LOS OSOS VALLEY GROUNDWATER BASIN
BOUNDARY MODIFICATION REQUEST

TECHNICAL MEMORANDUM
SEPTEMBER 2018

Prepared for

SAN LUIS OBISPO COUNTY
FLOOD CONTROL AND
WATER CONSERVATION DISTRICT

September 21, 2018

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1.0 INTRODUCTION

This technical memorandum presents hydrogeologic and jurisdictional information in support of a groundwater Basin Boundary Modification Request (BBMR) for the Los Osos Valley Groundwater Basin (Los Osos Basin). It was prepared by Cleath-Harris Geologists, Inc., on behalf of the San Luis Obispo County Flood Control and Water Conservation District for the Los Osos Basin Fringe Areas - County of San Luis Obispo Groundwater Sustainability Agency (Los Osos Basin GSA). The information presented in this memorandum has been prepared in accordance with the California Department of Water Resources (DWR) requirements for boundary modifications contained in the California Code of Regulations, Title 23 (Waters), Division 2 (Department of Water Resources), Charter 1.5 (Groundwater Management), Subchapter 1 (Groundwater Basin Boundaries), Article 5 (Supporting Information), referred to herein as the DWR Boundary Regulations. The objective of this BBMR is to promote sustainable groundwater management, in accordance with the 2014 Sustainable Groundwater Management Act, through jurisdictional and scientific adjustments to the basin boundaries.

1.1 SGMA GSA and Adjudicated Basin Areas

The Sustainable Groundwater Management Act (SGMA) took effect on January 1, 2015, and requires that certain actions be taken in groundwater basins designated as either high or medium priority by DWR. DWR's Bulletin 118 Report defines basin boundaries throughout California, which are relied on for determining areas subject to SGMA compliance. DWR identified the Los Osos Basin as a high priority basin subject to critical conditions of overdraft due to seawater intrusion and nitrate impairment (DWR, 2014, 2016). SGMA does not apply to the Los Osos Basin area that is at issue in *Los Osos Community Services District v. Southern California Water Company* [Golden State Water Company], et al.[1] (Adjudicated Plan Area), for which a Stipulated Judgment and Updated Basin Plan for the Los Osos Groundwater (Basin Plan) were approved by the San Luis Obispo Superior Court on October 14, 2015. However, there are areas between the Bulletin 118 basin boundary (Basin 3-8) and the Adjudicated Plan Area boundary, referred to as "Fringe Areas," that are currently subject to SGMA. In order to comply with SGMA requirements, the County formed a GSA over these Fringe Areas on April 4, 2017.

Los Osos Basin boundary modifications proposed in a 2016 BBMR were denied because the scientific information provided did not adequately characterize areas outside of the proposed basin and did not include sufficient evidence of a clear hydrogeologic barrier. The proposed addition of estuary areas into the basin was also denied as the areas did not meet the alluvial definition of a basin (DWR, 2016a; CHG 2016). The current 2018 BBMR incorporates the

1 Pursuant to Water Code 10720.8(d), SGMA does not apply to the adjudicated areas of the Los Osos Valley Groundwater Basin.

support and direction received from DWR staff, along with additional scientific information from the Los Osos Valley Groundwater Basin Fringe Areas Characterization Technical Memorandum (2018 Fringe Areas TM; CHG, 2018), supplemental prior work from the court-approved Basin Plan for the Adjudicated Plan Area, and decades of technical studies of the basin.

1.2 Basin Boundary Emergency Regulation Requirements

The DWR Boundary Regulations require that documentation of specific processes and information be submitted by a local agency (requesting agency), as part of a basin boundary modification request. The requirements of a requesting agency include, but are not limited to:

- Providing a notice of intent to DWR and providing public information about the request within 15 days of the initial decision to explore boundary modification;
- Consulting with all affected local agencies[2] or affected systems[3] regarding the proposed revision and providing copies of all associated communications;
- Providing copies of the requesting agency's enabling statute and a resolution adopted by the agency formally initiating the boundary modification request;
- Providing a detailed description of the proposed basin boundaries, including a written description, graphical map, and supporting geographic information system (GIS) files;
- Developing a "Hydrogeologic Conceptual Model" that provides a detailed description of the proposed subbasins demonstrating key geologic and hydrologic characteristics;
- Conducting a comprehensive technical study including further geologic and hydrologic evidence of groundwater conditions within the proposed subbasins[4;]
- Determining if the proposed revision will trigger action under the California Environmental Quality Act (CEQA) and, if so, providing necessary information to enable DWR to satisfy its requirements as a responsible agency; and
- Notifying all interested local agencies and systems within five days of receiving notice from DWR that the request is complete.
- The requesting agency that involves basin subdivision pursuant to Section 342.4(c) of the DWR Boundary Regulations, shall provide information demonstrating that the proposed boundary modification is supported by at least three-fourths of the local agencies and public water systems in the affected basins.

2 Affected agency is defined by DWR as "a local agency, as defined in Water Code §10721(m), whose jurisdictional area would, as a result of a boundary modification, include more, fewer, or different basins or subbasins than without the modification."

3 Affected system is defined by DWR as "a public water system, as defined in Water Code §10721(r), whose service area would, as a result of a boundary modification, include more, fewer, or different basins or subbasins than without the modification."

4 Information to be provided in the technical study includes, but is not limited to: a qualified map depicting lateral boundaries; subsurface data illustrating vertical thickness; a qualified map depicting geology structures or features impeding flow; historical potentiometric surface maps; current potentiometric surface map; groundwater level data; recharge and discharge areas; aquifer performance testing results; water quality information; geophysical investigations and supporting data; and other relevant technical information.

All information required of boundary modification requests must be submitted through DWR's web portal, the Basin Boundary Modification Request System. This technical memorandum provides Supporting Information under Article 5 of the DWR Boundary Regulations. The table of contents lists the Sections from Article 5 that are covered by this technical memorandum. Article 5 Sections that are not part of this technical memorandum include Requesting Agency Information (§344.2), Notice and Consultation (§344.4), Local Agency Input (§344.8), and CEQA Compliance (§344.18), which will be provided separately in the BBMR application to DWR.

2.0 DESCRIPTION OF PROPOSED BOUNDARY MODIFICATION (§344.6)

2.1 Overview of Request for Boundary Modification (§344.6(a))

The Los Osos Basin (DWR's Basin 3-8) is located on the Pacific Coast of San Luis Obispo County. The basin area within the Adjudicated Plan Area has a groundwater management plan, the court approved Basin Plan. The Basin Plan provides a comprehensive plan for the long-term sustainable management of the Los Osos basin. The boundaries of the Adjudicated Plan Area do not coincide with the basin boundaries as documented in DWR's Interim Update to Bulletin 118 (DWR, 2016). The basin areas within the fringe areas are governed by the Los Osos Basin GSA. Based on the current DWR basin prioritization (DWR, 2014), a groundwater sustainability plan would be required for the fringe areas by January 31, 2020.

The proposed boundary modifications divide the basin into two subbasins through an internal jurisdictional modification (with supporting scientific information) and make two adjustments to the external scientific basin boundary. These modifications will promote groundwater sustainability by formally recognizing the significant differences in hydrogeology, land use, and governance/stakeholder organization between the two proposed subbasins. The proposed basin boundary modification will result in a more accurate boundary and will support sustainable management within the basin.

The proposed modifications are to:

- Establish the Los Osos Area subbasin within the Adjudicated Plan Area (4,183 acres).
- Establish the Warden Creek subbasin in the fringe area between the existing Adjudicated Plan Area and the San Luis Obispo Valley Groundwater Basin on the east (1,764 acres).
- Remove the Montaña de Oro exclusion area between the Bulletin 118 basin boundary and the existing scientific boundary for the Adjudicated Plan Area (1,017 acres).
- Remove an exclusion area containing minor fringe areas along the northern basin boundary between the existing scientific boundary for the Adjudicated Plan Area and the Bulletin 118 basin boundary (44 acres).

Information on California's groundwater resources are compiled in Bulletin 118 (DWR, 2016b). The current Bulletin 118 area for Los Osos Basin 3-8 covers 6,990 acres (10.9 square miles). The proposed modified basin area would cover 5,929 acres (9.3 square miles), and consist of the Los Osos Area subbasin and the Warden Creek subbasin. Figure 1 presents a basin overview and identifies the proposed subbasins and exclusion areas.

2.1.1 Category of proposed boundary modification (§344.6(a)(1))

One internal jurisdictional boundary modification is being proposed that will create two jurisdictional modified basin subdivisions (subbasins). Two external scientific boundary modifications are also being proposed.

- The proposed subbasins include (1) a subbasin located in the Adjudicated Plan Area called the Los Osos Area subbasin and (2) a subbasin located in the Eastern Valley fringe area called the Warden Creek subbasin.
- The proposed exclusion areas include (1) the removal of the Montaña de Oro State Park to the Los Osos fault line, and (2) the removal of a minor fringe area north of the adjudicated basin area (see Figure 1).

2.1.2 Identification of all affected basins or subbasins (§344.6(a)(2))

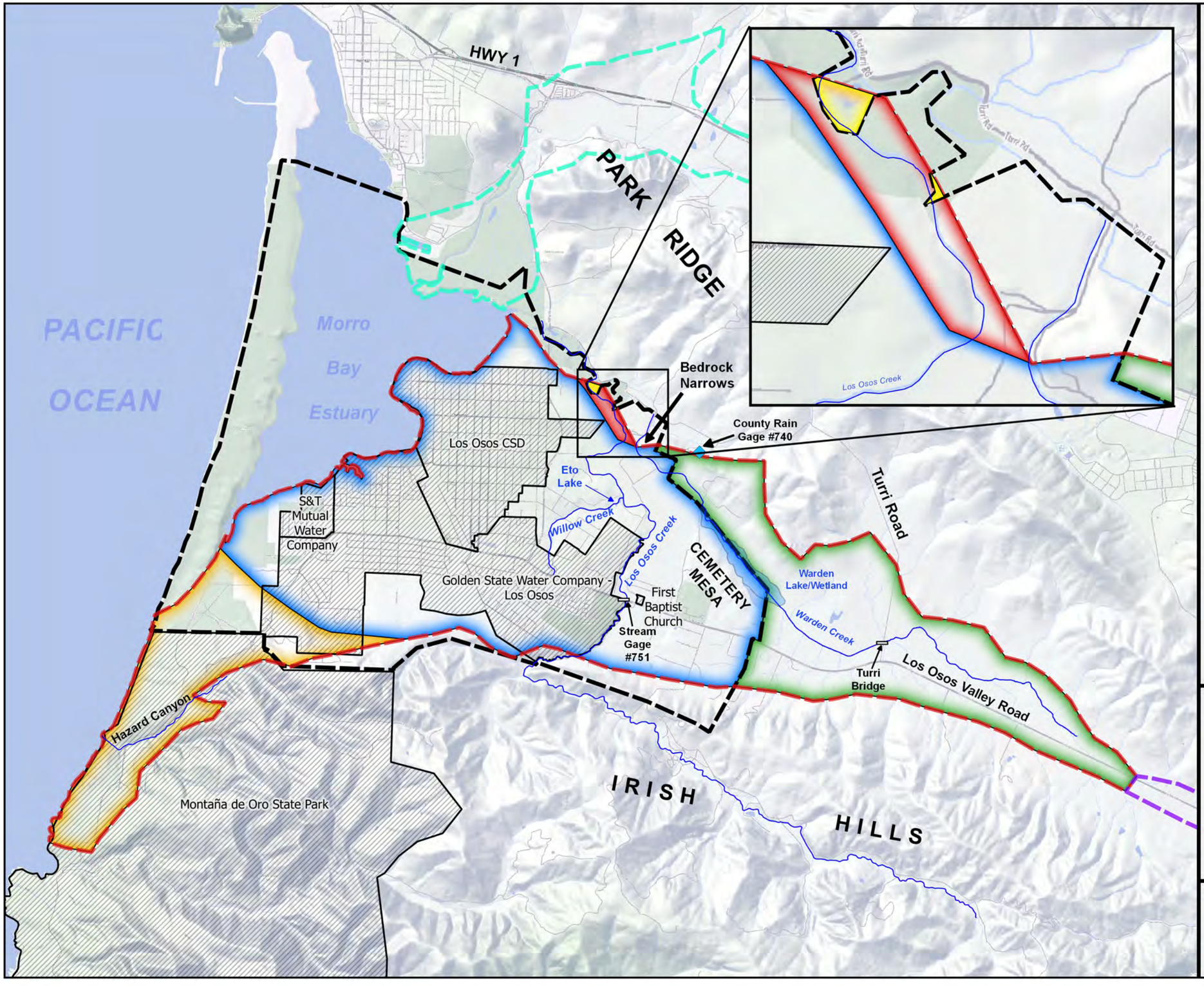
The only affected basin is the subject basin: Los Osos Valley Groundwater Basin (DWR 3-8).

The adjacent San Luis Obispo Valley Groundwater Basin (DWR 3-9) and nearby Chorro Valley Groundwater Basin (DWR 3-42) are not "affected basin" as defined by DWR §341. Definitions, listed below.

> *"Affected basin" means a basin or subbasin that is the subject of a boundary modification request and any basin or subbasin where the ability to achieve sustainable groundwater management could be significantly affected by groundwater use or management practices in another existing or proposed basin or subbasin. An adjacent basin or subbasin is presumed to be an affected basin for purposes of this Subchapter. The Department may determine a non-adjacent basin or subbasin is an affected basin if convincing evidence shows that the hydraulic connection to another basin or subbasin is likely to affect the ability of the non-adjacent basin or subbasin to achieve sustainable groundwater management over the planning and implementation horizon.*

San Luis Obispo Basin – Adjacent Basin / Not an Affected Basin

The proposed Los Osos Basin boundary modification will not affect the ability of the adjacent San Luis Obispo Valley Groundwater Basin (Basin No. 3-9) to sustainably manage groundwater, as the two basins only touch along a narrow geologic/watershed (drainage) divide (discussed in



Explanation

- Affected Water Systems
- Adjudicated Plan Area
- Los Osos Area Subbasin
- Warden Creek Subbasin
- Montaña de Oro Exclusion Area
- Minor Fringe Exclusion Area
- Minor Fringe Areas

Bulletin 118 Basin Boundaries

- Chorro Valley Groundwater Basin
- Los Osos Valley Groundwater Basin
- San Luis Obispo Valley Groundwater Basin

Basemap: Stamen Terrain

0 4000 8000 ft

NORTH

Figure 1 - Basin Area Overview

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

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further scientific detail below, see Figure 1). Furthermore, the County took on the role of GSA in each of the two basins and would help facilitate any future coordination of basin management efforts between the two basins, to the extent it becomes necessary. Therefore, the proposed boundary modification should improve the ability of the San Luis Obispo Valley Basin GSA to sustainably manage its groundwater resources.

The watershed (drainage) divide between the two basins is defined in DWR's Bulletin 118 – Los Osos Basin description, which overlies a bedrock high at the eastern edge of the proposed Warden Creek subbasin, as shown in Figure 11 – Base of Permeable Sediments. Figure 12 – Groundwater Elevation Contours depicts the 2017 groundwater levels and inferred groundwater flow direction, showing groundwater within each basin flowing away from the shared basin boundary, resulting in a groundwater divide at the location of the bedrock high and drainage divide. The proposed Warden Creek subbasin would not change the shared physical basin boundary location or groundwater conditions in the San Luis Obispo Valley Basin, and would not change the Bulletin 118 basin boundary extent along the shared basin boundary. This boundary request will not affect the San Luis Obispo Valley Basin GSA's ability to achieve sustainable groundwater management over their planning and implementation horizon. The boundary request will improve coordination between key management agencies and the adjacent basin.

Chorro Valley Basin – near (not adjacent to) the Los Osos Basin/ Not an Affected Basin

Chorro Valley Basin (Basin No. 34-2) is near the Los Osos Basin, but not attached or directly adjacent (Figure 1). This basin is not an "affected basin" as defined by DWR §341. Definitions, listed above. The boundary modification request will not affect the ability to achieve sustainable groundwater management in the Chorro Valley Basin, because the basin drains into Morro Bay estuary and does not share a common boundary with the Los Osos Basin.

These two basins are approximately 300 feet apart at their closest point along the southern edge of the Chorro Creek mudflats within the Morro Bay estuary. The Morro Bay estuary is outside the Bulletin 118 Los Osos Basin. However, the court-defined Adjudicated Plan Area and related Basin Plan includes parcels overlying the Morro Bay estuary and portions of the Chorro Creek mudflats within the Chorro Valley Basin. This creates an opportunity for coordination between the Los Osos Basin Management Committee and the neighboring Chorro Valley Basin. The proposed boundary modifications would not change groundwater conditions or change the physical relationship between the basins and, therefore, will not affect the ability to sustainably manage the groundwater resources of the Chorro Valley Basin.

2.1.3 Proposed name of each new subbasin (§344.6(a)(3))

Two jurisdictional modification basin subdivisions (subbasins) are proposed. The subbasin proposed for the Adjudicated Plan Area is called the Los Osos Area subbasin and the subbasin proposed for the Eastern Valley fringe area, east of the adjudicated basin, is called the Warden Creek subbasin (see Figure 1).

2.2 Jurisdictional Boundary Explanations (§344.6(b))

2.2.1 Explanation of how the proposed boundary modification would promote sustainable groundwater management in proposed basin or subbasin (§344.6(b)(1))

The proposed basin boundary modifications will result in a more accurate boundary to support a sustainable groundwater basin. As discussed in this technical report, the proposed boundary modifications are scientific and jurisdictional based on differing geology, hydrogeology, land use, and management entities within the basin. The proposed modifications will improve sustainable management within the basin and participation by the appropriate parties.

Los Osos Area Subbasin

Local water purveyors and the County of San Luis Obispo developed the Updated Basin Plan for the Los Osos Groundwater Basin (ISJ, 2015) for sustainable groundwater management covering the Adjudicated Plan Area. Under the proposed boundary modification, the Bulletin 118 basin area within the Adjudicated Plan Area would become the Los Osos Area subbasin of the Los Osos Basin (Bulletin 118 Basin No. 3-8).

The basin boundary definition used for the adjudication was the area at ground surface beneath which the Paso Robles Formation is present and saturated. The court-approved Adjudicated Plan Area was extended past this boundary to include the legal boundaries of parcels overlying the basin area (ISJ, 2015). The proposed Los Osos Area subbasin would maintain the hydrogeologic and jurisdictional continuity of the Adjudicated Plan Area, promoting sustainable management through the reconciliation of adjudicated and historically defined (Bulletin 118 Basin No. 3-8) basin boundaries.

Warden Creek Subbasin

Formation of the Warden Creek subbasin is the first step toward addressing sustainable groundwater management for the main fringe area outside of the Adjudicated Plan Area, and is supported by scientific and jurisdictional rationale. The Warden Creek subbasin has a unique hydrogeologic setting that can be scientifically differentiated from the Los Osos Area subbasin. Aligning the internal subbasin boundary with the Adjudicated Plan Area will avoid overlap in jurisdictional coverage for the Warden Creek subbasin.

The proposed boundary modification would promote sustainable groundwater management by ensuring that subbasin-specific scientific and stakeholder considerations are being addressed and that fringe area management does not conflict with the existing management entity in the Los Osos Area subbasin. Unlike the Los Osos Area subbasin, the proposed Warden Creek subbasin is not subject to seawater intrusion and does not include urban areas or public water systems. The stakeholders are primarily growers and ranchers. Groundwater resource management in this fringe area requires a separate hydrogeologic characterization and

management structure than the court approved Adjudicated Plan Area. The proposed subbasins provide that separation, and will allow the Warden Creek subbasin to pursue sustainability with more efficiency and self-direction under the Sustainable Groundwater Management Act.

2.2.2 Explanation of how the proposed boundary modification would affect the ability of adjacent basins or subbasins to sustainably manage groundwater in those basins or subbasins (§344.6(b)(2))

Two groundwater basins, San Luis Obispo Valley (3-9) and Chorro Valley (3-42), are near or directly adjacent to the Los Osos Basin.

San Luis Obispo Basin – Adjacent Basin / Not an Affected Basin

The proposed Los Osos Basin boundary modification will not affect the ability of the adjacent San Luis Obispo Valley Groundwater Basin (Basin No. 3-9) to sustainably manage groundwater, as the two basins only touch along a narrow geologic/watershed (drainage) divide (discussed in further scientific detail below, see Figure 1). Furthermore, the County took on the role of GSA in each of the two basins and would help facilitate any future coordination of basin management efforts between the two basins, to the extent it becomes necessary. Therefore, the proposed boundary modification should improve the ability of the San Luis Obispo Valley Basin GSA to sustainably manage its groundwater resources.

The watershed (drainage) divide between the two basins is defined in DWR's Bulletin 118 – Los Osos Basin description, which overlies a bedrock high at the eastern edge of the proposed Warden Creek subbasin, as shown in Figure 11 – Base of Permeable Sediments. Figure 12 – Groundwater Elevation Contours depicts the 2017 groundwater levels and inferred groundwater flow direction, showing groundwater within each basin flowing away from the shared basin boundary, resulting in a groundwater divide at the location of the bedrock high and drainage divide. The proposed Warden Creek subbasin would not change the shared physical basin boundary location or groundwater conditions in the San Luis Obispo Valley Basin, and would not change the Bulletin 118 basin boundary extent along the shared basin boundary. This boundary request will not affect the San Luis Obispo Valley Basin GSA's ability to achieve sustainable groundwater management over their planning and implementation horizon. The boundary request will improve coordination between key management agencies and the adjacent basin.

Chorro Valley Basin – near (not adjacent to) the Los Osos Basin/ Not an Affected Basin

Chorro Valley Basin (Basin No. 34-2) is near the Los Osos Basin, but not attached or directly adjacent (Figure 1). This basin is discussed here because the map scale of Figure 1 brings the basin in close visual proximity to the Los Osos Basin, and it's important to clarify that the two basins do not touch. The Chorro Valley Basin is not an "affected basin" as defined by DWR §341. Definitions, listed below.

> *"Affected basin" means a basin or subbasin that is the subject of a boundary modification request and any basin or subbasin where the ability to achieve sustainable groundwater management could be significantly affected by groundwater use or management practices in another existing or proposed basin or subbasin. An adjacent basin or subbasin is presumed to be an affected basin for purposes of this Subchapter. The Department may determine a non-adjacent basin or subbasin is an affected basin if convincing evidence shows that the hydraulic connection to another basin or subbasin is likely to affect the ability of the non-adjacent basin or subbasin to achieve sustainable groundwater management over the planning and implementation horizon.*

The boundary modification request will not affect the ability to achieve sustainable groundwater management in the Chorro Valley Basin, because the basin drains into Morro Bay estuary and does not share a common boundary with the Los Osos Basin.

These two basins are approximately 300 feet apart at their closest point along the southern edge of the Chorro Creek mudflats within the Morro Bay estuary. The Morro Bay estuary is outside the Bulletin 118 Los Osos Basin. However, the court-defined Adjudicated Plan Area and related Basin Plan includes parcels overlying the Morro Bay estuary and portions of the Chorro Creek mudflats within the Chorro Valley Basin. This creates an opportunity for coordination between the Los Osos Basin Management Committee and the neighboring Chorro Valley Basin. The proposed boundary modifications would not change groundwater conditions or change the physical relationship between the basins and, therefore, will not affect the ability to sustainably manage the groundwater resources of the Chorro Valley Basin.

2.2.3 A historical summary of groundwater management in the proposed basin or subbasin (§344.6(b)(3))

Groundwater management has historically been focused on the water supply for the urban area, which is within the proposed Los Osos Area subbasin. The proposed Warden Creek subbasin has only recently been included in management efforts, although growers and ranchers in this area have been practicing sustainable management for decades by adjusting crop types and associated water use to align with the groundwater resource availability. Groundwater management summaries for both proposed subbasins are presented below.

Los Osos Area Subbasin

Groundwater management activities in the Los Osos Basin began in earnest in the 1970's, when the population served by local water companies in the proposed Los Osos Area subbasin increased three-fold. Studies during in the 1970's identified seawater intrusion as a potential threat and found an urgent need for management of the basin water resources, including water conservation and enhanced recharge, pumping distribution management, and treatment and disposal or domestic wastewater (DWR, 1973). By the 1980's the focus of groundwater management was on mitigating the nitrate contamination. In 1983, the Regional Water Quality Control Board (Regional Water Board) passed Resolution 83-13 on septic tank discharge prohibition, which became a *de facto* building moratorium in 1989 (ISJ, 2015). During the 1990's, the County developed the County Resource Management System, which provide annual Resource Summary Reports for basins. A Resource Capacity Study was completed for the basin in 1992 (ISJ, 2015).

Seawater intrusion was quantified in 2005 with the Seawater Intrusion and Lower Aquifer Source Investigation (C&A, 2005). An updated County Resource Capacity Study was completed in 2007, recommending a high level of severity ranking and urging aggressive conservation measures. The Interlocutory Stipulated Judgment, which was a result of litigation, also went into effect in 2007, and resulted in the formation of the ISJ Working Group. The ISJ Working Group developed the court-approved Basin Plan[5]. Meanwhile, coordination between the Regional Water Board and the County led to construction of the community sewer system and completion of the Los Osos Water Recycling Facility (LOWRF), which became operational in 2016. The LOWRF requires an annual Monitoring and Reporting Program to the Regional Water Board per the LOWRF Waste Discharge/Recycled Water Requirement Order R3-2011-2001 (WDR Order) and a Salt and Nutrient Management Plan (SNMP) monitoring report every three years to the Regional Water Board. The SNMP is prepared per the Recycled Water Policy and WDR Order, and this plan manages salts, nutrients, and other significant chemical compounds in the Adjudicated Plan Area.

The basin adjudication was completed in 2015 through approval of a Stipulated Judgment between the parties by the San Luis Obispo Superior Court. The Stipulated Judgment and associated Basin Plan presented a physical solution to sustainable groundwater management in the proposed subbasin. The Adjudicated Plan Area (which would include the proposed Los Osos Area subbasin, if approved by DWR) is exempted from most SGMA provisions per Water Code Section 10720.8, except reporting requirements.

Groundwater management within the proposed Los Osos Area subbasin includes semi-annual water level and water quality monitoring, water conservation and efficiency programs, recycled

5 Basin Plan details and Annual Reports may be accessed at: <https://slocountywater.org/site/Water%20Resources/LosOsos/>.

water reuse, and basin infrastructure programs for water treatment, production and purveyor system inter-ties. The groundwater monitoring program incorporates metrics based on chloride, nitrate, and water levels at key wells that serve as measures of effectiveness for basin management. Annual groundwater monitoring reports are available for 2015 and 2016.

In 2012, the Regional Water Board adopted Waste Discharge Order No. R3-2012-0011, a Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands. This Order required operators of irrigated agricultural lands to comply with provisions intended to protect groundwater and surface water quality. A continuation of the Irrigated Lands Regulatory Program for waste dischargers was adopted as Agricultural Order No. R3-2017-0002 and is in effect through March 2020. A few of the ranches overlying the Los Osos Area subbasin are required to comply with this Order.

Local ordinances affecting groundwater management have historically been implemented at the County level and codified in the County Code. The County has adopted ordinances which address plumbing retrofits and water conservation in the Los Osos Basin (Title 8 Chapter 8.91 and Title 19, Chapter 7.042), which helps support sustainable management in the basin.

Warden Creek Subbasin

Groundwater management in the proposed Warden Creek subbasin has historically been based on localized pumping capacities and land use as regulated by local ordinances. There are no public water purveyors, irrigation districts or other water agencies operating in the proposed Warden Creek subbasin. Growers and ranchers with overlying rights to pump water for beneficial use have managed their groundwater supply based on experience and well performance. Groundwater extractions are limited by seasonal recharge and water level fluctuations. System water pressure and pump discharge is the common measure of well performance. These parameters, along with precipitation, evapotransipiration rates, water quality, and crop development indicators are the basis for adjustments to groundwater use.

Local ordinances affecting groundwater management have historically been implemented at the County level and codified in the County Code. A recent County ordinance (No. 3354) scheduled for codification addresses permit requirements for agricultural ponds, reservoirs, and basins. In addition to the groundwater management ordinances described above, the County has adopted a well construction ordinance that applies Countywide as required by State statue (Title 8, Chapter 8.40).

As discussed in the Los Osos Area subbasin, the Irrigated Lands Regulatory Program, adopted as Agricultural Order No. R3-2017-0002, is currently in effect. Several of the ranches overlying the Warden Creek subbasin are required to comply with the Order from the Regional Water Board, which includes water quality monitoring for selected general physical and general mineral constituents at the primary irrigation well and at domestic wells on a semi-annual basis.

2.2.4 An explanation of how the proposed boundary modification may affect state programs, including, but not limited to the California Statewide Groundwater Elevation Monitoring (Water Code Section 10920 et seq.), Groundwater Management Plans developed pursuant to AB 3030 (Water Code Section 10750 et seq.), Groundwater Sustainability Plans or alternatives developed pursuant to the Sustainable Groundwater Management Act (Water Code Section 10720 et seq.), any applicable state or regional board plans, and other water management and land use programs (§344.6(b)(4))

The proposed basin boundary modifications will not affect the majority of the State groundwater programs listed or other applicable State or regional plans, nor water management and land use programs – this is further described in Table 1 below for each proposed subbasin.

The Los Osos Area subbasin includes the removal of two scientific exclusion areas and the proposed subbasin boundary helps align the Adjudicated Plan Area with the State's Bulletin 118 basin boundary. The proposed Warden Creek subbasin aligns with the Adjudicated Plan Area and extends out to the current external Bulletin 118 eastern boundary – this is in recognition of distinct hydrogeology from the proposed Los Osos Area subbasin. All requested modifications are supported by the best available scientific data to substantiate a subbasin and exclusion areas based on differing geology, barrier to groundwater flow to the other subbasin/exclusion areas, land use, and management entities.

Overall, the proposed Los Osos Areas subbasin will support the LOWRF permit requirements, implementation of the SNMP Monitoring Program, along with the continuation of the Basin Plan programs and monitoring, which will continue to improve the proposed subbasin water quality. The proposed boundary request will have no negative impacts on these programs and plans. Results from the boundary request will improve sustainable management in the Los Osos Basin.

Table 1
State and Regional Water Management and Land Use Programs

No.	State Programs	Program Overview	Los Osos Area Subbasin - Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
1.	**California Statewide Groundwater Elevation Monitoring Program (CASGEM)**	The Department of Water Resources CASGEM Program tracks seasonal and long-term groundwater elevation trends in groundwater basins statewide. The program's mission is to establish a permanent, locally-managed program of regular and systematic monitoring in all of California's alluvial groundwater basins. The San Luis Obispo County Flood Control and Water Conservation District (County Flood Control District), as the designated Monitoring Entity, reports water level data directly into the CASGEM program. The Los Osos Basin has nine CASGEM monitoring wells in the Adjudicated Plan Area, five of the wells are sentry wells on the beach for sea water intrusion detection. Data collection for the CASGEM Program will continue for the basin. In 2014, the County Flood Control District prepared a CASGEM Monitoring Plan for High and Medium Priority Groundwater Basins (County CASGEM Monitoring Plan), including a data gap analysis for Los Osos Basin.	**LIMITED AFFECT** – Four CASGEM monitoring wells are in this subbasin. The County Flood Control District will review and update the County CASGEM Monitoring Plan (2014) as needed to reassess the current data gaps analysis and determine what additional data is needed within this subbasin. From the data gap analysis, the County Flood Control District will discuss and coordinate with landowners to consider adding new CASGEM wells into a voluntary monitoring program for the proposed Los Osos Area subbasin, as necessary. The proposed basin boundary modifications would align the Bulletin 118 boundary with the best available scientific data and existing groundwater management boundaries in the basin. The distinct hydrogeology of the two subbasins would allow the County Flood Control District to refine its CASGEM data gap analysis and ensure that the monitoring program adequately covers both subbasins.	**AFFECTED** – Currently, the County Flood Control District has no CASGEM wells in this proposed subbasin. The County Flood Control District will expand the CASGEM Program as needed into this subbasin in alignment with the preferred monitoring well density defined in the County CASGEM Monitoring Plan (2014), and will update the plan as needed. Pending a refined data gap analysis, the County Flood Control District will need to discuss and coordinate with landowners to consider adding new CASGEM wells into a voluntary monitoring program for the proposed Warden Creek subbasin, as necessary. This proposed subbasin boundary aligns with the Bulletin 118 boundary basin for this basin area. The basin subdivision is supported by the best available scientific data to substantiate a subbasin based on differing geology, barrier to groundwater flow to the other subbasin, land use, and management entities. It recognizes distinct hydrogeology of the two subbasins and allows the County Flood Control District to refine its data gap analysis and ensure that the monitoring program adequately covers both subbasins.

No.	State Programs (continued)	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
2.	**Water Quality Control Plan for the Central Coastal Basin**	The objective of the Water Quality Control Plan for the Central Coastal Basin (State's Basin Plan) for the Regional Water Quality Control Board (Regional Water Board), State Water Resources Control Board (State Water Board), and California Environmental Protection Agency (EPA) is to show how the quality of surface water and groundwater in the Central Coast Region should be managed to provide the highest water quality reasonably possible. The Vision for the State is Healthy Watersheds, which includes the Morro Bay Watershed. This watershed surrounds the Los Osos Basin and a proposed basin subdivision with scientific exclusion areas, should not affect the objective, vision, or actions of the State's Basin Plan.	**NOT AFFECTED** –The proposed subbasin is within the Morro Bay Watershed. The State's Basin Plan objectives, vision, or actions for the Morro Bay Watershed will not be impacted by this basin modification. In fact, the studies performed will help provide additional data that could be used to refine the State's Basin Plan. Furthermore, results from the study substantiated this basin subdivision by delineating differing geology, barrier to groundwater flow to the other subbasin and exclusion areas, land use, and management entities.	**NOT AFFECTED** – The proposed subbasin is within the Morro Bay Watershed. The State's Basin Plan objectives, vision, or actions for the Morro Bay Watershed will not be impacted by this basin modification. In fact, the studies performed will help provide additional data that could be used to refine the State's Basin Plan. Furthermore, results from the study substantiated this basin subdivision by delineating differing geology, barrier to groundwater flow to the other subbasin and exclusion areas, land use, and management entities.
3.	**Groundwater Ambient Monitoring and Assessment (GAMA) Program**	The State Water Board GAMA Program is a comprehensive groundwater quality monitoring program. The program integrates existing monitoring programs and new program elements as necessary, resulting in a publicly-accepted plan to monitor and assess groundwater quality in basins that account for 95% of the state's groundwater use.	**NOT AFFECTED** –The proposed subbasin will not affect the GAMA Program data, except the shapefile for the basin modification will need to be updated in GAMA Geotracker. Basin entities that provide data for this program are still located in the basin. The proposed scientific exclusion areas attached to this subbasin area are based on differing geology, land use, management and significant groundwater barriers (Los Osos fault). These exclusion areas should not affect the reporting of public water systems (such as California State Park - Montaña de Oro State Park) to the GAMA Program.	**NOT AFFECTED** – The proposed subbasin will not affect the GAMA Program data. Basin entities that provide data for this program are still located in the basin. The proposed subbasin boundary aligns with the Bulletin 118 basin boundary.

No.	State Programs (continued)	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
4.	**Irrigated Lands Regulatory Program (ILRP)**	The ILRP was initiated in 2003 to prevent agricultural runoff from impairing surface waters, and in 2012, groundwater regulations were added to the program. The Regional Water Board adopted Agricultural Order No. R3-2012-001 (2012), a *Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands* (Agricultural Order). The goal of the ILRP is to protect surface water and groundwater quality and to reduce impacts of irrigated agricultural discharges to waters of the State.	**NOT AFFECTED** –The proposed subbasin will not affect the ILRP Program, except the shapefile for the basin modification will need to be updated in Geotracker. This propose subbasin boundary modification did not remove farmland overlying the Los Osos Basin.	**NOT AFFECTED** – The proposed subbasin will not affect the ILRP Program. This proposed subbasin boundary modification did not remove farmland overlying the Los Osos Basin. In fact, the proposed subbasin boundary aligns with the Bulletin 118 boundary.
5.	**LOWRF Monitoring and Reporting Program**	Monitoring and Reporting Program (MRP) is a groundwater monitoring report for the Los Osos Water Recycling Facility (LOWRF), prepared by the County per the Waste Discharge/Recycled Water Requirement Order No. R3-20110001 (WDR Order) for the Regional Water Board. This report is submitted annually to the Regional Water Board. The proposed boundary modification will support the permit requirements for the program, as beneficial use of recycled water is only used in the Adjudicated Plan Area. Modifying the basin boundaries to create the Los Osos Area subbasin will reduce possible conflicts by creating a consistent understanding of local and state boundaries.	**NOT AFFECTED -** The proposed subbasin will not affect this program. In fact, the proposed boundary modification will support the permit requirements for the program, as beneficial use of recycled water is only used in the Adjudicated Plan Area (within the proposed Los Osos Area subbasin) and will help to ensure there are no conflicts between the local and state understanding of subbasin conditions.	**NOT AFFECTED -** The proposed subbasin will not affect this program. In fact, the basin boundary subdivision supports the LOWRF MRP. The LOWRF MRP is not developed for this subbasin because recycled water cannot be used for beneficial use in this area per the LOWRF permit.

No.	State Programs (continued)	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
6.	**Salt and Nutrient Monitoring Plan (SNMP)**	The SNMP was developed to meet the LOWRF conditions of beneficial use of recycled water under the WDR Order and Recycled Water Policy for the State Water Board and Regional Water Board. The Recycled Water Policy states that the SNMP is to be developed to manage salts, nutrients, and other significant chemical compounds on a watershed- or basin/subbasin-wide basis to ensure attainment of water quality objectives and protection of beneficial uses. Pursuant the WDR Order, recycled water is not permitted for beneficial use in the areas outside of the Adjudicated Plan Area. Therefore, the SNMP and its Groundwater Quality Monitoring Program were developed within the Adjudicated Plan Area (over the Los Osos Area subbasin). Modifying the basin boundaries to create the Los Osos Area subbasin will reduce possible conflicts by creating a consistent understanding of local and state boundaries.	**NOT AFFECTED** –The proposed subbasin will not affect the SNMP. In fact, the basin boundary subdivision supports the SNMP and its Groundwater Quality Monitoring Program. The SNMP and its Groundwater Quality Monitoring Program were developed within the Adjudicated Plan Area (over the Los Osos Area subbasin) were recycled water can only be used per the LOWRF permit.	**NOT AFFECTED** – The proposed subbasin will not affect the SNMP. In fact, the basin boundary subdivision supports the SNMP and its Groundwater Quality Monitoring Program. The SNMP and its Groundwater Quality Monitoring Program were not developed for this subbasin because recycled water cannot be used for beneficial use in this area per the LOWRF permit.

No.	State Programs (continued)	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
7.	**Recycled Water Management Plan (RWMP)**	The RWMP includes the Recycled Water Reuse Program, Water Conservation Program, Groundwater Monitoring Program, Environmental Monitoring Program, Reporting and Adaptive Management Program for the LOWRF per the California Coastal Commission's Coastal Development Permit (CDP) No. A-3-SLO-09-055/069. The RWMP is submitted in an annual report to the California Coastal Commission. The proposed boundary request will have no negative impacts any of the programs listed in the RWMP. In fact, the proposed boundary modification will support the permit requirements for the program, as beneficial use of recycled water is only used in the Adjudicated Plan Area (over the Los Osos Area subbasin) and will help to ensure there are no conflicts between the local and state understanding of subbasin conditions.	**NOT AFFECTED -** The proposed subbasin will not affect these programs. In fact, the proposed boundary modification will support the permit requirements for the program, as beneficial use of recycled water is only used in the Adjudicated Plan Area (over the Los Osos Area subbasin). The RWMP and associated programs are part of the California Coastal Commission's permit in the adjudicated basin area.	**NOT AFFECTED -** The proposed subbasin will not affect these programs. The RWMP is not developed for this subbasin because recycled water cannot be used for beneficial use in this area per the LOWRF permit, which includes language from the CDP.

No.	Regional Programs	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
1.	**County Resource Management System (RMS)**	During the 1990's, the County of San Luis Obispo established the RMS—an important tool that provides county-wide information to guide decisions about balancing land development with resources necessary to sustain such development. The County conducts biennial Resource Summary Reports describing the state of the county's natural and human-made resources, including water supply (includes groundwater basins), water systems and wastewater collection and treatment. When a resource deficiency becomes apparent, the County designates alert levels or levels of severity to identify the level of deficiency. For each of the three levels of severity, the Board of Supervisors may take corrective actions to address a deficiency. The County Resource Management System continues to be an important tool for monitoring the overall health of the water supply and ensuring that appropriate actions are taken to reduce impacts on basins. Currently, the entire Los Osos Basin Levels of Severity (LOS) is a Level III. In general, a Level III occurs when the demand for the resource currently equals or exceeds its supply and is the most critical level of concern.	**NOT AFFECTED -** The proposed subbasin will not affect the County Resource Management System. This subbasin has known issues that are anticipated to be resolved in the future with groundwater management and implementation projects, such as the Los Osos Water Recycling Facility. However, the County Planning Department will need to update their report with the proposed subbasin. The proposed basin boundary modifications would align the Bulletin 118 boundary with the best available scientific data and existing groundwater management boundaries in the basin, thereby not impacting this program, but rather helping to create consistency between local conditions/understanding and statewide programs.	**AFFECTED -** The proposed subbasin will affect the County Resource Management System. The County Planning Department will need to update their report with the proposed subbasin and rank the LOS, anticipated to be ranked to a lower level, as appropriate. The studies performed on this subbasin supports a revision to this report. The studies substantiate a subbasin based on differing geology, barrier to groundwater flow to the other subbasin, land use, and management entities.

No.	Regional Programs	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
2.	**Countywide Groundwater Level Monitoring Program**	The County Flood Control District established a Groundwater Level Monitoring Program and has been monitoring groundwater levels countywide on a semi-annual basis (spring and fall) for more than 50 years. This data has been used to support planning, decision making, and engineering purposes. Monitoring primarily takes place using a voluntary network of privately-owned wells. The voluntary monitoring network has changed over time as access to wells has been lost or new wells have been added to the network.	**NOT AFFECTED -** The proposed subbasin will not affect the Program. The Los Osos Area subbasin (similar boundary alignment with Adjudicated Plan Area) has approximately 44 wells in the County Flood Control District's Groundwater Level Monitoring Program, which are measured by the County Flood Control District and partner agencies. This data is leveraged in the Basin Management Committee's Groundwater Monitoring Program (in the Adjudicated Plan Area). The County Flood Control District coordinates with local, state, and federal agencies to develop better information on groundwater level monitoring and comply with current monitoring and report requirements, such as the CASGEM Program.	**AFFECTED – The** proposed subbasin will affect the Program. The County will need to be expand the volunteer Program into this subbasin, as appropriate. The County Flood Control District will discuss and coordinate with landowners to consider adding new wells into a voluntary monitoring program for the proposed Warden Creek subbasin, as necessary. The proposed subbasin boundary aligns with the Bulletin 118 boundary basin for this basin area. This basin subdivision is supported by the best available scientific data to substantiate a subbasin based on differing geology, barrier to groundwater flow to the other subbasin, land use, and management entities.
3.	**Los Osos Community Plan**	On December 11, 2012, the County Board of Supervisors authorized the Department of Planning & Building to update the Los Osos Community Plan of the County's General Plan and Local Coastal Plan. The Community Plan is the official plan for land use and transportation in Los Osos which determines how the community will grow and develop over the next 20 years. The update is underway and will focus on protecting resources and providing adequate infrastructure.	**NOT AFFECTED -** The proposed subbasin will not affect this plan. The Community Plan covers the population/community within the Urban Reserve Line of Los Osos, which is entirely inside the Los Osos Area subbasin.	**NOT AFFECTED -** The proposed subbasin will not affect this plan. The subbasin is outside the Urban Reserve Line of Los Osos, and therefore is not the Community Plan's area of focus nor would it be subject to the Community Plan.

No.	Regional Programs	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
4.	**Integrated Regional Water Management (IRWM) Plan**	In 2005, local agencies and organizations adopted the IRWM Plan that covered the entire San Luis Obispo County boundary (including the Los Osos Basin as a part of the North Coast Subregion). The purpose of the IRWM Plan is to inventory local water resources conditions and provide for coordinated regional planning and implementation of a broad range of programs and projects designed to enhance regional water resources management and develop multi-benefit solutions. The IRWM Plan crosses jurisdictional, watershed, and political boundaries within the region to facilitate this integrated planning and implementation. The IRWM Plan is a dynamic document and is updated over the years (2007, 2014, 2018). The Regional Water Management Group (RWMG) was established by over 20 agencies and is responsible for IRWM Plan development/update and implementation activities. IRWM planning efforts have continued to develop and serve as means to create a common understanding at both a regional-scale and a subregional-scale. IRWM serves as a key program for fostering regional/subregional relationships and helps to improve a community's effectiveness in achieving sustainable water resources. Among those 20 RWMG	**NOT AFFECTED -** The proposed subbasin will not affect the plan. The proposed basin boundary modifications would align the Bulletin 118 boundary with the best available scientific data and existing groundwater management boundaries in the basin, thereby not impacting this program, but rather helping to create consistency between local conditions/understanding and statewide programs. Boundary modifications would be included in future IRWM Plan updates, and IRWM planning efforts would reflect the community's aim to achieve sustainability in the proposed subbasins.	**NOT AFFECTED -** The proposed subbasin will not affect the plan. The proposed basin boundary modifications would align the Bulletin 118 boundary with the best available scientific data and existing groundwater management boundaries in the basin, thereby not impacting this program, but rather helping to create consistency between local conditions/understanding and statewide programs. Boundary modifications would be included in future IRWM Plan updates, and IRWM planning efforts would reflect the community's aim to achieve sustainability in the proposed subbasins.

	(continuation of IRWM Plan)	members are the four members of the Los Osos Basin Management Committee, which facilitates coordination from the basin-scale to the regional-scale.		
No.	**Regional Programs**	**Program Overview**	**Los Osos Area Subbasin – Affected / Not Affected**	**Warden Creek Subbasin- Affected / Not Affected**
5.	***Local Agency Management Program (LAMP) Onsite Wastewater Treatment Systems (OWTS)***	In Winter 2018, the County Board of Supervisors may consider approving and adopting the countywide Local Agency Management Program (LAMP) for the Onsite Wastewater Treatment Systems (OWTS), in accordance with the State Water Resources Control Board and Assembly Bill 885. The purpose of the LAMP is to allow the continued use of OWTS within the unincorporated areas of the County as well as to expand the local program to permit and regulate alternative OWTS while protecting water quality and public health. This program will not be affected by the proposed basin boundary modification. Appropriate data from the countywide OWTS LAMP will be incorporated into groundwater monitoring programs (e.g. associated with the Salt and Nutrient Management Plan), once approved and adopted by State Water Board and County Board of Supervisors.	**NOT AFFECTED -** The proposed subbasin will not affect the program since the program would continue to apply countywide in non-sewered unincorporated areas of San Luis Obispo County, regardless of basin boundaries.	**NOT AFFECTED -** The proposed subbasin will not affect the program since the program would continue to apply countywide in non-sewered unincorporated areas of San Luis Obispo County, regardless of basin boundaries.

No.	Other Programs	Program Overview	Los Osos Area Subbasin – Affected / Not Affected	Warden Creek Subbasin- Affected / Not Affected
1.	***Basin Management Plan***	On October 14, 2015, the San Luis Obispo Superior Court signed an order approving the Stipulated Judgment and Basin Management Plan for the Los Osos Groundwater Basin (more specifically the Adjudicated Plan Area). The Stipulated Judgment established the Basin Management Committee (BMC), comprised of three local water purveyors and the County of San Luis Obispo, tasked with implementing the sustainable groundwater management activities defined in the Basin Management Plan.	**NOT AFFECTED -** The proposed subbasin will not affect the plan. In fact, the basin boundary subdivision supports the Basin Management Plan and its annual report. This Plan was developed within the Adjudicated Plan Area (over the Los Osos Area subbasin). Any modified basin boundaries will be noted in the BMC's annual report. However, the modifications will not impact the BMC, its Basin Management Plan, or its ability to implement the plan, but rather will support it by not creating unnecessary governance or groundwater management conflicts, or by diverting community resources to non-basin or disconnected subbasin areas.	**NOT AFFECTED -** The proposed subbasin will not affect the plan. Both scientific exclusion areas and the proposed Warden Creek subbasin are not part of the Basin Management Plan due to distinctly different geology/hydrogeology, land use, and significant impediments to groundwater connectivity with the Adjudicated Plan Area. Therefore, separating and/or excluding these areas will not inhibit the Basin Management Plan from pursuing or achieving its goals toward sustainability within the Adjudicated Plan Area (Los Osos Area subbasin).

2.2.5 Any other information deemed appropriate by the requesting agency, including but not limited to, an explanation of opportunities that would arise for or obstacles that would be overcome by the boundary modification request (§344.6(c))

The boundary modification request is based upon the most current scientific assessment of the Los Osos Basin. The proposed basin boundary modification includes two jurisdictional subdivisions ("subbasins") and two scientific exclusion areas. Both proposed subbasins will have different management entities, the BMC over the Adjudicated Plan Area subbasin and the GSA over the proposed Warden Creek subbasin. The Adjudicated Plan Area includes both the proposed Los Osos Are subbasin as well as two scientific exclusion areas (the removal of Montaña de Oro State Park to the Los Osos fault line and a minor 44 acre area removal). Both scientific exclusion areas and the proposed Warden Creek subbasin are not part of the Basin Plan due to different geology/hydrogeology, land use, and minor groundwater connectivity to the Adjudicated Plan Area. The proposed basis boundary modifications will help align the Adjudicated Plan Area and the Bulletin 118 basin boundary, which will support the groundwater management and monitoring in the proposed subbasin.

In addition, the Salt and Nutrient Management Plan (SNMP) covers the groundwater basin boundaries defined for the Adjudicated Plan Area. The SNMP was prepared for the LOWRF (WDR Order) and Recycled Water Policy for the State Water Board and Regional Water Board. The WDR Oder states the recycled water must be used for beneficial use in the Adjudicated Plan Area. The proposed subbasins will support the SNMP development for recycled water reuse in the Adjudicated Plan Area.

The exclusion of the Montaña de Oro Park to the Los Osos fault line and the minor 44 acre area will not impact sustainable management of the Los Osos Basin. The removal of these areas is based on the best available scientific information, including significant hydrogeological barriers to groundwater flow (Los Osos fault and rising bedrock), land use, differing geology, and management entities (such as the State Parks, BMC, and GSA).

3.0 GENERAL INFORMATION (§344.10)

3.1 Description of lateral boundaries and definable bottom (§344.10(a))

The DWR Bulletin 118 Los Osos Basin is bounded on the north by Park Ridge, on the south by the Irish Hills, and on the west by the Morro Bay estuary. The eastern boundary is a drainage divide separating the Los Osos Basin from the San Luis Obispo Valley Groundwater Basin (Figure 1). In general hydrogeologic terms, the proposed lateral basin boundary is the onshore extent of the contiguous area overlying the principal aquifers. The bottom of the basin is the base of permeable sediments, which is defined by the contiguous base of the stacked principal aquifers within the lateral basin boundary. Principal aquifers include Holocene-age alluvial deposits and

active dune sands, older (stabilized) dune sands, the Paso Robles Formation, and the Careaga Formation.

Los Osos Area Subbasin – Located in the Adjudicated Section of the Los Osos Basin

The proposed Los Osos Area subbasin boundary encloses an area at ground surface beneath which the Paso Robles Formation is present and saturated. Members of the Los Osos BMC used this scientific definition to develop the Adjudicated Plan Area (ISJ, 2015). The final Adjudicated Plan Area was extended past this boundary to include the legal boundaries of all parcels overlying the scientifically defined area. Therefore, while based on hydrogeology, the Los Osos Area subbasin would include a jurisdictional boundary with the proposed Warden Creek subbasin and two scientific external boundary modifications. The subbasin bottom is the base of permeable sediments, which reaches 800 feet in saturated thickness and overlies Pismo Formation, Monterey Formation, serpentinite, and Franciscan Assemblage bedrock.

Warden Creek Subbasin

The proposed Warden Creek subbasin encompasses the eastern portion of the Los Osos Valley alluvium from the eastern edge of the proposed Los Osos Area subbasin to the drainage divide separating Los Osos Basin from the San Luis Obispo Valley Groundwater Basin. This subbasin, drained by Warden Creek, encloses an area where saturated Holocene-age alluvial deposits are present and directly overlie Franciscan Assemblage bedrock. The subbasin bottom is the base of the alluvial deposits, which reaches 70 feet in saturated thickness.

3.2 Graphical Map of lateral basin boundaries (§344.10(b))

Figure 1 presents a graphical map of the proposed subbasins in relation to the existing Bulletin 118 basin, along with affected public water systems. There are six affected agencies and five affected public water systems that are within or bordering the existing and proposed basins, as listed below:

- Los Osos Community Services District (affected agency and system)
- Golden State Water Company (affected agency and system)
- S&T Mutual Water Company (affected agency and system)
- Montaña de Oro State Park (affected agency and system)
- San Luis Obispo County (affected agency)
- San Luis Obispo County Flood Control and Water Conservation District (affected agency)
- First Baptist Church (affected system until November 2017)[6]

6 The First Baptist Church is not a public water system as of November 2017, due to closure of their school.

4.0 HYDROGEOLOGIC CONCEPTUAL MODEL (§344.12)

A conceptual model is a compilation and interpretation of available information on the physical system being modeled. For a groundwater basin, it includes a characterization of basin structure, boundary conditions, aquifer geometry, physical parameters, and components of inflow and outflow.

The hydrogeologic conceptual model of the proposed Los Osos Area subbasin has been developed over the last 30 years and is summarized herein and in the Basin Plan. The hydrogeologic conceptual models of the Eastern Valley and Montaña de Oro fringe areas were developed concurrently with this BBMR and are presented in the 2018 Fringe Areas TM (CHG, 2018). The Eastern Valley fringe area described in the 2018 Fringe Areas TM is proposed herein as a subbasin. The Montaña de Oro fringe area and minor fringe areas are scientific exclusion areas and removed through external scientific boundary modification based on the 2018 Fringe Areas TM.

4.1 Principal Aquifers and Aquitards (§344.12(a)(1))

The Los Osos Basin (DWR Basin 3-8) is a coastal sedimentary basin with direct hydraulic connection to the Pacific Ocean. Principal aquifers include older dune sands, the Paso Robles Formation, the Careaga Formation, and the recent alluvium of Los Osos Creek and Warden Creek. The relationship between geologic units and aquifers for the basin is shown in Figure 2.

Los Osos Area Subbasin

Principal aquifers in the proposed Los Osos Area subbasin are divided into five zones (Zone A through E) plus an alluvial aquifer (Figure 2). Zones A and B are the perched and transitional (semi-perched) aquifers. Zone C is the upper aquifer, and Zones D and E are referred to collectively as the lower aquifer. There is a regional aquitard (the AT2 Clay) that separates the upper and lower aquifers (C&A, 2003).

Surface geology of the Los Osos Area subbasin is shown in Figure 3. The only basin sediments mapped at ground surface are dune sands and alluvial deposits, although the Paso Robles Formation has been mapped at ground surface in older geologic maps (e.g. Hall, 1979). The Careaga Formation has been inferred beneath the Paso Robles Formation based on lithologic correlation from borehole logs (Yates and Weise, 1988). Representative geologic cross-sections for the subbasin are shown in Figure 4 and Figure 5.

A series of nine geologic cross-sections from prior work that define the lateral extents and bottoms of the six basin aquifers have been updated to show the existing Bulletin 118 basin boundaries and proposed Los Osos Area subbasin boundaries (Figures A1-2 through A1-10;

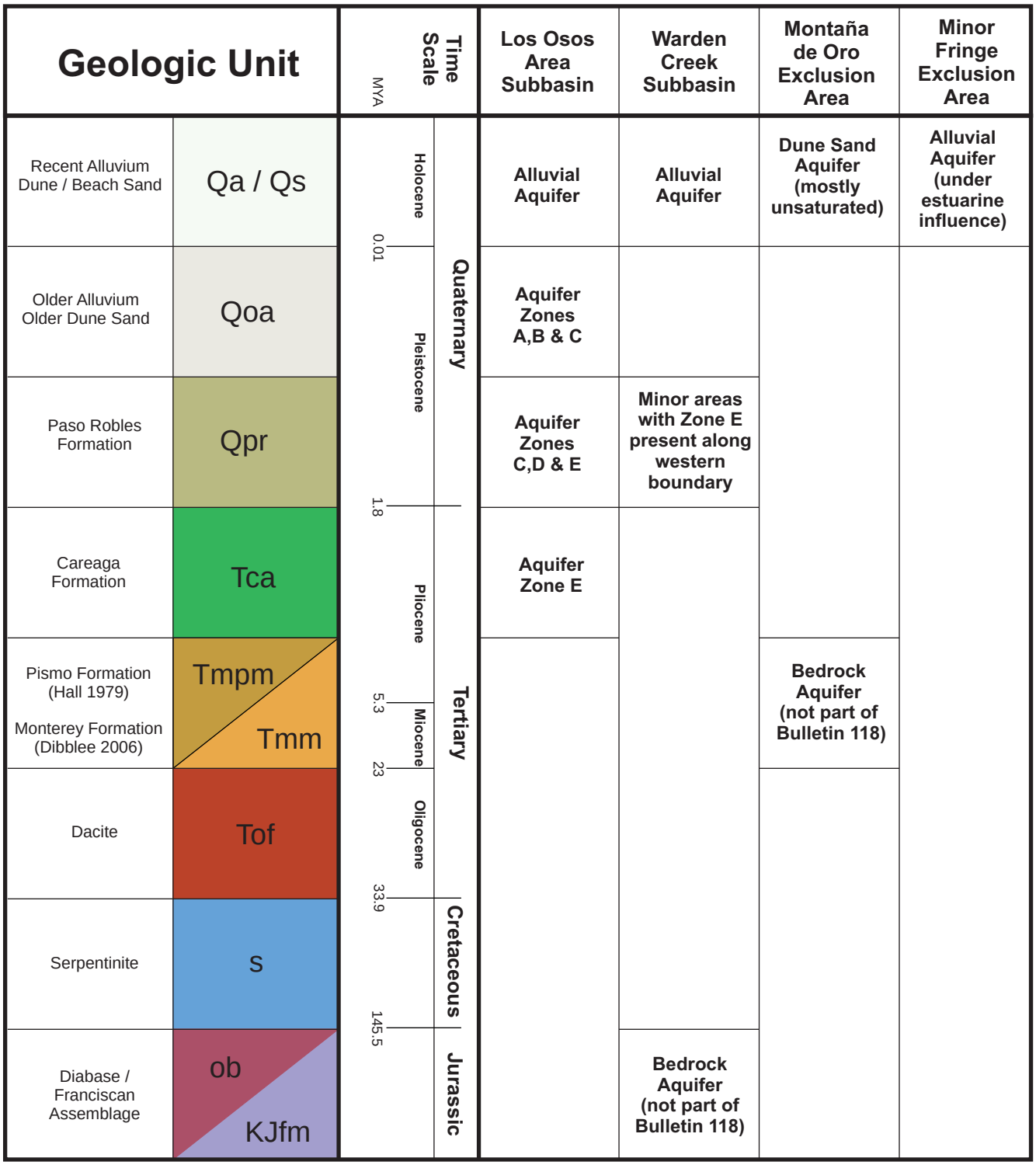


Figure 2
Stratigraphic Column with Aquifer Correlations

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

Geology Key (Dibblee, 2006)

- Qa - Alluvium
- Qs - Dune Sand
- Qls - Landslide Deposits
- Qoa - Older Alluvium
- Tmm - Monterey Formation
- Tml - Monterey Formation
- Tmts - Monterey Formation
- Tot - Obispo Formation
- Tov - Obispo Formation
- Tr - Rincon Shale
- Tof - Dacite
- sp - Serpentine
- ob - Diabase
- fm - Franciscan Assemblage
- fs - Franciscan Assemblage
- fc - Franciscan Assemblage

Morro Bay Estuary

PACIFIC OCEAN

PARK RIDGE

Bedrock Narrows

Los Osos Creek

LOS OSOS CREEK VALLEY

CEMETERY MESA

IRISH HILLS

Los Osos Fault

Bedrock (Hall, 1979)

B

B'

F

F'

L

Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Los Osos Area Subbasin
- Cross-section Line
- Boundary Segment Node

Boundary Segment

- 1
- 2
- 3
- 4

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 3000 6000 ft

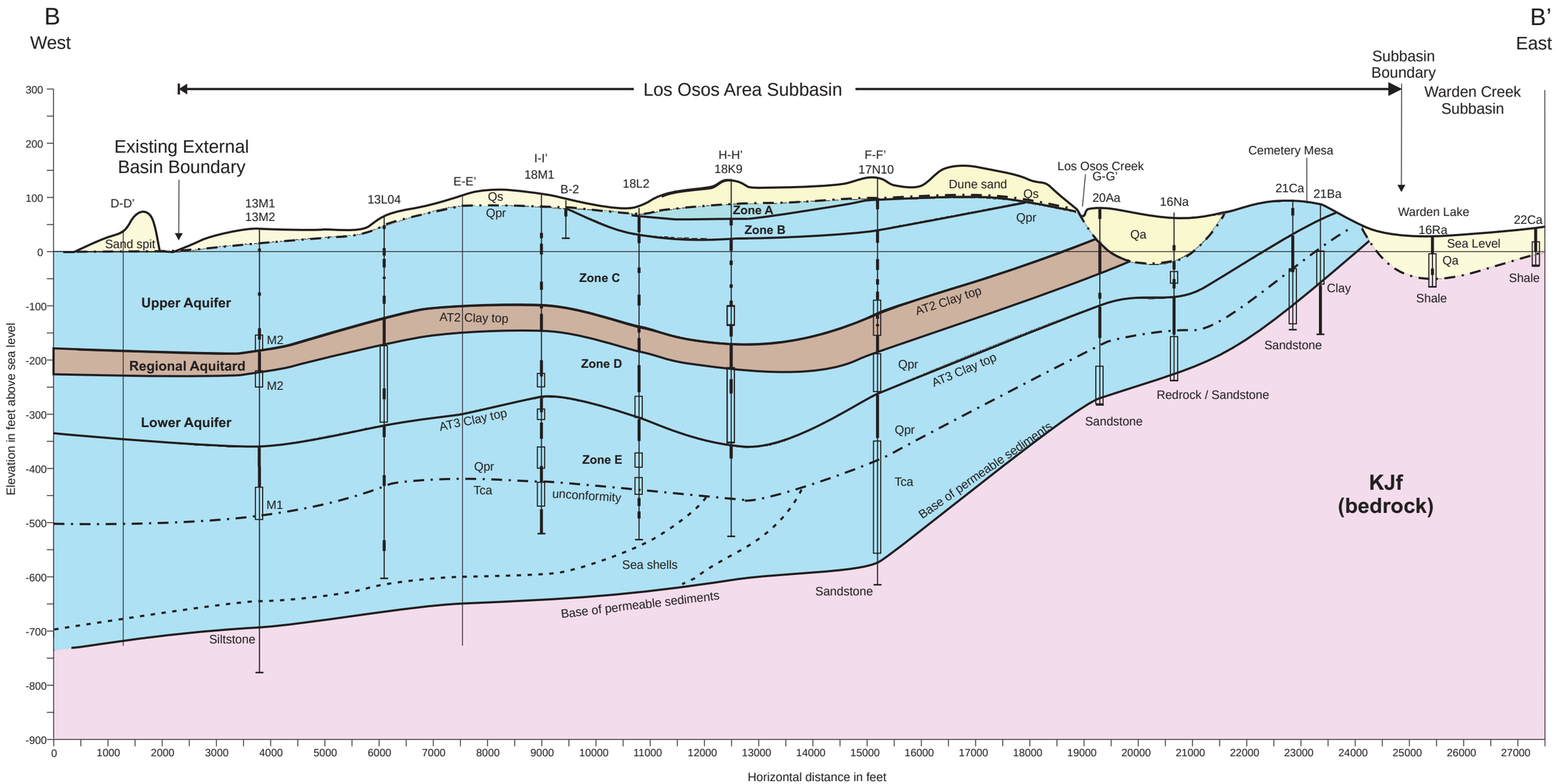
NORTH

Figure 3 - Surface Geology - Los Osos Area Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists



Explanation

Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point

18M1 Well ID

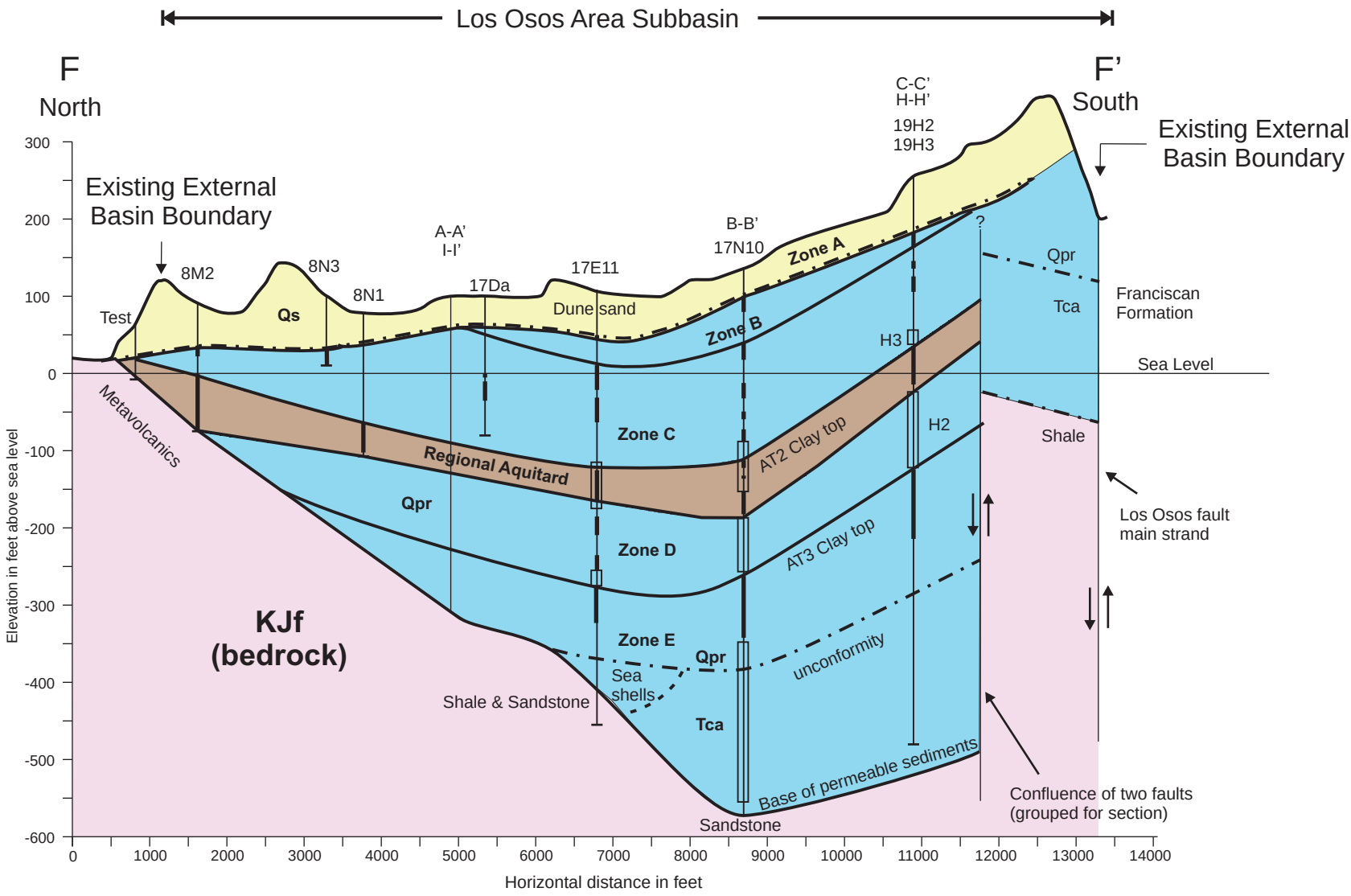
Clay layer

Well screen

Formations:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation
KJf - Franciscan Assemblage

Figure 4
Cross Section B-B'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists



Explanation

Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
19H2 Well ID
Clay layer
Well screen

Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation
KJf - Franciscan Assemblage

Figure 5
Cross Section F-F'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

Appendix A1). A base of permeable sediments map is included in Appendix A2. Spring 2016 Groundwater elevation contours maps from the 2016 Annual Groundwater Monitoring Report for the perched aquifer, upper aquifer, and lower aquifer are in Appendix A3.

Pumping tests in the main water supply aquifers include tests for individual zones and combinations of zones. A summary of aquifer test results is listed below in Table 2.

Table 2
Aquifer Tests
Los Osos Area Subbasin

Well ID	Aquifer Zone	Flow (gpm)	Duration	T (gpd/ft)	K (gpd/ft^2)	K (ft/day)
30S/11E-07N1	C	82	8 hours	3,900	140	18.7
30S/10E-13L	C	85	4 hours	9,000	150	20.1
30S/11E-18K3	C	170	24 hours	9,500	150	20.1
30S/11E-18K9	C, D	300	8 hours	15,800	90	12.0
30S/11E-17E11	C, D	190	8 hours	4,600	60	8.0
30S/11E-17N10	C, D, E	320	24 hours	5,800	17	2.3
30S/11E-07Q3	D	180	24 hours	7,400	180	24.1
30S/10E-13N	D	150	24 hour	13,200	160	21.4
30S/11E-18M1	D, E	418	6 hours	10,500	80	10.7
30S/11E-18L2	D, E	540	12 hours	10,500	110	14.7
		750	8 hours	11,000	120	16.0
30S/11E-18L6	D, E	50	7 hours	13,200	110	14.7
30S/11E-19H2	D	20	12 hours	6,200	62	8.3
30S/10E-13M1	E	50	4 hours	14,200	240	32.1
30S/11E-21B	E	12	8 hours	530	9	1.2
30S/11E-20Aa	E	30	8 hours	2,930	42	5.6

Notes: Pumping test data references: Cleath & Associates, 2005; CHG, 2018 (Well 21B1).
T = transmissivity; K = Hydraulic Conductivity; gpm = gallons per minute; gpd = gallons per day; ft = foot.

Specific yield estimates for San Luis Obispo County alluvial deposits range from 3 percent in clay to 25 percent in sand (Johnson, 1967). Specific yield for aquifer zones has be estimated based on individual lithology, and averages 10 percent for the Adjudicated Plan Area (CHG, 2017). Where Zone C is unconfined (portions of western basin area), specific yield estimates apply to aquifer storativity estimates. Where confined or semi-confined (beneath Morro Bay estuary and downtown Los Osos), aquifer storativity values may be several orders of magnitude lower. Pumping test conducted at a Zone C well in downtown Los Osos (30S/11E-18K3) indicated a storativity of 0.0001 (Weber Hayes, 2001).

Zone A - Perched Aquifer

Zone A is a perched aquifer that overlies a clay layer at the base of the older dune sands. Zone A is not generally used as a source of water supply for Los Osos. The perched aquifer is unconfined and completely within dune sands, although there are also many areas with saturated dune sands that are not specifically in Zone A. The dune sands are wind-blown (eolian) deposits, also referred to as the Baywood fine sand. These deposits typically comprise poorly graded, fine to medium-grained sand, and reach a maximum estimated thickness of close to 100 feet along the dune ridges in Baywood Park (Cleath & Associates, 2003).

The average hydraulic conductivity of the older dune sand in Zone A is estimated to range from 70 to 230 gallons per day per square foot (gpd/ft^2), based on the first and third quartile of 50 laboratory and fields tests from various locations across the proposed subbasin (Cleath & Associates, 2005). The specific yield for these shallow sands is estimated between 20 and 25 percent (Johnson, 1967).

Zone A receives recharge from direct percolation of precipitation and return flows from anthropogenic activities. Groundwater movement in Zone A is within dune sand and flow directions are generally northwest to northeast, with relatively steep hydraulic gradients of up to 0.06 ft/ft between Bayview Heights and downtown (parallel to the topographic slope). Flow in Zone A drains to Willow Creek and issues from seeps in the Los Osos Oaks Preserve and along the banks of Los Osos Creek. To the north and west, the perching clay pinches out and groundwater spills into aquifer Zone C. A groundwater high between downtown Los Osos and eastern Baywood Park separates water moving to the east toward Los Osos Creek from water moving to the west toward the Morro Bay estuary (CHG, 2015a).

Zone B - Transitional Aquifer

Zone B, the transitional aquifer, is composed of fine sands and silty sands with occasional clayey and gravelly lenses. Zone B is separated from Zone A by a clay and clayey sand aquitard up to 30 feet thick beneath downtown Los Osos. The piezometric head in Zone B lies between the Zone A perched aquifer and the uppermost community water supply aquifer, which is Zone C. Water levels in Zone B have been measured up to 16 feet lower than Zone A, and close to 60 feet higher than Zone C at multi-level monitoring wells (Weber Hayes, 2001). These water level

differences, along with differences in general mineral water quality, led to the identification of Zone B as a separate aquifer. Subsequent lithologic correlations between downtown and wells to the north and east placed Zone B within the Paso Robles Formation (Cleath & Associates, 2003). No pumping tests specific to Zone B are available. Zone B is not generally used as a source of water supply for Los Osos.

Zone C - Upper Aquifer

Zone C, which is the shallowest aquifer used as a source of water supply for the Los Osos community, overlies the regional aquitard and extends up to the water table, except where overlain by Zones A or B. Zone C is predominantly within Paso Robles Formation deposits, except at lower topographic elevations where dune sands are saturated. The Paso Robles Formation is composed of unconsolidated sands, gravels, and clays. Gravel clasts are generally derived from Franciscan Assemblage rocks, including cherts, metavolcanics and hard sandstone. Shales, quartz and diabase/dacite are also commonly logged. The depositional environment has included beach and near-shore marine conditions. As a result, sea shells are occasionally present locally in the Paso Robles Formation. West of downtown Los Osos, Zone C is generally composed of fine to medium grained sands, with relatively few clays or gravels, except one notable basal gravel. In the downtown area, Zone C sediments coarsen, with more fine gravels noted in logs, although interbedded clays are also common.

Recharge to Zone C occurs via direct percolation of precipitation, return flow from irrigation and septic system discharges, stream seepage from Los Osos Creek, subsurface inflows across the proposed subbasin boundaries, and through leakage from Zones A and B. Movement of groundwater in Zone C is variable, but generally flows north and west toward Morro Bay, with some easterly flow from Baywood toward Los Osos Creek. Upper aquifer water levels have increased historically in some areas due to increased return flow from development.

Regional Aquitard

Individual clay beds in the Paso Robles Formation are generally discontinuous across the proposed subbasin, with one important exception. A regional aquitard has been recognized since the early 1980s, when Brown & Caldwell (1983) noted differences in water quality above and below the clay. The regional aquitard ranges from approximately 20 to 80 feet thick, and averages 50 feet thick over 27 drilled locations (Cleath & Associates, 2003). The regional aquitard is one of the most significant hydrogeologic features in the proposed subbasin and separates the upper and lower aquifers. Hydraulic communication between the upper (Zones A through C) and lower (Zones D and E) aquifers is restricted by the regional aquitard, although the large areal extent and vertical hydraulic gradient across this layer, along with open wellbore flows, results in several hundred acre-feet of leakage through the aquitard each year (Cleath & Associates, 2005).

Zone D - Lower Aquifer

Below the regional aquitard is lower aquifer Zone D. This is currently the primary source of water for the community. Zone D is a Paso Robles Formation aquifer zone composed predominantly of sands and gravels. Gravel clast composition is Franciscan Assemblage sandstone, chert, and metavolcanics, along with siliceous shales and claystones. Shell fragments are noted in Zone D lithology at wells on the sand spit and in Baywood Park. The structure of Zone D is generally conformable with the overlying aquitard, except where displaced by faulting in the Bayview Heights area. The aquifer zone averages close to 100 feet thick over the central portions of the Basin, thinning toward the east. Pumping tests indicate a confined aquifer condition in Zone D. The hydraulic conductivity of Zone D is estimated at 129-140 gpd/ft^2.

Groundwater is generally moving toward downtown Los Osos from surrounding areas in Zone D. Water levels have shown declining trends over time in many areas. Much of this decline took place during the 1970s and early 1980s, in concert with growing population and groundwater withdrawal.

The principal sources of freshwater recharge to the lower aquifer (Zones D and E) are leakage through the regional aquitard from the upper aquifer and Los Osos Creek stream seepage. Subsurface inflow from bedrock sources is believed to be a lesser source of recharge. Seawater intrusion is occurring in the lower aquifer, and has been advancing at an estimated 200-250 feet per year in Zone D since 2005 (CHG, 2015b).

Zone E - Lower Aquifer

An aquitard separates Zone D from Zone E in the lower aquifer. This aquitard is typically thinner than the regional aquitard and possibly discontinuous. The two lower aquifer zones differ with respect to salinity near the coast and with respect to permeability in inland areas, warranting the hydrogeologic aquifer distinction. The contact between the Plio-Pleistocene Paso Robles Formation and the Pliocene Careaga Formation occurs in the middle of Zone E. The Careaga Formation is the lowermost basin hydrostratigraphic unit. The base of the Careaga Formation is up to 800 feet below sea level in the southwestern portion of the basin.

Zone E contains a mixture of sands and gravels that are associated with Paso Robles Formation and Careaga Formation. The Careaga Formation has not been mapped regionally in outcrop, and there is considerable variation in what has been tentatively identified as Careaga Formation, including coarser grained and finer grained zones. The deep basin sediments in the western portion of the proposed subbasin include much coarser sands and gravel, compared to the finer sands and silty sands in the eastern portion of the proposed subbasin.

At wells along South Bay Boulevard east of downtown Los Osos, the fine grained silty sandstone attributable to the Careaga Formation is estimated to have a hydraulic conductivity of approximately 7 gpd/ft^2. Adjusting for differences in permeability and screened intervals between Zone D and Zone E aquifers, the hydraulic conductivity of Zone E in the vicinity of the Los Osos Community Park is estimated at 60-90 gpd/ft^2. An aquifer test also was conducted in September 2017 at east edge of the Cemetery Mesa, near the proposed internal jurisdictional boundary, where hydraulic conductivity measured 9 gpd/ft^2 (CHG, 2018).

Alluvial Aquifer

The alluvial aquifer formed from stream channel and floodplain deposits of Los Osos Creek. Recent alluvial deposits are interpreted to overlie Paso Robles and Careaga Formation sediments in the Los Osos Creek valley. These alluvial deposits are typically close to 70 feet thick. The base of the alluvial deposits are interpreted to extend to approximately 50 feet below sea level where Los Osos Creek and Warden Creek exit the proposed subbasin at the bedrock narrows in the lower creek valley, assuming the depth of the alluvial channel on Warden Creek in the Warden Lake area carries through to the narrows (CHG, 2018).

The Los Osos Creek valley alluvium typically consists of mostly clay with interbedded sand and gravel lenses. A basal sand and gravel unit is also inferred from inspection of well drilling logs, although the similarities in lithology with underlying Paso Robles Formation deposits make alluvial sediment interpretation difficult. Active irrigation or private domestic wells may tap the basal gravel in the alluvium, but typically extend into deeper aquifer zones.

Groundwater in the alluvial aquifer of the Los Osos Creek valley moves north toward the Morro Bay estuary. Recharge occurs from a variety of sources: direct percolation of precipitation; return flow from irrigation and septic system discharges; stream seepage from Los Osos Creek; and subsurface inflow from bedrock.

During drought years, alluvial water levels may decline in excess of 10 feet between spring and fall, but typical seasonal fluctuations are closer to 5 feet. Many agricultural wells in the creek valley tap the lower aquifer below the alluvium, where water level fluctuations are greater due to seasonal production to meet irrigation demands.

Groundwater in Storage

Groundwater in storage for the proposed Los Osos Area subbasin would be equivalent to the combined storage of the Western, Central, and Eastern basin areas of the Adjudicated Plan Area. The resulting total fresh groundwater in storage estimated for the Los Osos Area subbasin is 120,000 acre-feet in Spring 2016 (CHG, 2017).

Warden Creek Subbasin

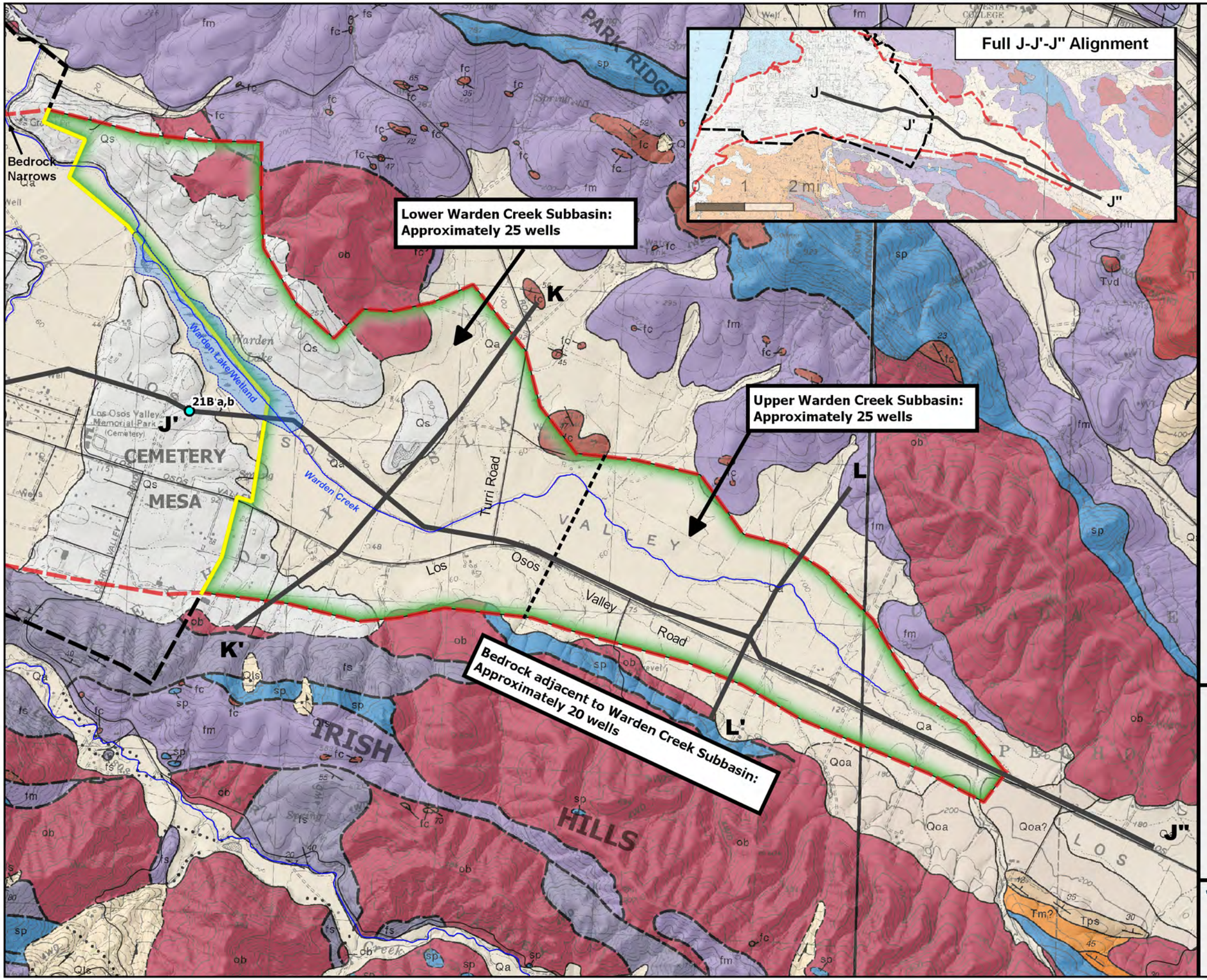
The 2018 Fringe Areas TM (CHG, 2018) describes the hydrogeologic conceptual model of the proposed Warden Creek subbasin in detail (as the Eastern Valley fringe area) and is an integral part of this BBMR. Portions of the 2018 Fringe Areas TM are included herein for ease of reference.

The proposed Warden Creek subbasin is a contiguous alluvial aquifer overlying bedrock. The dune sands mapped on the slopes north of Warden Lake are thin (less than 40 feet thick) and unsaturated, except for seasonally perched water on top of shallow bedrock. There is also a bedrock aquifer, consisting mostly of fractured Franciscan Assemblage metavolcanics, that is the principal source of water to wells on the south side of Los Osos Valley Road. Areas of groundwater production from fractured rock aquifers are not included in the groundwater basins defined by DWR Bulletin 118 (DWR, 2003). The distinction in drillers logs between bedrock, fractured (water-bearing) bedrock, and alluvial gravels derived from fractured bedrock can be uncertain. In the Warden Creek subbasin, "fractured red rock" and "red rock gravel" logged beneath the valley floor are interpreted as alluvial gravels and therefore subbasin aquifer sediments for this hydrogeologic conceptual model (CHG, 2018).

Surface geology of the Warden Creek subbasin is shown in Figure 6, with geologic cross-sections shown in Figures 7 through 10. Figure 11 presents the base of permeable sediments, and Summer 2017 groundwater elevation contours are included in Figure 12.

The alluvial aquifer formed from stream channel and floodplain deposits of Warden Creek overlies serpentinite and Franciscan Assemblage graywacke, mélange, and metavolcanics. The alluvial deposits are typically close to 60 feet thick where tapped by wells, based on an analysis of 35 well logs within the proposed subbasin area. Average saturated thickness, based on water levels reported on the well logs, is 40 feet. The upper 20 to 30 feet of alluvium is mostly clay, while the lower portion includes mostly sand and gravel, frequently described as fractured red rock or red rock gravel. Active irrigation and private domestic wells typically tap the sands and gravels in the alluvium and also extend into bedrock. The base of the alluvial deposits is close to 50 feet below sea level near Warden Lake, although some of the deepest alluvial channel deposits in the Warden Creek subbasin may be in-situ fractured rock, rather than Holocene-age alluvial deposits.

Groundwater in the alluvial aquifer of the proposed Warden Creek subbasin generally moves west, toward Warden Lake, at an average hydraulic gradient of 0.01 ft/ft based on Summer 2017 measurements. Recharge occurs from a variety of sources: direct percolation of precipitation; return flow from irrigation and septic system discharges; stream seepage from Warden Creek; and subsurface inflow from bedrock and the Cemetery Mesa (Adjudicated Plan Area). Warden Lake is a wetland, beneath which the hydraulic gradient appears to be flat through the confluence of the Warden Creek alluvial channel with the Los Osos Creek valley. This flat



Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Internal Jurisdictional Boundary
- Warden Creek Subbasin
- Cross-section Line
- Upper/Lower Warden Creek Subbasin Divide
- Well Discussed in Text

Geology Key on Figure 3

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 2000 4000 ft

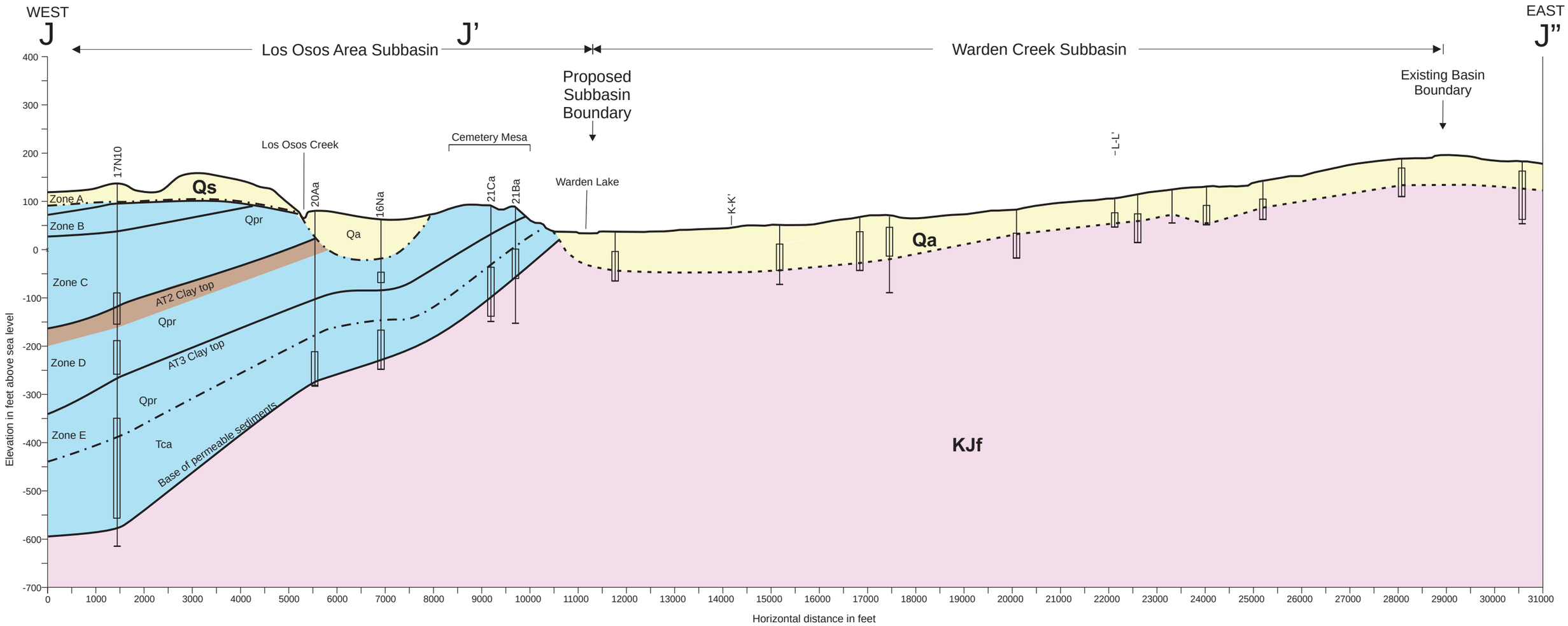
NORTH

Figure 6 - Surface Geology - Warden Creek Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists



Explanation

Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point

17N10 Well ID

Perforations

Formations:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation
KJf - Franciscan Assemblage

Note: Well data from Well Completion Reports

Figure 7
Cross Section J-J'-J''

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

J' WEST

Los Osos Area Subbasin

Warden Creek Subbasin

San Luis Obispo Valley Basin

J'' EAST

Adjudicated Plan Boundary

Warden Lake

K-K'

L-L'

Qpr/ Tca

Qa Clay

Qa Sand / Gravel

KJf

Elevation in feet above Sea Level

200
150
100
50
0
-50
-100
-150
-200

0
1,500
3,000
4,500
6,000
7,500
9,000
10,500
12,000
13,500
15,000
16,500
18,000
19,500
21,000
22,500

Distance in Feet

Explanation

- Sand / Gravel
- Clay
- Mixed Sediments
- Fractured Rock (Interpreted as Basin Gravel)
- Bedrock
- Perforations

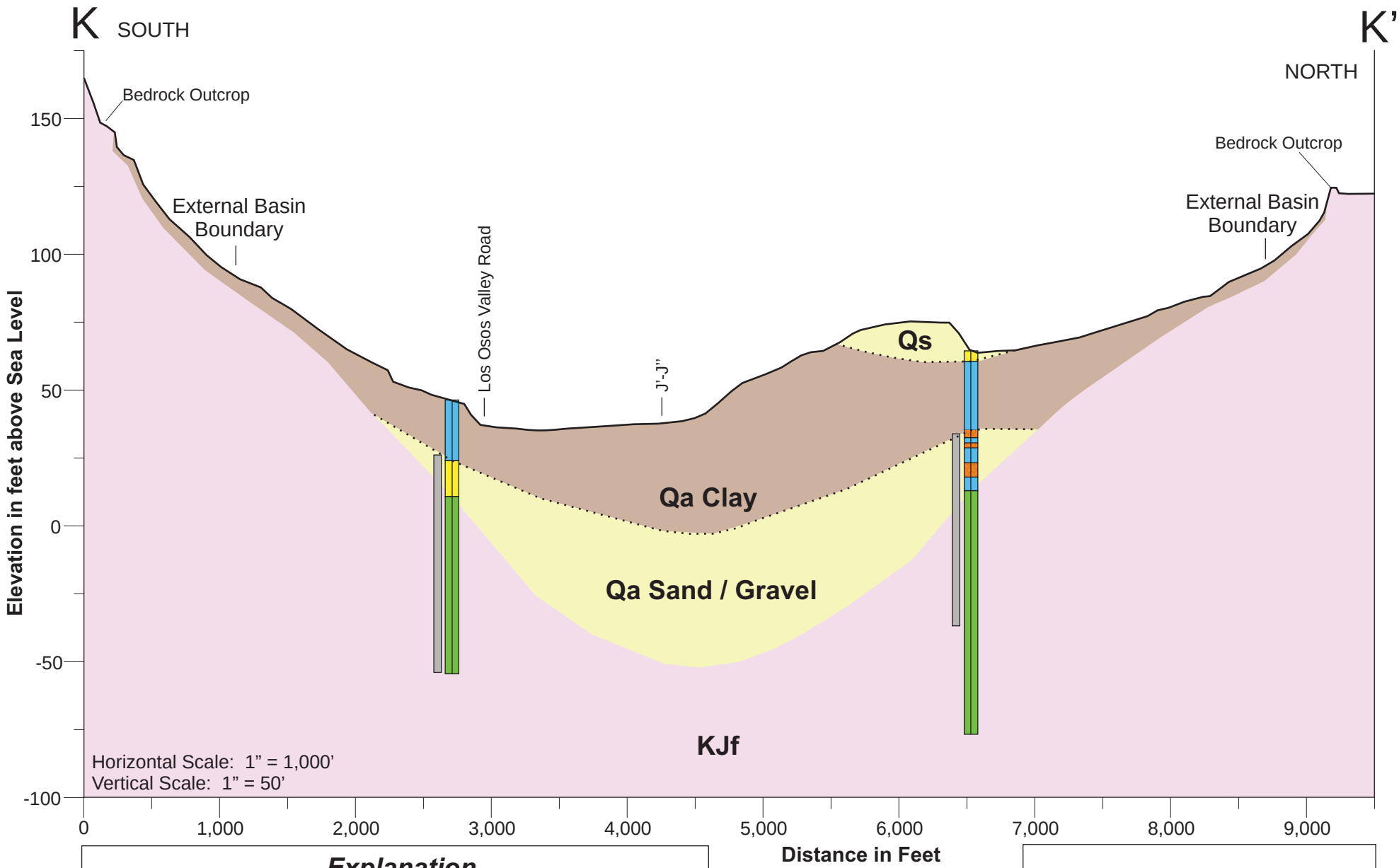
Qa Quaternary Alluvium
Qpr Paso Robles Fm.
Tca Careaga Fm.
KJf Franciscan Bedrock

Well data from Well Completion Reports

Figure 8
Cross Section J'-J''

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

Horizontal Scale: 1" = 1,500'
Vertical Scale: 1" = 50'



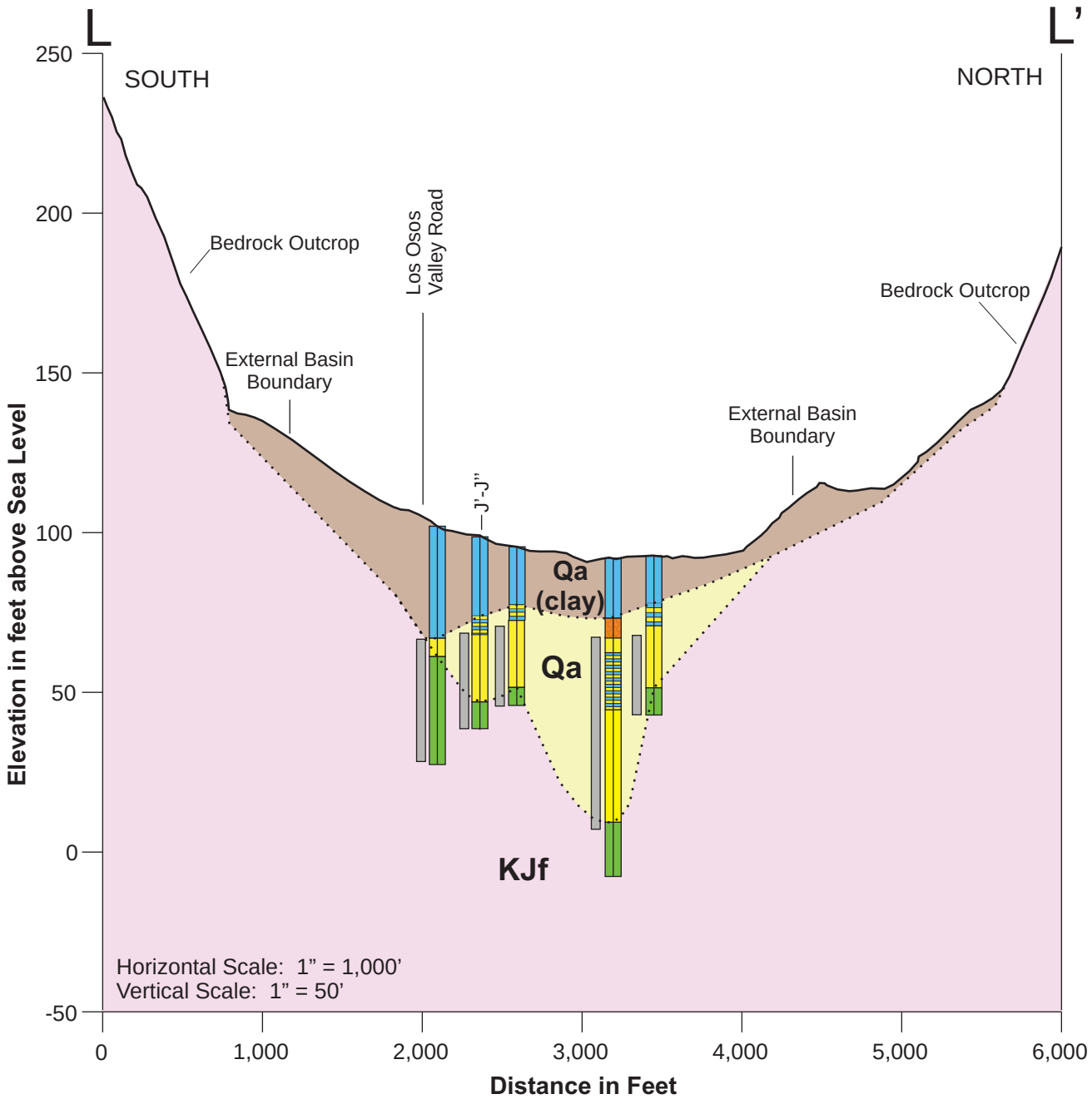
Explanation

- Sand / Gravel
- Clay
- Mixed Sediments
- Fractured Rock (Interpreted as Basin Gravel)
- Bedrock
- Perforations
- **Qa** Quaternary Alluvium
- **Qs** Dune Sand
- **KJf** Franciscan Bedrock

Well data from Well Completion Reports

Figure 9
Cross Section K-K'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists



Explanation

- Sand / Gravel
- Clay
- Mixed Sediments
- Fractured Rock (Interpreted as Basin Gravel)
- Bedrock
- Perforations

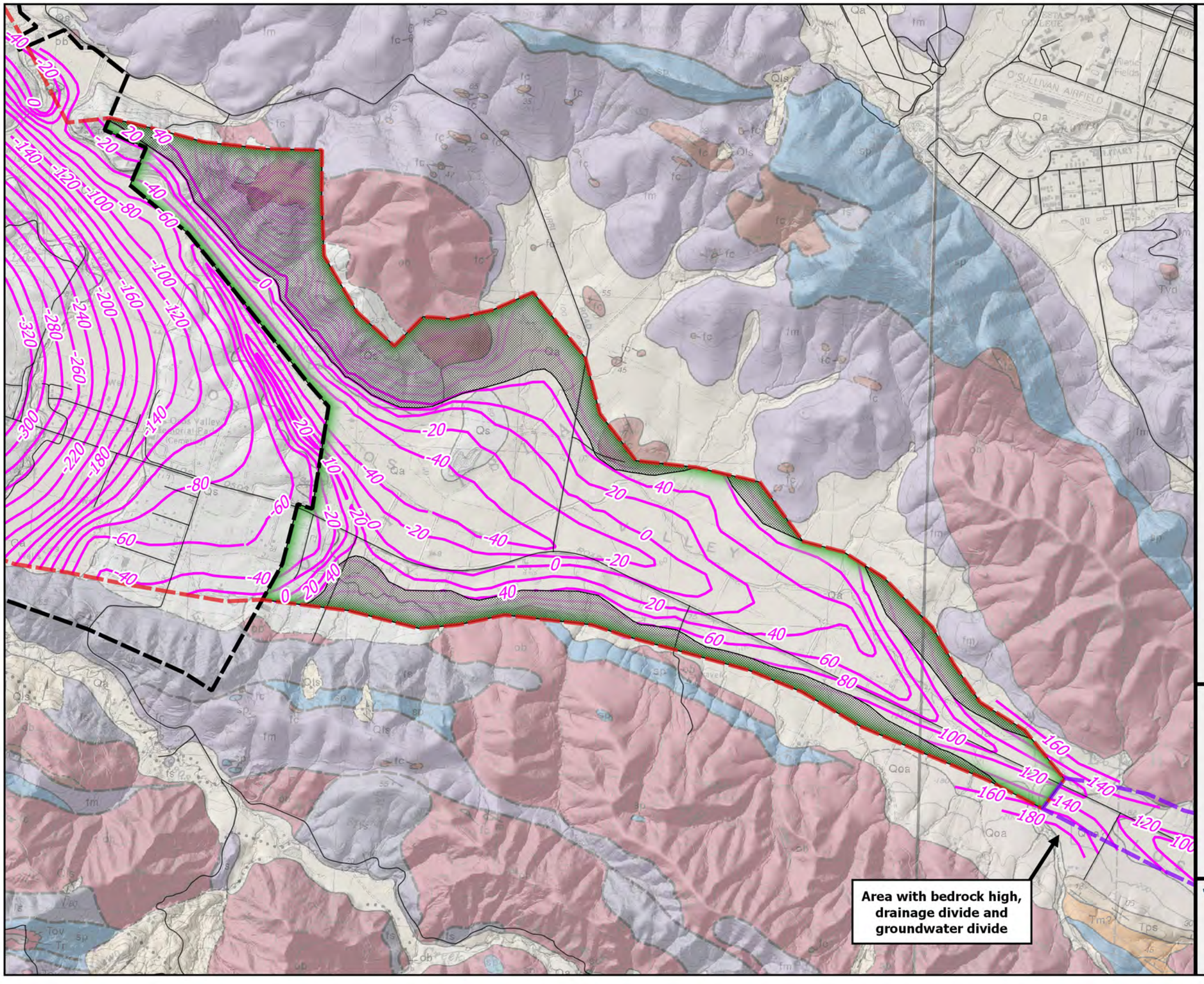
Qa Quaternary Alluvium

KJf Franciscan Bedrock

Well data from Well Completion Reports

Figure 10
Cross Section L-L'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists



Explanation

- Adjudicated Plan Area
- Warden Creek Subbasin
- Unsaturated Areas within Bulletin 118 Boundary
- Contours - Base of Permeable Sediments [ft above MSL]

Bulletin 118 Basin Boundaries

- Los Osos Valley Groundwater Basin
- San Luis Obispo Valley Groundwater Basin

Warden Creek Subbasin contours are based on lithologic data from 40 wells within the subbasin and 29 wells adjacent to the subbasin.

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 2000 4000 ft

NORTH

Figure 11 - Base of Permeable Sediments - Warden Creek Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists

Explanation

- Adjudicated Plan Area
- Warden Creek Subbasin
- Unsaturated Areas within Bulletin 118 Boundary
- Contours - Groundwater Elevation [ft above MSL]

Bulletin 118 Basin Boundaries

- Los Osos Valley Groundwater Basin
- San Luis Obispo Valley Groundwater Basin

Contours are based on 12 water levels inside the fringe area and 14 water levels adjacent to the fringe area.

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 2000 4000 ft

NORTH

Figure 12 - Summer 2017 Groundwater Elevation Contours - Warden Creek Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists

hydraulic gradient is likely controlled by the invert elevation of Warden Creek downstream of Warden Lake; groundwater moving into the wetland area that is not evapotranspired becomes baseflow in Warden Creek (CHG, 2018).

Historical water level trends prior to 2017 are not documented in the Warden Creek subbasin. Two pressure transducers installed in 2017 provided seasonal water level fluctuations, ranging from 8 feet near the Adjudicated Plan Area boundary to 1 foot in the upper valley of the Warden Creek subbasin (CHG, 2018).

Pumping tests in the local water supply aquifers include tests for the Warden Creek alluvial aquifer, Lower Aquifer Zone E (Los Osos Area subbasin near the boundary of the Warden Creek subbasin), and the bedrock aquifer. A summary of aquifer test results is listed below in Table 3.

Table 3
Aquifer Tests
Warden Creek Subbasin and Vicinity

Aquifer Zone	Flow (gpm)	Duration	T (gpd/ft)	Thickness (ft)	K (gpd/ft^2)	K (ft/day)
Lower Warden Creek subbasin[1] Alluvial Aquifer	110	4 hours	2,760	70	39	5.2
	117	4 hours	2,070	70	30	4.0
Upper Warden Creek subbasin[2] Alluvial Aquifer	49	4 hours	2,640	27	98	13.1
	50	4 hours	2,170	27	80	10.7
	42	4 hours	2,300	28	82	11
	25	4 hours	1,320	31	43	5.7
Los Osos Area subbasin (Zone E) at Boundary	12	8 hours	530	60	9	1.2
Bedrock Aquifer[3]	300	12 hours	3,900	100	39	5.2
OUT OF BASIN	150	12 hours	2,920	320	9.1	1.2

[1]Lower Warden Creek subbasin - from Turri Road area west to Adjudicated Plan Area boundary
[2]Upper Warden Creek subbasin - from Turri Road area east to boundary with San Luis Obispo Valley Basin
[3]Bedrock aquifer parameters are not directly comparable to basin parameters due to variable fracture and reservoir geometry.
gpm = gallons per minute; gpd = gallons per day; ft = foot.

Specific yield estimates for San Luis Obispo County alluvial deposits range from 3 percent in clay to 25 percent in sand. The specific yield for the fractured red rock and red rock gravels is estimated at 14 percent, based on classifying the material as similar to tight gravel or cemented gravel (Johnson, 1967). The average specific yield of the saturated alluvial deposits of the proposed Warden Creek subbasin is 12 percent. Groundwater in storage within the subbasin is 5,200 acre-feet (CHG, 2018).

4.2 Lateral Boundaries (§344.12(2))

The lateral basin boundaries are generally the mapped extent of the Quaternary sedimentary deposits between Morro Bay estuary and the drainage divide with the San Luis Obispo Creek watershed. The original geologic map used for Bulletin 118 was the Geologic Map of California, San Luis Obispo Sheet (Jennings, 1959). Due to the relatively small scale of the 1959 base map (1:250,000), there are discrepancies in the locations of geologic contacts when matching the Bulletin 118 basin boundary with more recent geologic maps, such as the 1:24,000 scale Geologic Map of the Morro Bay South Quadrangle (Dibblee, 2006) used for this BBMR. These discrepancies between geologic maps are, for the most part, not significant from a basin management perspective.

The description of the lateral boundaries for the subbasins is presented below. The external boundaries follow Bulletin 118, except for two proposed modifications supported by scientific evidence. The internal subbasin boundary is jurisdictional and also supported by scientific evidence.

Los Osos Area Subbasin

Los Osos Area subbasin boundary segments are shown in Figure 3. Geologic cross-sections through the subbasin are included in Figures 4 and 5 and in Appendix A1.

- *Segment 1 (External): Morro Bay Estuary Shoreline.* Segment 1 begins at the Los Osos fault near the south end of Morro Bay Estuary and follows the shoreline to the confluence with Los Osos Creek.

- *Segment 2 (External with modification): Los Osos Creek Confluence to the Narrows*. Beginning at the Los Osos Creek confluence with Morro Bay Estuary, the Bulletin 118 boundary (based on the original 1959 geology map) follows the edge of the dune sand sheet and crosses the creek valley at a bedrock narrows. A scientific boundary modification is needed along Segment 2 to remove minor fringe areas relating to the discrepancies in the locations of geologic contacts between the 1959 map and more current maps. The proposed scientific boundary modification would follow the boundary defined for basin adjudication.

- *Segment 3 (Internal): The Narrows to the Irish Hills*. From the east side of the bedrock narrows on Los Osos Creek, the proposed Los Osos Area subbasin boundary follows an internal jurisdictional boundary along the edge of the Adjudicated Plan Area until reaching bedrock along the base of the Irish Hills. This segment follows the parcel boundaries of the Adjudicated Plan Area, but also parallels a scientific boundary along the eastern edge of the topographic bench known as the Cemetery Mesa.

- *Segment 4 (External with modification): The Irish Hills to Morro Bay Estuary*. The subbasin boundary generally follows bedrock outcrops along the Irish Hills to Rodman Drive, where the boundary is modified to follow the Los Osos fault toward the southern end of Morro bay Estuary. Basin sediments terminate against the fault.

Warden Creek Subbasin

Warden Creek subbasin boundaries are shown in Figure 6. Geologic cross-sections through the subbasin are included in Figure 7, 8, 9, and 10.

- *External Boundary:* The external boundary for the Warden Creek subbasin encompasses the mapped extent of Quaternary sediments in the eastern Los Osos Valley. As presented in Bulletin 118, the boundary traces formation contacts shown on the 1959 geologic map, resulting in minor discrepancies when compared to the current geologic map. The external subbasin boundary separates from the north end of the internal boundary near the narrows on Los Osos Creek, extending part way up the south-facing slopes of Park Ridge, where older dune sands overlie bedrock. The external boundary returns to the valley floor and continues east along the edge of the alluvial deposits to the watershed divide with San Luis Obispo valley. Crossing the valley near the watershed divide, the boundary then turns west, following the alluvial contact with bedrock at the base of the Irish Hills, until reaching the south end of the internal subbasin boundary.

- *Internal Boundary (Jurisdictional Basin Subdivision):* From the east side of the bedrock narrows on Los Osos Creek, the proposed internal boundary follows the edge of the Adjudicated Plan Area until rejoining the external boundary along the base of the Irish Hills. This jurisdictional boundary separates the proposed Warden Creek and Los Osos Area subbasins based on parcel boundaries for the Adjudicated Plan Area, and also parallels a scientific boundary.

Geologic Features Impacting Groundwater Flow (§344.12(2)(A,B,C))

Los Osos Area Subbasin

The primary geologic features that significantly impede or impact groundwater flow within the Los Osos Area subbasin includes the synclinal structure of the subbasin, faulting, and the regional aquitard. The hydraulic conductivity of stratified sediments (stacked aquifers) is generally much greater parallel to bedding planes than perpendicular. The stacked aquifers of the Los Osos Area subbasin are folded into a synclinal trough, with a southeast-northwest trending fold axis. Dips along stratigraphic horizons on the limbs of the syncline reach approximately four degrees, although dips of up to eight degrees are present near the Los Osos fault zone at the southeast end of the basin (Figures 4 and 5). By comparison, the synclinal fold axis is relatively flat, plunging less than 1 degree to the west between the Los Osos Creek valley and Morro Bay estuary. An elevation contour map on the base of upper aquifer Zone C shows the basin syncline (Figure A2-2; Appendix A2). Groundwater would generally flow parallel to the fold axis and to the limbs of the syncline.

An elevation contour map on the base of permeable sediments is also shown in Appendix A2. Basin sediments are at depths of over 800 feet below sea level near the southwest corner of the subbasin, gradually rising to the north and east until reaching elevations close to sea level along the northeast external boundary and eastern internal subbasin boundary. The southeast-northwest trending fold axis is only partially developed on the base of permeable sediments, but is more pronounced on the base of the upper aquifer (Zone C).

Seawater intrusion, which is controlled by hydraulic pressure, has intruded farthest inland along the synclinal axis of the subbasin. The greater depth of basin sediments along the axis has allowed increased inland intrusion compared to shallower areas on the limbs of the syncline.

The regional aquitard averages 50 feet thick and impedes flow between the upper and lower aquifers, where there are major differences in water quality. Nitrate contamination from high-density septic systems is prevalent in the upper aquifer, while sea water intrusion threatens the lower aquifer.

Faulting both adjacent to and within subbasin sediments is present which can also significantly impede and impact groundwater flow. Cross-sections illustrating offsets within basin sediments, including an uplifted portion of the subbasin along the southern boundary, are shown in Figure 5 and Figures A1-7, A1-8, and A1-9 (Appendix A1). This uplift acts as an impediment to groundwater flow between the alluvial deposits in the upper Los Osos Creek valley and downtown Los Osos area (Cleath & Associates 2005).

Groundwater flow between the Los Osos Area subbasin and the Warden Creek subbasin is significantly restricted by geologic features. These features are described below.

Warden Creek Subbasin

Groundwater flow within the Warden Creek subbasin is controlled primarily by alluvial aquifer transmissivity and hydraulic gradient. The lateral boundaries on the north and south are bedrock contacts, while the boundaries on the east and west are shared by the San Luis Obispo Valley Groundwater Basin and the Los Osos Area subbasin, respectively.

The topographic saddle that creates a drainage divide separating the Los Osos Basin and the San Luis Obispo Valley Groundwater Basin, also coincides with a groundwater divide based on available groundwater levels and the occurrence of a bedrock high in the same general location (Figure 8 and Figure 11). The groundwater divide effectively separates the Los Osos Basin from the San Luis Obispo Valley Groundwater Basin.

Groundwater flow between the Warden Creek subbasin and the Los Osos Area subbasin is restricted by a bedrock high that roughly parallels the proposed jurisdictional boundary. This bedrock high is a structural feature resulting from the east-west tilting of the base of permeable sediments within the Los Osos Area subbasin, which brings bedrock close to ground surface along the eastern edge of the Cemetery Mesa (Figure 7, Figure 11, and Figures A1-2, A1-3, and A1-4 in Appendix A1. The structural boundary was recognized in the late 1980's by the Morro Group (1987), resulting in removal of the Warden Creek area from the groundwater basin in 1988 by the U.S. Geological Survey (Yates, 1988). The structural boundary was also recognized by the DWR (1989) and eventually incorporated into the scientific basin boundary used for the Adjudicated Plan Area (CHG, 2003; and ISJ, 2015).

Key Surface Water Bodies and Significant Recharge Sources (§344.12(a)(2)(D))

Los Osos Area Subbasin

The principal surface water bodies within the Los Osos Area subbasin are Los Osos Creek, Willow Creek/Eto Lake, Warden Creek, and the Morro Bay estuary (Figure 1). Stream seepage from Los Osos Creek is one of the primary sources of recharge to the Los Osos Area subbasin. Los Osos Creek drains the Clark Valley watershed, which is approximately seven square miles. County stream gage #751 is located on Los Osos Creek at the Los Osos Valley Road bridge, and measures runoff from a watershed area of 7.27 square miles. Stream flow records are available for 19 years between 1976 and 2002 (San Luis Obispo County, 2005). The average flow on Los Osos Creek at the gage was 3,769 acre-feet per year. Median flow was 2,110 acre-feet per year. Annual flow ranged from no flow (2002) to over 19,270 acre-feet (partial flow for 1995). Most of the seepage into the groundwater basin takes place upstream of the gage location, therefore surface flows entering the basin on Los Osos Creek are typically greater than measured at the gage. Inflow to the basin from surface flows in Los Osos Creek directly recharges the valley alluvial deposits.

Willow Creek is a short water course in dune sands overlying the perched aquifer that discharges into Eto Lake and then Los Osos Creek. Warden Creek flows into the Los Osos Creek valley from the Warden Creek subbasin and follows the northeast edge of the valley through the narrows. Despite draining a watershed area of roughly nine square miles at the confluence with the Los Osos Creek valley, Warden Creek does not contribute significant recharge to the Los Osos Area subbasin (Yates and Wiese, 1988; ISJ, 2015; and CHG, 2018).

Morro Bay estuary encompasses 2,300 acres off the northwest subbasin boundary. Principal groundwater aquifers extend beneath the estuary to the coastline, where they are hydraulically connected to the Pacific Ocean. The upper aquifer discharges into the Morro Bay estuary through spring seepage along the bay front and upwelling beneath the bay.

Warden Creek Subbasin

The principal surface water bodies within the Warden Creek subbasin include Warden Creek and Warden Lake (Figure 1). Warden Lake is a marshy depression where surface water ponds along the riparian corridor. Development of the wetland has been attributed to impoundment as a result of possible faulting (Treiman, 1989) and to alluvial fan deposit buildup in the Los Osos Creek valley (Balance Hydrologics, 2003). There are also a few agricultural reservoirs near Warden Lake.

The Warden Creek subbasin watershed encompasses approximately nine square miles at the confluence of Warden Creek with the Los Osos Creek valley. Stream seepage of surface water runoff along Warden Creek and tributaries is a significant source of recharge to the Warden Creek subbasin. Surface water runoff from this watershed to creeks was estimated by the U.S. Geological Survey at 870 acre-feet per year for water years between 1970 and 1977 (Yates and Weise, 1988).

4.3 Recharge and Discharge Areas (§344.12(a)(3))

Los Osos Area Subbasin

The majority of recharge to the Los Osos Area subbasin consists of the following elements:

- Direct percolation of precipitation, including localized runoff into percolation basins and natural depressions
- Stream seepage from Los Osos Creek
- Return flow from irrigation and septic system discharges
- Return flow from Broderson and Bayridge Estates tertiary treated recycled water disposal areas
- Subsurface inflow across subbasin external boundaries, including seawater intrusion

The attached Figure 24 and Figure 74 in Appendix A4 are from the Basin Plan (ISJ Group, 2015) and present the primary recharge areas in the Los Osos Area subbasin and the water balance under wastewater project conditions with no further development. Percolation of precipitation is greatest within the dune sands, which covers the basin west of Los Osos Creek. Deep percolation of precipitation to the upper aquifer is restricted where overlain by the perching clay layer. Groundwater in the perched aquifer contributes base flow to Willow Creek, leaks through and around the edges of the perching clay in to the upper aquifer, and seeps out at ground surface along the eastern outcrop of the perching clay. The majority of stream flow percolation occurs in the upper Los Osos Creek valley, where recharge to the lower aquifer is not restricted by the regional aquitard. Agricultural irrigation return flow occurs throughout the Los Osos Creek valley. Septic and landscape irrigation return flow were historically concentrated within the "Prohibition Zone Boundary" (Basin Plan Figure 24; Appendix A4), but since completion of the Los Osos Water Recycling Facility Project in 2016, septic return flow is now limited to low-density residential areas outside of the Prohibition Zone.

Seawater intrusion into the lower aquifer is the greatest threat to the subbasin. The subbasin aquifers are hydraulically connected to the Pacific Ocean. Pumping from deep aquifer wells in the western portion of the subbasin has significantly lowered groundwater pressures, allowing recharge to occur from offshore.

The primary natural component of basin discharge is outflow to Morro Bay from the upper aquifer. The outflow occurs along the bay front and likely as upwelling beneath the bay mud. Groundwater outflow also occurs in the lower Los Osos Creek valley, where the perched aquifer and upper aquifer contribute flow to Los Osos Creek (Basin Plan Figure 74, Appendix A4).

Warden Creek Subbasin

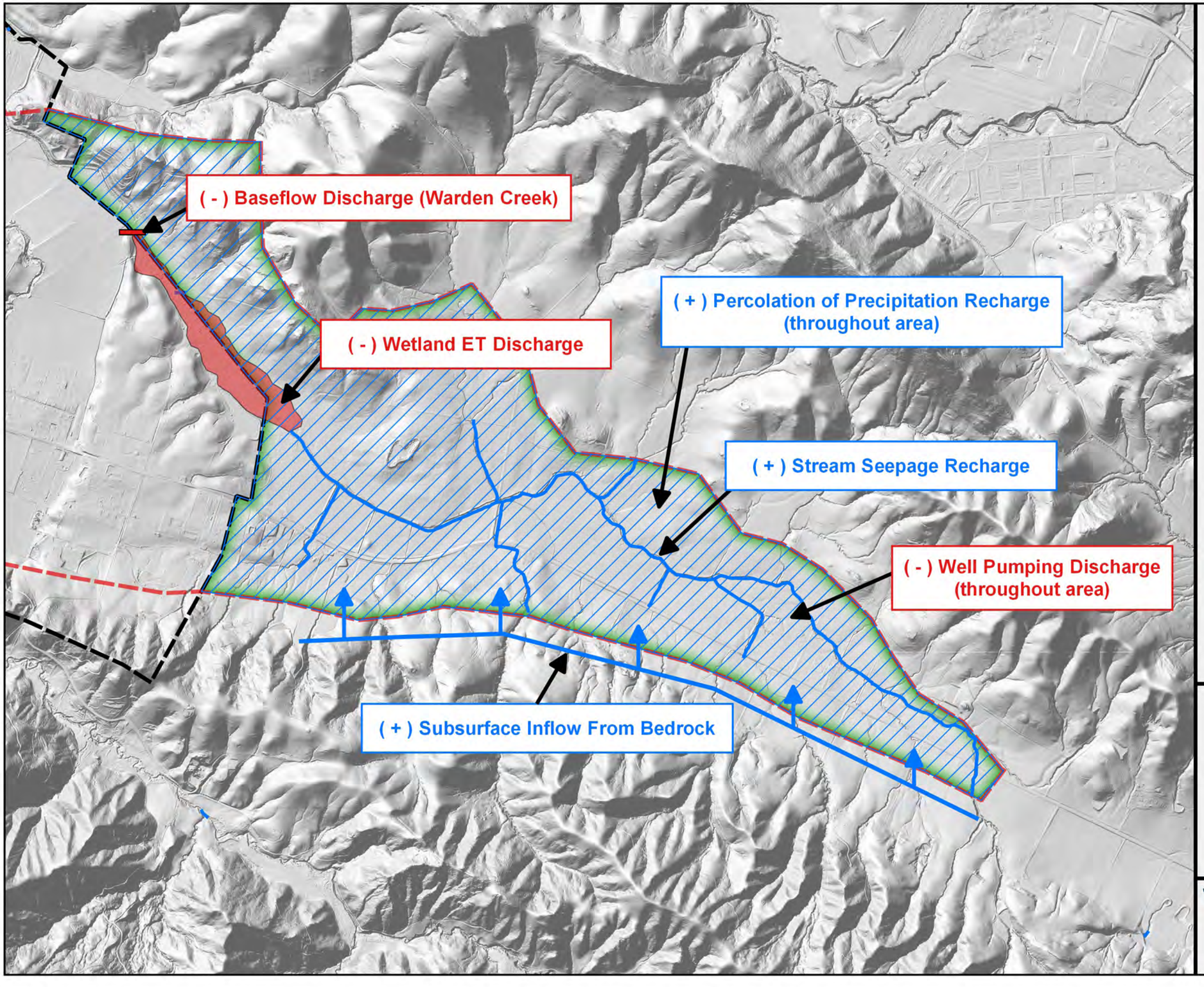
The majority of recharge to the proposed Warden Creek subbasin consists of the following elements:

- Direct percolation of precipitation
- Stream seepage from Warden Creek and tributaries
- Return flow from agricultural irrigation
- Subsurface inflow across subbasin external boundaries

The primary natural components of subbasin discharge are surface outflow on Warden Creek and evapotranspiration by vegetation in the Warden Lake wetland and riparian area. Figure 13 presents recharge and discharge areas for the Warden Creek subbasin.

A water balance was prepared for the Warden Creek subbasin[7] in the 2018 Fringe Areas TM and is summarized in Table 4. The water balance assumes that the alluvial aquifer is not in a state of

7 The Warden Creek subbasin is referred to as the Eastern Valley in the 2018 Fringe Areas TM.



Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Warden Creek Subbasin

Basemap: ESRI National Geographic USA Topo Maps

0 2000 4000 ft

NORTH

Figure 13 - Recharge/Discharge Areas - Warden Creek Subbasin

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overdraft and groundwater in storage is stable over time. This assumption is supported by the historical use of the shallow alluvial resources for agriculture, even during drought, as observed through aerial imagery review and by the DWR 2014 land use survey (CHG, 2018). There is no seawater intrusion in the proposed Warden Creek subbasin.

Table 4
Water Balance Summary
Warden Creek Subbasin

INFLOW ITEMS	AFY
Percolation of precipitation	390
Return flow	95
Stream seepage	210
Subsurface	55
TOTAL INFLOW	750
OUTFLOW ITEMS	AFY
Wells	470
Wetland ET	155
Subsurface	<1
Base flow	125
TOTAL OUTFLOW	750

Source: 2018 Fringe Areas TM (CHG, 2018)

4.4 Definable Bottom of the Basin (§344.12(4))

The bottom of the groundwater basin is the top of bedrock, which includes Monterey Formation shales and siltstones (also referenced as Pismo Formation on some maps), diabase, serpentinite, and Franciscan Assemblage graywacke sandstones, shales, and metavolcanicst. Elevation contours on the base of permeable sediments (top of bedrock) are shown in Appendix A2 for the Los Osos Area subbasin, and Figure 11 for the Warden Creek subbasin. The proposed definable bottom of the basin is shown in all the geologic cross-sections.

Los Osos Area Subbasin

The bottom of the Los Osos Area subbasin is the contact between the Lower Aquifer and bedrock (Figure 4 and Figure 5). This subbasin bottom is deepest (800 feet below sea level) in the southwest portion of the subbasin, rising close to sea level in the northeast portion of the subbasin (Figure A2-1; Appendix A).

Warden Creek Subbasin

The bottom of the Warden Creek subbasin is the contact between the Warden Creek alluvial aquifer and bedrock (Figures 8, 9 and 10). This subbasin bottom is deepest (50 feet below sea level) in the southwest portion of the subbasin, rising to over 100 feet above sea level in the east portion of the subbasin (Figure 11).

5.0 INFORMATION FOR SCIENTIFIC MODIFICATION (§344.14)

As previously mentioned, there are discrepancies in the locations of geologic contacts when matching the Bulletin 118 basin boundary (based on Jennings, 1959) with more recent geologic maps, such as the 1:24,000 scale Geologic Map of the Morro Bay South Quadrangle (Dibblee, 2006) used for this BBMR.

While most of these discrepancies do not significantly affect sustainable management issues, they have created two minor fringe areas downstream of the narrows, where the Bulletin 118 boundary was drawn through portions of the alluvial stream channel deposits that directly overly bedrock (see Section 5.2 - Minor Exclusion Areas).

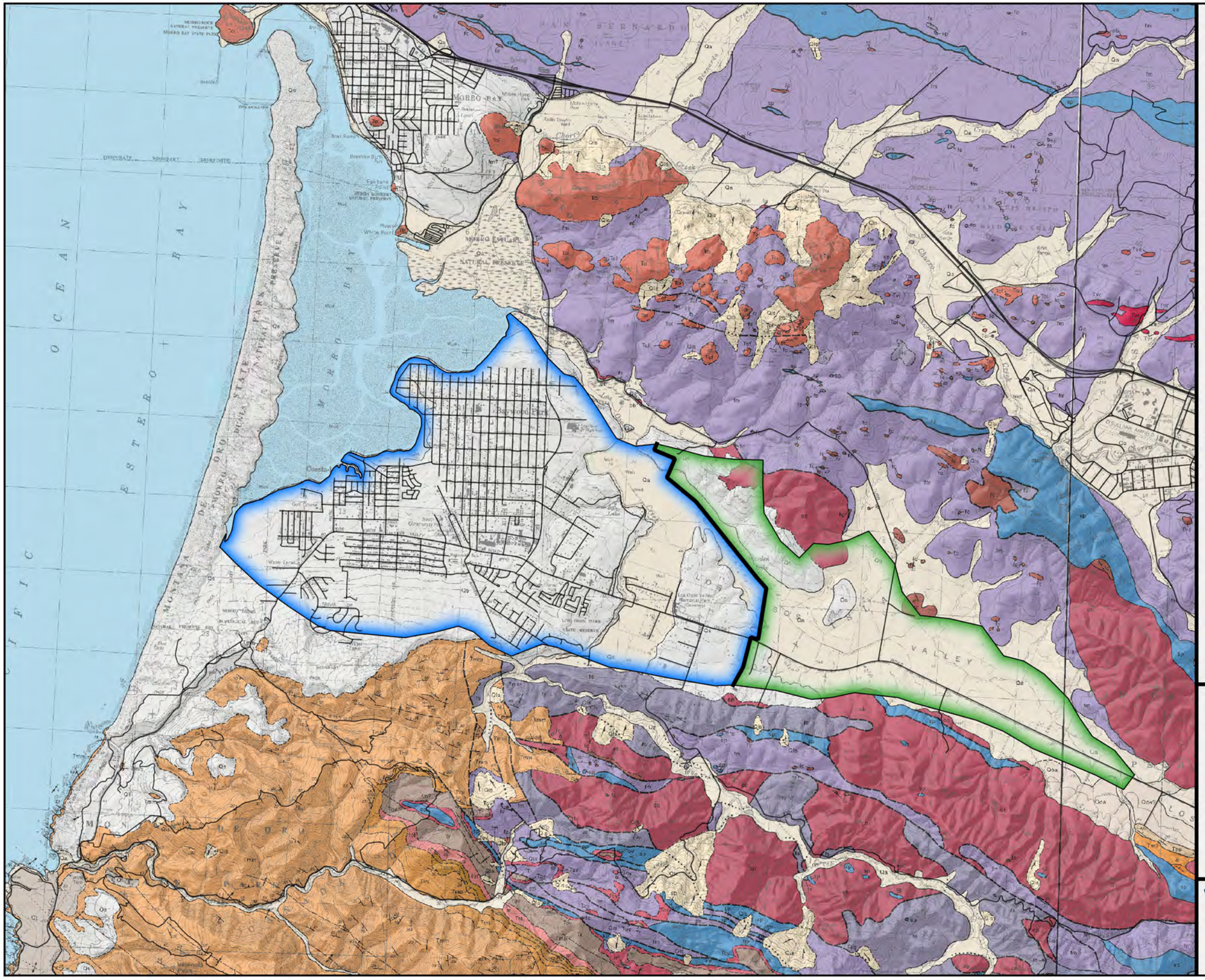
5.1 Qualified Map (§344.14(a)(1))

The qualified map used to depict the lateral basin boundaries for this request is the 1:24,000 scale Geologic Map of the Morro Bay South Quadrangle (Dibblee, 2006). Figure 14 shows the proposed basin boundaries on the qualified map, using the lateral boundary description as defined above in section § 344.12(2).

5.2 Technical Study (§344.14(a)(2)) and (§344.14(d))

The technical study supporting this BBMR is the 2018 Los Osos Valley Groundwater Basin Fringe Areas Characterization Technical Memorandum (2018 Fringe Areas TM; CHG, 2018). The proposed external scientific boundary modifications would remove 1,061 acres from the basin due to the removal of the Montaña de Oro exclusion area and a small exclusion area containing the minor fringe areas near Morro Bay estuary (Figure 1).

The exclusion of these areas is supported on both a scientific and management basis, including significant barriers to groundwater flow, unsaturated sediments, estuarine influence, and no wells (except in bedrock sources). The excluded areas are either within the Adjudicated Area Plan or are on State Parks land with limited access and no potential for future groundwater development.



Explanation

- Los Osos Area Subbasin
- Warden Creek Subbasin
- Internal Jurisdictional Boundary

Geology Key (Dibblee, 2006)

- Qa - Alluvium
- Qs - Dune Sand
- Qls - Landslide Deposits
- Qoa - Older Alluvium
- Tmm - Monterey Formation
- Tml - Monterey Formation
- Tmts - Monterey Formation
- Tot - Obispo Formation
- Tov - Obispo Formation
- Tr - Rincon Shale
- Tof - Dacite
- sp - Serpentine
- ob - Diabase
- fm - Franciscan Assemblage
- fs - Franciscan Assemblage
- fc - Franciscan Assemblage

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 4000 8000 ft

NORTH

Figure 14 - Qualified Map

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Montaña de Oro Exclusion Area

The Montaña de Oro exclusion area encompasses 1,017 acres, or 1.6 square miles (Figure 1). The area is proposed for removal from the Bulletin 118 groundwater basin through external scientific boundary modification.

Marine Terraces

Mostly obscured beneath dune sands, a series of wave-cut platforms on bedrock rise from the shoreline to the east as uplifted marine terraces. There are several terrace levels mapped in the Montaña de Oro exclusion area (Lettis and Hall, 1994; 2018 Fringe Areas TM). Surface Geology of the exclusion area is shown in Figure 15. The geologic cross-sections in Figures 16, 17, 18, and 19 show the marine terraces between the coast and the Montaña de Oro exclusion area boundary. The available subsurface borehole and water level data are limited, but support a hydrogeologic conceptual model of marine terraces overlain by mostly unsaturated dune sands.

Dune Sand Aquifer

The Montaña de Oro exclusion area has a narrow strip of saturated dune/beach sand along the coast between the Los Osos fault and the reef north of Hazard Canyon (Figure 17). Dune sands that overlie marine terraces inland of the beach are interpreted to be mostly dry, with locally perched water lenses on top of bedrock and seasonal saturation adjacent to drainages. The saturated thickness of dune sand in the exclusion area south of the Los Osos fault zone is estimated to be less than 30 feet, based on geophysical data and projections of the modern wave-cut platform (Figure 17 and Appendix B1). This dune sand aquifer in Montaña de Oro is not considered suitable for development as a groundwater resource due to the limited saturated thickness, high potential for sea water intrusion, and lack of accessibility.

Fault Offset as Subsurface Flow Barrier and Basin Boundary

Subsurface lithologic data indicates a major fault offset is present north of the boundary between the Montaña de Oro fringe area and the Adjudicated Plan Area that acts as a significant subsurface barrier to groundwater flow. The offset is caused by movement along the Los Osos Fault (DWR, 1973; Brown and Caldwell, 1974; Lettis and Hall, 1994). Uplift of the Irish Hills and tectonic subsidence of the Los Osos Valley juxtaposes the principal aquifers within the Los Osos Area subbasin against soft shale and siltstone bedrock in the Montaña de Oro exclusion area. The fault boundary not only creates a subsurface restriction to flow, but also truncates all Quaternary basin sediments north of the fault except the dune sands and other marine terrace deposits, which are uplifted and mostly unsaturated in the exclusion area.

Some prior investigators (e.g. USGS, 1988 and Lettis, 1994) have interpreted the DWR (1972) deep borehole at MBO-2 (Figure 15 and Figure 16) as being on the north side of the Los Osos fault, and drilled into basin sediments. DWR (1973), Brown & Caldwell (1974; 1982) and Cleath

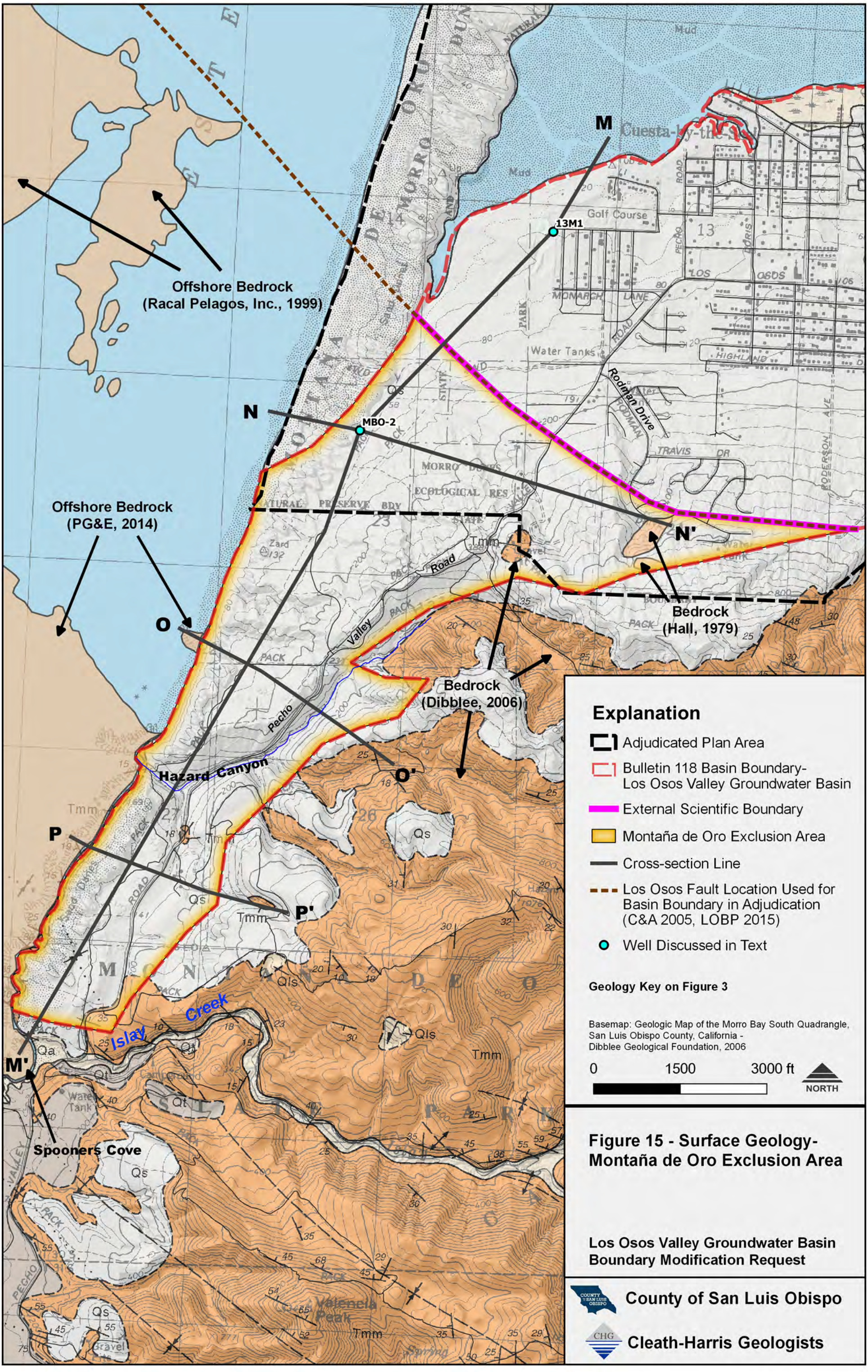

Figure 15 - Surface Geology- Montaña de Oro Exclusion Area

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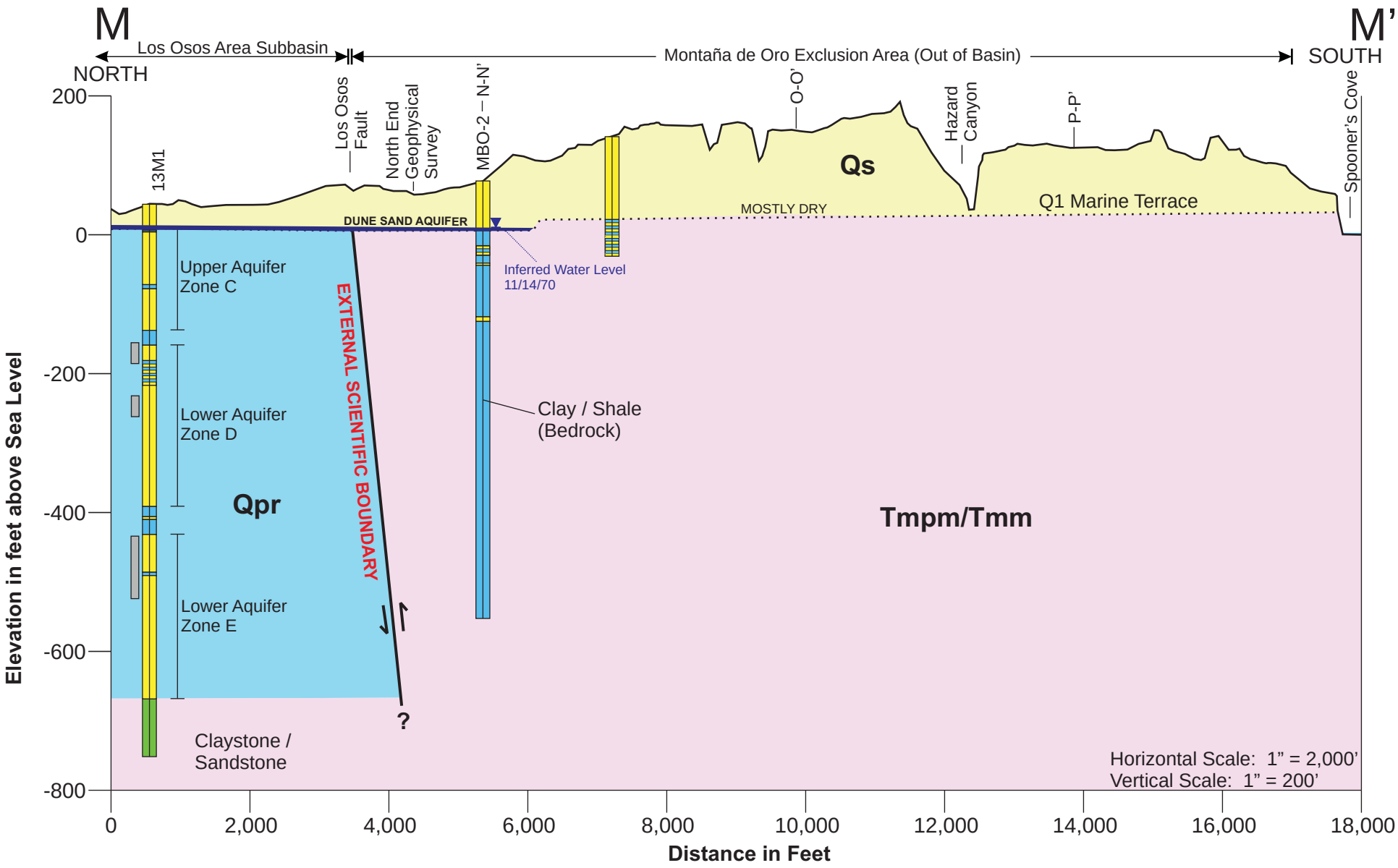


Explanation

- Sand / Gravel
- Clay / Shale
- Mixed Sediments
- Bedrock

Qs Dune Sands

Qpr Paso Robles Formation

Perforations

Tmpm Pismo Formation

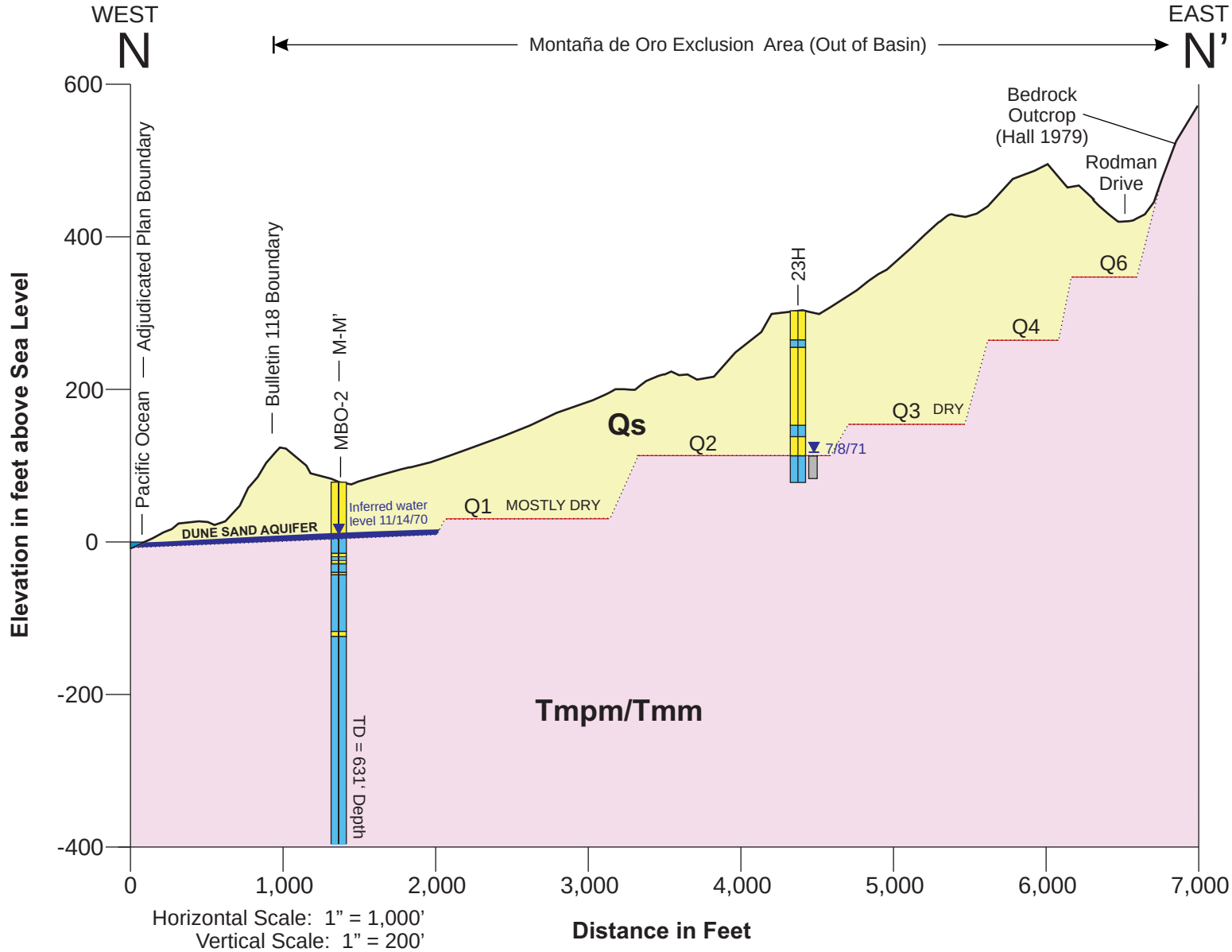
Tmm Monterey Formation

Dune Sand Aquifer

Well data from Well Completion Reports

Figure 16
Cross Section M-M'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

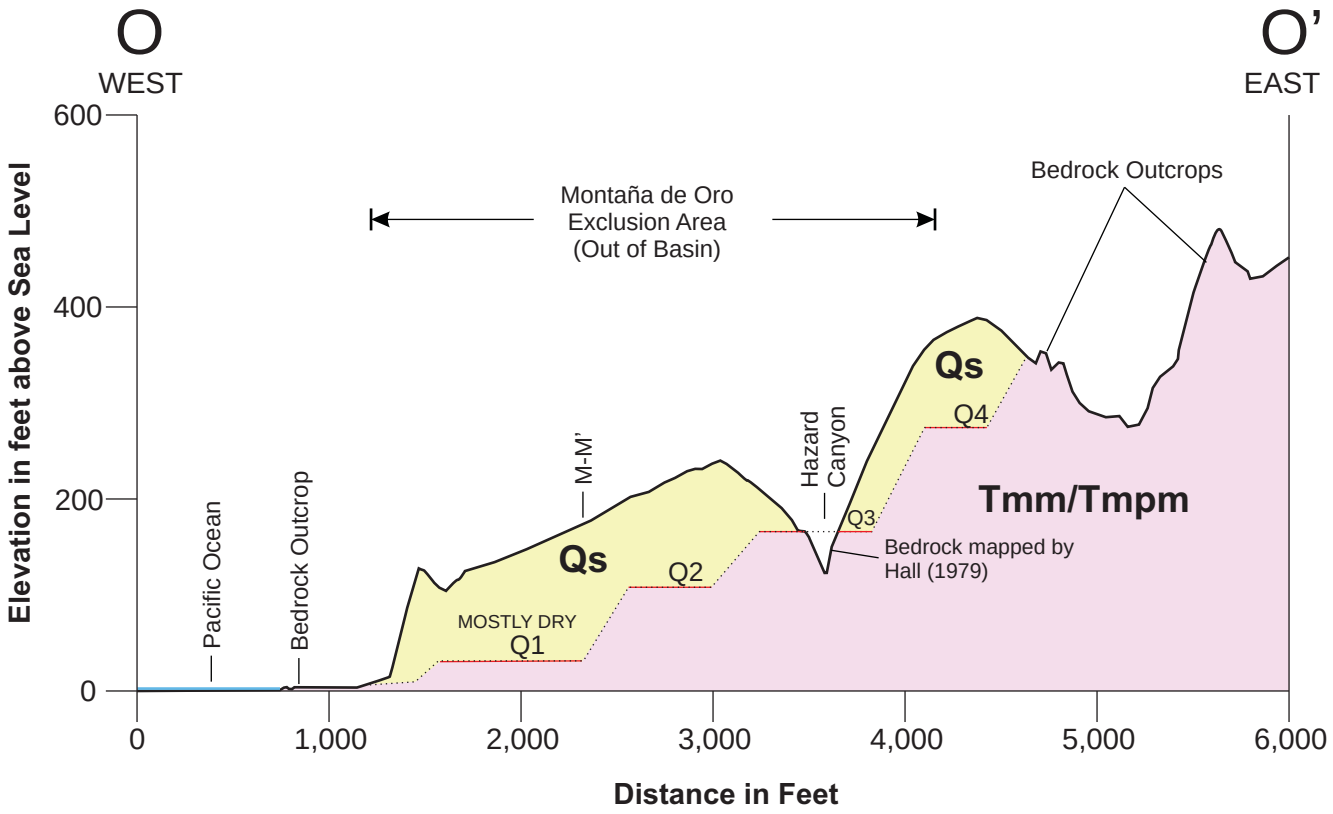


Explanation

- Sand / Gravel
- Clay / Shale
- Dune Sand Aquifer
- Q1 Wave-Cut Terraces
- **Qs** Dune Sands
- **Tmpm** Pismo Formation
- **Tmm** Monterey Formation
- Perforations
  Well data from
  Well Completion Reports

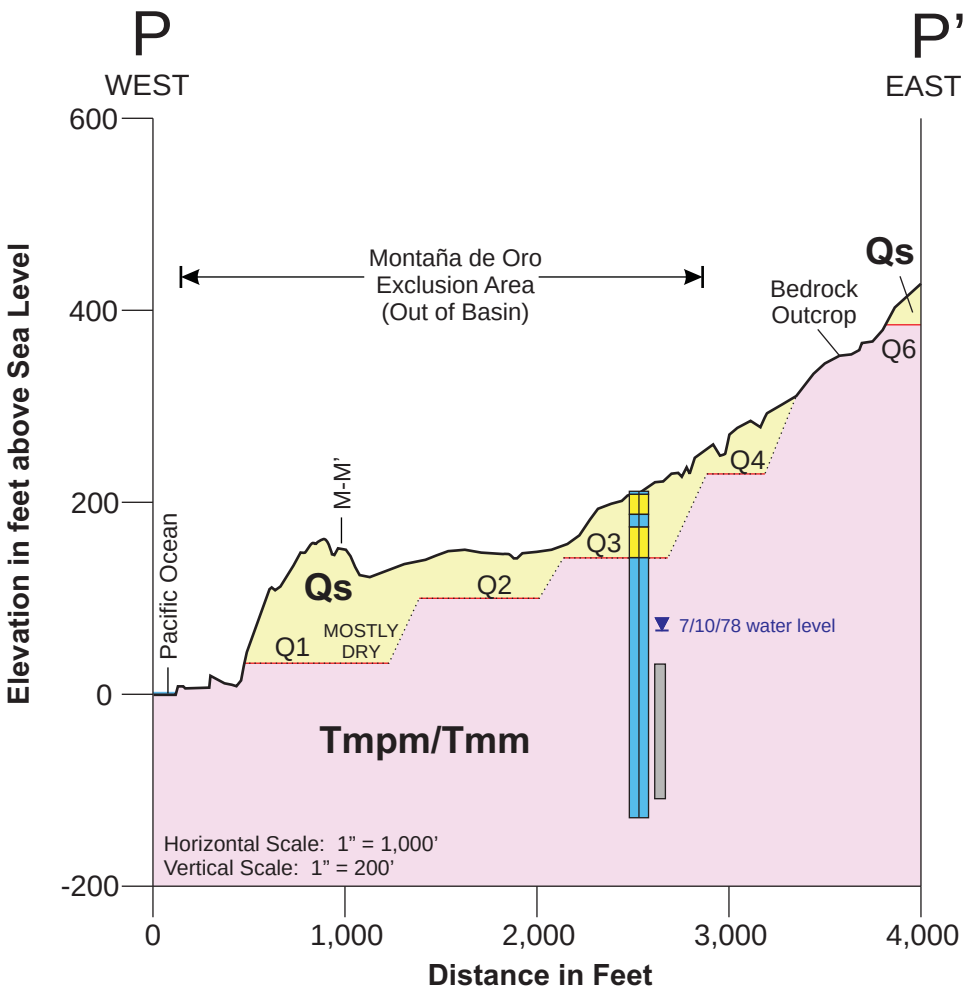
Figure 17
Cross Section N-N'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists



Horizontal Scale: 1" = 1,000'
Vertical Scale: 1" = 200'

Explanation	
Qs Dune Sands **Tmpm** Pismo Formation **Tmm** Monterey Shale Q1 Wave-Cut Terraces	Figure 18 Cross Section O-O' Los Osos Valley Groundwater Basin Boundary Modification Request San Luis Obispo County Cleath-Harris Geologists



Explanation	
Sand / Gravel	
Clay / Shale	
Perforations	
Qs Dune Sands	
Tmpm Pismo Formation	
Tmm Monterey Shale	
Q1 Wave-Cut Terraces	
Well data from Well Completion Reports	

Figure 19
Cross Section P-P'

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County
Cleath-Harris Geologists

& Associates (2003) interpreted the borehole as being on the south side of the fault and drilled in Pismo Formation (Miguelito member) sediments below the shallow dune sand aquifer. The latter interpretation of MBO-2 being south of the Los Osos fault (and associated flow barrier) is considered correct based on the available lithologic, geophysical, and water quality data, as discussed below.

DWR Borehole MBO-2 Lithology

The lithologic log for MBO-2 extends to a depth of 631 feet. Below the shallow dune sands (70 feet thick), the log indicates silt, clay, and/or shale, with less than 20 feet of sand and gravel. Other adjacent deep well logs that are actually in basin sediments show hundreds of feet of permeable sands and gravels (Figure 16 and Appendix B2). Furthermore, the silts and clays logged at MBO-2 contained an abundance of diatoms and radiolarians, which suggest Tertiary-age sediments, consistent with the local diatomaceous shale (DWR, 1973). According to the 1973 DWR report, occurrence of the type of sediments logged at MBO-2 were unknown elsewhere within the basin study area. A monitoring well was installed at MBO-2 (23C1) to depth of 142 feet, but there was insufficient water to develop the well or obtain a water level; material below the dune sands at MBO-2 is non-water bearing (DWR, 1972).

Geophysical data

Geophysical data is available as an electrical resistivity line and a seismic refraction line (Gasch & Associates, 2000). These geophysical lines were part of the Worldcom's Morro Bay fiber optic cable landing project, and covered roughly 6,000 linear feet along the beach opposite the location of MBO-2. The geophysical data were interpreted to indicate shallow bedrock (approximately 30 feet or less depth) throughout the profiles (Appendix B1). Potential faults with normal-motion were mapped both north and south of MBO-2, which is indicative of the Edna fault zone. The Los Osos fault is a reverse-motion fault and lies north of the Edna fault zone (PG&E, 2014). Shallow bedrock and normal-motion faulting indicated by geophysics supports the Los Osos fault being located north of both MBO-2 and the geophysical lines (Figure 15).

Water levels

Inland of the coast, the location of the Los Osos fault is constrained by information from a water well. The log for well 23H, located along Pecho Valley Road near the exclusion area boundary, reported a water level in July 1971 of 185 feet depth (approximately 115 feet above sea level). The well was completed to 220 feet depth, and is interpreted to tap shale bedrock beginning at a depth of 200 feet (100 feet above sea level). By comparison, basin water levels along Pecho Valley Road north of the Los Osos fault were at approximate elevations between 5 and 20 feet above sea level in 1973 (DWR, 1973; Appendix B2). Well 23H was equipped and operational in

2017, therefore water levels have remained 100+ feet above sea level at that location, evidence of a significant barrier to flow north of the well.

Water Quality

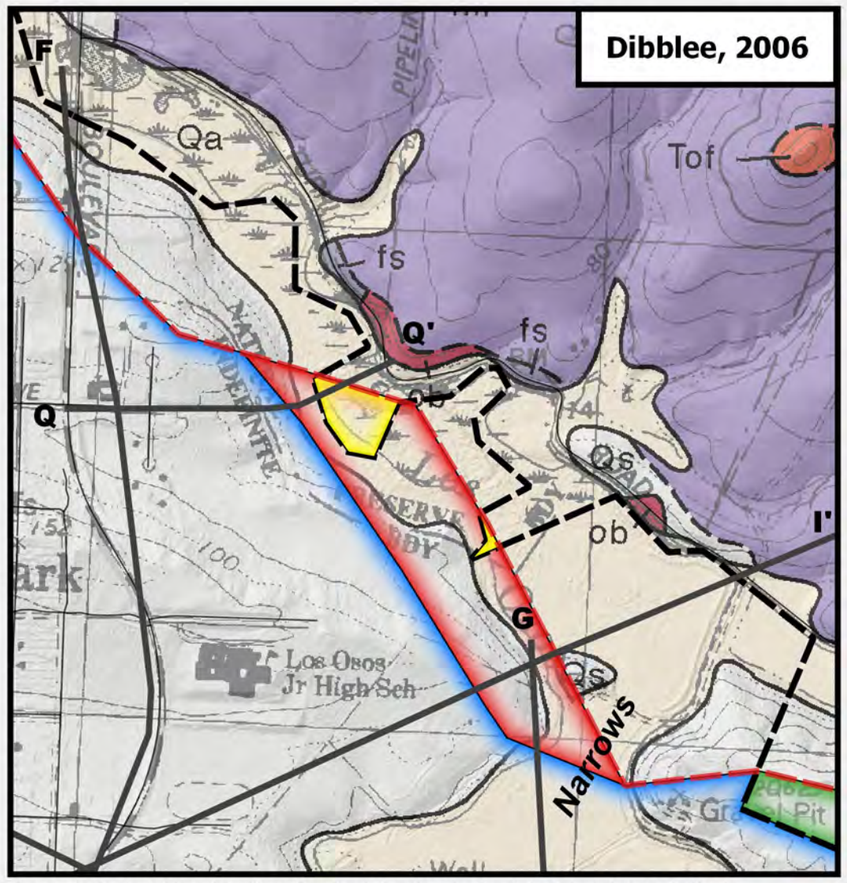
Seawater intrusion at the coast was interpreted from geophysical logs along a cross-section of deep boreholes on the Morro Bay sandspit and MBO-2 (DWR, 1979). The cross-section shows brackish water zones separated into <9,000 mg/L and >9,000 mg/L chloride (Appendix B3). At MBO-2, however, freshwater is present near the coast to a depth of 400 feet below sea level, which supports a potential flow barrier between MBO-2 and the sandspit wells. The inferred water level in November 1970 at MBO-2, based on the pressure required to maintain freshwater at depth per the Ghyben-Herzberg relation, would be 10 feet above sea level. In comparison, pressure heads in the permeable brackish water aquifers at sandspit wells in 1977 were between 0.5 and 3 feet above sea level (DWR, 1979).

Offshore Bedrock

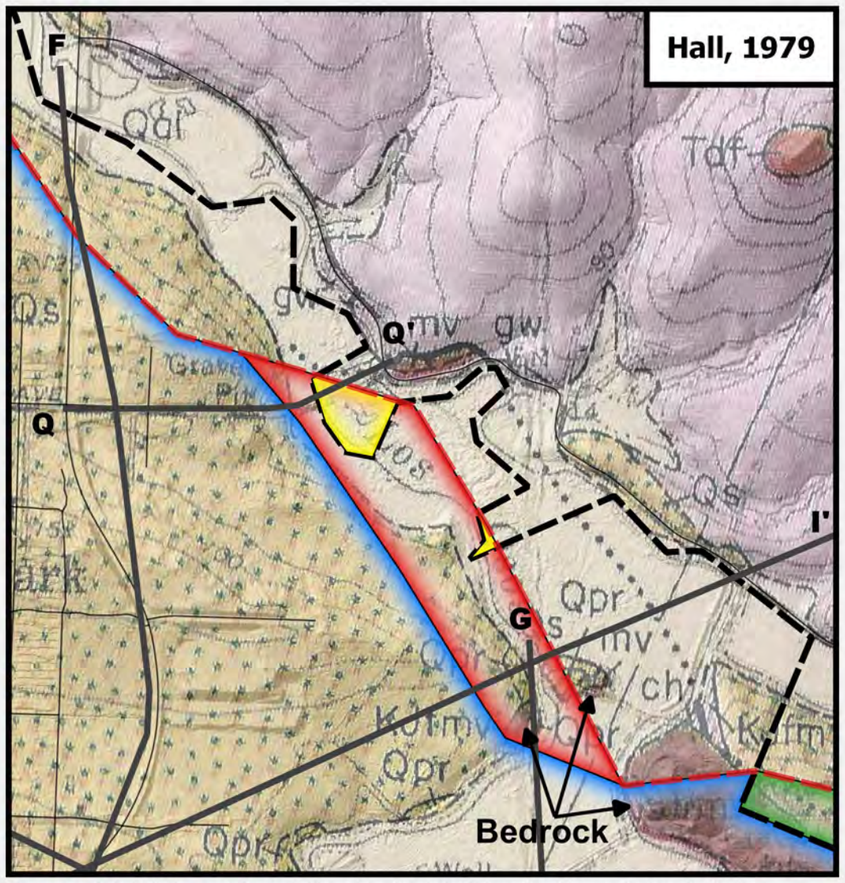
Shale bedrock is mapped on the ocean floor west of the Morro Bay sandspit, beginning at approximately 50 feet below sea level (Racal Pelagos, 1999; PG&E 2014). The occurrence of large areas of Pliocene shale bedrock on the ocean floor, which is the same unit comprising the marine terraces south of the Los Osos fault, indicates that the Los Osos fault zone, and associated lateral boundary to flow, turns to the northwest from its east-west alignment in the Irish Hills. The point of departure from the east-west fault alignment was projected by Cleath & Associates (2005) by connecting the offshore and onshore outcrops (Appendix B3).

Minor Fringe Exclusion Area

Figure 20 shows the surface geology of the minor fringe areas and associated basin exclusion area near the confluence of Los Osos Creek and Morro Bay estuary. The geologic map by Hall and others (1979) is included on this figure due the increased detail relative to the 2006 map used elsewhere, and shows the bedrock cropping out at the narrows. The regional aquitard (as Paso Robles Formation) is also present at the narrows and along the edge of the dune sand sheet (Hall, 1979; Cleath & Associates, 2005). Geologic cross-sections Q-Q' (Figure 21) and I-I' (Figure 22) show the subsurface relationship between bedrock, basin sediments, and the alluvial channel incised into bedrock. Downstream of the bedrock narrows, the stream channel alluvium is incised into bedrock. Flow between the stream channel alluvium and basin aquifers is interpreted to be hydraulically restricted by bedrock and the regional clay aquitard. Figure 21 shows the subsurface directly beneath the larger of the two minor fringe areas while Figure 22 shows the subsurface at the bedrock narrows. The alluvial aquifer in the minor fringe areas is under estuarine influence and subject to seawater intrusion (DWR, 1972; and MBNEP, 2016).



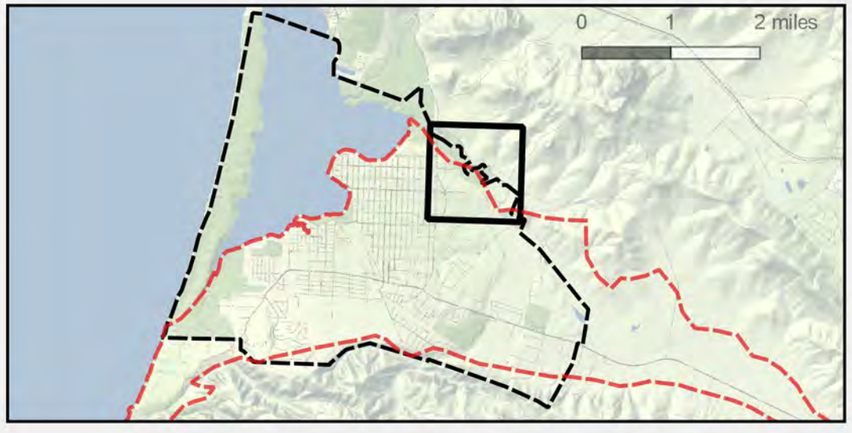
Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006



Basemap: C.A. Hall, Jr., et al, Geologic Map of the San Luis Obispo-San Simeon Region, California - U.S. Geological Survey, 1979.

Geology Key (Dibblee, 2006)

- Qa - Alluvium
- Qs - Dune Sand
- Tof - Dacite
- ob - Diabase
- fm - Franciscan Formation
- fs - Franciscan Formation



Geology Key (Hall, 1979)

- Qal - Alluvium
- Qs - Dune Sand
- Qpr - Paso Robles Formation
- Tdf - Dacite
- KJfm - Franciscan Formation
- KJfmv - Franciscan Formation

Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Warden Creek Subbasin
- Los Osos Area Subbasin
- Minor Fringe Exclusion Area
- Minor Fringe Areas
- Cross-section Line

The Hall (1979) geologic map includes bedrock (as KJfmv) and the regional aquitard (as Qpr) at the narrows. These features are not shown by Dibblee (2006), but are important for characterizing minor fringe area geology.

0 1000 2000 ft

NORTH

Figure 20 - Surface Geology - Minor Fringe Areas

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County of San Luis Obispo

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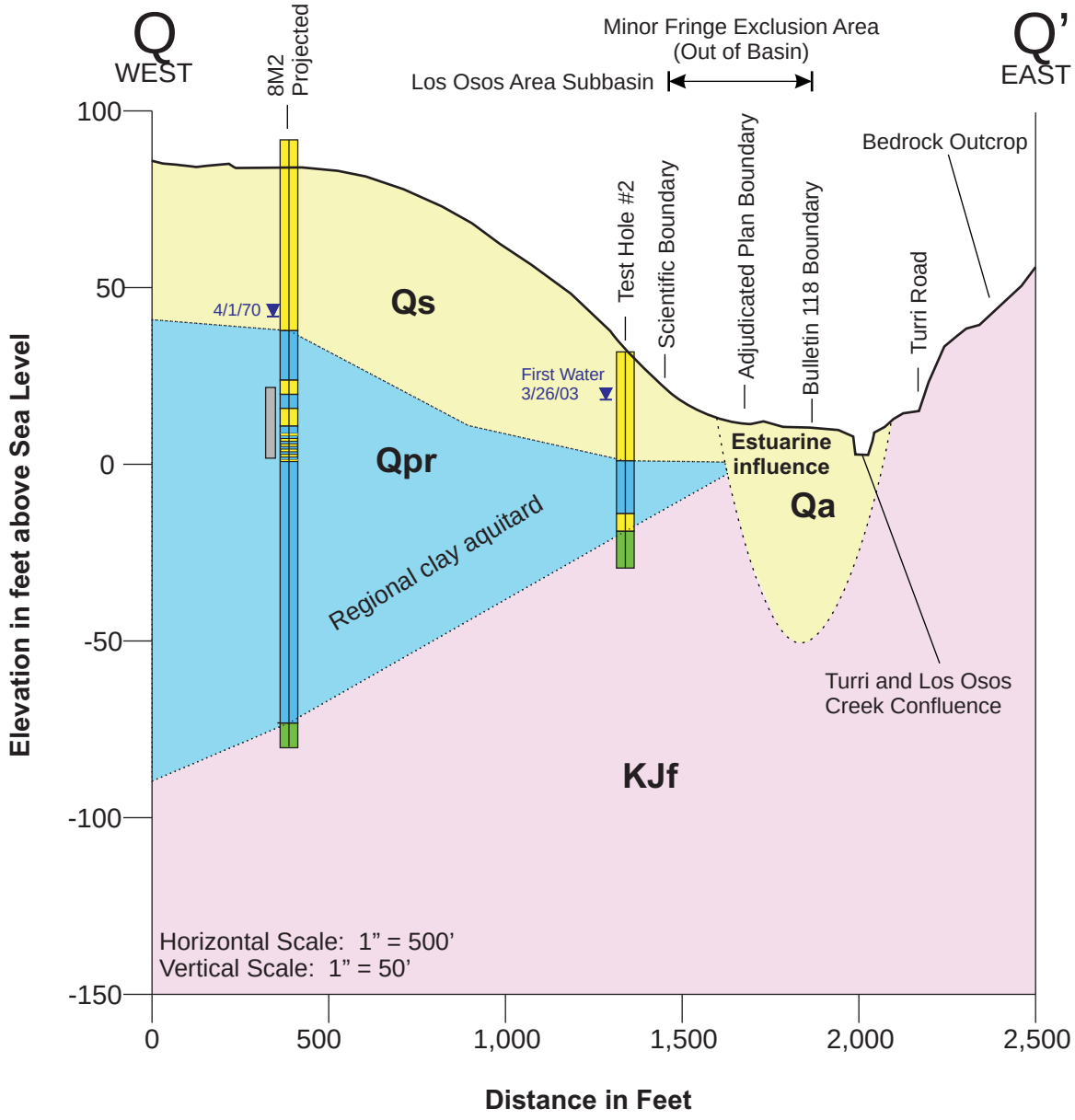
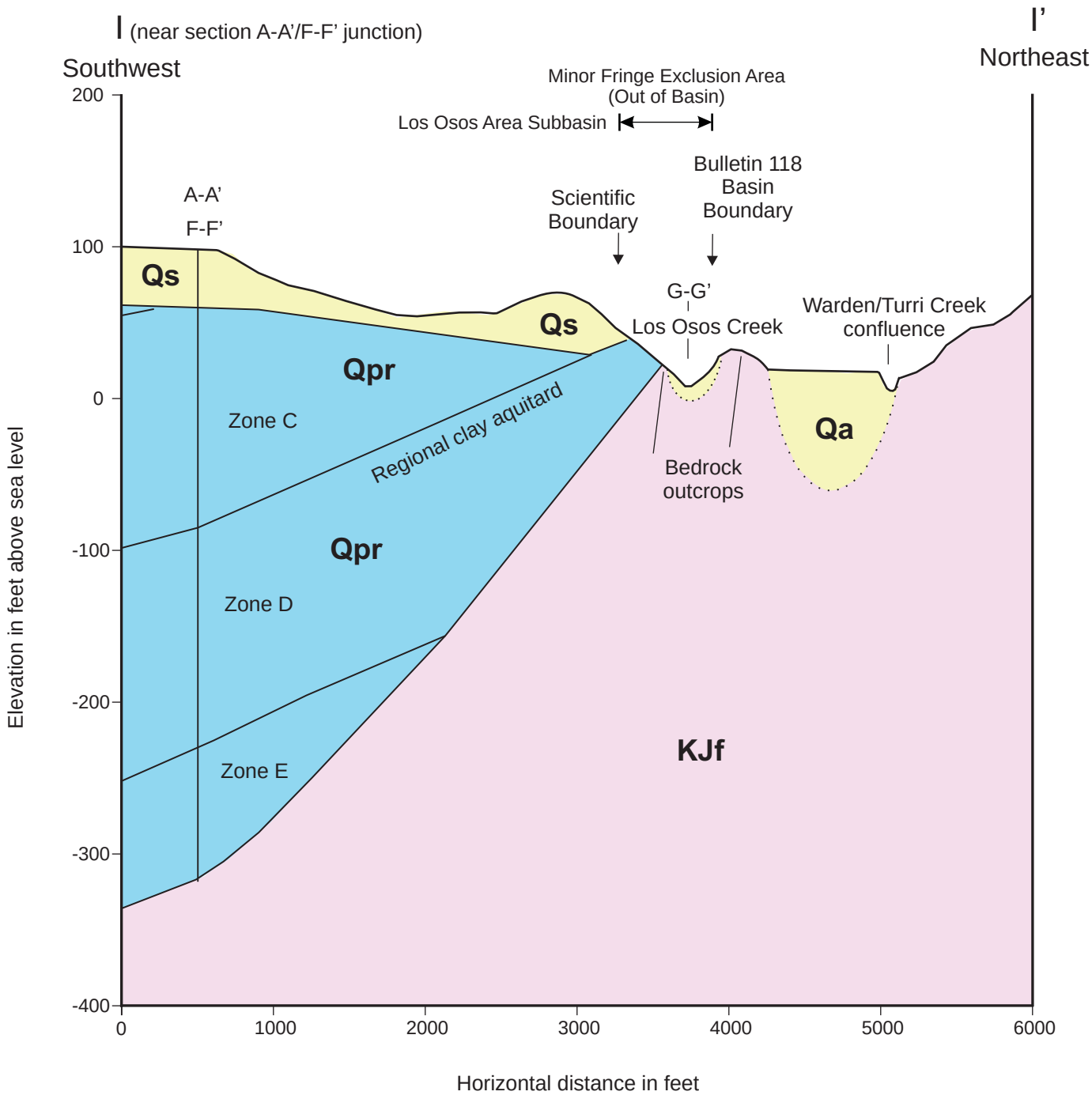


Explanation	
Sand / Gravel	Figure 21 Cross Section Q-Q'
Clay	
Mixed Sediments	Los Osos Valley Groundwater Basin Boundary Modification Request San Luis Obispo County Cleath-Harris Geologists
Bedrock	
Qa Quaternary Alluvium	
Qs Dune Sands	
KJf Franciscan Bedrock	
Perforations	
Well data from Well Completion Reports	



Explanation	
Qa Quaternary Alluvium **Qs** Dune Sands **Qpr** Paso Robles Formation **KJf** Franciscan Bedrock Full cross-section I-I' in Figure A1-10, Appendix A	Figure 22 Cross Section I-I' (Portion) Los Osos Valley Groundwater Basin Boundary Modification Request San Luis Obispo County Cleath-Harris Geologists

The Los Osos Creek channel in the vicinity of the minor fringe areas is tidally-influenced by Morro Bay. The Regional Board is reclassifying a surface water monitoring location at the east end of Santa Ysabel Avenue, directly opposite the minor fringe areas, from creek to estuarine (MBNEP, 2016). The estuarine influence on alluvial groundwater quality at the east end of Santa Ysabel Avenue in the vicinity of the minor fringe areas is also documented in DWR Bulletin No. 63-6 (DWR, 1972). Estuary areas do not meet the alluvial definition of a basin, per DWR 2016 Final Basin Boundary Modifications, Table 1 (DWR, 2016a).

Historical water quality is available for one well completed in alluvial sediments (8J1) located approximately 1,500 feet west of the minor fringe areas. Water quality measured at Well 8J1 included chloride measurements of 790-1,090 milligrams per liter (mg/L), which was attributed to seawater intrusion (DWR, 1972).

The minor fringe areas, which combine for less than 5 acres in total area, are located on State Parks and Coastal San Luis Resource Conservation District property with no wells and restricted access for drilling equipment. The areas have no expectation of being suitable for groundwater development due to estuarine influence and a high probability of experiencing seawater intrusion. The area proposed for exclusion includes State Parks and Coastal San Luis Resource Conservation District property and covers 44 acres between the scientific boundary established for the Adjudicated Plan Area and the Bulletin 188 boundary (Figure 20). Dune sands in the minor fringe exclusion area have limited saturated thickness and directly overlie either the regional aquitard or bedrock (Figure A1-10; Appendix A1).

6.0 INFORMATION FOR JURISDICTIONAL MODIFICATION (§344.16)

A jurisdictional boundary is proposed to separate the Los Osos Area subbasin from the Warden Creek subbasin. This boundary would follow the Adjudicated Plan Area boundary between the bedrock narrows and the Irish Hills (Figure 1).

6.1 Water Management and Planned Coordination (§344.16(a))

A water management plan that covers all or a portion of the proposed basin or subbasin and contributes to meeting the requirements of Water Code Sections 10753.7(a) or 10727 (§ 344.16(a)(1))

6.1.1 Adjudicated Plan Area Groundwater Management Plan (§ 344.16(a)(1)(B))

The Basin Plan[8] was completed pursuant to basin adjudication and provides a physical solution to sustainable groundwater management over the Los Osos Area subbasin, which covers most of the basin area (ISJ, 2015).

8 Basin Plan details may be accessed at: <https://slocountywater.org/site/Water%20Resources/LosOsos/>.

6.1.2 Los Osos Basin Fringe Areas Characterization (§344.16(a)(1)(C))

The results of the 2018 Fringe Areas TM are intended to produce a basis of knowledge for use in boundary modification requests and potential future use in development of a GSP. This technical memorandum supplements prior work, which together provide a comprehensive hydrogeologic characterization and conceptual model of the fringe areas. As discussed earlier, the basin's Bulletin 118 boundary encompasses an area of 6,990 acres (10.9 square miles). Within this area, the proposed Warden Creek subbasin[9] covers 1,760 acres (2.8 square miles), the Montaña de Oro fringe area covers 643 acres (1.0 square mile), and the minor fringe areas cover less than 5 acres. The areas excluded from the basin for scientific justification are the Montaña de Oro fringe area with the adjacent portion of the Adjudicated Plan Area south of the Los Osos fault (1,017 acres) and the minor fringe area with the adjacent portion of alluvial deposits under estuarine influence (44 acres); excluded areas total 1,061 acres.

6.1.3 Groundwater Sustainability Plan (GSP) (§344.16(a)(1)(D))

On April 4, 2017, the County Board of Supervisors took formed a GSA over the fringe areas (covering approximately 40 parcels). The proposed basin boundary modification will establish the proper management entities over the basin and all modifications are based on the best scientific evidence for basin. Should the BBMR result in a reprioritization for the Warden Creek subbasin to a high or medium (not critical) priority, the deadline for a GSP for SGMA would be extended to January 2022. Should the subbasin be reprioritized to a low or very low priority basin, then SGMA will not required. Pending these future DWR determinations, the County will consider whether or not development of a GSP is still required or appropriate.

Should a GSP be required, the plan and associated monitoring program would involve entities (such as the Los Osos BMC, County, and property owners) who have been cooperating with each other through coordination of data collection for basin studies and have been supportive during the BBMR process. The GSA may need to develop coordination agreements with adjacent management entities, such as the BMC or San Luis Obispo Basin GSAs. While successful intra-basin coordination is crucial to meeting SGMA sustainability objectives, inter-basin coordination is also a critical component of SGMA implementation. The GSA and BMC have a proven record of success in cooperating in regional water resources management planning.

Regardless of SGMA designations, the State and County will still retain jurisdictions, authorities and programs that help to manage local resources described above. For example, the County's Groundwater Level Monitoring Program is a volunteer program and may be extended to the Warden Creek subbasin for property owners to voluntarily participate in, as appropriate.

9 The Warden Creek subbasin is referred to as the Eastern Valley in the 2018 Fringe Areas TM.

A statement of the existing and planned coordination of sustainable groundwater management activities and responsibilities where required by the act (§ 344.16(a)(2))

The County of San Luis Obispo is the GSA for the fringe areas outside of the Adjudicated Plan Area, and is a member of the Los Osos Basin Management Committee (BMC), which coordinates sustainable groundwater management within the Adjudicated Plan Area. The Los Osos BMC also includes the three water purveyors serving the community within the Adjudicated Plan Area, and holds bi-monthly public meetings in Los Osos. Related agendas and meeting materials are posted on the County's website (www.slocountywater.org).

The County prepared a Salt and Nutrient Management Plan for the Adjudicated Plan Area, and, through the County Flood Control District, has also taken proactive measures to ensure compliance with SGMA in the fringe areas of the basin. The County also retained a hydrogeologist consultant to develop a Los Osos Valley Groundwater Basin Fringe Areas Characterization Technical Memorandum (2018 Fringe Areas TM) (CHG, 2018).

This BBMR is a key component of coordinating sustainable groundwater management. The BBMR development process brought the County and Warden Creek subbasin stakeholders together and fostered a better understanding of both the basin and SGMA. The County continues to support transparent coordinated efforts toward sustainable groundwater management in Los Osos Basin.

6.2 Descriptions and Supporting Documentation (§344.16(b))

A description and supporting documentation of historical and current conditions and coordination related to groundwater level monitoring programs, historical and current groundwater level trends, and areas of significant groundwater level declines (§ 344.16(b)(1))

Los Osos Area Subbasin

Groundwater level monitoring in the Los Osos Area subbasin has historically been performed by the water purveyors, County, and consultants. Current monitoring programs with water level components, some of which have data sets extending back to the 1970's, include the following:

- County Flood Control District, Groundwater Level Monitoring Program: County Department of Public Works staff monitors water levels in approximately 40 subbasin wells in April and October.
- County of San Luis Obispo - Los Osos Water Recycling Facility waste discharge order monitoring program: Consultants monitor water levels at up to 30 subbasin wells on a semi-annual to bi-annual basis.

- Los Osos BMC groundwater monitoring program: This monitoring program includes approximately 80 wells in the subbasin. Close to 30 water levels are obtained from the above County programs, with consultants and water purveyor staff monitoring water levels in approximately 50 additional subbasin wells in April and October.
- CASGEM is the State monitoring program resulting from Senate Bill SBx7 6: Currently, the County reports water level data to the CASGEM database for 9 subbasin wells, and the Los Osos BMC reports data for an additional 26 subbasin wells.

Spring and Fall 2016 groundwater elevation contours, along with representative water level hydrographs for first water, upper aquifer, and lower aquifer wells in the Los Osos Area subbasin are included in Appendix A3.

There has been an estimated 4-7 feet of overall groundwater level decline over the last 10 years in the perched and upper aquifers of the Los Osos Area subbasin, compared to a rise of 3 feet in lower aquifer water levels over the same period. Historical and current water level trends are further discussed in the 2016 Annual Groundwater Monitoring Report (CHG, 2017).[10]

Warden Creek Subbasin

There are no historical groundwater level monitoring programs in the Warden Creek subbasin. Water levels are measured and reported by the driller when a well is constructed and tested, and by pump contractors during service calls, but are not measured or reported on a regular basis. Growers typically rely on pump discharge rates and system pressure, rather than static water level measurements, as an indicator of available groundwater in storage.

The County Flood Control District will discuss and coordinate with landowners to consider adding new wells into a voluntary monitoring program for the proposed Warden Creek subbasin, as appropriate, to monitor groundwater levels.If wells are added to the voluntary monitoring program, County staff would monitor water levels in April and October.

As the designated GSA, the County has been providing technical and administrative support for SGMA compliance outside of the Adjudicated Plan Area (or proposed Los Osos Area subbasin). The County held public meetings, funded technical studies, and expended staff time to coordinate these efforts, including outreach and data requests to stakeholders in the Warden Creek Subbasin. The overall response to the County efforts has been supportive and positive. Several stakeholders with private domestic and irrigation wells have allowed access for water level and water quality testing. Confidentiality of the data has been the main concern with private well owners. Results of field studies in the Warden Creek subbasin are summarized herein.

10 2016 Annual Groundwater Monitoring Report details may be accessed at: <https://slocountywater.org/site/Water%20Resources/LosOsos/>.

CHG measured water levels at 26 wells as part of fringe area characterization between August and October 2017. Twelve of the wells visited were within the Warden Creek subbasin, six wells were across the internal subbasin boundary in the adjacent Los Osos Area subbasin, and eight were bedrock wells along the base of the Irish Hills (out of the basin). Groundwater elevation contours are presented in Figure 12.

Nine of the subbasin wells where static water levels were measured in 2017 also had available historical water level data. The water level differences range from 4.5 feet higher elevation to 16 feet lower elevation when comparing 2017 water levels to prior years. The average difference in elevation at the nine wells is 4 feet lower elevation in 2017 compared to prior years. Table 5 summarizes the water level comparison.

Table 5
Groundwater Level Comparison
Proposed Warden Creek Subbasin Wells

Area	Historical Water Level Date	Recent Water Level Date	Water Level Change (feet)
Lower Warden Creek Subbasin Wells	9/16/1981	8/14/2017	-16
	7/26/1989	8/14/2017	-10.8
	5/21/1990	8/14/2017	-7.8
Upper Warden Creek Subbasin Wells	7/27/1998	8/14/2017	-5.0
	11/3/2000	10/12/2017	4.5
	11/20/2001	8/14/2017	-2.6
	7/30/2002	9/7/2017	0.3
	10/8/2004	10/12/2017	4.3
	10/11/2004	10/12/2017	-2.2
Average difference between historical and recent level (feet)			-4

Lower Warden Creek Subbasin - from Turri Road area west to Los Osos Area subbasin
Upper Warden Creek Subbasin - from Turri Road area east to boundary with San Luis Obispo Valley Groundwater Basin

The water level declines shown in Table 5 are greatest when comparing the oldest available water levels with 2017 levels, which also correspond to the water levels in the lower Warden Creek subbasin. The information in Table 5 is relatively limited for interpreting subbasin groundwater conditions, but the overall water level declines do not appear significant from a sustainable management perspective, considering that the above historical levels were measured prior to putting each well into service, and the 2017 static water level measurements were measured between pumping cycles.

A description and supporting documentation of historical and current conditions and coordination related to groundwater quality issues that may impact the supply and beneficial uses of groundwater, including a map of known impacted sites and areas, mitigation measures planned or in place, and a description of impact to the water budget (§ 344.16(b)(2))

Los Osos Area Subbasin

Water quality issues in the Los Osos Area subbasin have been central to both the adjudication action and development of the Los Osos Water Recycling Facility Project. Seawater intrusion is active in the lower aquifer, and nitrate loading to groundwater from high density residential septic systems have contaminated the upper aquifer beneath the urban area. Maps showing the historical development of seawater intrusion and nitrates are in Appendix A4.

Groundwater quality monitoring in the Los Osos Area subbasin has historically been performed by water purveyor staff, County staff, consultants, and growers. Current monitoring programs with water quality components, some of which have data sets extending back to the 1970's, include the following:

- Public water system monitoring programs per Title 22, administered by the State Water Board, Division of Drinking Water: The community water purveyors routinely test public drinking water wells for selected general physical, general mineral, organic, and inorganic water quality constituents and provide Annual Water Quality reports to the public.
- County of San Luis Obispo, Los Osos Water Recycling Facility waste discharge order groundwater monitoring program: Consultants monitor selected general physical and general mineral water quality constituents at up to 25 subbasin wells on a semi-annual to bi-annual basis. Monitoring reports are submitted annually to the Regional Water Board.
- Los Osos BMC groundwater monitoring program: This monitoring program includes semi-annual to annual water quality sampling for selected general physical and general mineral constituents at approximately 24 wells and selected constituents of emerging concern (CEC's) at 2 wells in the subbasin. Results for several wells are obtained from the above County programs.
- Irrigated Lands Regulatory Program: This is a program requiring operators of irrigated agricultural lands to comply with Agricultural Order provisions intended to protect groundwater and surface water quality. The program typically requires selected general physical and general mineral water quality constituents for the primary irrigation well and for domestic wells on a semi-annual basis.

A Salt and Nutrient Management Plan (SNMP) was prepared by the County for the Los Osos Basin (County of San Luis Obispo, 2017). The plan addresses salt loading and tertiary treated recycled water reuse, including assimilative capacity and antidegradation analyses for the Los Osos Area

subbasin. Once the SNMP is approved by the Regional Water Board, a monitoring report will be prepared and submitted to them every three years.

Mitigation measures to resolve seawater intrusion and associated water budget impacts, including the projected water balance with tertiary treated recycled water reuse are documented in the Basin Plan (Water Balance included in Appendix A4).[11]

Warden Creek Subbasin

Groundwater quality in the Warden Creek subbasin has been monitored under the Irrigated Lands Regulatory Program since 2013. Additional water quality analyses were collected in 2017 for the 2018 Fringe Areas TM (CHG, 2018). Surface water in Warden Creek has also been monitored for the Morro Bay National Estuary Program, beginning in 2002 (CHG, 2018).

Water quality from 34 wells were available between 2013 and 2017 from the Irrigated Lands Regulatory Program database and field investigation in 2017. Twelve of these wells were within the fringe area, seven wells were in the Cemetery Mesa portion of the Adjudicated Plan Area, and fifteen wells were from bedrock sources adjacent to the fringe area. Table 6 summarizes the available general mineral and nitrate water quality data collected between 2013 and 2017. The major solutes of general minerals, along with nitrate, comprise approximately 95 percent of the total dissolved solids in water samples from the Warden Creek subbasin, and are useful for comparing water quality from different source aquifers.

11 Basin Plan details may be accessed at: <https://slocountywater.org/site/Water%20Resources/LosOsos/>.

Table 6
Groundwater Quality 2013-2017
Proposed Warden Creek Subbasin and Vicinity

Total No. Samples	Area	TDS	Na	K	Mg	Ca	Cl	SO4	HCO3	NO3-N
		milligrams per liter (mg/L)								
12	Warden Creek Subbasin Average	781	121	1	63	73	204	65	375	7.9
6	Lower Subbasin Area	**1,007**	193	3	71	76	**302**	102	436	4.5
6	Upper Subbasin Area	554	50	0	55	70	107	28	314	**11.5**
7	Cemetery Mesa	686	125	4	50	50	161	41	385	0.2
15	Bedrock	541	56	1	58	54	94	46	361	2
Drinking Water Standards										
Primary MCL		--	--	--	--	--	--	--	--	10
Secondary MCL (recommended)		500	--	--	--	--	250	250	--	--
Secondary MCL (upper Limit)		1000	--	--	--	--	500	--	--	--

Areas shown in Figure 6
Lower Subbasin Area - from Turri Road area west to Los Osos Area subbasin boundary
Upper Subbasin Area - from Turri Road area east to boundary with San Luis Obispo Valley Basin
Cemetery Mesa - east end of Los Osos Area subbasin
TDS - total dissolved solids; Na - sodium; K - potassium; Mg - magnesium; Ca - calcium; Cl - chloride
SO4 - sulfate; HCO3 - bicarbonate; NO3-N - nitrate as nitrogen; mg/L - milligrams per liter; MCL - Maximum Contaminant Level (California Code of Regulations, Title 22),
Bolded values exceed the following State drinking water standards: TDS (1,000 mg/l upper limit, secondary standard); Chloride (250 mg/L recommended limit, secondary standard), and NO_3-N (10 mg/L, primary standard); "--" no primary or secondary standard.

Potential water quality impacts include elevated salinity in the lower Warden Creek subbasin area and elevated nitrate concentrations in the upper subbasin area. Salt and nutrient loading to groundwater includes natural, agricultural, residential, and animal sources. Natural spring seeps in Los Osos Area subbasin on the bluff north of the Los Osos Water Recycling Facility were noted to have elevated electrical conductivity measurements (5,600 µmhos/cm) during site reconnaissance in September 2012, prior to facility construction (CHG, 2012). Surface water quality in Warden Creek, as measured at the Turri Road bridge, has a history of elevated nitrate concentrations (MBNEP, 2015; CCRWQCB, 2004).

Coordination to address potential water quality impacts from agricultural operations is provided by the Irrigated Lands Regulatory Project. In 2012, the Regional Water Board adopted Waste Discharge Order No. R3-2012-0011, a Conditional Waiver of Waste Discharge Requirements for

Discharges from Irrigated Lands. This Order required operators of irrigated agricultural lands to comply with provisions intended to protect groundwater and surface water quality. A continuation of the Irrigated Lands Regulatory Program for waste dischargers was adopted as Agricultural Order No. R3-2017-0002 and is in effect through March 2020. Several of the ranches overlying the Warden Creek subbasin are required to comply with the Order.

As part of the watershed draining to the Morro Bay estuary, the Warden Creek subbasin is also within the purview of the Morro Bay National Estuary Program (MBNEP). The MBNEP partners with public agencies and non-profit groups to obtain and leverage grant funding for scientific monitoring and research, natural habitat restoration, and local educational outreach programs benefiting the estuary and watershed. The MBNEP has been monitoring surface water quality on Warden Creek in the Warden Creek subbasin since 2002.

A description and supporting documentation of historical and current conditions and coordination related to inelastic land surface subsidence (§ 344.16(b)(3))

Historical and current conditions for land surface subsidence has not previously been studied in the Los Osos Basin, and the description of these conditions, along with a compilation of supporting documentation is presented as an Appendix to this BBMR (Appendix C). The conclusions of the available information presented in Appendix C is as follows:

- No public reports of subsidence related damage are known for the basin.
- No historic studies of pumping related subsidence are known for the basin. PG&E estimates tectonic subsidence rates to be between -0.06 and -0.1 millimeters per year.
- All areas of the basin contain material susceptible to subsidence, with the alluvium of the Los Osos Creek valley (Los Osos Area subbasin) and the Warden Lake area (Warden Creek subbasin) being most susceptible.
- Based on historic and projected water levels, peak subsidence due to groundwater pumping in the basin has likely already occurred. Little additional subsidence would be expected within the basin provided water levels are maintained above historic lows.

A description and supporting documentation of historical and current conditions and coordination related to groundwater-surface water interactions (§ 344.16(b)(4))

Los Osos Area Subbasin

Surface water resources of the Los Osos Area subbasin are shown in Appendix A4 (Basin Plan Figure 21), which include Los Osos Creek, a short reach of Warden Creek, and Willow Creek/Eto Lake. Groundwater seeps and springs occur along the shoreline of Morro Bay estuary, and include Pecho marsh, Sweet Springs marsh, 3rd Street marsh, Baywood Point spring, and Baywood marsh. The surface water of spring seeps along the shore of Morro Bay estuary emanate from the upper aquifer.

Groundwater-surface water interactions have been investigated on Los Osos Creek. Los Osos Creek flow originates in the Clark Valley, and is generally a losing stream between the subbasin boundary and the confluence of Willow Creek/Eto lake. Downstream of the confluence, the creek generally gains flow from the perched aquifer via Willow Creek and from water rising into the creek from the upper aquifer. Los Osos Creek contributed an estimated 610 AFY to subbasin recharge under 2012 conditions. Roughly two-thirds of the stream seepage recharging the subbasin is estimated to occur upstream of Los Osos Valley Road (CHG, 2014).

Water quality in Los Osos Creek at Los Osos Valley Road is calcium-magnesium bicarbonate with an average TDS of 540 mg/l and no detectable nitrate (C&A, 2005). The MBNEP also monitors surface water quality on Los Osos Creek at Los Osos Valley Road.

Warden Creek Subbasin

Surface water bodies in the Warden Creek subbasin are shown in Figure 6, and include Warden Creek and Warden Lake. Groundwater seeps and springs occur along the slopes of Park Ridge and the Irish Hills, generally emanating from bedrock outside of the subbasin boundary.

Groundwater-surface water interactions have not been studied in the Warden Creek subbasin. Based on the Summer 2017 water level contour map (Figure 12), a review of historical aerial imagery, and interpretation of the preliminary water balance for the subbasin (Table 4), Warden Creek generally appears to be a gaining stream with base flow, except during drought. Stream seepage is estimated at approximately 210 AFY (Table 4).

Surface water quality monitoring by the MBNEP on Warden Creek is focused on the nutrient suite for Total Maximum Daily Load monitoring. Total nitrogen concentrations for 57 surface water samples collected at the Turri Road bridge averaged 11.4 mg/L between 2002 and 2016, comparable to the 11.5 mg/L average nitrate as nitrogen concentration in groundwater samples collected in the upper area of the Warden Creek subbasin between 2013 and 2017.

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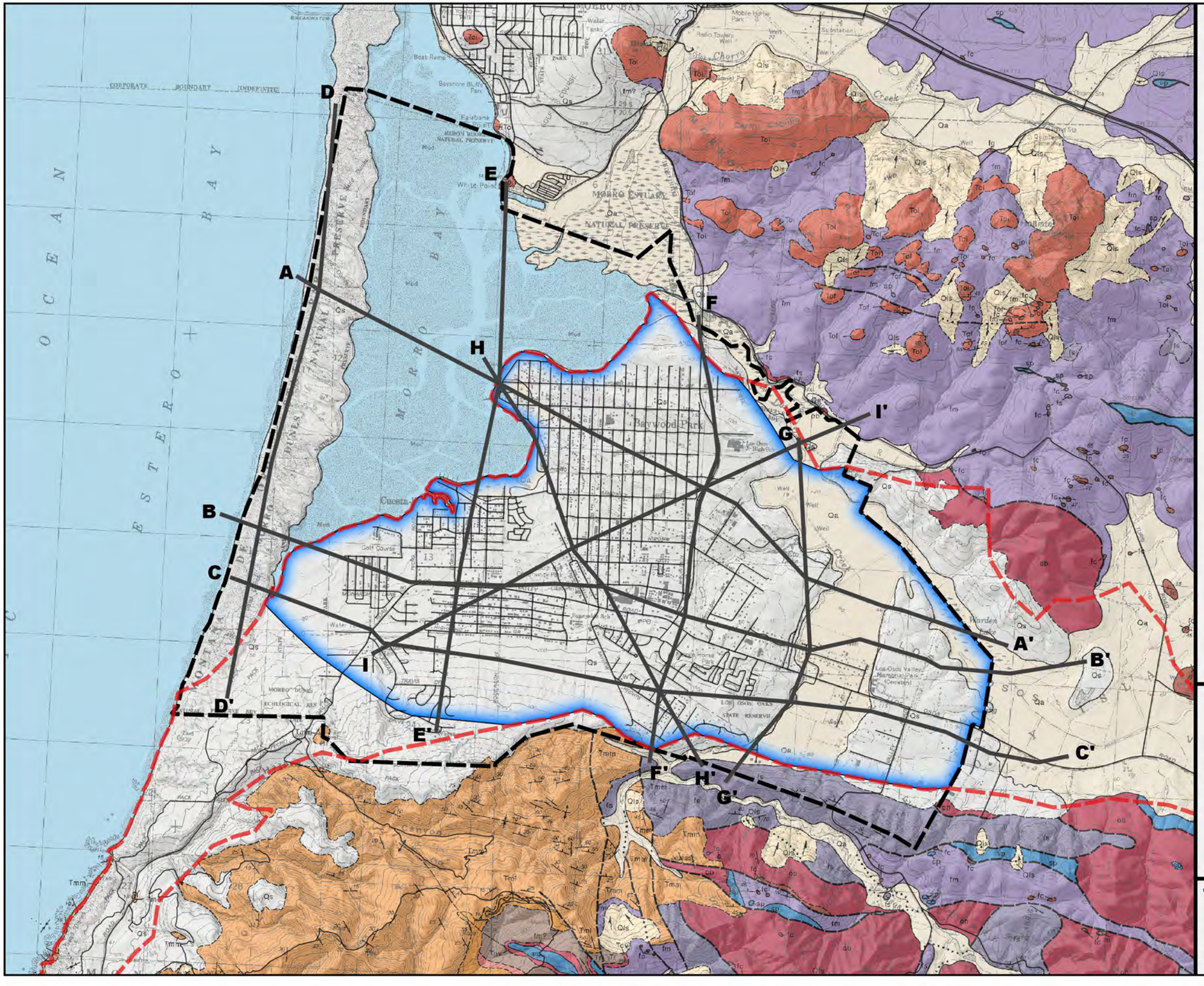
APPENDIX A

Los Osos Area Subbasin Information

A1 - Geologic Cross-sections



Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Los Osos Area Subbasin
- Cross-section Line

Geology Key on Figure 3

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 3000 6000 ft

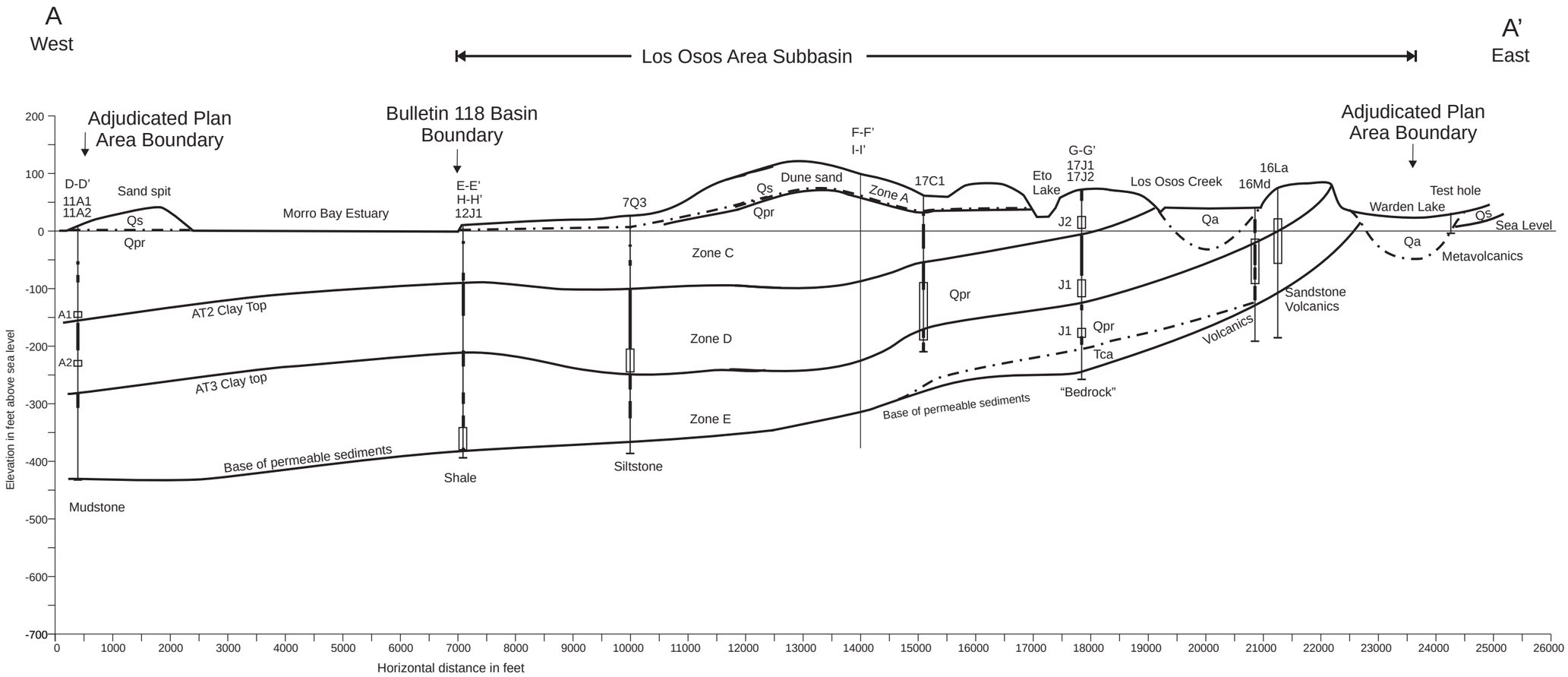
NORTH

Figure A1-1 - Geologic Cross-sections - Los Osos Area Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
12J1 Well ID
Clay layer
Well screen

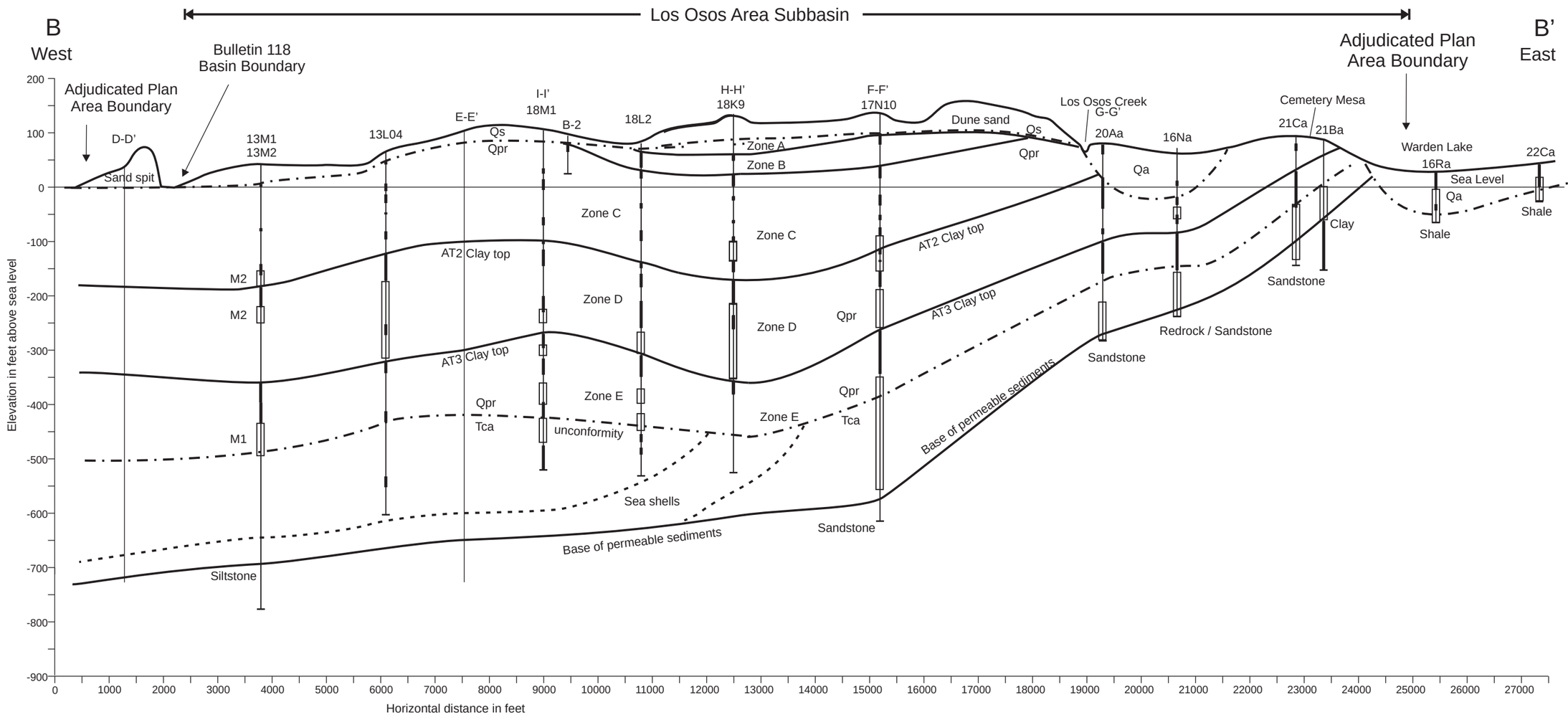
Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-2

Cross-Section A-A'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
18M1 Well ID
Clay layer
Well screen

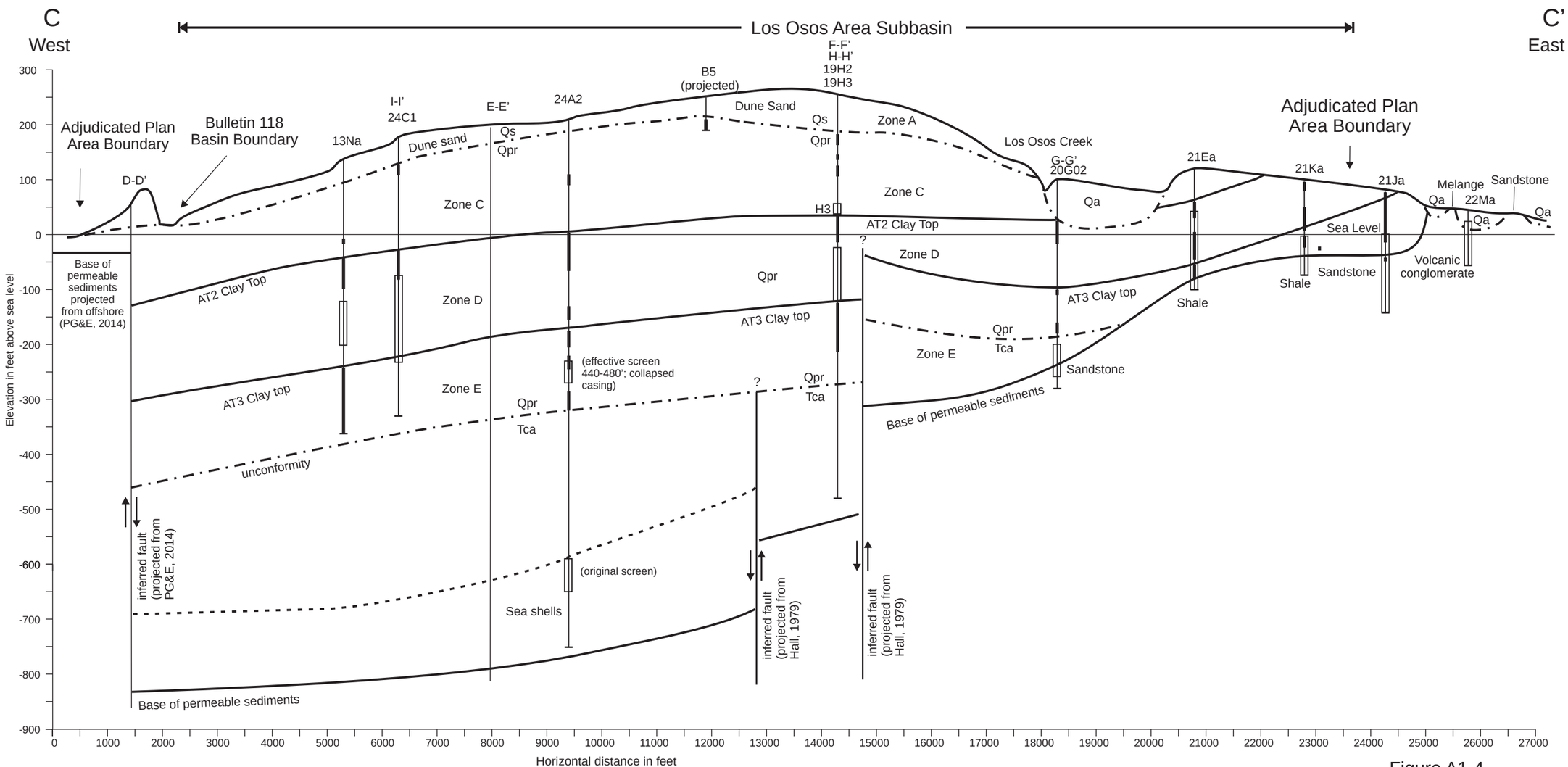
Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-3

Cross-Section B-B'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
24A2 Well ID
Clay layer
Well screen

Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-4

Cross-Section C-C'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists

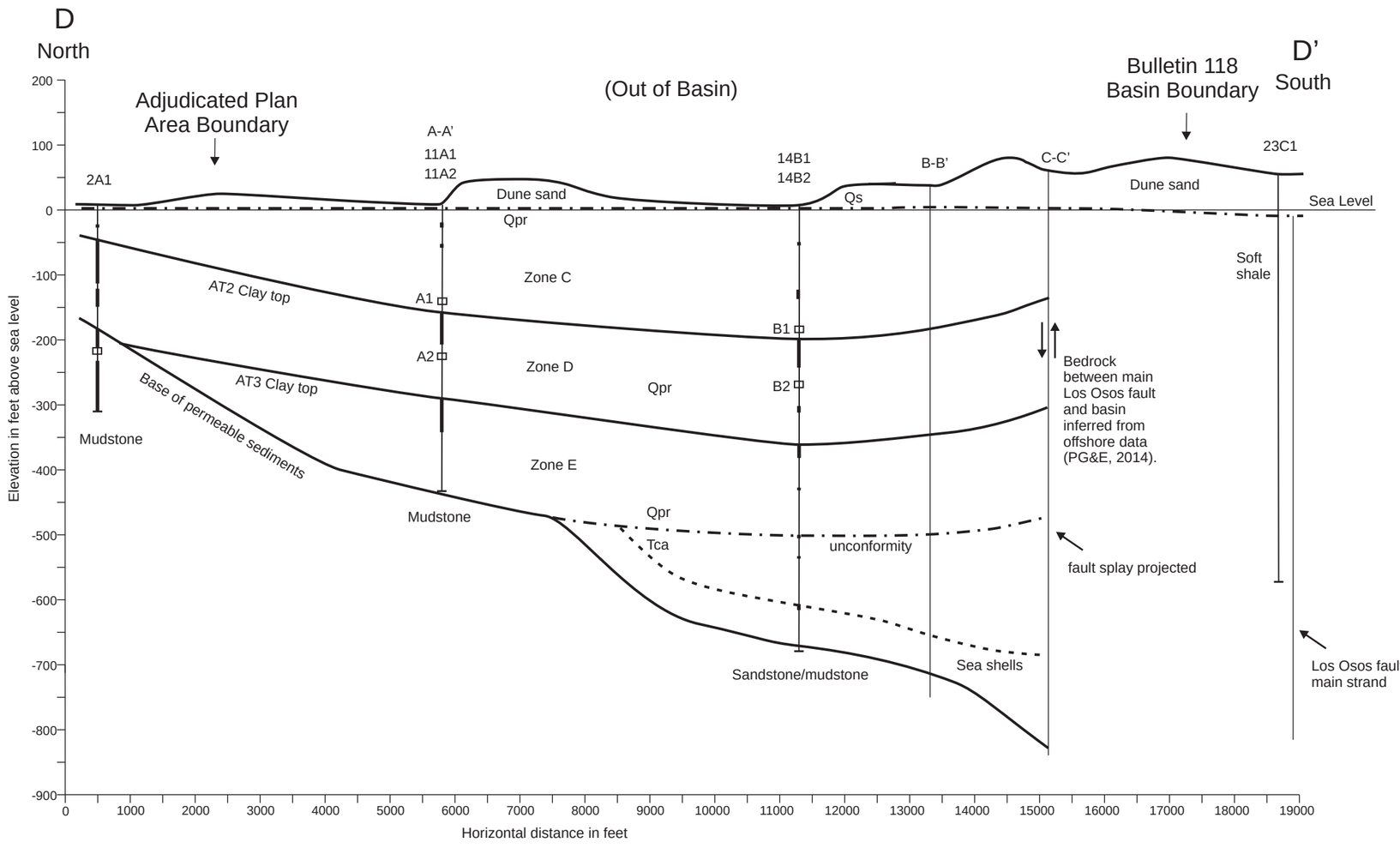


Figure A1-5

Cross-Section D-D'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists

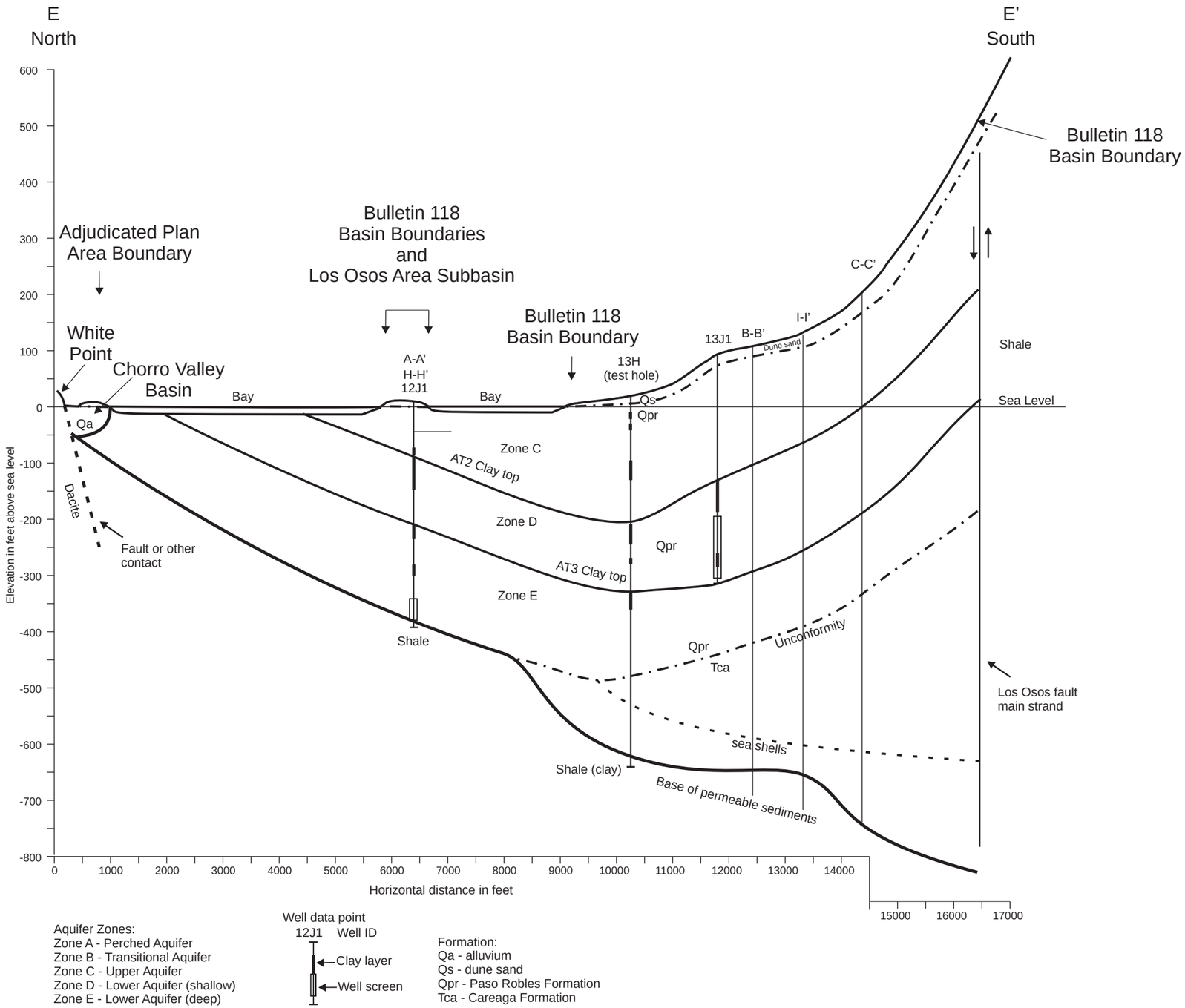
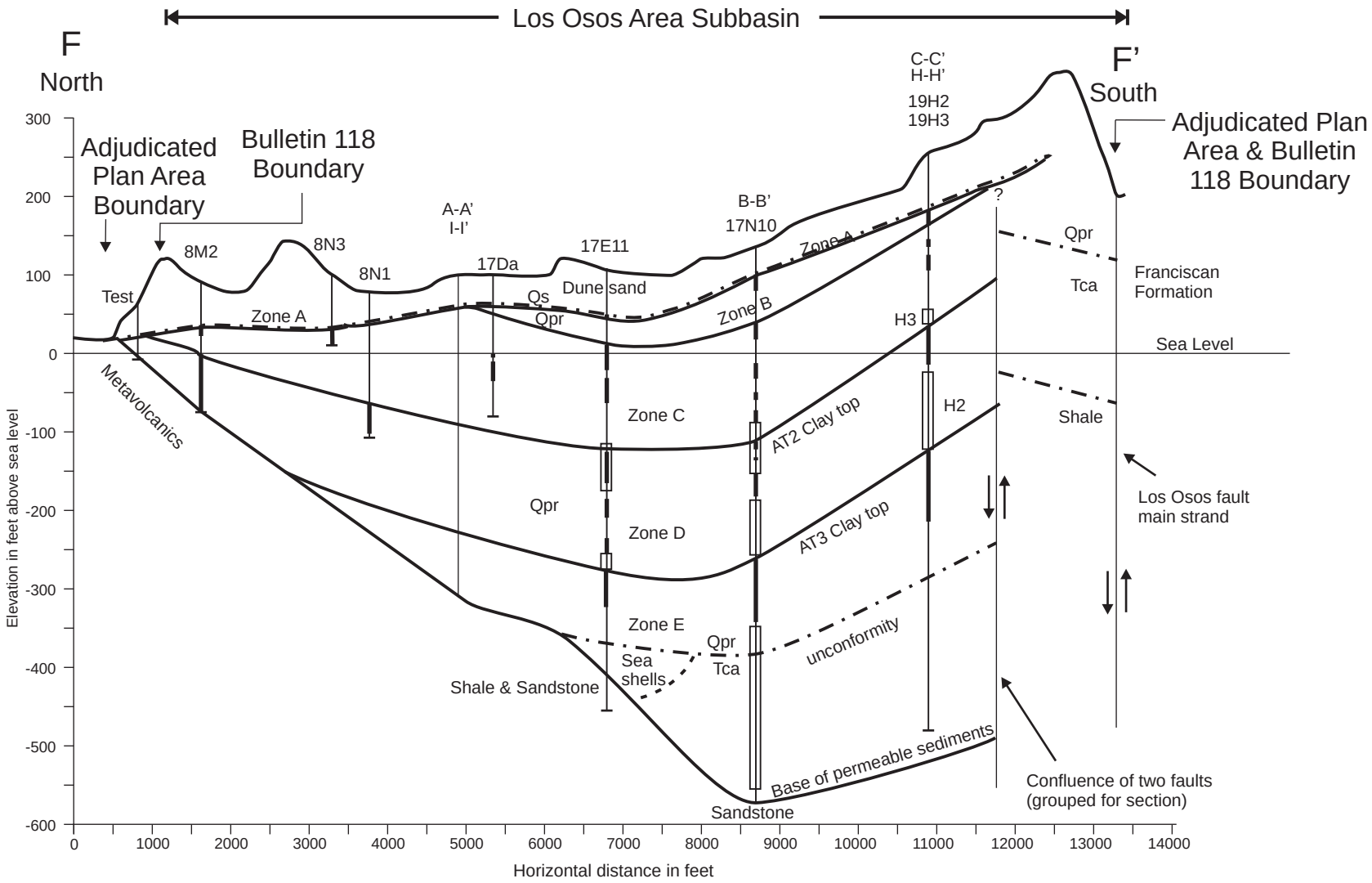


Figure A1-6

Cross-Section E-E'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologsts



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
19H2 Well ID
Clay layer
Well screen

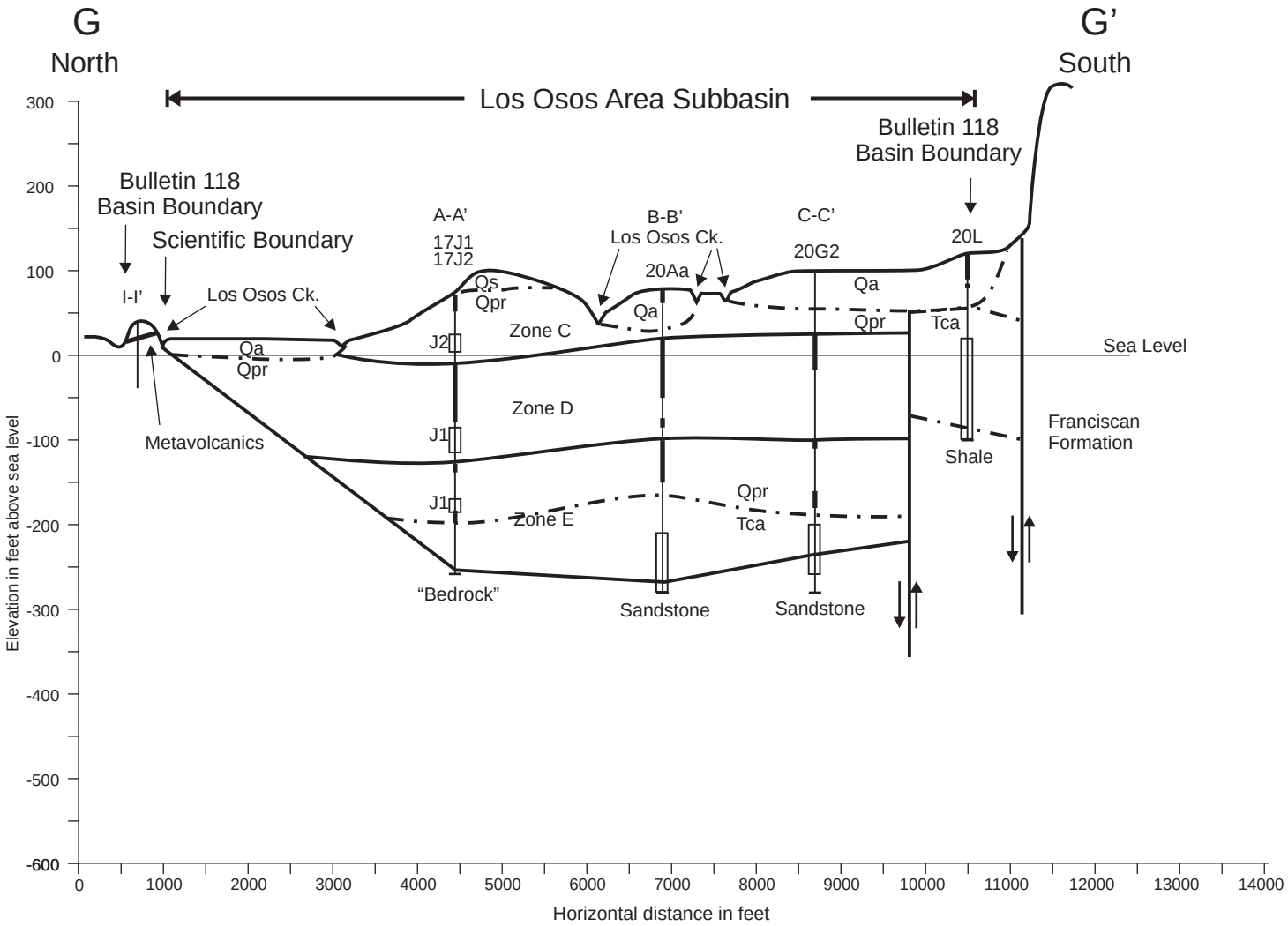
Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-7

Cross-Section F-F'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
20G2 Well ID
Clay layer
Well screen

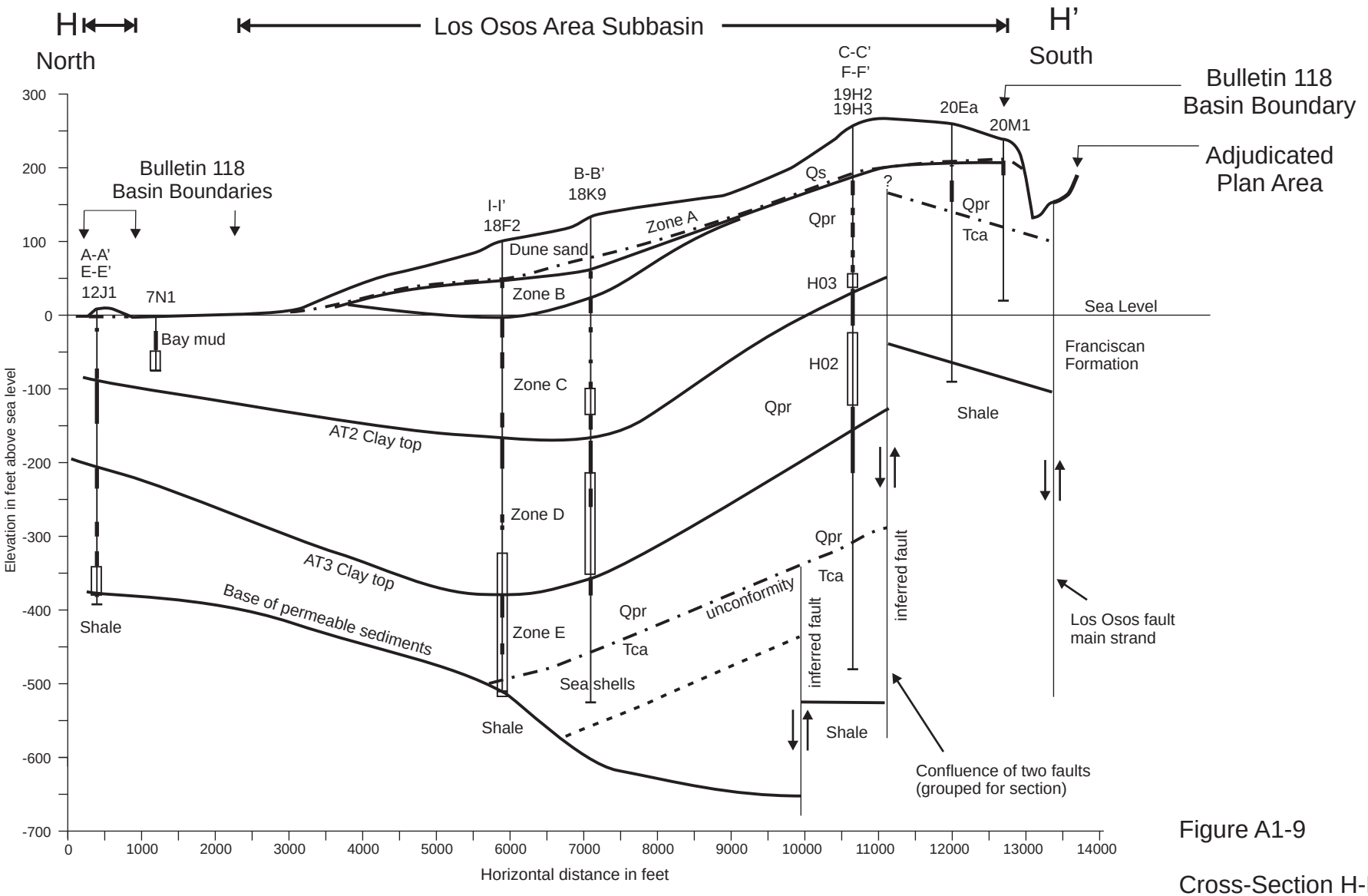
Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-8

Cross-Section G-G'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
18F2 Well ID
Clay layer
Well screen

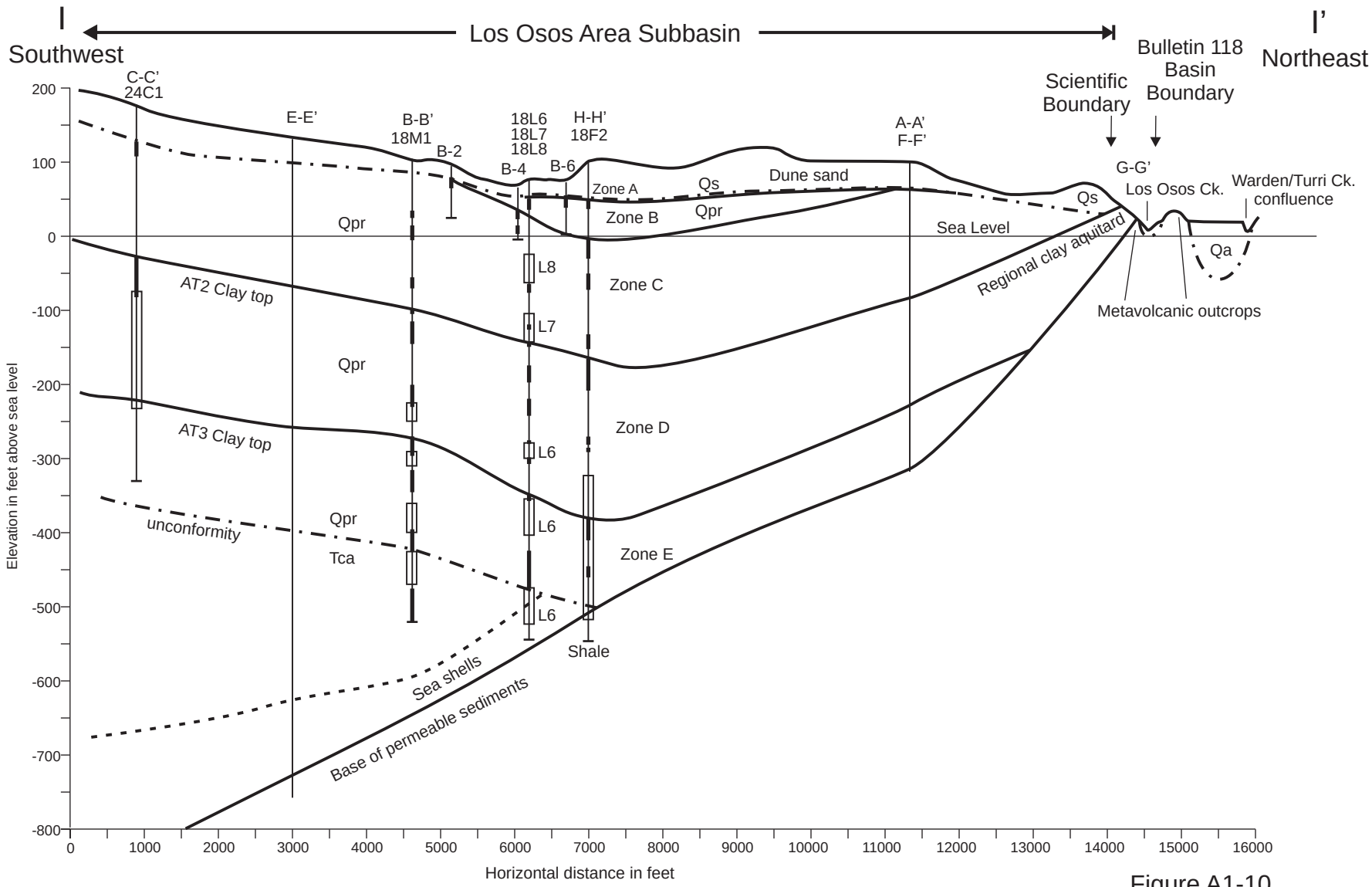
Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-9

Cross-Section H-H'
Los Osos Valley
Groundwater Basin

February 2018 Revision

Cleath-Harris Geologists



Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
18M1 Well ID
Clay layer
Well screen

Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

Figure A1-10

Cross-Section I-I'
Los Osos Valley
Groundwater Basin

San Luis Obispo County
February 2018 Revision

Cleath-Harris Geologists

APPENDIX A

Los Osos Area Subbasin Information

A2 - Base of Permeable Sediments
Base of Upper Aquifer Zone C

Explanation

- Adjudicated Plan Area
- Bulletin 118 Basin Boundary- Los Osos Valley Groundwater Basin
- Los Osos Area Subbasin
- Contours - Base of Permeable Sediments [ft above MSL]

Basemap: Geologic Map of the Morro Bay South Quadrangle, San Luis Obispo County, California - Dibblee Geological Foundation, 2006

0 3000 6000 ft

NORTH

Figure A2-1 - Base of Permeable Sediments - Los Osos Area Subbasin

Los Osos Valley Groundwater Basin Boundary Modification Request

County of San Luis Obispo

Cleath-Harris Geologists

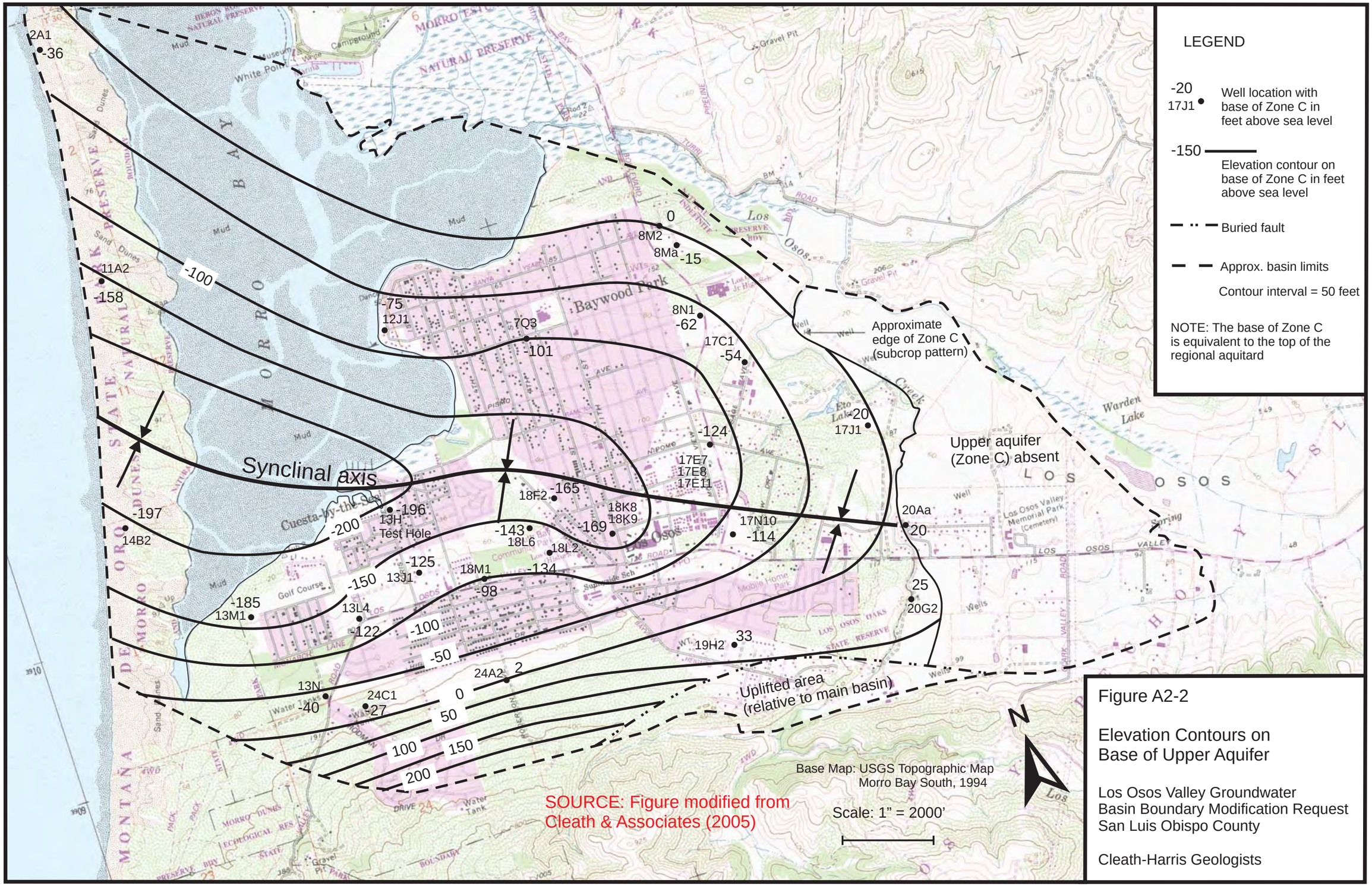


Figure A2-2

Elevation Contours on
Base of Upper Aquifer

Los Osos Valley Groundwater
Basin Boundary Modification Request
San Luis Obispo County

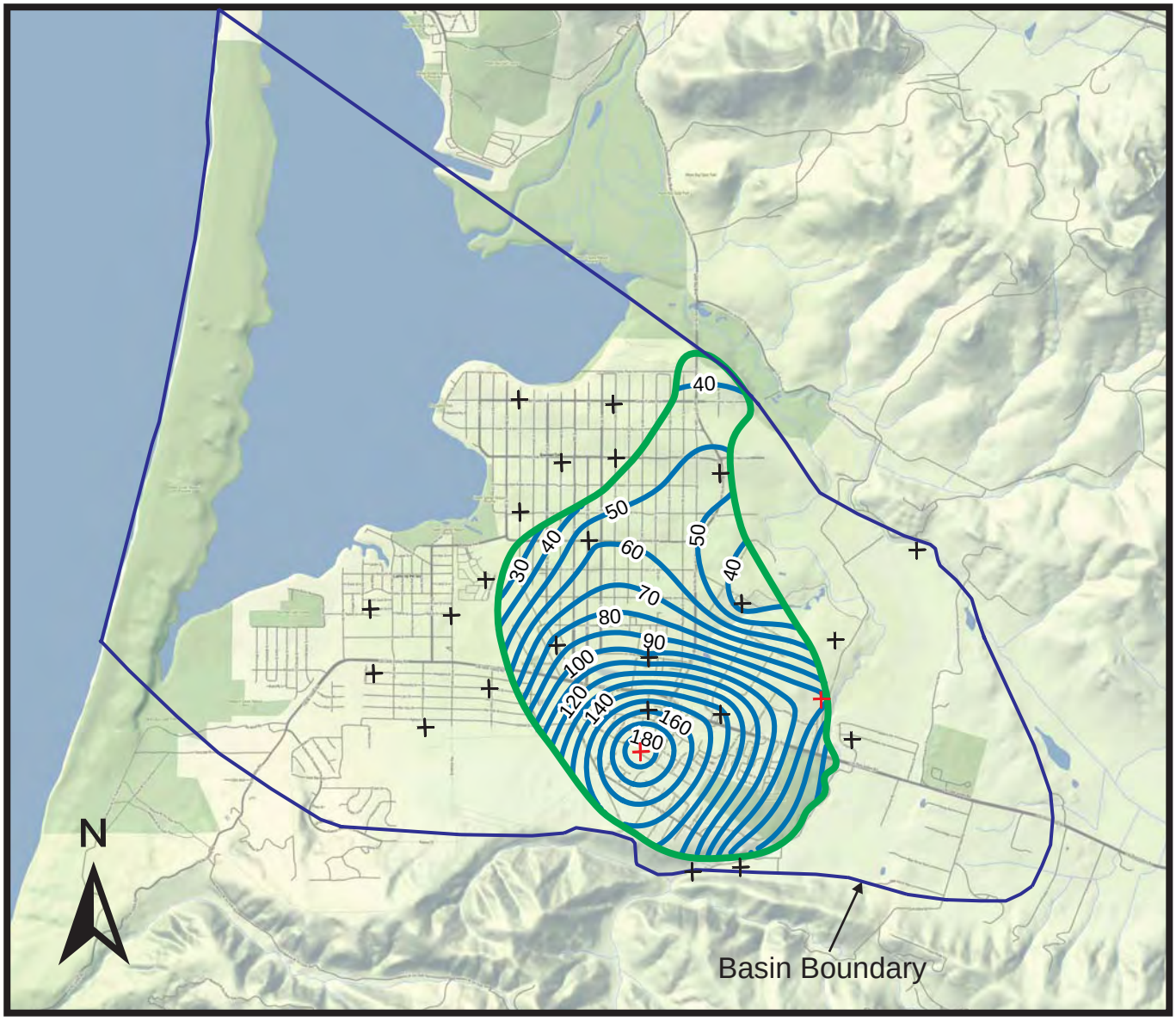
Cleath-Harris Geologists

APPENDIX A

Los Osos Area Subbasin Information

A3 - Water Level Maps from 2016 Annual Report

NOTE: Figures in Appendix A3 reflect the locally defined groundwater basin from the court approved Adjudicated Plan Area. These figures provide information for the proposed Los Osos Area subbasin, which is within the Adjudicated Plan Area.



Base Image: Stamen-Terrain

0 2000 4000 6000 8000 ft

Scale: 1 inch ≈ 4,000 feet

Explanation

40 Groundwater elevation contour in feet above sea level (NAVD 88 datum)

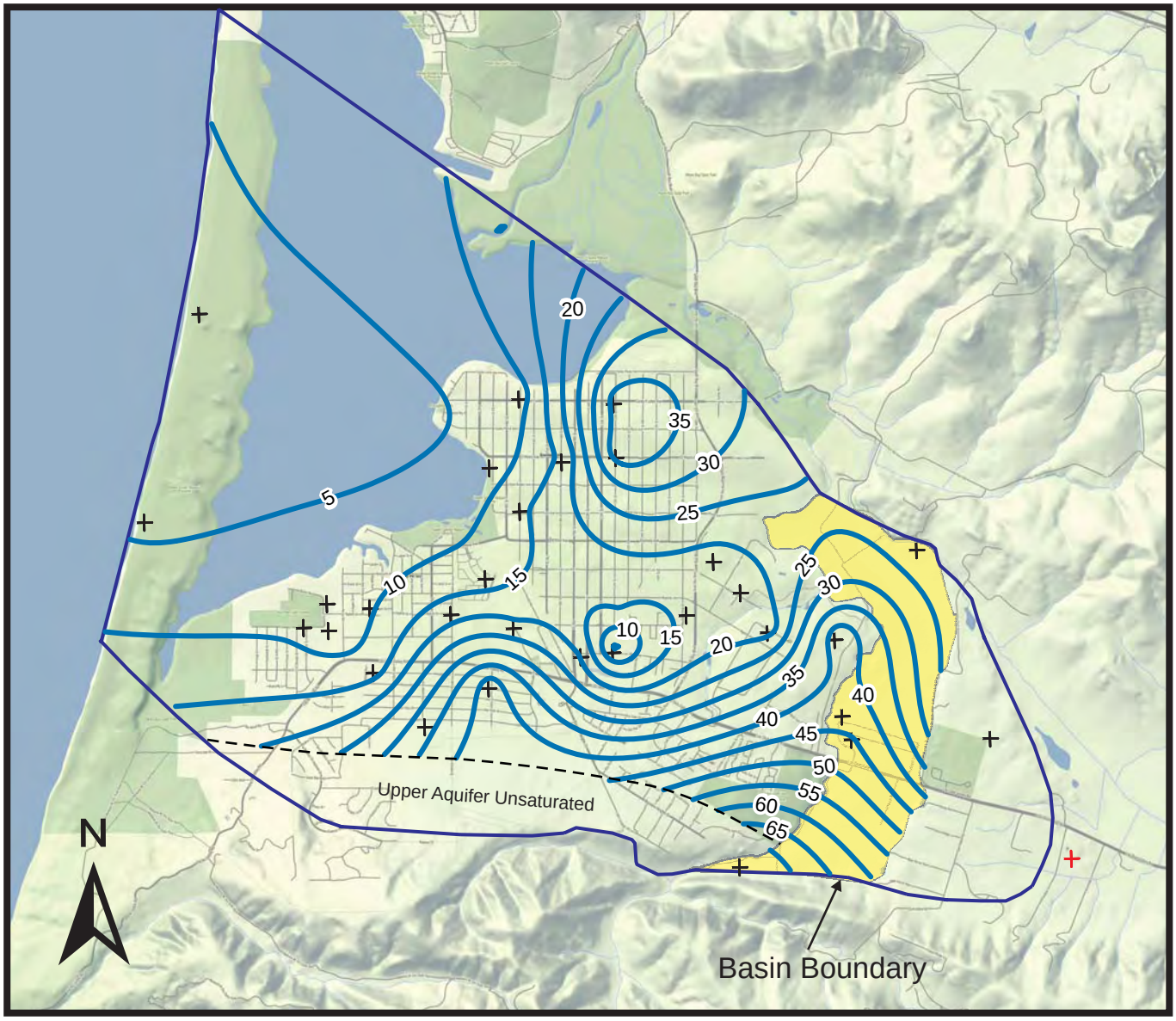
Approximate limits of Perched Aquifer

\+ Spring 2016 groundwater elevation data point (contours not applicable outside of Perched Aquifer limits)

\+ Alternate date groundwater elevation data point

Figure 9
Spring 2016 Water Level Contours
Perched Aquifer
Los Osos Groundwater Basin
2016 Annual Report

Cleath-Harris Geologists



Base Image: Stamen-Terrain

0 2000 4000 6000 8000 ft

Scale: 1 inch ≈ 4,000 feet

Explanation

40 Groundwater elevation contour in feet above sea level (NAVD 88 datum)

Limits of Alluvial Aquifer

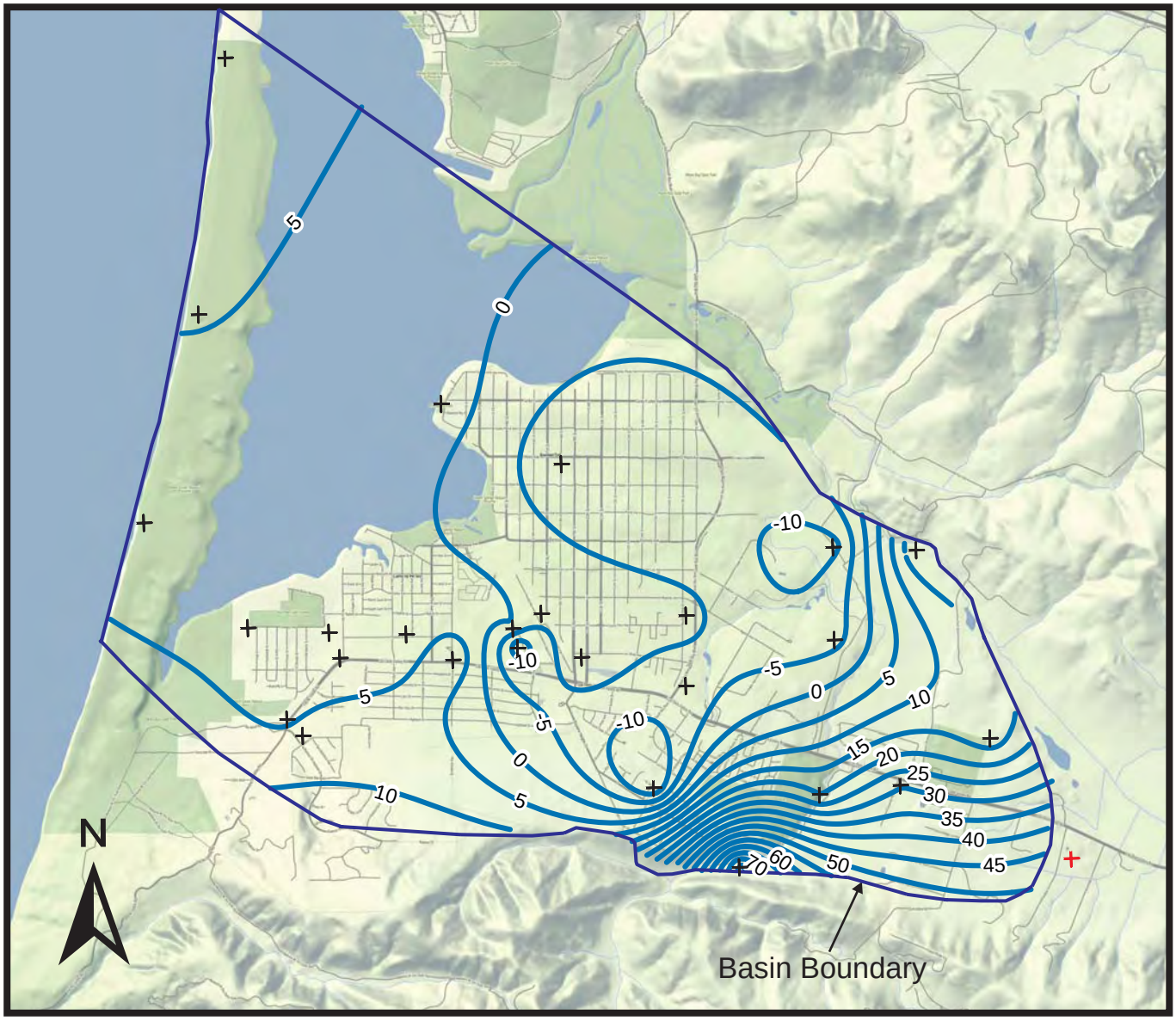
\+ Spring 2016 groundwater elevation data point (contours not applicable outside of Upper Aquifer and Alluvial Aquifer limits)

\+ Alternate date groundwater elevation data point

NOTE: Area where Upper Aquifer is unsaturated along southern Basin boundary determined from comparison of water levels with aquifer base contours. This condition was present in 2015 but not shown in 2015 Annual Report.

Figure 10
Spring 2016 Water Level Contours
Upper Aquifer and Alluvial Aquifer
Los Osos Groundwater Basin
2016 Annual Report

Cleath-Harris Geologists



Base Image: Stamen-Terrain

0 2000 4000 6000 8000 ft

Scale: 1 inch ≈ 4,000 feet

Explanation

40 Groundwater elevation contour in feet above sea level (NAVD 88 datum)

\+ Spring 2016 groundwater elevation data point

\+ Alternate date groundwater elevation data point

Figure 11
Spring 2016 Water Level Contours
Lower Aquifer
Los Osos Groundwater Basin
2016 Annual Report

Cleath-Harris Geologists

APPENDIX A

Los Osos Area Subbasin Information

A4 - Figures from 2015 Los Osos Basin Plan

NOTE: Figures in Appendix A4 reflect the locally defined groundwater basin from the court approved Adjudicated Plan Area. These figures provide information for the proposed Los Osos Area subbasin, which is within the Adjudicated Plan Area.

Figure 21. Surface Water Resources of the Basin

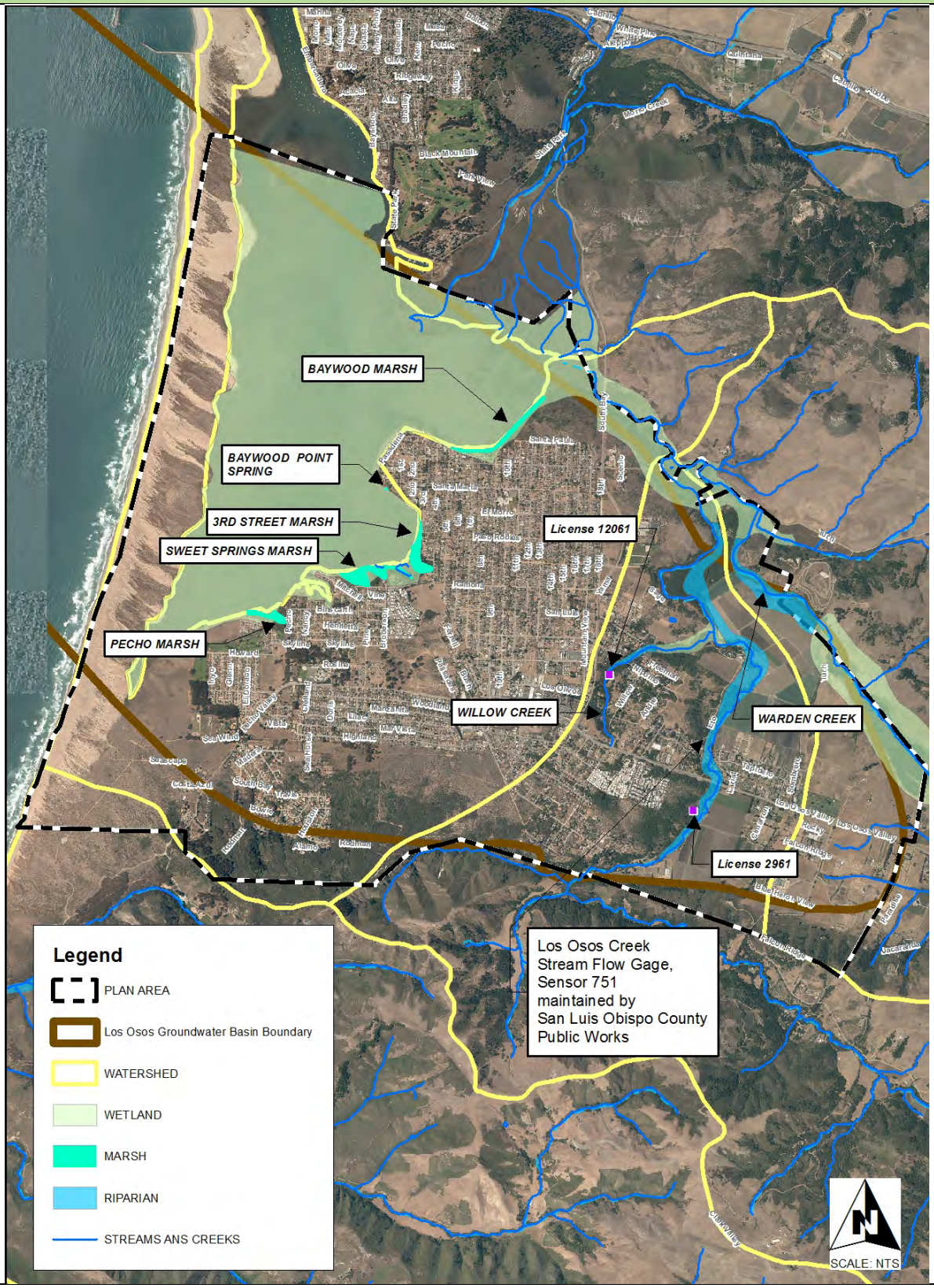
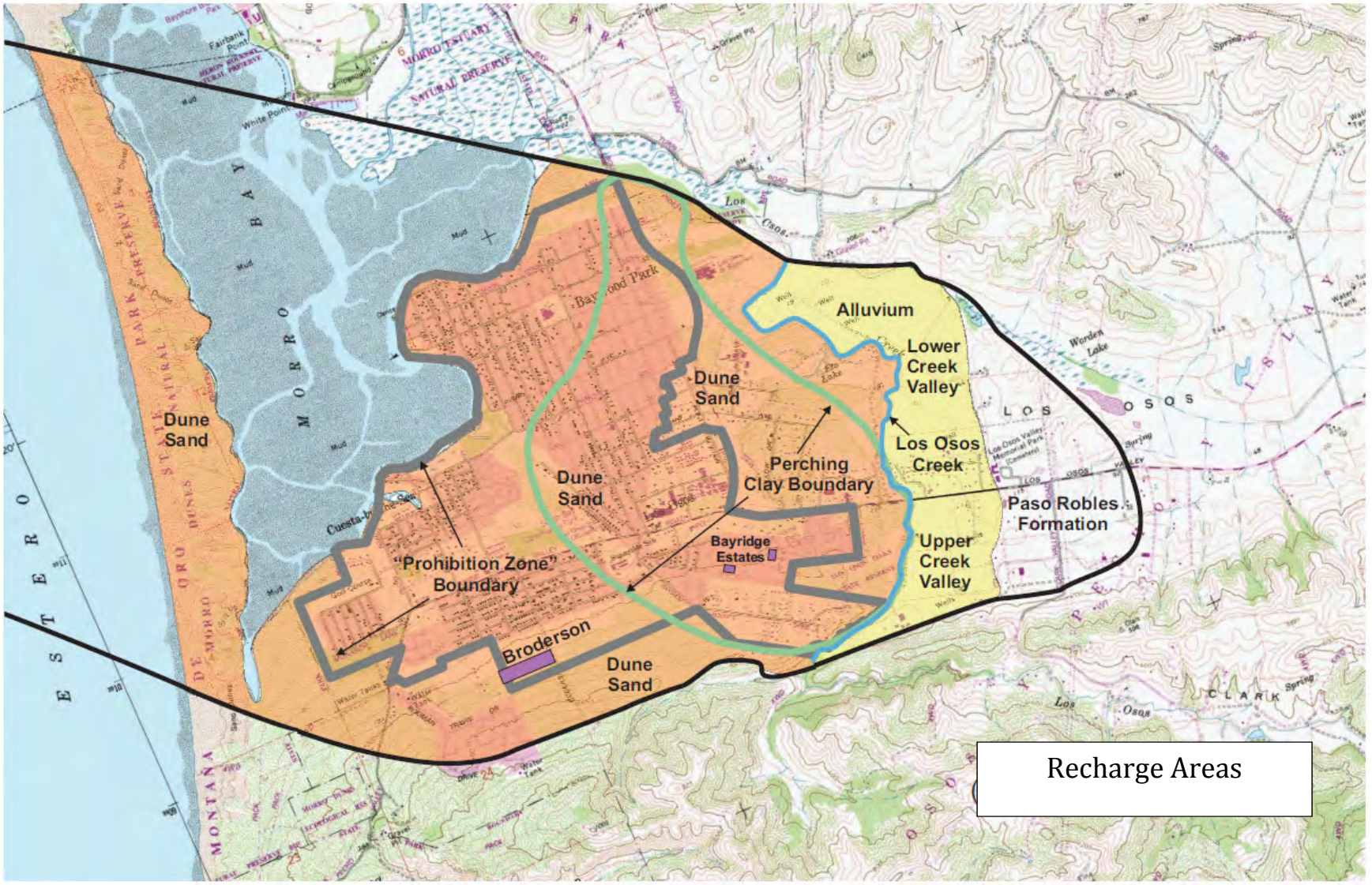
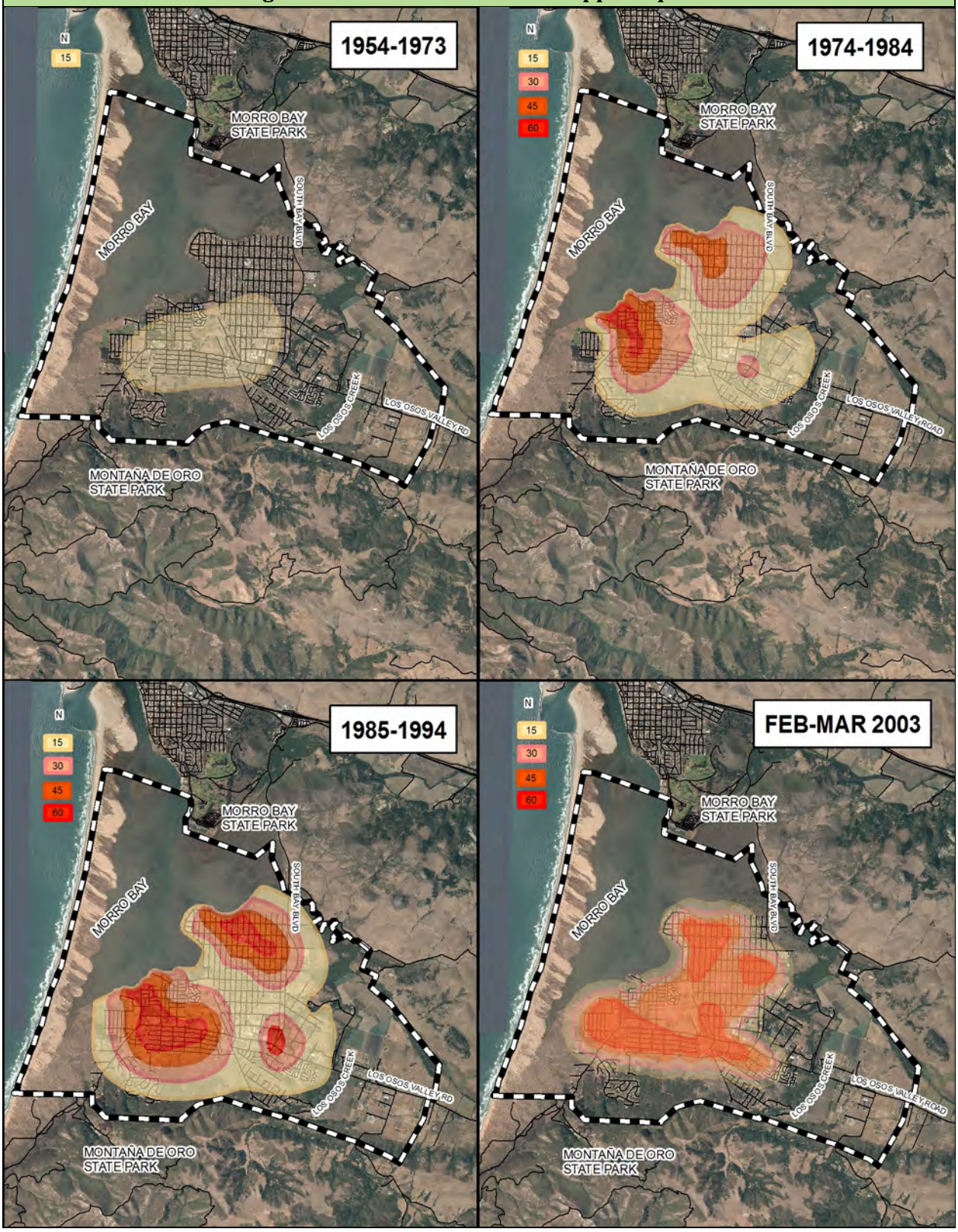


Figure 24. Recharge Areas of the Basin



Source: CHG.

Figure 25. Nitrate Levels in the Upper Aquifer



Note: All nitrate concentrations are expressed in mg/L.

Figure 26. Historical Progression of Seawater Intrusion in the Lower Aquifer

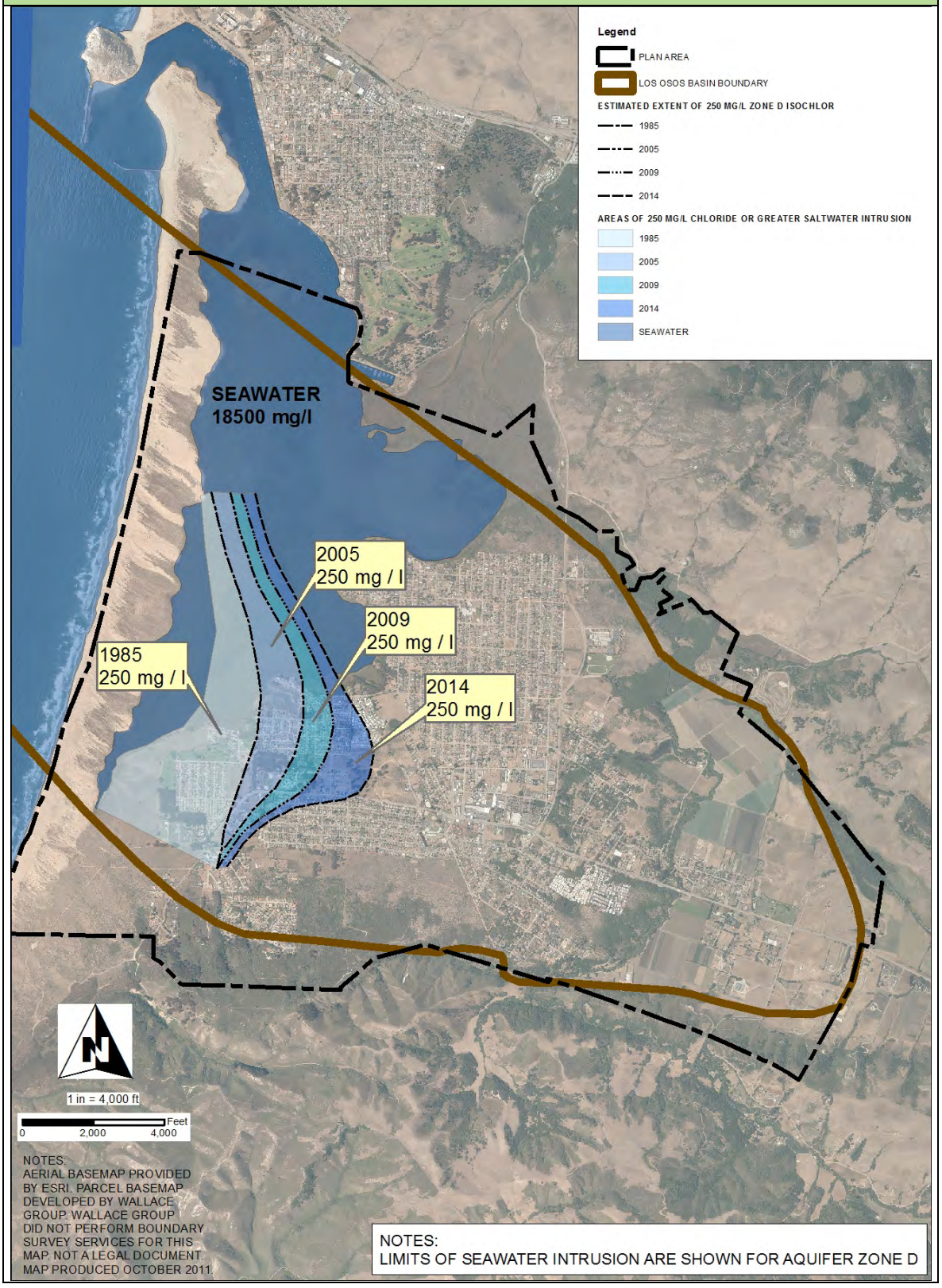
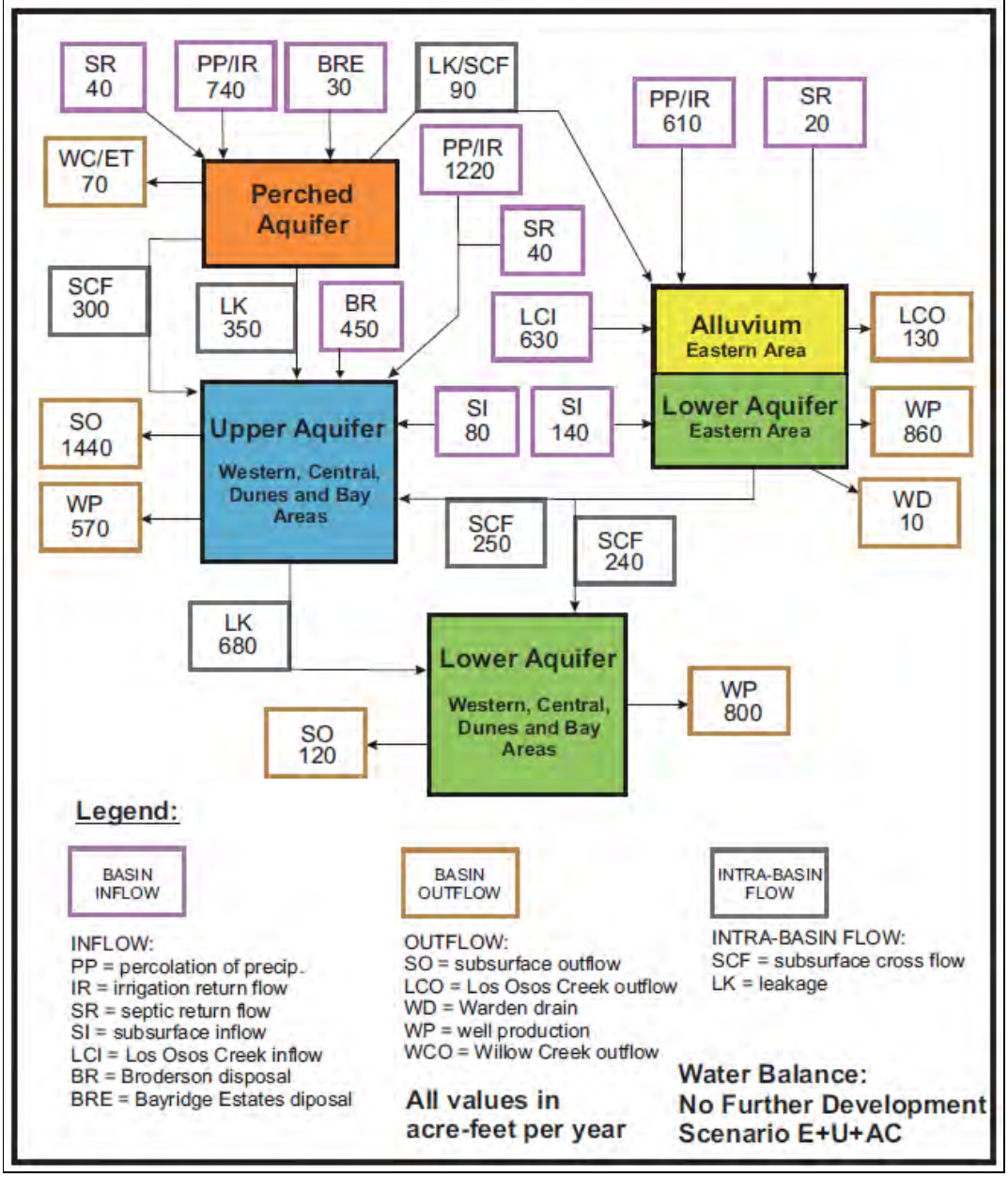


Figure 74. Water Balance: No Further Development



APPENDIX B

Montaña de Oro Fringe Area Information

B1 - Geophysical Lines

Regional Site Map

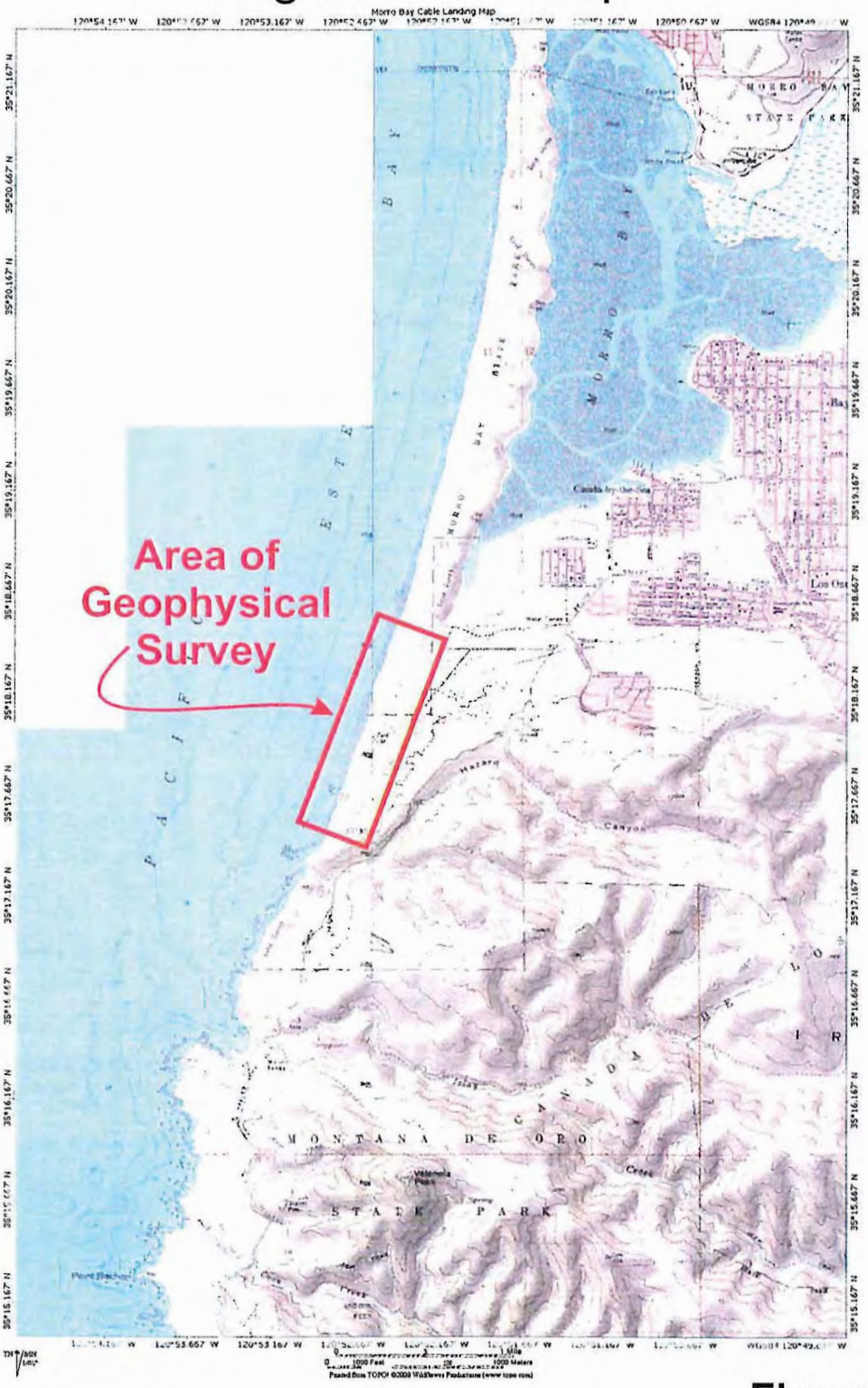


Figure 1

North

CONSULTANTS IN GEOPHYSICS AND GEOLOGY FOR THE ENGINEERING, GEOTECHNICAL ENVIRONMENTAL and LEGAL PROFESSIONS.
GASCH & ASSOCIATES
3174 Luyung Drive, Building #2
Rancho Cordova, California 95742 U.S.A.
(916) 635-8906 • FAX (916) 635-8907

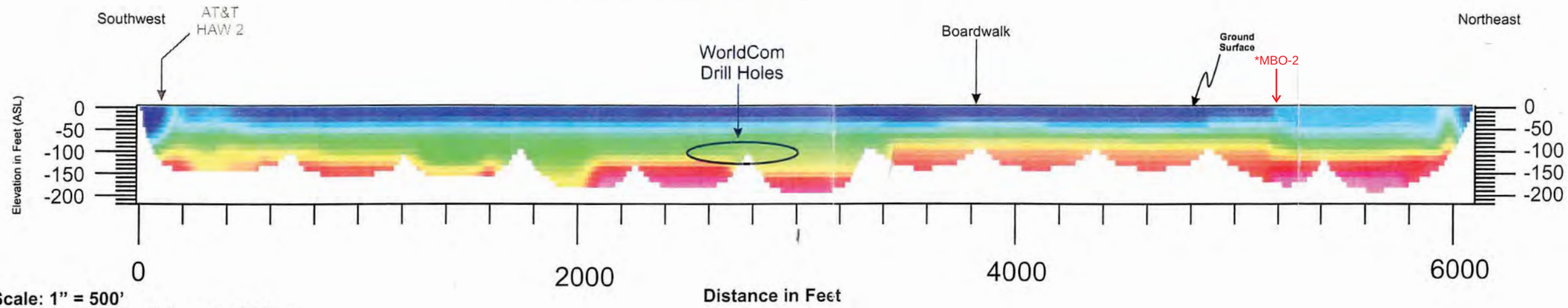
WorldCom Morro Bay Landing Fiber Optic Project

Prepared for: Caprock Geology, Inc.

Project Number: 2000-52.01 **Date:** November, 2000

FIGURE B1-1

Refraction Seismic Velocity Section • Line 1



Scale: 1" = 500'
Geophone Station Interval = 25 feet
V:H = 2:1

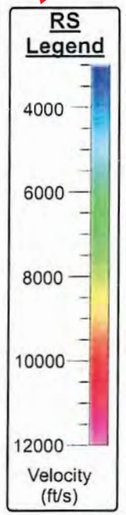
Explanation*

Darker Blues: 3,000 - 4,000 ft/sec = surficial beach sands and gravels.

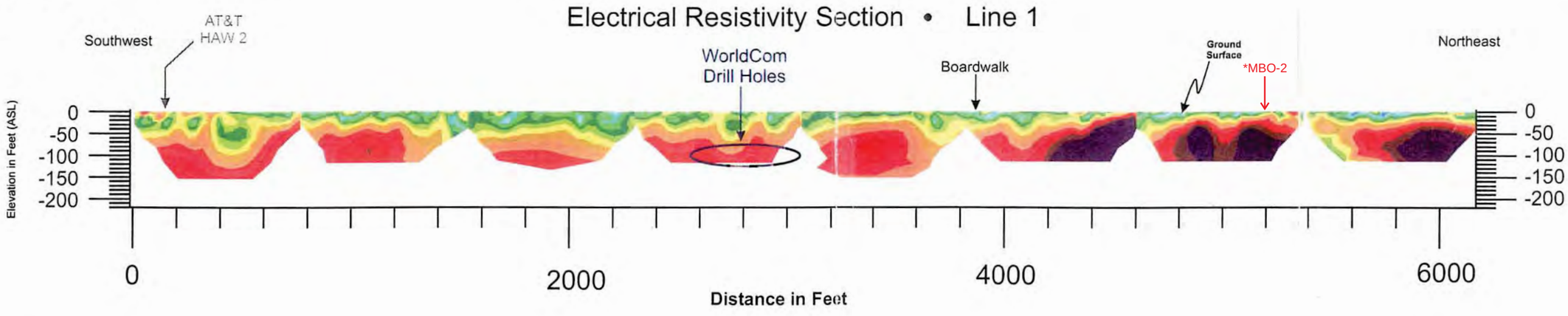
Lighter Blues and Greens: 5,000 - 8,000 ft/sec = moderately weathered Monterey Formation or equivalent.

Yellows: ~8,500 ft/sec = Top of slightly weathered Monterey Formation.

Light Reds, Pinks: >8,500 ft/sec = Un-weathered Monterey Formation.



Electrical Resistivity Section • Line 1



Scale: 1" = 500'
Electrode Spacing = 32.8 Feet (10 Meters)
V:H = 2:1

Explanation*

Dark Blues to Light Greens: saturated sands and Monterey Formation erosion deposits.

Yellow to Orange: Broken and weathered Monterey Formation, some moisture

Dark Orange to Purple: Slightly weathered Monterey Formation, low permeability and porosity, little moisture.

ER Legend

0.28 0.76 2.09 5.73 15.7 43.2 118 325

Resistivity in Ohm-Meters

*Red explanations added by CHG from Geophysical Report text

FIGURE B1-2
Results of Geophysical Lines

Figure 3

CONSULTANTS IN GEOPHYSICS AND GEOLOGY FOR THE ENGINEERING, GEOTECHNICAL and ENVIRONMENTAL INDUSTRIES
GASCH & ASSOCIATES
3174 Luyung Drive, Building #2
Rancho Cordova, California 95742 U.S.A.
(916) 635-8906 • FAX (916) 635-8907

WorldCom Morro Bay Landing Fiber Optic Project

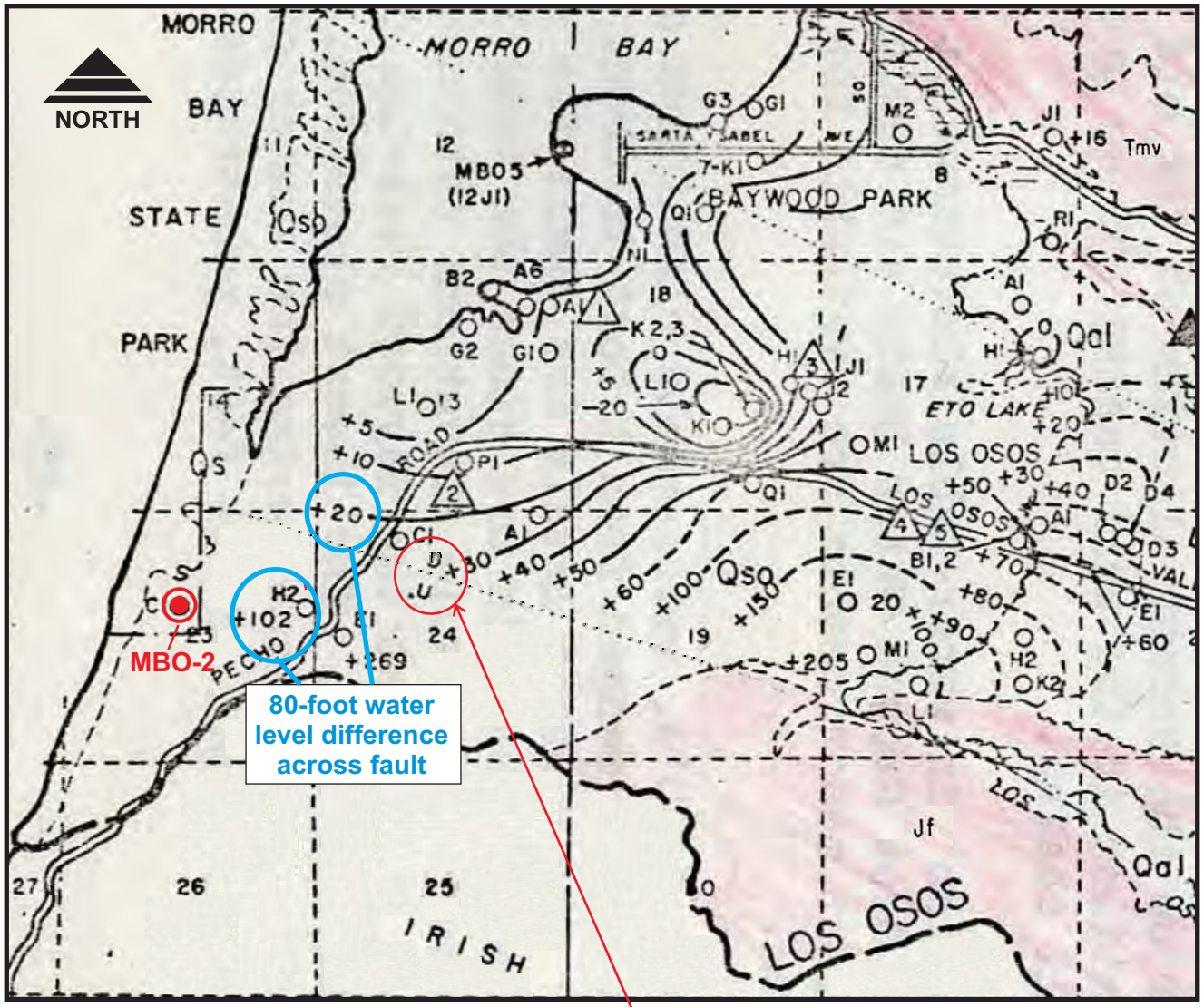
Prepared for: Caprock Geology Inc.

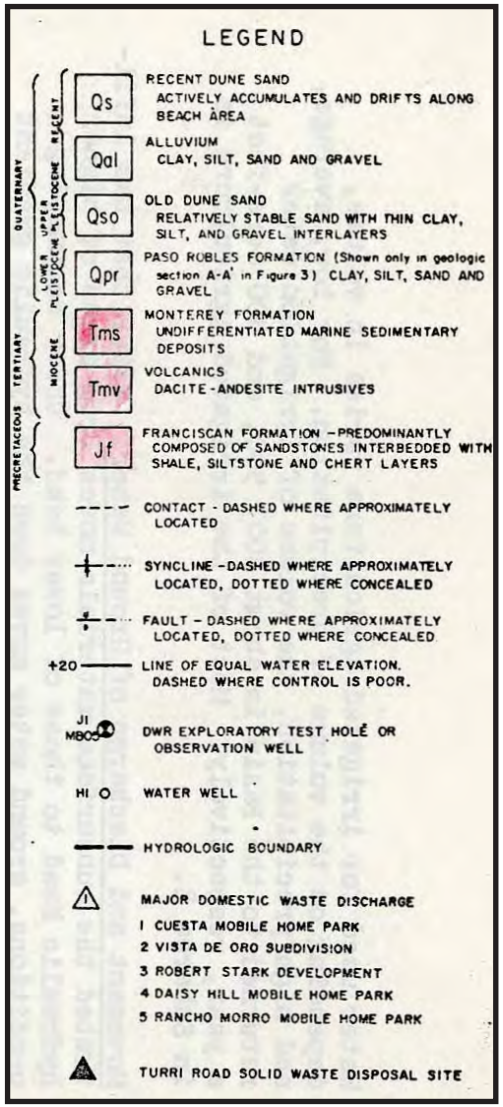
Project Number: 2000-52.01 **Date:** November, 2000

APPENDIX B

Montaña de Oro Fringe Area Information

B2 - Figures from DWR (1973, 1979)





Source: State of California Department of Water Resources; *Los Osos-Baywood Ground Water Protection Study.* District Report, page 26. October 1973

0 1,000 2,000

Scale: 1 inch = 1,000 feet

Additions by CHG for Fringe Study shown in color.

Orientation and up/down motion on the Los Osos Fault consistent with Brown and Caldwell (1974) and Cleath & Associates (2005).

FIGURE B2-1: Historical water level difference across Los Osos fault supports flow barrier. Fault is mapped by DWR north of MBO-2.

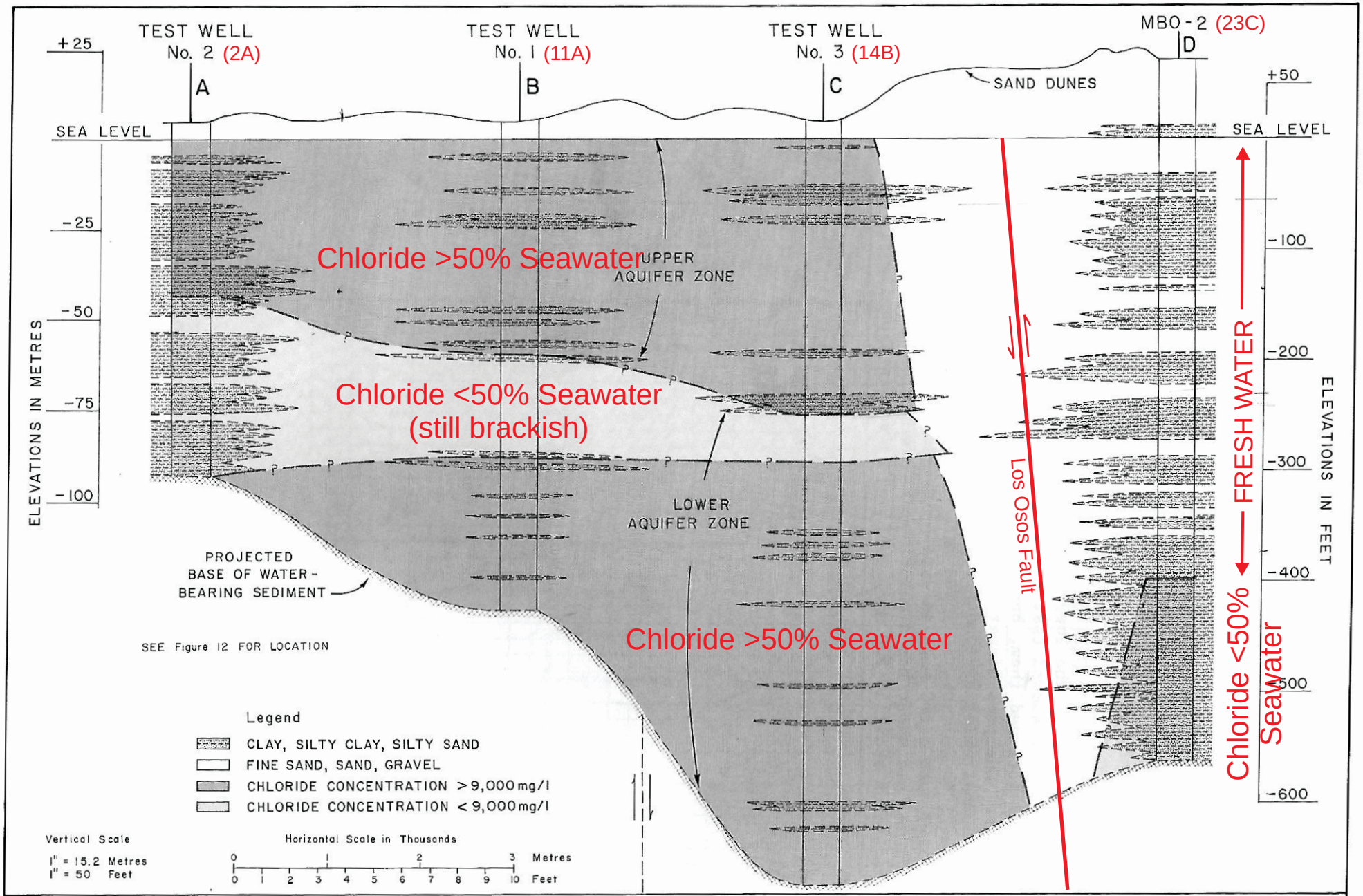


Figure 11 - SEA WATER INTRUSION SECTION A-B-C-D OF THE MORRO BAY SANDSPIT

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1979

Source: DWR, 1979, Morro Bay Sandspit Investigations

Additions by CHG for Fringe Study shown in color.

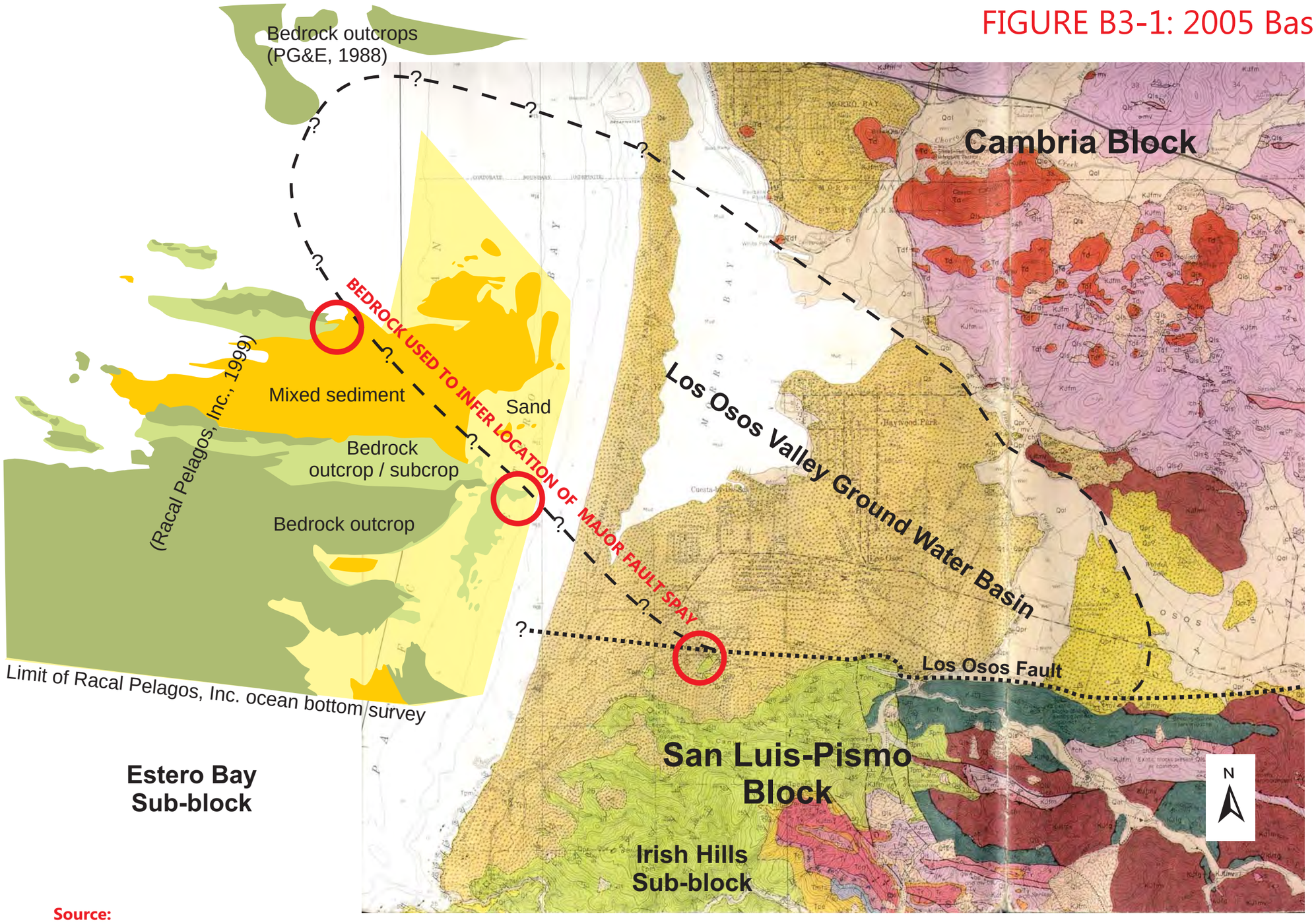
FIGURE B2-2: Water quality differences across Los Osos fault at coast.

APPENDIX B

Montaña de Oro Fringe Area Information

B3 - Area Geology with Scientific Basin Boundary for Adjudicated Plan Area (C&A 2005)

FIGURE B3-1: 2005 Basin Boundary



Map Geology:

(Onshore)

C.A. Hall, Jr., et al, 1979
Geologic Map of the
San Luis Obispo-
San Simeon Region,
California
U.S.G.S. Map I-1097

(Offshore)

Racal Pelagos, Inc. 1999
Draft Pre-Installation Geophysical
Survey Preliminary Interpretation
Morro Bay, California
Plate 5A

PG&E, 1988
Diablo Canyon Power Plant
Long-Term Seismic Program
Plate 4, Sheet 2

explanation of map symbols and geologic units attached seperately

Approximate Basin Limits

Main strand of Los Osos fault (approximate location)

Scale: 1” = 4000’

Figure 1

Geology
Los Osos Area

DWR Grant Project
Los Osos CSD

Cleath & Associates

Source:
Cleath & Associates, 2005 Sea Water Intrusion Assessment and Lower Source Investigation of the Los Osos Valley Ground Water Basin

Additions by CHG for BBMR shown in color.

APPENDIX C

Land Subsidence in the Los Osos Basin

APPENDIX C - LAND SUBSIDENCE IN THE LOS OSOS BASIN

Land subsidence in the study area was evaluated through existing published reports and literature, along with data from the County semi-annual water level program, and is intended as a preliminary evaluation of subsidence issues in the Los Osos Basin. Focus areas for this study include the proposed Los Osos Area Subbasin and Warden Creek Subbasin (see BBMR Figure 1).

Overview of Land Subsidence

Land subsidence is the settling and compaction of subsurface materials in response to changes in subsurface stresses or in response to the dissolution or removal of underlying material. Causes can include but are not limited to: tectonics, isostatic responses, oil and gas production, drainage of organic soils, dewatering of compressive soils, hydrocompaction, sinkholes, underground mining, and thawing permafrost. Pumping related subsidence accounts for some 80% of all reported instances of subsidence in the United States (Galloway et al. 1999). Pumping related subsidence, along with natural and tectonically driven subsidence, are the main mechanisms active within the Los Osos Basin. While subsidence has been reported in the basin, there are no known reports of damages related to subsidence to date.

Pumping-induced subsidence can be viewed principally as a function of both declines in water levels and the presence of clay and peat layers. Clays are a flat, platey mineral which, when deposited, typically have a random orientation. Under normal conditions the weight of overlying material is supported by both the clay 'plates' and fluid (water) in the spaces between the plates. When fluid is removed, the 'plates' must support a greater load and re-orient, becoming flatter stacks. This re-orientation results in the loss of pore space (volume) and subsidence (Terzaghi 1925). Organic material, when dewatered, decomposes resulting in significant losses of volume. Both of these changes are generally inelastic and permanent (although some clay can have limited swelling and shrinking capacity). The degree of vertical shrinkage (compaction) can be thought of as a percentage of newly dewatered material (generally clay) in feet of subsidence per foot decline in water level. The value of this shrinkage is a function of the exact composition of the sediment with factors like clay type, silt and sand concentration, and organic content factoring into the ultimate degree of shrinkage. Once dewatered and compacted, this material generally will not compact further with additional cycles of dewatering.

Existing Data and Supporting Documentation

In preparing this assessment, historical water level data from the County semi-annual water level program was reviewed, along with the following pubic documents and consultant reports:

1. Pacific Gas and Electric Company, *Seismic Source Characterization for the Diablo Canyon Power Plant, San Luis Obispo County, California; report on the results of a SSHAC level 3 study, Rev. A* , March 2015- Quantifies tectonic Subsidence within the Los Osos Groundwater Basin.

2. Valentine et al., *Use of InSAR to Identify Land-Surface Displacements Caused by Aquifer-System Compaction in the Paso Robles Area, San Luis Obispo County, California, March to August 1997, U.S. Geologic Survey Open File Report 00-447*, 2001. – Indirect evidence of subsidence in the Los Osos Groundwater Basin.

3. Cleveland, G.B., *Drought and Ground Deformation Cambria, San Luis Obispo County, California, California Division of Mines and Geology*, 1980 –Discussion of threshold of damage for subsidence in Cambria, California.

4. Luhdorff and Scalmanini Consulting Engineers, *Land Subsidence from Groundwater Use in California*, April 2014- Discussion of subsidence and related impacts in the Laguna Subbasin, City of San Luis Obispo, California.

5. County of San Luis Obispo, *Safety Element, San Luis Obispo County General Plan*, 1999 – Discussion of reported subsidence in San Luis Obispo County, California.

6. ISJ Group, *Updated Basin Plan for the Los Osos Groundwater Basin*, January 2015.

7. Cleath and Associates, *Sea Water Intrusion Assessment and Lower Aquifer Source Investigation of Los Osos Valley Groundwater Basin*, October 2005.

8. Cleath & Associates, *Basin hydrologic budget with simulated groundwater elevation contour maps*, prepared for the County of San Luis Obispo *in* Los Osos Wastewater Project DEIR, Appendix D, August 7, 2008.

9. Cleath-Harris Geologists, *Los Osos Basin Plan Groundwater Monitoring Program 2016 Annual Monitoring Report*, June 2017.

10. Cleath-Harris Geologists, *Los Osos Valley Groundwater Basin Fringe Areas Characterization Technical Memorandum, Prepared for San Luis Obispo County Flood Control and Water Conservation District*, May 2018.

SGMA and Subsidence

SGMA regulations (Water Code §10721 and Water Code §10727.2(b)(4)) list six undesirable outcomes including "Significant and unreasonable land subsidence that substantially interferes with surface land uses (DWR 2017)." As part of basin evaluation criteria should be set which indicate and document what conditions constitute significant and unreasonable subsidence as part of basin management efforts. This can include the use of minimum threshold metrics. Best management practices for this effort include addressing the following questions (DWR 2017):

- Do principal aquifers in the basin contain material susceptible to subsidence?
- What are the historic, current, and projected groundwater levels, particularly the historic low
- What is the historic rate of subsidence?
- What are the land uses and property interests in the areas susceptible to subsidence?
- What is the location of infrastructure and facilities susceptible to subsidence (e.g. canals, levees, pipelines, major transportation corridors)?
- What are the basin's minimum thresholds?

Location of Infrastructure

The bulk of infrastructure (homes, roads, utilities, ect.) within the area is located in the urban areas of the Los Osos Area Subbasin (labeled "Prohibition Zone" in Appendix A4, Figure 24). Within the eastern portion of the Los Osos Area Subbasin there are fewer homes and a lower infrastructure density, but some critical pieces of infrastructure, including the Los Osos Water Recycling Facility are in this area. The Warden Creek Subbasin is dominated by farms and agricultural operations with only minor infrastructure associated with these operations.

Minimum Thresholds

The minimum threshold for subsidence is the point at which tangible or unreasonable damage begins to manifest. To date, no tangible damage to infrastructure from subsidence has been publically recorded in the Los Osos Basin. In examining where this threshold should exist, two incidences of subsidence related damage in San Luis Obispo County were examined.

Cambria

The first instance of subsidence related damage was in Cambria, following the 1975-1976 drought and the decommissioning of area septic tanks in 1972. Construction of a sewage treatment plant led to the loss of recharge in the basin, and when coupled with high pumping demands associated with the drought (which led to a 30-50 foot drop in water levels), resulted in widespread dewatering and subsequent compaction of the interbedded sands and clays which underlie the town. Both subsidence and fissure style failures were observed. The degree of subsidence varied across the Santa Rosa Valley Groundwater Basin (up to 10 centimeters/4 inches), but there was substantial damage to subsurface utility infrastructure. Damage was principally sheared water and sewage pipes. Reports note a critical threshold for groundwater level declines (of 30-50 feet below typical levels) before compaction related problems manifest (Cleveland 1980). Material underlying the zone was relatively lean, organic poor clays which had a vertical shrink rate of approximately 0.5-1%.

City of San Luis Obispo

The second significant instance of subsidence related damage occurred in the City of San Luis Obispo in the Laguna Lake area during the 1986-1992 drought. Beginning in 1989, in response to stressed municipal water supplies, new wells were drilled in the Laguna Lake area and groundwater pumping was increased. This pumping resulted in groundwater level declines of up to 37 feet. Material underlying the zone was organic clays with interbedded peats, which exhibited vertical shrink rates of approximately 5-10%. Ultimately, compaction of underlying sediments resulted in subsidence of up to two feet. This ground surface decline resulted in substantial damage to roads, buildings, drainage systems, and increased flood risk. This instance is the most severe case of subsidence-related damage reported to date within the County of San Luis Obispo.

Based on local analogues, infrastructure damage in urbanized area of the Los Osos Basin could begin with as little as 4 inches of subsidence. This would suggest a conservative threshold of 3 inches may be appropriate for urbanized areas of the basin. In non-urban and farmed areas, considerably more subsidence could occur with negligible damage to the system. Thus the tolerance of subsidence in these areas may be higher than the 3 inch threshold of more developed zones.

Warden Creek Subbasin

The Warden Creek Subbasin is an alluvial aquifer. Holocene alluvial material tends to be both highly unconsolidated and high in organic material, conditions which lend to a high degree of subsidence risk. Within the Los Osos Basin, alluvial material is concentrated in the Los Osos

Creek valley (see Los Osos Area subbasin below) and in the Warden Creek Subbasin. As a coastal alluvial valley, behavior of material in these zones would be expected to be similar to that observed in the Santa Rosa Valley Groundwater Basin, with vertical shrinkage rates on the order of 1% of water level declines. In the vicinity of Warden Lake, higher organic content would be expected with behavior more like what was observed in the organic and peat rich clays of the Laguna Lake area of San Luis Obispo, with vertical shrinkage on the order of 5-10%.

The shallow clay horizon within the Warden Creek Subbasin alluvium can be up to 50 feet thick and is generally underlain by coarser sands and gravels. In the Warden Creek Subbasin, the high potential for subsidence is partially offset by two considerations. The first consideration is that infrastructure is relatively light, with subsidence unlikely to have a substantial impact on agricultural operations. The second is that, while pumping records are very limited, it is likely that, over decades of agricultural operations, groundwater has already been extracted at its maximum potential rate for existing uses during one or more of the historic droughts. This would imply that any potential pumping related subsidence in this area has most likely already occurred.

Limited available historic water levels exist for the Warden Creek Subbasin prior to 2017. Water levels are reported on drillers logs, and comparisons to 2017 levels can be found in BBMR Table 4. This area has been used for agricultural operations for decades and groundwater extraction has occurred during several significant droughts. As such, this aquifer has likely been stressed at the maximum level possible for the existing operations. While water levels in 2017 averaged 4 feet below available historic levels (Table 4), they are likely higher than historic (drought) lows. These historic stresses (low water levels) would have led to subsidence in the clays within valley alluvium. While alluvial clays are highly susceptible to subsidence, no substantial additional subsidence is anticipated for this subbasin, provided existing water uses and demands are maintained.

Los Osos Area Subbasin

The Los Osos Area subbasin in composed of a series of stacked aquifers, each of which has specific considerations for land subsidence potential, and are discussed separately below.

Los Osos Creek Alluvial Aquifer

Alluvial material in the Los Osos Creek valley is recently deposited, unconsolidated, and higher in organic content than the underlying Paso Robles and Careaga Formations. Mechanical behavior would be expected to be similar to that of the Santa Rosa Valley Groundwater Basin in Cambria with vertical shrinkage rates on the order of 1% of water level declines. Alluvium is

typically close to 70 feet thick in the Los Osos Creek valley (Figure 4) and percolates creek water into deeper aquifers.

Groundwater production in the Los Osos Creek valley area is dominated by production from the Lower Aquifer, which can dewater the overlying alluvium and lead to subsidence. Available estimates indicate groundwater production for agricultural irrigation was greatest in the early 1970's, with a decline during the mid-1970's followed by another peak demand period in the late 1980's (ISJ, 2015). A review of County historical water level data beginning in the mid-1970's for wells in the Los Osos Creek valley show water level declines in response to drought periods, with the lowest recorded water levels during the recent 2013-2016 drought. Recycled water deliveries are anticipated for agricultural use under future development scenarios, and significant alluvial water level declines are not considered likely (Cleath & Associates, 2008).

Perched and Upper Aquifer

The Perched and Upper Aquifers are largely unconfined or semi-confined aquifers, which would compact in response to drainage and dewatering related to pumping.

Dune Sand Deposits. Dune sand deposits overlie most of the Los Osos Area Subbasin (Figures 3 and 4). These deposits are relatively shallow, with deposits frequently lying above the water table, and are relatively non-compactable. The risk of subsidence in this material is low.

Paso Robles Formation. Underlying the dune deposits in the subbasin are the interbedded sands, gravels, and clays of the Paso Robles Formation. The upper-most portion of these deposits has been dewatered and compacted historically, but deeper portions pose some risk of subsidence. Based on analysis of analogous material in Cambria (Cleveland 1980), Santa Clara (Ingebritsen and Jones 1999), and Cuyama (Everett et al. 2014), this material would be expected to have a vertical subsidence rate of 0.5-3.0% of water level decline. This means that subsidence on the order of the threshold value (0.25 feet) would require minimum groundwater level declines of 10-50 feet below historic lows for threshold subsidence to occur.

Based on a review of available water level data from the County semi-annual water level program, groundwater levels in some areas of the Perched and Upper Aquifers were at historical lows during the mid 1970's drought, which also corresponded to a period of relatively high production for shallow municipal wells. Other historic groundwater lows in the Perched and Upper Aquifer were observed during and following the 1987-1991 drought, and during the recent 2012-2016 drought. Perched and Upper Aquifer water levels in the Los Osos Area subbasin have also been influenced by septic return flows, which have been collected and redistributed as recycled water since 2016.

Basin management programs include additional Upper Aquifer development, although average water level declines of less than 5 feet from current conditions would be expected in most areas, with increases in water levels near recycled water disposal sites (Cleath & Associates, 2008). Average water decline exceeding the minimum threshold is not expected under existing build-out development scenarios, meaning that the subsidence related risk for the Perched and Upper Aquifer is considered low.

Lower Aquifer

The Lower Aquifer begins at and below the AT2 regional clay (Cleath and Associates, 2005). This zone includes Zone D (Paso Robles Formation), the AT3 clay, and Zone E (Paso Robles/Careaga Formations). The AT2 clay marks the transition from the unconfined and semi-confined aquifer mechanics to fully confined aquifer mechanics. As such, consolidation comes as a decline in aquifer head rather than dewatering. Based on regional studies of analogous material (Ingebritsen and Jones 1999 and Everett et al. 2014), compaction would be expected to be on the order of 0.5-2.0% of head decline for this Lower Aquifer zone.

The Paso Robles Formation in the Lower Aquifers is largely sands and gravels, with the significant clays being the regional aquitards AT2 and AT3 (Cleath and Associates, 2005). These aquitards are up to 50 feet thick (Figure 4) and are the most compressible material in this formation.

The Careaga Formation is comprised of marine deposited sands silts and minor clays. The high sand and silt content of this aquifer limits compressibility and subsidence.

Groundwater levels in the Lower Aquifer reached their lowest levels in the early 2000's (CHG, 2016), and have been on a rising trend since this time. This groundwater level low would correspond with the maximum compaction for the Lower Aquifer to date. Managing Lower Aquifer groundwater levels is critical to controlling seawater intrusion in the basin, and Lower Aquifer groundwater levels are unlikely to decline below historic lows. The Lower Aquifer in the Los Osos Area Subbasin is considered at low risk for additional subsidence related to pumping.

Previous Work and Other Data Sets

PG&E's 2015 Diablo Canyon SSC Study Review evaluated tectonic subsidence within the basin. This study determined that, based on dateable buried horizons, the subsidence rate for the Los Osos Basin was between -0.02 and -0.2 millimeters per year with a best fit range laying between -0.06 and -0.1 millimeters per year (<-0.004 inches per year). This rate of tectonic

subsidence is an average over geologic time, and would require hundreds of years to reach the minimum threshold for potential infrastructure damage.

To date, no U.S. Geological Survey (USGS) work has directly evaluated subsidence within the Los Osos Basin. However, the 2001 USGS Interferometric synthetic-aperature radar (InSAR) study of the Paso Robles Groundwater Basin (OFR 00-447) captured subsidence conditions from March to August of 1997. This study demonstrates that the basin has undergone subsidence historically, but was too short in duration to provide significant insights into both the full degree of subsidence and the correlation to pumping. Additionally, InSAR weakness in assessing tilled acreage (Everett et al. 2013) limits its usefulness in the Los Osos Creek valley and Warden Creek Subbasin. Numerous raw InSAR data sets are available from the European Space Union (ESA) with dates ranging from 1992-2011. This data could be processed to provide insight into basin subsidence.

The 2001 USGS study does demonstrate that Light Detection and Ranging (LiDAR) can be used for subsidence assessment. As part of ongoing geologic mapping related to the Diablo Canyon a single, high-resolution, airborne LiDAR was flown in 2011 (PGE 2011). A second dataset would be required to evaluate subsidence but this dataset can provide a useful baseline, particularly when coupled with other data sources.

Conclusions

- No public reports of subsidence related damage are known for the basin.
- No historic studies of pumping related subsidence are known for the basin. PG&E estimates tectonic subsidence rates to be between -0.06 and -0.1 millimeters per year.
- All areas of the basin contain material susceptible to subsidence, with the alluvium of the Los Osos Creek valley (Los Osos Area Subbasin) and the Warden Lake area (Warden Creek Subbasin) being most susceptible.
- Based on historic and projected water levels, peak subsidence due to groundwater pumping in the basin has likely already occurred. Little additional subsidence would be expected within the basin provided water levels are maintained above historic lows.

APPENDIX C REFERENCES

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