Appendix 5A

DRAFT

MONTGOMERY
& ASSOCIATES
Water Resource Consultants

Groundwater experts since 1984

TECHNICAL MEMORANDUM

DATE: December 18, 2024 **PROJECT #:** 9100

TO: Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA)

FROM: Victoria Hermosilla, P.G., Abby Ostovar, Ph.D., Tiffani Cañez, Derrik Williams, P.G., C.Hg.

REVIEWED BY: Amy Woodrow, MCWRA

PROJECT: Salinas Valley Hydrogeological Conceptual Model (HCM) Updates

SUBJECT: 180/400-Foot Aquifer Subbasin HCM Update: Data, Methods, and Findings

---

INTRODUCTION

The Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA) and partner agencies have analyzed new information and filled data gaps identified in the 180/400-Foot Aquifer Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) (SVBGSA, 2020). Montgomery & Associates (M&A) used this new information to update the Subbasin's Hydrogeologic Conceptual Model (HCM) to better inform management decisions and prepare the 5-year Periodic Evaluation. To acquire and analyze data, M&A worked with partner agencies including Marina Coast Water District Groundwater Sustainability Agency (MCWD GSA) and their consultant EKI Environment & Water, Monterey County Water Resources Agency (MCWRA), and California American Water. The updated HCM strengthens and refines the geologic model that forms the basis for the groundwater flow modeling.

The HCM update focused on key areas where new data indicated an updated understanding was needed. The primary updates to the HCM included the following:

- Refining the extents and depths of coastal aquitards including the Salinas Valley Aquitard (SVA), and incorporating data-supported gaps and thin-spots in the 180/400 Aquitard
- Updating the thickness of the 400-Foot Aquifer in the southern portion of the Subbasin
- Refining the location and depth of the Deep Aquifers based on results of the Deep Aquifers Study
- Updating the depth of the bedrock surface and offshore geology

- Refining the boundary of the 180/400-Foot Aquifer Subbasin with the Corral de Tierra portion of the Monterey Subbasin

This memo summarizes the data used, the analyses and methods employed, and the findings for the updated 180/400-Foot Aquifer Subbasin HCM.

DATA

The data used to update the HCM include published cross sections and reports, well completion reports (WCRs), numerical groundwater flow model layers, geophysical data, and geologic maps, as detailed in the following subsections.

Published Cross Sections and Reports

The 2020 GSP and 2022 GSP Amendment 1 summarized published cross sections and reports. For this HCM update, the following reports and cross sections were re-reviewed, compared with new data and information, and incorporated into the revised HCM. These included:

- *Hydrogeologic Investigation of Salinas Valley Basin in the Vicinity of Fort Ord and Marina Salinas Valley, California - Final Report* (Harding ESE, 2001)
- *El Toro Groundwater Study Monterey County, California (*GeoSyntec, 2007)
- *Accompanying Documentation Geologic Map and Cross-Sections from El Toro to Salinas Valley (*GeoSyntec, 2010)
- *Deep Aquifer Investigation - Hydrogeologic Data Inventory, Review, Interpretation and Implications (*Feeney and Rosenberg, 2003)
- *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* (Kennedy/Jenks, 2004)
- *Hydrogeologic Report on the Deep Aquifer, Salinas Valley, Monterey County, California* (Thorup, 1976 and 1983)
- *Map Series — Monterey Canyon and Vicinity, California: U.S. Geological Survey Open-File Report 2016–1072* (Dartnell et al, 2016)
- *Deep Aquifers Study* (M&A, 2024a)

Well Completion Reports (WCRs)

WCRs helped refine geologic interpretations, and included important information such as driller-observed lithology, screen intervals, and date of well installation. Some WCRs were more detailed than others with more frequent lithologic descriptions, electric logs (e-logs), and other construction or water level details.

M&A obtained WCRs through the California Department of Water Resources (DWR) Online System for Well Completion Reports (OSWCR) database, the Monterey County Health Department, Monterey County Water Resources Agency, other collaborating partner agencies, and private entities. In particular, MCWRA provided hundreds of well completion reports that were primarily used to update and refine the depths and thicknesses of the aquitards in key areas.

Numerical Groundwater Flow Model Layers

Previous and current groundwater flow models reflect various conceptual understandings of the Subbasin. Models reviewed for the HCM update included:

- The Salinas Valley Geologic Model (Sweetkind, 2023) defines the spatial extent, depth, and distribution of geologic material textures for the provisional Salinas Valley Integrated Hydrologic Model (SVIHM). It is being developed by the USGS, which covers the entire Salinas Valley and includes a geological framework with documentation.
- The Monterey Subbasin Groundwater Flow Model (MBGWFM) (EKI, 2022). This model was developed for MCWD and informed the 2022 Monterey Subbasin GSP. It covers the Monterey Subbasin and adjacent part of the 180/400-Foot Aquifer Subbasin southwest of the Salinas River.
- The Seaside Subbasin Model (HydroMetrics Water Resources, 2009). This model was developed for the Seaside Watermaster and covers the Seaside Subbasin and adjacent part of the Monterey Subbasin.
- The Salinas Valley Seawater Intrusion Model (SWI Model) (M&A, 2023; 2024b). This model was developed by M&A for SVBGSA and the County of Monterey in 2023 and covers the coastal area of the Salinas Valley north of Chualar. It was updated based in part on the HCM updates included in this memo in 2024.

These models were primarily used to compare and refine the depths and thicknesses of the hydrostratigraphic layers within the Salinas Valley Groundwater Basin HCM update.

Geophysical Data

The following 3 primary types of geophysical data were used in this HCM update:

- Airborne Electromagnetic (AEM) resistivity data. These data were collected by the California Department of Water Resources (DWR) and SVBGSA between 2020 and 2023, and provide a broad coverage of general lithologic trends.

- Borehole resistivity data. These geophysical data are collected in boreholes prior to well installation and provided detailed interpretation of localized lithology.
- Seismic data. Seismic data used in this HCM update were from the USGS (Dartnell *et al.*, 2016) and provided stratigraphic information about offshore geology.

The first 2 types of data are electrical resistivity data, which are collected by sending electrical pulses into the subsurface and receiving signals back. The third type of geophysical data, seismic data, are collected from measuring the reflected, refracted, and direct waves from an active wave source, such as an explosion or hammer impact.

AEM Data

AEM surveys measure the resistivity of both solid and liquid materials in the subsurface over large areas. Lower resistivity materials are clays, silts, and/or higher total dissolved solids (TDS) water. Higher resistivity materials are sands and gravels, some types of bedrock, and/or lower TDS water. AEM data are useful for filling gaps between known data points such as wells. This effort focused on reviewing and analyzing the lower resistivities at various target depths where aquitards are expected.

Three sets of AEM surveys were used to fill data gaps, confirm other data, and refine the primary aquifers and aquitards. These data came from the following sources:

- DWR Survey Area 1, 2020 (DWR, 2020)
- DWR Survey Area 8, 2022 (DWR, 2022)
- Deep Aquifers Survey, 2023 (M&A, 2024)

E-logs/Borehole geophysical logs

Borehole geophysical logs measure the resistivity of materials in the subsurface adjacent to a borehole. Like AEM data, borehole geophysics can help qualitatively differentiate between clays, silts, sands and gravels, high TDS water, and low TDS water. Borehole geophysics data show much more detail than AEM data, but only reflect conditions immediately adjacent to a borehole. Several borehole geophysical logs used were sourced from other studies or included with WCRs.

Seismic Data

Seismic data are collected from measuring the reflected, refracted, and direct waves from an active wave source such as an explosion or hammer impact. The seismic waves travel through the subsurface, reflect off various lithologic surfaces, and return to the ground surface. Based on the timing of the waves, investigators can determine the locations and general rock types of the subsurface lithology up to a few kilometers below land surface. Seismic survey data from the *Seismic Study in Monterey Bay* (Dartnell *et al.*, 2016) were used to refine the offshore portion of the HCM.

Geologic Maps

Geologic maps provide a visual representation of the rocks, formations, and structures encountered at land surface. The 2 primary maps used for this HCM update were the Clark *et al.*, 2002 surface geology map, and the subsequently revised version derived from the Dartnell *et al.*, 2016 Seismic Study in Monterey Bay. These geologic maps supplemented other data during the HCM update by verifying surface expressions of the various lithologic units.

METHODS

Geologic visualization software was used to update the Subbasin hydrostratigraphy through the following steps:

1. Integrating and reviewing the data using Leapfrog Geo visualization software.
2. Prioritizing data based on reliability and availability.
3. Selecting the best data to define the new hydrostratigraphic layers.
4. Contouring the data to create new hydrostratigraphic layers within Leapfrog Geo software.

Geologic Visualization Software

Developed by Seequent, Leapfrog Geo software was the primary 3D visualization software used to relate and analyze the different types of data described above. All data were imported into the software and methodically reviewed and compared to each other.

Data Prioritization

Various data have differing levels of confidence. The list below demonstrates the general hierarchy of confidence in the various data types used in this analysis, starting with the data with the most confidence.

1. Geologic maps
2. Published cross sections and reports, unless more recent data was available
3. Borehole logs (well completion reports and e-logs)
4. AEM and seismic data
5. Numerical groundwater flow models

Concurrently using multiple data sources can improve confidence in geologic interpretations. For example, confidence in AEM data can be significantly improved when it is combined and coordinated with geologic maps.

Data are not uniformly distributed throughout the Subbasin. Wells and associated WCRs are more concentrated in areas with more infrastructure, whereas AEM flightlines cover areas with less or no infrastructure. Therefore, hydrogeologic interpretations are more strongly influenced by availability of data in different areas.

Hydrogeologic interpretations initially focused on areas with a higher density of multiple data types to cross validate in these data. Developing a confidence in any data type allowed analyses using those data to expand horizontally and vertically and revise the HCM as needed.

The decision-making procedures for updating the HCM generally used the following guidelines. These guidelines do not represent a decision-making hierarchy, rather they are a group of guidelines that interact in various ways based on circumstances in each particular area of focus.

- Newer geologic maps were prioritized over older geologic maps.
- Newer published cross sections were prioritized over older published cross sections, unless there was higher confidence in older cross sections based on the author and how the sections correlated with other data.
- Geologic maps provided anchor locations for the geologic surface contacts, including bedrock contacts, where available.
- The hydrostratigraphy was refined by jointly using AEM data, WCRs, and published cross sections in places where the various data types overlapped. This strengthened confidence in AEM data interpretation.
- Where AEM data and cross sections did not align, well logs used to develop the cross section were reviewed and used in conjunction with the AEM data.
- AEM data were the primary data source for hydrostratigraphic interpretation in areas with limited borehole data.
- E-logs and published cross sections were used where AEM data were not available and were correlated with the nearest AEM data.
- WCRs were used as verification and interpolation points for key priority areas.
- Places with no other nearby data relied on the SVIHM geologic model or other groundwater flow model layers to interpolate the hydrostratigraphic layers.

Figure 1 shows an example of an analysis that encompasses many of types of data and shows how they are correlated to provide a cohesive understanding of the hydrostratigraphy. The cross section on Figure 1 was exported from the Leapfrog software and spans the 180/400-Foot Aquifer, Monterey, and Seaside Subbasins. Hydrostratigraphy in the north (left on Figure 1) is based primarily on well completion reports, with finer sediments highlighted in blue. Hydrostratigraphy in the center of Figure 1 is based on AEM data, with finer sediments highlighted in blue. A previously published map of the Monterey Formation (Rosenberg, 2009) provided structural data in the south, as well as locations of surface outcrops of Monterey Formation highlighted with yellow disks. The only data not shown are published cross-sections e-logs, and surface geology map; however, in this location they were also reviewed for confirmation of other data. Through careful analysis and integration of all data types, a new bedrock surface was developed, shown in pink mesh and green contour lines in Figure 1.

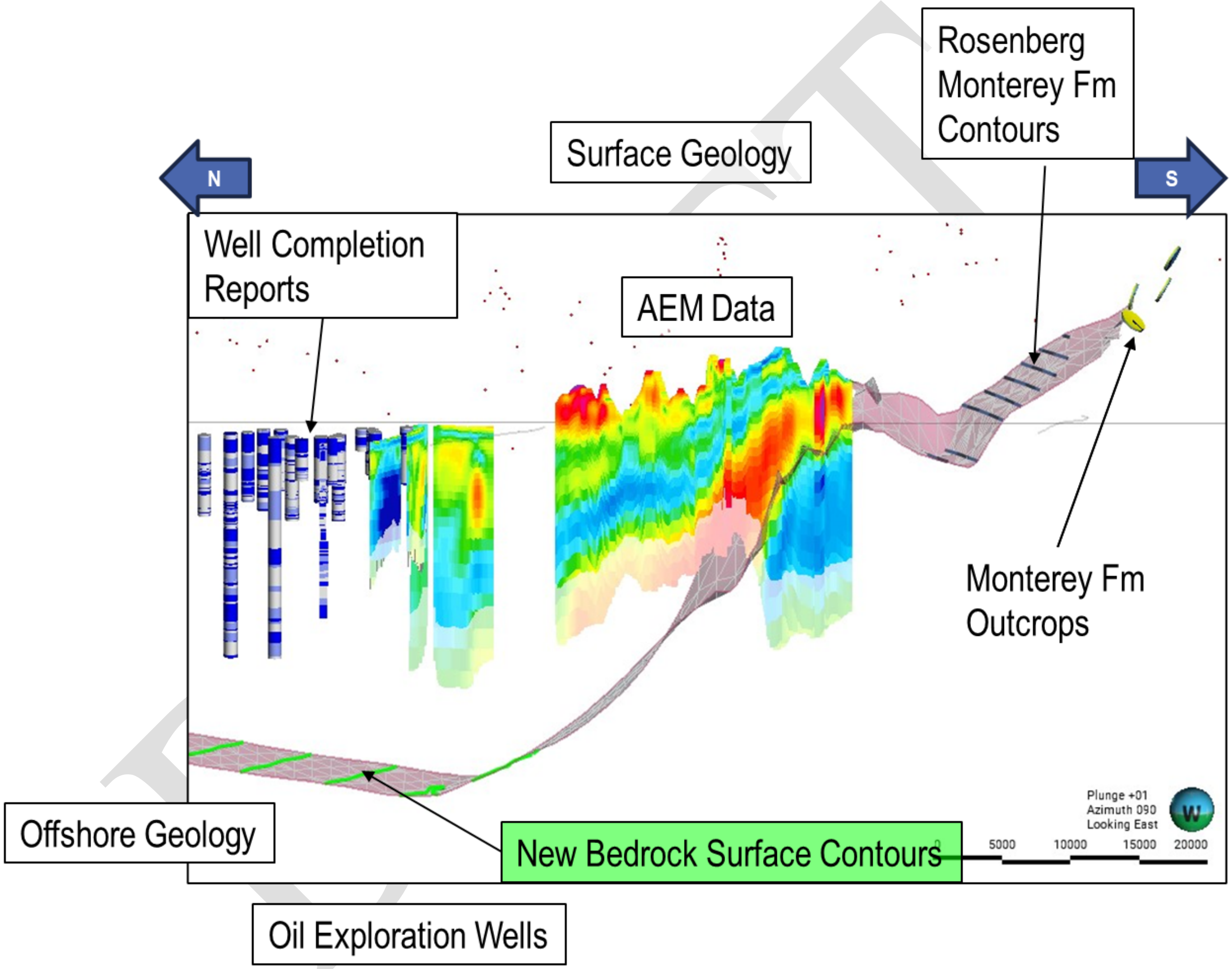


Figure 1. Example of Different Types of Data Juxtaposted in Leapfrog Geo Software

Across the Subbasin, hydrostratigraphic decision-making was prioritized from deepest to shallowest layers. The bedrock surface was the first priority and modified using AEM data, oil exploration wells, and the Salinas Valley Geological Framework. After revising the bedrock surface, the location and depth of the aquitard between the 400-Foot Aquifer and Deep Aquifers was revised based on the Deep Aquifers Study (M&A, 2024). Following that, the aquitard between the 400-Foot Aquifer and 180-Foot Aquifer and SVA were revised based on AEM data and additional WCRs. The respective aquifers were assumed to exist between the aquitards and the bedrock.

RESULTS/FINDINGS

Results of the 5 primary HCM updates listed in the introduction are detailed below.

Extents and Gaps in Shallow Aquitards

Principal Data Used: WCRs, published cross sections, AEM data, Salinas Valley Geological Framework

M&A updated the extents and thicknesses of the coastal aquitards that factor into vertical migration of seawater intrusion between aquifers. Previous groundwater flow models, all of which were developed based on hydrogeologic data available at the time of their development, provided a starting point for the 3D extents and depths of aquitards. Where newer data indicated the aquitards should be refined from previous models, more in-depth mapping was completed, such as through analysis of driller-observed lithology. From these analyses, as well as MCWRA's efforts to identify thin spots and gaps in the aquitards, M&A added them to show where brackish waters could potentially migrate through the aquitards into other aquifers. This effort focused on 3 aquitards: the SVA, the Intermediate Aquitard between the Upper 180-Foot Aquifer and the Lower 180-Foot Aquifer, where present, and the 180/400-Foot Aquitard.

SVA

The lateral extent and thickness of the SVA was refined based on Survey Area 1 (DWR, 2020), Survey Area 8 (DWR, 2022), and Deep Aquifers Survey (M&A, 2024) AEM data, published cross sections, well completion reports, and information in the SVIHM and MBGWFM. The revised extent of the SVA is shown on Figure 2.

Near the coast, the extent and thickness of the aquitard was refined based on a more thorough review of WCRs and cross sections from the *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* (Kennedy/Jenks, 2004). Farther inland, AEM data and WCRs were used to refine the extent and previously noted gaps in the SVA. The SVA was re-interpreted as a portion of an extensive shallow clay; the SVA being the distinct blue-gray marine-deposited clay, and the more extensive body of shallow clay including more brown and red derived from continental deposition. The SVA is part of a larger system of shallow clays in other areas of the Salinas Valley as shown on Figure 2. These clays extend into the parts of the Eastside, Langley, and Forebay Subbasins; however, they are likely not from a marine depositional environment. Most shallow clays found in the Eastside Subbasin are from alluvial deposits and were defined using AEM data. The SVA near the Fort Ord area in the Monterey Subbasin is based primarily on the extent delineated in the *Final Report, Hydrogeologic Investigation of the Salinas Valley Basin in the Vicinity of Fort Ord and Marina* (Harding ESE, 2001). Near the Fort Ord area, from northeast to southwest, the SVA starts as a single thicker layer of clay that overlies the 180-Foot Aquifer. At the Salinas River, the SVA transitions to several layers of clay that separate multiple aquifers as shown on Figure 3. These several layers of clay include the Intermediate Aquitard discussed below.

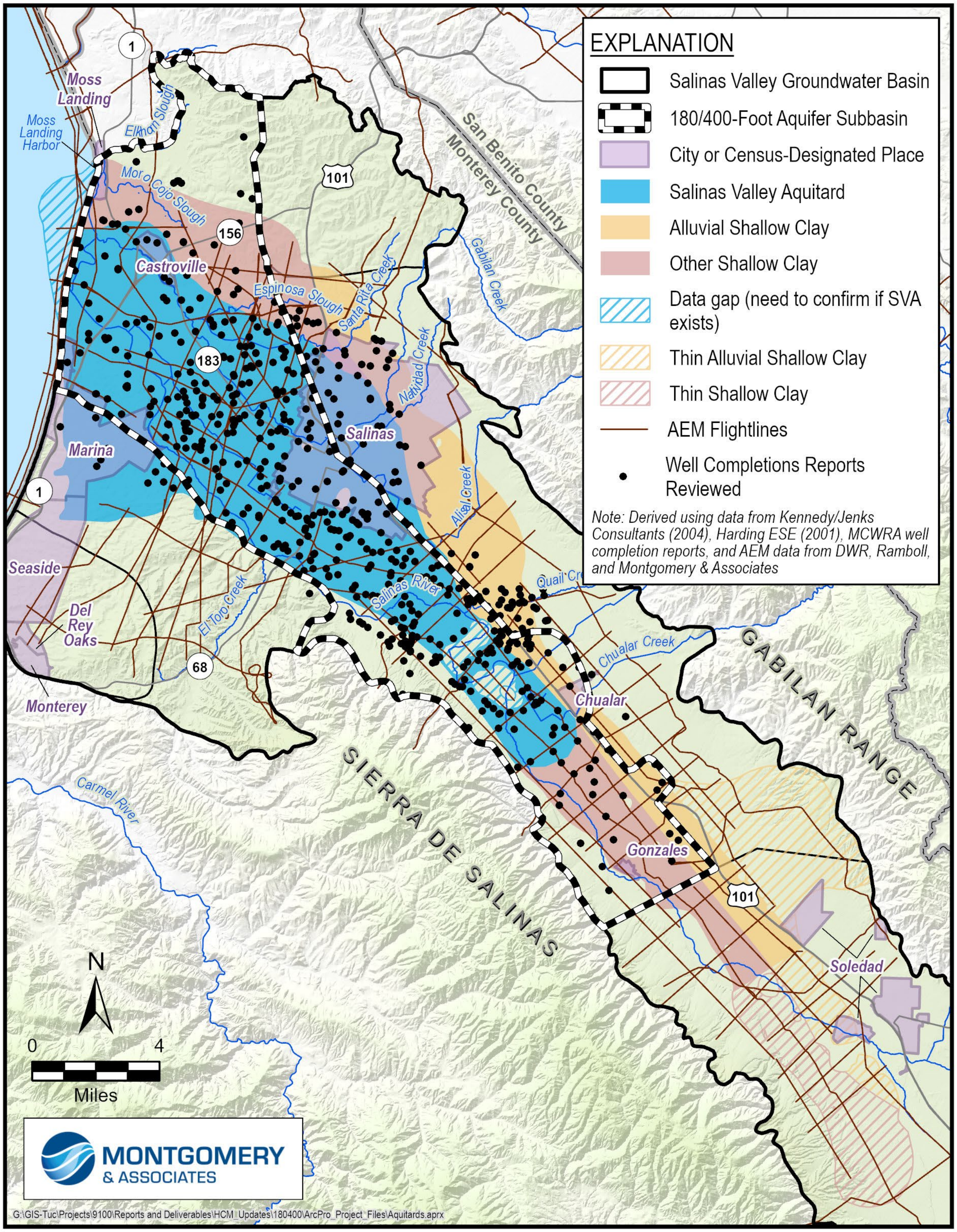
Intermediate Aquitard

As the 180-Foot Aquifer approaches the Monterey Subbasin near the coast, it separates into the Upper and Lower 180-Foot Aquifer with the Intermediate Aquitard in between. The conceptual understanding of the Intermediate Aquitard was updated using AEM data and WCRs and in collaboration with EKI. This aquitard only exists in a limited portion of the 180/400-Foot Aquifer Subbasin; the upper and lower portions of the 180-Foot Aquifer are not separated by a distinct aquitard throughout most of the Subbasin. Figure 3 shows how the Intermediate Aquitard separates the Upper 180-Foot Aquifer from the Lower 180-Foot Aquifer just outside of the 180/400-Foot Aquifer Subbasin in the Monterey Subbasin.

180/400 Aquitard

The extent and thickness of the 180/400 Aquitard was refined using data from previous studies including the *Hydrogeologic Investigation of Salinas Valley Basin in the Vicinity of Fort Ord and Marina Salinas Valley, California* (Harding ESE, 2001) and the *Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley* (Kennedy/Jenks, 2004). Additionally, data from several WCRs and AEM data were used to validate many of the aquitard's thin spots. The refined extent of the aquitard is shown on Figure 4.

The revised interpretation shows this aquitard as uneven in thickness and intermittently present. Several newer wells have been added to the analysis, and carefully reviewed with other data. The holes in the aquitard to the south were added through the use of AEM data. Additionally, this aquitard was linked to clays in the alluvial fans in the Eastside Subbasin to represent connectivity of correlative low permeability zones (as higher clay contents), despite not being from the same depositional environment. Figure 4 shows an interfingering zone that indicates where the blue clay that defines the 180/400 Aquitard becomes less dominant than other areas of the northern 180/400-Foot Aquifer Subbasin. In this area both red and blue clay can be found in WCRs, which seem to be indicative of the sedimentary interfingering sequence of fluvial, marine, and eolian deposits of the Aromas Sands (Fugro West, Inc., 1995). In the Marina-Ord Area, a portion of the 180/400 Aquitard is shown as intermittent because groundwater elevations in the 180- and 400-Foot Aquifers are similar, as illustrated on Figure 5 by EKI Environment & Water.



Note: Derived using data from Kennedy/Jenks Consultants (2004), Harding ESE (2001), MCWRA well completion reports, and AEM data from DWR, Ramboll, and Montgomery & Associates

G:\GIS-Tuc\Projects\9100\Reports and Deliverables\HCM_Updates\180400\ArcPro_Project_Files\Aquitards.aprx

Figure 2. Updated Understanding of the SVA and Shallow Clays with Key Data Sources

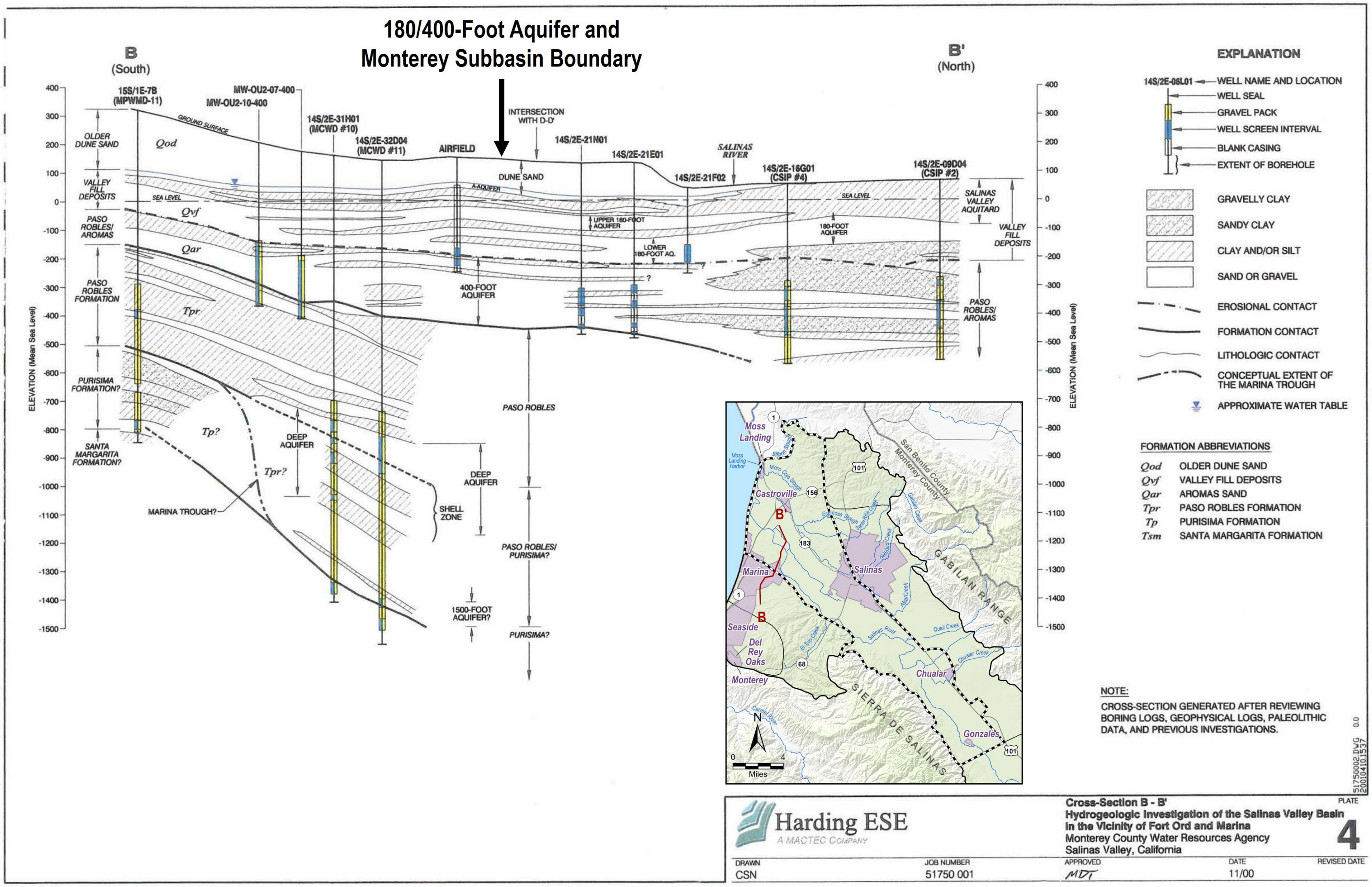
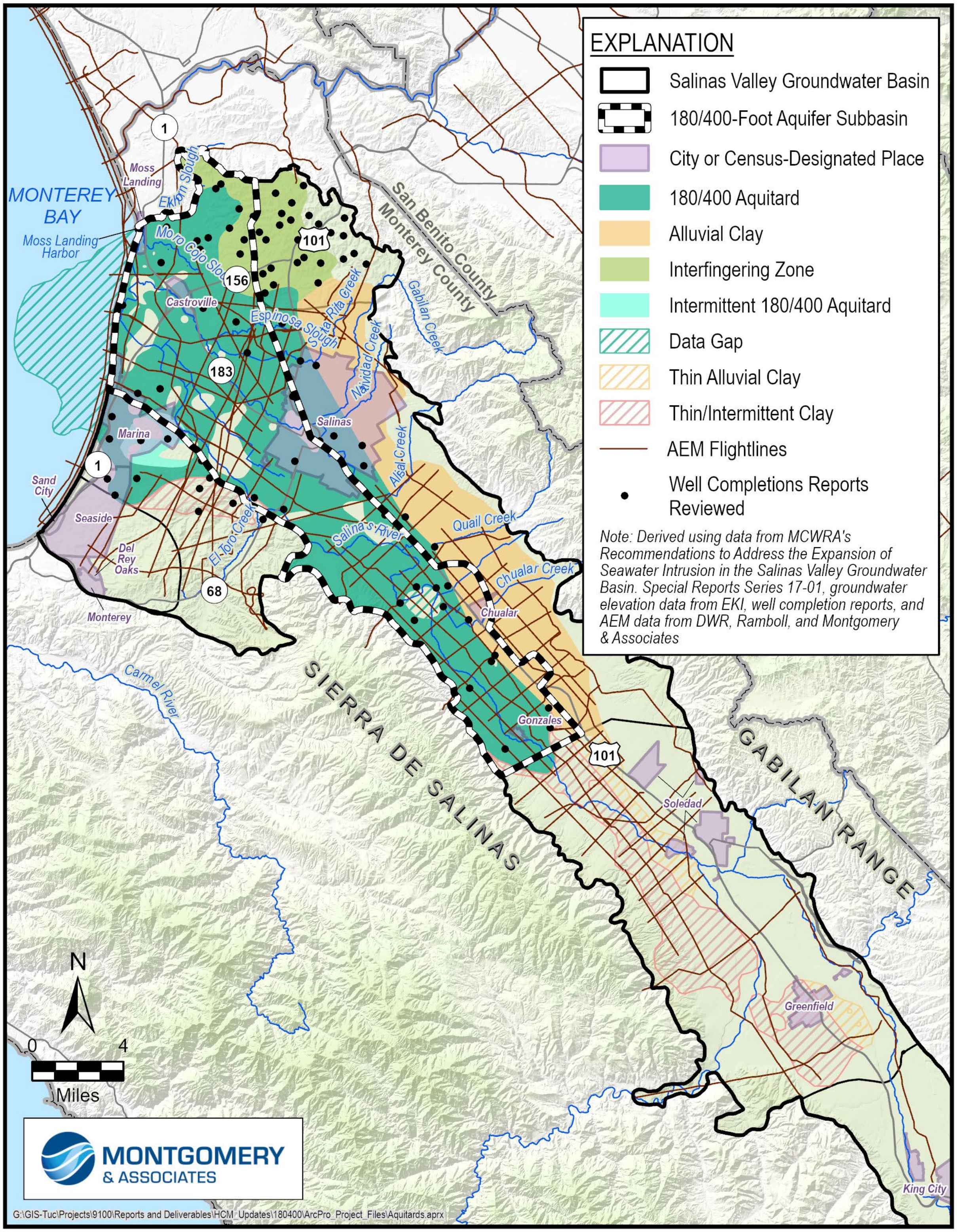


Figure 3. Cross Section of SVA and Intermediate Aquitard (adapted from Harding ESE, 2001)



Note: Derived using data from MCWRA's Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin. Special Reports Series 17-01, groundwater elevation data from EKI, well completion reports, and AEM data from DWR, Ramboll, and Montgomery & Associates

G:\GIS-Tuc\Projects\9100\Reports and Deliverables\HCM_Updates\180400\ArcPro_Project_Files\Aquitards.aprx

Figure 4. Updated Understanding of the 180/400 Aquitard

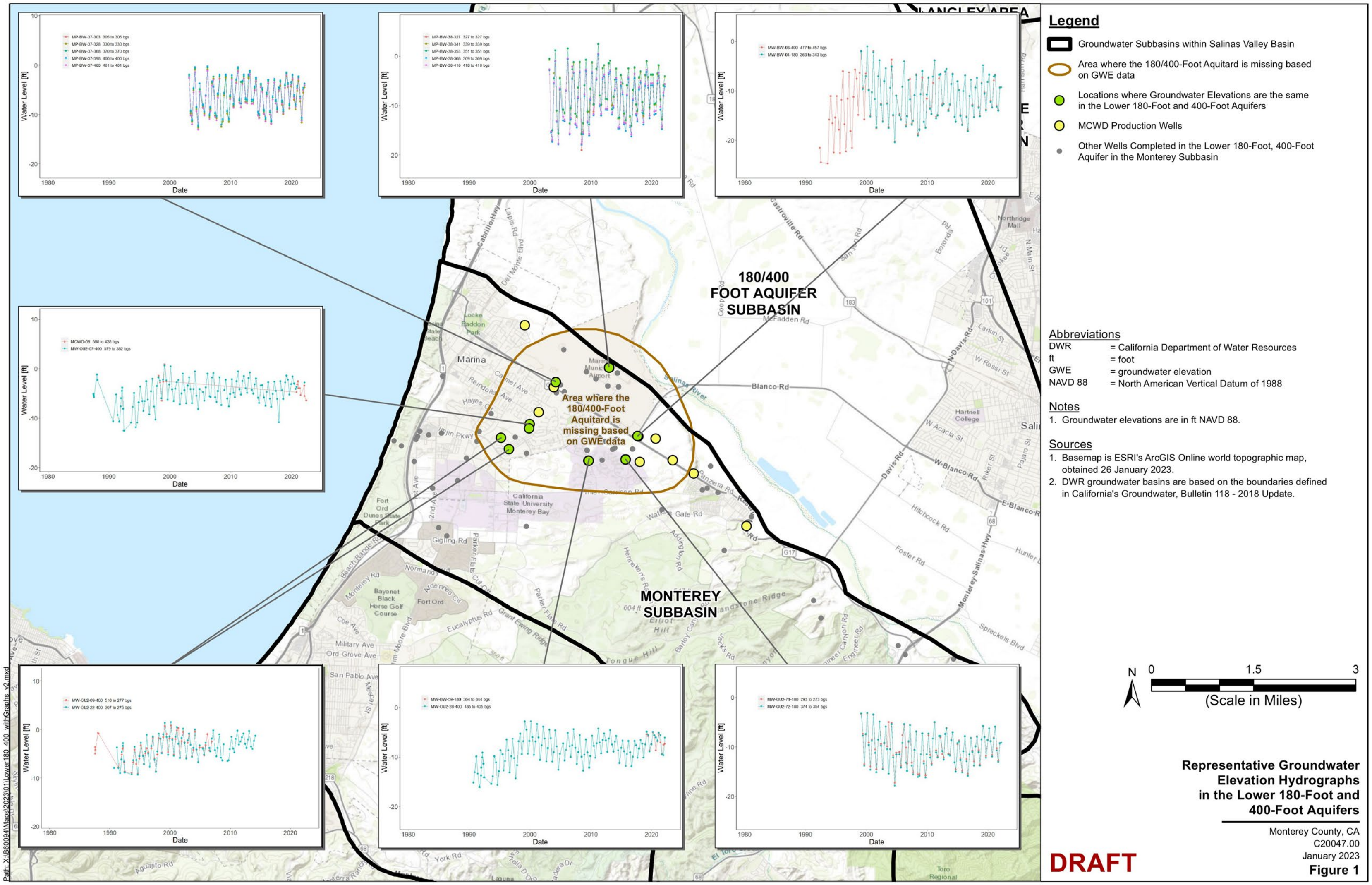


Figure 5. Hydrographs with Similar Groundwater Elevation in the 180- and 400-Foot Aquifers in the Marina-Ord Area

400-Foot Aquifer Thickness

Principal Data Used: AEM data, Salinas Valley Geological Framework

The 400-Foot Aquifer's thickness is defined by the distance between the base of the 180/400-Foot Aquitard and the top of the 400/Deep Aquitard. Previous interpretations of the 400/Deep Aquitard were that it was fairly consistent in depth and thickness along the main axis within the 180/400-Foot Aquifer Subbasin. The 400-Foot Aquifer was understood to have a thickness of up to 450 feet, averaging 250 feet thick, and ranging anywhere from 200 to 700 feet below land surface based on WCRs and published cross sections.

AEM data gathered for the *Deep Aquifers Study* (M&A, 2024) provided a much more refined view of the depth of the 400/Deep Aquitard, which in turn improved the conceptual understanding of the 400-Foot Aquifer's thickness. The Deep Aquifers Study found that the 400/Deep Aquitard extends southward throughout the Subbasin, generally following the trough shape of the Salinas Valley Basin. The Aquitard both deepens and thickens southward, which results in the 400-Foot Aquifer thickening southward.

These new data show that the 400-Foot Aquifer is still generally encountered at the previously estimated initial depth below ground surface (bgs): approximately 200 ft bgs. However, the revised conceptual model shows the aquifer extends up to approximately 1,000 ft bgs to the top of the 400/Deep Aquitard. This results in a significantly thicker aquifer than previously known. Figure 6 shows the revised elevation of the bottom of the 400-Foot Aquifer in the Subbasin and revised thickness of the 400-Foot Aquifer.

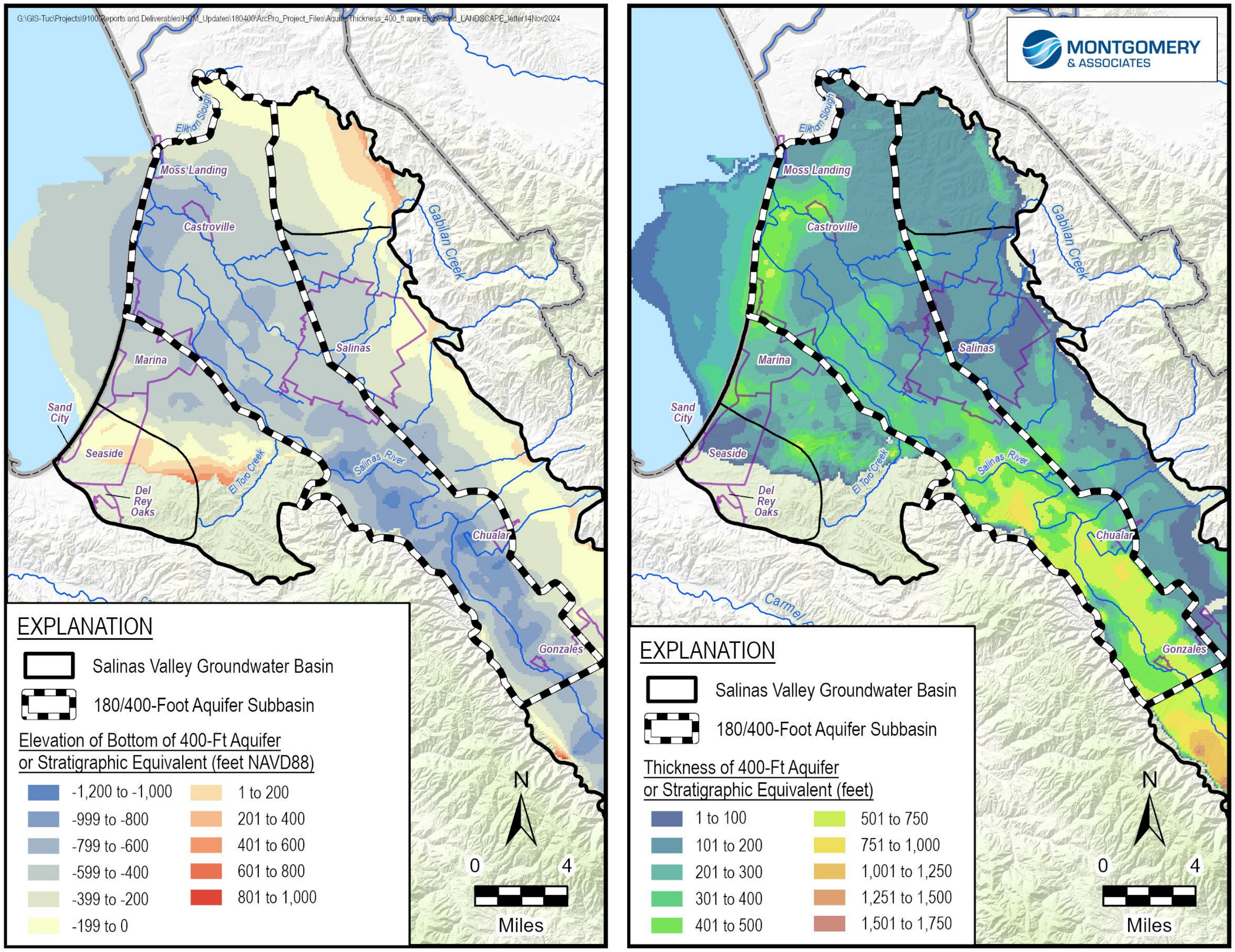


Figure 6. Revised Bottom Elevation and Thickness of 400-Ft Aquifer or Stratigraphic Equivalent

400/Deep Aquitard and Deep Aquifers' Extent

Principal Data Used: Previously published studies, AEM data, WCRs

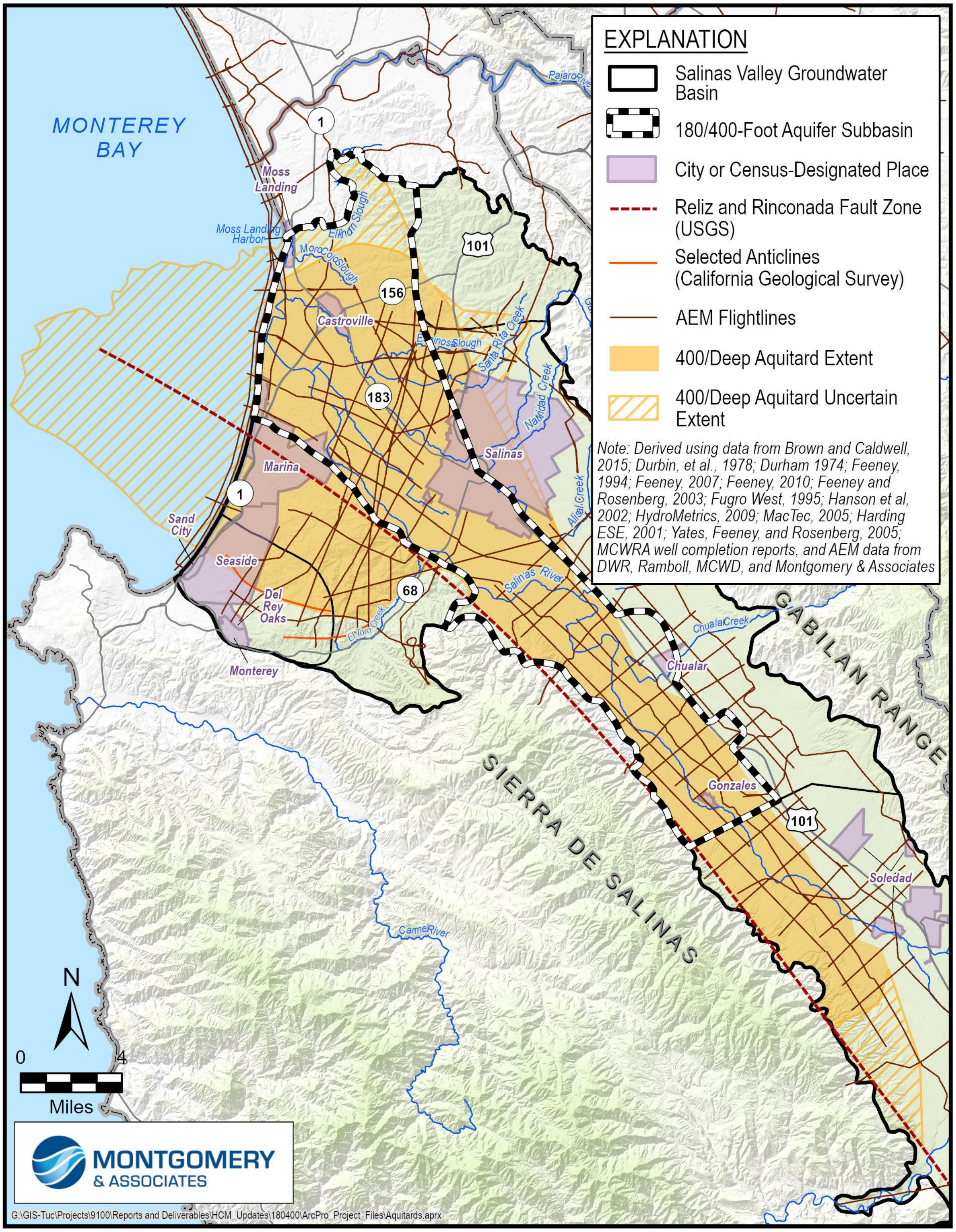
The Deep Aquifers' extent was revised by incorporating results and data from the *Deep Aquifers Study* (Study) (M&A, 2024). Attachment A to the Study details the data, methods, and extent findings, which are summarized here.

No cohesive description of the Deep Aquifers' depth and extent existed prior to the Study. The previous understanding of the Deep Aquifers focused on the coastal areas of the 180/400-Foot Aquifer and Monterey Subbasins, where the majority of the deep wells were installed. The *Deep Aquifer Investigation - Hydrogeologic Data Inventory, Review, Interpretation and Implications* (Feeney and Rosenberg, 2003) detailed the geology that constitutes the Deep Aquifers and summarized the known Deep Aquifers wells' screened intervals, extraction, and locations.

The *Hydrogeologic Report on the Deep Aquifer, Salinas Valley, Monterey County, California* (Thorup, 1976) defined the Deep Aquifers as the entirety of the Paso Robles Formation within the Salinas Valley Basin and developed recharge and storage estimates assuming the whole formation was the Deep Aquifers. Other studies and analyses generally defined the Deep Aquifers based on the presence of the overlying 400-Foot Aquifer or MCWRA-designated Deep Aquifers wells, but notably there was no defined extent.

The updated understanding of the Deep Aquifers presented in the Study focused on the presence of the 400/Deep Aquitard to delineate the Deep Aquifers from the shallower principal aquifers. The Deep Aquifers incorporate all the productive zones below the 400/Deep Aquitard, including the previously named 800-Foot, 900-Foot, 1,100-Foot, and 1,500-Foot Aquifers; and comprise portions of the Paso Robles Formation, Purisima Formation, and Santa Margarita Sandstone. Insufficient data exist to divide the Deep Aquifers into component horizons.

The Study delineated the lateral extent of the Deep Aquifers throughout the majority of the 180/400-Foot Aquifer Subbasin and into adjacent and nearby subbasins. The extent of the Deep Aquifers in the 180/400-Foot Aquifer Subbasin is shown on Figure 7, which also shows the extent defined in the Deep Aquifers Study. This figure includes areas marked as the uncertain extent, where current data is not sufficient to conclusively determine if Deep Aquifers are present.



Note: Derived using data from Brown and Caldwell, 2015; Durbin, et al., 1978; Durham 1974; Feeney, 1994; Feeney, 2007; Feeney, 2010; Feeney and Rosenberg, 2003; Fugro West, 1995; Hanson et al, 2002; HydroMetrics, 2009; MacTec, 2005; Harding ESE, 2001; Yates, Feeney, and Rosenberg, 2005; MCWRA well completion reports, and AEM data from DWR, Ramboll, MCWD, and Montgomery & Associates

Figure 7. Updated Deep Aquifers Extents, as Determined by the Deep Aquifers Study (M&A, 2024)

Top of Bedrock and Offshore Hydrostratigraphy

Principal Data Used: Oil exploration wells, AEM data, SVIHM geologic model, seismic data, surface geology maps, and bathymetry

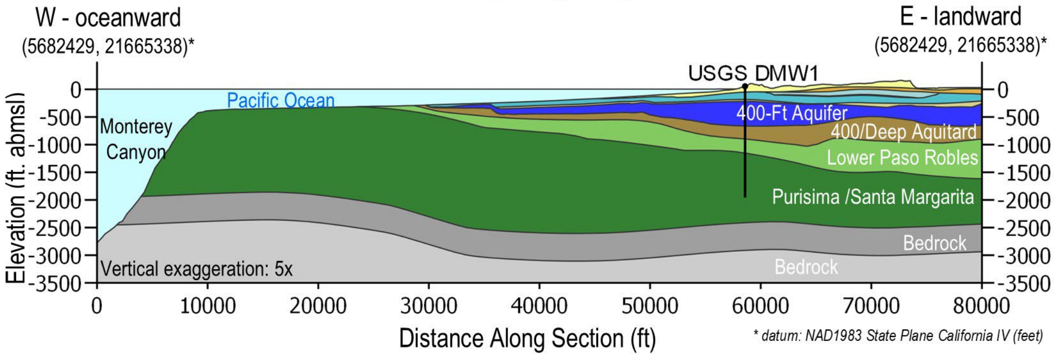
The Monterey Formation and granitic rocks comprise the primary bedrock units. This surface defines the bottom elevation of what is considered usable aquifer. Previous conceptualization of the top of bedrock surface is based on the 1978 Durbin model (Durbin *et al.*, 1978) that relied on geophysical gravity studies. This surface conforms to a traditional bathtub shape, generally dipping down toward the Sierra de Salinas and tilting up toward the coast. The Salinas Valley Geological Framework (Sweetkind, 2023) generally follows this same conceptualization. For this update, the onshore portion of the 180/400-Foot Aquifer Subbasin is consistent with this same conceptualization, with only minor adjustments along the coastline based on lithology from several deep oil exploration wells.

Top of bedrock elevations deviate from the SVIHM elevations for the offshore area adjacent to the 180/400-Foot Aquifer Subbasin. The revisions are based on oil exploration wells previously mentioned, mapped outcrops of bedrock in Monterey Bay (Dartnell *et al.*, 2016, and Wagner *et al.* 2002), and seismic reflection cross sections (Dartnell *et al.*, 2016). The combination of these data and lack of known significant faulting offsets indicates the top of bedrock surface extends offshore with the same, gently sloping upward trend as onshore to nearly flat. This also follows the same slightly upward slope as in the B – B' geologic cross section in Feeney and Rosenberg (2003).

M&A updated the offshore hydrostratigraphy above bedrock based on more recent offshore geologic maps and the most recent bathymetry data (seafloor topography). These updates provide a refined conceptualization of how the aquifers interact with the ocean in Monterey Bay. The primary modifications to the offshore hydrostratigraphy consisted of connecting geologic units to outcrops from the most recent offshore geologic maps, smoothing and revising the offshore hydrostratigraphy, and updating it based on the bathymetry data available from NOAA (NOAA, 2024). Units that have not been mapped as outcropping offshore were assumed to pinch between the coastline and Monterey Canyon following the similar pinch outs as the SVIHM.

Figure 8 shows a cross section extending offshore of the revised hydrostratigraphic interpretation. The updated bedrock surface, shown in grey, is a relatively flat-lying layer with no substantial discontinuities between the coastline and Monterey Canyon. Figure 8 also shows the revised hydrostratigraphy above the Monterey Formation, and how the various units outcrop along the wall of Monterey Canyon. Included on Figure 8 are drillholes with bedrock contact and the AEM surveys, which were used in the analysis where surveys indicated bedrock contact.

Offshore to Onshore Hydrogeologic Cross-Section



Top of Bedrock Elevation Map and Cross-Section Location

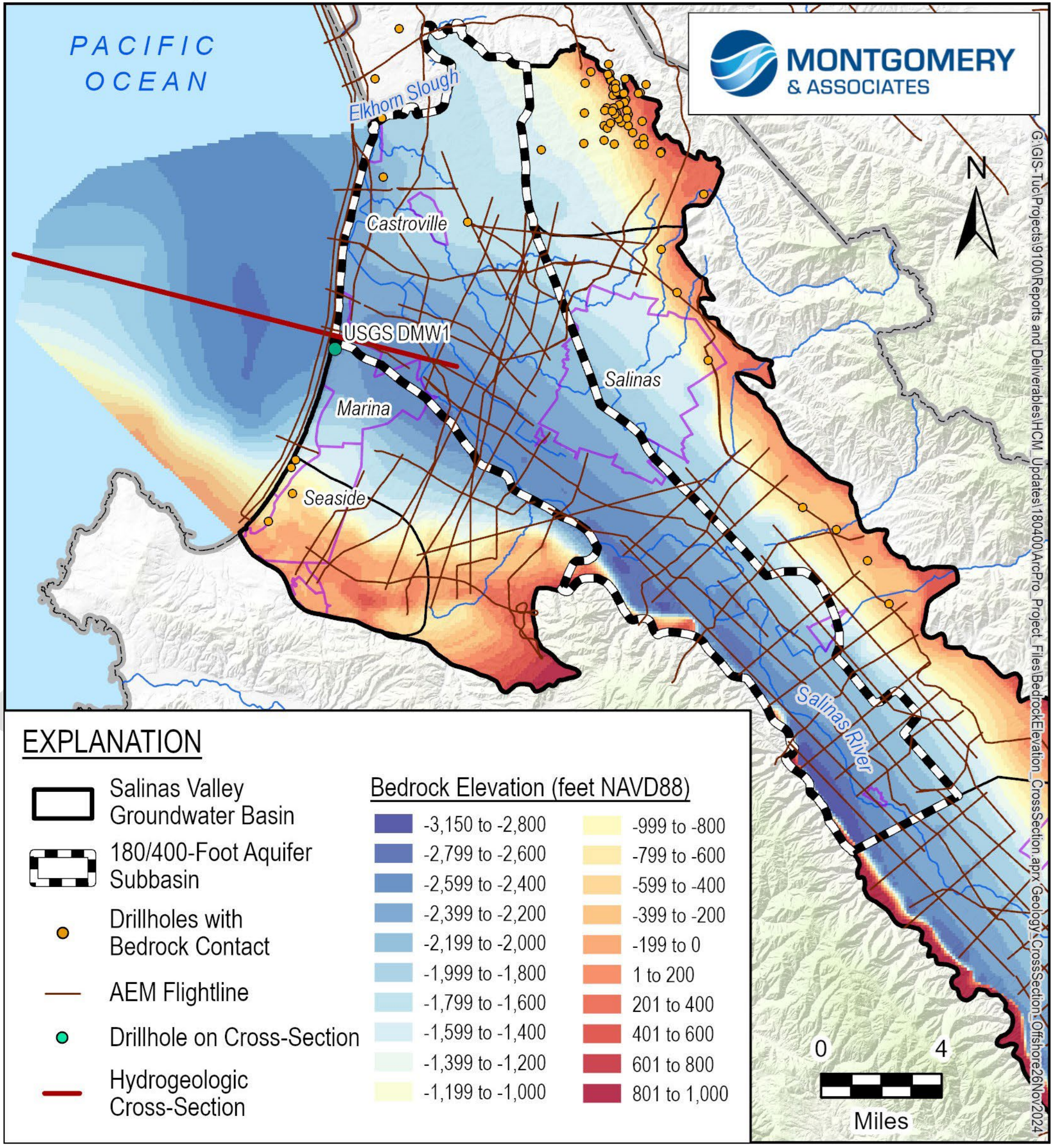


Figure 8. Revised Conceptual Understanding of Offshore Bedrock and Hydrostratigraphy

Boundary of the 180/400-Foot Aquifer Subbasin with the Corral de Tierra

Principal Data Used: AEM data, published cross sections, surface geology maps

The relationship between the 180/400-Foot Aquifer Subbasin and the El Toro Primary Aquifer System has been poorly defined due to a lack of data across the subbasins' boundary. Previous conceptualizations of the connectivity were based on the previously published map of the Monterey Formation surface contours (Rosenberg, 2009). The aquifers in the El Toro area were assumed to follow the contours of the mapped Monterey Formation surface, and conceptually connect with the Deep Aquifers and/or other aquifers of the 180/400-Foot Aquifer Subbasin. There was limited understanding regarding whether the principal aquifers and aquitards in the 180/400-Foot Aquifer Subbasin flowed across or were truncated by the Reliz Fault, but it was generally thought that water flowed from the El Toro area into the 180/400-Foot Aquifer Subbasin.

Cross-section X_1-Z in the *Geologic Map and Cross-Sections from El Toro to Salinas Valley* (Geosyntec, 2010), as shown in the Monterey Subbasin GSP (MCWDGSA and SVBGSA, 2022), shows some uplift of the bedrock. AEM data collected in the Corral de Tierra Area revealed that along Highway 68 corridor, as the 180/400-Foot Aquifer Subbasin boundary is approached, the Monterey Formation reaches the surface and then dives steeply near the Reliz Fault, as shown in Figure 9, along with the location of AEM surveys, of which relevant lines were used in the analysis. These data suggest that groundwater flow between the El Toro area and the 180/400-Foot Aquifer Subbasin is likely limited. This interpretation is similar to what was shown on Cross-section X_1-Z (Geosyntec, 2010). This subbasin boundary remains an area of uncertainty due to the geologic complexity, and this conceptual understanding may be updated in the future with more refined data.

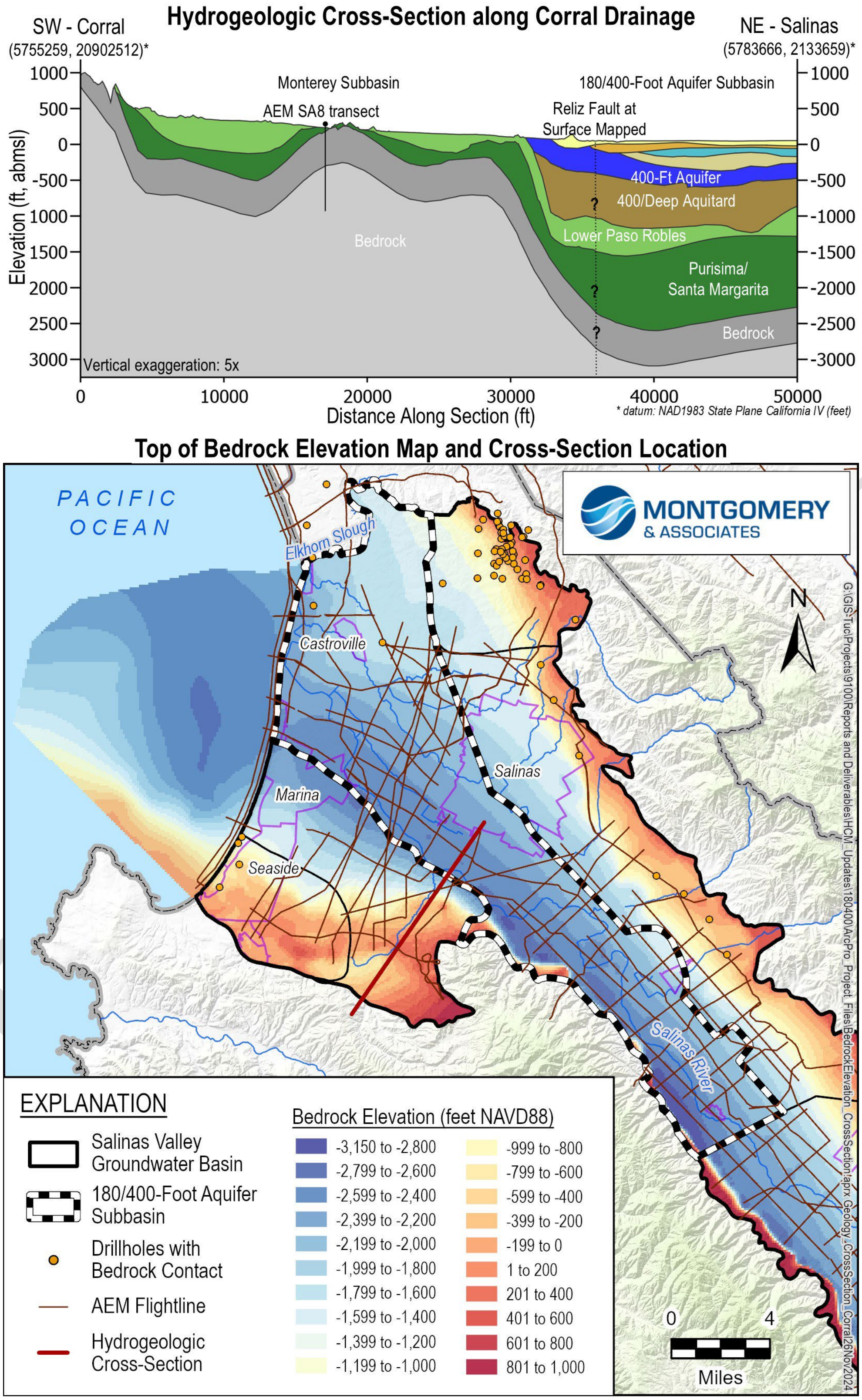


Figure 9. Revised Layers Across the Subbasin Boundary near Toro Creek

CONCLUSIONS

The HCM included in the 2020 180/400-Foot Aquifer Subbasin GSP used the best available analyses and published reports. The SVBGSA has collected and analyzed significant amounts of new data to refine and update the conceptual model. This update provides clear refinements for the overall Subbasin.

The following include principal updates to the HCM:

- The gaps previously found in the coastal aquitards have been refined and incorporated into the shallower coastal aquitards, which could be important for allowing vertical migration of brackish groundwater.
- The 400-Foot Aquifer in the southern portion of the Subbasin is thicker than previously understood, based on the refined depth of the 400/Deep Aquitard.
- The Deep Aquifers are deeper and more extensive than previously mapped, based on information from the *Deep Aquifer Study* (M&A, 2024).
- The offshore bedrock surface and hydrostratigraphy, smoothing the units from onshore geology to offshore mapped surface geology.
- The aquifers in the El Toro area of the Monterey Subbasin do not appear to be well connected to the aquifers in the 180/400-Foot Aquifer Subbasin, however, this is an area with remaining conceptual uncertainty.

.

REFERENCES

Dartnell, P., K.L. Maier, M.D. Erdey, B.E. Dieter, N.E. Golden, S.Y. Johnson, S.R. Hartwell, G.R. Cochrane, A.C. Ritchie, D.P. Finlayson, R.G. Kvitek, R.W. Sliter, H.G. Greene, C.W. Davenport, C.A. Endris, and L.M. Krigsman (P. Dartnell and S.A. Cochran, eds.), 2016, California State Waters Map Series — Monterey Canyon and Vicinity, California: U.S. Geological Survey Open-File Report 2016–1072. http://dx.doi.org/10.3133/ofr20161072.

Durbin, Timothy J., G.W. Kapple, and J.R. Freckleton. 1978. Two-Dimensional and Three-Dimensional Digital Flow Models of the Salinas Valley Ground-Water Basin, California. U.S. Geological Survey. Water Resources Investigations Report 78-113. Prepared in cooperation with the U.S. Army Corps of Engineers.

DWR (California Department of Water Resources). 2020. Survey Area 1 – Salinas Valley Data Report and Appendices. DWR Airborne Electromagnetic (AEM) Surveys Data. Available at: https://data.cnra.ca.gov/dataset/aem.

_____. 2022. Survey Area 8 – Data Report and Appendices. DWR Airborne Electromagnetic (AEM) Surveys Data. Available at: https://data.cnra.ca.gov/dataset/aem.

EKI Environment & Water. 2022. Monterey Subbasin Groundwater Flow Model.

Fugro West Inc. 1995. "North Monterey County Hydrogeologic Study Volume I Water Resources." Prepared for Monterey County Water Resources Agency. Available at: http://www.elkhornsloughctp.org/uploads/files/1421885098Fugro%20Water%20Study%20October%201995%20Vol%201.pdf

Harding ESE, 2001. Hydrogeologic Investigation of Salinas Valley Basin in the Vicinity of Fort Ord and Marina Salinas Valley, California - Final Report.

GeoSyntec, 2007, El Toro Groundwater Study Monterey County, California. Prepared for Monterey County Water Resources Agency. Available at: https://digitalcommons.csumb.edu/hornbeck_cgb_6_b/9.

_____. 2010. Accompanying Documentation Geologic Map and Cross-Sections from El Toro to Salinas Valley. Prepared for Monterey County Water Resources Agency. Available at https://www.countyofmonterey.gov/home/showdocument?id=19618.

Feeney, M.B., L.I. Rosenberg. 2003, Deep Aquifer Investigation - Hydrogeologic Data Inventory, Review, Interpretation and Implications. Technical Memorandum prepared for Wrime, Inc. Available at: https://digitalcommons.csumb.edu/hornbeck_cgb_5/37.

HydroMetrics LLC. 2009. Seaside Groundwater Basin Modeling and Protective Groundwater Elevations. Prepared for Seaside Basin Watermaster.

Kennedy/Jenks Consultants. 2004. Final Report, Hydrostratigraphic Analysis of the Northern Salinas Valley. Prepared for Monterey County Water Resources Agency. Available at: https://digitalcommons.csumb.edu/hornbeck_cgb_5/29.

M&A (Montgomery & Associates). 2023. Salinas Valley Seawater Intrusion Model Report. Produced for SVBGSA and County of Monterey. Available at:

_____. 2024a. Salinas Valley Deep Aquifers Study. Prepared for Salinas Valley Basin Groundwater Sustainability Agency and Collaborative Funding Partners. Available at: https://svbgsa.org/wp-content/uploads/2024/05/Deep-Aquifers-Study-Report_no-appendices_compressed.pdf.

_____. 2024b. Seawater Intrusion Model Updates (Addendum 2 to the Salinas Valley Seawater Intrusion Model Report). Available at: https://svbgsa.org/resources/seawater-intrusion/salinas-valley-seawater-intrusion-model/.

MCWDGSA (Marina Coast Water District Groundwater Sustainability Agency) and SVBGSA (Salinas Valley Basin Groundwater Sustainability Agency). 2022. Monterey Subbasin Groundwater Sustainability Plan.

National Oceanic Atmospheric Administration (NOAA), 2024. Maps and Geospatial Products. Available for download at https://www.ncei.noaa.gov/maps-and-geospatial-products.

SVBGSA (Salinas Valley Basin Groundwater Sustainability Agency). 2020. Salinas Valley: 180/400-Foot Aquifer Subbasin Groundwater Sustainability Plan.

_____. 2022. Salinas Valley: 180/400-Foot Aquifer Subbasin Groundwater Sustainability Plan Amendment 1.

Sweetkind, D.S. 2023. Digital data for the Salinas Valley Geological Framework, California: U.S. Geological Survey data release, https://doi.org/10.5066/P9IL8VBD

Thorup, 1976 and1983, Hydrogeologic Report on the Deep Aquifer, Salinas Valley, Monterey County, California. Prepared for the Monterey County Board of Supervisors. Available at: https://www.countyofmonterey.gov/home/showdocument?id=61934 with inclusion of supplemental plates prepared in 1982 and revised in 1983.

Wagner, D.L., Greene, H.G., Saucedo, G.J., Pridmore, C.L. 2002. Geologic Map of the Monterey 30'x60' Quadrangle and Adjacent Areas, California. Regional Geologic Map

Series, 1:100,000 Scale. Map No. 1 Plate 1 of 3. Digitized by Watkins, S.E., Little, J.D., Bizzarro, J.J. Department of Conservation, California Geological Survey, and Moss Landing Marine Laboratories and Monterey Bay Aquarium Research Institute.