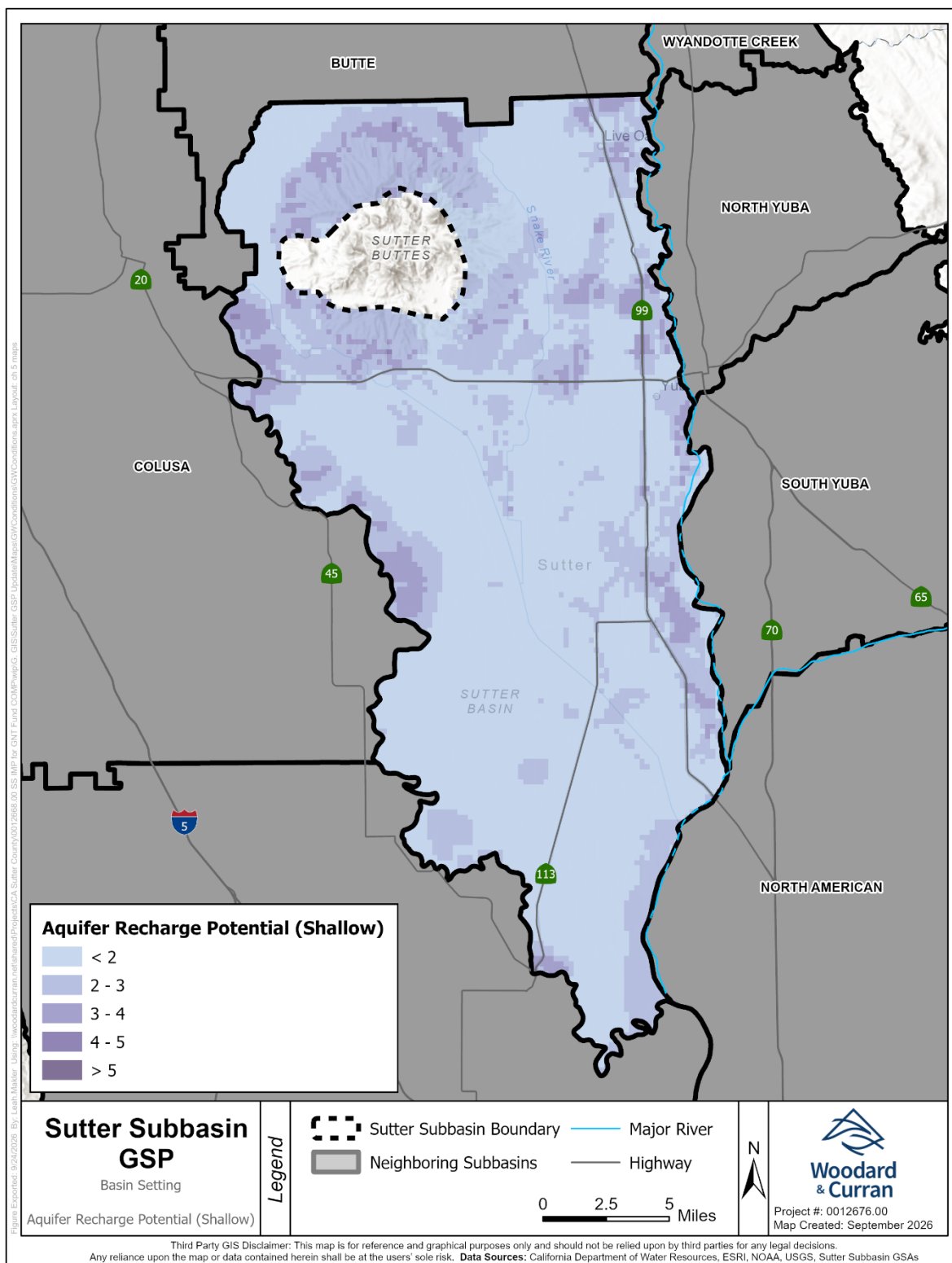


Figure 5-49. Aquifer Recharge Potential – Shallow (Natural)

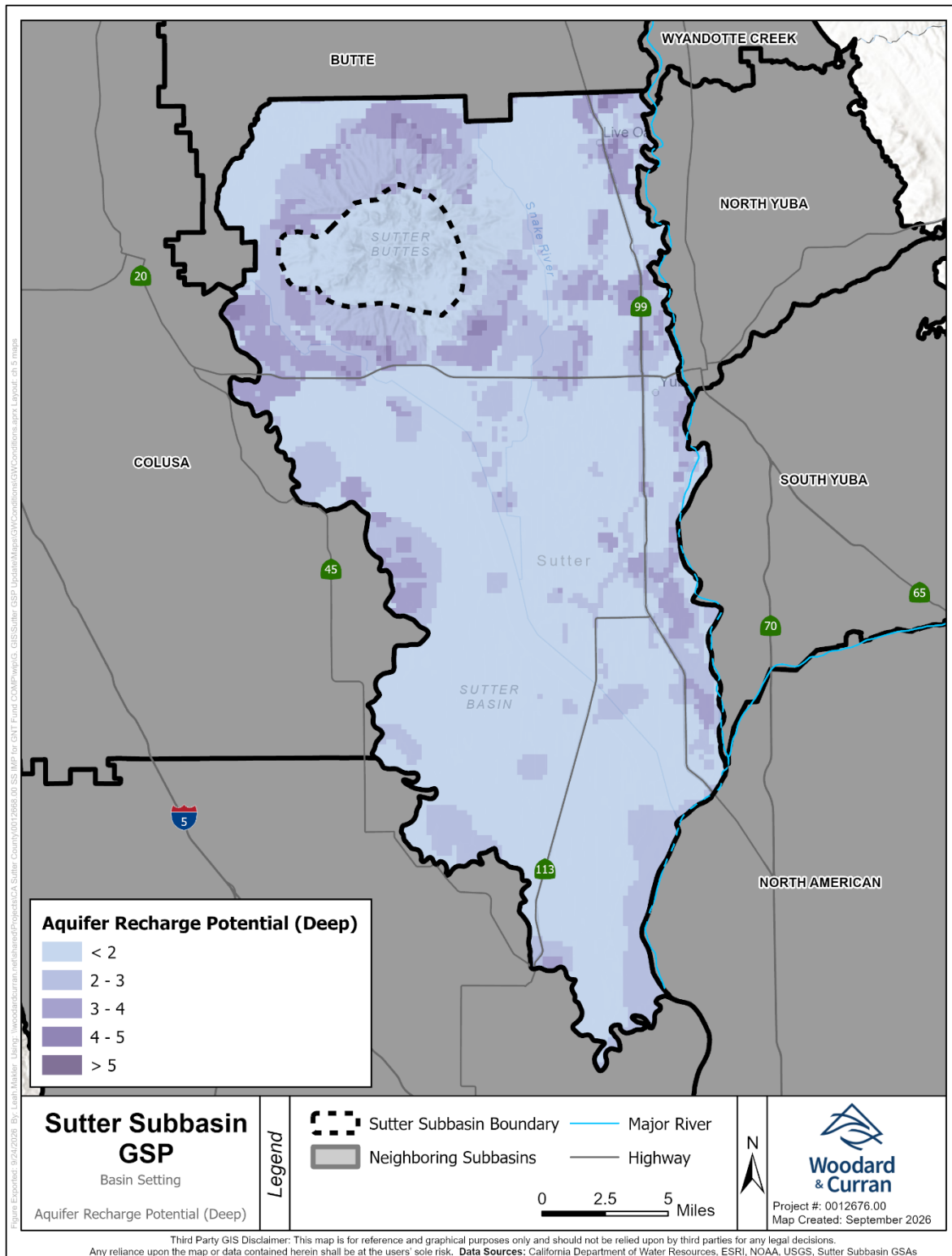


Figure 5-50. Aquifer Recharge Potential – Deep Preferential Pathways (Natural)

In response to California Executive Order D-5-99, California State Water Board staff created a map where published hydrogeologic information indicates soil or rock conditions that may be more vulnerable to groundwater contamination, referred to as Hydrogeological Vulnerable Areas (HVAs). The map was created due to groundwater concerns over releases of methyl-tert-butyl ether (MTBE), primarily from leaking underground storage tank sites. The map was created in 2000 using DWR and USGS publications. Data from these publications were used to identify areas where geologic conditions are more likely to allow recharge at rates substantially higher than in lower permeability or confined areas of the same groundwater basin. **Figure 5-51** shows the HVA map for the Sutter Subbasin, indicating what appears to be highly permeable sediments in similar areas as the SAGBI map; however, the HVA mapping does show some areas where recharge could occur in the southern areas of the Sutter Subbasin.

Some of the major sources of groundwater recharge in the area include agricultural lands, the area around the Sutter Buttes, and rivers and bypasses. Much of the water applied for irrigation of agricultural areas in the Sutter Subbasin is surface water diverted from the Feather and Sacramento Rivers, with applied water being supplemented by precipitation. The average annual recharge of applied water in the area covered by the Feather River Regional Agricultural Water Management Plan is 1.25 acre-feet per acre (AF/ac), while comparable recharge of precipitation is 0.35 AF/ac (Davids Engineering, 2014).

The most prominent agricultural land use in the Sutter Subbasin is rice production, followed by fruit and nut orchards and a variety of other crops. Rice production is characterized by flooding of relatively impermeable soils, while irrigation of other crops is performed either by traditional irrigation techniques or by newer low-volume methods including drip and micro-jet systems.

In recent years, growers have been changing orchards from fruits to nuts (almonds). Fruit and nut orchards have an average crop evapotranspiration (ET_c) of about 36.3 inches per year which converts to 3.0 AF/ac. Therefore, shifts between fruit and nut crops have little impact on water use; however, changes in irrigation practices have been accompanying these changes in cropping. For example, new orchards are being irrigated almost exclusively with drip and micro-jet systems. This shift away from flood irrigation practices applies less water to fields, so while crop consumption may actually increase due to better timing of applications, deep percolation diminishes. In addition, the low-volume systems are often supplied by wells, which can be turned on and off, rather than from canal deliveries; though several irrigation districts have noted in recent years many orchards may be shifting back to surface water presumably due to the high cost of electricity for wells. Both the reduction in deep percolation from newly established orchards and the increased reliance on groundwater to irrigate these lands have implications on the water budget.

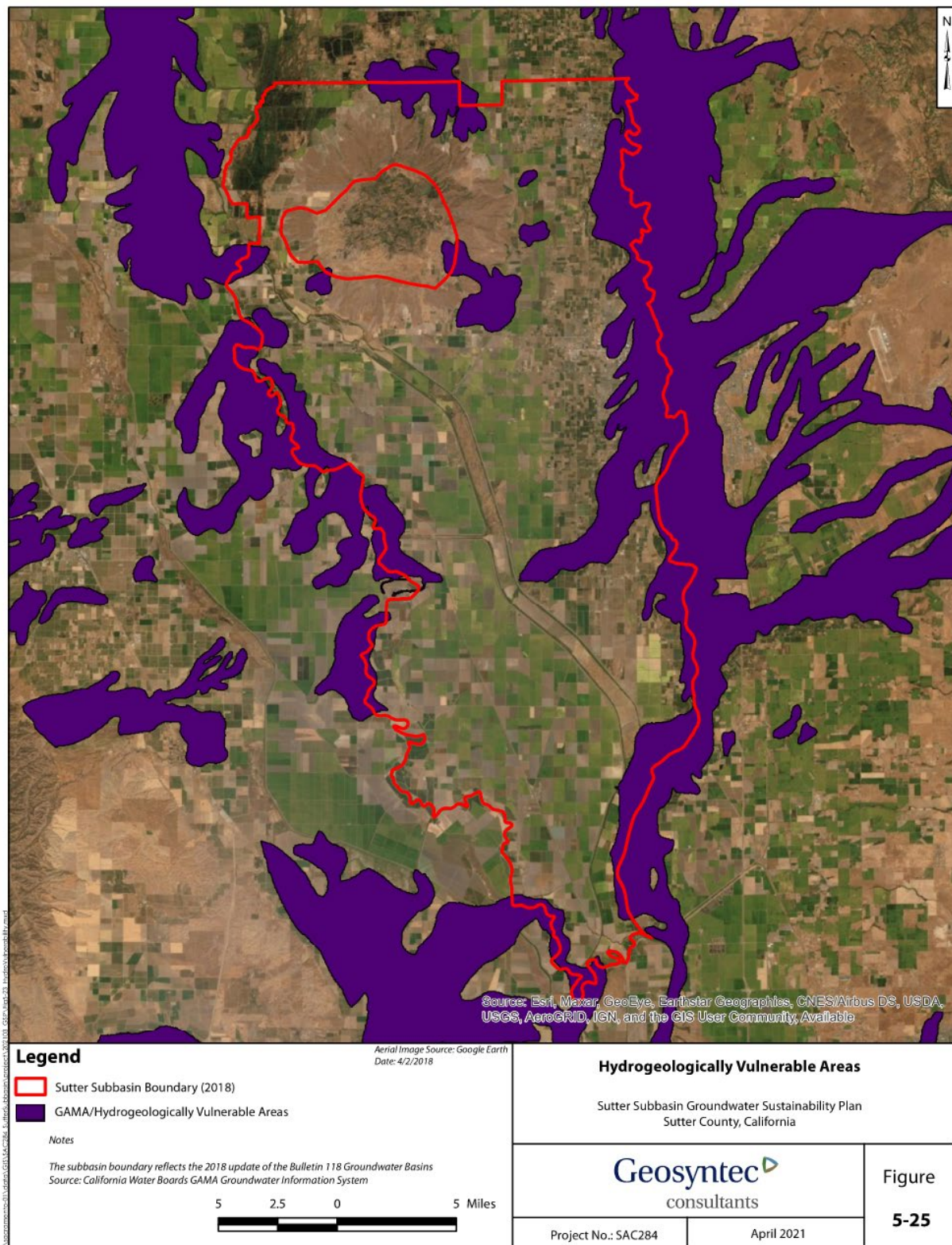


Figure 5-51. Hydrologically Vulnerable Areas, Sutter Subbasin

The Sutter Buttes Rampart Formation is exposed in an apron surrounding Sutter Buttes, allowing precipitation and agricultural applied water to migrate horizontally along the principal aquifer beds. The amount of recharge, based on surface exposure of the Sutter Buttes Rampart Formation and an average precipitation of 18 inches per year (about 10 percent recharged), is about 220 acre-feet per year (AFY), or less than 1 percent of the total inflow to the basin based on the water budget.

Detailed geotechnical investigations along the rivers and bypasses show multiple sand and gravel layers are present which could allow surface water to recharge the shallow aquifer zone at a relatively high rate. Water can still recharge through silt and clayey layers, but at a much slower rate. The amount of water recharge, based on C2VSimFG-Sutter, is presented in **Section 5.3**.

Prior to 2013, some areas along the rivers and bypasses had low permeability slurry walls installed to stabilize the levees (on the order of 10 percent or less of the total leveed area). Starting in 2013 and continuing through 2016, slurry walls have been installed just north of the confluence of the Feather and Bear Rivers, as shown on the profiles contained in **Appendices 5-C** through **5-E**. This ongoing work has extended the slurry wall coverage to about 50 percent of the river. The depths of the slurry walls have ranged/will range between 21 and 105 feet and reduce, though not stop surface water recharge or portions of the subsurface inflow from the Yuba Subbasins to the east. Estimates on the reduction of groundwater recharge were not described in the California Environmental Quality Act documentation for the slurry wall installations (ICF International, 2013).

5.1.5.4 Groundwater Discharge Areas

Significant sources of groundwater discharge in the Sutter Subbasin include the Sacramento and Feather Rivers, the Butte Sink Wildlife Management Area, and Sutter and Tisdale Bypasses (**Figure 5-52**). Minor groundwater discharge also occurs along creeks and sloughs.

The Sacramento River is topographically at the bottom of the basin and therefore would act under predevelopment conditions as a drain for groundwater within the shallow aquifer zones. Groundwater also may discharge to the Feather River along the southern portion where slurry walls and levee improvements are not planned. The low-lying Butte Sink Wildlife Management Area, located around the Sutter Buttes, constitutes an area of significant groundwater discharge (CH2MHill, 2014).

Detailed geotechnical investigations along the Sacramento River and the Sutter and Tisdale Bypasses, as discussed in **Section 5.1.4.3**, showed that multiple sand and gravel layers are present adjacent to the surface water courses. These permeable layers could allow groundwater to discharge to surface water from the shallow aquifer at a relatively high rate. Water can still be discharged through silt and clayey layers, but at a much slower rate. The average discharge from the basins is presented in **Section 5.3**.

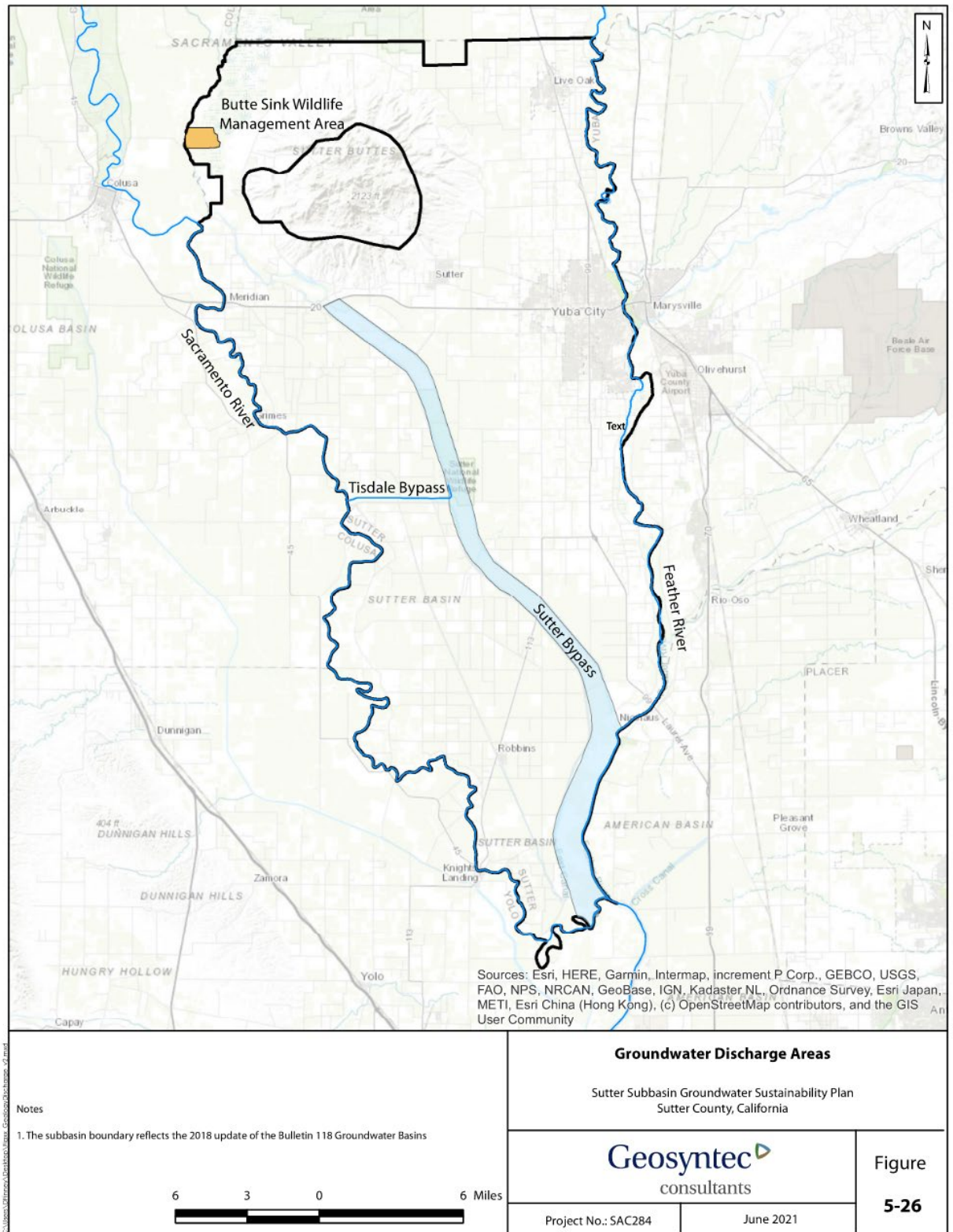


Figure 5-52. Groundwater Discharge Areas

5.1.6 Surface Water and Imported Supplies (Reg. 354.14(d)(6), (d)(7))

5.1.6.1 Surface Water Bodies

There are no reservoirs within the Subbasin. The Feather and Sacramento Rivers, due to their lengths do, on a dynamic basis, contain surface water in excess of 100 AF.

Figure 2-1 shows these surface water bodies.

5.1.6.2 Imported Surface Water Supplies

Surface water is primarily used for agricultural purposes within the Sutter Subbasin and is obtained through Sacramento River Settlement Contracts Central Valley Project (CVP) contractors, Feather River diverters, and surface water rights held by individual users. For more information about Sacramento River Settlement Contractors and Feather River diverters, refer to **Section 2.1.3.2.3**. Sacramento River Settlement Contractors include Sutter Mutual Water Company, Meridian Farms Water Company, Tisdale Irrigation & Drainage Company, Pelger Mutual Water Company, Oji Brothers Farm, Inc., and Oji Family Partnership (**Figure 5-53**). Imported water is diverted directly from the Sacramento River by the Settlement Contractors in the Sutter Subbasin. Feather River diverters hold diversion agreements with DWR to transport water from the Feather River using State Water Project facilities for both diversion and storage. Butte Water District and Sutter Extension Water District entered into agreement with DWR in May 1969 along with Biggs-West Gridley Water District and Richvale Irrigation District. Feather Water District and Garden Highway Mutual Water Company hold separate contracts with DWR for diversion of Feather River water.

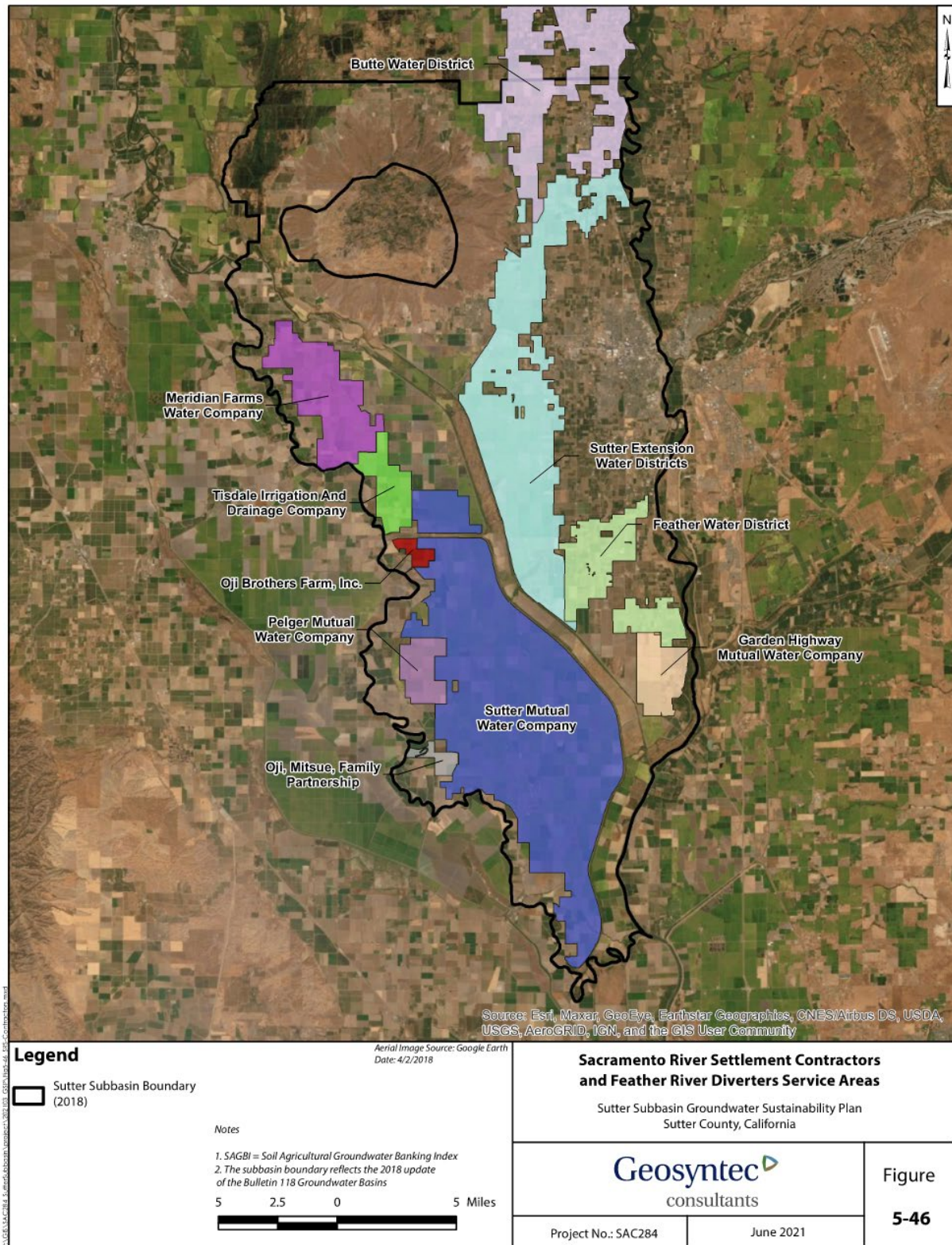


Figure 5-53. Imported Water Supplies, Sutter Subbasin

5.1.7 HCM Data Gaps and Uncertainty

The HCM forms the framework for understanding the movement of water from the surface to the subsurface and at the boundaries of the Subbasin based on the available information. An important function of the HCM is the identification of data gaps and uncertainties within this framework that will form the basis for development of future data collection efforts. For successful management of the Subbasin, it is critical that as new data are collected this HCM is updated.

The following presents data gaps identified for the Sutter Subbasin HCM that will be updated with future monitoring, modeling, and data refinement efforts.

5.1.7.1 Interactions between Sacramento, Feather, and Other River Stage Response to Changes in Groundwater Levels

Data needed to develop appropriate sustainable management criteria for interconnected surface waters includes definition of stream reaches and associated priority habitat, streamflow measurements to develop profiles at multiple time periods, and corresponding measurements of groundwater levels directly adjacent to stream channels for both the Shallow AZ and for deeper aquifer zones. These data are not available and constitute a data gap for the GSP. Currently, Sutter County is negotiating with DWR to install nested monitoring wells at sites near selected surface water gage locations near rivers and wetlands to collect the data needed to assess these interactions.

Expansion of stream gaging locations should also occur to document and better understand changes in stream-aquifer interactions. In addition to the stream gaging, a series of shallow dedicated monitoring wells equipped with temperature sensors should be installed along stream courses in the recharge corridor and downstream to the Sacramento and Feather Rivers to help identify what sections of streams are losing or gaining.

5.1.7.2 Source of Elevated Salinity within Shallow Aquifer Zone

As noted in the Salinity section under **Section 5.1.3.5**, the Alternative Plan stated that it is unclear why elevated salinity (reported as specific conductance) occurring in the Shallow AZ (which suggests an agricultural source) does not appear to correlate with elevated nitrate concentrations as is often found for groundwater impacts related to agriculture. However, the existence of reducing conditions in the shallow zone could result in lower levels of nitrate due to denitrification, suggesting that the high salinity values in the shallow zone are, in fact, from agricultural sources. As such, the source of the elevated salinity in the shallow aquifer is unknown at this time. Studies to address this data gap could include collecting nitrogen isotopes and oxidation-reduction values to allow assessment of areas with reducing conditions in addition to isotopic analysis.

5.1.7.3 Aquifer Properties

Only one limited aquifer pumping test was identified to assess aquifer properties for the Sutter Subbasin. This type of information could be collected by conducting pumping tests as part of existing irrigation practices within the Subbasin simply by monitoring groundwater elevations in and around pumping wells during pumping start up and following the cessation of pumping. For such a program, existing nested monitoring wells as observation wells would be used to assess groundwater pumping-aquifer interactions. This type of test program will eliminate the need for discharge permits and handling of extracted water and will allow an assessment of the actual stresses on the aquifer during the agricultural season.

5.1.7.4 Further Assess Groundwater Recharge

Future recharge and aquifer studies should include the collection and interpretation of stable isotope data. Methodology considerations include: 1) seasonal sampling as part of future surface water and groundwater isotope studies for purposes of assessing groundwater recharge; 2) using the existing nested monitoring wells with multiple screened intervals to assess stable isotope data at different depths; and 3) monitoring wells with relatively short screened zones (20 feet or less) to minimize mixing between aquifer zones or between aquifer zones and residual water retained within the aquitard zones.

5.1.7.5 Recharge Rate

Most well locations and depths should be sampled and analyzed for presence of tritium to help distinguish whether recharge to individual aquifer zones is occurring over periods shorter than about 60 years, or whether recharge is occurring over longer timeframes. This can help better understand the nature of hydraulic connection between different zones in the aquifer system.

5.1.7.6 Hydrogeologic Conceptual Model

Additional data to better understand the hydrogeology of the basin will assist in identifying and improving the understanding of recharge mechanisms and connectivity between aquifer layers and refining the water budget for the Subbasin. In 2023, DWR completed AEM surveys of the Sacramento Valley and other areas of the State. Due to extensive nature of the survey work, survey data were collected in a coarsely spaced grid (approximately 2 miles by 8 miles) and analyzed at a relatively high level. Data collected from these surveys helped address some data gaps in the Subbasin and has been incorporated into the updated HCM discussed herein. However, information around the Sutter Buttes remains limited.

Recently, with funds received from a Proposition 68 Sustainable Groundwater Management Act (SGMA) Implementation grant, the Sutter Subbasin GSAs reprocessed the available State AEM data around the Sutter Buttes at a greater level of detail. A work plan was prepared to conduct additional AEM surveys around the Sutter

Buttes (a recognized data gap area in the Subbasin) to fill in the gaps in the State's dataset. At this time, the surveys are being scheduled; it is anticipated that the results of the additional survey work will help address uncertainties in the complex structure of the northern portion of the Subbasin.

5.1.7.7 Definition of Stratigraphic Zones

It is recommended that a uniform set of criteria for logging of cuttings from soil boring drilled in the Subbasin be developed. Such an effort would need the participation and cooperation of various agencies and researchers in the region. The criteria adopted should be such that the contacts between geologic formations are easily identifiable from the drill cuttings, such as developed by Blair and others (1991) for the Oroville area. The different studies reviewed for this project use a wide range of definitions and terminology that are not consistent from one investigation to the next. This lack of consistency presents a challenge when attempting to correlate the definition of stratigraphic sequences, aquifer zones, and even geologic formations between different studies. Many previous studies do not follow USGS standards and the North American Stratigraphic Code, resulting in confusing and sometimes incorrect naming of geologic units. Future studies would benefit from development of a uniform methodology and clearly defined set of stratigraphic terminology so that studies conducted by different investigators can be correlated and the value of the data maximized.

5.1.8 Conclusions

The Sutter Subbasin is characterized by one principal aquifer system composed of laterally and vertically variable freshwater-bearing deposits. The geologic framework reflects both regional depositional processes and alterations associated with the Sutter Buttes, including deformation, reworking, and deposition of volcanic and volcanoclastic materials. As a result, the stratigraphic units and low permeability intervals that influence groundwater conditions are not expressed uniformly across the Subbasin.

Available hydrogeologic information, including stratigraphic interpretations, AEM data, and hydrographs from multi-completion monitoring wells, supports the use of aquifer zones to describe vertical intervals within the principal aquifer system. These aquifer zones provide a consistent framework for evaluating pumping depths, groundwater level responses, and monitoring network effectiveness. However, the aquifer zones are not interpreted as separate principal aquifers or as fixed formation-based units.

Two low permeability intervals are interpreted within the principal aquifer system, but their thickness, continuity, and hydraulic effectiveness vary spatially. These intervals locally influence vertical gradients and groundwater level responses, but available data do not support defining laterally continuous aquitards that divide the Subbasin into multiple principal aquifers. Therefore, the GSP Amendment retains the definition of a single principal aquifer system and clarifies the use of aquifer zones as hydrostratigraphic and management intervals within that system.

5.2 Groundwater Conditions

This section describes the current and historic groundwater conditions within the Sutter Subbasin and presents data from January 1, 2015 through the end of Water Year 2025 (October 1, 2024 through September 30, 2025) as publicly available during the development of this GSP. The current and historic conditions of the following parameters are described herein: groundwater elevations, groundwater storage, groundwater quality, land subsidence, interconnected surface water systems, and groundwater dependent ecosystems (GDEs). Seawater intrusion is not discussed herein as the Sutter Subbasin is inland from the Pacific Ocean and distant from the Sacramento-San Joaquin River Delta (Delta) and is not impacted by seawater intrusion.

Baseline conditions are established in this section in order to facilitate the monitoring of changes relative to established sustainable management criteria and will help support monitoring to demonstrate measurable efforts in achieving the sustainability goal for the Sutter Subbasin. This section has been developed pursuant to §354.16 of the GSP Emergency Regulations.

5.2.1 Useful Terminology

This section includes descriptions of the amounts, quality, and movement of groundwater, among other related components. A list of technical terms and a description of those terms are listed below. The terms and their descriptions are identified here to guide readers through the section and are not a definitive definition of each term:

- **Depth to Groundwater** – The distance from the ground surface to first-detected, non-perched groundwater; typically reported at a well.
- **Horizontal gradient** – The slope of the hydraulic head between two locations in the same aquifer, where hydraulic head is defined as the groundwater surface elevation for unconfined aquifers and the pressure head (the height of the water column) for confined aquifers.
- **Vertical gradient** – Describes the change in hydraulic head between different depths or aquifer, indicating the direction groundwater is moving perpendicular to the ground surface. Vertical gradient is measured by comparing the hydraulic head in wells screened at different depths. A downward gradient indicates groundwater is moving down into the ground toward deeper aquifers, and an upward gradient indicates groundwater is upwelling toward shallower aquifers closer to the ground surface.
- **Contour Map** – A map containing contour lines which join points of equal potentiometric elevation (groundwater surface elevations in unconfined aquifers or hydraulic head in confined aquifer). The contour lines shown on the map represent equal potentiometric elevations, while the contour interval, or the difference between

adjacent contour lines, shows the vertical differences in elevation or hydraulic head. Contour maps can be presented in two ways:

- Elevation of groundwater or hydraulic head above mean sea level (MSL), which can be used to identify the horizontal gradients of groundwater, and
- Depth to water (i.e., the distance from the ground surface to groundwater), which can be used to identify areas of shallow or deep groundwater.
- **Hydrograph** – A graph that shows changes in groundwater elevation or depth to groundwater over time at a specific location. Hydrographs show how groundwater elevations change over the years and indicate whether groundwater levels or head are rising or descending over time.
- **Maximum Contaminant Level (MCL)** – MCLs are standards that are set by the State of California and the U.S. Environmental Protection Agency for drinking water quality. MCLs are legal threshold limits on the amount (concentration) of an identified constituent that is allowed in public drinking water supplies. At both the State and Federal levels, there are Primary MCLs, set to be protective of human health, and Secondary MCLs (SMCLs) for constituents that do not pose a human health hazard but do pose a nuisance through either smell, odor, taste, and/or color. MCLs differ for different constituents and not all constituents found in groundwater currently have either a federal or state Primary or Secondary MCL.
- **Elastic Land Subsidence** – Reversible and temporary fluctuations in the elevation of the earth's surface in response to seasonal periods of groundwater extraction and recharge.
- **Inelastic Land Subsidence** – Irreversible and permanent decline in the elevation of the earth's surface resulting from the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system.
- **Gaining Stream** – A stream in which groundwater flowing into a streambed contributes to a net increase in surface water flows across an identified reach.
- **Losing Stream** – A stream in which surface water lost through the streambed to the underlying groundwater aquifer results in a net decrease in surface water flows across an identified reach.

5.2.2 Groundwater Elevations

Historic and current groundwater conditions within the Sutter Subbasin, measured as groundwater elevations, are assessed to determine flow directions, horizontal and vertical gradients, and regional pumping patterns, both spatially and temporally, as depicted in groundwater elevation contour maps and hydrographs.

5.2.2.1 Historic Conditions

Groundwater in the Sutter Subbasin generally follows the topography of the land surface, flowing from the Sierra Nevada on the east toward the center of the

Sacramento Valley (east to west) and north to south within the valley (Wood Rodgers, 2012), eventually flowing toward the Sacramento-San Joaquin Delta. Seasonal and short-term fluctuations in groundwater elevations have been observed in the Sutter Subbasin due to irrigation requirements and hydrologic conditions but have generally remained relatively stable for more than 70 years.

One of the earliest groundwater contour maps for the Sutter Subbasin area was prepared in 1923 (Bryan, 1923), as shown in **Figure 5-54**, for Fall 1912 and Fall 1913 conditions (prior to the development of the deep well turbine pump). The contours in **Figure 5-54** presents depth to groundwater and show groundwater entering the Subbasin from the north and east, ranging from 70 feet above MSL to 20 feet above MSL in the southern end of the Subbasin. Groundwater appears to have historically flowed through and beneath the Feather River. The groundwater contours show groundwater discharges to the Sacramento River and to the south towards the Delta.

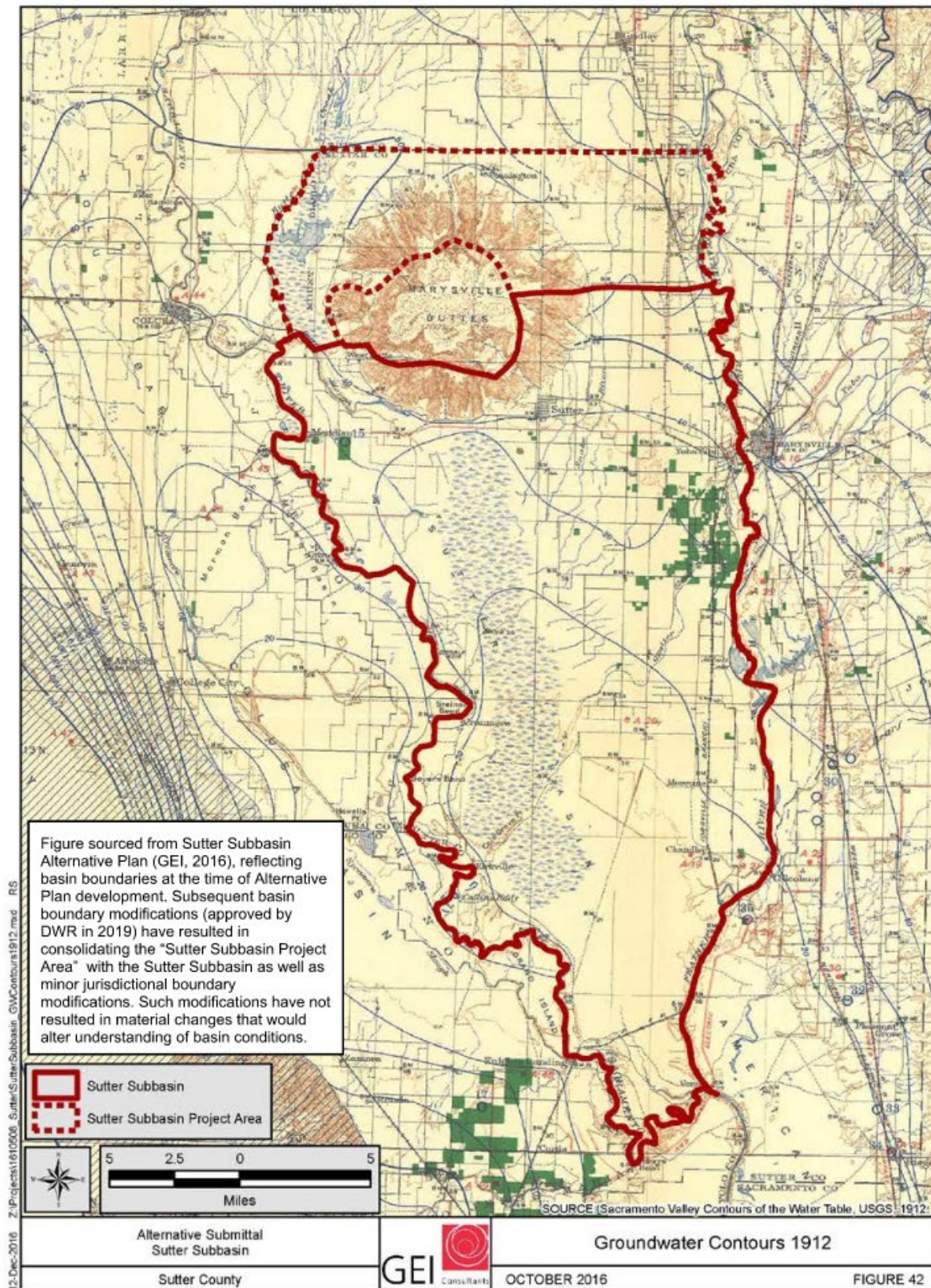


Figure 5-54. Groundwater Elevation Contours, Fall 1912 and Fall 1913

As discussed in the Hydrogeologic Conceptual Model (**Section 5.1**), the Sutter Subbasin consists of one principal aquifer with four aquifer zones delineated and defined as follows:

- **Shallow Aquifer Zone (AZ)** is delineated separately from Aquifer Zone-1 (AZ-1) and is considered to be the upper 50 feet of the principal aquifer. While the Shallow Zone is not hydraulically separate from AZ-1, this zone was defined separately to assess and monitor for impacts related to interconnected surface water and GDEs that occur in this zone.
- **Aquifer Zone-1 (AZ-1)** roughly aligns with the “shallow aquifer” zone defined in the Sutter Subbasin Alternative Plan (GEI, 2016), extending from the ground surface to a depth of about 50 feet below ground surface (bgs) near the Sutter Buttes and up to 150 feet bgs further away from the Sutter Buttes. In this GSP, AZ-1 is defined as extending from 50 to 150 bgs to accommodate the Shallow AZ definition.
- **Aquifer Zone-2 (AZ-2)** generally aligns with the “intermediate aquifer” zone identified in the Alternative Plan, and is defined in this GSP as ranging from 150 to 400 feet bgs.
- **Aquifer Zone-3 (AZ-3)** generally aligns with the “deep aquifer” zone identified in the Alternative Plan and is defined in this GSP as the zone deeper than 400 feet bgs.

Maps of historic conditions presented in this section represent the Bulletin 118 basin boundaries for the Sutter Subbasin and East Butte Subbasin as available during Alternative Plan development. Basin boundary modifications occurred after Alternative Plan development as part of DWR’s Basin Boundary Modification Request System in 2018, including consolidating the East Butte Subbasin within the Sutter Subbasin, jurisdiction boundary modifications to include the Biggs-West Gridley Water District GSA entirely within the Butte Subbasin, and aligning the Sutter Subbasin boundary with the Sutter County jurisdictional boundary. Such boundary modifications have not resulted in material changes that would alter understanding of historic basin conditions within the current Sutter Subbasin boundary but should be noted.

Descriptions of the aquifer zones are further clarified in this GSP, as described in **Section 5.1.3**.

Figure 5-55 through **Figure 5-57** show groundwater elevations within the Sutter Subbasin in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones during Spring 1998 as presented in the Alternative Plan, representing the highest groundwater elevations during a Wet year (as classified by the Sacramento River Water Year Index). Groundwater elevations in the shallow aquifer zone (AZ-1) range from 21 feet above MSL along the central portion of the western boundary of Subbasin to 75 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-55**). In the intermediate aquifer zone (AZ-2), groundwater elevations range from 15 feet above MSL in the southern portion of the Subbasin to 69 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-56**). Groundwater elevation data are limited for Spring

1998 in the deep aquifer zone (AZ-3), but ranges from approximately 67 feet above MSL in the northern portion of the Subbasin to approximately 14 feet above MSL in the southern portion of the Subbasin (**Figure 5-57**). In all aquifer zones in Spring 1998, the general direction of groundwater flow is from the north and east portion of the Subbasin towards the south.

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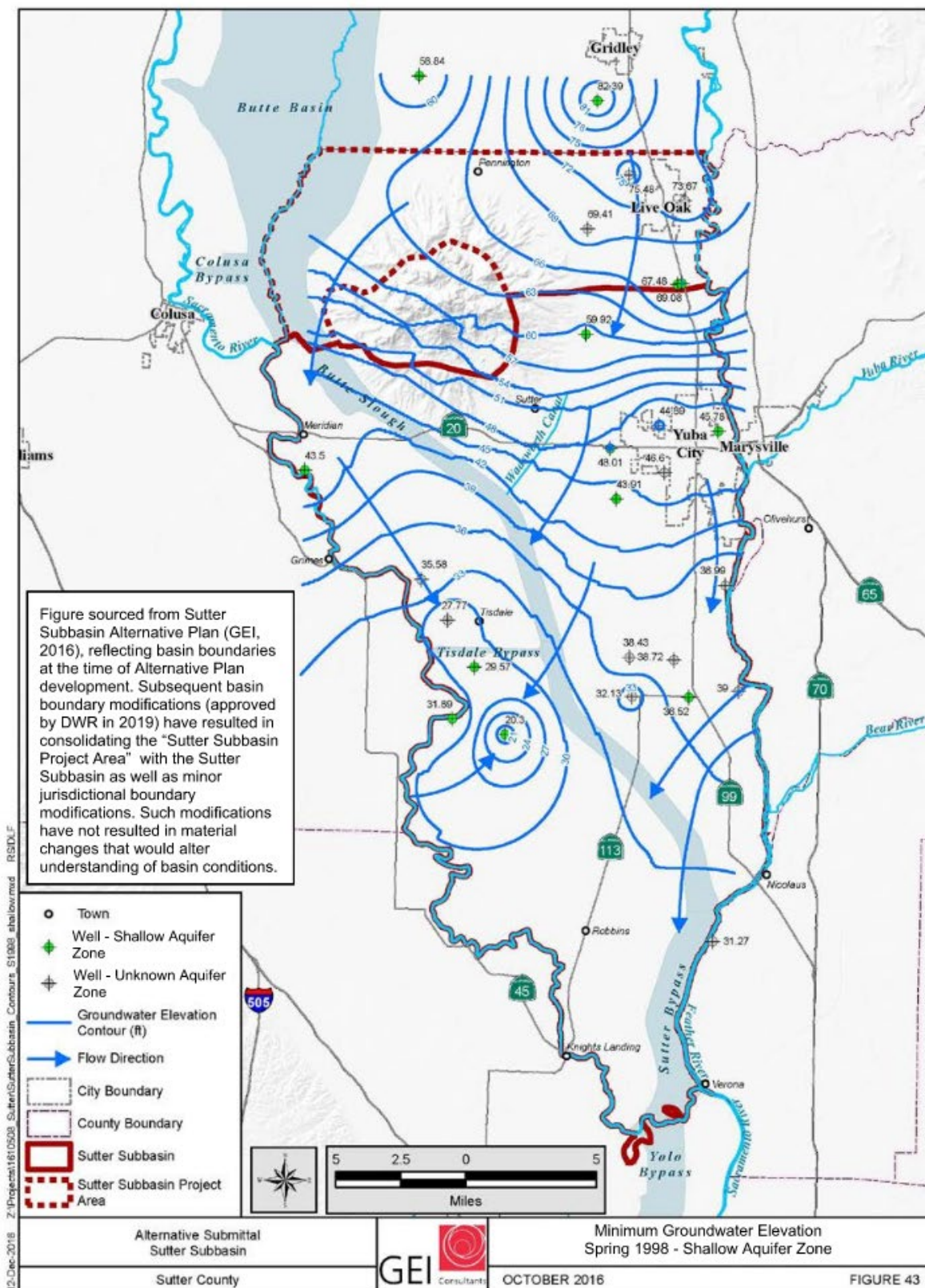


Figure 5-55. Groundwater Elevation in Shallow Aquifer Zone (AZ-1), Spring 1998

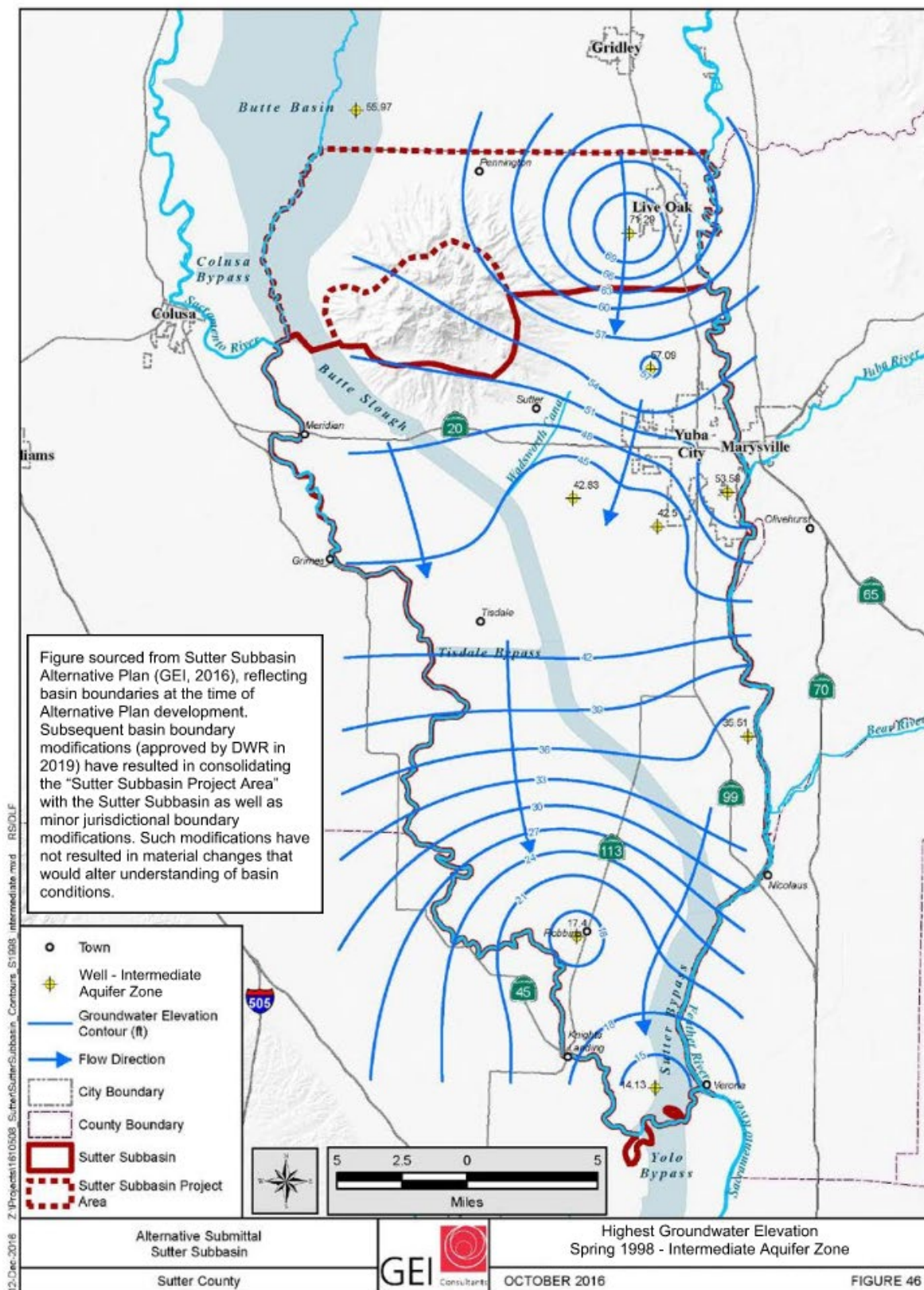


Figure 5-56. Groundwater Elevation in Intermediate Aquifer Zone (AZ-2), Spring 1998

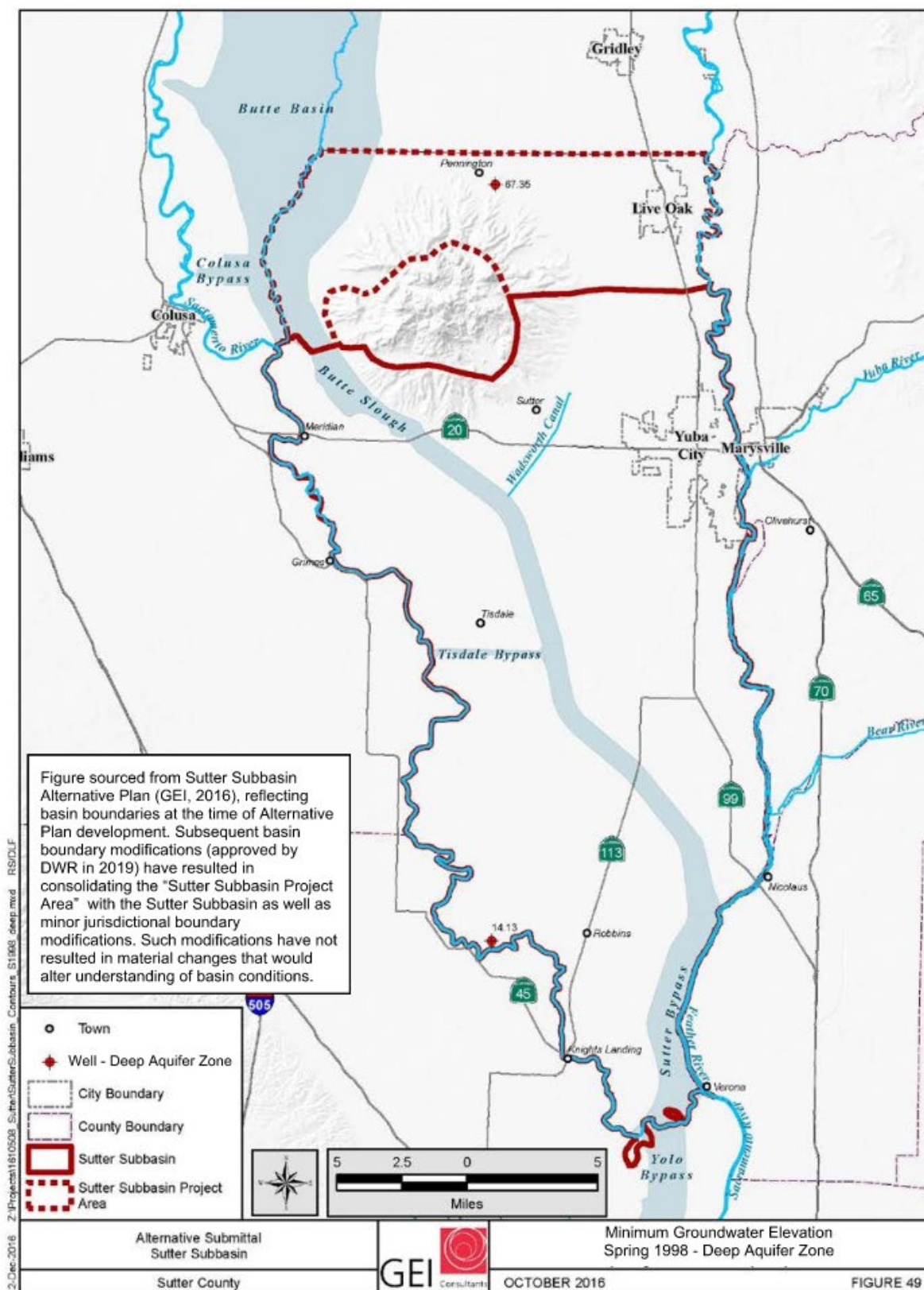


Figure 5-57. Groundwater Elevation in Deep Aquifer Zone (AZ-3), Spring 1998

Figure 5-58 through **Figure 5-60** show groundwater elevations in the Subbasin in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones during Fall 2009 as presented in the Alternative Plan, representing the lowest groundwater elevations during a Dry year (as classified by the Sacramento River Water Year Index).

Groundwater elevations in the shallow aquifer zone (AZ-1) range from 12 feet above MSL in the southern portion of the Subbasin to 69 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-58**). In the intermediate aquifer zone (AZ-2), groundwater elevations range from 15 feet above MSL in the southern portion of the Subbasin to 63 feet above MSL in the northeastern corner of the Subbasin (**Figure 5-59**). Groundwater elevations in the deep aquifer zone (AZ-3) range from 15 feet above MSL in the southern portion of the Subbasin to 45 feet above MSL along the northern boundary of the Subbasin (**Figure 5-60**). In all aquifer zones during Fall 2009, the general direction of groundwater flow is similar to that during Spring 1998, with groundwater entering the Subbasin from the north and east and leaving the Subbasin to the south.

The difference in groundwater elevations from the highest groundwater level in Spring 1998 to the lowest groundwater elevation in Fall 2009 within each zone of the principal aquifer as presented in the Alternative Plan are summarized below:

- **Shallow Aquifer Zone (AZ-1; Figure 5-61)** – East of the Sutter Buttes along the northern Subbasin boundary, the groundwater level difference between Spring 1998 and Fall 2009 is about 6 feet. Along the Feather River (the eastern side of the Subbasin), the differences in groundwater elevations vary between 6 and 20 feet. Along the western edge of the Subbasin, the difference in groundwater elevation is about 10 feet.
- **Intermediate Aquifer Zone (AZ-2; Figure 5-62)** – Groundwater levels between Spring 1998 and Fall 2009 differ by about 10 feet along the northern Subbasin boundary near the Sutter Buttes. Along the Feather River, the differences in groundwater elevation vary between 12 and 22 feet. Along the southern end of the Subbasin, the difference in groundwater elevation is about 0.5 feet.
- **Deep Aquifer Zone (AZ-3; Figure 5-57 and Figure 5-60)** – Only two measurement points were available in Spring 1998 and eight measurement points available in Fall 2009. The northern well in Fall 2009 appears to have been pumping, which results in almost a 20-foot decline in groundwater levels. Comparison of data from the southern well between Spring 1998 and Fall 2009 shows a rise in groundwater levels of about 0.6 feet.

Localized pumping depressions are observed in all zones of the principal aquifer during Spring 1998 and Fall 2009, as shown in **Figure 5-55** through **Figure 5-60**. These localized pumping depressions are primarily located within or near the northeastern corner and central portion of the Sutter Subbasin.

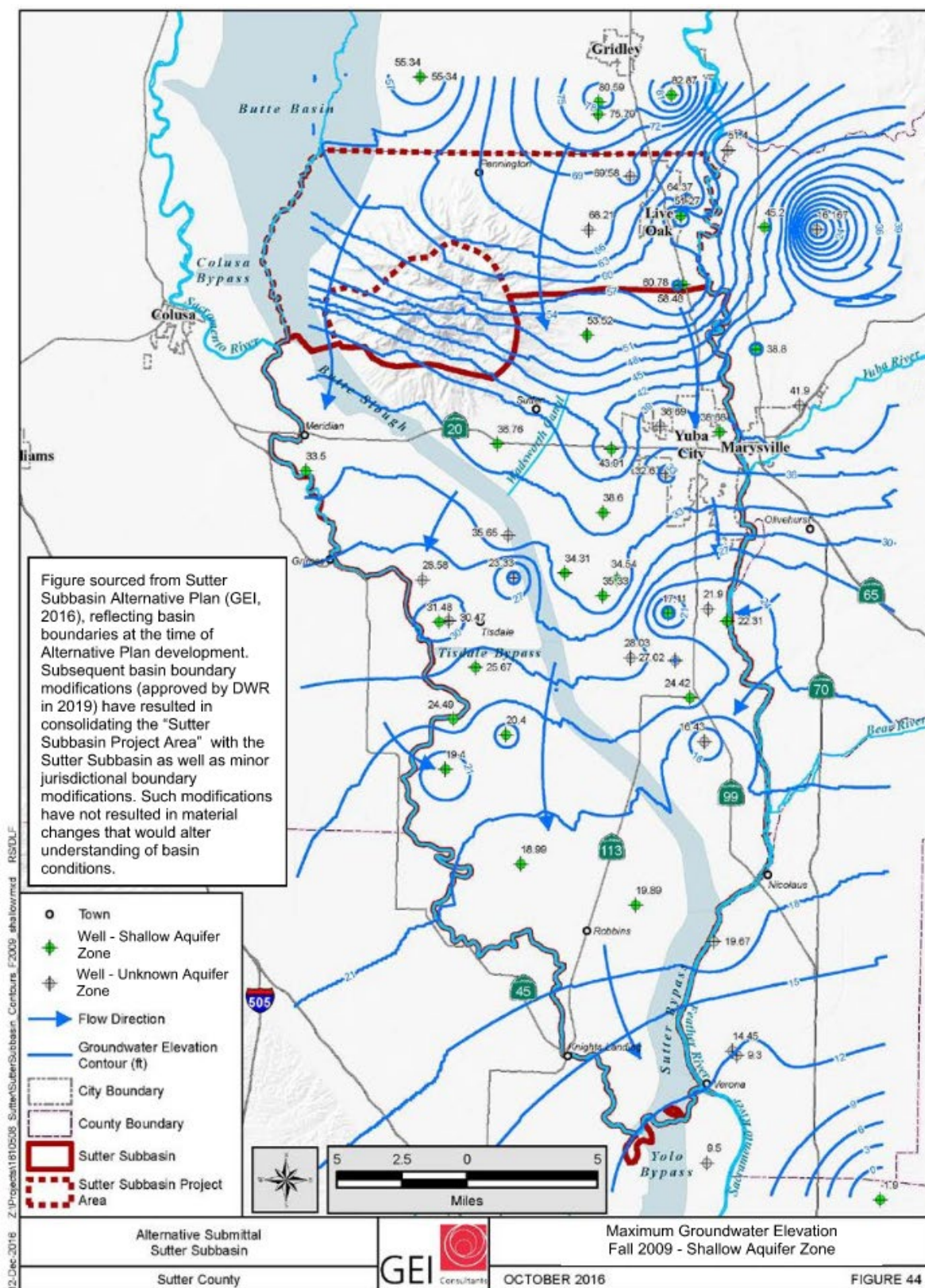


Figure 5-58. Groundwater Elevation in Shallow Aquifer Zone (AZ-1), Fall 2009

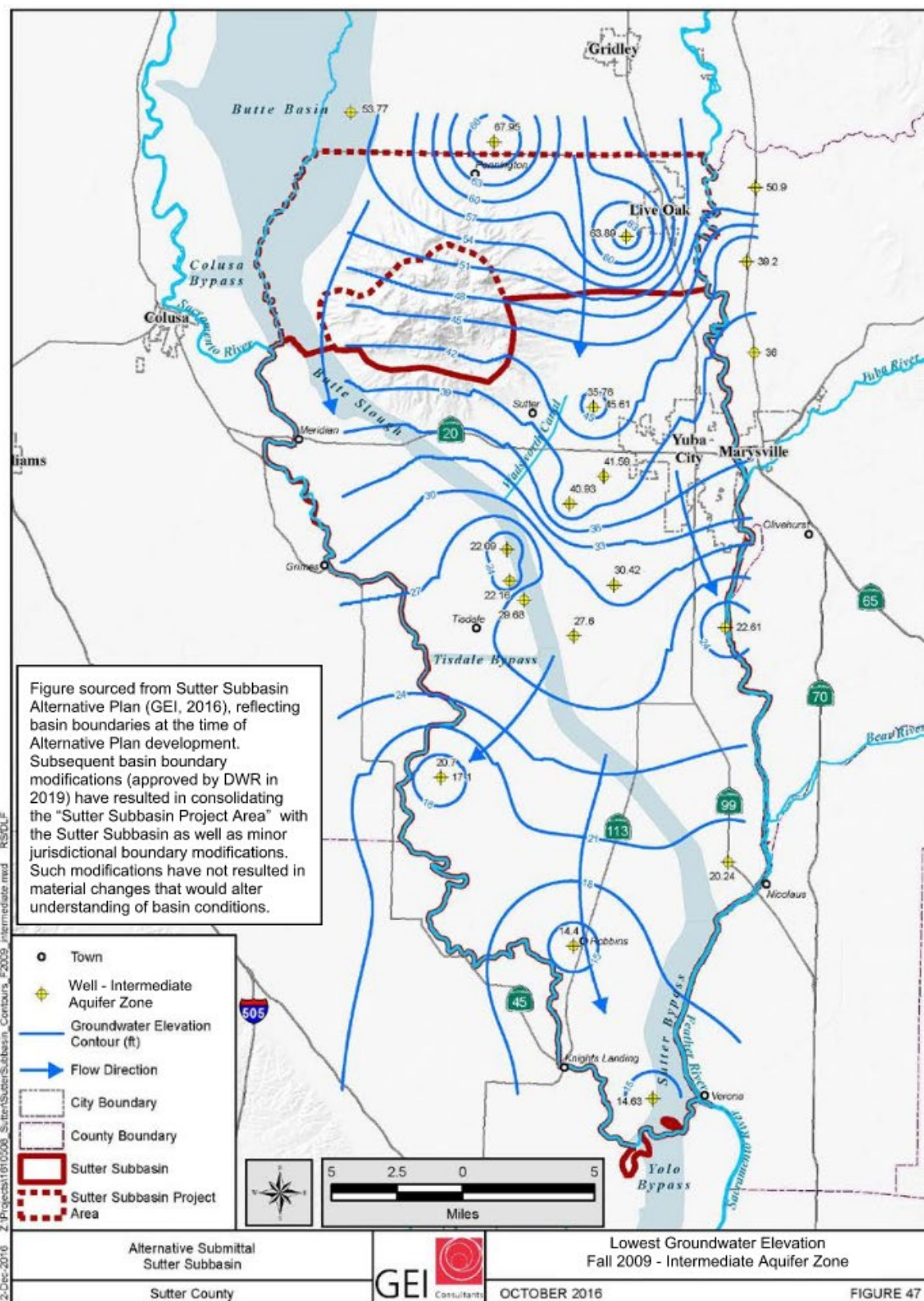


Figure 5-59. Groundwater Elevation in Intermediate Aquifer Zone (AZ-2), Fall 2009

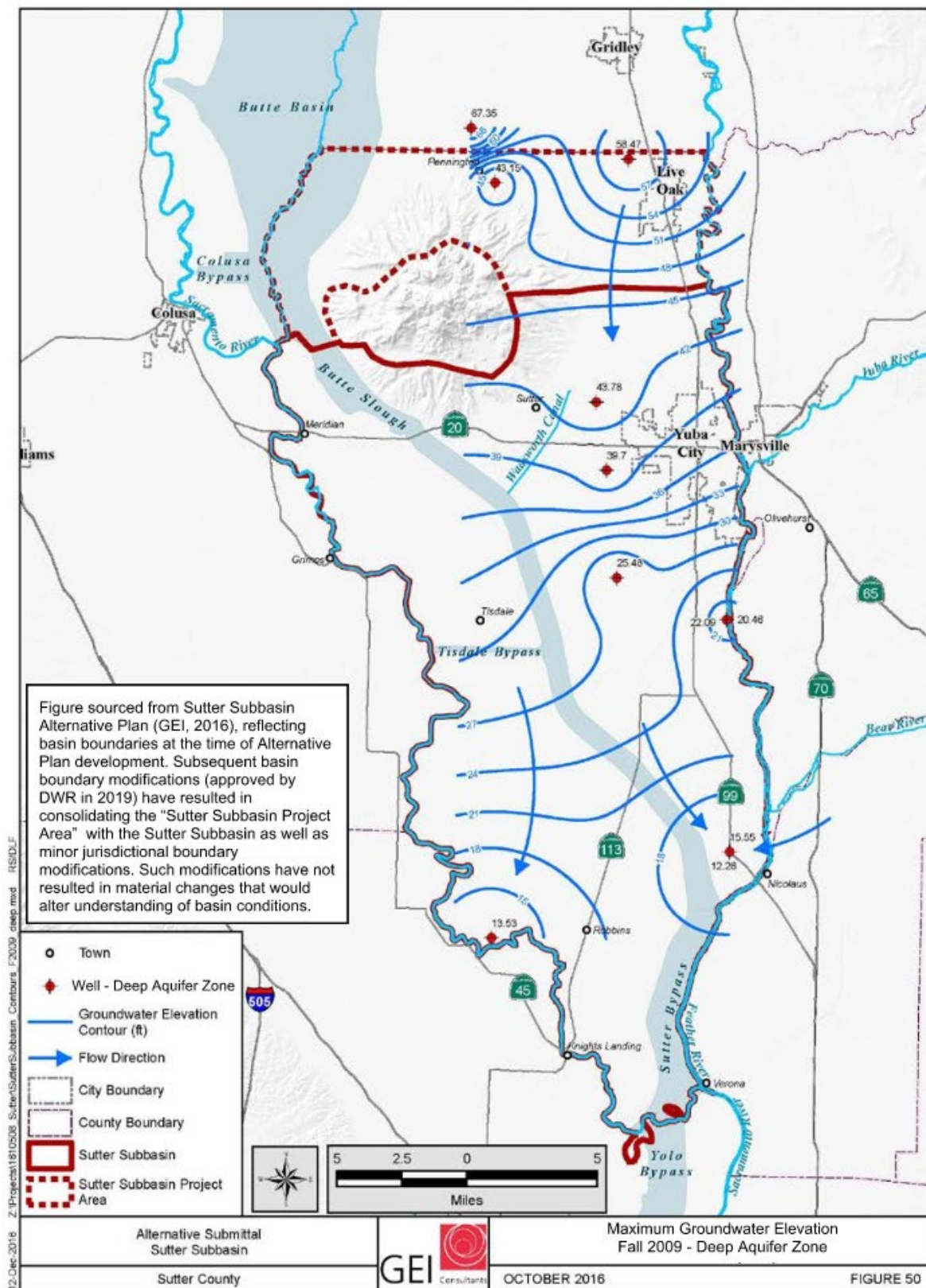


Figure 5-60. Groundwater Elevation in Deep Aquifer Zone (AZ-3), Fall 2009

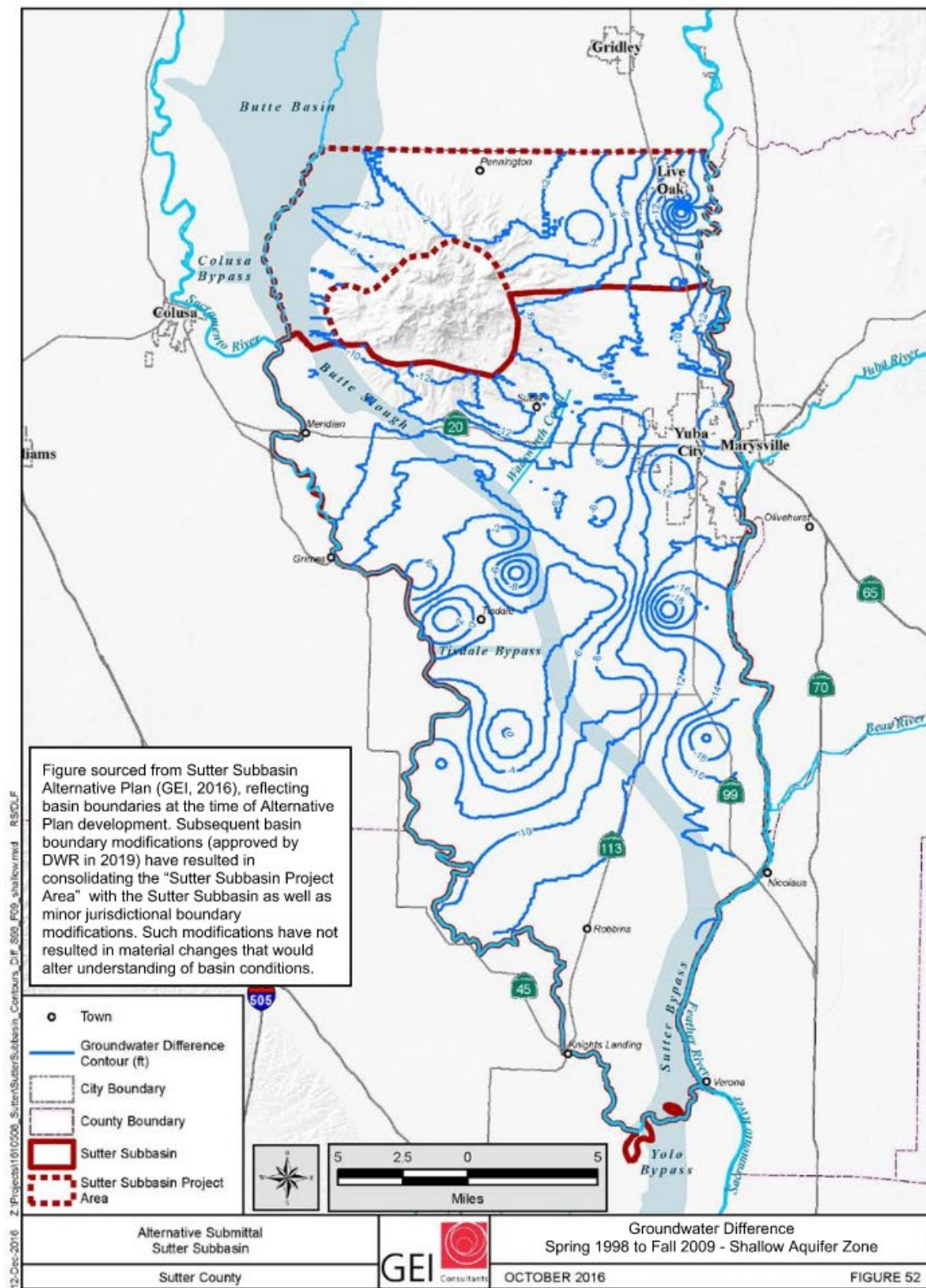


Figure 5-61. Difference in Groundwater Elevation in Shallow Aquifer Zone (AZ-1), Spring 1998 to Fall 2009

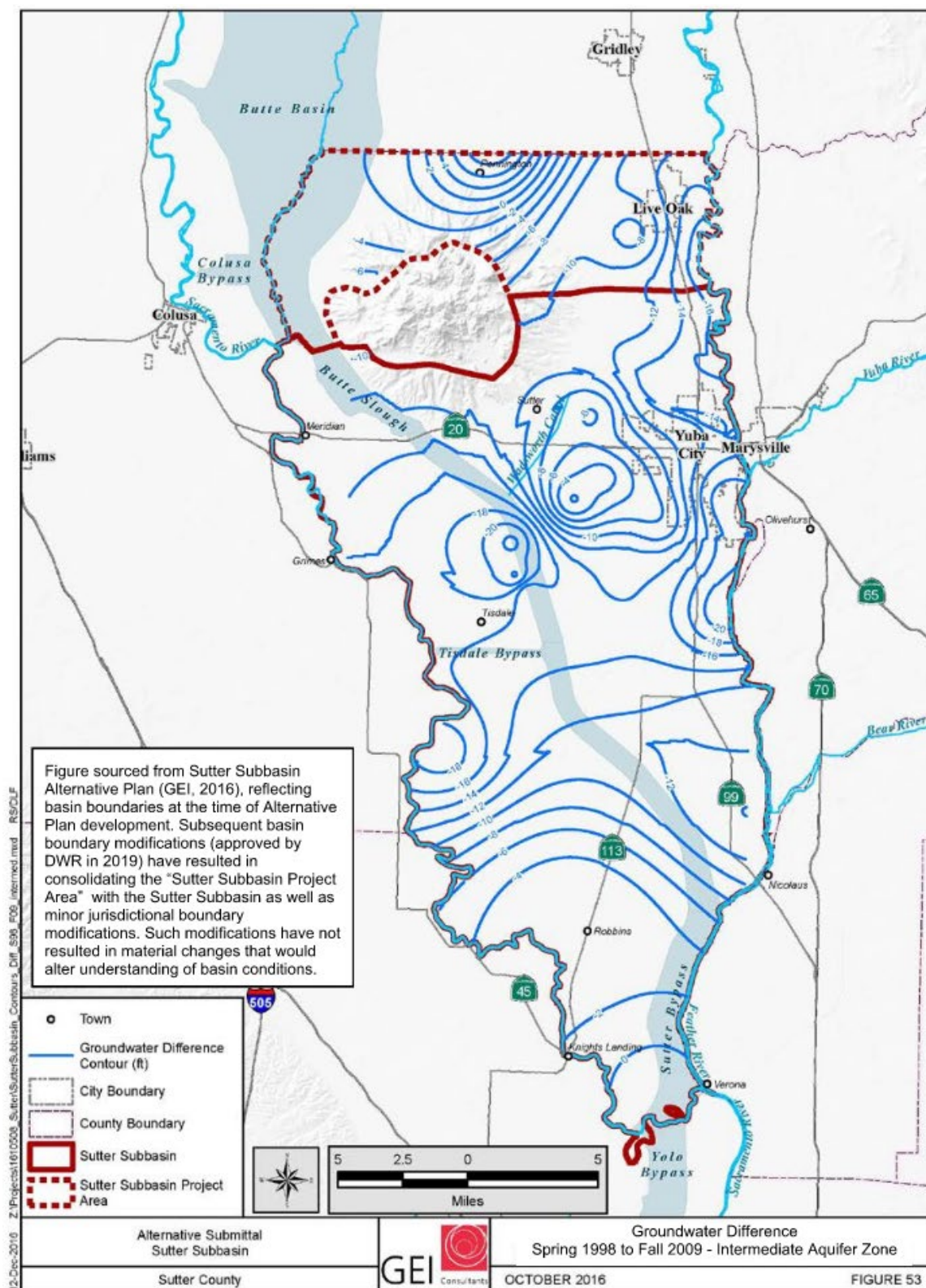


Figure 5-62. Difference in Groundwater Elevation in Intermediate Aquifer Zone (AZ-2), Spring 1998 to Fall 2009

The previous groundwater level contour maps were sourced from the *Sutter Subbasin Alternative Plan* (GEI, 2016) and utilize different terminology for the aquifer zones than definitions contained in the Hydrogeologic Conceptual Model of this GSP (**Section 5.1**). Since development of the original GSP in 2021, aquifer zones have been defined as follows and contour maps have been developed aligning with four separate aquifer zones:

- **Shallow AZ**– up to 50 feet bgs
- **AZ-1** – between 50 feet and 150 feet bgs
- **AZ-2** – between 150 feet and 400 feet bgs
- **AZ-3** – deeper than 400 feet bgs

WY 2013 was selected to represent “normal” in terms of water use (not heavily impacted by drought or wet conditions). Groundwater elevation contour maps for March 2013, representing seasonal high conditions, are shown in **Figure 5-63** through **Figure 5-66**. Groundwater elevation contour maps for October 2013, representing seasonal low conditions following the end of WY 2013, are shown in **Figure 5-67** through **Figure 5-70**.

During March 2013, limited data were available for the Shallow AZ. Based on data that are available, groundwater elevations ranging from 40 to 60 feet above MSL and groundwater flows from east to west directly south of the Sutter Buttes (**Figure 5-63**). Groundwater elevations in AZ-1 range from 20 to 70 feet above MSL (**Figure 5-64**), and between 20 and 60 feet above MSL in AZ-2 (**Figure 5-65**) and AZ-3 (**Figure 5-66**) with flow in the general north to south direction in all three AZs.

During October 2013, limited data are available in the Shallow Aquifer Zone, with groundwater elevations ranging from 40 to 50 feet above MSL and groundwater flowing from east to west directly south of the Sutter Buttes, similar to March 2013 (**Figure 5-67**). In AZ-1, groundwater elevations are approximately 10 feet lower in October 2013 as compared to March 2013, ranging from 10 to 60 feet above MSL with similar flow patterns as March 2013 (**Figure 5-68**). Groundwater elevations in AZ-2 range from 20 to 40 feet above MSL in October 2013, with the highest elevation approximately 20 feet lower than in March 2013 and flowing in the southerly direction (**Figure 5-69**). In AZ-3, groundwater elevations range from 10 to 40 feet above MSL, with the lowest elevation approximately 10 feet lower and the highest elevation approximately 20 feet lower as compared to March 2013 measurements (**Figure 5-70**); groundwater follows a similar general flow patterns observed in October 2013 as in March 2013.

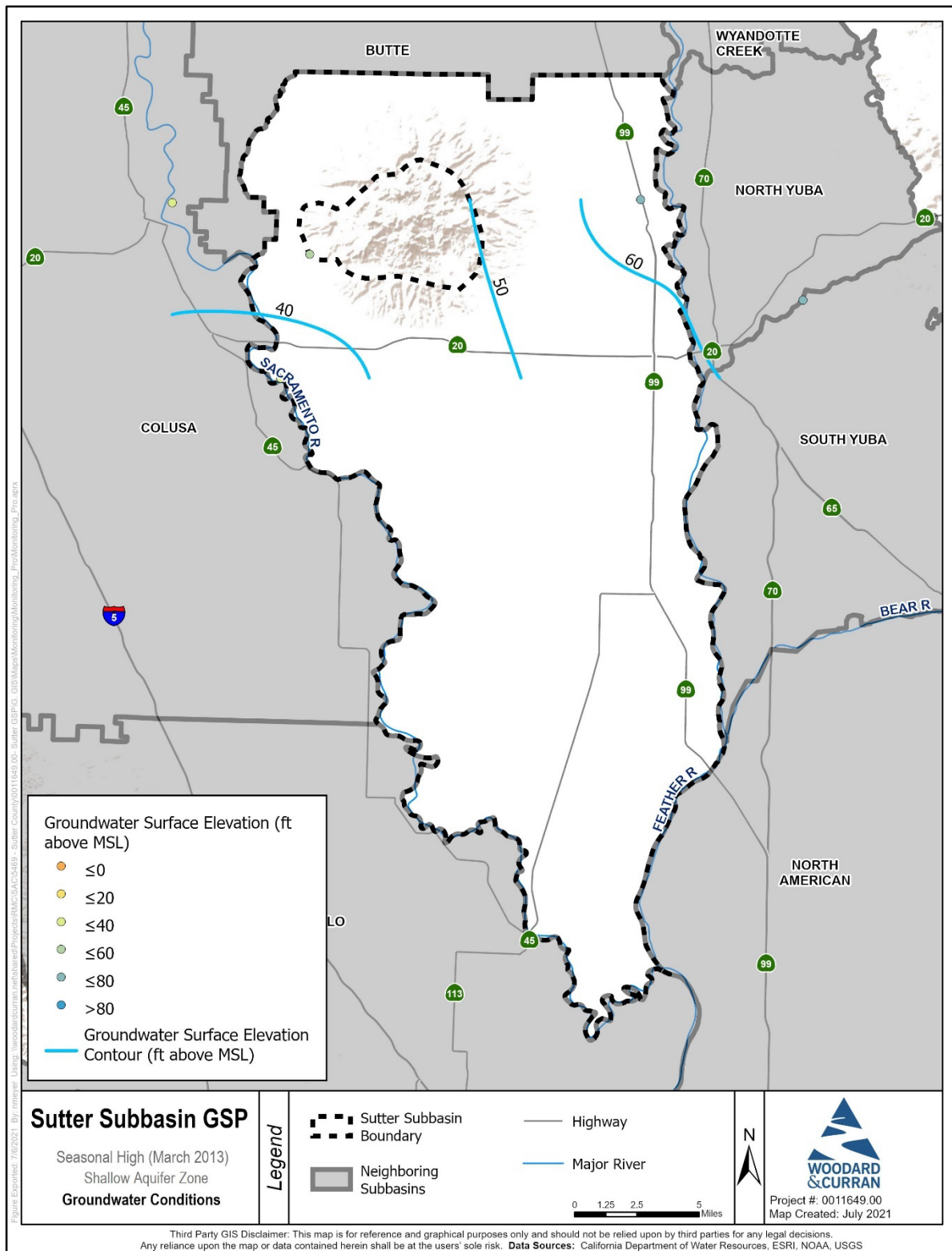


Figure 5-63. March 2013 Groundwater Elevations, Shallow Aquifer Zone

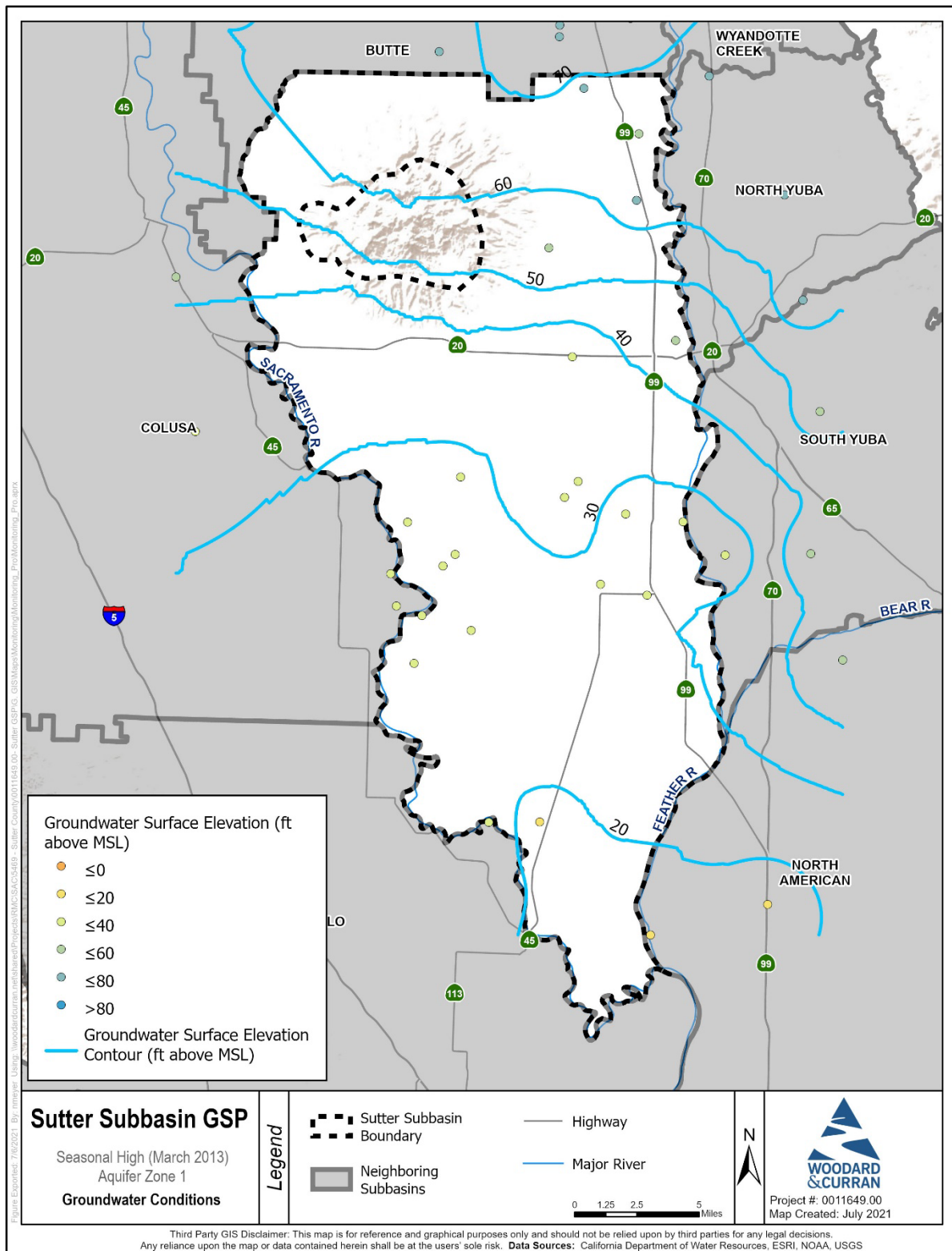


Figure 5-64. March 2013 Groundwater Elevations, AZ-1

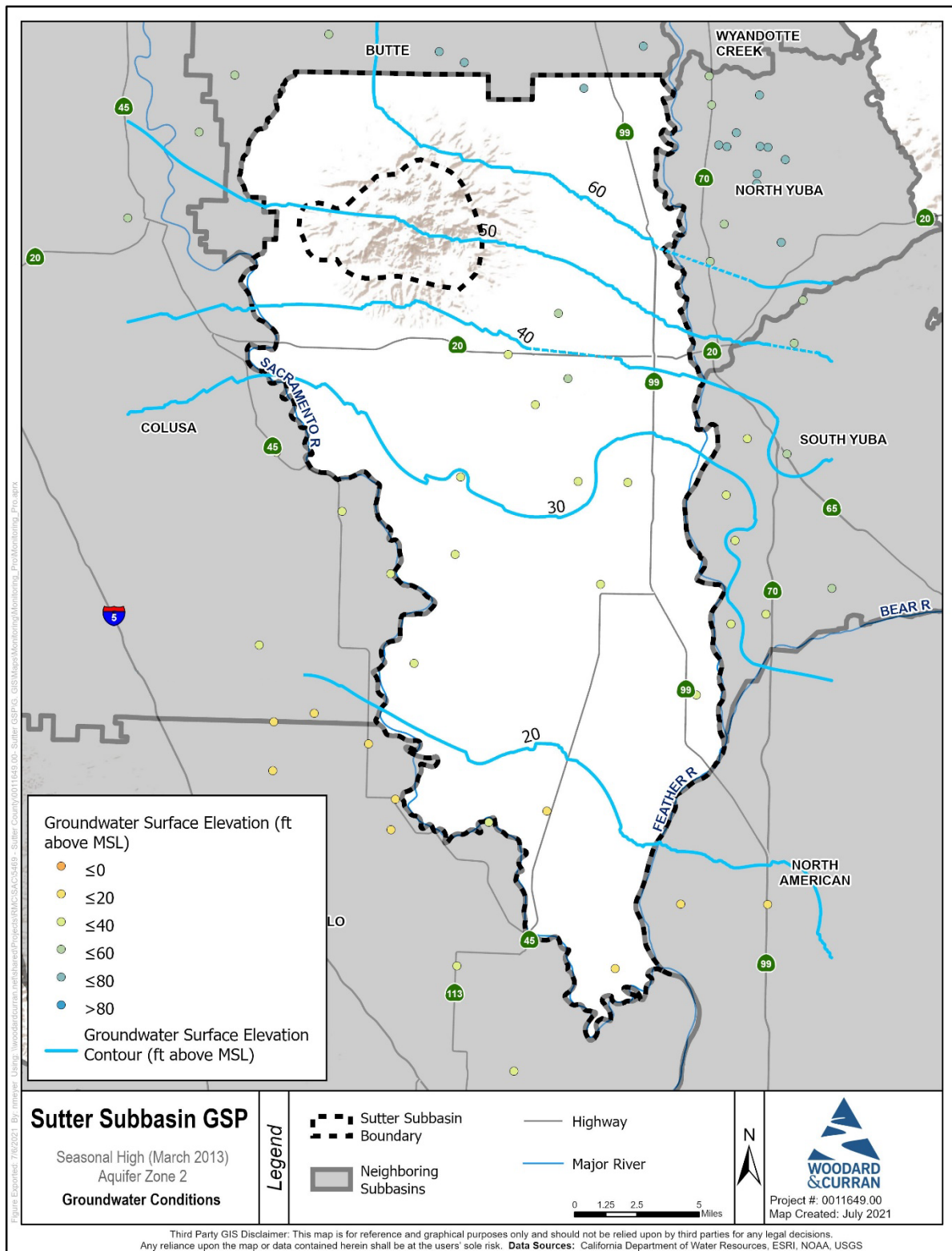


Figure 5-65. March 2013 Groundwater Elevations, AZ-2

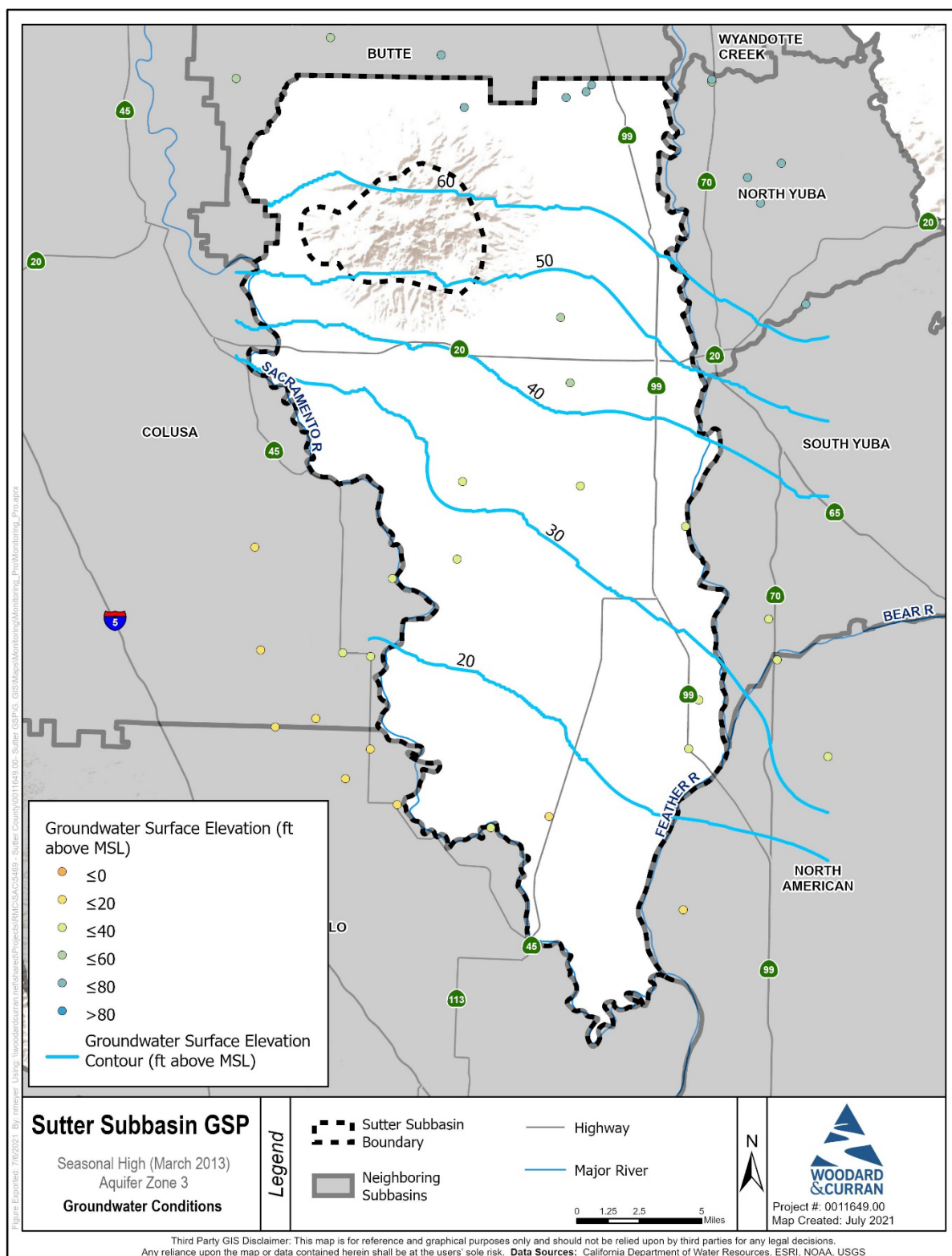


Figure 5-66. March 2013 Groundwater Elevations, AZ-3

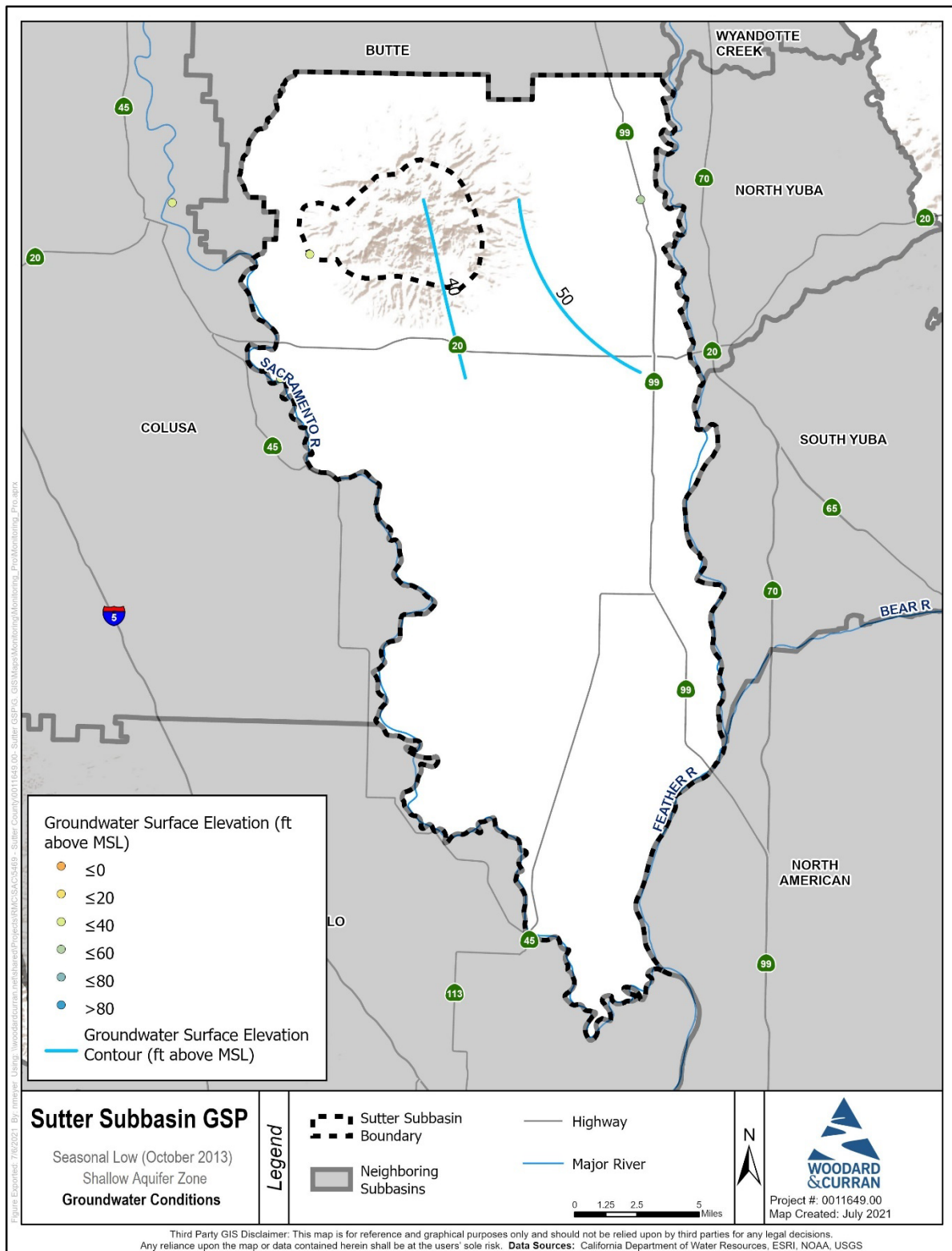


Figure 5-67. October 2013 Groundwater Elevations, Shallow Aquifer Zone

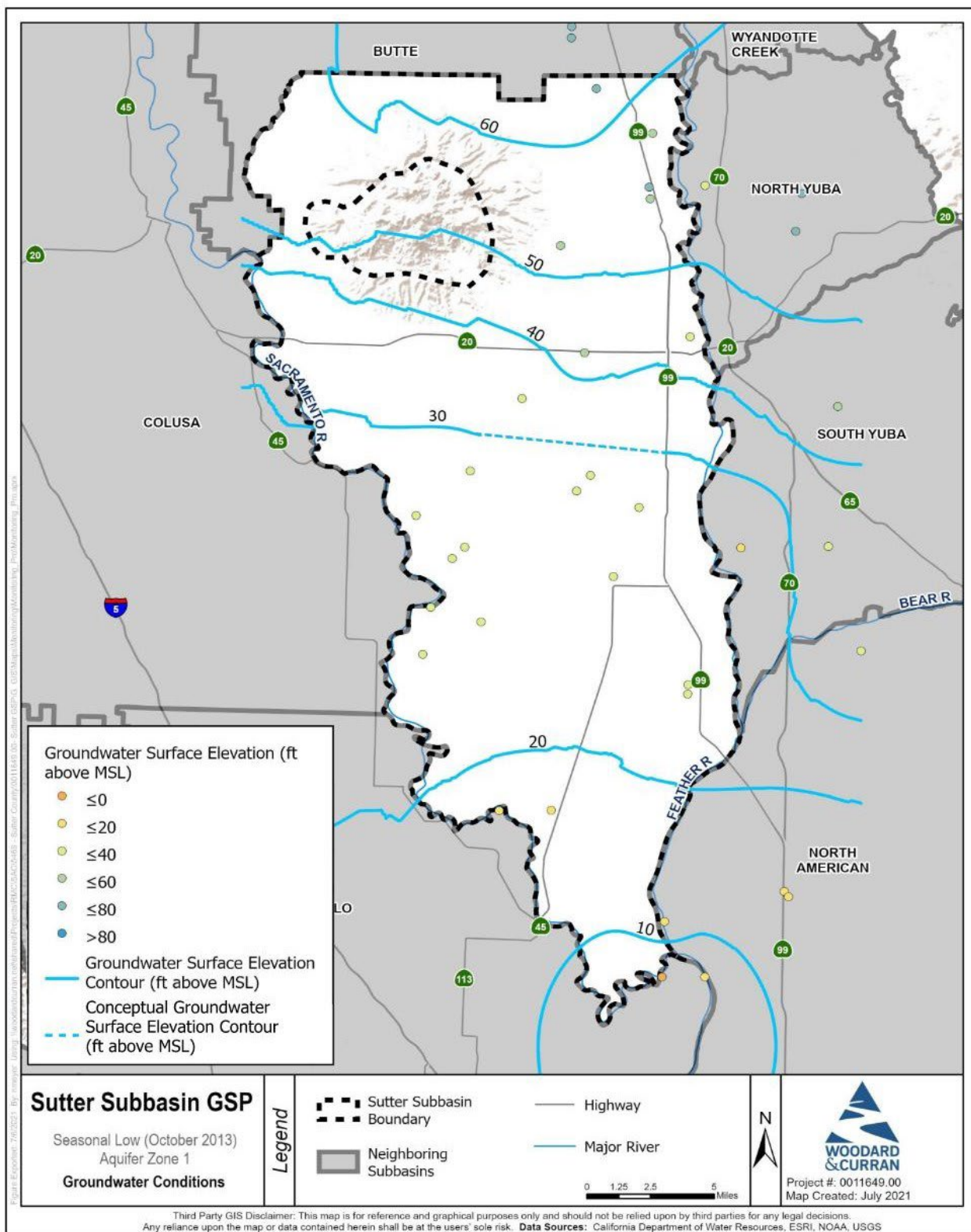


Figure 5-68. October 2013 Groundwater Elevations, AZ-1

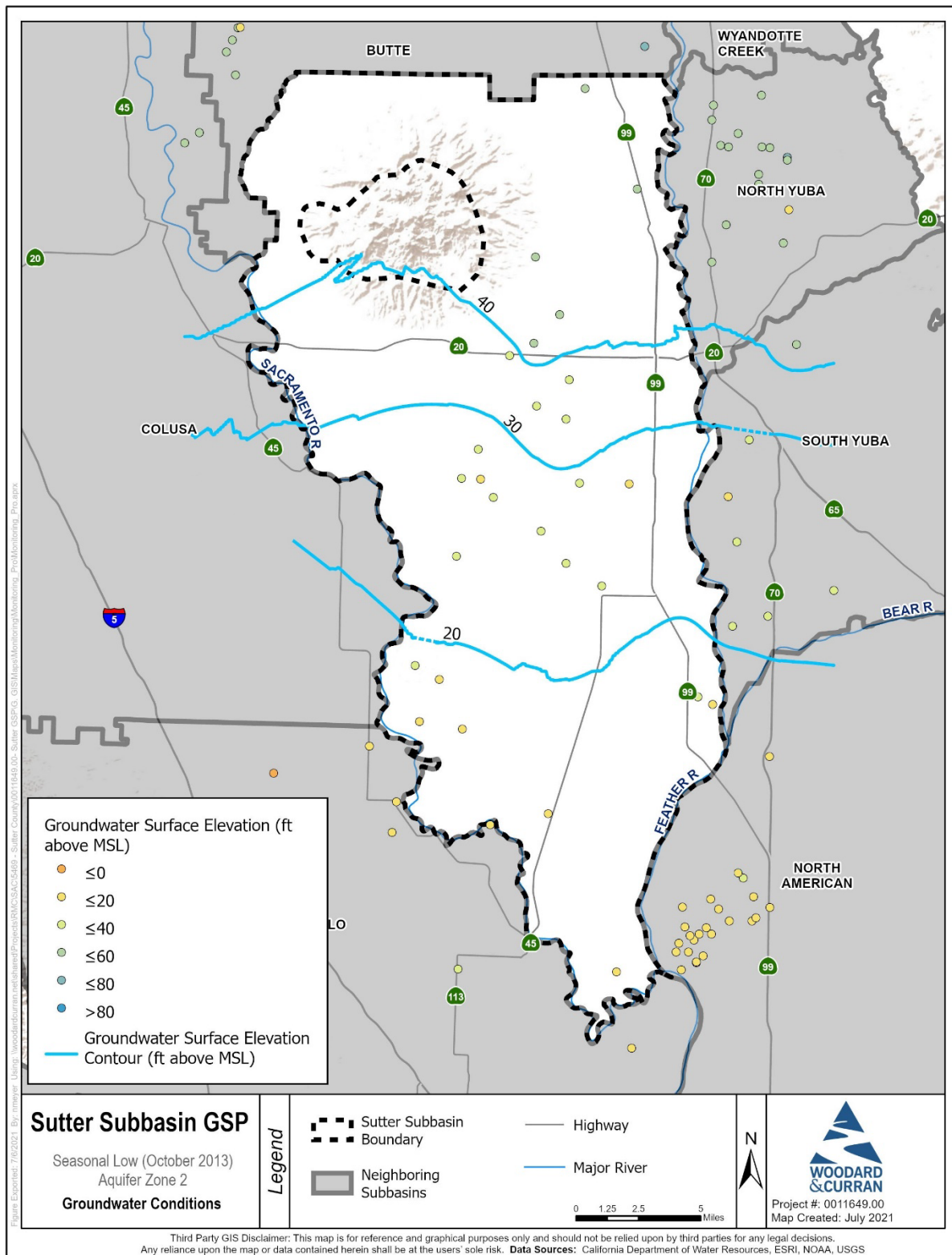


Figure 5-69. October 2013 Groundwater Elevations, AZ-2

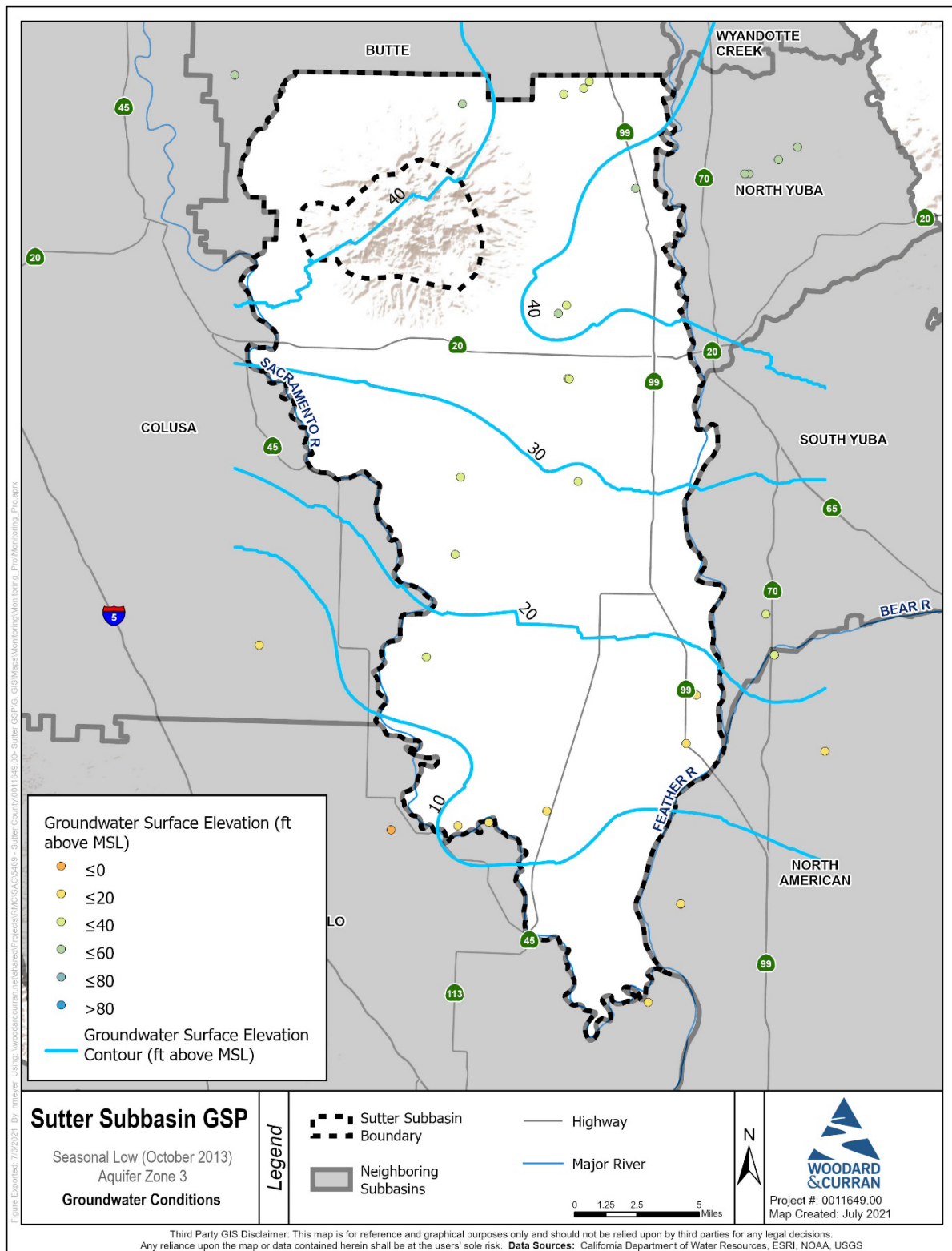


Figure 5-70. October 2013 Groundwater Elevations, AZ-3

Figure 5-71 through **Figure 5-73** present available groundwater elevation contour maps from the Sutter Subbasin Alternative Plan for Fall 2015 in the shallow (AZ-1), intermediate (AZ-2), and deep (AZ-3) aquifer zones, respectively, representing seasonal low groundwater elevations during a Critical year (as classified by the Sacramento Water Year Index). As previously noted, contour maps developed as part of the Sutter Subbasin Alternative Plan (GEI, 2016) differ slightly in aquifer zone definitions than what is defined in the HCM section of this GSP (**Section 5.1.3**).

In the shallow aquifer zone (AZ-1), groundwater elevations range from 18 to 66 feet above MSL with pumping depressions mostly observed along the central portion of the eastern Subbasin boundary (**Figure 5-71**). Within the intermediate aquifer (AZ-2), groundwater elevations range from 63 feet below MSL to 57 feet above MSL with a cone of depression observed along the central portion of the eastern Subbasin boundary causing a reversal of groundwater flow from west to east (**Figure 5-72**). In the deep aquifer (AZ-3), groundwater elevations range from 3 feet below MSL to 54 feet above MSL with a cone of depression observed along the central portion of the western boundary of the Subbasin (**Figure 5-73**).

Compared to Fall 2009 groundwater levels, as presented in **Figure 5-58** through **Figure 5-60**:

- **Shallow Aquifer Zone (AZ-1)** – Groundwater elevations were approximately 1 to 3 feet deeper during Fall 2015.
- **Intermediate Aquifer Zone (AZ-2)** – Groundwater elevations were about 1 to 6 feet deeper during Fall 2015, with the exception of a pumping depression near the confluence of the Bear and Feather rivers observed in Fall 2015.
- **Deep Aquifer Zone (AZ-3)** – Groundwater elevations were about 1 to 3 feet deeper during Fall 2015.

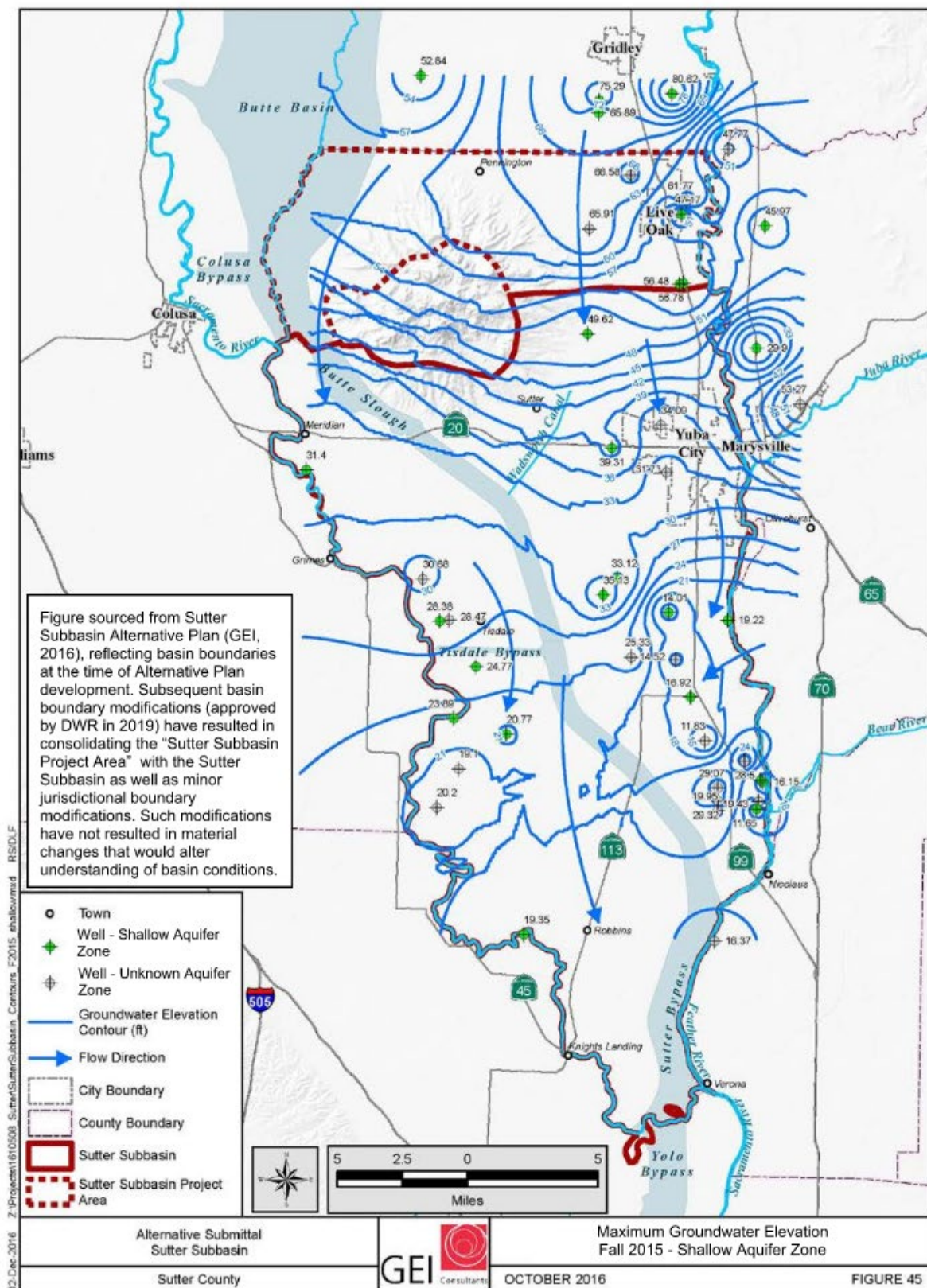
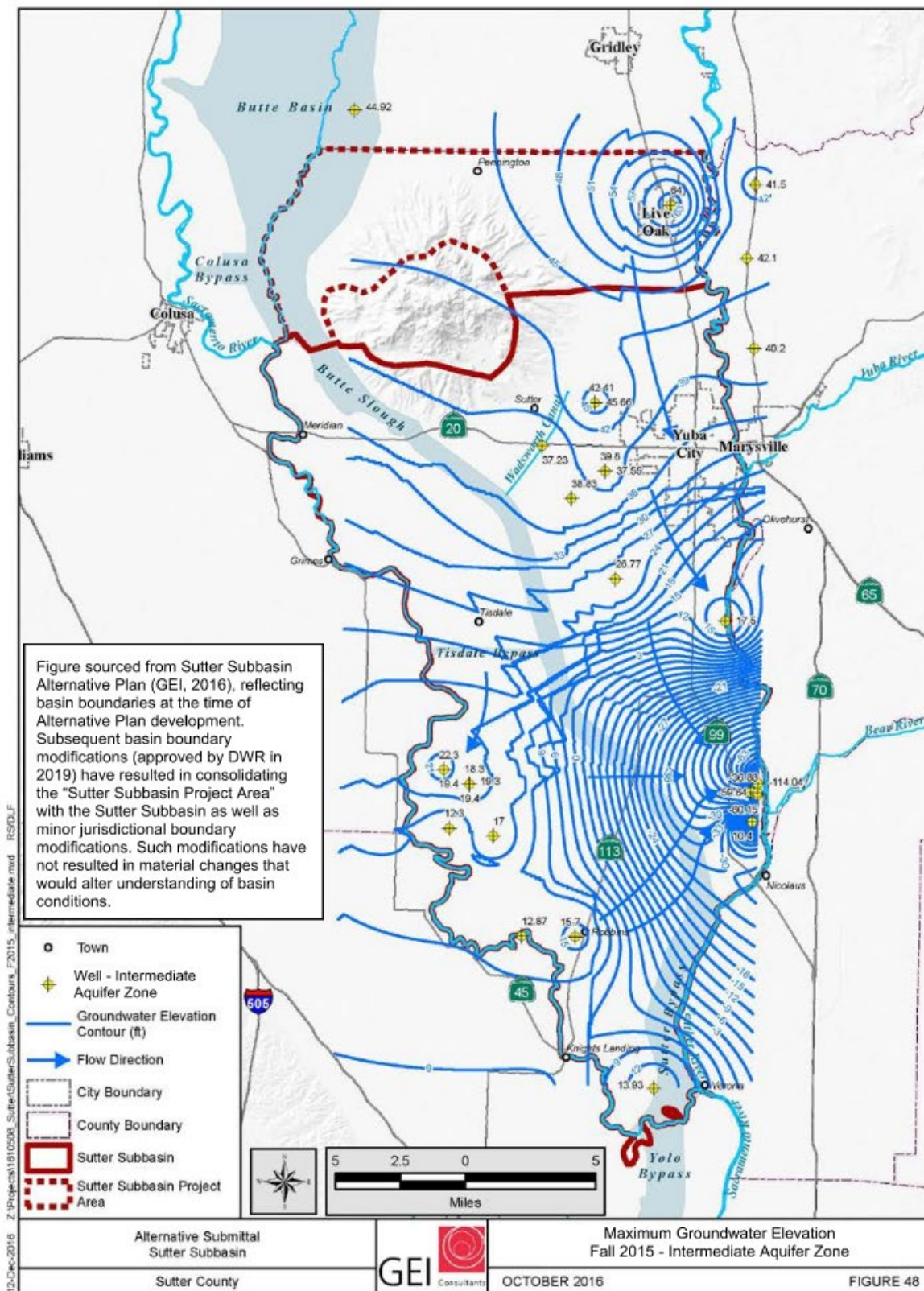


Figure 5-71. Groundwater Elevation in Shallow Aquifer Zone, Fall 2015



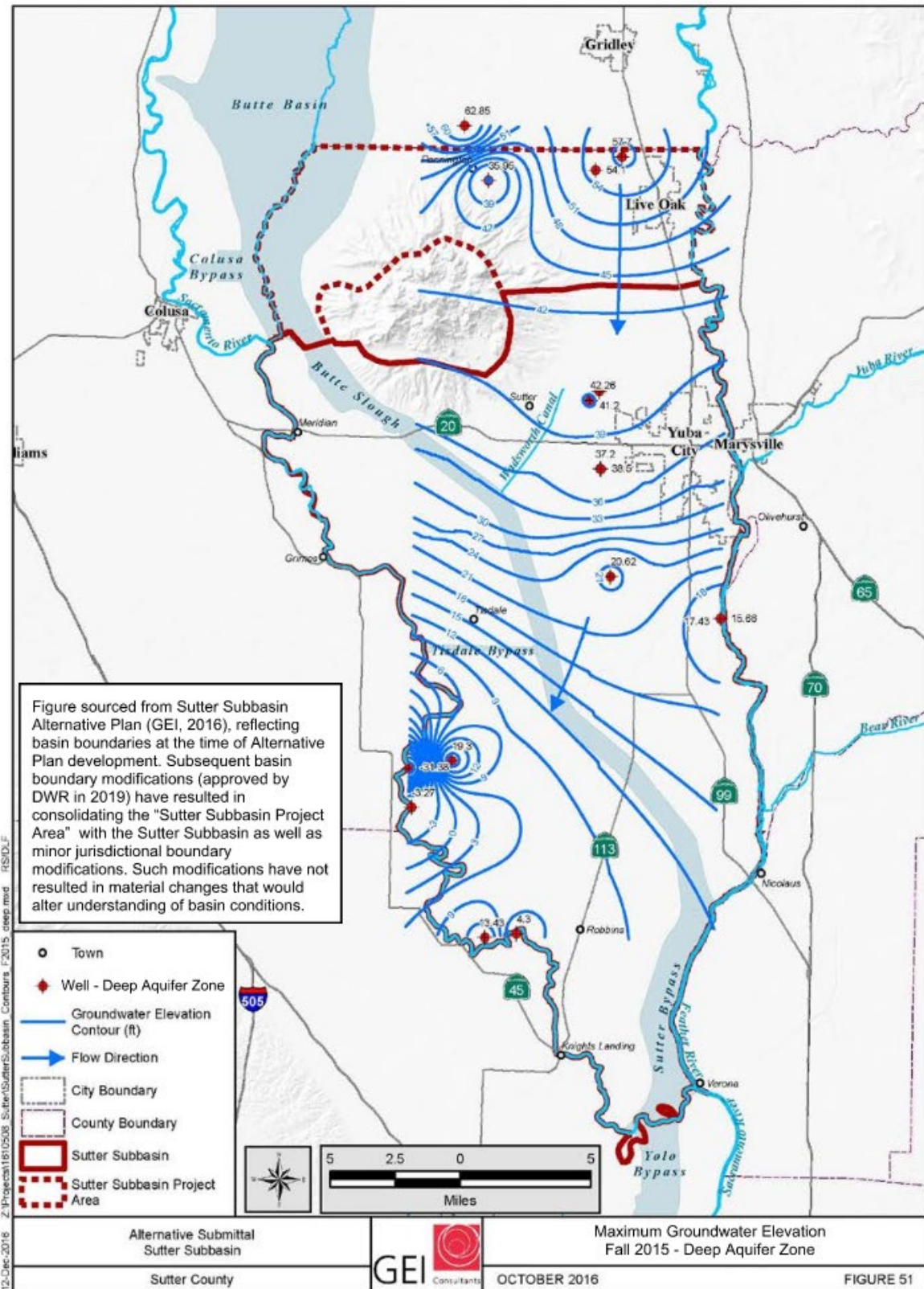


Figure 5-73. Groundwater Elevation in Deep Aquifer Zone, Fall 2015

Representative hydrographs depicting long-term groundwater elevations, historical highs and lows, and hydraulic gradients from eleven nested wells equipped with transducers at 33 perforation intervals are shown in **Section 5.1.3.3** in **Figure 5-15** through **Figure 5-25**. Measurements range from 2004 through 2025. For each of these hydrographs, AZ-1 hydrographs are in green, AZ-2 in blue, and AZ-3 in red. Where a nested well has two screens within the same aquifer zone, the deeper well hydrograph is dashed.

Consistent trends are observed over the historical record. Shallow groundwater levels, largely within AZ-1, are relatively stable over time and indicate that most groundwater production is occurring below this zone. More groundwater appears to be produced from the deeper aquifer zones (deeper portion of AZ-1 as well as the intermediate [AZ-2] and deep [AZ-3] aquifer zones) as indicated by large fluctuations in groundwater elevations where responses to groundwater pumping are observed (drawdown) with rebound following the irrigation season as the aquifer recharges and returns to pre-pumping levels on a seasonal basis. Overall, groundwater level trends are largely flat over time, indicating sustainable conditions in the Sutter Subbasin as the aquifer rebound is observed during all water year types.

5.2.2.2 Current Conditions

Figure 5-74 through **Figure 5-77** present contour maps of groundwater levels for seasonal high conditions (March and April 2025) for each aquifer zone during the most recent water year, WY 2025. As has been the case historically, insufficient data were available for the Shallow AZ for March and April 2025, therefore **Figure 5-74** only shows wells with available groundwater elevation measurements during this period. Only one Shallow AZ well with March and April 2025 data is available, located approximately in the center of the Subbasin, with an elevation of 30 feet above mean sea level (MSL). Groundwater elevations ranged from approximately 17 to 71 feet above MSL in AZ-1 (**Figure 5-75**), from approximately 17 to 71 feet above MSL in AZ-2 (**Figure 5-76**), and from approximately 15 to 68 feet above MSL in AZ-3 (**Figure 5-77**).

Figure 5-78 through **Figure 5-81** present contour maps of groundwater levels for seasonal low conditions (September and October 2025) for each aquifer zone during WY 2025. Insufficient data were available for the Shallow AZ for September and October 2025, therefore **Figure 5-78** shows only wells with available groundwater elevation measurements during this period. Only one Shallow AZ well with September and October 2025 data is available, located approximately in the center of the Subbasin, with an elevation of 30 feet above MSL. Groundwater elevations ranged from approximately 16 to 68 feet above MSL in AZ-1 (**Figure 5-79**), from approximately 16 to 62 feet above MSL in AZ-2 (**Figure 5-80**), and from approximately 12 to 58 feet above MSL in AZ-3 (**Figure 5-81**).

At the monitored wells, groundwater levels dropped a maximum of 10 feet from seasonal high to seasonal low. The seasonal drop in groundwater levels was highest in

the deepest aquifer zone (AZ-3). This seasonal change in groundwater levels is consistent with conditions observed in normal WY 2013, shown in **Figure 5-63** through **Figure 5-70**. Consistent with historical conditions, groundwater flow in both seasons of WY 2025 moved generally from the north to the south in AZ-1, AZ-2, and AZ-3.

Hydrographs showing groundwater levels through 2025 are shown in **Figure 5-15** through **Figure 5-25**. As previously noted, annual groundwater fluctuations are observed throughout the Sutter Subbasin due to irrigation demands and subsequent wet season recharge but there is little to no variation in groundwater elevations by water year type.

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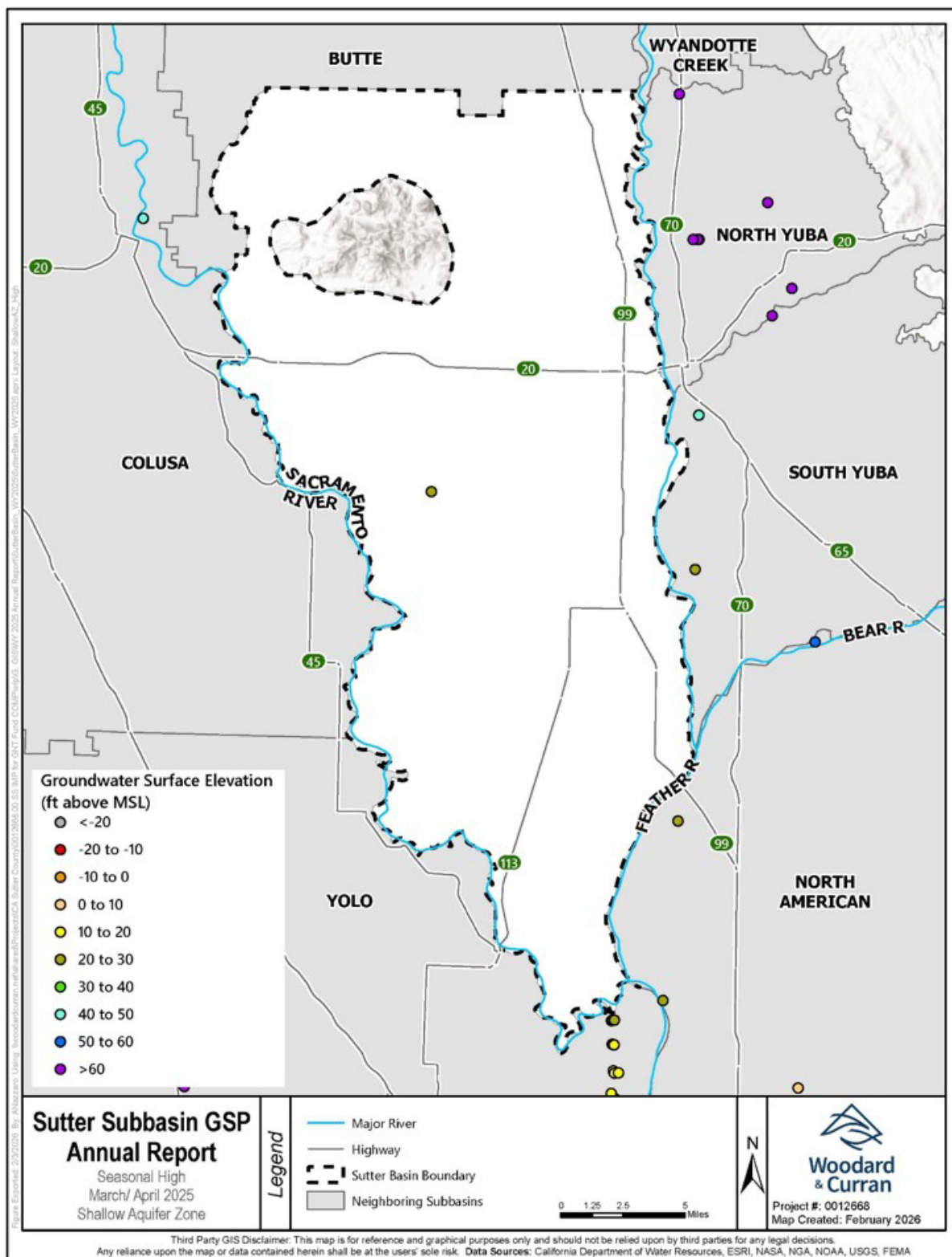


Figure 5-74. March/April 2025 Groundwater Elevations, Shallow Aquifer Zone

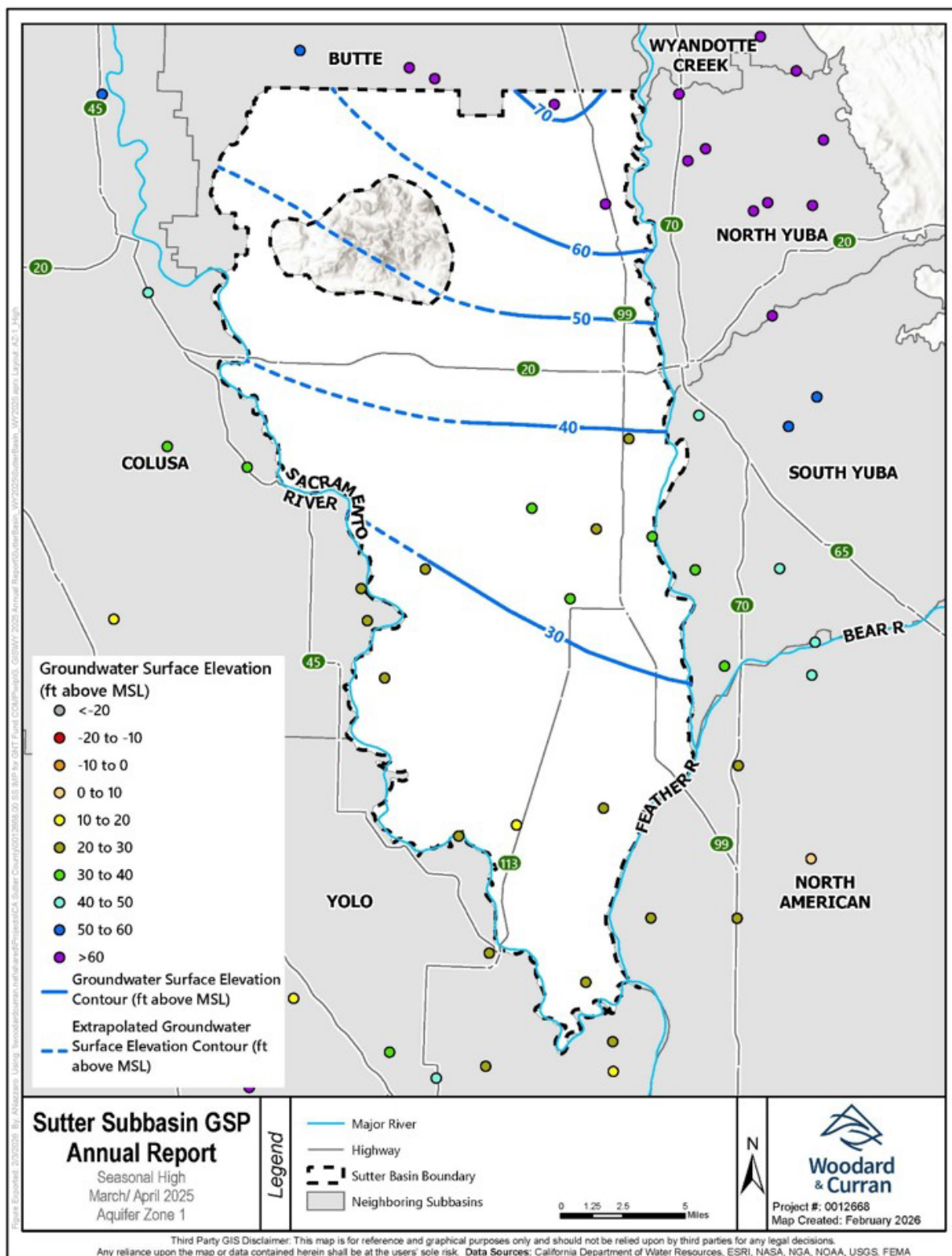


Figure 5-75. March/April 2025 Groundwater Elevations, AZ-1

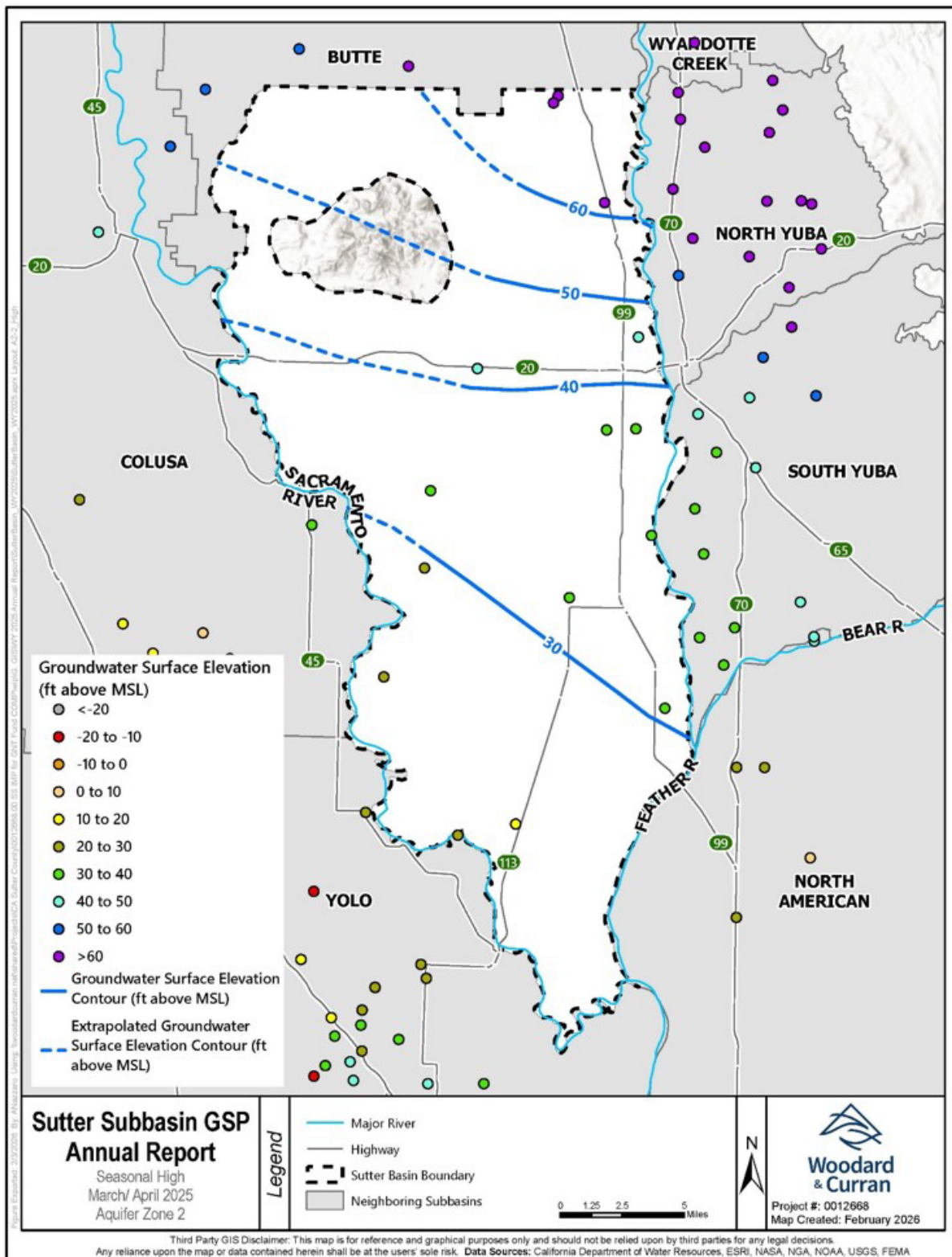


Figure 5-76. March/April 2025 Groundwater Elevations, AZ-2

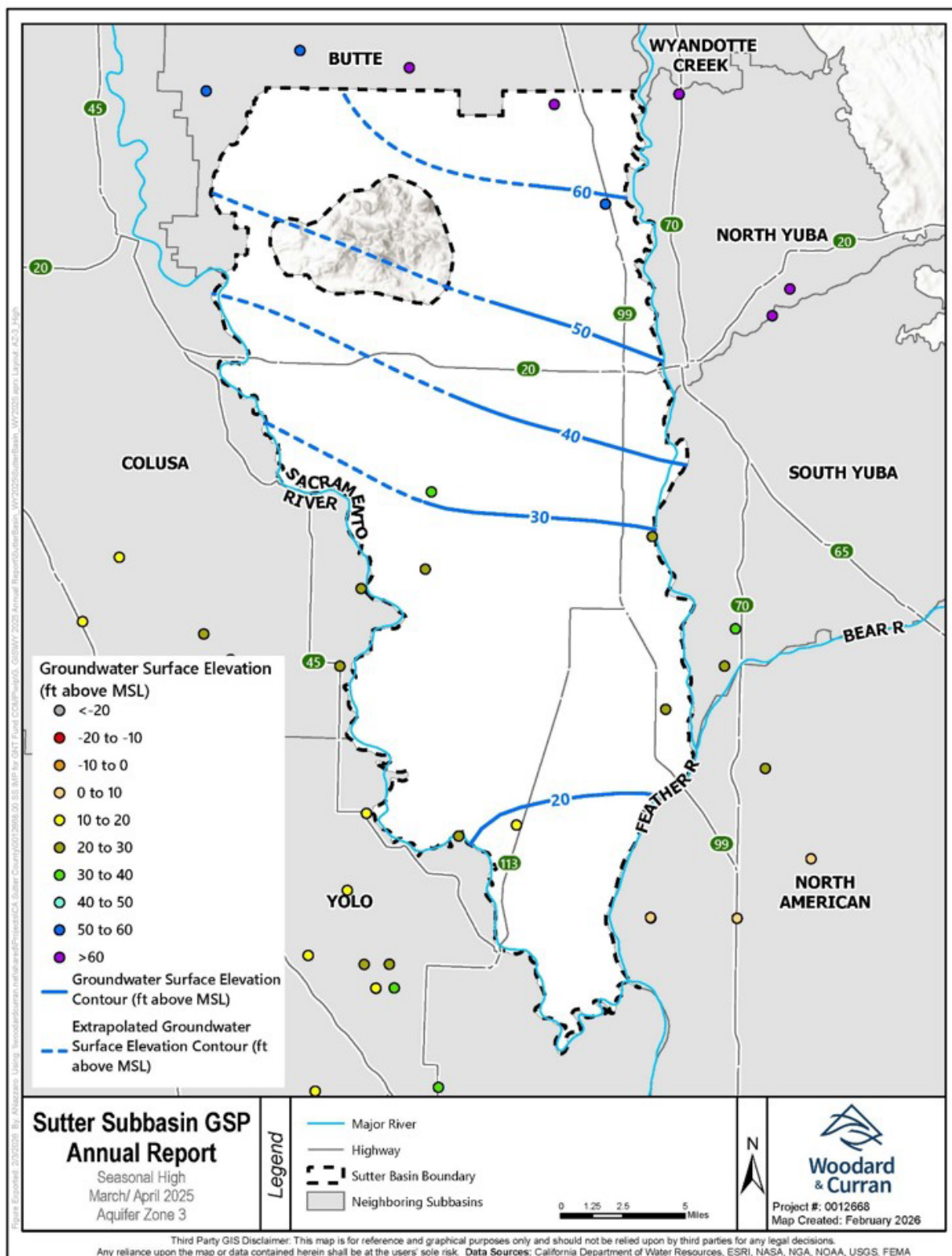


Figure 5-77. March/April 2025 Groundwater Elevations, AZ-3

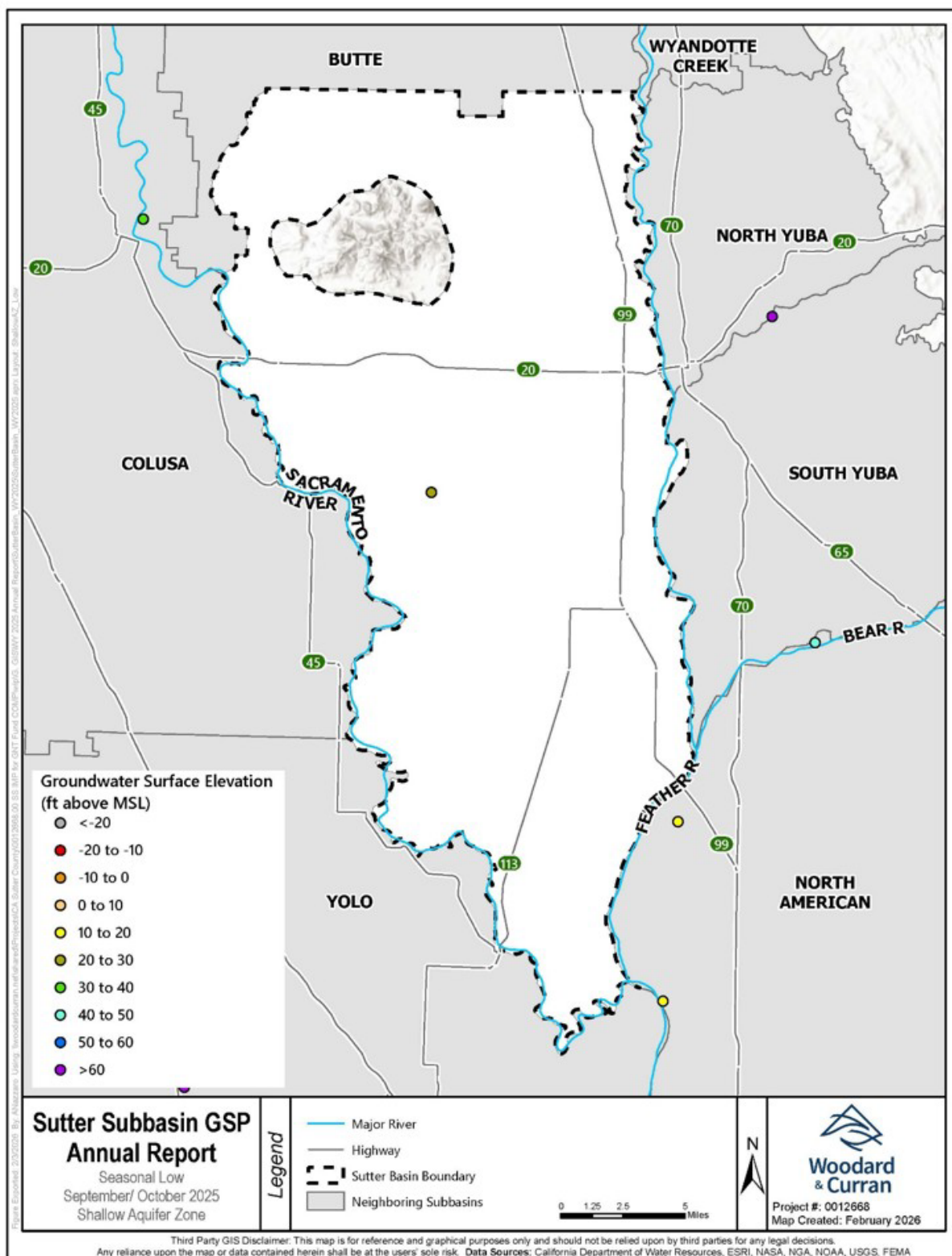


Figure 5-78. September/October 2025 Groundwater Elevations, Shallow Aquifer Zone

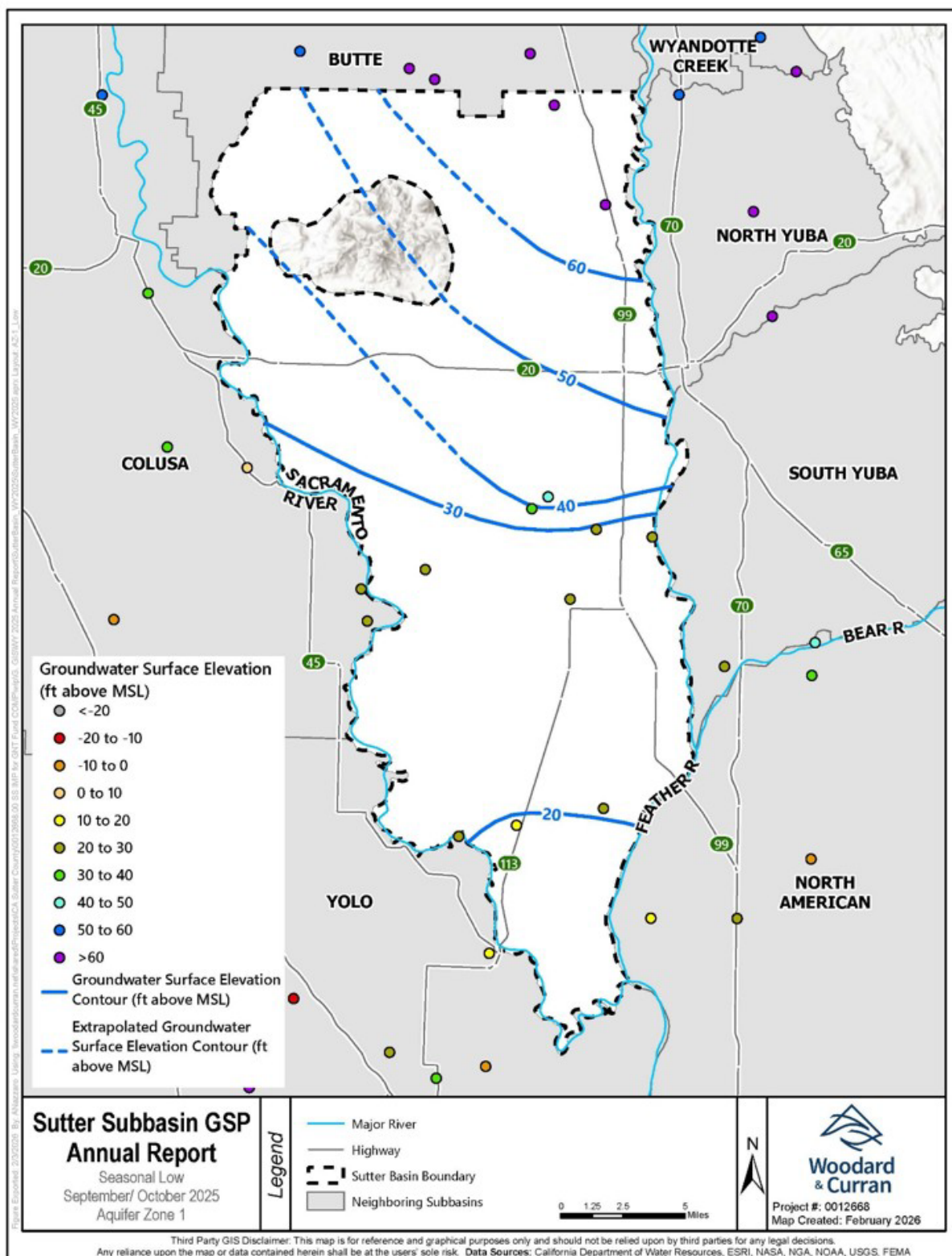


Figure 5-79. September/October 2025 Groundwater Elevations, AZ-1

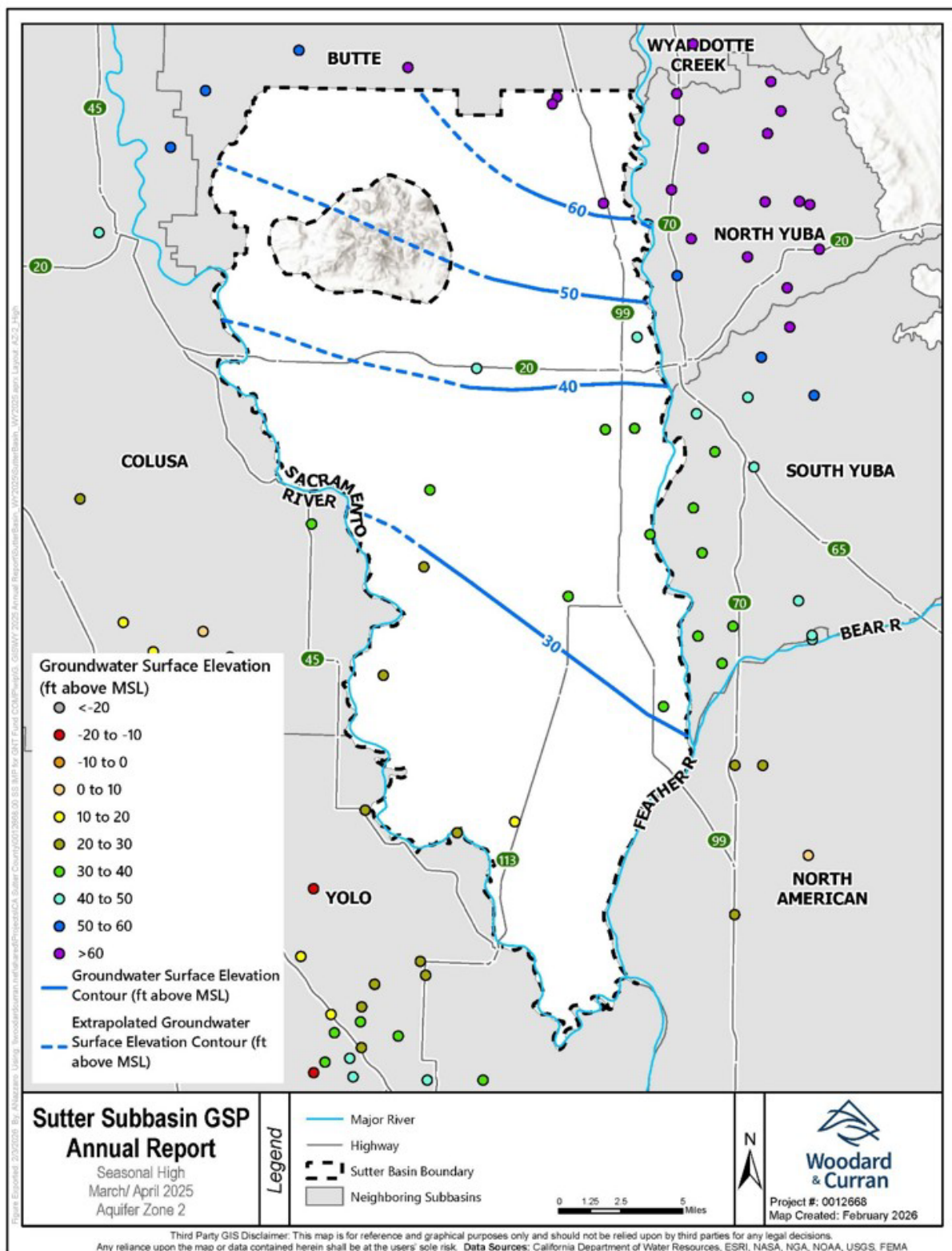


Figure 5-80. September/October 2025 Groundwater Elevations, AZ-2

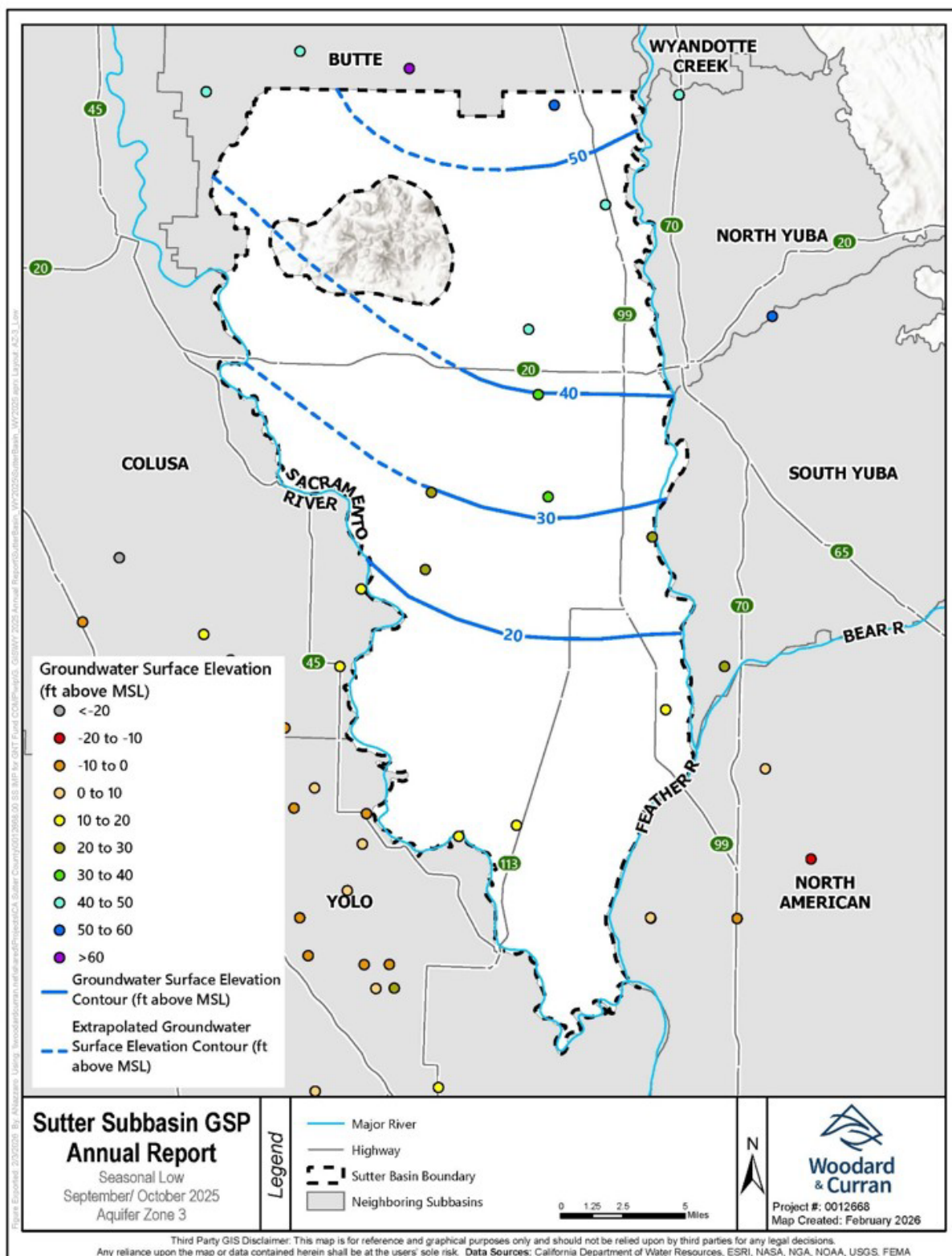


Figure 5-81. September/October 2025 Groundwater Elevations, AZ-3

5.2.2.3 Groundwater Trends

Hydrographs within the Sutter Subbasin show two distinct patterns, the first where groundwater levels in the shallowest portion of the principal aquifer (upper portion of AZ-1) are constantly higher than groundwater levels in the intermediate and deeper portions of the aquifer (deeper portion of AZ-1 as well as AZ-2 and AZ-3) indicating a downward gradient, and the second where groundwater levels in the deeper portion of the aquifer are higher than groundwater levels in the intermediate and shallow portion of the principal aquifer indicating an upward gradient. **Figure 5-82** shows where the upward and downward gradients occur. There is no distinct pattern as to where and when each of these patterns are observed within the Sutter Subbasin. The head differences are typically on the order of a few feet, but may be up to 10 to 20 feet during the summer months (GEI, 2016).

Upward gradients in the deeper portion of the aquifer appear to exist in the southern half of the Sutter Subbasin. In these areas, the base of fresh water is relatively shallow. Pumping in the deeper portion of the aquifer could reduce heads and allow migration of brackish water into the freshwater aquifer. The hydrographs show that pumping is occurring in AZ-3 (deeper than 400 feet bgs) and/or in wells that are screened across all aquifer zones as seasonal reversals of gradients are observed and groundwater levels decline in all of the aquifer zones.

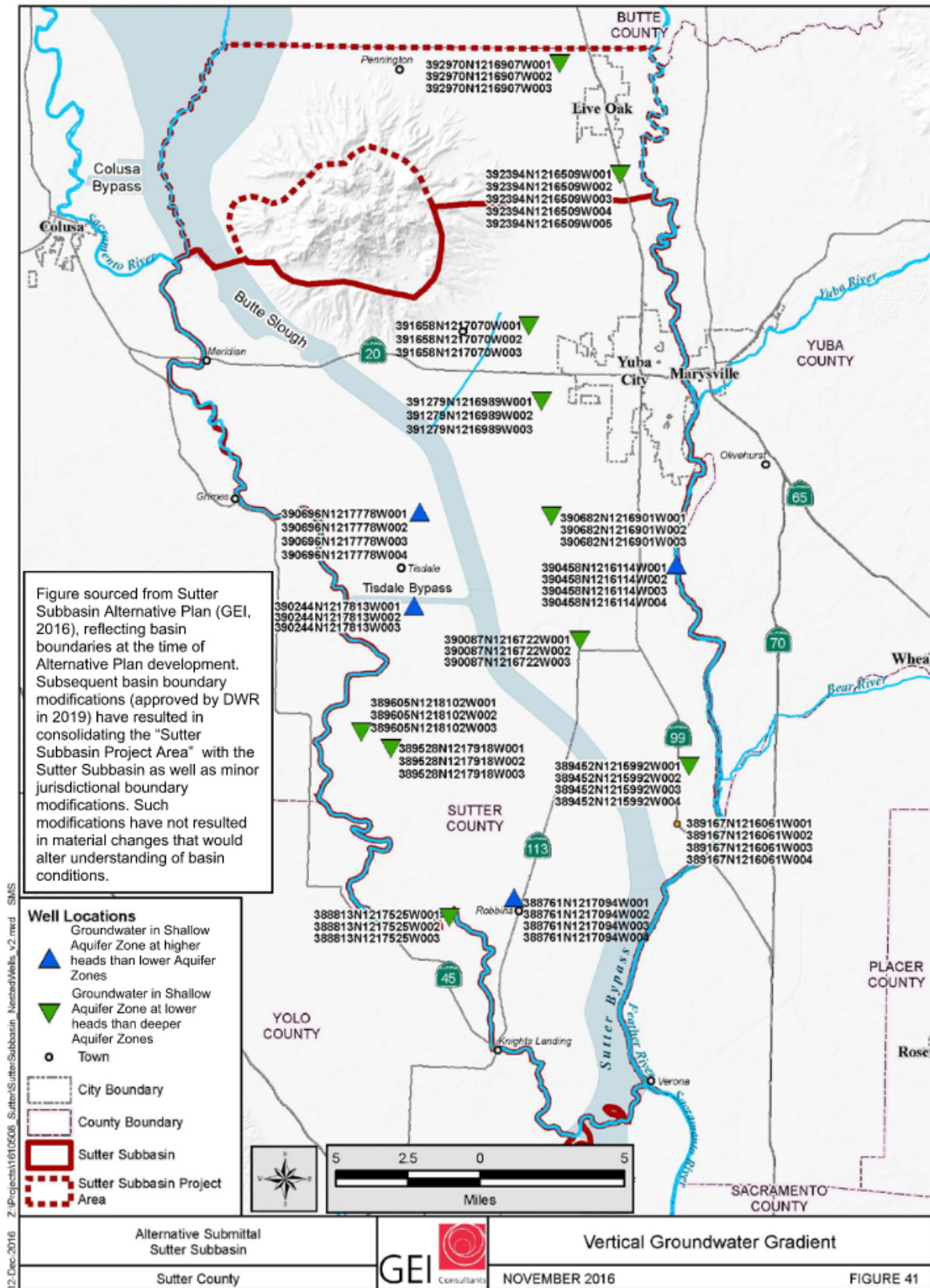


Figure 5-82. Vertical Groundwater Gradients

5.2.3 Groundwater Storage

As with groundwater levels, groundwater storage volumes in the Sutter Subbasin have been generally stable over at least the past 30 years (the length of available record). The volume of groundwater in storage increases as groundwater levels rise and decreases as groundwater levels fall; thus, stable groundwater level conditions also result in stable groundwater storage conditions. Change in storage volumes have been estimated for the Sutter Subbasin using C2VSimFG-Sutter Version 2.0 integrated flow model. **Figure 5-83** shows annual (pink) and cumulative change in storage (black line) plotted together for WY 1996 to WY 2025 for all aquifer layers combined (i.e., for the entire principal aquifer). DWR's Sacramento Valley Water Year Type Index is indicated in parenthesis for each year where:

- "C" indicates a Critical Year
- "D" indicates a Dry Year
- "BN" indicates a Below Normal Year
- "AN" indicates an Above Normal Year
- "W" indicates a Wet Year

Annual total groundwater pumping is also plotted in grey (**Figure 5-83**). In drier years, more groundwater is pumped from the Subbasin, which results in reduction of groundwater available in storage (i.e., a negative change in storage bar and a downward sloping cumulative change in storage line). In wetter years, that storage reduction has typically replenished as pumping is reduced (i.e., a positive change in storage bar and an upward sloping cumulative change in storage line). The total available groundwater in storage in the Subbasin was estimated by C2VSimFG-Sutter to be approximately 49 million acre-feet (MAF). Details on the use of C2VSimFG-Sutter for water budgeting purposes is further discussed in **Section 5.3**.

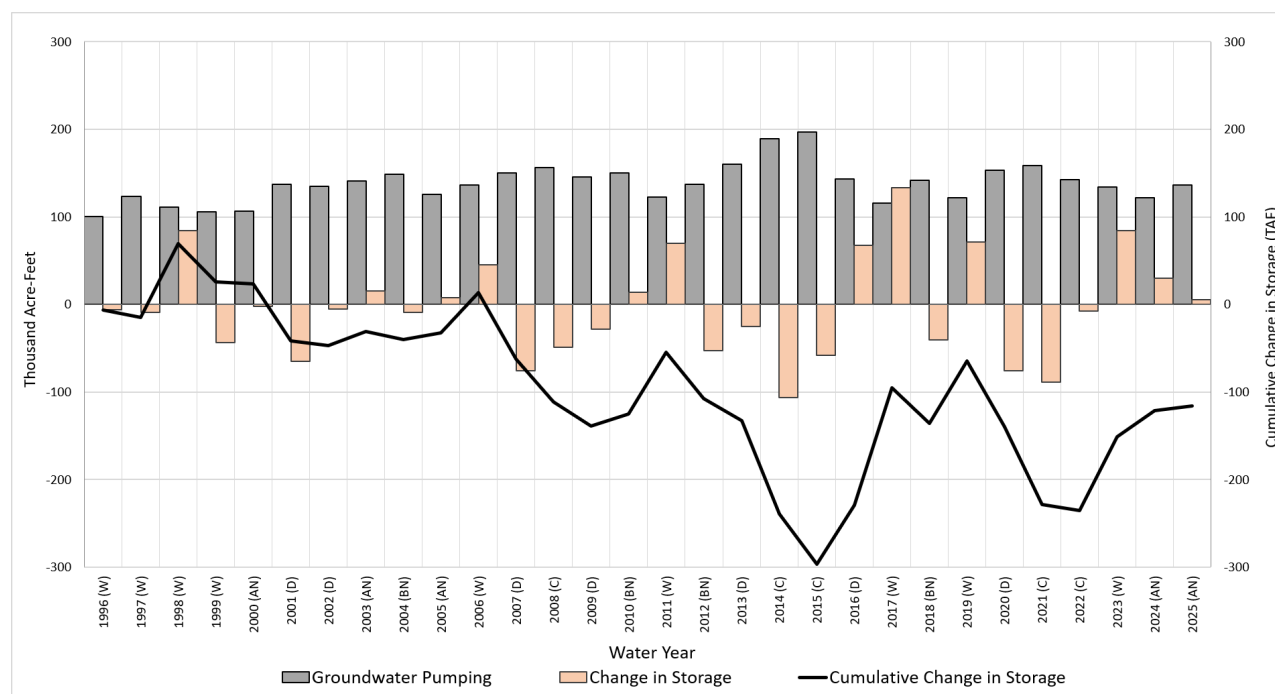


Figure 5-83. Annual and Cumulative Groundwater Storage

5.2.4 Seawater Intrusion

Seawater intrusion is not an applicable sustainability indicator for the Sutter Subbasin as the Subbasin is located inland from the Pacific Ocean and is set back from the Sacramento-San Joaquin Delta. Therefore, groundwater conditions related to seawater intrusion are not applicable to the Sutter Subbasin.

5.2.5 Groundwater Quality

As discussed in **Section 5.1.3.5**, groundwater quality in the Sutter Subbasin was primarily evaluated via data from the Groundwater Ambient Monitoring and Assessment Program (GAMA) well network (SWRCB, 2026). The *Sutter County Groundwater Management Plan* (Wood Rodgers, 2012) identifies several constituents within the Sutter Subbasin that are at levels that exceed their relative Water Quality Objective (the Primary or SMCL or other water quality limit such as the agricultural water quality objective) for drinking water. These constituents include arsenic, boron, total dissolved solids (TDS), and nitrate as N. As discussed in **Section 5.1.3.5**, all of the constituents, except nitrate, were detected in historic studies but were later found to be naturally occurring. Areas of elevated nitrate and chloride (a measure of salinity) were delineated as part of the *Sutter Subbasin Alternative Plan* (GEI, 2016) and are presented in **Figure 5-84**. Nitrate detections are few and scattered throughout the Subbasin, whereas chloride detections are predominantly in the southern portion of the Sutter Subbasin.

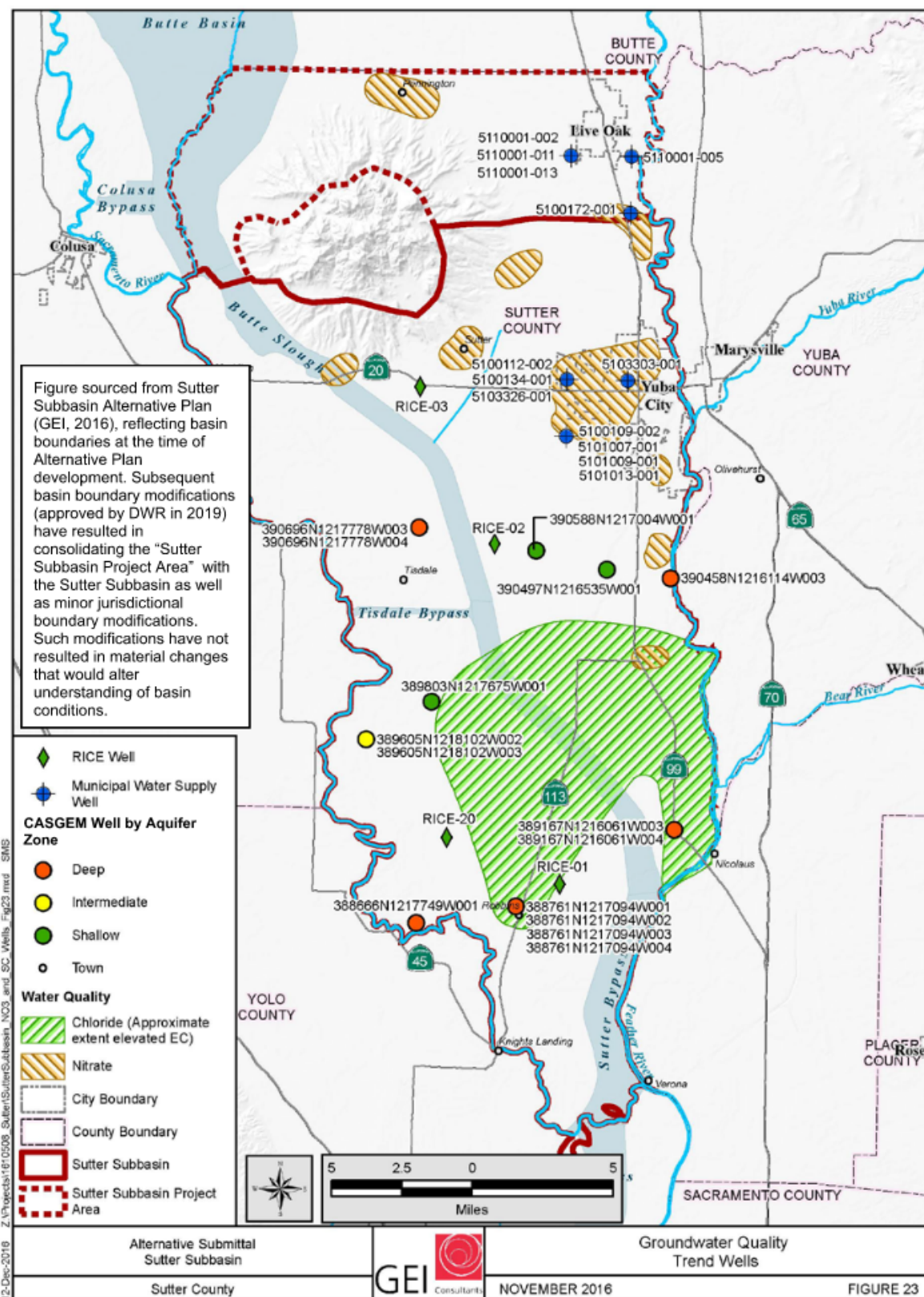


Figure 5-84. Areas of Elevated Nitrate and Chloride Detections

An analysis of the state of these constituents over time is presented in **Table 5-9**, broken into four time periods using data available from the GAMA Program (SWRCB, 2021):

- 1952 to 2008 - Beginning of the period of record in the GAMA data set (SWRCB, 2026)
- 2009 to 2012 - General water quality analysis presented in **Section 5.1.3.5**
- 2013 to 2020 - Beginning of the current condition water budget (in the 2022 GSP)
- 2021 to 2025 - Most recent period since the development of the original GSP through the latest available water quality data

Median concentrations of arsenic have decreased since 1952 and most recently, the majority of sampling results are below the Primary MCL of 0.01 mg/L. The maximum concentration detected between 2021 and 2025 (0.194 milligrams per liter or mg/L) does exceed the Primary MCL. Median concentrations of boron peaked between 2009 and 2012 but remained below the agricultural water quality objective of 0.7 mg/L. Maximum concentrations of boron have decreased over time with the most recently observed concentrations at 2.1 mg/L in between 2021 and 2025. Maximum TDS concentrations have substantially decreased since 1952, peaking at 8,200 mg/L (in 2006), with the most recently observed maximum concentration (occurring at 2,300 mg/L in between 2021 and 2025) above the Upper SMCL of 1,500 mg/L. Median nitrate concentrations have increased since 1952 and have been detected above the Primary MCL of 10 mg/L as of 2012. The most recently observed maximum concentration of 85 mg/L between 2021 and 2025 exceeds the Primary MCL of 10 mg/L by over 8 times. Median concentrations of arsenic and TDS have remained relatively stable over time. As described in **Section 5.1.3.5**, naturally occurring arsenic is consistently close to the Primary MCL. Median concentrations of boron increased and median concentrations of nitrate as N decreased between 2021 and 2025, in comparison to 2013 to 2020.

Groundwater quality varies across the Subbasin based on location and depth by constituent. GAMA data available from 2000 through 2020 (SWRCB, 2021) by well location and aquifer zone for arsenic, boron, TDS, and nitrate as N are presented in **Figure 5-85** through **Figure 5-88**. It should be noted that GAMA data are reflective of ambient groundwater quality prior to treatment. Data are evaluated against the Water Quality Objectives identified in **Table 5-9** for the purpose of using a common metric for the highest beneficial use, which is drinking water. Further treatment or blending may be required prior to groundwater use.

In the Shallow AZ, groundwater quality data are limited to a single monitoring event in 2006 (**Figure 5-85**). All constituents evaluated were at or below their respective water quality objective with the exception of one exceedance of the agricultural water quality objective for boron at 1.26 mg/L in the southern portion of the Subbasin and two exceedances of TDS above the Recommended SMCL but below the Upper SMCL (**Figure 5-86**). One exceedance of TDS well above the Short-Term SMCL was

observed in the southern portion of the Subbasin at 8,200 mg/L. This measurement may be an outlier, but insufficient data at the site are available to make this determination.

In AZ-1, arsenic concentrations were at or below the Primary MCL except along the eastern boundary of the Sutter Subbasin near the North and South Yuba Subbasins where exceedances of 0.011 mg/L (in 2008) and 0.016 mg/L (in 2006) were recorded (**Figure 5-86**). Similar patterns were observed for boron, where concentrations throughout much of the Subbasin were below the agricultural water quality objective except for exceedances of 0.379 mg/L (in 2006) and 0.073 mg/L (in 2008) along the eastern boundary near the South Yuba Subbasin. Nitrate was below the Primary MCL throughout the Subbasin except along the eastern portion of the Subbasin near the North Yuba Subbasin where a concentration of 18.3 mg/L was recorded in 2008. Exceedances above the Recommended SMCL for TDS occurred along the eastern boundary of the Subbasin near the North Yuba Subbasin at 715 mg/L (in 2008) and near the South Yuba Subbasin at 1,200 mg/L (in 2008). An additional TDS exceedance above the Short-Term SMCL was observed near the South Yuba Subbasin at 5,553 mg/L. For the remainder of the Subbasin in AZ-1, recorded concentrations of TDS were all below the Recommended SMCL.

In AZ-2, only exceedances of arsenic and boron were recorded (**Figure 5-87**). All nitrate concentrations were below the Primary MCL and all TDS concentrations were below the Recommended SMCL. Arsenic concentrations above the Primary MCL were recorded along the Sacramento River bordering the Colusa Subbasin at 0.017 mg/L (in 2006) and near the Yolo Subbasin boundary at a maximum of 0.027 mg/L (in 2008). Boron concentrations above the agricultural water quality objective were observed in the southern portion of the Subbasin along the Yolo Subbasin boundary at 0.712 mg/L.

In AZ-3, arsenic concentrations exceedances occurred at both sampled sites in the northeast corner and central portion of the Subbasin at 0.02 mg/L (in 2006) and 0.022 mg/L (in 2012), respectively (**Figure 5-88**). Boron concentrations were below the agricultural water quality objective and nitrate concentrations were below the Primary MCL at both sites. In the central portion of the Subbasin, observed TDS concentrations were above the Recommended SMCL but below the Upper SMCL at 874 mg/L (in 2012).

Table 5-9. Summary of Sutter Subbasin Historic and Current Water Quality Constituents

Constituent	Water Quality Objective (mg/L)	Median Measurement (mg/L) (minimum – maximum measurements)			
		1952-2008	2009-2012	2013-2020	2021-2025
Arsenic	0.01 ⁽¹⁾	0.010 (0.001 – 0.350) 77 measurements	0.019 (0.002 – 0.201) 38 measurements	0.007 (0.001 – 0.190) 28 measurements	0.0177 (0.001 – 0.194) 401 measurements
Boron	0.7 ⁽²⁾	0.1 (ND – 5.4) 225 measurements	0.5 (ND – 2.4) 30 measurements	0.1 (ND – 1.0) 11 measurements	0.42 (ND – 2.1) 33 measurements
TDS	500-1,500 ⁽³⁾	351 (95 – 8,200) 344 measurements	505 (115 – 2,290) 46 measurements	600 (180 – 1,220) 47 measurements	432 (129 – 2,300) 54 measurements
Nitrate as N	10 ⁽¹⁾	2 (ND – 280) 199 measurements	11 (ND – 92) 52 measurements	15 (ND – 137) 91 measurements	5 (ND – 85) 462 measurements

(1) Primary drinking water MCL (SWRCB, October 2017; SWRCB, November 2017a)

(2) Agricultural objective (Ayers and Westcot, 1985 [Table 21])

(3) Recommended Secondary MCL is 500 mg/L, Upper Secondary MCL is 1,000 mg/L, and Short-Term Secondary MCL is 1,500 mg/L (SWRCB, November 2017b)

Key:

mg/L = milligrams per liter

ND = Non-detect (concentration in sample is below detection limit)

Source: GAMA (SWRCB, 2026)

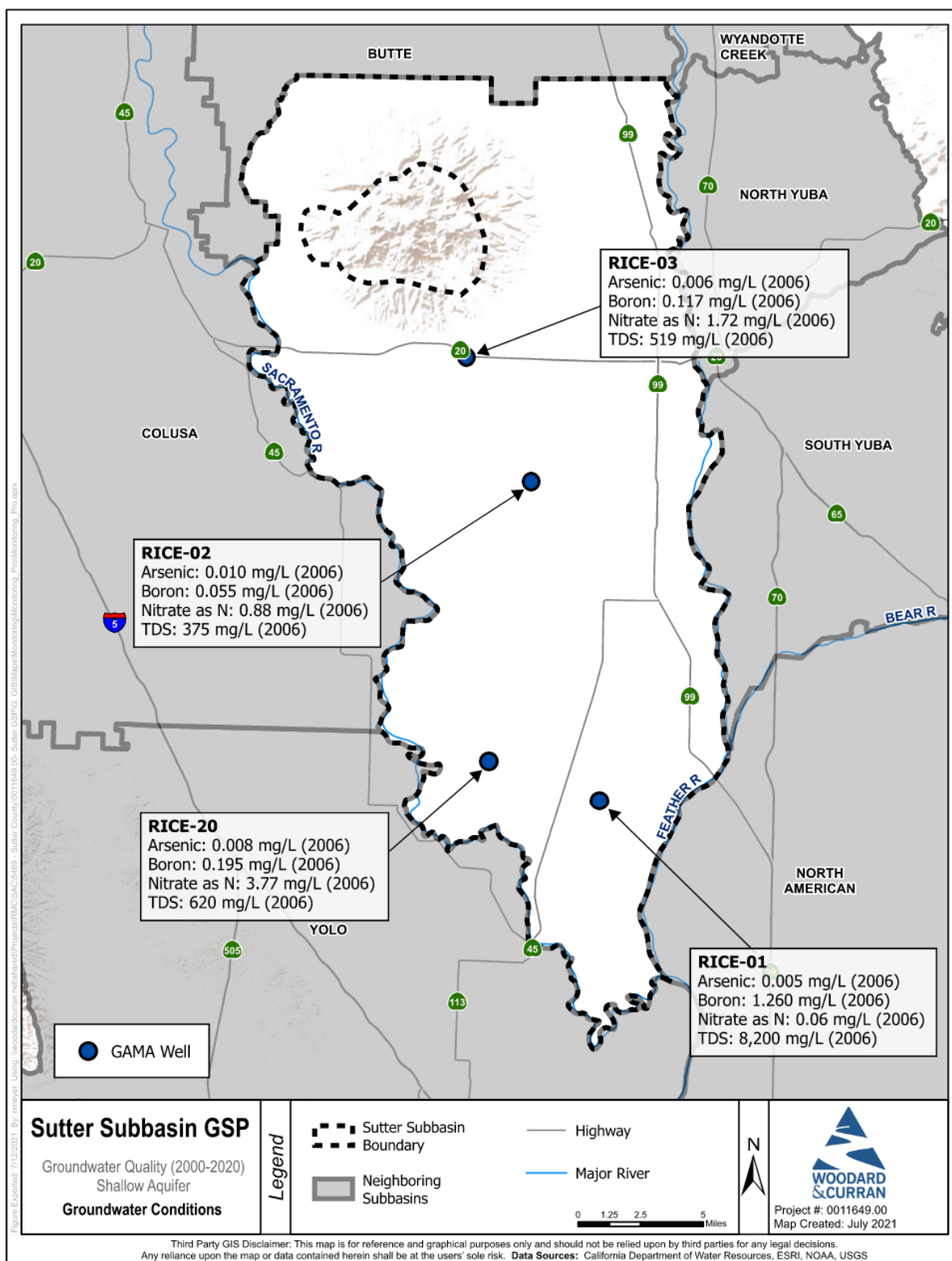


Figure 5-85. Historic Groundwater Quality (2000-2020), Shallow Aquifer Zone

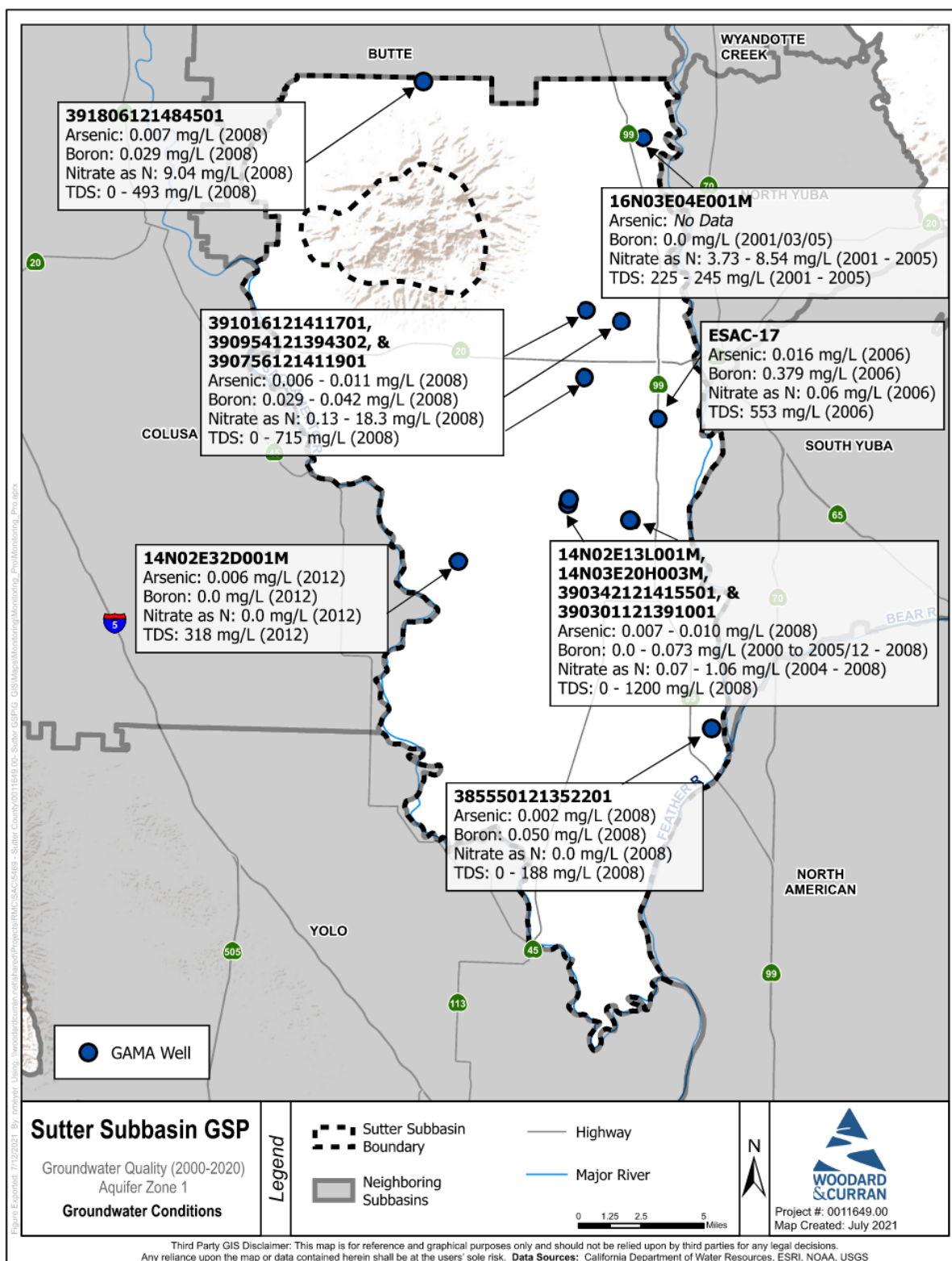


Figure 5-86. Historic Groundwater Quality (2000-2020), AZ-1

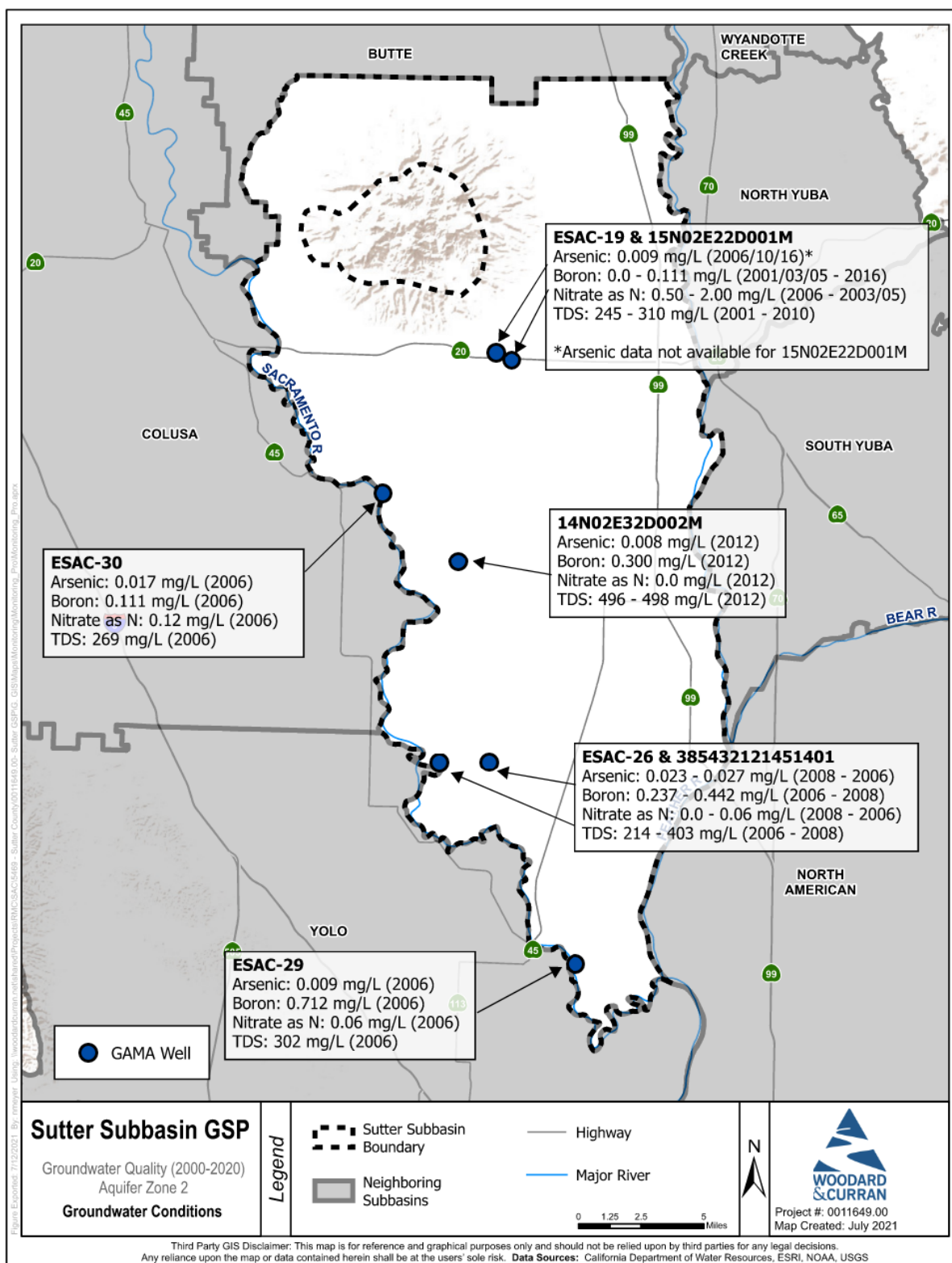


Figure 5-87. Historic Groundwater Quality (2000-2020), AZ-2

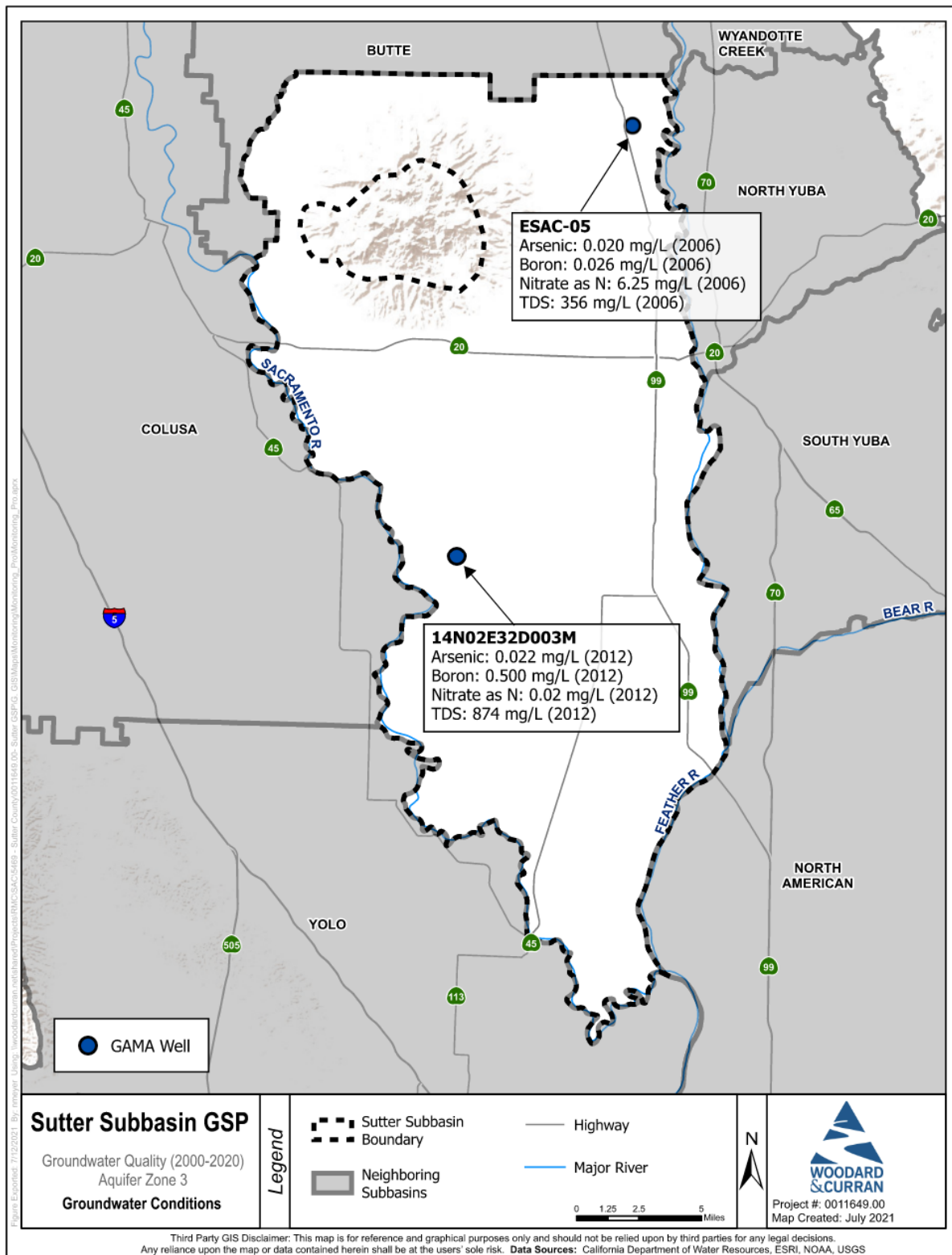


Figure 5-88. Historic Groundwater Quality (2000-2020), AZ-3

Figure 5-89 through **Figure 5-92** show available monitoring data from the GAMA Program for arsenic, boron, TDS, and nitrate as N for the most recent 5-year period (2021-2025). Arsenic concentrations varied throughout the Subbasin with many wells below the Primary MCL of 0.01 mg/L (**Figure 5-89**). Exceedances of the arsenic Primary MCL mostly occurred in the central portion of the Subbasin and along the eastern boundary of the Subbasin. Boron concentrations were primarily below the agricultural water quality objective of 0.7 mg/L throughout the Subbasin, with exceedances observed in the southern portion and northeast corner of the Subbasin (**Figure 5-90**). TDS concentrations were well below the Upper SMCL of 1,000 mg/L throughout much of the Subbasin (< 500 mg/L), with exceedances up to 2,000 mg/L scattered throughout the Subbasin (**Figure 5-91**). Nitrate as N concentrations were below the Primary MCL of 10 mg/L throughout the majority of wells with exceedances observed in the southern portion and along the northeastern boundary of the Subbasin (**Figure 5-92**).

Table 5-10 and **Table 5-11** summarizes sampling results for TDS and Nitrate as N, respectively, collected by the Sutter Subbasin GSAs since development of the original GSP. Wells in the current groundwater quality representative monitoring network were sampled for nitrate as N and TDS during the designated monitoring period of July through October starting in 2023, where sampling was possible. Of the samples collected during WY 2023, all nitrate as N samples were below the Primary MCL of 10 mg/L, with the exception of Local ID Well-2A within the City of Live Oak. All TDS samples were below the Upper SMCL of 1,000 mg/L, with the exception of Local ID SEWD MW-3C which was above the Upper SMCL for TDS but collected prior to the designated sampling period. In WY 2024, all TDS samples were below the Upper SMCL of 1,000 mg/L, with the exception of Local ID SEWD MW-3C. Local ID SEWD MW-3C also exceeded the Upper SMCL for TDS WY 2023. In WY 2025, all samples collected were below the Primary MCL for nitrate as N with the exception of Local ID Well-2A. All TDS samples were below the Upper SMCL, with the exception of Local ID SEWD MW-3C.

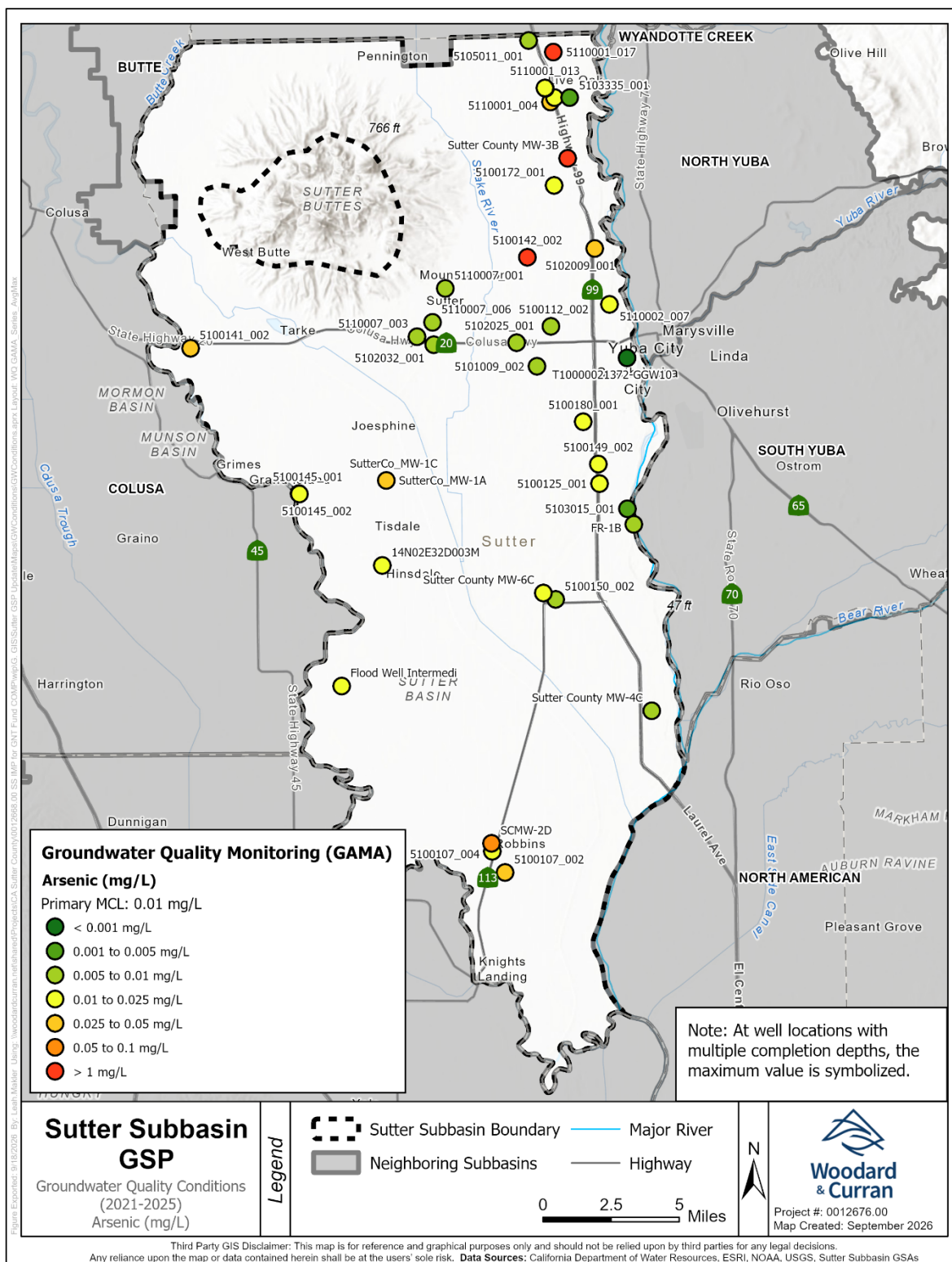


Figure 5-89. Current Groundwater Quality (2021-2025), Arsenic

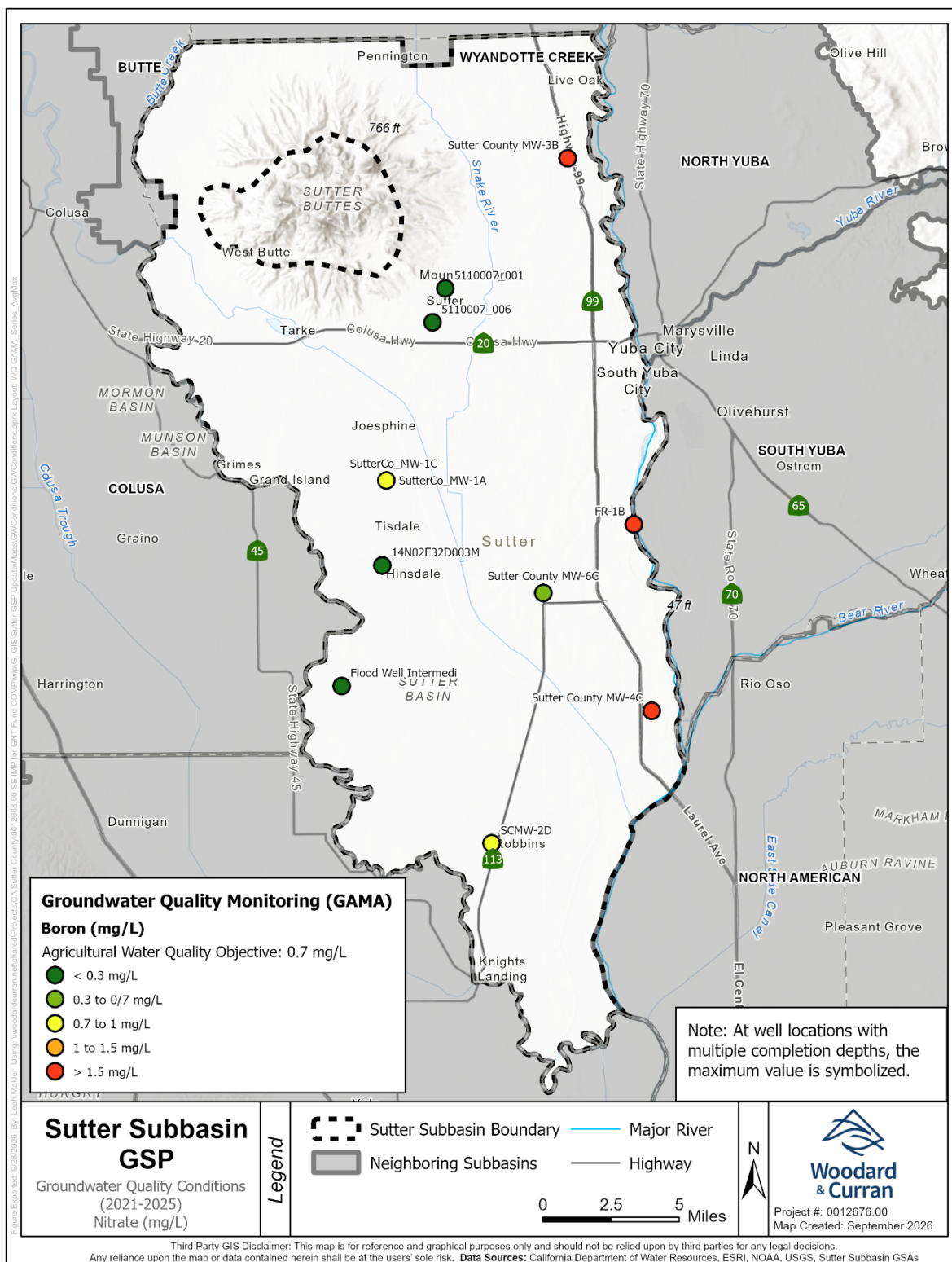


Figure 5-90. Current Groundwater Quality (2021-2025), Boron

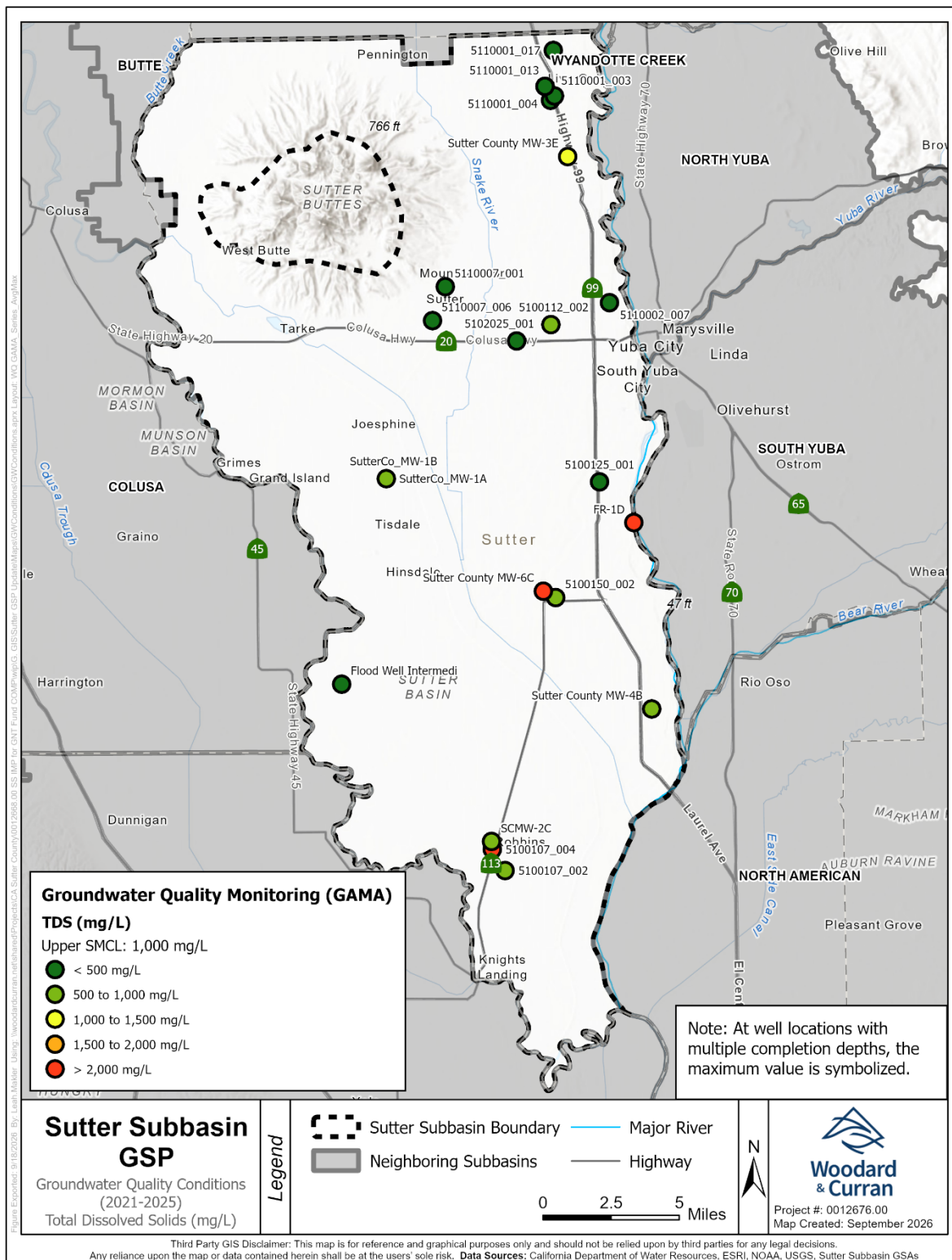


Figure 5-91. Current Groundwater Quality (2021-2025), TDS

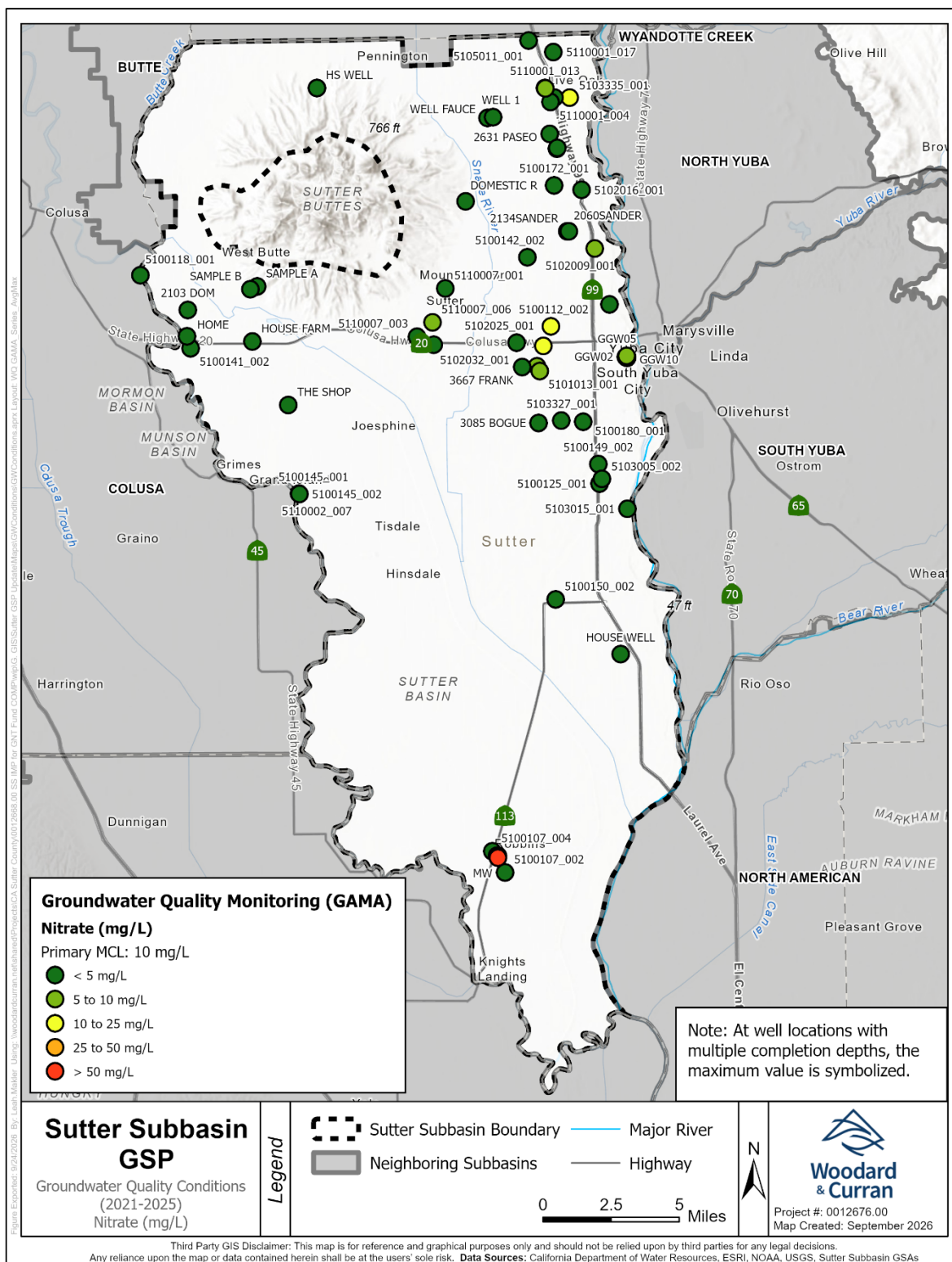


Figure 5-92. Current Groundwater Quality (2021-2025), Nitrate as N

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Table 5-10. Summary of Sutter Subbasin Recent TDS Constituent Monitoring

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Overlying GSA	WY 2023 TDS Result (mg/L)	WY 2024 TDS Result (mg/L)	WY 2025 TDS Result (mg/L)	Average (2023-2025) (mg/L)
390682N1216901W001	14N02E13A003M	SEWD MW-3A	AZ-1	Sutter Extension WD GSA	230	250	278	252.7
392970N1216907W003	17N02E25J003M	BWD MW-1C	AZ-1	Butte WD GSA	210	250	240	233.3
-	-	Well 2-C	AZ-1	Sutter CSD GSA	-	270	280	275
391456N1218904W001	-	MFWC Prop 50	AZ-1	Reclamation District No. 70 GSA	670	674	567	637
390682N1216901W002	14N02E13A004M	SEWD MW-3B	AZ-2	Sutter Extension WD GSA	260	270	281	270.3
391658N1217070W001	15N02E12E001M	SEWD MW-1A	AZ-2	Sutter Extension WD GSA	310	350	336	332
391658N1217070W002	15N02E12E002M	SEWD MW-1B	AZ-2	Sutter Extension WD GSA	220	270	265	251.7
391279N1216989W001	15N02E24P001M	SEWD MW-2A	AZ-2	Sutter Extension WD GSA	250	280	271	267
391279N1216989W002	15N02E24P002M	SEWD MW-2B	AZ-2	Sutter Extension WD GSA	270	290	269	276.3
391012N1218222W001	-	BS1-McClatchy	AZ-2	Reclamation District No. 70 GSA	480	428	538	482
392970N1216907W002	17N02E25J002M	BWD MW-1B	AZ-2	Butte WD GSA	180	190	240	203.3
-	-	Well-1A / 5110001-011	AZ-2	City of Live Oak GSA	430	390	405	408.3
-	-	Well-2A / 5110001-013	AZ-2	City of Live Oak	510	400	428	446
-	-	Akins Well	AZ-2	Reclamation District No. 1500 GSA	-	516	610	563
391613N1216236W001	-	WTP Well	AZ-2 and AZ-3	City of Yuba City GSA	140	157	171	156
390682N1216901W003	14N02E13A005M	SEWD MW-3C	AZ-3	Sutter Extension WD GSA	1200	1200	1170	1190
391658N1217070W003	15N02E12E003M	SEWD MW-1C	AZ-3	Sutter Extension WD GSA	170	200	214	194.7
391279N1216989W003	15N02E24P003M	SEWD MW-2C	AZ-3	Sutter Extension WD GSA	160	200	208	189.3
392970N1216907W001	17N02E25J001M	BWD MW-1A	AZ-3	Butte WD GSA	220	250	260	243.3

Table 5-11. Summary of Sutter Subbasin Recent Nitrate as N Constituent Monitoring

Site Code	State Well Number	Local ID / Other ID	Aquifer Zone	Overlying GSA	WY 2023 Nitrate as N Result (mg/L)	WY 2024 Nitrate as N Result (mg/L)	WY 2025 Nitrate as N Result (mg/L)	Average (WY 2023-2025) (mg/L)
390682N1216901W001	14N02E13A003M	SEWD MW-3A	AZ-1	Sutter Extension WD GSA	-	1.41	1.4	1.4
392970N1216907W003	17N02E25J003M	BWD MW-1C	AZ-1	Butte WD GSA	Not detected	0.5	0.5	Between not detected and 0.5
-	-	Well 2-C	AZ-1	Sutter CSD GSA	7.5	7.7	1.2	5.5
391456N1218904W001	-	MFWC Prop 50	AZ-1	Reclamation District No. 70 GSA	0.49	0.86	0.746	0.7
390682N1216901W002	14N02E13A004M	SEWD MW-3B	AZ-2	Sutter Extension WD GSA	-	20	Not detected	Between not detected and 20
391658N1217070W001	15N02E12E001M	SEWD MW-1A	AZ-2	Sutter Extension WD GSA	-	1.14	1.1	1.1
391658N1217070W002	15N02E12E002M	SEWD MW-1B	AZ-2	Sutter Extension WD GSA	-	1.02	0.942	1
391279N1216989W001	15N02E24P001M	SEWD MW-2A	AZ-2	Sutter Extension WD GSA	-	1.57	1.46	1.5
391279N1216989W002	15N02E24P002M	SEWD MW-2B	AZ-2	Sutter Extension WD GSA	-	1.18	0.989	1.1
391012N1218222W001	-	BS1-McClatchy	AZ-2	Reclamation District No. 70 GSA	0.25	0.54	0.27	0.4
392970N1216907W002	17N02E25J002M	BWD MW-1B	AZ-2	Butte WD GSA	Not detected	Not detected	Not detected	Not detected
-	-	Well-1A / 5110001-011	AZ-2	City of Live Oak GSA	7.6	5.79	7.22	6.9
-	-	Well-2A / 5110001-013	AZ-2	City of Live Oak	12.1	8.07	10.6	10.3
-	-	Akins Well	AZ-2	Reclamation District No. 1500 GSA	-	Not detected	Not detected	Not detected
391613N1216236W001	-	WTP Well	AZ-2 and AZ-3	City of Yuba City GSA	0.1	Not detected	Not detected	Between not detected and 0.1
390682N1216901W003	14N02E13A005M	SEWD MW-3C	AZ-3	Sutter Extension WD GSA	-	20	Not detected	Between not detected and 20
391658N1217070W003	15N02E12E003M	SEWD MW-1C	AZ-3	Sutter Extension WD GSA	-	2.03	1.98	2
391279N1216989W003	15N02E24P003M	SEWD MW-2C	AZ-3	Sutter Extension WD GSA	-	1.22	1.18	1.2
392970N1216907W001	17N02E25J001M	BWD MW-1A	AZ-3	Butte WD GSA	0.5	0.4	0.6	0.5

5.2.5.1 Contaminated Sites

A review of active sites listed in California's EnviroStor and GeoTracker/GAMA databases that could potentially impact groundwater in the Sutter Subbasin is included in **Section 5.1.3.5**. **Table 5-7** and **Table 5-8** lists the open GeoTracker sites and the active EnviroStor sites in the Subbasin, and **Figure 5-46** and **Figure 5-47** show their locations, respectively. Typically, the Clean-up Program Sites and leaking underground storage tank (LUST) Clean-up Sites are associated with leaky underground fuel tanks (LUFTs) and underground storage tanks (USTs). Their typical constituents of concern are fuel hydrocarbons and/or chlorinated solvents and the contaminant extent is small.

No large groundwater contamination plumes are known to be present in the Subbasin (GEI, 2016).

5.2.6 Land Subsidence

Land subsidence and its associated impacts have not been recorded within the Sutter Subbasin (Wood Rodgers, 2012). While elastic land subsidence is observed as a result of seasonal fluctuations in groundwater levels and associated aquifer pressure, inelastic land subsidence has not been recorded within the Sutter Subbasin. Sutter County previously coordinated with DWR to monitor for potential land subsidence within the county boundaries as part of the Sacramento Valley Subsidence Network (DWR North Region Office, 2018). Land subsidence continues to be measured within the Sutter Subbasin by the National Aeronautics and Space Administration's (NASA's) Jet Propulsion Laboratory (JPL) using Interferometric Synthetic Aperture Imagery (InSAR), available through DWR's SGMA Data Viewer.

5.2.6.1 Historic and Current Conditions

Land subsidence monitoring within the Sutter Subbasin has a relatively short period of record. DWR, in cooperation with federal, state, and local agencies, installed and surveyed monuments to measure and monitor ground surface elevations over time in the Sacramento Valley. The Sacramento Height-Modernization Project consisted of 339 monuments, spaced approximately 7 kilometers apart in 10 counties (Wood Rodgers, 2012). The network was intended to be monitored on a 5-year schedule and was initially surveyed in 2008. DWR was unable to survey the monuments in 2013 due to budgetary limitations and the second survey was completed in 2017. In 2022, monitoring of this network was discontinued. Twenty-two monuments were located within the Sutter Subbasin (**Figure 5-93**) with recorded subsidence values between 2008 and 2017 ranging from 0.05 to 0.33 feet of subsidence (**Table 5-12**).

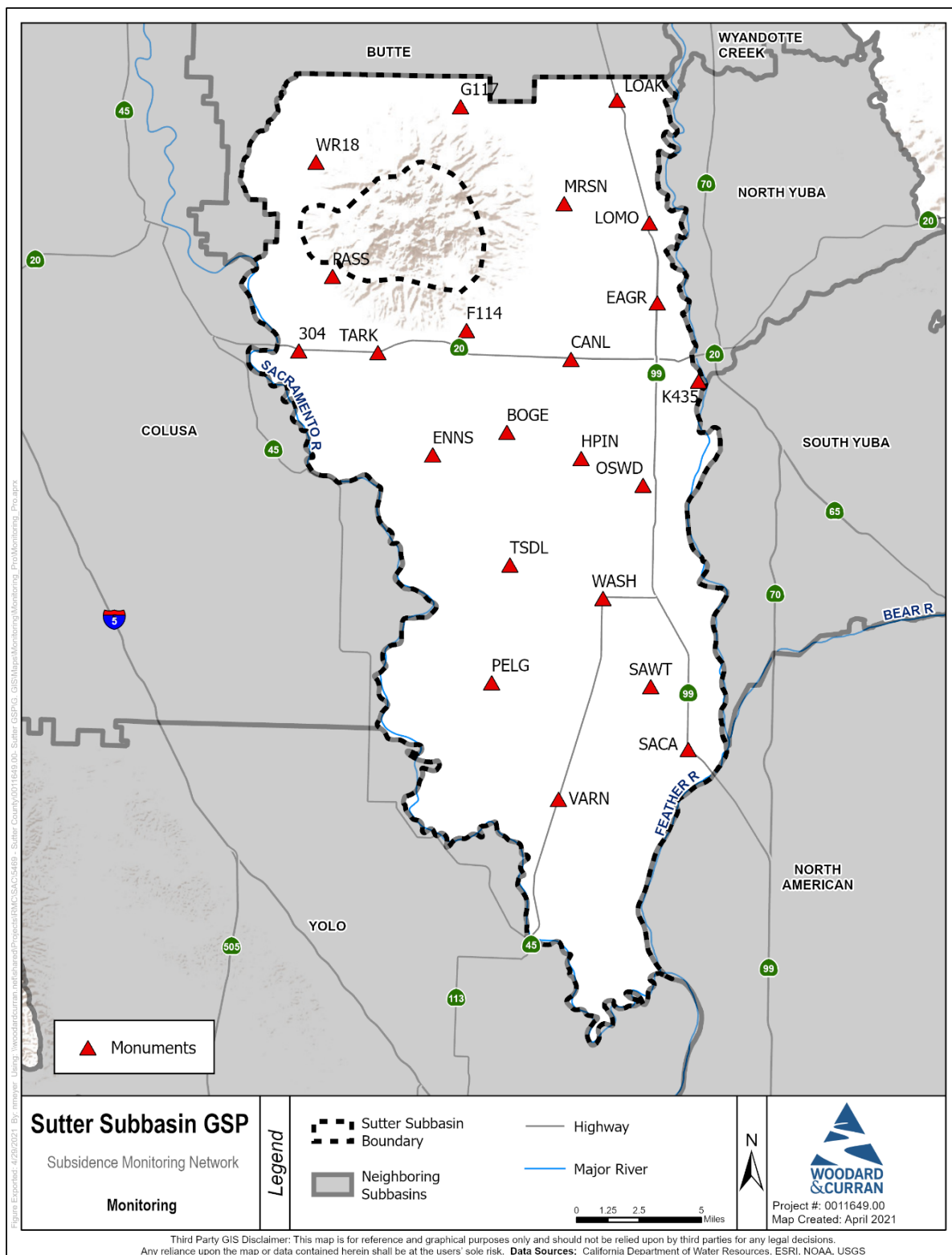


Figure 5-93. Sacramento Valley Subsidence Monitoring Network, Sutter Subbasin

Table 5-12. DWR Sacramento Valley Subsidence Network in the Sutter Subbasin, Ellipsoid Height Difference from 2008 to 2017

DWR Station ID	DWR Station Name	Station Differences* in Ellipsoid Height from 2008 to 2017 (feet)
304	HPGN CA 03 04	-0.203
BOGE	BOGUE	-0.227
CANL	CANAL KS1836	-0.139
EAGR	EAGER	-0.109
ENNS	ENNIS	-0.231
F114	F 114	-0.188
G117	G 1175	-0.046
HPIN	HOPPIN	-0.185
K435	K 1435	-0.131
LOAK	LIVE OAK	-0.078
LOMO	LOMO	-0.089
MRSN	MORRISON	-0.112
OSWD	OSWALD	-0.148
PASS	PASSBUTTE	-0.22
PELG	PELGER	-0.168
SACA	SACRAMENTO AVENUE	Data not available
SAWT	SAWTELLE	-0.098
TARK	TARKE	-0.334
TSDL	TISDALE	-0.196
VARN	VARNEY	-0.118
WASH	WASHINGTON	-0.137
WR18	DWR18	-0.082

*Negative values indicate that elevations were lower in 2017 compared to 2008. The Department of Water Resources, North Central Region Office (2018) noted an error of uncertainty of approximately 0.17 feet and that any change of less than 0.17 feet was not considered to be statistically significant.

NASA's JPL uses InSAR to evaluate land surface fluctuations from satellite imagery. Between October 2015 and September 2025, between -0.1 and +0.1 feet of vertical displacement was observed within much of the Sutter Subbasin, with small areas of up to -0.6 ft and greater along the Sacramento River (**Figure 5-94**). Similar vertical displacement measurements (-0.1 to +0.1 feet) were also observed between October 2024 and October 2025 (**Figure 5-95**). Therefore, land subsidence within the Sutter Subbasin has been minimal in recent years and there have been no reported negative impacts of land subsidence on critical infrastructure.

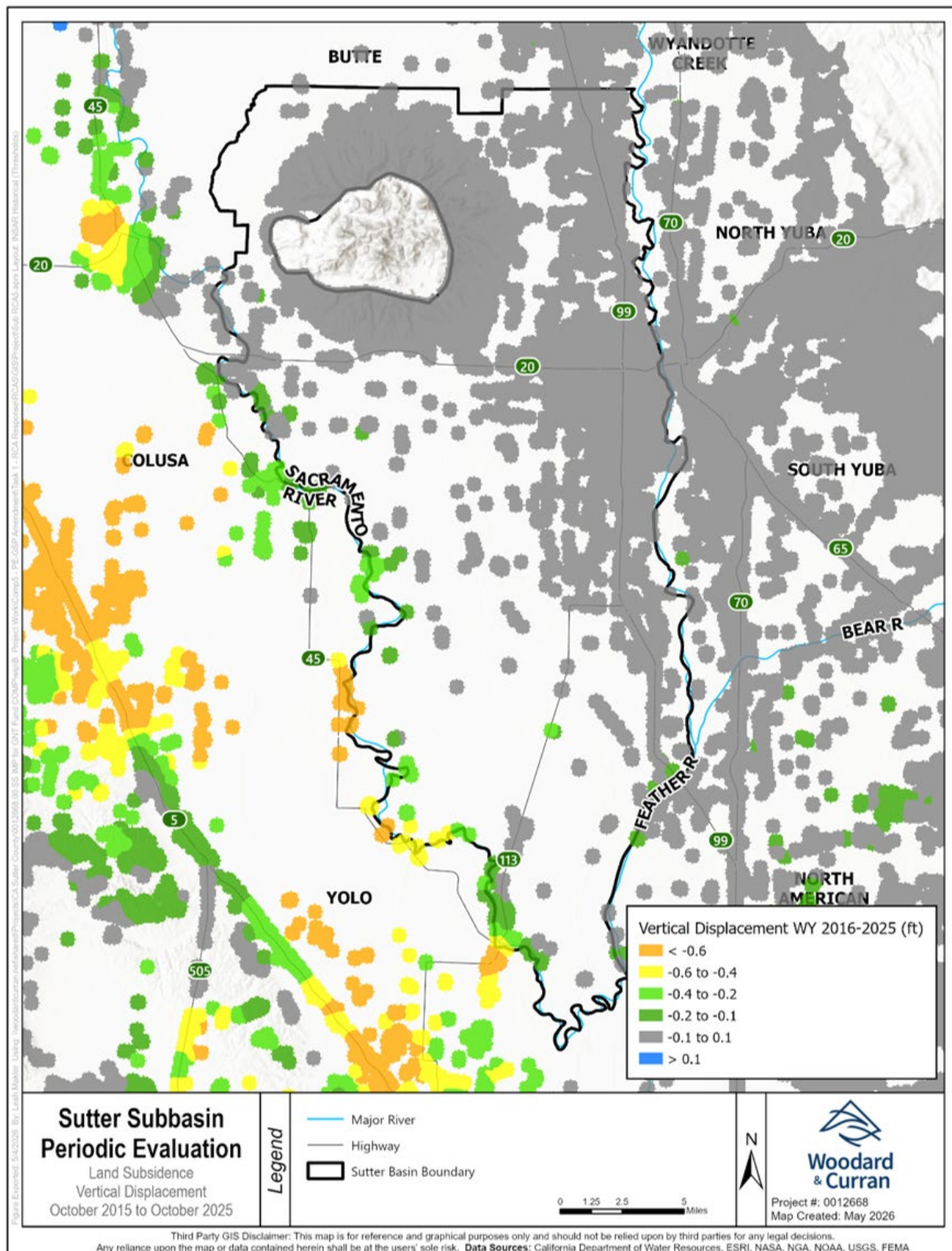


Figure 5-94. Vertical Displacement in the Sutter Subbasin, WY 2016 to October 2025

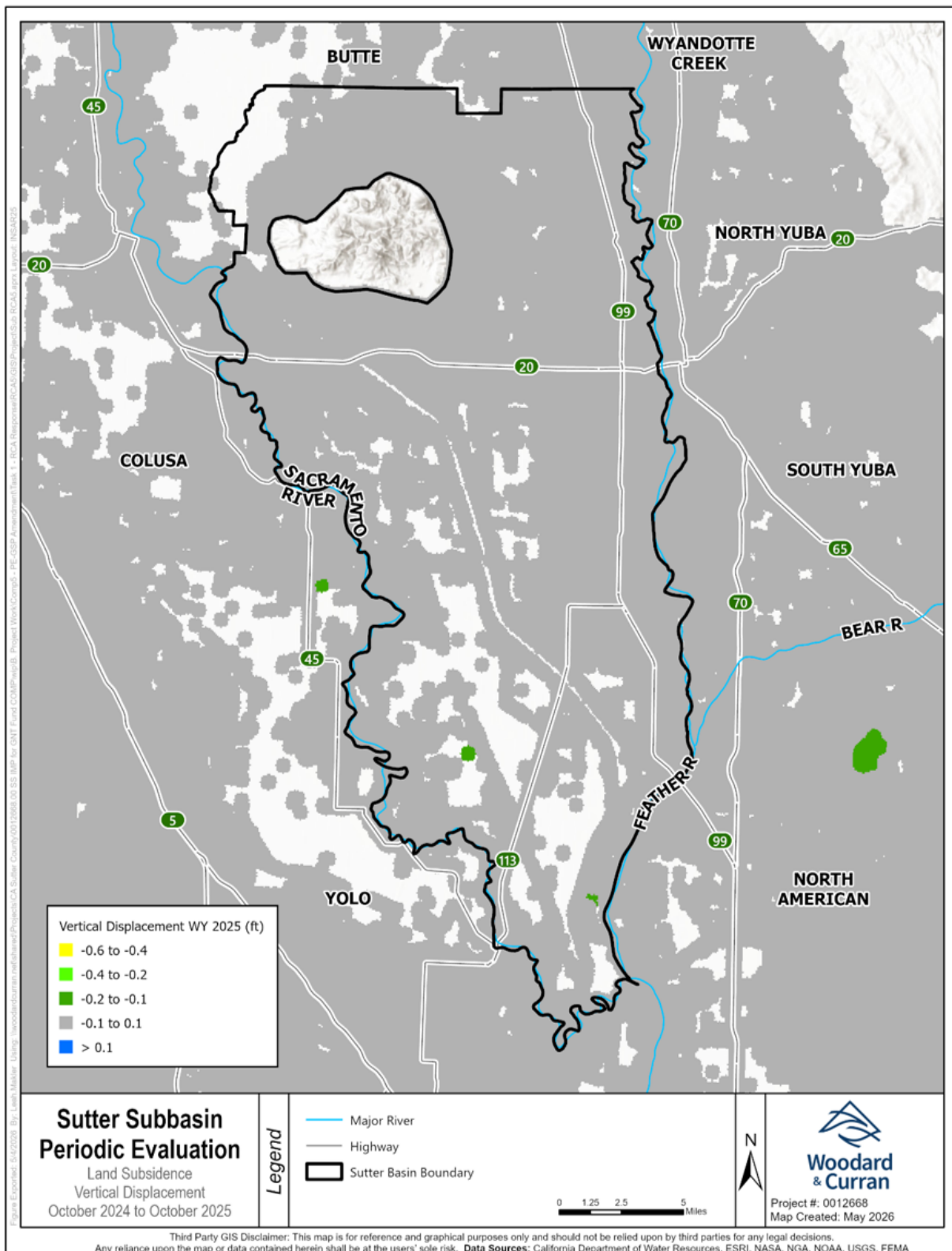


Figure 5-95. Vertical Displacement in the Sutter Subbasin, October 2024 to October 2025

5.2.7 Interconnected Surface Water Systems

Interconnected surface waters are surface water features that are hydraulically connected by a saturated zone to the underlying groundwater system. Interconnected surface waters can be categorized as gaining (when the surface water feature is gaining water from the aquifer system) or losing (when the surface water feature is losing water to the aquifer system) (**Figure 5-96**).

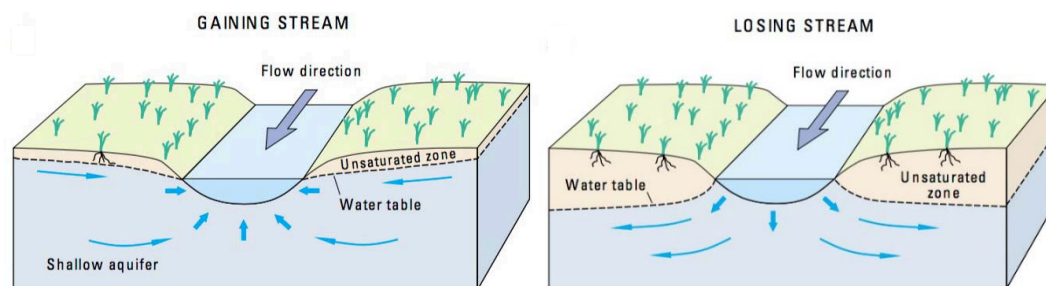


Figure 5-96. Gaining and Losing Surface Water Features

Interactions between groundwater and surface water in the Sutter Subbasin were analyzed by comparing water table elevations to streambed elevations. As in most areas of California, the direct measurement of the gain or loss to groundwater from surface water bodies is not feasible in the Sutter Subbasin. Therefore, the C2VSimFG-Sutter Version 2.0 integrated flow model was used to characterize the interconnected surface waters of simulated streams and to approximate the rates of gains and losses. The groundwater elevation is estimated by the historical model and compared to streambed elevations for the 308 stream nodes representing the Sacramento River, Feather River, and Sutter Bypass. The gradient created by the difference in elevation between groundwater levels and the streambed was evaluated at the stream node scale. The portions of the stream that were found to be gaining or losing in at least 80% of the simulated months from WY 1996 to WY 2025 were categorized as such (gaining or losing nodes), while stream nodes that did not meet the 80% threshold for either categorization were classified as having mixed conditions (**Figure 5-97**). Average monthly streamflow gains and losses from WY 1996 to WY 2025 as estimated from C2VSimFG-Sutter Version 2.0 are shown in **Table 5-13** for the Sacramento River, Feather River, and Sutter Bypass. Positive values indicate average gains to stream from groundwater and negative values indicate average losses from stream to groundwater. These averages cover all nodes with monthly gaining and losing conditions. Since no stream has all nodes behaving consistently in any month, the averages follow the trends of the majority of the nodes. Various thresholds were assessed, but an 80% threshold was determined to best align with local knowledge of the Subbasin and The Nature Conservancy's Interconnected Surface Water in the Central Valley (ICONS) dataset (**Figure 5-98**) (TNC, 2021), which was used as an independent check in assessing the stream reaches.

Table 5-13. Average Monthly Sutter Subbasin Streamflow Gains and Losses, Water Year 1996 to 2025 (TAF)

Stream/ Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Overall Annual
Sacramento River	4.0	3.0	-5.0	-3.0	-1.0	-2.0	5.0	3.0	4.0	3.0	4.0	3.0	18.0
Feather River	4.0	4.0	2.0	3.0	2.0	2.0	3.0	3.0	3.0	1.0	3.0	3.0	33.0
Sutter Bypass	0.8	-1.0	-2.4	-2.0	-1.2	-1.1	1.7	1.8	2.1	1.3	1.0	1.0	2.0

The ICONS dataset utilizes groundwater elevation data from DWR for WY 2011 to WY 2018. Disconnected streams, where groundwater depth is greater than 50 feet below the stream surface, will always be losing streams, whereas connected streams may be either losing or gaining depending on the surface water and groundwater conditions.

Both the model results and ICONS datasets indicate that Sutter Bypass has mostly mixed or gaining conditions throughout Sutter Subbasin. The Feather River at the border near North Yuba Subbasin has fluctuating gaining and losing conditions as it moves southward; while near the South Yuba Subbasin, the Feather River has longer, more distinct stretches of either gaining or losing conditions. For the Sacramento River, model results show broad consistency at the node scale compared to the ICONS dataset, with gaining sections aligning and C2VSimFG-Sutter labeling areas as mixed that ICONS show as losing. Differences may be due to differing thresholds for which gaining or losing conditions are defined. The C2VSimFG-Sutter Version 2.0 model does not contain stream nodes in the Sutter Buttes foothills, and therefore the interaction between those streams and the underlying groundwater elevations were not evaluated.

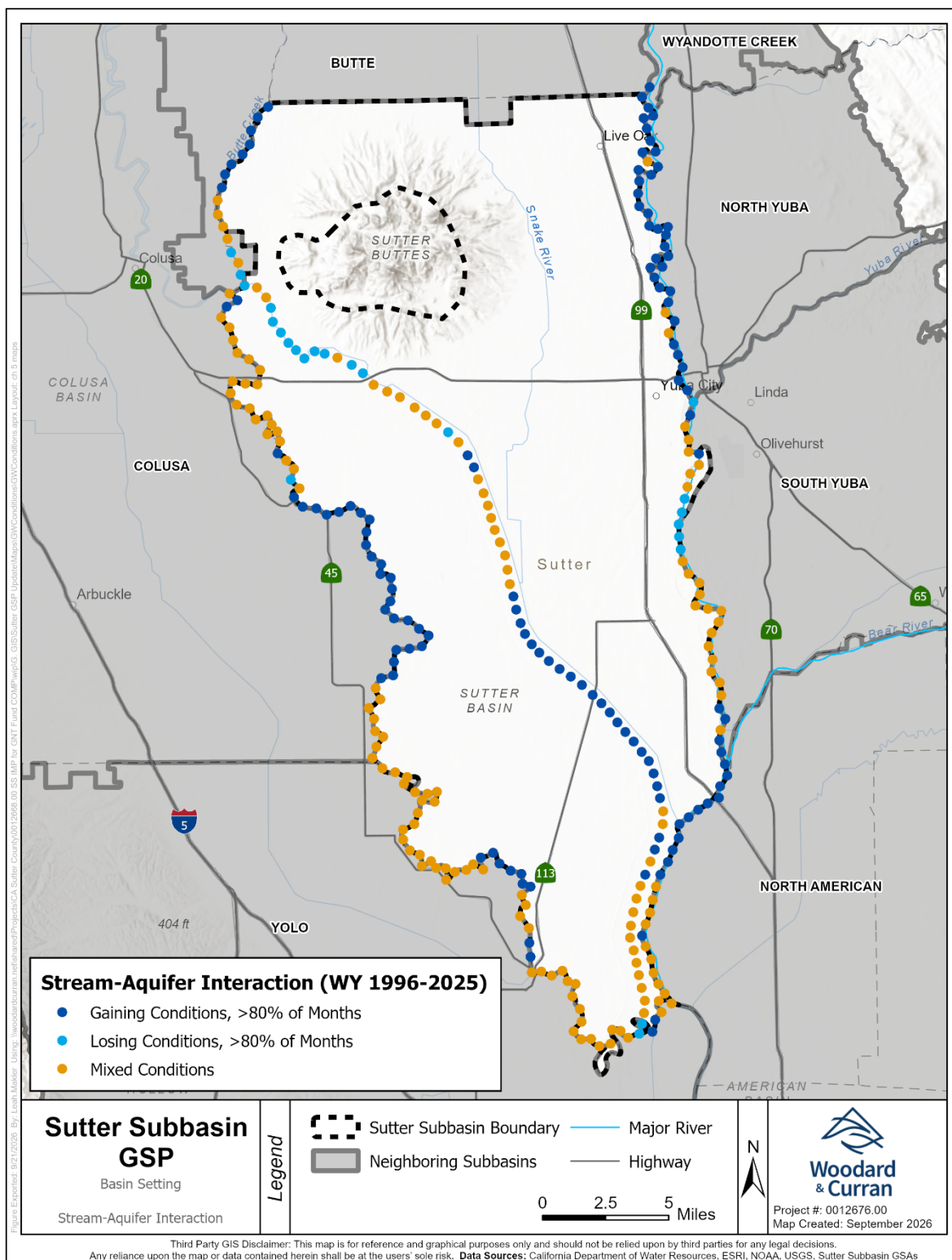


Figure 5-97. Losing and Gaining Streams, C2VSimFG-Sutter Version 2.0 Model

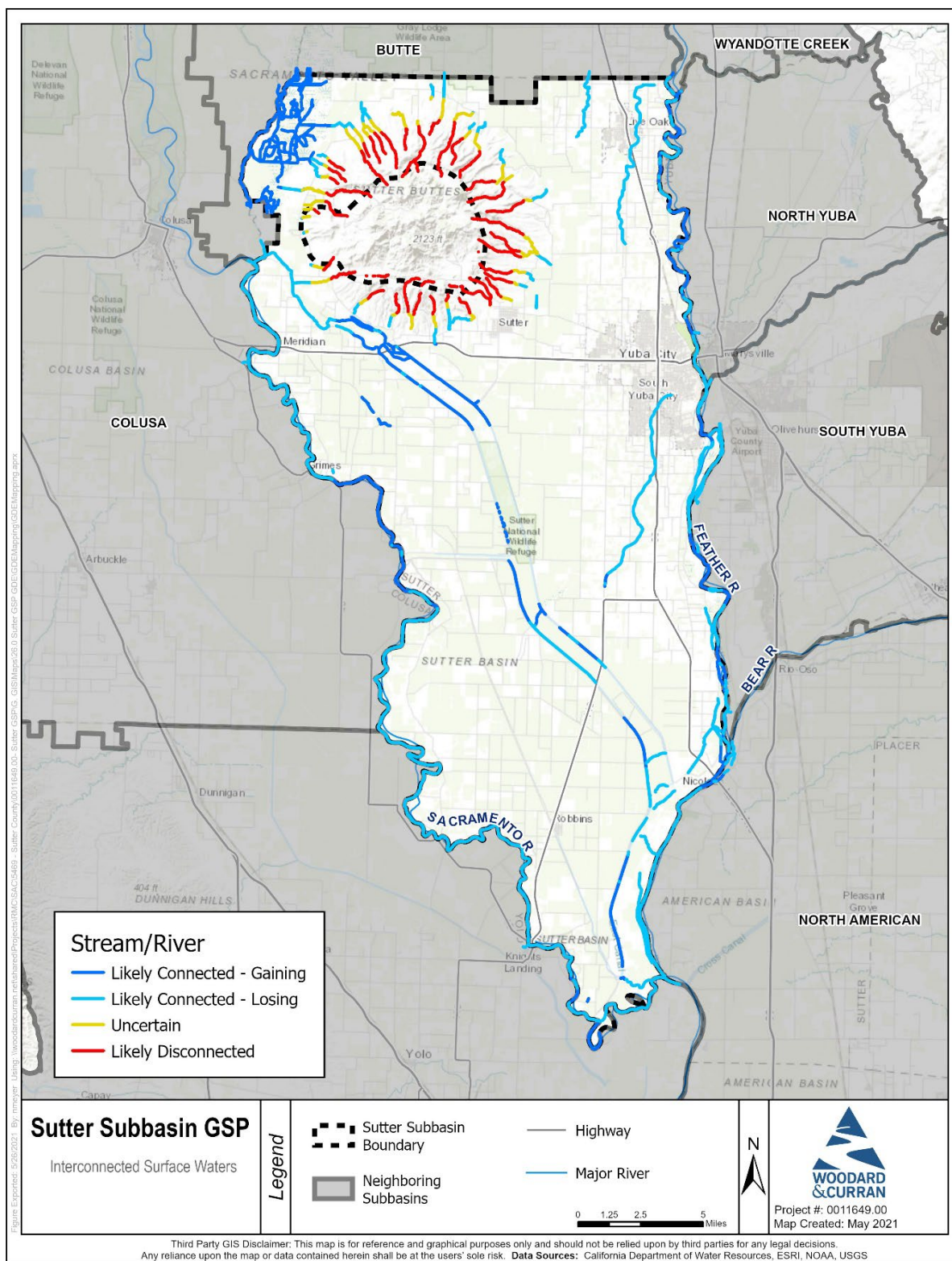


Figure 5-98. Losing and Gaining Streams, ICONS

5.2.7.1 Depletions of Interconnected Surface Water

Depletions of interconnected surface water refers to reductions in flow or water levels of interconnected surface waters due to groundwater pumping. In other words, groundwater pumping causes changes to flow paths and alters the net stream gain/loss. A full description of depletions and the mechanics of depletions is beyond the scope of this document. Additional resources are available in three technical papers released by DWR: *Depletions of Interconnected Surface Water: An Introduction* (DWR, 2024a), *Techniques for Estimating Interconnected Surface Water Depletion Caused by Groundwater Use* (DWR, 2024b), and *Examples for Estimating Interconnected Surface Water Depletion Caused by Groundwater* (DWR, 2024c). The final technical paper/guidance document has not yet been released as of October 2026.

Depletions cannot be measured directly because they represent the difference between surface water flows with groundwater pumping in place, which can be measured, and surface water flows without groundwater pumping in place, which cannot be easily measured. Therefore, quantifying depletions requires the modeling comparison of stream gains/losses between a With-Pumping scenario and a Without-Pumping scenario. The With-Pumping scenario is the C2VSimFG-Sutter Version 2.0 historical conditions model, discussed further in **Section 5.3** and also in the model report included in **Appendix 5-F**. A Without-Pumping scenario was also created based on the historical C2VSimFG-Sutter Version 2.0 that removed all groundwater pumping in the entire model. This includes groundwater pumping for agriculture (including groundwater substitution transfer pumping), rural residential and urban groundwater pumping, and pumping for managed wetlands. The entire model was impacted, which includes areas outside of Sutter Subbasin in Butte Subbasin and Colusa Subbasin. The sections below summarize the quantity, timing, and location of recent depletions of interconnected surface water. The model report in **Appendix 5-F** includes a thorough discussion of each category.

Time periods discussed in this section do not match the historical time period of WY 1996-2025 used to discuss stream gains and losses above. In order to capture only the current or recent depletions, WY 2021-2025 was used as it best represents recent depletions and matches the Current Conditions time period in the water budgets in **Section 5.3**. Additionally, since streams can take years to decades to fully reflect the effects of a change in pumping, any earlier in the simulation period is not fully representing the true recent stream depletion.

5.2.7.2 Depletions of Interconnected Surface Water Quantity

The current depletion is based on the recent five-year average (WY 2021-2025) and is estimated to be 89 thousand acre-feet (TAF) per year. **Table 5-14** summarizes the Sutter Subbasin depletion for the last five years of the model period and is referenced further in the sections below.

Table 5-14. 5-Year (2021-2025) Average Annual Depletions by Stream

Water Year	Year Type	Average Annual Depletion (TAF per year)			
		Sutter Bypass	Sacramento River	Feather River	Sutter Subbasin*
2021	Critical	40	36	18	94
2022	Critical	41	30	21	92
2023	Wet	40	26	20	86
2024	Above Normal	38	28	19	85
2025	Above Normal	38	31	19	88
5-Year Average*					
WY 2021-2025		40	30	19	89

*Note: Summations and averages may not match the numbers in the table. This is due to the rounding of model results.

5.2.7.3 Depletions of Interconnected Surface Water Timing

Depletions occur in every water year type and in every month of the simulation. Because the five-year period (WY 2021-2025) used to estimate current depletion does not contain any Below Normal or Dry water year types, a ten-year (WY 2016-2025) average period was used to estimate depletions for each water year type. **Table 5-15** presents ten-year average annual depletions by water year type and shows that generally wetter years have lower depletions and drier years have higher depletions. The five-year period (WY 2021-2025) was used to calculate average depletions by month (**Table 5-16**). **Table 5-16** shows that monthly depletions are estimated to be between seven to ten percent of the annual total, with slightly lower depletions in January through April and slightly higher depletions in July and August. Both water year type and monthly averages do not present strong trends in terms of the timing of depletions of interconnected surface water. This is because depletions in any given month or water year reflect pumping over many prior years, not just the pumping occurring in that month or year.

Table 5-15. 10-Year (2016-2025) Average Annual Depletions by Water Year Type

Water Year Type	Average Annual Depletion (TAF per year)
Wet	88
Above Normal	86
Below Normal	102
Dry	90
Critical	93

Table 5-16. 5-Year (2021-2025) Average Depletions by Month

Month	Average Depletion (TAF per year)
October	7.9 (9%)
November	7.1 (8%)
December	6.8 (8%)
January	6.4 (7%)
February	6.2 (7%)
March	5.9 (7%)
April	6.2 (7%)
May	7.8 (9%)
June	8.4 (9%)
July	9.0 (10%)
August	9.2 (10%)
September	8.4 (9%)
<i>Total</i>	<i>89.2 (100%)</i>

5.2.7.4 Depletions of Interconnected Surface Water Location

Averaged over the most recent five years of the simulation period (WY 2021–2025), depletions within the Sutter Subbasin are generally distributed as follows (**Table 5-14**):

- Sutter Bypass: 44% or 40 TAF per year
- Sacramento River: 34% or 30 TAF per year
- Feather River: 22% or 19 TAF per year

The Sutter Bypass, which is almost wholly within Sutter Subbasin, is most impacted by the Without-Pumping scenario as it is not managed by upstream releases as the Sacramento and Feather River are, and therefore has more depletions along it as compared to Sacramento River and Feather River. Since Sacramento River and Feather River are both on the border of Sutter Subbasin and are shared with adjacent groundwater subbasins, depletions from those streams may also be included in shallow subsurface flows in the model.

5.2.8 Groundwater Dependent Ecosystems

Groundwater dependent ecosystems (GDEs) are defined as “ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface” (GSP Emergency Regulations § 351(m)). Identification of GDEs is used to assess whether groundwater management could affect the beneficial uses of groundwater associated with GDEs.

In the Sutter Subbasin, GDEs exist primarily where vegetation is reliant on shallow groundwater supply for survival. Therefore, the identification of GDEs in the Sutter Subbasin was generally based on the following question: “Would the ecosystem exist if groundwater levels were deeper?” If the answer is “no,” then it was determined to be a

GDE; if “yes,” then it was not selected as a GDE. This analysis demonstrates the nature of shallow groundwater as critical to maintaining ecosystem health.

To identify GDEs, an analysis of the Natural Communities Commonly Associated with Groundwater (NCCAG) dataset was performed (DWR, 2018). Developed by DWR, California Department of Fish and Wildlife (CDFW), and The Nature Conservancy, the NCCAG database was created by reviewing publicly available State and federal agency maps of California vegetation, wetlands, springs, and seeps and by conducting a screening process to retain types and locations commonly associated with groundwater. Two classes of the results were defined: 1) wetland features commonly associated with the surface expression of groundwater under natural, unmodified conditions and 2) vegetation types commonly associated with the subsurface presence of groundwater (i.e., phreatophytes).

Noting that no land use protections are conferred on GDEs or NCCAGs through this document or other documents, the distinction between GDEs and NCCAGs that are not GDEs is important from a management perspective. As noted above, SGMA focuses on beneficial uses, rather than on the simple existence of surface water and other possible GDEs. Management of NCCAGs may require more focus on land use or irrigation activities more so than groundwater management. The analysis methodology to identify GDEs was developed to focus groundwater management activities on the most appropriate areas.

Potential GDEs in normal (2013), dry (2015), and wet (2017) years in the Sutter Subbasin were identified through the creation of elimination criteria. GDEs identified under each water year type were retained for further consideration.

The following criteria identify NCCAG areas with likely access to non-groundwater supplies that were removed from consideration as potential GDEs, as shown in **Figure 5-99** through **Figure 5-101**:

1. **Areas with a depth to groundwater greater than 30 feet during winter months (January through March)** – Oak trees are considered the deepest-rooted plant in the region with a root zone of roughly 25 to 30 feet, with mature trees reaching rooting depths of up to 80 feet. Groundwater depths deeper than 80 feet are highly unlikely to support vegetative growth dependent on groundwater, as groundwater in such areas would be inaccessibly deep. In evaluating available groundwater level data during the winter (January through March) of 2013, 2015, and 2017 used in this analysis, all groundwater levels in the Sutter Subbasin were shallower than 30 feet with the exception of a depression anomaly observed near the Sutter Buttes in 2017 (a wet year). Therefore, the 30-foot depth was used as a threshold identifying GDEs, except in the area of depression. NCCAGs in the area impacted by the depression anomaly in 2017 are retained as potential GDEs until further evaluation is performed.
2. **Areas adjacent to losing surface water bodies** – Rivers and streams recharge groundwater systems in the Sutter Subbasin. It was assumed that vegetation

within 150 feet of such areas would be accessing this surface water recharge and therefore dependent on surface water flows, not groundwater. As such, NCCAGs within 150 feet of rivers and streams were eliminated from consideration as a GDE.

3. **Areas adjacent to irrigated lands** – Irrigated areas benefit not only targeted crops but surrounding vegetation through the recharge of groundwater systems with applied surface water. Therefore, NCCAGs within 50 feet of Fish and Wildlife Service-irrigated land, State-irrigated land, and irrigated farmland were eliminated from consideration as a GDE. A 150-foot elimination buffer was used for irrigated rice cropland due to extent of percolation and lateral seepage associated with rice fields that apply surface water, resulting in more extensive recharge of the underlying aquifer and adjacent areas than typical irrigation methods for other crops.

As previously noted, in determining which lands to remove from possible GDE consideration, the following question was asked: “Would the ecosystem exist if groundwater levels were deeper?” If the answer was “yes,” the area in question was subject to the other steps of GDE identification process. For areas with supplemental water delivery, if the answer was “no”, the ecosystem was considered to be dependent on the supplemental water deliveries unless, based on plant type, the ecosystem would exist if groundwater levels were deeper. Similarly, NCCAGs that are not adjacent to irrigated fields were further considered as potential GDEs, subject to the requirements of the other steps of the GDE identification process.

Agricultural lands are dependent on reliable water supplies to ensure a successful harvest, and substantial surface water or deeper groundwater is used to irrigate crops in the Sutter Subbasin. Such irrigation benefits not only the crops but also surrounding vegetation. Away from this water supply, NCCAGs are dependent on groundwater rather than water from the irrigated field. Without the adjacent irrigated field, if the answer to “Would the ecosystem not exist if groundwater levels were deeper?” is “yes,” the area was subject to the other steps in the GDE identification process. While with adjacent irrigated agriculture if the answer is “no, the ecosystem would exist if groundwater levels were deeper,” these areas are assumed to be accessing irrigation water from the field. NCCAGs farther than 150 feet from irrigated rice and areas farther than 50 feet from other irrigated agriculture were assumed to be unable to access irrigation water.

Losing streams are streams that recharge the groundwater system; this requires groundwater levels that are lower than stage in the stream and that are progressively lower away from the stream. Areas with losing streams were identified using the C2VSimFG-Sutter Version 2.0. In identifying GDEs under such a situation, the question of “Would the ecosystem not exist if groundwater levels were deeper?” was asked. If the answer was deemed “no, the ecosystem would exist if groundwater levels were deeper,” these areas are assumed to be accessing water flowing out of the stream. NCCAGs not within 150 feet of streams within the losing-stream area were assumed to be GDEs, subject to the other steps in the evaluation process.

Based on the screening process above, all remaining NCCAG areas were identified as potential GDEs, as shown in **Figure 5-102** through **Figure 5-104**. The results of the GDE analysis are shown in the two NCCAG habitat classes: vegetation and wetlands. Potential GDEs have been identified along the Feather River and the most northeastern portion of the Sutter flyway. Due to potential inaccuracies in the wet year groundwater depth data in 2017, NCCAGs within the area of depression anomalies (as shown by the hatched area in **Figure 5-101** and **Figure 5-104**) in the northwestern portion of the Subbasin were assumed to be potential GDEs in the wet year, as they had qualified in the normal and dry years, until further evaluation is performed. **Table 5-17** includes all species within the Sutter Subbasin region, as identified by TNC, that have been observed or have the potential to exist within the region and may be reliant on groundwater (TNC, n.d.). Further efforts in GDE mapping will be performed as part of subsequent 5-Year GSP Updates to further confirm the presence of and refine the delineation of GDEs in the Sutter Subbasin, using the preliminary analyses contained in this multi-year evaluation approach as a starting point for further analyses (refer to **Section 7.1.6.3.1** for more information about GDE mapping confirmation).

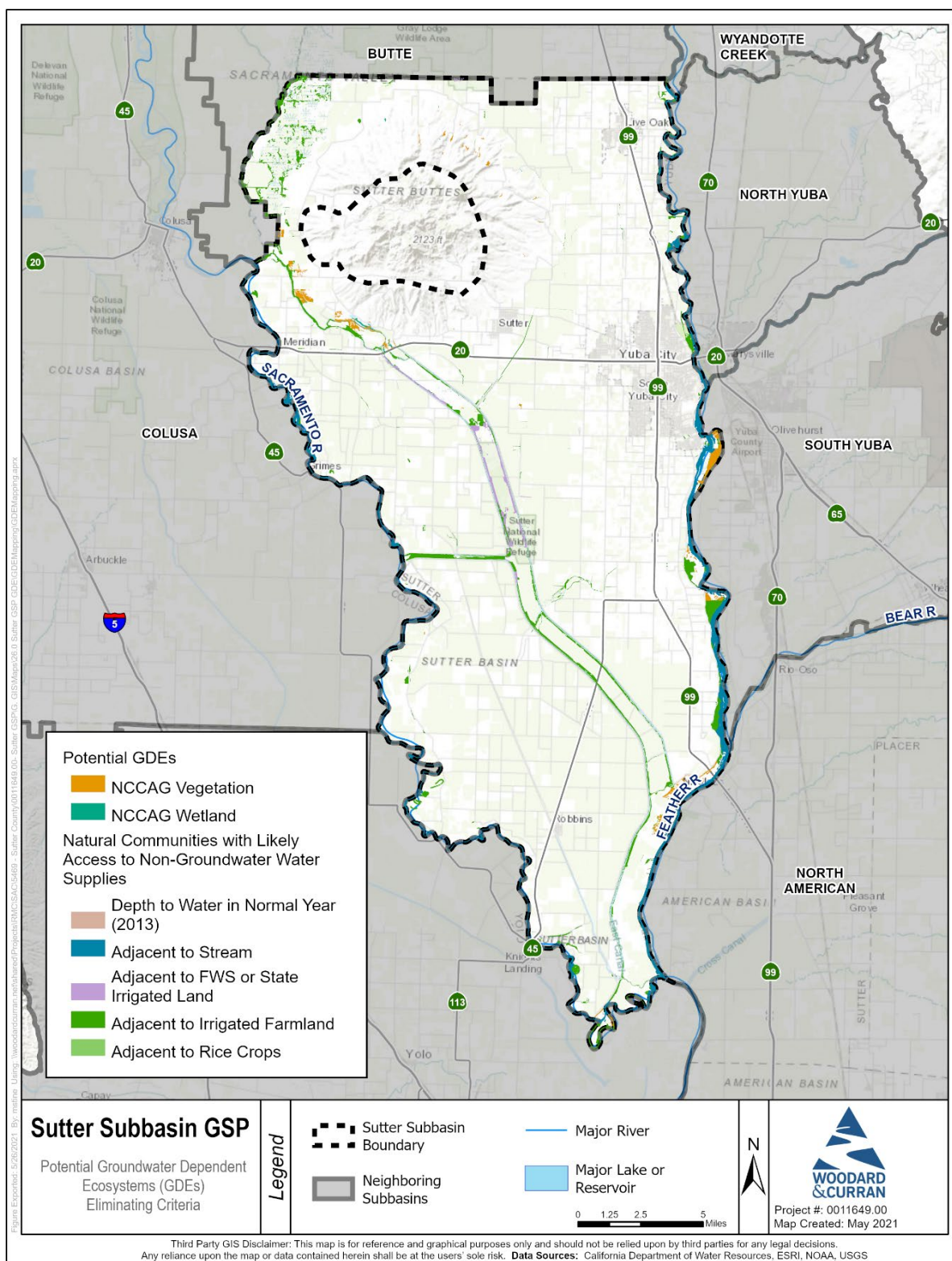


Figure 5-99. GDE Elimination Criteria in Sutter Subbasin, Normal Year (2013)

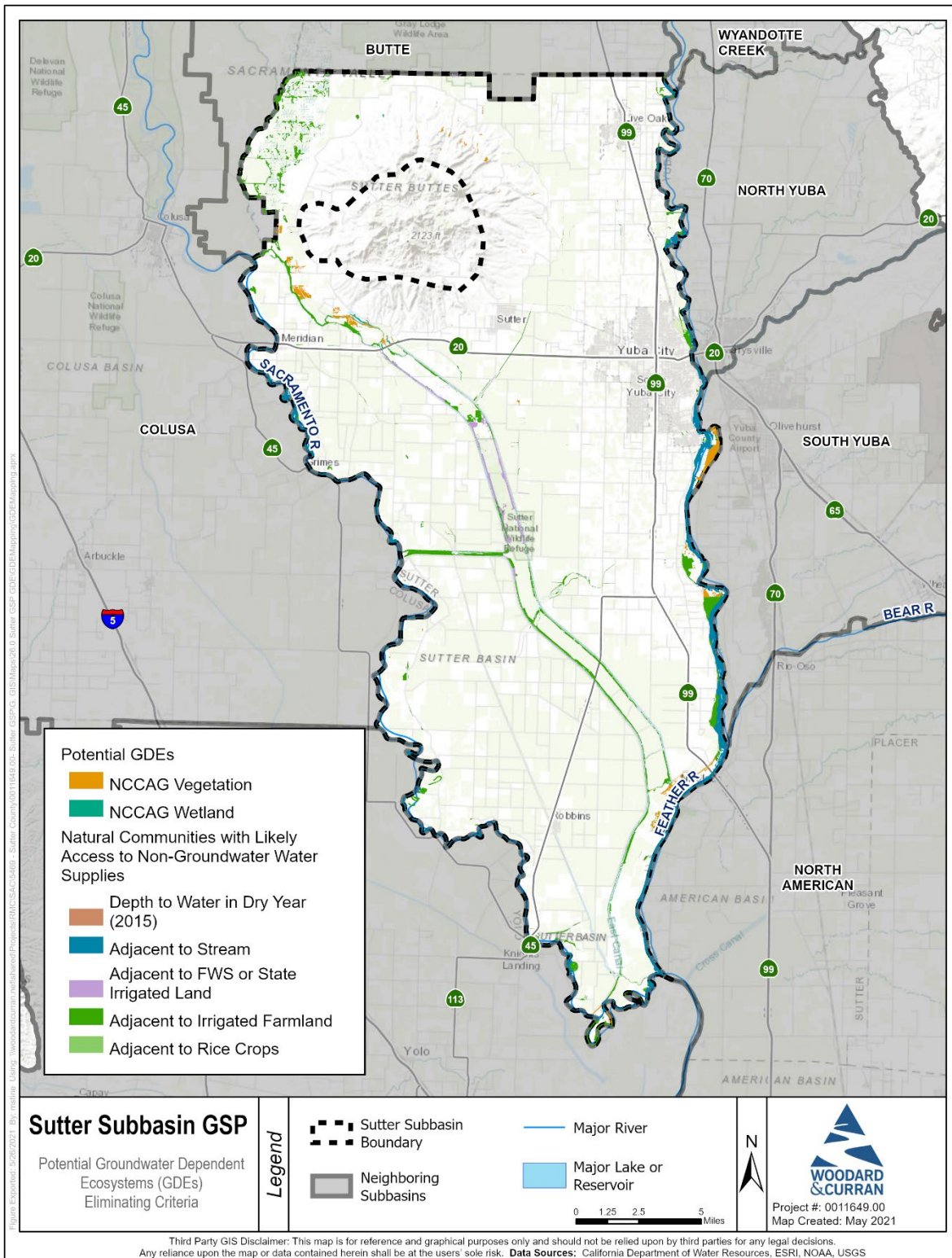


Figure 5-100. GDE Elimination Criteria in Sutter Subbasin, Dry Year (2015)

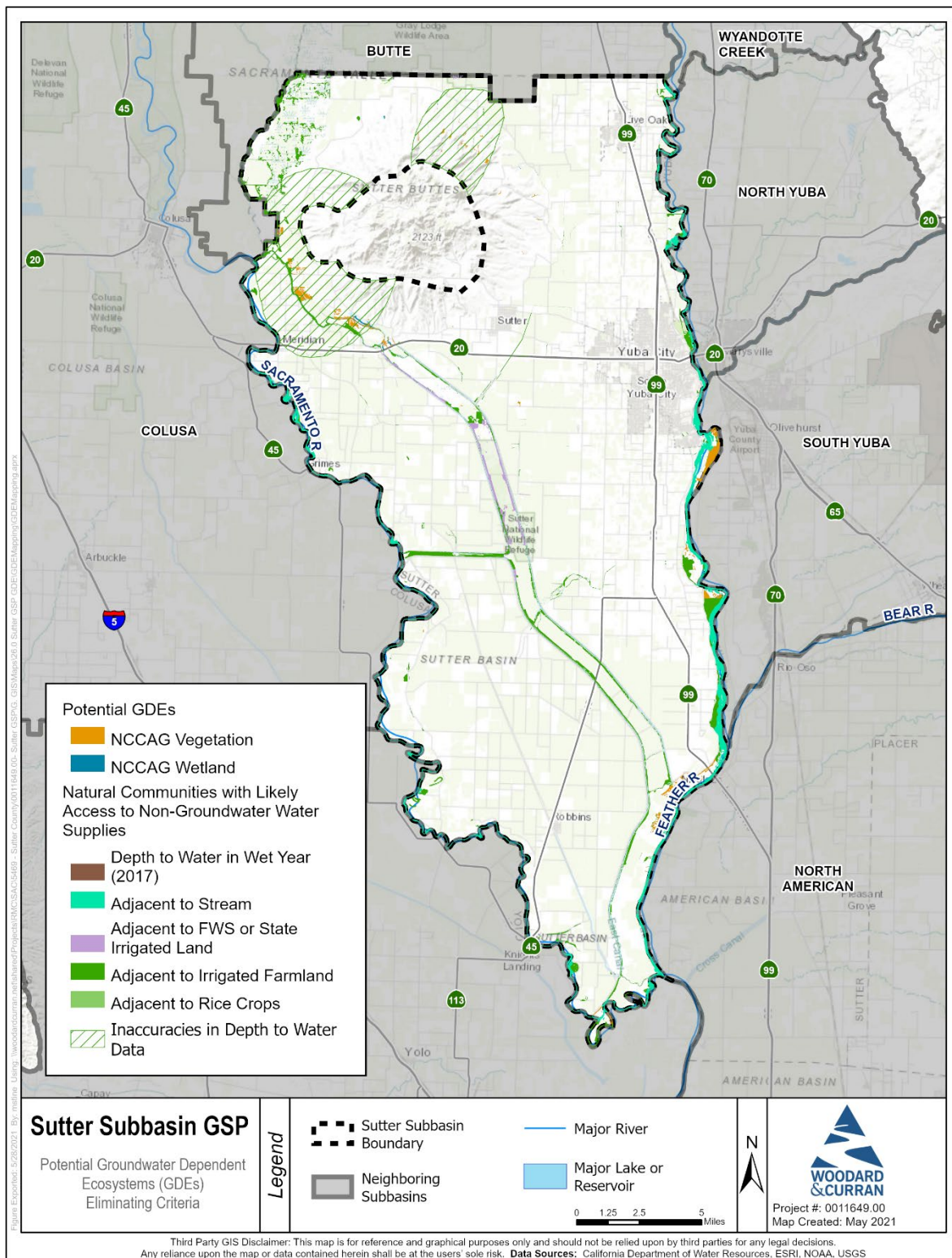


Figure 5-101. GDE Elimination Criteria in Sutter Subbasin, Wet Year (2017)

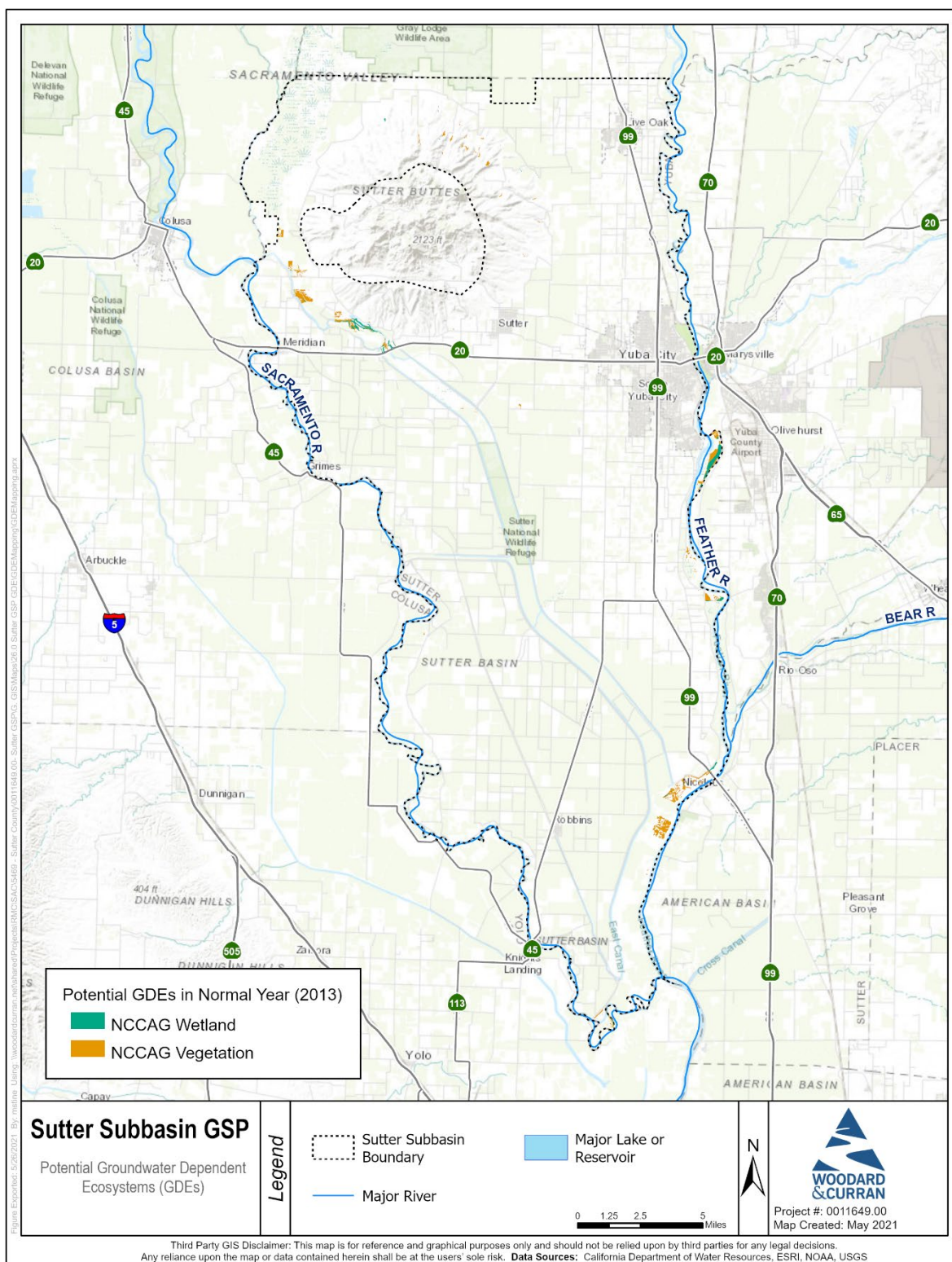


Figure 5-102. Potential GDEs in Sutter Subbasin, Normal Year (2013)

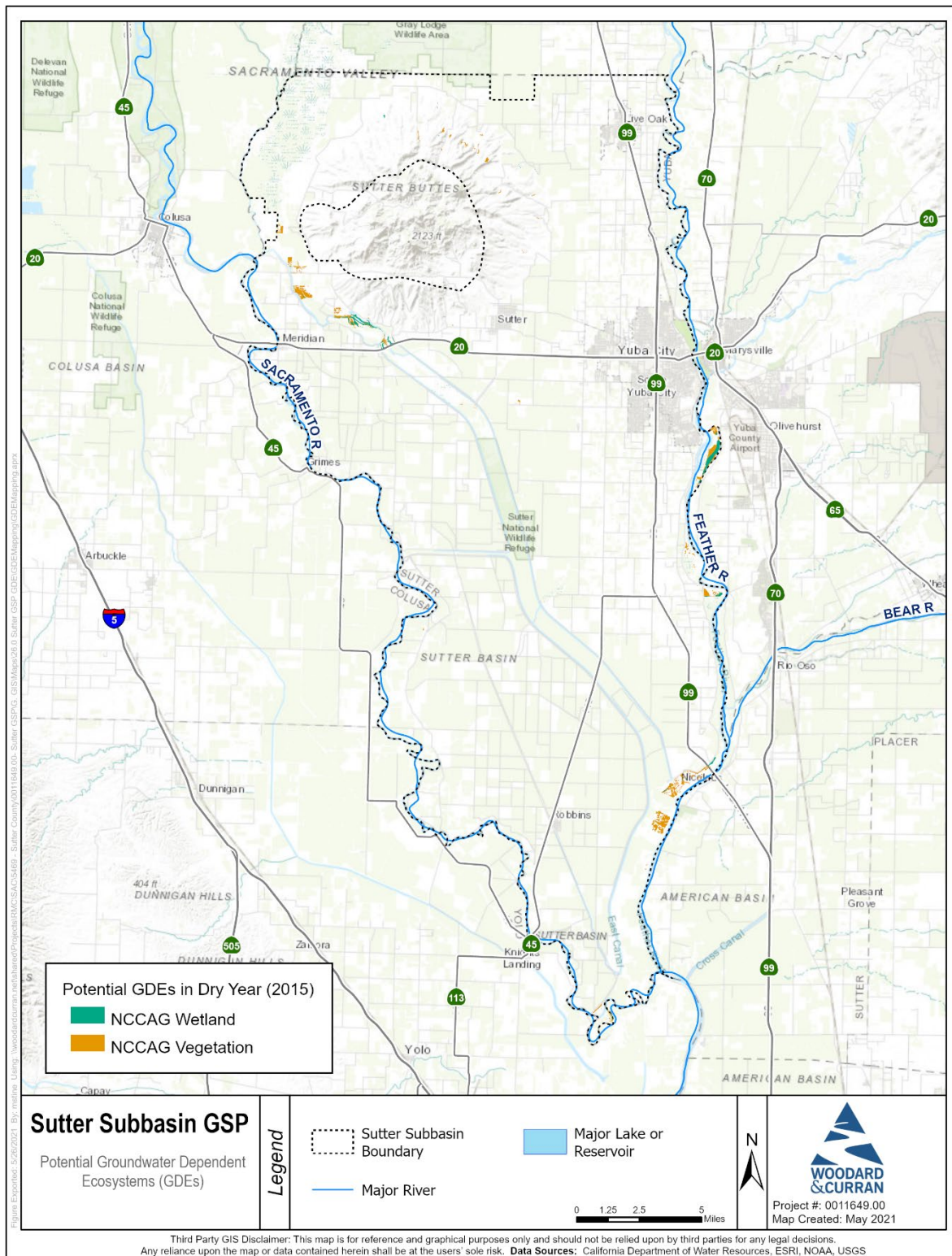


Figure 5-103. Potential GDEs in Sutter Subbasin, Dry Year (2015)



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Table 5-17. List of Potential Freshwater Species, Sutter Subbasin

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
<i>Ambystoma californiense</i>	California tiger salamander	Amphibians	Threatened	Threatened
<i>Rana boylei</i>	foothill yellow-legged frog	Amphibians	None	Endangered
<i>Agelaius tricolor</i>	tricolored blackbird	Birds	None	Threatened
<i>Antigone canadensis tabida</i>	greater sandhill crane	Birds	None	Threatened
<i>Athene cunicularia</i>	burrowing owl	Birds	None	None
<i>Branta hutchinsii leucopareia</i>	cackling (Aleutian Canada) goose	Birds	Delisted	None
<i>Buteo swainsoni</i>	Swainson's hawk	Birds	None	Threatened
<i>Coccyzus americanus occidentalis</i>	western yellow-billed cuckoo	Birds	Threatened	Endangered
<i>Laterallus jamaicensis coturniculus</i>	California black rail	Birds	None	Threatened
<i>Melospiza melodia</i>	song sparrow ("Modesto" population)	Birds	None	None
<i>Nycticorax nycticorax</i>	black-crowned night heron	Birds	None	None
<i>Riparia riparia</i>	bank swallow	Birds	None	Threatened
<i>Spinus lawrencei</i>	Lawrence's goldfinch	Birds	None	None
<i>Vireo bellii pusillus</i>	least Bell's vireo	Birds	Endangered	Endangered
<i>Branchinecta lynchi</i>	vernal pool fairy shrimp	Crustaceans	Threatened	None
<i>Lepidurus packardii</i>	vernal pool tadpole shrimp	Crustaceans	Endangered	None
<i>Linderiella occidentalis</i>	California linderiella	Crustaceans	None	None
<i>Amsinckia lunaris</i>	bent-flowered fiddleneck	Dicots	None	None
<i>Astragalus tener var. ferrisiae</i>	Ferris' milk-vetch	Dicots	None	None
<i>Brasenia schreberi</i>	watershield	Dicots	None	None
<i>Cuscuta obtusiflora var. glandulosa</i>	Peruvian dodder	Dicots	None	None
<i>Delphinium recurvatum</i>	recurved larkspur	Dicots	None	None
<i>Hibiscus lasiocarpus var. occidentalis</i>	woolly rose-mallow	Dicots	None	None
<i>Layia septentrionalis</i>	Colusa layia	Dicots	None	None

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
<i>Monardella venosa</i>	veiny monardella	Dicots	None	None
<i>Navarretia leucocephala</i> ssp. <i>bakeri</i>	Baker's navarretia	Dicots	None	None
<i>Pseudobahia bahiifolia</i>	Hartweg's golden sunburst	Dicots	Endangered	Endangered
<i>Trichocoronis wrightii</i> var. <i>wrightii</i>	Wright's trichocoronis	Dicots	None	None
<i>Oncorhynchus mykiss irideus</i> pop. 11	steelhead - Central Valley DPS	Fish	Threatened	None
<i>Oncorhynchus tshawytscha</i> pop. 11	chinook salmon - Central Valley spring-run ESU	Fish	Threatened	Threatened
<i>Pogonichthys macrolepidotus</i>	Sacramento splittail	Fish	None	None
<i>Spirinchus thaleichthys</i>	longfin smelt	Fish	Candidate	Threatened
<i>Thaleichthys pacificus</i>	eulachon	Fish	Threatened	None
<i>Northern Hardpan Vernal Pool</i>	Northern Hardpan Vernal Pool	Herbaceous	None	None
<i>Anthicus antiochensis</i>	Antioch Dunes anthicid beetle	Insects	None	None
<i>Anthicus sacramento</i>	Sacramento anthicid beetle	Insects	None	None
<i>Cicindela hirticollis abrupta</i>	Sacramento Valley tiger beetle	Insects	None	None
<i>Desmocerus californicus dimorphus</i>	valley elderberry longhorn beetle	Insects	Threatened	None
<i>Antrozous pallidus</i>	pallid bat	Mammals	None	None
<i>Dipodomys californicus eximius</i>	Marysville California kangaroo rat	Mammals	None	None
<i>Erethizon dorsatum</i>	North American porcupine	Mammals	None	None
<i>Lasiurus blossevillii</i>	western red bat	Mammals	None	None
<i>Lasiurus cinereus</i>	hoary bat	Mammals	None	None
<i>Perognathus inornatus</i>	San Joaquin pocket mouse	Mammals	None	None
<i>Coastal and Valley Freshwater Marsh</i>	Coastal and Valley Freshwater Marsh	Marsh	None	None
<i>Gonidea angulata</i>	western ridged mussel	Mollusks	None	None
<i>Heteranthera dubia</i>	water star-grass	Monocots	None	None
<i>Sagittaria sanfordii</i>	Sanford's arrowhead	Monocots	None	None

Scientific Name	Common Name	Group	Federal Protection Status	State Protection Status
<i>Wolffia brasiliensis</i>	Brazilian watermeal	Monocots	None	None
<i>Emys marmorata</i>	western pond turtle	Reptiles	None	None
<i>Thamnophis gigas</i>	giant gartersnake	Reptiles	Threatened	Threatened
<i>Great Valley Cottonwood Riparian Forest</i>	Great Valley Cottonwood Riparian Forest	Riparian	None	None
<i>Great Valley Mixed Riparian Forest</i>	Great Valley Mixed Riparian Forest	Riparian	None	None
<i>Great Valley Willow Scrub</i>	Great Valley Willow Scrub	Riparian	None	None

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5.3 Water Budget

5.3.1 Water Budget Background

Water budgets are developed to provide a quantitative account of water entering and leaving the Sutter Subbasin. Water entering and leaving the Subbasin includes flows at the surface and in the subsurface environment. Water enters and leaves due to natural conditions, such as precipitation and streamflow, and/or through human activities, such as groundwater pumping or recharge from applied water. Additionally, the interconnection between the groundwater system and rivers/streams accounts for other components of the water budget. **Figure 5-105** depicts the major components of a water budget and their interconnection as presented in the context of surface and groundwater systems.

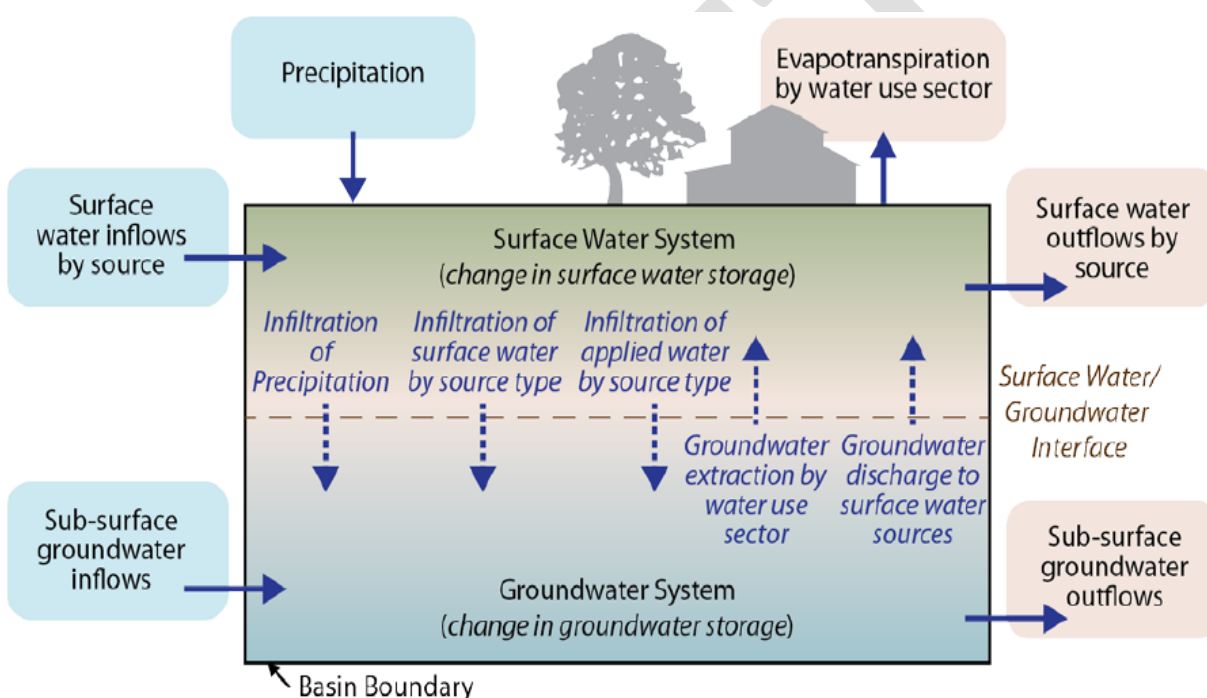


Figure 5-105. Generalized Water Budget Diagram

Quantities presented for the water budget components of the Sutter Subbasin provide information on historical, current, and projected conditions as they relate to hydrology, water demand, water supply, land use, population, climate variability, groundwater and surface water interaction, and groundwater flow. This information can assist in the management of the Subbasin by identifying the relationship between different components affecting the water budget in the Subbasin, which provides context in the development and implementation of strategies and policies to achieve and maintain Subbasin groundwater sustainability conditions. Water budget quantities presented are based on the simulation results from the California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid, Sutter Subbasin (C2VSimFG-Sutter) integrated

water flow model. Results in this section utilize the C2VSimFG-Sutter Version 2.0 updated for the 2027 GSP Amendment.

C2VSimFG-Sutter was developed to be the primary analytical tool supporting the development of the GSP water budgets and simulates WY 1986 through WY 2025. The C2VSimFG-Sutter model was adapted from C2VSimFG v1.0, released by DWR in December 2020, with updates to better represent local conditions (DWR SGMO, 2020). C2VSimFG-Sutter Version 2.0 was completely updated from C2VSimFG-Sutter Version 1.0 utilized for the original GSP. C2VSimFG-Sutter Version 2.0 features a clipped model domain to focus the updates on Sutter Subbasin and immediately surrounding areas. The updated model version also has model layering refined based on the State's AEM survey results with a new shallow layer specifically added to aid in the simulation of interconnected surface waters. More details regarding the update and calibration of C2VSimFG-Sutter Version 2.0 model are included in the model report (**Appendix 5-F**). Water budget results shown in this section of the GSP represent only the water budgets of the Subbasin. Simulated flows from Sutter Subbasin to surrounding groundwater subbasins are also derived from C2VSimFG-Sutter Version 2.0.

Consistent with the GSP Emergency Regulations §354.18, the water budgets presented in this document encompass the combined surface and groundwater system of the Sutter Subbasin. The Subbasin water budget focuses on the full water year (12 months spanning October 1 of the previous year to September 30 of the year in question), with some consideration of monthly variability.

The GSP Regulations require that the annual water budget quantify three different conditions: historical, current, and projected. Budgets are developed to capture typical conditions during these time periods. Typical conditions are developed by selecting historical hydrologic periods that incorporate droughts, wet periods, and normal periods. By incorporating these varied conditions within the budgets, the Subbasin is analyzed under varying hydrologic conditions, such as drought or very wet events, along with long-term averages.

This GSP relies on historical hydrology to identify time periods for water budget analysis and uses the C2VSimFG-Sutter model and associated data to develop the water budget and resulting budget estimates. The water budget components developed for the Sutter Subbasin are based upon estimates developed from historical and projected data as well as modeling assumptions. As the availability of data continues to improve, the water budget assumptions may be refined in the future, the water budget may change, and the conclusions and recommendations derived from the water budget may also change.

5.3.2 Identification of Hydrologic Periods

The historical hydrologic periods used in this GSP were selected to meet the SGMA requirements for developing historical, current, and projected conditions water budgets. The GSP Regulations require that the projected conditions water budget reflect at least

a 50-year hydrologic period in order to project how the Subbasin's surface and groundwater systems may react under long-term average hydrologic conditions. Consistent with the Regulations, the minimum 50-year historical record characterizes future conditions with respect to precipitation, evapotranspiration, and streamflow. Historical precipitation or rainfall in the Sutter Subbasin was used to identify a hydrologic period that would provide a representation of wet and dry periods and long-term average conditions needed for water budget analyses. Rainfall data for the Subbasin are derived from the PRISM (Precipitation-Elevation Regressions on Independent Slopes Model) dataset of DWR's California Simulation of Evapotranspiration of Applied Water (CALSIMETAW) model. PRISM is a spatial estimation of rainfall data developed using monitoring network point data and interpolated using a variety of factors (OSU, 2026).

Wet and dry hydrologic periods were identified by evaluating various historical periods between which average precipitation was similar to the long-term average precipitation conditions and that had representative water year type distributions using the Sacramento Valley Water Year Hydrologic Classification (DWR, 2026a). In the original GSP, the 20-year period between WY 1996 and WY 2015 was found to have the same amount of average precipitation as the 99-year long-term average precipitation from 1922-2020. Using the C2VSimFG-Sutter Version 2.0 precipitation, the updated 30-year period between WY 1996-2025 has the same average precipitation as WY 1996-2015 (19.1 inches) and is reasonably close to the average precipitation from WY 1986-2025 (19.4 inches).

For the original GSP, the year selected as representative of current conditions was WY 2013. This was updated to an average of recent historical years from WY 2021-2025 for the 2027 GSP Amendment. WY 2021-2025 has an annual average rainfall of 17.3 inches, and has land use, demands, and surface water supplies similar to current values. For this reason, the average of WY 2021-2025 in the historical calibration was selected to best represent the Subbasin current conditions.

Figure 5-106 shows the Subbasin annual precipitation, average precipitation, and cumulative departure from mean precipitation in each year. This plot represents the spatially-averaged precipitation across Sutter Subbasin elements. The long-term average precipitation is subtracted from annual precipitation within each water year to calculate the departure from average precipitation for each water year. Wet years have a positive departure, dry years have a negative departure, and a year with exactly average precipitation would have zero departure. Starting at the first year analyzed, the departures are added cumulatively for each year. For example, if the departure for Year 1 is 5 inches and the departure for Year 2 is -2 inches, the cumulative departure would be 5 inches for Year 1 and 3 inches (5 plus -2) for Year 2. **Figure 5-106** includes bars displaying annual precipitation for each water year from 1986 through 2025 and a horizontal line representing the average precipitation of 19.4 inches. The cumulative departure from average precipitation is based on these data sets and is displayed as a

line that highlights wet periods with upward slopes (positive departure) and dry periods with downward slopes (negative departure). More severe events are shown by steeper slopes and greater changes. For example, a recent drought period can be observed as a decline between 2011 and 2016 where there is approximately a 3.4-inch decline per year in cumulative departure within that 6-year period.

The PRISM estimates for rainfall in the Subbasin were confirmed by comparing the cumulative departure from average precipitation results to the water year types in the Sacramento Valley Water Year Hydrologic Classification (DWR, 2026a), which classifies WYs 1901 through 2025 as wet, above normal, below normal, dry, and critical based on inflows to major reservoirs or lakes. Wet (W) or Above Normal (AN) years generally show upward sloping cumulative departures, while Below Normal (BN), Dry (D), or Critical (C) water year types show downward trending cumulative departures (Figure 5-106).

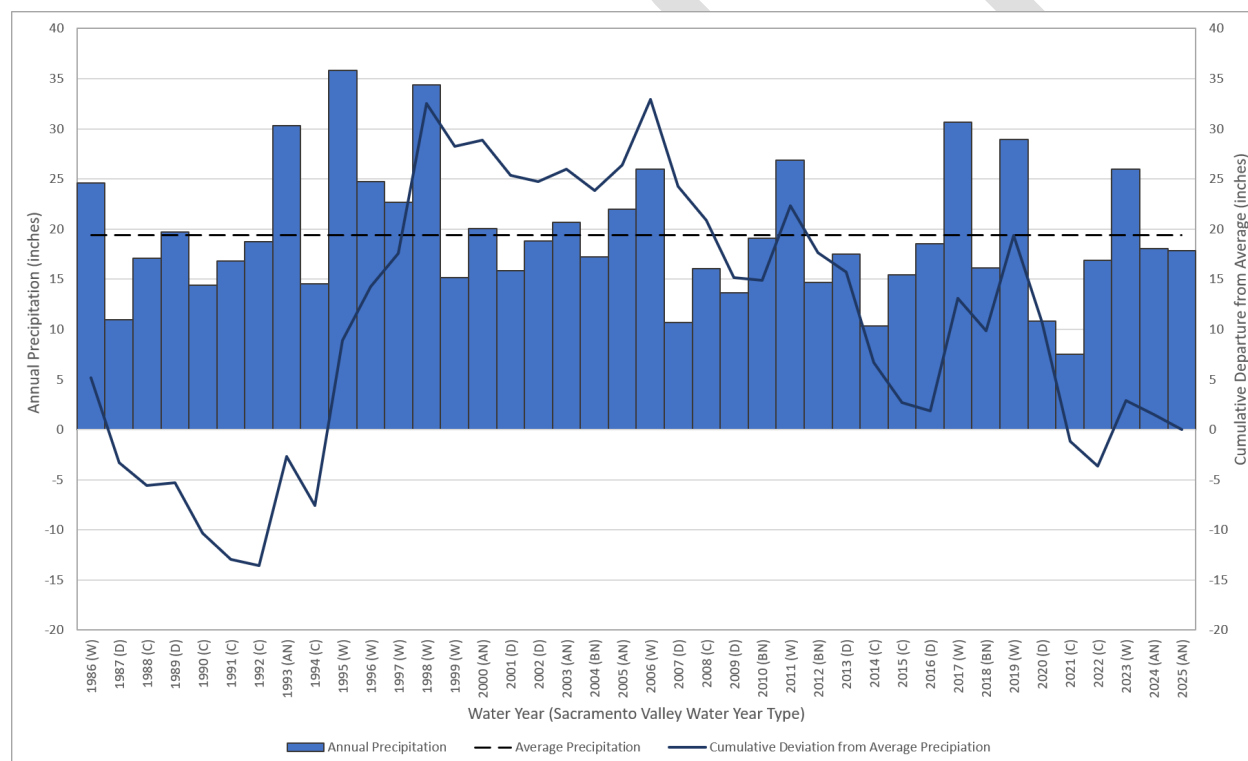


Figure 5-106. Historical Precipitation and Cumulative Departure from Mean Precipitation

5.3.3 Use of C2VSimFG-Sutter Version 2.0 and Associated Data in Water Budget Development

This GSP includes water budgets developed utilizing the C2VSimFG-Sutter Version 2.0 model, a fully integrated surface and groundwater flow model covering Sutter Subbasin.

With C2VSimFG-Sutter Version 2.0 as the underlying framework, four model scenarios were developed representing historical, current, projected conditions, and projected conditions with climate change in the Sutter Subbasin, as discussed below:

- **Historical conditions water budget** represents the average over the historical model period from WYs 1996 through 2025 (30 years).
- **Current conditions water budget** is an average of recent years in the historical model calibration that represent current trends in level of development, water supply, and water demand. WYs 2021-2025 were selected to represent current conditions.
- **Projected conditions water budget** represents estimated long-term conditions of the Subbasin under the foreseeable future level of development over a long-term period of hydrologic conditions (averaged by water year type from the 20-year period of WYs 1996 through 2015 and repeated three times).
- **Projected conditions water budget with climate change** represents estimated long-term conditions of the Subbasin under the foreseeable future level of development over a long-term period of hydrologic conditions (averaged by water year type from the 20-year period of WYs 1996 through 2015) with additional modifications to precipitation, evapotranspiration, and streamflow to reflect impacts of climate change.

5.3.4 Water Budget Definitions and Assumptions

Definitions and assumptions for the historical, current, and projected conditions (without and with climate change) water budgets are provided in the sections below and summarized in **Table 5-18**.

Table 5-18. Summary of Water Budget Assumptions – Historical, Current, and Projected Periods

Water Budget Type	Historical	Current	Projected Conditions	Projected Conditions with Climate Change
Tool	C2VSimFG-Sutter	C2VSimFG-Sutter	C2VSimFG-Sutter	C2VSimFG-Sutter
Scenario	Historical Calibration	Current Conditions	Projected Conditions	Projected Conditions with Climate Change
Hydrologic Years (WYs)	1996-2025	2021-2025	1996-2015 ³	1996-2015 ³
Level of Development	Historical ²	Current (2021-2025)	Projected 2040 conditions based on local information ¹	Projected 2040 conditions based on local information ¹
Agricultural Demand ²	Historical ²	Current (2021-2025)	Projected based on recent historical local data from 2006-2025	Projected based on recent historical local data from 2006-2025, increased to reflect 2070 climate change conditions
Urban Demand	Historical ²	Current (2021-2025)	Projected based on recent historical population growth rates from 2006-2025	Projected based on recent historical population growth rates from 2006-2025
Managed Wetlands Demand	Historical	Current (2021-2025)	Projected based on recent historical local data from 2006-2025	Projected based on recent historical local data from 2006-2025
Water Supplies	Historical ²	Current (2021-2025)	Projected based on recent historical local data from 2006-2025	Projected based on recent historical local data from 2006-2025, modified to reflect 2070 climate change conditions

¹ Yuba City and Live Oak are assumed to build out to sphere of influence boundaries.

² For more information on historical assumptions, see the model report (Appendix 5-F).

³ Hydrologic years WYs 1996-2015 are repeated 3 times for a total of 60 years of projected water year types.

5.3.4.1 Assumptions Used in the Historical Water Budget

The historical water budget is intended to evaluate availability and reliability of past surface water supply deliveries, aquifer response to water supply, and demand trends relative to water year type. The historical water budget period of the C2VSimFG-Sutter Version 2.0 model reflects the historical conditions in the Sutter Subbasin over WYs 1996 through 2025. The hydrologic period has an average annual precipitation of approximately 19.1 inches and includes the recent 2012-2016 and 2020-2022 droughts, the wetter years of 1996-2000, and periods of normal precipitation. The GSP Regulations require the use of a minimum of 10 years to develop the historical water budget.

Calibration of the historical model was focused on the clipped area of C2VSimFG-Sutter Version 2.0 covering the Sutter Subbasin and select areas around the Subbasin. A focused effort on groundwater level calibration was made to ensure interbasin flows were simulated accurately. Additional details of the data used in the development of the historical calibration can be found in the model report (**Appendix 5-F**).

The historical water budget includes the following:

- **Hydrologic Period:** WYs 1996 through 2025 (30-year hydrology)
- **Stream Flows:** Historical stream gages
- **Reservoir Operations:** While Oroville Dam, Nimbus Dam, and Shasta Dam (among others) lie upstream and mediate flow into the Sacramento and Feather Rivers, there are no reservoir operations modeled within the C2VSimFG-Sutter Version 2.0 boundary.
- **Land Use and Cropping Patterns:** Based on the published C2VSimFG v1.0 with time series extended using the DWR Statewide Crop Mapping for WY 2016 and 2018-2024.
- **Urban Water Demand:** Calculated for the Subbasin's urban areas, including the cities of Yuba City and Live Oak. Demands for other domestic areas are estimated based on rural population. Urban water demand is based on:
 - Urban water use is based on the published C2VSimFG v1.0.
 - Urban center population was estimated based on data from the U.S. Census and updated using local data.
- **Surface Water Deliveries:** Deliveries to agricultural and urban areas based on the published C2VSimFG v1.0 with refinements due to local agency information.
- **Groundwater Pumping:** Simulated by C2VSimFG-Sutter Version 2.0.
 - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter Version 2.0 model.

5.3.4.2 Assumptions Used in the Current Conditions Water Budget

The current conditions water budget represents a recent level of development and agricultural demand.

The current conditions water budget includes the following assumptions:

- **Hydrologic Period:** WYs 2021-2025
- **Stream Flows:** WY 2021-2025 average
- **Reservoir Operations:** While Oroville Dam, Nimbus Dam, and Shasta Dam (among others) lie upstream and mediate flow into the Sacramento and Feather Rivers, there are no reservoir operations modeled within the C2VSimFG-Sutter Version 2.0 boundary.
- **Land Use and Cropping Patterns:** Consistent with the historical model for WYs 2021-2025. Land use from WYs 2021-2025 is considered to represent current conditions based on local knowledge that land use has changed relatively little in recent years.
- **Urban Water Demand:** Urban water demands are consistent with the historical model WYs 2021-2025 and calculated for all the urban areas in the model, including the City of Yuba City and the city of Live Oak.
- **Surface Water Deliveries:** Consistent with the historical model for WYs 2021-2025.
- **Groundwater Pumping:** Simulated by C2VSimFG-Sutter Version 2.0.
 - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter Version 2.0 model.

5.3.4.3 Assumptions Used in the Projected Conditions Water Budget

The projected conditions water budget is intended to assess the conditions of the Subbasin under future conditions of water supply and agricultural and urban demand. The projected conditions scenario applies future land and water use conditions and uses a 60-year hydrologic period. The model is assumed to represent 2042 conditions in progress toward full buildout. These conditions are represented using projected population, land use, and water demand and supply projections. Assumptions used in the projected conditions scenario under potential climate change conditions (changes to precipitation, stream flows, and evapotranspiration) are presented in **Section 5.3.4.4**.

The projected conditions scenario includes the following conditions:

- **Hydrologic Period:** WYs 2006 through 2025, repeated three times for a 60-year projected hydrology.
- **Stream Flows, Evapotranspiration, and Precipitation:** Historical WY 1996-2015 time series were averaged using aggregated water year types and applied to the

projected water year type sequence throughout the 60-year simulation period. Historical WYs 1996 through 2015 were utilized to minimize extreme variations in hydrology found in recent years of the historical model. Extreme hydrology is tested in the projected conditions with climate change scenario.

- **Reservoir Operations:** Unchanged from historical model.
- **Land Use and Cropping Patterns:** Land use is based on the previous projected conditions and relies on local information received from the Sutter Subbasin GSAs on expected changes to their crop distribution at the end of the historical model. The city of Live Oak and City of Yuba City are assumed to be built out to their sphere of influence boundaries. Land use is averaged using aggregated water year types and applied to the projected water year type sequence throughout the 60-year simulation period.
- **Urban Water Demand:** Calculated for all the urban areas in the model, including the city of Live Oak and City of Yuba City, based on growth applied to the last year of the historical simulation (WY 2025). Population in Sutter Subbasin is assumed to grow at the same rate as it did in the last 12 years of the historical simulation, projected out to 2050.
- **Agricultural Operations:** Operations in the projected model are based on the conditions simulated at the end of the historical model.
- **Surface Water Deliveries:** Based on the historical diversion time series. The most recent 12 years of diversions were averaged by water year type. These diversions were projected into the future using the 60-year hydrologic period to determine the pattern of water year types.
- **Groundwater Pumping:** Simulated by C2VSimFG-Sutter Version 2.0.
 - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter Version 2.0 model.

5.3.4.4 Assumptions Used in the Projected Conditions with Climate Change Water Budget

The projected conditions water budget with climate change is intended to assess the impact of climate change under future conditions of water supply and agricultural and urban demand. The projected conditions with climate change scenario applies the same future land and water use conditions as the projected conditions scenario and uses the same simulated 60-year hydrologic period that is used in the projected conditions scenario. The climate change impacts evaluated in the model are assumed to represent 2070 precipitation, evapotranspiration, and streamflow conditions. Climate change conditions were estimated using 2070 central tendency datasets provided by DWR. These datasets were derived from output produced by an ensemble of global climate models chosen by DWR to best represent impacts of climate change in California.

Further detail on how these datasets were developed and adapted to the Sutter Subbasin can be found in **Appendix 5-F**.

The projected conditions with climate change scenario includes the following conditions:

- **Hydrologic Period:** WYs 2006 through 2025, repeated three times for a 60-year projected hydrology.
- **Stream Flows and Precipitation:** Historical WY 1996-2015 time series were averaged using aggregated water year types and applied to the projected water year type sequence throughout the 60-year simulation period, modified by watershed-specific perturbation factors reflecting 2070 climate change conditions provided by DWR.
- **Reservoir Operations:** Unchanged from historical model.
- **Land Use and Cropping Patterns:** Same as projected conditions model.
- **Urban Water Demand:** Same as projected conditions model. Urban landscape evapotranspiration is increased to reflect increasing temperatures under 2070 climate change conditions using the Variable Infiltration Capacity (VIC) model-derived perturbation factors provided by DWR.
- **Agricultural Operations:** Operations in the projected model are based on the conditions simulated at the end of the historical model. Agricultural evapotranspiration is increased to reflect increasing temperatures under 2070 climate change conditions using VIC model-derived perturbation factors provided by DWR.
- **Surface Water Deliveries:** Same as projected conditions model.
- **Groundwater Pumping:** Simulated by the C2VSimFG-Sutter model.
 - Data on private pumping were not available on a consistent basis across the model, so private pumping was estimated as that which would be required to meet agricultural and rural residential water needs using the C2VSimFG-Sutter Version 2.0 model.

5.3.5 Water Budget Estimation

The C2VSimFG-Sutter Version 2.0 model simulates the major hydrologic processes that affect the surface and groundwater systems in the Sutter Subbasin. The major hydrologic processes can be represented by separate water budgets which detail inflows and outflows occurring at the surface scale (budget balancing how demands on urban, agricultural, and native lands are met by rainfall, surface water deliveries available from streamflow, or groundwater pumping) and at the groundwater scale (budget detailing flows occurring within the groundwater aquifers of the Subbasin).

The primary components of the surface system are:

- **Inflows:**
 - Precipitation
 - Surface water supplies to meet agricultural, urban, or managed wetlands uses
 - Groundwater pumping (i.e., groundwater supplies to meet agricultural, urban, industrial, and managed wetlands uses)
 - Riparian intake from streams
- **Outflows:**
 - Evapotranspiration
 - Runoff to the stream system
 - Return flow to the stream system
 - Deep percolation from precipitation, applied water (surface water and groundwater) for agricultural lands, outdoor water use in urban areas or for industrial purposes, and refuge use

The primary components of the groundwater system are:

- **Inflows:**
 - Deep percolation from precipitation, applied water (surface water and groundwater) for agricultural lands, outdoor water use in the urban areas or for industrial purposes, and refuge use
 - Stream seepage (i.e., losses from Sacramento River, Feather River, and Sutter Bypass to the groundwater system)
 - Conveyance seepage
 - Subsurface inflow (i.e., from surrounding subbasins and the Sutter Buttes)
- **Outflows:**
 - Groundwater outflow to streams (i.e., loss from the groundwater system to or stream gains for Sacramento River, Feather River, and Sutter Bypass)
 - Groundwater pumping (i.e., groundwater supplies to meet agricultural, urban, industrial, and managed wetlands uses)
 - Subsurface outflow (i.e., to surrounding subbasins)
- **Change in Groundwater Storage (Inflows Minus Outflows):** This reflects average annual change in groundwater storage.

The estimated water budgets for the historical, current conditions, projected conditions, and projected conditions with climate change scenarios are provided below, with results summarized in **Table 5-19** and **Table 5-20**.

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Table 5-19. Average Annual Surface System Water Budget Components

Component	Historical Calibration (AF/year)	Current Conditions (AF/year)	Projected Conditions (AF/year)	Projected Conditions With Climate Change (2070 CT) (AF/year)
Hydrologic Period	WY 1996-2025	WY 2021-2025	WY 2006-2015 Repeated 3 Times	WY 2006-2015 Repeated 3 Times with Climate Change
Inflows				
Precipitation	455,000 (19 inches)	411,000 (17 inches)	451,000 (19 inches)	475,000 (20 inches)
Surface Water Delivery ¹	580,000	591,000	561,000	560,000
<i>Agricultural</i>	520,000	510,000	445,000	445,000
<i>Urban</i>	14,000	15,000	15,000	15,000
<i>Managed Wetlands</i>	46,000	66,000	101,000	100,000
Groundwater Pumping	138,000	139,000	223,000	240,000
<i>Agricultural</i>	127,000	127,000	182,000	198,000
<i>Urban</i>	10,000	11,000	26,000	26,000
<i>Managed Wetlands</i>	1,000	1,000	15,000	16,000
Riparian Intake from Streams ²	20,000	24,000	15,000	15,000
Total Inflow	1,193,000	1,165,000	1,250,000	1,290,000
Outflows				
Evapotranspiration ³	649,000	658,000	671,000	693,000
<i>Agricultural</i>	527,000	544,000	569,000	589,000
<i>Urban</i>	13,000	15,000	25,000	26,000
<i>Managed Wetlands</i>	5,000	5,000	20,000	20,000
<i>Native and Riparian Vegetation</i>	104,000	94,000	57,000	58,000
Runoff to Streams ⁴	145,000	123,000	122,000	146,000
Return Flow to Streams ⁵	227,000	235,000	256,000	250,000
<i>Agricultural</i>	149,000	140,000	120,000	116,000
<i>Urban</i>	15,000	16,000	25,000	25,000
<i>Managed Wetlands</i>	36,000	57,000	77,000	76,000
<i>Pond Drain</i>	27,000	22,000	34,000	33,000
Deep Percolation ⁶	172,000	150,000	200,000	200,000
<i>Precipitation</i>	67,000	54,000	73,000	74,000
<i>Applied Surface Water</i> ⁷	85,000	78,000	91,000	88,000
<i>Applied Groundwater</i> ⁸	20,000	18,000	36,000	38,000
Total Outflow ⁹	1,193,000	1,166,000	1,249,000	1,289,000
Change in Storage ¹⁰	0	-1,000	1,000	1,000

¹ Surface water deliveries shown in this table are the volumes of water delivered to the different areas of the Subbasin. These totals are after losses due to evaporation and canal seepage. Differences between scenarios are due to differences in current and planned surface water deliveries.

² Riparian intake from streams is the portion of the riparian vegetation evapotranspiration met by stream flows. Differences between scenarios may be due to availability of stream flows or extent of riparian vegetation, which may be affected by growth in urban areas.

³ Evapotranspiration is the demand required by agricultural land (i.e., crops); municipal and domestic areas (i.e., urban demands); and refuge, native, and riparian areas. Differences in evapotranspiration are largely related to differences in urban areas between the scenarios and the loss of agricultural or native/riparian land as urban growth occurs. Temperature increases under climate change account for higher evapotranspiration rates under the projected conditions climate change scenario.

⁴ Runoff to the stream system is due to precipitation. As urban areas are assumed to have greater runoff of precipitation (resulting from more paved area), the changes in runoff between the model scenarios are largely due to differences in the size of urban areas and the amount of precipitation the occurs in the historical/current/projected scenarios.

⁵ Return flow to the stream system is due to applied water, either surface water or groundwater used for agricultural, urban, or managed wetland purposes. Differences between the scenarios are primarily related to the urban growth in the projected conditions scenario causing higher urban demand in relation to agricultural demand. This results in less applied water to irrigable lands that can return to the streams.

⁶ Deep percolation is the amount of infiltrated water ultimately reaching the groundwater system. The source of the water may be from precipitation or applied water used for agricultural, urban, or managed wetland purposes. Differences between scenarios are related to differences already noted between these sources of water and differences in the infiltration parameters related to land use.

⁷ Applied surface water is the volume of delivered surface water that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences between scenarios are due to differences in current and planned surface water deliveries and crop types.

⁸ Applied groundwater is the volume of delivered groundwater that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences in demand largely drive the amount of groundwater pumped and therefore applied.

⁹ Summations in table may not match the numbers in the table. This is due to the rounding of model results.

¹⁰ Change in storage in the surface system water budget refers to the change in root zone soil moisture.

Table 5-20. Average Annual Groundwater System Water Budget Components

Component	Historical Calibration (AF/year)	Current Conditions (AF/year)	Projected Conditions (AF/year)	Projected Conditions With Climate Change (2070 CT) (AF/year)
Hydrologic Period	WY 1996-2025	WY 2021-2025	WY 2006-2025 Repeated 3 Times	WY 2006-2025 Repeated 3 Times with Climate Change
Inflows				
Deep Percolation ¹	172,000	151,000	200,000	200,000
Precipitation ²	67,000	55,000	73,000	75,000
Applied Surface Water ³	85,000	78,000	91,000	87,000
Applied Groundwater ⁴	20,000	18,000	36,000	38,000
Stream Seepage ⁵	87,000	90,000	96,000	110,000
Sacramento River	38,000	36,000	40,000	48,000
Feather River	12,000	18,000	13,000	17,000
Sutter Bypass	37,000	36,000	43,000	45,000
Land Subsidence Inflow	36,000	36,000	36,000	36,000
Conveyance Seepage	80,000	88,000	91,000	95,000
Subsurface Inflow ⁶	30,000	34,000	41,000	41,000
Butte Subbasin	7,000	6,000	7,000	8,000
Colusa Subbasin	3,000	4,000	3,000	3,000
North American Subbasin	6,000	6,000	6,000	6,000
North Yuba Subbasin	10,000	10,000	10,000	11,000
South Yuba Subbasin	2,000	2,000	3,000	3,000
Wyandotte Creek Subbasin	14,000	17,000	15,000	16,000
Yolo Subbasin	8,000	9,000	6,000	7,000
Sutter Buttes	172,000	151,000	200,000	200,000
Total Inflow	375,000	365,000	423,000	441,000
Outflows				
Groundwater Outflow to Streams ⁵	140,000	113,000	99,000	101,000
Sacramento River	56,000	52,000	46,000	49,000
Feather River	45,000	34,000	33,000	33,000
Sutter Bypass	39,000	27,000	20,000	19,000
Groundwater Pumping ⁷	138,000	139,000	223,000	240,000
Agricultural	127,000	127,000	182,000	198,000
Urban	10,000	11,000	26,000	26,000
Managed Wetlands	1,000	1,000	15,000	16,000
Subsurface Outflow ⁶	101,000	108,000	101,000	100,000
Butte Subbasin	14,000	13,000	14,000	13,000
Colusa Subbasin	38,000	46,000	37,000	36,000
North American Subbasin	13,000	14,000	15,000	15,000
North Yuba Subbasin	4,000	5,000	4,000	4,000
South Yuba Subbasin	4,000	3,000	3,000	3,000
Wyandotte Creek Subbasin	2,000	2,000	2,000	2,000
Yolo Subbasin	26,000	25,000	26,000	27,000
Total Outflow ⁸	379,000	360,000	423,000	441,000
Change in Groundwater Storage	-4,000	5,000	0	0

¹ Deep percolation is the amount of infiltrated water ultimately reaching the groundwater system. The source of the water may be from precipitation or applied water used for agricultural, urban, or managed wetland purposes. Differences between scenarios are related to differences already noted between these sources of water and differences in the infiltration parameters related to land use.

² Precipitation includes the amount of precipitation that ultimately enters the groundwater system as deep percolation. Table 5-19 shows the total precipitation that falls in the Sutter Subbasin on an average annual basis.

³ Applied surface water is the volume of delivered surface water that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences between scenarios are due to differences in current and planned surface water deliveries and crop types.

⁴ Applied groundwater is the volume of delivered groundwater that leaves the surface system as deep percolation after agricultural, urban, and managed wetland demands are met. Differences in demand largely drive the amount of groundwater pumped and therefore applied.

⁵ Streams interacting with Sutter Subbasin include Feather River, Sacramento River, and Sutter Bypass. Stream gain from groundwater and stream seepage represent the interactions between surface water and groundwater. Differences between the scenarios are related to differing hydrologic periods and differences in stream flows and long-term average groundwater elevations.

⁶ Subsurface inter-basin flows are estimated by the C2VSimFG-Sutter model to maintain a reasonable balance between the neighboring groundwater subbasins. Continuing inter-basin coordination may refine these numbers. C2VSimFG-Sutter Version 2.0's update focused efforts on refining and aligning subsurface flows with historical groundwater level trends.

⁷ Groundwater pumping is estimated by the C2VSimFG-Sutter model based on the need for additional water to meet remaining demands after surface water deliveries occur. Differences in demand largely drive the amount of groundwater pumped.

⁸ Summations in table may not match the numbers in the table. This is due to the rounding of model results.

5.3.5.1 Historical Conditions Water Budget Estimates

The historical water budget in **Table 5-19** and **Table 5-20** is a quantitative tabulation of the historical surface and groundwater systems as represented in the historical simulation of the C2VSimFG-Sutter Version 2.0 model covering the 30-year period of WYs 1996 through 2025. The historical calibration is discussed in detail in the historical model documentation (**Appendix 5-F**). Per the GSP Emergency Regulations §354.18, the water budget includes estimates for supply and demand while summarizing flows within the Subbasin, including the movement of all primary sources of water such as precipitation, agricultural water supplies, stream interaction, and subsurface flows. The stream network that borders the Sutter Subbasin supplies water to multiple agricultural water users as well as the City of Yuba City. Stream interactions and managed operations in adjacent groundwater subbasins that share a stream boundary with Sutter Subbasin may impact water budget estimations within Sutter Subbasin. The largest boundary is shared with North and South Yuba Subbasins along Feather River and the Colusa Subbasin along Sacramento River.

The surface system water budget in the historical calibration of the Sutter Subbasin, shown in **Figure 5-107**, estimates almost 1.193 million acre-feet per year (MAF/year) of inflows resulting from a combination of precipitation (455,000 acre-feet [AF]/year), surface water supply (580,000 AF/year), groundwater supply (138,000 AF/year), and riparian intake from streams (20,000 AF/year). The outflow from the surface system in the historical calibration (also estimated to be just over 1.193 MAF/year) is comprised of evapotranspiration (close to 649,000 AF/year), runoff to the stream system (145,000 AF/year), return flow of applied water to the stream system (227,000 AF/year), and deep percolation of precipitation or applied water (172,000 AF/year). Approximately 90% of surface water deliveries are used for agricultural use, with 8% for managed wetlands and 2% for urban uses. The historical model indicates that approximately 81% of evapotranspiration losses occur from agriculture and 16% from native and riparian vegetation, with the remaining 3% for urban and managed wetlands.

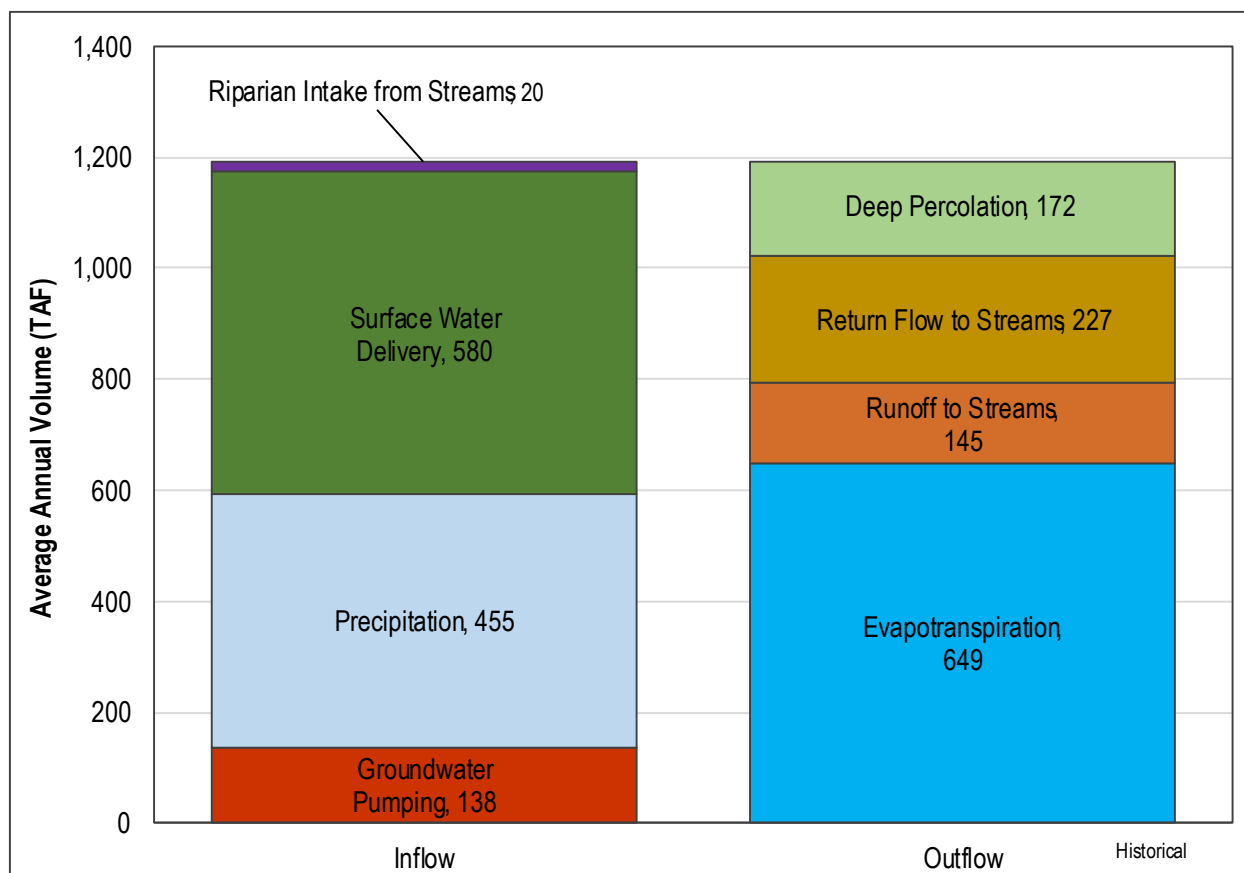


Figure 5-107. Historical Average Annual Water Budget – Surface System

The groundwater system of the Sutter Subbasin includes 375,000 AF/year of inflows in the historical calibration (not including change in groundwater storage), of which 172,000 AF/year is deep percolation of precipitation or applied water (groundwater and surface water). There is also stream seepage (87,000 AF/year), conveyance seepage (36,000 AF/year), and subsurface inflows (80,000 AF/year) from the neighboring groundwater subbasins of Colusa, Yolo, North American, North and South Yuba, Butte, and a very small portion from Wyandotte Creek Subbasin. The Sutter Buttes also contributes subsurface inflows. The primary outflows from the groundwater system are groundwater pumping (138,000 AF/year) and loss to streams (140,000 AF/year). Subsurface outflow to the neighboring groundwater subbasins is approximately 101,000 AF/year. Approximately 92% of the groundwater pumping from the groundwater system is for agricultural use, 7% for urban use, and the remaining 1% for managed wetlands.

The Sutter Subbasin average historical groundwater budget has slightly greater outflows than inflows, leading to an estimated average annual decrease in groundwater storage of approximately 4,000 AF/year. **Figure 5-108** summarizes the average historical calibration groundwater inflows and outflows of the Sutter Subbasin.

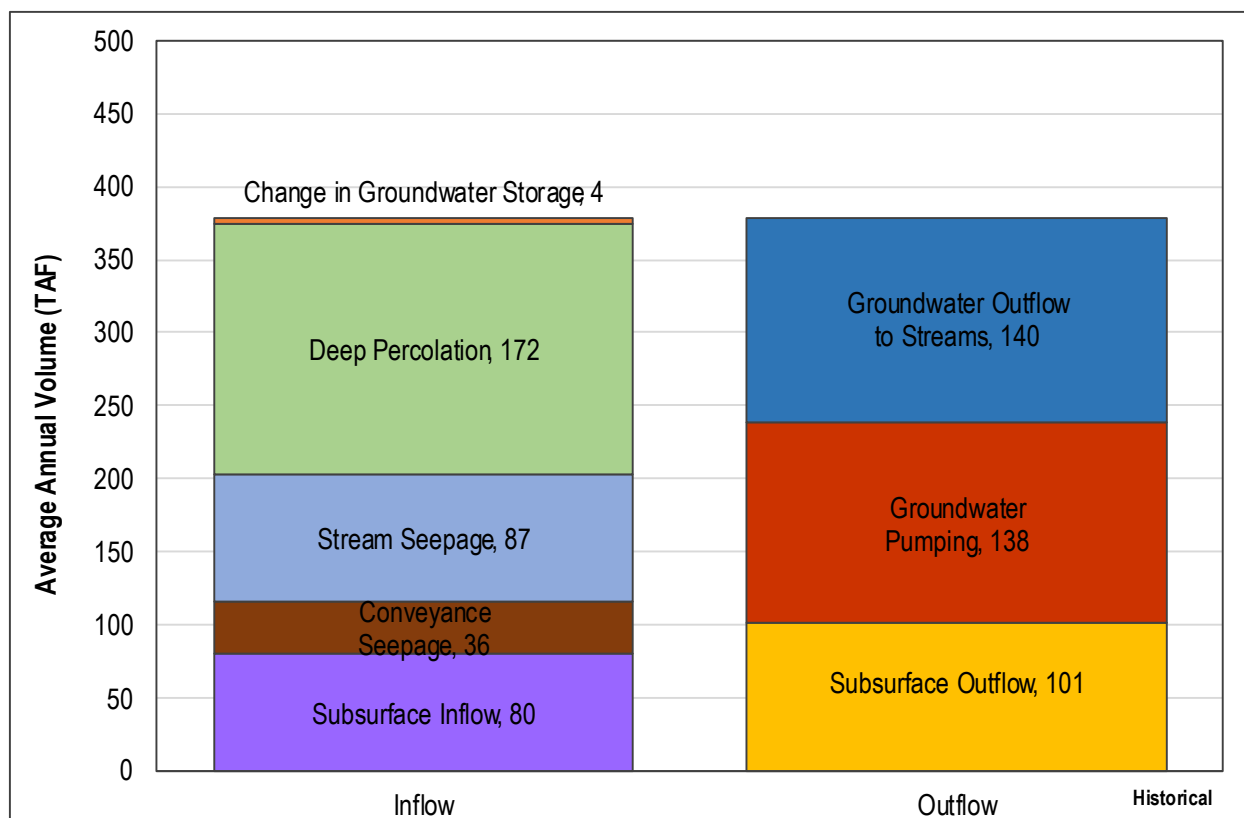


Figure 5-108. Historical Average Annual Water Budget – Groundwater System

Table 5-21 shows a breakdown of the major water budget components of the surface and groundwater systems by percentage use, including a change in overall groundwater storage of 4,000 AF/year. This constitutes a 0.008% change as a percent of the 49 MAF of total storage available.

Figure 5-109 shows the urban, agricultural (ponded and non-ponded crops), and managed wetlands supplies and demands from the previous tables broken down annually. Supplies are divided out by water source, either groundwater or surface water. Supplies are displayed as positive and demands as negative. **Figure 5-110** shows groundwater pumping annually plotted with annual change in storage. The cumulative change in storage is included throughout the water budget calibration period. In dry years with high groundwater pumping, there is a negative annual change in storage and the cumulative change in storage drops. This can be observed during the 2012-2016 drought. In wetter years, the groundwater gains storage and therefore the change in storage is positive and there is an increase in the cumulative change in storage.

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Table 5-21. Average Annual Water Budget Surface Water and Groundwater Major Components by Use

Component	Historical Calibration (thousand acre-feet [TAF]/year)	Current Conditions (TAF/year)	Projected Conditions (TAF/year)	Projected Conditions With Climate Change (2070 CT) (TAF/year)
Hydrologic Period	WY 1996-2015	WY 2021-2025	WYT 2006-2025 Repeated 3 Times	WYT 2006-2025 Repeated 3 Times with Climate Change
Surface System Major Components				
Precipitation	455	411	451	475
Surface Water Delivery	580	593	560	560
<i>Agricultural</i>	90%	86%	79%	79%
<i>Urban</i>	2%	3%	3%	3%
<i>Managed Wetlands</i>	8%	11%	18%	18%
Evapotranspiration	649	658	671	693
<i>Agricultural</i>	81%	83%	85%	85%
<i>Urban</i>	2%	2%	4%	4%
<i>Managed Wetlands</i>	1%	1%	3%	3%
<i>Native and Riparian Vegetation</i>	16%	14%	8%	8%
Groundwater System Major Components				
Net Groundwater Outflow to Streams	54	22	2	-9
Groundwater Pumping	138	139	224	241
<i>Agricultural</i>	92%	91%	81%	83%
<i>Urban</i>	7%	8%	12%	11%
<i>Managed Wetlands</i>	1%	1%	7%	7%
Change in Groundwater Storage	4	-5	0	0
As Percent of Overall Groundwater Storage (~49 MAFY)	0.008%	-0.010%	0.000%	0.000%

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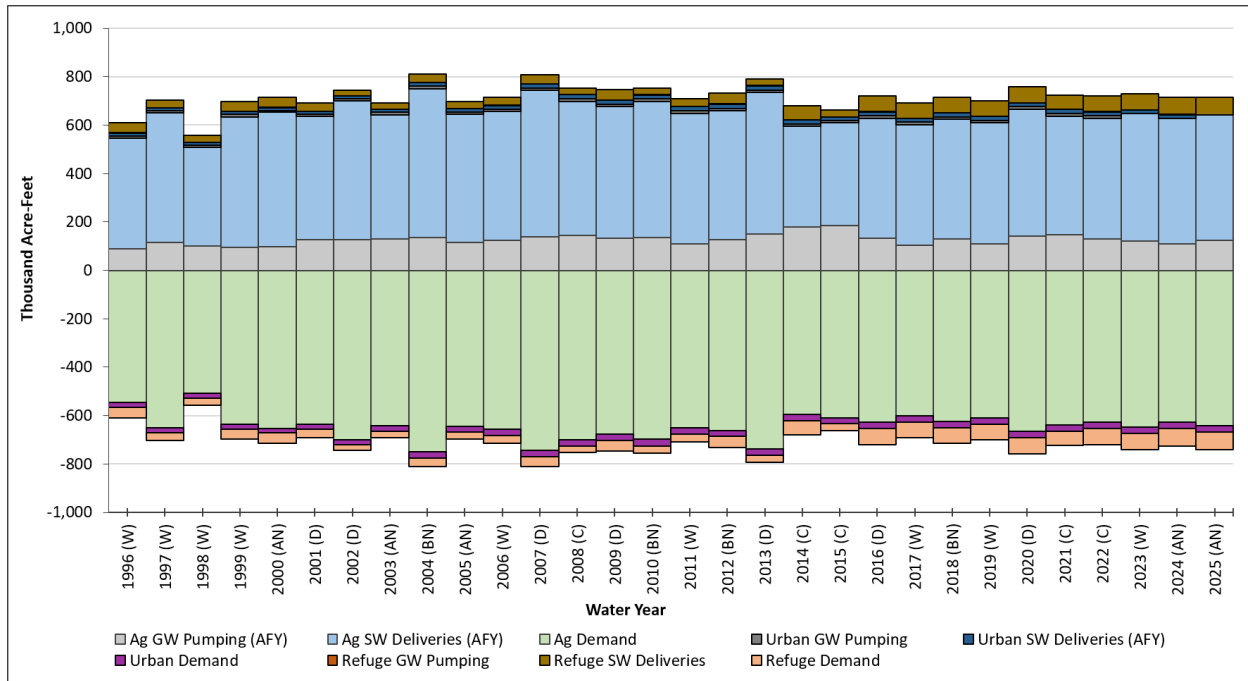


Figure 5-109. Historical Urban, Agricultural, and Refuge Demand and Supply ¹

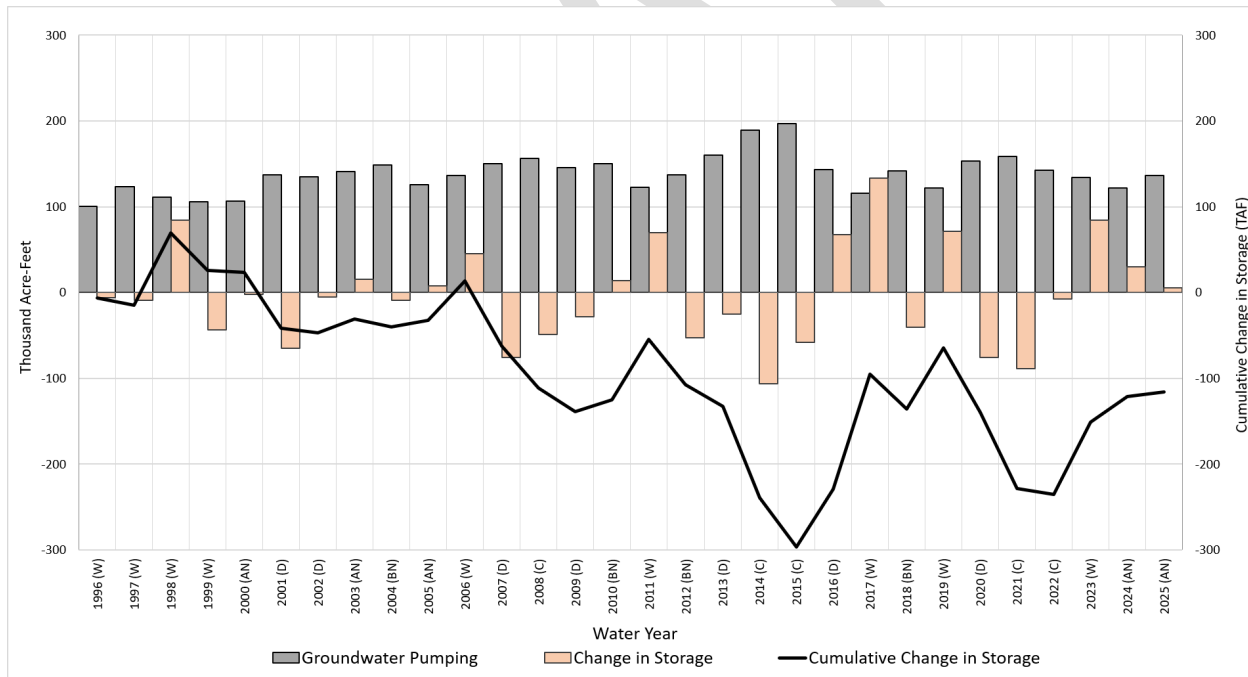


Figure 5-110. Historical Groundwater Pumping and Change in Storage

¹ Refuge in this figure refers to managed wetlands in Sutter Subbasin.

5.3.5.2 Current Conditions Water Budget Estimates

The current conditions water budget in **Table 5-19** and **Table 5-20** represents a quantitative tabulation of the average of WYs 2021-2025 extracted from the historical calibration of the C2VSimFG-Sutter model. As described in **Section 5.3.4**, the current conditions scenario is meant to simulate the most representative conditions available in the model at the time this GSP was written. The original GSP utilized WY 2013 as the current conditions, based on the model period being extended only through WY 2015; this was updated to an average of the five most recent years in the historical calibration.

The surface system water budget in the current conditions scenario is shown below in **Figure 5-111**. There are an estimated 1.165 MAF/year of inflows, approximately 28,000 AF/year lower than the historical model. This total is a combination of precipitation (411,000 AF/year), surface water supply (591,000 AF/year), groundwater supply (139,000 AF/year), and riparian intake from streams (24,000 AF/year). The outflow from the land surface system in the current conditions scenario estimates evapotranspiration (658,000 AF/year), runoff to the stream system (123,000 AF/year), return flow of applied water to the stream system (235,000 AF/year), and deep percolation of precipitation or applied water (150,000 AF/year). Approximately 86% of surface water deliveries are used for agricultural use, 11% for managed wetlands, and 3% for urban uses.

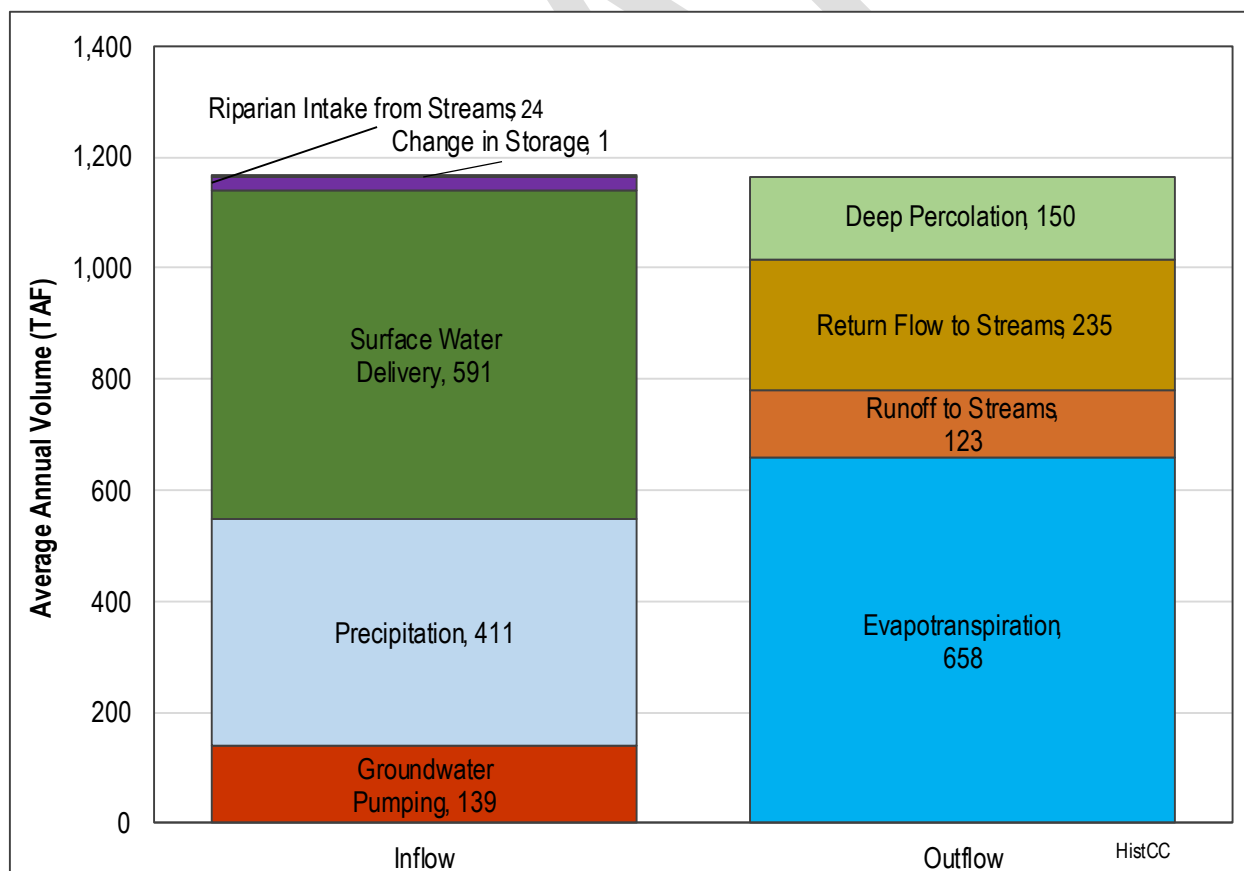


Figure 5-111. Current Conditions Average Annual Water Budget – Surface System

The groundwater system of the Sutter Subbasin (**Figure 5-112**) includes 365,000 AF/year of inflows in the current conditions (not including change in groundwater storage), of which 151,000 AF/year is deep percolation of precipitation or applied water (groundwater and surface water). There is also stream seepage (90,000 AF/year), conveyance seepage (36,000 AF/year), and subsurface inflows (88,000 AF/year) from the neighboring groundwater subbasins of Colusa, Yolo, North American, North and South Yuba, Butte, and a very small portion from Wyandotte Creek Subbasin. The Sutter Buttes also contributes subsurface inflows. The primary outflows from the groundwater system are loss to streams (113,000 AF/year) and groundwater pumping (139,000 AF/year). Subsurface outflow to the neighboring groundwater subbasins is approximately 108,000 AF/year. Approximately 91% of the groundwater pumping from the groundwater system is for agricultural use, 8% for urban use, and the remaining 1% for managed wetlands.

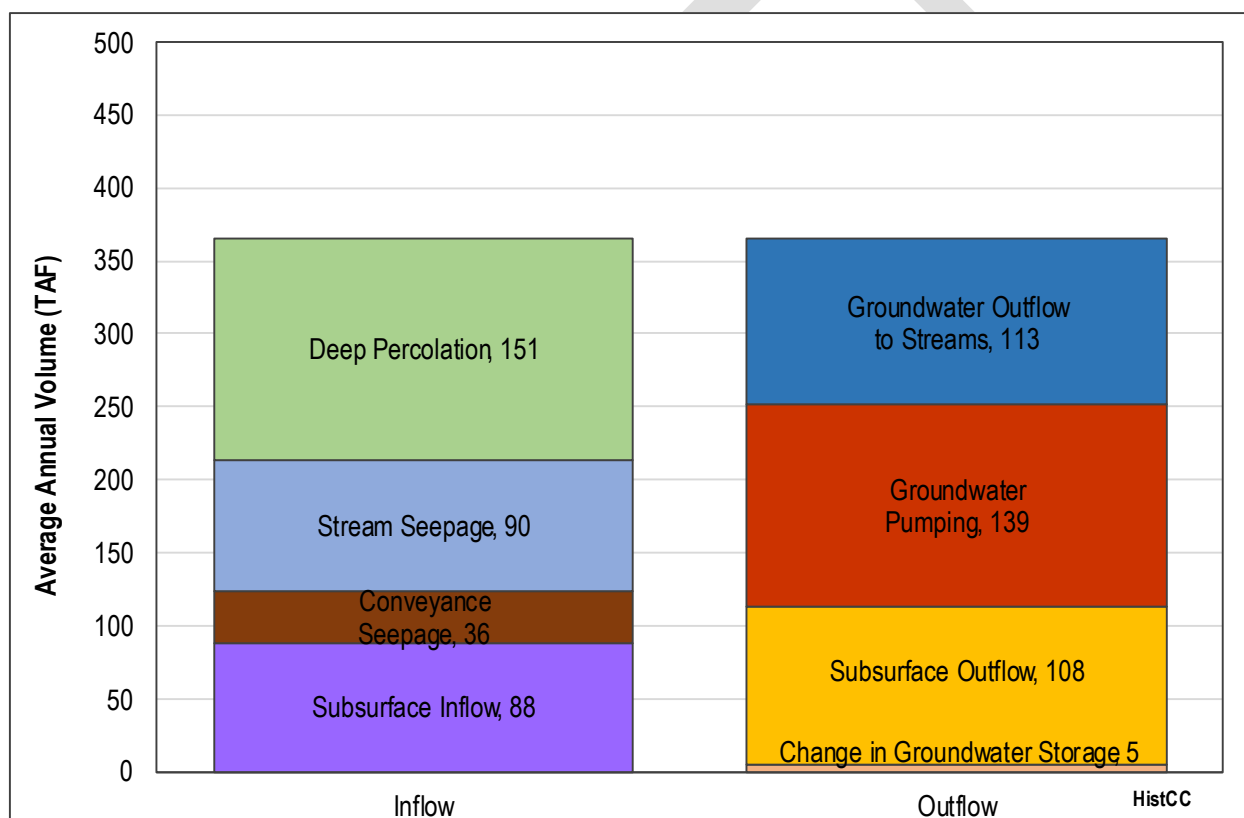


Figure 5-112. Current Conditions Average Annual Water Budget – Groundwater System

The Sutter Subbasin average current conditions groundwater budget has slightly greater inflows than outflows, leading to an estimated average annual increase in groundwater storage of approximately 5,000 AF/year. This change in storage is approximately 0.010% of the estimated 49 MAF of groundwater in storage, a relatively small change in comparison to the total overall available groundwater storage. **Table**

5-21 includes this change in storage as compared to the historical model as well as the surface and groundwater major components broken down by use.

5.3.5.3 Projected Conditions Water Budget Estimates

The projected conditions water budget is used to estimate future baseline conditions of supply, demand, and aquifer response to GSP implementation. The projected conditions scenario of the C2VSimFG-Sutter Version 2.0 model is used to evaluate the projected conditions water budget assuming a 2042 level of development and using hydrology from WYs 1996 through 2015, averaged by aggregated water year type and applied to the water year type time series for 2006 to 2025 repeated three times to meet the minimum 50-year projection requirement. Results of the projected conditions scenario under potential climate change conditions (changes to precipitation, stream flows, and evapotranspiration) are presented in **Section 5.3.5.4**.

Development of the projected water demand is based on historical population growth trends projected into the future and urban per capita water use consistent with projections in 2025. An important assumption made in the projected conditions water budget analysis is that, due to projected urban buildout in the City of Live Oak and City of Yuba City, agricultural acreage is expected to decrease by approximately 19,000 acres over the projected period compared to current conditions. This buildout and population growth drives more urban pumping in the projected conditions compared to the historical or current conditions.

The surface water budget for the projected conditions scenario has annual average inflows and outflows of 1.25 MAF/year and 1.249 MAF/year, respectively. Inflows consist of precipitation (451,000 AF/year), surface water supply (561,000 AF/year), groundwater supply (223,000 AF/year), and riparian intake from streams (15,000 AF/year). Outflows consist of average annual evapotranspiration (671,000 AF/year), runoff of precipitation to the stream system (122,000 AF/year), return flow of applied water to the stream system (256,000 AF/year), and deep percolation (200,000 AF/year). A summary of these flows can be seen below in **Figure 5-113**.

Figure 5-114 summarizes the average projected groundwater inflows and outflows in Sutter Subbasin under projected conditions. The groundwater system experiences an average of 423,000 AF/year of inflows each year, of which 200,000 AF/year is deep percolation under projected conditions. There is estimated to be 96,000 AF/year of stream seepage inflow, which is more than historical conditions, conveyance seepage is estimated to be 36,000 AF/year, and subsurface inflows from neighboring subbasins are estimated to be 91,000 AF/year. Groundwater outflows to streams are approximately 99,000 AF/year and subsurface outflow are estimated to be 101,000 AF/year. Groundwater pumping increases from historical levels to 224,000 AF/year under projected future conditions.

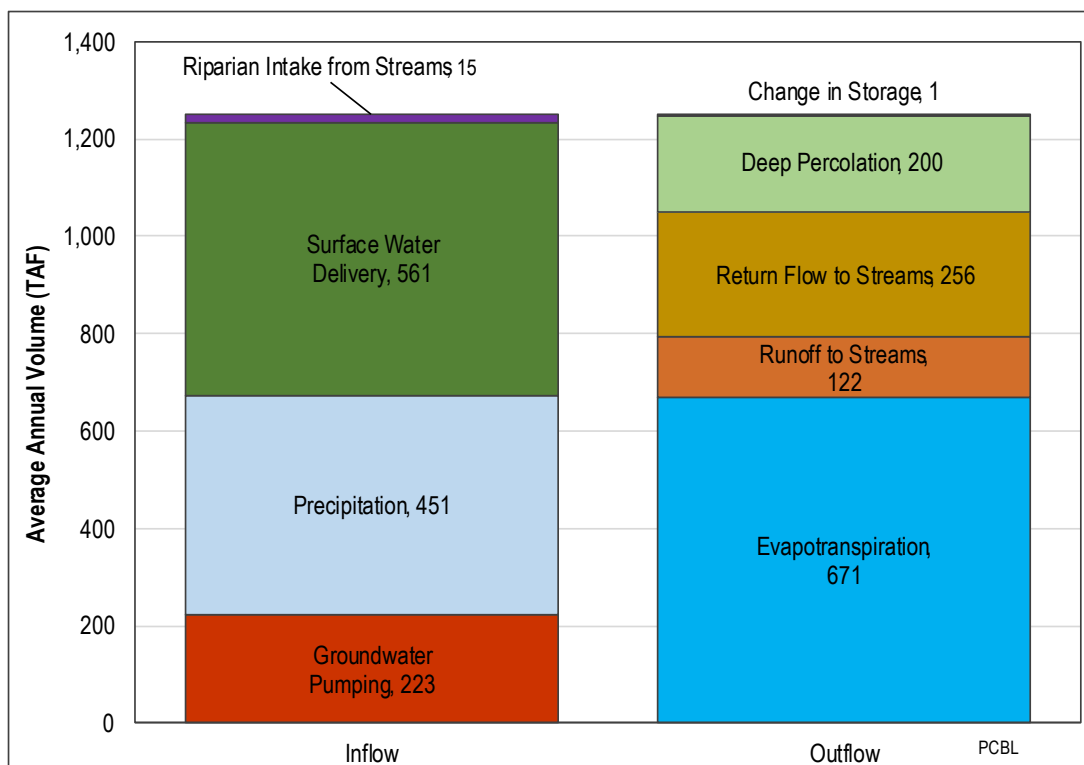


Figure 5-113. Projected Conditions Average Annual Water Budget – Surface System

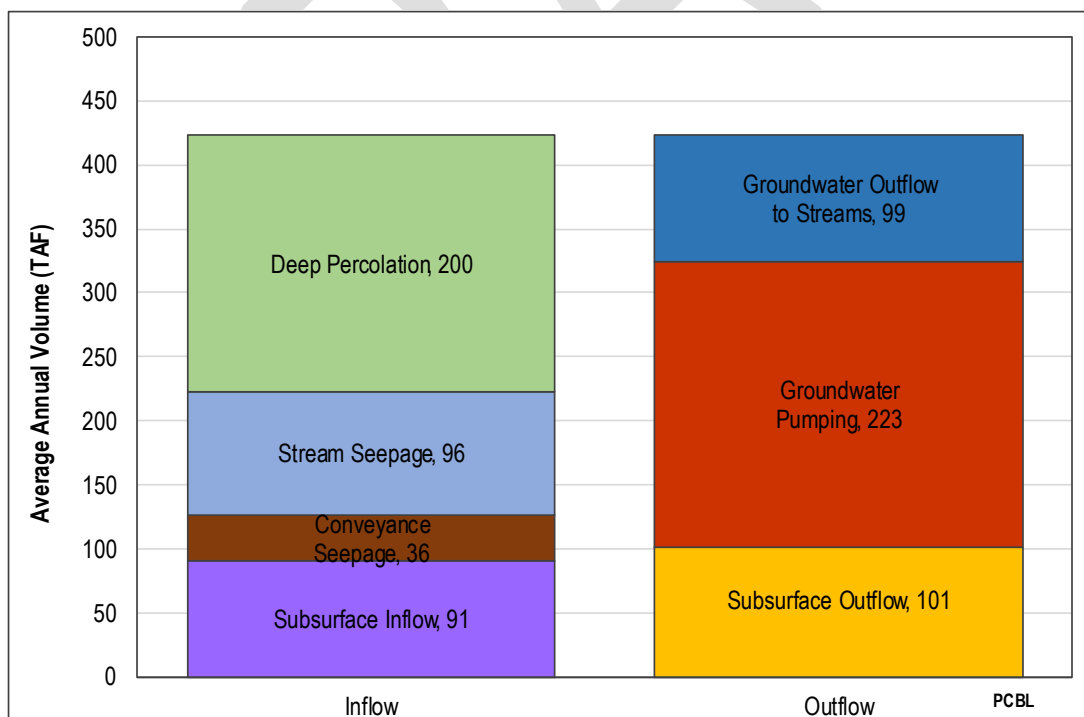


Figure 5-114. Projected Conditions Average Annual Water Budget – Groundwater System

The projected conditions water budget has balanced inflows and outflows resulting in no change in groundwater storage. **Table 5-21** shows the major water budget components of the surface and groundwater systems discussed above for all scenarios. Under projected conditions, 85% of the groundwater pumping is expected to be for agricultural use, which is slightly higher than the current conditions model's 83% average. There are decreases in the proportion of surface water delivered for agricultural use in comparison to historical and current conditions and corresponding increases in the proportion delivered to managed wetlands. Increased urban demand is expected to be met by increasing the proportion of supply from groundwater pumping; this is a conservative estimate since additional surface water supply may be available in a future scenario.

5.3.5.4 Projected Conditions with Climate Change Water Budget Estimates

Consistent with Section 354.18(d)(3) and Section 354.18(e) of the GSP Emergency Regulations, an analysis was performed for the Sutter Subbasin evaluating the projected conditions water budget under the influence of climate change. The regulations require that at least one climate change scenario is incorporated into the GSP. Sutter Subbasin elected to use the datasets DWR developed and provided for SGMA purposes. The following four possible scenarios were provided by DWR:

- 2030 Central Tendency
- 2070 Central Tendency
- 2070 Dry, Extreme Warming
- 2070 Wet, Moderate Warming

The projected conditions in the C2VSimFG-Sutter Version 2.0 model were modified to include adjustments to precipitation, evapotranspiration, and streamflow to simulate the impacts of climate change using the 2070 Central Tendency (CT) scenario. This scenario was chosen for its useful long-term planning horizon (about 50 years) and moderate climate change impact estimations. The projected conditions with climate change water budget includes all of the assumptions of the projected conditions water budget, along with more variable precipitation and streamflow and increased evapotranspiration due to increasing temperatures.

The surface water budget for the projected conditions with climate change scenario has annual average inflows and outflows of 1.29 MAF/year and 1.289 MAF/year, respectively. Inflows consist of precipitation (475,000 AF/year), surface water supply (560,000 AF/year), groundwater supply (240,000 AF/year), and riparian intake from streams (15,000 AF/year). The balance of this is the summation of average annual evapotranspiration (693,000 AF/year), runoff of precipitation to the stream system (146,000 AF/year), return flow of applied water to the stream system (250,000 AF/year), and deep percolation (200,000 AF/year). A summary of these flows can be seen below in **Figure 5-115**.

Results from a comparison between the projected conditions with and without climate change show that the C2VSimFG-Sutter Version 2.0 model estimates precipitation to increase by 5% on average and evapotranspiration to increase by 3% on average in the surface system under the 2070 Central Tendency climate scenario. **Appendix 5-F** includes more detail on how the datasets provided by DWR were derived as well as further explanation regarding the methods used in this analysis.

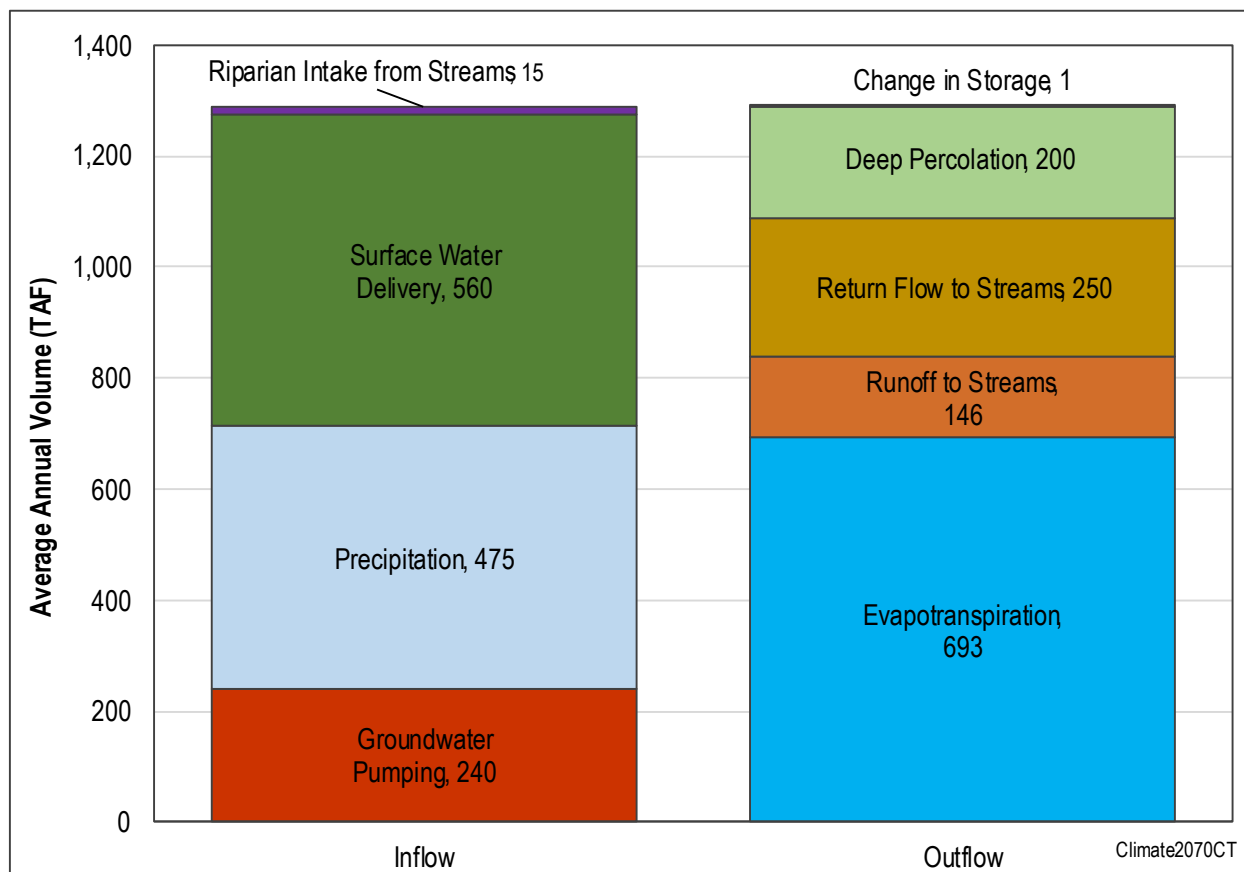


Figure 5-115. Projected Conditions with Climate Change Average Annual Water Budget – Surface System

Figure 5-116 summarizes the average projected groundwater inflows and outflows in Sutter Subbasin under projected conditions with climate change. The groundwater system experiences an average of 441,000 AF/year of inflows each year, of which 200,000 AF/year is deep percolation under projected conditions with climate change, which is the same as projected conditions without climate change. The projected conditions with climate change scenario shows more stream seepage (110,000 AF/year) than historical conditions, the same conveyance seepage of 36,000 AF/year compared to other water budget conditions, and subsurface inflows of 95,000 AF/year from neighboring subbasins, a slight increase from historical model estimations and also slightly higher than projected conditions without climate change. Groundwater outflows to streams is approximately 101,000 AF/year and subsurface outflow 100,000 AF/year.

Groundwater pumping is expected to increase as a result of shifting availability of streamflow and higher agricultural demand to 240,000 AF/year.

The principal groundwater budget elements that are impacted by climate change are seepage to groundwater from streams (15% average increase) and groundwater pumping (8% average increase), based on C2VSimFG-Sutter model's estimates under the 2070 Central Tendency climate scenario.

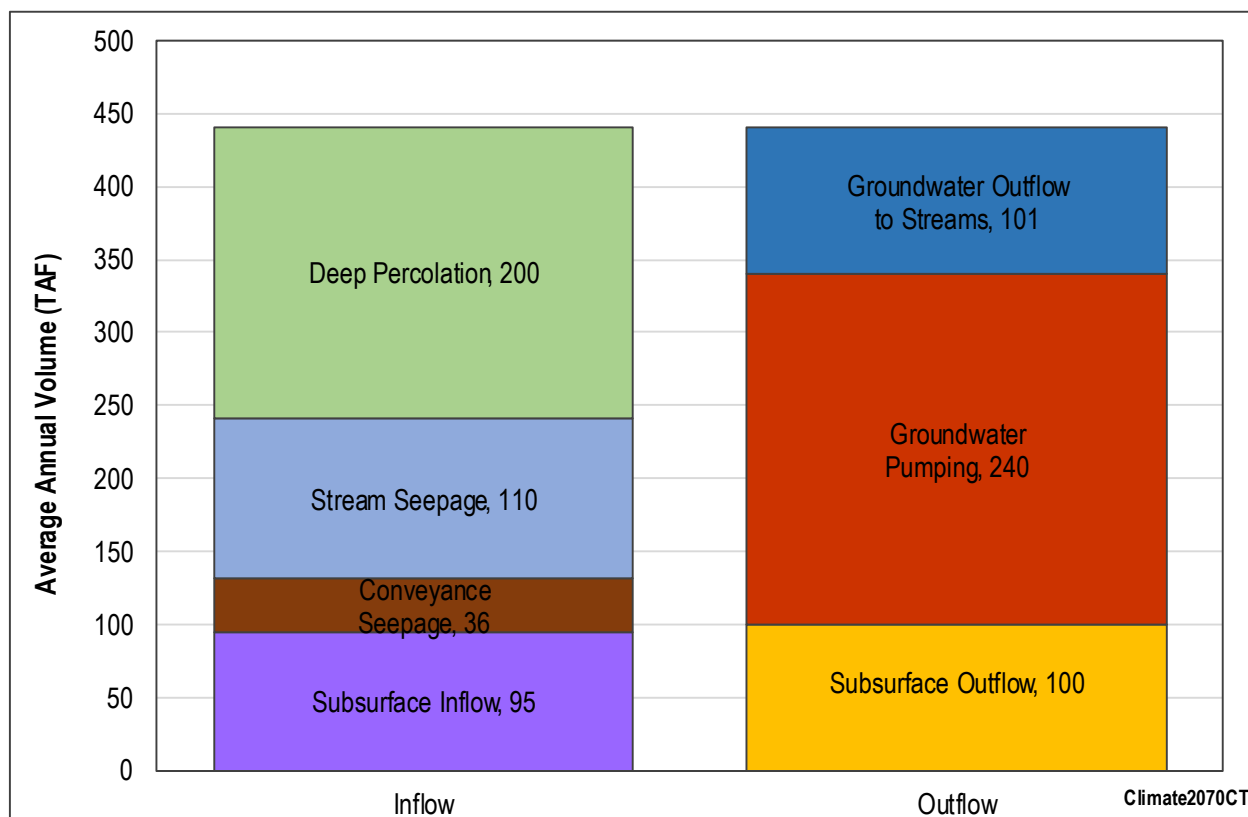


Figure 5-116. Projected Conditions with Climate Change Average Annual Water Budget – Groundwater System

Table 5-21 tabulates each of the major surface system and groundwater system components discussed in this section by the proportion of their use. Most notable may be the shifting distribution of use of groundwater pumping and surface water deliveries between historical conditions and projected conditions with climate change. Groundwater pumping for agricultural use from historical conditions to projected conditions with climate change changes from 92% to 83%. For urban use, groundwater pumping changes from a historical use of 7% to a projected use of 11%, and for managed wetlands, from 1% to 3%. Surface water deliveries change from 90% agricultural to 79% and 8% to 18% for managed wetlands. Only a small amount of surface water is used for urban use and it is not expected to change significantly with climate change conditions.

5.3.6 Estimation of Sustainable Yield

Sustainable yield is defined for SGMA purposes as “the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.” (CWC §10721(w)).

Sustainable yield for the Sutter Subbasin was calculated using C2VSimFG-Sutter Version 1.0 in the original GSP by increasing the demand over the 60-year hydrology of the projected conditions model to analyze where the change in storage is close to zero and at what point undesirable results begin to occur and impact the overall water budget balance (sustainable conditions scenario). Increased demand was simulated in the model by increasing evapotranspiration. Various scenarios of increased demand/evapotranspiration rates were simulated and their water budgets compared to see what level of groundwater production resulted in a long-term change in storage of, or very close to, zero.

The increase in demand that resulted in a change in groundwater storage of almost zero was a 20% increase in evapotranspiration. This increased demand led to a 33% increase in groundwater pumping over the projected conditions scenario. The sustainable conditions scenario resulted in groundwater outflows almost equal to groundwater inflows, bringing the long-term (60-year) average change in groundwater storage to close to zero. Based on this analysis, the sustainable yield of the Subbasin was calculated to be 182,000 AF/year.

As previously discussed and shown in **Table 5-21**, the change in storage under the projected water budget simulated using C2VSimFG-Sutter Version 2.0 resulted in a zero acre-foot change in storage over the 60-year simulation period. Groundwater pumping in this scenario was estimated to be 224,000 AF/year on an annual average. This number is larger than the current pumping in the Subbasin (estimated to be 139,000 AF/year over the past five years) and the sustainable yield estimated using C2VSimFG-Sutter Version 1.0 in the original GSP. Recognizing the currently sustainable conditions of the Subbasin and applying conservative assumptions, the sustainable yield for the Subbasin will remain at the original 182,000 AF/year for the purposes of this GSP amendment. The sustainable yield value will be reviewed every five years as part of the Subbasin’s Periodic Evaluation, and if indicated by future average pumping volumes increasing closer to the previously estimated sustainable yield (182,000 AF/year) and observed sustainable conditions in the Subbasin, the sustainable yield value may be increased to a volume estimated using a future improved C2VSimFG-Sutter model.

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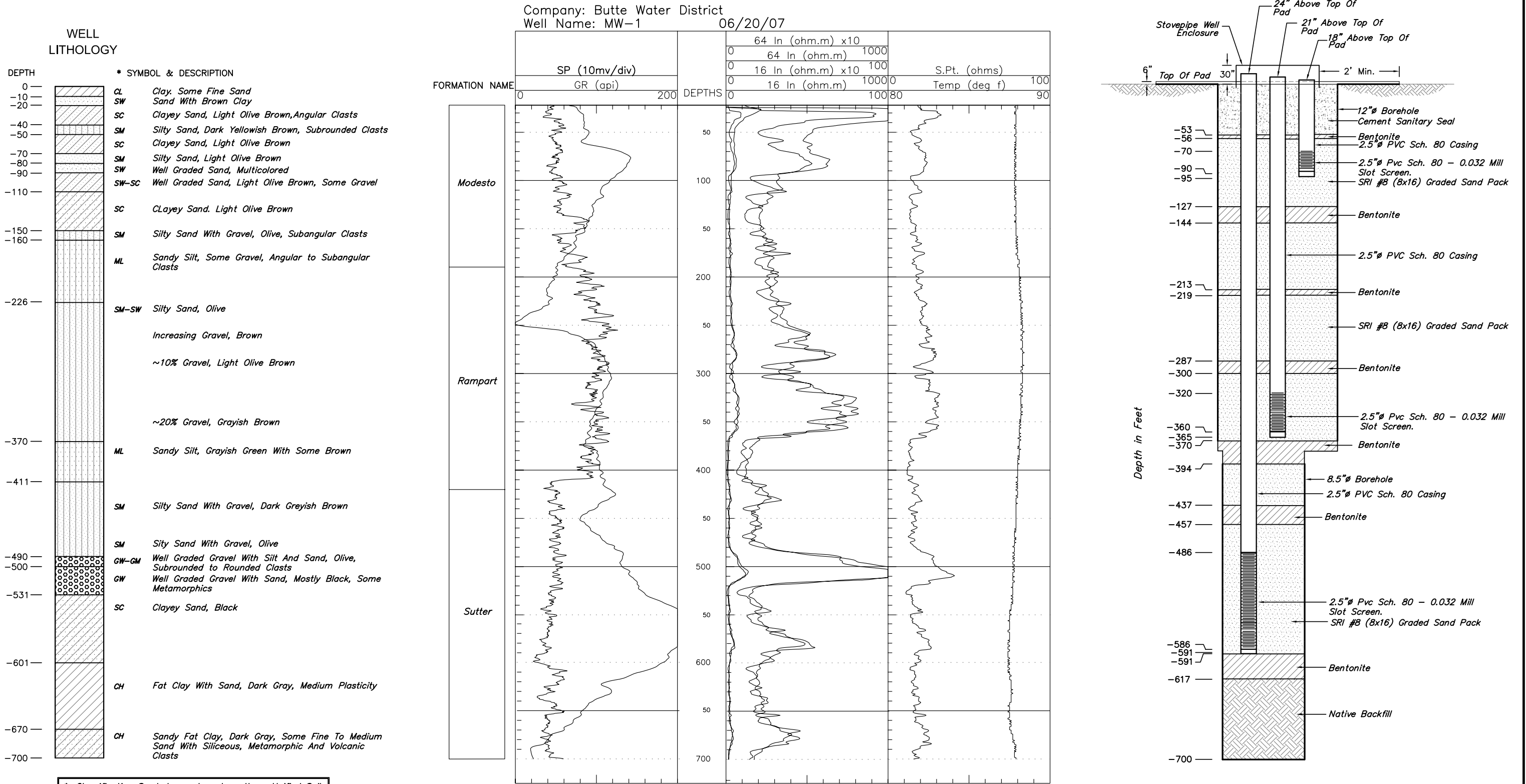
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Appendix 5-A
Well Logs Used to Develop Geologic Cross Sections

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S:\Water Resource\Projects\050790\As-Built\BWD MW-1\Figure 2 MW-1 As-Built.dwg C-01-MW-1 Mar 04, 2008 05:20:16 pm



5201 Woodmere Drive, Bakersfield, CA 93313-- www.welenco.com--(800) 445-9914
California Contractor's License No. 722373

ELECTRIC - GAMMA RAY - TEMPERATURE LOG

FILING NO.	COMPANY <u>Eaton Drilling</u>	
	WELL	<u>DWR-SC-MW-2</u>
	FIELD	<u>Robbins</u>
	STATE	<u>California</u> COUNTY <u>Sutter</u>
	LOCATION:	<u>Hwy 113 & Reclamation Road</u>
JOB NO. 12348	OTHER SERVICES: <u>Guard</u> <u>Borehole Geometry</u> <u>Dual Induction</u>	
SEC: <u>23</u> TWP: <u>12N</u> RGE: <u>2E</u> LAT.: <u>38° 52' 33.3"</u> LONG.: <u>121° 42' 33.8"</u> MERIDIAN.: <u>Mt. Diablo</u>		
Permanent Datum: <u>Ground Level</u> , Elev. <u>78</u> Ft. Elev.: K.B. <u> </u> Ft.		
Log Measured From: <u>Ground Level</u> , <u>0</u> Ft. Above Perm. Datum D.F. <u> </u> Ft.		
Drilling Measured From: <u>Ground Level</u> G.L. <u>78</u> Ft.		
Run	<u>One</u>	
Date	<u>Apr. 22, 2010</u>	
Depth-Driller	<u>1500</u> Ft	Ft
Depth-Logger	<u>1498</u> Ft	Ft
Top Logged Interval	<u>20</u> Ft	Ft
Btm. Logged Interval	<u>1498</u> Ft	Ft
Casing-Driller	<u>n/a</u> In @ Ft	In @ Ft
Casing-Logger	<u>n/a</u> In @ Ft	In @ Ft
Bit Size	<u>8.5</u> In	In
Time On Bottom	<u>11:30</u>	
Type Fluid In Hole	<u>Bentonite</u>	
Density	<u>n/a</u>	<u>n/a</u>
pH	<u>n/a</u> ml	ml
Source of Sample	<u>Circ</u>	
Rm @ Measured Temp.	<u>6.7</u> @ <u>82</u> °F	@ °F
Rmf @ Measured Temp.	<u>5.4</u> @ <u>75</u> °F	@ °F
Rmc @ Measured Temp.	<u>n/a</u> @ °F	@ °F
Source Rmf	<u>Meas</u>	
Rm @ BHT	<u>n/a</u> @ °F	@ °F
Time Since Circulation	<u>2 hr</u> Hr	Hr
Max. Rec. Temp.	<u>79.8</u> °F	°F
Van No.	<u>LV-2</u>	<u>Sac</u>
Recorded By	<u>M. F. Sharpless</u>	
Witnessed By	<u>S. Springhorn</u>	

Miscellaneous Information

A recreational GPS accurate to +/- 45 feet set for Datum NAD27 was used to calculate Latitude, Longitude & Elevation values. The Section, Township, and Range then determined using the TRS program (TRS accuracy is not guaranteed). The TRS program converts Latitude and Longitude to Section, Township, and Range. The NOTICE at the bottom of this heading also applies.

SP Calculations For Water Quality

LOG DEPTHS	S.P.	Rwe	Rw RANGE Ohmeters2/M		E.C. RANGE MSiemens		TDS RANGE ppm	
			NaCl	NaHCo3	NaCl	NaHCo3	NaCl	NaHCo3
95 to 145 Feet	-30	2.0	1.9	2.2	5263	4545	2789	5000
205 to 220 Feet	-7	4.3	4.9	5.8	2041	1724	1082	1667
260 to 400 Feet	-3	4.9	5.8	6.8	1724	1471	914	1429
450 to 500 Feet	-2	5.1	6.1	7.2	1639	1389	869	1429
560 to 790 Feet	-2	5.1	6.1	7.2	1639	1389	869	1429
810 to 1000 Feet	-4	4.7	5.5	6.5	1818	1538	964	1429
1200 to 1250 Feet	-20	2.8	2.9	3.4	3448	2941	1828	3333
1250 to 1430 Feet	-38	1.6	1.5	1.8	6667	5556	3533	5000

Class I (Excellent to Good)

Less than 700 ppm

Class II (Good to Injurious)

700-2000 ppm

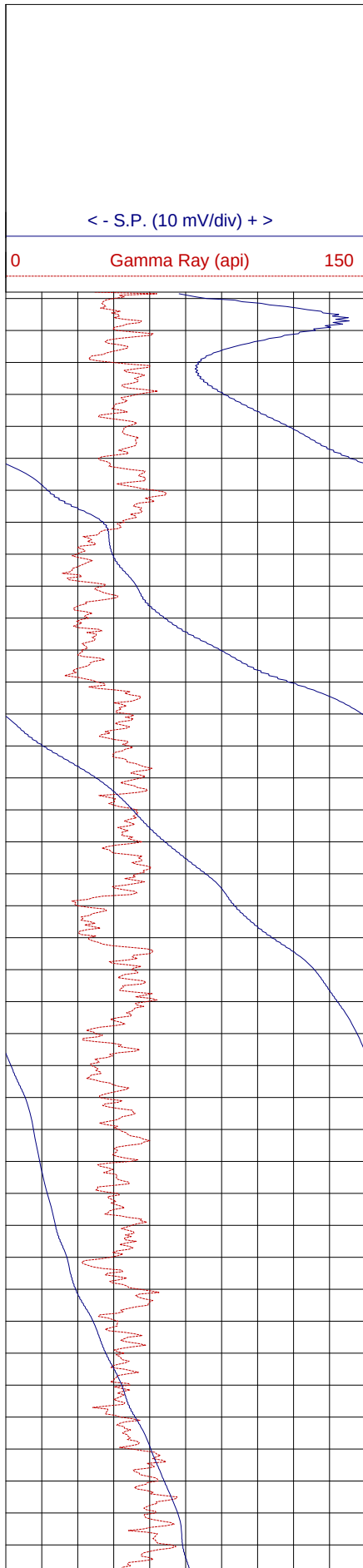
Class III (Injurious to Poor)

More than 2000 ppm

NOTICE

All interpretations are opinions based on inferences from electrical and other measurements and we do not guarantee the accuracy or correctness of any verbal or written interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by one of our officers, agents or employees. These interpretations are also subject to our General Terms and Conditions as set out in our current Price Schedule.

welenco, inc. April 22, 2010



DEPTHS

2 in/100ft

18

50

100

150

200

250

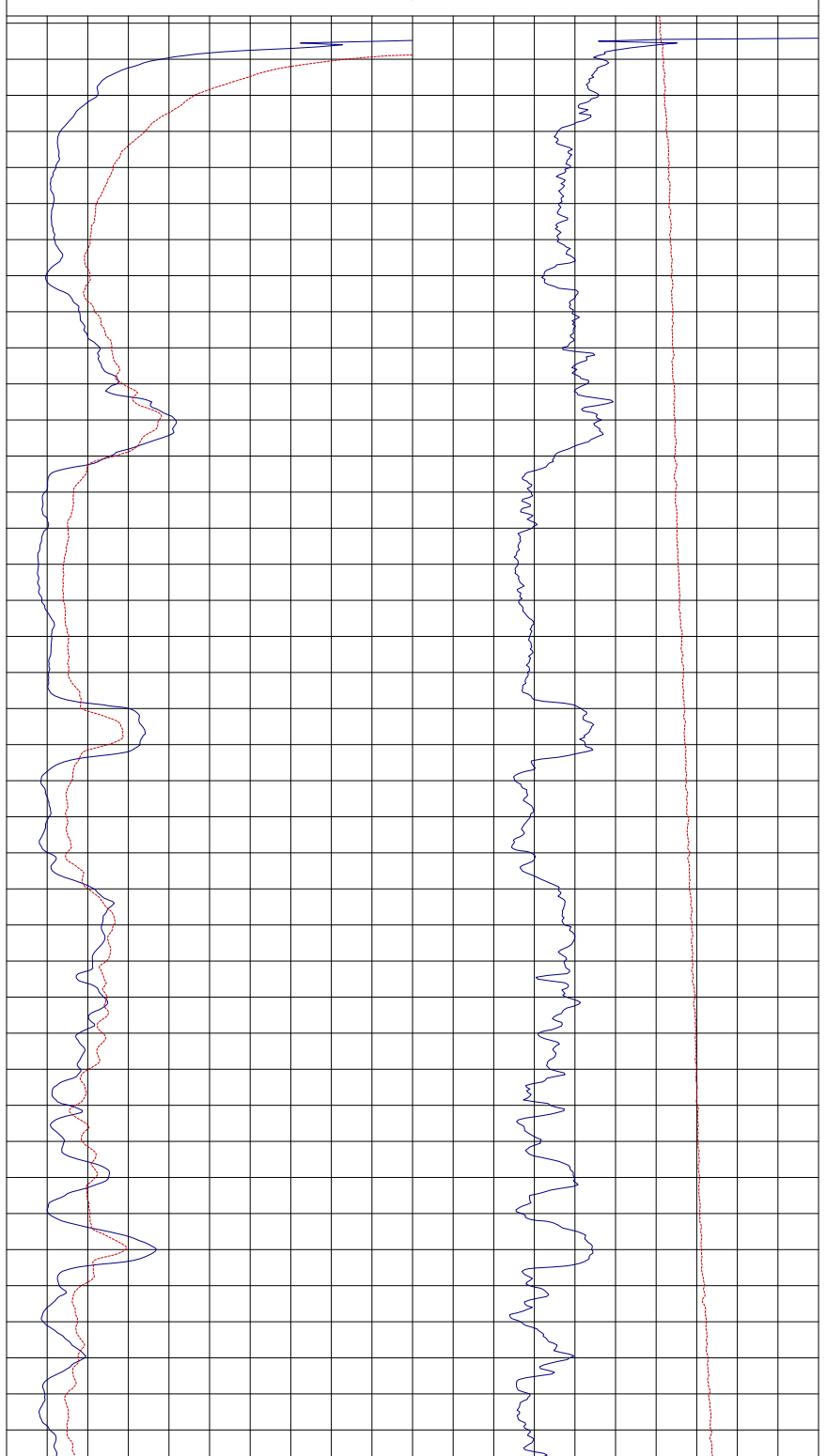
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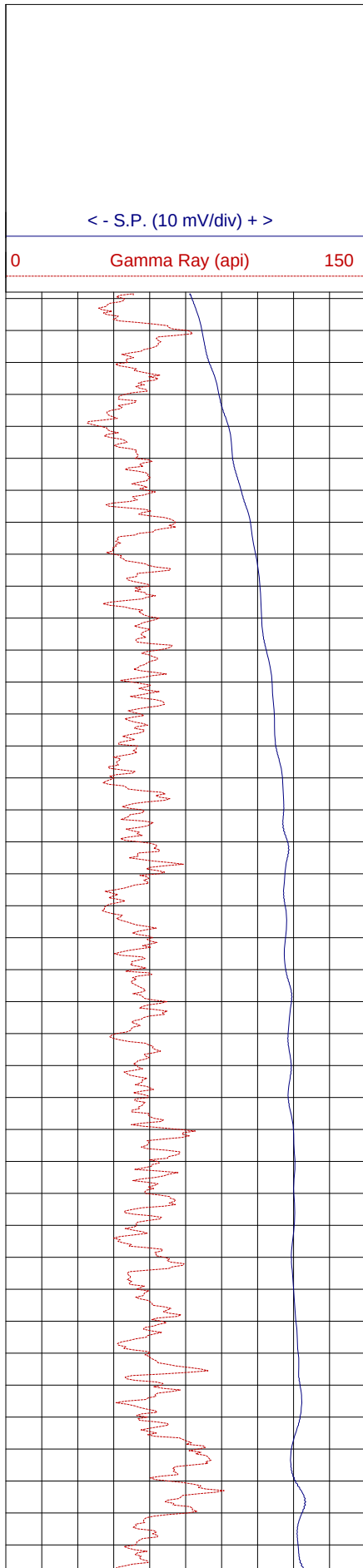
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400

ELECTRIC - GAMMA RAY - TEMPERATURE LOG

0	64 Inch Normal (ohmmeter ² /m)	100	0	Single Point (ohms)	50
0	16 Inch Normal (ohmmeter ² /m)	100	70	Temperature (°F)	80





DEPTHS

2 in/100ft

450

500

550

600

650

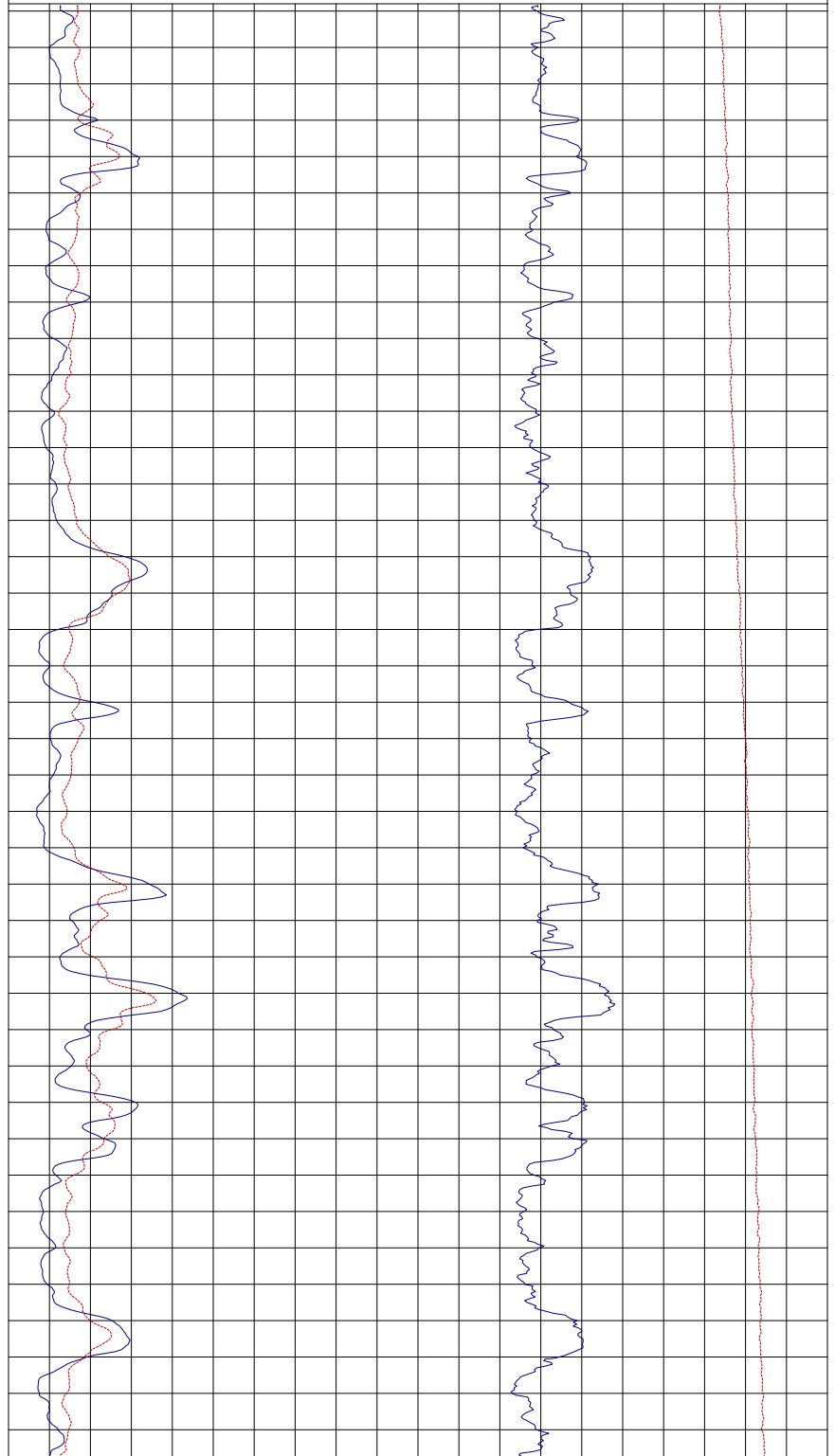
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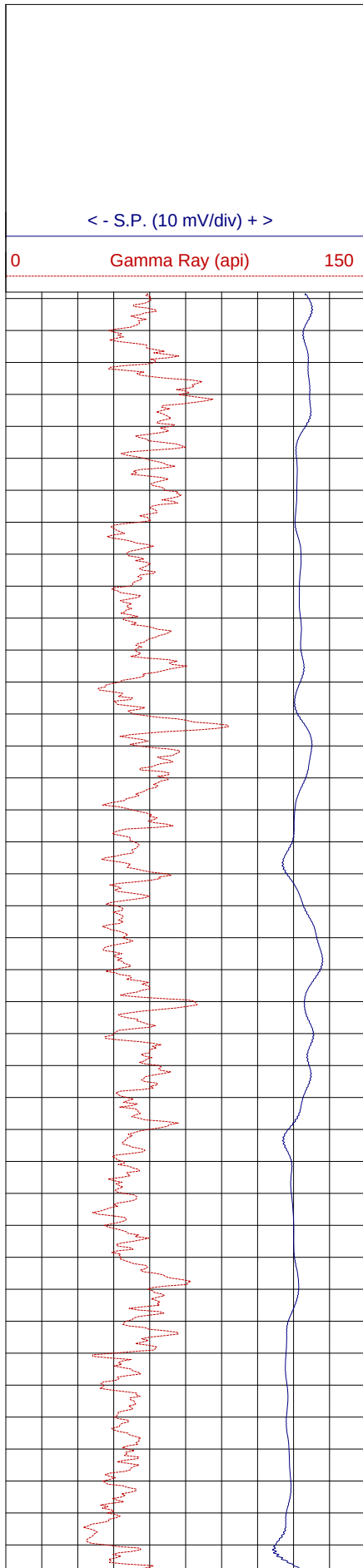
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800

ELECTRIC - GAMMA RAY - TEMPERATURE LOG

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0	16 Inch Normal (ohmmeter ² /m)	100	70	Temperature (°F)	80





DEPTHS

2 in/100ft

850

900

950

1000

1050

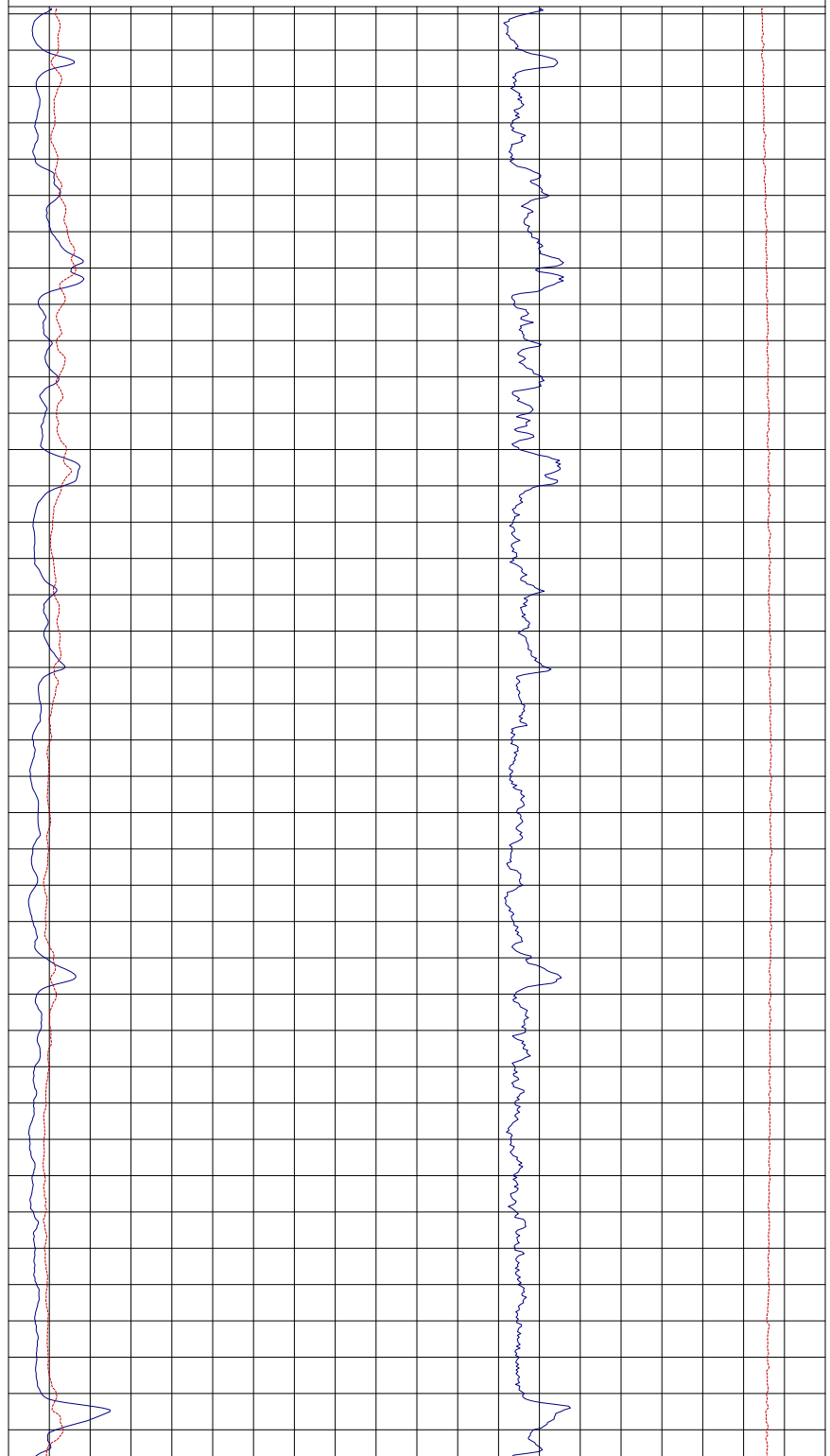
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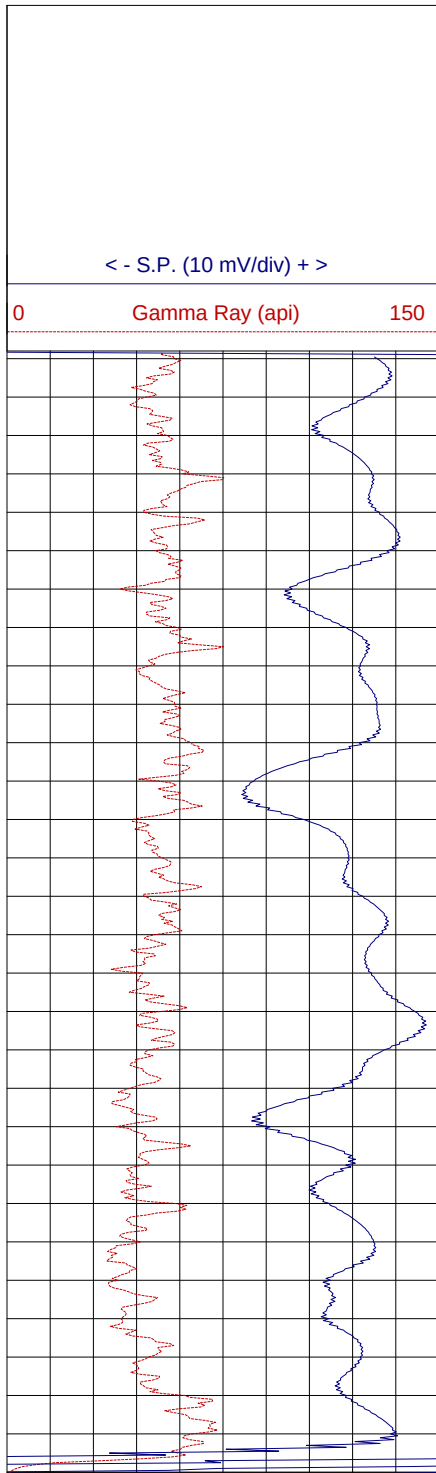
1150

1200

ELECTRIC - GAMMA RAY - TEMPERATURE LOG

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0	16 Inch Normal (ohmmeter ² /m)	100	70	Temperature (°F)	80





Log Page No. 4 of 4 Pages

DEPTHS

2 in/100ft

1250

1300

1350

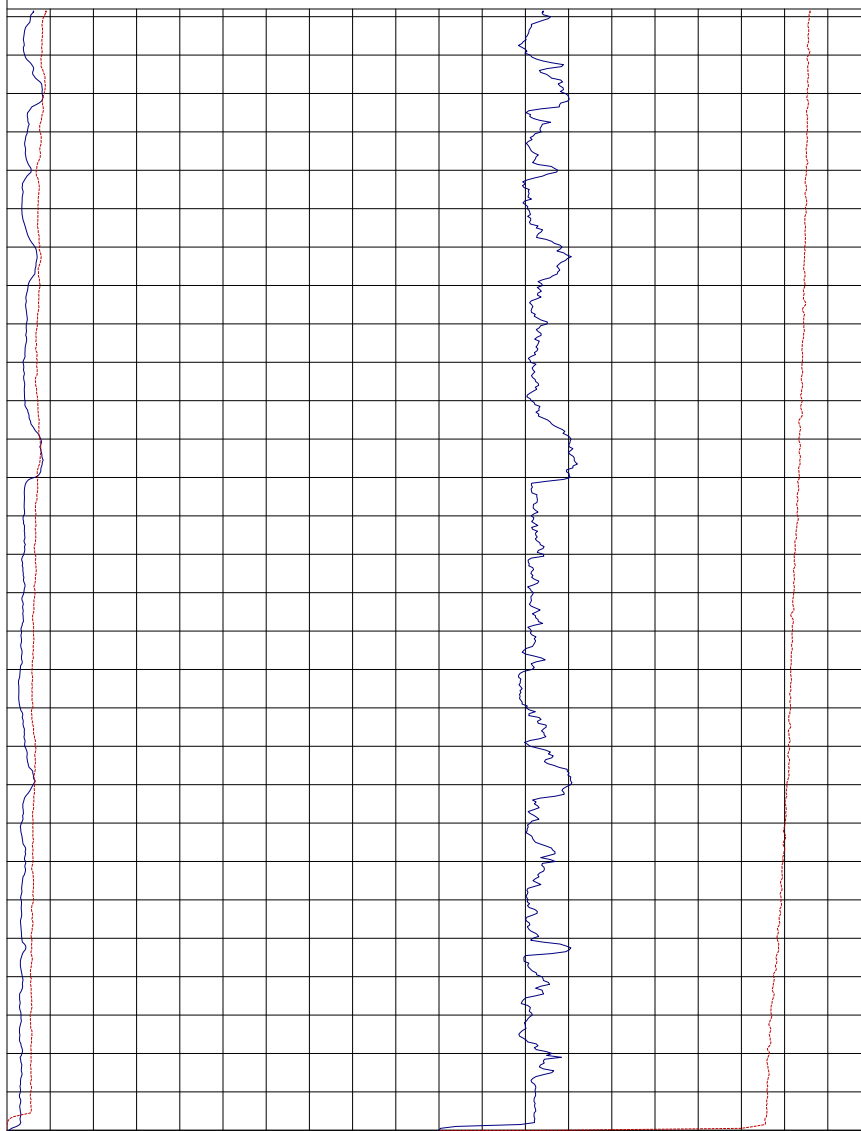
1400

1450

1500

ELECTRIC - GAMMA RAY - TEMPERATURE LOG

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0	16 Inch Normal (ohmmeter ² /m)	100	70	Temperature (°F)	80

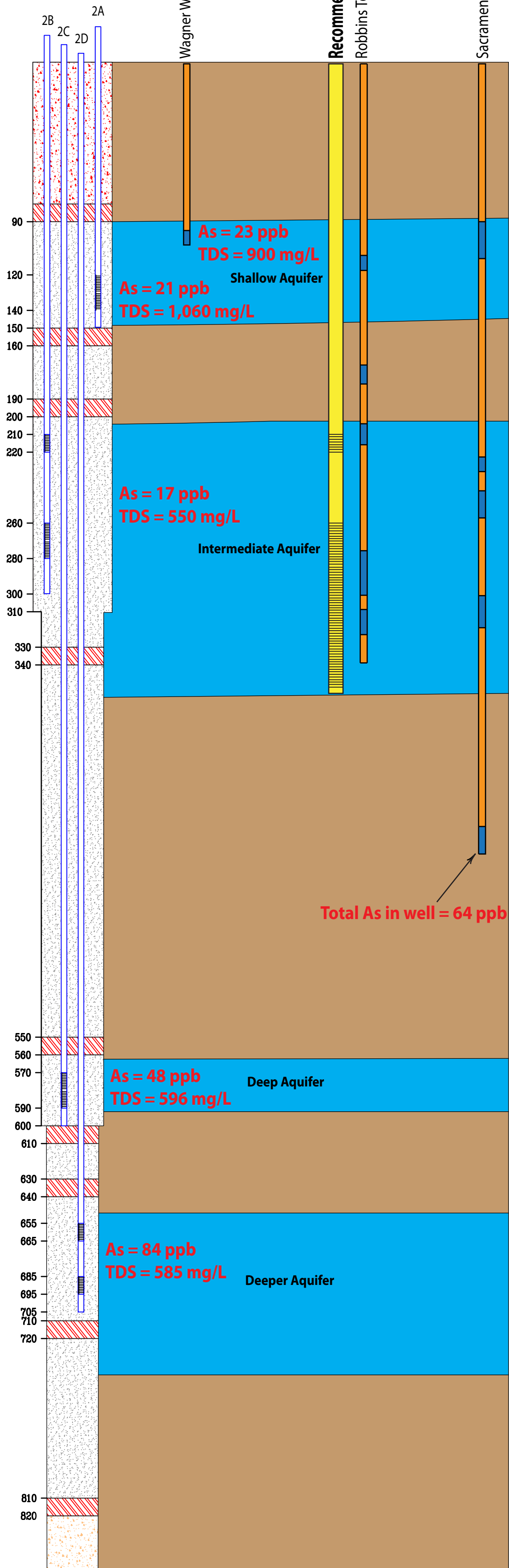


Page Length: 1218 - 1510 Feet (292 Feet)

Time: 05:19:16 PM

Date: Apr 22, 2010

DWR
Sutter County MW-2A,B,C,D



Legend			
Recommended Well		Well Screen	
Permiable Unit (as identified in Driller's Log)		Aquifer	
Non-permiable Unit (as identified in Driller's Log)		Aquatard	

ORIGINAL
File with DWR

Page 1 of 6

Owner's Well No. 7912

Date Work Began 11/8/05, Ended 11/17/05

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0259 Permit Date 10/28/05

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **816295**

DWR USE ONLY — DO NOT FILL IN	
15ND2E11	
STATE WELL NO./STATION NO.	
LATITUDE	LONGITUDE
APN/TRS/OTHER	

GEOLOGIC LOG

ORIENTATION (✓)		DRILLING METHOD	REVERSE	FLUID WATER
DEPTH FROM SURFACE		DESCRIPTION		
Ft.	to Ft.	Describe material, grain, size, color, etc.		
0	22	WELL GRADED SAND		
22	70	CLAY WITH SANDY SILT		
70	103	YELLOW BROWN CLAY		
103	133	LIGHT YELLOW BROWN SANDY CLAY		
133	158	RED BROWN SILT		
158	175	RED POORLY GRADED SAND		
175	198	BROWN SANDY SILT		
198	250	GRAY POORLY GRADED SNAD WITH GRAVEL		
250	260	BROWN WELL GRADED GRAVEL WITH SAND		
260	445	GRAY CLAYEY SAND WITH GRAVEL		
445	500	YELLOW BROWN SAND WITH GRAVEL		
500	510	YELLOW BROWN SILTY SAND		
510	570	YELLOW BROWN SAND WITH SILTSTONE CHIP		
570	630	YELLOW BROWN CLAYEY SAND WITH SILTSTO		
630	640	BROWN CLAY WITH SAND		
640	650	BROWN CLAYEY SAND		
650	665	RED BROWN SILT WITH SAND		
665	700	RED GRAY SAND WITH GRAVEL		
700	730	GREEN GRAY SILT WITH SAND AND SILTSTON		
730	740	GREEN GRAY SAND WITH SILT AND GRAVEL		
740	900	GREEN GRAY SANDY SILT WITH GRAVEL		

TOTAL DEPTH OF BORING 640 (Feet)
TOTAL DEPTH OF COMPLETED WELL 559 (Feet)

WELL OWNER

Name **SUTTER EXTENTION WATER DIS**
Mailing Address **4525 FRANKLIN ROAD**
YUBA CITY **CA** **95993**
CITY STATE ZIP

WELL LOCATION

Address **100' NOE BUTTE HOUSE RD & 1.05 MI W OF**
City **TOWNSHIP RD CA**
County **SUTTER**
APN Book **013** Page **240** Parcel **510**
Township **15 N** Range **2 E** Section **11**
Latitude

LOCATION SKETCH

WEST NORTH EAST SOUTH
Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL
MODIFICATION/REPAIR
— Deepen
— Other (Specify)

— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
— Domestic — Public
— Irrigation — Industrial

MONITORING — ☒

TEST WELL —

CATHODIC PROTECTION —

HEAT EXCHANGE —

DIRECT PUSH —

INJECTION —

VAPOR EXTRACTION —

SPARGING —

REMEDIATION —

OTHER (SPECIFY) —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER — (Ft.) BELOW SURFACE

DEPTH OF STATIC

WATER LEVEL — (Ft.) & DATE MEASURED

ESTIMATED YIELD * — (GPM) & TEST TYPE

TEST LENGTH — (Hrs.) TOTAL DRAWDOWN — (Ft.)

May not be representative of a well's long-term yield.

DEPTH FROM SURFACE	BORE - HOLE DIA. (Inches)	CASING (S)					
		TYPE (✓)				MATERIAL / GRADE	INTERNAL DIAMETER (Inches)
Ft. to Ft.		BLANK	SCREEN	CON- DUCTOR	FILL PIPE		
ZONE 1	1						
0	148	14	✓			PVC	2.5
148	168	14		✓		PVC	2.5
168	173	14	✓			PVC	2.5
ZONE 2	2						
0	240	14	✓			PVC	2.5

DEPTH FROM SURFACE	ANNULAR MATERIAL			
	TYPE			
Ft. to Ft.	CE- MENT (✓)	BEN- TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	127	✓		SAND SLURRY
127	139		✓	BENTONITE C
139	174		✓	SRI#8 SAND
174	190		✓	BENTONITE C
190	221		✓	SRI#8 SAND
221	230		✓	BENTONITE C

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO**
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE
ADDRESS

Signed **Mark Damin**
WELL DRILLER/AUTHORIZED REPRESENTATIVE

WOODLAND
CITY

CA 95695
STATE ZIP

01/24/06
DATE SIGNED

C57 A HIC - 133783
C-57 LICENSE NUMBER

ORIGINAL
File with DWR

Page 2 of 6

Owner's Well No. 7912

Date Work Began 11/8/05, Ended 11/17/05

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0259

Permit Date 10/28/05

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **816295**

DWR USE ONLY - DO NOT FILL IN

15202871

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

WELL OWNER

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE (SPECIFY)

DRILLING METHOD REVERSE

FLUID WATER

DESCRIPTION

Describe material, grain, size, color, etc.

Name **SUTTER EXTENTION WATER DIS**

Mailing Address **4525 FRANKLIN ROAD**

YUBA CITY

CA

95993

CITY

STATE

ZIP

WELL LOCATION

Address **100' NOF BUTTE HOUSE RD & 1.05 MI WOF**

City **TOWNSHIP RD CA**

County **SUTTER**

APN Book **Q13**

Page **240**

Parcel **510**

Township **15 N**

Range **2 E**

Section **11**

Latitude

DEG. MIN. SEC.

DEG. MIN. SEC.

LOCATION SKETCH

ACTIVITY (✓)

☒ NEW WELL
MODIFICATION/REPAIR
— Deepen
— Other (Specify)

— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY
— Domestic — Public
— Irrigation — Industrial

MONITORING ☒

TEST WELL ☐

CATHODIC PROTECTION ☐

HEAT EXCHANGE ☐

DIRECT PUSH ☐

INJECTION ☐

VAPOR EXTRACTION ☐

SPARGING ☐

REMEDIATION ☐

OTHER (SPECIFY) ☐

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER (Ft.) BELOW SURFACE

DEPTH OF STATIC

WATER LEVEL (Ft.) & DATE MEASURED

ESTIMATED YIELD (GPM) & TEST TYPE

TEST LENGTH (Hrs.) TOTAL DRAWDOWN (Ft.)

May not be representative of a well's long-term yield.

TOTAL DEPTH OF BORING **840** (Feet)

TOTAL DEPTH OF COMPLETED WELL **559** (Feet)

DEPTH FROM SURFACE		BORE - HOLE DIA. (Inches)	CASING (S)							DEPTH FROM SURFACE		ANNULAR MATERIAL				
			TYPE (✓)				MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS			SLOT SIZE IF ANY (Inches)	TYPE			
Ft.	to Ft.	BLANK	SCREEN	CON- DUCTOR	FILL PIPE									Ft.	to Ft.	CE- MENT (✓)
240	260	14		✓			PVC	2.5	SCH 80	.030	230	270			✓	SRI#8 SAND
260	265	14	✓				PVC	2.5	SCH 80		270	281		✓		BENTONITE C
ZONE	3										281	493			✓	SRI#8 SAND
0	524	14/8-5/8	✓				PVC	2.5	SCH 80		493	518		✓		BENTONITE C
524	554	8-8/5		✓			PVC	2.5	SCH 80	.030	518	566			✓	SRI#8 SAND
554	559	8-5/8	✓				PVC	2.5	SCH 80		566	581		✓		BENTONITE C

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO**

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE

ADDRESS

WOODLAND

CITY

CA

STATE

95695

ZIP

Signed

Mark Dainoff
WELL DRILLER/AUTHORIZED REPRESENTATIVE

01/24/08

DATE SIGNED

C57 A HIC - 133783

C-67 LICENSE NUMBER

Owner's Well No. 7912

Date Work Began 11/8/05, Ended 11/17/05

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0259 Permit Date 10/28/05

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **816295**

DWR USE ONLY - DO NOT FILL IN

15 N 02 E 17

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE (SPECIFY)		DRILLING METHOD REVERSE	FLUID WATER
DEPTH FROM SURFACE		DESCRIPTION	
Ft.	to Ft.	Describe material, grain, size, color, etc.	
0	22	WELL GRADED SAND	
22	70	CLAY WITH SANDY SILT	
70	103	YELLOW BROWN CLAY	
103	133	LIGHT YELLOW BROWN SANDY CLAY	
133	158	RED BROWN SILT	
158	175	RED POORLY GRADED SAND	
175	198	BROWN SANDY SILT	
198	250	GRAY POORLY GRADED SNAD WITH GRAVEL	
250	260	BROWN WELL GRADED GRAVEL WITH SAND	
260	445	GRAY CLAYEY SAND WITH GRAVEL	
445	500	YELLOW BROWN SAND WITH GRAVEL	
500	510	YELLOW BROWN SILTY SAND	
510	570	YELLOW BROWN SAND WITH SILTSTONE CHIP	
570	630	YELLOW BROWN CLAYEY SAND WITH SILTSTO	
630	640	BROWN CLAY WITH SAND	
640	650	BROWN CLAYEY SAND	
650	665	RED BROWN SILT WITH SAND	
665	700	RED GRAY SAND WITH GRAVEL	
700	730	GREEN GRAY SILT WITH SAND AND SILTSTON	
730	740	GREEN GRAY SAND WITH SILT AND GRAVEL	
740	900	GREEN GRAY SANDY SILT WITH GRAVEL	

TOTAL DEPTH OF BORING **640** (Feet)

TOTAL DEPTH OF COMPLETED WELL **559** (Feet)

WELL OWNER

Name **SUTTER EXTENTION WATER DIS**

Mailing Address **4525 FRANKLIN ROAD** CA **95993**

CITY **YUBA CITY** STATE **CA** ZIP **95993**

Address **100' NOE BUTTE HOUSE RD & 1.05 MI WOF**

City **TOWNSHIP RD CA**

County **SUTTER**

APN Book **013** Page **240** Parcel **510**

Township **15 N** Range **2 E** Section **11**

Latitude _____ DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST

EAST

SOUTH

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL

MODIFICATION/REPAIR

— Deepen

— Other (Specify)

— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY

— Domestic — Public

— Irrigation — Industrial

MONITORING — ☒

TEST WELL —

CATHODIC PROTECTION —

HEAT EXCHANGE —

DIRECT PUSH —

INJECTION —

VAPOR EXTRACTION —

SPARGING —

REMEDIATION —

OTHER (SPECIFY) —

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER _____ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL _____ (Ft.) & DATE MEASURED _____

ESTIMATED YIELD * _____ (GPM) & TEST TYPE _____

TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ (Ft.)

May not be representative of a well's long-term yield.

DEPTH FROM SURFACE	BORE HOLE DIA. (Inches)	CASING (S)						DEPTH FROM SURFACE	ANNULAR MATERIAL				
		TYPE (✓)	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	CE-MENT (✓)		BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)		
ZONE 1													
0	148	14	✓		PVC	2.5	SCH 80						
148	168	14	✓		PVC	2.5	SCH 80						
168	173	14	✓		PVC	2.5	SCH 80						
ZONE 2													
0	240	14	✓		PVC	2.5	SCH 80						

DEPTH FROM SURFACE	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
581				
605				
624				

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO**

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE

ADDRESS

WOODLAND

CITY

CA

STATE

95695

ZIP

Signed **Mark Davison**

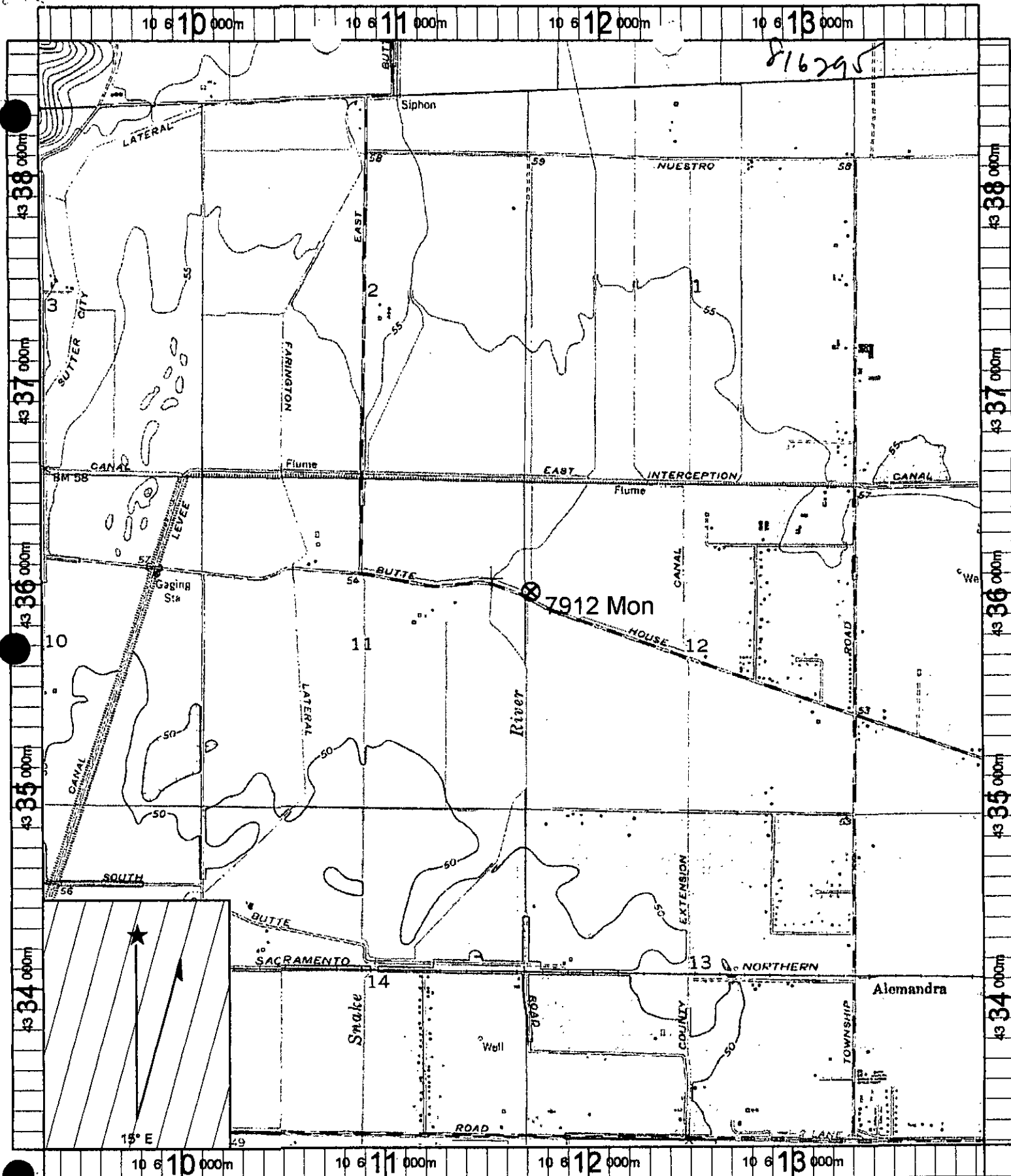
WELL DRILLER/AUTHORIZED REPRESENTATIVE

01/24/06

DATE SIGNED

C57 A HIC - 133783

C-57 LICENSE NUMBER



Name: SUTTER
 Date: 10/28/2005
 Scale: 1 inch equals 2000 feet

Caption: Sutter Extension Water District - Job# 7812 Mon
 APN: 013-240-510
 T15N R2E s12

Owner's Well No. 7913

Date Work Began 1/27/06, Ended 2/7/06

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0260

Permit Date 10/28/05

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

No. **E036360**

DWR USE ONLY — DO NOT FILL IN

1 5 N 0 2 E 2 4

STATE WELL NO / STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE (SPECIFY)

DRILLING METHOD ☒ ROTARY ☐ FLUID MUD

DEPTH FROM SURFACE		DESCRIPTION
Ft.	to Ft.	
0	20	TOP SOIL AND BROWN CLAY WITH SAND
20	55	YELLOW BROWN CLAY WITH COARSE SAND
55	100	SAND AND GRAVEL
100	160	LARGE GRAVEL WITH SANDY YELLOW CLAY
160	300	YELLOW BROWN CLAY WITH SAND AND GRAV
300	360	SAND AND GRAVEL WITH YELLOW BROWN CL
360	650	SAND AND SMALL GRAVEL WITH YELLOW BROWN CLAY
650	670	SAND AND SMALL GRAVEL WITH RED BROWN CLAY
670	700	BLACK COARSE SAND

TOTAL DEPTH OF BORING 620 (Feet)

TOTAL DEPTH OF COMPLETED WELL 488 (Feet)

WELL OWNER

Name SUTTER EXTENTION WATER DIS

Mailing Address 4525 FRANKLIN ROAD CA 95993

CITY YUBA CITY STATE CA ZIP 95993

WELL LOCATION

Address 300' NO. FRANKLIN RD & 52 MI W OF TOWNSHI

City RD CA

County SUTTER

APN Book 013 Page 280 Parcel 054

Township 15 N Range 2 E Section 24

Latitude _____

DEG. MIN. SEC. _____

LOCATION SKETCH

NORTH _____

WEST _____

SOUTH _____

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL

MODIFICATION/REPAIR

— Deepen

— Other (Specify) _____

— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY

— Domestic — Public

— Irrigation — Industrial

MONITORING — ☒

TEST WELL —

CATHODIC PROTECTION —

HEAT EXCHANGE —

DIRECT PUSH —

INJECTION —

VAPOR EXTRACTION —

SPARGING —

REMEDIATION —

OTHER (SPECIFY) _____

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER _____ (Ft.) BELOW SURFACE

DEPTH OF STATIC WATER LEVEL _____ (Ft.) & DATE MEASURED _____

ESTIMATED YIELD * _____ (GPM) & TEST TYPE _____

TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ (Ft.)

May not be representative of a well's long-term yield.

DEPTH FROM SURFACE	BORE-HOLE DIA. (Inches)	CASING (S)					
		TYPE (✓)				MATERIAL / GRADE	SLOT SIZE IF ANY (Inches)
Ft. to Ft.		BLANK	SCREEN	CON-DUCTOR	FILL PIPE		
ZONE 1							
0	204	14	✓			PVC	2.5
204	244	14		✓		PVC	2.5
244	254	14	✓			PVC	2.5
ZONE 2							
0	354	14	✓			PVC	2.5

DEPTH FROM SURFACE	ANNULAR MATERIAL			
	TYPE			
Ft. to Ft.	CE-MENT (✓)	BEN-TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	178	✓		SAND SLURRY
178	192		✓	BENTONITE C.
192	276		✓	SRI#8 SAND
276	290		✓	BENTONITE C.
290	318		✓	SRI#8 SAND
318	330		✓	BENTONITE C.

ATTACHMENTS (✓)

— Geologic Log

— Well Construction Diagram

— Geophysical Log(s)

— Soil/Water Chemical Analysis

— Other _____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME EATON DRILLING CO

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE WOODLAND CA 95695

ADDRESS CITY STATE ZIP

Signed Mark Davis DATE SIGNED 02/23/06

WELL DRILLER/AUTHORIZED REPRESENTATIVE C57 A HIC - 133783

C-57 LICENSE NUMBER

Page 2 of 6

Owner's Well No. 7913

Date Work Began 1/27/06, Ended 2/7/06

Local Permit Agency SUTTER COUNTY HEALTH DEPT.

Permit No. 05-0260Permit Date 10/28/05

STATE OF CALIFORNIA WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **E036360**

DWR USE ONLY										DO NOT FILL IN									
15N 02624																			
STATE WELL NO / STATION NO.																			
LATITUDE										LONGITUDE									
APN/TRS/OTHER																			

GEOLOGIC LOG

[illegible]**WELL OWNER**

Name SUTTER EXTENTION WATER DIS			
Mailing Address 4525 FRANKLIN ROAD		CA	95993
YUBA CITY		STATE	ZIP
CITY			
WELL LOCATION			
Address 300' NOE FRANKLIN RD & 52 MI WOF TOWNSHI			
City RD CA			
County SUTTER			
APN Book 013	Page 280	Parcel 054	
Township 15 N	Range 2 E	Section 24	
Latitude			
DEG.	MIN.	SEC.	
LOCATION SKETCH		ACTIVITY (✓)	
NORTH		☒ NEW WELL MODIFICATION/REPAIR ___ Deepen ___ Other (Specify)	
WEST	EAST		___ DESTROY (Describe Procedures and Material Under "GEOLOGIC LOG")
			PLANNED USES (✓) WATER SUPPLY ___ Domestic ___ Public ___ Irrigation ___ Industrial
			MONITORING ☒ TEST WELL ___ CATHODIC PROTECTION ___ HEAT EXCHANGE ___ DIRECT PUSH ___ INJECTION ___ VAPOR EXTRACTION ___ SPARGING ___ REMEDIATION ___ OTHER (SPECIFY) ___
SOUTH			
<i>Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.</i>			
WATER LEVEL & YIELD OF COMPLETED WELL			
DEPTH TO FIRST WATER _____ (Ft.) BELOW SURFACE			
DEPTH OF STATIC _____			
WATER LEVEL _____ (Ft.) & DATE MEASURED _____			
ESTIMATED YIELD • _____ (GPM) & TEST TYPE _____			
TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ (Ft.)			
<i>May not be representative of a well's long-term yield</i>			

DEPTH FROM SURFACE		BORE - HOLE DIA. (Inches)	CASING (S)							
			TYPE (✓)				MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)
Ft.	to Ft.	BLANK	SCREEN	CON- DUCTOR	FILL PIPE					
354	374	14		✓			PVC	2.5	SCH 80	.030
374	379	14	✓				PVC	2.5	SCH 80	
ZONE 3										
0	438	14/8.5	✓				PVC	2.5	SCH 80	
438	478	8.5		✓			PVC	2.5	SCH 80	.030
478	488	8.5	✓				PVC	2.5	SCH 80	

DEPTH FROM SURFACE		ANNULAR MATERIAL			
		TYPE			FILTER PACK (TYPE/SIZE)
Ft.	to Ft.	CE- MENT (✓)	BEN- TONITE (✓)	FILL (✓)	
330	380			✓	SR#8 SAND
380	406		✓		BENTONITE C
406	490			✓	SR#8 SAND
490	498		✓		BENTONITE C
498	537			✓	SR#8 SAND
537	548		✓		BENTONITE C

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other _____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

1. the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME EATON DRILLING CO

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE

ADDRESS

WELL DRILLER/AUTHORIZED REPRESENTATIVE

WOODLAND
CITY

CA
STATE

95695
ZIP

02/23/06

DATE SIGNED

C57 A HIC - 133783

C-57 LICENSE NUMBER

ORIGINAL
File with DWR

Page 1 of 6

Owner's Well No. 7914

Date Work Began 11/21/2005, Ended 12/1/2005

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0258

Permit Date 10/28/2005

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **E038757**

DWR USE ONLY -- DO NOT FILL IN

14N 02E 13A 003M

STATE WELL NO / STATION NO

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓)		DRILLING METHOD	FLUID MUD	DESCRIPTION
VERTICAL — HORIZONTAL — ANGLE — (SPECIFY)		ROTARY		
DEPTH FROM SURFACE		Describe material, grain, size, color, etc.		
Ft.	to Ft.			
0	10	SANDY CLAY		
10	35	BROWN CLAY		
35	90	GRAVELLY SAND		
90	115	GRAVEL		
115	195	GRAVELLY CLAY		
195	280	CLAY TO SILT		
280	300	SILT TO CLAY		
300	348	CLAY WITH GRAVEL TO SILT WITH GRAVEL		
348	397	SILT TO CLAY		
397	536	SANDY CLAY		
536	548	SILT TO CLAY		
548	571	WELL GRADED GRAVEL WITH CLAY		
571	613	CLAY WITH SAND		
613	662	WELL GRADED SAND WITH CLAY AND GRAVEL		
662	678	CLAY WITH SAND		
678	700	CLAYEY SAND		
700	710	CLAY TO SILT		
710	750	CLAYEY SAND		

A - 003 M
B - 004 M
C - 005 M

TOTAL DEPTH OF BORING 740 (Feet)
TOTAL DEPTH OF COMPLETED WELL 585 (Feet)

WELL OWNER

Name **SUTTER EXTENTION WATER DIS**
Mailing Address **4525 FRANKLIN ROAD**
YUBA CITY **CA** **95993**
CITY STATE ZIP

WELL LOCATION

Address **250' SOF OSWALD RD & 75' WOF S**
City **TOWNSHIP RD CA**
County **SUTTER**
APN Book **021** Page **310** Parcel **048**
Township **14 N** Range **2 E** Section **13**
Latitude

DEG. MIN. SEC.		DEG. MIN. SEC.	
LOCATION SKETCH		ACTIVITY (✓)	
NORTH		☒ NEW WELL	
WEST		MODIFICATION/REPAIR	
		— Deepen — Other (Specify)	
SOUTH		— DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")	
		PLANNED USES (✓)	
EAST		WATER SUPPLY	
		— Domestic — Public — Irrigation — Industrial	
MONITORING ☒		TEST WELL	
		CATHODIC PROTECTION	
HEAT EXCHANGE		DIRECT PUSH	
		INJECTION	
VAPOR EXTRACTION		SPARGING	
		REMEDICATION	
OTHER (SPECIFY)			

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER (Ft.) BELOW SURFACE
DEPTH OF STATIC
WATER LEVEL (Ft.) & DATE MEASURED
ESTIMATED YIELD * (GPM) & TEST TYPE
TEST LENGTH (Hrs.) TOTAL DRAWDOWN (Ft.)
May not be representative of a well's long-term yield.

DEPTH FROM SURFACE		BORE - HOLE DIA. (Inches)	CASING (S)					DEPTH FROM SURFACE		ANNULAR MATERIAL			
			BLANK	SCREEN	TYPE (✓)		MATERIAL / GRADE			INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	TYPE
CON-DUCTOR	FILL PIPE	CE- MENT (✓)			BEN- TONITE (✓)	FILL (✓)		FILTER PACK (TYPE/SIZE)					
			Ft.	to			Ft.						
ZONE:	1												
0:	88	14	✓			PVC	2.5	SCH 80					SAND SLURRY
88:	108	14		✓		PVC	2.5	SCH 80					BENTONITE C
108:	113	14	✓			PVC	2.5	SCH 80				✓	SR#8 SAND
ZONE:	2												BENTONITE C
0:	208	14	✓			PVC	2.5	SCH 80				✓	PEA GRAVEL
												✓	BENTONITE C

DEPTH FROM SURFACE		ANNULAR MATERIAL				
		TYPE				
FL	to	FL	CE- MENT (✓)	BEN- TONITE (✓)	FILL (✓)	FILTER PACK (TYPE/SIZE)
0	68		✓			SAND SLURRY
68	80			✓		BENTONITE C
80	128				✓	SR#8 SAND
128	140			✓		BENTONITE C
140	170				✓	PEA GRAVEL
170	181			✓		BENTONITE C

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO.**

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE

ADDRESS

WOODLAND

CITY

CA

STATE

95695

ZIP

Signed

Mark Danner

WELL DRILLER/AUTHORIZED REPRESENTATIVE

05/02/06

DATE SIGNED

C57 A HIC - 133783

C-57 LICENSE NUMBER

Permit No. 05-0258 Permit Date 10/28/2005

No. **E038757** *A, B, C*

DWR USE ONLY — DO NOT FILL IN

14 N 02 E 134 003 M

STATE WELL NO./STATION NO.

004 M

005 M

LATITUDE

LONGITUDE

APN/TRS/OTHER

WELL OWNER[illegible]

Name SUTTER EXTENTION WATER DIS			
Mailing Address 4525 FRANKLIN ROAD			
YUBA CITY		CA	95993
CITY		STATE	ZIP
WELL LOCATION			
Address 250' SOF OSWALD RD & 75' WOF S			
City TOWNSHIP RD CA			
County SUTTER			
APN Book 021	Page 310	Parcel 048	
Township 14 N	Range 2 E	Section 13	
Latitude _____			
DEG.	MIN.	SEC.	DEG. MIN. SEC.
LOCATION SKETCH		ACTIVITY (✓)	
NORTH		☒ NEW WELL MODIFICATION/REPAIR ___ Deepen ___ Other (Specify) _____ _____ ___ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")	
WEST	EAST		PLANNED USES (✓) WATER SUPPLY ___ Domestic ___ Public ___ Irrigation ___ Industrial MONITORING ☒ TEST WELL ___ CATHODIC PROTECTION ___ HEAT EXCHANGE ___ DIRECT PUSH ___ INJECTION ___ VAPOR EXTRACTION ___ SPARGING ___ REMEDIATION ___ OTHER (SPECIFY) _____
SOUTH			
<i>Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.</i>			
WATER LEVEL & YIELD OF COMPLETED WELL			
DEPTH TO FIRST WATER _____ (Ft.) BELOW SURFACE			
DEPTH OF STATIC WATER LEVEL _____ (Ft.) & DATE MEASURED _____			
ESTIMATED YIELD * _____ (GPM) & TEST TYPE _____			
TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ (Ft.)			
<i>May not be representative of a well's long-term yield.</i>			

DEPTH FROM SURFACE			BORE - HOLE DIA. (Inches)	CASING (S)					DEPTH FROM SURFACE			ANNULAR MATERIAL					
				TYPE (✓)				MATERIAL / GRADE				INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	TYPE		
Ft	to	Ft	BLANK	SCREEN	CON-DUCTOR	FILL PIPE									Ft	to	Ft
208	238	14		✓			PVC	2.5	SCH 80	.030	181	250			✓		SRI#8 SAND
238	243	14	✓				PVC	2.5	SCH 80		250	261		✓			BENTONITE C
ZONE	3										261	411			✓		PEA GRAVEL
0	550	14/8.75	✓				PVC	2.5	SCH 80		411	425		✓			BENTONITE C
550	580	8.75		✓			PVC	2.5	SCH 80	.030	425	535			✓		PEA GRAVEL
580	585	8.75	✓				PVC	2.5	SCH 80		535	543		✓			BENTONITE C

ATTACHMENTS ()

____ Geologic Log

____ Well Construction Diagram

____ Geophysical Log(s)

____ Soil/Water Chemical Analysis

____ Other _____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT			
I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.			
NAME EATON DRILLING CO.			
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)			
20 WEST KENTUCKY AVE		WOODLAND	CA 95695
ADDRESS		CITY	STATE ZIP
Signed <i>Mark D. Damion</i>		05/02/06	C57 A HIC - 133783
WELL DRILLER/AUTHORIZED REPRESENTATIVE		DATE SIGNED	C-57 LICENSE NUMBER

ORIGINAL
File with DWR

Page 3 of 6

Owner's Well No. 7914

Date Work Began 11/21/2005, Ended 12/1/2005

Local Permit Agency SUTTER COUNTY HEALTH DEPT

Permit No. 05-0258

Permit Date 10/28/2005

STATE OF CALIFORNIA
WELL COMPLETION REPORT

Refer to Instruction Pamphlet

No. **E038757**

DWR USE ONLY -- DO NOT FILL IN

14N 02E 73A 003 M

STATE WELL NO./STATION NO. 004 M

005 M

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE (SPECIFY)

DRILLING METHOD **ROTARY** FLUID MUD

DEPTH FROM SURFACE
Ft. to Ft. DESCRIPTION
Describe material, grain, size, color, etc.

0	10	SANDY CLAY
10	35	BROWN CLAY
35	90	GRAVELLY SAND
90	115	GRAVEL
115	195	GRAVELLY CLAY
195	280	CLAY TO SILT
280	300	SILT TO CLAY
300	348	CLAY WITH GRAVEL TO SILT WITH GRAVEL
348	397	SILT TO CLAY
397	536	SANDY CLAY
536	548	SILT TO CLAY
548	571	WELL GRADED GRAVEL WITH CLAY
571	613	CLAY WITH SAND
613	662	WELL GRADED SAND WITH CLAY AND GRAVEL
662	678	CLAY WITH SAND
678	700	CLAYEY SAND
700	710	CLAY TO SILT
710	750	CLAYEY SAND

TOTAL DEPTH OF BORING 740 (Feet)

TOTAL DEPTH OF COMPLETED WELL 585 (Feet)

WELL OWNER

Name **SUTTER EXTENTION WATER DIS**

Mailing Address **4525 FRANKLIN ROAD**

YUBA CITY CA 95993

CITY STATE ZIP

WELL LOCATION

Address **250' SOF OSWALD RD & 75' WOF S**

City **TOWNSHIP RD CA**

County **SUTTER**

APN Book 021 Page 310 Parcel 048

Township 14 N Range 2 E Section 13

Latitude

DEG. MIN. SEC. DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST EAST

ACTIVITY (✓)

☒ NEW WELL

MODIFICATION/REPAIR

☐ Deepen

☐ Other (Specify)

☐ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

MONITORING ☒

TEST WELL ☐

CATHODIC PROTECTION ☐

HEAT EXCHANGE ☐

DIRECT PUSH ☐

INJECTION ☐

VAPOR EXTRACTION ☐

SPARGING ☐

REMEDIATION ☐

OTHER (SPECIFY) ☐

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER (Feet) BELOW SURFACE

DEPTH OF STATIC

WATER LEVEL (Feet) & DATE MEASURED

ESTIMATED YIELD (GPM) & TEST TYPE

TEST LENGTH (Hrs.) TOTAL DRAWDOWN (Feet)

May not be representative of a well's long-term yield.

DEPTH FROM SURFACE Ft. to Ft.	BORE-HOLE DIA. (Inches)	CASING (S)					ANNULAR MATERIAL TYPE
		TYPE (✓)	MATERIAL / GRADE	INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	
ZONE 1							
0	88	14	✓	PVC	2.5	SCH 80	543 600 SRI#8 SAND
88	108	14	✓	PVC	2.5	SCH 80	600 610 BENTONITE C
108	113	14	✓	PVC	2.5	SCH 80	610 659 PEA GRAVEL
ZONE 2							
0	208	14	✓	PVC	2.5	SCH 80	659 669 BENTONITE C
							669 740 BACKFILL

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO.**
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 WEST KENTUCKY AVE

ADDRESS

Signed

Mark Damion

WELL DRILLER/AUTHORIZED REPRESENTATIVE

WOODLAND

CITY

CA

STATE

95695

ZIP

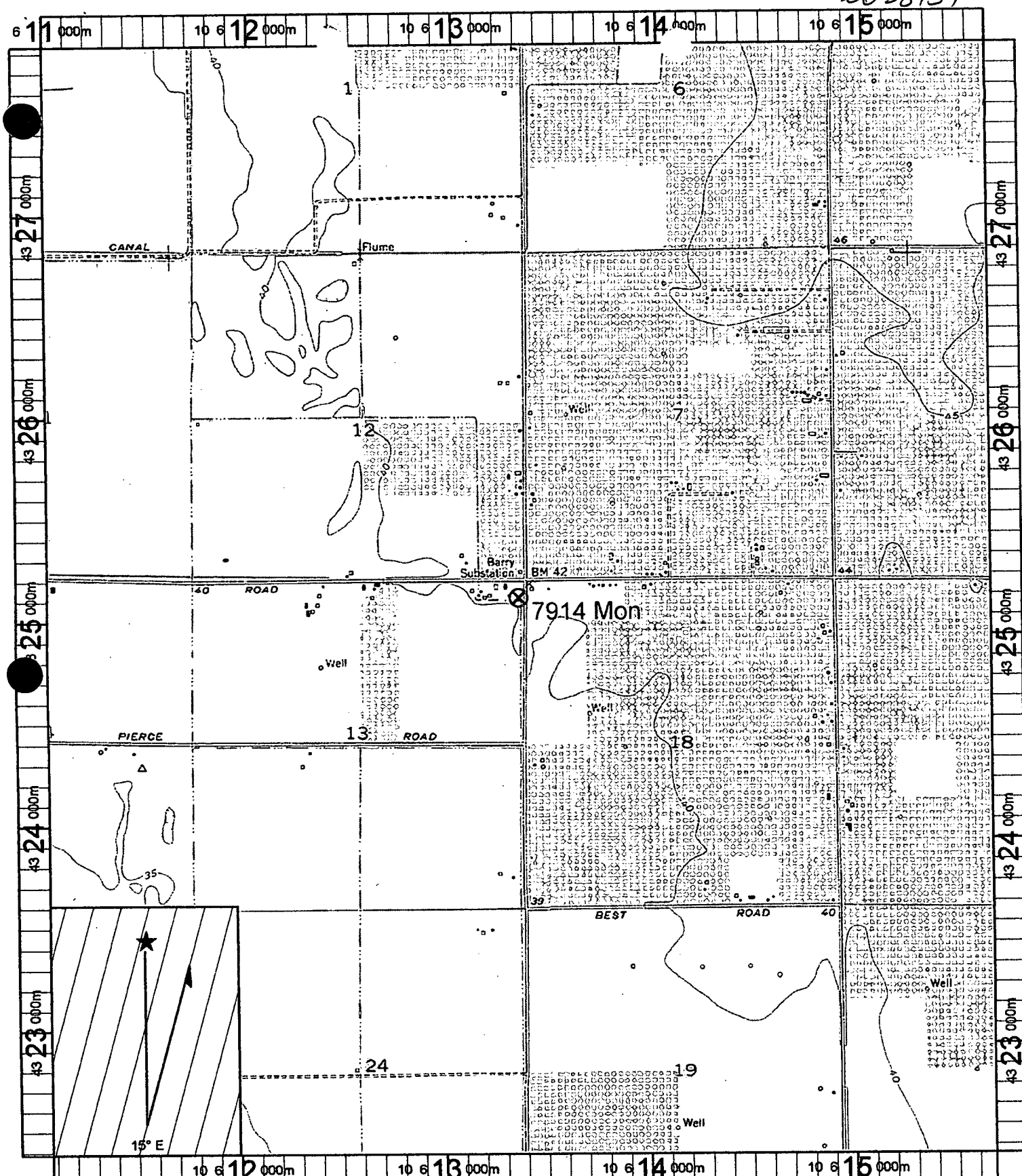
05/02/06

DATE SIGNED

C57 A HIC - 133783

C-57 LICENSE NUMBER

2038757



Name: GILSIZER SLOUGH
Date: 10/28/2005
Scale: 1 inch equals 2000 feet

Caption: Sutter Extension Water District - Job# 7814 Mon
APN: 021-310-048
T14N R2E s13

ORIGINAL
File with DWR

Page 1 of 3

Owner's Well No. 8519 11W-6A,B,C
Date Work Began 12/20/2010, Ended 12/22/2010

Local Permit Agency Sutter County Health Dept

Permit No. 10-0310 Permit Date 12/7/2010

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

E-124062 A-C

DWR USE ONLY -- DO NOT FILL IN	
<u>13N03E06A001M</u>	
STATE WELL NO./STATION NO. <u>2</u>	
LATITUDE	LONGITUDE <u>3</u>
APN/TRS/OTHER	

GEOLOGIC LOG

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE ☐ (SPECIFY)

DRILLING METHOD ROTARY FLUID MUD

DEPTH FROM SURFACE	FL.	to	FL.	DESCRIPTION
				Describe material, grain, size, color, etc.

0	10	Top soil
10	20	Yellow brown clay
20	60	Sand and gravel
60	170	Sandy yellow clay
170	800	Gray clay with sand
800	1300	Brittle gray clay with sand

11W-6A - 13N03E06A001M
11W-6B - A002M
11W-6C - A003M

WELL OWNER

Name DWR - Central

Mailing Address 901 P Street, 2nd Floor

Sacramento CA 95814
CITY STATE ZIP

Address 80' W of S George Washington Blvd & 37

City Mi Nof Tudor Rd CA

County SUTTER

APN Book 025 Page 010 Parcel 004

Township 13 N Range 3 E Section 6

Latitude 39 0 32

DEG MIN SEC

LOCATION SKETCH

NORTH

WEST

EAST

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL

MODIFICATION/REPAIR

☐ Deepen

☐ Other (Specify)

☐ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY

☐ Domestic ☐ Public

☐ Irrigation ☐ Industrial

MONITORING ☒

TEST WELL ☐

CATHODIC PROTECTION ☐

HEAT EXCHANGE ☐

DIRECT PUSH ☐

INJECTION ☐

VAPOR EXTRACTION ☐

SPARGING ☐

REMEDIATION ☐

OTHER (SPECIFY) ☐

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER ☐ (Feet) BELOW SURFACE

DEPTH OF STATIC

WATER LEVEL ☐ (Feet) & DATE MEASURED ☐

ESTIMATED YIELD ☐ (GPM) & TEST TYPE ☐

TEST LENGTH ☐ (Hrs.) TOTAL DRAWDOWN ☐ (Feet)

May not be representative of a well's long-term yield.

TOTAL DEPTH OF BORING 1300 (Feet)

TOTAL DEPTH OF COMPLETED WELL 255 (Feet)

DEPTH FROM SURFACE		BORE - HOLE DIA. (Inches)	CASING (S)						DEPTH FROM SURFACE		ANNULAR MATERIAL			
			TYPE (✓)				MATERIAL / GRADE	INTERNAL DIAMETER (Inches)			GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	TYPE	
Fl.	to Fl.		BLANK	SCREEN	CON-DUCTOR	FILL PIPE			CE-MENT (✓)	BEN-TONITE (✓)			FILL (✓)	FILTER PACK (TYPE/SIZE)
Zone	1													
0	45	12	✓			PVC	2.5	SCH 80		0	20	✓		Sand Slurry
45	55	12		✓		PVC	2.5	SCH 80	.030	20	35		✓	Bentonite Seal
55	65	12	✓			PVC	2.5	SCH 80		35	90		✓	SRI#8 Sand
Zone	2									90	100		✓	Bentonite Seal
0	155	12	✓			PVC	2.5	SCH 80		100	130		✓	SRI#8 Sand
										130	140		✓	Bentonite Seal

ATTACHMENTS (✓)

- ☐ Geologic Log
- ☐ Well Construction Diagram
- ☐ Geophysical Log(s)
- ☐ Soil/Water Chemical Analysis
- ☐ Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME EATON DRILLING CO.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 W. Kentucky Ave
ADDRESS

Woodland
CITY

CA 95695
STATE ZIP

Signed [Signature]
WELL DRILLER/AUTHORIZED REPRESENTATIVE

01/21/11
DATE SIGNED

C57 A 133783
C-57 LICENSE NUMBER

ORIGINAL
File with DWR

Page 2 of 3

Owner's Well No. 8519

Date Work Began 12/20/2010, Ended 12/22/2010

Local Permit Agency Sutter County Health Dept

Permit No. 10-0310

Permit Date 12/7/2010

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

0124062

DWR USE ONLY - DO NOT FILL IN

73M03E06

STATE WELL NO./STATION NO.

LATITUDE LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

WELL OWNER

ORIENTATION (✓) ☒ VERTICAL ☐ HORIZONTAL ☐ ANGLE (SPECIFY)

DRILLING METHOD **ROTARY** FLUID **MUD**

DEPTH FROM SURFACE
Fl. to Fl. DESCRIPTION
Describe material, grain, size, color, etc.

0	10	Top soil
10	20	Yellow brown clay
20	60	Sand and gravel
60	170	Sandy yellow clay
170	800	Gray clay with sand
800	1300	Brittle gray clay with sand

Name **DWR - Central**

Mailing Address **901 P Street, 2nd Floor**

Sacramento

CA

95814

CITY

STATE

ZIP

WELL LOCATION

Address **80' W of S George Washington Blvd & 37**

City **Mi Nof Tudor Rd CA**

County **SUTTER**

APN Book **025** Page **010** Parcel **004**

Township **13 N** Range **3 E** Section **6**

Latitude

DEG. MIN. SEC.

DEG. MIN. SEC.

LOCATION SKETCH

NORTH

WEST

EAST

Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.

ACTIVITY (✓)

☒ NEW WELL

MODIFICATION/REPAIR

Deepen

Other (Specify)

DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")

PLANNED USES (✓)

WATER SUPPLY

Domestic

Irrigation

Public

Industrial

MONITORING ☒

TEST WELL

CATHODIC PROTECTION

HEAT EXCHANGE

DIRECT PUSH

INJECTION

VAPOR EXTRACTION

SPARGING

REMEDIATION

OTHER (SPECIFY)

WATER LEVEL & YIELD OF COMPLETED WELL

DEPTH TO FIRST WATER (Ft.) BELOW SURFACE

DEPTH OF STATIC

WATER LEVEL (Ft.) & DATE MEASURED

ESTIMATED YIELD (GPM) & TEST TYPE

TEST LENGTH (Hrs.) TOTAL DRAWDOWN (Ft.)

May not be representative of a well's long-term yield.

TOTAL DEPTH OF BORING **1300** (Feet)

TOTAL DEPTH OF COMPLETED WELL **255** (Feet)

DEPTH FROM SURFACE			BORE - HOLE DIA. (Inches)	CASING (S)					DEPTH FROM SURFACE		ANNULAR MATERIAL					
				TYPE (✓)				MATERIAL / GRADE			INTERNAL DIAMETER (Inches)	GAUGE OR WALL THICKNESS	SLOT SIZE IF ANY (Inches)	TYPE		
Ft.	to	Ft.		BLANK	SCREEN	CON- DUCTOR	FILL PIPE		CE- MENT (✓)	BEN- TONITE (✓)				FILL (✓)	FILTER PACK (TYPE/SIZE)	
155	165		12		✓			PVC	2.5	SCH 80			✓	SRI#8 Sand		
165	175		12	✓				PVC	2.5	SCH 80			✓	Bentonite Seal		
Zone	3												✓	SRI#8 Sand		
0	235		12/8	✓				PVC	2.5	SCH 80			✓	Bentonite Seal		
235	245		8		✓			PVC	2.5	SCH 80			✓	SRI#8 Sand		
245	255		8	✓				PVC	2.5	SCH 80			✓	Bentonite Seal		

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME **EATON DRILLING CO.**

(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 W. Kentucky Ave

ADDRESS

Woodland

CITY

CA

STATE

95695

ZIP

Signed

WELL DRILLER/AUTHORIZED REPRESENTATIVE

DATE SIGNED

C57 A 133783

C-57 LICENSE NUMBER

Page 3 of 3

Owner's Well No. 8519

Date Work Began 12/20/2010, Ended 12/22/2010

Local Permit Agency Sutter County Health Dept

Permit No. 10-0310 Permit Date 12/7/2010

STATE OF CALIFORNIA
WELL COMPLETION REPORT
Refer to Instruction Pamphlet

Refer to Instruction Pamphlet

e0124062

BWR USE ONLY -- DO NOT FILL IN

13M03E06

STATE WELL NO./STATION NO.

LATITUDE

LONGITUDE

APN/TRS/OTHER

GEOLOGIC LOG

- WELL OWNER

ORIENTATION (☒) VERTICAL _____ HORIZONTAL _____ ANGLE _____ (SPECIFY)		Name <u>DWR - Central</u>	
DRILLING METHOD <u>ROTARY</u> FLUID <u>MUD</u>		Mailing Address <u>901 P Street, 2nd Floor</u> <u>Sacramento</u> CA <u>95814</u>	
DEPTH FROM SURFACE Ft. to Ft.		CITY _____ STATE _____ ZIP _____	
DESCRIPTION <i>Describe material, grain, size, color, etc.</i>		WELL LOCATION Address <u>80' Wof S George Washington Blvd & .37</u> City <u>Mi Nof Tudor Rd CA</u> County <u>SUTTER</u> APN Book <u>025</u> Page <u>010</u> Parcel <u>004</u> Township <u>13 N</u> Range <u>3 E</u> Section <u>6</u> Latitude _____ DEG. MIN. SEC. _____	
		LOCATION SKETCH NORTH WEST SOUTH EAST <div style="height: 150px; position: relative;"><div style="position: absolute; left: -30px; top: 50%; transform: translateY(-50%); white-space: nowrap;">WEST</div><div style="position: absolute; right: -30px; top: 50%; transform: translateY(-50%); white-space: nowrap;">EAST</div></div>	
		ACTIVITY (☒) ☒ NEW WELL MODIFICATION/REPAIR ____ Deepen ____ Other (Specify) _____ ____ DESTROY (Describe Procedures and Materials Under "GEOLOGIC LOG")	
		PLANNED USES (☒) WATER SUPPLY ____ Domestic ____ Public ____ Irrigation ____ Industrial MONITORING ☒ TEST WELL ____ CATHODIC PROTECTION ____ HEAT EXCHANGE ____ DIRECT PUSH ____ INJECTION ____ VAPOR EXTRACTION ____ SPARGING ____ REMEDIATION ____ OTHER (SPECIFY) _____	
		SOUTH <i>Illustrate or Describe Distance of Well from Roads, Buildings, Fences, Rivers, etc. and attach a map. Use additional paper if necessary. PLEASE BE ACCURATE & COMPLETE.</i>	
		WATER LEVEL & YIELD OF COMPLETED WELL DEPTH TO FIRST WATER _____ (Ft.) BELOW SURFACE DEPTH OF STATIC _____ WATER LEVEL _____ (Ft.) & DATE MEASURED _____ ESTIMATED YIELD * _____ (GPM) & TEST TYPE _____ TEST LENGTH _____ (Hrs.) TOTAL DRAWDOWN _____ (Ft.) <i>May not be representative of a well's long-term yield</i>	
TOTAL DEPTH OF BORING <u>1300</u> (Feet) TOTAL DEPTH OF COMPLETED WELL <u>255</u> (Feet)			

[illegible]

ATTACHMENTS (✓)

- Geologic Log
- Well Construction Diagram
- Geophysical Log(s)
- Soil/Water Chemical Analysis
- Other _____

ATTACH ADDITIONAL INFORMATION, IF IT EXISTS.

CERTIFICATION STATEMENT

I, the undersigned, certify that this report is complete and accurate to the best of my knowledge and belief.

NAME EATON DRILLING CO.

NAME ENTON SCREENING CO.
(PERSON, FIRM, OR CORPORATION) (TYPED OR PRINTED)

20 W. Kentucky Ave

ADDRESS

Woodland
CITY

CA 95695
STATE ZIP

Signed Mark D. Carr
WELL DRILLER/AUTHORIZED REPRESENTATIVE

01/21/11
DATE SIGNED

C57 A 133783

C-57 LICENSE NUMBER

col 24062



State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

PROJECT American Basin Conjunctive Use HOLE NUMBER AB-1
 FEATURE SSWD Corporation Yard DATE DRILLED 5/22/96-5/23/96
 LOCATION _____ LOGGED BY Senter/Killingsworth
 CONTRACTOR Eaton Drilling ATTITUDE Vertical
 DRILLER Duane Smith DEPTH TO WATER Not determined
 DRILL RIG Mayhew 1000, modified HOLE DEPTH 1008 ft ELEVATION N/A

Depth	Log	Field Classification and Description	Mode	Remarks
0	SM	0-30': <u>SANDY SILT</u> : soft, buff brown to red orange in color, interbedded with <u>SAND</u> , medium to pebble size, angular to subrounded, predominantly lithic clasts.	RD	Spudded @ 1000 hrs 65': rough drilling
20				
	CL	30-50': <u>CLAY</u> : lean, contains non-plastic fines, soft, orange-brown to gray-brown in color.		
40				
	SP	50-100': <u>SAND</u> : coarse to med grained, loose (uncemented), angular to subangular, clasts appear to be primarily of granitic origin w/ up to 10% mafic lithic fragments. Occasional stringers of <u>SANDY SILT</u> . Grades coarser, becomes iron-oxide stained, and composed predominantly of mafic of non-granitic fragments below 60'.		
60				
80				
100	SM	100-125': <u>SANDY SILT</u> : brittle (stiff), red-brown to orange-brown in color, contains up to 10% medium to coarse grained lithic fragments w/ occasional gravel-size clasts.		
120	SP	125-145': <u>SAND</u> : coarse to medium-grain size, angular to subangular, composed of mafic mineral fragments and lithic fragments of metamorphic & igneous origin.		
140	SM	145-180': <u>SANDY SILT</u> : brittle, as above, w/ common soft, non-plastic interbeds.		
160				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

Project & Feature American Basin Conjunctive Use, SSWD Monitoring Well

Hole No. AB-1

Depth	Log	Field Classification and Description	Mode	Remarks
160	SM	<u>SANDY SILT</u> continued	RD	Driller said water return only about 50% from 160-180'
180	SP	180-200': <u>SAND</u> : fine to med grained minerals and lithic clasts, angular to subrounded, loose. Up to 30% of sand fragments appear to be sandstone, weakly indurated, friable. Possible lahar?		
200	SM	200-330': <u>SILTY SAND/SANDY SILT</u> interbedded: reddish brown, brittle silts, subangular, med to coarse sand. Occasional soft <u>SANDY SILT</u> interbeds, esp. below 220'. Color changes to dark gray at 230'.		
220				Assume that color change at 250' corresponds to top of Mehrten Formation Hole taking water
240		Color alternates between gray and red-brown. Degree of induration increases with depth; cuttings become harder. Below 250', color is predominantly dark gray, w/ minor orange-red interbeds.		
260		MEHRTEN FORMATION: gray to greenish, interbedded, tuffaceous sands, silts, clays, claystones, some interbedded gravels, gray tuffs, all as described below.		
280				
300				
320	SP	330-340': <u>SAND</u> : fine to medium grained, dark gray, angular, loose.		5/23/96: probable Mehrten
340	SM	340-390': <u>SANDY SILT</u> with occasional silty sand interbeds: brittle w/ occasional soft interbeds, dark gray w/ infrequent red-orange interbeds; sand is fine to med grained.		
360				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

Project & Feature American Basin Conjunctive Use, SSWD Monitoring Well

Hole No. AB-1

Depth	Log	Field Classification and Description	Mode	Remarks
360	SM	<u>SANDY SILT</u> continued	RD	390': rough drilling 5/23/96 gravel zone definitely appears to be Mehrten
380				
	GP	390-400': <u>SANDY GRAVEL</u> : loose, dark gray, subangular to rounded lithic and mineral clasts. Appear to be mainly metamorphics; fine; max diam. 0.5". Some basalt clasts <5%.		
400	SP	400-410': <u>SAND with CLAY</u> : gray, coarse grained, otherwise same as above; contains about 10% med plastic clay		
	Tuff	410-500': <u>TUFF</u> : andesitic, gray, brittle; may occasionally grade to stiff clay; trace of subrounded pebbles.		Good water return: about 80%
420				
440				
460				
480				
500	SC	500-650': <u>CLAYEY SAND</u> : tuffaceous; dark gray-green, coarse grained, angular to subrounded; qtz and metamorphic grains, abundant greenish metavolcanic grains		Fast drilling Fast drilling; good water returns about 80%
520				
540				
560				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

Project & Feature American Basin Conjunctive Use, SSWD Monitoring Well

Hole No. AB-1

Depth	Log	Field Classification and Description	Mode	Remarks
560	SC	<u>CLAYEY SAND</u> continued	RD	Driller says added 4 sacks bentonite earlier in day
580				
600				
620				Stopped drilling at 620'; added 5 sacks bentonite, circulated, pulled drill string
640				Ended shift @2015
660	SP	650-700': <u>SAND</u> : med to coarse, uncemented, dark gray, angular to subangular, predominantly metamorphic clasts; qtz uncommon (<5%), contains +/-10% andestic (?) clasts: plag. & hornblende xtals in red groundmass.		5/23/96: began shift @ 0700; ran in hole, circulated; began new hole @ 1000 hrs.
680		Below 680', qtz becomes more abundant, but still no more than 5% of returns. Cuttings also contain chips of gray, angular clasts that resemble siltstone, but are probably tuff; minor soft clay.		Penetration rate is faster than circulation rate; cuttings samples taken @ 10-' intervals are probably composite of 20' drill length
700	Tuff	700-720': <u>SANDY TUFF</u> : hard, gray w/medium grain-size lithic clasts of metamorphic origin, some rhyolite/dacite; resembles siltstone.		
720	SP/ Tuff	720-820: Interbedded <u>SAND</u> and <u>TUFF</u> : as above; difficult to distinguish individual layers because tuff cuttings are the same size as sand clasts. Overall, there appears to be a 30/70 split between sand particles and sand-size tuff cuttings.		1100 hrs; fast drilling
740				
760				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

Project & Feature American Basin Conjunctive Use, SSWD Monitoring Well

Hole No. AB-1

Depth	Log	Field Classification and Description	Mode	Remarks
760	SP/ Tuff	Interbedded <u>SAND and TUFF</u> continued.	RD	Circulating @ 1200 hrs
780				
800				
820	CH	820-860': <u>FAT CLAY</u> : blue-gray, tuffaceous, high plasticity, contains abundant frags of tuff <1/8" diameter.		Circulating @1330 hrs, reamed borehole due to swelling formation; driller says fluid return is about 70% Fast drilling
840				
860	Tuff	860-940': <u>TUFF with SAND</u> : gray to mostly bluish-green, andesitic tuff and/or lahar w/ minor interbedded med to coarse sand(<5%); grains are angular to subrounded, qtz, basalt, greenstone and some orange-brown tuffaceous clasts.		
880				
900				
920				
940	SP	940-970': <u>SAND</u> : tuffaceous, as previously described at 500-580', but not clayey.		
960				

State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
DRILL HOLE LOG

Project & Feature American Basin Conjunctive Use, SSWD Monitoring Well

Hole No. AB-1

Depth	Log	Field Classification and Description	Mode	Remarks
960	SP	<u>SAND</u> continued	RD	
	Tuff	970-980': <u>TUFF with SAND</u> : andesitic, as previously described.		
980	Tuff	980-1000': <u>TUFF</u> : andesitic, as previously described, no sand or pebbles.		
1000				
		1008': BOTTOM OF HOLE		
1020				
1040				
1060				
1080				
1100				
1120				
1140				
1160				

51-1071

State of California
The Resources Agency
Department of Water Resources

State Well No. 12N04E03N04MDISTRICT Central**WELL DATA**

Owner California Department of Water Resources
Address 3251 S Street, Sacramento 95816
Tenant _____
Address _____

State Well No. 12N04E03N04M
Other No. AB-1, Shallow

Type of Well: Hydrograph ☒ Key ☐ Index ☐ Semiannual ☐
Location: County Sutter Basin North American No. 5-21.64
U.S.G.S. Quad. Nicholaus Quad. No. _____

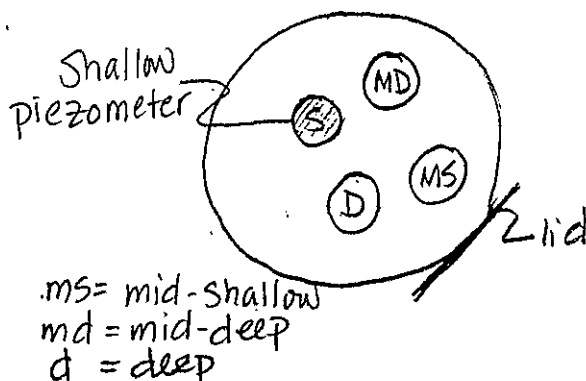
SW 1/4 SW 1/4 Section 03, Township. 12N, Range. 04E MD
SB Base & Meridian
H

Description Single vault, quadruple-completion, nested piezometer. Each piezometer is 2" in diameter, steel cased, with a stainless-steel perforated interval. Vault is secured with a padlock - lock is available at Central District office.

Reference Point description Top of the 2" piezometer, with cap removed. Shallow well is the tallest of the four casings.

Which is. 1.2 ft. Above land surface. Ground Elevation 48 ft.
Reference Point Elev. 49.2 ft. Below
Well: Use Monitoring Condition Very good - nearly new Depth 190 ft.
Casing, size 2 in., perforations 170 - 180 feet bgs

Measurement By: DWR ☒ USGS ☐ USBR ☐ County ☐ Irr. Dist. ☐ Water Dist. ☐ Cons. Dist. ☐
Chief Aquifer: Name _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Type of Material _____ Perm. Rating _____ Thickness _____
Gravel Packed? Yes ☒ No ☐ Depth to Top Gr. 80 feet Depth to Bot. Gr. 200 feet
Supp. Aquifer _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Driller Eaton Drilling
Date drilled May 22-23, 1996 Log, filed yes Open (1) ☒ Confidential (2) _____
Equipment: Pump, type _____ Make _____
Serial No. _____ Size of discharge pipe _____ in. _____
Power, Kind _____ Make _____
H.P. _____ Motor Serial No. _____
Elec. Meter No. _____ Transformer No. _____
Yield _____ GPM Pumping level _____ ft. _____
Water Analysis: Min. (1) ☒ San. (2) _____ H.M.(3) _____
Water Levels Available: Yes (1) ☒ No _____
Period of Record: Begin 07/11/96 End active
Collecting Agency California Department of Water Resources
Prod. Rec. (1) _____ Pump Test (2) _____ Yield (3) _____

SKETCH**REMARKS**

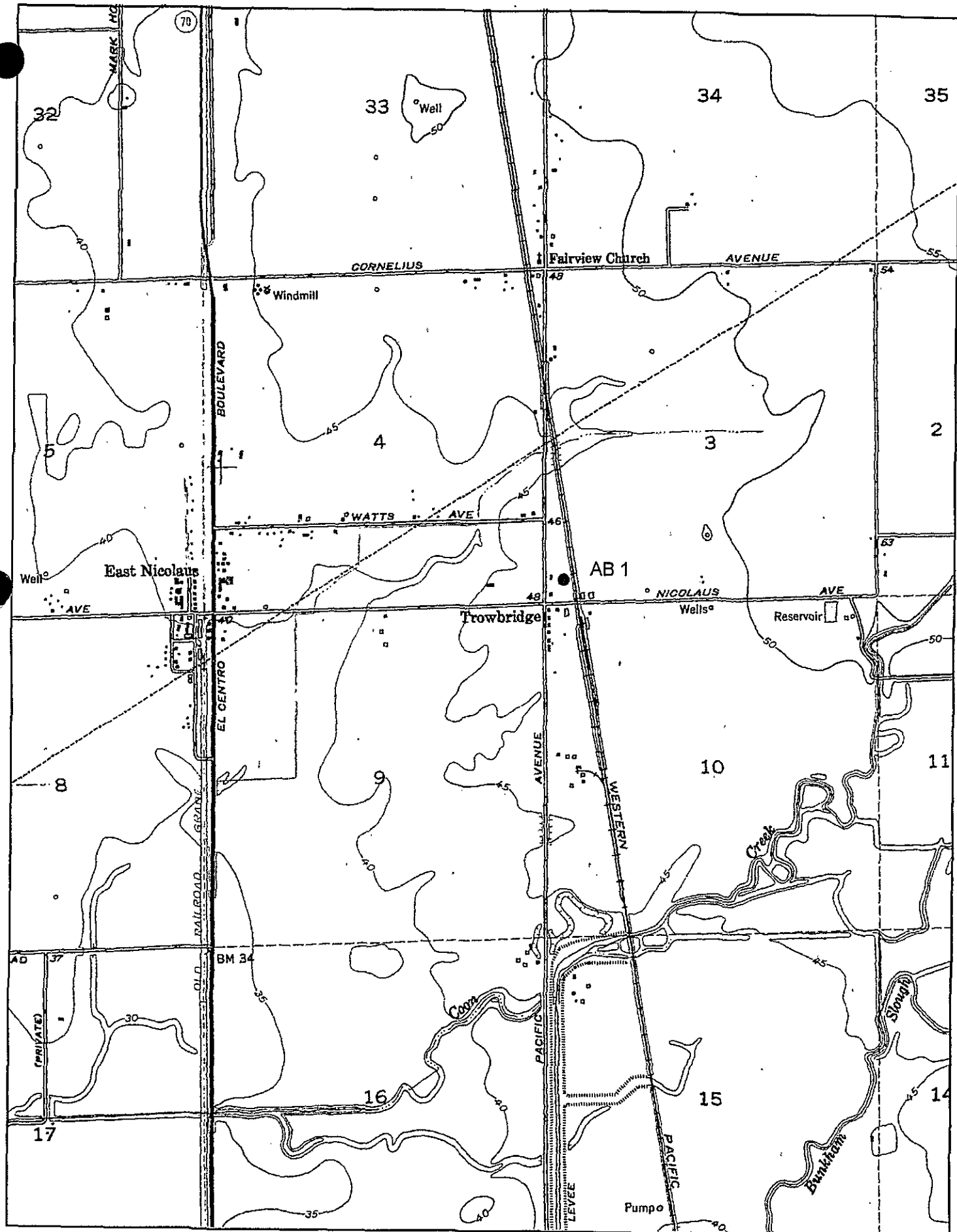
This is the shallow well of a quadruple-completion monitoring well.
The middle-shallow well is 530 feet deep, the middle-deep well is 710 feet, and the deep well is 980 feet. The four wells are separated by bentonite seals. A 1" steel air tube is attached to the well casing at 150' depth, and was used for well development. The well is located within the boundaries of RD 108 and was constructed with their permission. See attached map for location. Electric log of well is on file.

Recorded by: Naomi Kalman
Date: 01/10/01

Location of AB 1
Nicholaus Quad

51-1071

1:7272



51-1069

State of California
The Resources Agency
Department of Water Resources

State Well No. 12N04E03N02MDISTRICT Central**WELL DATA**

Owner California Department of Water Resources
Address 3251 S Street, Sacramento 95816
Tenant _____
Address _____

State Well No. 12N04E03N02M
Other No. AB-1, Middle-Deep

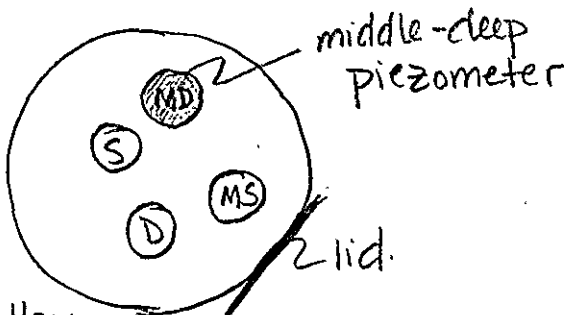
Type of Well: Hydrograph ☒ Key ☐ Index ☐ Semiannual ☐
Location: County Sutter Basin North American No. 5-21.64
U.S.G.S. Quad. Nicholaus Quad. No. _____
SW 1/4 SW 1/4 Section 03, Township. 12N, Range. 04E MD
SB Base & Meridian
H

Description Single vault, quadruple-completion, nested piezometer. Each piezometer is 2" in diameter, steel cased, with a stainless-steel perforated interval. Vault is secured with a padlock -- lock is available at Central District office.

Reference Point description Top of the 2" piezometer, with cap removed. Middle-deep well is the second shortest of the four casings.

Which is 0.9 ft. Above land surface. Ground Elevation 48 ft.
Reference Point Elev. 48.9 ft. Below ft. Determined from USGS Quad
Well: Use Monitoring Condition Very good -- nearly new Depth 710 ft.
Casing, size 2 in., perforations 680 - 700 feet bgs

Measurement By: DWR ☒ USGS ☐ USBR ☐ County ☐ Irr. Dist. ☐ Water Dist. ☐ Cons. Dist. ☐
Chief Aquifer: Name _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Type of Material _____ Perm. Rating _____ Thickness _____
Gravel Packed? Yes ☒ No ☐ Depth to Top Gr. 620 feet Depth to Bot. Gr. 855 feet
Supp. Aquifer _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Driller Eaton Drilling
Date drilled May 22-23, 1996 Log, filed yes Open (1) ☒ Confidential (2) _____
Equipment: Pump, type _____ Make _____
Serial No. _____ Size of discharge pipe _____ in. _____
Power, Kind _____ Make _____
H.P. _____ Motor Serial No. _____
Elec. Meter No. _____ Transformer No. _____
Yield _____ GPM Pumping level _____ ft. _____
Water Analysis: Min. (1) ☒ San. (2) _____ H.M. (3) _____
Water Levels Available: Yes (1) ☒ No _____
Period of Record: Begin 07/11/96 End active
Collecting Agency California Department of Water Resources
Prod. Rec. (1) _____ Pump Test (2) _____ Yield (3) _____

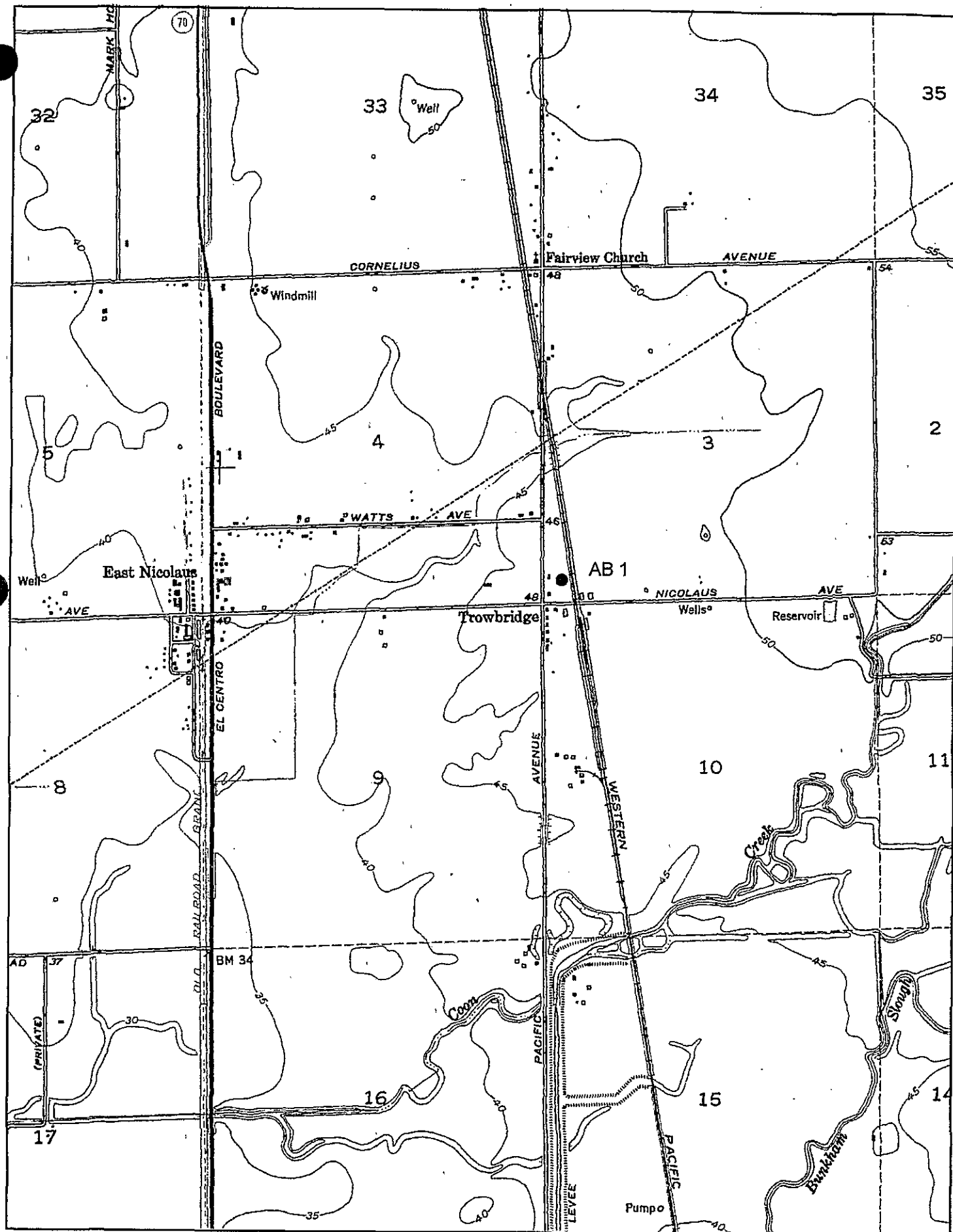
SKETCH

S=shallow
ms=middle-shallow
d=deep

REMARKS

This is the middle-deep well of a quadruple-completion monitoring well. The shallow well is 190 feet deep, the middle-shallow well is 530 feet, and the deep well is 980 feet. The four wells are separated by bentonite seals. A 1" steel air tube is attached to the well casing at 150' depth, and was used for well development. The well is located within the boundaries of RD 108 and was constructed with their permission. See attached map for location. Electric log of well is on file.

Recorded by: Naomi Kalman
Date: 01/10/01



51-1070

State of California
The Resources Agency
Department of Water Resources

State Well No. 12N04E03N03MDISTRICT Central**WELL DATA**

Owner California Department of Water Resources
Address 3251 S Street, Sacramento 95816
Tenant _____
Address _____

State Well No. 12N04E03N03M
Other No. AB-1, Middle-Shallow

Type of Well: Hydrograph ☒ Key ☐ Index ☐ Semiannual ☐
Location: County Sutter Basin North American No. 5-21.64
U.S.G.S. Quad. Nicholaus Quad. No. _____
SW 1/4 SW 1/4 Section 03, Township. 12N, Range. 04E MD
SB Base & Meridian
H

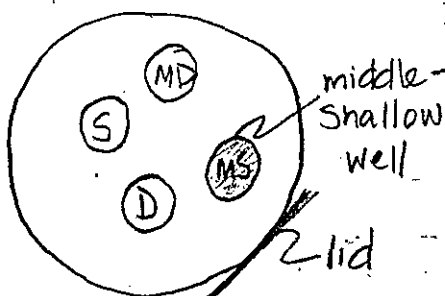
Description Single vault, quadruple-completion, nested piezometer. Each piezometer is 2" in diameter, steel cased, with a stainless-steel perforated interval. Vault is secured with a padlock - lock is available at Central District office.

Reference Point description Top of the 2" piezometer, with cap removed. Middle-shallow well is the second-tallest of the four casings.

Which is 1.0 ft. ^{Above} land surface. Ground Elevation -48 ft.
Reference Point Elev. 49 ft. Determined from USGS Quad
Well: Use Monitoring Condition Very good - nearly new Depth 530 ft.
Casing, size 2 in., perforations 390 - 400 and 510 - 520 feet bgs

Measurement By: DWR ☒ USGS ☐ USBR ☐ County ☐ Irr. Dist. ☐ Water Dist. ☐ Cons. Dist. ☐
Chief Aquifer: Name _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Type of Material _____ Perm. Rating _____ Thickness _____
Gravel Packed? Yes ☒ No ☐ Depth to Top Gr. 370 feet Depth to Bot. Gr. 600 feet
Supp. Aquifer _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Driller Eaton Drilling
Date drilled May 22-23, 1996 Log, filed yes Open (1) ☒ Confidential (2) _____
Equipment: Pump, type _____ Make _____
Serial No. _____ Size of discharge pipe _____ in.
Power, Kind _____ Make _____
H.P. _____ Motor Serial No. _____
Elec. Meter No. _____ Transformer No. _____
Yield _____ GPM Pumping level _____ ft.

Water Analysis: Min. (1) ☒ San. (2) _____ H.M. (3) _____
Water Levels Available: Yes (1) ☒ No _____
Period of Record: Begin 07/11/96 End active
Collecting Agency California Department of Water Resources
Prod. Rec. (1) _____ Pump Test (2) _____ Yield (3) _____

SKETCH

S = Shallow
md = middle deep
d = deep

REMARKS

This is the middle-shallow of a quadruple-completion monitoring well.
The shallow well is 190 feet deep, the middle-deep well is 710 feet, and the deep well is 980 feet. The four wells are separated by bentonite seals. A 1" steel air tube is attached to the well casing at 150' depth, and was used for well development. The well is located within the boundaries of RD 108 and was constructed with their permission. See attached map for location. Electric log of well is on file.

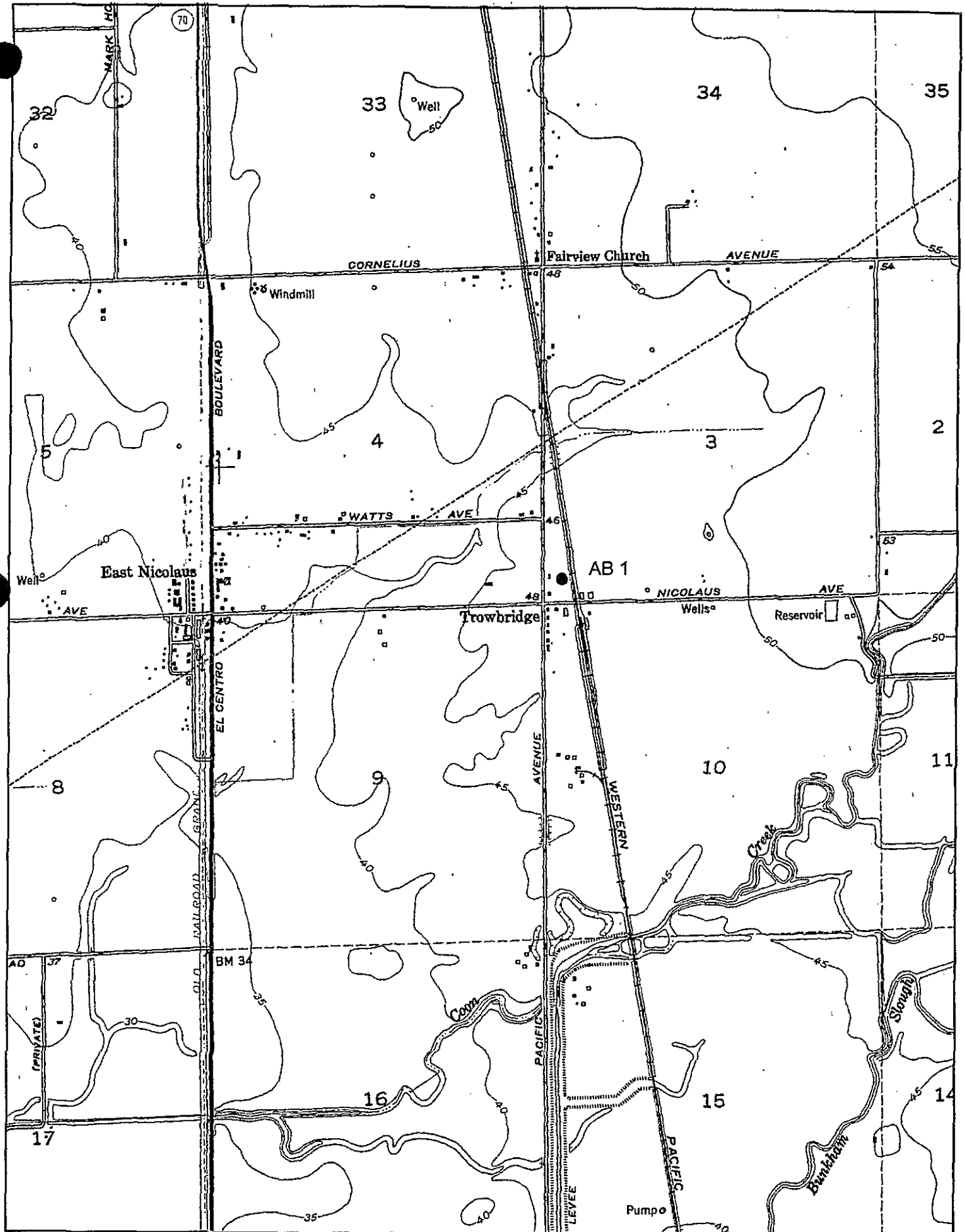
Recorded by: Naomi Kalman
Date: 01/10/01

Location of AB 1
Nicholaus Quad



51-1070

1:7272



51-1068

State of California
The Resources Agency
Department of Water Resources

State Well No. 12N04E03N01MDISTRICT Central**WELL DATA**

Owner California Department of Water Resources State Well No. 12N04E03N01M
Address 3251 S Street, Sacramento 95816 Other No. AB-1, Deep
Tenant _____
Address _____

Type of Well: Hydrograph ☒ Key ☐ Index ☐ Semiannual ☐
Location: County Sutter Basin North American No. 5-21.64
U.S.G.S. Quad. Nicholaus Quad. No. _____

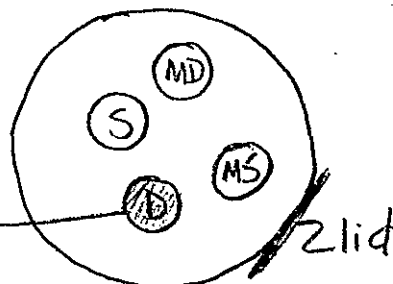
SW 1/4 SW 1/4 Section 03, Township. 12N, Range. 04E MD SB H Base & Meridian

Description Single vault, quadruple-completion, nested piezometer. Each piezometer is 2" in diameter, steel cased, with a stainless-steel perforated interval. Vault is secured with a padlock - lock is available at Central District office.

Reference Point description Top of the 2" piezometer, with cap removed. Deep well is the shortest of the four casings.

Which is 0.4 ft. Above land surface. Ground Elevation 48 ft.
Reference Point Elev. 48.4 ft. Below ft. Determined from USGS Quad
Well: Use Monitoring Condition Very good - nearly new Depth 980 ft.
Casing, size 2 in., perforations 950 - 970 feet bgs

Measurement By: DWR ☒ USGS ☐ USBR ☐ County ☐ Irr. Dist. ☐ Water Dist. ☐ Cons. Dist. ☐
Chief Aquifer: Name _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Type of Material _____ Perm. Rating _____ Thickness _____
Gravel Packed? Yes ☒ No ☐ Depth to Top Gr. 895 feet Depth to Bot. Gr. 1000 feet
Supp. Aquifer _____ Depth to Top Aq. _____ Depth to Bot. Aq. _____
Driller Eaton Drilling
Date drilled May 22-23, 1996 Log, filed yes Open (1) ☒ Confidential (2) _____
Equipment: Pump, type _____ Make _____
Serial No. _____ Size of discharge pipe _____ in. _____
Power, Kind _____ Make _____
H.P. _____ Motor Serial No. _____
Elec. Meter No. _____ Transformer No. _____
Yield _____ GPM Pumping level _____ ft. _____
Water Analysis: Min. (1) ☒ San. (2) _____ H.M. (3) _____
Water Levels Available: Yes (1) ☒ No _____
Period of Record: Begin 07/11/96 End active
Collecting Agency California Department of Water Resources
Prod. Rec. (1) _____ Pump Test (2) _____ Yield (3) _____

SKETCH

S = shallow
MS = middle - shallow
MD = middle - deep

REMARKS

This is the deep well of a quadruple-completion monitoring well.
The shallow well is 190 feet deep, the middle-shallow well is 530 feet, and the middle-deep well is 710 feet. The four wells are separated by bentonite seals. A 1" steel air tube is attached to the well casing at 150' depth, and was used for well development. The well is located within the boundaries of RD 108 and was constructed with their permission. See attached map for location. Electric log of well is on file.

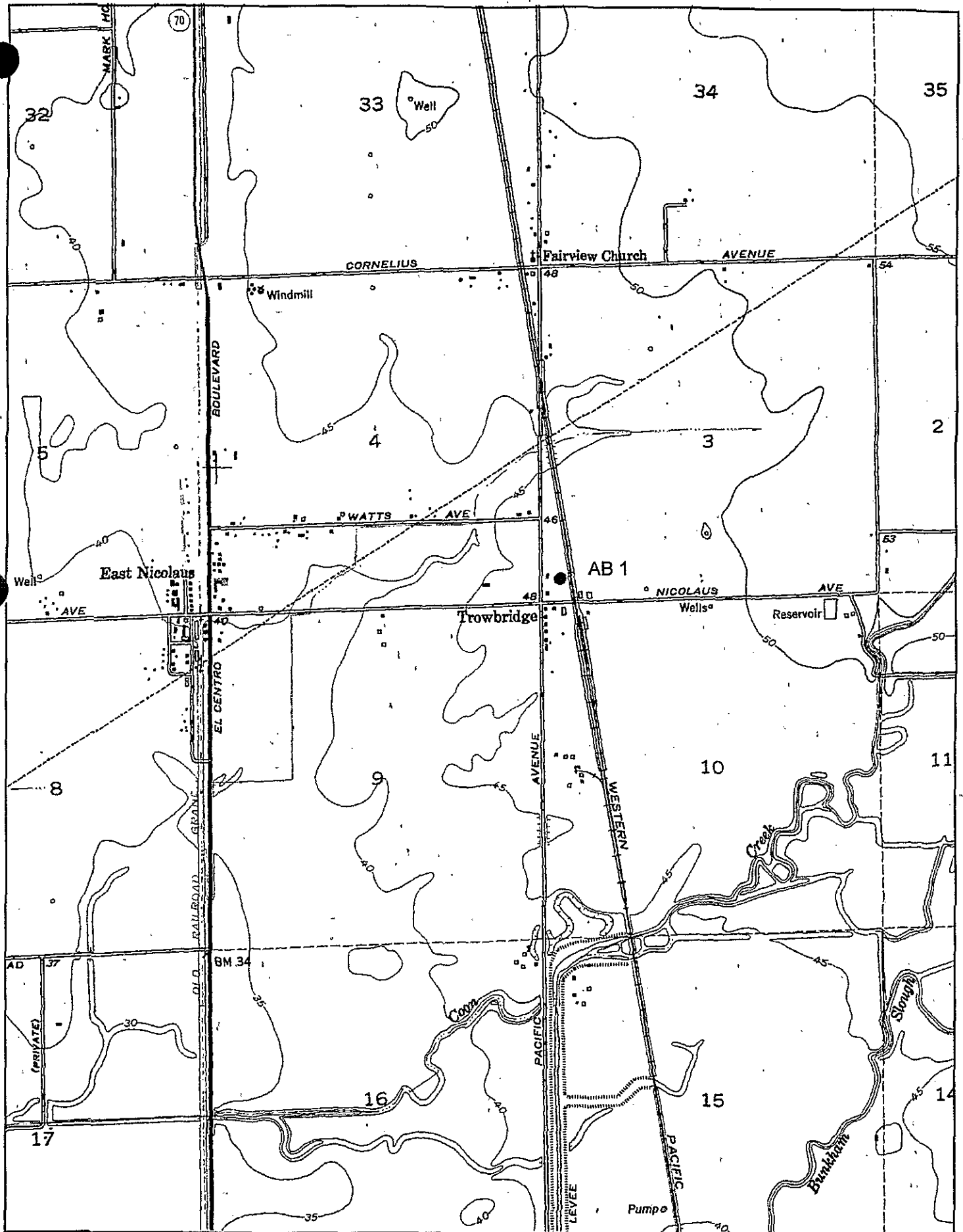
Recorded by: Naomi Kalman
Date: 01/10/01

Location of AB 1
Nicholaus Quad



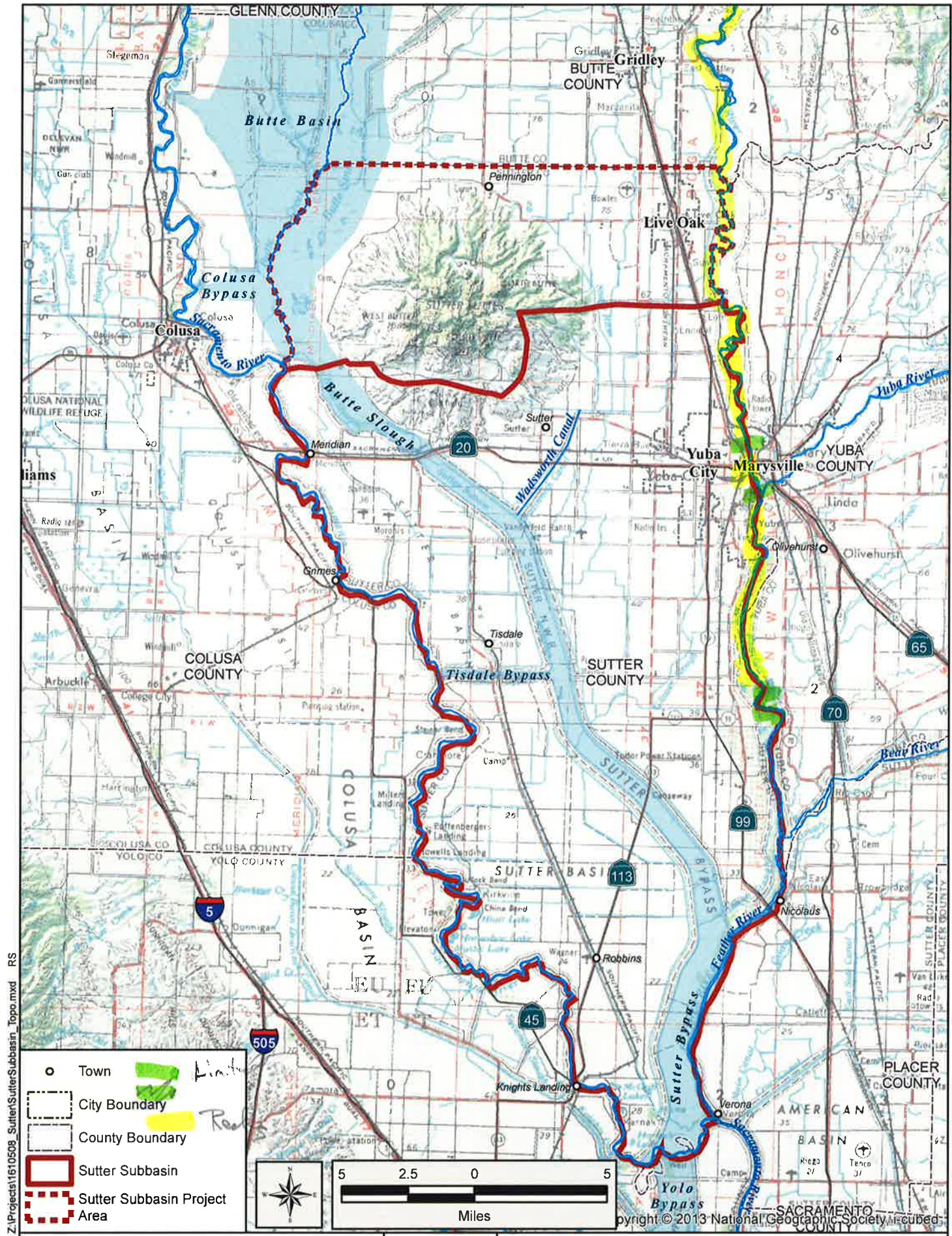
51-1068

1:7272



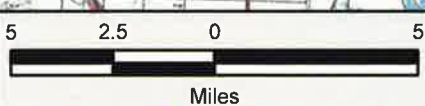
Appendix 5-B
Geologic Sections – Feather River Levees

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30-Sep-2016 Z:\Projects\1610508_Sutter\1610508_SutterSubbasin_Topo.mxd RS

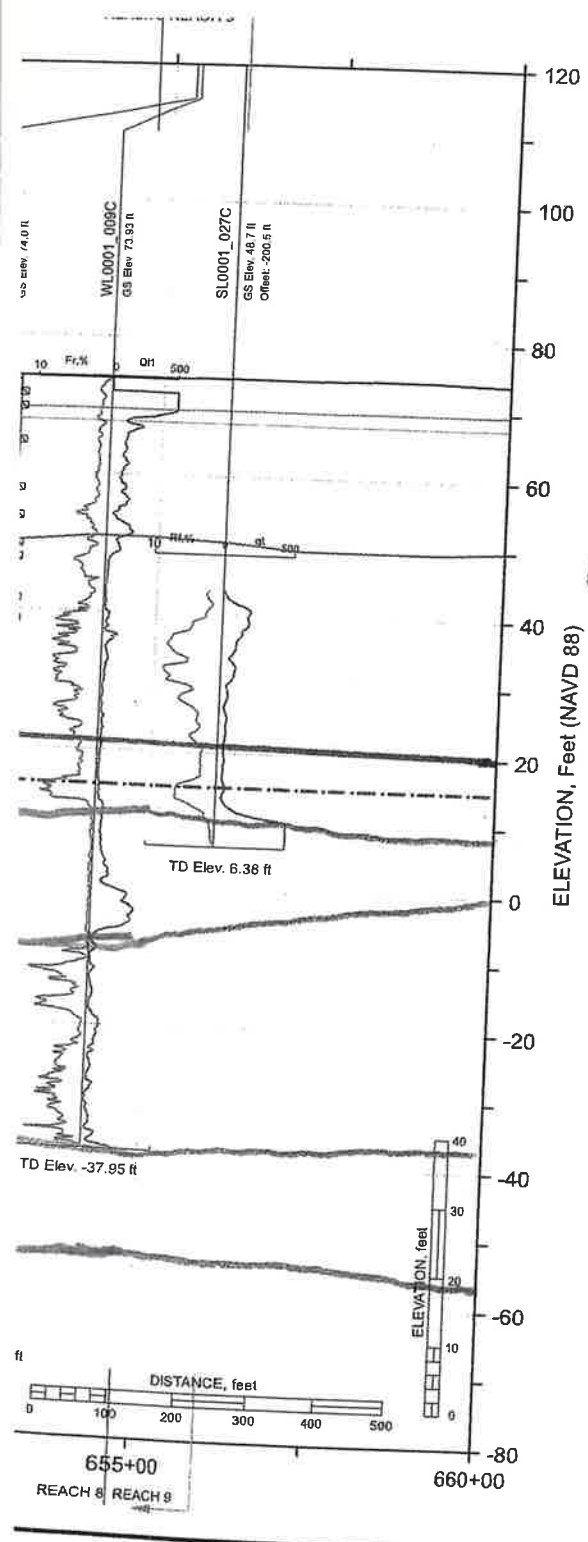
- Town
- City Boundary
- County Boundary
- Sutter Subbasin
- Sutter Subbasin Project Area



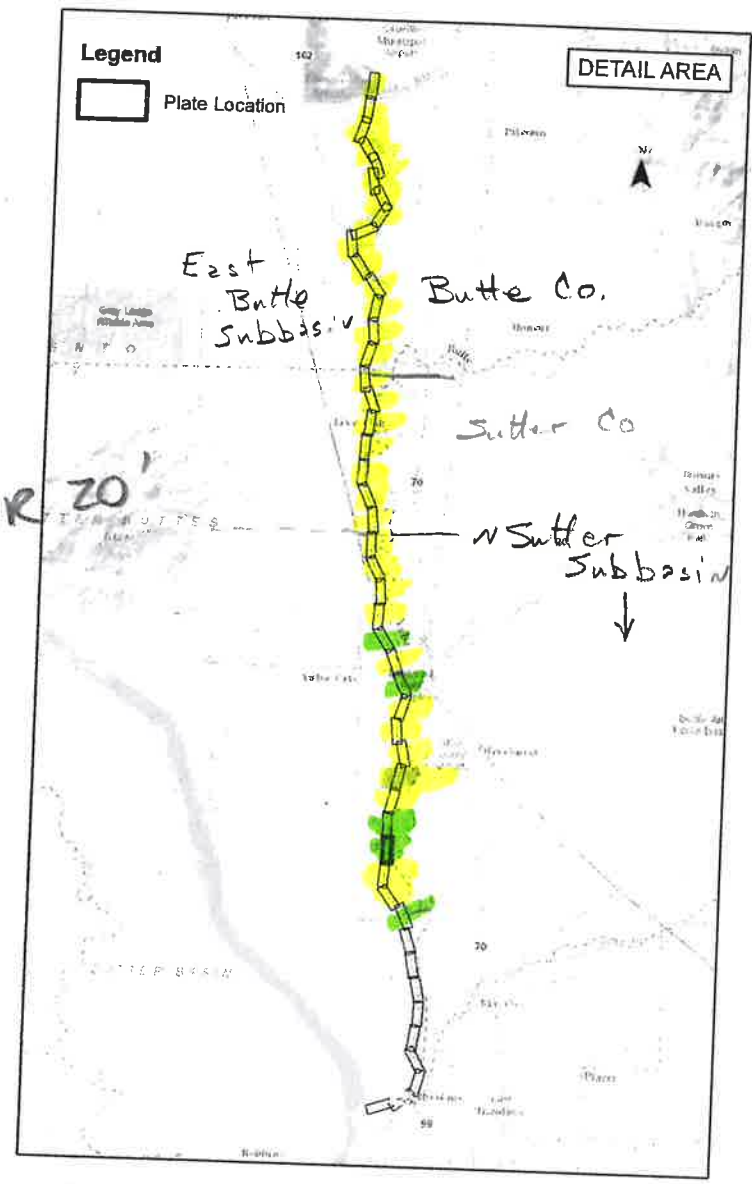
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Project Title	Sutter Groundwater Subbasin		
Location	2nd By-Pass Geology		
Client	GEI Consultants	SEPTEMBER 2016	FIGURE

Groundwater Recharge Areas from Rivers



BOR 20'



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 610+00 to Station 660+00

URS

Geotechnical Design
Recommendations Report



Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A15

Direct Sand and Gravel opposite invert of River, not previously blocked by slurry wall
Clay to silt opposite invert of River (pre-2013)
not p

EXPLORATIONS & LEVEE FEATURES

- ### DOCUMENTED HISTORICAL LEVEE DISTRESS

- SURFICIAL GEOLOGY LEGEND** (Source: DWR-2010a)

Surficial Geology was mapped at 1:20,000.

Geologic contact; dashed where approximate, dotted where concealed, queried where uncertain; solid contacts within 30' of line shown on map.

Water bodies, circa 1937

GEOLOGIC UNITS*

- | | | |
|------------|--|---|
| Historical | L | Levee; Culturally deposited |
| | SP | Spills pile; Artificial fill, circa 1937 |
| | DT | Dredge fillings; Spills material from gold dredge operations |
| | Rob | Overbank deposits; sand, silt, and clay; deposited during high-stage water flow, overtopping channel banks |
| | Rcs | Crawasse spray deposits; Fine to coarse sand, with minor lenses of clay deposited from leaching of natural or artificial levees |
| | Rdf | Distributary fan deposits; Sand, silt and clay |
| | Rdc | Distributary channel deposits; Distributary channel deposits, trace gravel, sand, silt, and clay; channelized flow conducting sediment to floodplain |
| | Rofo | Over-flow channels; Vertically stratified sand, silt and clay in channels' occupation during high-stage water overtops channel banks |
| | Rcl | Slough deposits; Sand, silt, and clay; lining upward flow, low energy channel deposit |
| | Rcu | Crawasse spray deposits; Cut of channel (chula); occurs on inside of meander banks with the river channel; on flood plain - enrichment of channel's contents into hydraulic mining channels |
| | Rhh | Channel deposits; Sorted sands and silts; lining upward (R11); channels as shown on historic logs |
| | Rb | Channel bar deposits; fine gravel, sand, and silt deposited in or along channel lateral margins |
| Rms | Channel meander/ scroll deposits; Sand, silt and clay from lateral channel migration | |
| Ra | Alluvial deposits, undifferentiated; sand, silt, and minor lenses of fine gravel | |

- Berm
- Ditch/Canal
- Levee Raise
- Levee Raise and Widening
- Levee Reconstruction
- *Relief Well
- Revetment
- Riprap
- Seepage Interceptor System
- Bentonite-Tire Slurry Wall
- Slurry Cutoff Wall
- Toe Drain
- Waterside Slope Repair
- Proposed Mitigation Measure
(See specifics on each plate)

*Dots are not representative of actual locations of relief wells

PROFILE LEGEND

- ## SOIL CLASSIFICATIONS

"S" for SBFCA
"W" for DWR

Local District Category
 "R" for Reclamation District
 "L" for Levee District
 "M" for Maintenance Area
 "C" for County of Local
 Maintenance Agency
 "S" for State. For areas not
 within any of the above
 districts or areas
 "P" for Private. Non-State
 doesn't fit into any of the
 above categories.

SX** ##YY**

Exploration Number
Use 001 through 999

Underscore
" " as a Separator

Local District Number/Special Designation
Use "0" at front if it is less than 4 digits. If "S", "C", or "F" is used in the Local District Category, a four character abbreviation describing the river or channel where the levee is located will be used here.

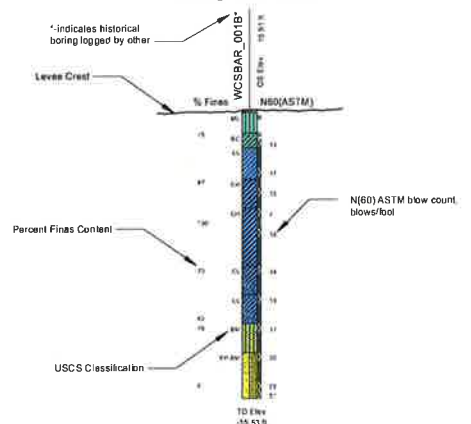
Hole Type Code
 "A" for Auger (Hollow Stem)
 "B" for Boring (Mud Rotary)
 "C" for CPT
 "H" for Hand-Auger
 "S" for Sonic
 "M" for Monitoring Well
 "T" for Test Pit
 "K" for Bucket Auger
 "V" for Vane Shear Exploration

SAMPLER GRAPHIC SYMBOLS	
	Standard Penetration Test
	Modified California
	Punch Core
	Standard California
	Shelby Tube
	Sieve Core
	Bag Sample

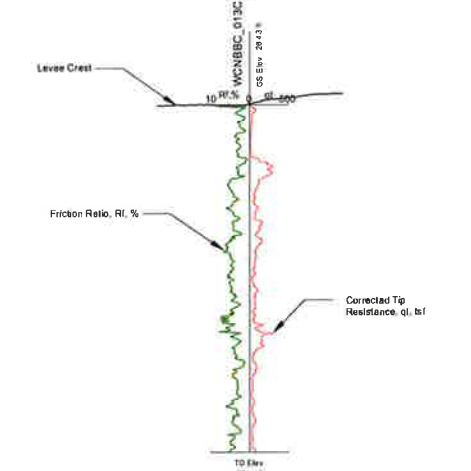
NOTE:
Some historical locations may not have stick figures in the profile view due to:

1. Incomplete data.
2. Available exploration on the plans and stick logs show comparable stratigraphy as historical explorations and are therefore not included due to limited space. However, all historical explorations are included in the GDR.

Boring Information



CPT Information



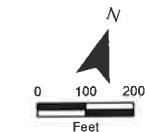
FRWL Project Plan Views and Stick Log Figures

Plate Legend

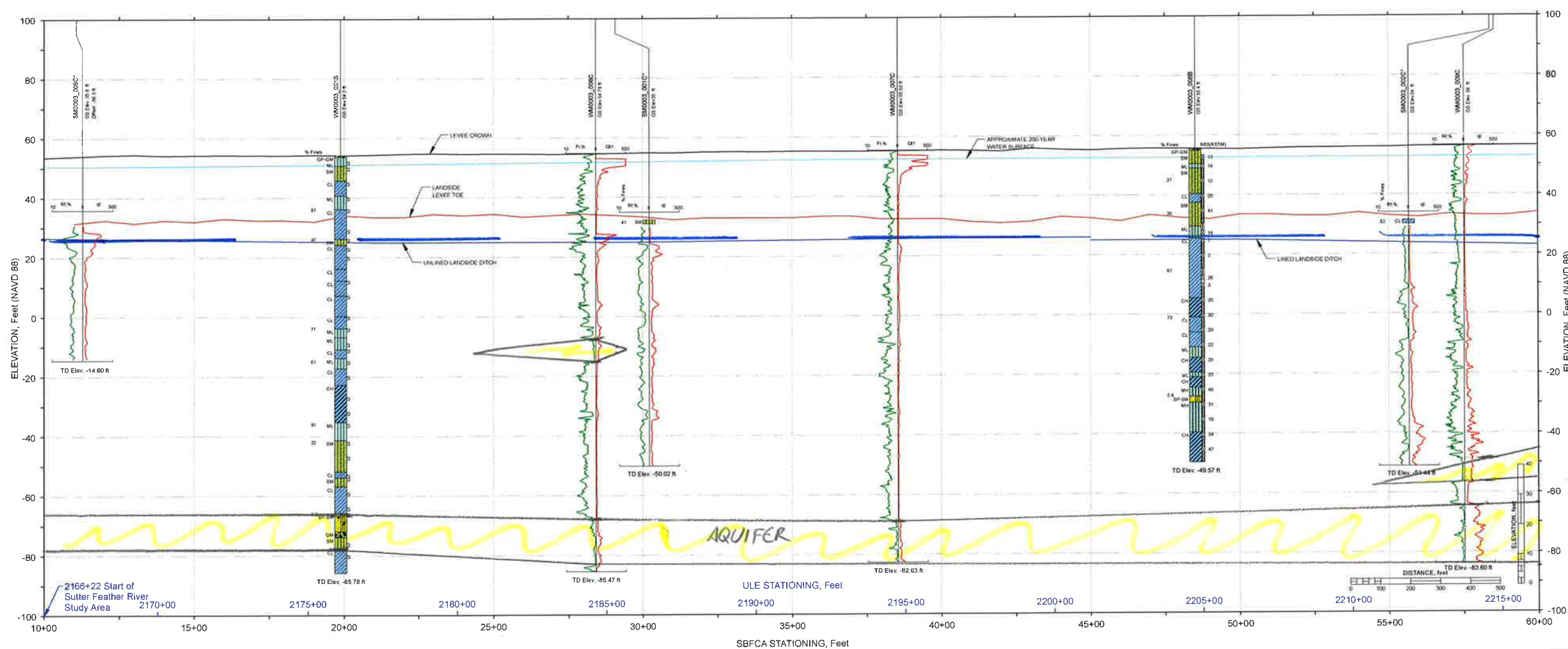
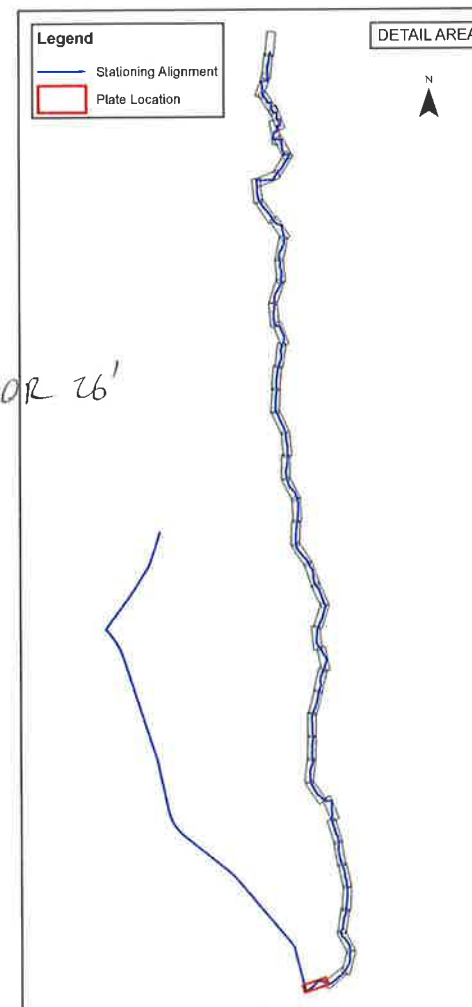
Geotechnical Design
Recommendations Report

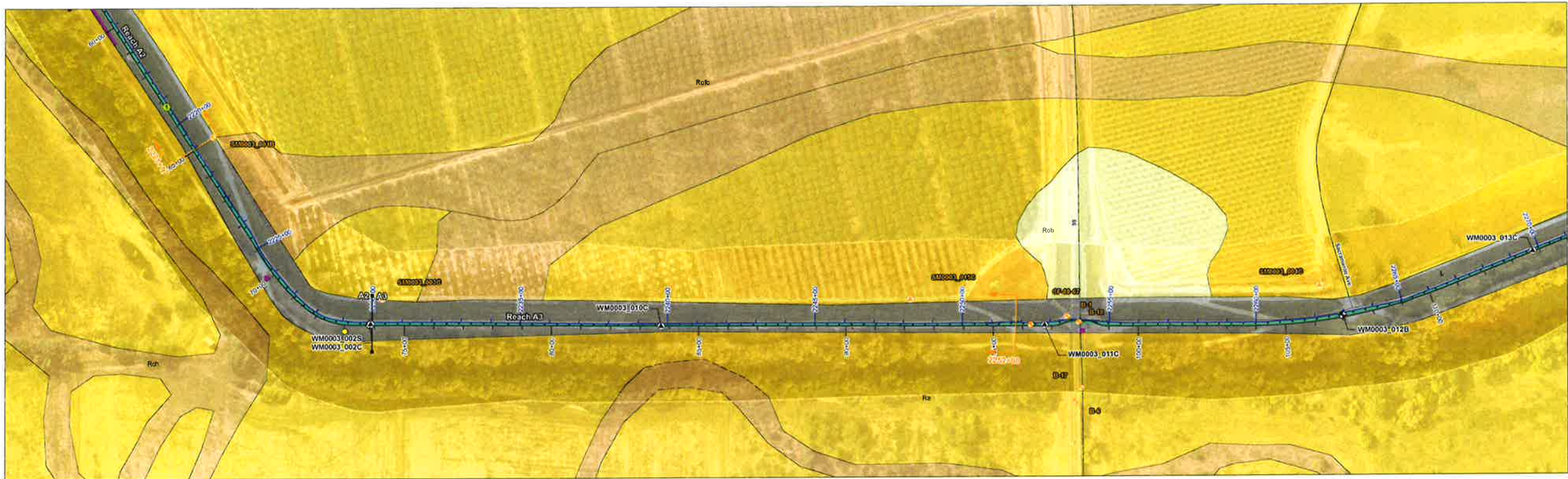
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A2



- NOTES:**
1. These Plan and Profile plates were adapted from Sutter Butte Flood Control Agency (SBFCA) Geotechnical Design Recommendation Report (GDRR) Plan and Profile Plates.
 2. Elevations of levee crown, landslide toe, and ditch inverts are approximate.
 3. Historical borings in the profile are denoted by an asterisk (*) after the boring name. Historical boring locations and profiles are based on available information. Some historic explorations are shown on the plan but not in the profile.
 4. Historical exploration symbols may represent a boring, CPT, or other exploration type.
 5. Refer to the preceding P1GD RR and/or SGDR for the Sutter Study Area and SBFCA CDR for a full understanding of the historical exploration information and data to assist with interpreting the information within this GER.
 6. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft).
 7. Where multiple exploration symbols overlap, see labels for clarification.
 8. The information provided in these Plan and Profile plates has been compiled from a variety of sources. The URS team does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.



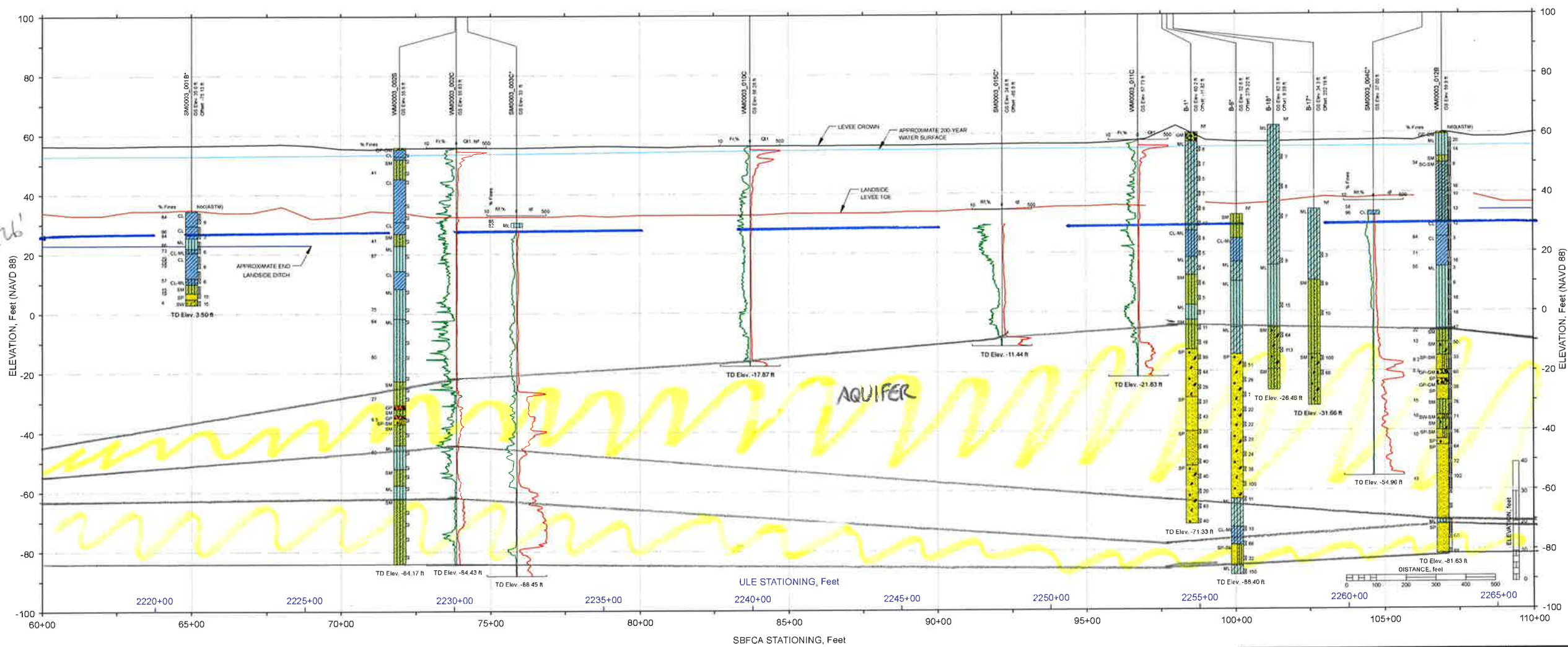
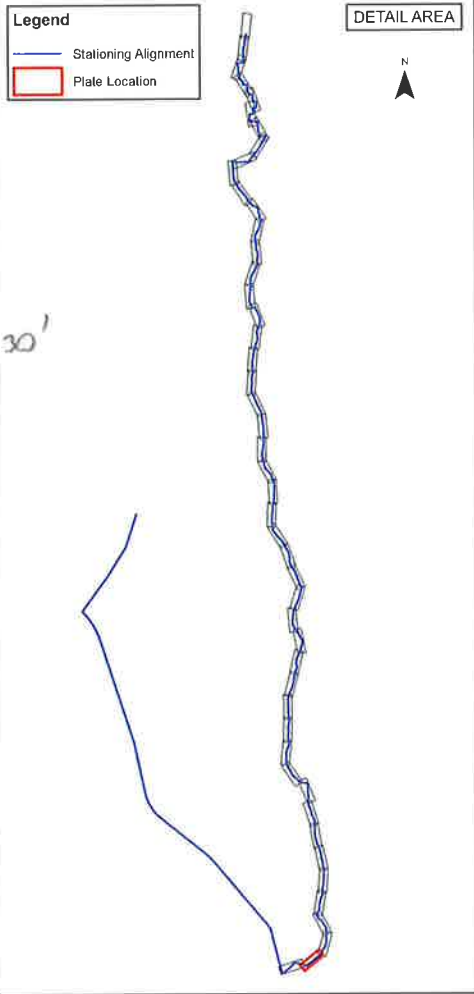


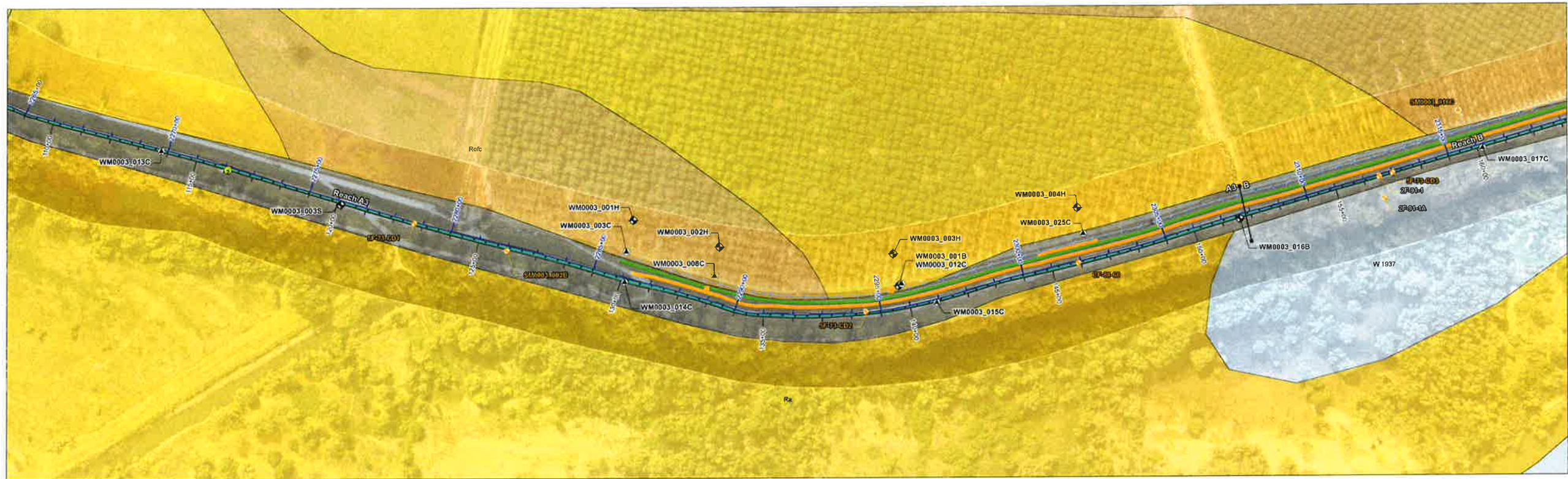
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Feet

1 inch equals 200 feet

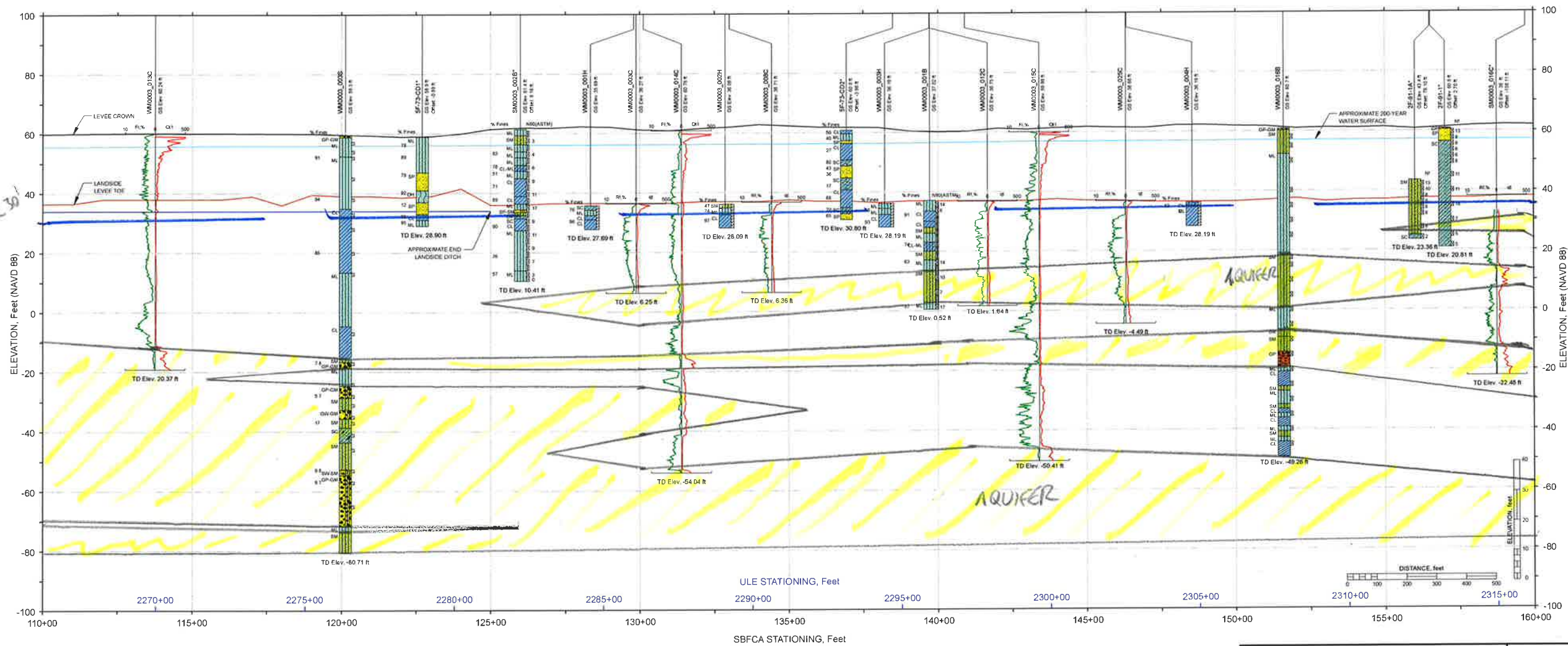
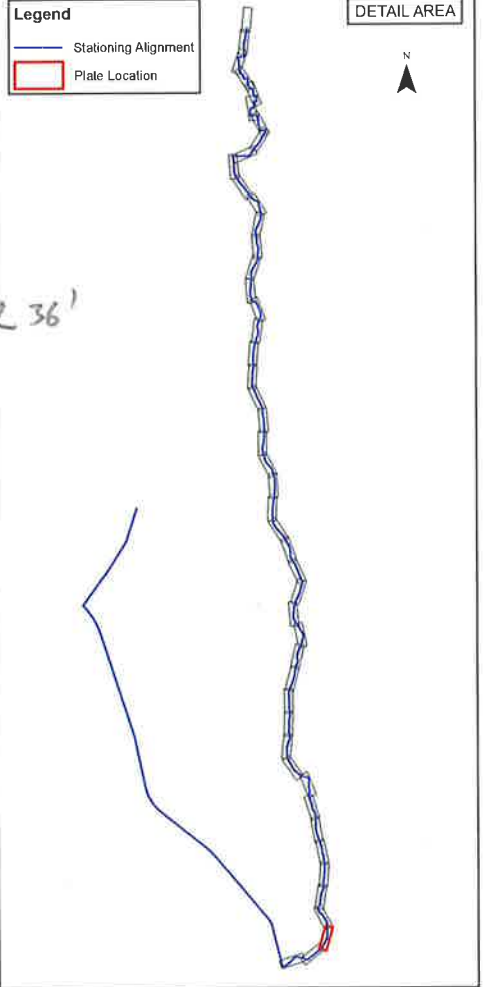
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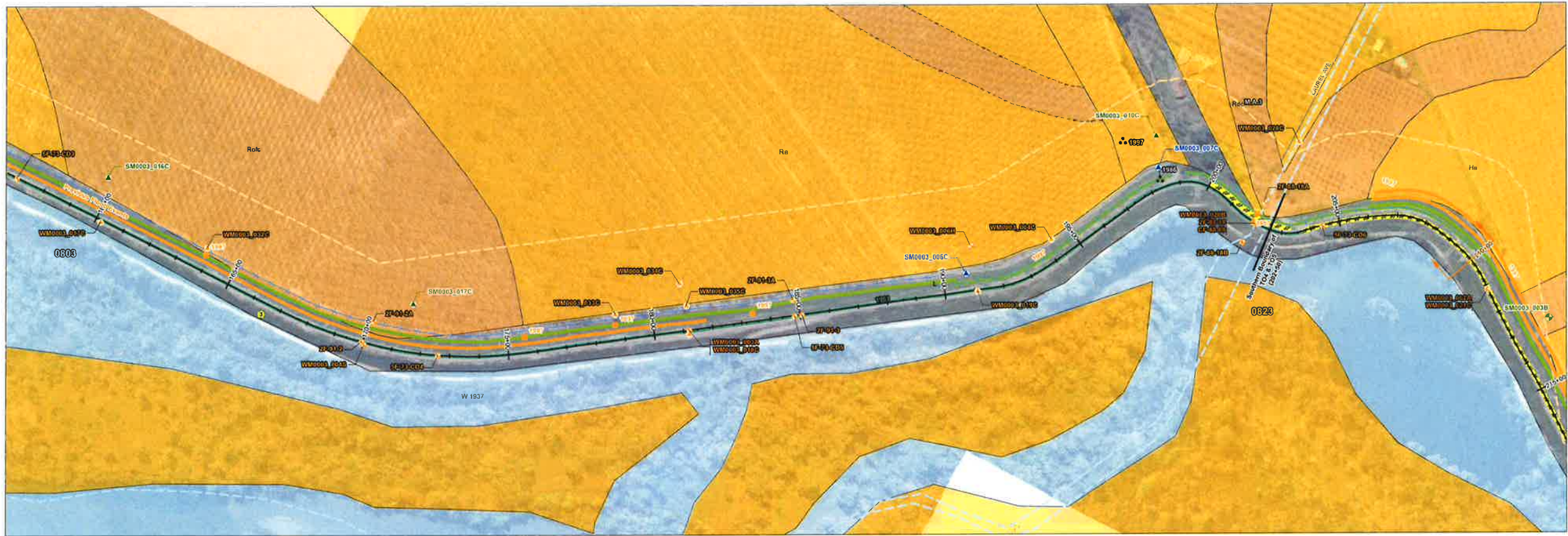
1. These Plan and Profile plates were adapted from Sutter Butte Flood Control Agency (SBFCA) Geotechnical Design Recommendation Report (GDRR) Plan and Profile Plates.
2. Elevations of levee crown, landside toe, and ditch inverts are approximate.
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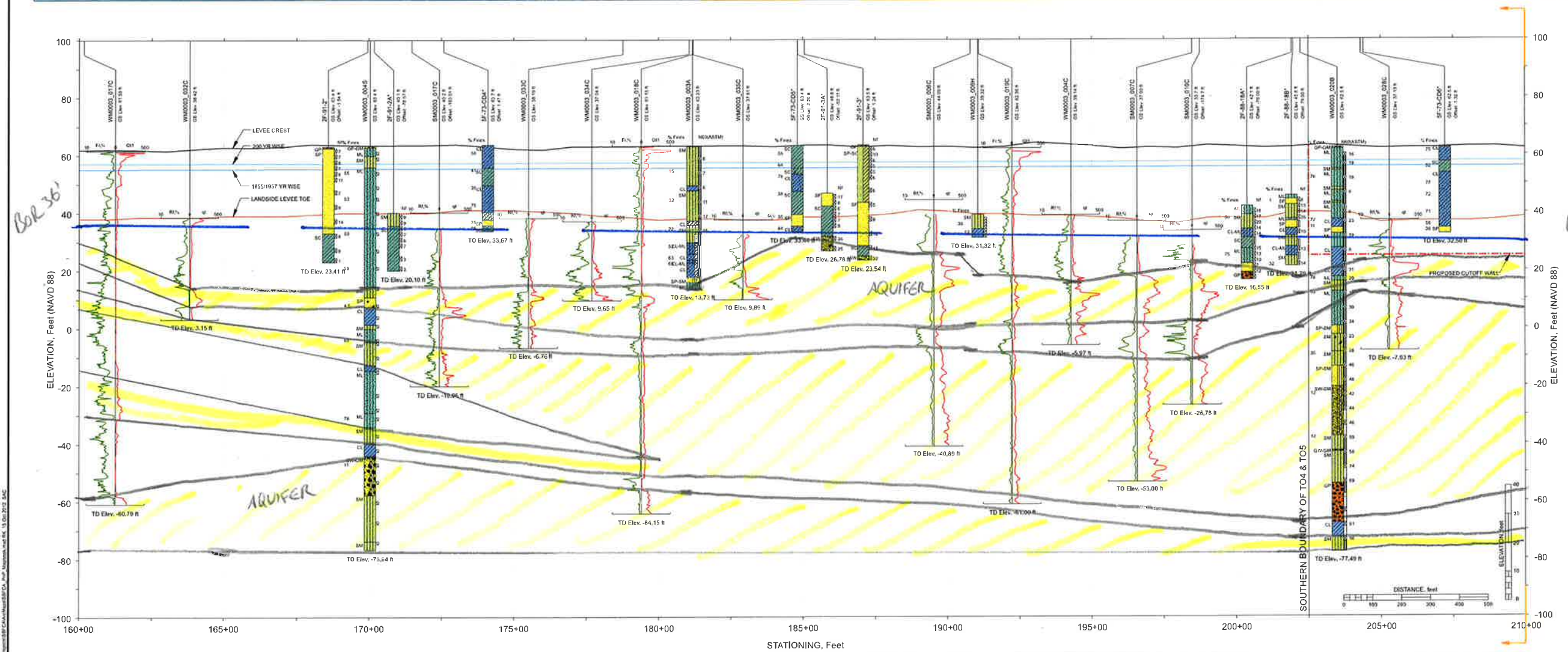
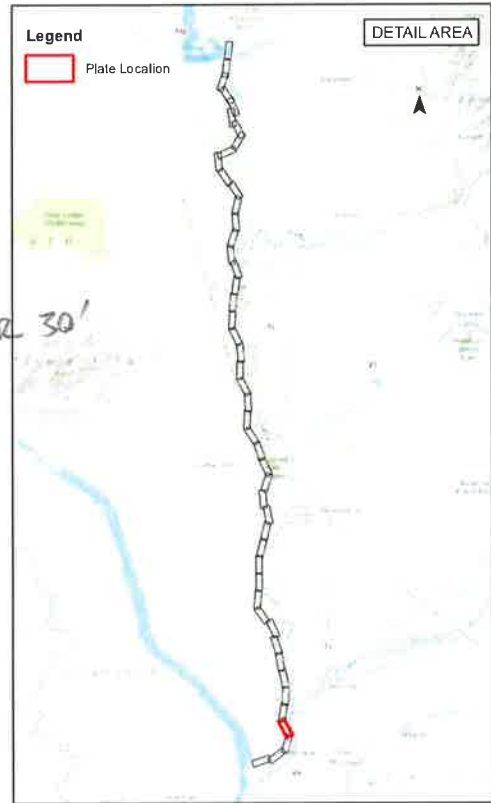


- NOTES:
1. These Plan and Profile plates were adapted from Sutter Butte Flood Control Agency (SBFCA) Geotechnical Design Recommendation Report (GDRR) Plan and Profile Plates.
 2. Elevations of levee crown, landside toe, and ditch inverts are approximate.
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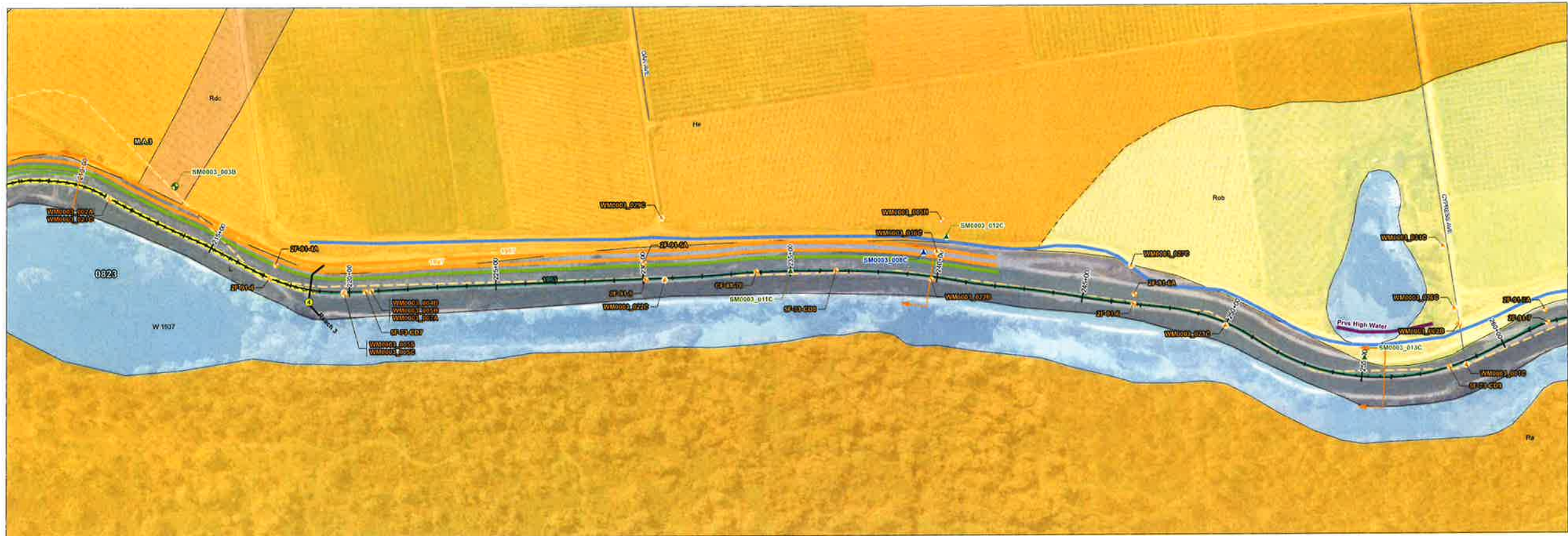




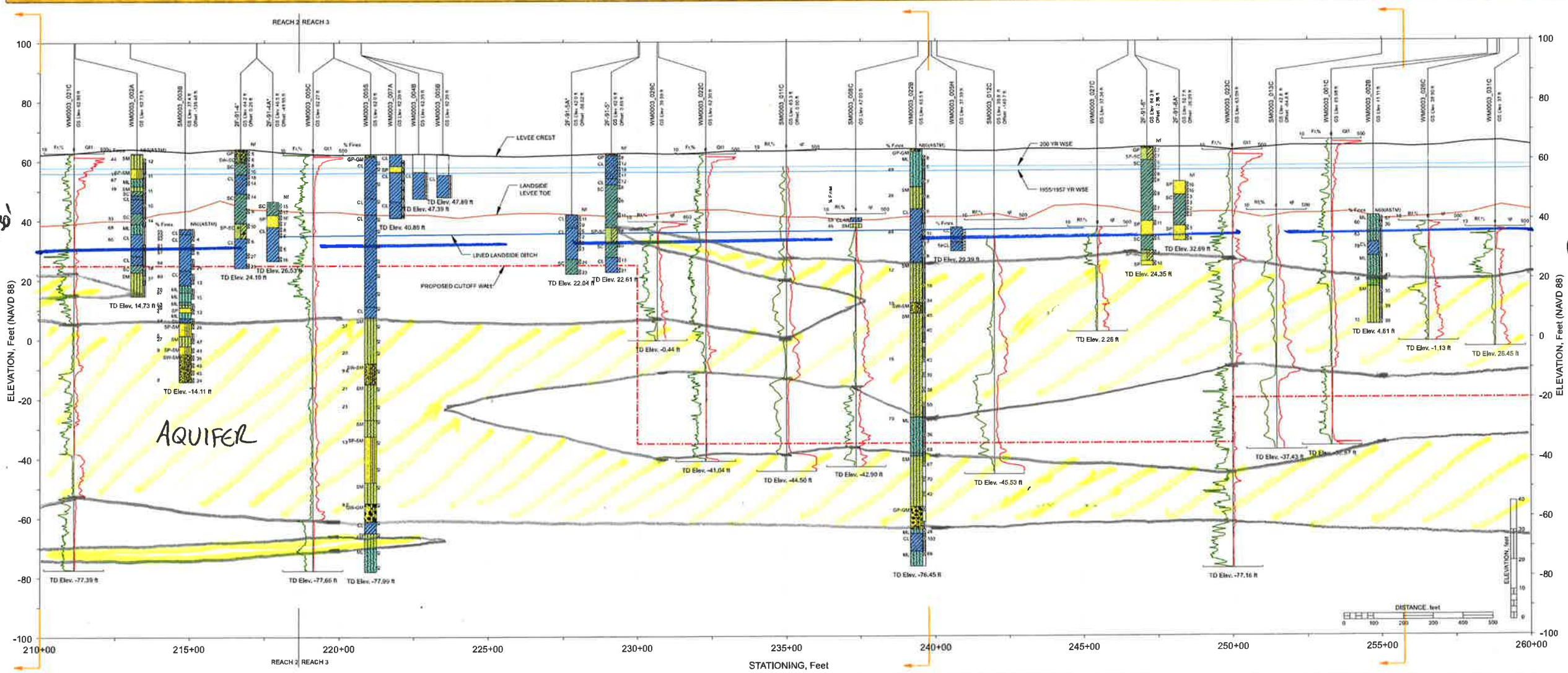
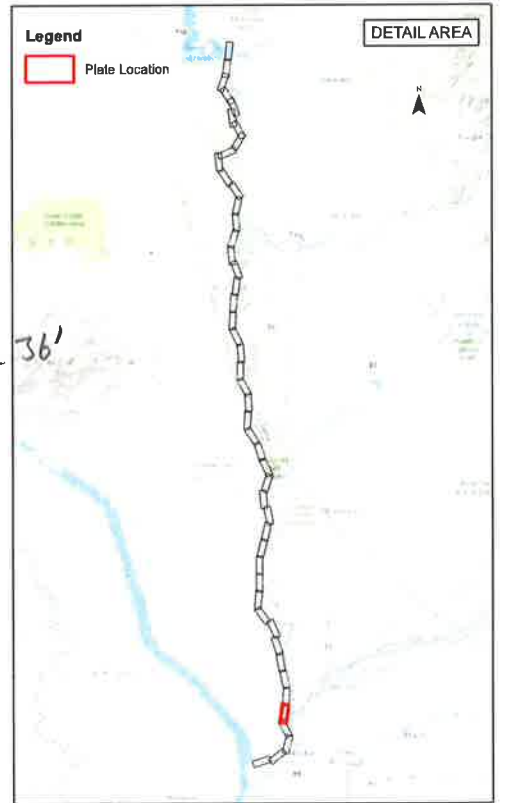
- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The cantalich elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 160+00 to Station 210+00



- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hemmer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hemmer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project, Station 210+00 to Station 260+00

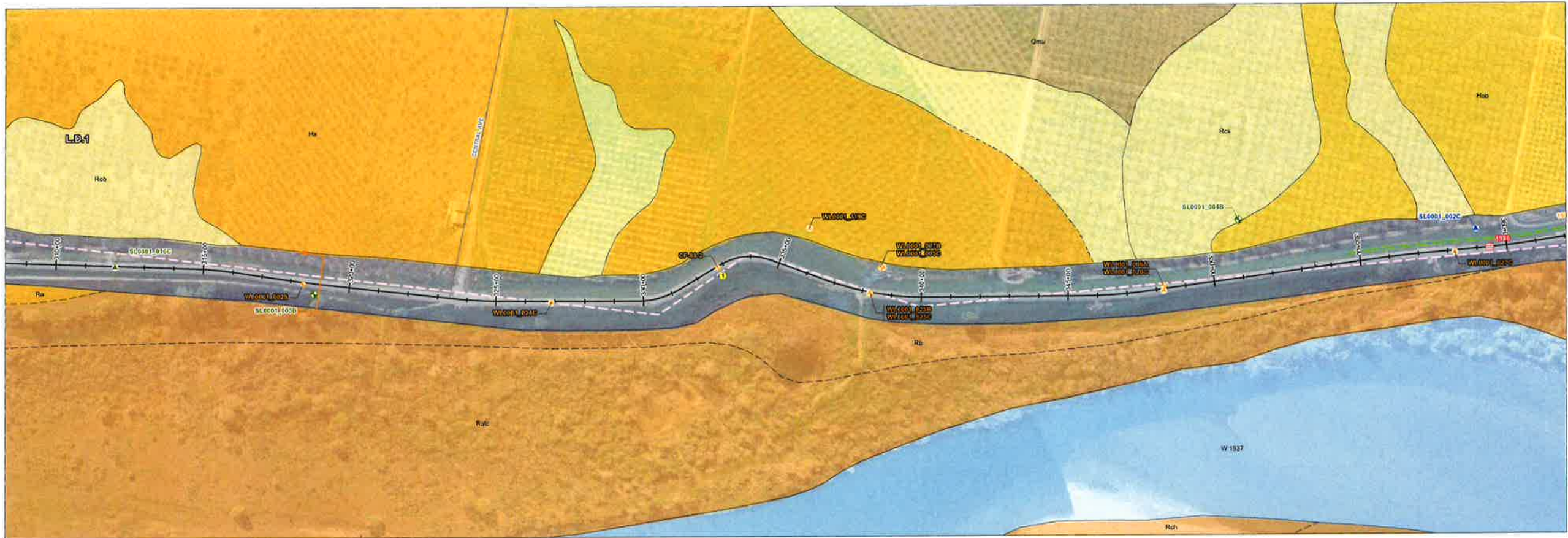
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Geotechnical Design
Recommendations Report

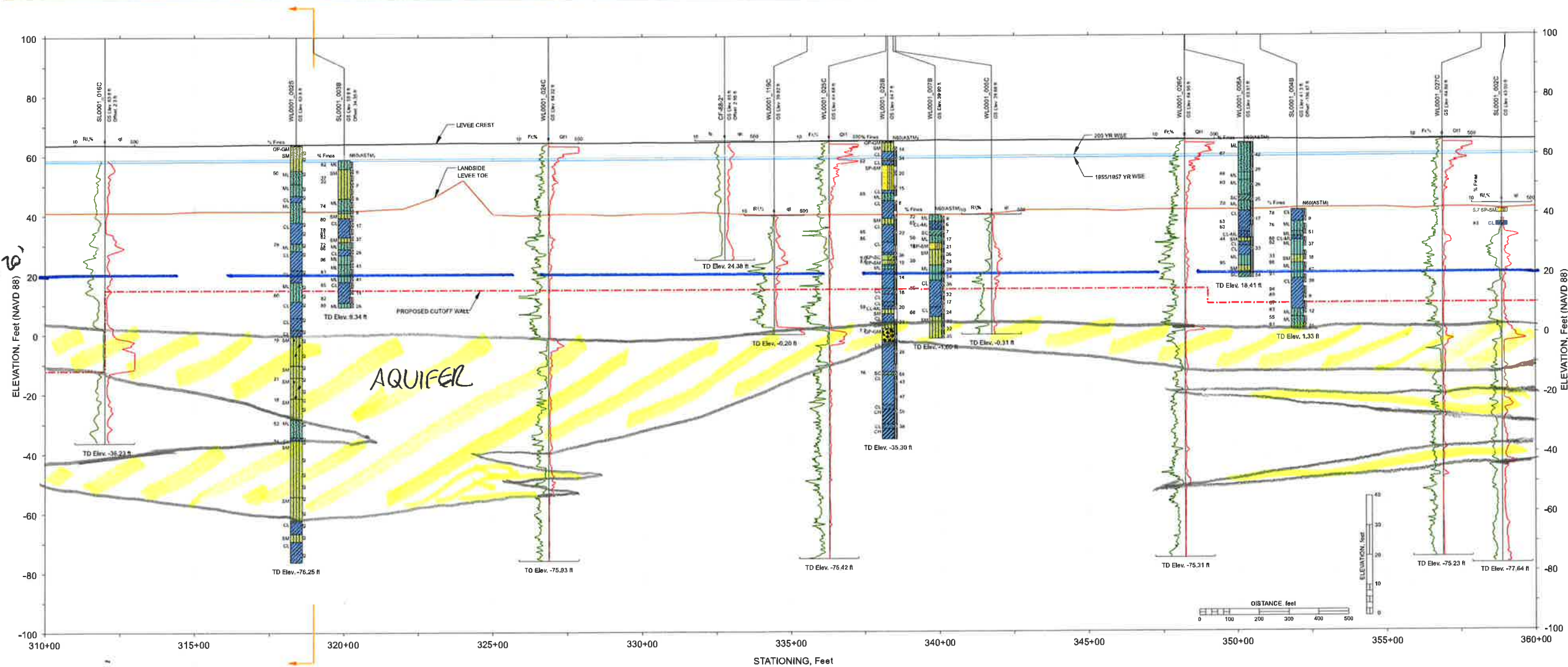
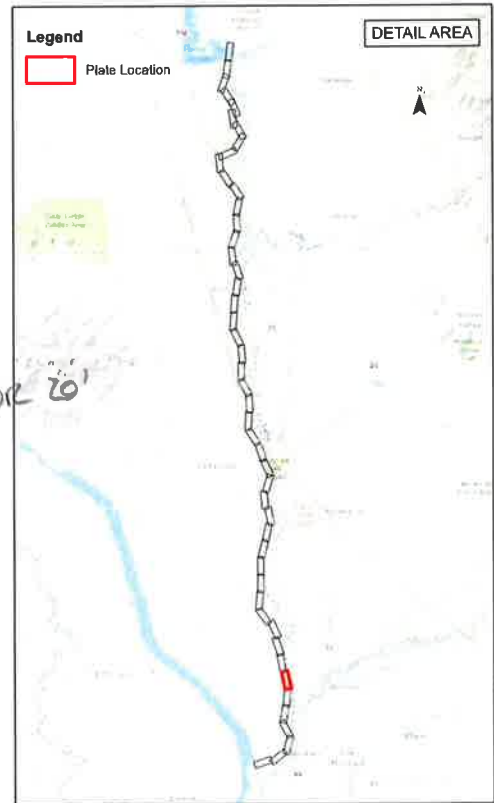


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A7



- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Bruslad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60}$ Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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 12. The canel/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 310+00 to Station 360+00

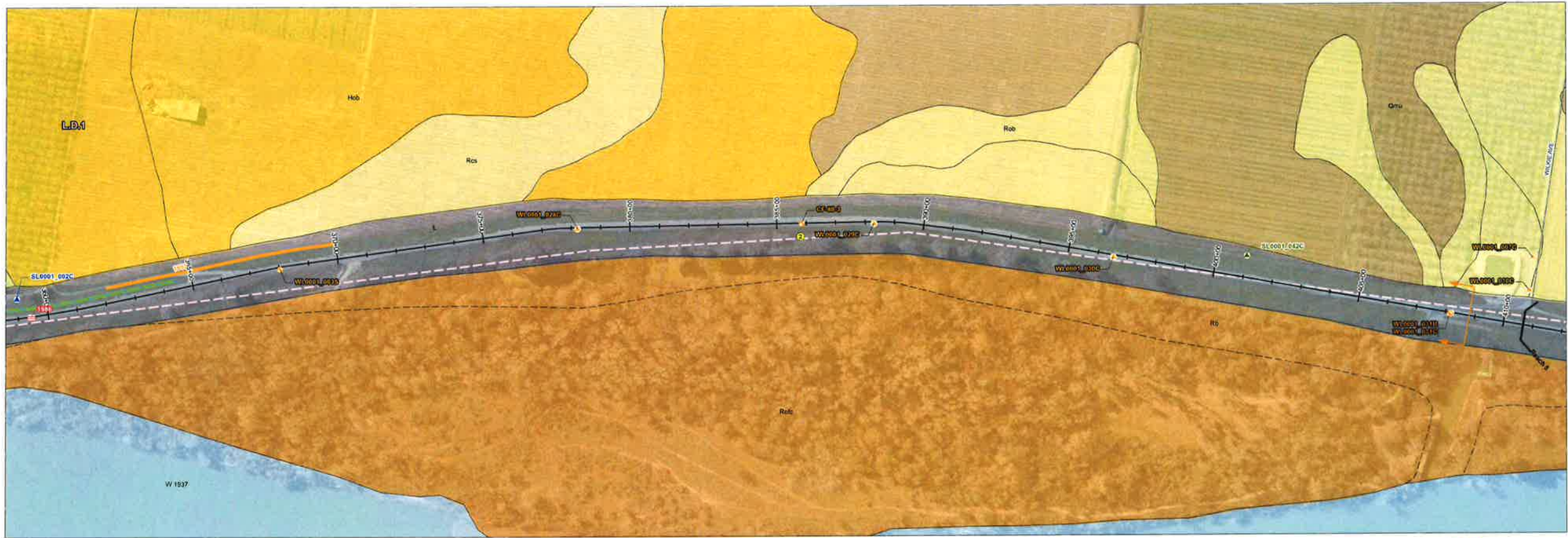
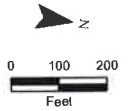
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Geotechnical Design
Recommendations Report

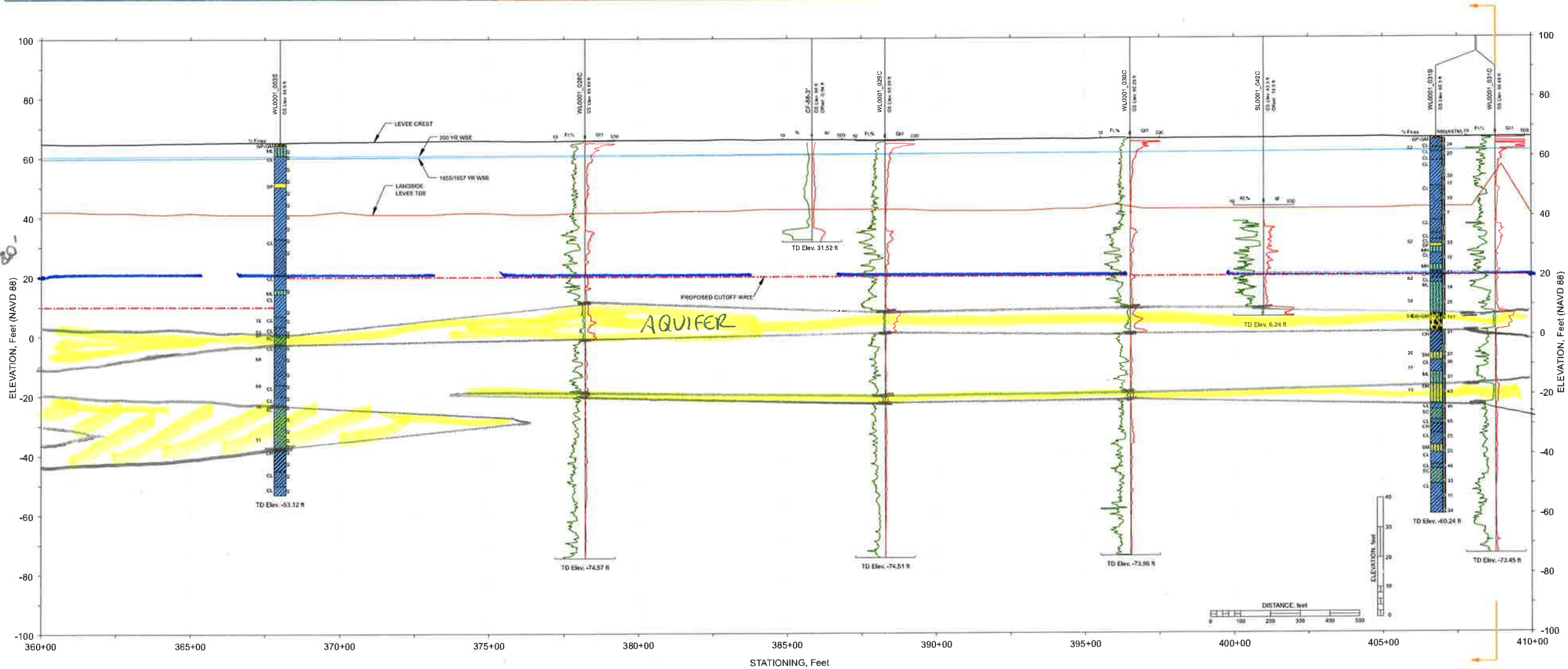
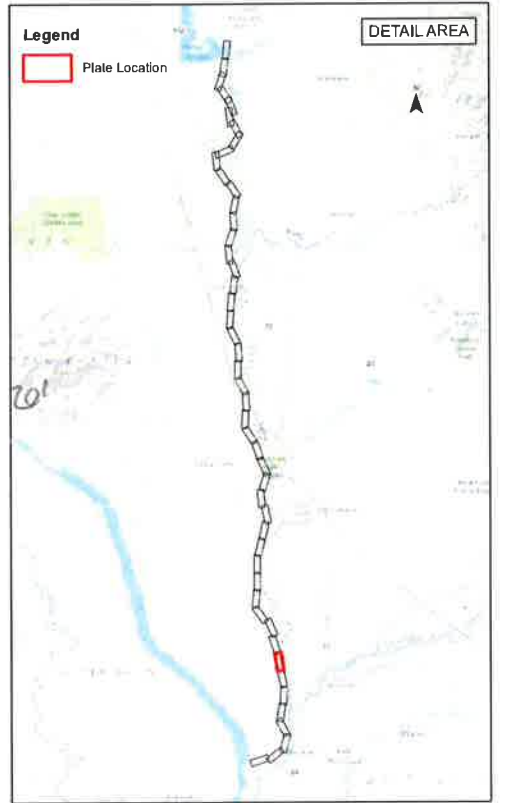


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A9



- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Bruslad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
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 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 360+00 to Station 410+00

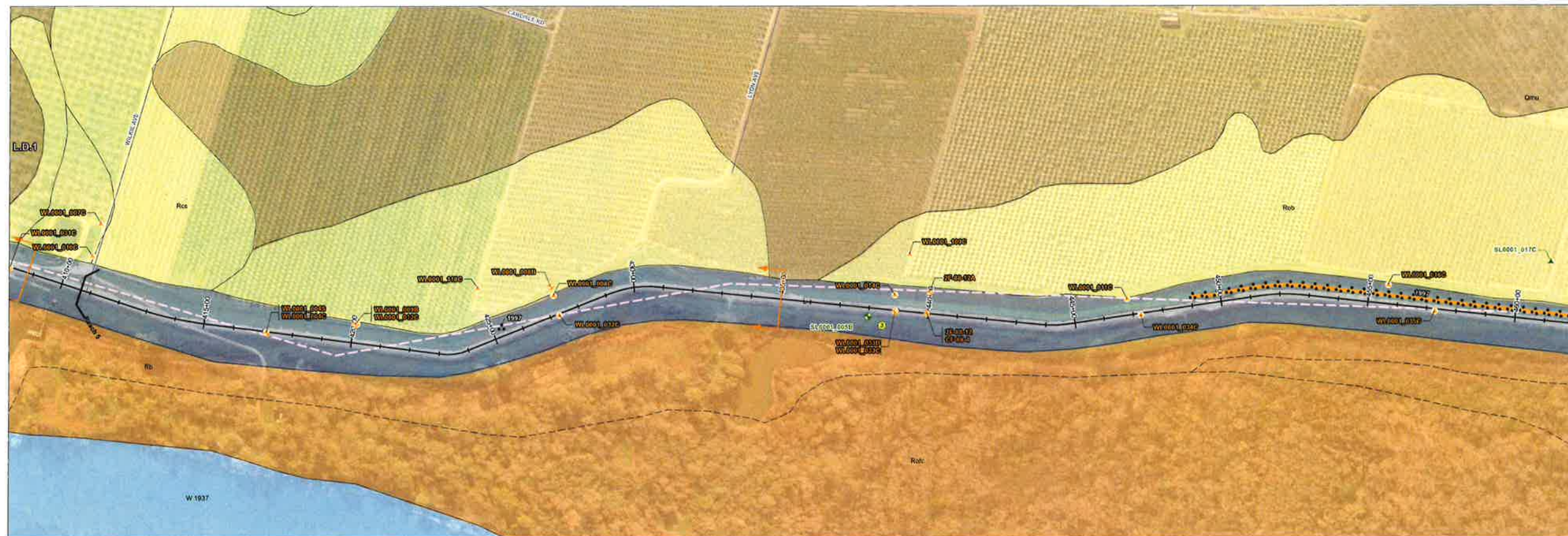
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Geotechnical Design
Recommendations Report

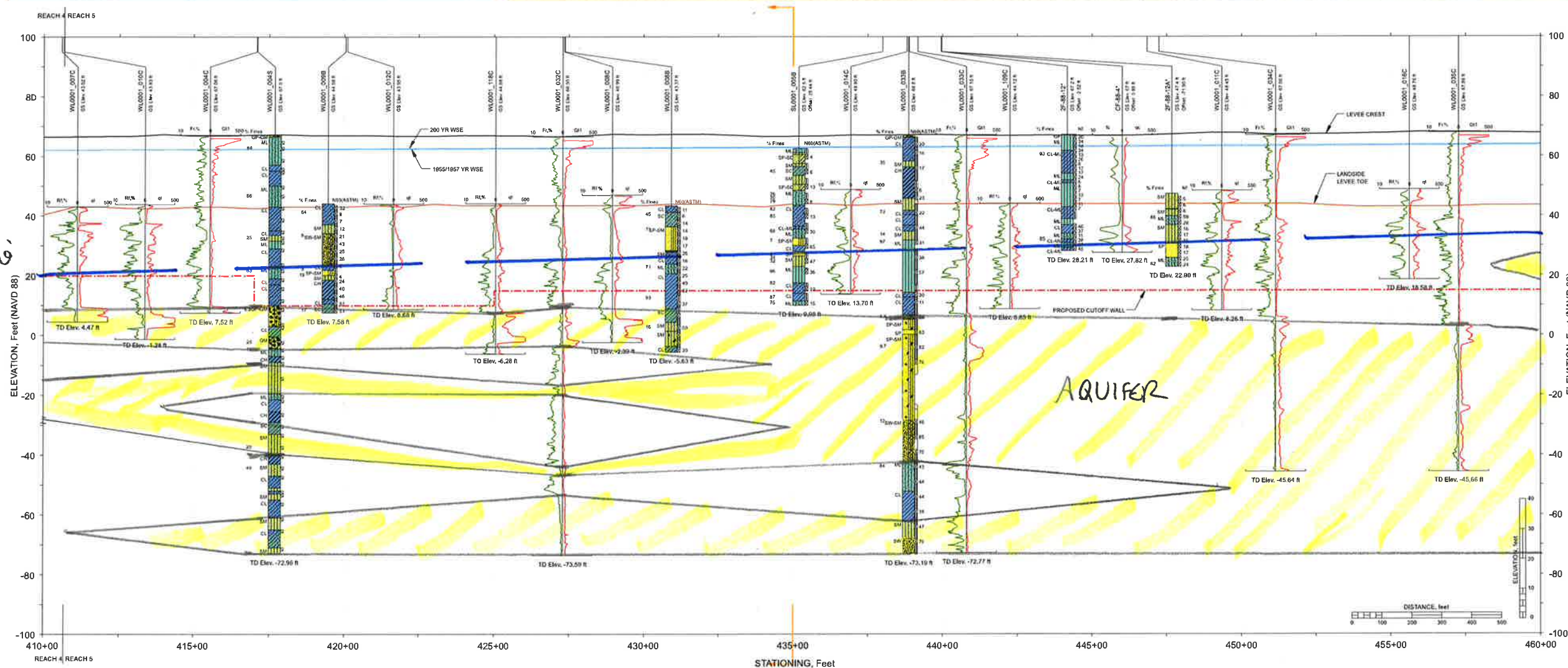


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A10

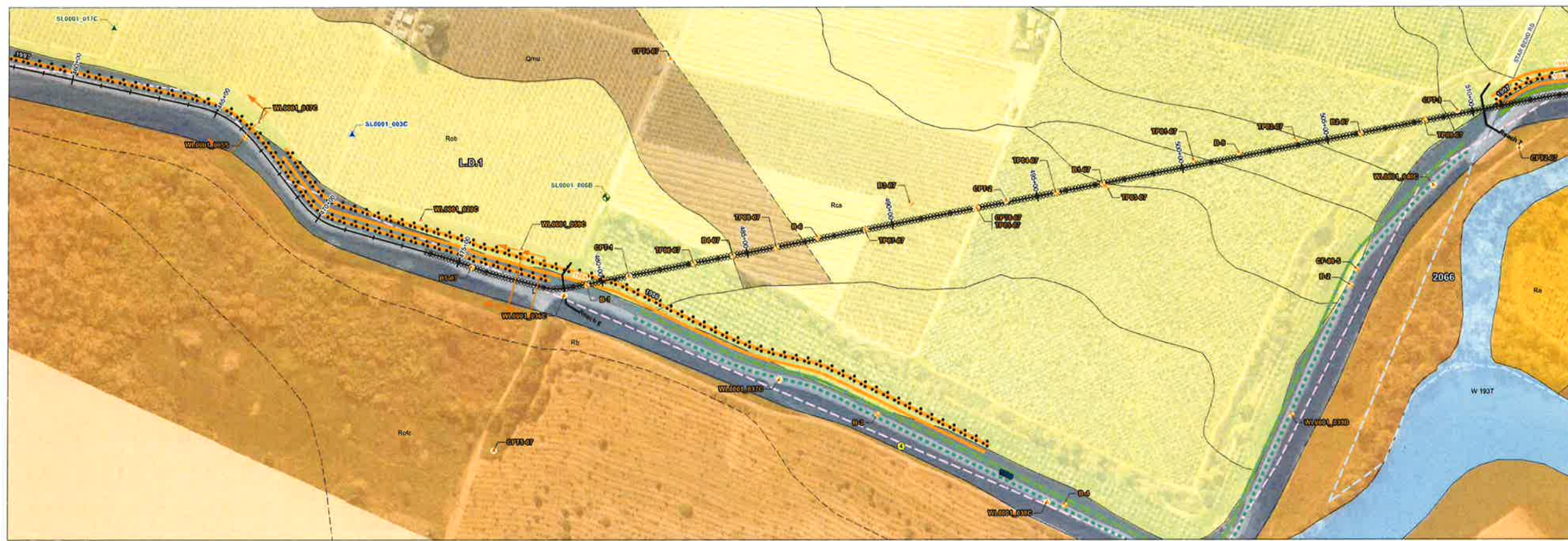


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
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 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

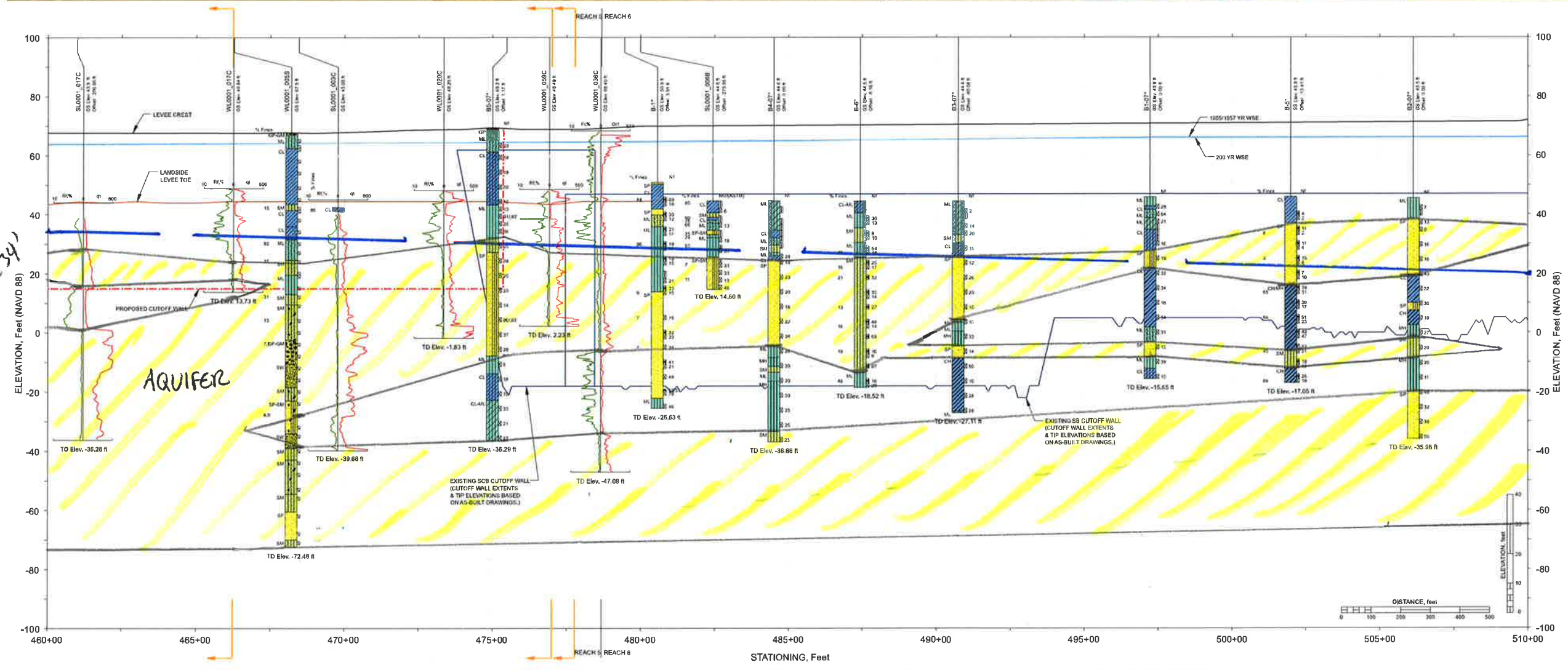


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 410+00 to Station 460+00

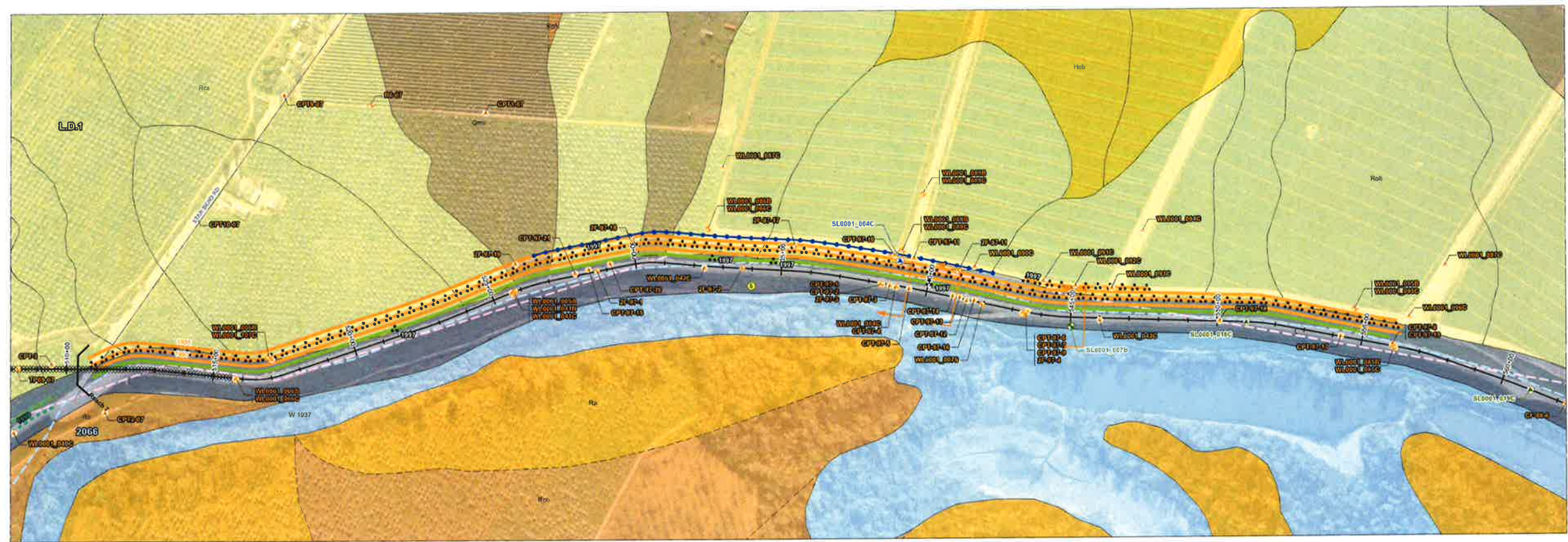
PART OF NEW WALL, ALL OF EXISTING WALL CUTS OFF UPPER AQUIFER



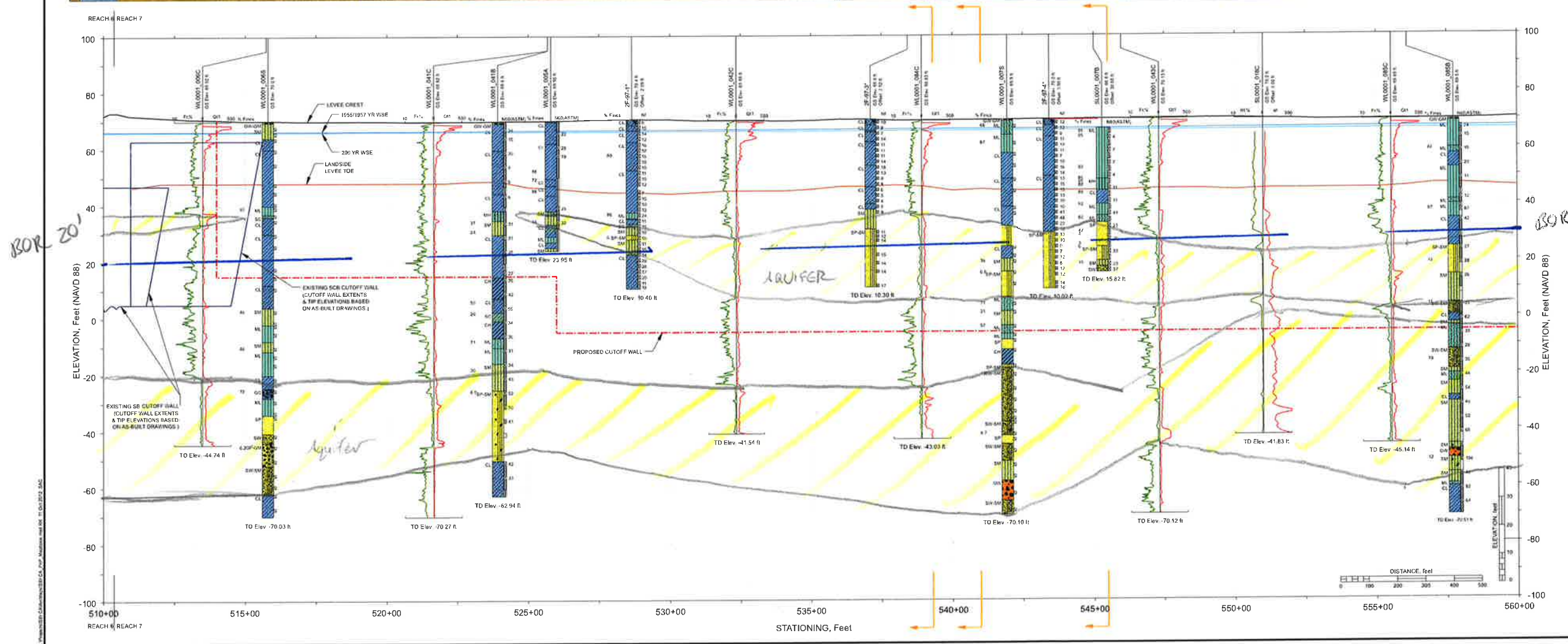
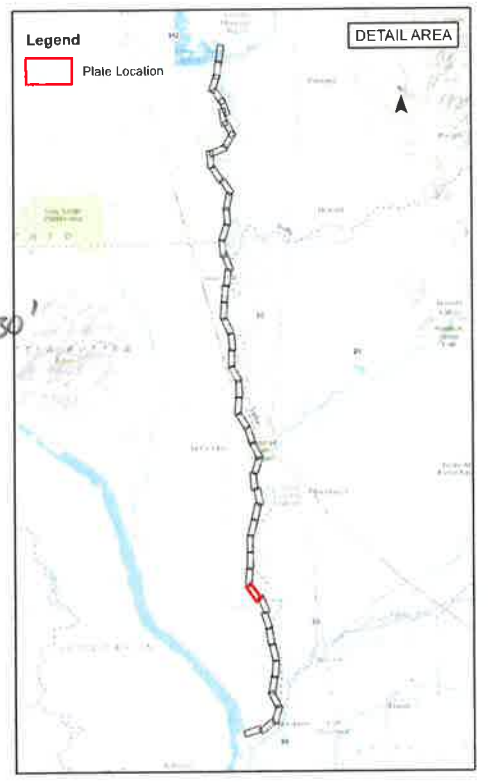
- NOTES:
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 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
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 12. The canalditch elevations are approximate. These elevations were estimated from the topography.



NEW WALL CUTS OFF UPPER AQUIFER

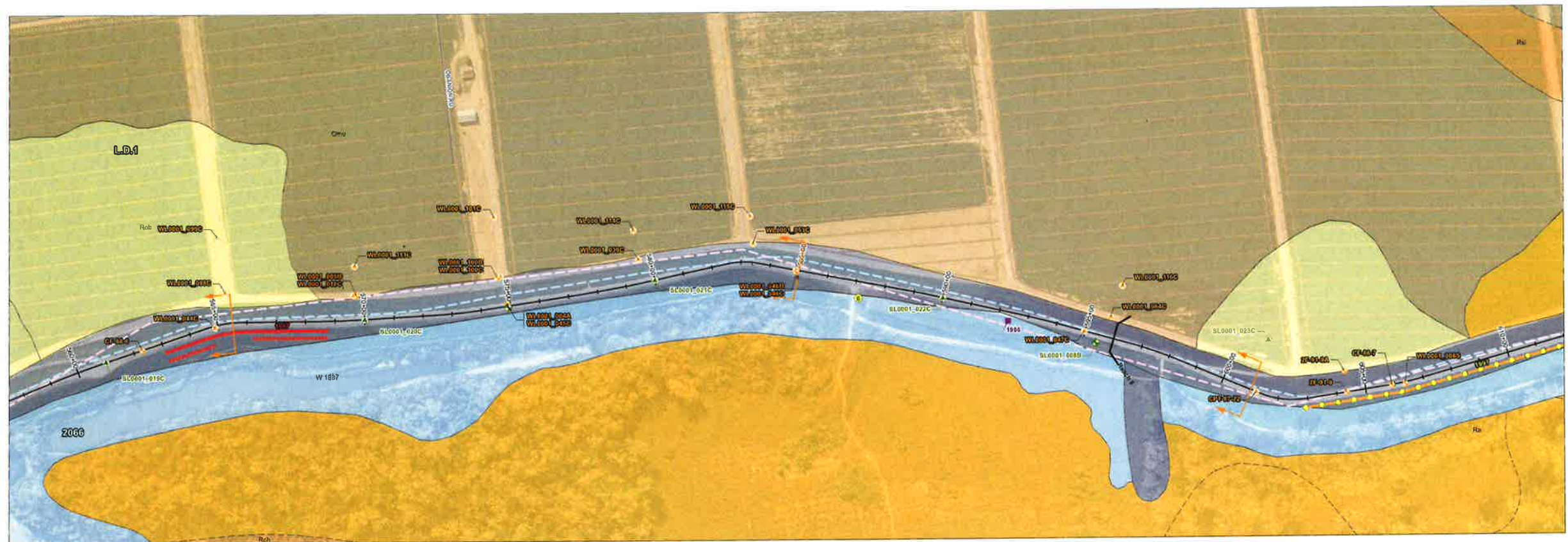


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 12. The canalside elevations are approximate. These elevations were estimated from the topography.

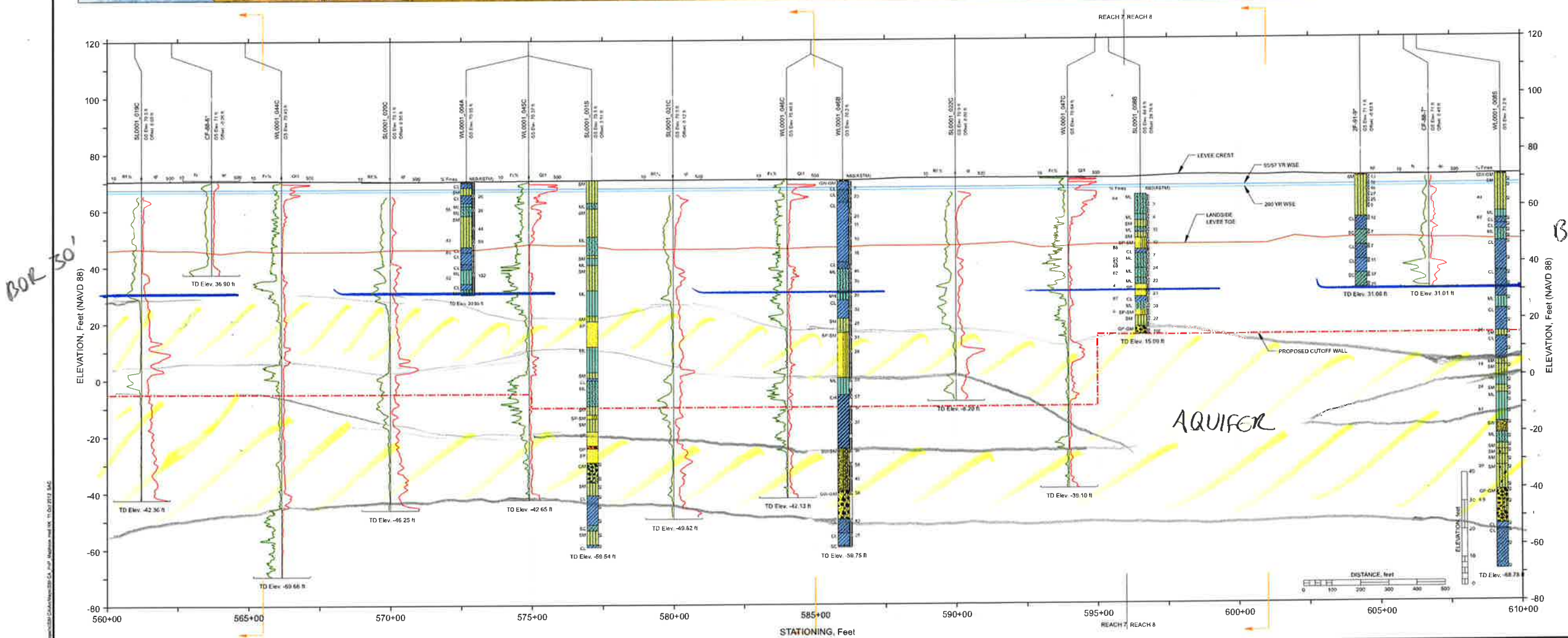
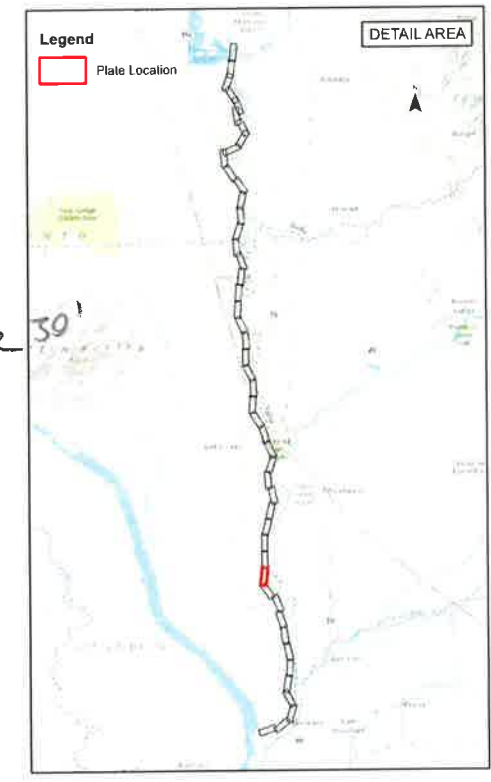


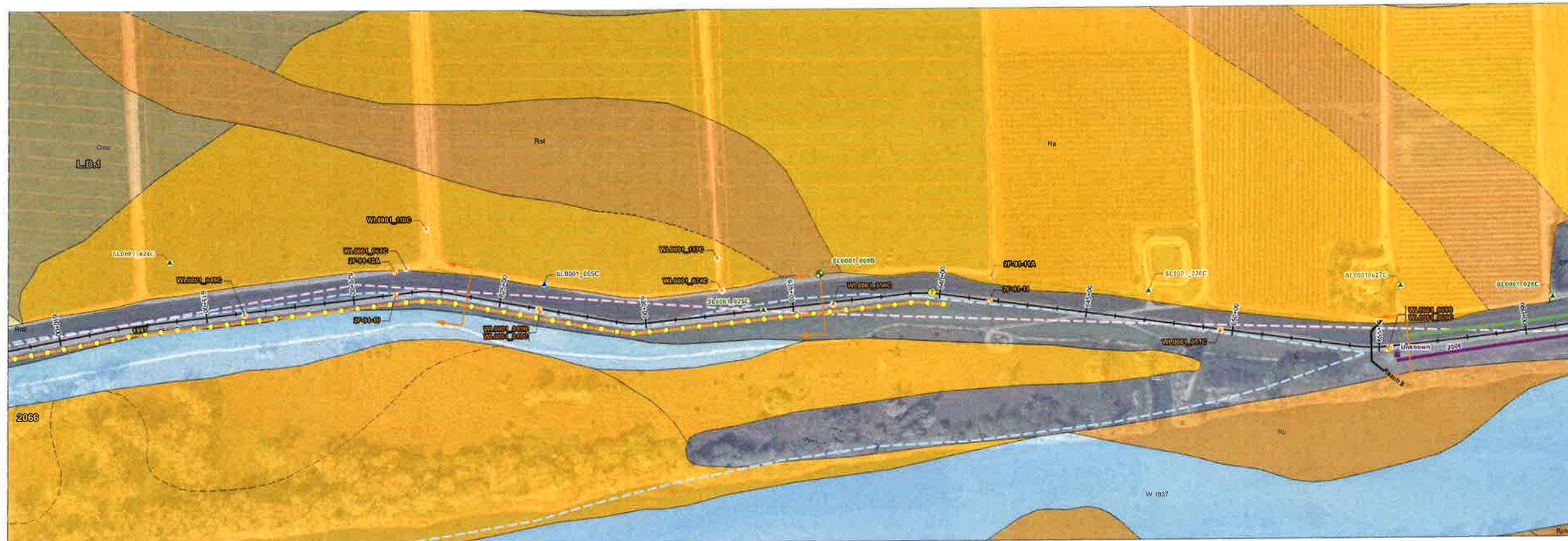
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 510+00 to Station 560+00

NEW WALL CUTS OFF UPPER AQUIFER TO STA. 595+00

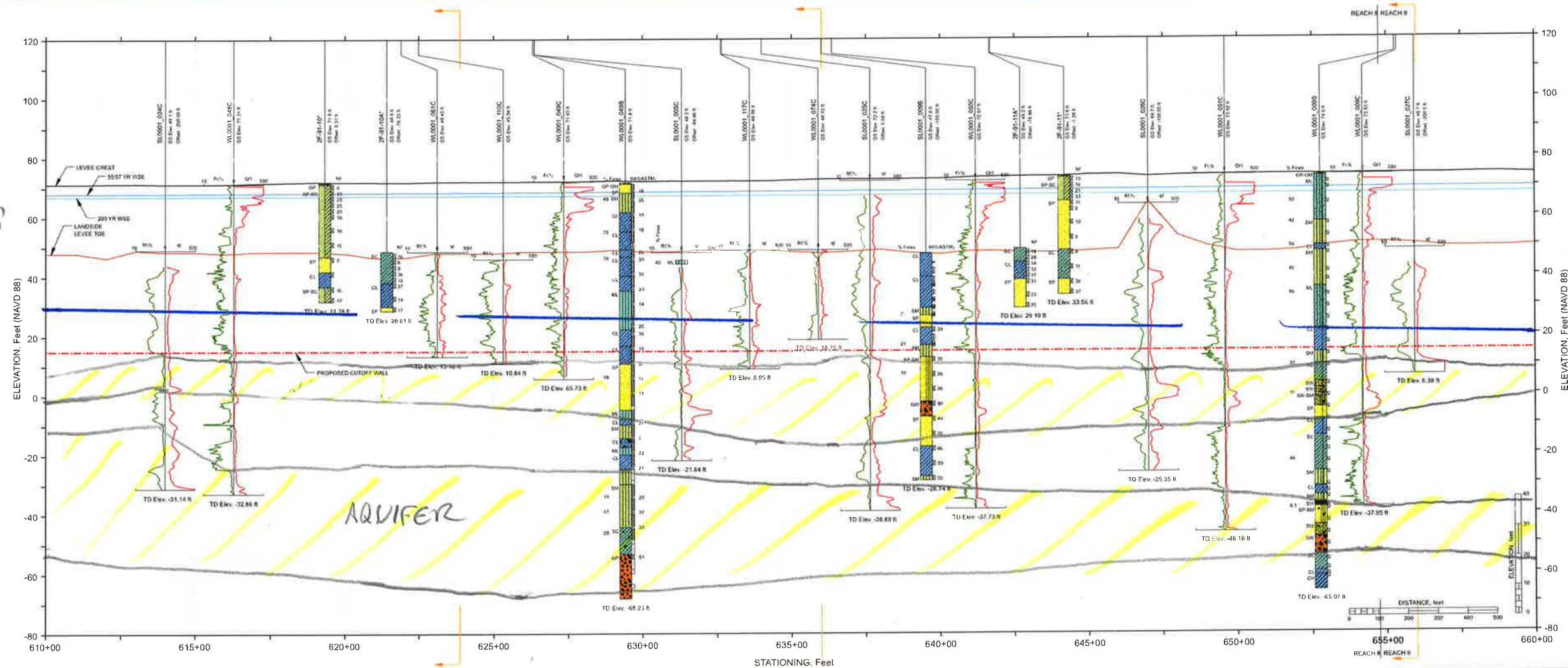


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 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual explorations.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The surficial elevations are approximate. These elevations were estimated from the topography.





- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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 12. The cannelitch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 610+00 to Station 660+00

URS

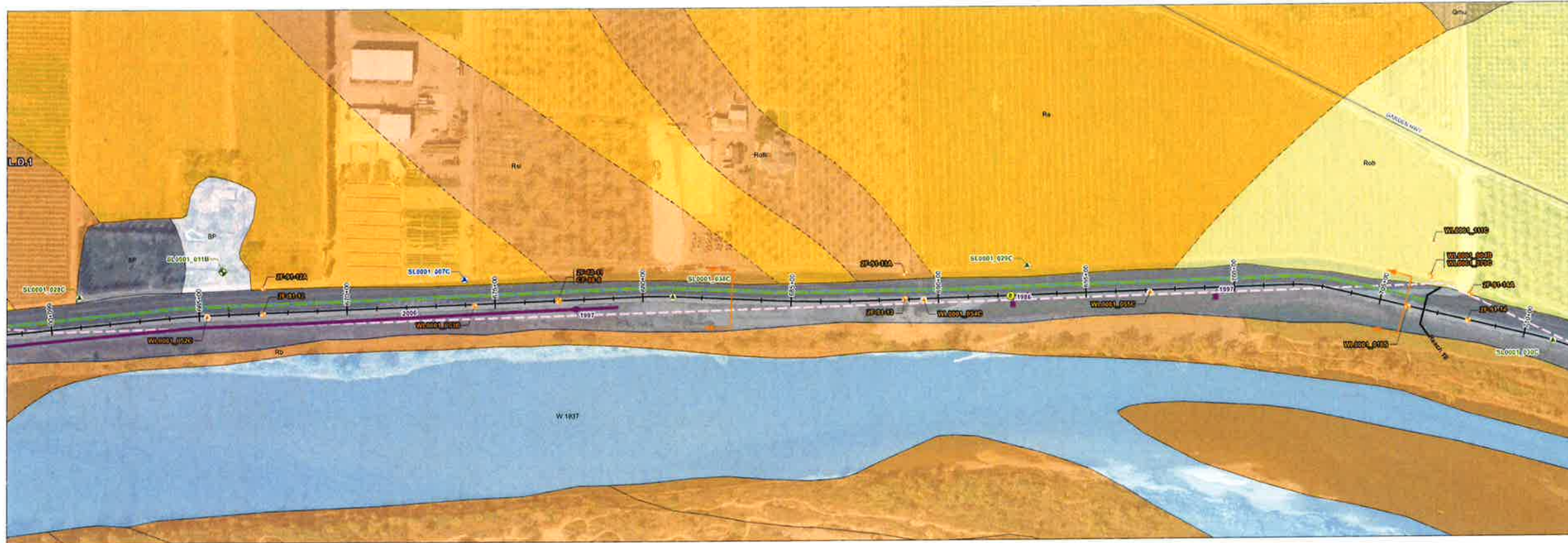
Geotechnical Design
Recommendations Report



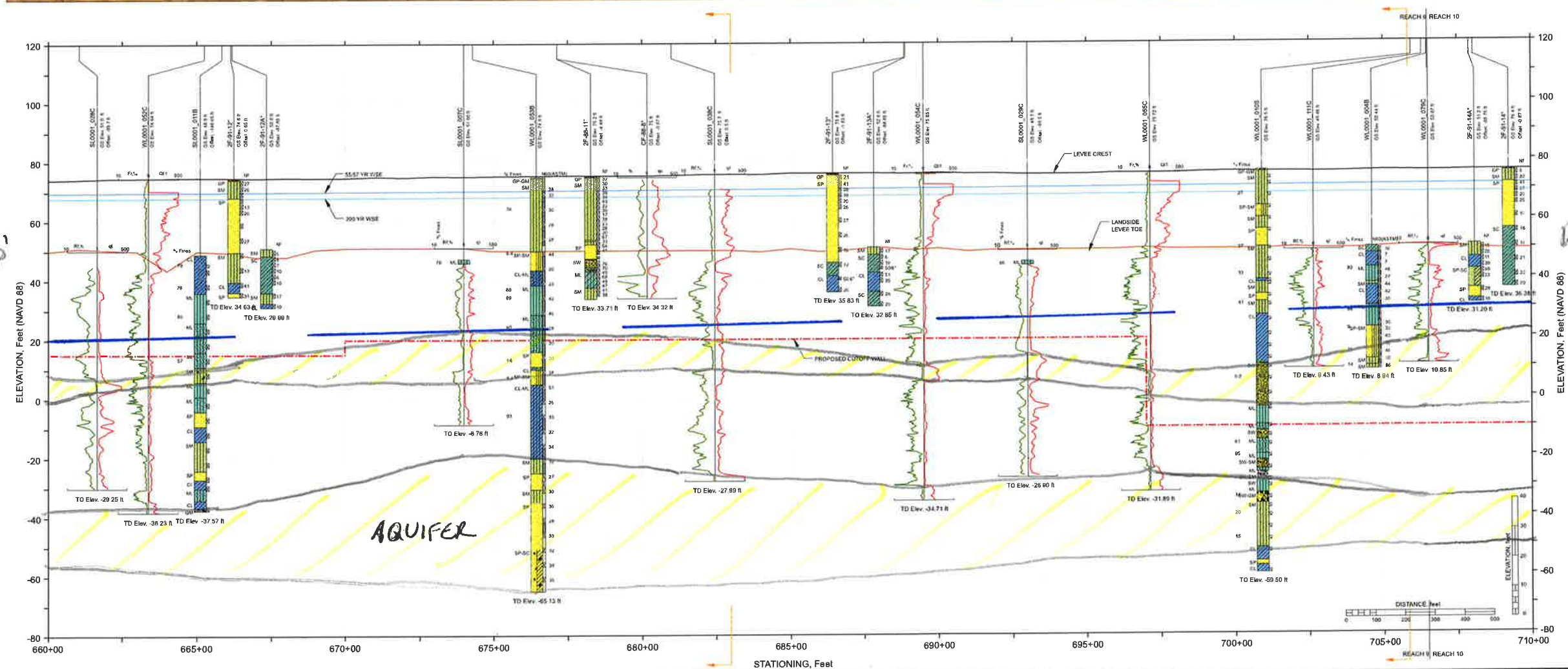
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
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NEW WALL CUTS OFF UPPER AQUIFER FROM ~STA. 697+00 TO 750+00

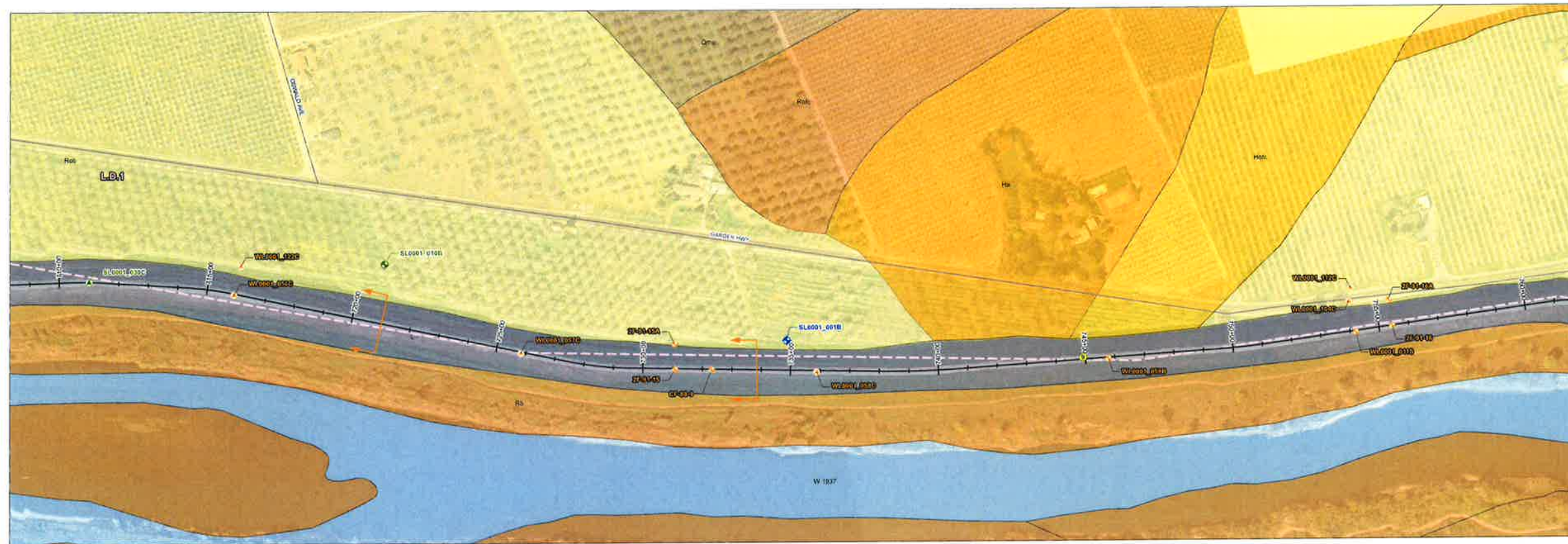


- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGR for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 - These plans and stick-log plates are for the use and benefit of HDR, SBFA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.

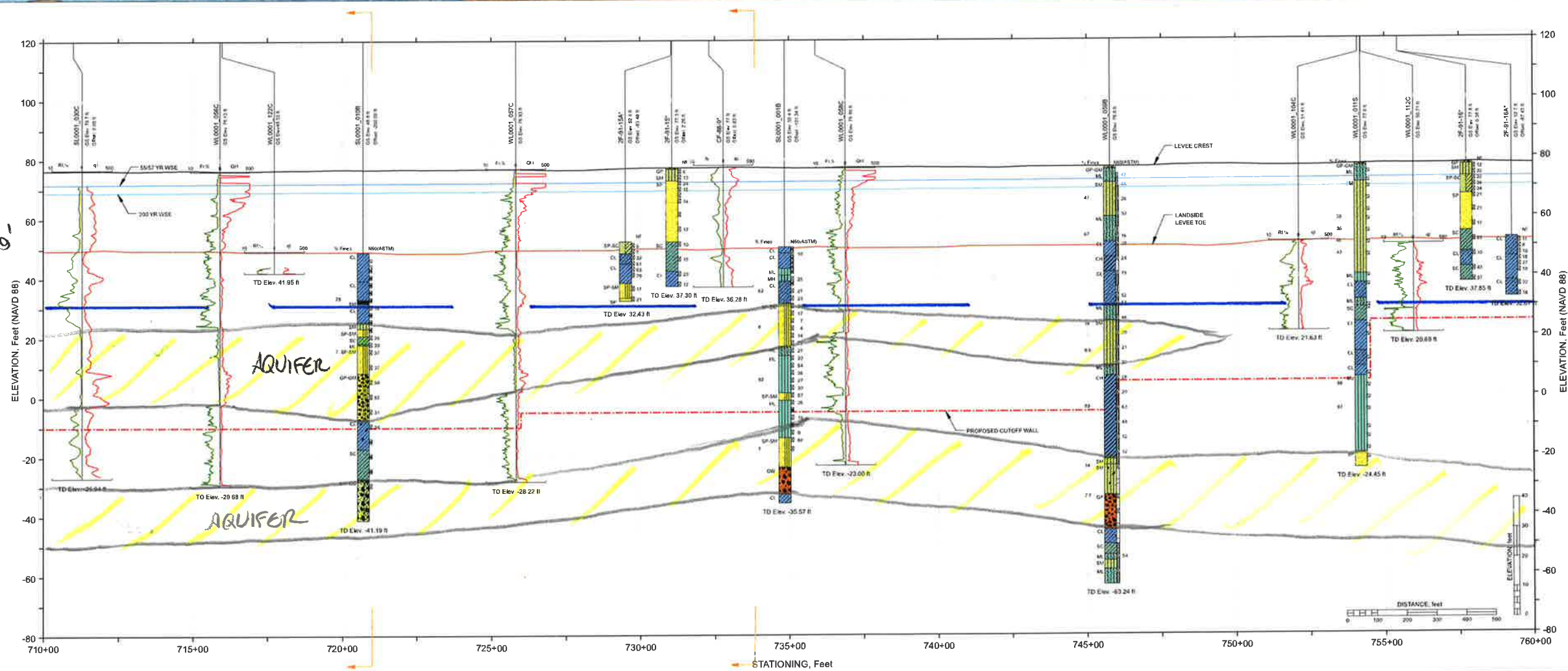
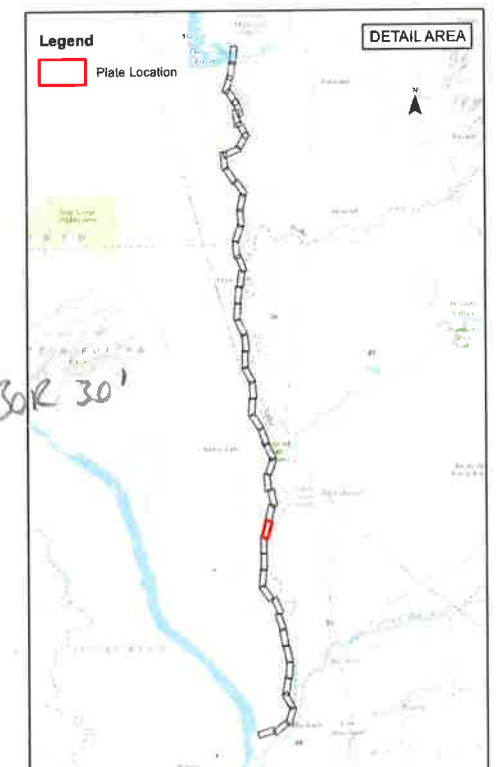


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 660+00 to Station 710+00

NEW WALL CUTS OFF UPPER AQUIFER FROM ~ STA. ~~757~~ 757+00 TO 759+00

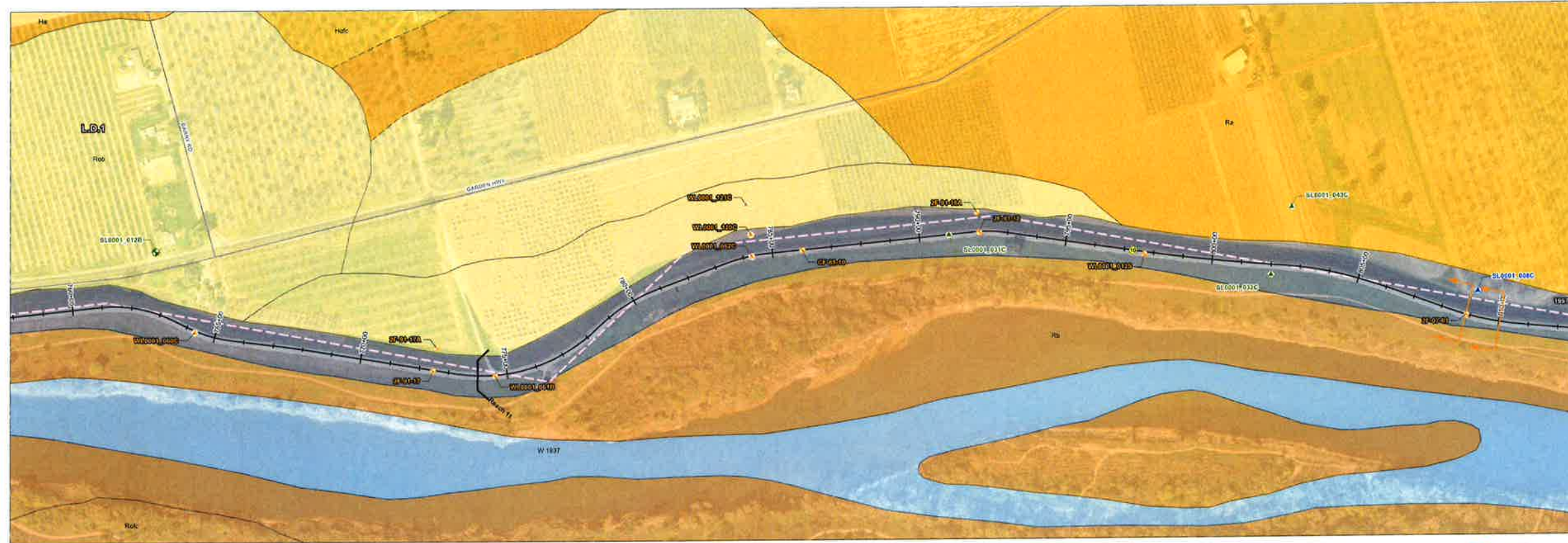


1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWFR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevation is based on the information provided by Peterson Bros., Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and SPT logs as provided on the Final Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the project profile view. Historical explorations from the ULE project profile view are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as a basis for design.
8. To prevent scale distortion, this map should be printed on a 6" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SDDR for DWFR ULE Project, URS, 2010).
10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and stick-log plates are for the use and benefit of HDR, SBSCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

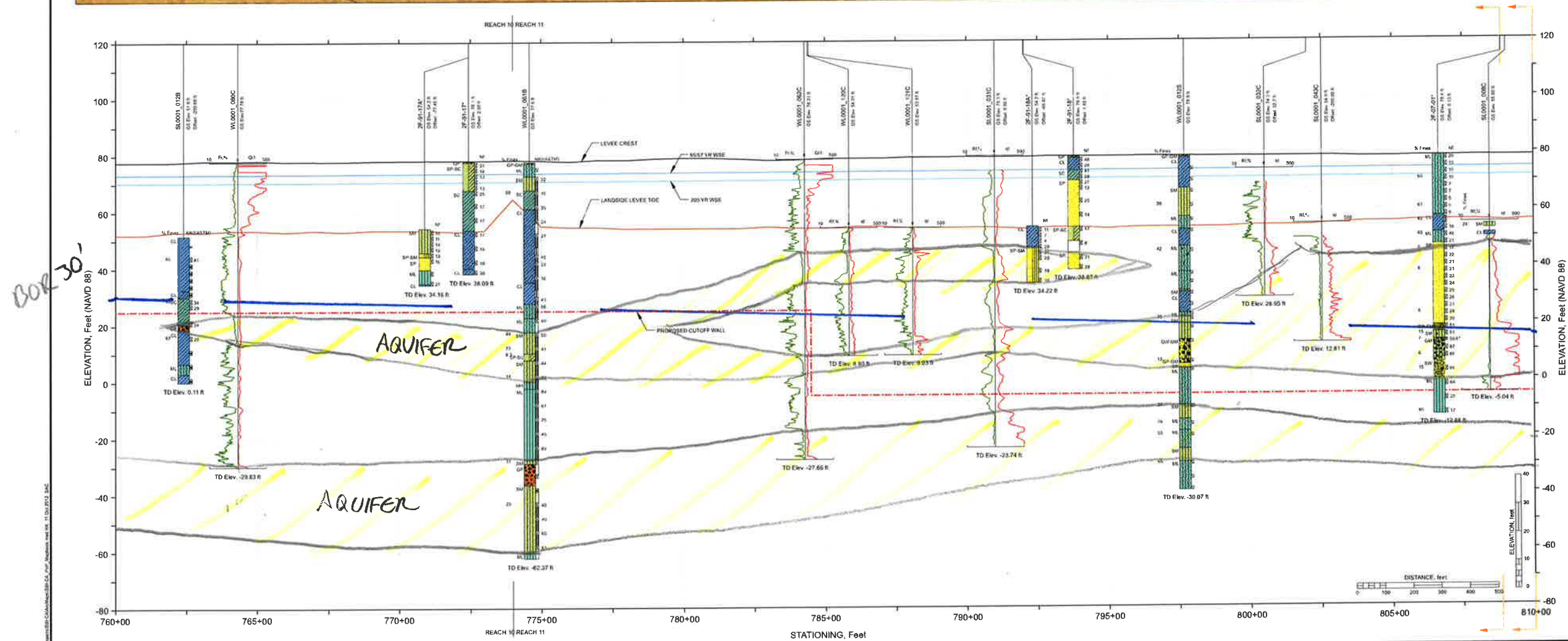
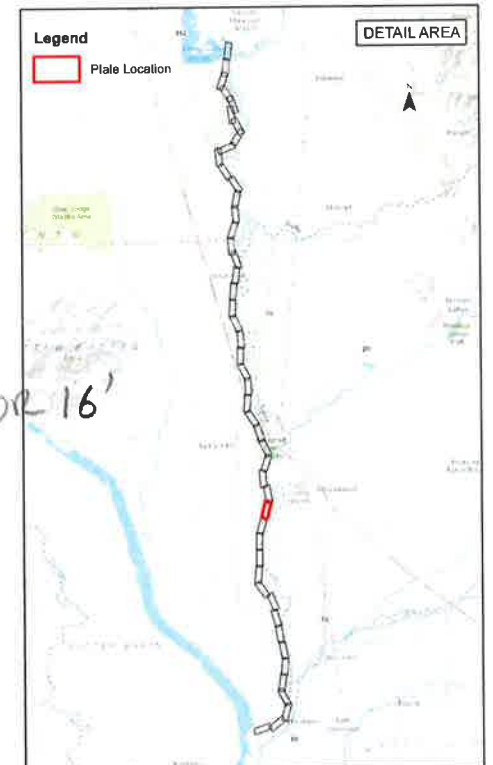


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 710+00 to Station 760+00

NEW WALL CUTS OFF UPPER AQUIFER FROM ~STA. 784+50 TO 827+50



- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brusted, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (N) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The general elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 760+00 to Station 810+00

URS

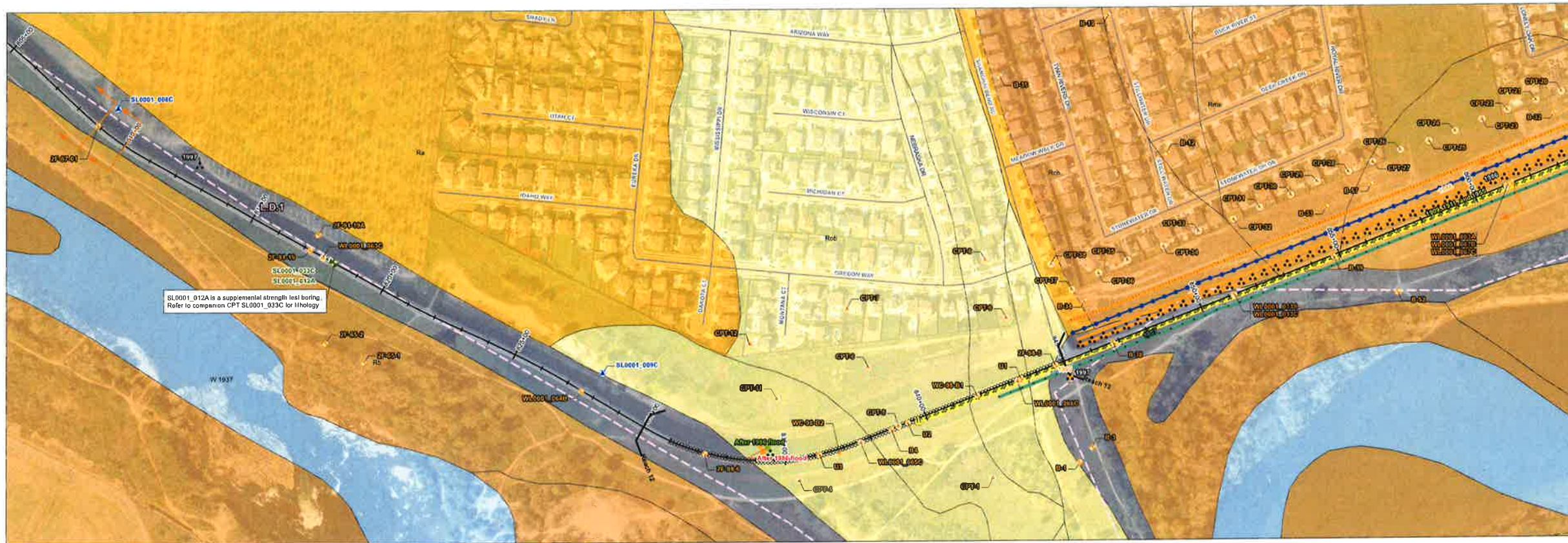
Geotechnical Design
Recommendations Report



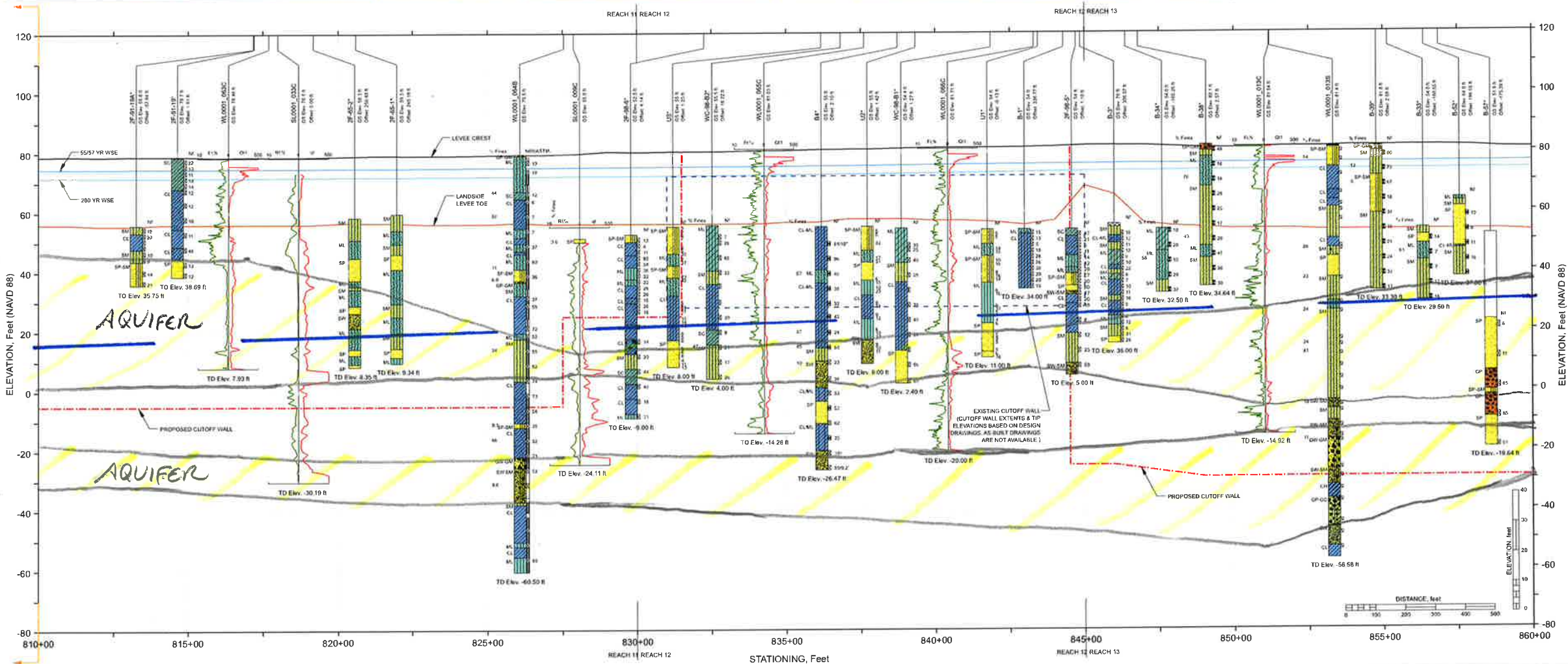
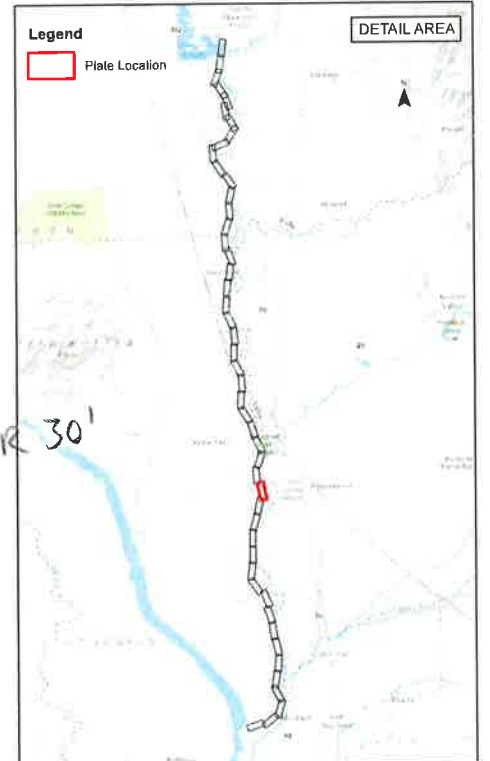
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A18

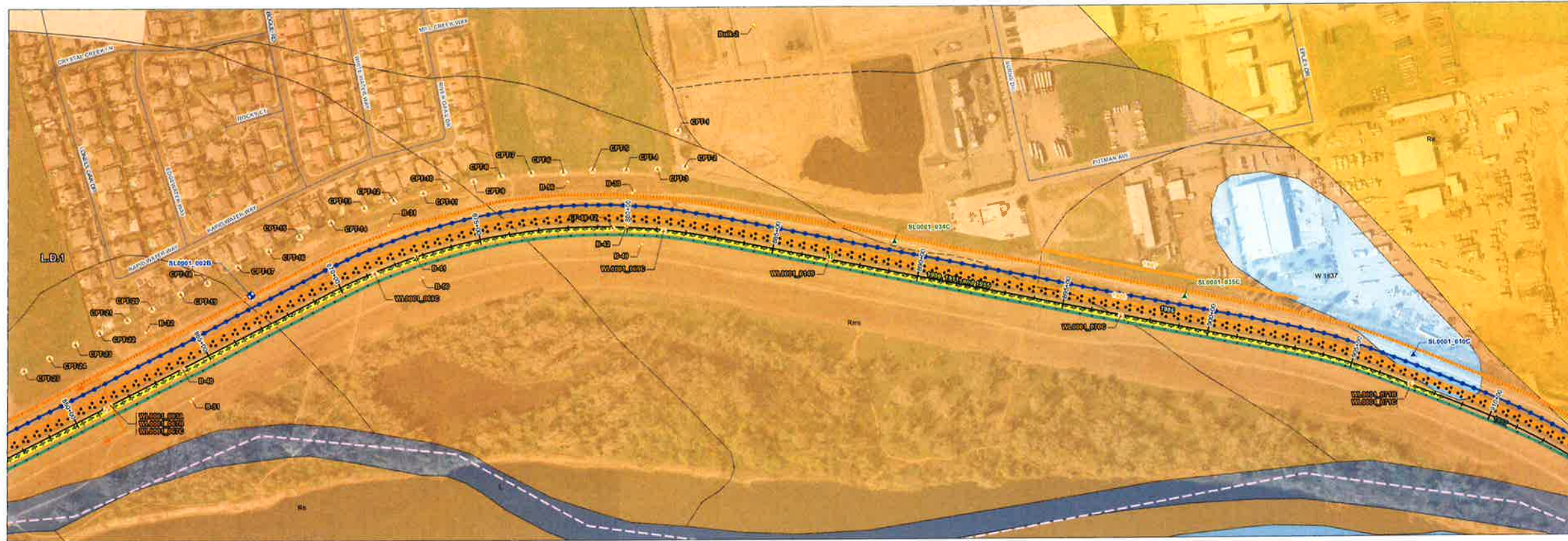
NEW WALL CUTS OFF UPPER AND LARGE PORTION OF DEEPAQUIFER FROM 844+50 TO 847+50



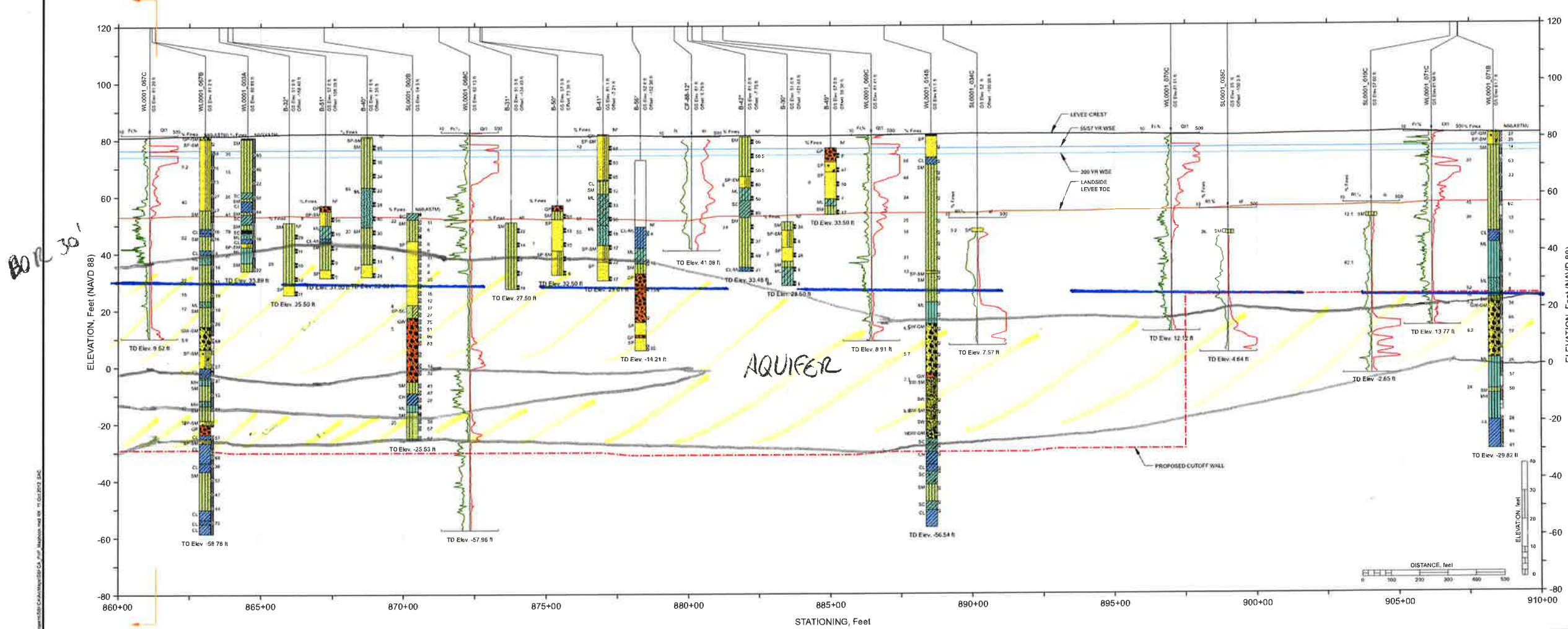
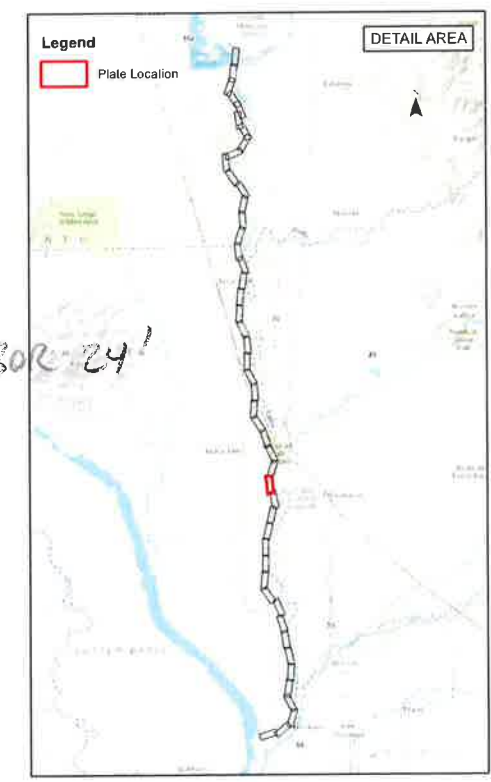
- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Pelarson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) \times N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
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 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
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 - The canal ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 810+00 to Station 860+00



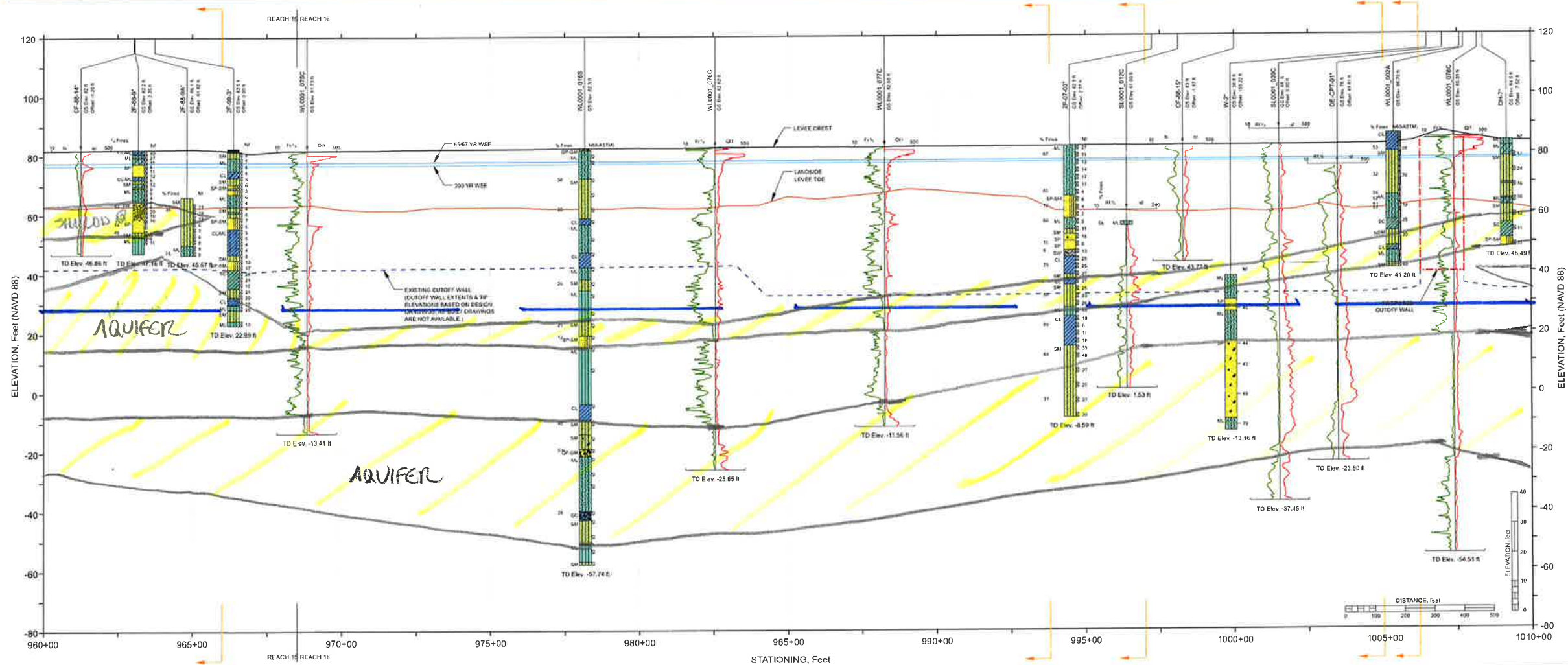
- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Bruslad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
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 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS, 2010).
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 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 860+00 to Station 910+00



- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LiDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 960+00 to Station 1010+00

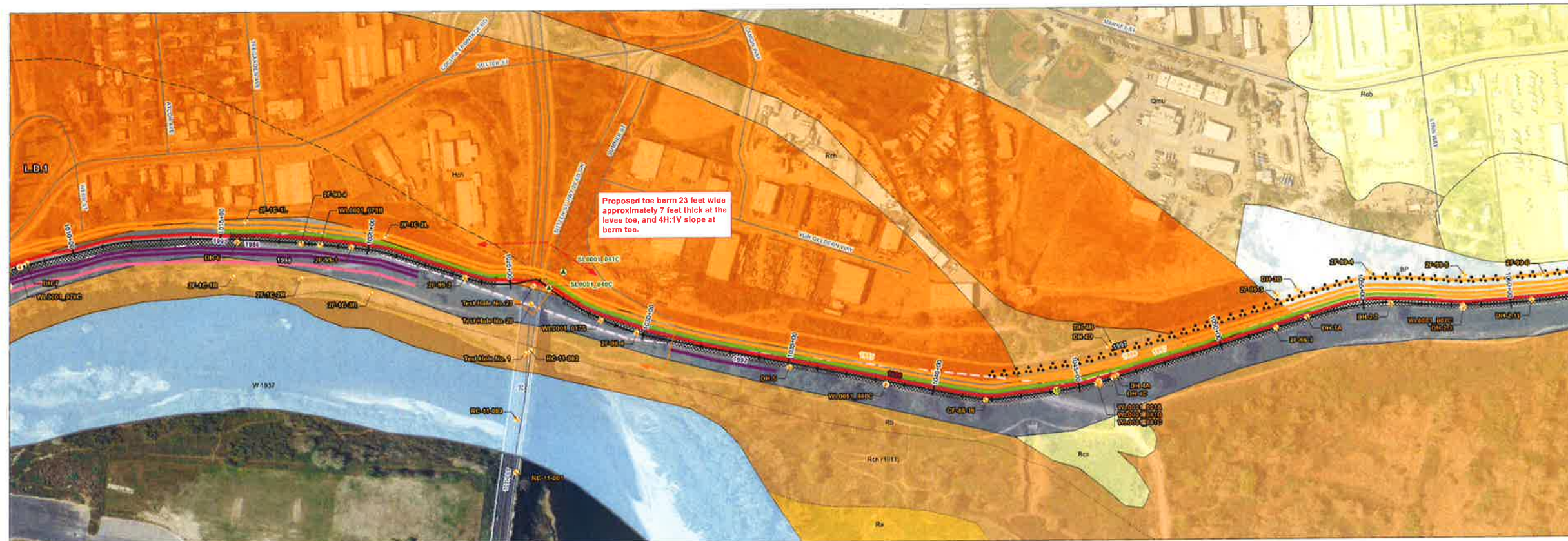
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Geotechnical Design
Recommendations Report

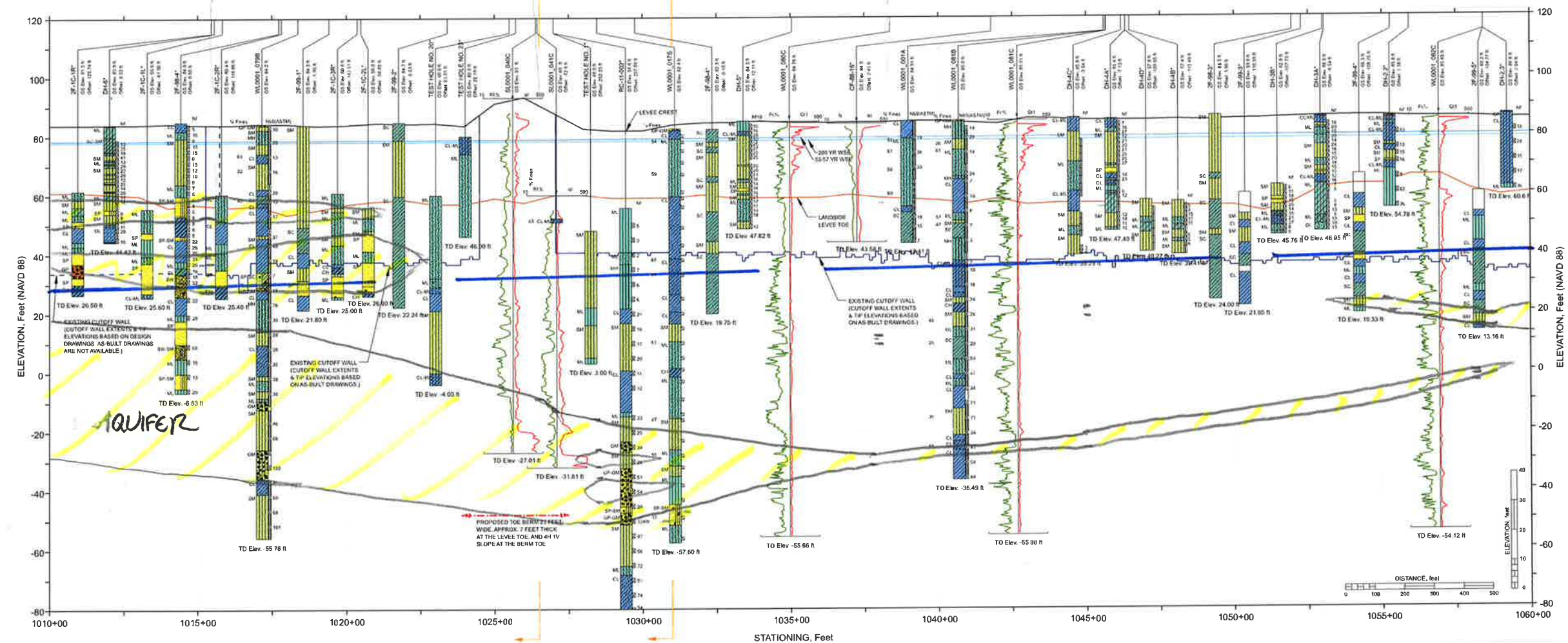
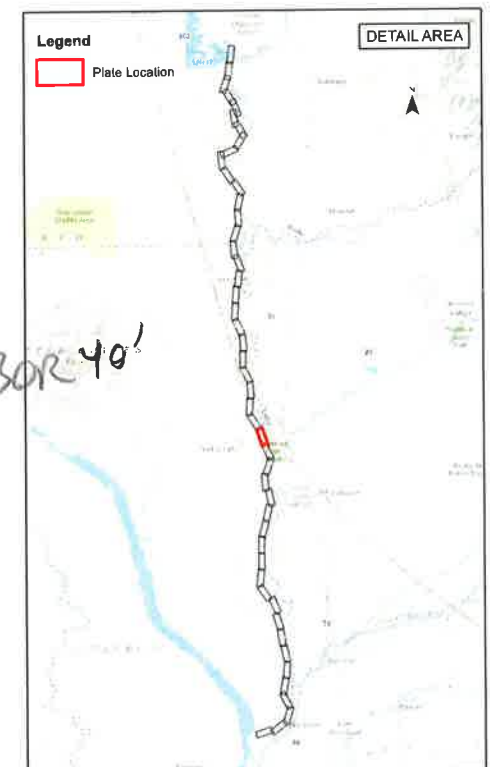


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A22



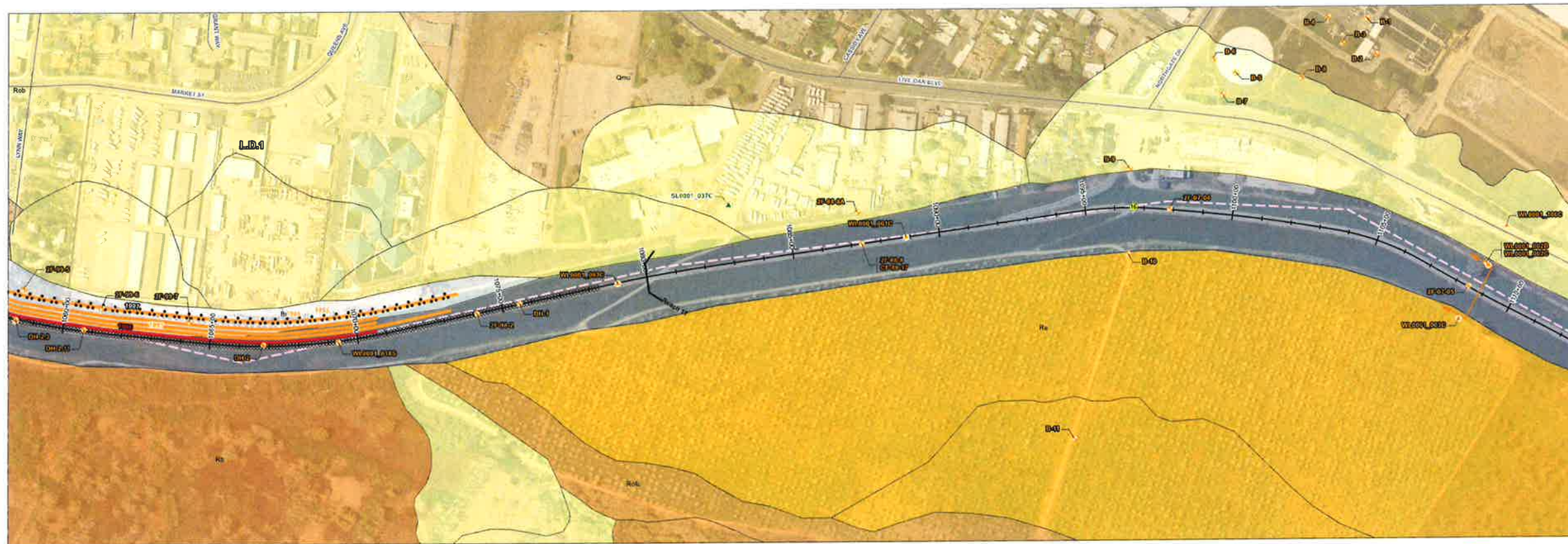
- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWFR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brunsen, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and SPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60}^{60}$ "Hammer Efficiency (%)". See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations performed by the DWFR ULE project are shown, "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color image. Black and white reproduction should not be relied upon as they will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geologic was mapped at 1:20,000 scale. (Source: SGRD for DWFR ULE Project, URS,2010).
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12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



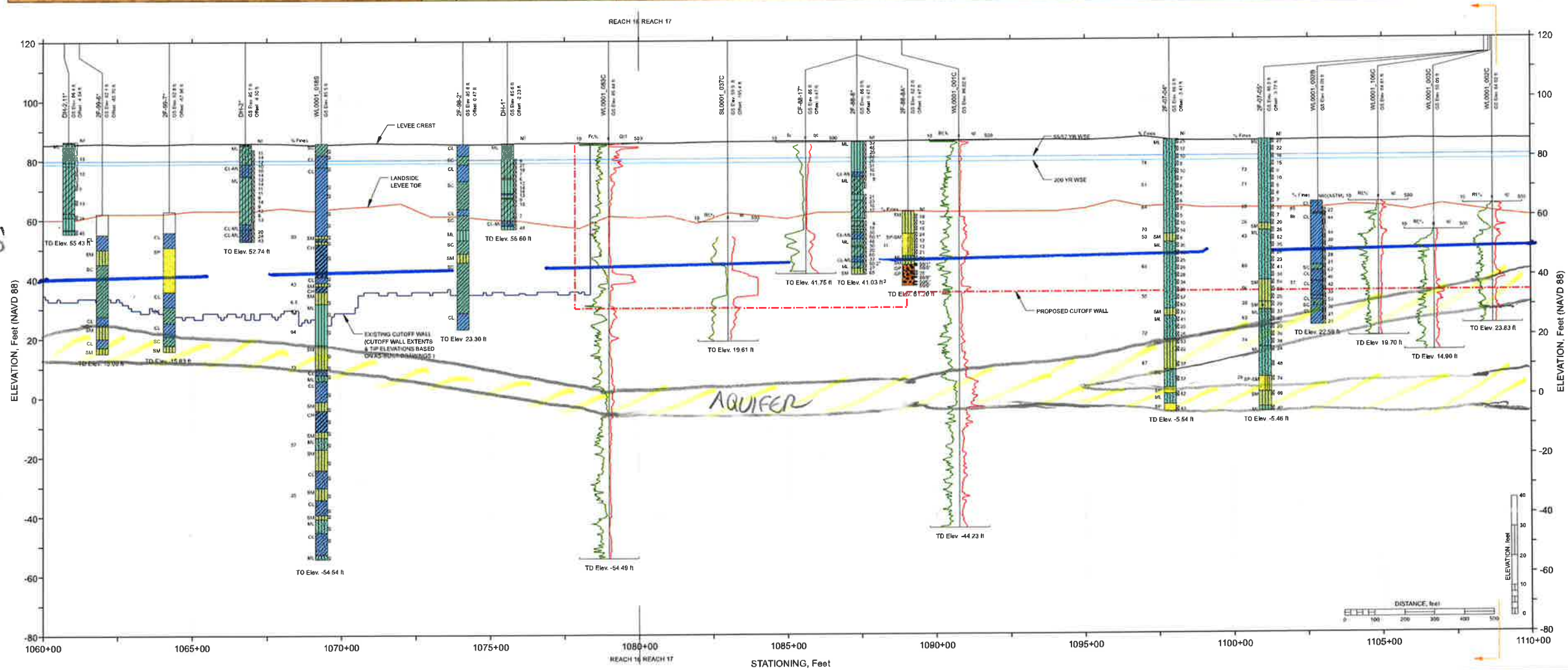
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1010+00 to Station 1060+00

Geotechnical Design
Recommendations Report

Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

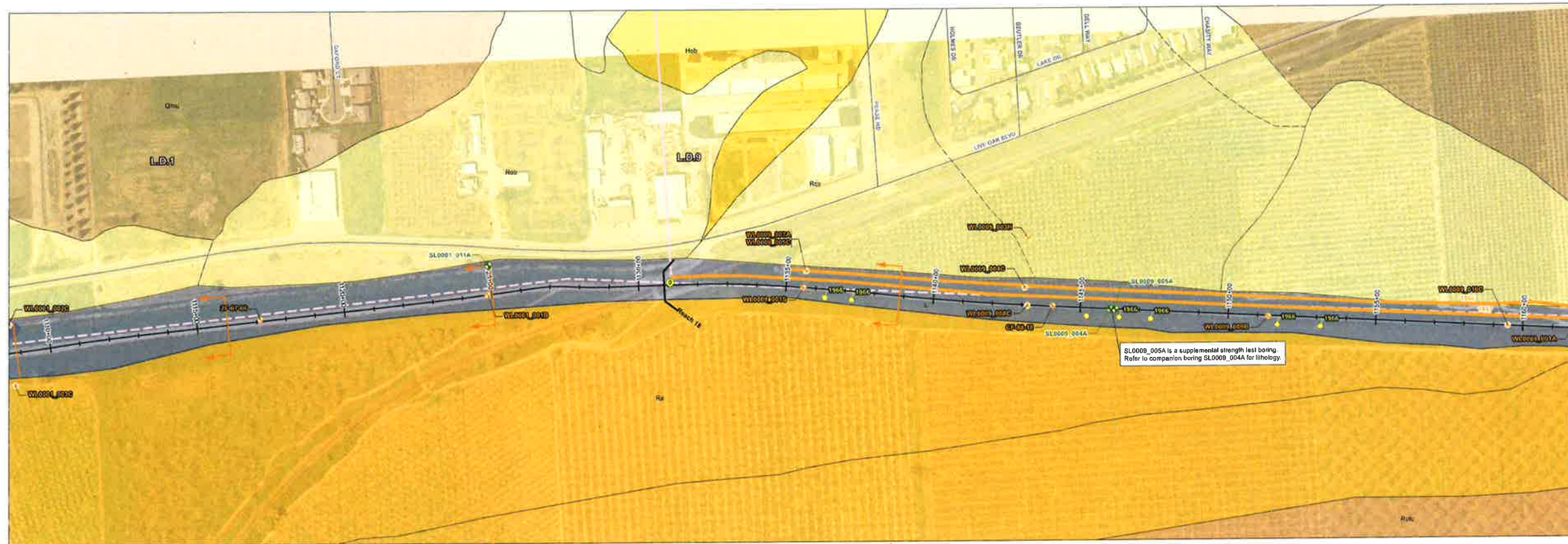


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs and to the Technical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} + \text{"Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations are identified by the text shown: "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classification.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as it will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS 2010).
10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and stick-log plates are for the use and benefit of HDR, SBFGA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. The designers should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

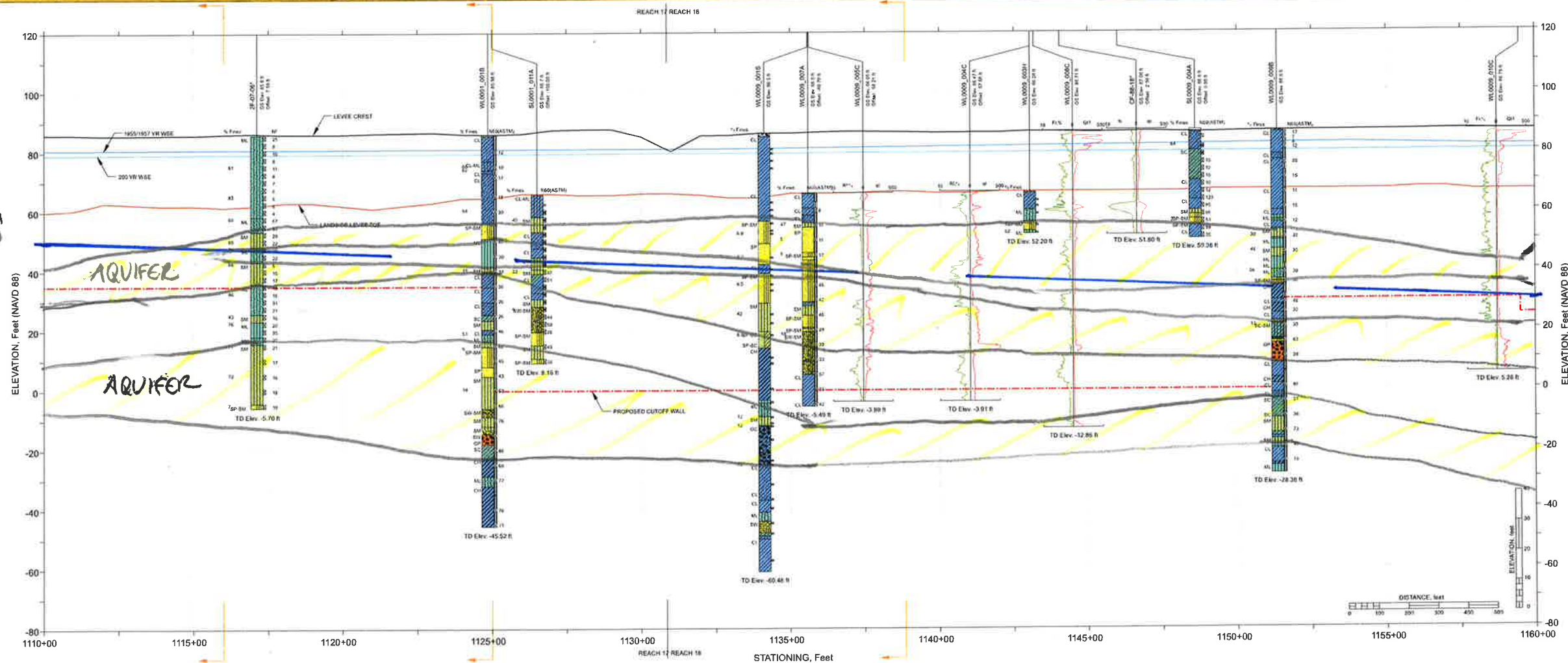


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1060+00 to Station 1110+00

NEW WALL CWS OF UPPER AQUIFER



- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 - These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 - The canal ditch elevations are approximate. These elevations were estimated from the topography.

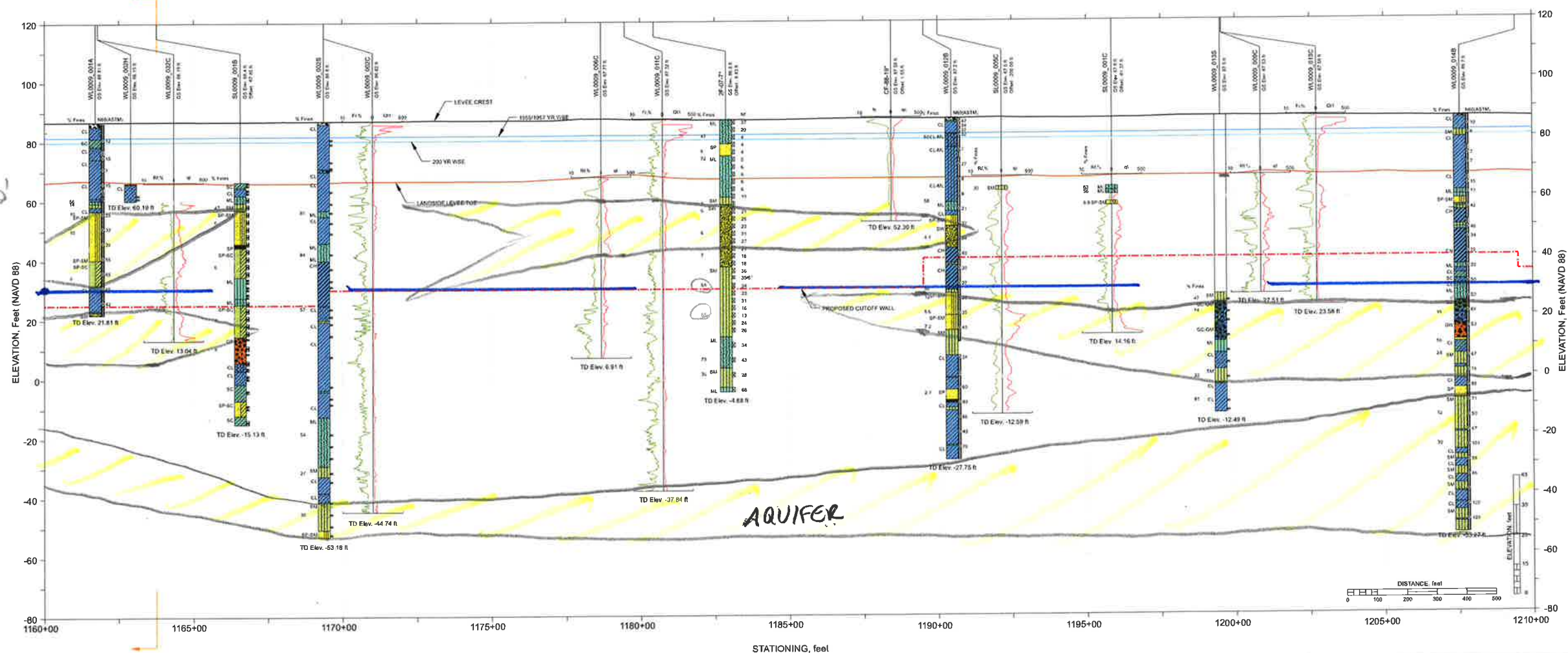


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1110+00 to Station 1160+00

NEW WALL CUTS OFF UPPER AQUIFER

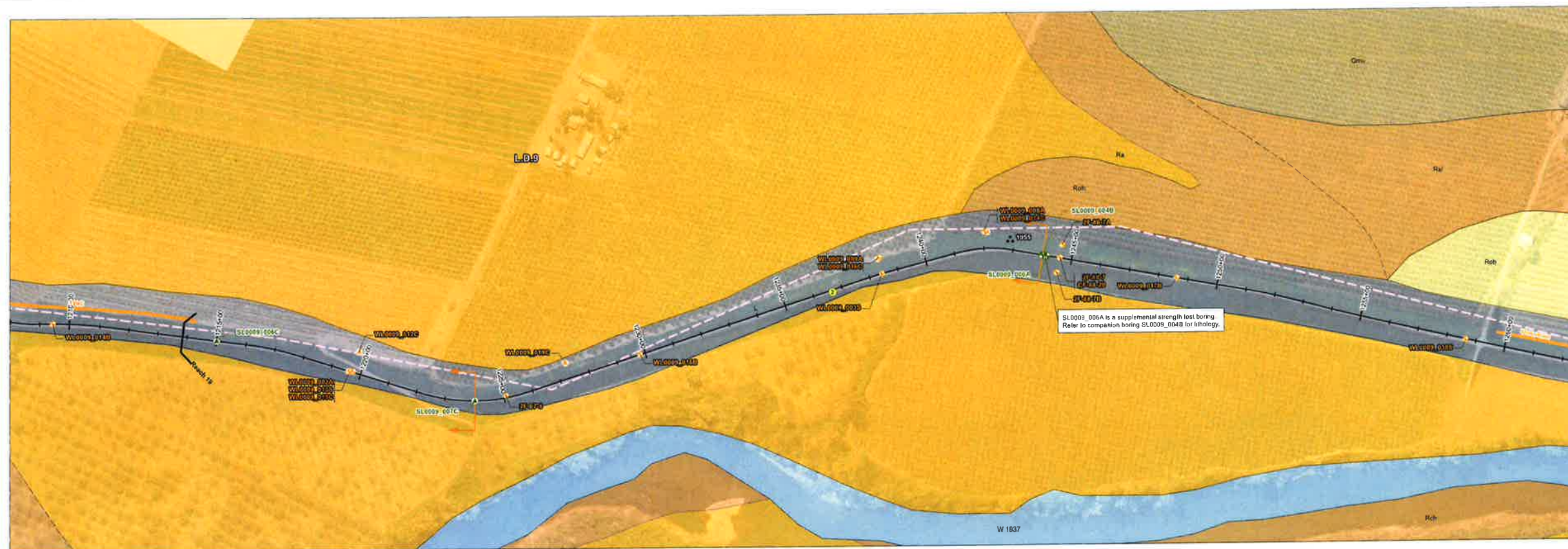


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$ refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remediation, or major capital spending decisions.
 12. The canal/itch elevations are approximate. These elevations were estimated from the topography.

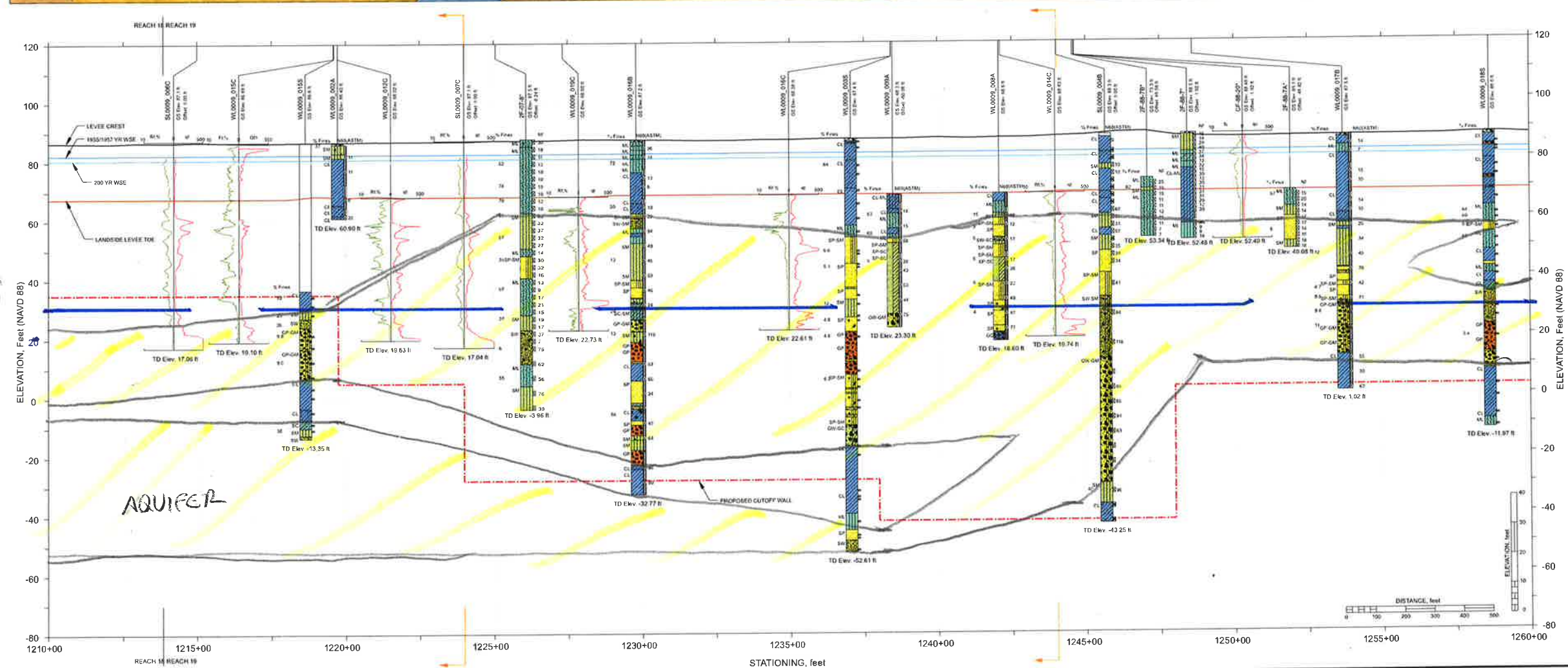


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1160+00 to Station 1210+00

NEW WALL CUTS OFF AQUIFER

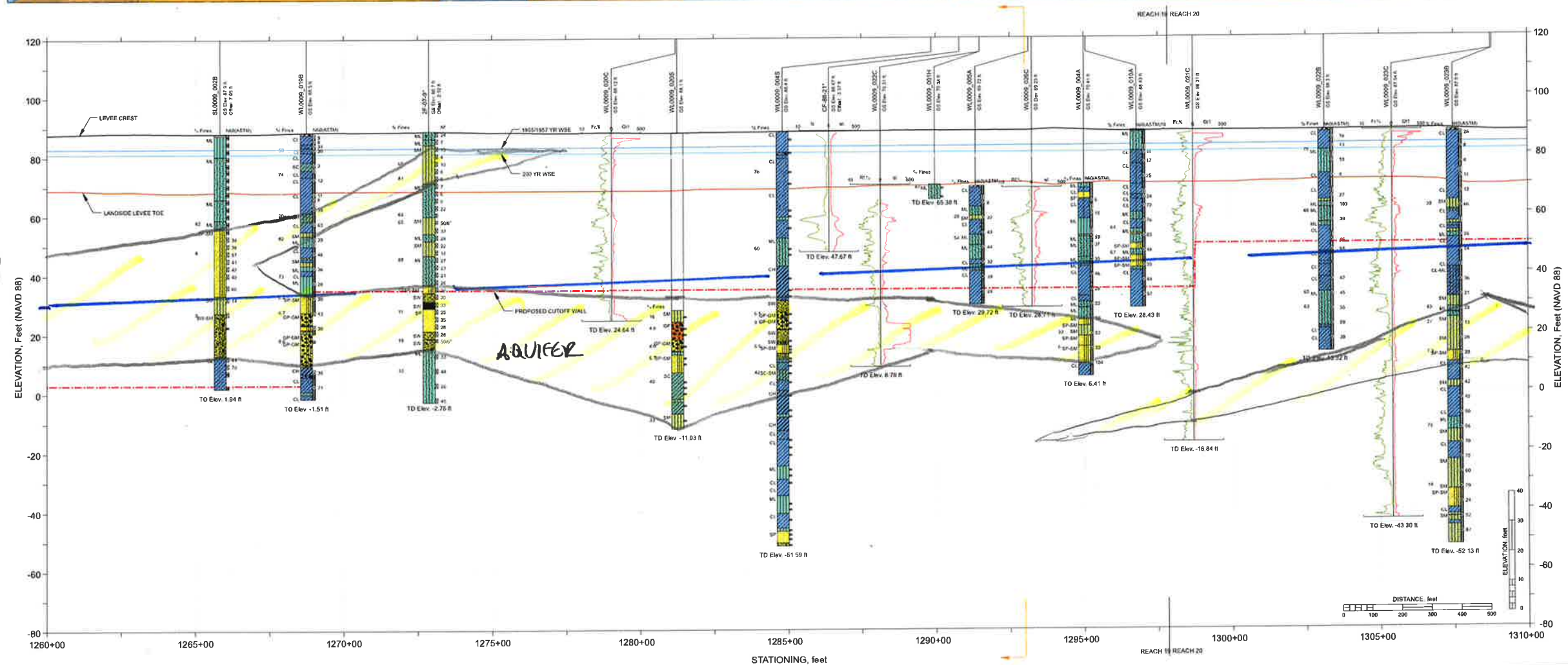


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWFR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to FRWL Final Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brunsel, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all of the explorations on the profile view. Historical explorations from the DWFR ULE project are shown. Other historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the slick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SSGDR for DWFR ULE Project, URS,2010).
10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and slick-log plates are for the use and benefit of HDR, SBFGA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. URS assumes no liability to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.





- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, N_{60} (ASTM) refers to N_{60} (ASTM) = N_{60} * Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 - These plans and stick-log plates are for the use and benefit of HDR, SBFA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1260+00 to Station 1310+00

URS

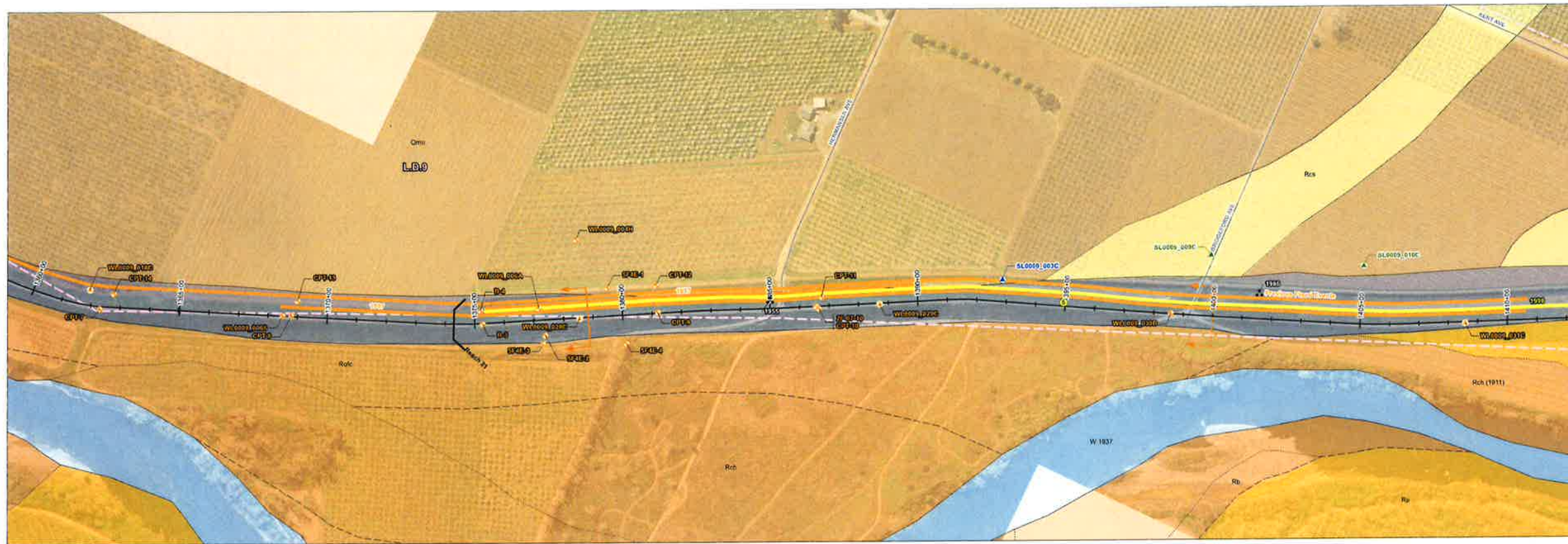
Geotechnical Design
Recommendations Report



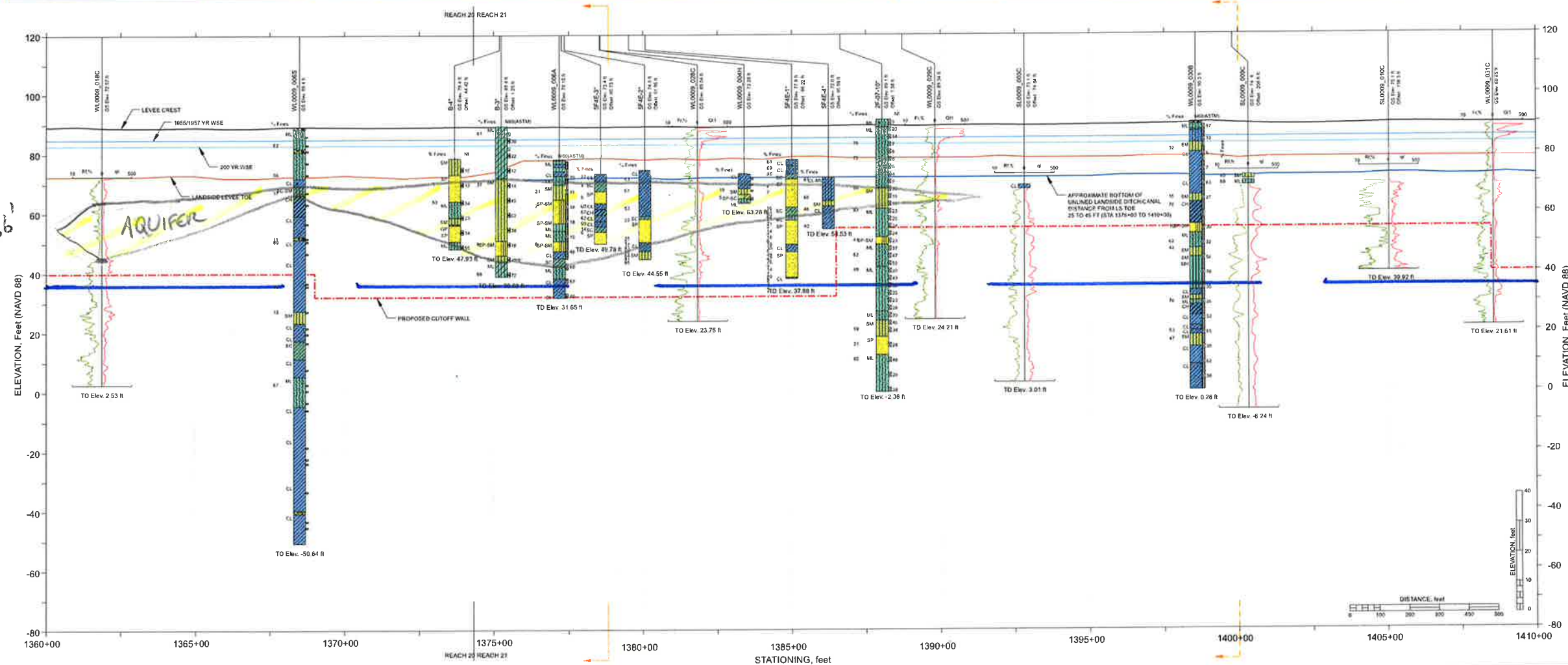
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
A28

NEW WALL CUTS OFF AQUIFER

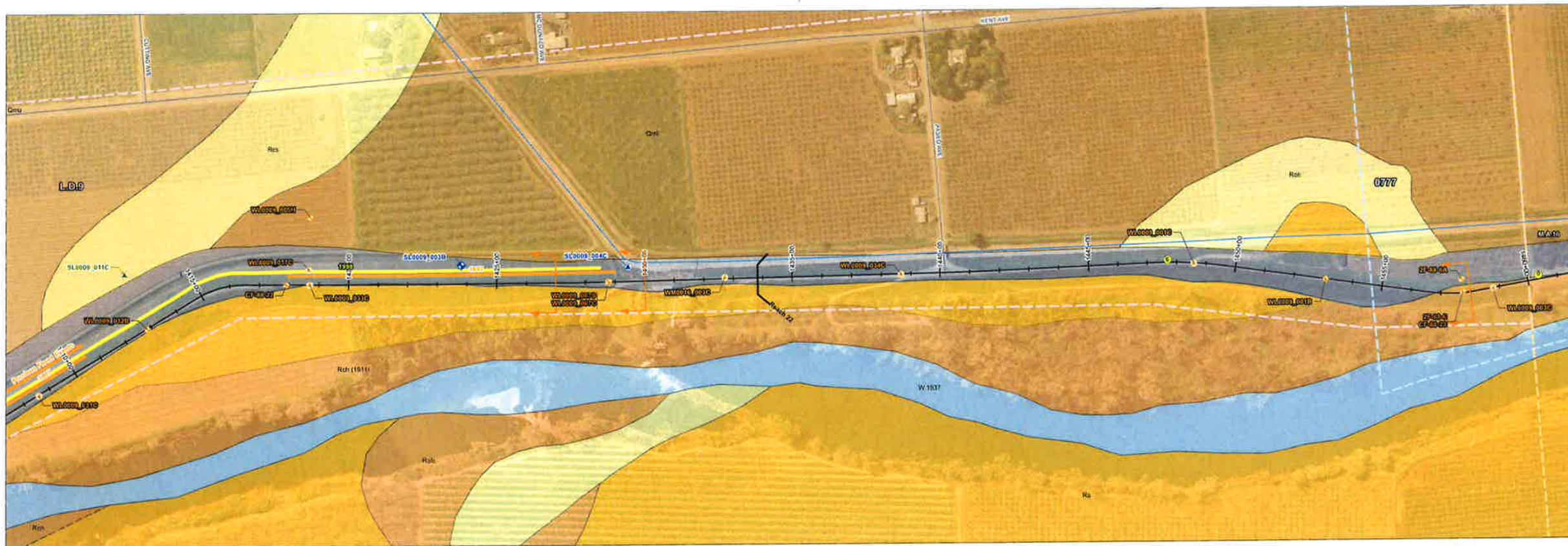


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

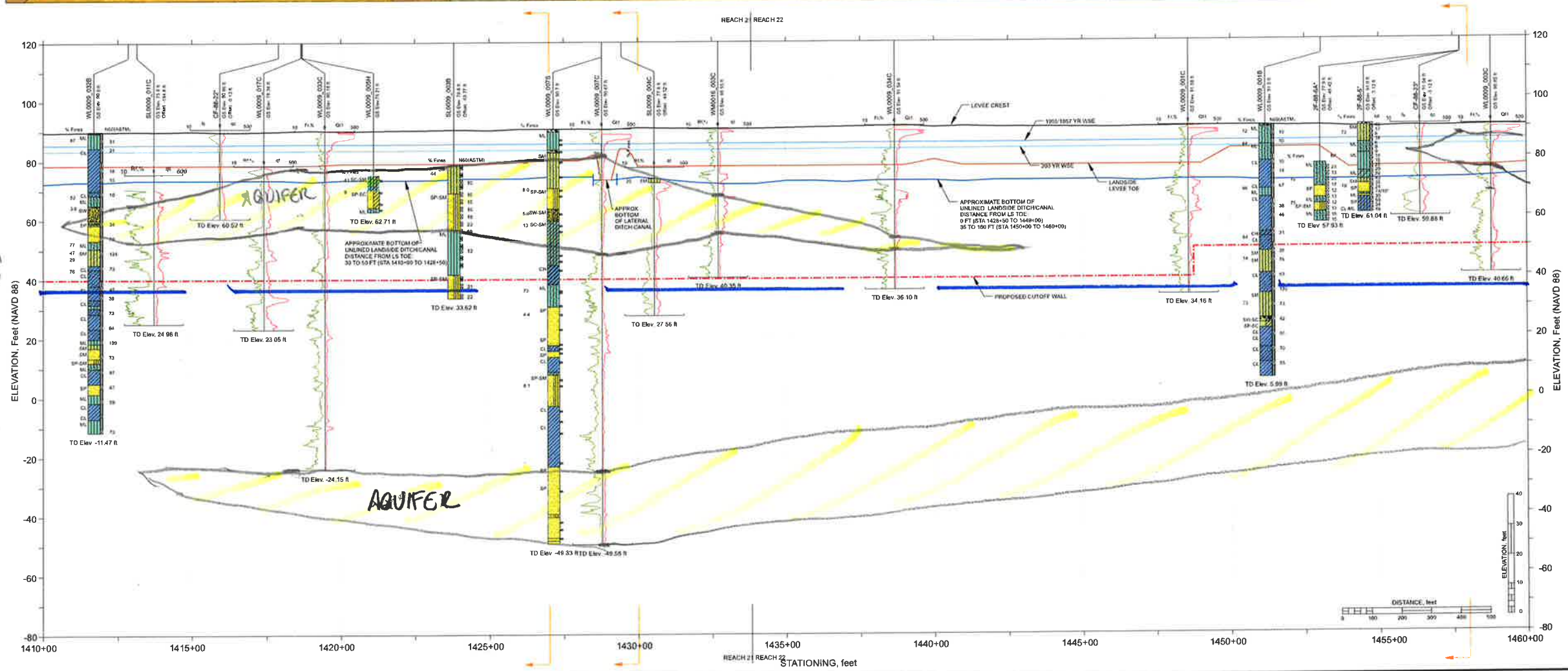


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1360+00 to Station 1410+00

NEW WALL CUTS OFF UPPER AQUIFER

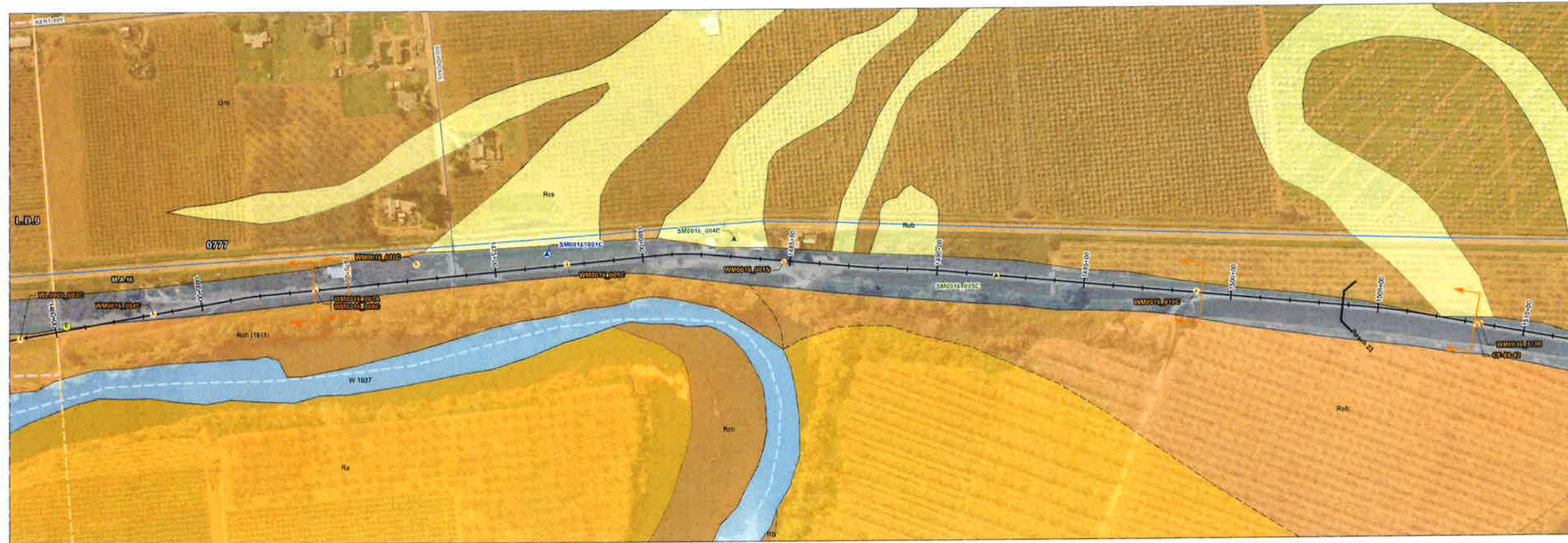


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all the materials encountered on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the slick logs for soil lenses (thickness less than 12 inches).
7. This is a color figure. Black and white reproduction should not be relied upon as it may be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surface geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and slick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. No warranty by any other party is at all made by URS. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

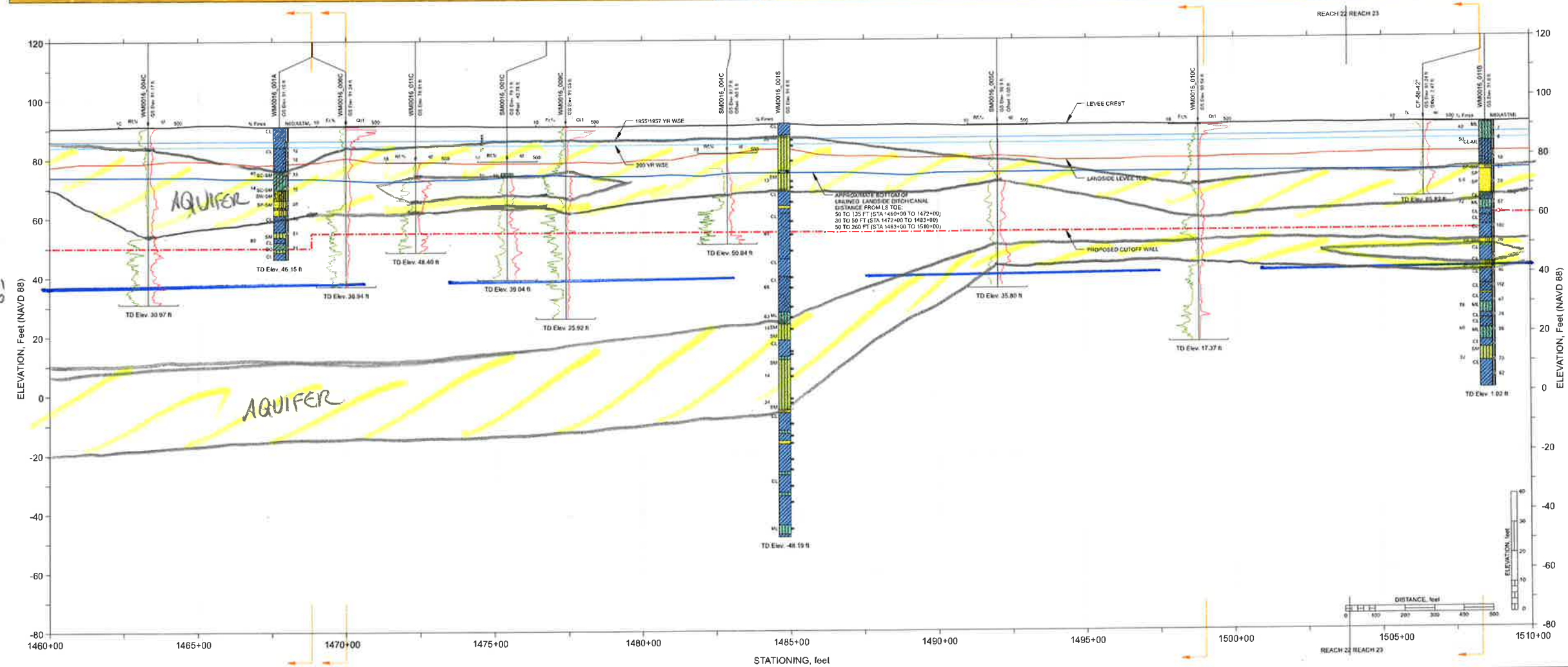
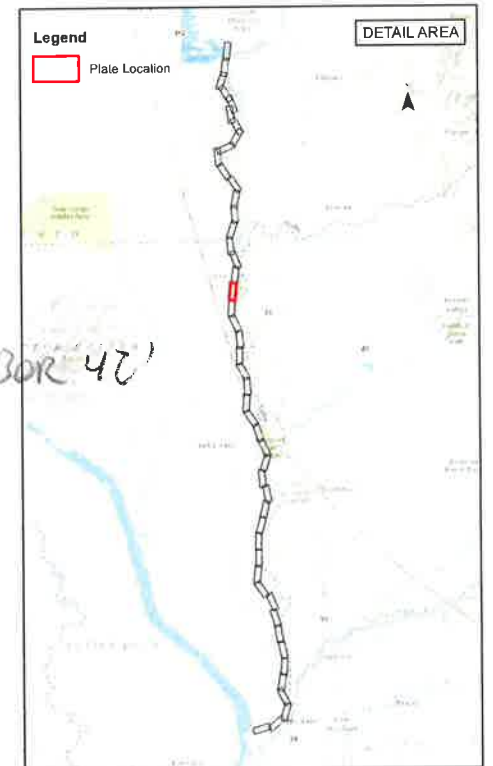


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1410+00 to Station 1460+00

NEW WALL CUTS OFF UPPER AQUIFER



- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1460+00 to Station 1510+00

URS

Geotechnical Design
Recommendations Report

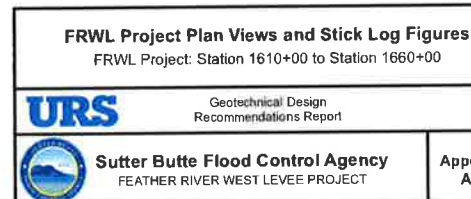


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

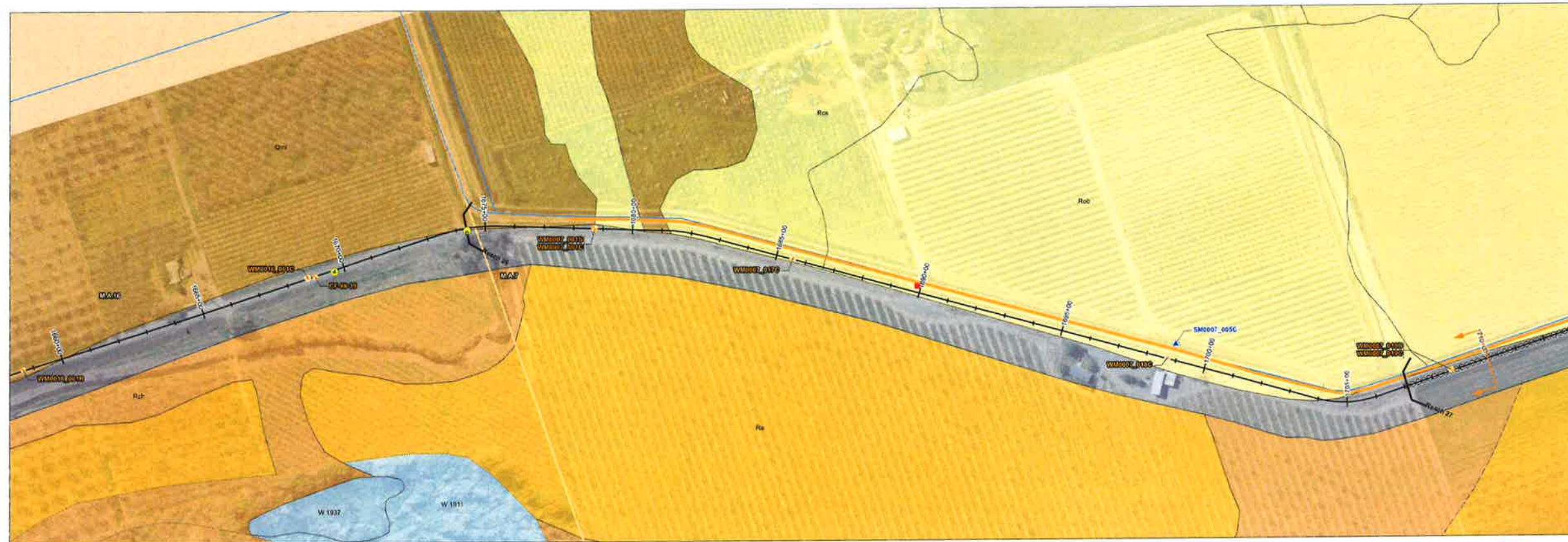
Appendix
A32



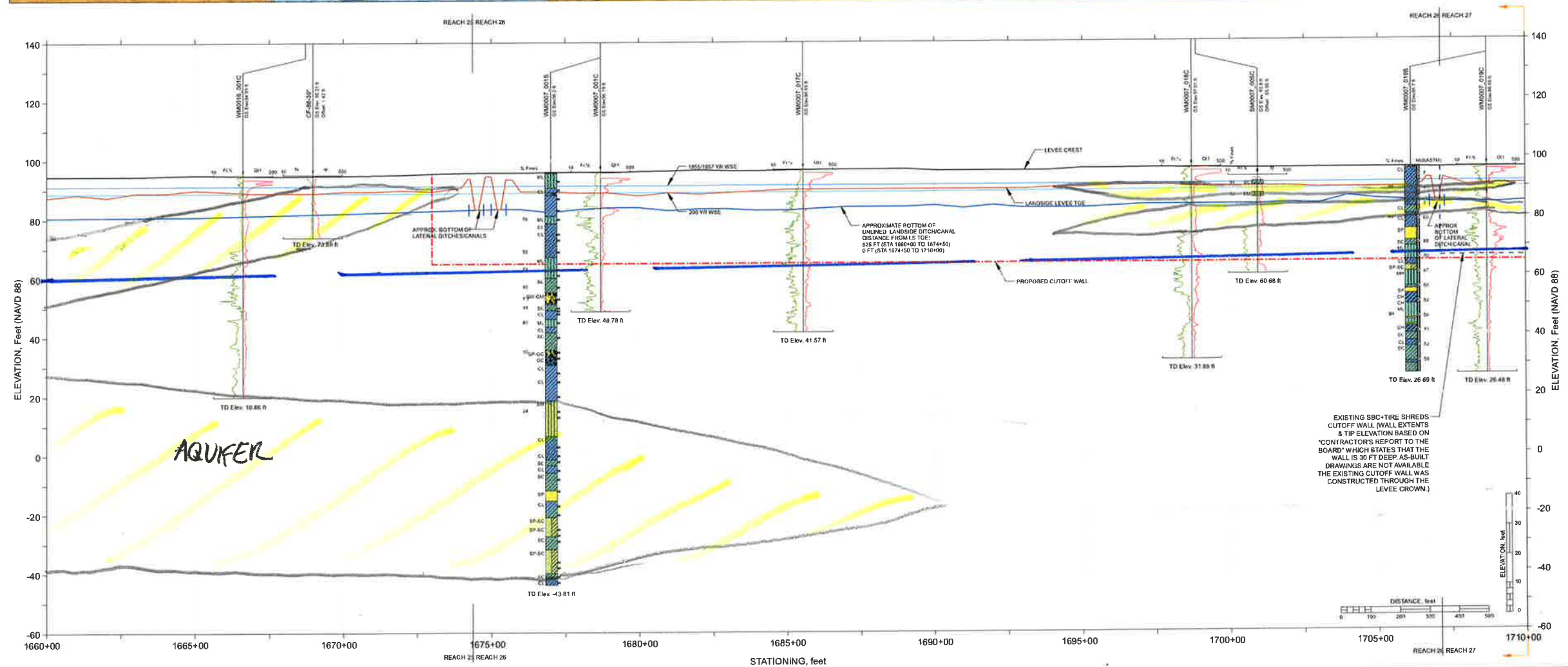
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 25, 2017 report entitled "Design Water Surface Profiles for the Faalther River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs and the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60}^{H} \cdot \text{Hammer Efficiency} (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations on the DWR ULE Project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as it will be less clear.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
10. The information provided in these plans and stick-log piles has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
11. These plans and stick-log piles are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



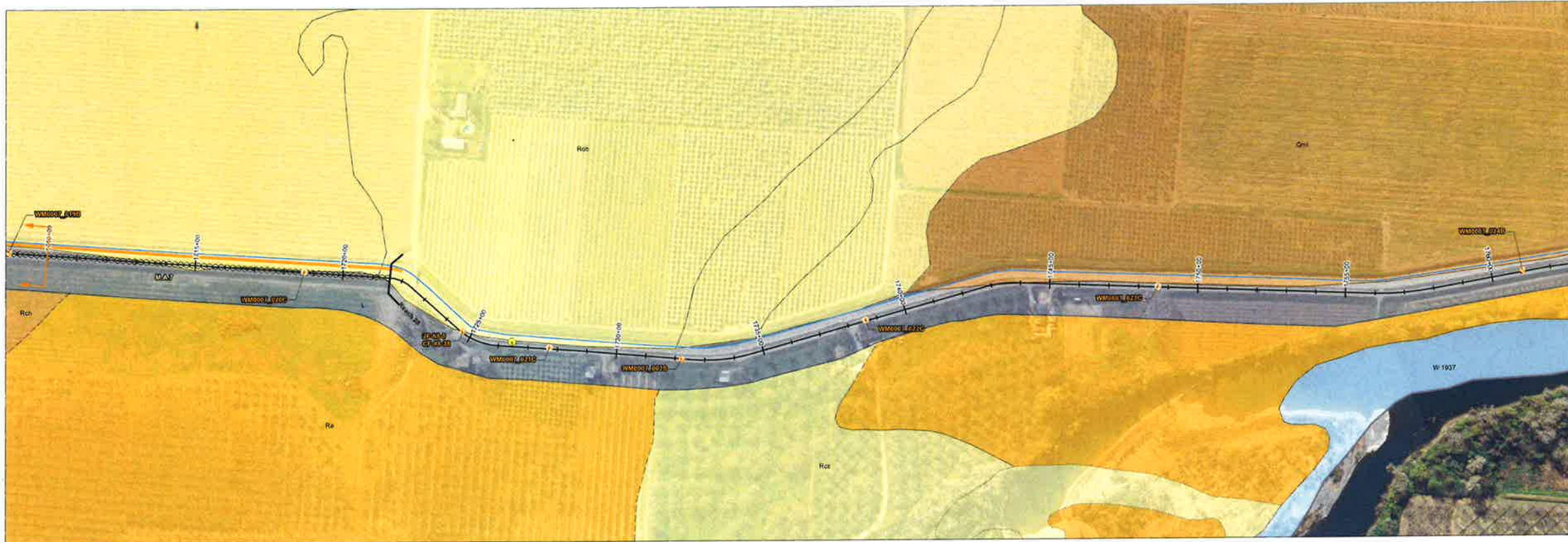
NEW WALL CUTS OFF SHALLOW AQUIFER FROM ~ STA. 1695+00 TO 1727+50



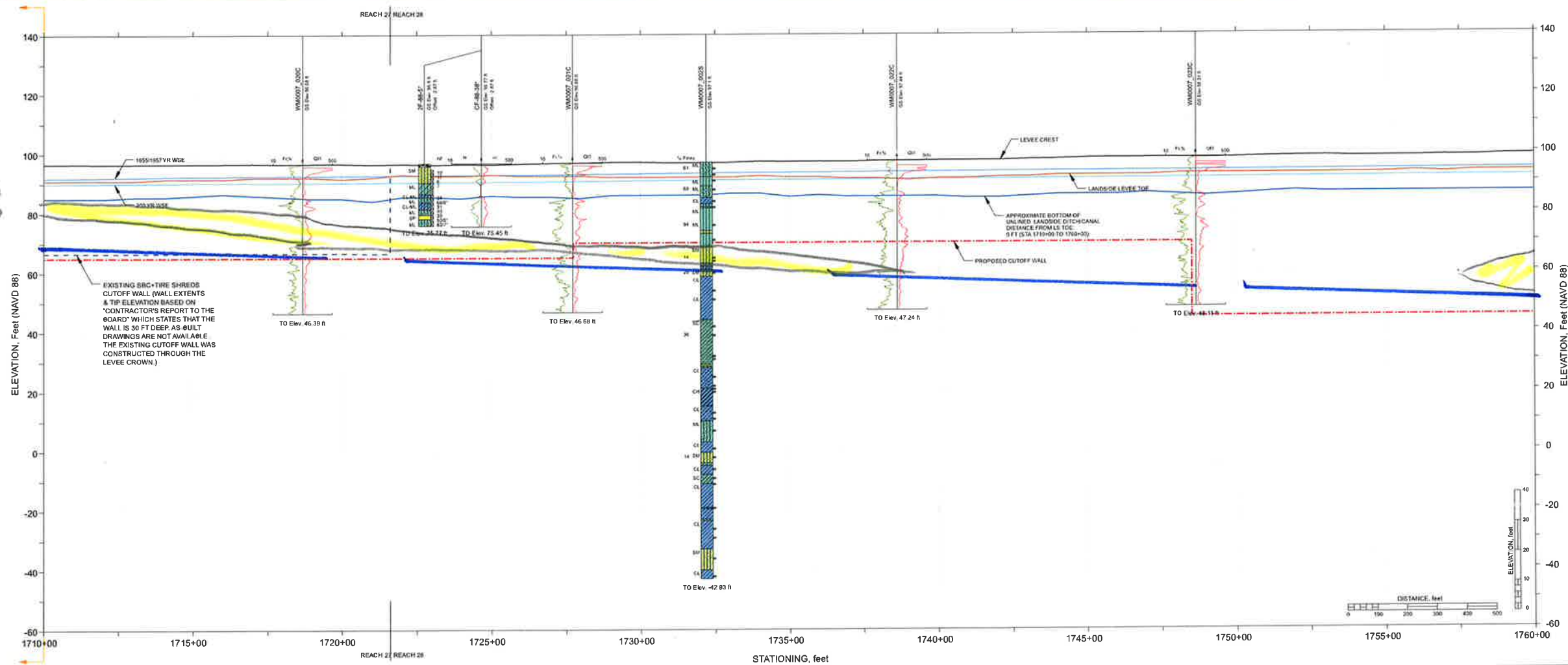
- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purposes only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brunsell, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1660+00 to Station 1710+00



- NOTES:
- Elevations of levee crown and landside loa are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside loa information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, N_{60} (ASTM) refers to N_{60} (ASTM) = N_{60} * Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
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 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures FRWL Project: Station 1710+00 to Station 1760+00

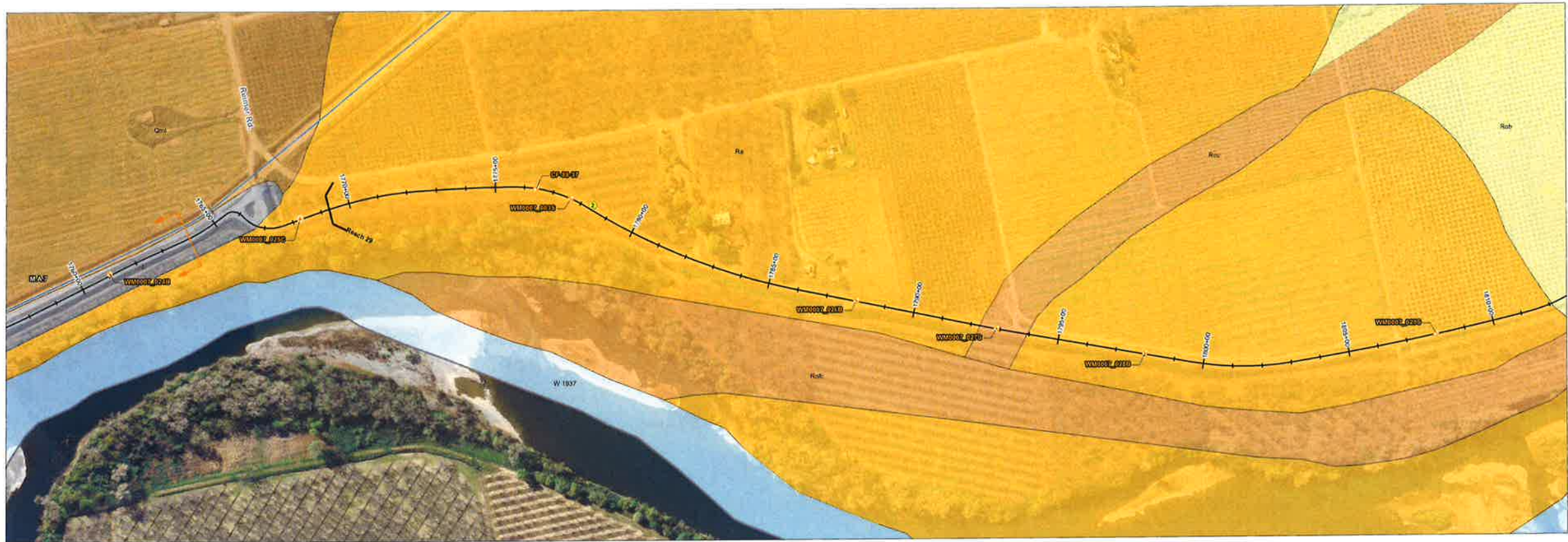
URS

Geotechnical Design
Recommendations Report

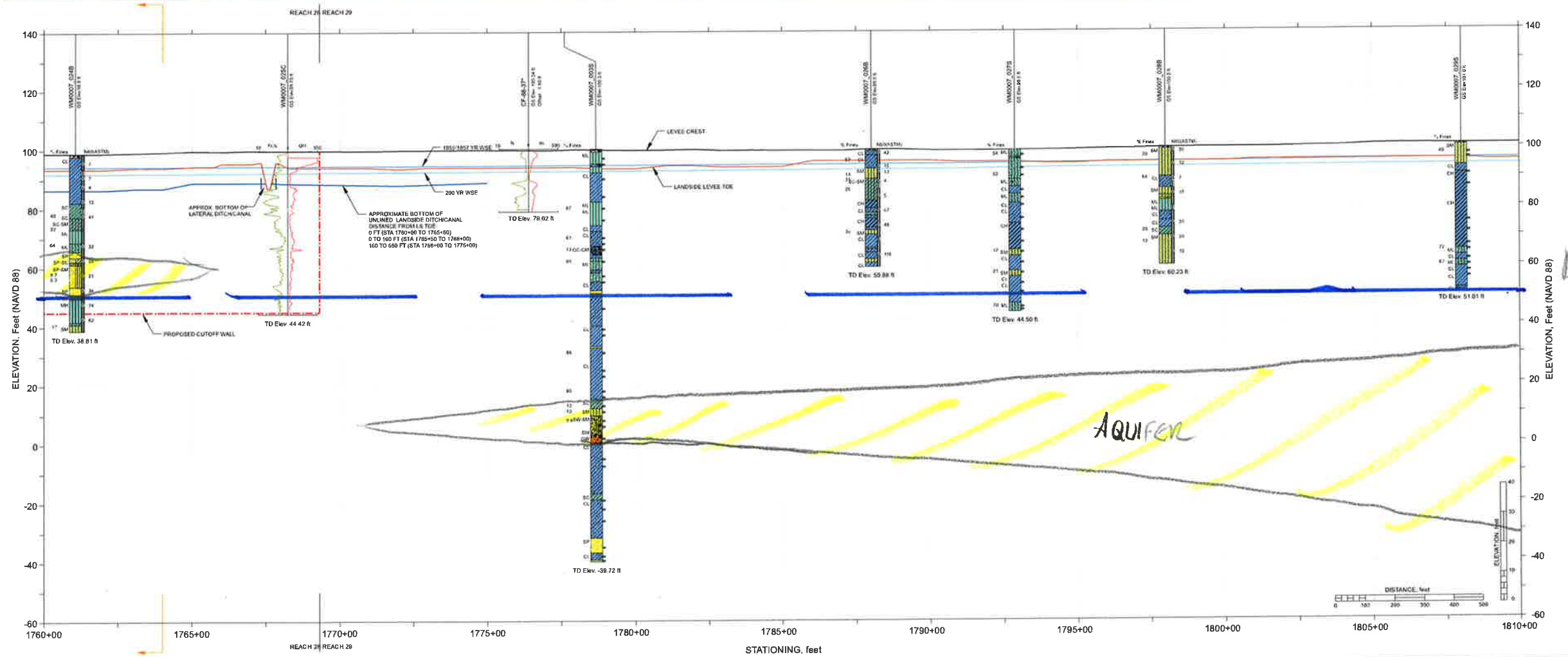
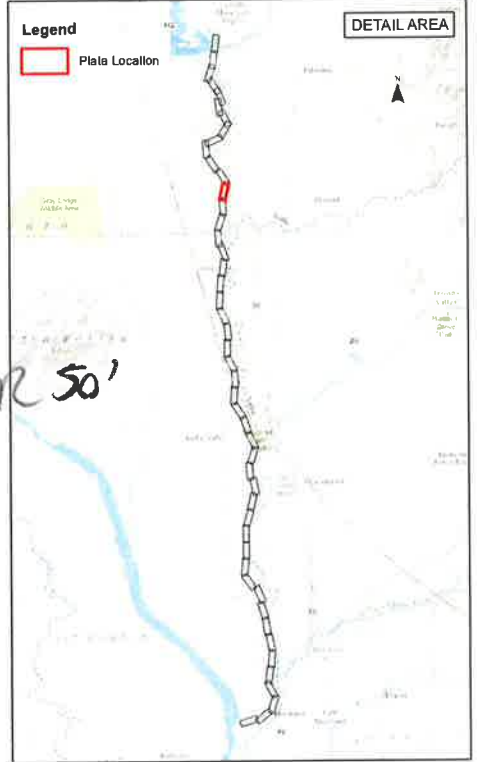


Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
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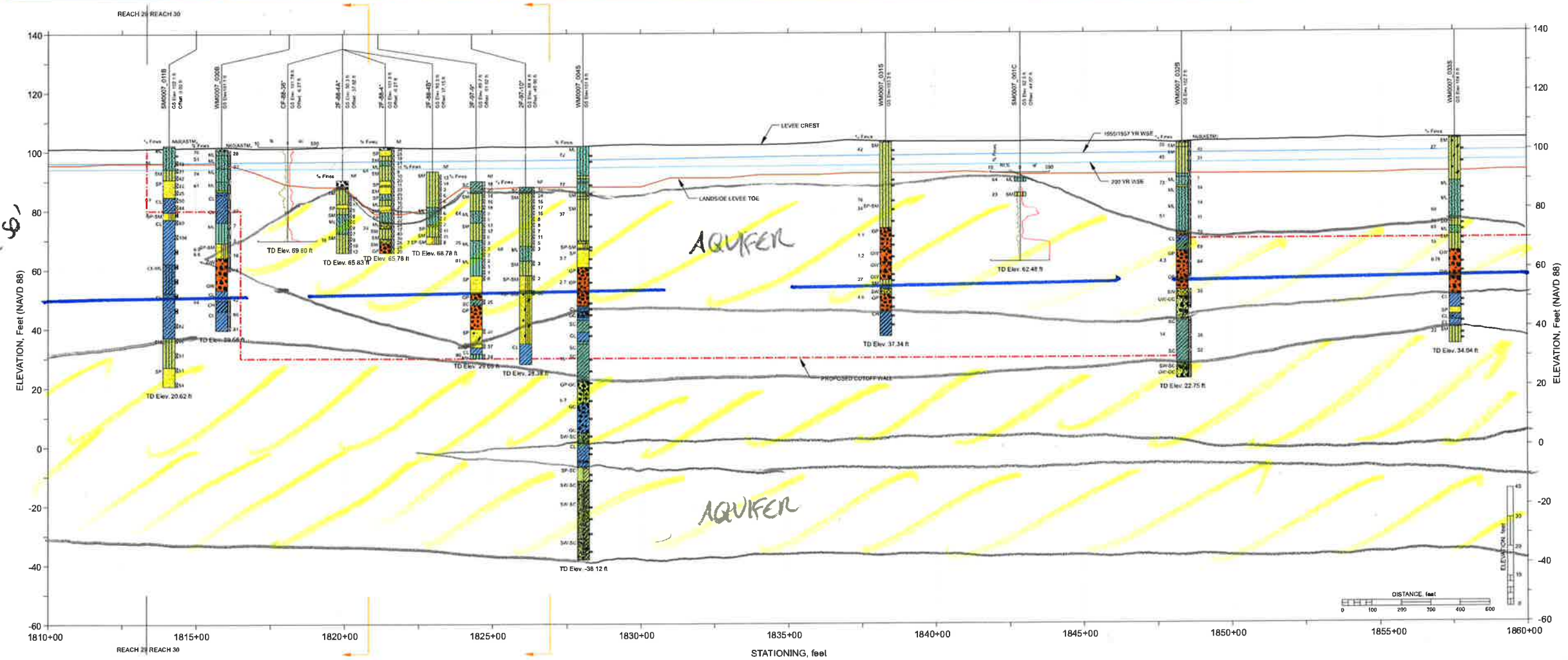
- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brasted, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, N_{60} (ASTM) refers to N_{60} (ASTM) = N_{60} * Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and stick-log plates are for the use and benefit of HDR, SBCEA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



NEW WALL CUTS OFF SHALLOW AQUIFER



1. Elevations of levee crown and lendisle toe are approximate. These elevations were obtained from DWFR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and lendisle toe information, please refer to the FRWLP Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. on their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered prior to boring and CPT logs in the Geotechnical Data Report for the FRWLP Project, No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) + N_{60} \times \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWLP Project for hammer efficiency data for individual borings.
5. These drawings do not include all materials encountered on the profile view. Historical explorations from the DWFR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classification.
6. USCS classification labels are not presented on the slick logs for soil lenses less than 12 inches (1 foot).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWFR ULE Project, USR, 2010).
10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. USR does not attest to the accuracy, completeness, or reliability of geotechnical exploration end other subsurface data by others that are included or referenced in these plates.
11. These plans and slick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWLP Project. Use by any other party is without any written consent. These files should not to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



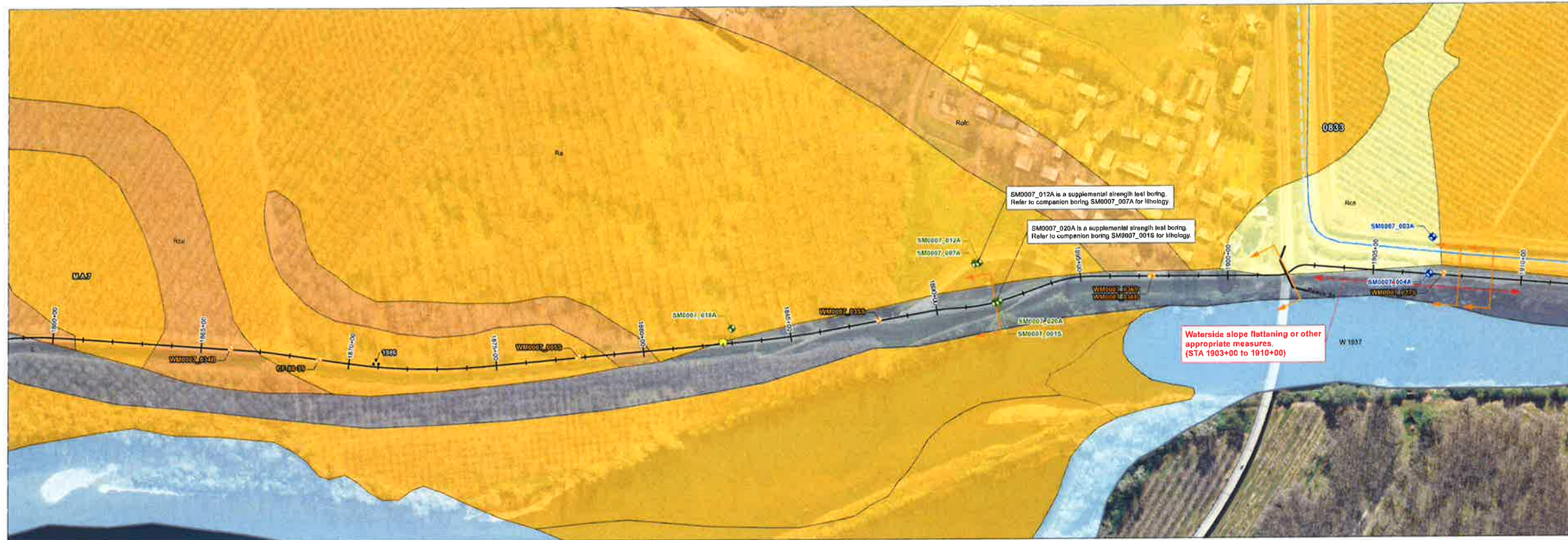
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1810+00 to Station 1860+00

Geotechnical Design
Recommendations Report

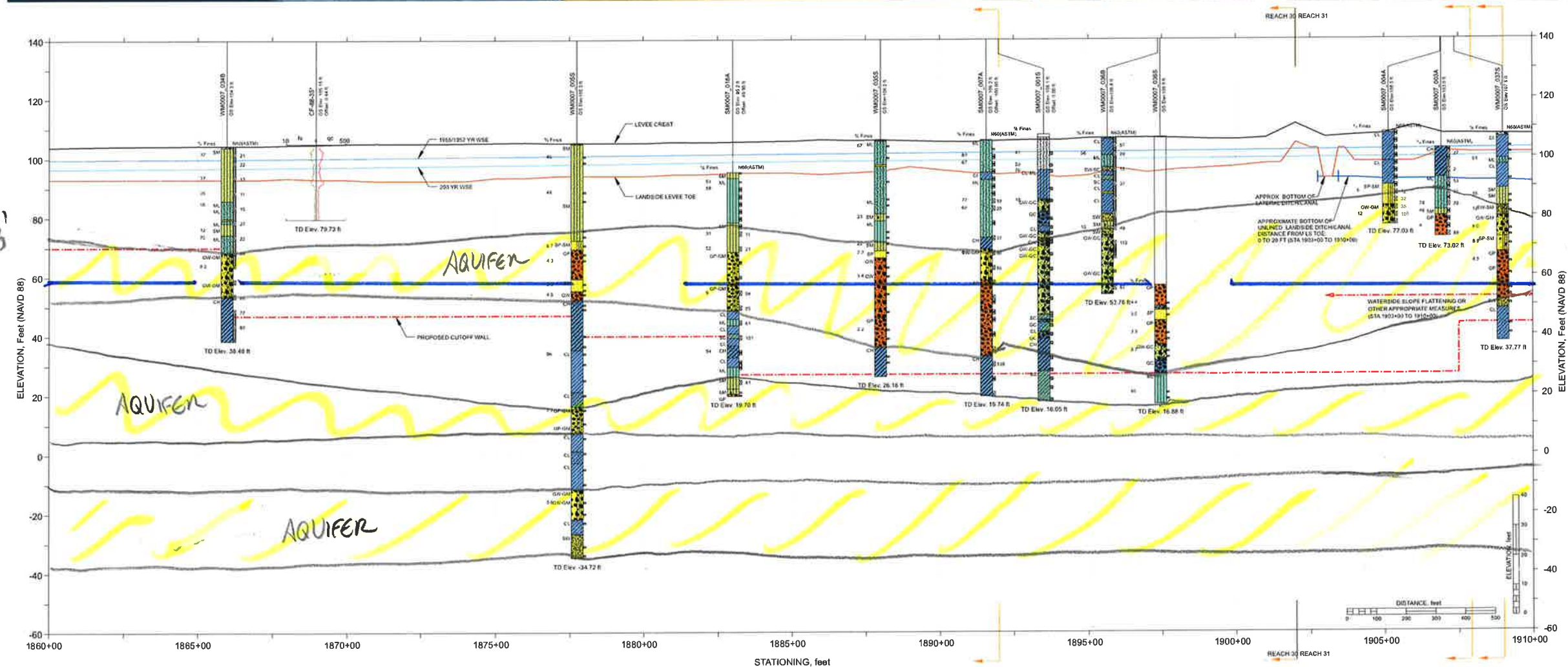
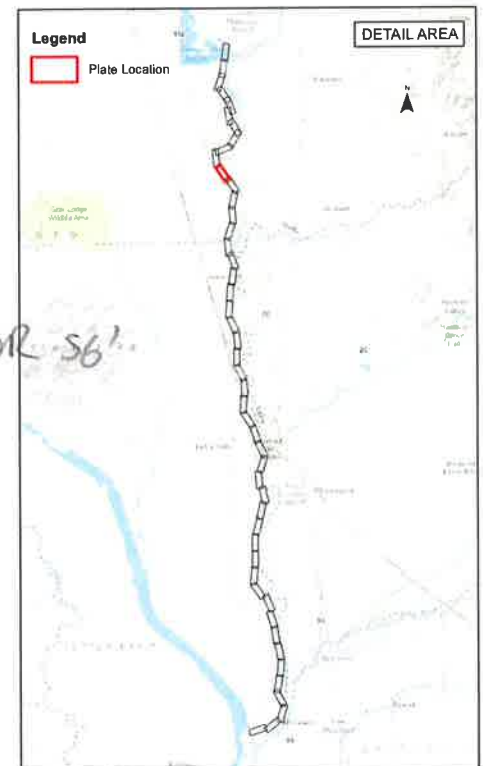
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

Appendix
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NEW WALL CUTS OFF UPPER AQUIFER

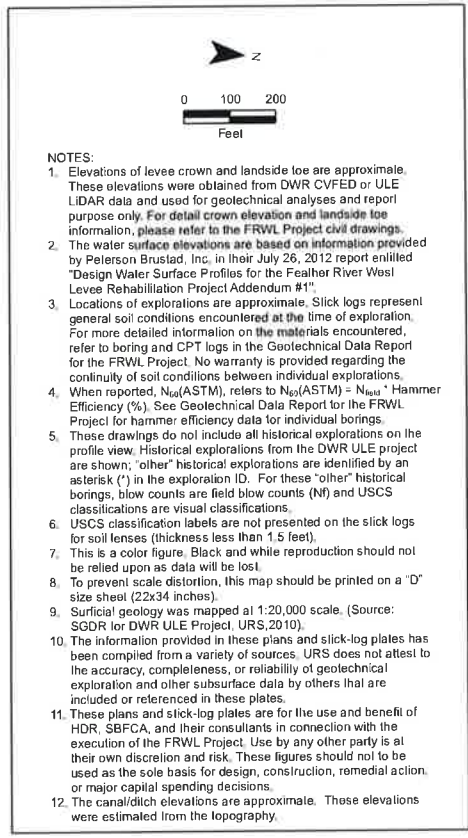


- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brundstad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 - These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 - These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.



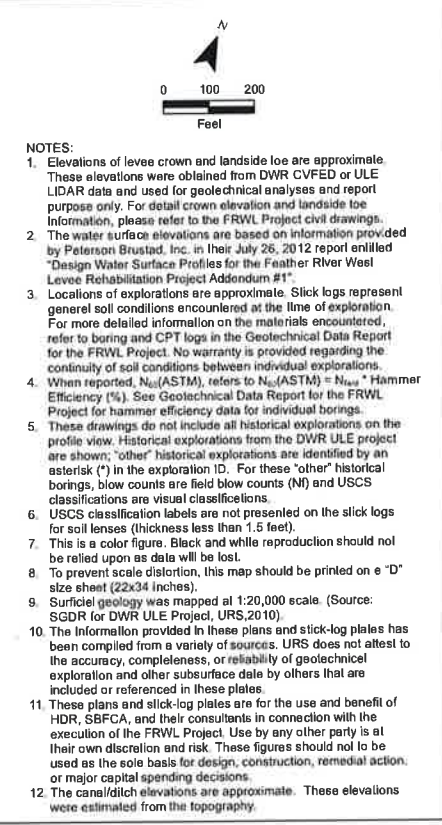
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 1860+00 to Station 1910+00

NEW WALL CUTS OFF UPPER AQUIFER

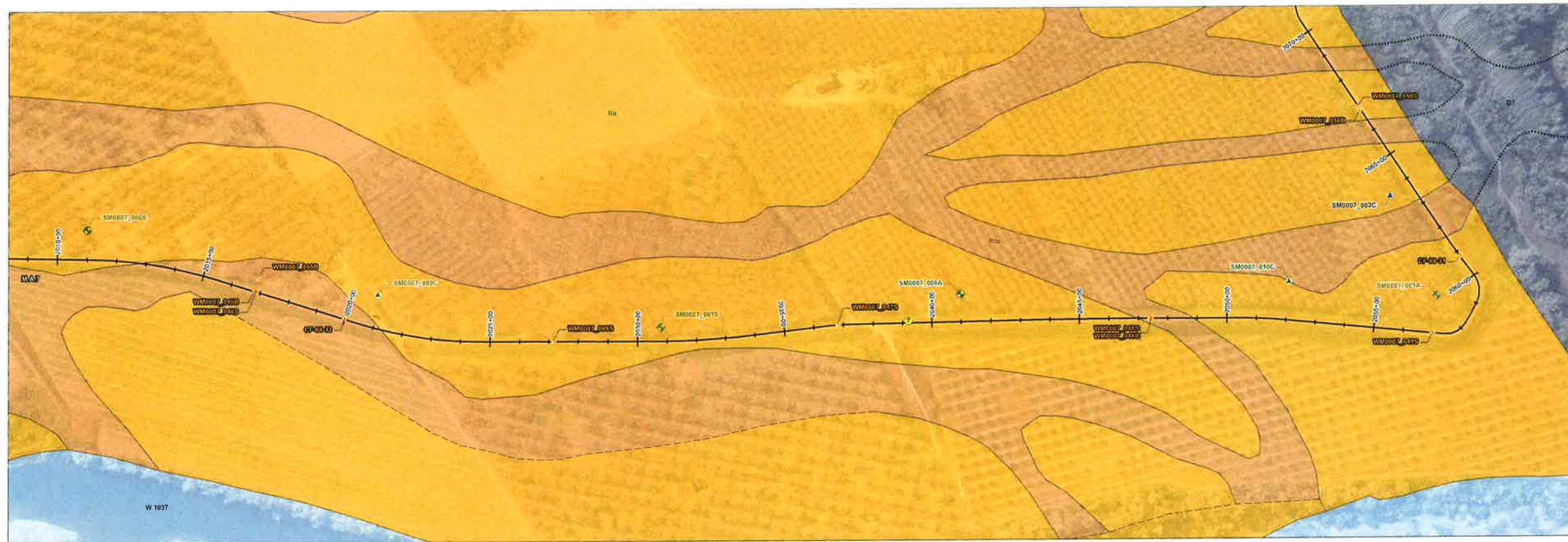


	Geotechnical Design Recommendations Report	Sutter Butte Flood Control Agency FEATHER RIVER WEST LEVEE PROJECT	Appendix A
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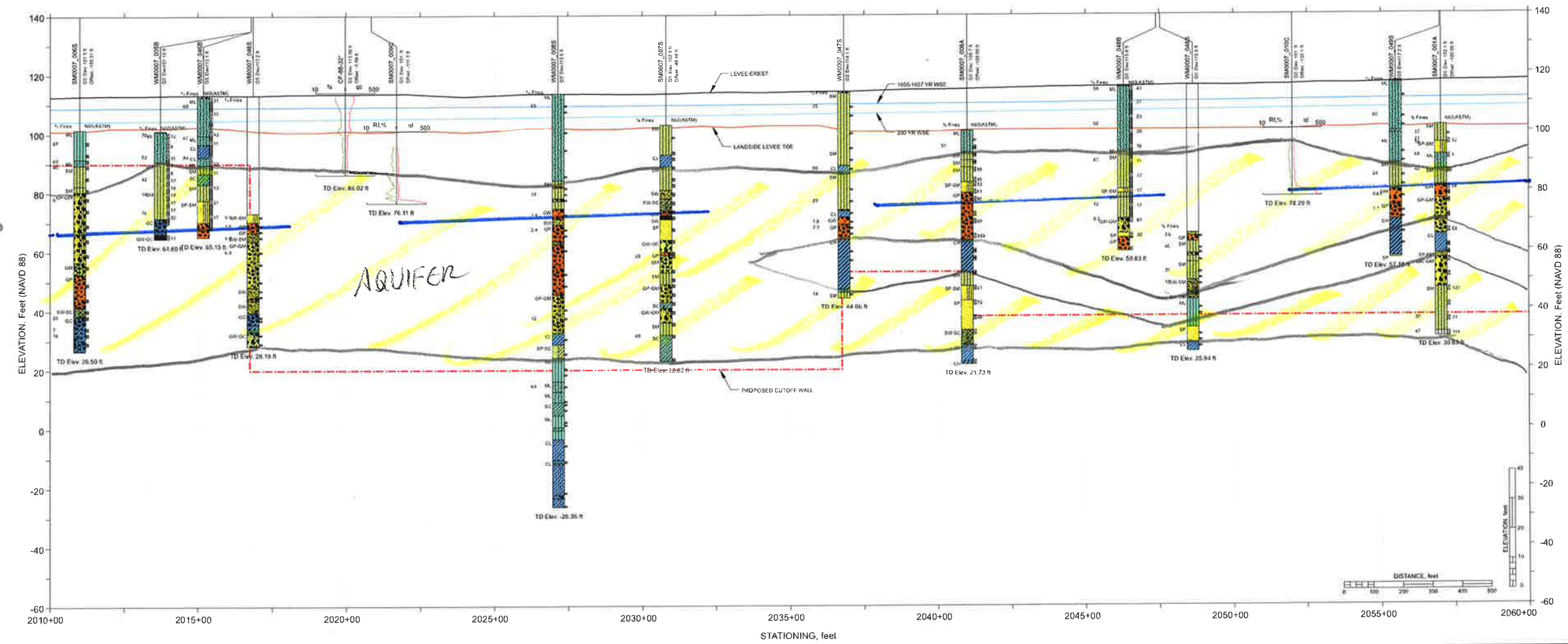
NEW WALL CUTS OFF UPPER AQUIFER



NEW WALL CUTS OFF AQUIFER



1. Elevations of levee crown and landside lse are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside lse information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Petersen Bruster, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the soil conditions encountered, refer to boring and blow count logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{New} \times$ Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical exploration data. The profile within the historical blow count logs for the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SDDR for DWR ULE Project, USR,2010).
10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. USR does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and stick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion. These plans and stick-log plates shall not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



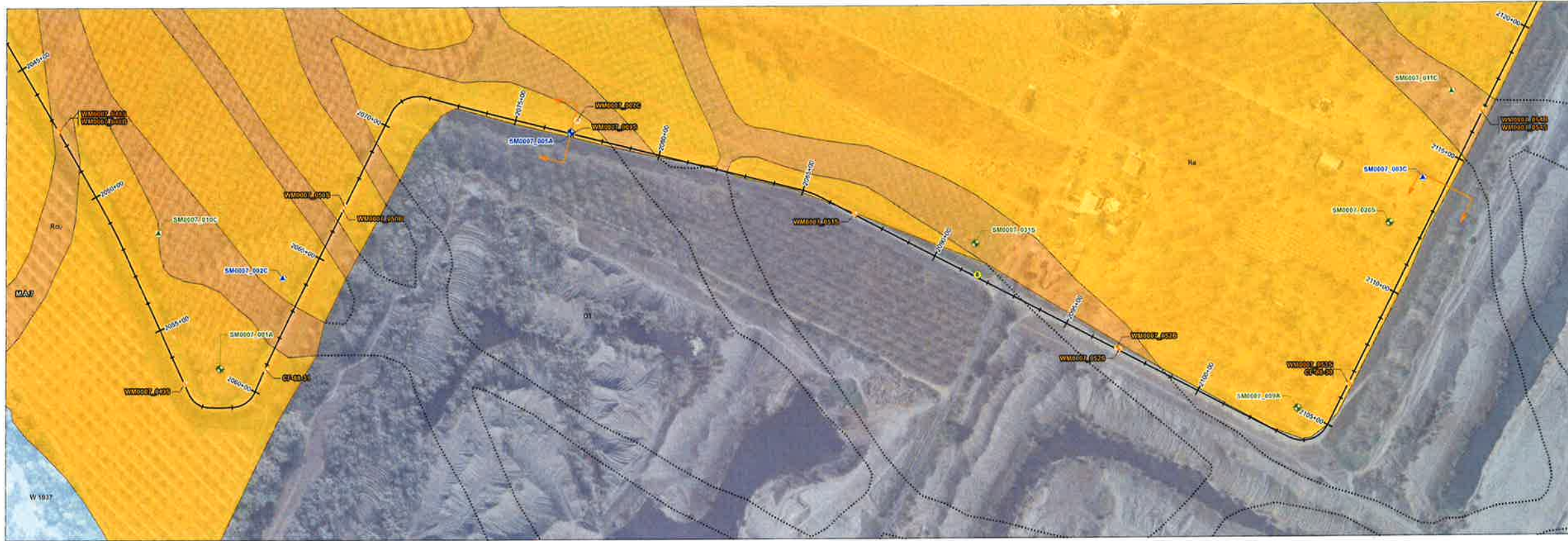
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 2010+00 to Station 2060+00



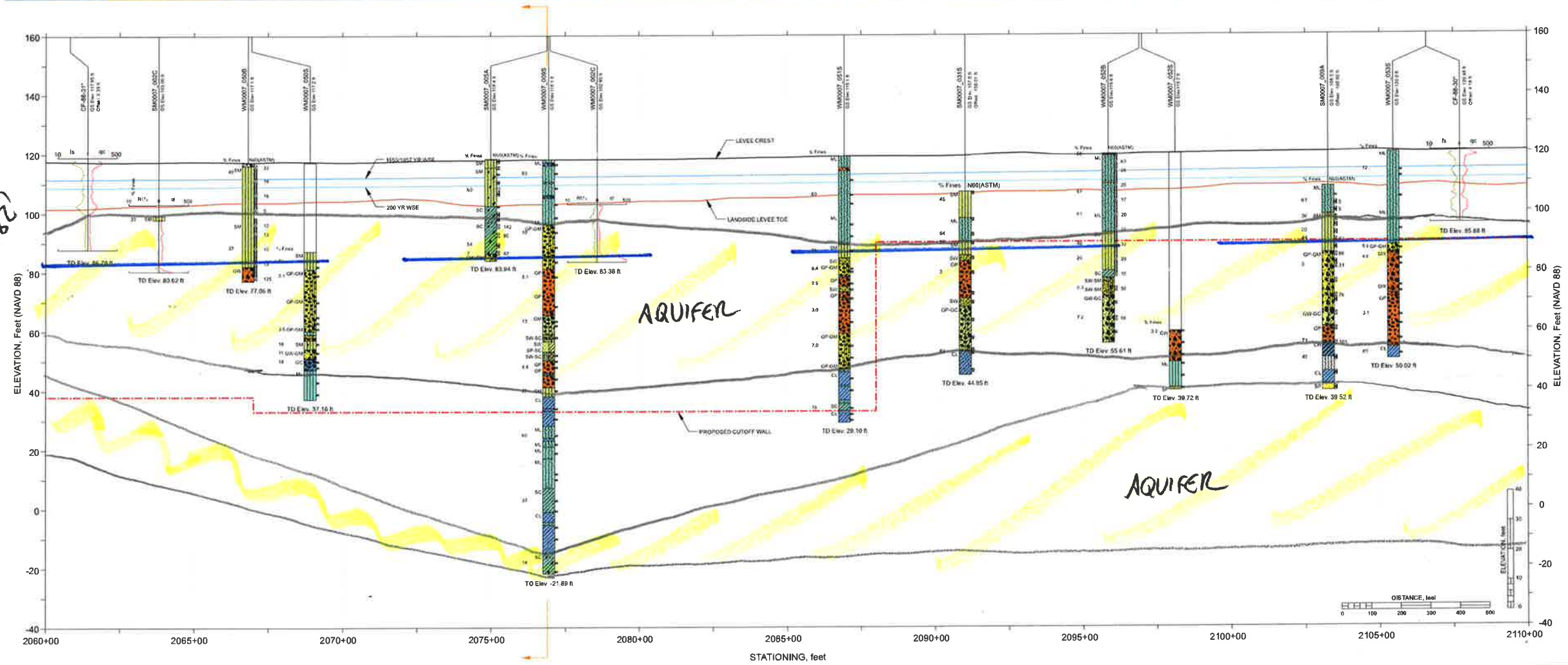
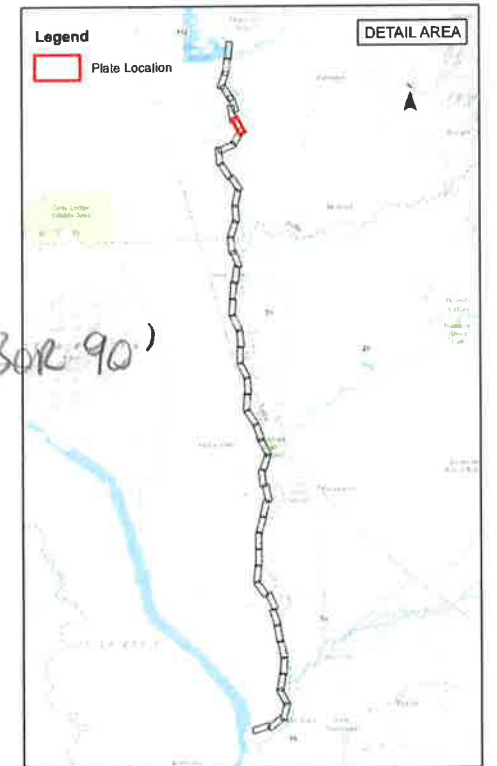
Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

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NEW WALL CUTS OFF UPPER AQUIFER

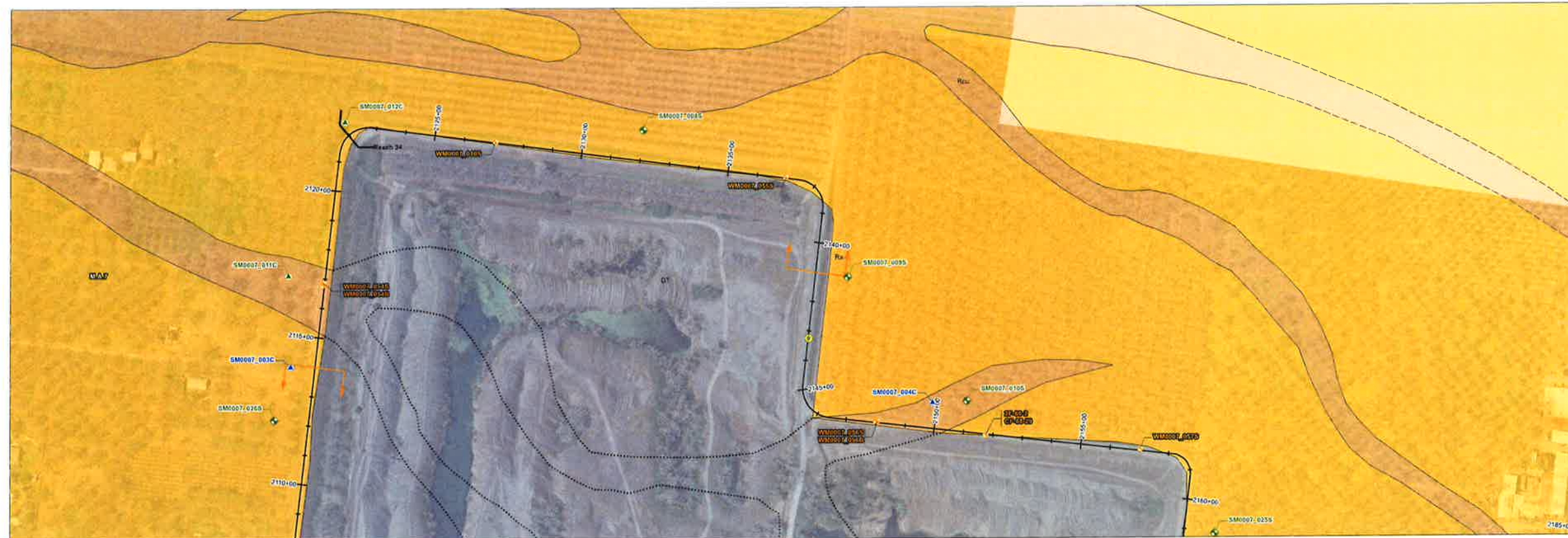


- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brustad, Inc. on their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) + N_{60} + \text{Hammer Efficiency } (\%)$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the slick logs for fill lenses (blow less than 1.5 fsp).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWR ULE Project, URS2010)
10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
11. These plans and slick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

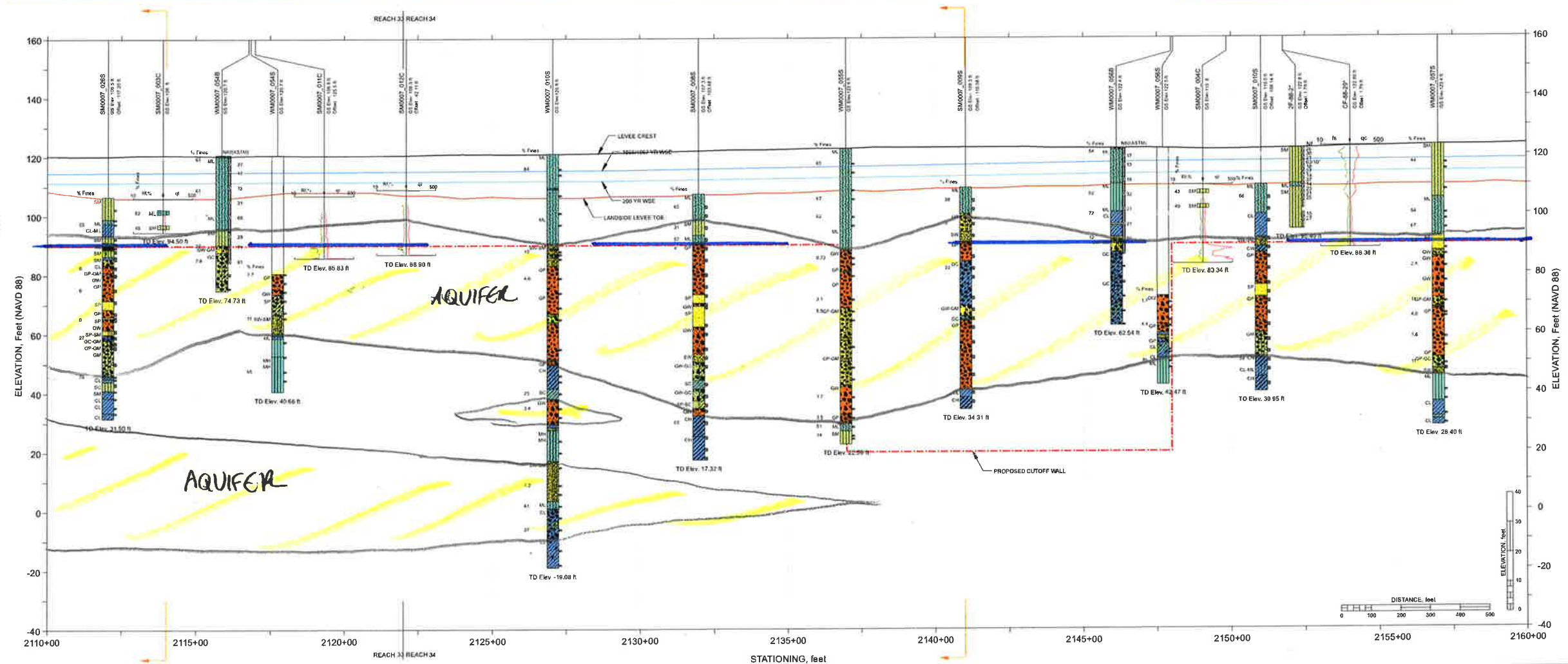
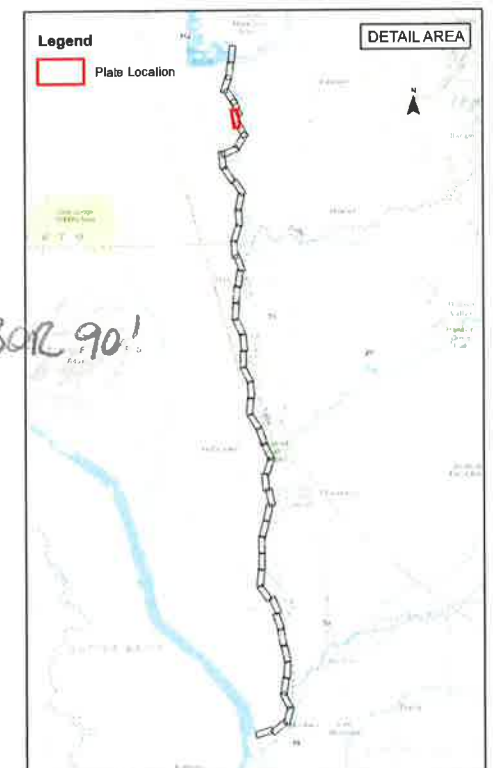


FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 2060+00 to Station 2110+00

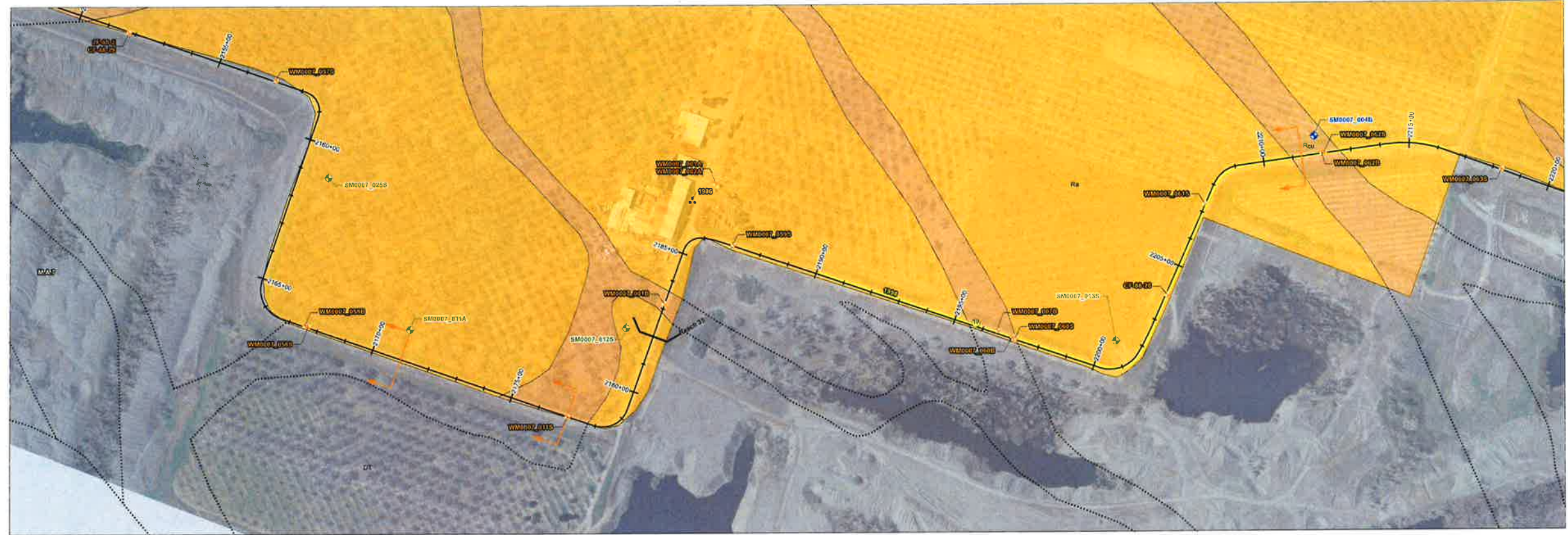
NEW WALL CUTS OFF AQUIFER FROM ~ STA. 2137+00 TO 2148+00



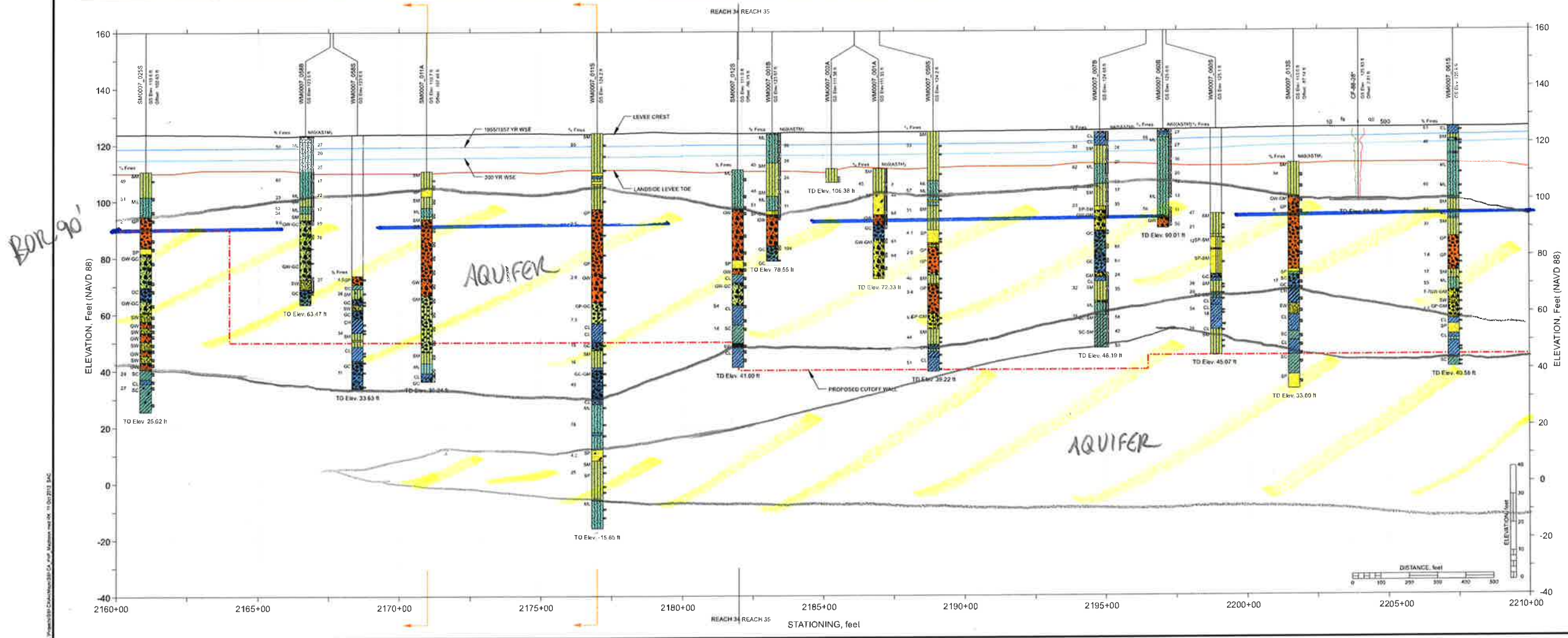
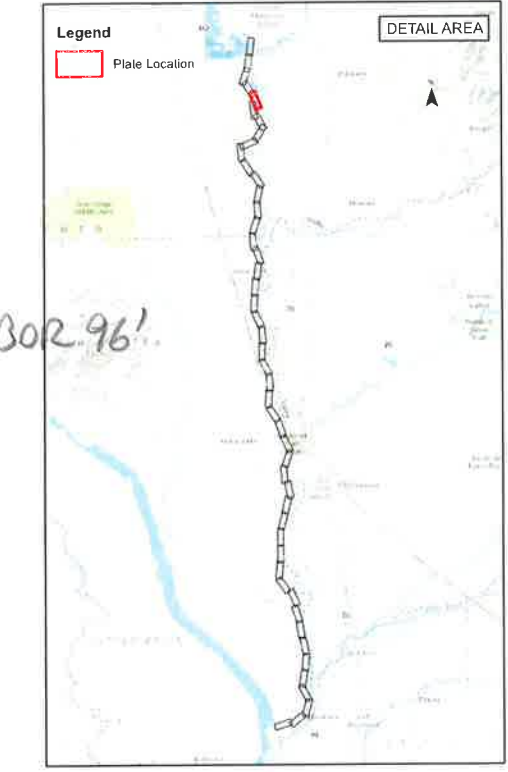
1. Elevations of levee crown and landslide toe are approximate. These elevations were obtained from DWFR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landslide toe information, please refer to the FRWL Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brusted, Inc. on their July 26, 2012 report entitled "Design Water Surface Profiles for the Feelher River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Technical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times$ Hammer Efficiency (%). See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWFR ULE Project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (Nf) and USCS classifications are visual classifications.
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as it will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SGRD for DWFR ULE Project, URS.2010).
10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



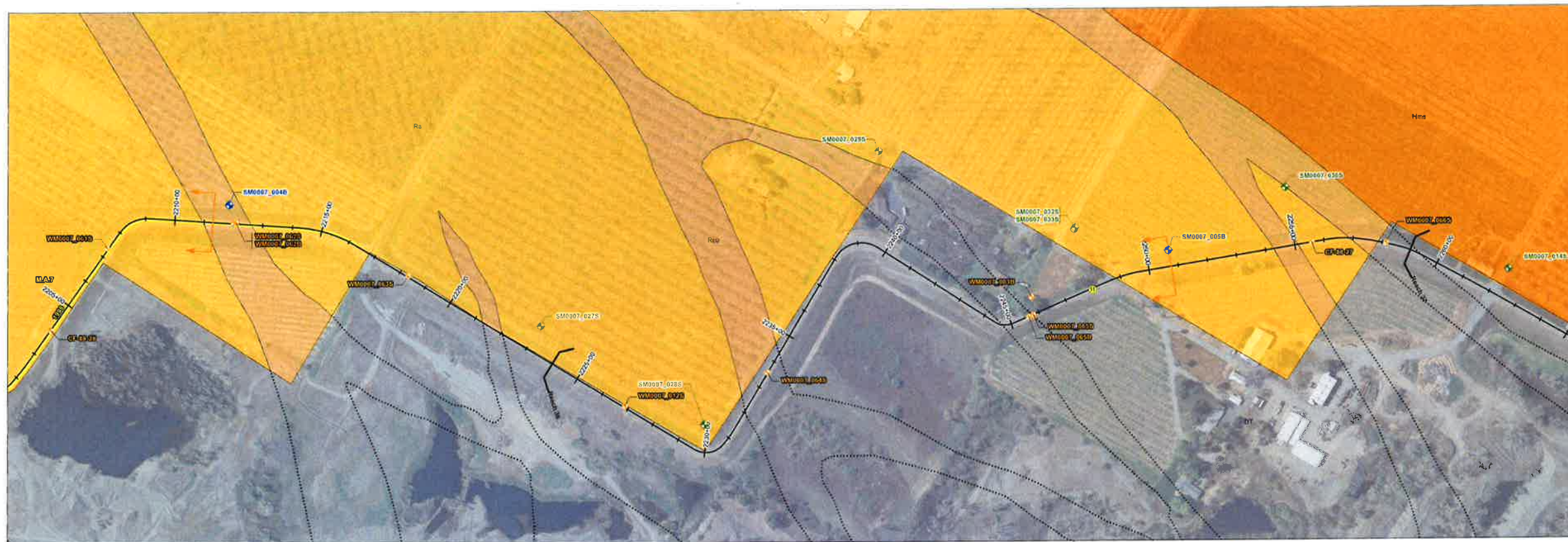
NEW WALL CUTS OFF UPPER AQUIFER



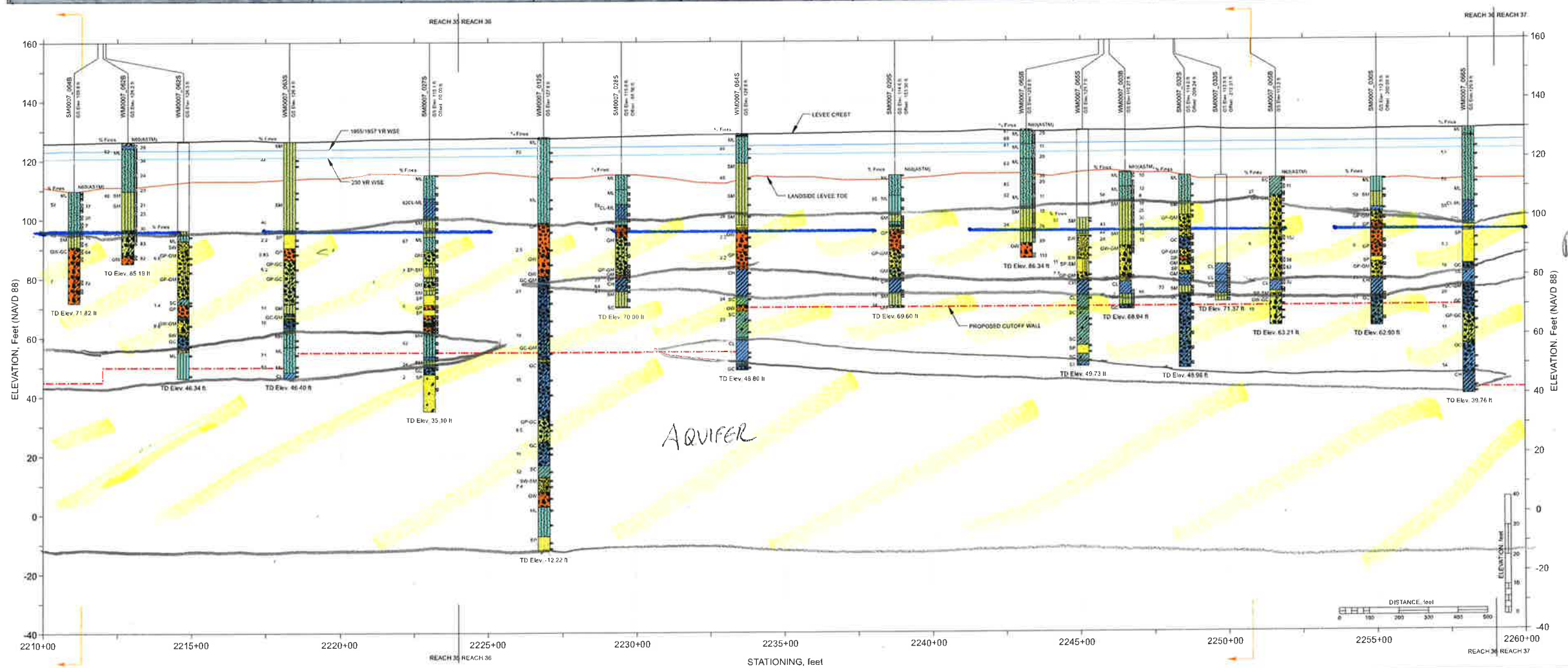
- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFD or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Pearson Brundage, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (N) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the slick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 10. The information provided in these plans and slick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
 11. These plans and slick-log plates are for the use and benefit of HDR, SBFCA, and their consultants in connection with the execution of the FRWL Project. Use by any other party is at their own discretion and risk. These figures should not be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



NEW WALL CUTS OFF UPPER PORTION OF AQUIFER

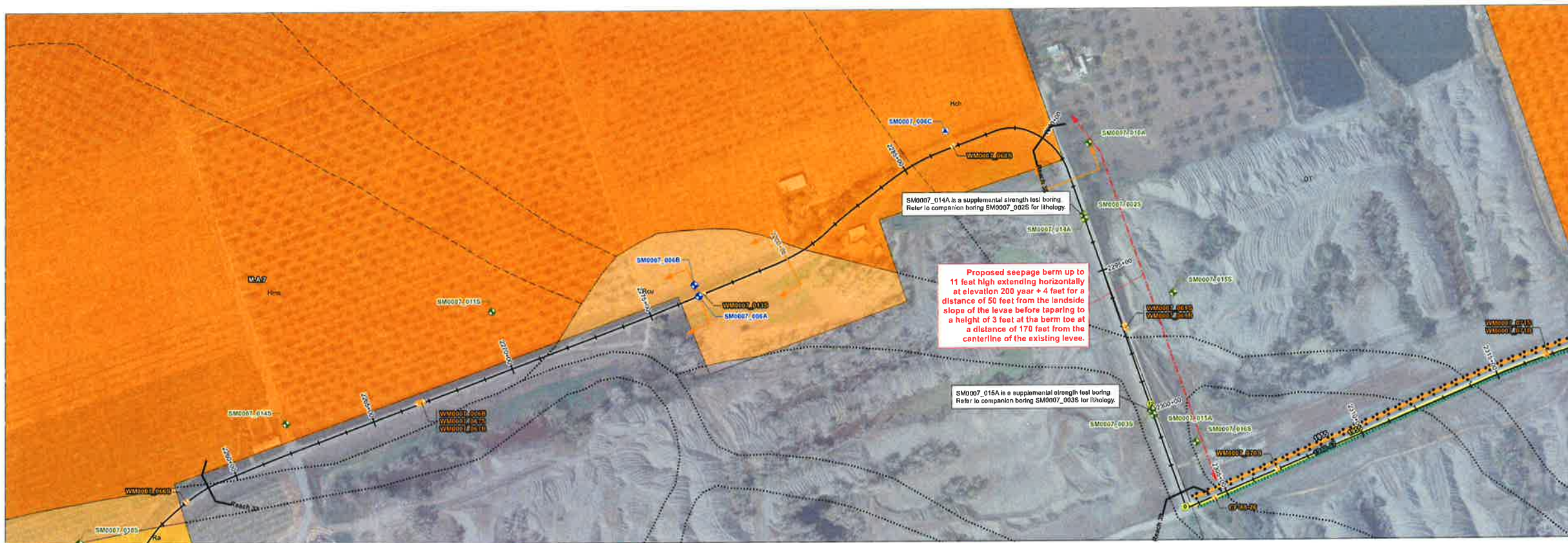


- NOTES:
1. Elevations of levee crown and inside/levee are approximate. These elevations were obtained from DWR CVFVED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and inside/levee information, please refer to the FRWLP, Project civil drawings.
2. The water surface elevations are based on information provided by Peterson Brstadt, Inc. in their July 26, 2017 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and blow count logs. Geotechnical Data Report for the FRWLP Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{HWS} \cdot \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWLP Project for hammer efficiency data for individual borings.
5. These drawings do not include all historical explorations on the profile view. Historical explorations are identified by the project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (N1 and USCS classifications are visual classifications).
6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
9. Surficial geology was mapped at 1:20,000 scale. (Source: SDDR for DWR ULE Project, USR 2010).
10. The information provided in these plans and stick-log plates has been compiled from a variety of sources. USR does not attest to the accuracy, completeness or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plans.
11. These plans and stick-log plates are for the use and benefit of HDR, SEBFA, and their consultants in connection with the execution of the FRWLP Project. Use by any other party is at their own discretion and risk. These figures should not to be used as the sole basis for design, construction, remedial action, or major capital spending decisions.
12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.

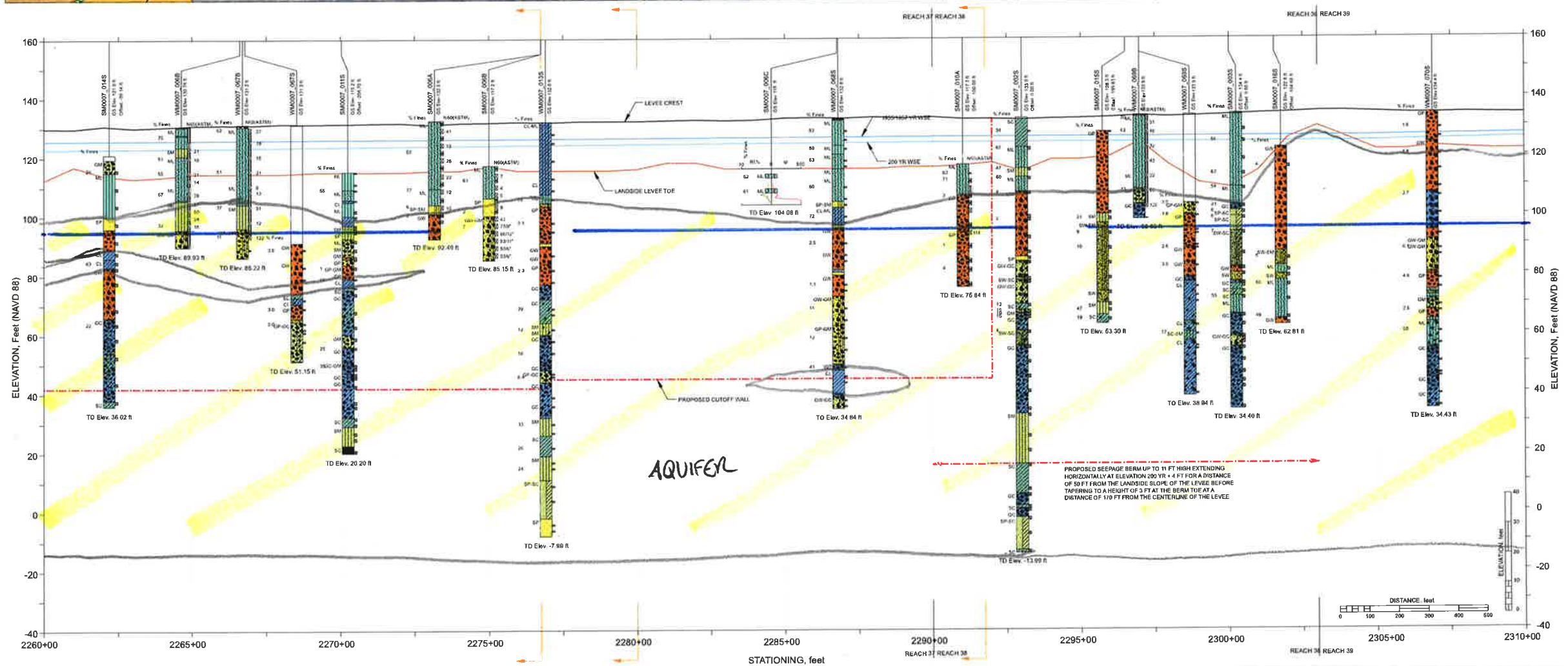
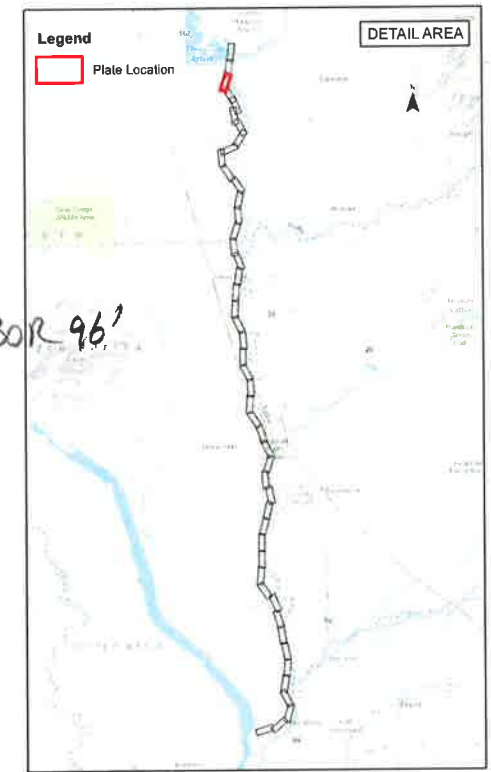


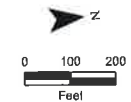
FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 2210+00 to Station 2260+00

Geotechnical Design
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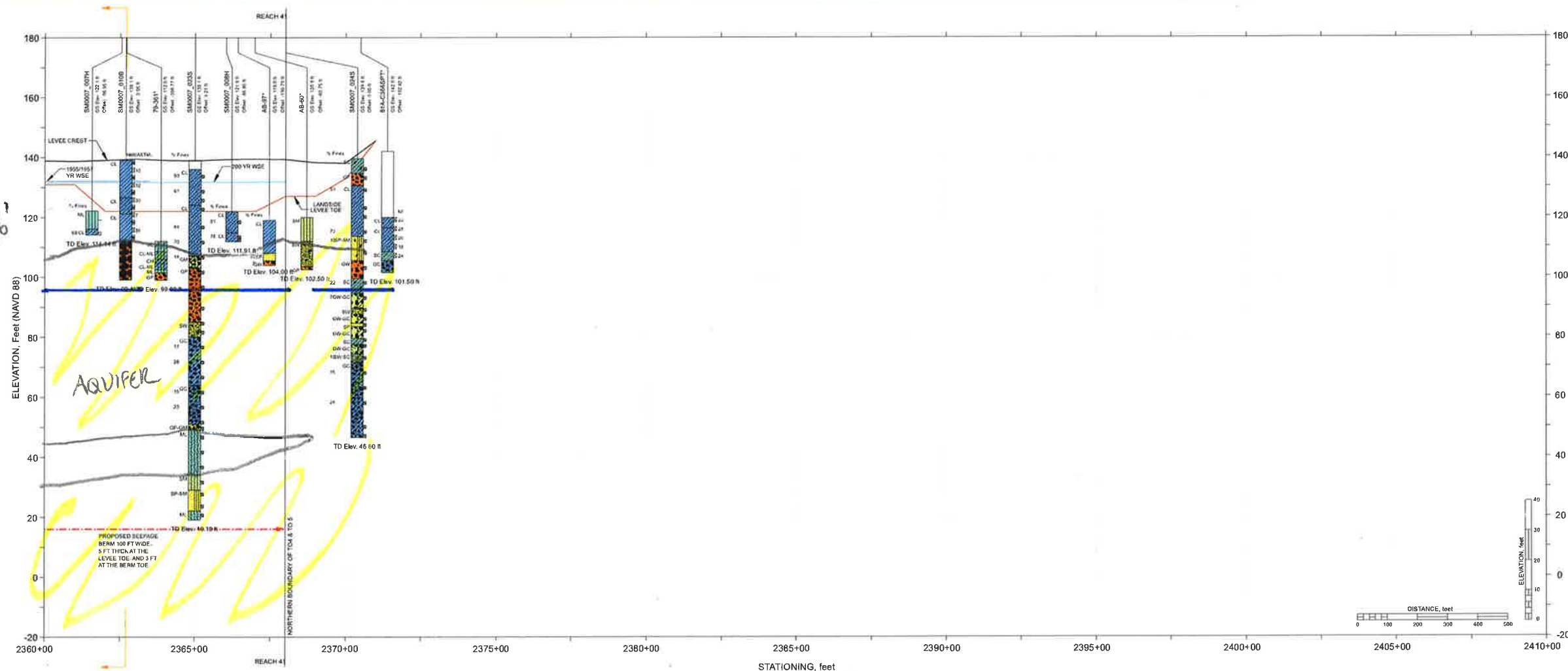
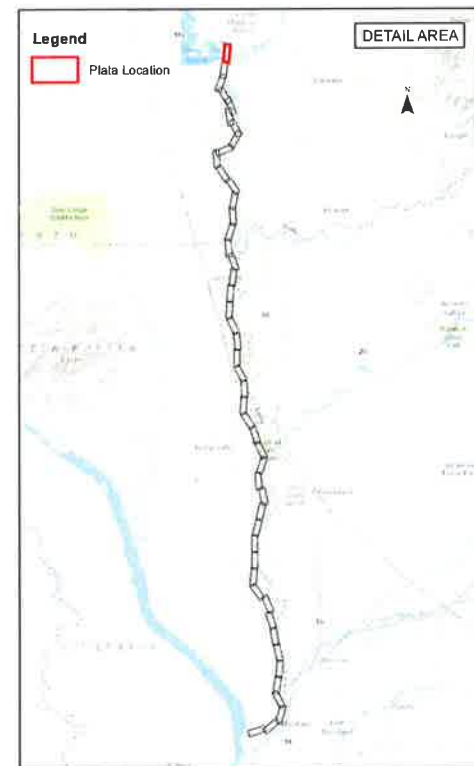


- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 - The water surface elevations are based on information provided by Peterson Brustad, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
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 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on e "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:20,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
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 - The canal/ditch elevations are approximate. These elevations were estimated from the topography.





- NOTES:
1. Elevations of levee crown and landside toe are approximate. These elevations were obtained from DWR CVFED or ULE LIDAR data and used for geotechnical analyses and report purpose only. For detail crown elevation and landside toe information, please refer to the FRWL Project civil drawings.
 2. The water surface elevations are based on information provided by Peterson Brasted, Inc. in their July 26, 2012 report entitled "Design Water Surface Profiles for the Feather River West Levee Rehabilitation Project Addendum #1".
 3. Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the FRWL Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 4. When reported, $N_{60}(ASTM)$, refers to $N_{60}(ASTM) = N_{60} \times \text{Hammer Efficiency (\%)}$. See Geotechnical Data Report for the FRWL Project for hammer efficiency data for individual borings.
 5. These drawings do not include all historical explorations on the profile view. Historical explorations from the DWR ULE project are shown; "other" historical explorations are identified by an asterisk (*) in the exploration ID. For these "other" historical borings, blow counts are field blow counts (NF) and USCS classifications are visual classifications.
 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
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 12. The canal/ditch elevations are approximate. These elevations were estimated from the topography.



FRWL Project Plan Views and Stick Log Figures
FRWL Project: Station 2360+00 to Station 2372+17



Geotechnical Design
Recommendations Report



Sutter Butte Flood Control Agency
FEATHER RIVER WEST LEVEE PROJECT

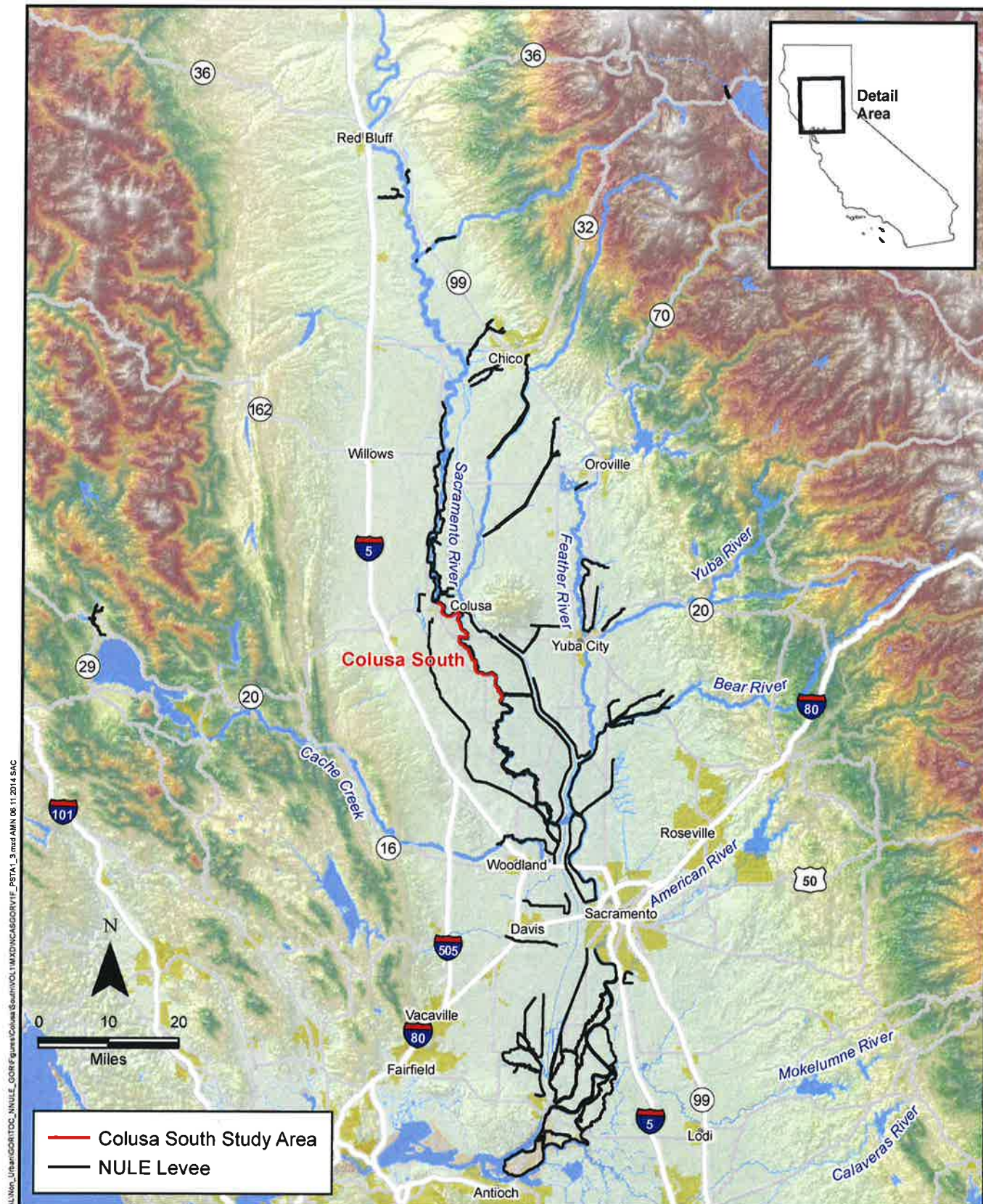
Appendix
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Appendix 5-C
Geologic Sections – Sacramento River Levees

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— Colusa South Study Area
— NULE Levee

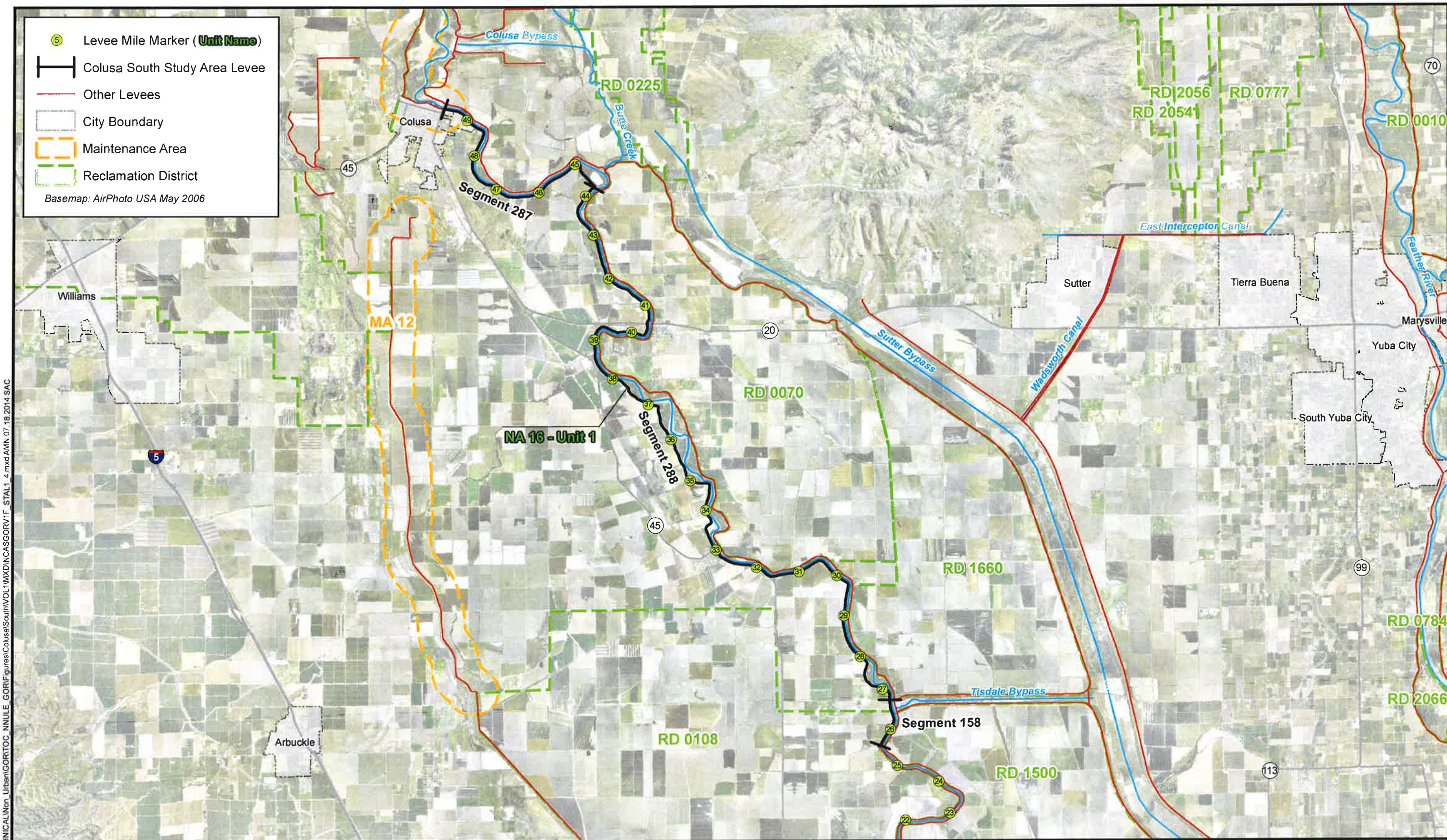


Department of Water Resources
Division of Flood Management

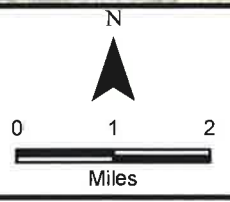


Colusa South Study Area
NON-URBAN LEVEE EVALUATIONS

Figure
1-3



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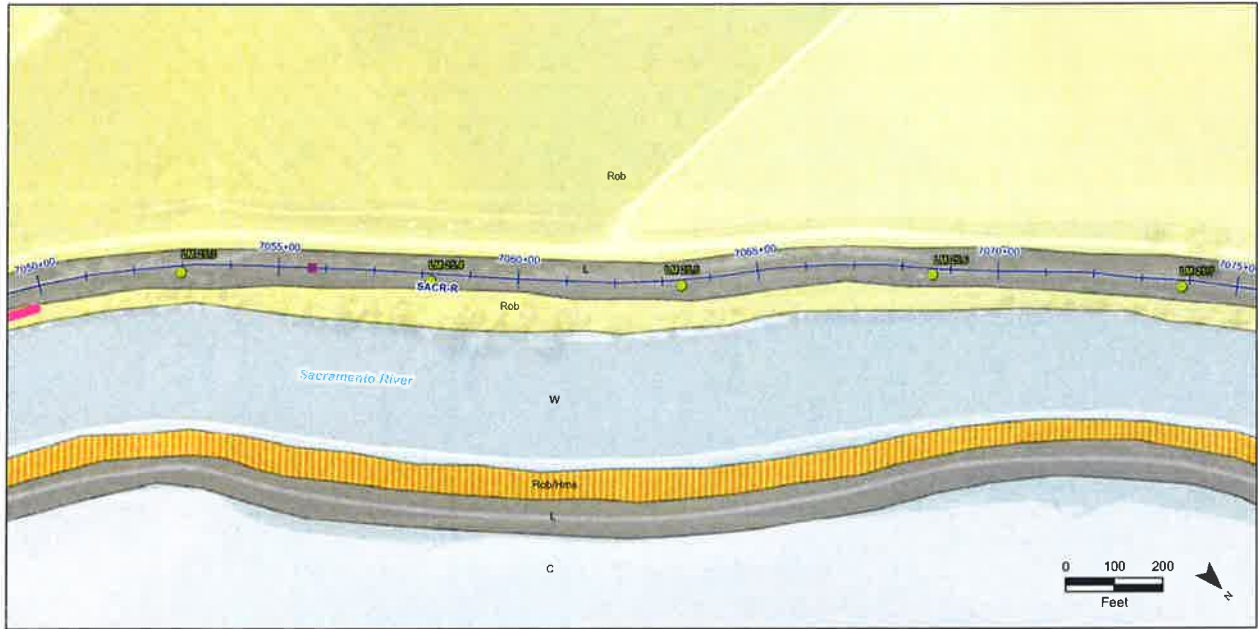
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Division of Flood Management



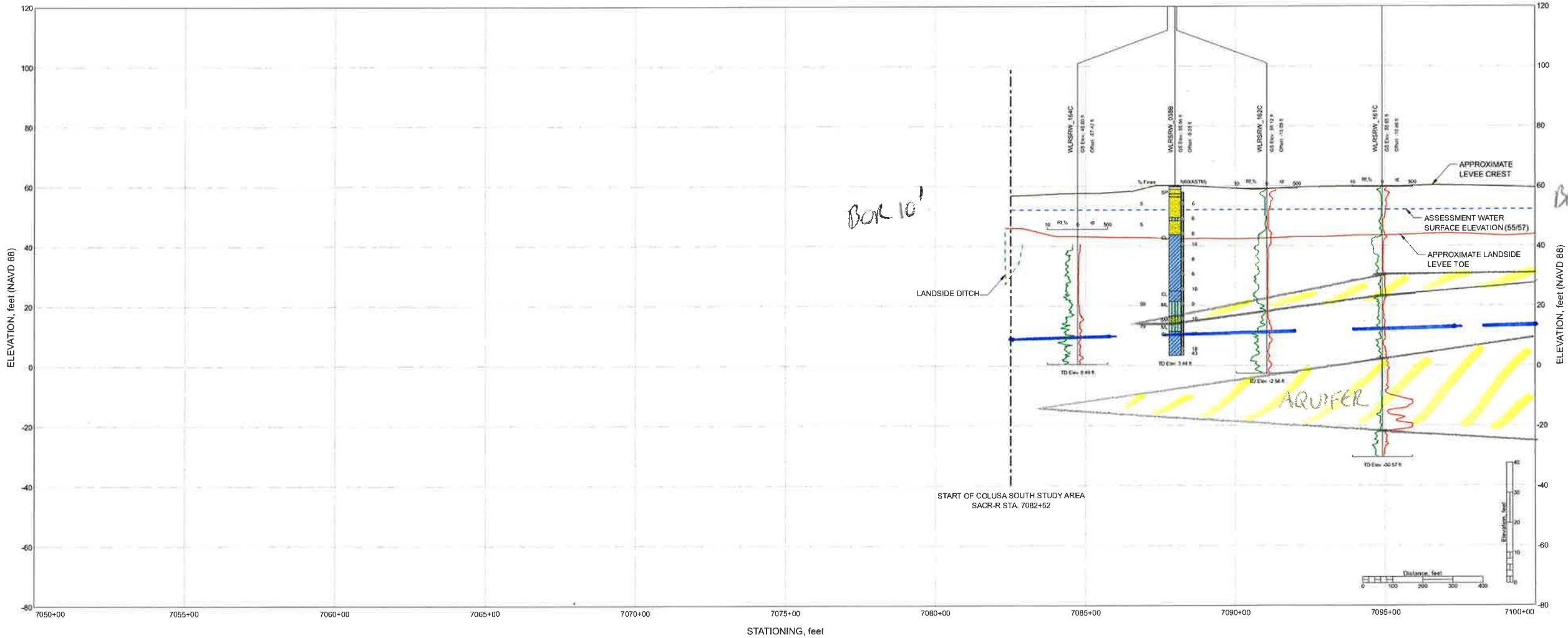
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Study Area Levees

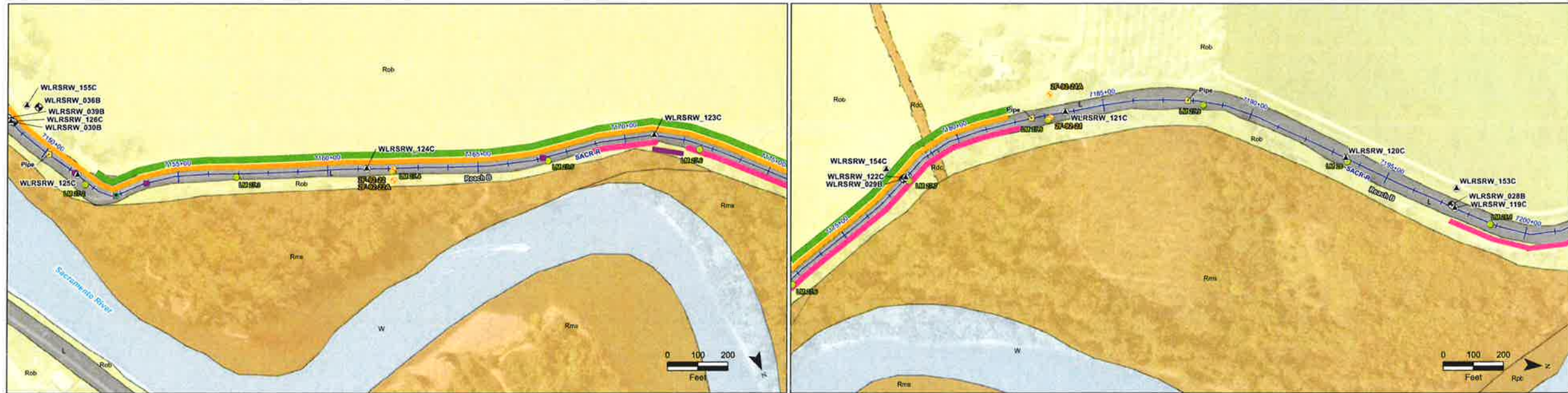
NON-URBAN LEVEE EVALUATIONS

Figure
1-4

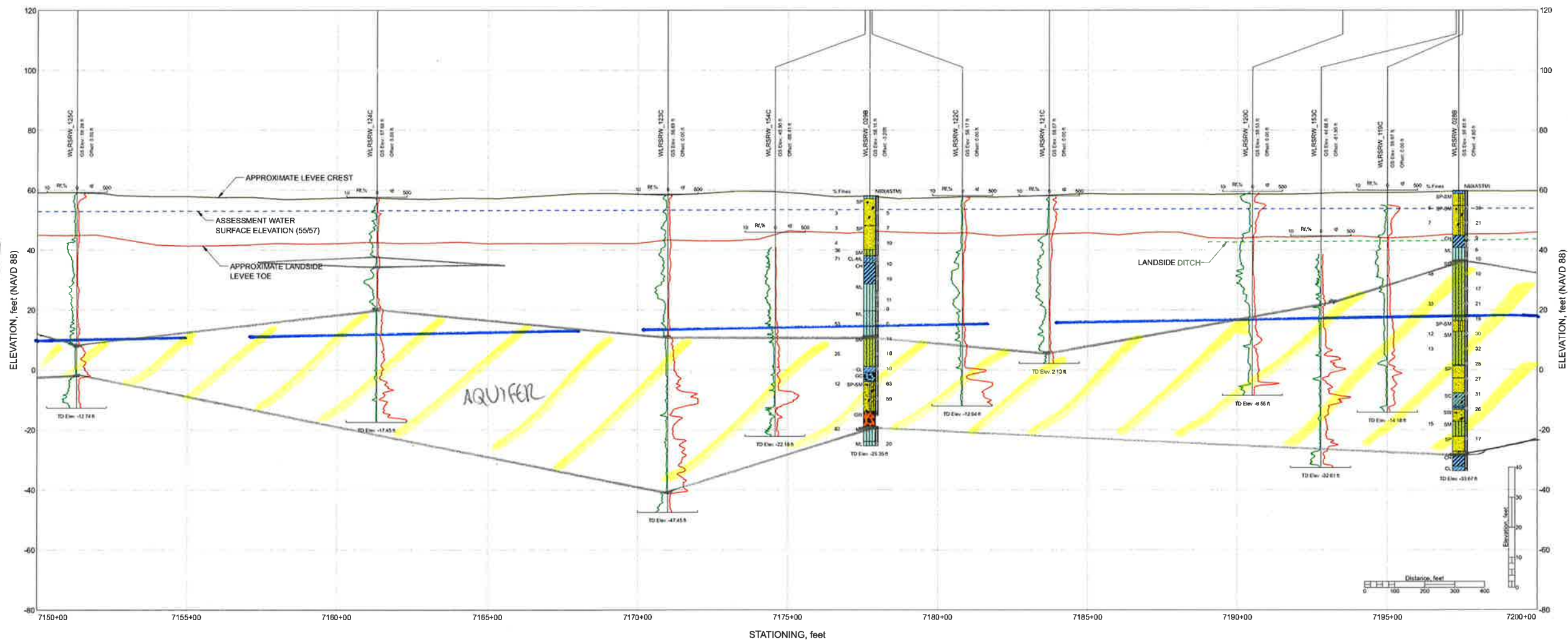


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 6. When reported, N_{60} (ASTM) = N field * (Hammer Efficiency/100). See Geotechnical Data Report for the NULE Colusa South study area for hammer efficiency data for individual borings.
 7. USCS classification labels are not presented on the stick logs for soil layers less than 1.5 feet thick or historical borings with limited data.
 8. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 9. To prevent scale distortion, this map should be printed on an ANSI "D" size sheet (22x34 inches).
 10. Where past performance and mitigation line features are geographically coincident, symbols have been offset for display purposes.
 11. Surficial geology was mapped at 1:24,000 scale. (Source: Level 2-II Geomorphic Assessment and Surficial Mapping of the Sacramento River below Colusa and Adjoining Areas for NULE Project, URS, 2010).
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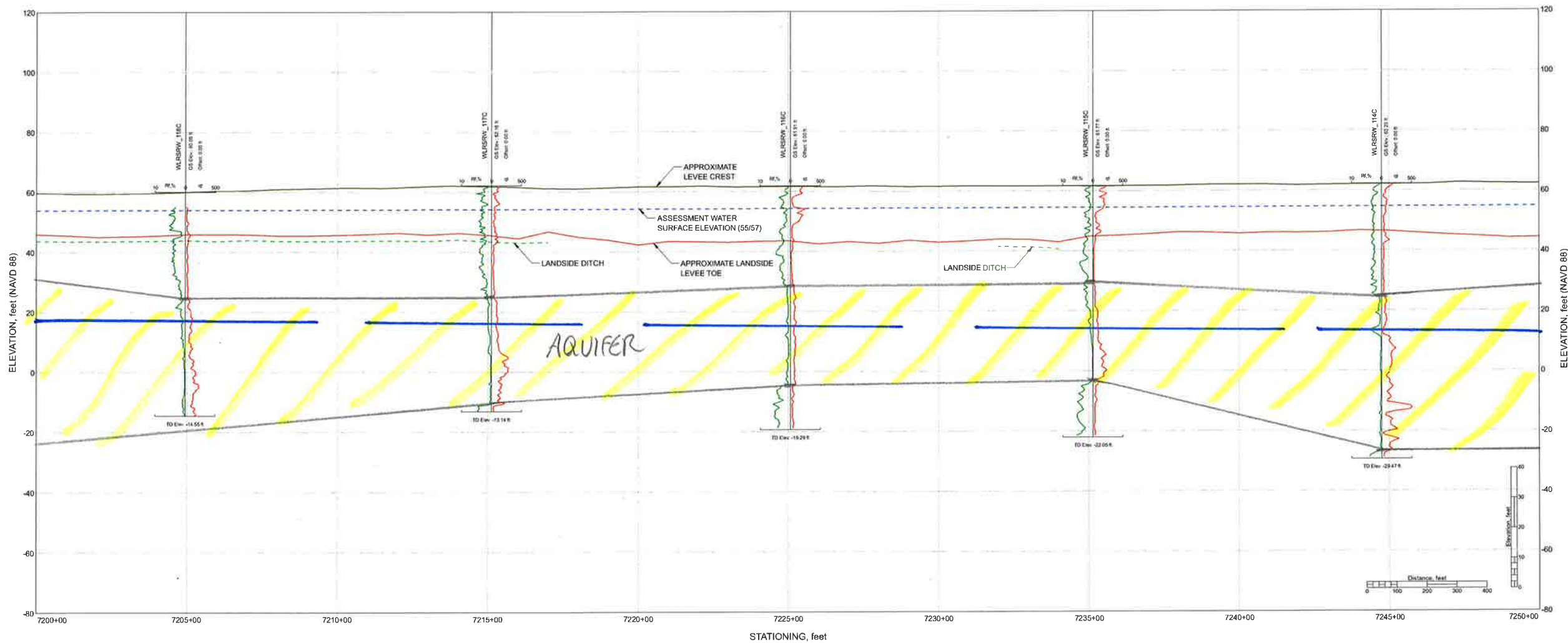


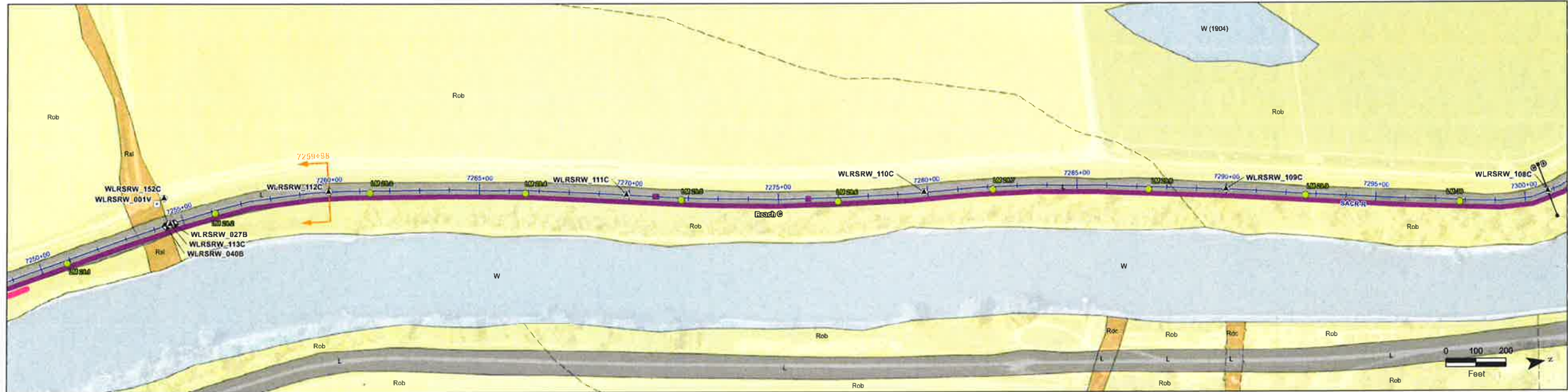
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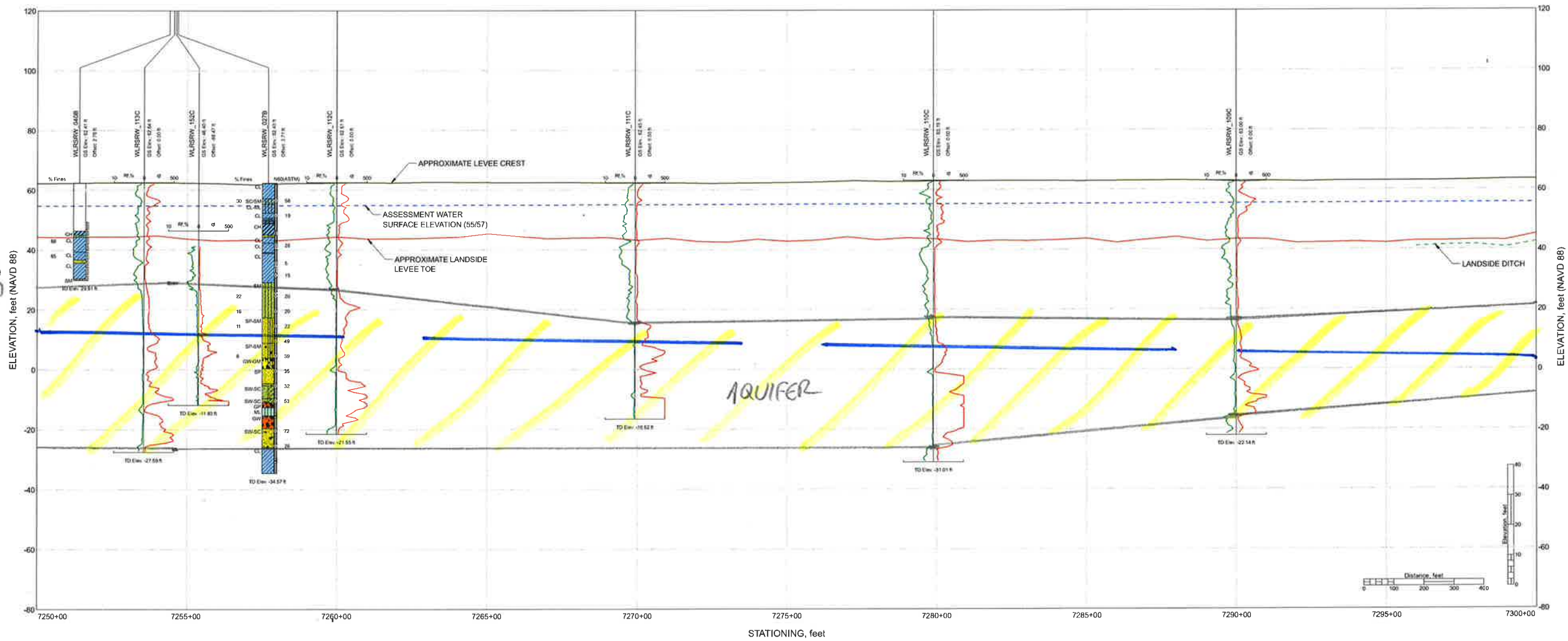


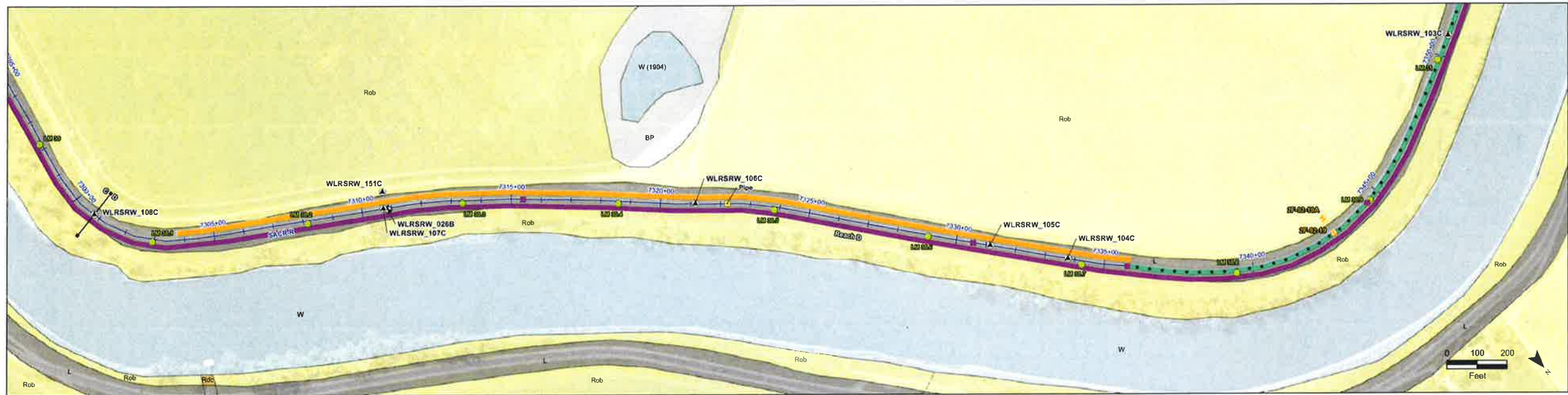
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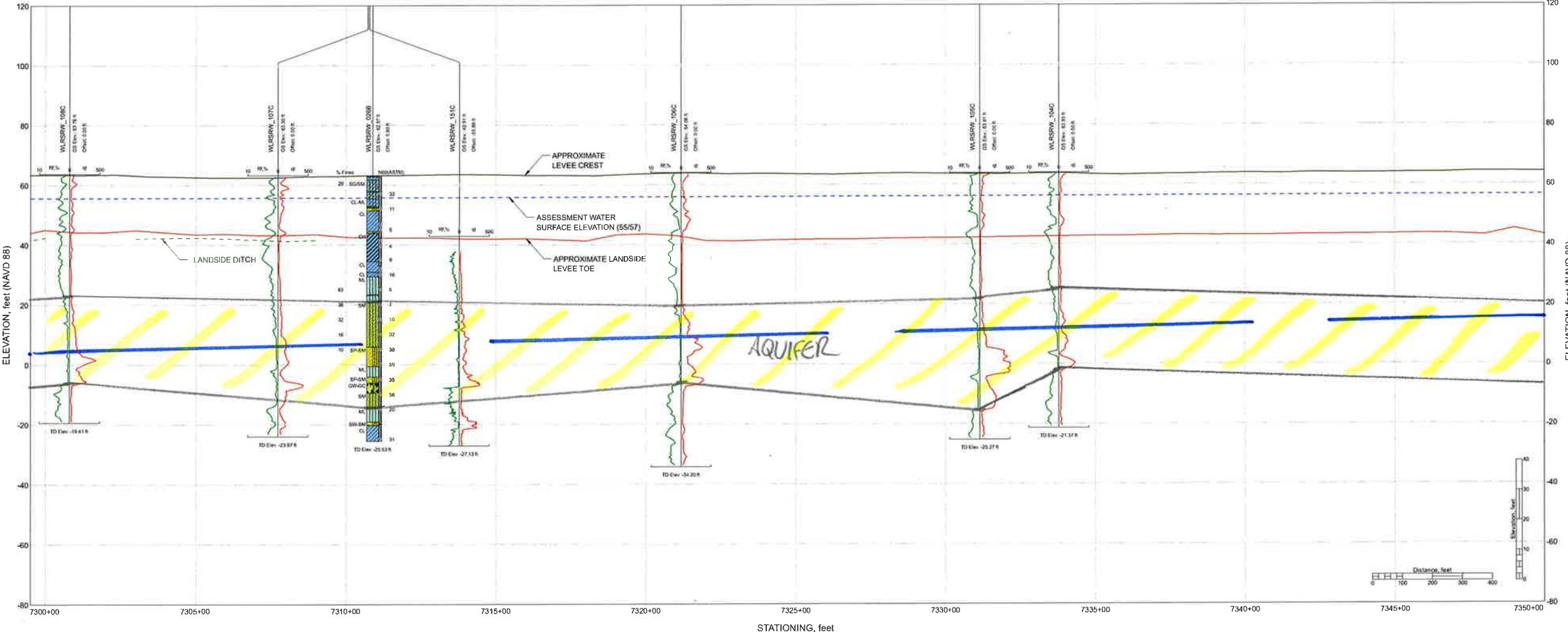


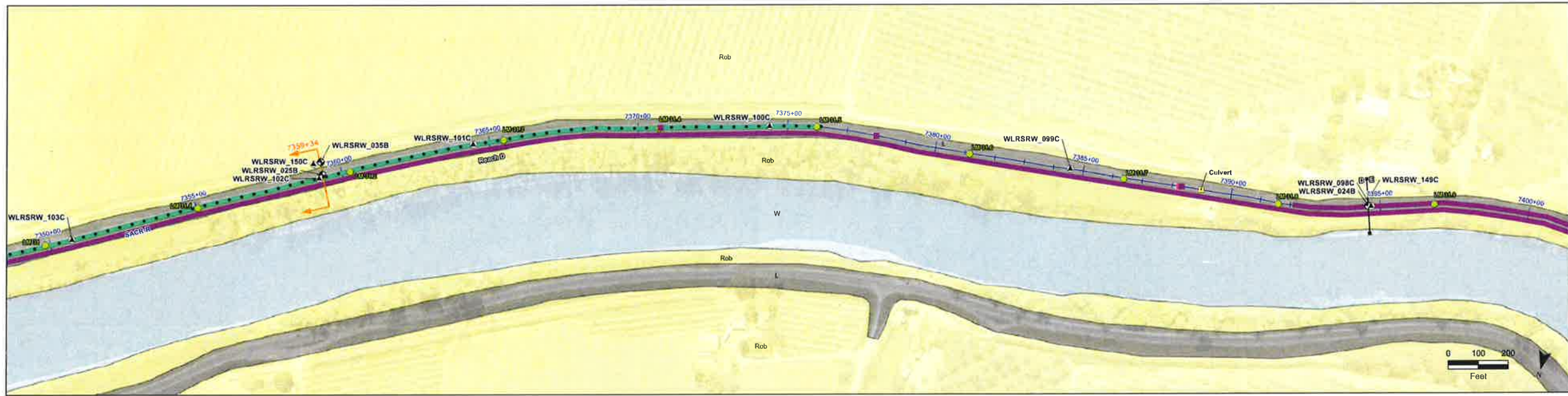
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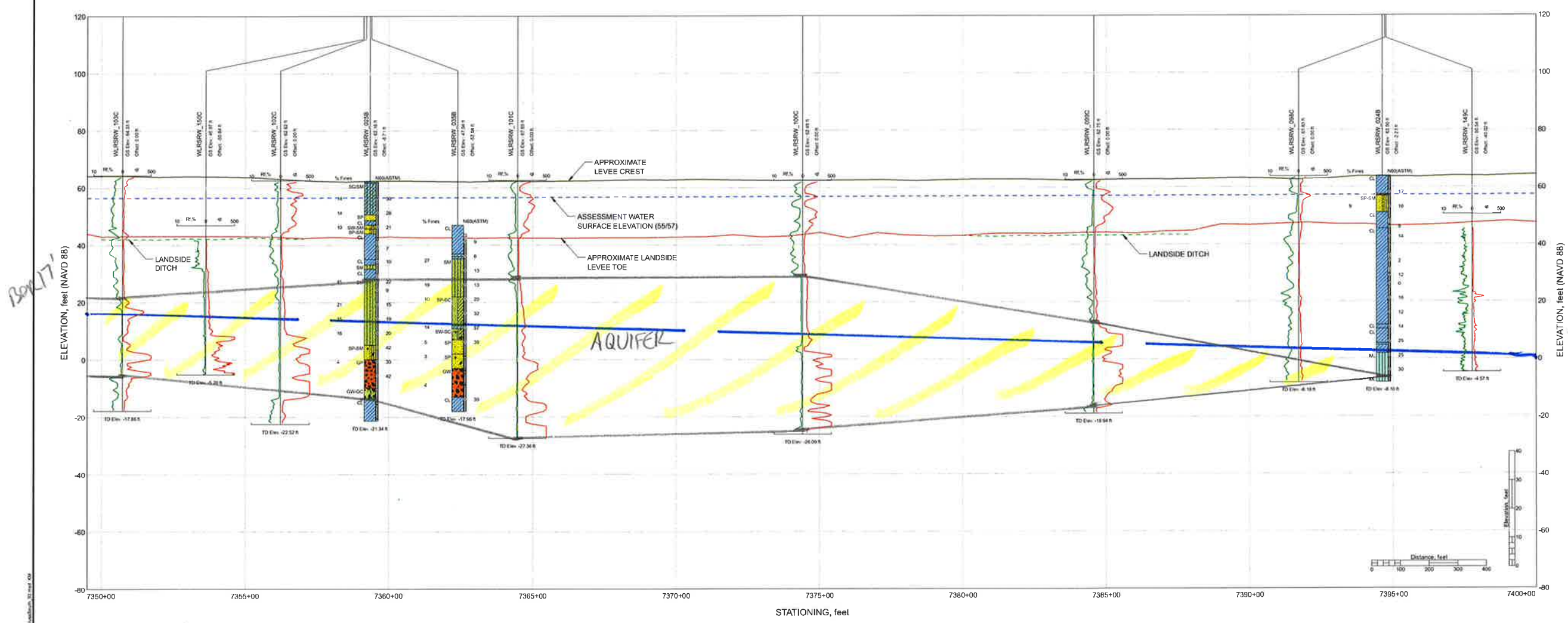


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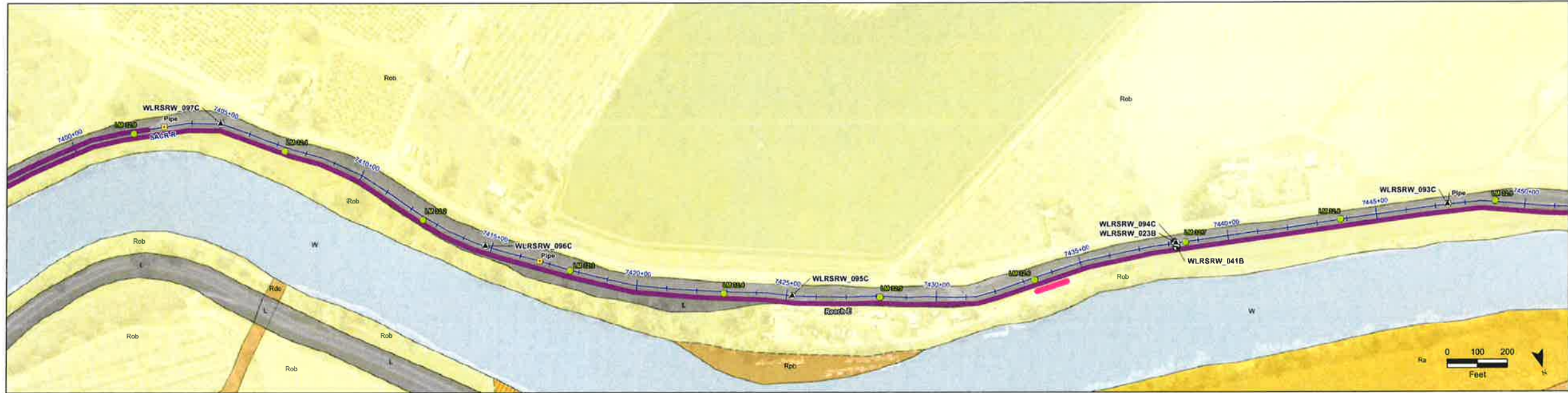




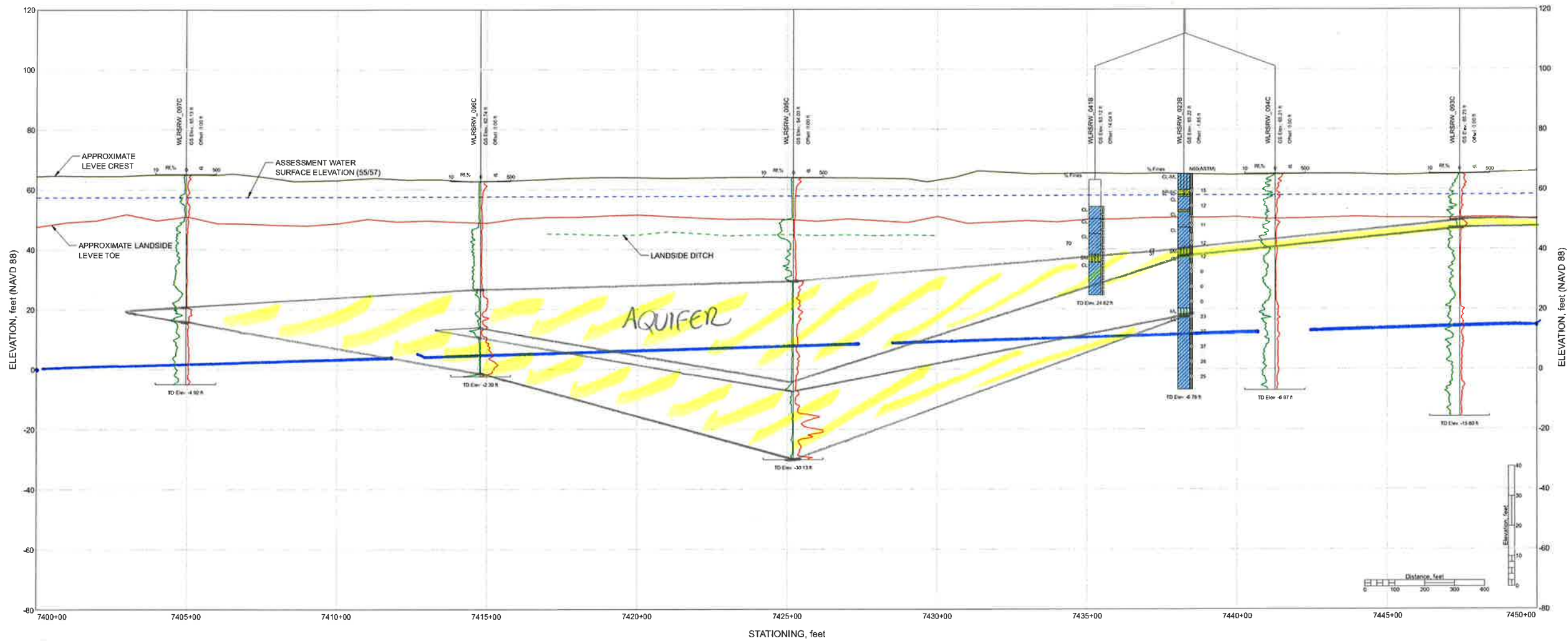
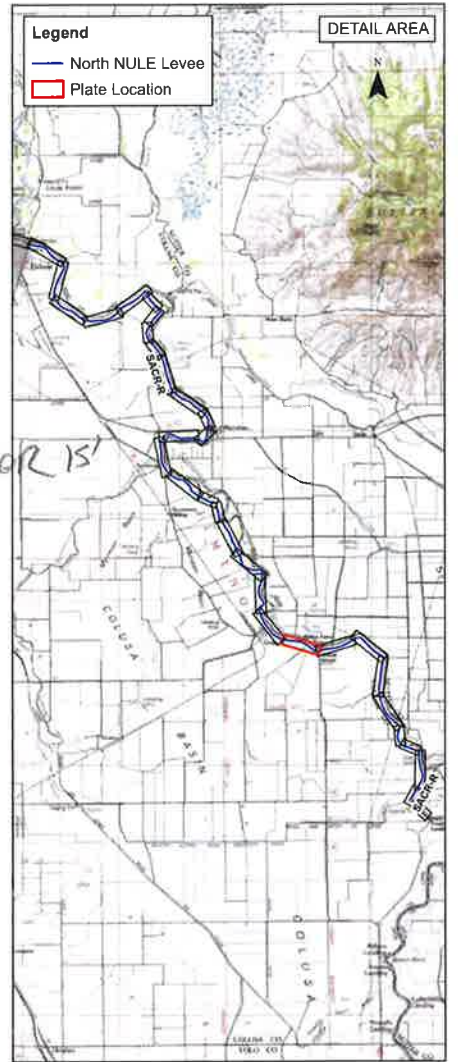
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 5. Locations of explorations are approximate. Slick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the NULE Colusa South study area. No warranty is provided regarding the continuity of soil conditions between individual explorations.
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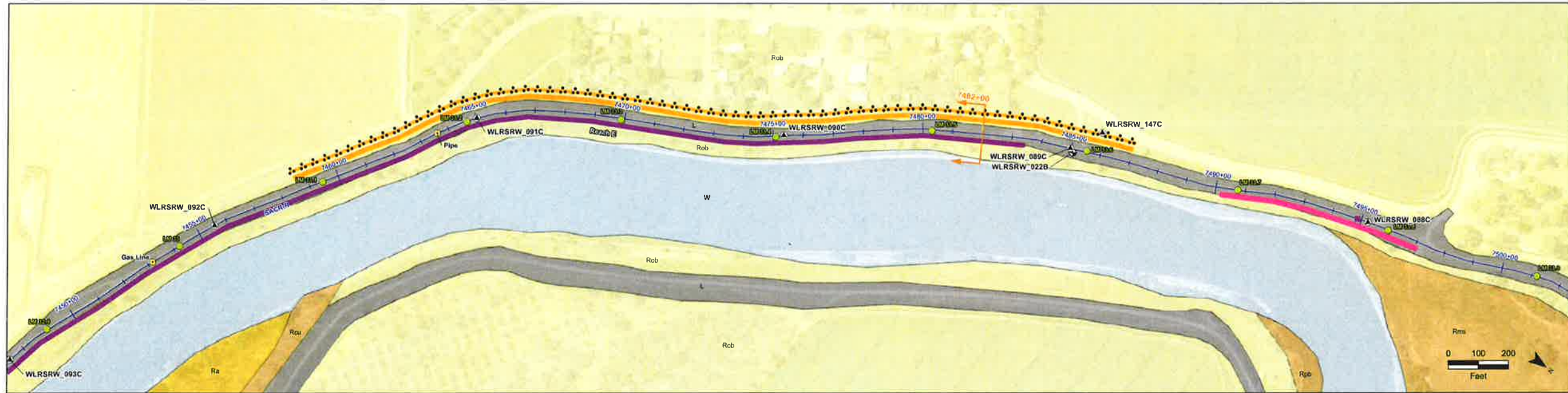


17 June 2013 2:00pm/colusa/NULE Colusa South Study Area

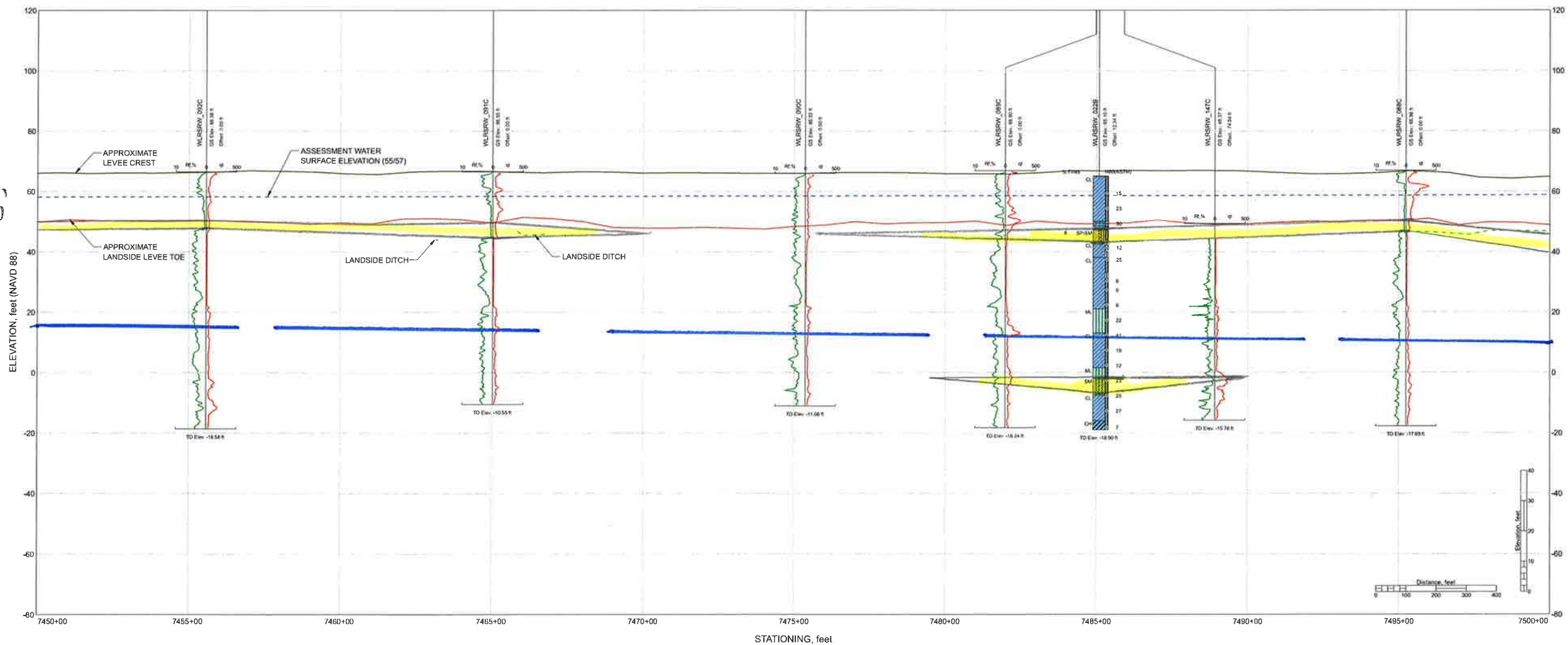
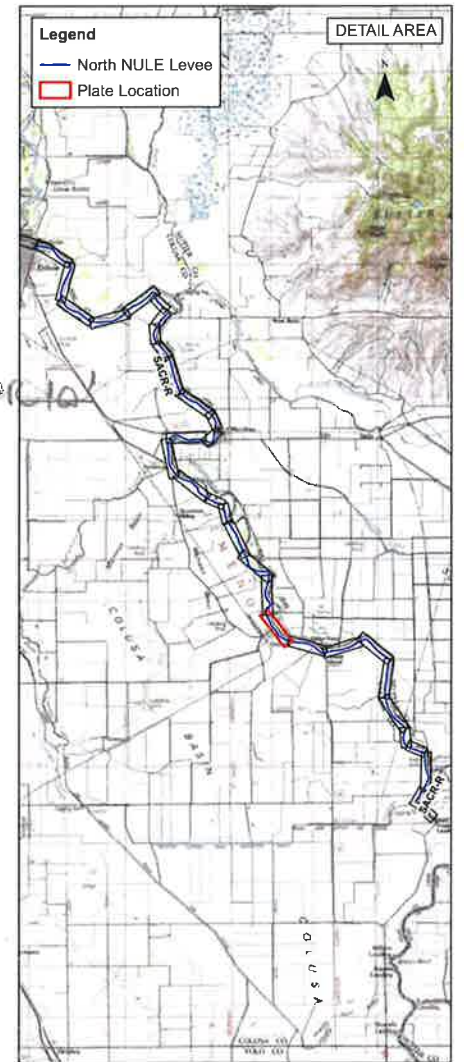


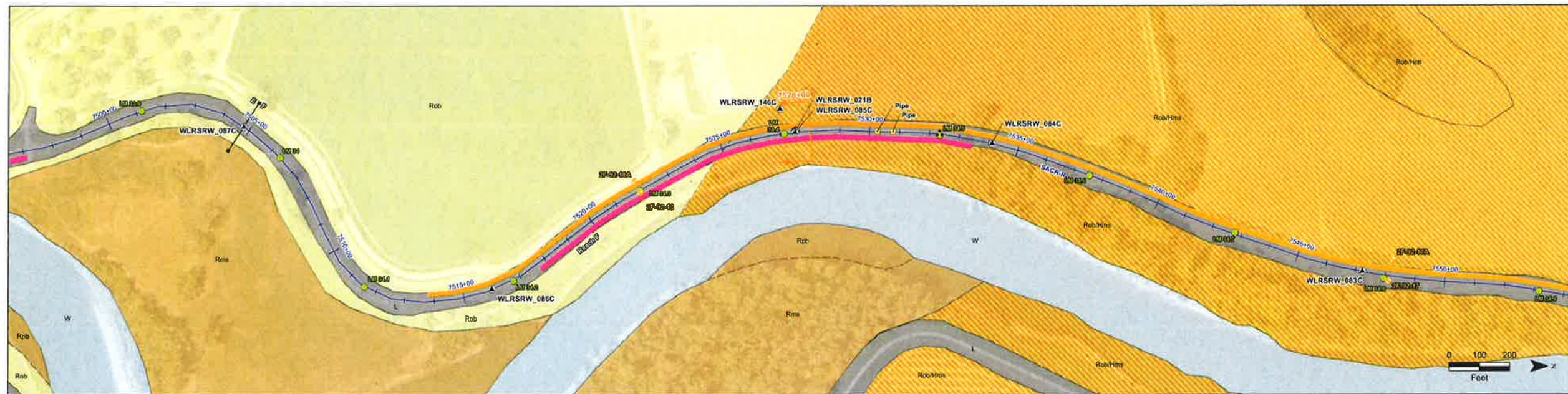
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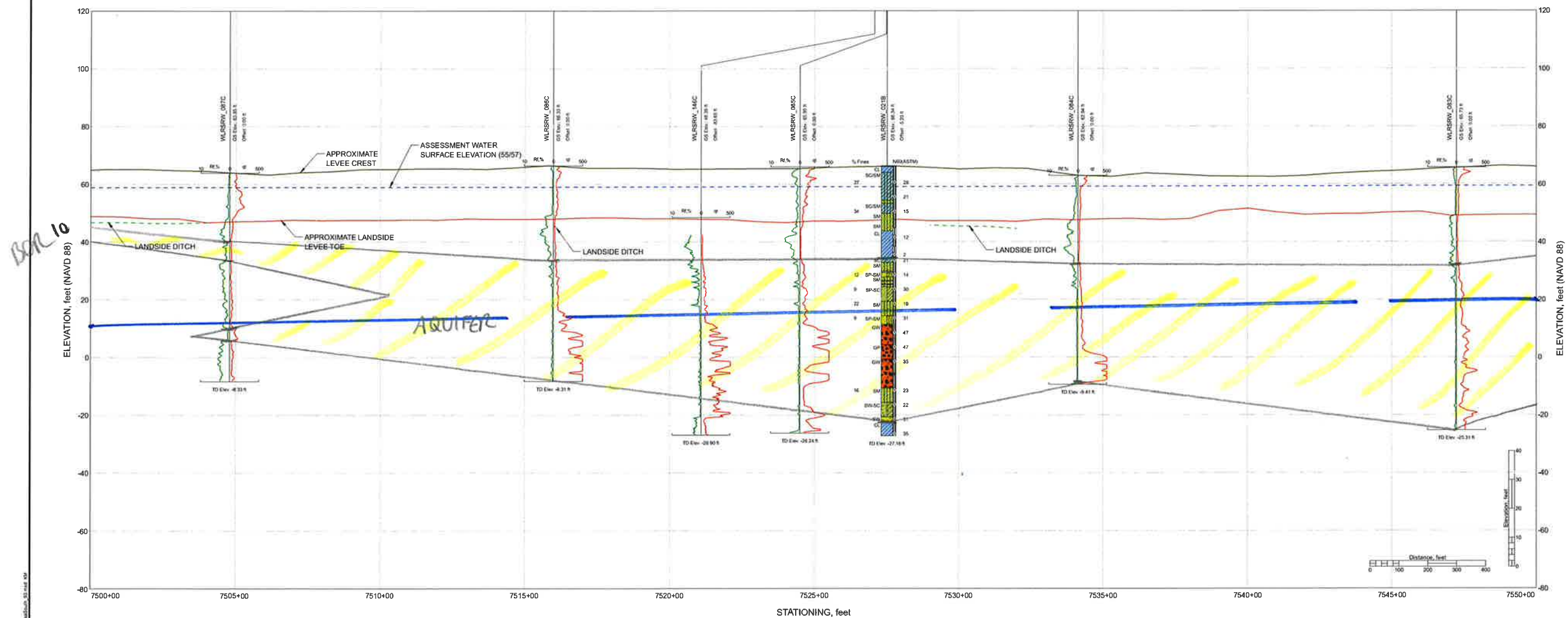


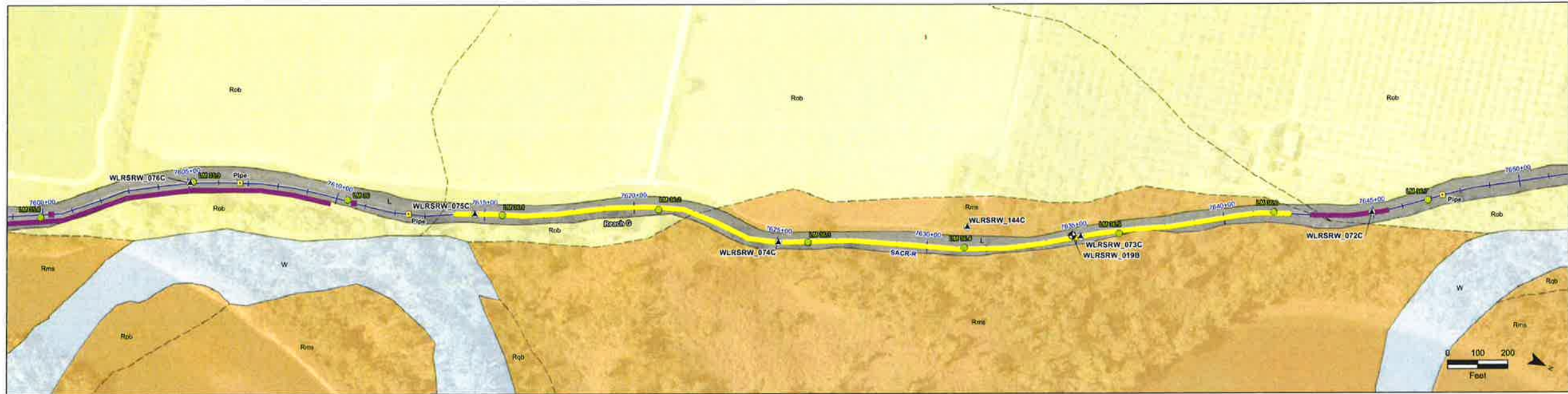
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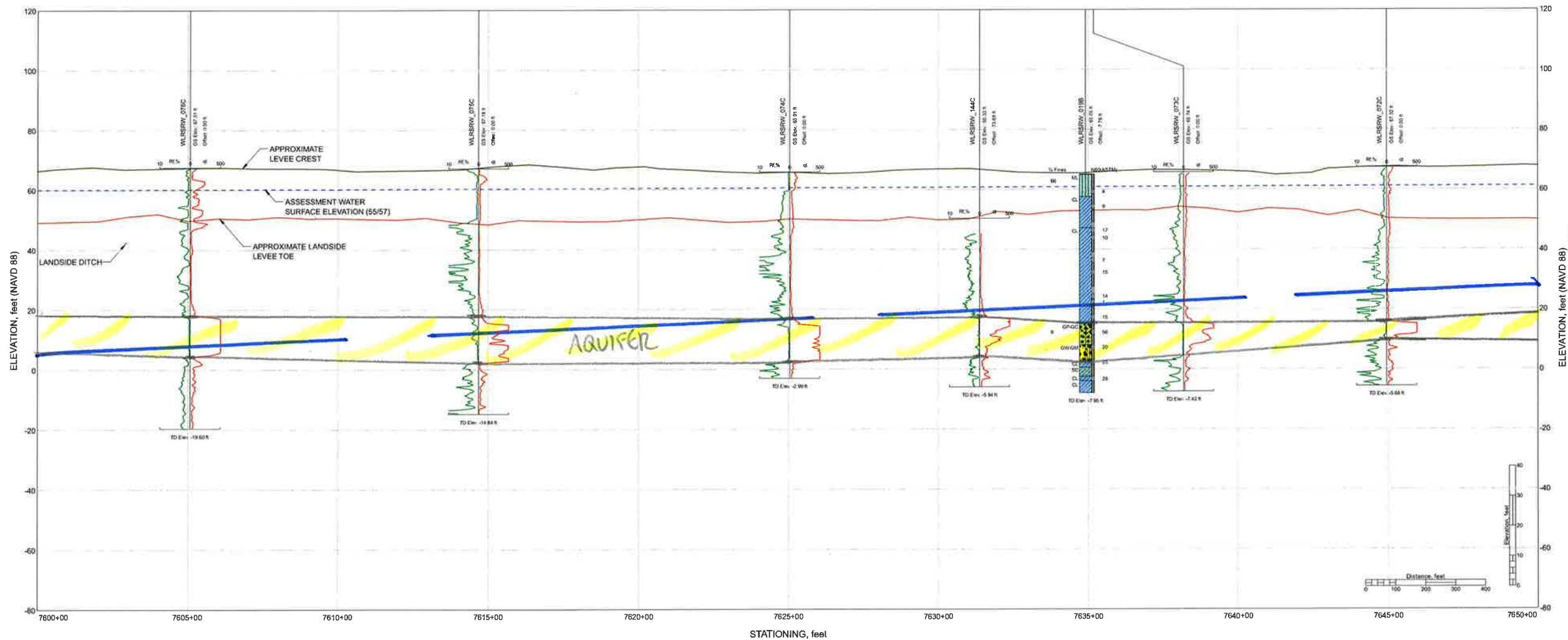
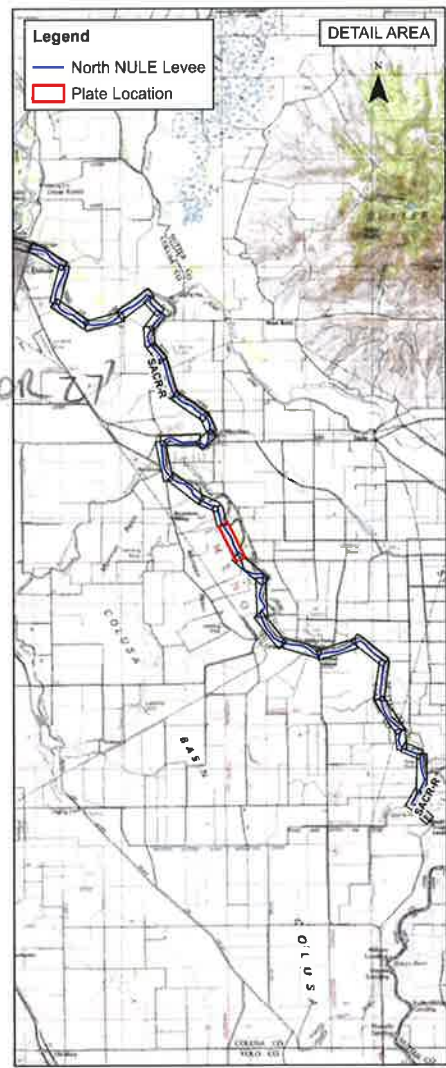


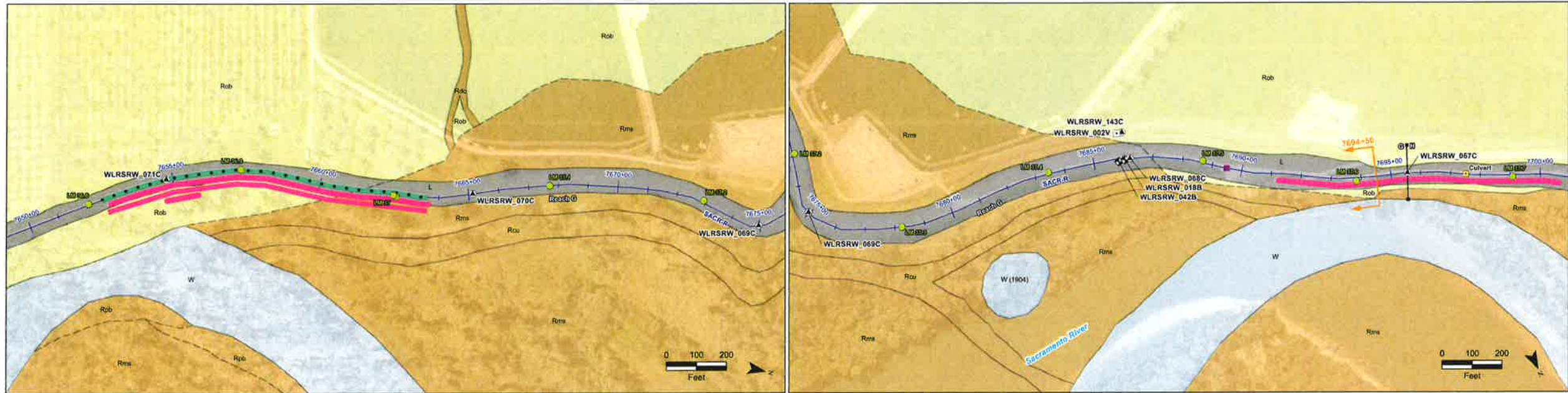
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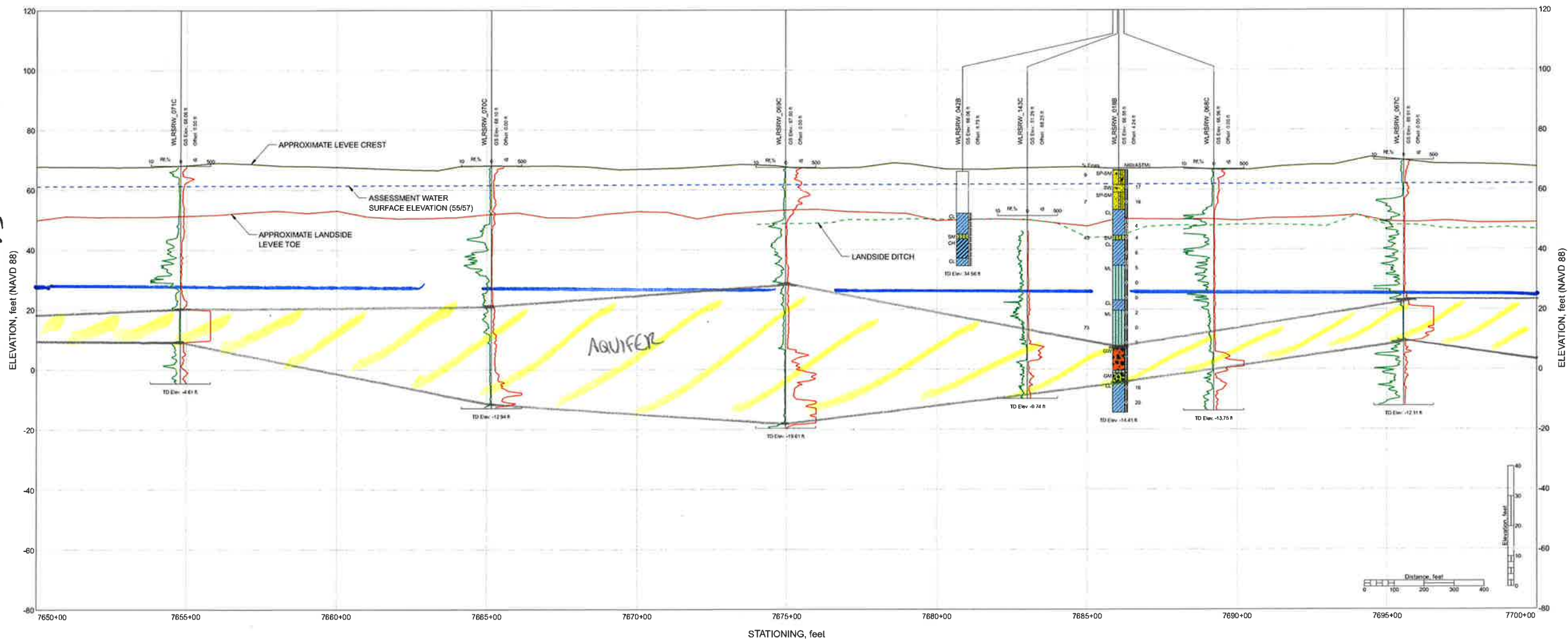


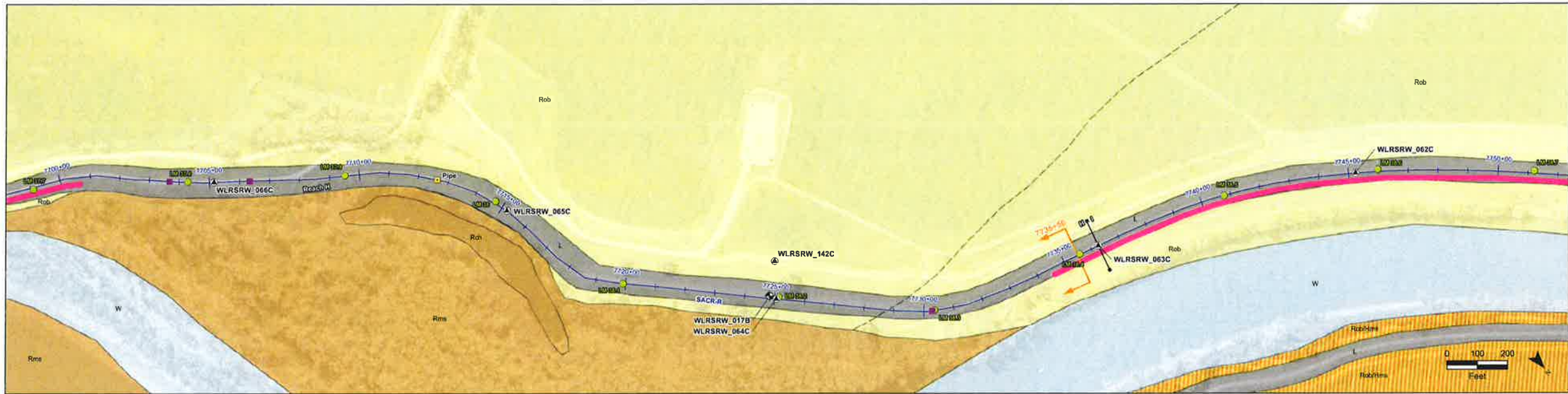
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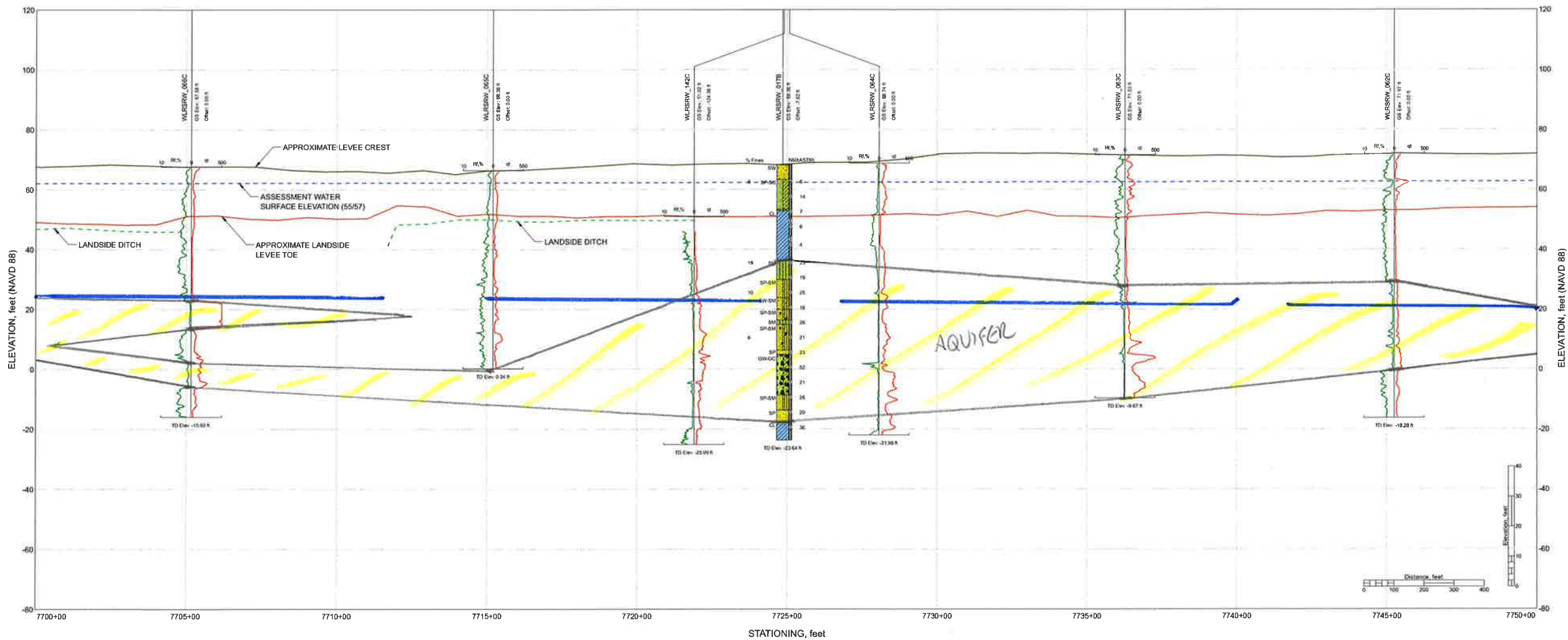


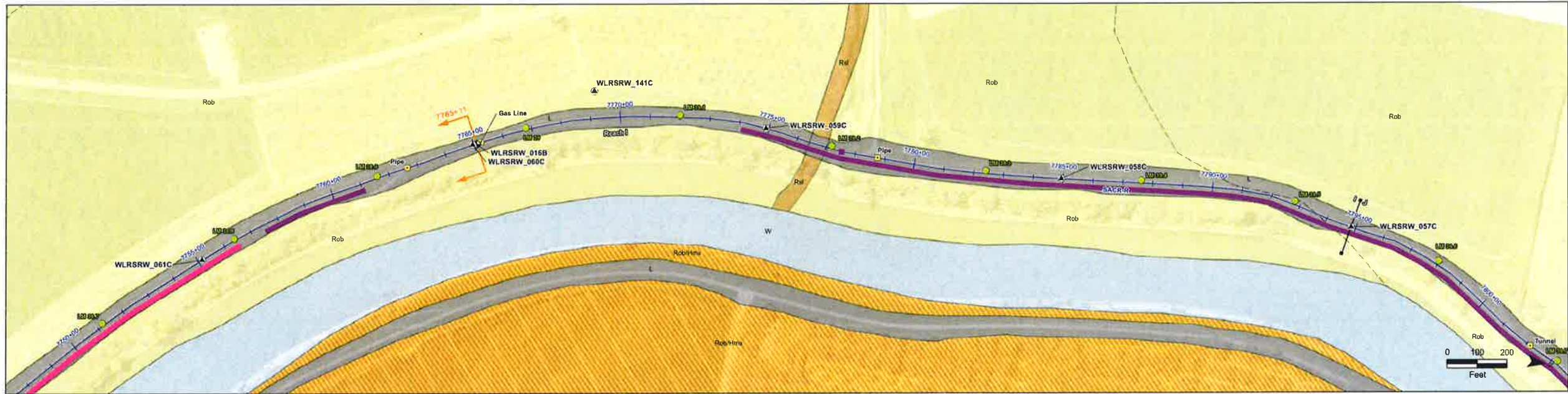
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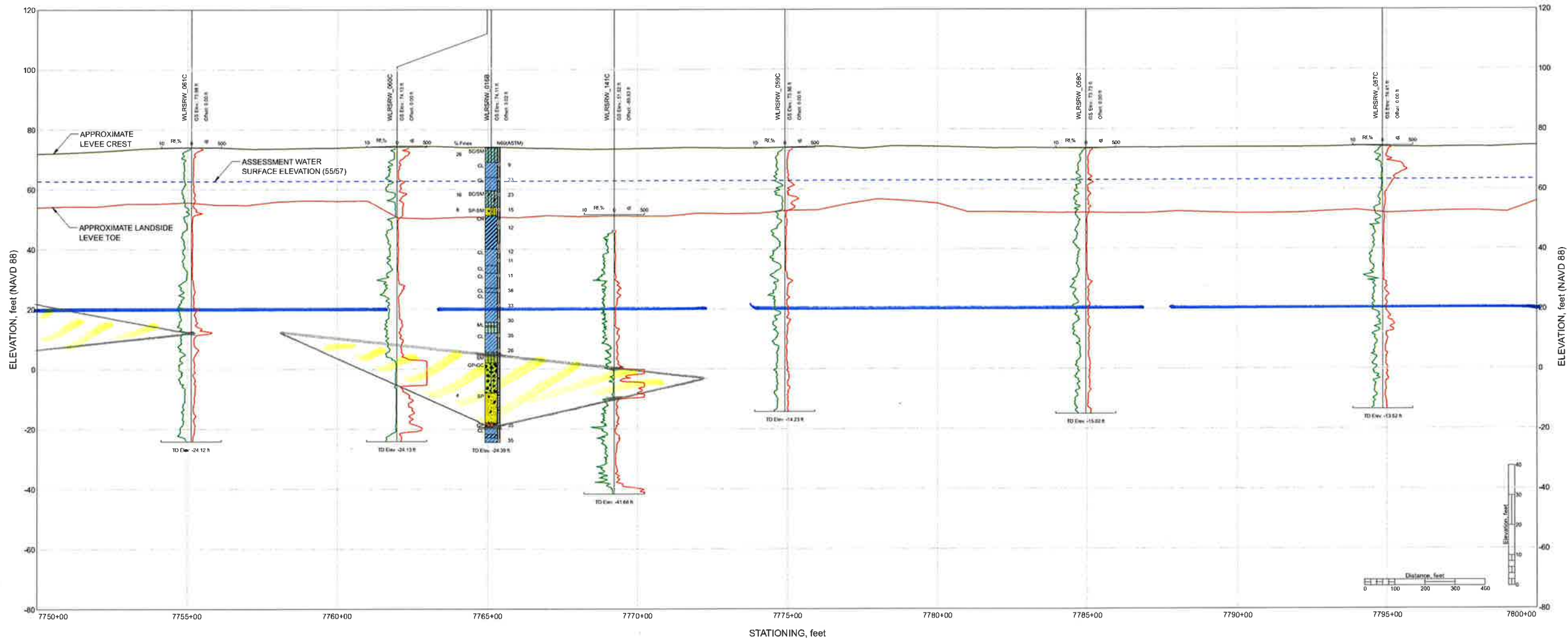


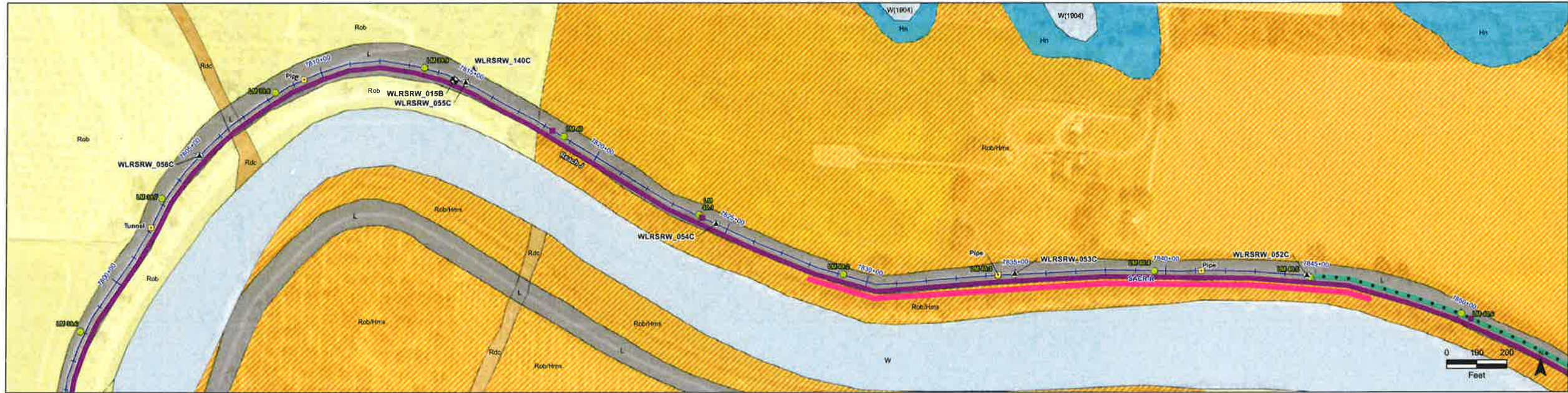
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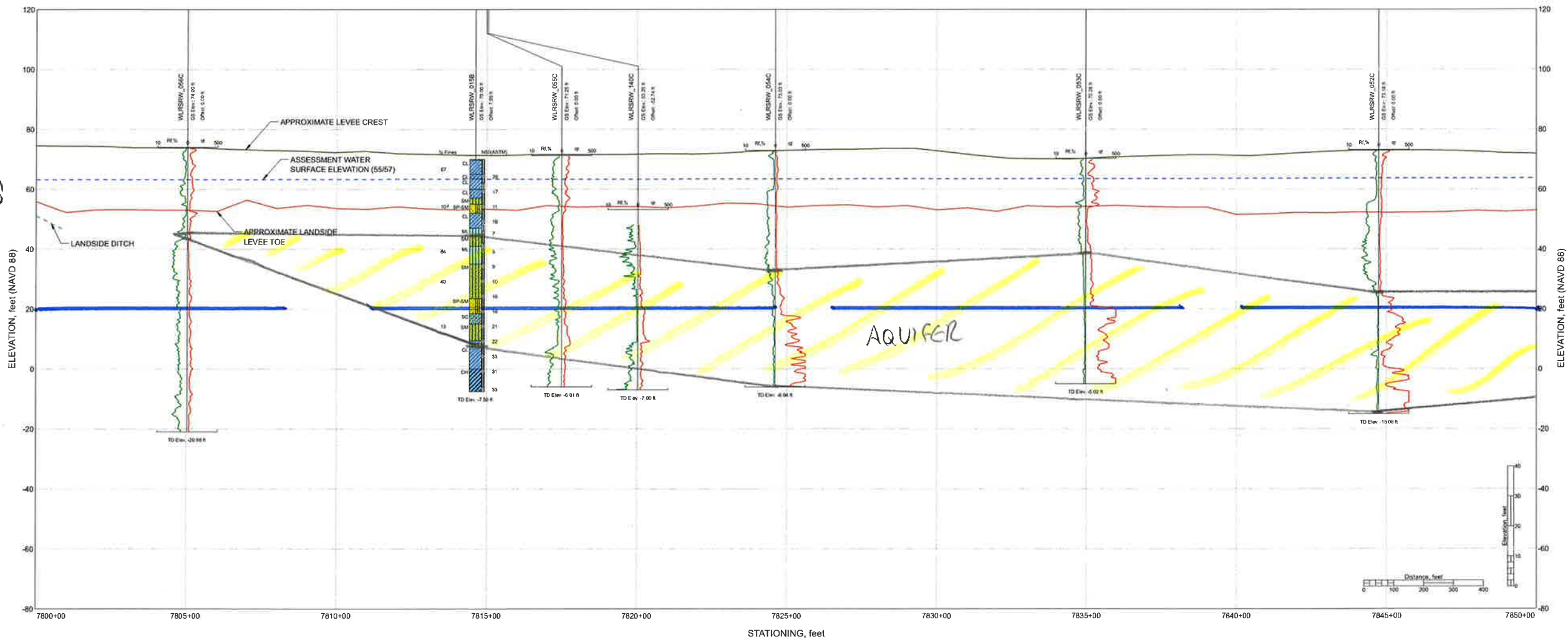


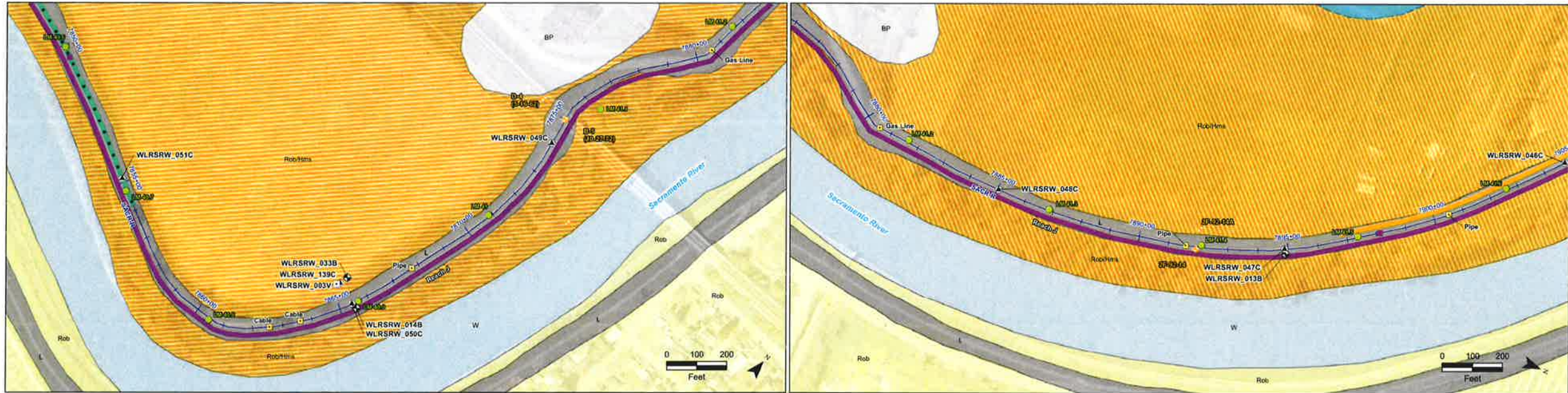
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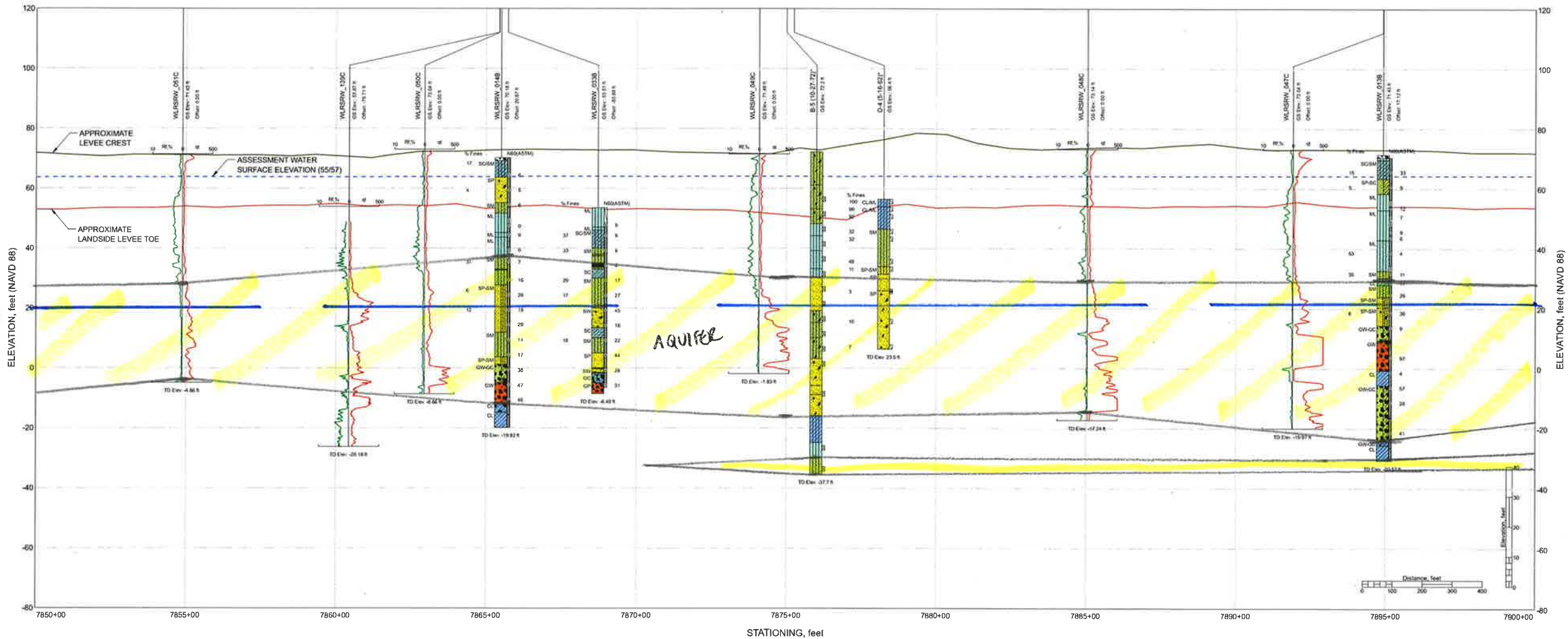


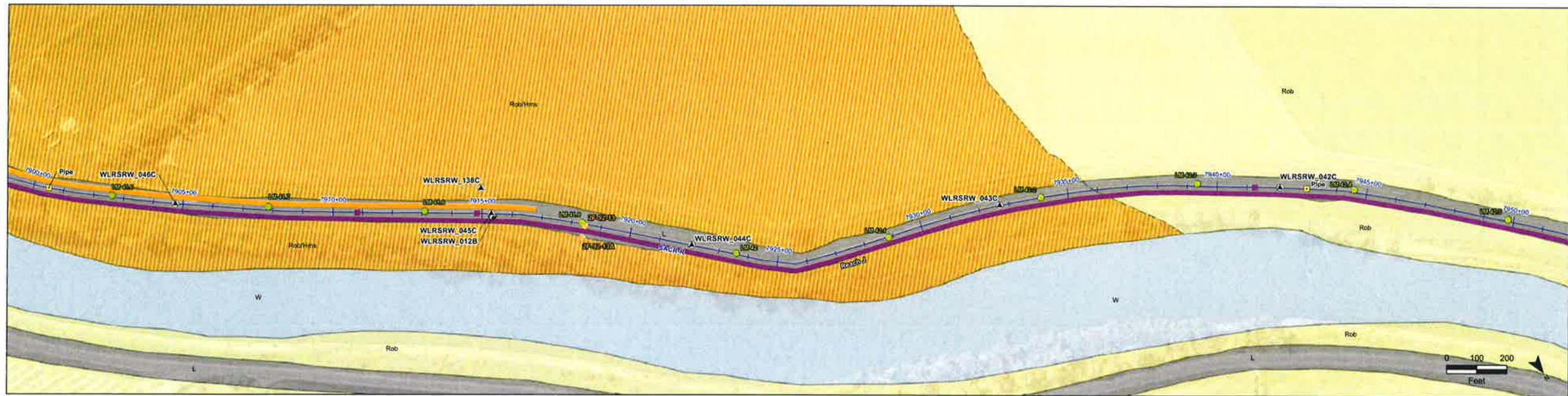
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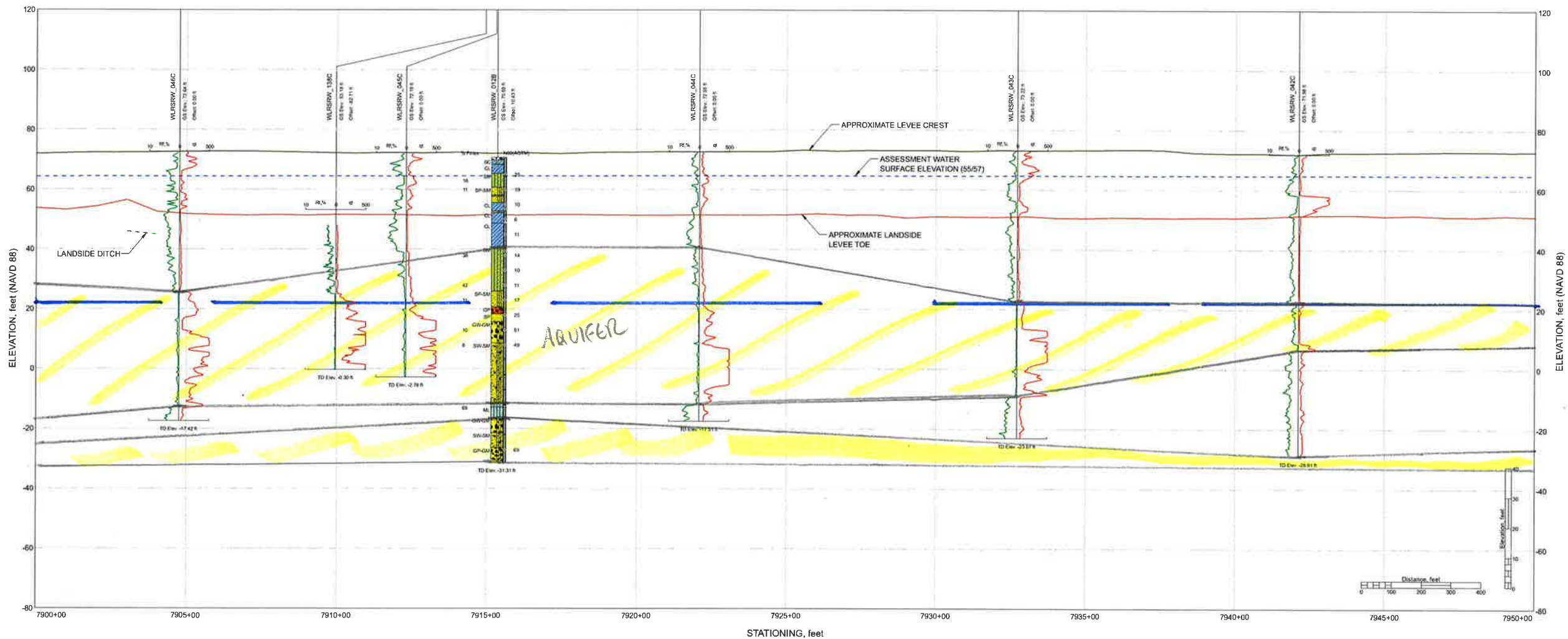


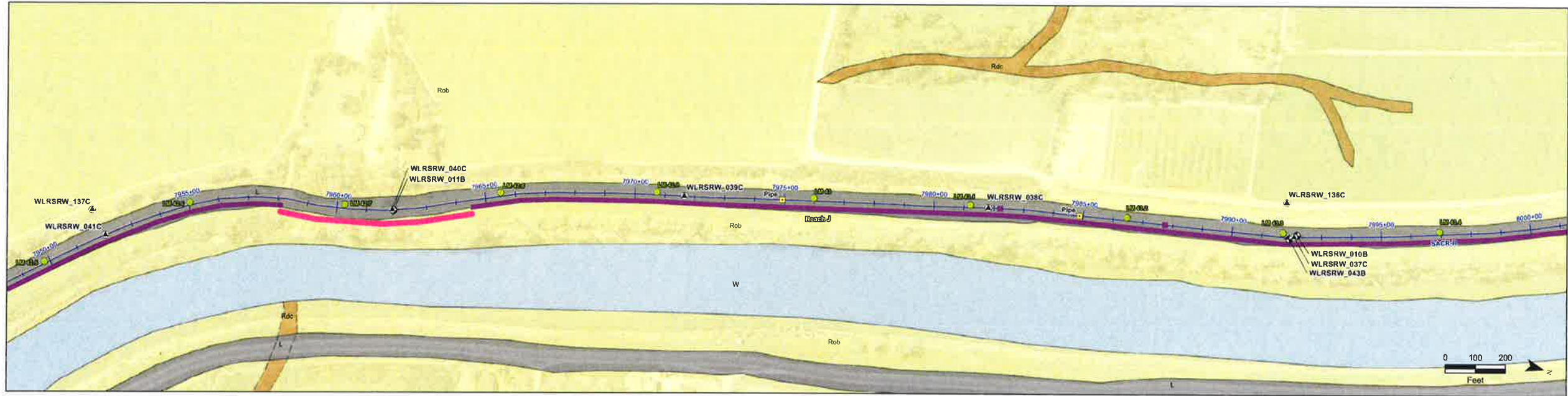
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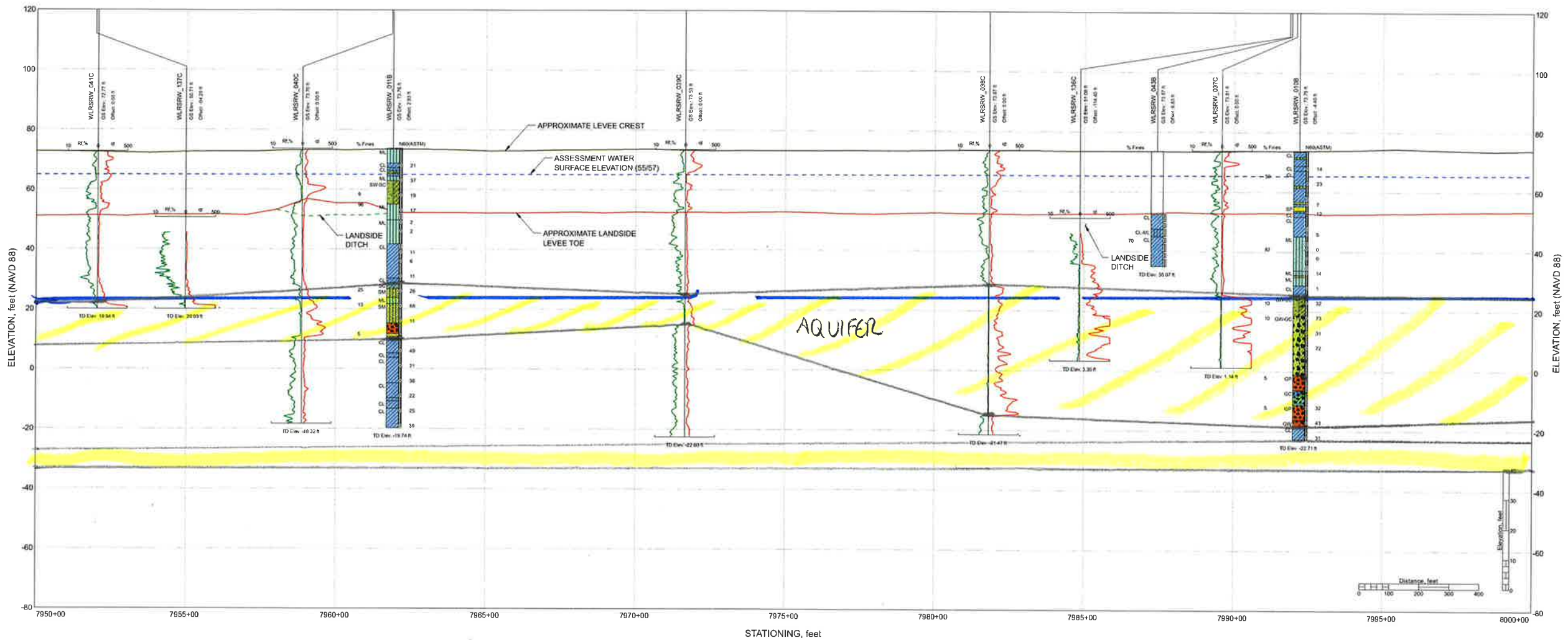


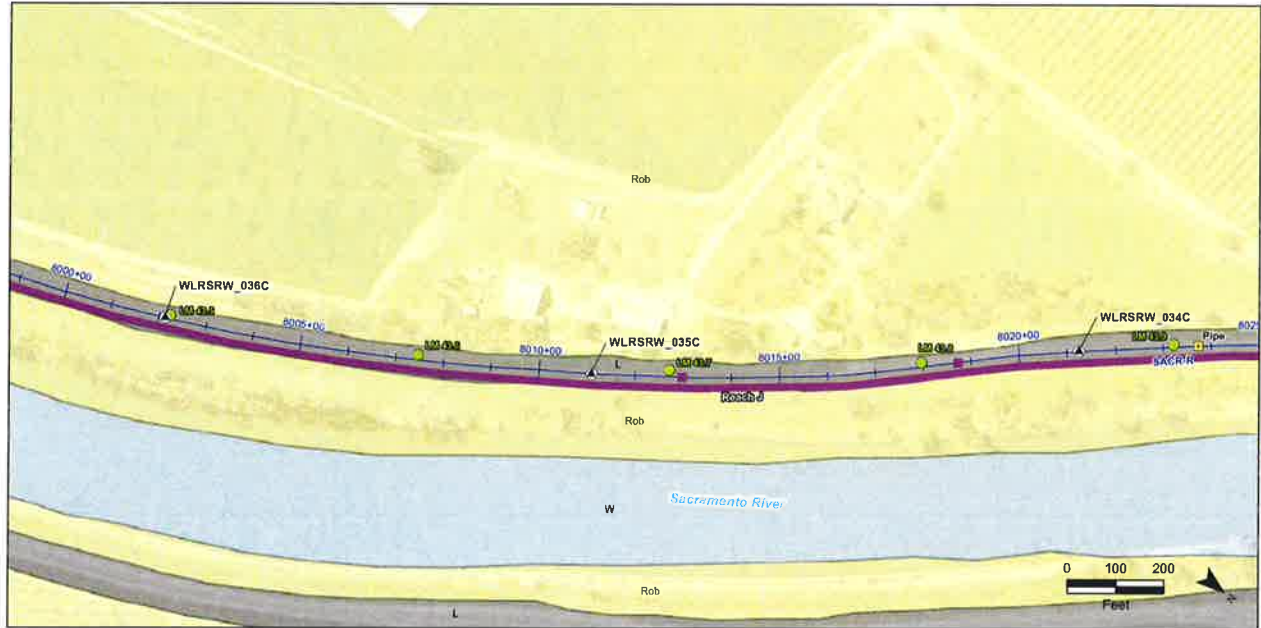
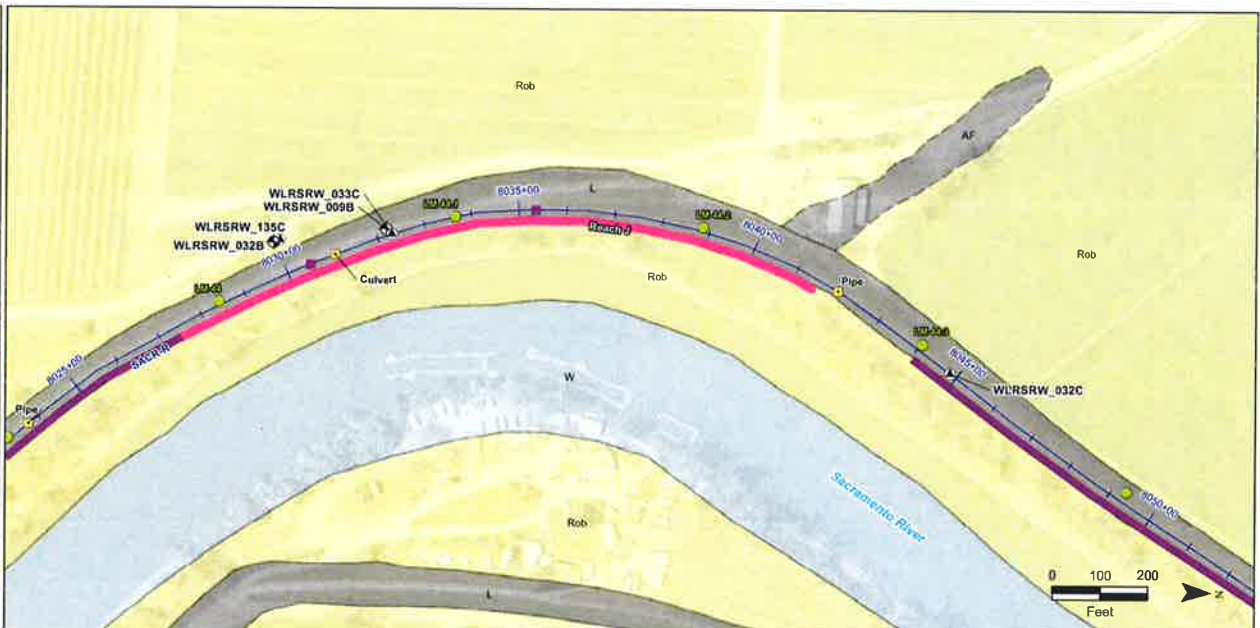
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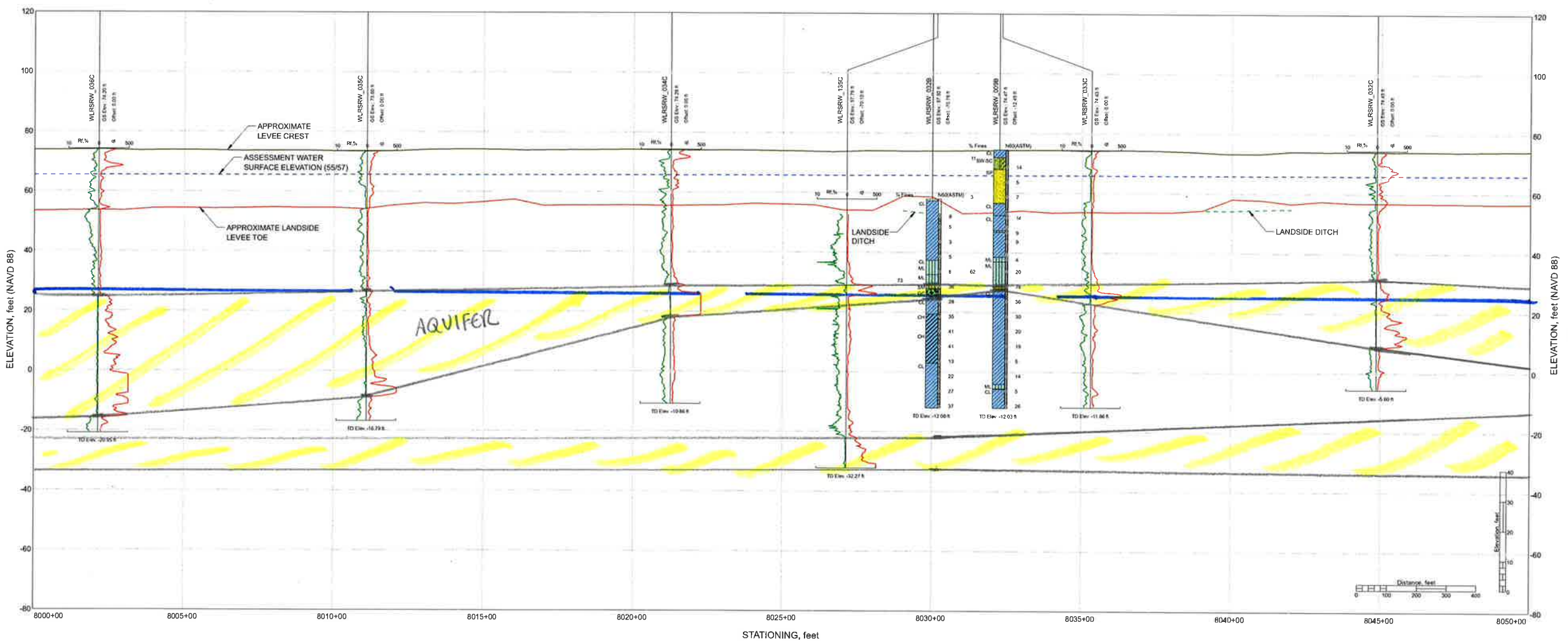


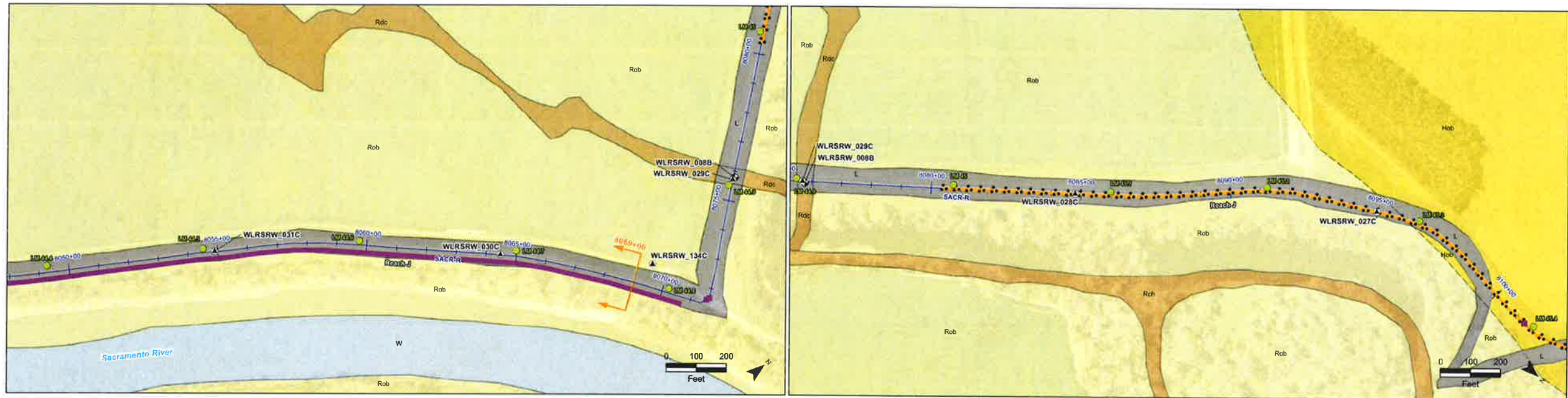
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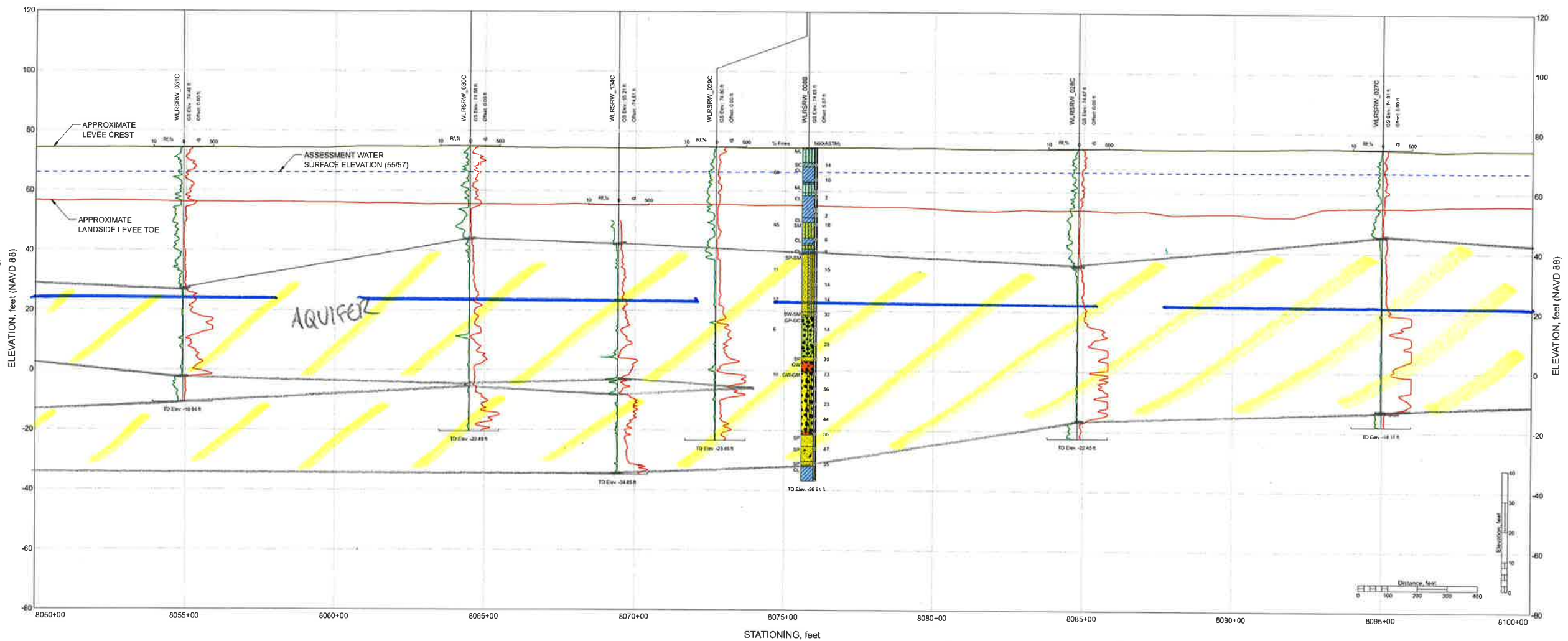


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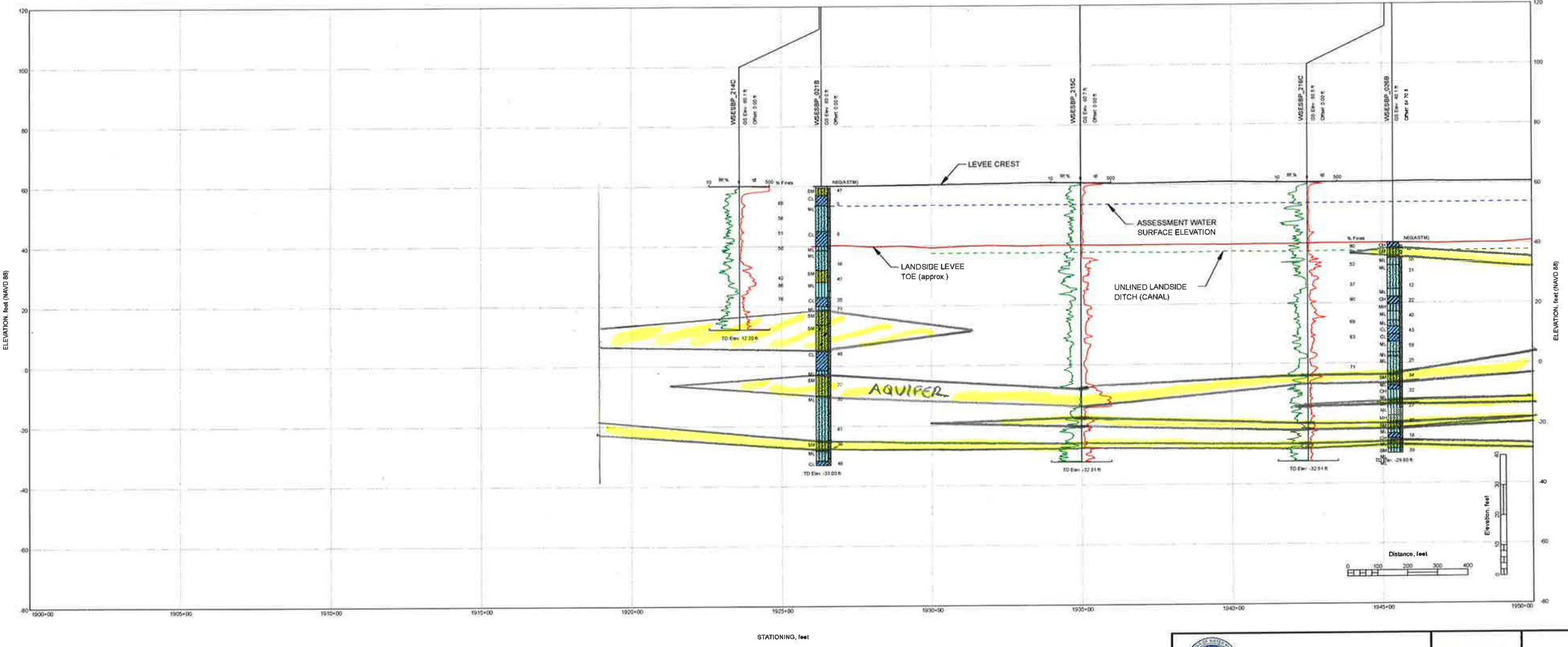
Appendix 5-D
Geologic Sections – Sutter Bypass and Wadsworth Canal

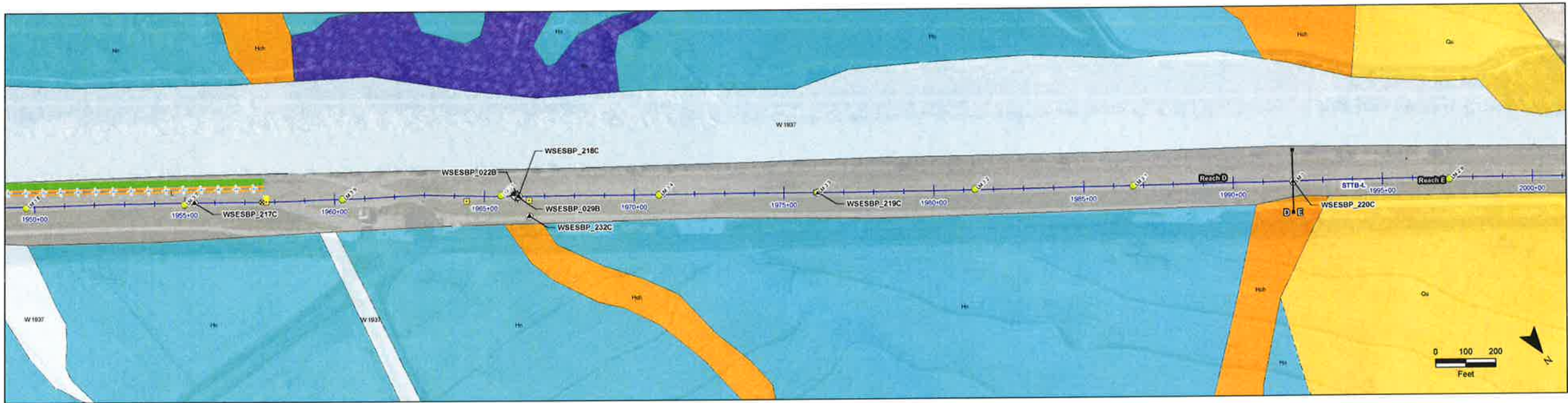
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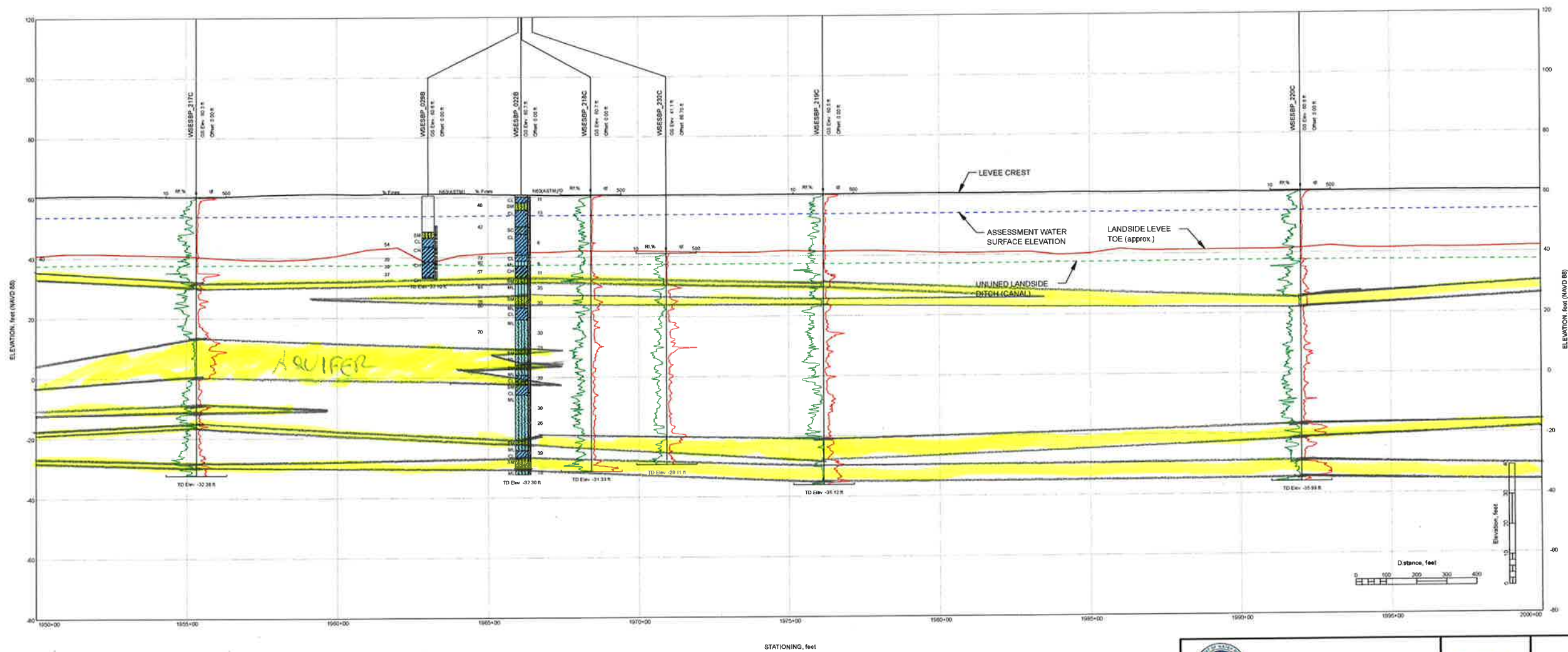
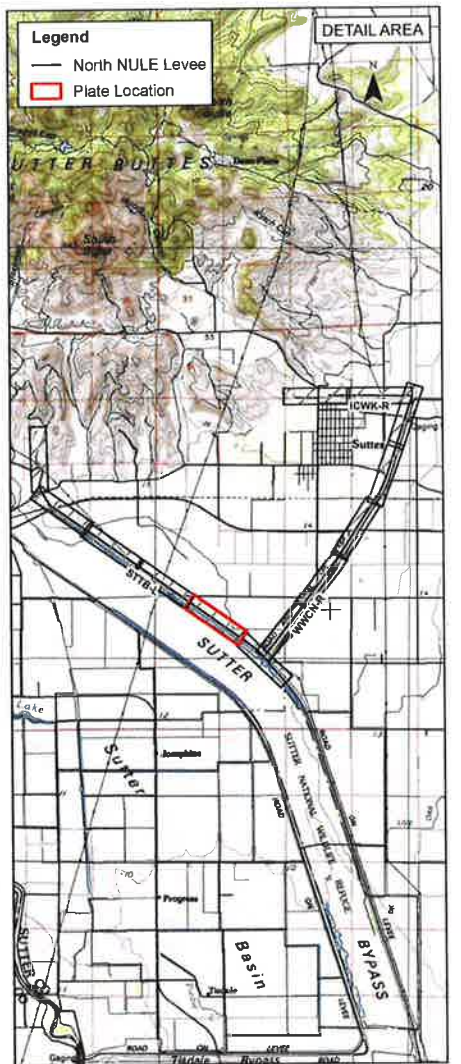
- NOTES:
- Elevations of levee crown and landside toe are approximate. These elevations were obtained from NULE LIDAR data and used for geotechnical analysis and report purpose only.
 - AWSEs are not available due to the 2- to 3-foot levee height, and no available 1950/57 design WSE.
 - Ditch bottom are shown from LIDAR data which reflects some areas of ditches were dry and other areas were filled with water when data was taken. See GOR for more information.
 - Locations of explorations are approximate. Stick logs represent general soil conditions encountered at the time of exploration. For more detailed information on the materials encountered, refer to boring and CPT logs in the Geotechnical Data Report for the Sutter Project. No warranty is provided regarding the continuity of soil conditions between individual explorations.
 - When reported, N_{60} (ASTM) refers to N_{60} (ASTM) = N field * Hammer Efficiency (%). See Geotechnical Data Report for the Sutter GOR Project for hammer efficiency data for individual borings.
 - USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 - This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 - To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 - Surficial geology was mapped at 1:24,000 scale. (Source: SGDR for DWR ULE Project, URS, 2010).
 - The information provided in these plans and stick-log plates has been compiled from a variety of sources. URS does not attest to the accuracy, completeness, or reliability of geotechnical exploration and other subsurface data by others that are included or referenced in these plates.
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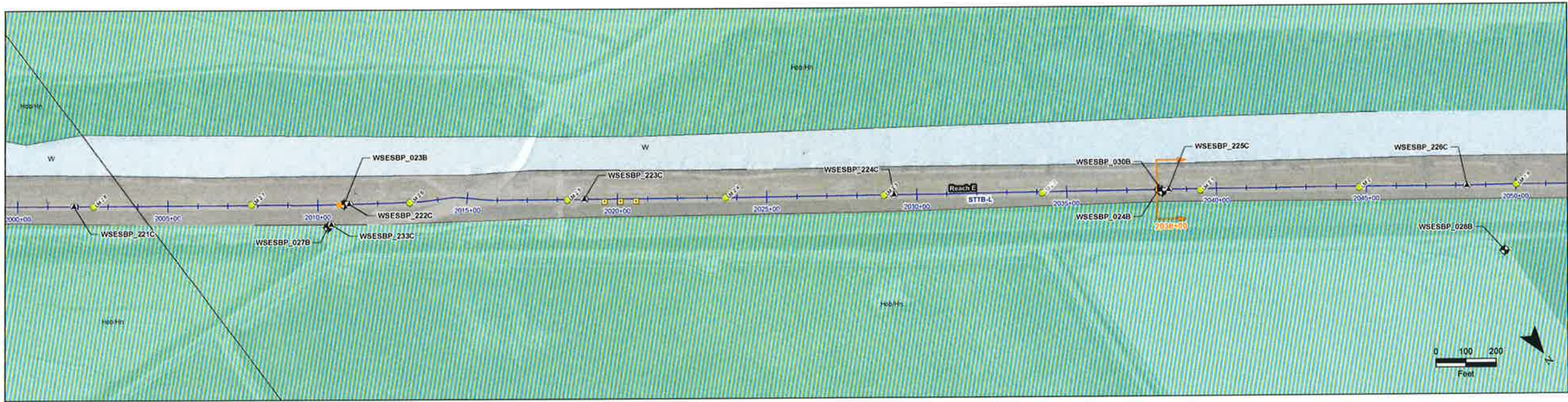
No BATHYMETRY



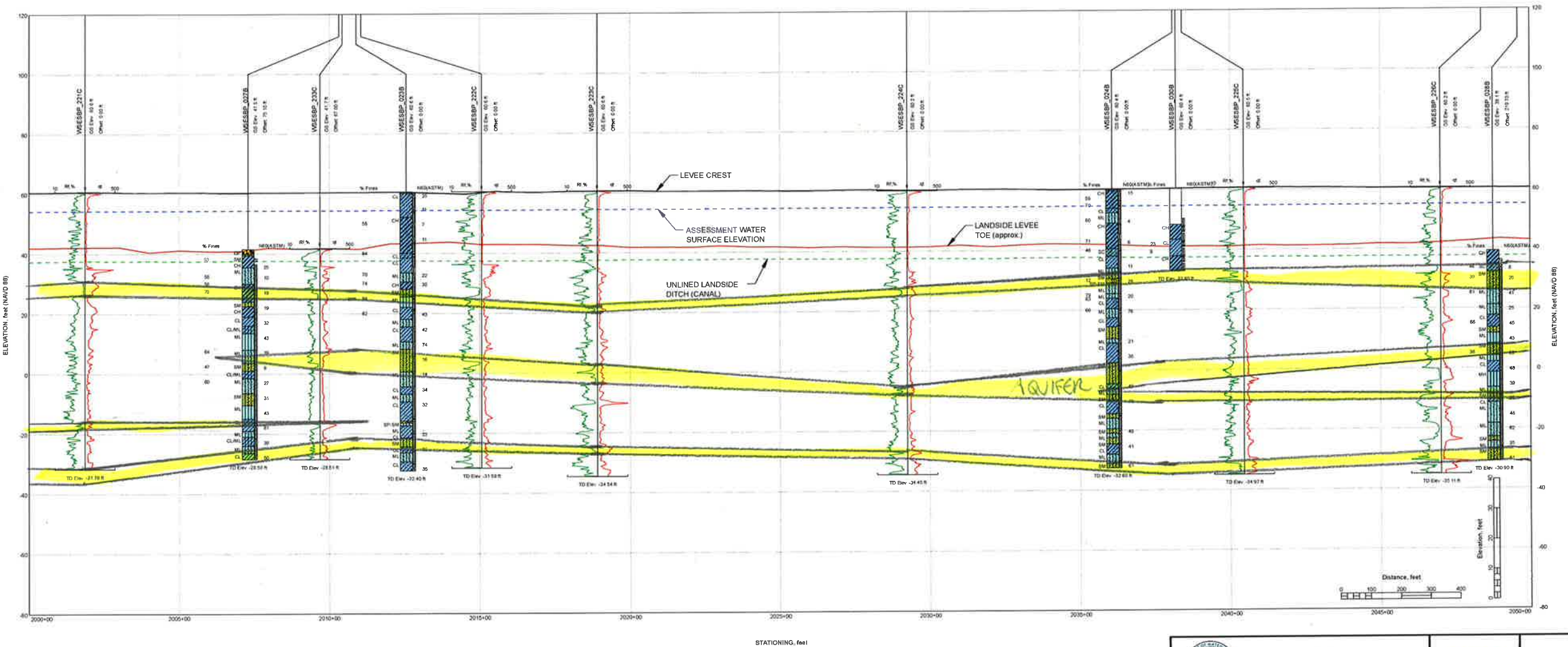
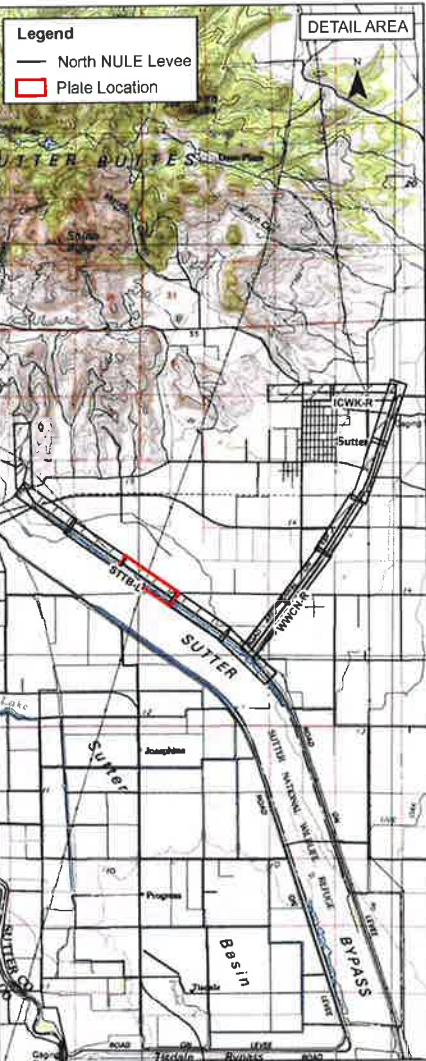


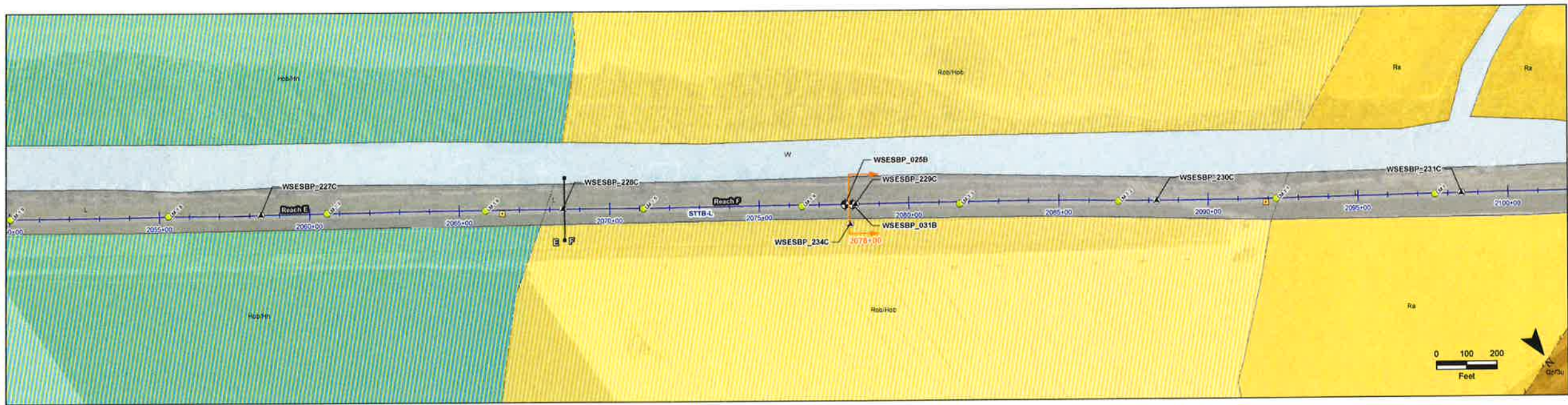
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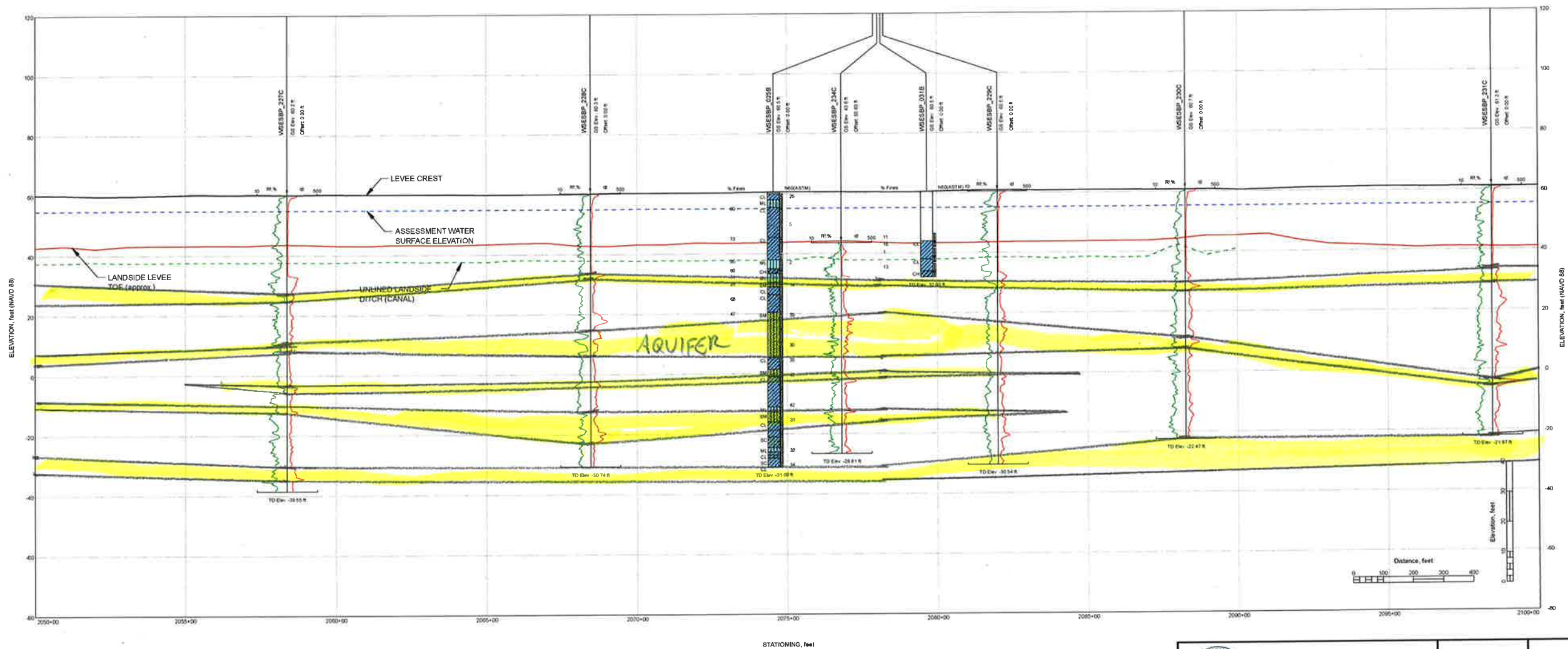
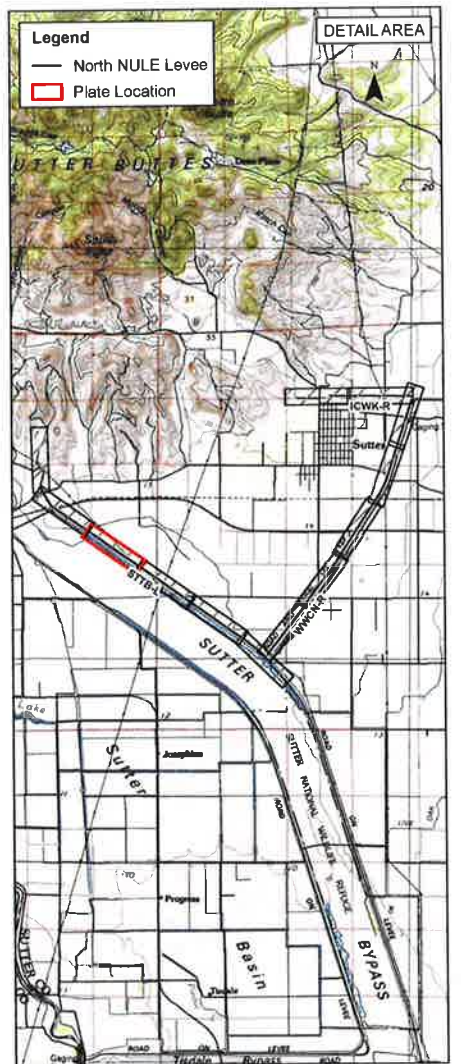
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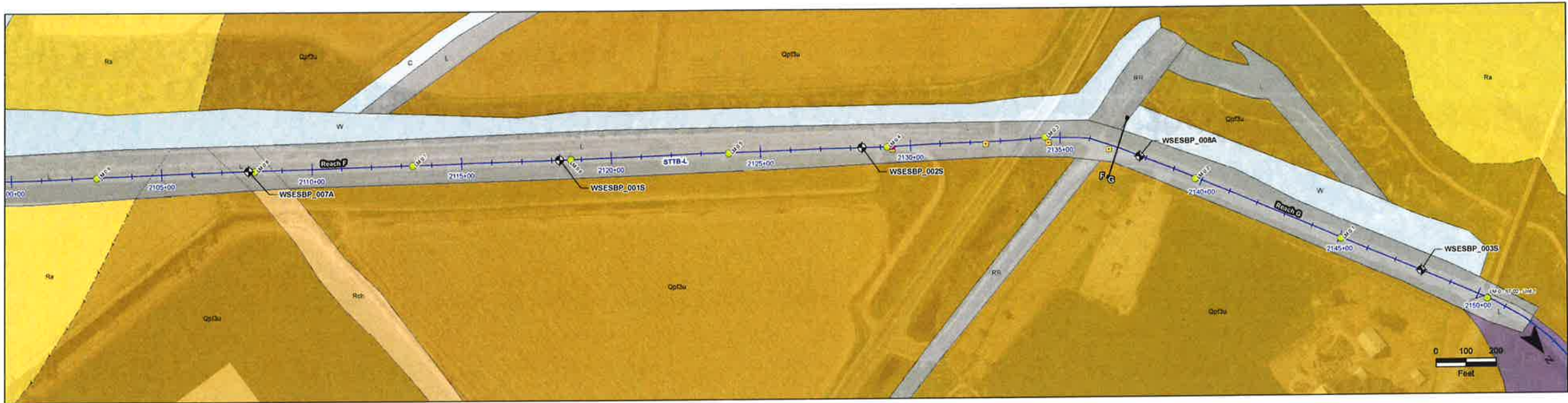


Department of Water Resources
Division of Flood Management

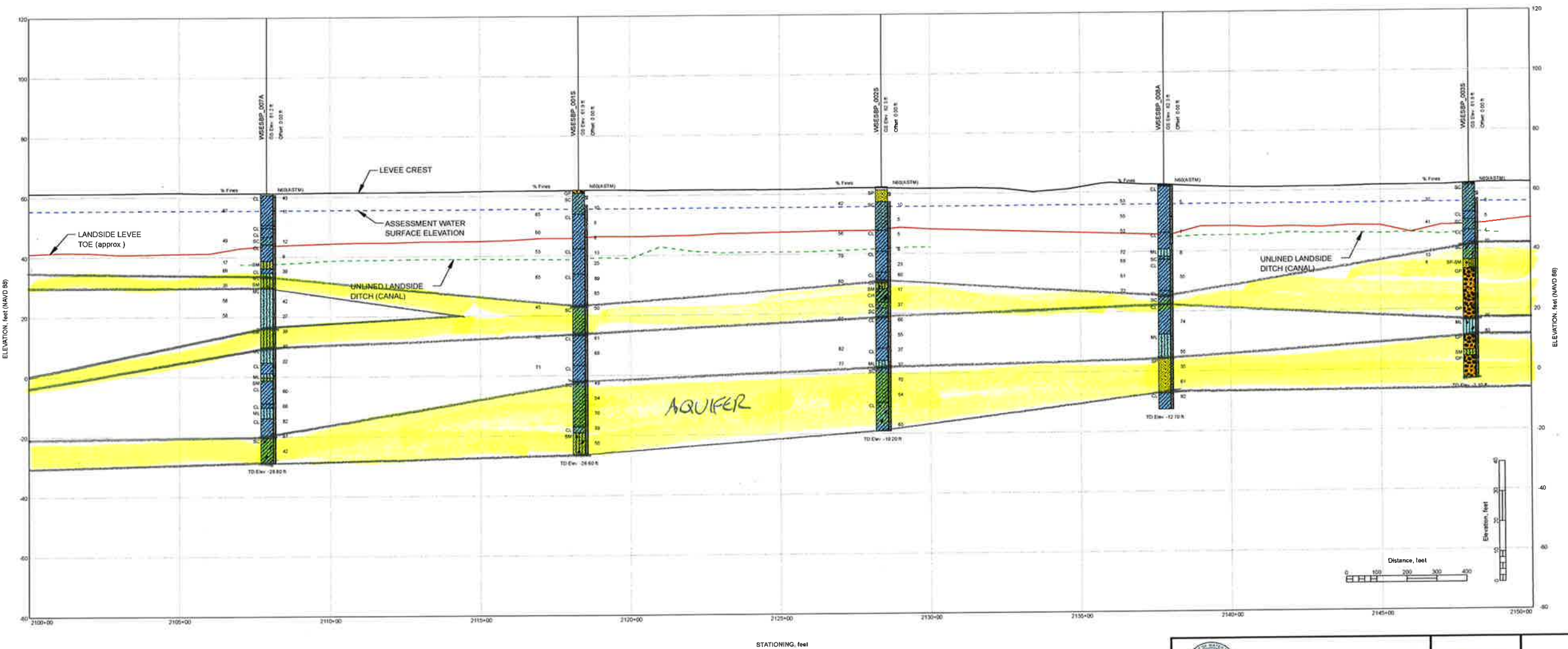
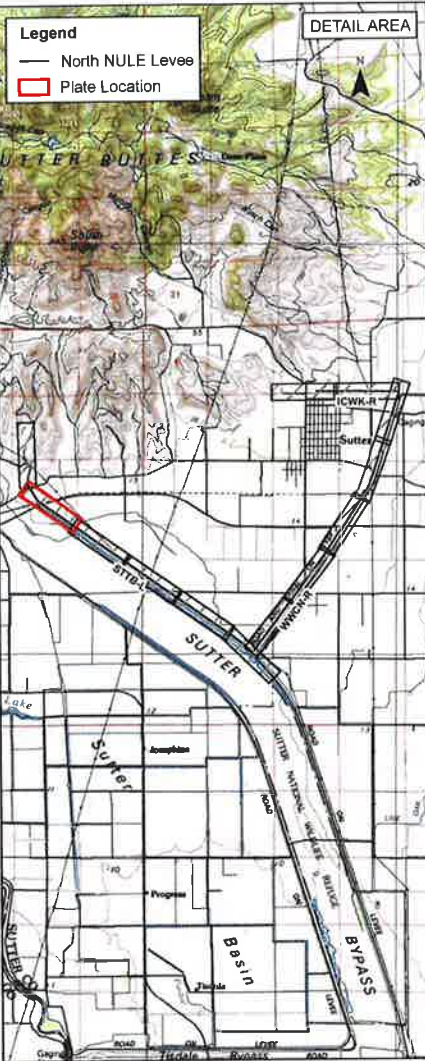
URS

Sutter Plan and Profile
Sutter Bypass Left Bank Station 2050+00 to Station 2100+00
Non-Urban Levee Evaluations

Plate
11

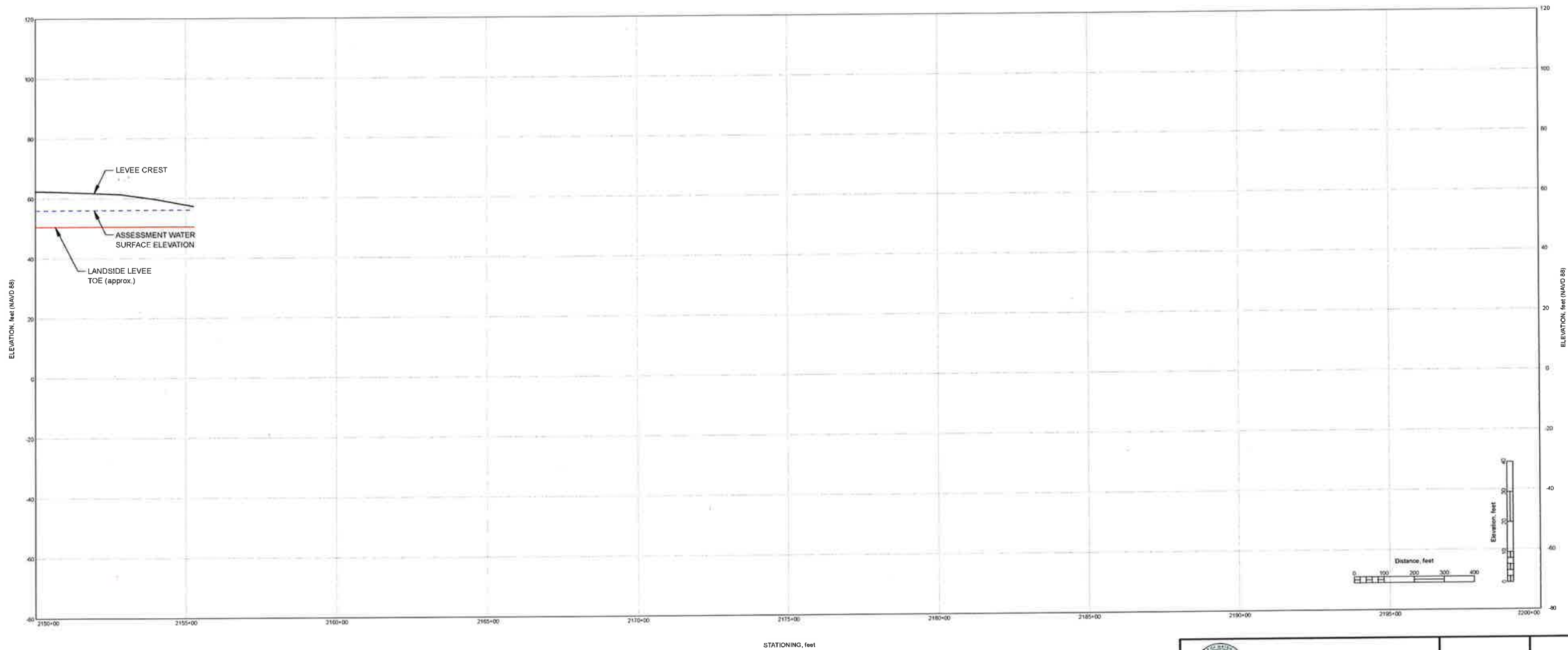
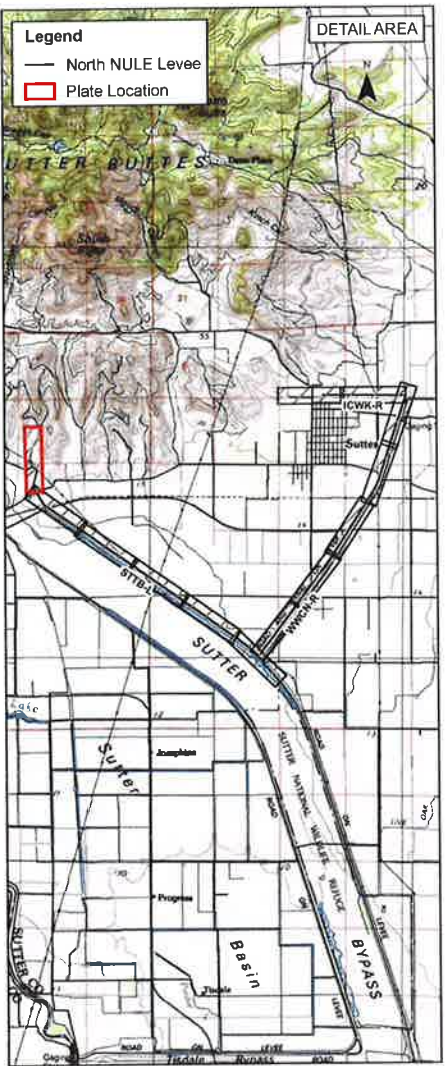


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 6. USCS classification labels are not presented on the stick logs for soil lenses (thickness less than 1.5 feet).
 7. This is a color figure. Black and white reproduction should not be relied upon as data will be lost.
 8. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 9. Surficial geology was mapped at 1:24000 scale.
(Source: SDDR for DWR ULE Project, URS, 2010)
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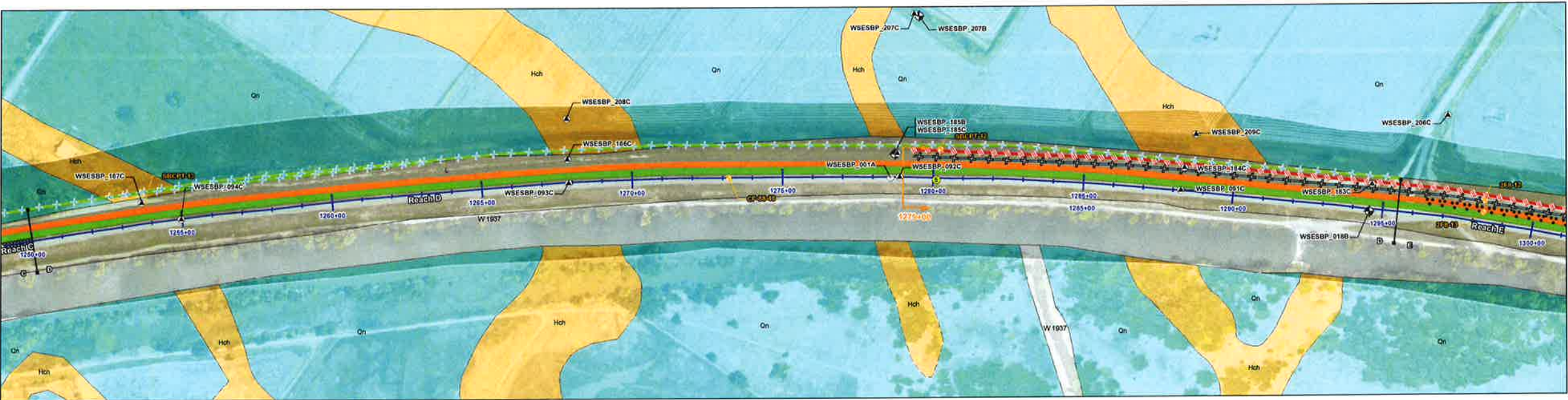


Department of Water Resources
Division of Flood Management

URS

Sutter Plan and Profile
Sutter Bypass Left Bank Station 2150+00 to Station 2155+26
Non-Urban Levee Evaluations

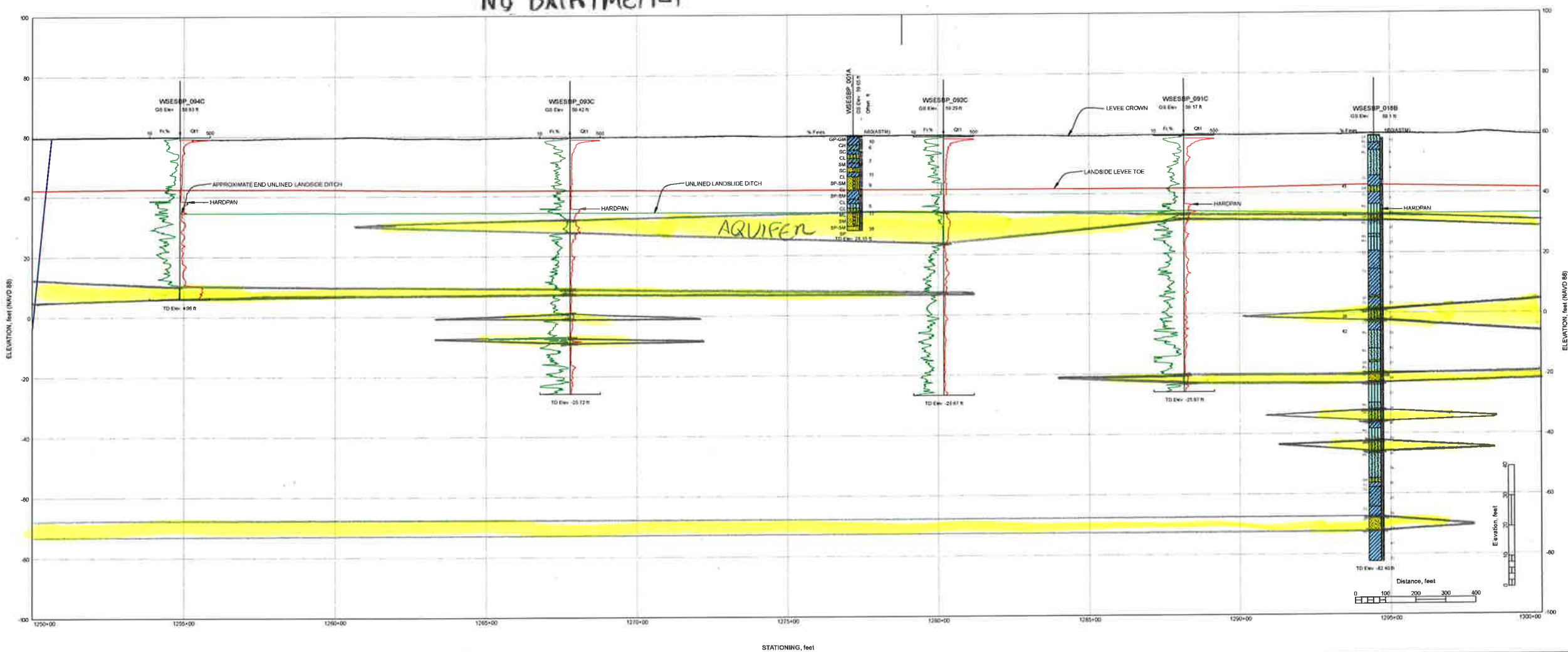
Plate
13



NOTES:

1. Elevations of levee crown, landside toe, and landside depression/ditch are approximate.
2. Stratigraphy between explorations may differ from that shown at exploration locations.
3. Only explorations through the levee crown are shown on the profile.
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7. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
8. Surficial geology was mapped at 1:20,000.

NO BATHYMETRY

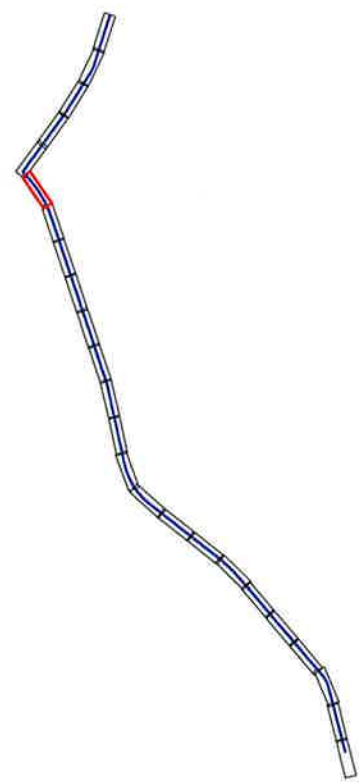


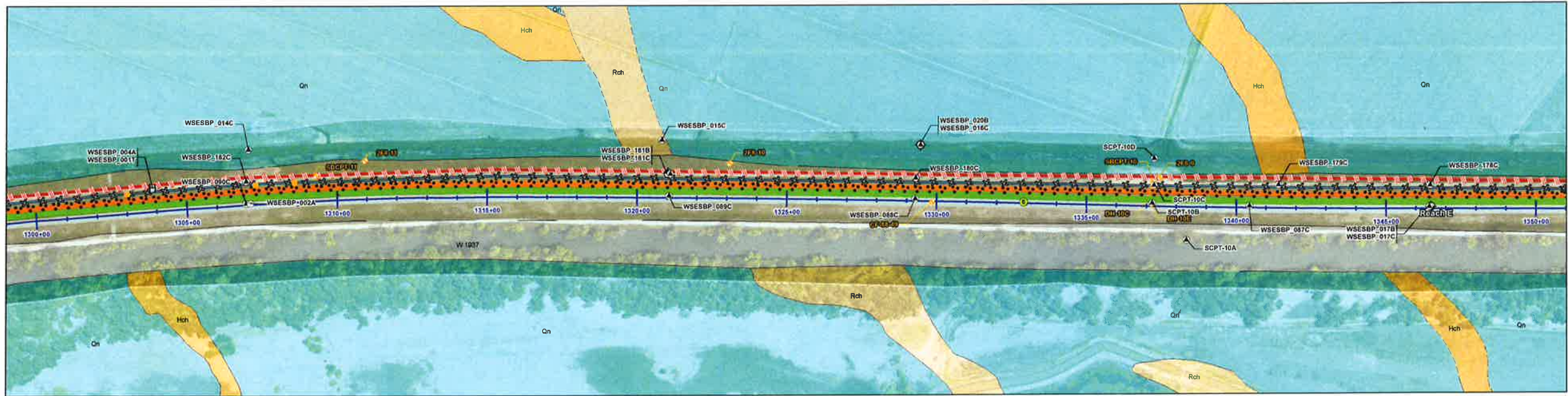
DETAIL AREA

Sutter Bypass

Legend

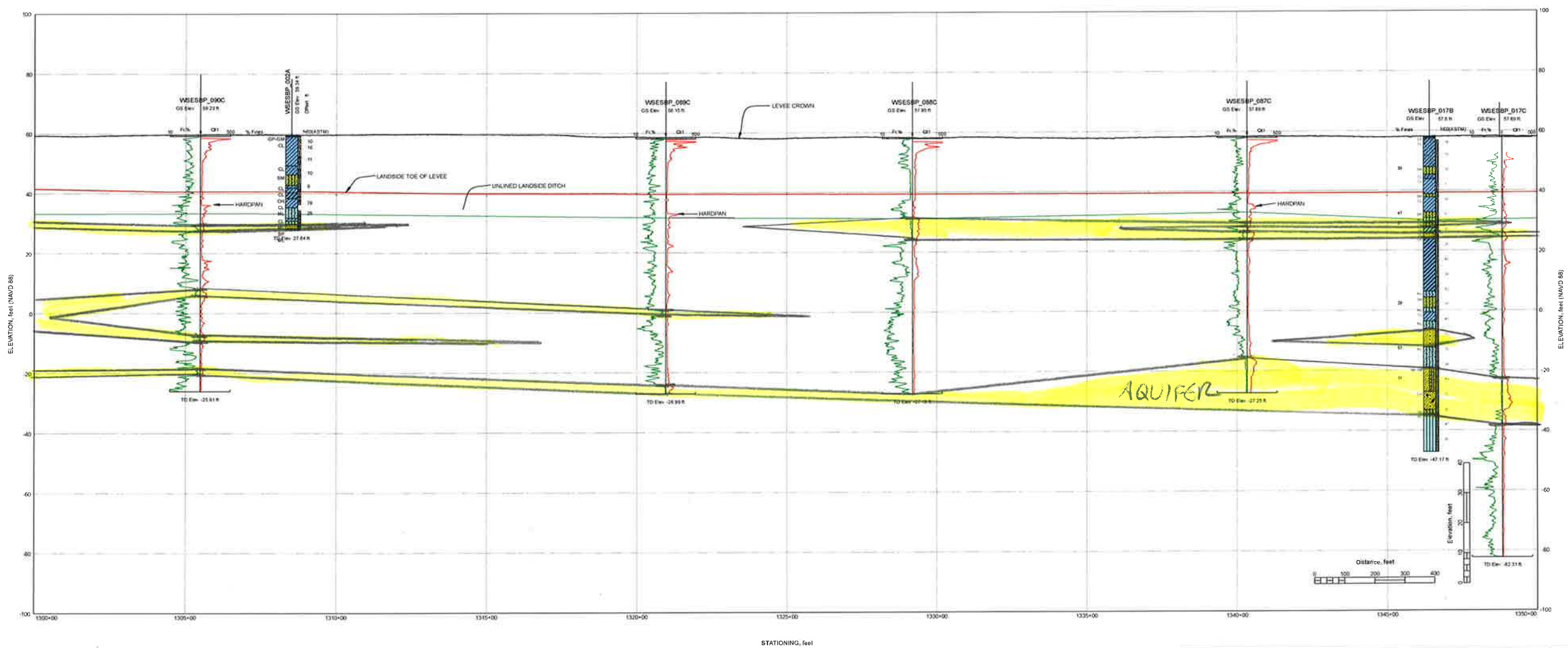
- Urban Project Levee
- Plate Location





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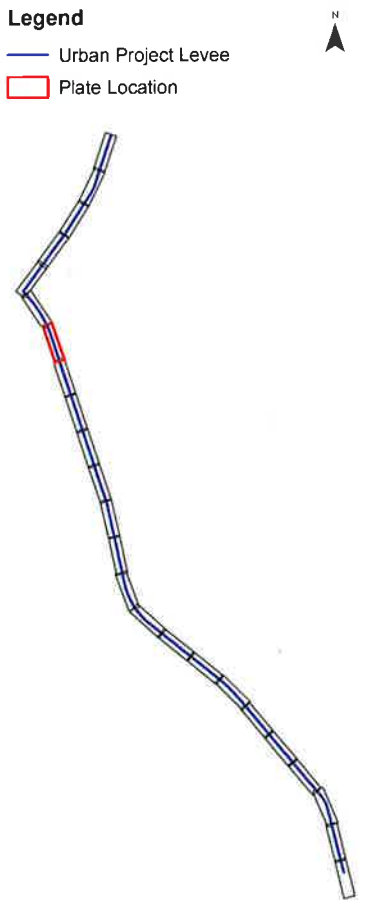


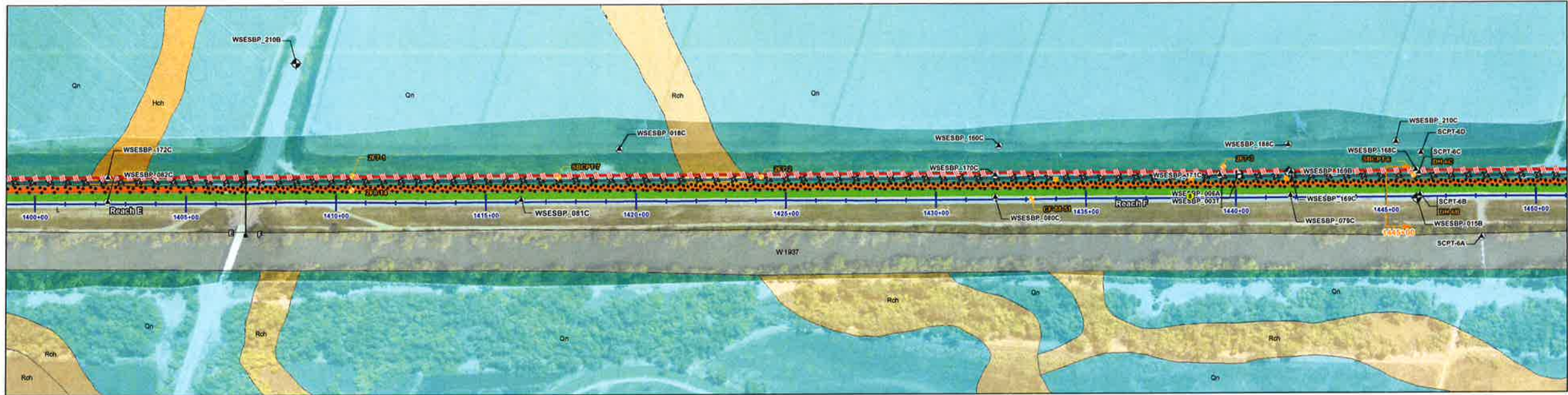
Legend

- Urban Project Levee
- Plate Location

DETAIL AREA

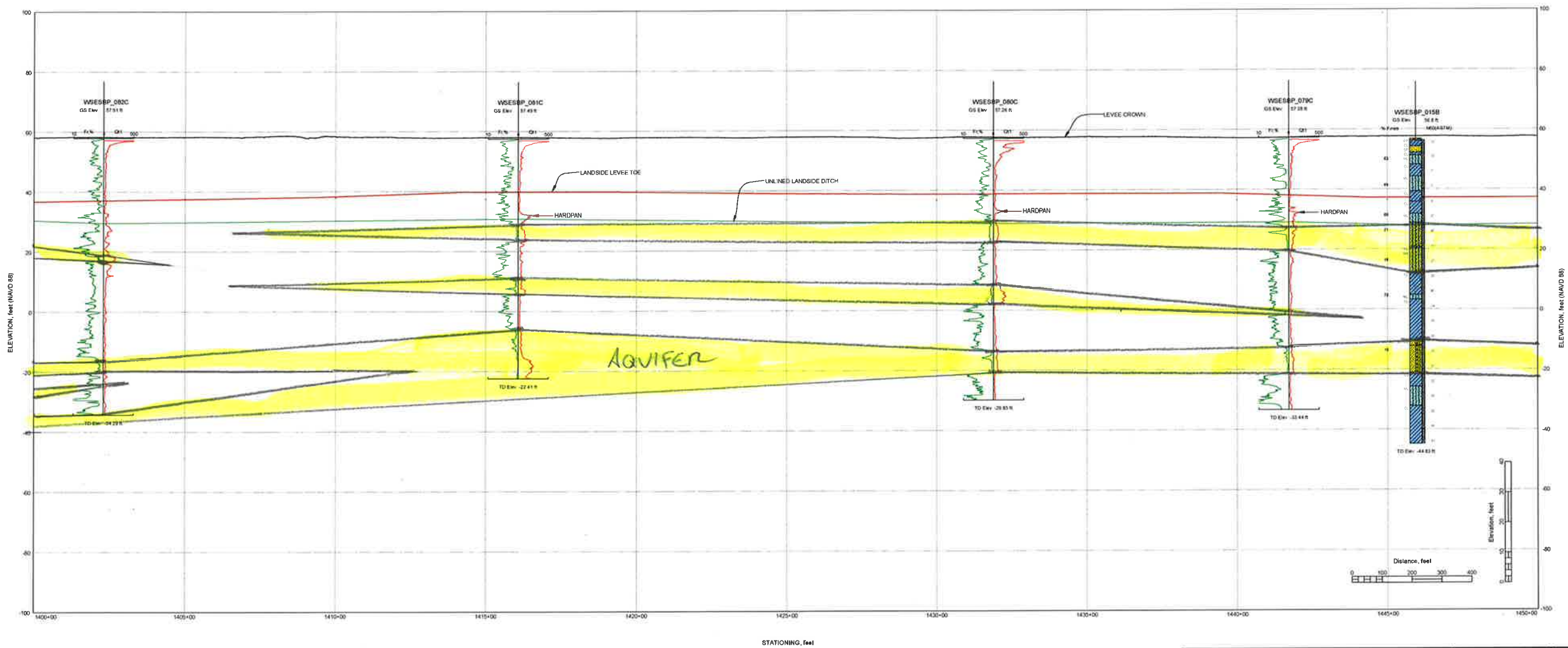
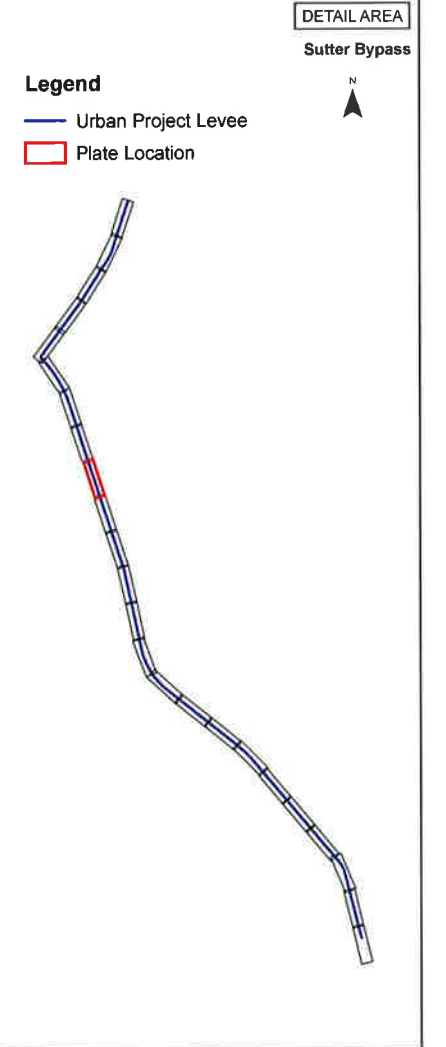
Sutter Bypass

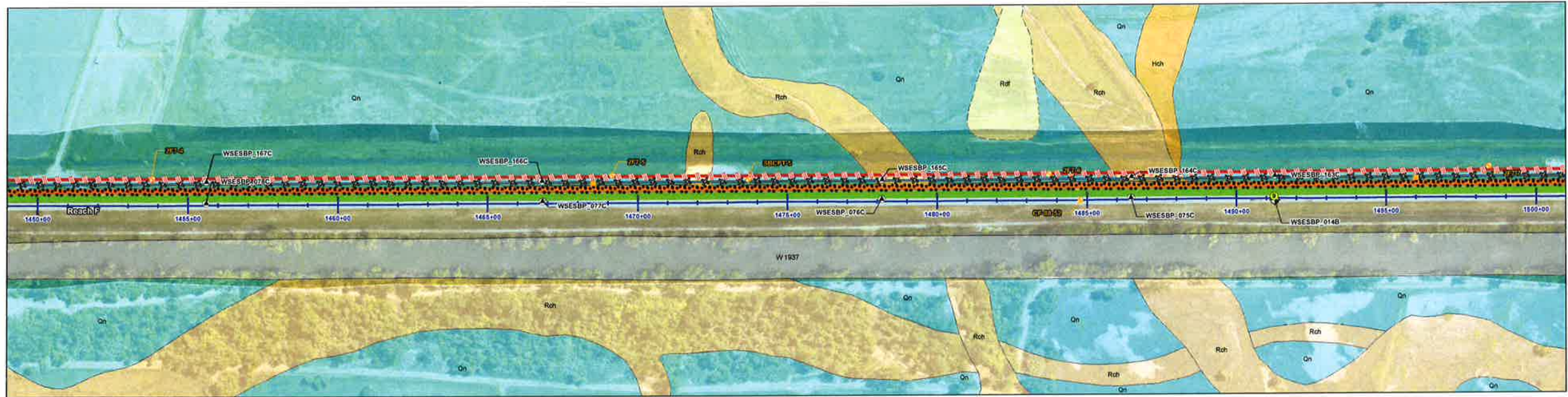




NOTES:

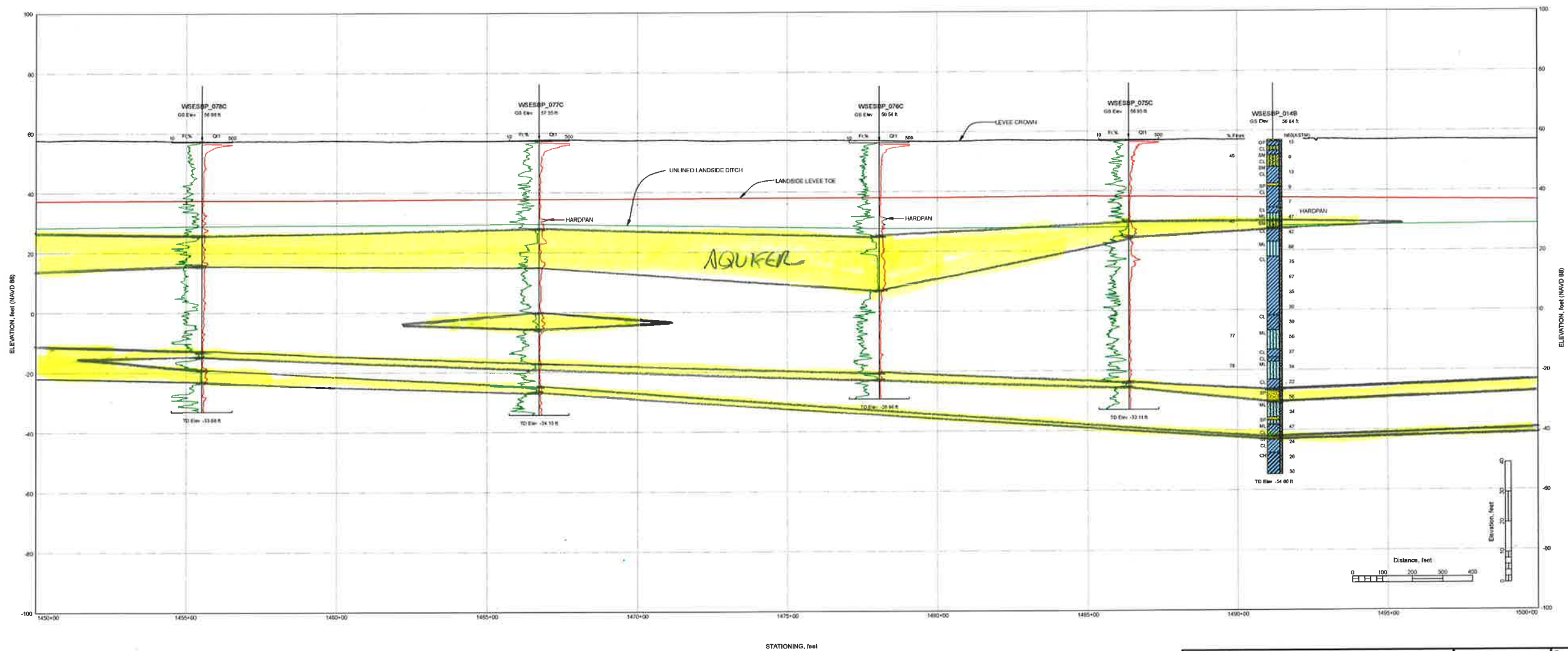
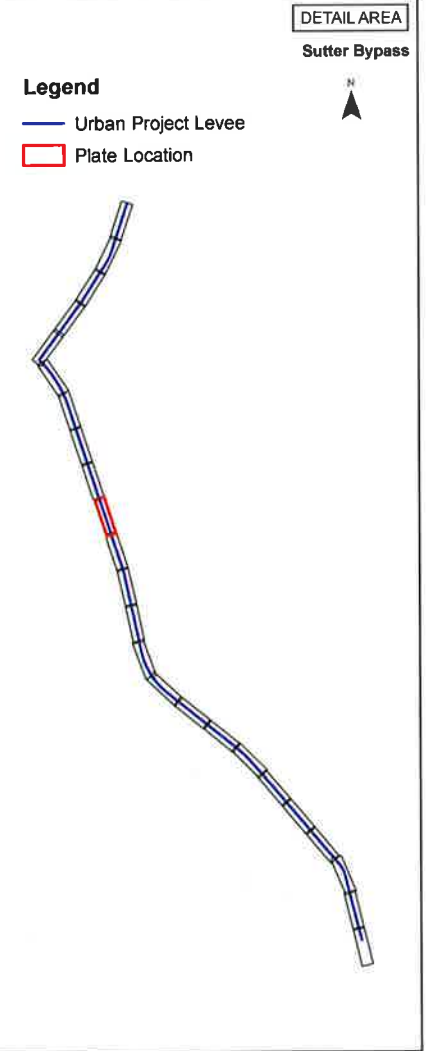
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7. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
8. Surficial geology was mapped at 1:20,000.

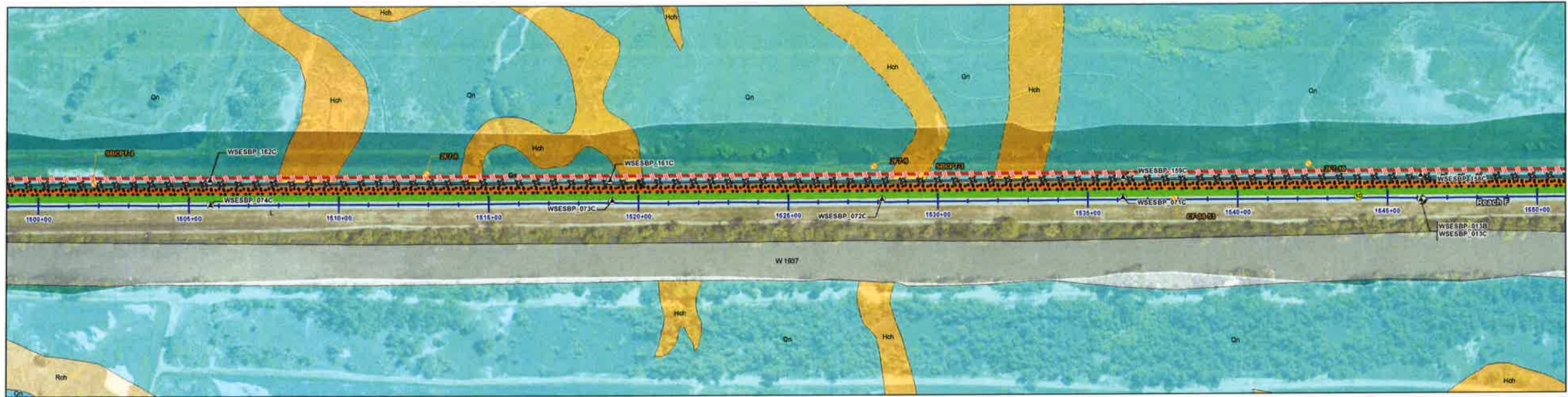




NOTES:

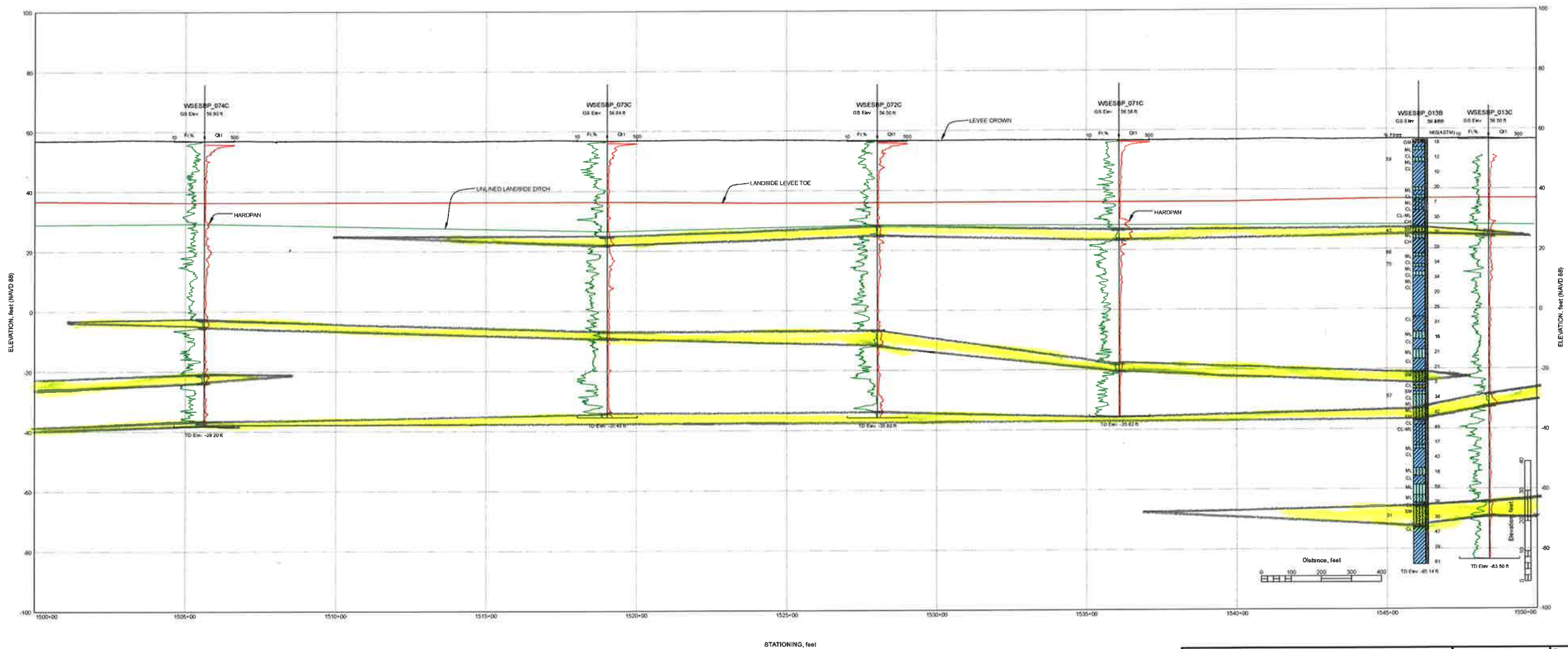
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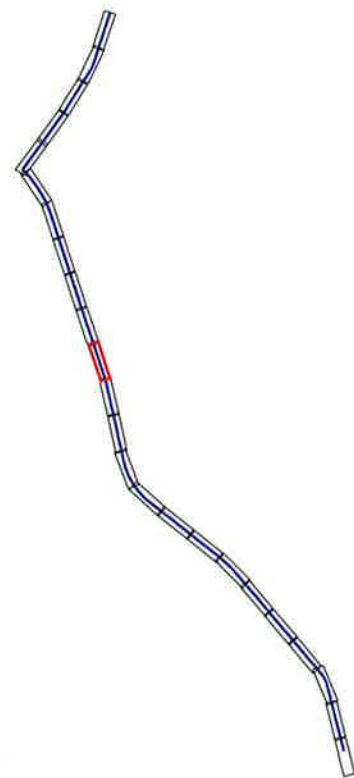


DETAIL AREA

Sutter Bypass

Legend

- Urban Project Levee
- Plate Location



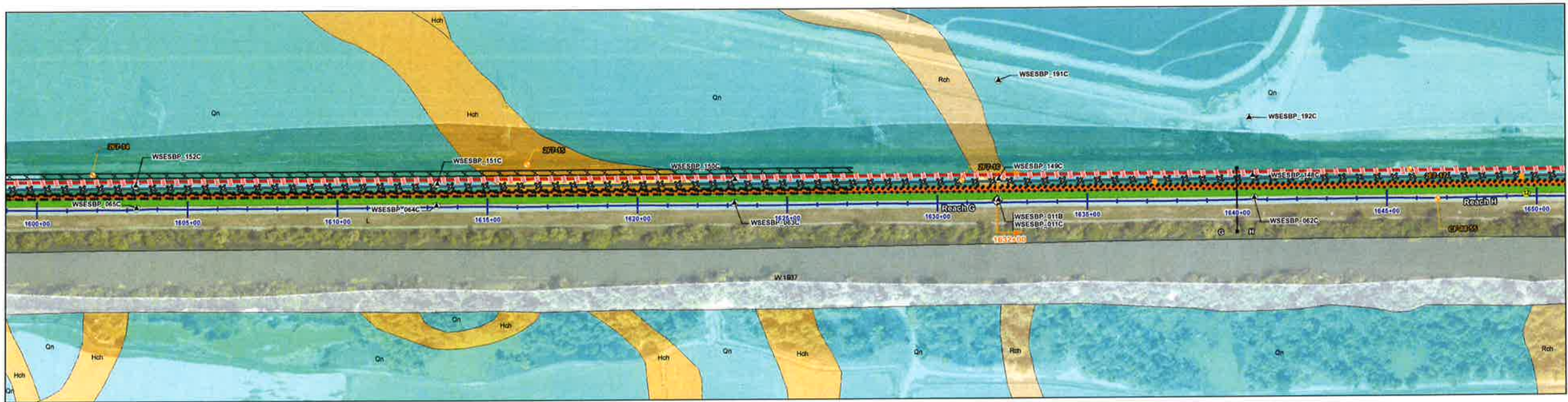
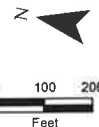
Department of Water Resources
Division of Flood Management

URS

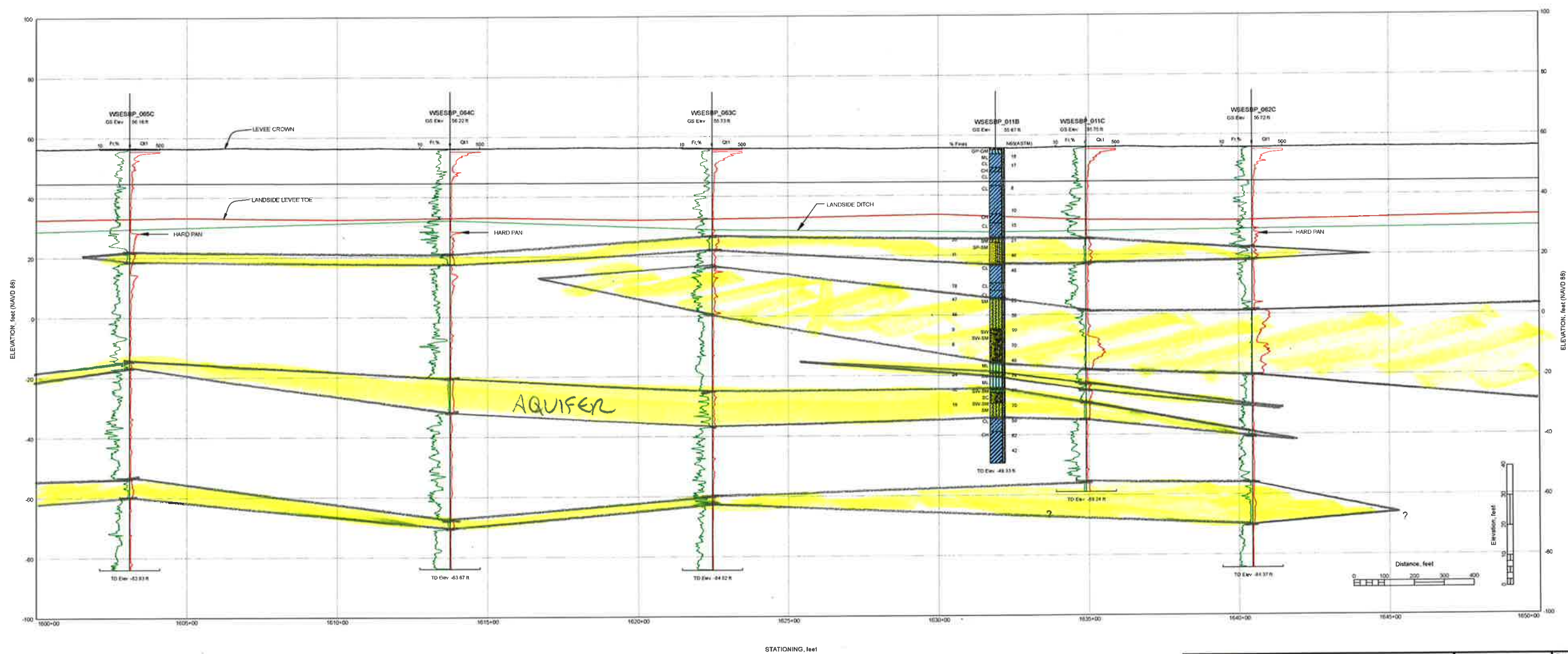
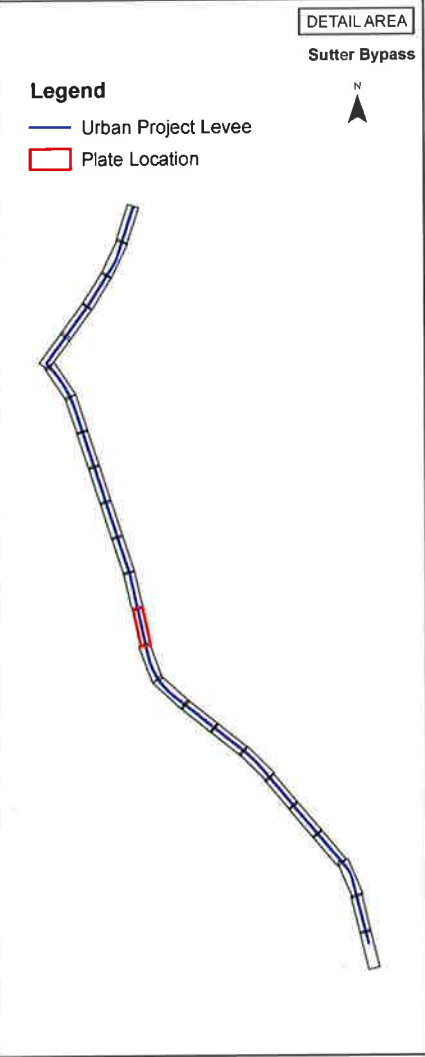
Sutter Bypass-Wadsworth Canal Plan and Profile
Station 1500+00 to Station 1550+00
Sutter Bypass

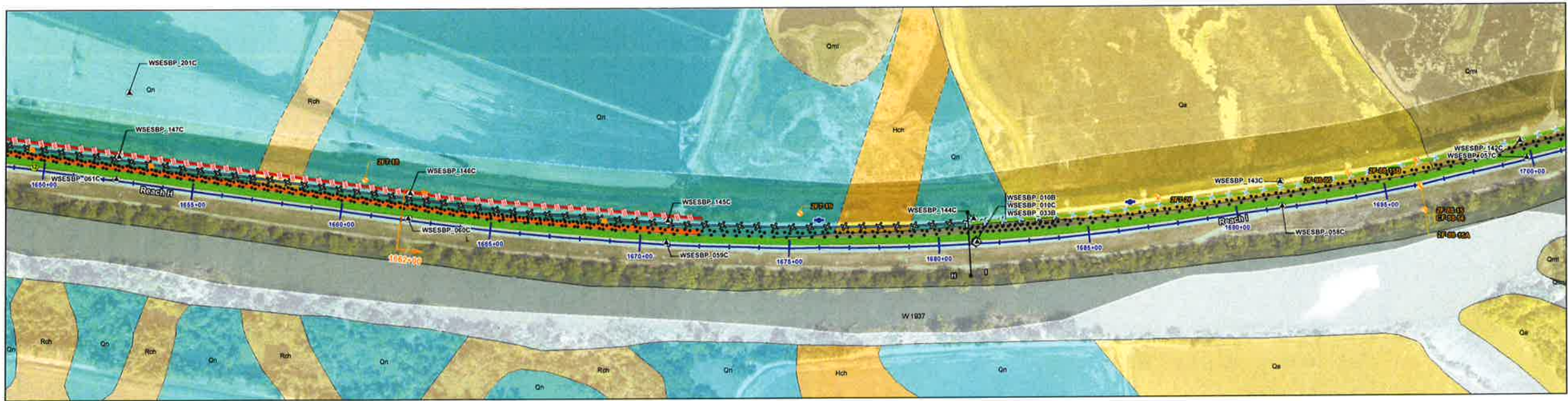
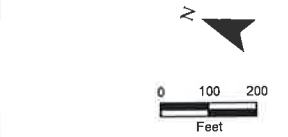
URBAN LEVEE EVALUATIONS

Plate
13

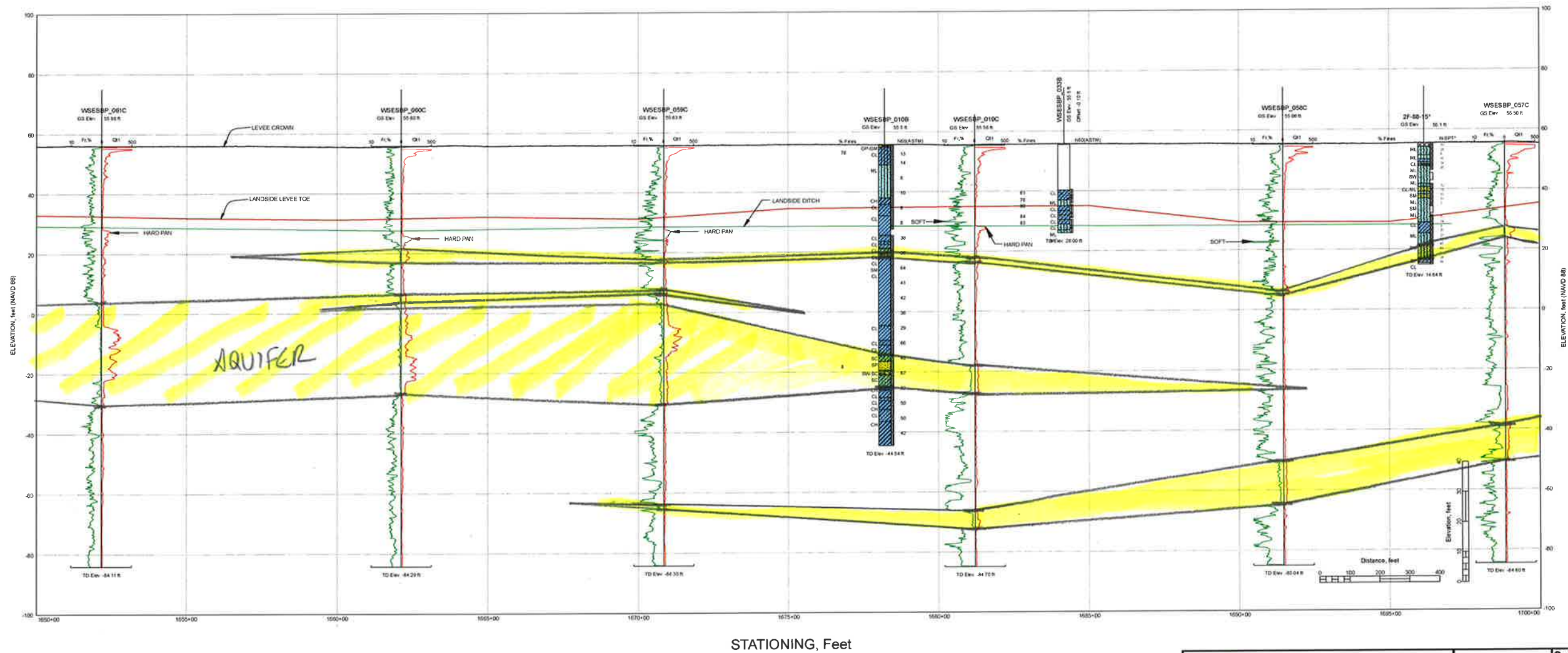


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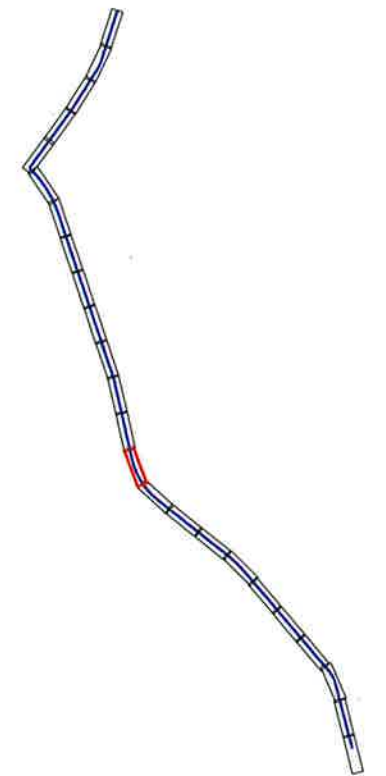


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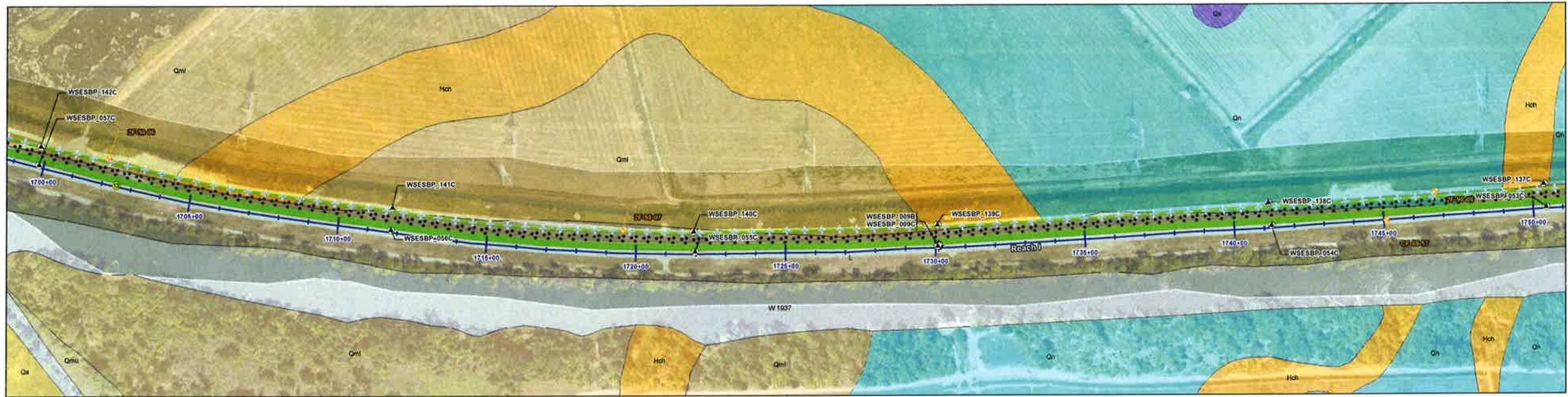


DETAIL AREA
Sutter Bypass

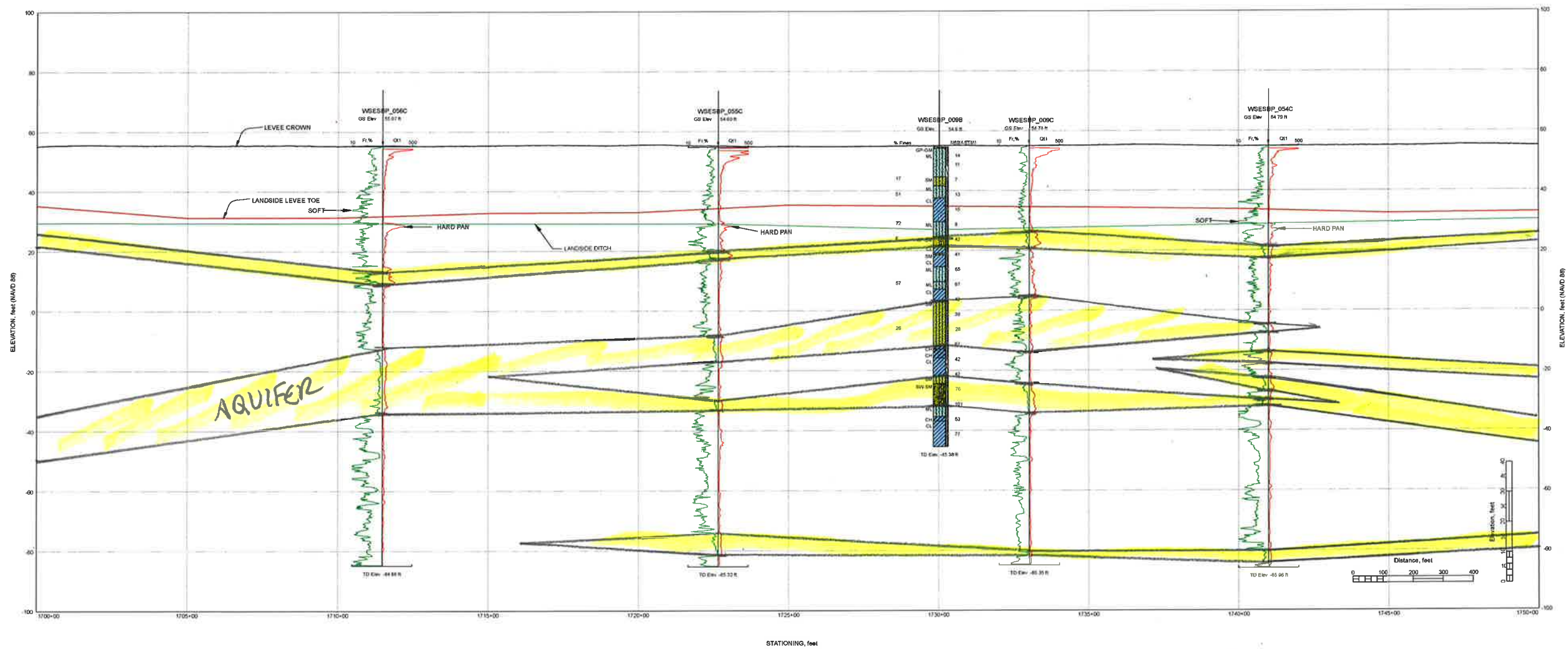
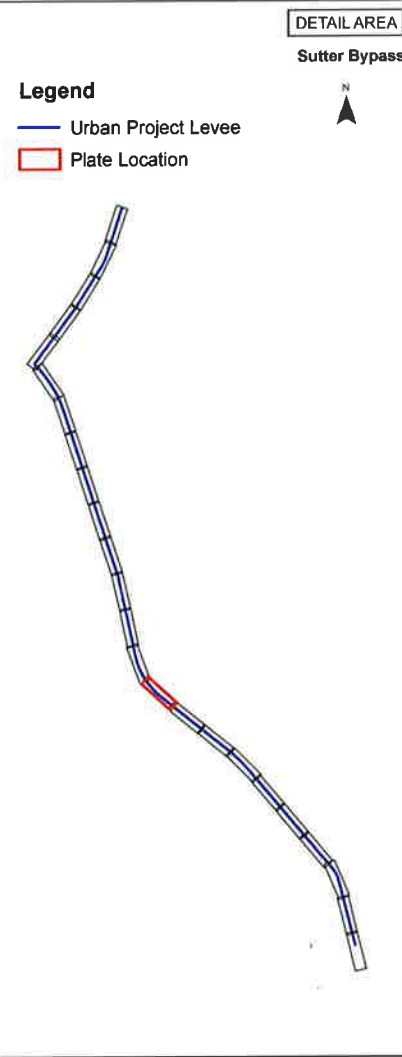
- Legend
- Urban Project Levee
 - Plate Location

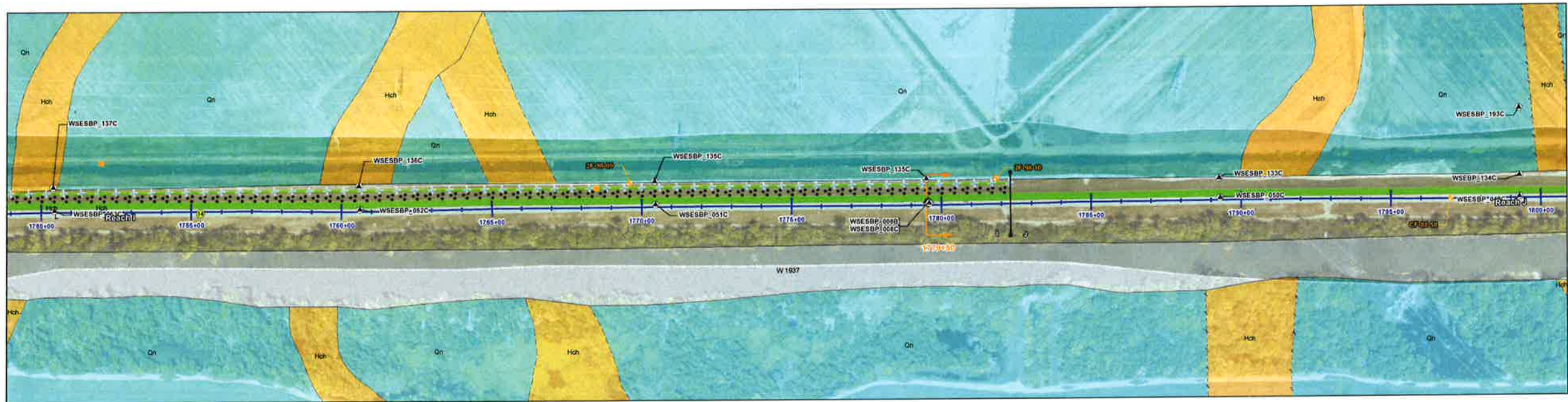


STATIONING, Feet

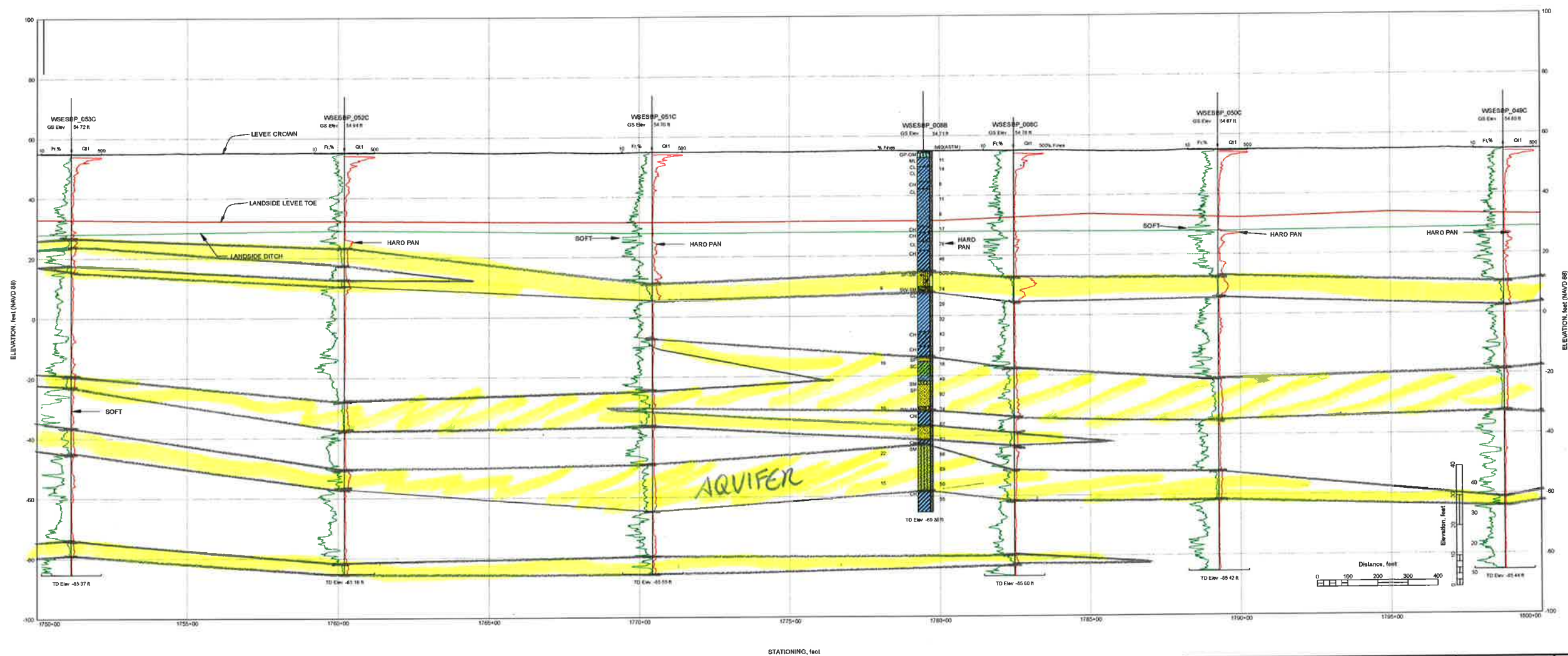
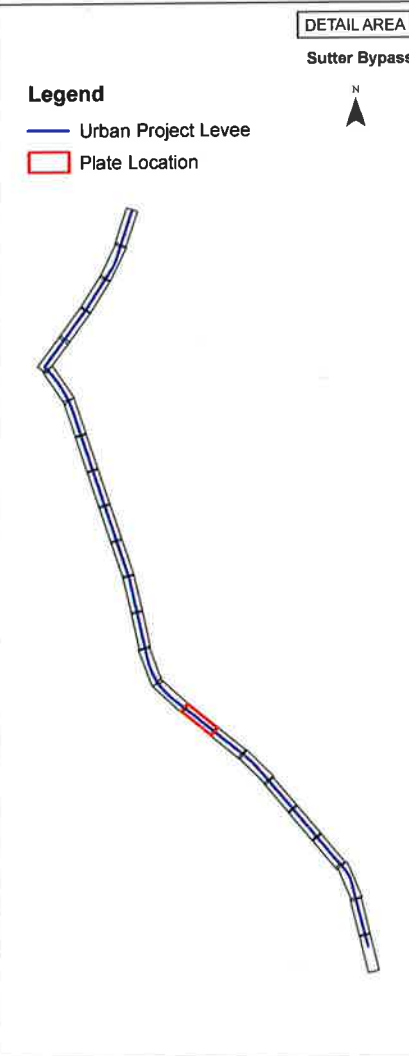


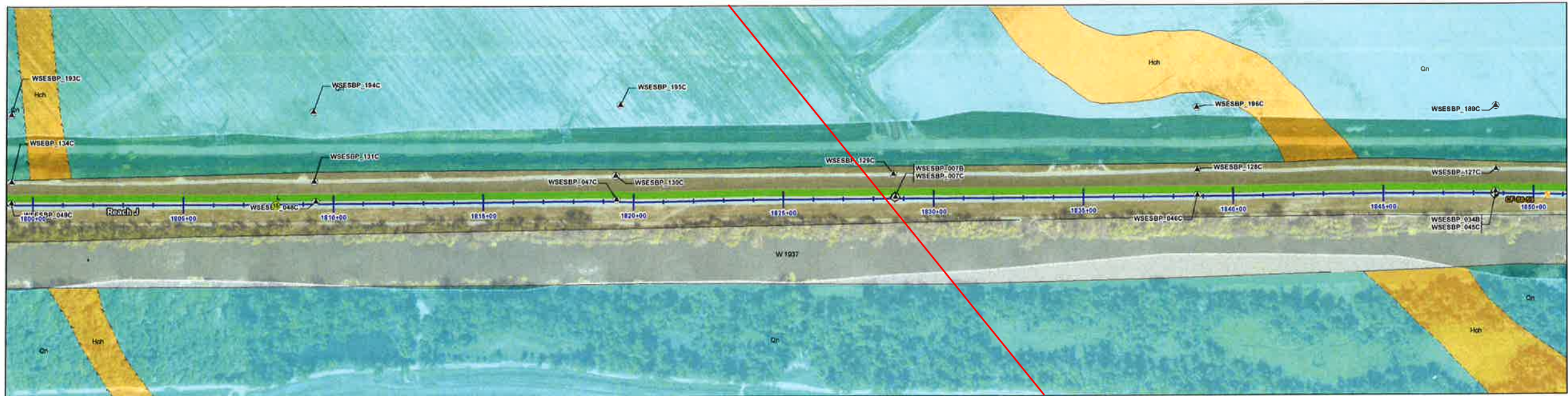
- NOTES:
1. Elevations of levee crown, landside toe, and landside depression/ditch are approximate.
 2. Stratigraphy between explorations may differ from that shown at exploration locations.
 3. Only explorations through the levee crown are shown on the profile.
 4. Historical borings on the profile are denoted by an asterisk (*) after the boring name. Historical boring locations and profiles are based on available information. Some historical explorations are shown on the plan but not in the profile if the log was not available or was close to a new exploration.
 5. USCS classification labels are not presented on the profiles for soil lenses (thickness less than 1.5 ft).
 6. This is a color figure. Black and white reproductions should not be relied upon as data will be lost.
 7. To prevent scale distortion, this map should be printed on a "D" size sheet (22x34 inches).
 8. Surficial geology was mapped at 1:20,000.





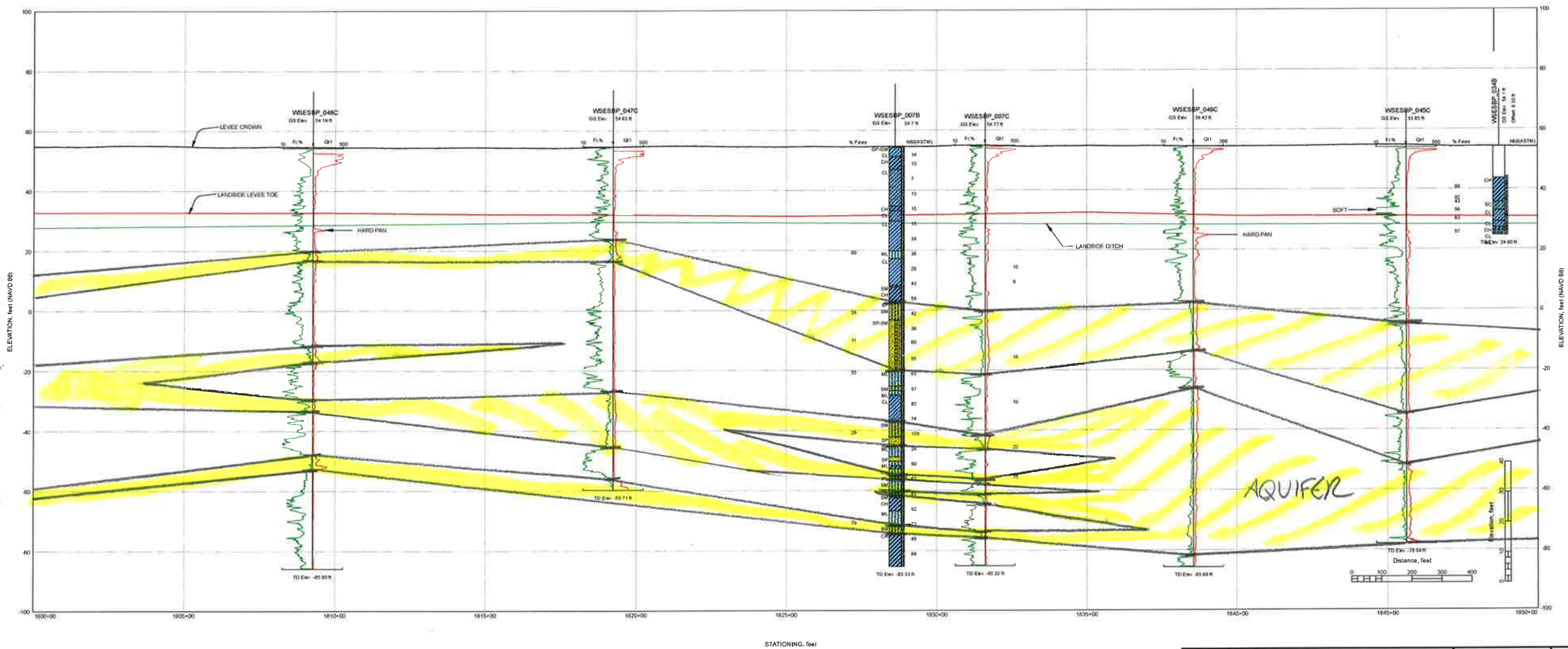
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1. Elevations of levee crown, landside toe, and landside depression/ditch are approximate.
 2. Stratigraphy between explorations may differ from that shown at exploration locations.
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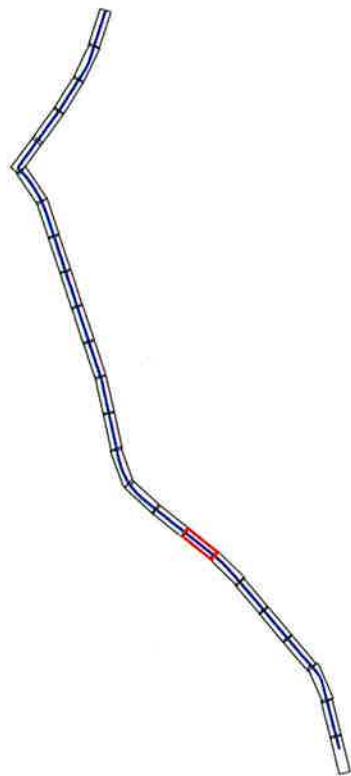


DETAIL AREA

Sutter Bypass

Legend

- Urban Project Levee
- Plate Location



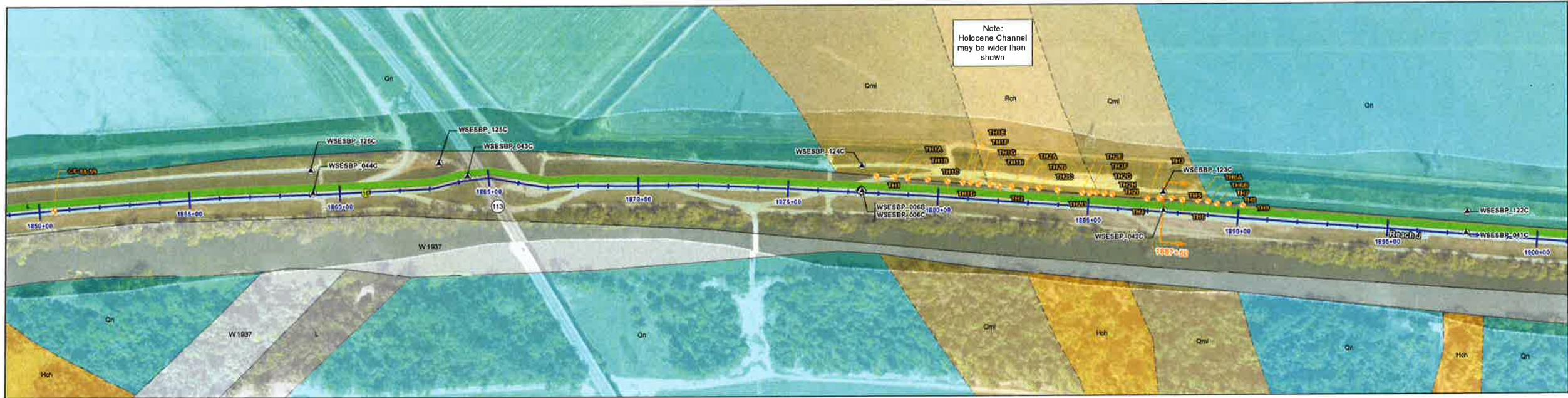
Department of Water Resources
Division of Flood Management

URS

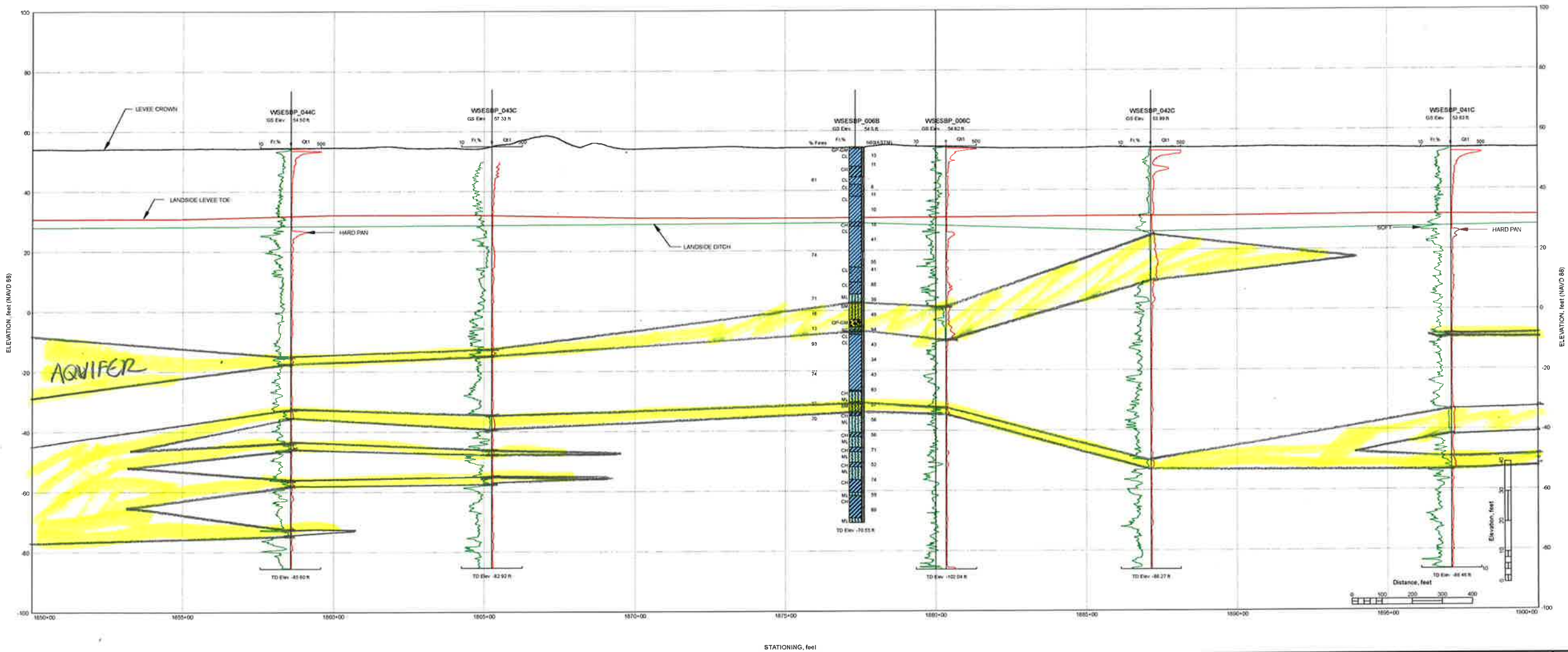
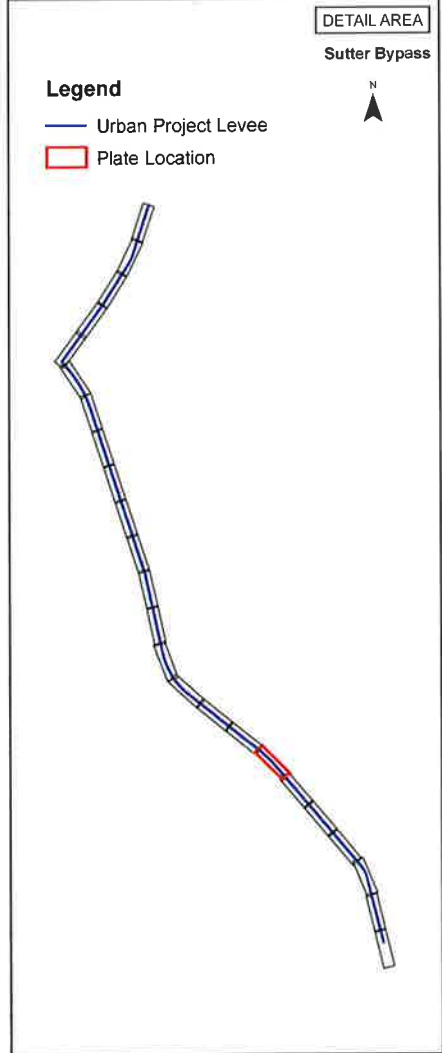
Sutter Bypass-Wadsworth Canal Plan and Profile
Station 1800+00 to Station 1850+00
Sutter Bypass

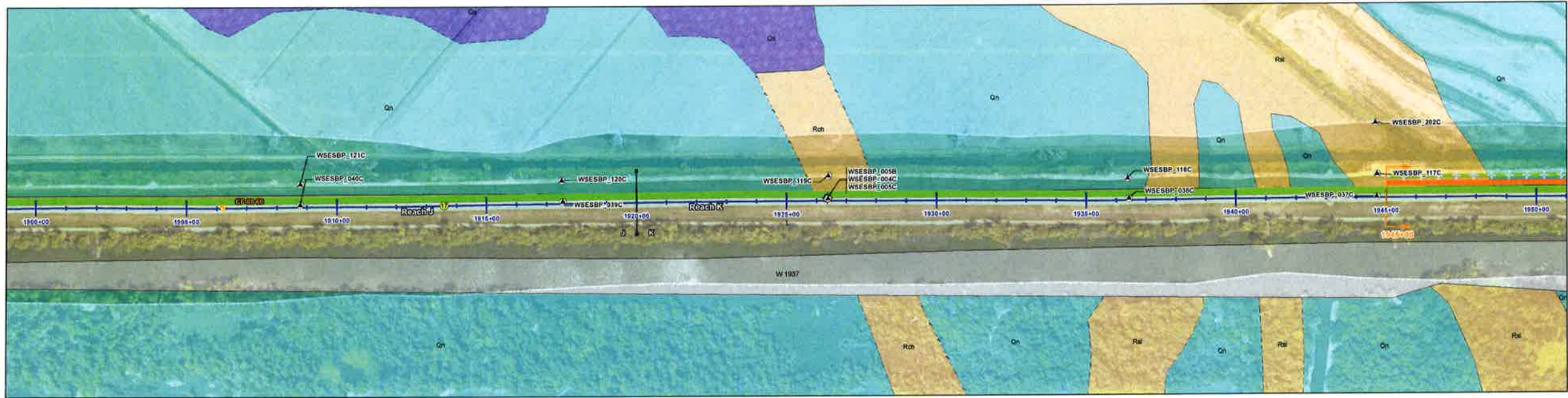
URBAN LEVEE EVALUATIONS

Plate
19



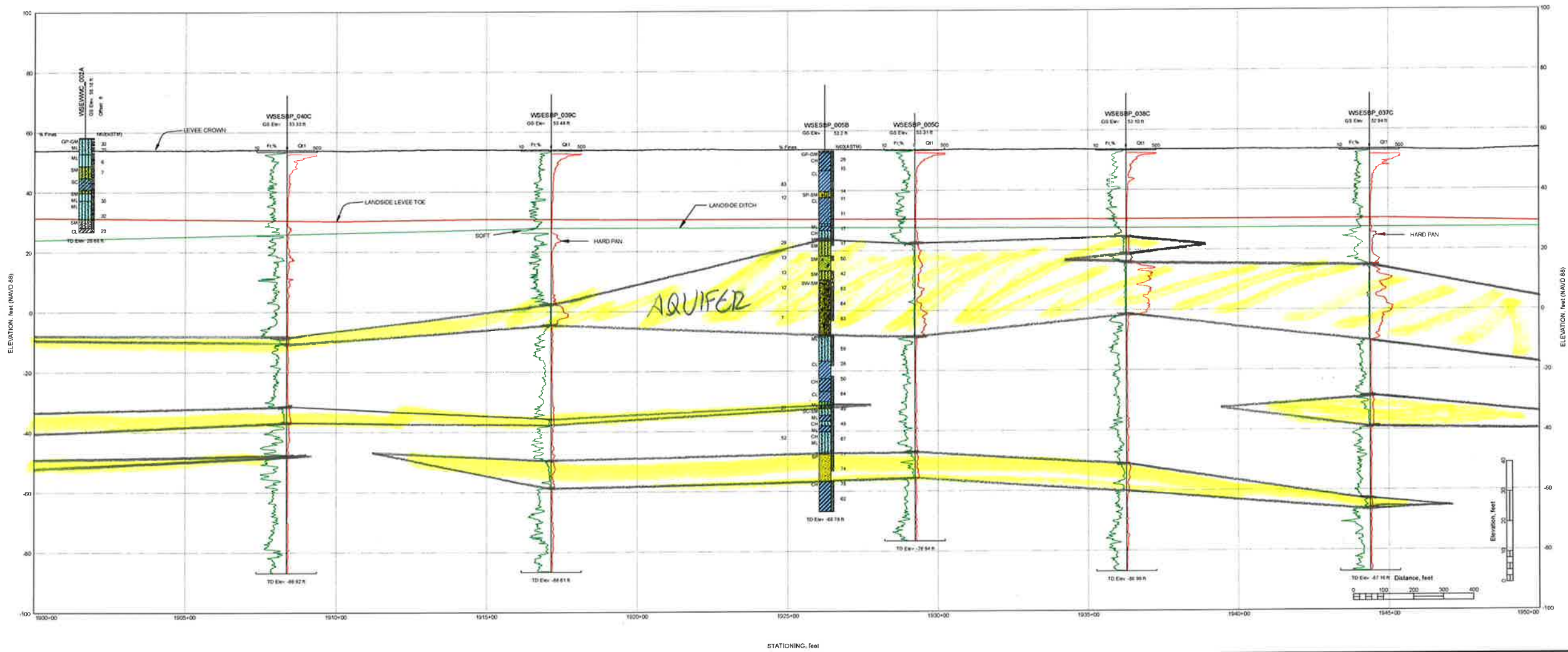
- NOTES:
1. Elevations of levee crown, landside toe, and landside depression/ditch are approximate.
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 8. Surficial geology was mapped at 1:20,000.





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8. Surficial geology was mapped at 1:20,000.

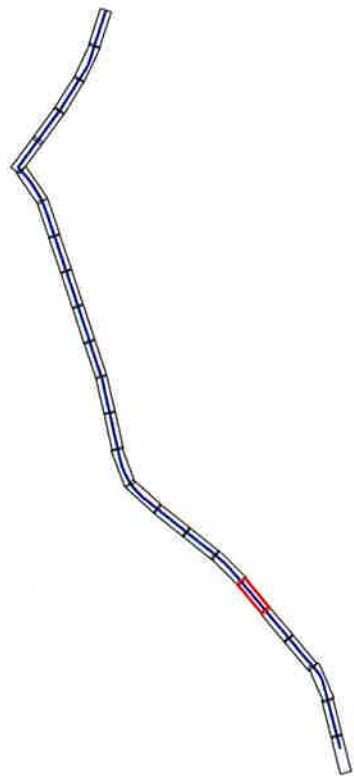


DETAIL AREA

Sutter Bypass

Legend

- Urban Project Levee
- Plate Location



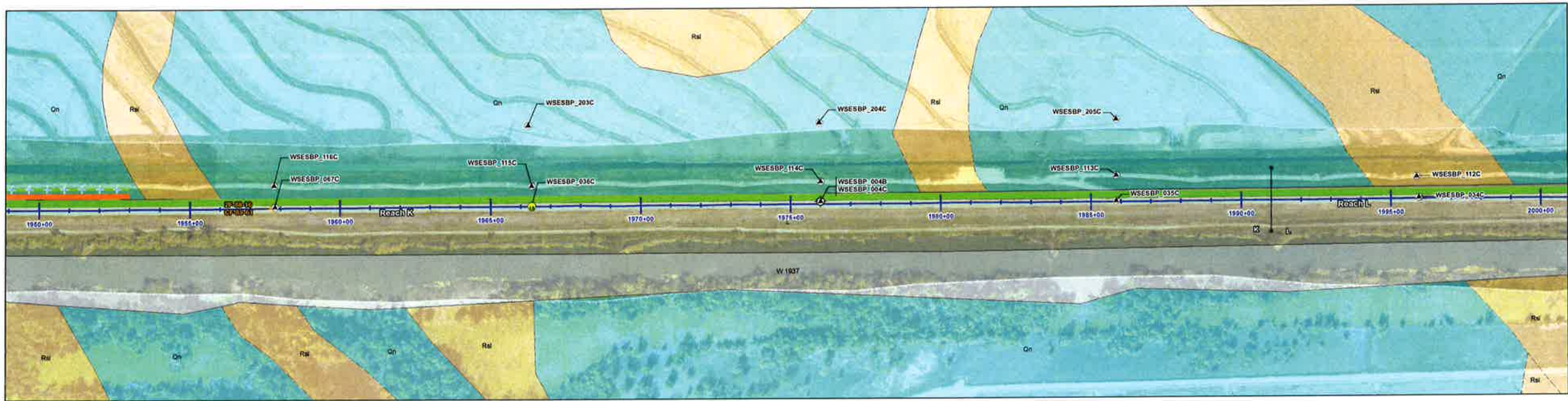
Department of Water Resources
Division of Flood Management

URS

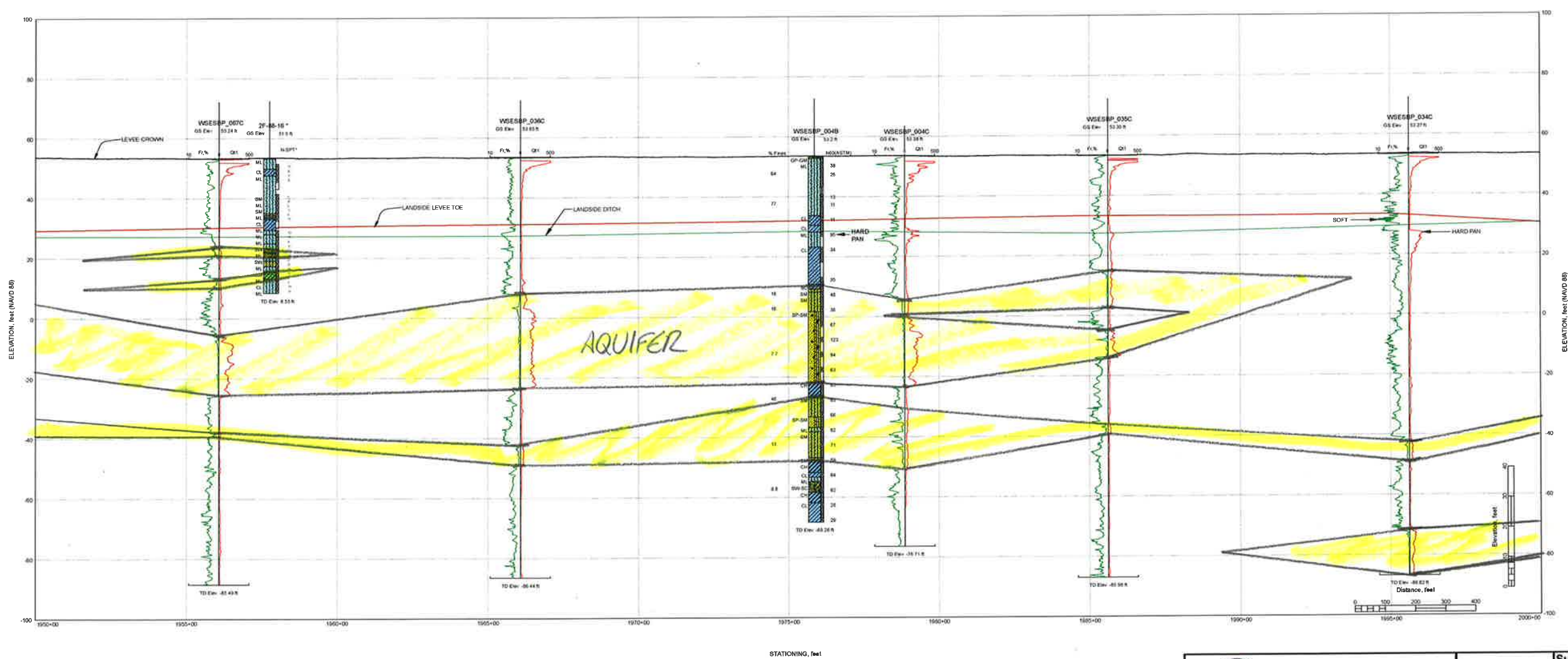
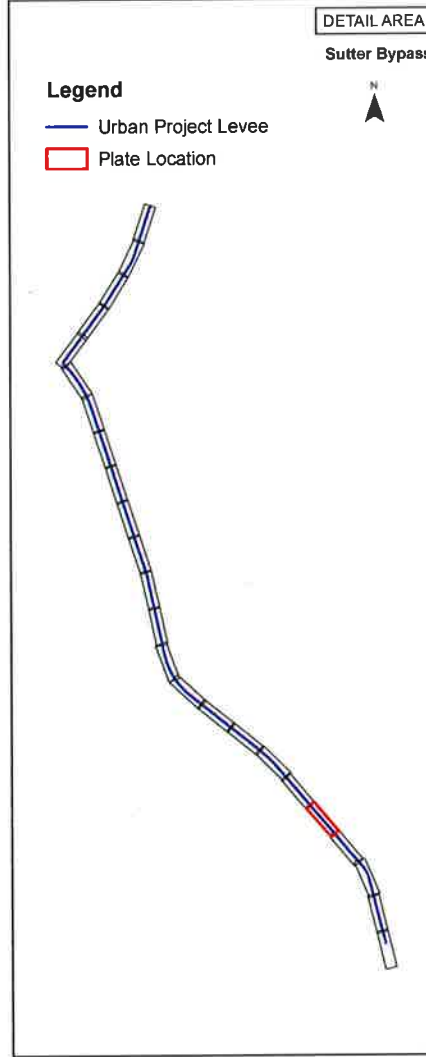
Sutter Bypass-Wadsworth Canal Plan and Profile
Station 1900+00 to Station 1950+00
Sutter Bypass

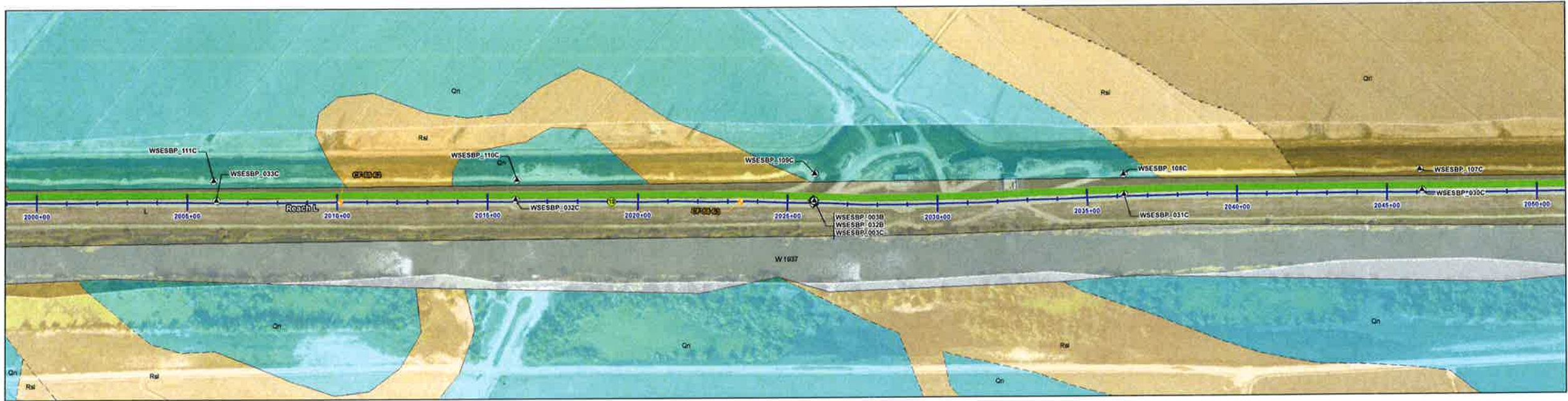
URBAN LEVEE EVALUATIONS

Plate
21



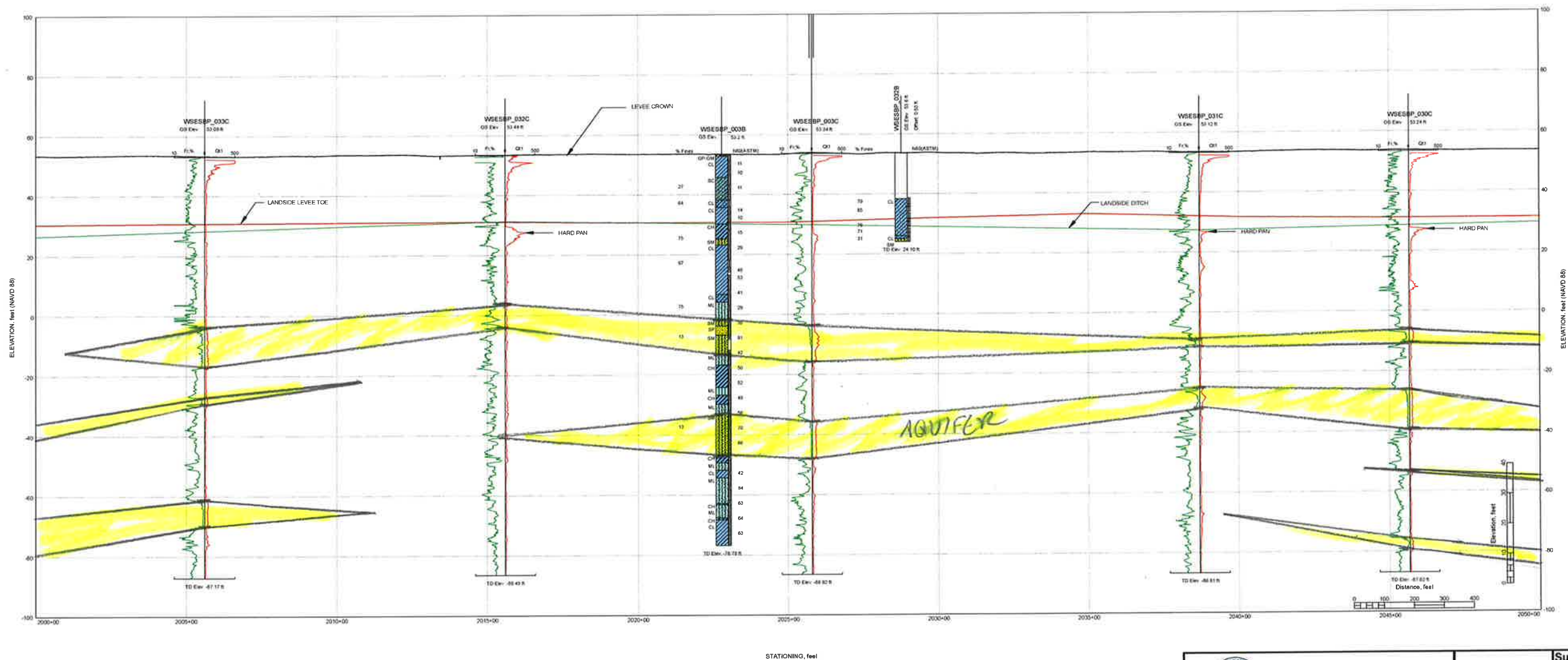
- NOTES:
1. Elevations of levee crown, landside toe, end landside depression/ditch are approximate.
 2. Stratigraphy between explorations may differ from that shown of exploration locations.
 3. Only explorations through the levee crown are shown on the profile.
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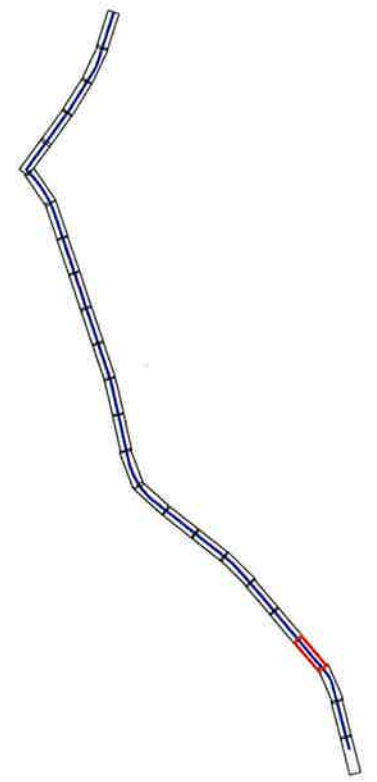


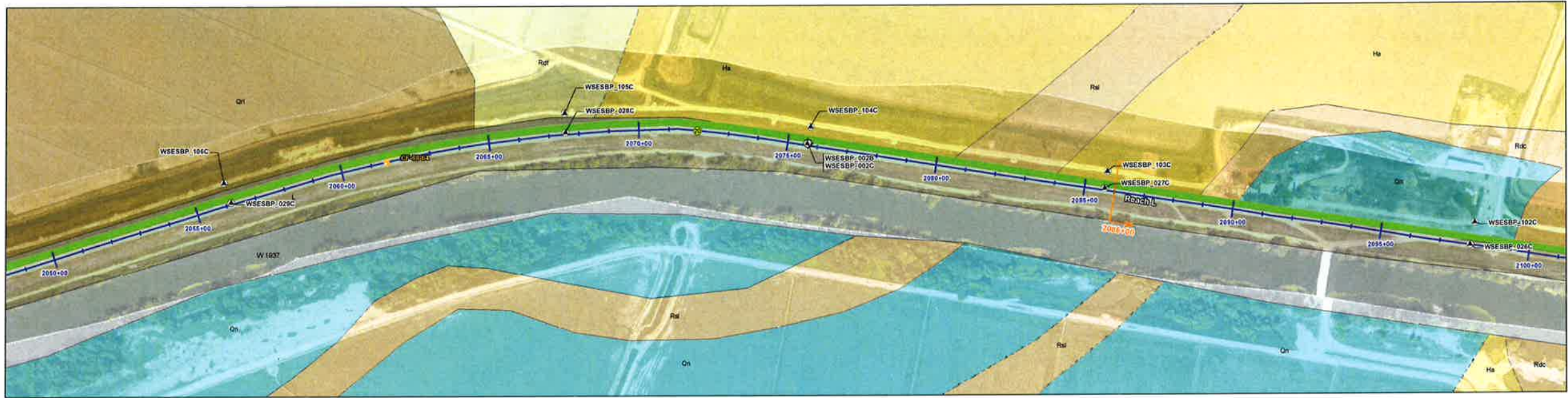
DETAIL AREA

Sutter Bypass

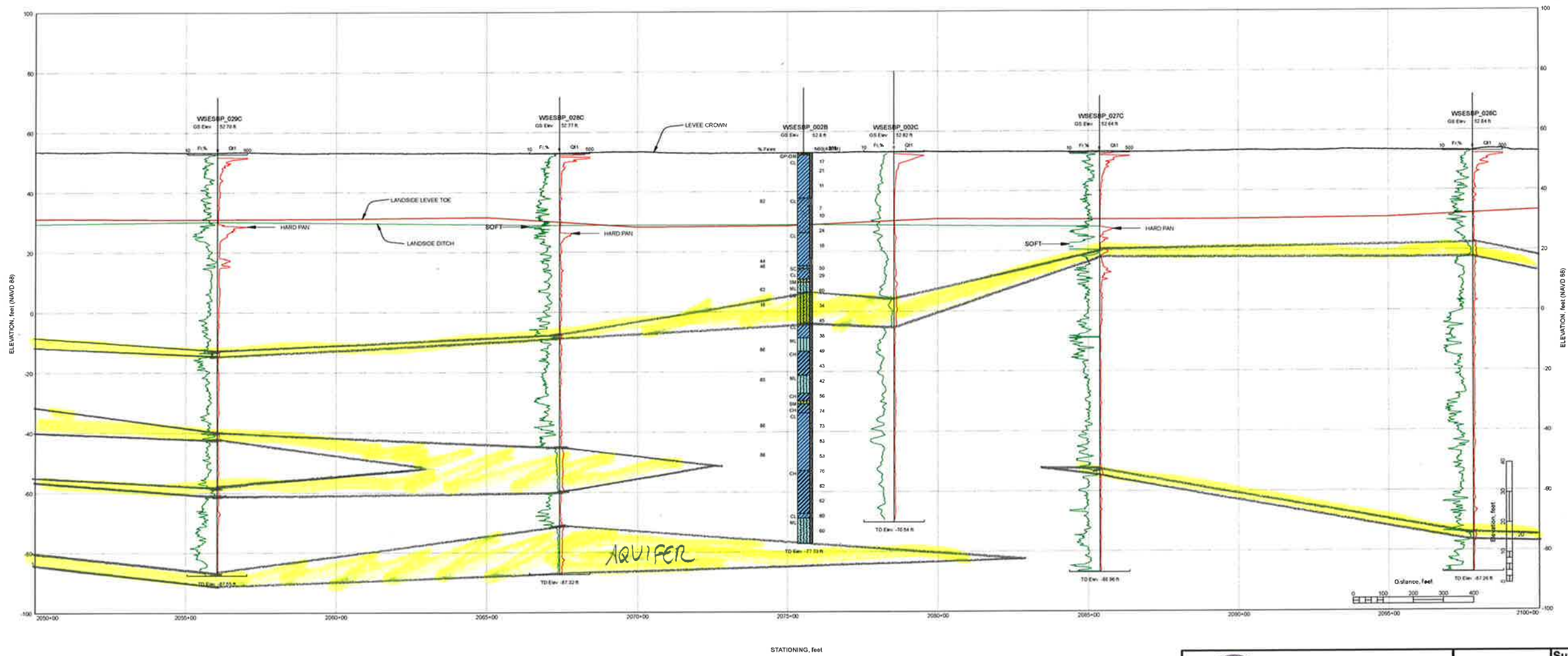
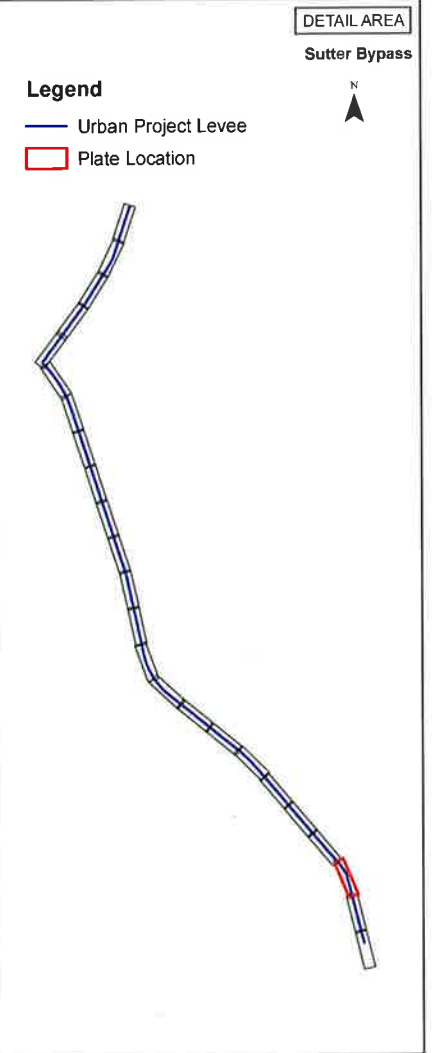
Legend

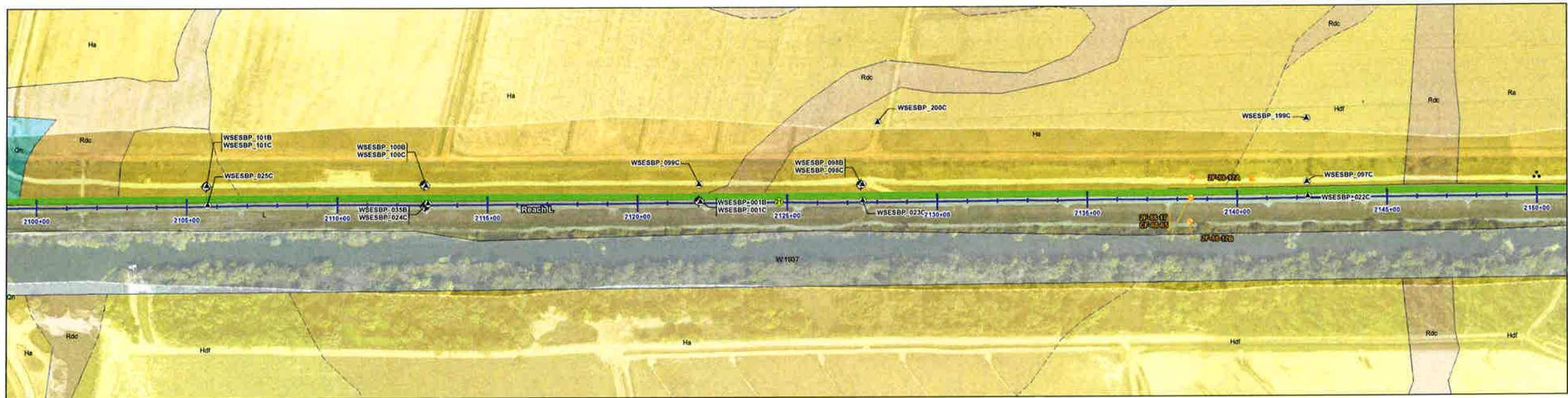
- Urban Project Levee
- Plate Location



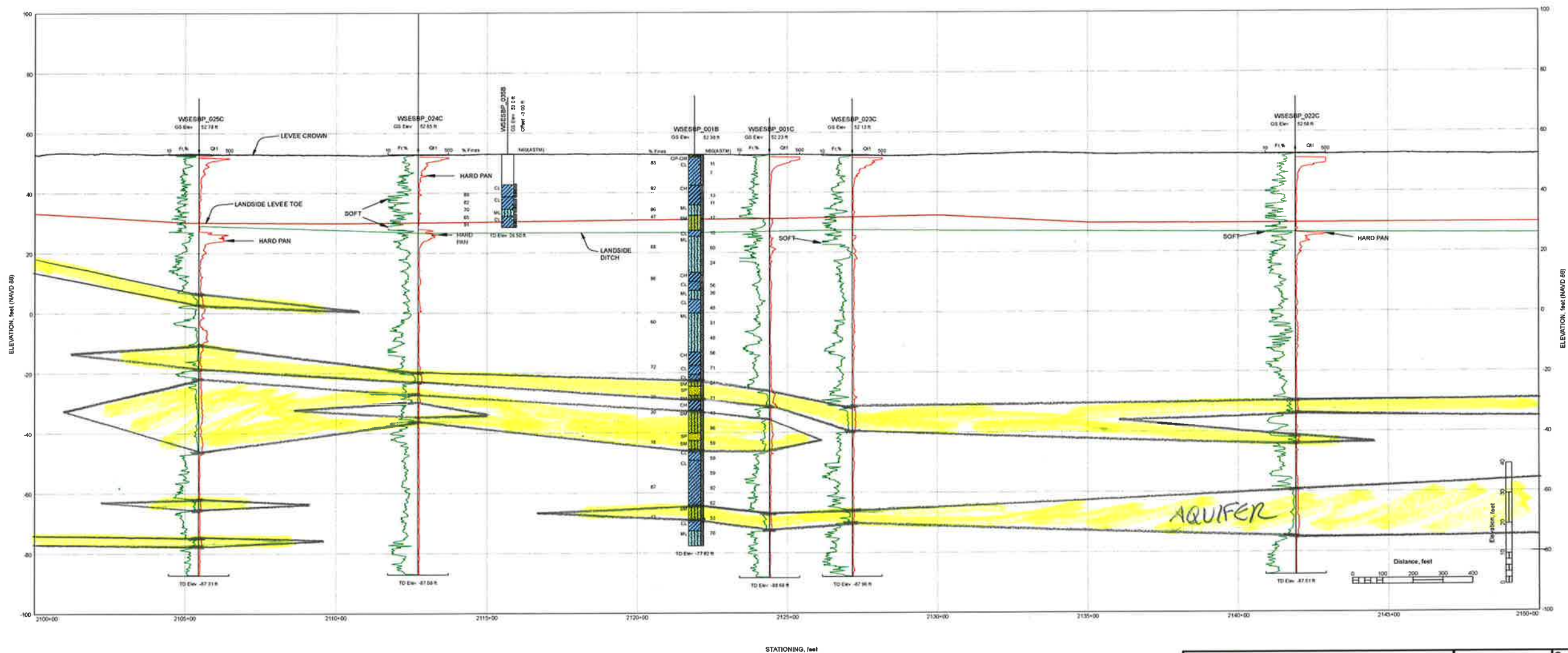
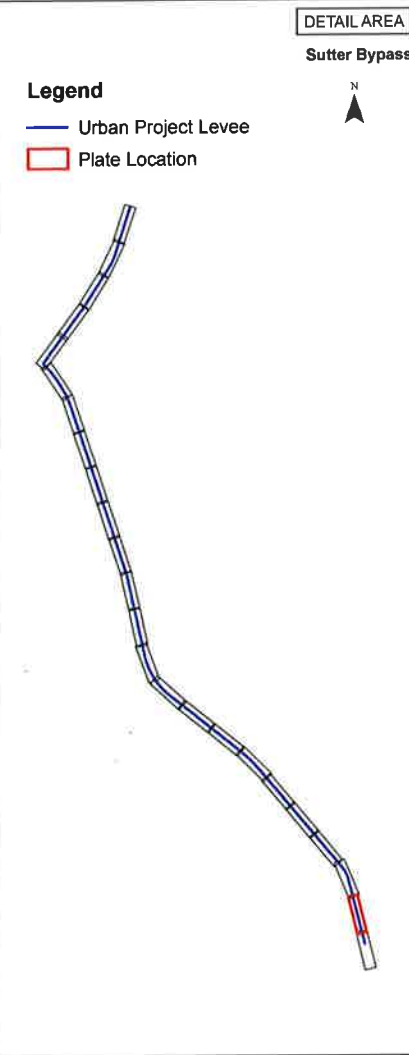


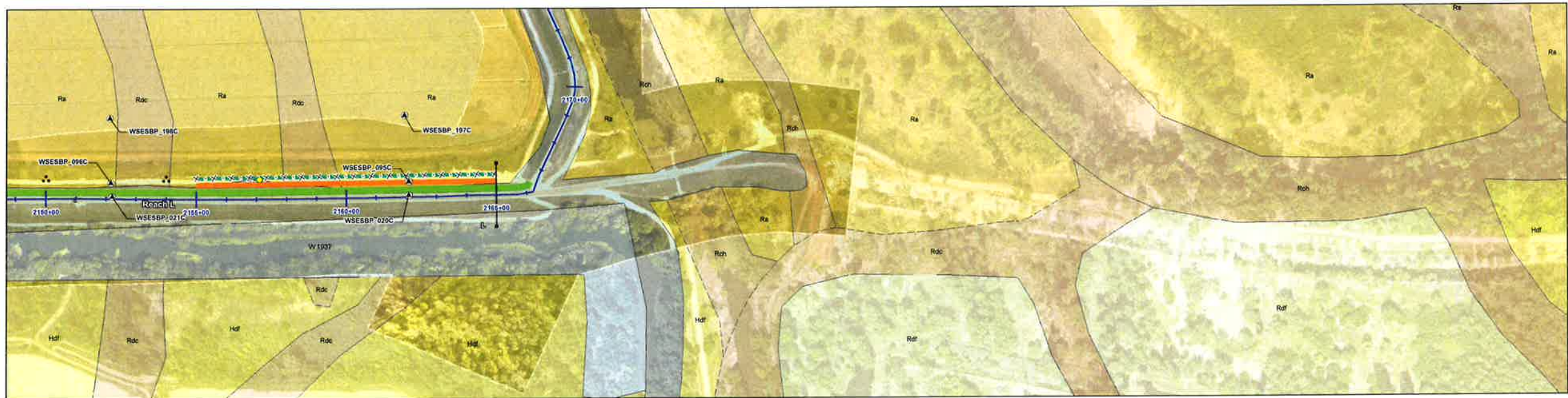
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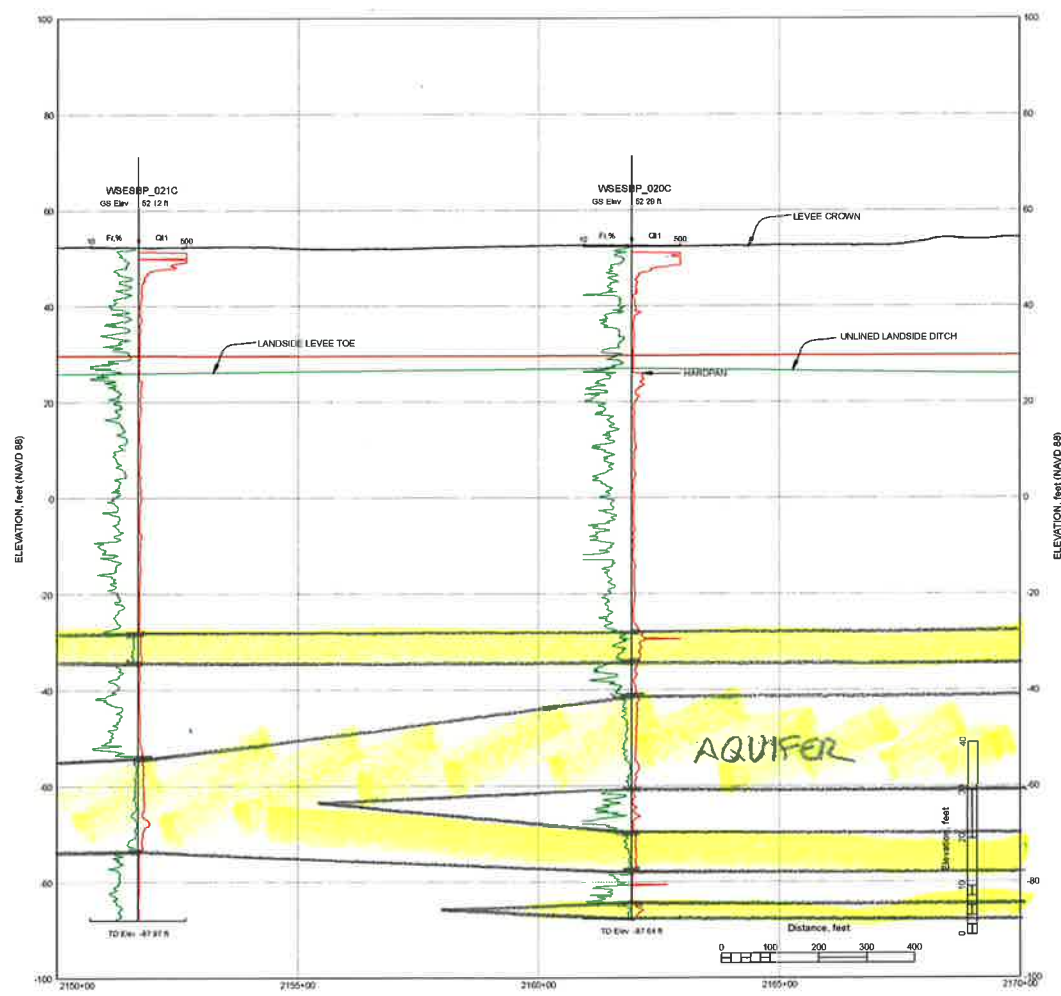
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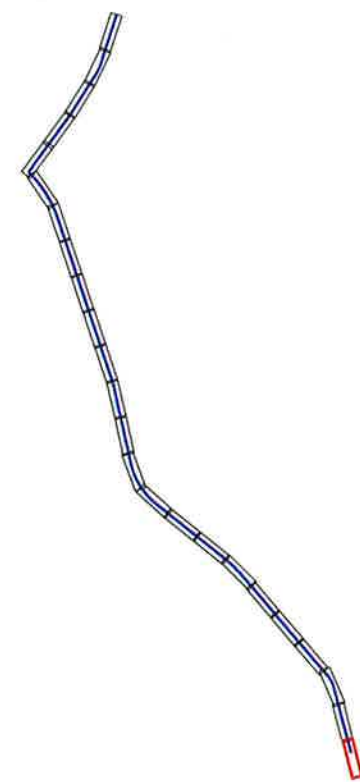


DETAIL AREA

Sutter Bypass

Legend

- Urban Project Levee
- Plate Location



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Sutter Bypass-Wadsworth Canal Plan and Profile
Station 2150+00 to Station 2166+22
Sutter Bypass

URBAN LEVEE EVALUATIONS

Plate
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Appendix 5-E
Wells from DWR Database, Specific Capacities, and
Estimated T and K Values

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Specific Capacity Calculations
Estimates of Transmissivity and Hydraulic Conductivity
Sutter Subbasin GSP

Data From DWR Webpage: <https://dwr.maps.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37>

Wells Completed in Aquifer Zone 1

Well Number	Well Location	Latitude	Longitude	Total Depth	Static Water Level	Total Drawdown	Pump Test Length	Pumping Rate	Specific Capacity	T (x200.52)	T (x 267.36)	Aquifer Zone	Thickness	K			
				Feet BGS	Feet BGS	Feet BGS	Hour	GPM	GPM/Ft	Ft/Day	Ft/Day		Ft	ft/day			
																x 1500	x 2000
WCR1995-005183	O'BANION RD	39.03262	-121.6626	60	6	35	8	600	17.14	3,437.49	4,583.31	1	150	23	31		
WCR2002-000570	3680 MAWSON RD	39.18167879	-121.9187762	60	11	50	1	200	4.00	802.08	1,069.44	1	150	5	7		
WCR2020-000998	2543 N Meridian RD	39.1620611	-121.9314566	65	8	20	40	700	35.00	7,018.20	9,357.60	1	150	47	62		
WCR2005-003899	3400 S BUTTE RD	39.14823668	-121.7099171	75	10	10	12	100	10.00	2,005.20	2,673.60	1	150	13	18		
WCR2019-011164	2833 Carmelita	39.1516936	-121.6679402	76	10.6	4	2	10	2.50	501.30	668.40	1	150	3	4		
WCR2010-000459	4912 BROADWAY	39.20234124	-121.6793316	80	10	80	2	50	0.63	125.33	167.10	1	150	1	1		
WCR2008-001304	6583 KENT AVE	39.22592	-121.64191	80	12	50	1	60	1.20	240.62	320.83	1	150	2	2		
WCR1995-005189	2272 SCHEIBER RD	38.91665737	-121.5666446	82	15	35	24	300	8.57	1,718.74	2,291.66	1	150	11	15		
WCR2012-000214	13184 S BUTTE RD	39.1461111	-121.8577778	88	18	60	2	50	0.83	167.10	222.80	1	150	1	1		
WCR2008-001384	7433 BURCH RD	39.01910958	-121.6492137	90	10	70	1	80	1.14	229.17	305.55	1	150	2	2		
WCR2011-000303	3705 MERIDIAN RD	39.18270902	-121.9393294	90	20	60	1	30	0.50	100.26	133.68	1	150	1	1		
WCR2004-004796	LOT 28 MAYOR RD	38.97442	-121.62558	95	58	8	12	25	3.13	626.63	835.50	1	150	4	6		
WCR2006-002741	2409 SCHEIBER RD	38.91188484	-121.5725354	95	10	16	5	45	2.81	563.96	751.95	1	150	4	5		
WCR2006-002865	2409 SCHEIBER RD	38.91674	-121.57021	95	10	16	5	45	2.81	563.96	751.95	1	150	4	5		
WCR2008-001311	BURCH RD	39.01182913	-121.6463455	99	19	60	8	1300	21.67	4,344.60	5,792.80	1	150	29	39		
WCR2006-002752	322 LEE RD	38.88147323	-121.6010323	100	8	21	4	35	1.67	334.20	445.60	1	150	2	3		
WCR2020-013577	None	39.110023	-121.72534	100	12	20	4	100	5.00	1,002.60	1,336.80	1	150	7	9		
WCR2019-012771	1779 Starr ST	39.0925217	-121.6478039	100	None	11	2	40	3.64	729.16	972.22	1	150	5	6		
WCR2019-011175	2611 Lincoln RD	39.1126113	-121.6642354	100	None	11	2	40	3.64	729.16	972.22	1	150	5	6		
WCR2008-001389	5272 FRANKLIN RD	39.12632497	-121.7142173	100	5	70	1	100	1.43	286.46	381.94	1	150	2	3		
WCR2019-011166	2717 Paseo RD	39.2528122	-121.6646209	100	12	7	1	10	1.43	286.46	381.94	1	150	2	3		
WCR2012-000308	3052 THOMPSON RD	38.99231418	-121.6768252	105	11	50	32.5	1500	30.00	6,015.60	8,020.80	1	150	40	53		
WCR2014-000103	174 LEE RD	38.8825313	-121.6062354	105	25	35	20	35	1.00	200.52	267.36	1	150	1	2		
WCR2006-002746	188 LEE RD	38.88242739	-121.6057253	105	12	21	4	26	1.24	248.26	331.02	1	150	2	2		
WCR2006-002747	220 LEE RD	38.88221964	-121.6047051	105	12	21	4	26	1.24	248.26	331.02	1	150	2	2		
WCR1990-007505	KARNACK RD	38.79913	-121.68223	105	None	40	1	40	1.00	200.52	267.36	1	150	1	2		
WCR2018-009923	None	39.2511562	-121.7289779	110	12	105	28	1000	9.52	1,909.71	2,546.29	1	150	13	17		
WCR2020-013147	None	38.981461	-121.653353	110	17	40	8	1200	30.00	6,015.60	8,020.80	1	150	40	53		
WCR2020-012008	5637 Seaton RD	39.2718	-121.71809	112	7	5	4	100	20.00	4,010.40	5,347.20	1	150	27	36		
WCR2008-001383	8851 GARDEN HWY	38.99968136	-121.6110539	115	18	60	1	50	0.83	167.10	222.80	1	150	1	1		
WCR2007-000582	None	38.87136953	-121.7022933	116	5	50	2	70	1.40	280.73	374.30	1	150	2	2		
WCR2011-000307	2941 RAILROAD AVE	39.08394536	-121.626216	118	30	60	4	100	1.67	334.20	445.60	1	150	2	3		
WCR2007-001067	None	38.86891486	-121.6103406	120	8	20	4	45	2.25	451.17	601.56	1	150	3	4		
WCR2010-000959	674 MORGAN ESTATES DR	39.07862192	-121.6186741	120	22	80	2	100	1.25	250.65	334.20	1	150	2	2		
WCR2008-001352	2082 PENNINGTON RD	39.27488926	-121.6528317	120	8	100	2	100	1.00	200.52	267.36	1	150	1	2		
WCR2008-001353	2351 PENNINGTON RD	39.2777034	-121.6573265	120	9	100	2	150	1.50	300.78	401.04	1	150	2	3		
WCR2018-000407	373 Shannon RD	39.0072827	-121.6105897	125	16	17.32	3	117	6.76	1,354.55	1,806.07	1	150	9	12		
WCR2010-000460	2198 FARMLAN RD	39.16288826	-121.9005293	130	12	53	30	2200	41.51	8,323.47	11,097.96	1	150	55	74		
WCR2004-005630	1198 3RD ST	39.14530641	-121.9150865	130	20	100	8	100	1.00	200.52	267.36	1	150	1	2		
WCR2007-001432	20832 CRANMORE RD	38.82443809	-121.7202187	130	20	80	4	500	6.25	1,253.25	1,671.00	1	150	8	11		
WCR2011-000299	980 OSWALD RD	39.06869717	-121.6268903	130	None	100	2	45	0.45	90.23	120.31	1	150	1	1		
WCR2013-000103	None	39.02994203	-121.6701727	130	15	70	2	200	2.86	572.91	763.89	1	150	4	5		
WCR1992-008199	None	39.18513397	-121.896449	135	20	21	48	600	28.57	5,729.14	7,638.86	1	150	38	51		
WCR2009-001111	833 TUDOR RD	39.00787811	-121.6208584	135	17	105	24	1800	17.14	3,437.49	4,583.31	1	150	23	31		
WCR2020-008504	O VARNEY RD	38.8892064	-121.6368468	135	16	10	8	250	25.00	5,013.00	6,684.00	1	150	33	45		
WCR1999-001083	933 BARRY RD #A	39.07687141	-121.6262527	135	18	60	8	1000	16.67	3,342.00	4,456.00	1	150	22	30		
WCR2020-009702	O VARNEY RD	38.889208	-121.636847	137	11	80	8	1200	15.00	3,007.80	4,010.40	1	150	20	27		
WCR2006-001088	None	39.18093503	-121.6920306	140	8	45	16	1000	22.22	4,456.00	5,941.33	1	150	30	40		
WCR2020-009284	O VARNEY RD	38.8868226	-121.6445662	140	8	102	8	1000	9.80	1,965.88	2,621.18	1	150	13	17		
WCR2012-003642	None	39.05696199	-121.7567986	140	5	40	8	2500	62.50	12,532.50	16,710.00	1	150	84	111		
WCR2011-000308	4545 NUESTRO RD	39.18654404	-121.6986425	140	6	60	4	80	1.33	267.36	356.48	1	150	2	2		
WCR2006-002438	40 W ONSTOTT FRONTAGE R	39.19338659	-121.6361534	140	20	60	2	60	1.00	200.52	267.36	1	150	1	2		
WCR2004-004377	1703 S MERIDIAN RD	39.10414572	-121.8994558	140	20	30	1	40	1.33	267.36	356.48	1	150	2	2		
WCR2007-001199	None	39.29429054	-121.8056304	140	55	120	1	200	1.67	334.20	445.60	1	150	2	3		
WCR2008-001356	956 MERIDIAN RD	39.14291617	-121.9175521	145	19	135	1	70	0.52	103.97	138.63	1	150	1	1		
WCR1991-005613	None	38.99560533	-121.5915619	145	None	25	0.5	20	0.80	160.42	213.89	1	150	1	1		
WCR2007-001785	None	39.14440193	-121.9000493	148	6	67	42.5	5000	74.63	14,964.18	19,952.24	1	150	100	133		
WCR2007-000573	2303 VALENCIA ST	39.15416302	-121.6581839	150	20	60	1	100	1.67	334.20	445.60	1	150	2	3		
								Average	10	1,975	2,634	-	-	13	18		
								Median	3	533	710	-	-	4	5		
								Maximum	75	14,964	19,952	-	-	100	133		
								Minimum	0.45	90.23	120.31	-	-	0.60	0.80		

Wells Completed in Aquifer Zone 2

Well Number	Well Location	Latitude	Longitude	Total Depth	Static Water Level	Total Drawdown	Pump Test Length	Pumping Rate	Specific Capacity	T (x200.52)	T (x 267.36)	Aquifer Zone	Thickness	K	
				Feet BGS	Feet BGS	Feet BGS	Hour	GPM	GPM/Ft	Ft2/Day	Ft2/Day		Ft	ft/day	
													x 1500	x 2000	
WCR1997-000769	21729 KNIGHTS RD	38.80864188	-121.7140711	153	6	8	2	40	5.00	1,002.60	1,336.80	1 to 2	150	7	9
WCR2007-000578	BISHOP AVE	39.25822558	-121.6506121	155	12	52	38	1200	23.08	4,627.38	6,169.85	1 to 2	150	31	41
WCR2012-000217	None	39.08219609	-121.6226287	155	40	80	4	90	1.13	225.59	300.78	1 to 2	150	2	2
WCR2011-000820	GARMIRE RD & GIRDNER RD	39.07759	-121.82803	157	6	50	56	4000	80.00	16,041.60	21,388.80	1 to 2	150	107	143
WCR2006-002179	3229 CAMINITO AVE	39.08109721	-121.6226272	160	15	80	4	80	1.00	200.52	267.36	1 to 2	150	1	2
WCR2005-004042	15710 CENTRAL ST	39.141215	-121.9063643	160	30	80	4	100	1.25	250.65	334.20	1 to 2	150	2	2
WCR2013-000096	1201 CIVIC CENTER BLVD	39.14543292	-121.6380236	160	17	80	4	300	3.75	751.95	1,002.60	1 to 2	150	5	7
WCR2008-001113	None	39.02992886	-121.6666952	160	18	80	2	200	2.50	501.30	668.40	1 to 2	150	3	4
WCR2009-001082	4443 BROADWAY	39.19510881	-121.6779474	160	15	45	1	70	1.56	311.92	415.89	1 to 2	150	2	3
WCR2009-001107	CLARK RD	39.22592	-121.64191	170	22	67	28	1300	19.40	3,890.69	5,187.58	1 to 2	150	26	35
WCR1991-000844	1691 CORSICA DR	39.15723416	-121.641697	170	None	31	0.5	30	0.97	194.05	258.74	1 to 2	150	1	2
WCR2014-000436	10925 KREHE RD	39.2894444	-121.7261111	175	8	40	8	1000	25.00	5,013.00	6,684.00	1 to 2	150	33	45
WCR2019-005702	1708 E Paseo AVE	39.2506128	-121.6438122	180	6	20	8	300	15.00	3,007.80	4,010.40	2	220	14	18
WCR2004-004233	CENTRAL ST.	39.1512	-121.90293	180	17	60	4	100	1.67	334.20	445.60	2	220	2	2
WCR2008-001305	9119 S BUTTE RD	39.15803059	-121.7823026	180	13	90	2	100	1.11	222.80	297.07	2	220	1	1
WCR2019-007479	2292 Tierra Buena RD	39.1604887	-121.6627441	180	None	3	2	20	6.67	1,336.80	1,782.40	2	220	6	8
WCR2013-000113	None	39.10288078	-121.6483068	180	32	80	2	190	2.38	476.24	634.98	2	220	2	3
WCR2008-001732	8921 S BUTTE RD	39.15821167	-121.7797725	186	33	35	8	30	0.86	171.87	229.17	2	220	1	1
WCR2018-004926	O GARDEN HWY	38.967104	-121.616182	190	14	123	8	6000	48.78	9,781.46	13,041.95	2	220	44	59
WCR2020-007682	O MARCUSE	38.9630156	-121.6161123	190	14.7	70	8	2000	28.57	5,729.14	7,638.86	2	220	26	35
WCR1997-006078	5087 S TOWNSHIP RD	39.05202017	-121.6945067	192	4	85	18	3000	35.29	7,077.18	9,436.24	2	220	32	43
WCR2014-001730	11 CYPRESS AVE	38.94826538	-121.5882352	195	22	69	5	1750	25.36	5,085.65	6,780.87	2	220	23	31
WCR2006-003037	10935 GLEDHILL RD	38.96854014	-121.621549	195	9	20	4	50	2.50	501.30	668.40	2	220	2	3
WCR2008-001307	3022 SANDERS RD	39.1977487	-121.6670223	195	18	77	3.5	1800	23.38	4,687.48	6,249.97	2	220	21	28
WCR2005-003519	STEWART RD	39.09118	-121.60675	198	25	68	16	1800	26.47	5,307.88	7,077.18	2	220	24	32
WCR2013-000107	3841 MAWSON RD	39.18537787	-121.9123859	200	10	41	26	1600	39.02	7,825.17	10,433.56	2	220	36	47
WCR2005-004035	16403 BURRIS RD	39.15456071	-121.9193635	200	15	100	4	150	1.50	300.78	401.04	2	220	1	2
WCR2003-000977	3934 BROADWAY	39.18740237	-121.679834	200	14	30	1	300	10.00	2,005.20	2,673.60	2	220	9	12
WCR2010-001077	None	39.11012862	-121.8311121	205	8	59	32	4000	67.80	13,594.58	18,126.10	2	220	62	82
WCR2014-000437	PASEO RD	39.24815207	-121.6705429	210	6	65	8	1000	15.38	3,084.92	4,113.23	2	220	14	19
WCR2007-001435	21711 KNIGHTS RD	38.80953396	-121.7140424	210	20	65	4	100	1.54	308.49	411.32	2	220	1	2
WCR2008-001299	None	39.28546248	-121.8869516	215	9	105	74	3000	28.57	5,729.14	7,638.86	2	220	26	35
WCR2002-000569	TOF FRONTAGE,E, N OF EAGE	39.1968	-121.64192	215	36	70	17	1200	17.14	3,437.49	4,583.31	2	220	16	21
WCR2009-001077	5236 BUTTE HOUSE RD	39.16123882	-121.7096227	222	6	81	24	4000	49.38	9,902.22	13,202.96	2	220	45	60
WCR2008-001385	3678 E BUTTE RD	39.18189905	-121.7211997	225	26	91	52	4500	49.45	9,915.82	13,221.10	2	220	45	60
WCR2009-001113	None	39.14686643	-121.7424419	225	19	60	38	1500	25.00	5,013.00	6,684.00	2	220	23	30
WCR2019-006771	2891 Paseo AVE	39.2504751	-121.6679899	225	7	78	20	900	11.54	2,313.69	3,084.92	2	220	11	14
WCR2019-007439	O paseo AVE	39.2503366	-121.6371429	225	8	28	8	300	10.71	2,148.43	2,864.57	2	220	10	13
WCR2009-001075	2760 ENCINAL RD	39.21648436	-121.6657935	227	13	93	15	700	7.53	1,509.29	2,012.39	2	220	7	9
WCR2013-000098	None	39.17817882	-121.6994276	240	6	56	37	2900	51.79	10,384.07	13,845.43	2	220	47	63
WCR2008-001110	6670 PENNINGTON RD	39.26811267	-121.7357304	240	1	100	2	250	2.50	501.30	668.40	2	220	2	3
WCR2019-007443	9413 S butte RD	39.1796728	-121.7896338	245	23	57	8	30	0.53	105.54	140.72	2	220	0.480	1
WCR2014-000441	None	39.19577205	-121.7031714	251	8	90	20	3200	35.56	7,129.60	9,506.13	2	220	32	43
WCR2007-001193	GIRDNER RD	39.07836	-121.86536	260	10	60	1	150	2.50	501.30	668.40	2	220	2	3
WCR2000-006758	5087 S TOWNSHIP RD	39.05202017	-121.6945067	262	7	65	2	700	10.77	2,159.45	2,879.26	2	220	10	13
WCR2008-001355	None	39.27778204	-121.7003741	275	7	68	24	1500	22.06	4,423.24	5,897.65	2	220	20	27
WCR2006-002186	None	39.0702972	-121.872433	280	15	60	4	2500	41.67	8,355.00	11,140.00	2	220	38	51
WCR2010-000958	2661 ENCINAL RD	39.21878373	-121.6630068	285	13	71	71	2000	28.17	5,648.45	7,531.27	2	220	26	34
WCR2009-001080	5852 BOGUE RD	39.09666271	-121.7219911	285	4	59	45.5	5000	84.75	16,993.22	22,657.63	2	220	77	103
WCR2011-000300	PASS RD	39.17767406	-121.7625015	285	37	135	24	210	1.56	311.92	415.89	2	220	1	2

Wells Completed in Aquifer Zone 3

Well Number	Well Location	Latitude	Longitude	Total Depth	Static Water Level	Total Drawdown	Pump Test Length	Pumping Rate	Specific Capacity	T (x200.52)	T (x 267.36)	Aquifer Zone	Thickness	K		
				Feet BGS	Feet BGS	Feet BGS	Hour	GPM	GPM/Ft	Ft2/Day	Ft2/Day		Ft	ft/day		
WCR1995-001276	2787 ENNIS RD	39.08724284	-121.8098937	480	12	129	6	2514	19.49	3,907.81	5,210.41	3	220	x 1500	x 2000	
WCR1995-001273	GARMIRE RD	39.06307	-121.82819	480	7	76	6	3008	39.58	7,936.37	10,581.83	3	220	36	48	
WCR2011-000310	8887 BIGELOW RD	39.29005432	-121.7781939	515	None	95	25	3300	34.74	6,965.43	9,287.24	3	220	32	42	
WCR2020-007645	None	38.993562	-121.785879	600	12.8	90.9	12	4000	44.00	8,823.76	11,765.02	3	220	40	53	
WCR2020-007653	None	38.985528	-121.7525	610	12.7	113.6	12	3800	33.45	6,707.54	8,943.38	3	220	30	41	
WCR2020-006713	None	38.990364	-121.782893	610	12	81	8	4200	51.85	10,397.33	13,863.11	3	220	47	63	
WCR2020-007067	None	38.987121	-121.778275	630	10.1	87.4	24	5500	62.93	12,618.54	16,824.71	3	220	57	76	
WCR2009-001108	None	39.25665072	-121.7146216	680	16	100	20	3700	37.00	7,419.24	9,892.32	3	220	34	45	
WCR1998-003770	PASS ROAD	39.19193	-121.93306	700	61	197	52	888	4.51	903.87	1,205.16	3	220	4	5	
WCR2010-002358	6900 S BUTTE RD	39.1494	-121.75397	930	9	98	37	2000	20.41	4,092.24	5,456.33	3	220	19	25	
								Average	35	6,977	9,303	-	-	32	42	
								Median	36	7,192	9,590	-	-	33	44	
								Maximum	63	12619	16825	-	-	57	76	
								Minimum	4.51	904	1205	-	-	4	5	

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Appendix 5-F
C2VSimFG-Sutter Model Report

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Model documentation in progress and to be included as part of final GSP document.

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Appendix 5-G
AEM Data Reprocessing

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AEM data reprocessing in progress and to be included as part of final GSP document.

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