07 June 2021

TECHNICAL MEMORANDUM

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Carol Mahoney (Zone 7)

From: Anona Dutton, PG, CHg (EKI Environment & Water, Inc. [EKI])
Aaron Lewis (EKI)
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Subject: **Draft Geologic Cross-Sections for 2022 Alternative Groundwater Sustainability Plan** (EKI C00065.00)

EKI Environment & Water, Inc. (EKI) is pleased to provide to Zone 7 Water Agency (Zone 7) a revised draft technical memorandum presenting three geologic cross-sections of the Livermore Valley Groundwater Basin (Basin) and accompanying written descriptions. Pursuant to our approved scope of work, EKI's work efforts include application of 3D geologic modeling software to develop three cross-sections for the Basin. A final version of these cross-sections and accompanying descriptions is anticipated to be included in the Basin Setting section of the 2022 Alternative Groundwater Sustainability Plan (Alt GSP).

BACKGROUND

Pursuant to Title 23, Section 358.2(a) of the California Code of Regulations (23-CCR §358.2(a)), Groundwater Sustainability Agencies (GSAs) with an approved Alternative Groundwater Sustainability Plan (Alt GSP or Plan) must resubmit an updated Plan to the California Department of Water Resources (DWR) every five years. As part of the five-year update process to the 2016 Alt GSP, Zone 7 contracted EKI to extend the existing Hydrogeologic Conceptual Model (HCM) framework to encompass the entirety of the Basin and to subsequently develop three geologic cross-sections of the Basin for subsequent inclusion in the 2022 Alt GSP. The cross-section locations are shown on Figure 1. A map of the surficial geology, major fault structures, and streams that were incorporated into the cross-sections are shown on Figure 2.

As described in EKI's *Progress Update on Extending Existing Hydrogeologic Framework* (dated 02 April 2021), the RockWorks[1] three-dimensional (3D) geologic modeling software platform was selected by Zone 7 to support data integration, HCM representation, and cross-section development. EKI has further refined the 3D geologic model in Rockworks and imported draft cross-section outputs into the AutoCAD[2] software program to assist in developing cross-section figures for inclusion in the 2022 Alt GSP. Two

[1] RockWorks 2020 Standard Level License from RockWare is downloaded and installed on 15 October 2020: https://www.rockware.com/product/rockworks/

[2] https://www.autodesk.com/products/autocad/overview?term=1-YEAR&support=null

versions of the geologic cross-sections are included in this technical memorandum. The first version includes all nearby borehole lithology and geophysical data used to inform cross-section development (see Figures 3a, 4a and 5a). The second version presents the total depth and screen intervals of Zone 7's nearby municipal and SGMA monitoring wells and labels the principal surface water features encountered along each trace (see Figures 3b, 4b, and 5b). Accompanying each cross-section is a written description documenting the principal geologic features, as well as the assumptions and references used to inform cross-section development. Also provided is a simplified schematic of the conceptual hydrostratigraphic model of the Basin (see Figure 6).

GEOLOGIC CROSS-SECTION A-A'

Cross-Section A-A' depicts a generally west-to-east trace through the Basin (see Figures 3a and 3b). The trace begins just west of the southwestern Basin boundary near the Calaveras Fault deformation zone and progresses eastward through the Main Basin Management Area (including the Castle, Bernal, Amador, and Mocho II subareas), where a majority of groundwater production occurs in the Basin. The trace cuts directly through a narrow corridor of alluvium connecting the Mocho II and Mocho I subareas (an area commonly referred to as "The Gap") and continues through the southern portion of the Eastern Fringe Management Area (including the Mocho I and Spring subareas) before terminating in the Uplands Management Area just west of the Greenville Fault deformation zone.

After crossing the main deformation zone of the Calaveras Fault and entering the Basin, Cross-Section A-A' cuts through the Castle subarea, which consists of "uplands underlain by the Livermore Formation and… adjacent valley fill material" (DWR 1974). Here, the Upper Aquifer is comprised of Holocene alluvial deposits ranging from approximately 50 to 75 feet thick. Most of the wells in the Castle Subarea draw from the upper 100 to 200 feet of Plio-Pleistocene Livermore Formation, which is present "as a sequence of gravel, sand, and silt interlayered by clay" (DWR 1974). This productive upper zone of the Livermore Formation (herein referred to as the "Upper Livermore Formation") comprises the Lower Aquifer in the area. "All of these materials apparently slope toward the valley at dips ranging up to ten degrees" (DWR 1974).

Cross-Section A-A' subsequently passes over another presumed splay of the Calaveras Fault and enters the Bernal subarea, which acts as the point of convergence for all major streams and subsurface flows that eventually drain the Basin via the Arroyo de La Laguna. Here, a confining surficial clay unit exists reaching up to 70 feet thickness (herein referred to as the "Overburden"). Beneath the Overburden is the Upper Aquifer, which is comprised of a 50 to >100-foot sequence of unconsolidated, Holocene sandy gravel and silty/clayey gravel deposits. Beneath the Upper Aquifer is a laterally extensive lacustrine clay and silt unit of up to 50 feet thick (herein referred to as the "Aquitard"). Below the Aquitard is a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts (Norfleet 2004). These Quaternary (Pleistocene-Holocene) deposits are believed to represent a "structurally influenced, incised channel complex" deposited by the ancestral Arroyo Mocho stream (Norfleet 2004) and are encountered up to >400 feet below ground surface (ft bgs) in the area (DWR 1974). Underlying the Quaternary fluvial and alluvial deposits is the Upper Livermore Formation, for which up to 200 feet is considered productive due to sufficient weathering and permeability relative to the more consolidated zones of the Lower Livermore Formation. The combined sequence of Quaternary alluvial/fluvial deposits and the Upper Livermore Formation are known collectively as the Lower Aquifer in the Main Basin. Well production (primarily by Zone 7 and the City of

Pleasanton) in this subarea ranges up to 3,500 gallons per minute (gpm) and specific capacities range from 3 to 260 gpm per foot of drawdown.

The trace subsequently crosses into the Amador subarea, whereby a majority of groundwater production occurs in the Basin. The Overburden is present in the western half of the Amador subarea, extending east approximately to the Chain of Lakes mining area, creating semi-confined conditions in the Upper Aquifer where it is present. Beneath the Overburden are Holocene alluvial deposits of the Upper Aquifer, which reach depths of up to 190 ft bgs in the subarea (and approximately 150 feet underlying Cross-Section A-A'). Here, the Upper Aquifer is consistent with the "Cyan" stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies. The Aquitard is present below the Upper Aquifer at a thickness of up to 50 ft under the Chain of Lakes area, before gradually thinning to the east. This unit is consistent with the "Grey Clay" sequence defined in the Norfleet (2004) and Zone 7 (2011) studies and serves to create semi-confined to confined conditions in the underlying Lower Aquifer. As in the Bernal Subarea, Lower Aquifer units in the western portion of the Amador subarea are comprised of up to 400 feet of interbedded, Quaternary alluvial/fluvial deposits (consistent with the "Grey" and "Purple" sequences from Norfleet (2004) and Zone 7 (2011)), underlain by 200-300 feet of productive Upper Livermore deposits (consistent with the "Red" sequence in Norfleet (2004)and Zone 7 (2011)). The Basin reaches a maximum depth of >800 feet in the central Amador subarea near the Chain of Lakes mining pits. Well production (primarily by Zone 7 and the City of Pleasanton) in this subarea ranges from 42 to 2,820 gpm and specific capacities range from 1.1 to 217 gpm per foot of drawdown.

Moving further east through the Amador Subarea, Cross-Section A-A' eventually reaches the Livermore Thrust fault zone, which presents a significant unconformity that serves to restrict groundwater flow from the Mocho II subarea to the Amador subarea. According to Norfleet (2004):

> *"The Livermore Thrust ha[s] a westward motion and dip[s] at a high angle to the east. [It] dies out rapidly to the north and do[es] not extend all the way across the current Livermore Valley. Evidence for the Livermore fault was discussed in Thomas et al. (1959) and DWR (1963, 1966, and 1974). The fault has historically been considered to be a strike-slip fault, but the data are more consistent with an east dipping, west-moving thrust fault. The Livermore thrust cut and uplifted Livermore Gravels, suggesting that the fault developed after deposition of the classical Livermore Gravels." (Norfleet 2004)*

Several varying interpretations exist in the literature regarding the nature and extent of this fault and the degree to which it impedes groundwater flow. In their Bulletin-118 description of the Basin, DWR notes:

> *"The Livermore [Thrust] is an effective barrier to ground water inflow from the Mocho subbasin except in the vicinity of the ancestral channel of Arroyo Mocho north of Oak Knoll, where ground water moves across this fault essentially unimpeded" (DWR 1974).*

Cross-Section A-A' traces north of Oak Knoll, within the ancestral Arroyo Mocho paleochannel. However, based on nearby water level observations collected in Fall 2019, an apparent 80-foot drop in groundwater elevation is observed in the Lower Aquifer moving westward across the fault, indicating that some degree of hydraulic restriction occurs across the fault zone in this area. Notably, this groundwater flow barrier across the fault is not observed in the Upper Aquifer.

The total depths of wells in the Mocho II subarea east of the Livermore Thrust suggest that the base of the Lower Aquifer (i.e., the bottom of the productive Upper Livermore Formation) is encountered 200-

300 feet higher in this subarea than in the Amador subarea west of the fault, indicating a significant discontinuity likely exists in the Lower Aquifer formations even within the incised ancestral Arroyo Mocho channel complex resulting from uplift on the eastern side of the fault. A relatively lower proportion of "clean gravels" is also observed east of the Livermore Thrust, resulting in lower productivity of the Lower Aquifer in the Mocho II subarea (Norfleet 2004). Upper Aquifer deposits progressively thin to around 50 feet thickness moving east through Mocho II subarea. The Aquitard and underlying Quaternary deposits gradually diminish as the trace moves further east outside the ancestral Arroyo Mocho paleochannel, and eventually disappear before reaching the Mocho II – Mocho I boundary such that Pleistocene-Holocene alluvial deposits are directly underlain by deposits of the Upper Livermore Formation.

Another apparent steepening of the hydraulic gradient in the Lower Aquifer is observed west of the Mocho II – Mocho I boundary as deposits of the Upper Livermore Formation continue to reduce to a total depth of approximately 330 ft bgs at well 3S2E10Q002. A short distance to the east, a narrow, roughly 50-foot thick sequence of young alluvial deposits of the Arroyo Seco channel underlain by older, interbedded sand and gravel deposits of the Upper Livermore Formation connects the Main Basin to the Eastern Fringe Management Area in an alluvial channel known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south, also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within the Gap that serves to restrict the vertical cross-sectional area of connection between Upper and Lower Aquifer deposits in the Eastern Fringe Management Area and the Main Basin to the west (DWR 1974, LLNL 1984). There is considerable uncertainty to the degree which flow is restricted across The Gap, though Fall 2019 water level trends suggests this area acts as an apparent groundwater divide in both the Upper and Lower Aquifers.

As the trace of Cross-Section A-A' moves across The Gap and into the Mocho I subarea, Upper Livermore deposits again deepen to a total depth around 350 ft bgs at well 3S2E11R046 near the southwestern corner of the Lawrence Livermore National Laboratory (LLNL). A local depression in Fall 2019 groundwater elevations was observed in the Lower Aquifer in this area, likely due to groundwater pumping. These deposits then begin to dip upward to the northeast as the trace moves into the Spring subarea, reducing to a total depth of 175 ft bgs at well 3S2E12J025 on the southeastern side of LLNL (LLNL 1984). Here, the Upper Livermore deposits are described as a series of "beds of cemented gravel, sandy gravel, and sandy clay separated by beds of less-permeable clay and silty clay" (DWR 1974). Overlying Pleistocene-Holocene valley-fill materials in this area "are of similar composition to the sediments of the Livermore Formation, as they are composed principally of reworked Livermore Formation detritus" (DWR 1974). Both the valley-fill and underlying Livermore deposits continue to dip upward to the northeast before reaching the Las Positas Fault, which likely serves to truncate both the Upper and Lower Aquifers completely. The trace then briefly crosses into the Uplands Management Area, where the Lower Livermore Formation is the dominant outcropping unit and no significant groundwater production occurs, before ending at the southeastern Basin Boundary near the Greenville Fault zone.

GEOLOGIC CROSS-SECTION B-B'

Cross-Section B-B' depicts a generally northwest-to-southeast trace through the western portion of the Basin (see Figures 4a and 4b). The trace begins at the northwestern Basin boundary with the neighboring San Ramon Valley Groundwater Basin to the north. It runs southeast through the Western Fringe Management Area (including the Bishop, Dublin, and Camp subareas) before entering the Main Basin. Cross-Section B-B' then passes through a large section of the west-central Main Basin (Amador subarea) and continues southeast up the Arroyo del Valle stream corridor before terminating at the contact between the Amador subarea and the Southern Uplands Management Area near the southern Basin boundary.

The trace begins in the Bishop subarea of the Western Fringe Management Area, which contains "one of the deepest developed prisms of water-bearing materials in the Basin…[with] sediments up to 800 feet in depth" (DWR 1974). Surficial deposits are consistent with Holocene alluvial and fluvial sands and gravels, underlain by a thick sequence of relatively fine-grained deposits of the Pleistocene to Plio-Pleistocene Tassajara Formation. These contain "eight to ten separate zones of sand and gravel separated by zones of silt and clay" (DWR 1974). It is assumed that "the greater portion of the sediments below a depth of 100 feet are part of the Tassajara Formation" (DWR 1974). The Upper Aquifer is defined as the sequence of surficial Holocene alluvial deposits, while the Lower Aquifer in this subarea comprises the thicker underlying sequence of permeable Tassajara Formation deposits (herein referred to as the "Upper Tassajara Formation"). Groundwater production is relatively minimal in this subarea and thus few borehole lithologic and e-log data are available to more accurately delineate individual aquifer zones within the Upper Tassajara Formation.

Moving further to the southeast, Cross-Section B-B' enters the Dublin subarea of the Western Fringe Management Area. Here, deposits are very similar to those encountered in the Bishop subarea, containing an "essentially flat-lying" sequence of sediments with a "maximum depth of…about 800 feet" (DWR 1974). "Valley-fill materials lap northward onto older sediments of the Tassajara Formation", though the depth at which the Tassajara Formation meets younger alluvial deposits of the Upper Aquifer is not well understood in the area (DWR 1974). Based on available borehole lithology and e-log data, it appears the surficial clay layer (i.e., Overburden) encountered in the Main Basin as well as a laterally extensive clay layer (i.e., Aquitard) underlying the Upper Aquifer are encountered in the southern portion of the Dublin subarea.

After passing through the Dublin subarea, the trace makes a brief east-southeasterly turn and cuts through a small portion of the Camp subarea of the Western Fringe Management Area before moving southeast and entering the Main Basin (Amador subarea). The Camp subarea is similar in composition to the Dublin and Bishop subareas to the northwest, containing "beds of sandy clay and sandy gravel which overly the Tassajara Formation" (DWR 1974).

The Camp subarea is delineated from the Amador subarea of the Main Basin by an observed groundwater flow barrier described as the "Parks Boundary" (Norfleet 2004). The Parks Boundary was originally inferred as a fault in DWR's Bulletin-118 hydrostratigraphy summary based on significant variations in groundwater elevations between the Dublin/Camp subareas of the Western Fringe and the Bernal/Amador subareas of the Main Basin (DWR 1974). However, updated interpretations provided in the Norfleet (2004) hydrostratigraphy study suggest that the Parks Boundary represents a buried valley wall delineating the northern extent of the "structurally influenced, incised-channel complex" deposited by the ancestral Arroyo Mocho stream (Norfleet 2004). While the Holocene alluvial deposits of the Upper Aquifer and the underlying Aquitard appear to be generally consistent across the Parks Boundary, deposits in the Lower Aquifer south of the boundary consist of a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts (Norfleet 2004). These are underlain by the Upper Livermore Formation, as opposed to the Tassajara Formation north of the boundary. Based on nearby water level observations collected in Fall 2019, an apparent 30 to 40-foot drop in groundwater elevation is observed in the Lower Aquifer moving south across the Parks Boundary. Lower Aquifer deposits south of the Parks Boundary are known to be more productive than those north of the boundary, thus marking the southern edge of the Western Fringe Management Area and the northern edge of the Main Basin.

As Cross-Section B-B' moves southwards across the Parks Boundary and into the Main Basin, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel are encountered at depths up to 500 ft bgs. As mentioned above, these are underlain by deposits of the Upper Livermore Formation, which reach >200 feet thickness in the west-central portion of the Amador Subarea. Holocene alluvial deposits comprising the Upper Aquifer reach a maximum thickness of approximately 150 feet underlying the southern Chain of Lakes mining area within the subarea. Here, the Upper Aquifer is generally consistent with the "Cyan" stratigraphic sequence defined in the Norfleet (2004) and Zone 7 (2011) hydrostratigraphy studies, while the Aquitard comprises the "Grey Clay" sequence and the interbedded sequence of Quaternary alluvial/fluvial deposits comprise the "Grey" and "Purple" sequences. Deposits of the Upper Livermore Formation are generally consistent with the "Red" sequence mapped in the Norfleet (2004) and Zone 7 (2011) studies.

Moving southeast through the Amador Subarea, deposits from the incised channel-complex are found roughly up to Concannon Rd, where another water level lineation has historically been observed. Norfleet (2004) interpreted this area as the southern extent of the ancestral Arroyo Mocho paleochannel, and delineated this feature as the "Concannon Boundary". South of the Concannon Boundary, deposits of the ancestral Arroyo Mocho paleochannel are not readily apparent and permeable deposits of the Upper Livermore Formation appear to directly underly the Upper Aquifer and Aquitard. Groundwater conditions range from "unconfined to confined" in this area, with unconfined groundwater occur[ing] principally near the channel of Arroyo del Valle and in the uppermost aquifer" (DWR 1974).

Moving further southeast up the Arroyo del Valle stream corridor, the Upper Livermore Formation continues to dip upward to the south at an angle of one to three degrees (DWR 1974). "Many of the aquifers merge near the course of Arroyo del Valle, where the combined aquifers are present as a deposit of sandy gravel up to 300 feet in thickness" (DWR 1974). The Las Positas Fault, described as a "high-angle tear fault" that "cut and uplifted Livermore Gravels" south of the fault line (Norfleet 2004), may act as a disconformity in the Upper Livermore Formation as maximum well depths are roughly 200 ft bgs southeast of the fault line. This may also explain the apparent confinement observed in Fall 2019 Lower Aquifer water levels in the vicinity of the fault. However, the degree to which the Las Positas Fault acts as a hydraulic barrier to groundwater flow is uncertain given the current lack of lithologic and geophysical data proximate to the fault line. Recent alluvial deposits of the Arroyo del Valle stream corridor (i.e., Upper Aquifer) continue to thin with the Upper Livermore Formation (i.e., Lower Aquifer) before pinching out at the contact between the Amador subarea and the Southern Uplands, where the relatively impermeable Lower Livermore Formation begins to outcrop. This terminus in permeable deposits marks the effective southern edge of the Basin within the Arroyo del Valle stream corridor.

GEOLOGIC CROSS-SECTION C-C'

Cross-Section C-C' depicts a generally northwest-to-southeast trace through the eastern portion of the Basin (see Figures 5a and 5b). The trace begins at the northeastern Basin boundary and progresses southeastward through a portion of the Eastern Fringe Management Area (May and Spring subareas). The trace then makes a turn to the south and continues through the Eastern Fringe Management Area (Spring and Mocho I subareas) before cutting directly through a narrow corridor of alluvium connecting the Mocho I and Mocho II subareas (an area commonly referred to as "The Gap"). The trace then progresses further south through the Main Basin (Mocho II subarea), taking another southeasterly turn and continuing up the Arroyo Mocho stream corridor. It then briefly enters the Southern Uplands Management Area before terminating at the southern Basin boundary.

Cross-Section C-C' begins in the May subarea of the Eastern Fringe Management Area, where outcrops of the relatively impermeable Lower Tassajara Formation define the northern edge of the Basin. South of the Basin boundary, "ground water occurs only in limited amounts in a relatively thin veneer of valley-fill materials which overlie a thick section of sediments belonging to the Tassajara Formation" (DWR 1974). The Upper Aquifer is defined as the thin veneer of recent (Holocene) alluvium deposited from smaller streams, and "does not exceed 40 feet" thickness in the May subarea (DWR 1974). The Lower Aquifer consists of the permeable upper deposits of the Plio-Pleistocene Tassajara Formation (herein referred to as the "Upper Tassajara Formation") where a majority of groundwater production occurs in the area. The Upper Tassajara Formation is comprised of "beds of sand and gravel, clay and gravel, clay, and silty clay… which range up to 50 feet in thickness [and] dip southward at an average gradient of ten degrees." (DWR 1974). Based on nearby water level observations collected in Fall 2019, it appears water level conditions are semi-confined to confined within the Lower Aquifer in this area.

Cross-Section C-C' further progresses southeastward into the Spring subarea of the Eastern Fringe Management Area. Here, surficial deposits are very similar to those encountered in the May subarea, containing a thin veneer of recent alluvium (the Upper Aquifer) not exceeding 50 feet thickness. Deposits underlying the recent alluvium change in composition to reflect those of the Upper Livermore Formation, though the geometry of the contact between the Tassajara and Livermore Formations is not well understood in this area. Upper Livermore deposits in the Spring subarea are described as a "wedge-shaped sequence" of permeable deposits that increase in depth moving southward (DWR 1974). Upper Livermore deposits continue to deepen as the trace turns south and moves into the Mocho I subarea (LLNL 1984). The "valley-fill portion of the Mocho I province…consists of a heterogeneous mixture of gravelly fan detritus overlying truncated beds of the Livermore Formation" (DWR 1974).

The base of the Upper Livermore Formation deepens in a southerly direction along the Cross-Section C-C' trace through the Mocho I subarea to approximately 300 feet bgs while the upper surface of the formation stays within approximately 30 ft bgs (LLNL 1984). Northeast of well 3S2E10Q002 the trace crosses through a narrow alluvial channel connecting the Mocho I and Mocho II subareas, known colloquially as "The Gap". The Gap is surrounded by outcrops of the relatively impermeable Lower Livermore Formation to the north and south (i.e., out of the plane of the Cross-Section), also known as Livermore Uplands. These outcrops are connected by way of a buried ridge of Lower Livermore Formation within The Gap that serves to restrict the vertical cross-sectional area of connection between Upper and Lower Aquifer deposits in the Eastern Fringe Management Area and the Main Basin to the southwest (DWR 1974, LLNL 1984). There is considerable uncertainty in the degree to which flow is restricted across The Gap, though recent water level trends suggest this area acts as an apparent groundwater divide in both the Upper and Lower Aquifers.

After moving across The Gap, Cross-Section C-C' progresses south through the Mocho II subarea of the Main Basin. Here, "the valley-fill materials become separated into identifiable strata consisting of beds of sandy gravel and cemented gravel separated by beds of silt and clay" (DWR 1974). In this area, Cross-Section C-C' encounters a thicker sequence of braided fluvial and deltaic "clean gravel" and sand deposits interbedded with fluvial overbank and floodplain clays and silts known to be deposited by the ancestral Arroyo Mocho paleochannel throughout much of the Main Basin (Norfleet 2004). Based on nearby water level observations collected in Fall 2019, it appears this thicker sequence of Quaternary alluvial/fluvial deposits creates some degree of confinement in the Lower Aquifer in the area.

As the trace turns to the southeast and begins traveling up the Arroyo Mocho stream corridor, Cross-Section C-C’ travels over the Las Positas Fault. The Las Positas Fault may present an unconformity in the Upper Livermore Formation, though the degree to which it acts as a hydraulic flow barrier in the Lower Aquifer is not well understood.

As Cross-Section C-C’ moves further southeast up the Arroyo Mocho stream corridor, the Quaternary alluvial/fluvial deposits of the ancestral Arroyo Mocho paleochannel pinch out and disappear. Here, the recent alluvial deposits of the Arroyo Mocho are underlain directly by semi-consolidated deposits of the Upper Livermore Formation. These deposits progressively thin moving up the stream corridor until they pinch out at the contact between the Mocho II subarea and the Southern Uplands Management Area. At this point, the relatively impermeable Lower Livermore Formation begins to outcrop, marking the effective southern edge of the Basin in the Arroyo Mocho stream corridor. Cross-Section C-C’ further travels a short distance through the Southern Uplands Management Area before reaching the southern Basin boundary.

LIST OF FIGURES

REFERENCES

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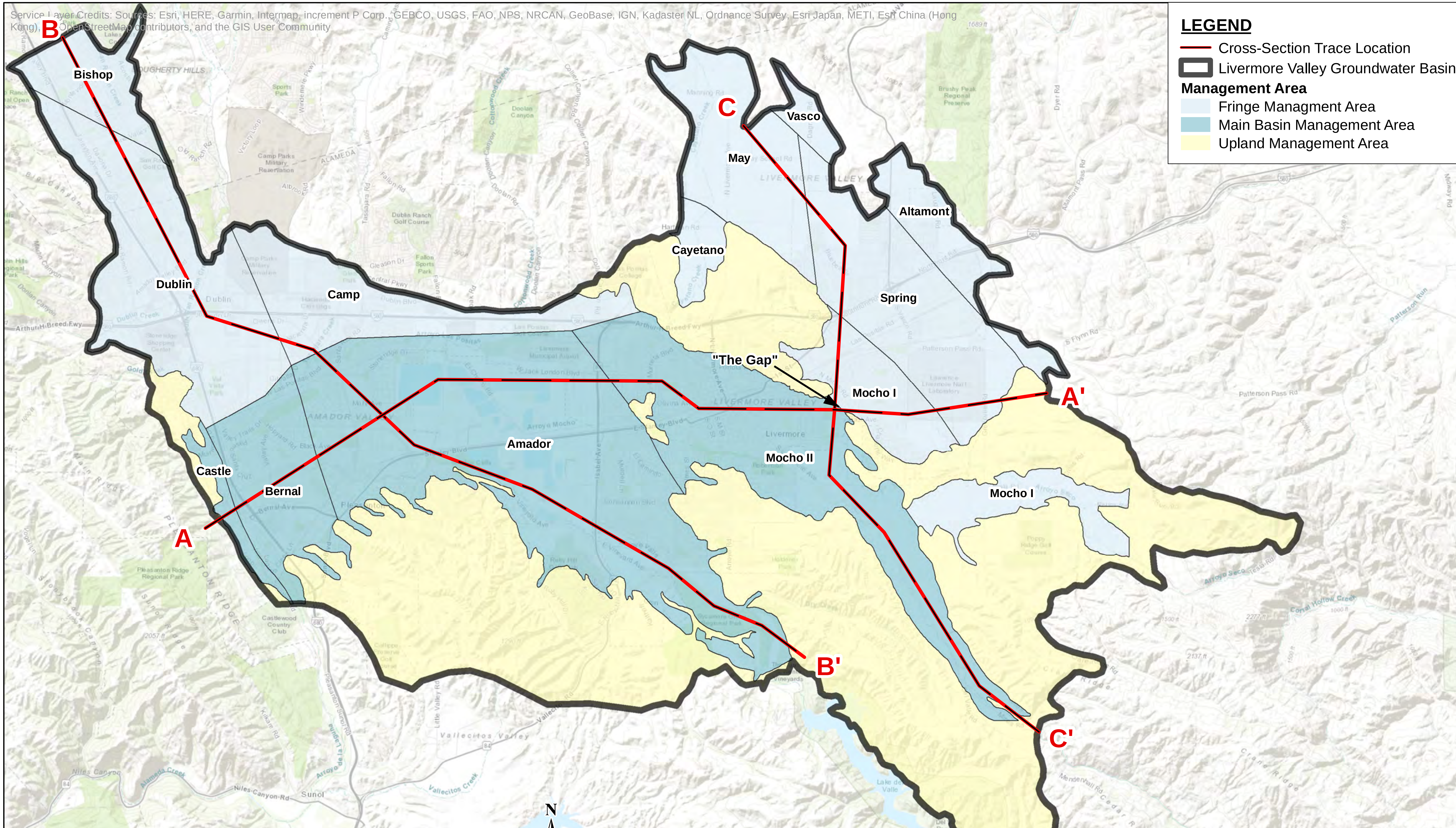

DATE: June 2021

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Figure 1
Cross-Section Trace Locations

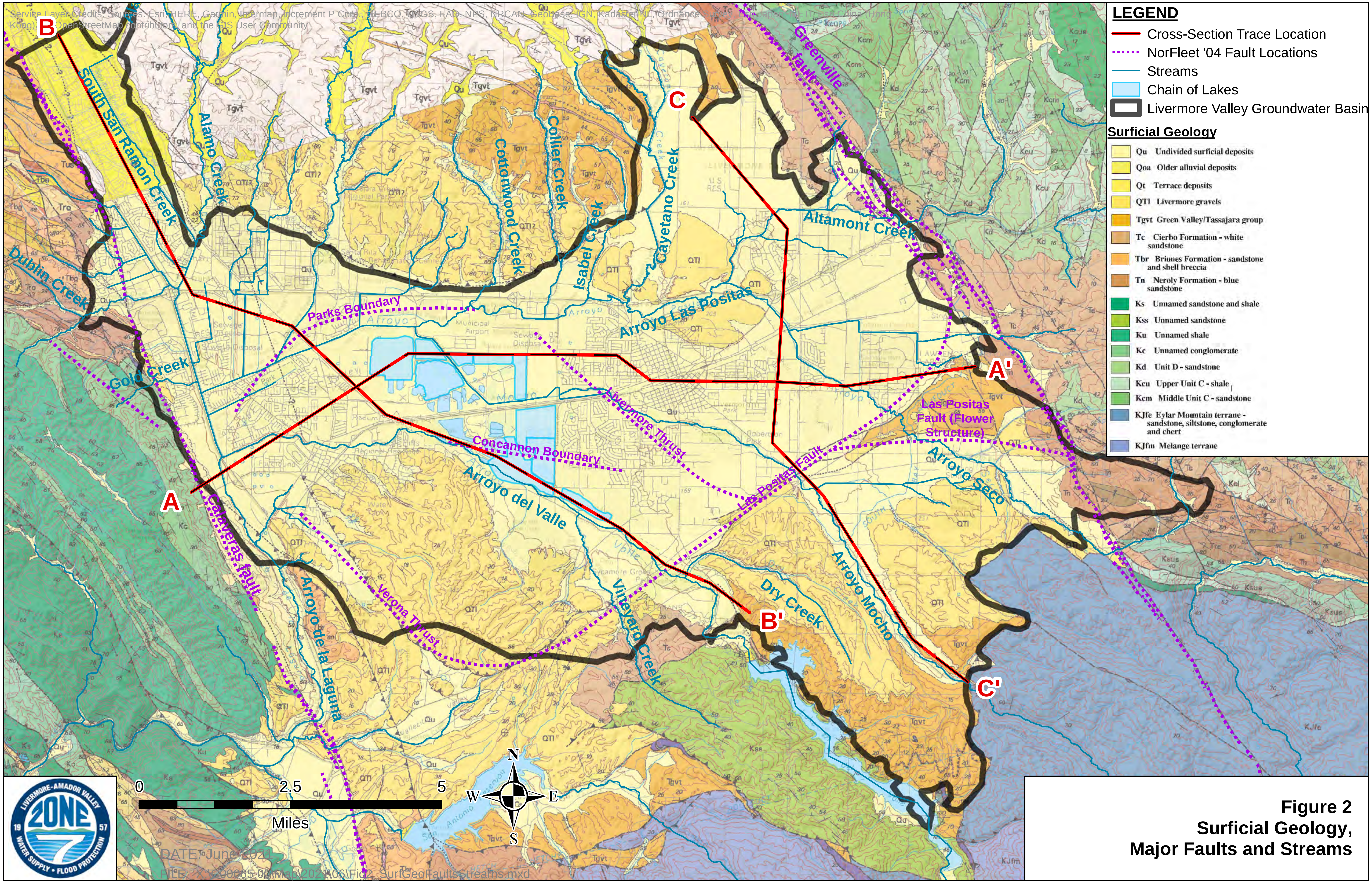
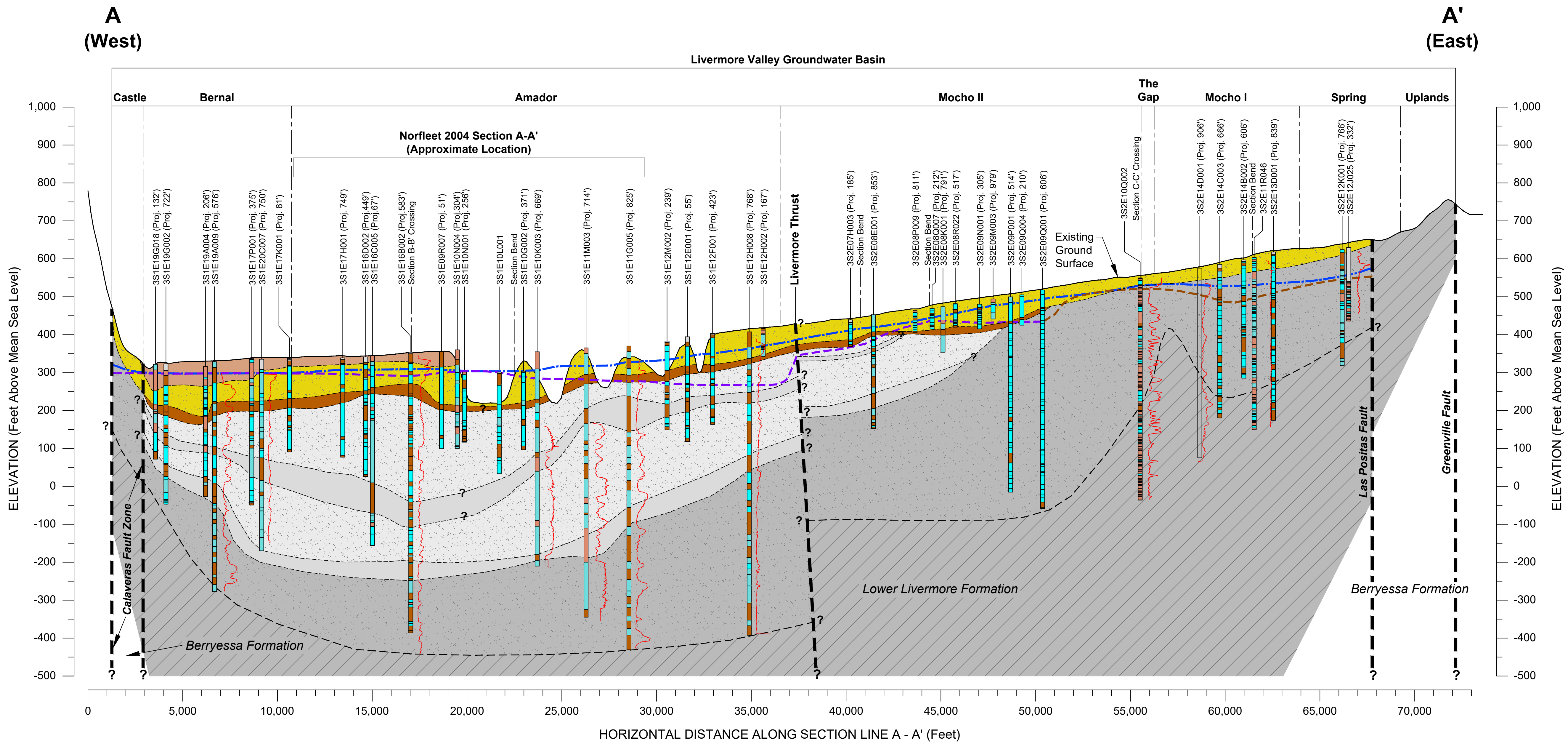
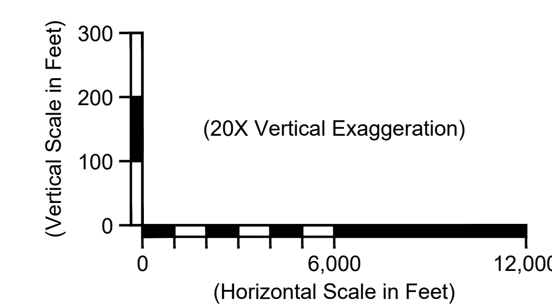


Figure 2
Surficial Geology,
Major Faults and Streams



Cross-Section A - A'



Legend:

Stratigraphy

- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

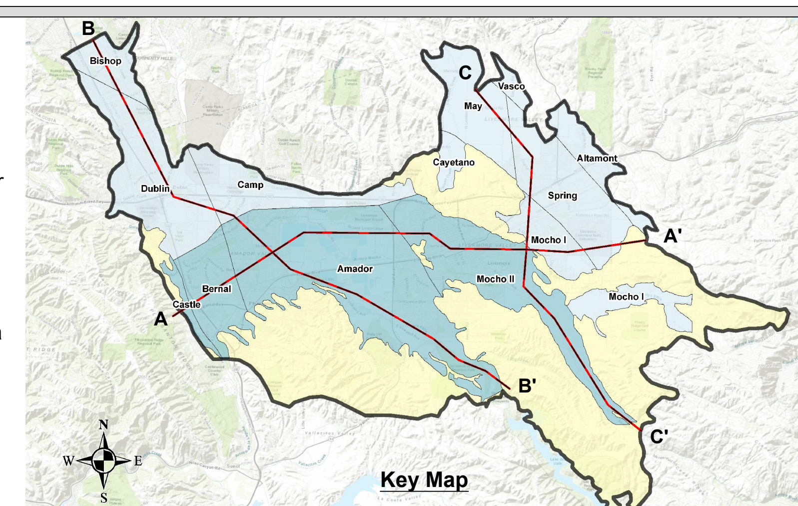
- Long-Normal Resistivity

Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Key Map

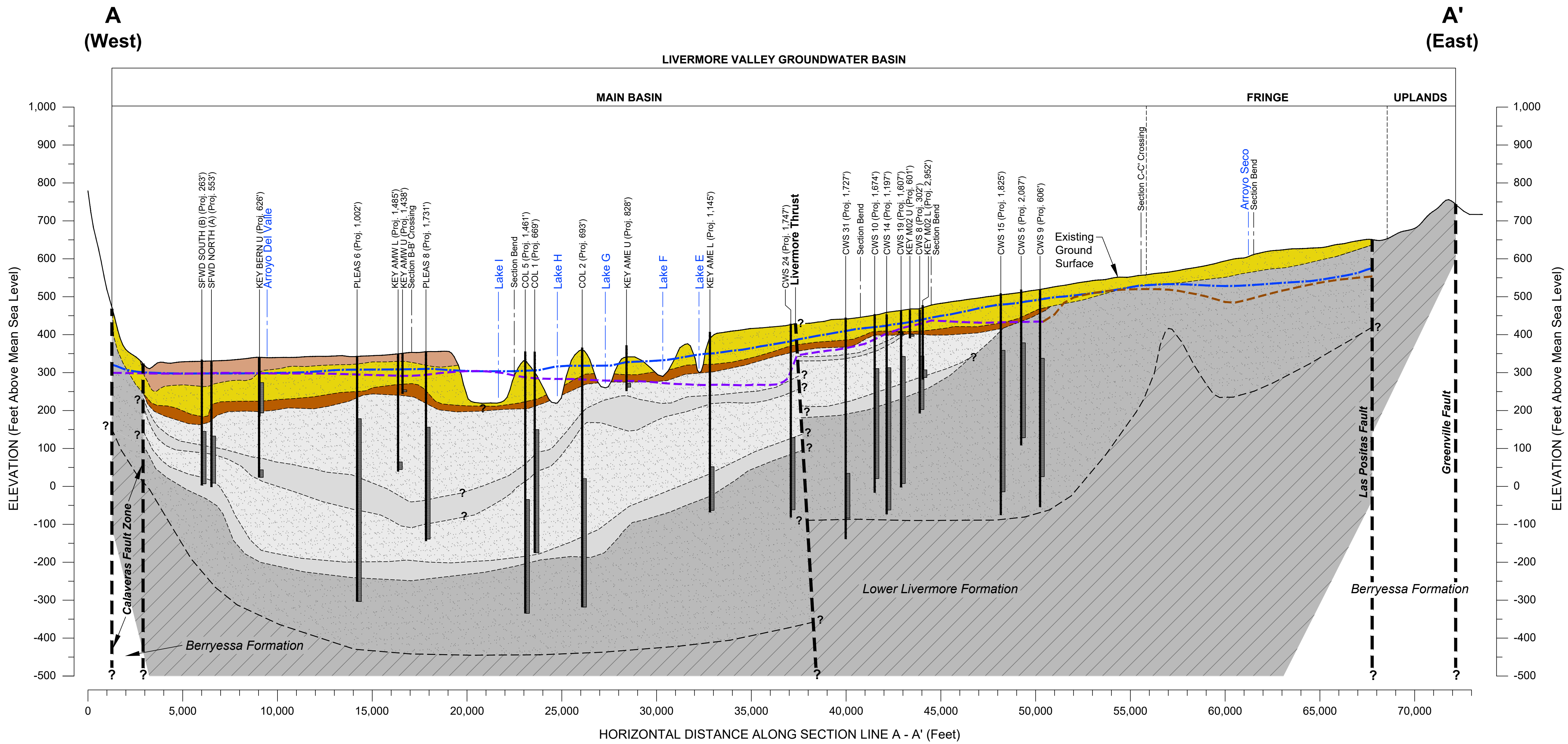
Geologic Cross-Section A - A'

Zone 7 2022 Alternative GSP
Livermore, CA
June 2021
EKI C00065.00

eki environment & water

Figure 3a

20210603.092158 G:\C00065.00\2021-06\Cross Section A-A.dwg Section A-A'



Cross-Section A - A'

Legend:

Stratigraphy

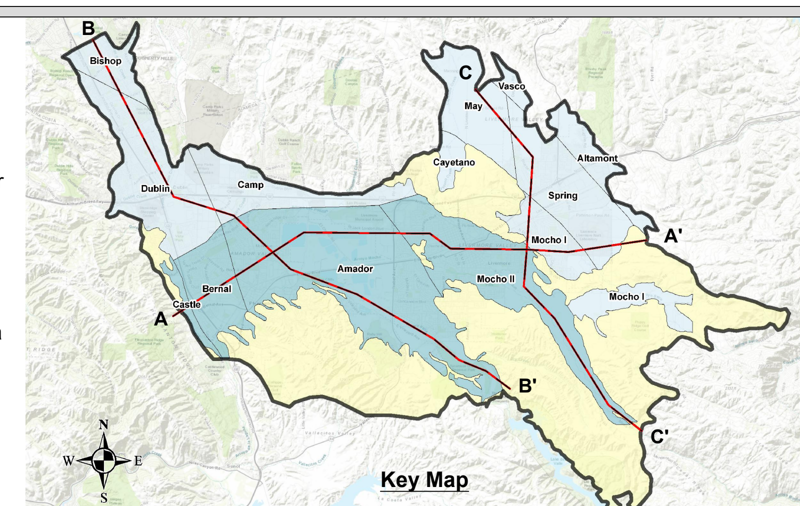
- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore (Fall 2019)
- Well Log
- Screen Interval

Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



(Vertical Scale in Feet) 300 200 100 0

(20X Vertical Exaggeration)

0 6,000 12,000

(Horizontal Scale in Feet)

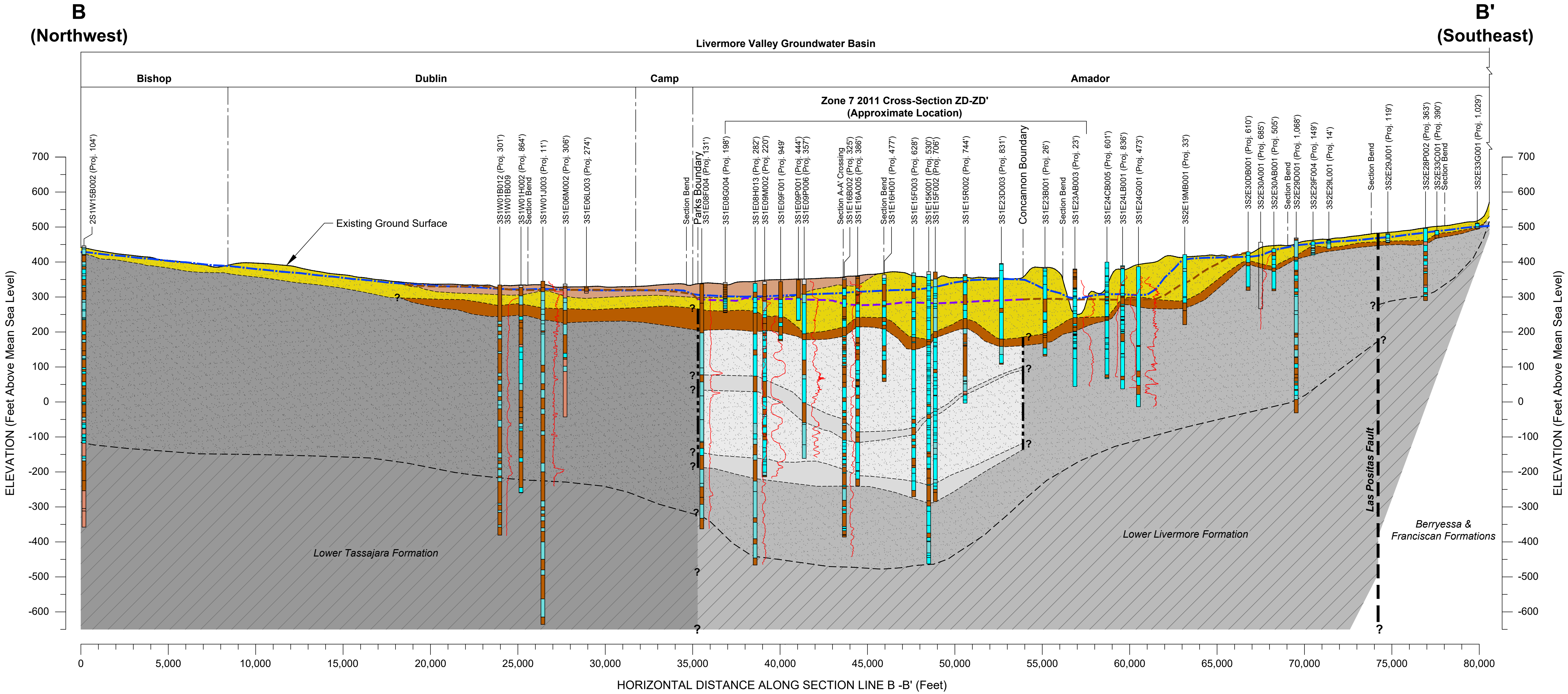
Geologic Cross-Section A - A'

Zone 7 2022 Alternative GSP
Livermore, CA
June 2021
EKI C00065.00

Figure 3b

eki environment & water

20210604.10191 C:\Users\ricasata\appdata\local\temp\AcPublish_31224_Cross Section A-A.dwg Section A-A'



Cross-Section B - B'

Legend:

Stratigraphy

- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

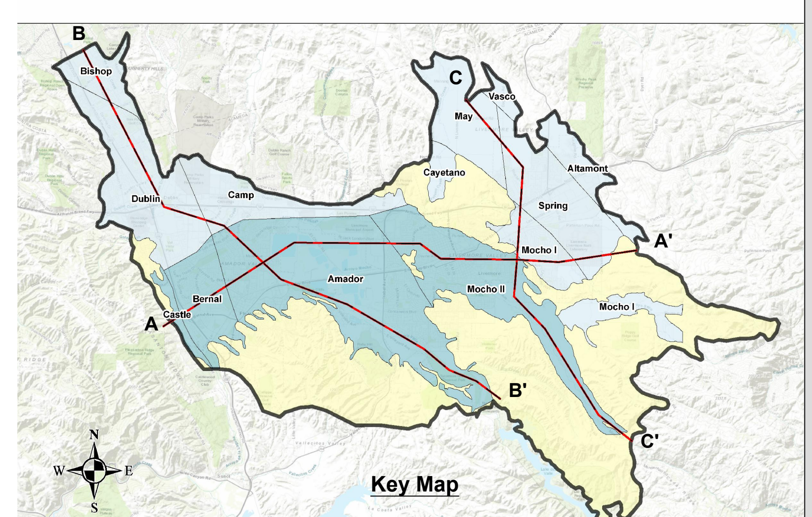
- Long-Normal Resistivity

Map Elements

- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



(20X Vertical Exaggeration)

(Vertical Scale in Feet) 0, 100, 200, 300

(Horizontal Scale in Feet) 0, 6,000, 12,000

Geologic Cross-Section B - B'

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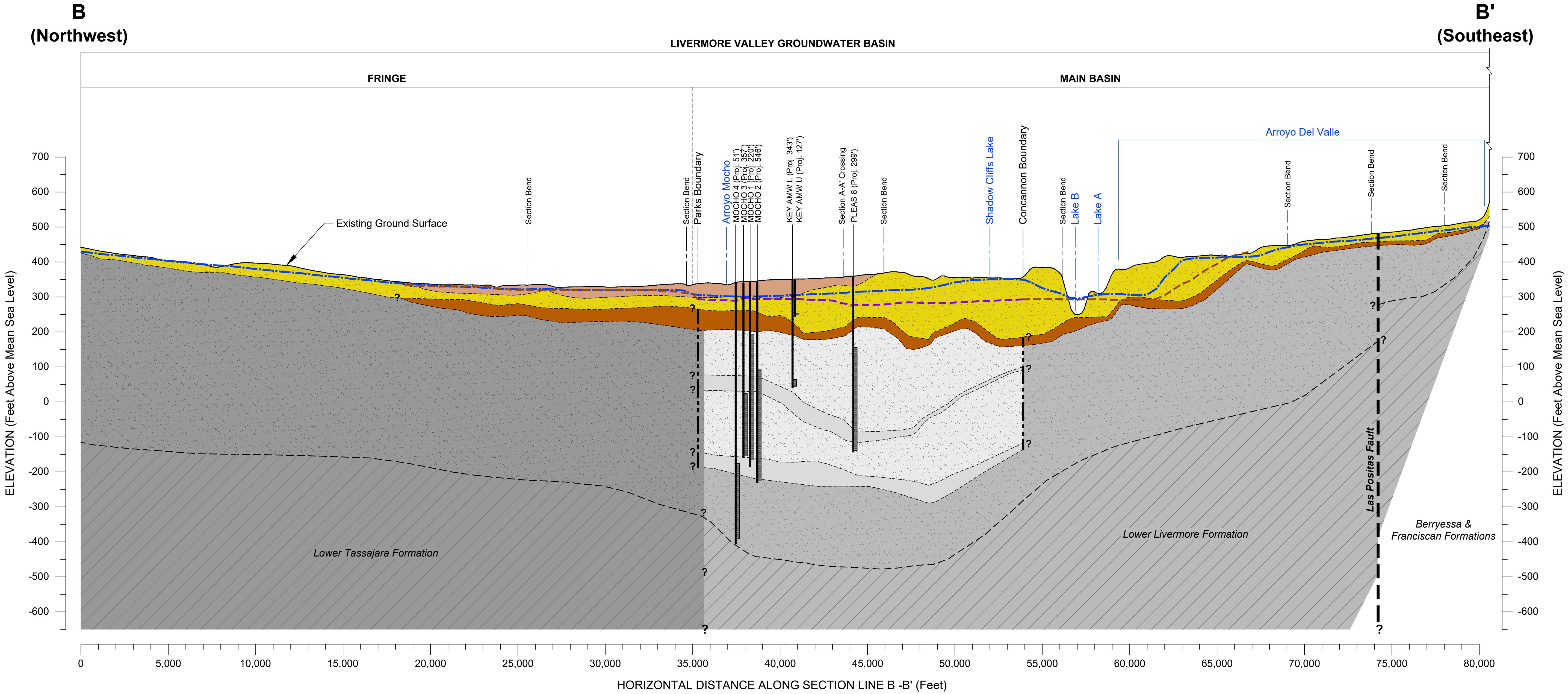
Figure 4a

20210603.085738 G:\C00065.00\2021-06\Cross Section B-B.dwg Section B-B'



Cross-Section B - B'

Legend:

Stratigraphy

- Overburden
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

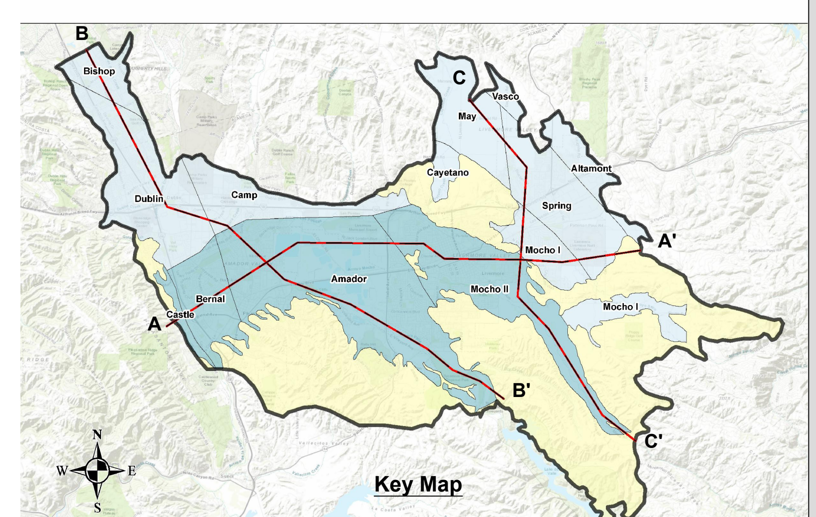
- Well Log
- Screen Interval

Map Elements

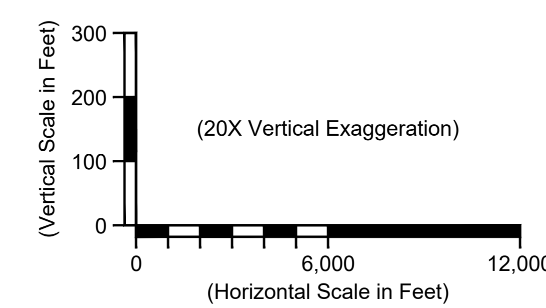
- A — A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Key Map



Geologic Cross-Section B - B'

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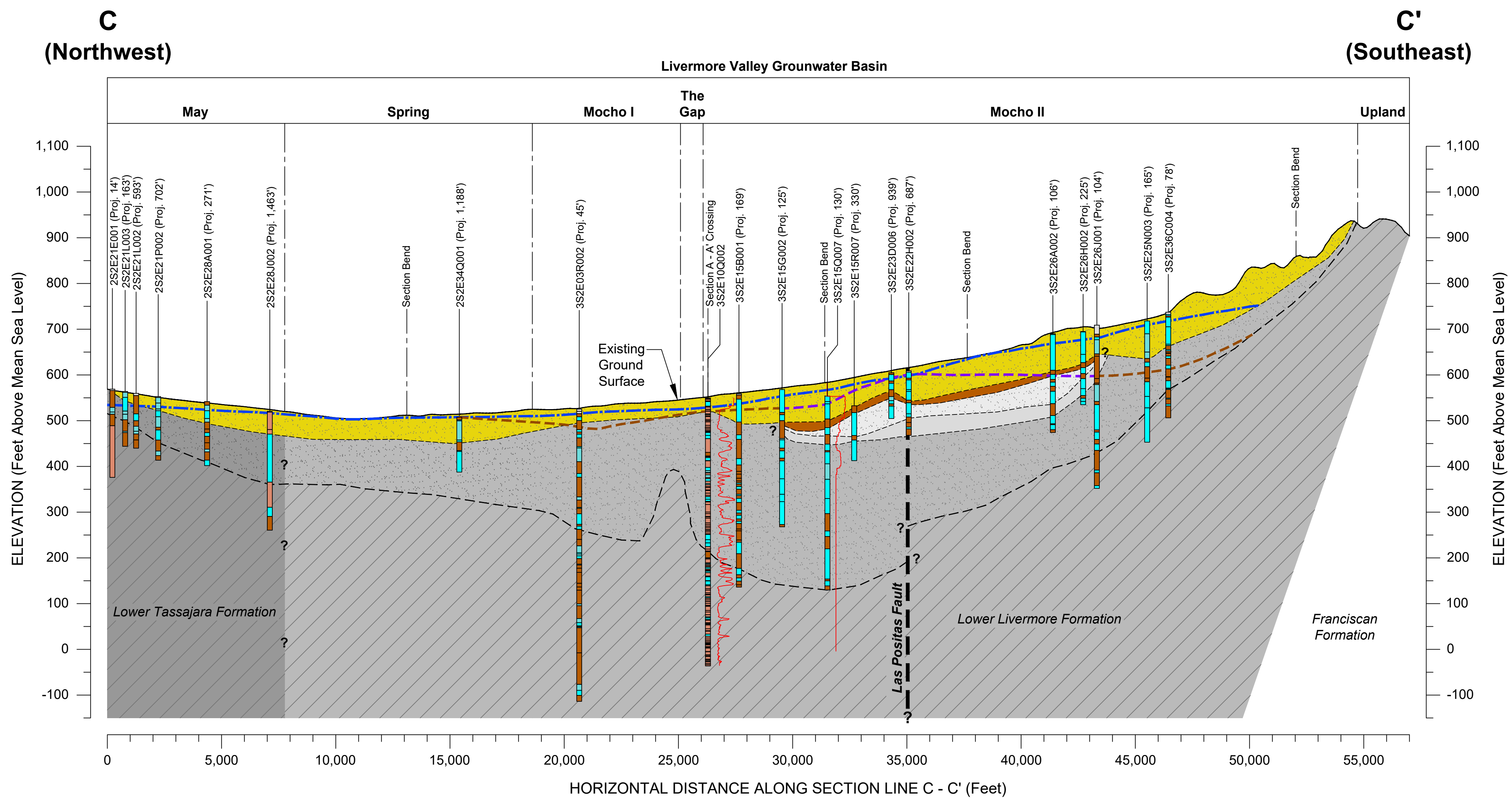
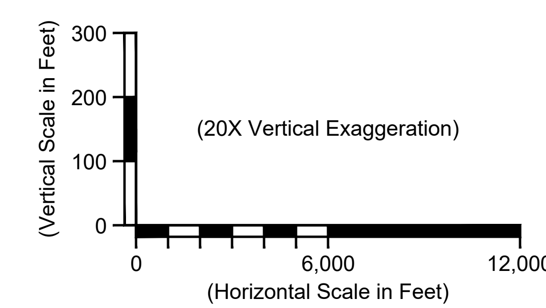
Figure 4b



Cross-Section C - C'



Legend:

Stratigraphy

- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

Lithology

- Topsoil/Fill
- Gravel
- Sand
- Silt
- Clay

Geophysical

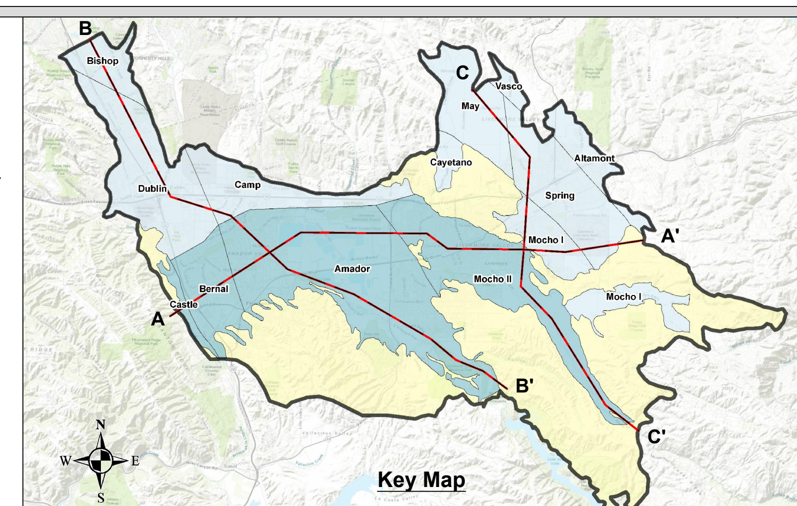
- Long-Normal Resistivity

Map Elements

- A —— A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area



Geologic Cross-Section C - C'

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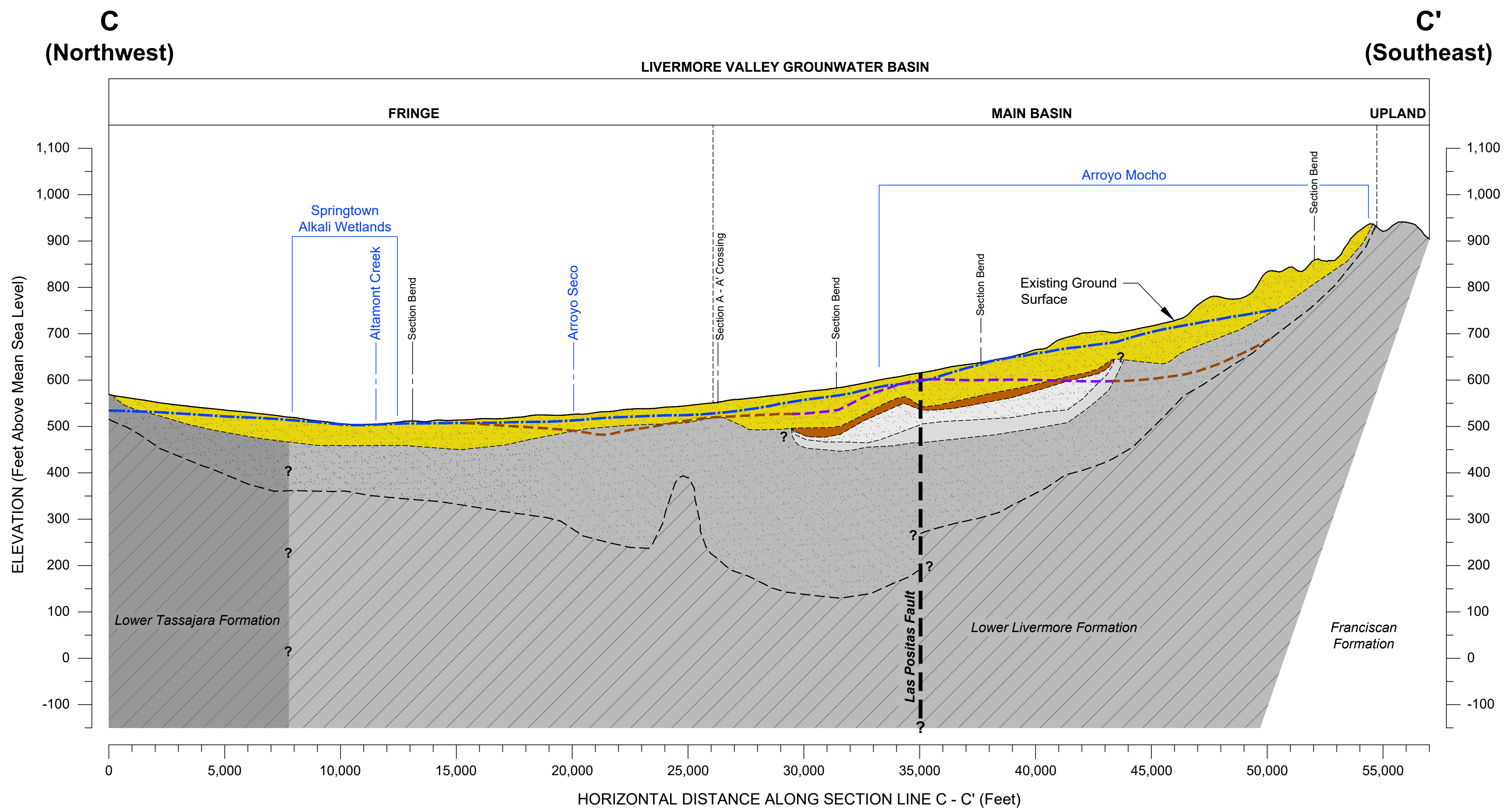
Figure 5a

20210603.085708 G:\C00065.00\2021-06\Cross Section C-C.dwg Section C-C'



Cross-Section C - C'

Legend:

Stratigraphy

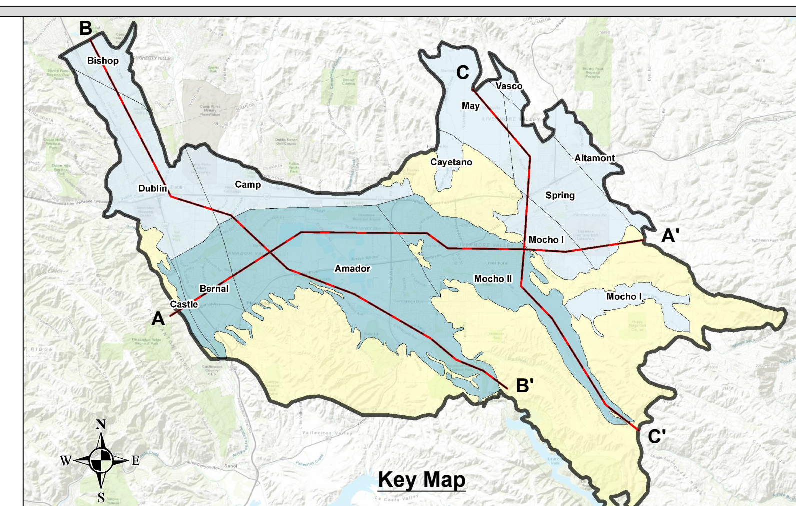
- Upper Aquifer
- Aquitard
- Lower Aquifer (Quaternary Gravels/Sands)
- Lower Aquifer (Quaternary Clays/Silts)
- Upper Livermore Formation
- Lower Livermore Formation
- Upper Tassajara Formation
- Lower Tassajara Formation
- Bottom of Groundwater Basin
- Static Water Level in Upper Aquifer (Fall 2019)
- Static Water Level in Lower Aquifer (Fall 2019)
- Static Water Level in Upper Livermore/Tassajara Formation (Fall 2019)

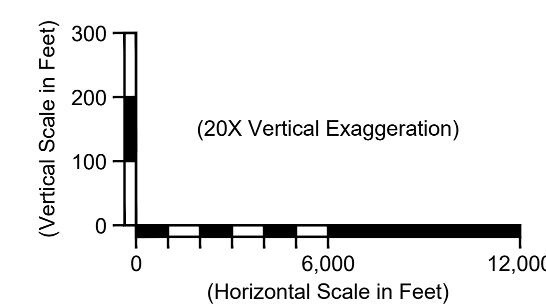
Map Elements

- A —— A' Cross-Section Trace Location
- Livermore Valley Groundwater Basin

Management Area

- Fringe Management Area
- Main Basin Management Area
- Upland Management Area





Geologic Cross-Section C - C'

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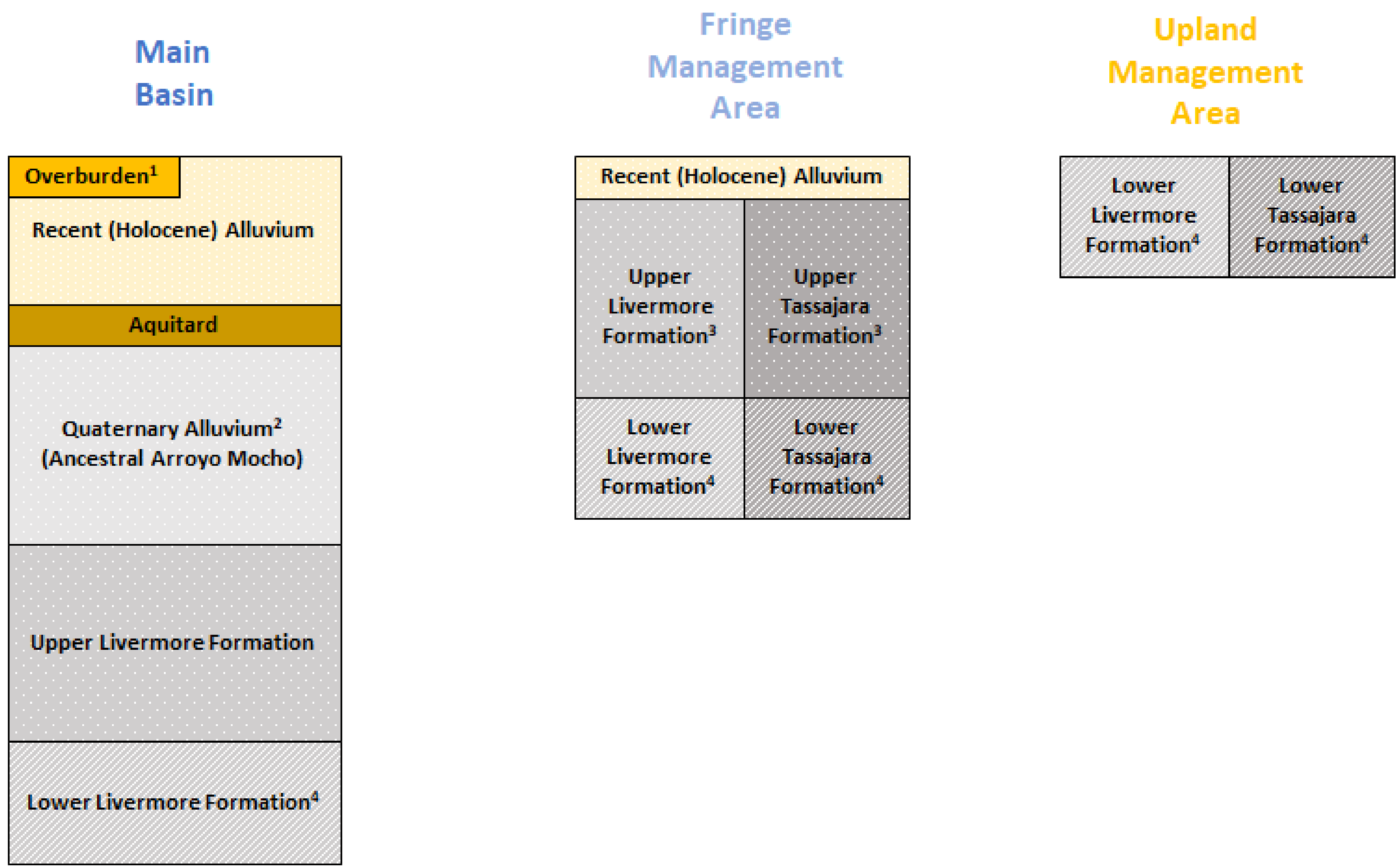
Figure 5b

20210603.085444 G:\C00065.00\2021-06_Cross Section C-C.dwg Section C-C'

Livermore Valley Groundwater Basin

Conceptual Hydrostratigraphy Model



Notes:

1 Only encountered in western portion of Main Basin (Bernal, Amador subareas)

2 Only encountered where Ancestral Arroyo Mocho incised valley complex exists (see Norfleet 2004, Figure 3-5)

3 Tassajara Formation encountered in northwestern (Bishop, Dublin, Camp subareas) and northeastern (May, Cayetano subareas) portion of Fringe Management Area; Livermore Formation encountered in all other Fringe subareas

4 Considered generally impermeable and below the bottom of the usable groundwater basin

5 Drawings not to scale; for discussion purposes only

Conceptual Hydrostratigraphy Model

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Livermore, CA
March 2021
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Figure 6