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A-3-MRA-19-0034 / 9-19-0918

September 17, 2020

EXHIBITS

Packet 3 of 4

Exhibit 9

Map of Project Area

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EXHIBIT 10

October 22, 2019

TO: Tom Luster, Energy Unit, Sr. Environmental Scientist

FROM: Lesley Ewing, Technical Services Unit, Sr. Coastal Engineer

SUBJECT: CalAm Monterey Peninsula Water Supply Project

This memo addresses some of the hazard issues related to the CalAm Monterey Peninsula Water Supply Project, specifically related to the hazards of erosion and storm damage at the well sites, and related to the possible migration of dunes into the well site that could cover or bury some of the wells. My main conclusions, discussed further in this memo are:

By 2040: The Test Well Site and the Proposed Slant Well Field will be safe from dune erosion and storm-related erosion through 2040.

By 2060: The Test Well Site will be safe from dune erosion through 2060, but, depending upon assumptions for future dune retreat rates, this site could be at risk from storm related erosion from a 100-year storm or greater, between 2040 and 2060. The Proposed Slant Well Field will be safe from dune erosion through 2060, as well as from storm related erosion from up to a 500-year storm.

By 2120: The Test Well and the Proposed Slant Well Field will be at risk from dune erosion with an Extreme Risk Adverse Sea Level Rise Scenario with or without a storm event and from Medium High Risk Aversion Sea Level Rise dune erosion with a 100-year or greater storm. In addition, the Test Well will be at risk from erosion related to all Sea Level Rise Scenarios with a 100-year or greater storm and, from dune erosion without a storm for all scenarios except the Low Risk Aversion Sea Level Rise Scenario.

Risks from Burial due to Inland Dune Migration and Profile Shifts: The Test Well and the Proposed Slant Well Field could be at risk from sand burial resulting from the overall dune response to rising sea level and inland migration and elevation of the profiles. The time period for such risk cannot be determined; however, risks of burial should be low through 2040 and increase over time.

In preparing this memo, I have reviewed the following:

- ESA Memorandum to Michael Burns and Eric Zigas from Elena Vandebroek, David Revell and Doug George, March 19, 2014, Use of Coastal Erosion Technical Memorandum Titled, Analysis of Historic and Future Coastal Erosion with Sea Level Rise.
- ESA Memorandum to "Insert to Appendix C2. Draft Environmental Impact Report/Environmental Impact Statement" July 21, 2016, Use of Coastal Erosion Technical Memorandum Titled, Analysis of Historic and Future Coastal Erosion with Sea Level Rise dated March 19, 2014.
- AECOM Memorandum to Tom Luster from John Chamberlain (AECOM), October 2, 2019, Updated Coastal Erosion Hazard Analysis for CalAm Monterey Peninsula Water Supply Project.

INTRODUCTION and BACKGROUND The general location of the Test Well and the Proposed Slant Well Field is an area of high dune erosion. Historically, this section of the Northern Monterey shoreline has had some of the highest erosion rates in the state, with projections of general retreat of 300' to 320' by 2060, and additional storm-related retreat up to 130', based on historic trends and storm response. (ESA 2014 and 2016). Based on the initial evaluation of erosion risks by ESA (2014), the Proposed Test Well and the Proposed Slant Well Field were relocated several hundred feet inland of the originally proposed locations.

Three reports of site conditions and anticipated site changes were developed for this project. The initial report by ESA (2014) examined changes to the overall dune areas at 7 locations – Moss Landing, Sandholdt Road, Potrero Road, Southern Cluster at CEMEX, Northern Cluster at CEMEX, Sand City and Del Monte; with the information for the Southern and Northern Cluster at CEMEX used for the siting of the Test Well and the proposed siting of the new Well Field. Retreat rates for these sites were projected, based upon historic information, assumed rise in sea level above 2012 levels of 15" by 2040 and 28" by 2060, and conditions with and without erosion from a 100-year storm event.

The ESA Report (2014) projected long-term retreat rates for the various study sites ranging from 65' to 320' by 2060 and additional 100-year storm-related retreat that ranged from 40' to 140'. The two CEMEX sites had both the highest rates of long-term erosion and also the highest retreat related to a 100-year storm event. Comparison between the northern cluster CEMEX location and the southern cluster CEMEX location found that both long-term retreat and storm-related retreat were slightly lower at the southern cluster CEMEX location. Figures 1 and 2 show the anticipated retreat rates for 2040 and 2060, with and without a 100-year storm for both of the CEMEX sites.

By 2016, the proposed Test Well site and the Well Field had been relocated several hundred feet inland of the areas examined initially in the 2014 ESA report. ESA prepared a one-page memo noting that the "proposed locations of some project components have been relocated. The result of the coastal erosion study are still applicable because the change in project component locations does not change the coastal erosion anticipated to occur in response to sea level rise." Using the 2014 ESA study with the new well locations, the test well site is inland of the long-term erosion by both 2040 and 2060; however, the test well site was within the area that could be at risk from erosion between 2040 and 2060 resulting from a 100-year storm or greater. The Well Field area would be inland of all erosion risks analyzed by the 2014 ESA report.

In 2019, AECOM prepared an update to the ESA reports (2014 and 2016). The AECOM report expanded upon the ESA analysis in several ways. It provided shoreline change (dune retreat) analysis for three different Sea Level Rise Scenarios, the Low Risk Aversion, the Medium High Risk Aversion and the Extreme Risk Aversion Scenarios, based on information from the 2018 California Ocean Protection Council Sea Level Rise Guidance (also adopted by the California Coastal Commission). In addition to examining risks for 2040 and 2060, AECOM also included analysis for 2120 and added in likely storm-related retreat from both a 100-year storm and a 500-year storm. AECOM also modified the erosion rates developed by ESA (2014 and 2016) to account for the closure of the CEMEX sand mine. The AECOM analysis reduced the erosion rates by 60%, based on a 2012 analysis from ESA that analyzed the likely benefits to the regional shoreline from closure of the CEMEX plant.

For the 25 to 40 year period of concern, the main changes that AECOM undertook were the addition of 500-year storm condition and the reduction in the erosion rate. The inclusion of the 500-year storm is precautionary; however, the changes to the retreat rates are not. The 500-year storm was included to cover possible extreme conditions, yet several studies[1] anticipate that storm severity and frequency will increase with future climate change, making the 500-year event a far more likely severe storm in the future than it is considered to be today. Thus the 500-year storm is an appropriate one to include for future changes in dune retreat since it might more closely approximate the 100-year event of the 2050s or 2060s. However, the reduction in erosion by 60% assumed a rapid and large response to the closure of the CEMEX mine. While improvements in shoreline change and reductions in dune retreat are anticipated and will be quite welcome in helping stave off the adverse effects from rising sea level, the 60% assumption might be high. The prior retreat analysis by ESA (2014 and 2016) can provide an upper bound to the anticipated retreat through to 2060 since these were developed under the assumption that the CEMEX mine would not be closed and modifications to the retreat rates were not used.

EROSION RISKS AT THE TEST WELL SITE: The current Test Well site has been located inland of the anticipated 2040 long-term dune retreat area as well as the 2040 long-term retreat area with added storm-related retreat from a 100-year storm. This is the case for the projected erosion from ESA (2014 and 2016) as well as from AECOM (2019). However, but 2060, the Test Well site could be at risk from long-term erosion with added storm-related retreat from a 100-year or greater storm. Using the unmodified retreat rates from ESA (2014 and 2016) the Test Well site could be at risk from long-term erosion and a 100-year or greater storm sometime in the period between 2040 and 2060. Using the AECOM modified erosion rates, the Test Well site would not be at risk till sometime between 2060 and 2120 for all but the lowest sea level rise related long-term erosion. By 2120, the site would be at risk from long-term erosion with a 100-year or greater storm for the Low Risk Aversion Sea Level Rise scenario, and from long term erosion with or without a 100-year or greater storm for the Medium High Aversion and the Extreme High Aversion Sea Level Rise Scenarios. Based on the combined analyses by ESA (2014 and 2016) and by AECOM, the Test Well site will be safe from long-term erosion through 2060 and storm-related erosion through 2040. Depending upon the reduction in future erosion from current trends that include the effects from sand mining, the Test Well site might be at risk from storm related erosion between 2040 and 2060.

EROSION RISKS AT THE WELL FIELD SITE: The proposed Well Field will be sited inland at a sufficient distance to protect the site from long-term erosion and storm related erosion through 2060, with either historic erosion trends or erosion modified to reflect the benefits from closure of sand mining at the CEMEX site. Beyond 2060, the Well Field site will be increasingly vulnerable to erosion with the greatest vulnerabilities from the Extreme Risk Aversion Sea Level Rise Scenario, and the 500-year storm event. The Well Field site will be safe for more of the period from 2060 to 2120 with the Low Risk Aversion or Medium High Risk Aversion Sea Level Rise Scenarios and with higher frequency storm events (those more frequent than the 100-year or 500-year events).

RISKS OF BURIAL AT THE TEST WELL AND WELL FIELD SITES. With erosion and rising sea level, unarmored dune-beach profiles are expected to migrate inland and to shift up in elevation. As noted in the ESA reports (2014 and 2016), changes from rising sea level were addressed in two ways. "The

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[1] See, for example, the 2019 IPCC Report, IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]. In press. https://report.ipcc.ch/srocc/pdf/SROCC_SPM_Approved.pdf

profiles were shifted horizontally inwards by the projected erosion and raised by the projected sea level rise. The existing dune elevations were held as maximums even though the profile shift would imply dune 'growth' in some locations. .... (M)ost of Monterey Bay shore is receding landward, erosion is cutting into relict dunes, and the steep dune faces and narrow beaches impede dune growth (Thornton et al 2006). Dune migration and other changes have not been modeled and dune elevations may change whether the shore is accreting or eroding due to change in vegetation, other disturbance, etc." Thus, there is uncertainty about how the inland portion of the dunes will change. There is also uncertainty about how far inland the dune profile changes will occur, and also about the time periods over which these changes will occur. Changes to the dune face might take some time before these changes are reflected fully in the entire dune profile.

None of the reports from ESA or AECOM examined the risks to the site from sand burial. Sand burial has been included in this memo since burial might require maintenance of the well sites beyond what might have been considered, and might lead to impacts to the surrounding area. The analysis relies upon assumptions and work already developed by ESA and AECOM. No modeling of the back profile has been done and the potential for burial is covered only in general terms.

With the general changes that would be expected with rising sea level, that the profiles would shift up at an amount equal to the rate of sea level rise, it can be expected that the dune profile at the Test Well and at the Well Field site would eventually experience 15" to 28" of increased dune elevation in the form of sand cover. Due to the anticipated lag, the sand elevation would not necessarily be 15" higher at 2040 or 28" higher at 2060 (using the sea level rise projections from the ESA report); however, some added sand cover would be likely to occur over the project life. This is likely to be experienced both at the Test Well Site as well as at the Well Field Site, although the changes at the Well Field site from the rise in sea level are likely to occur later than at the Test Well site due to their greater setback from the active dune face. See Figures 3 and 4 for locations of the Test Well and the Well Field relative to the dune system.

The shift of the full profile inland with erosion is likely to cause greater changes at the Well Field Site than at the Test Well Site. The dune profile at the Test Well site has only small changes in topographic relief. An inland shift in the profile is thus likely to result in only small changes in topographic relief, either from increased sand cover or a loss of sand. However, at the Well Field site, the wells would be about 110' inland of the high dunes and the Well Field Site is about 12' to 15' lower than the more seaward dunes. With a long-term retreat at this site by 2060 ranging from 300' (from ESA, 2014 and 2016) to 120' (as modified by AECOM), the profile shift could potentially start to add sand cover to the Well Field by 2040 with the long-term erosion assumptions from ESA (2014 and 2016) or by 2050 or 2060 with the long-term erosion retreat as modified by AECOM. Since the full profile shift is not likely to be instantaneous with the long-term erosion at the face of the dune, the period for active burial of the well is not likely to start until 2040 or after. The potential for burial of the Well Field site increases from 2040 to 2060 and beyond; the potential for sand burial will depend upon both the future retreat of the dune face and the lag between the changes to the dune face and the full dune profile.

CONCLUSIONS: The changes made by AECOM to add in a greater than 100-year storm event are useful for the analysis since such storms are likely to be more frequent in the future with changes in sea level and climate. The changes made by AECOM to the retreat rate to account for benefits from closure of the CEMEX sand mine may anticipate less long-term erosion of the dunes that might actually occur. As a result, the work from ESA (2014 and 2016), which assumes no reduction from historic erosion, has been included to provide a reasonable upper bound for erosion risks to the Test Well site and the Well Field site. With the ESA analysis included, the Test Well site might be at risk from large storms and long-term erosion between 2040 and 2060.

None of the analyses by ESA or AECOM looked at the risks to the sites from sand burial. While there are many unknowns related to the actual shifts in the full dune profile over time and whether there would be a lag between the response of the frontal dune area and the back dune area, it is possible that there could be some burial of the well sites, both from sea level rise causing an elevation of the dune profile, and from an inland shift in the dune profile due to erosion. The Test Well site is likely to experience the greatest risk from burial (up to 1' to 2') due to the elevation of the profile with rising sea level. The Well Field is likely to be a greatest risk of burial from an inland shift in the dune profile. The timing of this risk would depend mainly upon the future rate of sea level rise, the future area of dune retreat and the time lag between a change in the dune face and the inland profile.

Overall, no appreciable erosion risks are anticipated to occur at the Test Well or the Well Field areas by 2040. There are small risks to the Test Well Site from storm-related erosion between 2040 and 2060. There are also small risks to the Test Well Site and the Well Field Site from possible sand burial that would be minimal through 2040. There is a small chance that the Well Field site might experience several feet of sand burial between 2040 and 2060. Beyond 2060, it becomes more likely that significant burial would occur.

MEMO EXHIBITS

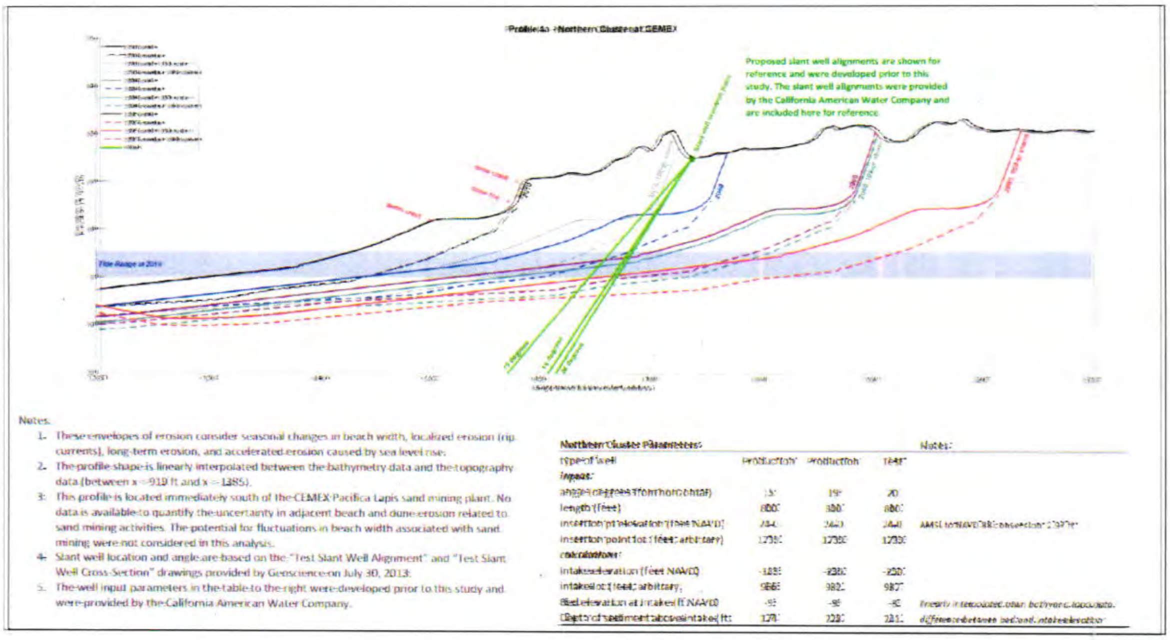

Figure 1, Retreat at the Northern Cluster CEMEX, From 2014 Report by ESA

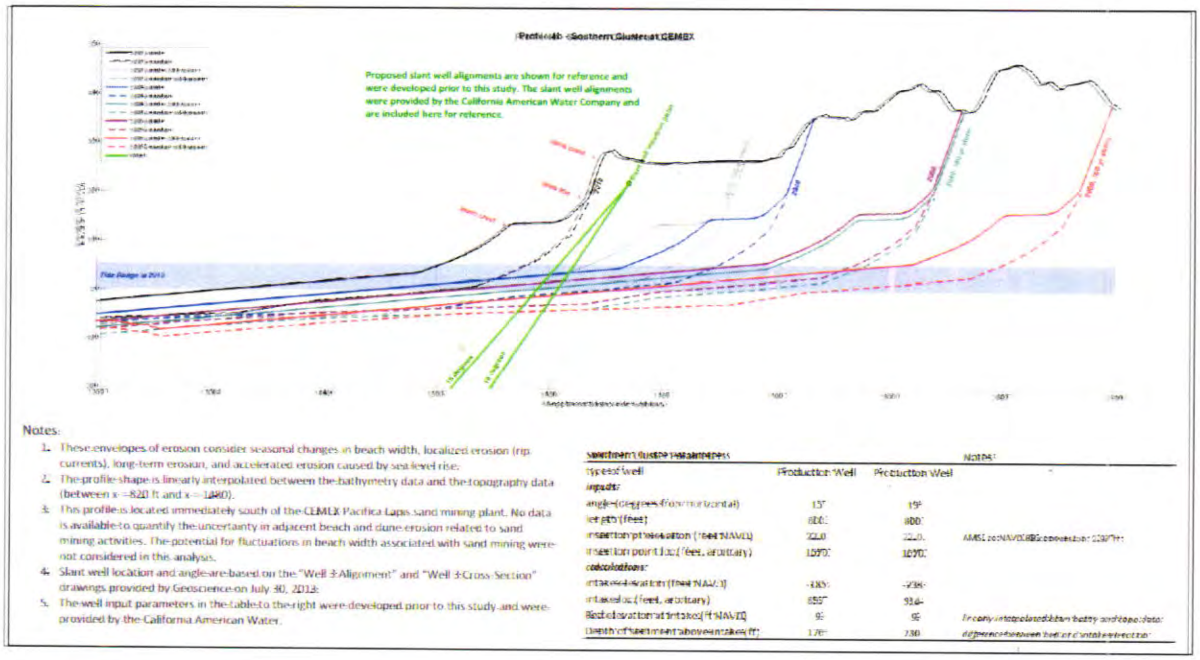

Figure 2, Retreat at the Southern Cluster CEMEX, From 2014 Report by ESA

Updated Coastal Erosion Hazard Zones: CalAm Monterey Peninsula Water Supply Project

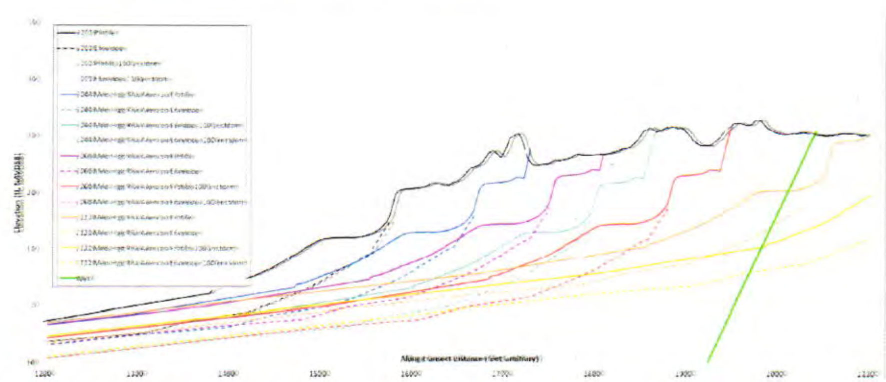

Figure 2. Test slant well site 100-year event profile erosion based on Medium-High Risk Aversion sea level rise projections for high emissions scenario (RCP 8.5)

AECOM 9/19

Figure 3: Location of Test Well Site and Dune Profile, From AECOM 2019

Updated Coastal Erosion Hazard Zones: CalAm Monterey Peninsula Water Supply Project

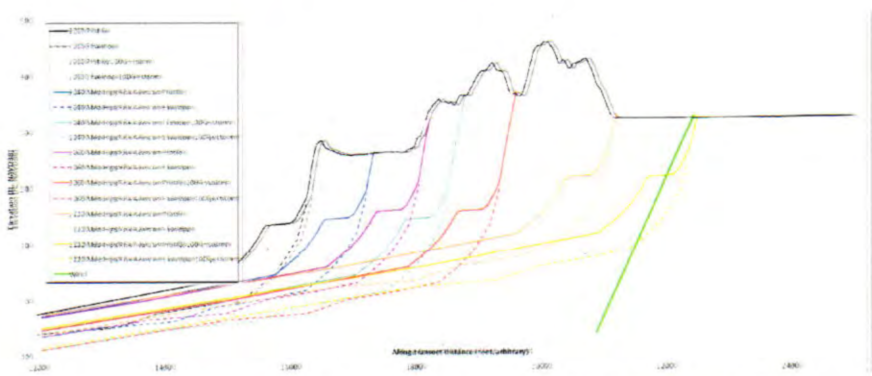

Figure 5. Proposed slant well field 100-year event profile erosion based on Medium-High Risk Aversion sea level rise projections for high emissions scenario (RCP 8.5)

AECOM 12/19

Figure 4: Location of Proposed Well Field and Dune Profile, From AECOM 2019

EXHIBIT 11

INDEPENDENT HYDROGEOLOGICAL REVIEW

NOVEMBER 2019

Weiss Associates Environmental Science, Engineering, and Management
2000 Powell Street, Suite 555, Emeryville, CA 94608 Phone: 510-450-6000

November 1, 2019

Tom Luster
California Coastal Commission
45 Fremont Street #2000
San Francisco, California 94105

RE: Independent Hydrogeological Review of Recent Data and Studies Related to California American Water's Proposed Monterey Regional Water Supply Project
Weiss Job No. 466-2148

Dear Mr. Luster:

This draft report documents Weiss Associates (Weiss's) independent hydrogeological review of data and studies related to California American Water's (Cal-Am) proposed Monterey Regional Water Supply Project (MRWSP). The MRWSP is expected to extract predominately seawater pumped from a planned well field near the Monterey Bay shoreline in the City of Marina California.

This review addresses recent questions raised by the California Coastal Commission (Commission) regarding the likely or potential effects of Cal-Am's proposed seawater extraction on local and regional groundwater resources.

The specific study questions the Commission requested technical opinions from Weiss to address are:

1. What were the effects of potential and actual changes in hydraulic gradient since January 2017, and what is the potential for these changes to affect potential seawater intrusion to, and capture of fresh water from, aquifers tapped by the well field?
2. What is the potential for the well field to adversely affect or capture previously unidentified volumes of fresh water? and
3. What are the possible project modifications to avoid or reduce the potential effects?

BACKGROUND

A Final Environmental Impact Report/Environmental Impact Statement (EIR/EIS) was published on March 29, 2018. It includes comments on the Draft EIR/EIS and responses to those comments, which were extensive regarding potential impacts of the MRWSP on local fresh groundwater resources. These occur primarily in the two uppermost important aquifers at the MRWSP: the Dune Sand Aquifer, and the 180-Foot/180-Foot Equivalent Aquifer.[1] After publication, further

[1] As used in this report, the term "180-Foot" Aquifer includes both the 180-Foot and 180-Foot Equivalent Aquifers.

comments were submitted and responded to on the potential fresh groundwater impacts, with differing scientific opinions, leading to the Commission's request for an independent review in support of their decision process, as to whether or not the project should receive Commission approval.

As documented in the Final EIR/EIS and more recent monitoring reports, a Test Slant Well (TSW) was constructed at the MRWSP site to determine hydrogeologic conditions and gather data to estimate potential freshwater capture by the full-scale project. Weiss reviewed hydrogeological reports and data from initial pumping of the TSW at 2,000 gallons per minute (gpm) and produced an independent hydrogeological review report dated September 29, 2015. This review focused on a permit violation after 2 months of initial testing of the TSW where water quality limit thresholds had been exceeded in a groundwater monitoring event. Among other things, Weiss's review concluded that based on available information, a groundwater model developed for the MRWSP was over-estimating the potential effects of the TSW, and that full scale testing "would not be expected to cause any measurable effects on the nearest agricultural well, located approximately 5,000 feet inland from the TSW, or on wells farther inland." This led to long-term testing of the TSW, which was pumped nearly continuously at 2,000 gpm for 22 months, from May 2, 2016 through February 28, 2018.

In the winter of 2016/2017, during the long-term TSW test, heavier than average rainfall resulted in a seaward steepening of the groundwater gradient in an area approximately 2,000 to 6,000 feet inland from the pumping well. This led to comments that the Final EIR/EIS may not have accounted for this change and potential additional post-2017 changes due to increased rainfall, and differences of scientific opinion on what those changes might be.

SUMMARY OF FINDINGS

Weiss's findings with respect to the Commission's study questions are addressed in detail in this report and summarized as follows:

1. A steepening of the hydraulic gradient seaward in the Dune Sand Aquifer in 2017 will likely result in a limited to negligible effect on seawater intrusion, and likely result in an increase in the fresh water percentage (FWP) of the well field flow due to capture of fresh water from the aquifers tapped by the well field. The gradient change appears to result from local and regional aquifer recharge due to increased rainfall in the 2016-2017 and 2018-2019 rain years. This is significant to the evaluation of the FWP percentages resulting from the MRWSP since there are significant data gaps with respect to groundwater flow paths in the Dune Sand Aquifer and the transfer of fresh water (total dissolved solids [TDS] <3,000 milligrams per liter [mg/L]) from the Dune Sand Aquifer to the 180-Foot Aquifer. Therefore, to be able to rely on Cal-Am's model results to accurately predict FWP, Weiss recommends additional data collection to address these data gaps, development of a consensus conceptual site model (CSM) and modifications of the model assumptions based on the CSM, and then calibration of the model to match the effects of these recent rainfall events.
2. The well field capture analysis presented in the project's Final EIR/EIS appears to be flawed as it does not account for potential freshwater capture beyond the identified capture zone of the well field due to seaward gradients. If such capture is greater than what is already accounted for, it will decrease the ocean water percentage (OWP) in

water extracted by the well field. The uncertainty in the range of OWP depends on how the hydrogeology of the Dune Sand Aquifer and underlying Fort Ord Salinas Valley Aquitard (FO-SVA) is interpreted and modeled. It could be reduced through adjustments to the groundwater model and applying it in non-superposition mode to more accurately reflect the site hydrogeology and implications of the TSW pumping results.

3. Potential project impacts on groundwater quantity and quality can be reduced by extending the planned well field intakes seaward by reducing the angle of slant of the wells or by using horizontal wells to shorten the seawater flow path to the well field intakes, thereby increasing the OWP and decreasing the size of the landward capture zone

DOCUMENT REVIEW

Weiss reviewed the following documents, which describe elements of the CSM for the hydrogeology of the MRWSP vicinity, and potential hydrogeologic impacts of the slant well field during pumping:

1. *Operable Unit 2 Fourth Quarter 2017 through Third Quarter 2018 Groundwater Monitoring and Treatment System Report, Former Fort Ord, California,* prepared for the United States Army Corps of Engineers, on behalf of the United States Department of the Army, by Ahtna Environmental, Inc. (August 2, 2019)
2. *Monterey Peninsula Water Supply Project (MPWSP) Hydrogeologic Investigation Technical Memorandum (TM1) Summary of Results - Exploratory Boreholes*, and Appendix A1 – Borehole Lithologic Logs, by Geoscience (July 8, 2014)
3. *Preliminary Findings of AEM Study*, presented at City of Marina City Council meeting August 7, 2017 by R. Knight (June 16, 2017)
4. *MPWSP – HWG Hydrogeologic Investigation Technical Report* by the Hydrogeologic Working Group (November 6, 2017)
5. Memorandum responding to comments on HWG Investigation Technical Report, From: The Hydrogeologic Working Group, To: Those considering comments on the HWG Final Report (January 4, 2018)
6. *Interpretation of Hydrostratigraphy and Water Quality from AEM Data Collected in the Northern Salinas Valley, CA* by Ian Gottschalk, Rosemary Knight, Stanford University, Stanford, CA Ted Asch, Jared Abraham, Jim Cannia, Aqua Geo Frameworks, Mitchell, NE, prepared for the Marina Coast Water District (15 March 2018)
7. *Final Environmental Impact Report/Environmental Impact Statement* by ESA, Prepared for California Public Utilities Commission and Monterey Bay National Marine Sanctuary (March 28, 2018)*:*
    a. *Chapter 4.4 (Groundwater resources);*
    b. *Chapter 8.2 (Master Responses 5-12);*
    c. *Chapters 8.5.1, 8.5.2 (Comment letters of City of Marina and MCWD and Responses to Comments)*

d. *Appendix E1, Lawrence Berkeley National Laboratories Peer Review;*

e. *Appendix E2, North Marina Groundwater Model Review, Revision, and Implementation for Slant Well Pumping Scenarios; and*

f. *Appendix E3, HWG Hydrogeologic Investigation Technical Report.*

8. *Technical Appendices to MCWD/City of Marina submittals to CPUC with technical appendices/attachments*, by MCWD, Knight, Aqua-Geo Frameworks (AGF), and Hopkins Groundwater (April 19, 2018)
9. *Integrated Coastal Groundwater Monitoring Program*, by M. Feeney and M. Zidar for Monterey County Water Resource Agency (May, 2018)
10. *Final EIR/EIS – Appendix J: Memorandum regarding Responses to Comments Received after Publication of MPWSP Final EIR/EIS*, File No. A. 12-04-019 Cal-Am MPWSP FEIR/EIS (September 12, 2018)
11. *MPWSP Test Slant Well Long Term Pumping Monitoring Report No. 64, 17-August-19 – 4-September-19* (September 10, 2019)

INDEPENDENT HYDROGEOLOGICAL REVIEW

This technical review addresses three study questions raised by the Commission which are indented here as corresponding Tasks and corollary questions. These Tasks and corollary questions are shown below in bold text, as worded by the Commission, followed by the results of the review. When referenced in the text, reviewed documents and figures that are excerpted from these references are indicated by a bold superscripted number ([##]) that corresponds to the numbered list of reviewed documents as referenced in the Document Review section above. The figures excerpted from reviewed documents have been renumbered for this document, using red figure numbers in the lower right corner of each page. The numbering system from the document of origin has also been maintained so the reader can examine it from its original context, if desired. Some of the figures have been annotated for clarification (e.g., generally identified in red but additional colors are used in annotation as noted in the figures and/or text).

The hydrogeology of the MRWSP is described in the Final EIR/EIS[7a] and Appendix E3[7f] of the EIR/EIS. If the reader is unfamiliar with the MRWSP, it is recommended to refer to these documents for background and context for the following discussion.

Task 1– Change in Hydrologic Gradient.

1. **Data adequacy: Recent data suggest that the hydraulic gradient in the 180-Foot Aquifer may have shifted from the landward direction that existed during the pump test to a seaward direction. The Final EIR/EIS evaluated the effects of this potential shift to some degree, but did not include data collected after December 2017. Do the more recent data indicate that the hydraulic gradient has shifted to a flat or seaward gradient?**

2. **Analysis – Effects of a shift in the hydraulic gradient:**

   a) **If the recent data indicate that the hydraulic gradient has shifted from its previous landward direction to a flat or seaward direction, do the analyses provided as part of the project's Final EIR/EIS adequately describe the expected effects of this shift on**

how the proposed project would affect the rate or volume of seawater intrusion into the aquifer or on how much fresh water (using both definitions below) the wells would extract?

b) **Do the more recent data (including the AEM study) support or contradict the Final EIR/EIS conclusions that the proposed project would not increase the rate of seawater intrusion, including under conditions of a shifted hydraulic gradient?**

c) **If the review determines that the project would exacerbate seawater intrusion, do the available data allow for an estimate of how much of an increase in the intrusion rate would occur due to the proposed project?**

Task 1-1. Data Adequacy

The TSW monitoring well clusters MW-1 and MW-3 through MW-9 (Figure 1)[7a] provide continuous water level data recorded from April 2015 through September 2019 (Figures 2 through 9),[11] including periods when the TSW was pumping at 2,000 gpm. Monitoring well clusters MW-3, MW-4, and MW-7 (Figures 3, 4, and 7), located at distances of approximately 700, 2,100, and 5,500 feet inland of the TSW screened interval, provide data that best depict the gradient over time for the Dune Sand Aquifer (shallow or "S" wells), 180-Foot Aquifer (medium or "M" wells), and the 400-Foot Aquifer (deep or "D" wells) in the near-project area. Inspection of these hydrographs show the effects of TSW pumping, and annual cycles reflecting winter recharge and summer pumping for irrigation. Comparison of peak-to-peak and trough-to-trough elements of the hydrographs shows longer-term trends and that changes in water level trends and therefore gradients occurred mainly prior to December 2017. After that date through September 2019, average water levels generally leveled off and did not trend up or down. This indicates that after 2017, there was no significant shift in average groundwater gradient.

To illustrate changes in groundwater gradients over time between well clusters MW-3, MW-4, and MW-7, the hydrographs of MW-4S, MW-4M, MW-7S, and MW-7M have been overlain in shades of blue and green on the MW-3 hydrographs (Figure 10) to allow comparison of water levels between these wells. The groundwater gradient between the wells over time can be calculated by selecting two of the "S" or "M" hydrographs and dividing the difference in feet between their water levels at any point in time by the distance in feet between the two wells.

Throughout the April 2015 to September 2019 monitoring period, the groundwater gradients from MW-3M to MW-4M to MW-7M (180-Foot Aquifer) have been consistently landward, at values ranging from 0.0004 to 0.004, regardless of whether or not the TSW was pumping. The magnitude of the upper end of this range is higher than the 0.0004, 0.0007, and 0.0011 landward gradients used by the 2016 North Marina Ground Water Model (NMGVM)[2016] to generate groundwater capture maps for the Dune Sand and 180-Foot Aquifers.[7e] Indeed, the average landward gradient between these wells is approximately 0.002, nearly double the steepest gradient that was modeled. The result of this difference is that had the well field been pumping from 2015 to 2019, the average capture zone in the 180-Foot Aquifer would be smaller than the smallest of the suite of capture zones depicted in the output from NMGVM.[2016]

In the Dune Sand Aquifer between MW-3S to MW-4S, gradients have ranged from flat to 0.0011 landward when the TSW was not pumping, to up to 0.0012 seaward when it was pumping. Between MW-4S and MW-7S (with one exception) the gradient has been consistently seaward at values ranging up to 0.001 during non-TSW pumping conditions, and from 0.0003 to 0.0012 during

TSW pumping. The exception occurred during a brief period in February-March 2016 when the gradient was flat to slightly landward (0 to 0.00015) between the two wells. Leaving out this exception, the change in gradient during 2017 between MW-4S and MW-7S can best be described as a four-fold steepening of the seaward gradient from 0.0003 to 0.0012 in the Dune Sand Aquifer. The significance of these gradients, in comparison to the modeled 0.0004, 0.0007, and 0.0011 landward gradients, is discussed below in response to question 2a). While it is likely that increased rainfall beginning in 2017 after a several-year dry period is driving these gradient changes, we do not know for certain if they are transient or permanent. The discussion below applies to either case.

Task 1-2. Analysis

2a). If the recent data indicate that the hydraulic gradient has shifted from its previous landward direction to a flat or seaward direction, do the analyses provided as part of the project's Final EIR/EIS adequately describe the expected effects of this shift on how the proposed project would affect the rate or volume of seawater intrusion into the aquifer or on how much fresh water (using both definitions below) the wells would extract?

While the Final EIR/EIS does not provide an analysis that specifically describes either a steeper landward gradient than what was assumed in the model, as is the case with the 180-Foot Aquifer, or a seaward gradient as is the case with the Dune Sand Aquifer, the methodology in the Final EIR/EIS can be applied to describe the expected effects of the shifts that did occur.

Regarding the extraction of fresh water by the wells, the 500 mg/L of TDS used to define fresh water in the Final EIR/EIS is the most conservative definition to use (of the two possible definitions for fresh water) for the purpose of calculating how much fresh water the wells would extract. The Final EIS/EIS[(Appendix H of 7f)] specifies that the OWP is defined as:

$$OWP = 100 \times (C_{pw} - 500)/(C_s - 500)$$

Where C_{pw} = Salinity (TDS in mg/L) concentration from project wells

C_s = Salinity (TDS in mg/L) concentration of ocean water [best estimate is 33,500 mg/L]

500 = Assumed Fresh Water TDS in mg/L

Therefore, if the project wells were pumping 100 percent water with 500 mg/L TDS, the OWP is 0 percent (the extracted water would be 100 percent fresh). If the project wells were pumping 100 percent water with a higher TDS, for example 3,000 mg/L, the OWP would be higher, 7.6 percent (92.4 percent fresh). If the equation was changed to assume that fresh water is defined as 3,000 mg/L instead of 500 mg/L, it would take the form of

$$OWP = 100 \times (C_{pw} - 3000)/(C_s - 3000)$$

and wells pumping 100 percent water with 3,000 mg/L TDS would have an OWP at 0 percent. This example illustrates that the higher the TDS in what is defined as fresh water, the higher OWP in the extracted water will be; or in other words, less fresh water is captured.

The effects of the changes in gradient on seawater intrusion and volume of fresh water extraction is different for the 180-Foot Aquifer and the Dune Sand Aquifer; these are therefore described separately.

180-Foot Aquifer

In the 180-Foot Aquifer, the changes in the gradient in the project area observed since 2017 are within or exceed the range used to model groundwater capture with NMGWM.[2016] To the extent that they are within the range of gradients modeled, the project's Final EIR/EIS adequately describes these gradients and calculates their effects. To the extent the gradients exceed that range, the project's Final EIR/EIS anticipates the expected effects, based on its recognition that a steeper landward gradient will result in a smaller capture area. Where the gradient is consistently landward as is the case with the 180-Foot Aquifer, seawater intrusion due to the well field pumping only occurs within the capture zone of the wells, as described in the Final EIR/EIS. Sea water intrusion beyond the capture zone is not affected, as any steepening of the landward gradient beyond the capture zone will be offset by the longer flow path inland for the sea water to take as the flow lines are deflected towards the capture zone.

As mentioned in Task 1-1, to the extent that the changes in gradient exceed the maximum modeled gradient of 0.0011, the capture zone will become smaller than the smallest capture zone calculated in the Final EIS/EIR. This will reduce the volume of "fresh" water extraction in the first few years of well field operation, as the smaller capture zone will contain a smaller volume of "fresh" water (actually brackish in this area) to be replaced by sea water as pumping continues. But longer term volumes of fresh water will also likely be reduced, as discussed below.

To determine how much fresh water the well field would extract both short- and long-term, the Final EIR/EIS estimated the OWP in the water extracted using an analytic method as well as a method based on the NMGWM.[2016 (Appendix H of 7f)] The methodology "…was calibrated using test slant well data from April 2015 to October 2016." The source of the fresh water contribution in these methods came from: (1) initial fresh water within the well field capture area that would be pulled in and replaced by ocean water in the first few years of pumping, and (2) estimates of groundwater recharge from rainfall within the capture area of the well field itself. As stated in the analysis, "…groundwater recharge is the only ongoing source of low TDS [i.e., fresh] water that contributes to the capture volume."[(Appendix H of 7f)] The results of the analytical OWP methodology estimated that long-term equilibrium OWP would range between 96 to 99 percent."[7a] This range of estimates was developed for landward gradients of 0.0004 to 0.0011, yielding the 96 and 99 percent OWP, respectively. Therefore, using the same assumptions as in the OWP calculations but substituting the much steeper landward gradient of 0.002 should result in a long-term equilibrium OWP well over 99 percent.

Dune Sand Aquifer

For the Dune Sand Aquifer, determining the effects of the 2017 change in gradient from 0.0003 to 0.0012 seaward is less straightforward, mainly because the Final EIR/EIS assumes only a landward gradient. It does not recognize any seaward gradient in its analysis of the Dune Sand Aquifer OWP, drawdown due to pumping, and groundwater capture. In brief, all else being equal, the seaward gradient will result in a reduction of the rate and volume of seawater intrusion, a larger capture area, smaller OWP, and greater volume of fresh water extracted by the wells than was modeled and described in the Final EIR/EIS. To clarify the reasons for this, and to assist in an understanding of the OWP in water pumped from the well field and the well field's potential to capture fresh water, and to serve as a basis for answering the remaining study questions, a discussion of the CSM for the Dune Sand Aquifer and underlying aquitard around and inland from the MW-7 well cluster (hereafter referred to simply as MW-7 to include MW-7S, MW-7M, and MW-7D) is presented below.

Conceptual Site Models (CSM) of the Dune Sand Aquifer Inland from MW-7

The geologic data serving as the foundation for the CSM is provided in the Final EIR/EIS.[7f] A map showing well and geologic cross-section locations (Figure 11), and the cross-sections themselves (Figures 12 through 16), provide a comprehensive view of the MRWSP vicinity. The "Illustration of Aquifer Zones" (Figure 17) shows a more generalized view, in a north-south cross-section just inland from the shore, looking landward at the MRWSP vicinity. The location of the MRWSP well field is indicated on Figure 17 by the arrow labeled "CEMEX". Not visible on the cross-section portion of Figure 17 because it is inland from the line of section is the FO-SVA. Its projection to ground surface is depicted by the irregular purple dashed line. Where present, the FO-SVA is stratigraphically between the Sand Dune Aquifer and the 180-Foot/180-Foot Equivalent Aquifer. A map view of the outline of the FO-SVA is shown on Figure 11.

Inland from the proposed MRWSP well field, it is debated in the Final EIR/EIS,[7a, 7b] comments on the Final EIR/EIS,[7c, 8] and responses,[7c, 8, 10] as to whether or not the FO-SVA at and/or east of MW-7 is discontinuous or continuous. This is mainly due to the lack of data in that area; Figure 11 shows no boreholes or wells in the 2-square-mile area bordered by MW-7, 14S/02E-18C01, 14S/2E-18H, MW-5, G-06, 14S/02E-20B1-3, 14S/02E-21N01, MCWD-6 and MCWD-12.

For purposes of this discussion, the CSM will be identified as CSM-1 where the FO-SVA is discontinuous, and CSM-2 where it is continuous. This CSM-1/CSM-2 terminology is unique to this review, and is not used in any of the reviewed documents.

CSM-1

While not illustrated specifically, CSM-1 is described extensively in the Final EIS/EIR[7a, 7b, 7c, 7e, 7f, and 10] and shown on Figure 18 which was developed for this report by annotating Geologic Cross Section 1A-1A' (Figure 12). Key features of CSM-1 are:

- East of MW-7, the FO-SVA is discontinuous and there are two hydrostratigraphic units above it: the Dune Sand Aquifer, and above that, the "perched/mounded" aquifer. The FO-SVA is shown as being continuous south of MW-7 on Geologic Cross Section 3-3' (Figure 15), and south of MW-5 on Geologic Cross Section 4-4' (Figure 16); however, in between these areas, it is considered discontinuous as shown on all cross-sections that include MW-7 (Figures 12, 13, and 16). As stated in Section 4.4-8 of the Final EIR/EIS,[7a] "The Perched A Aquifer appears to be hydraulically connected with a shallow aquifer local to the Monterey Peninsula Landfill area (referred to as the "-2- Foot" Aquifer) and the Dune Sand Aquifer near CEMEX area (HWG, 2017; see Appendix E3, TM2). The Dune Sand Aquifer is at a lower elevation and not hydraulically connected to the inland perched, mounded aquifers, namely the shallow, local 35-Foot Aquifer at the Monterey Peninsula Landfill and the "A" Aquifer in the Fort Ord Area (approximately 1.5 miles inland). The "A" Aquifer near Fort Ord is at a higher elevation than the Salinas Valley A-Aquifer and is perched on the Fort Ord-Salinas Valley Aquitard."
- CSM-1 considers the groundwater elevations in the "perched/mounded" aquifer (Figures 19 and 20) as separate from the Dune Sand Aquifer (Figures 21 and 22), so the two aquifers are contoured separately. Water from the "perched/mounded" aquifer presumably flows laterally across the perching horizon, then down as if descending stair steps to the lower level Sand Dune Aquifer and/or 180-Foot

Aquifer (Figure 18). As stated in the Final EIR/EIS in Section 8.5 (page 733),[7c] "The shallow perched/mounded aquifer is of limited extent, which results in the water from that aquifer flowing over the edge of the underlying clay layer (similar to a waterfall) into the deeper Dune Sand Aquifer and equivalents, or the 180-Foot Aquifer, depending of the hydrostratigraphy at the particular location. This effect is the same as described in the *Protective Groundwater Flows* section above *[this refers to the EIR/EIS and is not included here]*. However, this occurs about 1.5 miles inland of the coast and, therefore, would not be affected by the proposed MPWSP pumping."

- As stated in the Final EIR/EIS in Section 8.5 (page 734), the "Dunes Sand Aquifer (MW-1S, MW-3S, MW-4S, MW-7S, MW-8S, and MW-9S)" does not include the perched aquifer screened by MW-5, and that "Proper contouring using corresponding groundwater elevation data would result in accurate contours that show groundwater in the Dune Sand Aquifer flowing inland from the Monterey Bay."
- The clay layer at MW-7 separating the Dune Sand Aquifer and 180-Foot Aquifer is of limited extent, such that water held up by it at a higher elevation flows laterally until it encounters the edges of the clay layer, or gaps in it, then flows vertically down into the 180-Foot Aquifer as depicted on Figure 18.
- The higher water level at MW-7S and seaward gradient towards MW-4S is a local anomaly that does not reflect the larger picture of the Dune Sand Aquifer, which has an overall gradient landward ranging from 0.0004 to 0.0011. As stated in Appendix E3 of the Final EIR/EIS, "Groundwater flow directions in the Dune Sand Aquifer are complex due to the influence of ocean and river heads; however, Dune Sand Aquifer groundwater flow is indicated to be inland across the CEMEX site".[7f]
- Most of the fresh water recharge replenishing the Dune Sand Aquifer migrates to the underlying 180-Foot Aquifer beyond the range of well field capture, and is not susceptible to being drawn into the pumping wells.

As stated in Appendix E2 of the Final EIR,[7e] (page 9):

> "The SVA and FO-SVA are composed of clay layers that, where present, reportedly confine underlying aquifers (for example, the 180-FT Aquifer). The SVA underlies most of the northern Salinas Valley floor deposits and the FO-SVA is present beneath most of the former Fort Ord Area. The available information indicates that the FO-SVA thins towards the coast and is absent beneath the younger dune sand deposits; at the CEMEX site, borehole logs for the younger dune sand deposits [MW-1, MW-3, and MW-4, Figures 12 and 13] confirm this clay layer is absent, however thin clay layers are reported in borehole logs further inland [MW-7, Figures 12 and 13] indicating transition zones can exist between the aquitards and where they are absent near the coast. The transition zones provide variable hydraulic connections between the
>
> overlying shallow aquifers and deeper aquifers …." "These aquitards and transition zones are collectively represented by Model Layer 3, and their water transmitting properties are variable throughout the NMGWM area."

And, in another portion of the Final EIR/EIS:

> "Understanding the hydrogeologic characteristics of the Dune Sand Aquifer, there are two important considerations. First, wells from the Dune Sand Aquifer (and equivalents) cannot be contoured with wells from the shallow perched/mounded aquifers to develop contour maps because these are two distinct and hydraulically disconnected aquifers. Second, the primary "connection" between the two, distinct water-bearing zones is that the areal extent of the shallow perched/mounded aquifers, including the A Aquifer underlying Fort Ord, is limited, which results in perched/ mounded water flowing over the edge of the perching clay layer (similar to a waterfall) into the underlying Dune Sand Aquifer (and equivalents) or 180-FTE Aquifer. The edge of the perched clay layer occurs about 1.5 miles inland of the ocean shoreline. Please see response to the comment letter MCWD-HGC and EIR/EIS Appendix E3, Section 2.4.5.2 [page 28 of the Monterey Peninsula Water Supply Project – HWG Hydrogeologic Investigation Technical Report], for additional clarification regarding the hydrogeologic connection of the Dune Sand Aquifer, the 180-FTE Aquifer, and the shallow perched/mounded aquifer."

Much of the contradiction between CSM-1 and CSM-2 (the latter to be discussed following the modeling section below) has resulted from water level data at MW-7S and the lack of nearby wells screened above and below the base of the Dune Sand Aquifer. While CSM-1 considers MW-7S as part of the Dune Sand Aquifer, it also needs to explain the seaward gradient between MW-7S and MW-4S. While not explicitly stated in the Final EIS/EIR, it appears that in the MW-7 location, the Final EIR/EIS assumes that the Dune Sand Aquifer is "perched, mounded" by a clay layer that separates the Dune Sand Aquifer from the underlying 180-Foot Aquifer localized at MW-7S. Figure 13 shows that this clay layer is approximately 4 feet thick, and is at an elevation -48 to -52 feet relative to the North American Vertical Datum of 1988 (NAVD88). It is absent at MW-4S, located approximately 3,400 feet closer to the coast. Evidence that this clay layer provides hydraulic separation as well as physical separation of the Dune Sand and 180-Foot Aquifers comes from comparing water levels between MW-7S, screened in the Dune Sand Aquifer, and MW-7M, screened in the 180-Foot Aquifer. Water levels in MW-7S range from a minimum of 3.5 to 6 feet higher than in MW-7M in the winter, and a maximum of 11 to 13 feet higher in the summer (Figure 10). In comparison, water level differences between the two aquifers are progressively less in the MW-4 and MW-3 well clusters, seaward from the MW-7 well cluster, and where the clay layer is absent. Levels in MW-4S range from a minimum of 2.5 to 3 feet higher than in MW-4M in the winter, and a maximum of 6 feet higher in the summer. Water levels in MW-3S range from a minimum of 1 foot higher than in MW-3M in the winter, and a maximum of 1.5 feet higher in the summer (Figure 10).

Further evidence of hydraulic separation between the Dune Sand and 180-Foot Aquifers at the MW-7 comes from water level trends at MW-7S relative to MW-7M. MW-7S rose approximately 6 feet between October 2015 and June 2017, from approximately 4 feet NAVD88 (1-foot above mean sea level [MSL] which is at 3 feet NAVD88) to 9 feet NAVD88, presumably in response to above-average rainfall following a period of drought. During this time, the water level in MW-7M remained at or below MSL (3 feet NAVD88) (Figure 7).

In summary, despite the landward gradient assumed for the Dune Sand Aquifer in the Final EIR/RIS, the higher water levels at MW-7S, which is screened in the Dune Sand Aquifer, imply a seaward gradient between MW-7S and MW-4S. The only way to retain both landward and seaward gradients in the Dune Sand Aquifer in CSM-1 is to assume that MW-7S is an isolated case, and the clay layer responsible for its higher level is localized and not connected to the FO-SVA, which itself is assumed to be discontinuous or absent up to 1 mile inland from MW-7.

Modeling

Despite CSM-1's assumption that there are multiple aquifers above the FO-SVA east of MW-7, in using the NMGWM^{2016} groundwater model to develop predictions of groundwater capture and OWP from the MRWSP well field, a single layer (Layer 2) was used to simulate both the "perched/mounded" aquifer and the Dune Sand Aquifer. As stated in the Final EIR/EIS, "It is important to note that the NMGWM^{2016} considers the Dune Sand Aquifer, the Salinas Valley A Aquifer, and the -2-Foot Aquifer, plus the hydraulically disconnected perched, mounded aquifers at the Monterey Peninsula Landfill and the Fort Ord "A" Aquifer (occurring 1.5 miles inland) as one connected aquifer. However, this is not the actual hydrogeologic condition and therefore, there would be no impacts on the perched, mounded aquifers because they are above the Dune Sands Aquifer."(7a) This is important in understanding how the Dune Sand Aquifer and FO-SVA were modeled, and how the advantages and limitations of the modeling approach impact the predictions of groundwater capture and OWP at the MRWSP well field.

NMGWM^{2016} assigns Layer 2 to the Dune Sand Aquifer and other aquifers, including the perched aquifer; it assigns the FO-SVA to Layer 3. Relevant features of the model are excerpted from Appendix E3 of the Final EIS/EIR(7e) to show model cross-section locations (Figure 23); cross sections A-A', B-B', and E-E' (Figures 24, 25, and 26); and the horizontal and vertical hydraulic conductivities of model layers 2 and 3 (Figures 27 and 28) with annotations to show key MRWSP monitoring well locations. An enlarged portion of cross section A-A' is annotated to illustrate conceptual features relevant to this discussion (Figure 29). Key features of the modeling of CSM-1 include:

- The horizontal hydraulic conductivity (HK) assigned to the Dune Sand Aquifer inland of the well field, represented by model Layer 2, Zones 16 and 20 (Figures 27 and 29), is 2 and 4 feet per day (ft/day), respectively, which is very low for dune sand. These model values are at the bottom end of the range in values from other sources (Figure 27) of up to 250 ft/day for Zone 16 and 400 ft/day for Zone 20. Indeed, all of the surrounding Zones in Layer 2 are assigned HK values of 1 to 3 orders of magnitude higher than Zones 16 and 20.
- The FO-SVA inland of the well field, represented by model Layer 3, Zones 18 and 21 (Figures 28 and 29), is modeled as being on the order of 1 to 2 feet thick but continuous, in contrast to CSM-1 which considers the FO-SVA to be discontinuous.
- The vertical hydraulic conductivity (VK) assigned to the FO-SVA in Zones 18 and 21 (Figures 28 and 29) is 0.0000005 and 0.0005 ft/day. This indicates that the FO-SVA is considered essentially impermeable in Zone 18, such that groundwater flow above it in the Dune Sand Aquifer (Zone 16 of the model; Figure 29) will be predominantly horizontal. In Zone 21, which includes MW-7, the vertical groundwater gradient across the FO-SVA is on the order of 1 to 10, given modeled thickness of the FO-SVA of 1 to 2 feet at that location, in contrast to the far lower horizontal gradient within the overlying Zone 20 (Dune Sand Aquifer), measured in the range of up to 0.0012. The result of this is that movement of groundwater out of Zone 21 is approximately 2 orders of magnitude greater vertically downward than in the horizontal direction (Figure 29).

This modeling approach results in groundwater mounding inland from MW-7S, such that the model-generated water levels at MW-5S (the well considered to tap a separate perched aquifer above the Dune Sand Aquifer) are in good agreement with actual levels. As stated in Section 8.5 of the Final EIR/EIS (7c) (page 739):

> "Figure 4.2 in Appendix E2 shows the water level at MW-5S calculated by the NMGWM^{2015} (approximately 0 feet above mean sea level), is greatly improved following the update to the (approximately 29 feet, which is much closer to the measured value of 35 feet)."

However, the limits to NMGWM^{2016} reliability for modeling the Dune Sand Aquifer are noted in Section 8.2 of the Final EIR/EIS(7c) (page 80):

> "… model calculated water levels at all monitoring wells located in Model Layer 2 cannot effectively evaluate model reliability for the single zone that represents the Dune Sand Aquifer (the Dune Sand Aquifer is represented by one of the 16 parameter zones in Model Layer 2)."

It therefore appears that this modeling approach used a single layer, continuous FO-SVA or transition zone layer, and unrealistically low hydraulic conductivity assumptions for the Dune Sand Aquifer to simulate multiple layers and a discontinuous FO-SVA, all of which are inconsistent with CSM-1 described here and in the Final EIR/EIS.

The limitations of this approach become apparent in the superposition application of the NMGWM^{2016}(7e) to simulate drawdown and groundwater capture in the Dune Sand Aquifer. The superposition application is described in Appendix E2 of the Final EIR/EIS (page 52):(7e)

> "The initial water levels in superposition are specified zero everywhere in the NMGWM$_{2016}$, and therefore the model does not account for regional background gradients. These regional gradients significantly influence groundwater-flow paths from the ocean to the pumping slant wells, and therefore are important to consider when calculating capture zone boundaries. For the steady-state modeling analysis, we superimposed the measured regional background gradient calculated from Fall 2015 maps that show contours of equal groundwater elevations. We first calculated the regional gradient across the CEMEX site from the contour maps, and then approximately reproduced the gradient in the NMGWM$_{2016}$ by assigning external water levels to the eastern-most general-head boundaries. **Table 5.3** compares the observed and model-calculated gradients, and shows that the average measured gradient (0.0010) is reasonably close to the model-calculated gradient (0.0007)."

Table 5.3
Comparison between calculated gradients at the CEMEX site

Model Layer	Measured Water Level Gradient	Model-Calculated Gradient
2	0.0004	0.0009
4	0.0020	0.0007
6	0.0009	0.0005
Average	**0.0010**	**0.0007**

Of key importance is the methodology for the calculation of regional gradients. It is unclear how the regional gradient was derived for model Layer 2 (Dune Sand Aquifer) from the Fall 2015 groundwater elevation map (Figure 21) in Appendix E2 of the Final EIR/EIS. Figure 21 shows the 2-, 3-, and 4-foot groundwater elevation contours bending in a "U" shape open to the east, with the limbs of the "U" nearly perpendicular to two key hydrogeologic features: the coastline and the margin of the FO-SVA.

This approach denies a simpler interpretation between MW-9S and MW-8S and between MW-7S and MW-4S that the gradient is seaward in those areas. In the Dune Sand Aquifer, the only time between April 2015 and September 2019 where the gradient between MW-4S and MW-7S was landward was during a 2- or 3-week period in February-March of 2016 (Figure 10). At all other times the gradient between these two wells was seaward. It is interesting that groundwater elevations from this period (the only period to show a true landward gradient between MW-4S and MW-7S and not representative of typical conditions) were used in one of only two groundwater elevation maps for the Dune Sand Aquifer provided in the Final EIS/EIR (Figure 28).

Another limitation of the superposition approach for Layer 2 is that initial water levels are set at zero, equal to sea level. As shown in annotated model cross sections A-A', B-B', and E-E' (Figures 30, 31, and 32), this places the bottom of Layer 2 above sea level, above the initial head setting for the model, indicating it would be unsaturated. The estimated areas where this condition occurs is shown on Figure 33. However, superposition analysis results show physical inconsistencies, such as cones of depression that includes these unsaturated areas (Figures 34 and 35), and drawdown of 2 feet in well MW-5S (Figure 34), which is presumably screened in a perched aquifer zone hydraulically separate from the Dune Sand Aquifer. The only way these results could have been achieved with the superposition approach is that some modification to model layers must have taken place that was not documented, along the lines of lowering the riverbed in the example superposition analysis provided in Appendix E2 of the Final EIR/EIS (Attachment 1).[7e] The effects of such modification are not documented and cannot be evaluated.

For these reasons, the accuracy of the Dune Sand Aquifer response to well field pumping modeled by the superposition application of $NMGWM^{2016}$ is questionable, and therefore superposition mode is not appropriate for calculating the expected effects of differences in the groundwater gradient on how the proposed project would affect the rate or volume of seawater intrusion into the aquifer or on how much fresh water the wells would extract. However, the $NMGWM^{2016}$ can be used in non-superposition mode to calculate these effects, as discussed below.

<u>CSM-2</u>

CSM-2 applies to the Fort Ord area, south of the MRWSP; whether or not it also applies to the area inland of MW-7 in the MRWSP project area is debated, as mentioned previously. CSM-2 assumes that the FO-SVA is continuous (Figure 36) and that recharge from rainfall enters the Dune Sand Aquifer and flows primarily horizontally above the FO-SVA. On the west seaward side, when this horizontal flow reaches the edges of the FO-SVA, it "waterfalls" downward to the underlying 180-Foot Aquifer, recharging it. And if pumping is occurring near the coast as is proposed at the MRWSP well field, a portion of this fresh water is more likely to be captured than if the fresh water is percolating down to the 180-Foot Aquifer further inland, as is the case with CSM-1.

Commenters on the Final EIR/EIS[7c, 8] have contoured the groundwater elevations in the Dune Sand Aquifer in accordance with CSM-2 (Figures 37 through 40). This contouring is consistent with the seaward gradient exhibited between MW-7S and MW-4S, and in one case, even shows the landward gradient between MW-3S and MW-4S (Figure 40). In these interpretations, given that the hydraulic head is lower in the 180-Foot Aquifer than in the Dune Sand Aquifer, downward flow at MW-4 is consistent with the presence of a groundwater sink in the Dune Sand Aquifer at MW-4S. This is acknowledged in the Final EIR/EIS in Section 8.5.2.2 (page 732):[(7c)] "The lower water level at MW-4S relative to 3S and 7S indicates that the movement of fresh water from the Dune Sand Aquifer to the 180-Foot Aquifer is occurring in that area, approximately 2,100 feet inland of the MPWSP slant wells."

Section 8.5 of the Final EIR/EIS (page 759) [(7c)] disputes the interpretation in Figure 40:

> "Therefore, the contouring map provided as Figure 5 in the EKI comment letter is in error because it included the groundwater elevation in MW-5S(P), which is now understood to represent the water level in the perched/mounded aquifer (35-Foot Aquifer in the landfill area and the A-Aquifer near Fort Ord) and not the Dune Sand Aquifer represented by the shallow completions of the MPWSP monitoring wells. Using well MW-5S(P) results in an erroneous seaward (west) gradient. Furthermore, the groundwater contour maps developed by EKI shows groundwater elevation contours where there is no groundwater data to support them."

This illustrates one of the fundamental differences between CSM-1 and CSM-2.

<u>Modeling</u>

As mentioned previously, in non-superposition mode, NMGWM^{2016} fairly and accurately models water levels in the Dune Sand Aquifer. While not provided in the Final EIS/EIR modeling, in Section 8.5.2 (page 345),[(7b)] one of the commenters performed model runs and generated groundwater elevation maps of the Dune Sand Aquifer as contoured by the model for both non-pumping and well field pumping conditions at 24.1 million gallons per day (MGD) (Figure 41). As seen in the non-pumping condition scenario, groundwater elevations decrease from 0 to -1 feet inland from the CEMEX site to the same groundwater sink in the Dune Sand Aquifer that is depicted on Figure 40; groundwater flow east of this area is seaward, consistent with CSM-2.

This model run also illustrates an apparent inaccuracy of the model – that MSL for the modeling is set to 0. This is a problem because relative to NAVD-88, MSL is approximately +3 in the MRWSP vicinity (+2.97 in Monterey, +2.87 at Moss Landing, and +3.03 at Pillar Point).[2] Setting the model MSL to +3 will increase the seaside gradient to the well field and result in higher OWP and a smaller area of pumping influence inland than what has been calculated or modeled, all else being equal. This principle is recognized in Section 4.4 of the Final EIR/EIS:[(7a)]

> "The Dune Sand Aquifer response from MPWSP pumping, with current sea level conditions and 0 percent return water, would extend a maximum of about 3 miles inland from the CEMEX site (Figure 4.4-14). Under sea level conditions after 63 years [1.5 feet higher], the area of influence would be reduced in size by about a mile."

MSL appears as 0 instead of +3 in several places in the Final EIR/EIS, such as the hydrographs (Figures 2 through 10) and cross-sections (Figures 12 through 16). However, this discrepancy would not affect the superposition modeling, which appears to be valid for the 180-Foot Aquifer.

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[2] As calculated from the datums portion of www.tidesandcurrents.noaa.gov

<u>Conclusion of the Response to the Task 1-2a. Question</u>

The available data are inadequate to determine which CSM is the most accurate and therefore a definitive answer to the question in Task 1-2a. is not available until a consensus CSM is reached. Several boreholes and/or monitoring well clusters are needed in the 2-square-mile area east of MW-7, which lacks a single data point, to achieve this. Available modeling in this area is flawed for representing both CSM-1 and CSM-2. However, the information provided in the Final EIR/EIS and reviewer comments can be applied to estimate the expected effects, of differences in the groundwater gradient, on how the proposed project would affect the rate or volume of seawater intrusion into the aquifer, and on how much fresh water the wells would extract. This is applied to answering the subsequent questions posed in Tasks 1-2b through Task 3, below.

2b). Do the more recent data (including the AEM study) support or contradict the Final EIR/EIS conclusions that the proposed project would not increase the rate of seawater intrusion, including under conditions of a shifted hydraulic gradient?

The recent data and studies, including the AEM study,[(6)] do not demonstrate a significant new understanding of the distribution of fresh water not already identified in the Final EIR/EIS. Water levels in the MPSWP monitoring wells have increased from 1 to 5 feet in the Dune Sand/ 180-/400-Foot Aquifer since 2017, in response to above-average rainfall, not a significant change, and likely to be reversed with the inevitable onset of drier weather.

To the extent that water levels have increased, in particular the greatest increase (approximately 5 feet) for the Dune Sand Aquifer at MW-7S, there is a steepening of the seaward gradient and a slight increase in fresh water flowing seaward from the MW-7S area. This would tend to push the seawater intrusion front seaward from what was assumed in the Final EIR/EIS. In addition, the steeper gradient in the 180-Foot Aquifer will decrease the size of the groundwater capture area where seawater replaces fresh water due to pumping.

2c). If the review determines that the project would exacerbate seawater intrusion, do the available data allow for an estimate of how much of an increase in the intrusion rate would occur due to the proposed project?

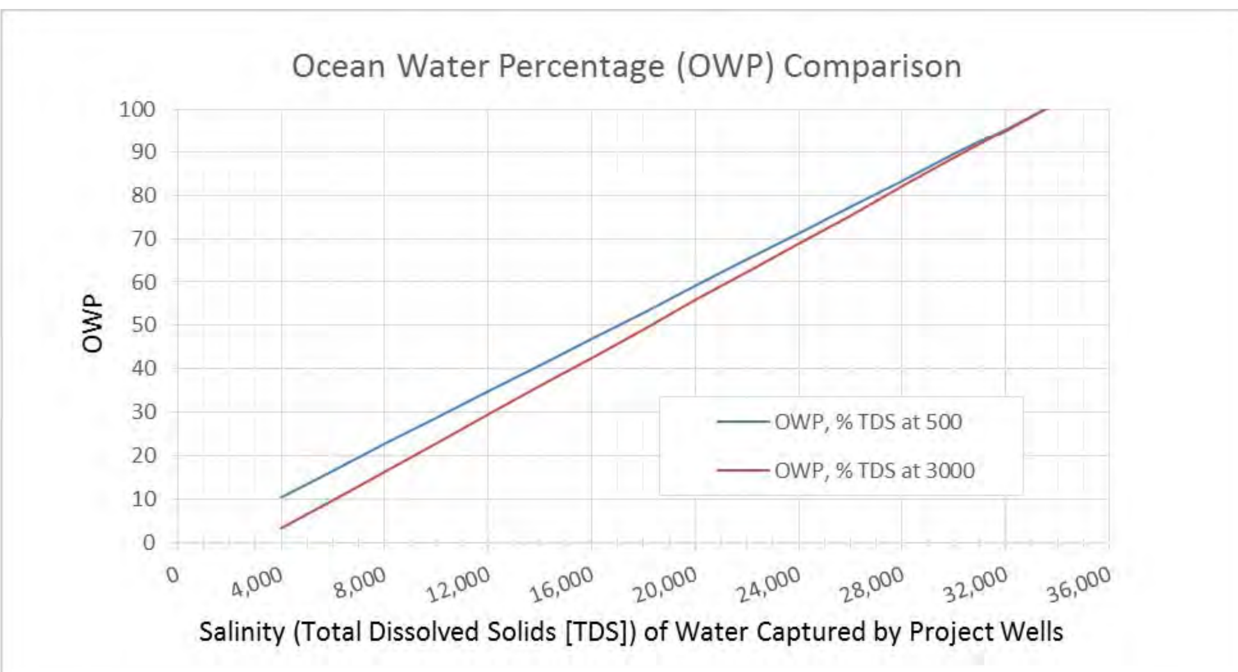
As described above, this review determines that the project would not exacerbate seawater intrusion, as defined in the Final EIR/EIS, where seawater replacement of fresh water within the well capture zone is not considered seawater intrusion since all of the introduced sea water is captured by the well field.

<u>Task 2 – Effects of intake well extractions on fresh water</u>.

1. **<u>Data Adequacy</u>: There have been several claims that the proposed project would extract greater volumes of fresh water from area aquifers than was identified in the Final EIR/EIS – for example, from the Dune Sands Aquifer or from other areas within the aquifers that were identified by an Aerial Electromagnetic ("AEM") survey and associated analyses as having greater volumes of fresh water than had been detected previously. Two key concerns about data adequacy are:**
   - **<u>Extent of "fresh" water:</u> A significant component of this issue area is that the there are two definitions of "fresh" water being applied to the groundwater affected by the proposed project. One is based on the secondary drinking water standard of**

500 mg/L TDS or less and the other is based on the groundwater basin's definition of "potential" drinking water of 3,000 mg/L TDS or less. The Final EIR/EIS used the 500 mg/L standard to determine that water extracted by the wells would be about 7% fresh water. Using the 3,000 mg/L standard, the amount of fresh water extracted would presumably be somewhat greater, as was concluded by the AEM study. Are there sufficient data to determine the extent and volume of fresh water that would be extracted under either definition – i.e., can the expected fresh water withdrawals be characterized under both the 500 mg/L TDS definition and the 3,000 mg/L TDS definition?

The answers would be "yes" and "no" depending on how the different definitions of the drinking water standard are applied. The Final EIR/EIS describes multiple methods of determining the OWP which all give similar results, including groundwater modeling for the test well pumping.[5, page 6] As described previously in the response to Task 1, Question 2a, the higher the TDS in the aquifer compared to what is defined as fresh water, the higher the OWP in the water extracted at the well field will be; in other words, less fresh water is captured. The assumption in the Final EIR/EIS that fresh water contains less than 500 mg/L, TDS accounts for the extent and volume for fresh water withdrawn under the 3,000 mg/L TDS definition. But if the 3,000 mg/L TDS definition of fresh water is used as a baseline, OWP will be lower than for the 500 mg/L TDS definition for a given salinity of water drawn into the wells. This is illustrated on the following chart, which plots increasing salinity of water drawn into the well field versus the OWP. If water drawn into the wells has relatively low salinity, i.e., TDS of 4,000 mg/L, the OWP difference between the 3,000 and 500 mg/L standards is on the order of 7.5 percent, and decreases as the salinity of water drawn into the well field increases, until at 26,000 mg/L TDS in the well field intake water, the OWP difference between the two standards is less than 2 percent.



Given that the OWP during TSW testing rose above 90 percent long-term, and reflects the high end of the TDS range, the decrease in OWP calculated by assuming a fresh water standard of 3,000 mg/L instead of 500 mg/L is on the order of 1 to 2 percent.

- **<u>Adequate data to characterize fresh water</u>: During Cal-Am's test well pump test, specific conductivity data were collected from within the test well at a single location. Samples from this location were intended to represent a mix of water from the Dune Sands Aquifer and the 180-Foot Aquifer. However, the test well extracted water from two separate aquifers – the Dune Sands Aquifer and the 180-Foot Aquifer – with each aquifer having different TDS concentrations. Do the data collected from this sampling location allow for an accurate representation of the amount of fresh water extracted from the test well (under both definitions of fresh water) and are they suitable to use for modeling the expected amount of fresh water that would be extracted by the full proposed project? If the data are not sufficient, what additional data are needed to allow for an accurate representation?**

Specific conductivity is not a precise measurement of TDS, which is being used by the project as an estimator for FWP/OWP. The ratio of TSD to specific conductivity varies with water type and generally is about 0.55 for fresh water and 0.7 for sea water. Therefore, a ratio of 0.7 for the TSW water is appropriate as an estimation of TDS at the TSW. Because the Dune Sand Aquifer and 180-Foot Aquifer have essentially the same hydraulic heads and TDS, a single specific conductivity sample is a reasonable estimator of the TDS in both aquifers at the TSW location. However, the single point specific conductivity data collected at the TSW are not an appropriate indicator of the TDS in each aquifer landward of MW-3 mainly due to uncertainty in the transition from the area of MW-3 seaward, where the Dune Sand and 180-Foot Aquifers behave as a single aquifer, and to the area of MW-7 landward, where they appear to hydraulically separate. Thus, the interpretations of the TSW specific conductivity data cannot be performed out of context, ignoring the data and hydrogeologic conditions at monitoring wells inland. Due to lack of consensus on the CSM inland from MW-7S and questionable modeling approach to the Dune Sand Aquifer and FO-SVA in this area, an accurate representation cannot be made. Additional data from borings and/or wells should be obtained from inland of MW-7S, and between MW-7S and MW-4S, to determine whether CSM-1 or CSM-2 applies. The NMGWM[2016] should be revised accordingly and run in non-superposition mode to determine just how much aquifer water (fresh or otherwise) will be captured by the well field from the Dune Sand Aquifer and 180-Foot Aquifer.

With regard to the data limitations stated above and a broader project context of the question, Weiss reviewed modeling results for OWP included in the Final EIR/EIS which gives a range of results, including the analytical approach that was described in the response to the Task 1-2a) question for the 180-Foot Aquifer. The results of the different methods of determining OWP are summarized in a memorandum addressing comments on the Hydrogeologic Working Group (HWG) analysis:**(Table 1 from 5)**

Table 1. Summary of OWP Analyses

Source	One Month OWP	One Year OWP	Two Year OWP	Long-Term OWP	Method
2015 DEIR	-	89-92	93-96	93-96	Variable Density Solute Transport Model
MCWD/ GeoHydros	69	89	90	90	Model Water Balance
TSW Field Data	85	92-95	90-92	-	Field Data
HWG Analytical	78-79	88-93	93-97	96+	Analytical Mixing Model
HWG Numerical	82	93	93-94	94	Variable Density Solute Transport Model
Overall Range	69-85	89-95	90-96	90-96+	Various

The low end of this range in values is from an analysis performed by GeoHydros, using water budgets from a model run of the NMGWM,[2016] as described in Section 8.5 of the Final EIR/EIS (page 358)[(7c)] and summarized in Table 3 from the GeoHydros report:

Table 3. Evolution of source water for the proposed extractions as defined by water budget reports exported from five timesteps of the calibrated and DD1-44/56 scenarios of the 2016 NMGWM.

Days after Start	Ocean	DSA	SVA	180-ft	400-ft	900-ft	*Total*	Total GW
30	69.1%	22.3%	4.2%	3.5%	0.6%	0.3%	*100%*	30.9%
365	89.0%	3.6%	0.1%	4.9%	1.6%	0.8%	*100%*	11.0%
730	89.7%	2.4%	0.0%	5.2%	1.8%	0.8%	*100%*	10.3%
3,650	90.0%	1.9%	0.0%	5.3%	1.9%	0.9%	*100%*	10.0%
11,680	90.0%	1.8%	0.0%	5.3%	1.9%	0.9%	*100%*	9.9%

The agreement between these approaches, which include the TSW field data, support the use of measurements from the combined Sand Dune Aquifer/180-Foot Aquifer for estimating purposes. The range in OWP from calculations, and OWP derived from field data, for one or more years after start of pumping, is from 89 to 95 percent. Even if all of the fresh water was coming from one or the other aquifers and the other aquifer was 100 percent ocean water, the OWP for the "fresh" aquifer could not be less than an estimated 78 to 90 percent.

The field data from the TSW test can also be used directly to assume that the OWP measured/calculated for the TSW pumping rate will increase for any greater pumping rate, by using the principle of superposition (also known as well interference) described in most hydrogeology texts and handbooks.[3] This principle states that in an aquifer of infinite extent, the drawdown at a given point influenced by multiple wells pumping together is the sum of the individual drawdowns created at that point by each well pumping alone. This principle is acknowledged in Section 4.4 of the Final (page 106):[(7a)]

> "When cones of depression from two or more pumping wells overlap, it causes what is referred to as well interference. Interference between pumping wells can create a combined drawdown effect where groundwater levels are lower than would be expected

[3] For example, Roscoe Moss, 1990, *Handbook of Ground Water Development*.

from the individual pumping wells. Typically, the combined drawdown of two or more wells is equal to the sum of the drawdowns caused by each well individually."

In applying this principle to wells pumping at the shoreline, the inland area can be considered for practical purposes to be the area where the cone of depression expands and at any given point water levels decrease over time, whereas in the seaward area a constant water level is maintained. Therefore, increasing pumping at the coast will create additive effects inland, expanding the cone of depression. Because the water level decrease associated with additional expansion of the cone of depression inland is on top of an already decreased water level, the groundwater gradients from inland towards the pumping wells will increase at a slower rate in response to increased pumping relative to the gradients on the ocean side, which increase to a greater extent because sea level is not affected by pumping. This greater increase in the gradients on the ocean side in response to greater pumping will act to increase the OWP as pumping rates increase. Thus, all else being equal, the values in the "Summary of OWP Analyses" table above can be considered as minimums for any project that produces more than the TSW flow at the TSW location.

With the caveat that more data is needed and the NMGWM2016 needs to be revised to reflect that additional data and rerun to obtain defensible results, an additional method can be used to approximate the OWP, extrapolating from the TSW testing results, where the OWP ranged from 94 to 96 percent over the 22 months of pumping. Since the test reflects real-world conditions, including a seaward gradient between MW-7S and MW-4S in the Dune Sand Aquifer, and regardless of whether or not CSM-1 or CSM-2 is correct, it serves as a basis for estimating the additional contribution of fresh water under a CSM-2 scenario, or the CSM-1 scenario as modeled by NMGVM.2016 The bottom half of Figure 41 shows the cone of depression in the Dune Sand Aquifer during pumping at 24.1 MGD at the well field, according to NMGWM2016 scenario DD1-44/56, as created by GeoHydros in a comment in Section 8.5.2 of the Final EIR/EIS (page 375).[(7b)]

Additionally, Weiss performed a simplified flow net analysis using the contours generated to estimate the additional area over which fresh water would be captured by pumping (Figure 42) beyond the capture zones estimated for the Final EIR/EIS. This assumed area is approximately 7 square miles. Assuming annual average groundwater recharge of 5 inches per year (0.42 feet/year), as was done for the Final EIR/EIS OWP analytical estimates,[(Appendix H of 7f)] this results in a potential annual average capture volume of 1,900 acre-feet per year. Assuming a worst-case scenario where the well field was pumping at 15.5 MGD (equal to 17,360 acre-feet per year), and assuming an OWP from within the original capture zone of 96 percent from the Final EIR/EIS calculations, the additional captured volume equates to 1,900/17,330, or 11 percent. Subtracting this from the OWP of 96 percent provides an overall OWP of 85 percent.

However, this result is likely to be an underestimate of the true OWP, because it denies any flow of groundwater from the Dune Sand Aquifer to the 180-Foot Aquifer inland of the capture zone (approximately 2,000 to 4,000 feet inland of the pumping wells) defined by the Final EIR/EIS. The NMGVM2016 (Figure 42) can also be used to generate a best-case scenario by estimating the horizontal flow towards the pumping wells through Layer 2, parameter Zone 20 (Figure 29). This layer has a hydraulic conductivity of 4 ft/day (Figure 27) in Zone 20. Given a conservatively high maximum seaward gradient of 0.0035, a length of Zone 20 of 4 miles perpendicular to the path of flow shown on Figure 42, porosity of 0.25, and a saturated thickness of 50 feet, the model can be estimated to produce a flow towards the pumping wells of only 30 acre-feet per year. This is because, as previously discussed, as modeled, most of the flow from Layer 2 is vertically downward to the 180-Foot Aquifer. This value is too small to have any effect on the original 96 to 99 percent estimated range in OWP calculated in the Final EIR/EIS and is likely to be unrealistically low.

The actual capture of fresh water is likely to be somewhere between the worst- and best-case extremes, and as stated previously, can only be determined by obtaining more data for the Dune Sand Aquifer and FO-SVA in the 2 square miles inland of MW-7, and in the area between MW-4 and MW-7.

For reasons already stated, it appears that the superposition method of applying NMGVM^{2016} to estimate drawdowns in wells inland from the well field is problematic, and appears to over-estimate them, as well as the size of the cones of depression. This would also have the effect of underestimating OWP. The combined effect of: (1) the model setting MSL at 0 instead of +3, which would increase OWP; (2) the results of extrapolating the TSW results to higher flows; (3) OWP estimates based on TSW results already take into account a seaward gradient in the Dune Sand Aquifer; and (4) the likely very low increase in OWP from capturing a portion of the Dune Sand Aquifer recharge indicates that the changes in gradient would not likely result in an OWP outside of the range of 90 to 99 percent derived from the different methods described above. A worst-case scenario estimates the OWP at 85 percent. However, due to the lack of consensus on the CSM inland from MW-7S and questionable modeling approach for the Dune Sand Aquifer and FO-SVA in this area, this is only a range of estimates. Additional data from borings and/or wells should be obtained from inland of MW-7S to determine whether CSM-1 or CSM-2 applies. The NMGWM^{2016} should be revised accordingly and run in non-superposition mode to determine an accurate representation of the amount of fresh water extracted from the test well (under both definitions of fresh water).

2. **<u>Analysis – Effects of recent monitoring data and modeling to determine the extent and volume of fresh water extraction</u>: If the above-reference data and studies are adequate to determine the extent and volume of fresh water extraction, do the recent data and studies, including the AEM study, show that freshwater extractions would result in greater adverse effects to the area aquifers than were identified in the Final EIR/EIS? Additionally, would the project extract fresh water from the Dune Sands Aquifer so as to interfere with recharge or to increase seawater intrusion into that aquifer?**

The recent data and studies, including the AEM study,[(6)] do not demonstrate a significant new understanding of the distribution of fresh water not already identified in the Final EIR/EIS. Water levels in the MRWSP monitoring wells have increased from 1 to 5 feet in the Dune Sand Aquifer and 180/400-Foot Aquifers since 2017, in response to above-average rainfall, not a significant change, and likely to be reversed with the inevitable onset of drier weather.

To the extent that water levels have increased, in particular the greatest increase (approximately 5 feet) for the Dune Sand Aquifer at MW-7S, there is a steepening of the seaward gradient and a slight increase in fresh water flowing seaward from the MW-7S area. Some portion of this additional fresh water will likely be extracted by the project well field.

Several of the predictions of the capture area and drawdowns inland from the well field made using the NMGWM^{2016} do not accord with the TSW results:

- The cones of depression appear to be too large, particularly in the Dune Sand Aquifer;
- Drawdown in the MW-S and MW-M wells does not stabilize until 2 to 3 years after the beginning of pumping in contrast to the stabilization of water levels within 2 months that occurred in the TSW pumping and the statement in the Final EIR/EIS that, "The development of the capture volume occurs much more rapidly

than the establishment of a steady-state salinity within the capture volume. While the boundaries of the capture volume evolve fairly quickly to a steady-state configuration (**over a period of a few months**)[*emphasis added*], the salinity within the capture volume takes several years to evolve to steady-state conditions";**(Appendix H in 7a)** and

- Predicted drawdowns are much greater than those estimated by extrapolating the TSW results.

Regarding the last point, using a conservative application of the principle of super-position/image wells described previously, pumping from the well field at 24.1 MGD compared to the TSW pumping of 2,000 gpm (2.88 MGD) should produce a maximum increase in drawdown of 24.1/2.88, or 8.37 times the drawdown seen at any given well in the TSW pumping. Thus, the drawdown observed at MW-4S of 0.3 feet, and at MW-4M of 0.2 feet, should increase to 2.5 and 1.7 feet respectively. However, the values from using the NMGWM^{2016} are 6.5 and 6 feet, respectively. And the drawdown values for MW-7S, which had zero drawdown in the TSW pumping, are not modeled correctly. As stated in the Final EIR, Appendix E2, pages 24-25:

> "The drawdown and drawdown recovery determined from measured water levels during and after cessation of test slant well pumping are plotted with the corresponding model-calculated drawdown in Figure 4.6. Additionally, the model-calculated drawdown from the NMGWM2015 and from a smaller focus area model developed by others (the CEMEX model) 7S is plotted in Figure 4.6." and, "Specifically, Figure 4.6 shows that drawdown **was not observed in MW-7S** [*emphasis added*]".

Zero drawdown from the TSW at MW-7S x multiplied by 8.37 for the 24.1 MGD scenario is zero. This compares to a drawdown of 3.5 feet calculated by the model. This indicates that the model over-predicts drawdowns from the well field pumping. All else being equal, this would result in an over-prediction of fresh water capture and an under-prediction of OWP. For a definitive analysis, more data is needed east of MW-7S and NMGWM^{2016} needs to be revised, as mentioned previously.

<u>Task 3 – Possible project modifications to avoid or reduce potential effects</u>: Various parties have proposed modifying two project components – the well intake locations and the proposed project's monitoring requirements – to avoid or reduce effects on fresh water and to better detect and respond to possible effects on nearby aquifers.

1. **<u>Data adequacy and analysis regarding well intake locations</u>: The monitoring data collected during the test well pump tests were based on the screened sections of the well being located landward of the shoreline. If the above reviews conclude that the project will affect fresh water in the aquifers at levels beyond those identified in the Final EIR/EIS, and considering factors such as vertical and horizontal conductivity at the proposed well field location and the extent of the aquifers offshore, are there sufficient data to determine how much less fresh water would be extracted if the screened portions of the wells were sited entirely seaward of the shoreline – i.e., if the wells were drilled to lengths that placed their screened sections entirely beneath the floor of Monterey Bay? If so, would the amount of fresh water extracted be within the projections provided in the Final EIR/EIS?**

As mentioned in the response to Task 2.1, there are inadequacies in the data and studies preventing an accurate representation of adverse effects, and potential interference with fresh water recharge, potential outcomes can be approximated. The limitations to these approximations and to a more accurate representation are described below.

The answer to this question depends on filling two data gaps: (1) the lack of hydrogeologic data east of MW-7S as described previously, and (2) the absence of any data seaward of the present TSW. At a minimum, the landward data gap should be addressed and NMGWM[2016] modified to incorporate the new data. A new test well should be drilled to address the seaward data gap, or at least a test boring, to establish geologic conditions beyond the TSW extent. About all that can be said is that *if* the geology encountered by the TSW continues seaward, less fresh water would be extracted.

2. **Data adequacy and analysis regarding monitoring: Several parties have developed a monitoring plan meant to detect and respond to the intake wells' effects on the area aquifers. Based on the above reviews, is the proposed monitoring plan adequate to detect the project's known or expected effects on fresh water withdrawals from the aquifers and on the rate of seawater intrusion? If not, what additional monitoring measures would be needed to detect these effects?**

The monitoring plan[(9)] proposed is marginally adequate to detect the project's known or expected effects on fresh water withdrawals from the aquifers and the rate of seawater intrusion. Continuous monitoring of water levels and electrical conductivity in the well clusters in the proposed well field, each cluster with wells screened in the Dune Sand Aquifer and the 180/400-Foot Aquifer, will be able to track the position of the saltwater/freshwater interface, regardless of how fresh water is defined.

Installing two additional monitoring well clusters inland of MW-7 would assist in determining the continuity of the FO-SVA in that area where currently there is no data. This would assist in modifying the NMGWM[2016] to better predict groundwater capture areas in the Dune Sand Aquifer and the 180-Foot Aquifer, as well as OWP captured by the pumping well field.

RECOMMENDATION

To obtain a more accurate and definitive groundwater capture zone and OWP estimates due to proposed pumping from the MRWSP well field, it is recommended that additional hydrogeologic data be obtained from the 2 square-mile area east of MW-7S so that a single CSM can be accepted to represent that area. In addition, the area west of MW-7, between MW-4 and MW-7, should be investigated to determine potential aquitards contiguous with those at MW-7, and vertical groundwater gradients between the Dune Sand Aquifer and 180-Foot Aquifer. The new data should be incorporated into NMGWM,[2016] which should be modified as follows:

- Change the thickness of the FO-SVA (Layer 3) inland from MW-7, and configure so that the top and bottom of Layer 3 approximates the configuration depicted in the geologic cross-section, such that the top resembles a "stair-step" surface;
- Potentially divide Layer 2 into two or more layers;
- Increase the HK of the Dune Sand Aquifer (Layer 2) in parameter Zones 16 and 20, currently modeled with HK of 2 and 4 ft/day, respectively, to values in the range of 50 to 200 ft/day, more akin to the actual HK for dune sand, and in the middle of the range in values from other sources (Figure 27); and

- Modify HK and VK as appropriate in Layers 2, 3, and 4 of the model in the vicinity of the well field, such that drawdowns in more distant wells, particularly MW-4 and MW-7, are in accord with those estimated from a conservative extrapolation of the TSW drawdown data.

Along with these changes, the model should be run in non-superposition mode in a range of scenarios, and flow lines plotted to illustrate the revised capture pattern. Mass balance information should be obtained for those portions of the model affected by groundwater flow to the well field, and from the Dune Sand Aquifer to the 180-Foot Aquifer, and used to calculate new fresh water capture and OWP estimates.

CLOSING

Weiss Associates' work at the California-American Water test slant well site and vicinity was conducted under my supervision. To the best of my knowledge, the data contained herein are true and accurate, based on what can be reasonably understood as a result of this project while satisfying the scope of work prescribed by the client for this project. The data, findings, recommendations, specifications, and/or professional opinions were prepared solely for the use of the California Marine Sanctuary Foundation and the California Coastal Commission in accordance with generally accepted professional engineering and geologic practice. Weiss makes no other warranty, either expressed or implied, and is not responsible for the interpretation by others of the contents herein

Sincerely,
Weiss Associates

William A. McIlvride

William A. McIlvride, PG, CEG, CHG
Senior Project Hydrogeologist

Attachment A – Figures

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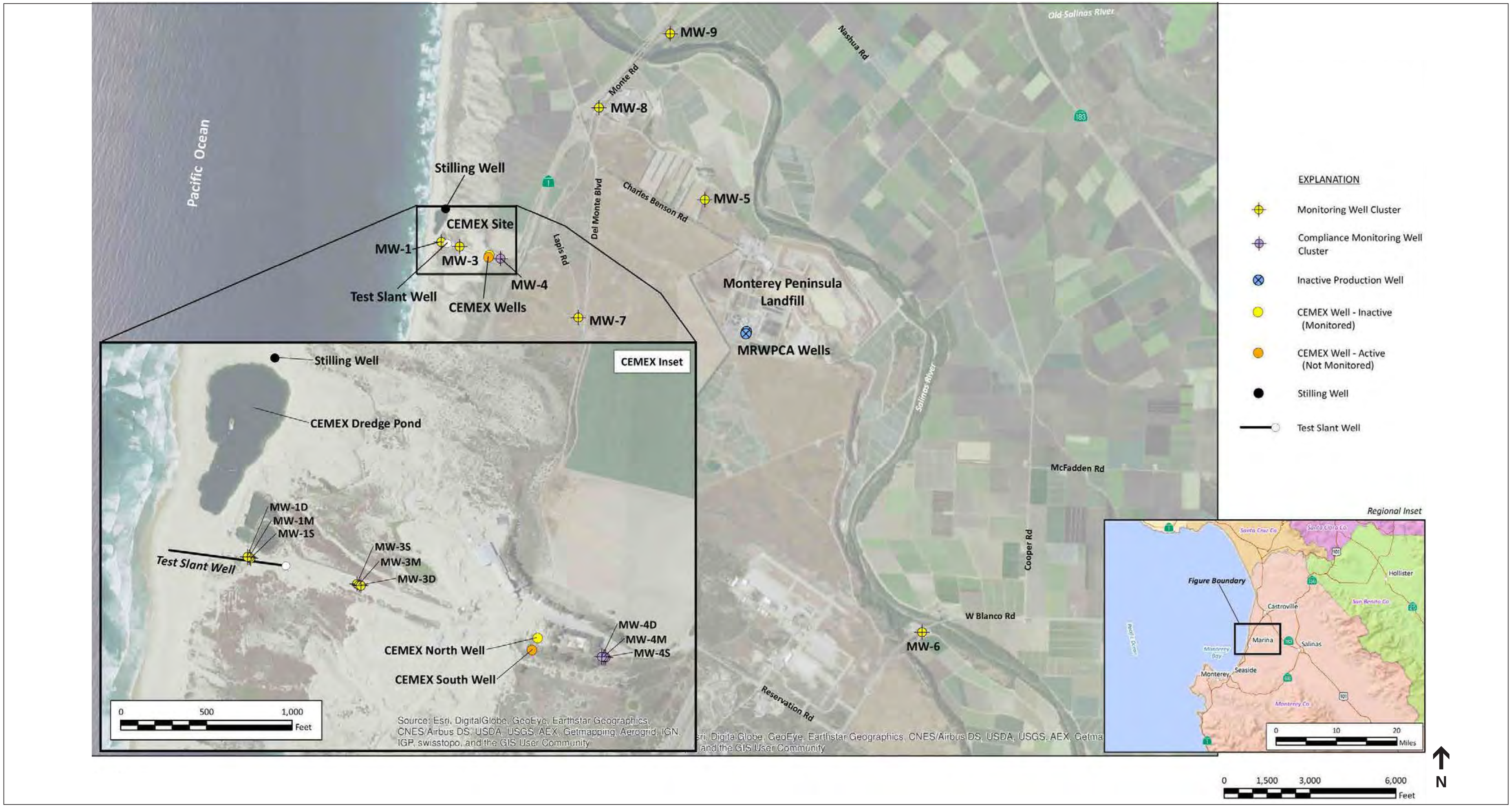
ATTACHMENT A

FIGURES



SOURCE: GeoScience, 2016

Monterey Peninsula Water Supply Project . 205335.01

Figure 4.4-9
Slant Well and Monitoring Well Locations

Figure 1

Groundwater Elevation in MPWSP MW-1

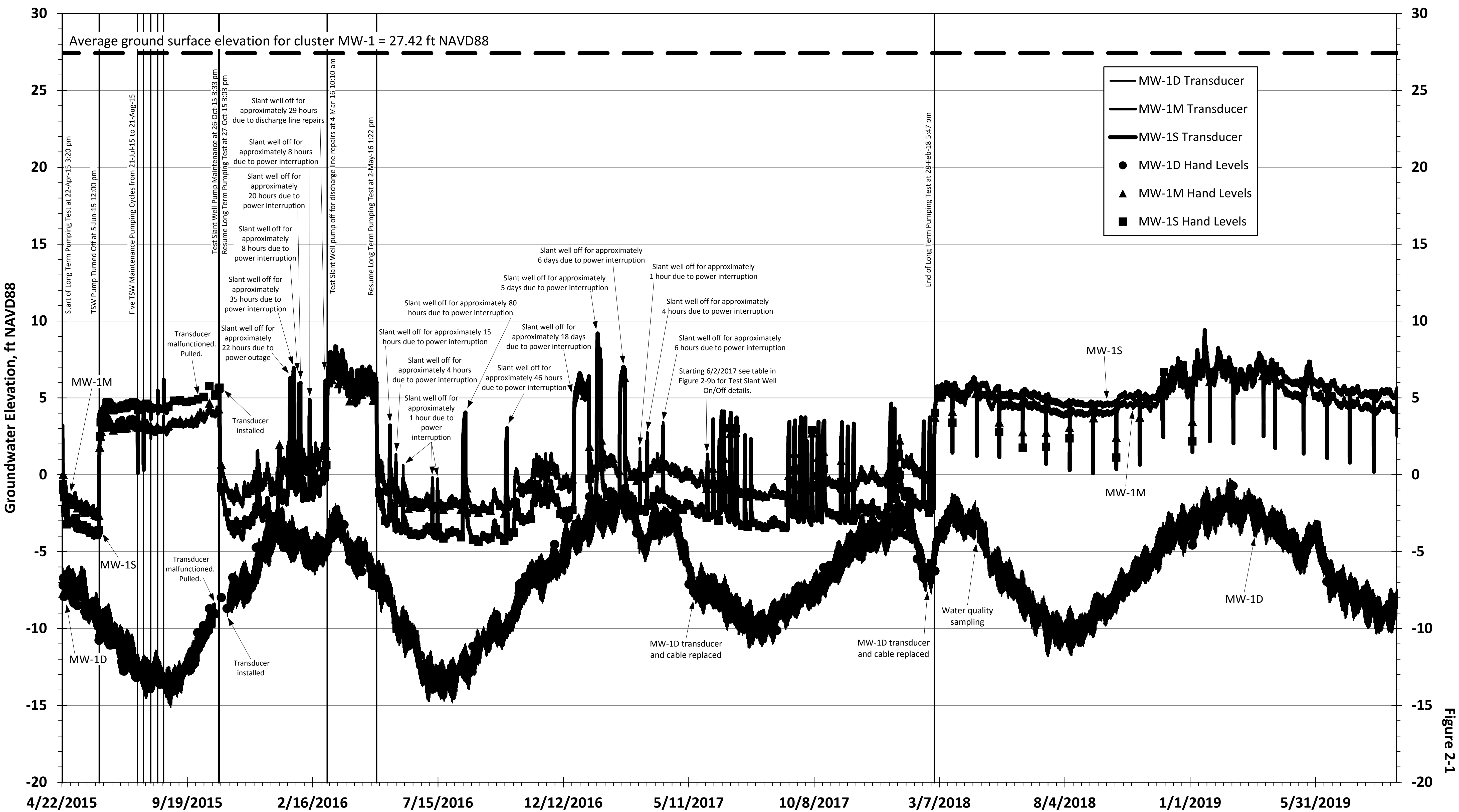


Figure 2

Groundwater Elevation in MPWSP MW-3

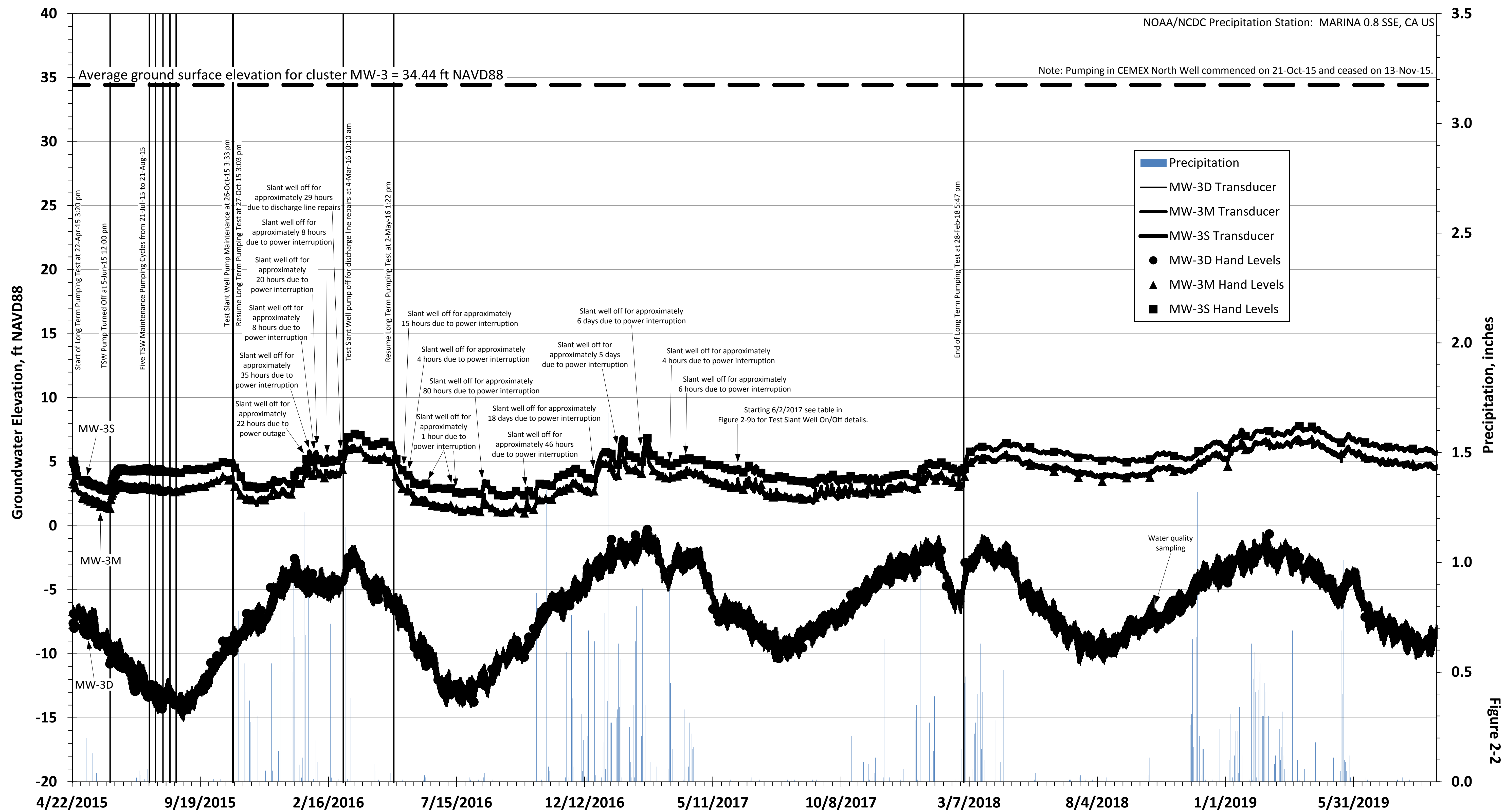


Figure 3

Groundwater Elevation in MPWSP MW-4

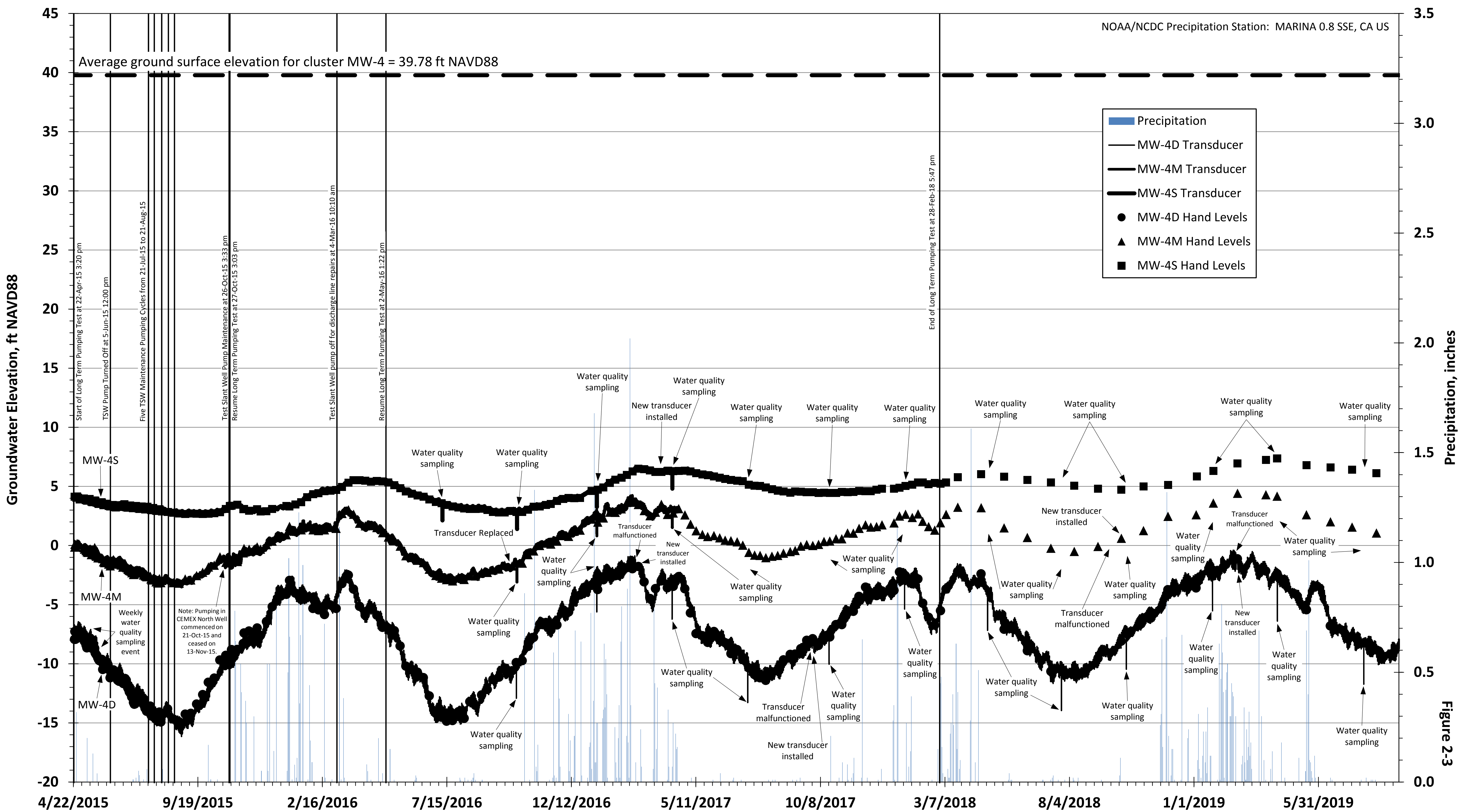
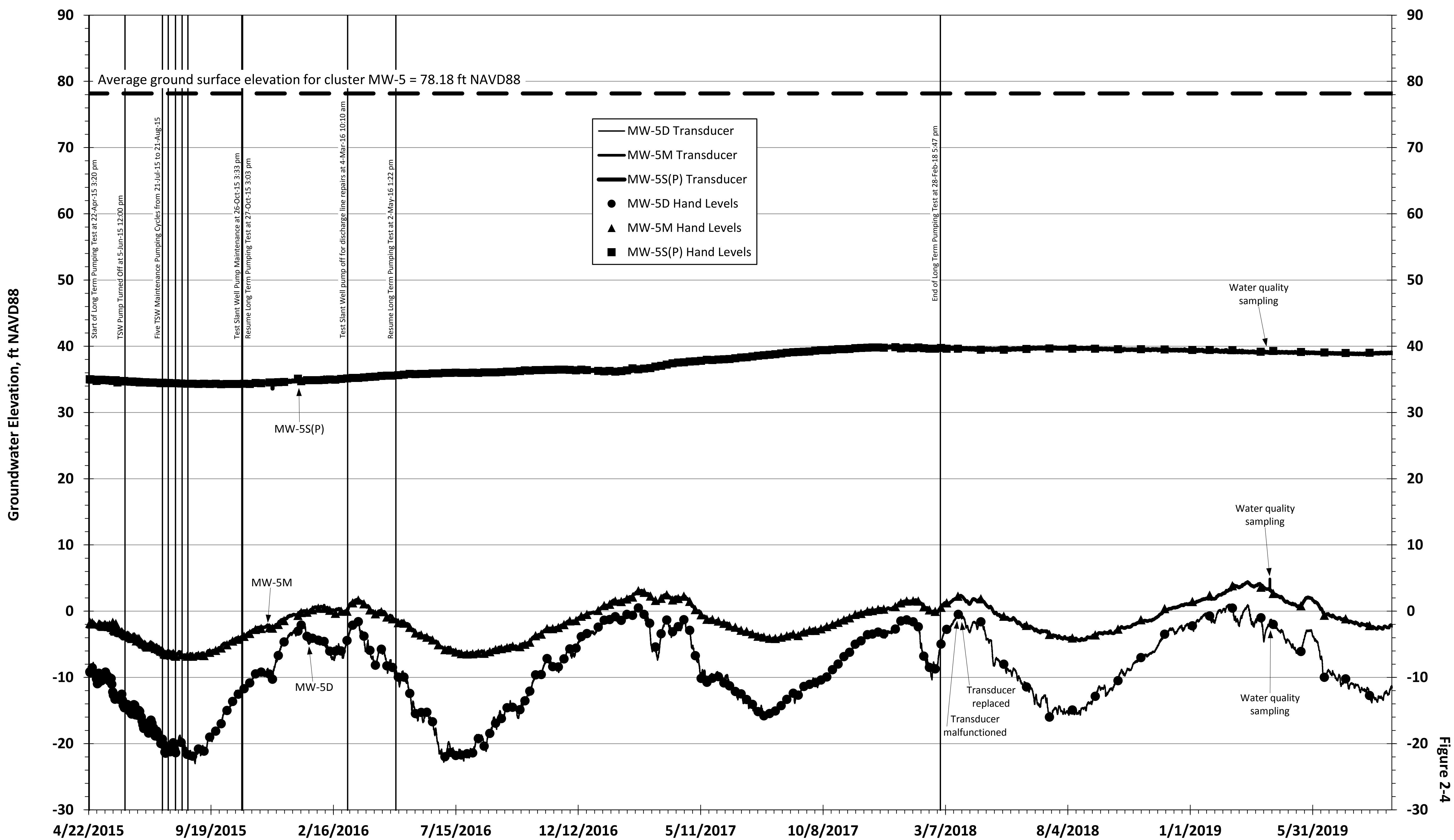


Figure 2-3

Figure 4

Groundwater Elevation in MPWSP MW-5



Groundwater Elevation in MPWSP MW-6

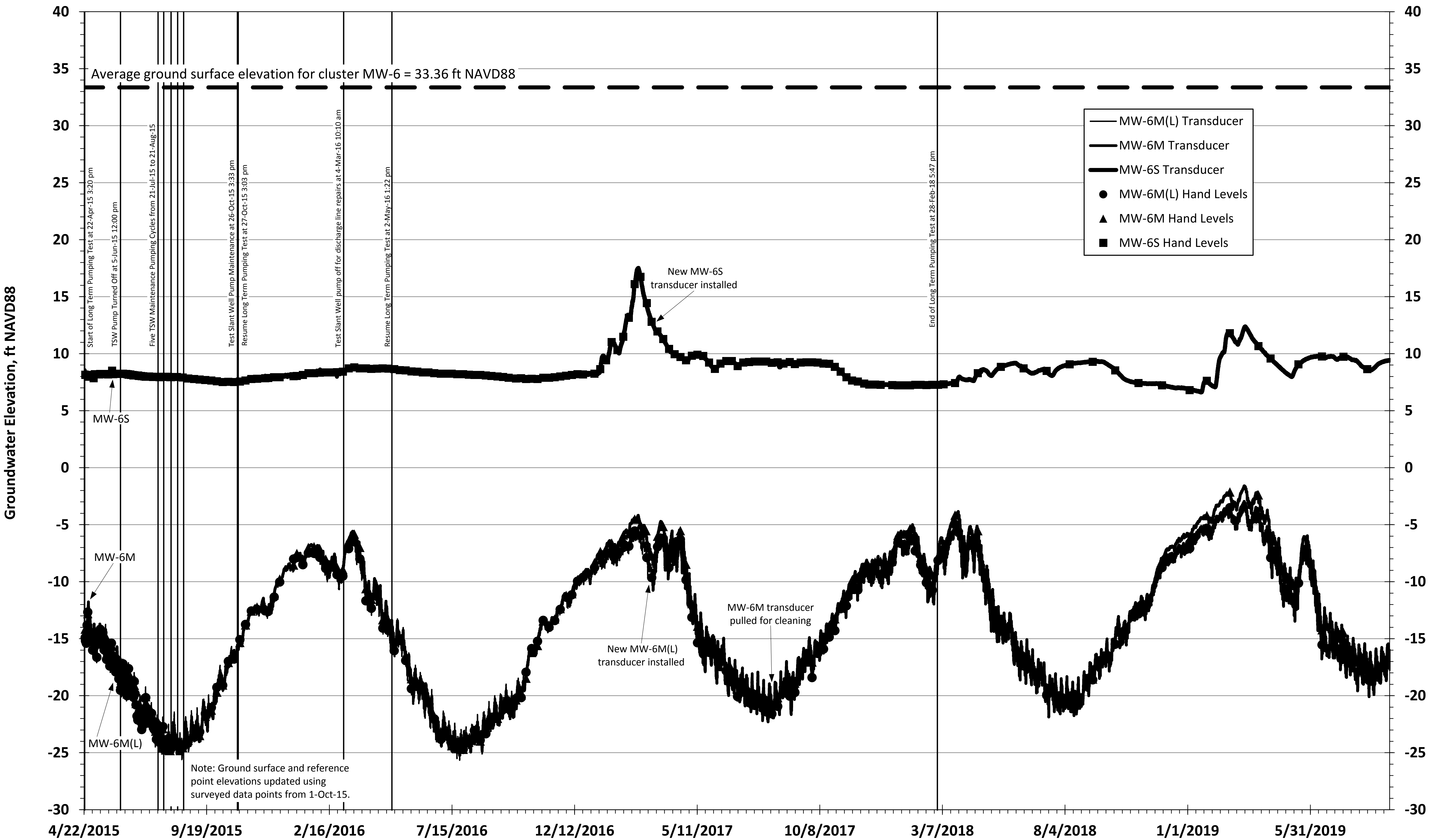
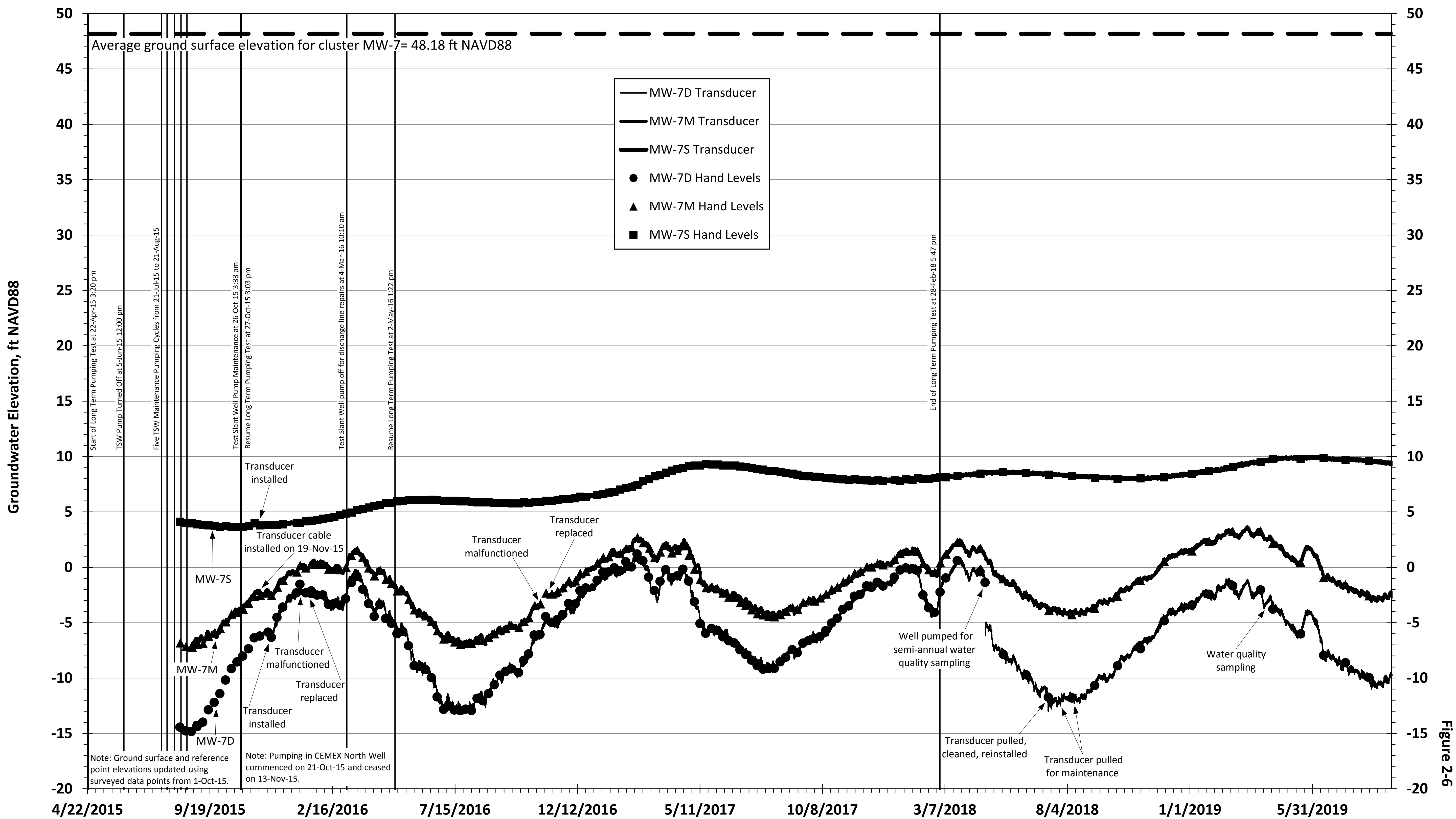


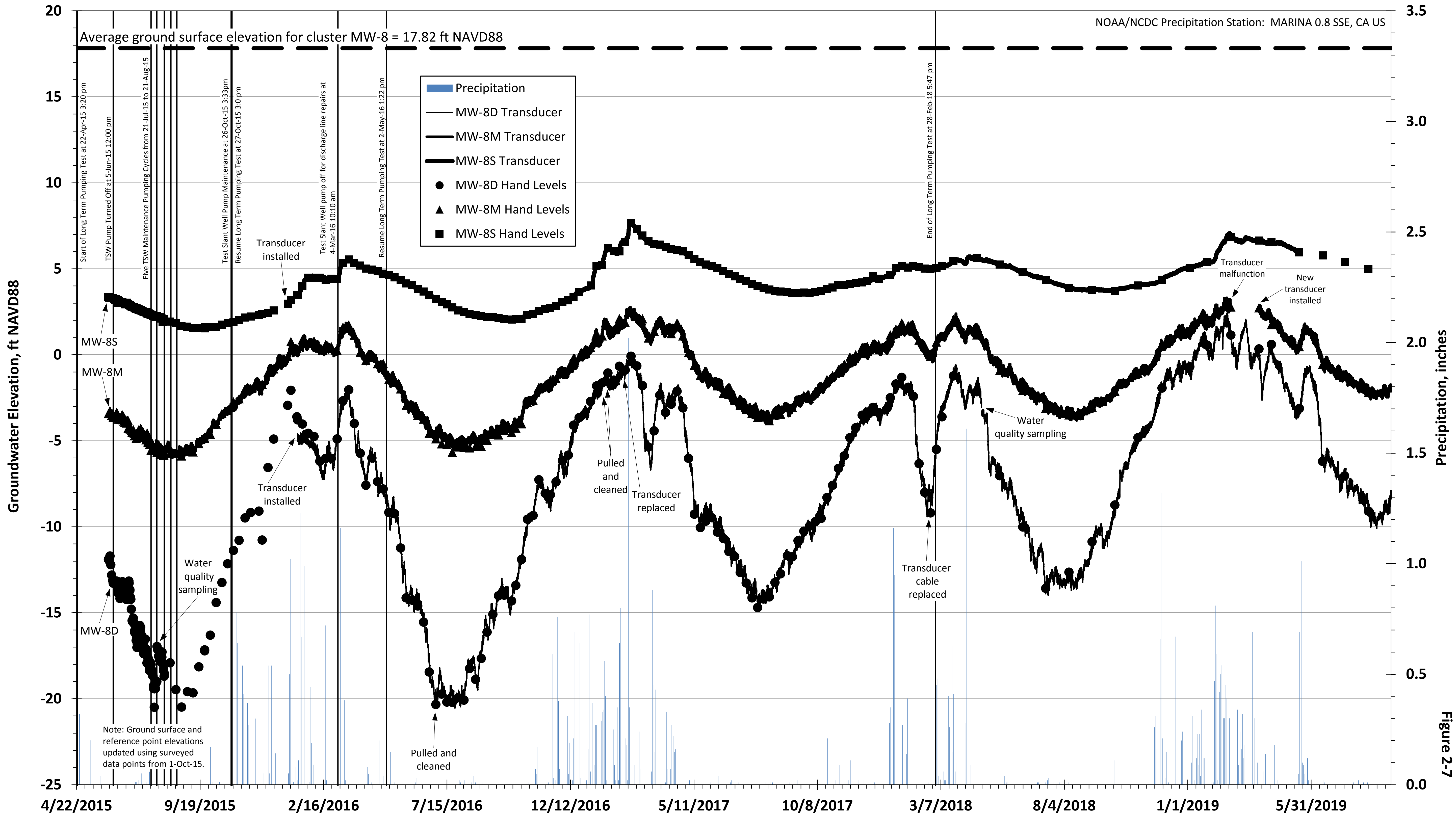
Figure 2-5

Figure 6

Groundwater Elevation in MPWSP MW-7



Groundwater Elevation in MPWSP MW-8



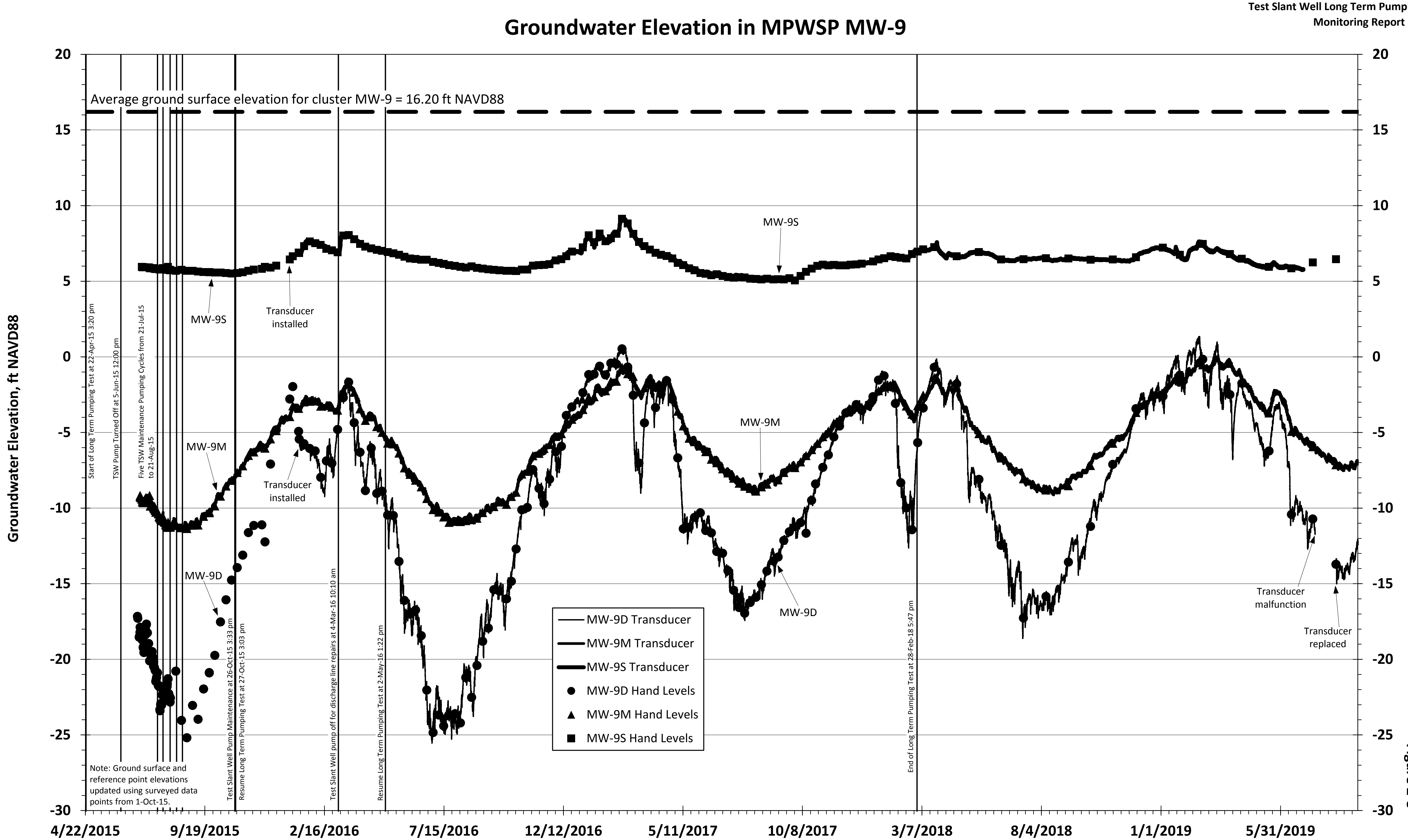

Groundwater Elevation in MPWSP MW-9
Groundwater Elevation, ft NAVD88
20
15
10
5
0
-5
-10
-15
-20
-25
-30
4/22/2015
9/19/2015
2/16/2016
7/15/2016
12/12/2016
5/11/2017
10/8/2017
3/7/2018
8/4/2018
1/1/2019
5/31/2019
Average ground surface elevation for cluster MW-9 = 16.20 ft NAVD88
Start of Long Term Pumping Test at 22-Apr-15 3:20 pm
TSW Pump Turned Off at 5-Jun-15 12:00 pm
Five TSW Maintenance Pumping Cycles from 21-Jul-15 to 21-Aug-15
Test Slant Well Pump Maintenance at 26-Oct-15 3:33 pm
Resume Long Term Pumping Test at 27-Oct-15 3:03 pm
Test Slant Well pump off for discharge line repairs at 4-Mar-16 10:10 am
Resume Long Term Pumping Test at 2-May-16 1:22 pm
End of Long Term Pumping Test at 28-Feb-18 5:47 pm
MW-9S
Transducer installed
MW-9M
MW-9D
Transducer malfunction
Transducer replaced
MW-9D Transducer
MW-9M Transducer
MW-9S Transducer
MW-9D Hand Levels
MW-9M Hand Levels
MW-9S Hand Levels
Note: Ground surface and reference point elevations updated using surveyed data points from 1-Oct-15.
Figure 2-8

Figure 9

CALIFORNIA AMERICAN WATER

Monterey Peninsula Water Supply Project
Test Slant Well Long Term Pumping Test
Monitoring Report No. 164

Groundwater Elevation in MPWSP MW-3

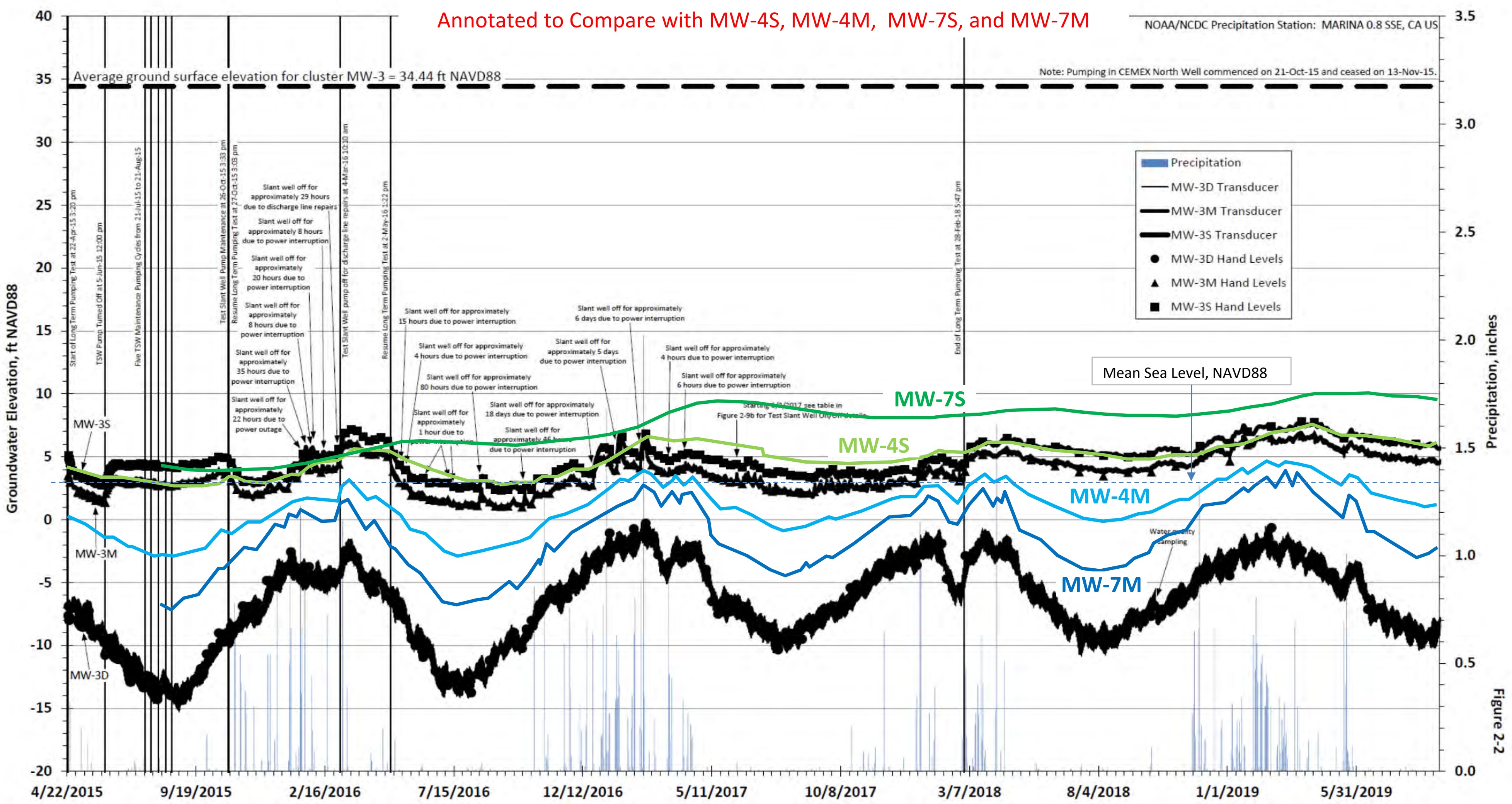
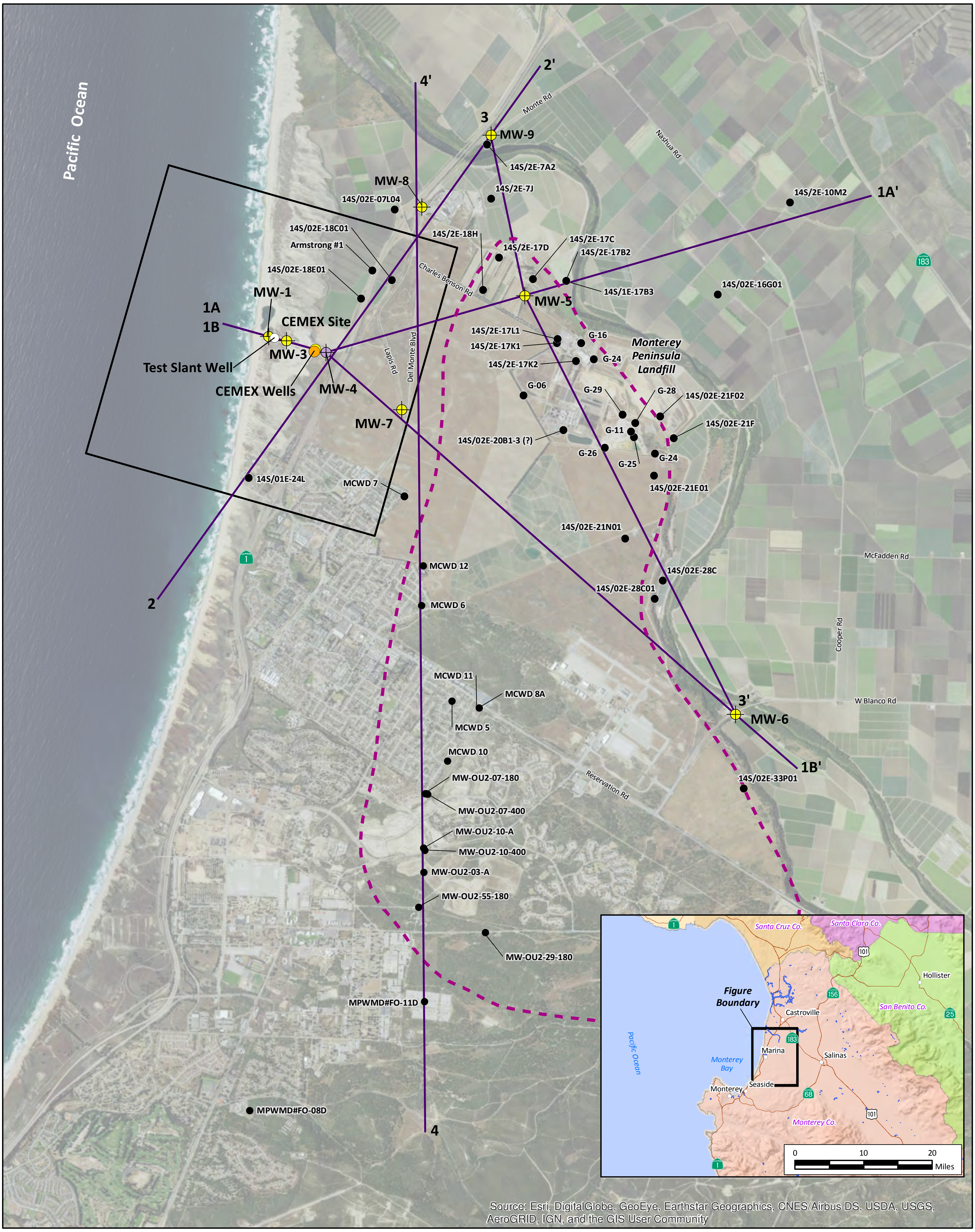


Figure 10

MONTEREY PENINSULA WATER SUPPLY PROJECT
MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE

CALIFORNIA AMERICAN WATER



W:\GIS_proj\mcwsp_cal_am\cal-am_CEMEX_model\Model_Calibration\10_Fig_2_x-sec_well_locs_port_2-17.mxd

EXPLANATION

- CEMEX Model Boundary
- 1 1' Cross-Section Location
- Fort Ord Salinas Valley Aquitard (FO-SVA) (GEOSCIENCE, 2016)
- Monitoring Well Cluster
- Compliance Monitoring Well Cluster
- CEMEX Well - Inactive (Monitored)
- CEMEX Well - Active (Not Monitored)
- Test Slant Well
- Other Well Used in Cross-Sections

NORTH

0 3,500 7,000 Feet

REGIONAL LOCATION MAP SHOWING WELL AND CROSS-SECTION LOCATIONS

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

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Figure 2

Figure 11

X:\Projects\MONTEREY AREA DESAL STUDIES\01a) Test Slant Well Project\01) Monitoring Wells\4) TM Monitoring Well Completion\03) Final TM Feb_17\Figures

Figure 12

CALIFORNIA AMERICAN WATER
MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REORT AND CEMEX MODEL UPDATE
GEOLOGIC CROSS-SECTION 1B-1B'
1B W-NW
1B' E-SE
CEMEX Site
Dune Complex - Highland Area
Salinas Valley
Elevation, ft NAVD88
Pacific Ocean
Deltaic Deposits (Qf?)
Older Dune Sand (Qod)
Terrace Deposits (Qt)
Qd
Older Dune Sand (Qod)
FO-SVA
180-Foot Equivalent Aquifer
180/400-Foot Aquitard
Terrace Deposits (Qt)
CEMEX North Well Screen Interval
CEMEX South Well Screen Interval
Aromas Sand (?) (Qar)
Salinas River
Flood Plain Deposits (Qfl)
Perched "A" Aquifer
SVA
Valley Fill (Qo)
180-Foot Aquifer
400-Foot Aquifer
Paso Robles Formation (QT)
MW-1
Test Slant Well
MW-3
CEMEX Well South
CEMEX Well North
MW-4
Cross-Section 2-2'
Highway 1
MW-7
Del Monte Blvd.
MCWD 7
14S/2E-21N1
14S/2E-28C1
W. Blanco Rd.
MW-6
Cross-Section 3-3'
14S/2E-33P1
Explanation
Holocene
Qfl
Qd
Pleistocene
Qo
Qt
Qod
Qf
Qar
Pliocene
QT
SVA Clay Layer
Clay Layer
Geologic Contact (approximate)
Wells
MPWSP Monitoring Well Screened Interval
Screened Interval from DWR Well Log
Well Lithology
Conductivity Induction Log Deep (CILD) [mmho/m]
Groundwater Elevation, ft NAVD88 10-Sep-2015)
Shallow Completion
Middle Completion
Deep Completion
34,500 Water Quality (TDS) Measurement, mg/L (February, March, April, and August 2015)
Horizontal Approximate Scale Feet
Vertical Approximate Scale Feet
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Figure 4
8-Feb-17
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Figure 13

X:\Projects\MONTEREY AREA DESAL STUDIES\01a) Test Slant Well Project\01) Monitoring Wells\4) TM Monitoring Well Completion\03) Final TM Feb_17\Figures

Figure 14

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE

GEOLOGIC CROSS-SECTION 3-3'

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Figure 6

X:\Projects\MONTEREY AREA DESAL STUDIES\01a) Test Slant Well Project\01) Monitoring Wells\4) TM Monitoring Well Completion\03) Final TM Feb_17\Figures

Figure 15

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE

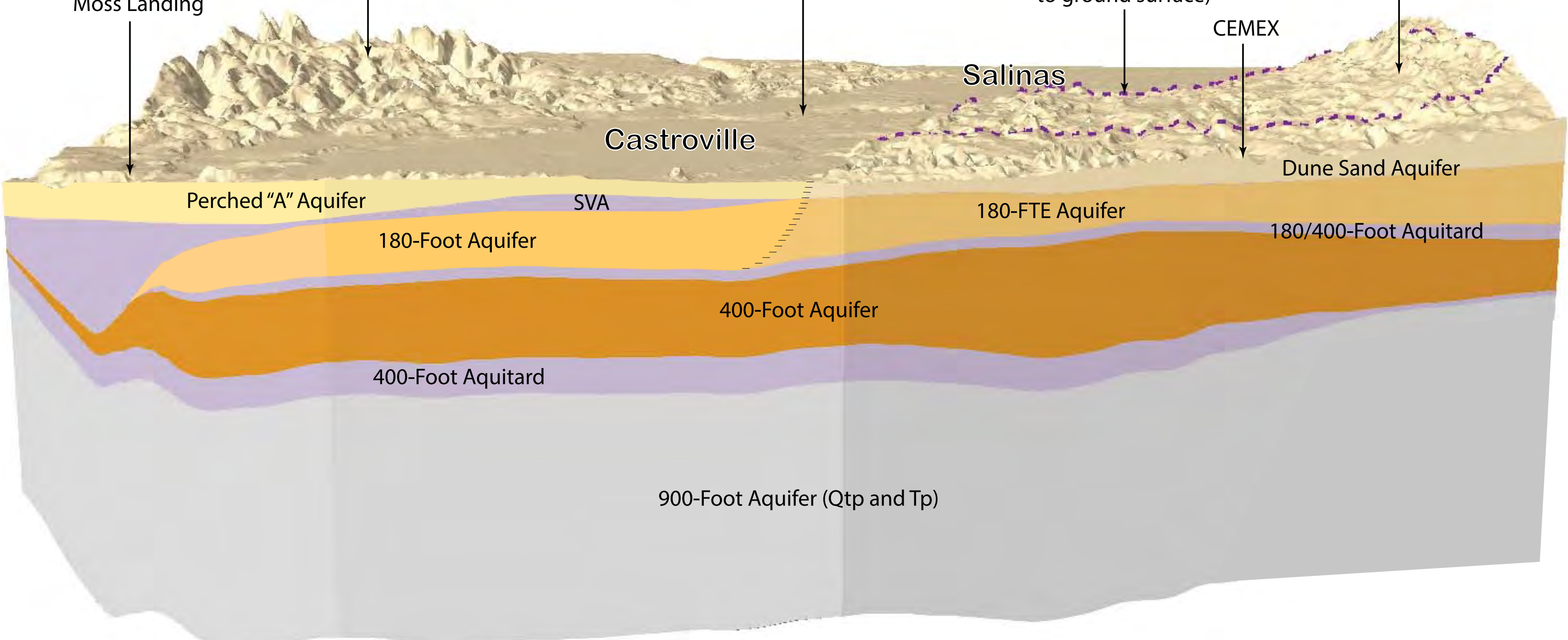
Figure 7

8-Feb-17

Figure 16

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE



Note: 10x Vertical Exaggeration

8-Feb-17

X:\Projects\MONTEREY AREA DESAL STUDIES\01a) Test Slant Well Project\01) Monitoring Wells\4) TM Monitoring Well Completion\03) Final TM Feb_17\Figures

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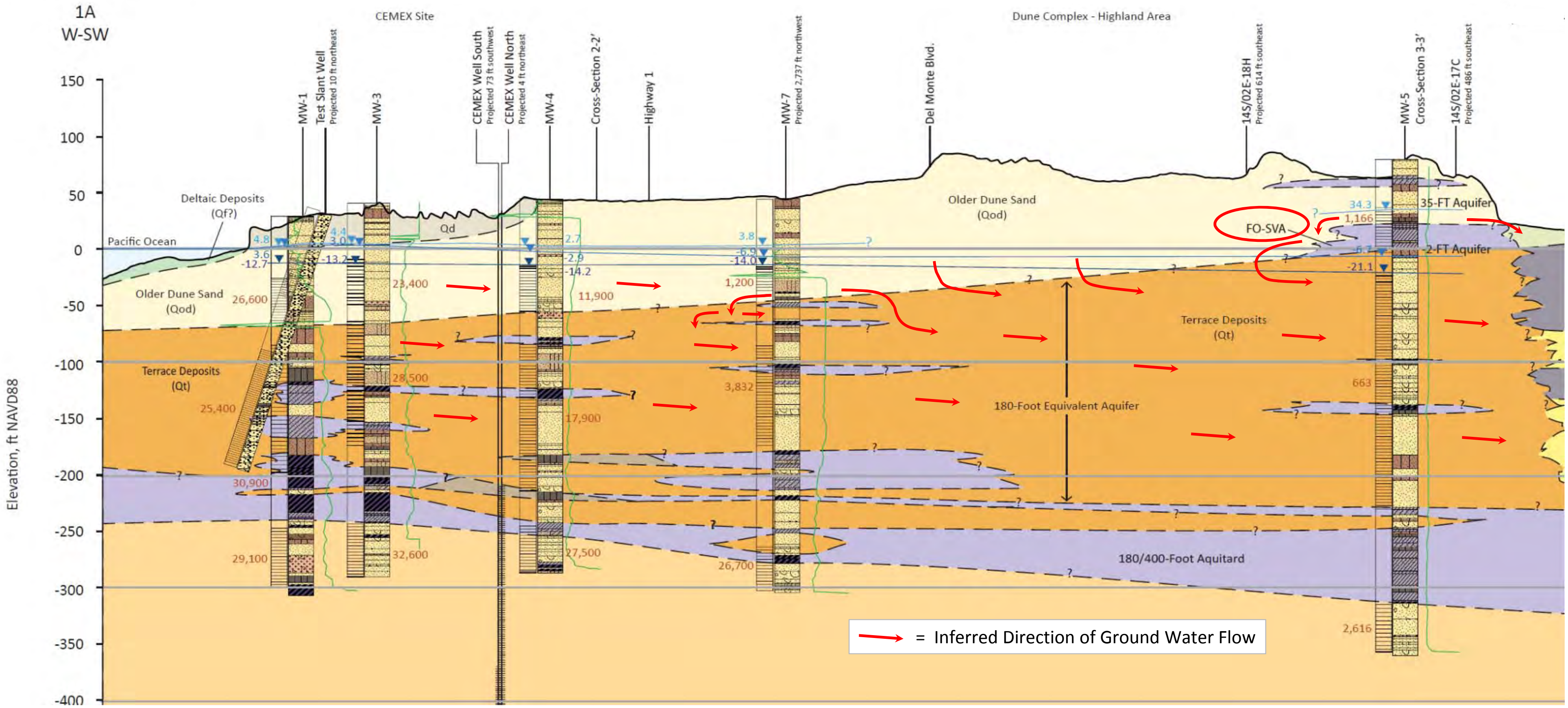
ILLUSTRATION OF AQUIFER ZONES

Figure 8

Figure 17

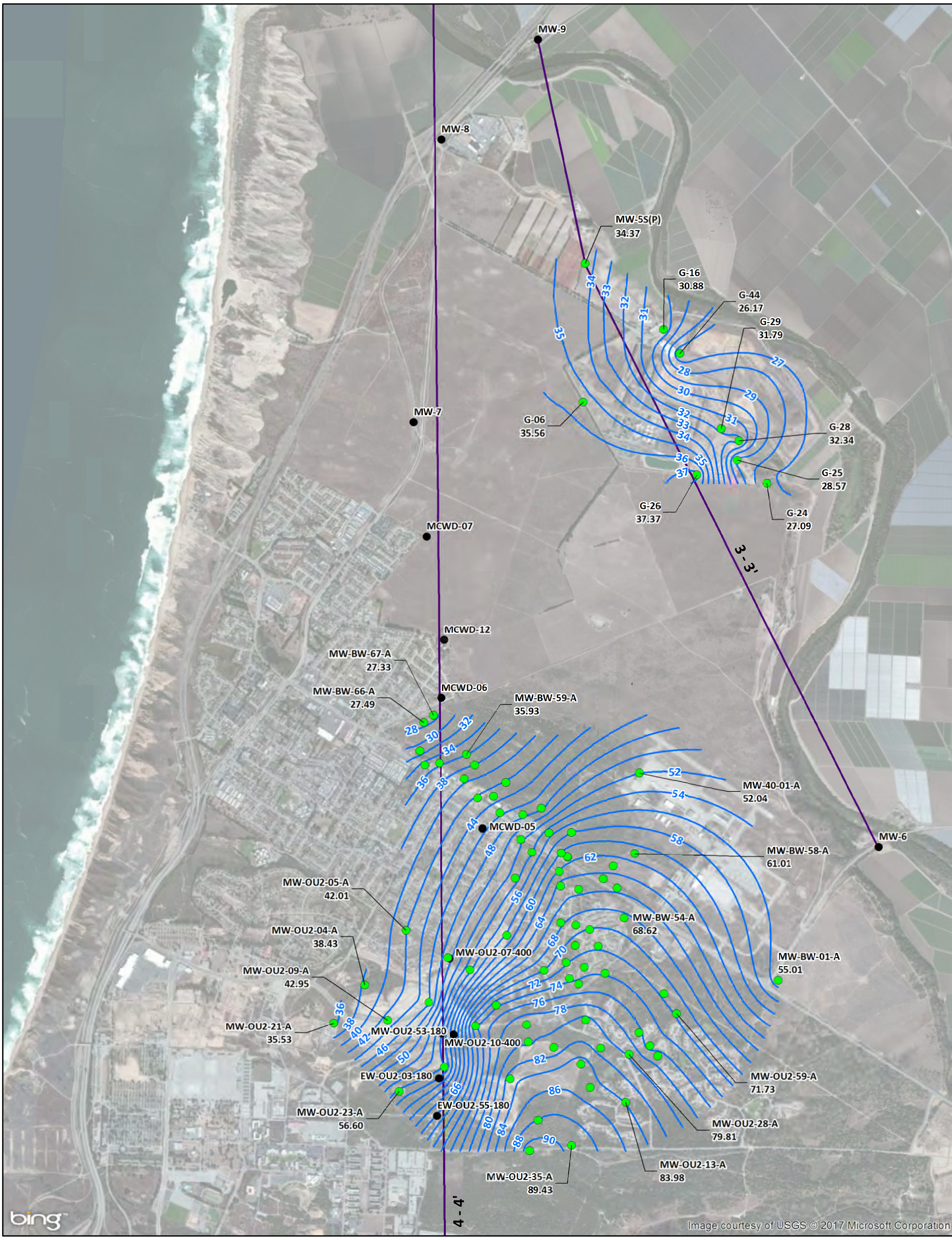
CALIFORNIA AMERICAN WATER

Conceptual Site Model (CSM-1) - Discontinuous Fort Ord Salinas Valley Aquitard (FO-SVA)



Excerpted from Figure 3, Geologic Cross Section 1A-1A', *Monterey Peninsula Water Supply Project - Monitoring Well Completion Report and Cemex Model Update* , Final EIR Appendix E3, annotations in red

Figure 18



W:\GIS_proj\mcwsp_cal_am\Cal-Am_CEMEX_model\Model_Calibration\10_Fig_9_Fort_Ord_A_MW-5s_and_Landfill_35ft_Aquifer_Fall_2015_2-17_v2.mxd

- Monitoring Well (used for contours)
- Other Well (not used for contours)
- —50— Groundwater Elevation (ft, NAVD88)
- Cross-Section Location

Note: Not all wells in the Fort Ord Area are labeled due to high density of wells.

GROUNDWATER ELEVATIONS - "PERCHED/MOUNDED AQUIFER" (USING FORT ORD "A" AQUIFER WELLS, MRWMD 35-FOOT AQUIFER WELLS, AND MPWSP MW-5S(P)) FALL 2015

NORTH

0 2,000 4,000 Feet

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

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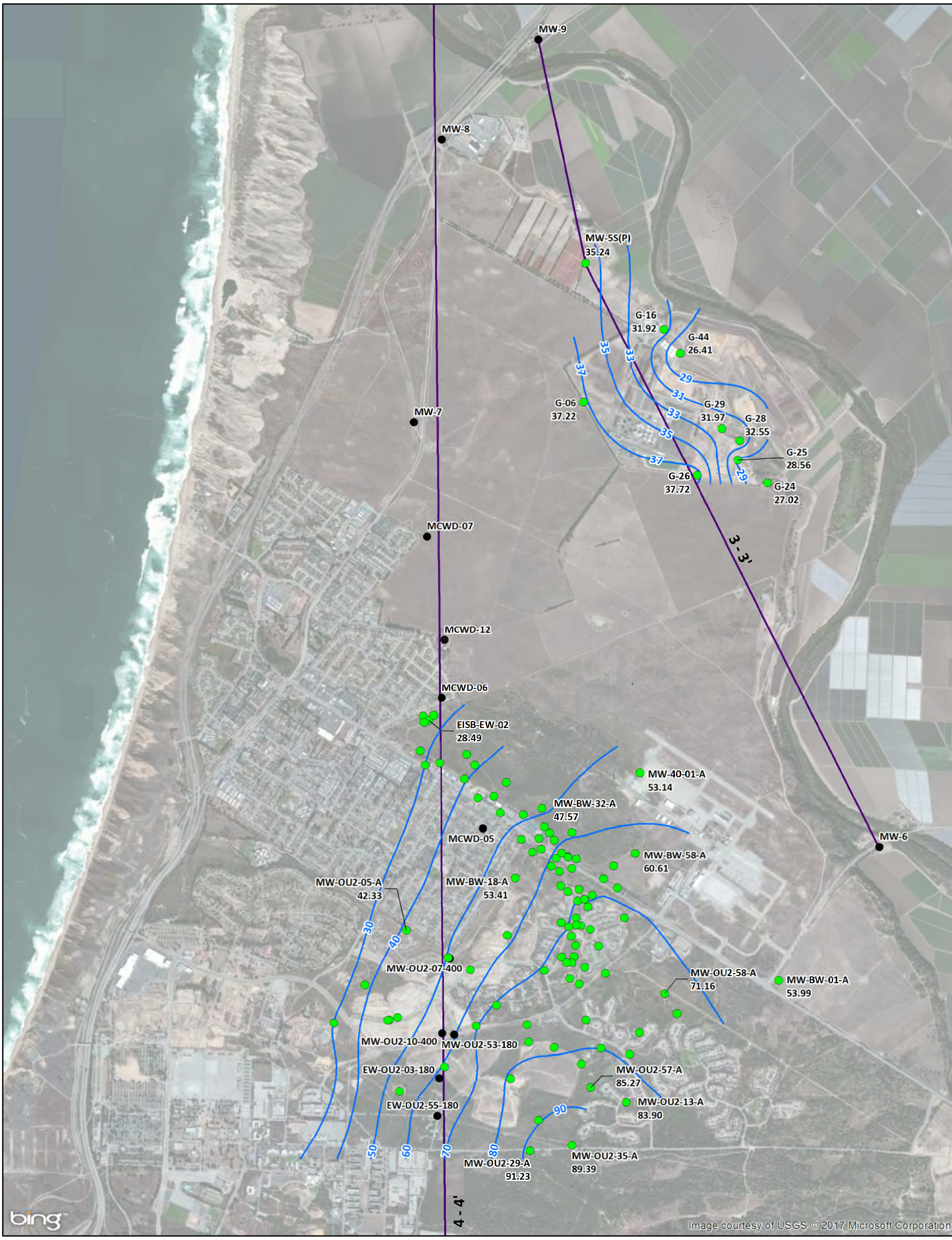
Figure 9

Figure 19

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE



- Monitoring Well (used for contours)
- Other Well (not used for contours)
- —50— Groundwater Elevation (ft, NAVD88)
- Cross-Section Location

Note: Not all wells in the Fort Ord Area are labeled due to high density of wells.

GROUNDWATER ELEVATIONS - "PERCHED/MOUNDED AQUIFER" (USING FORT ORD "A" AQUIFER WELLS, MRWMD 35-FOOT AQUIFER WELLS, AND MPWSP MW-5S(P)) SPRING 2016

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

NORTH

0 2,000 4,000 Feet

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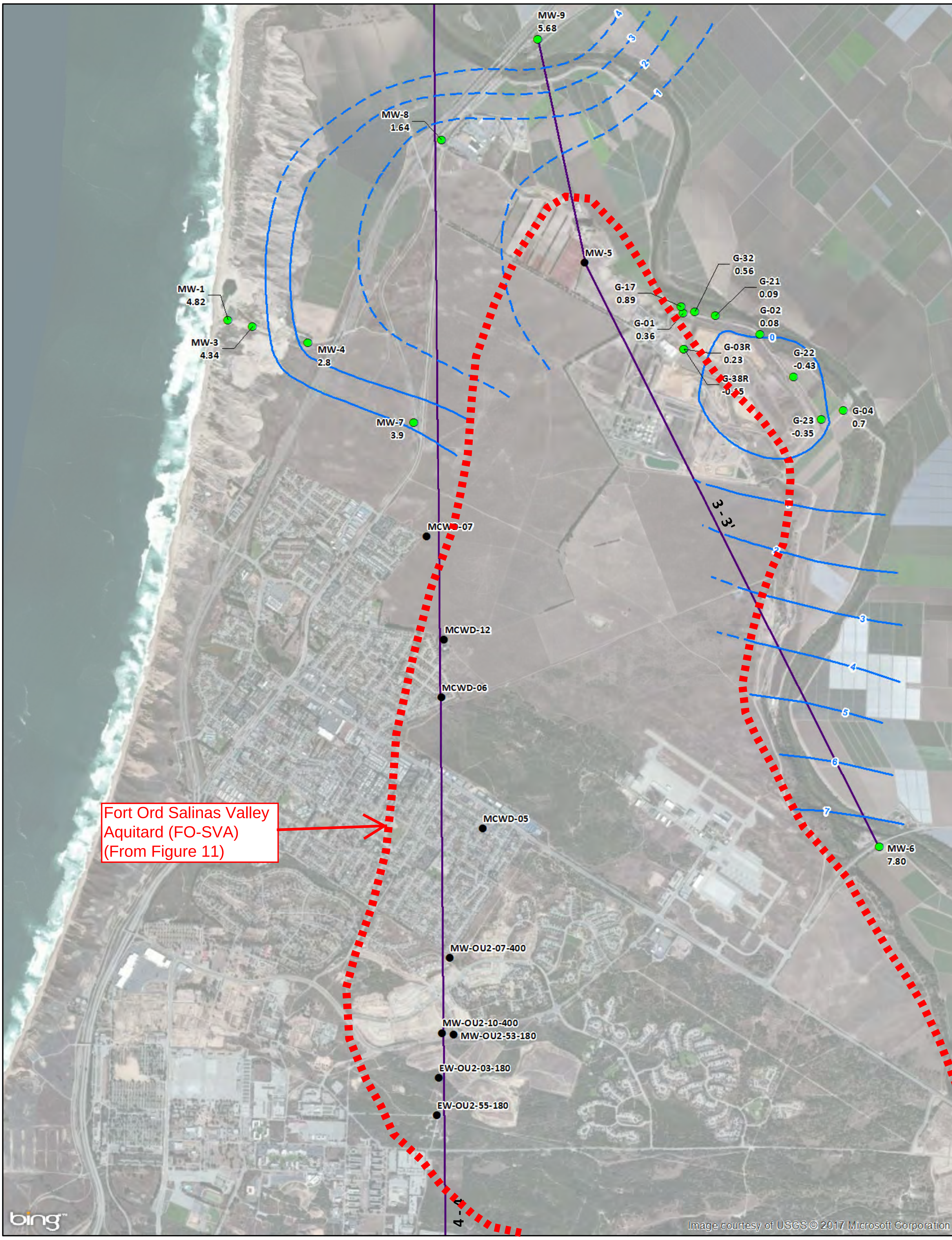
Figure 10

Figure 20



W:\GIS_proj\mcwsp_cal_am\cal-am_CEMEX_model\Model_Calibration\10_Fig_11_Fort_Ord_A_MWs_-2ft_Aquifer_Well_Fall_2015_2-17.mxd

- Monitoring Well (used for contours)
- Other Well (not used for contours)
- Groundwater Elevation (ft, NAVD88) Dashed where inferred
- Cross-Section Location

GROUNDWATER ELEVATIONS - "DUNE SAND AQUIFER" (USING MRWMD -2-FOOT AQUIFER WELLS AND MPWSP SHALLOW COMPLETIONS) FALL 2015

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

NORTH

0 2,000 4,000 Feet

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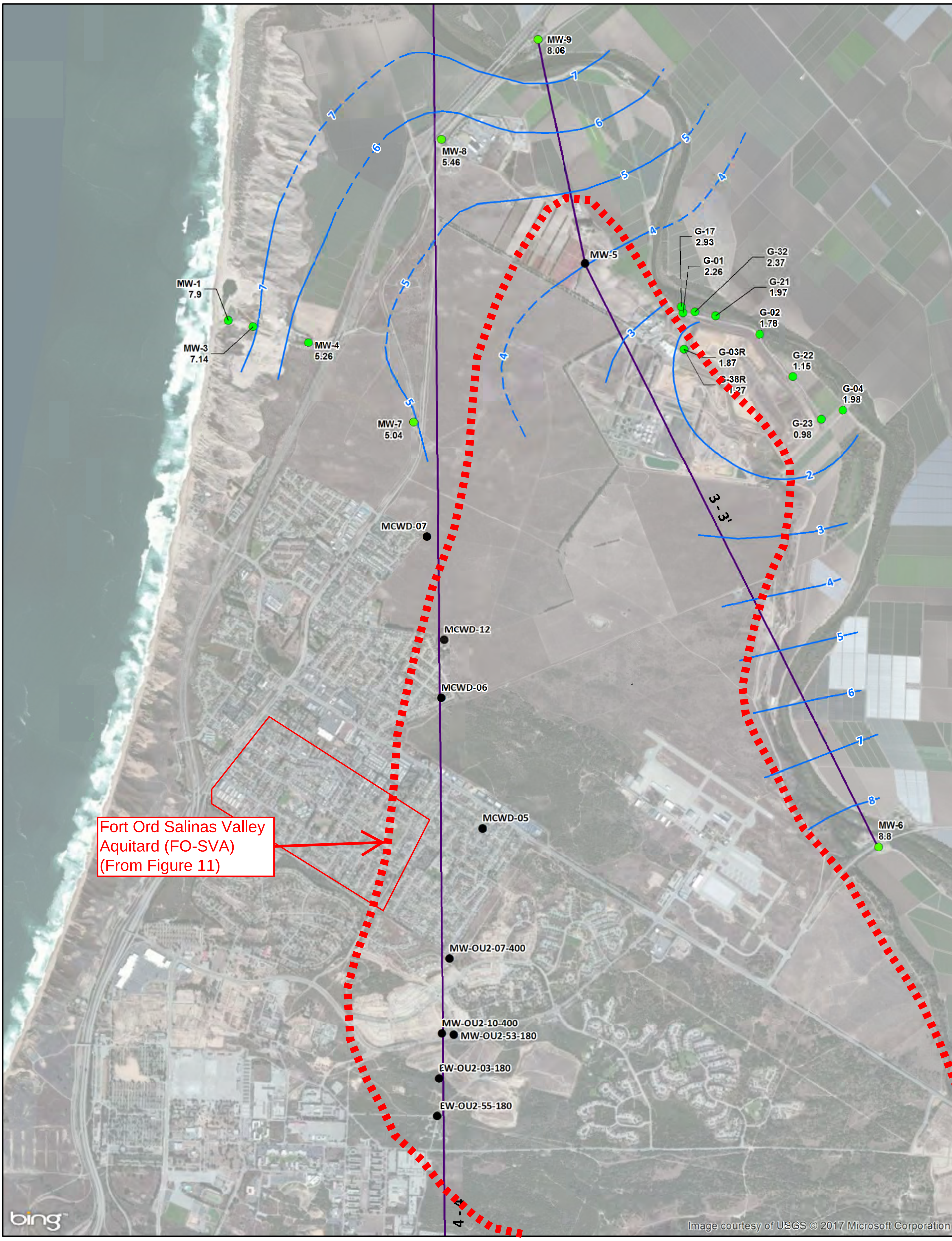
Figure 11

Figure 21

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE



W:\GIS_proj\mcwsp_cal_am\cal-am_CEMEX_model\Model_Calibration\10_Fig_12_Fort_Ord_A_MWs_-2ft_Aquifer_Spring_2016_2-17.mxd

- Monitoring Well (used for contours)
- Other Well (not used for contours)
- Groundwater Elevation (ft, NAVD88) Dashed where inferred
- Cross-Section Location

GROUNDWATER ELEVATIONS - "DUNE SAND AQUIFER" (USING MRWMD -2-FOOT AQUIFER WELLS AND MPWSP SHALLOW COMPLETIONS) SPRING 2016

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

NORTH

0 2,000 4,000 Feet

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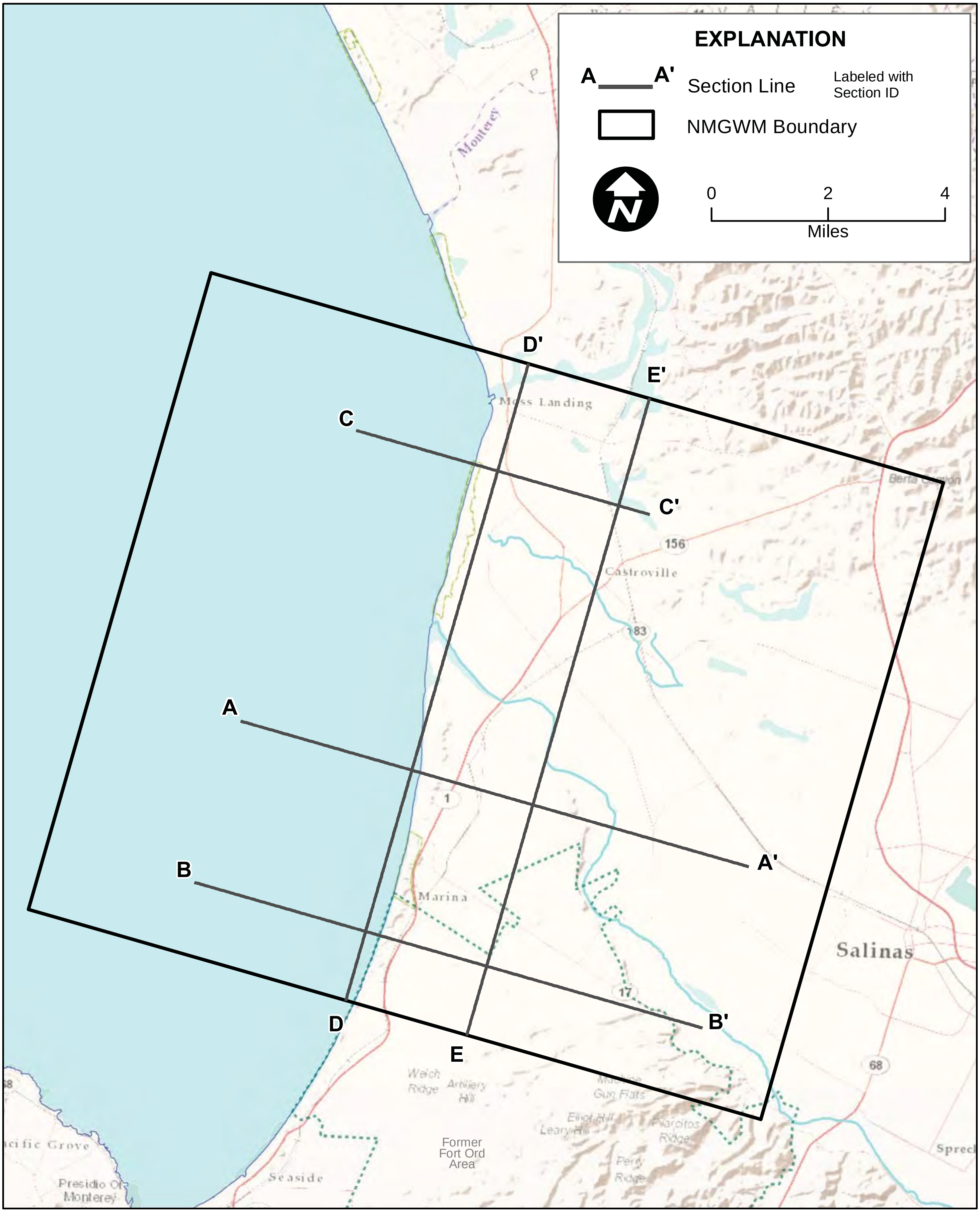
Figure 12

Figure 22



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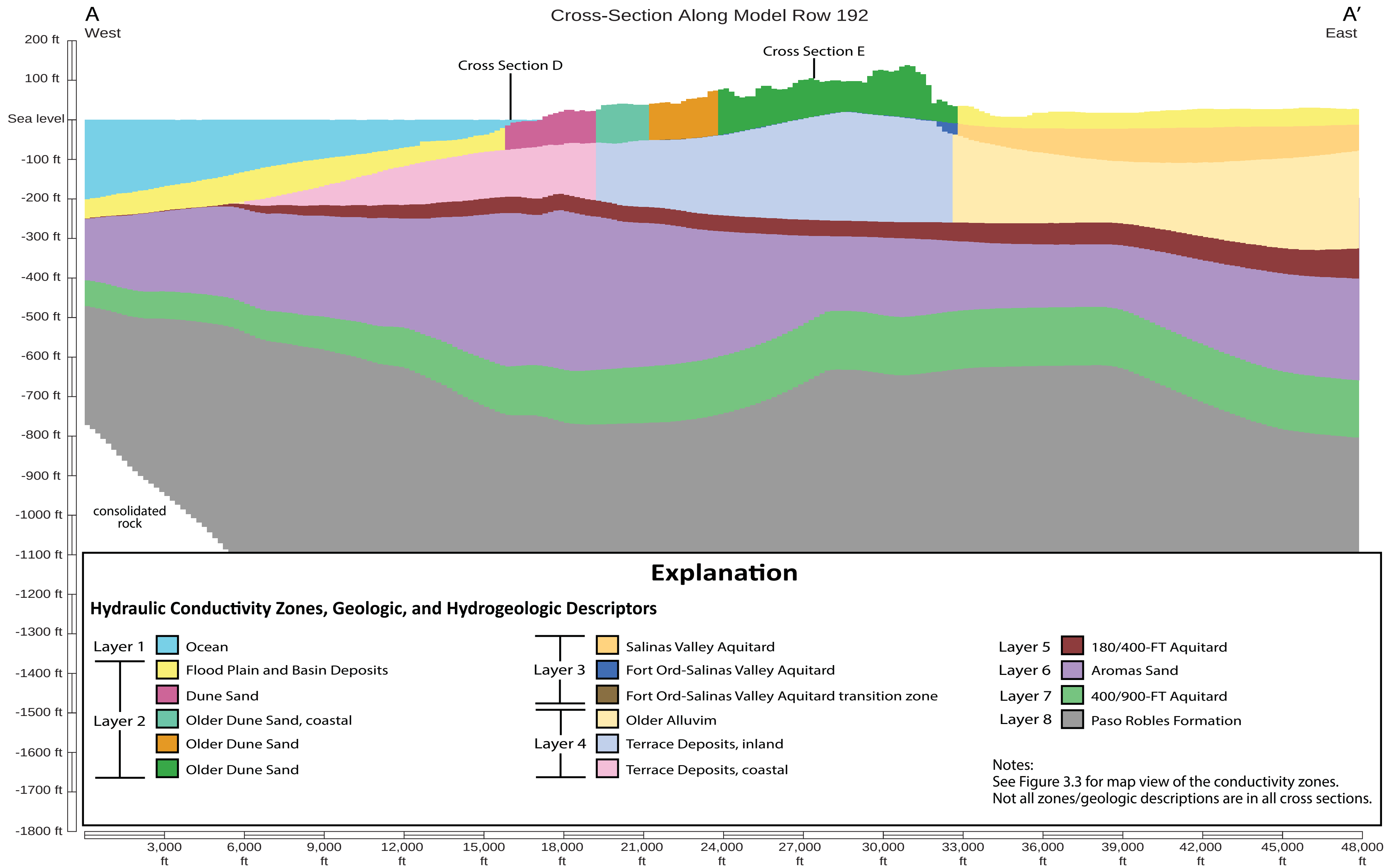
NMGWM[2016] section lines.

Figure 3.2a

PROJECT: 5073

DATE: 8/12/2016

Figure 23



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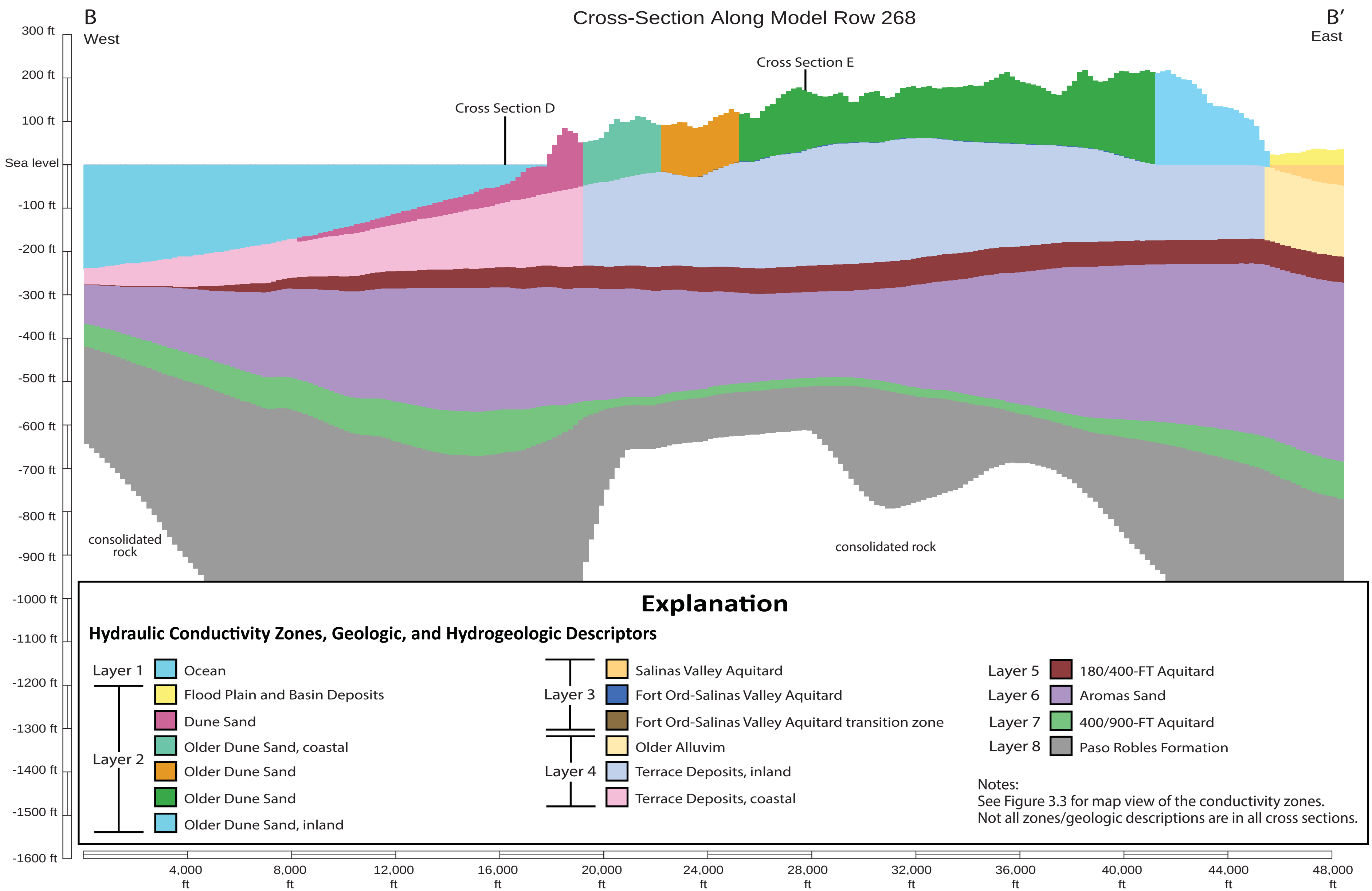
Section A-A′, NMGWM[2016].

Figure 3.2b

PROJECT: 5073

DATE: 11/8/2016

Figure 24



Explanation

Hydraulic Conductivity Zones, Geologic, and Hydrogeologic Descriptors

Layer 1	Ocean
Layer 2	Flood Plain and Basin Deposits
Layer 2	Dune Sand
Layer 2	Older Dune Sand, coastal
Layer 2	Older Dune Sand
Layer 2	Older Dune Sand
Layer 2	Older Dune Sand, inland
Layer 3	Salinas Valley Aquitard
Layer 3	Fort Ord-Salinas Valley Aquitard
Layer 3	Fort Ord-Salinas Valley Aquitard transition zone
Layer 4	Older Alluvim
Layer 4	Terrace Deposits, inland
Layer 4	Terrace Deposits, coastal
Layer 5	180/400-FT Aquitard
Layer 6	Aromas Sand
Layer 7	400/900-FT Aquitard
Layer 8	Paso Robles Formation

Notes:
See Figure 3.3 for map view of the conductivity zones.
Not all zones/geologic descriptions are in all cross sections.

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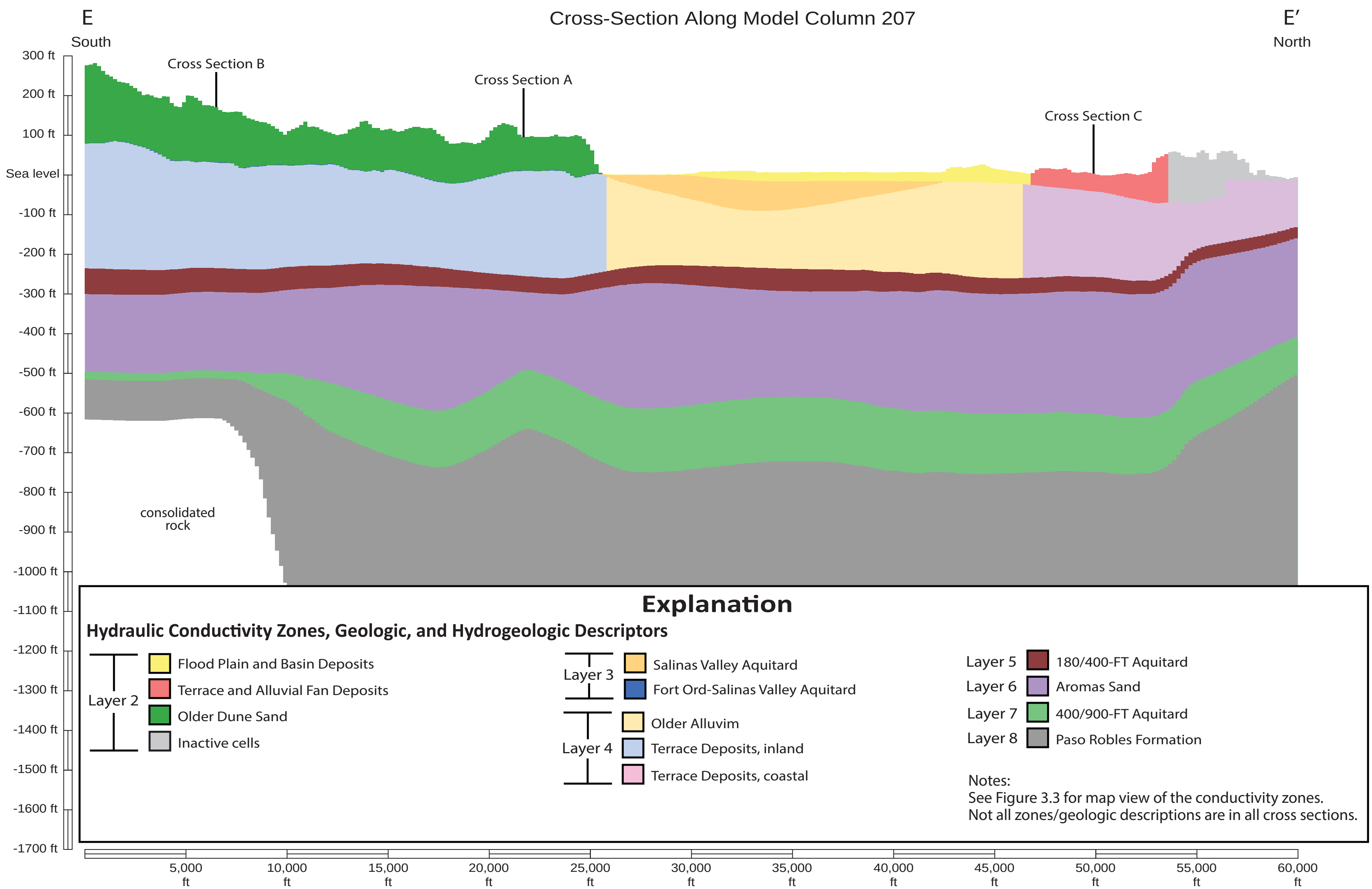
Section B-B', NMGWM[2016].

Figure 3.2c

PROJECT: 5073

DATE: 11/21/2016

Figure 25



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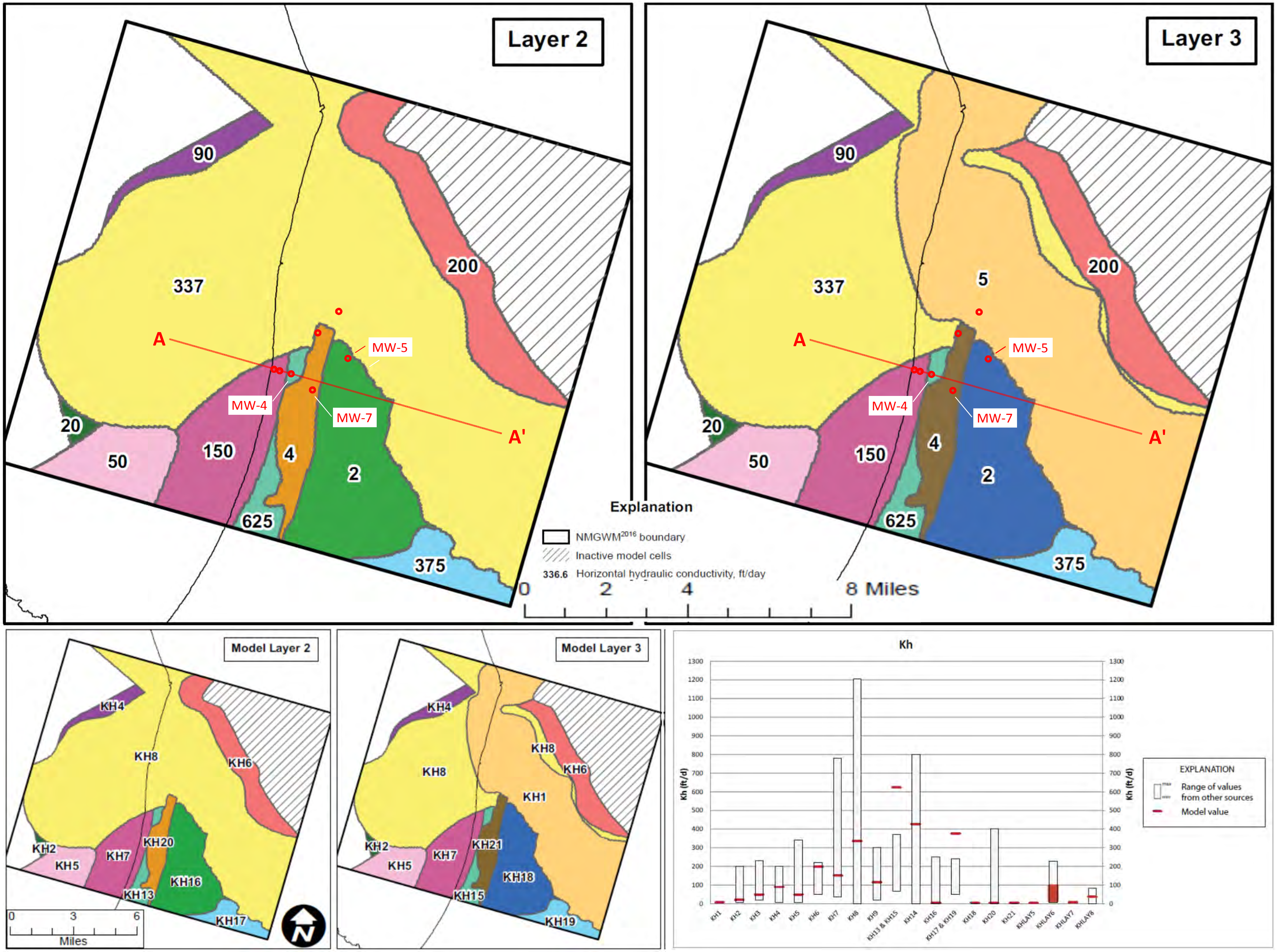
Section E-E', NMGWM[2016].

Figure 3.2f

PROJECT: 5073

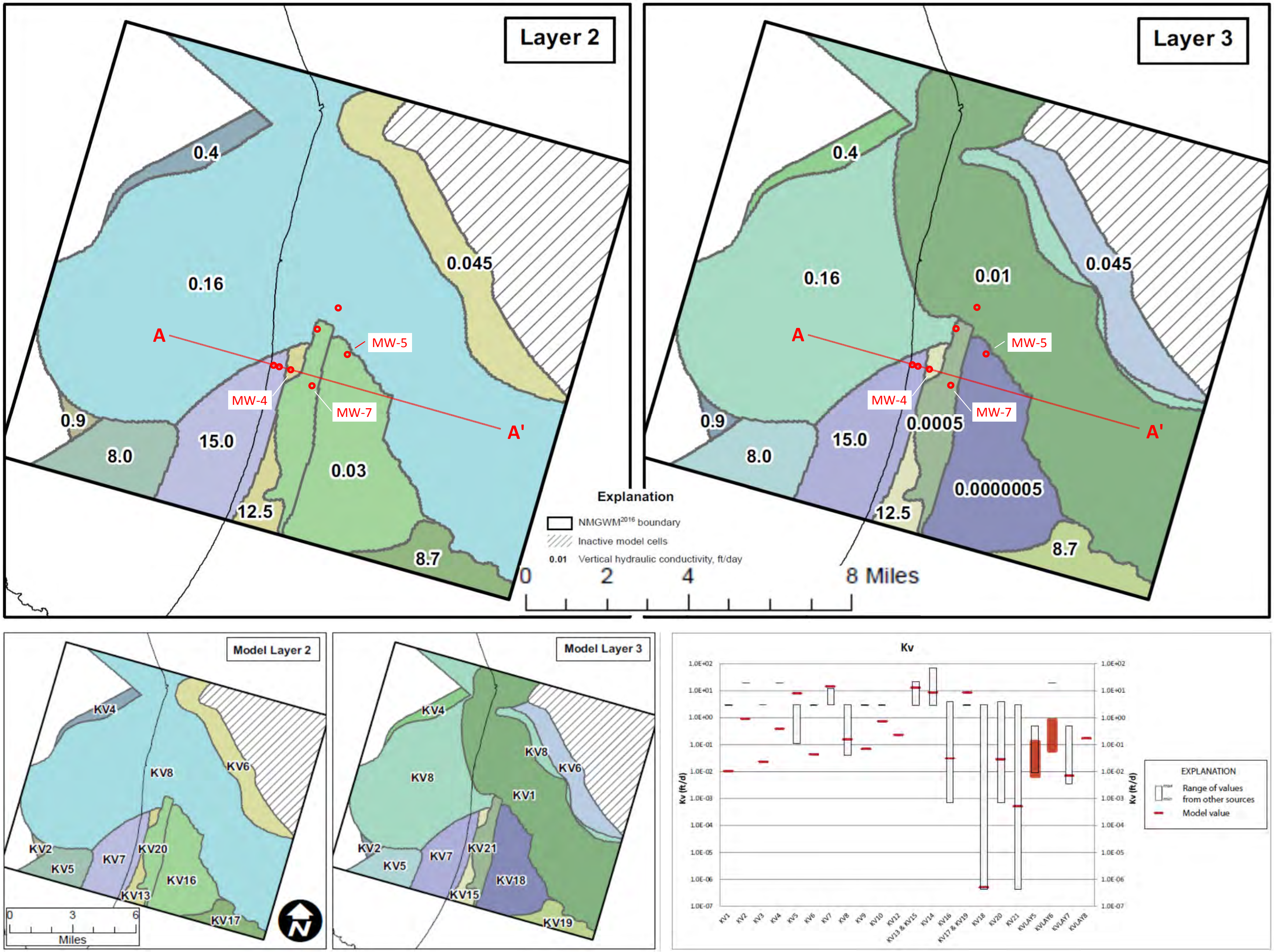
DATE: 11/21/2016

Figure 26



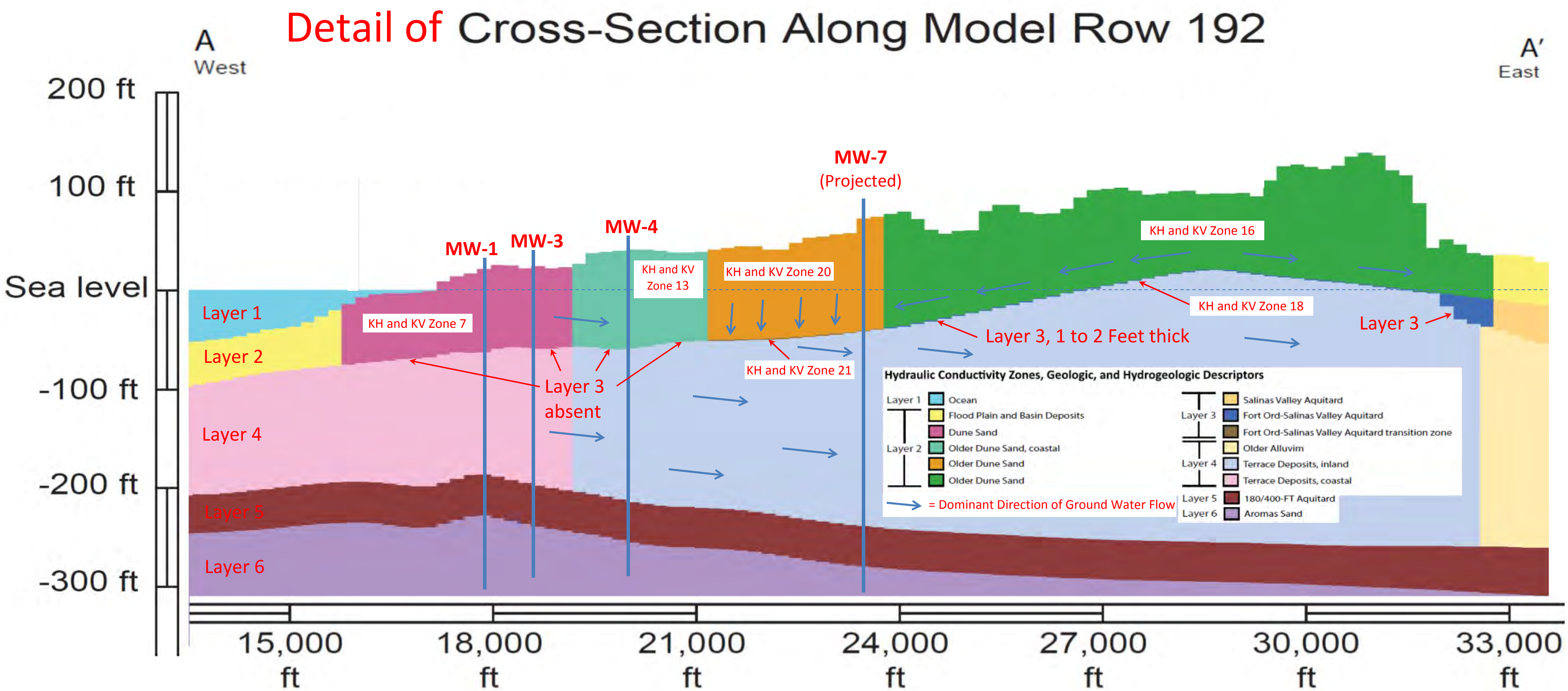
Horizontal Hydraulic Conductivity (KH) Parameter Zones and Values, Model Layers 2 and 3, NMGWM^{2016}, Excerpted from Figures 3.3a and 3.4a, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2*, March 28, 2018. Red lines and text are added based on other figures in Appendix E2

Figure 27



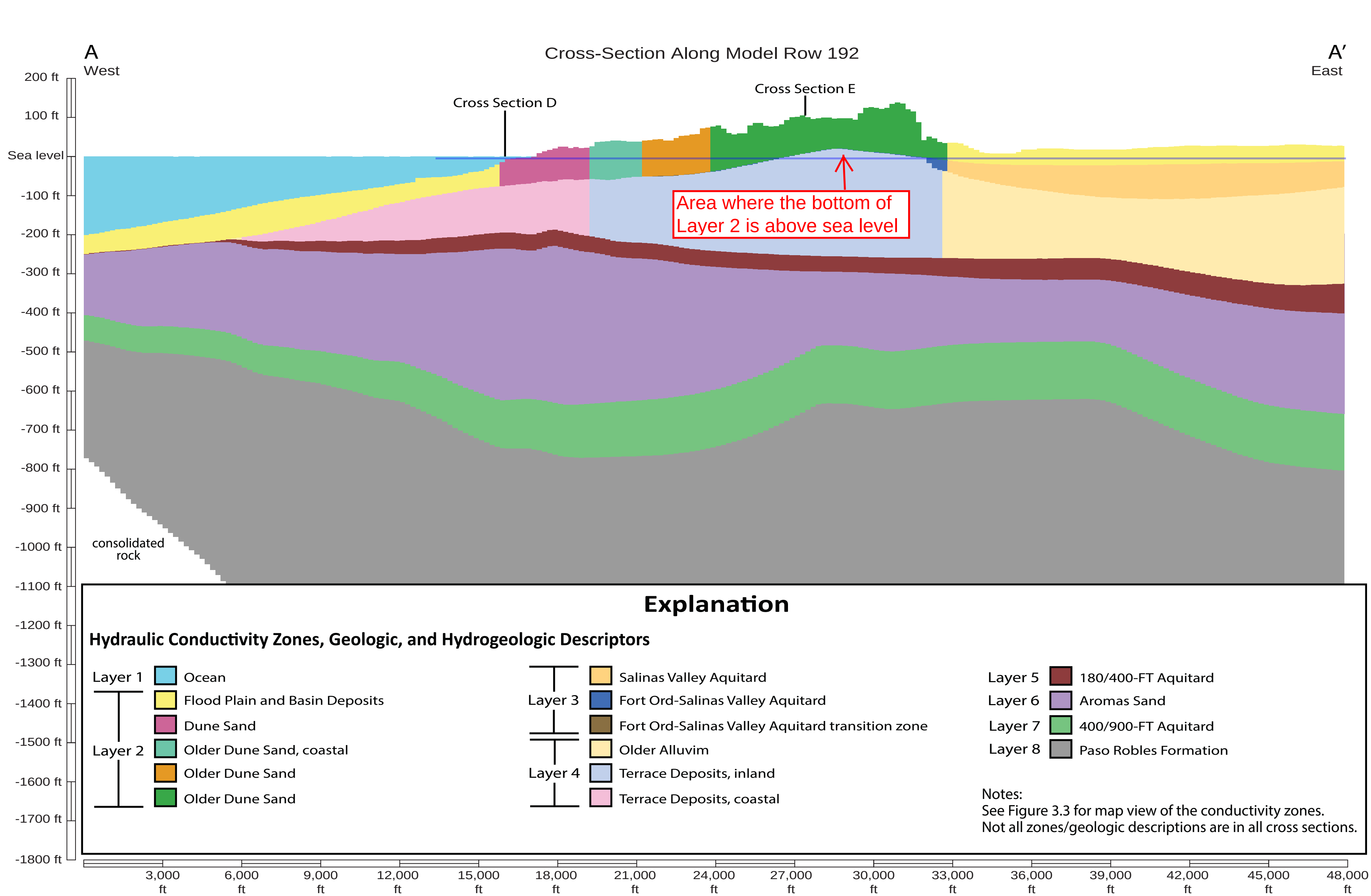
Vertical Hydraulic Conductivity (KV) Parameter Zones and Values, Model Layers 2 and 3, NMGWM2016, Excerpted from Figures 3.3b and 3.4b, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2*, March 28, 2018. Red lines and text are added based on other figures in Appendix E2

Figure 28



Hydraulic Conductivity Zones, Model Cross Section A-A', NMGWM[2016], excerpted from Figure 3.2b, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2*, March 28, 2018. Well and Layer notations are added based on other figures in Appendix E2

Figure 29



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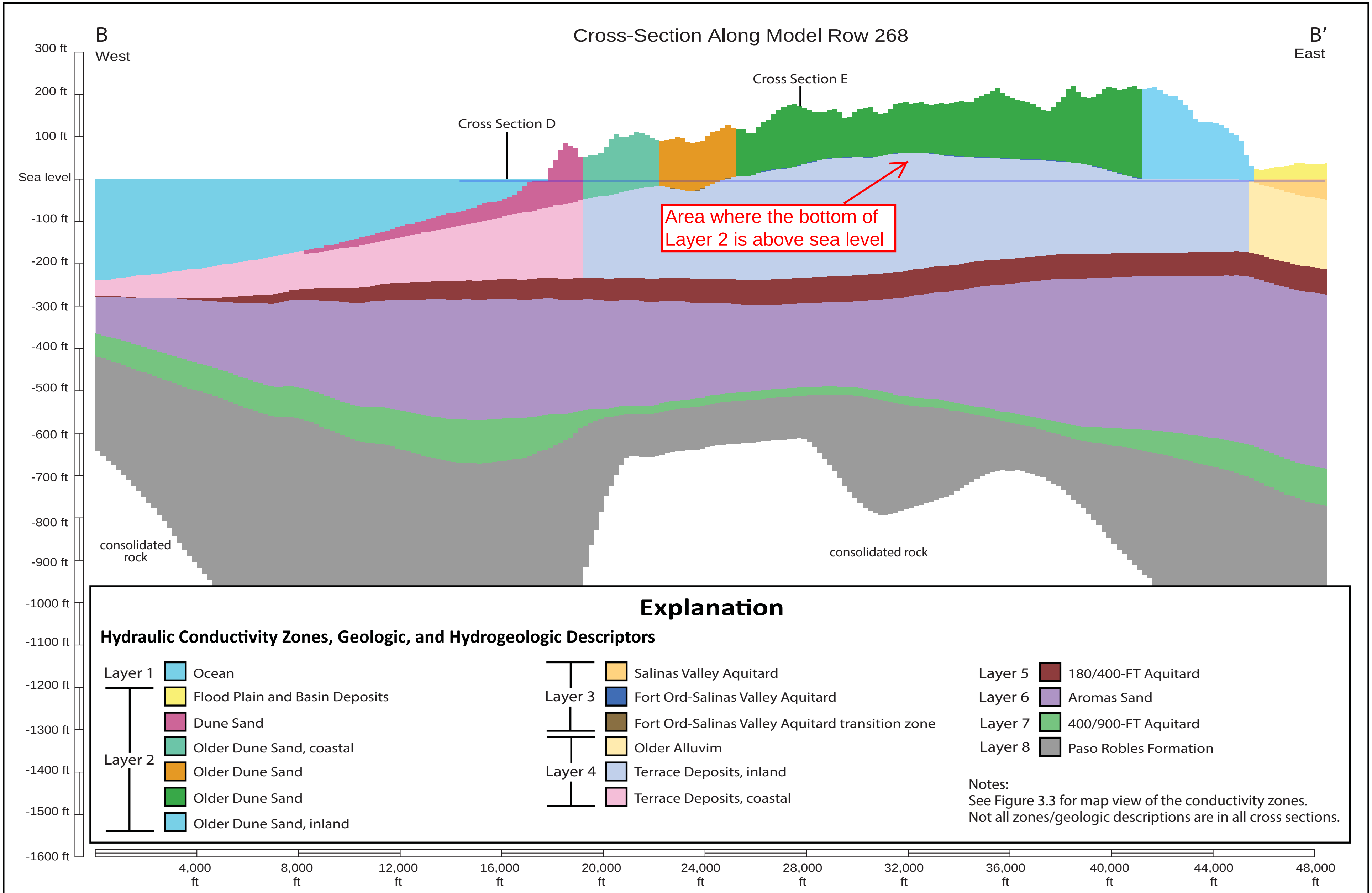
Section A-A', NMGWM2016 Layer 2 Elevation Issue

Figure 3.2b

PROJECT: 5073

DATE: 11/8/2016

Figure 30



HYDROFOCUS INC. Solutions for Land and Water Resources	Section B-B', NMGWM2016. Layer 2 Elevation Issue	Figure 3.2c
PROJECT: 5073	DATE: 11/21/2016	

Figure 31

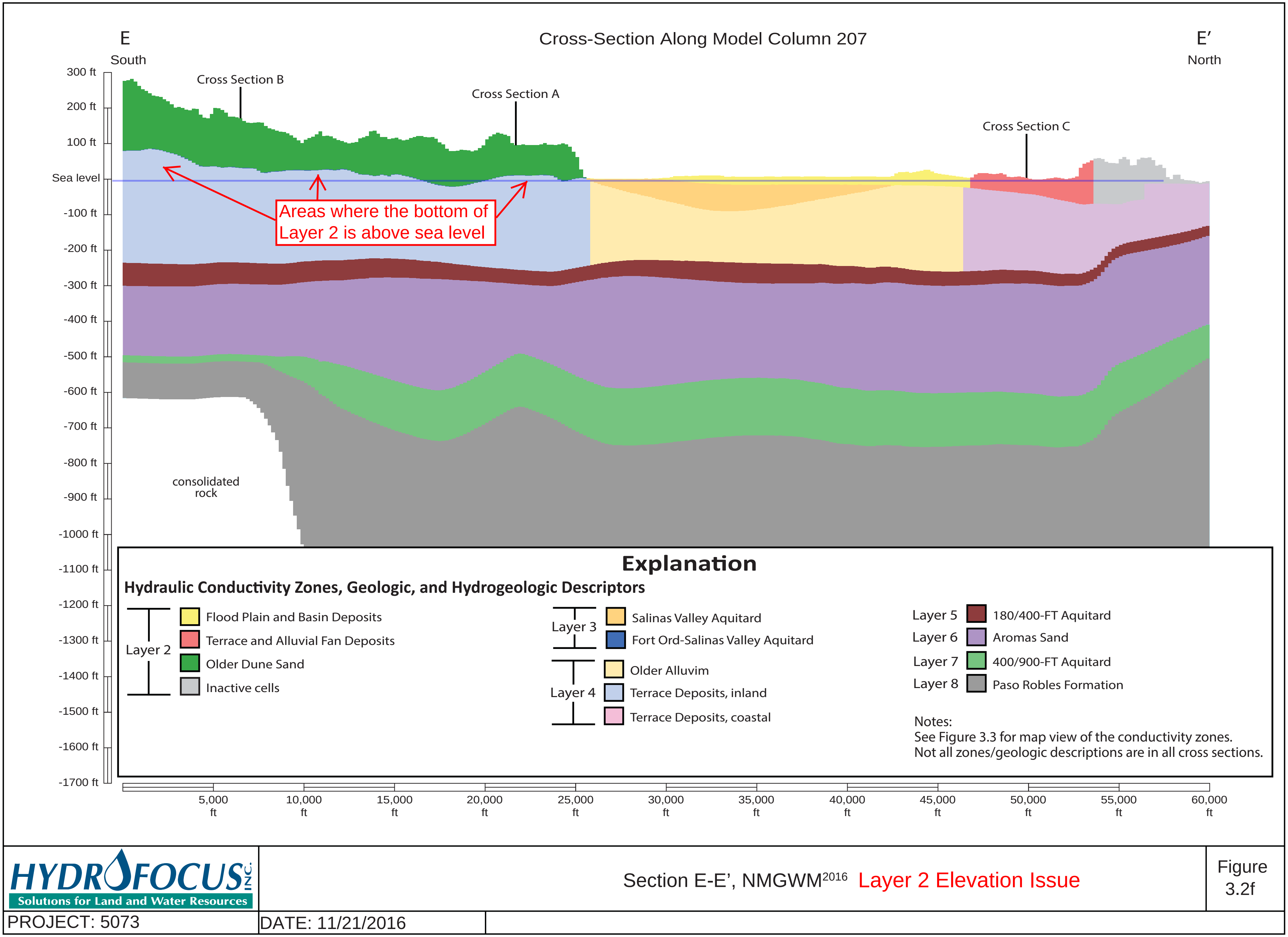
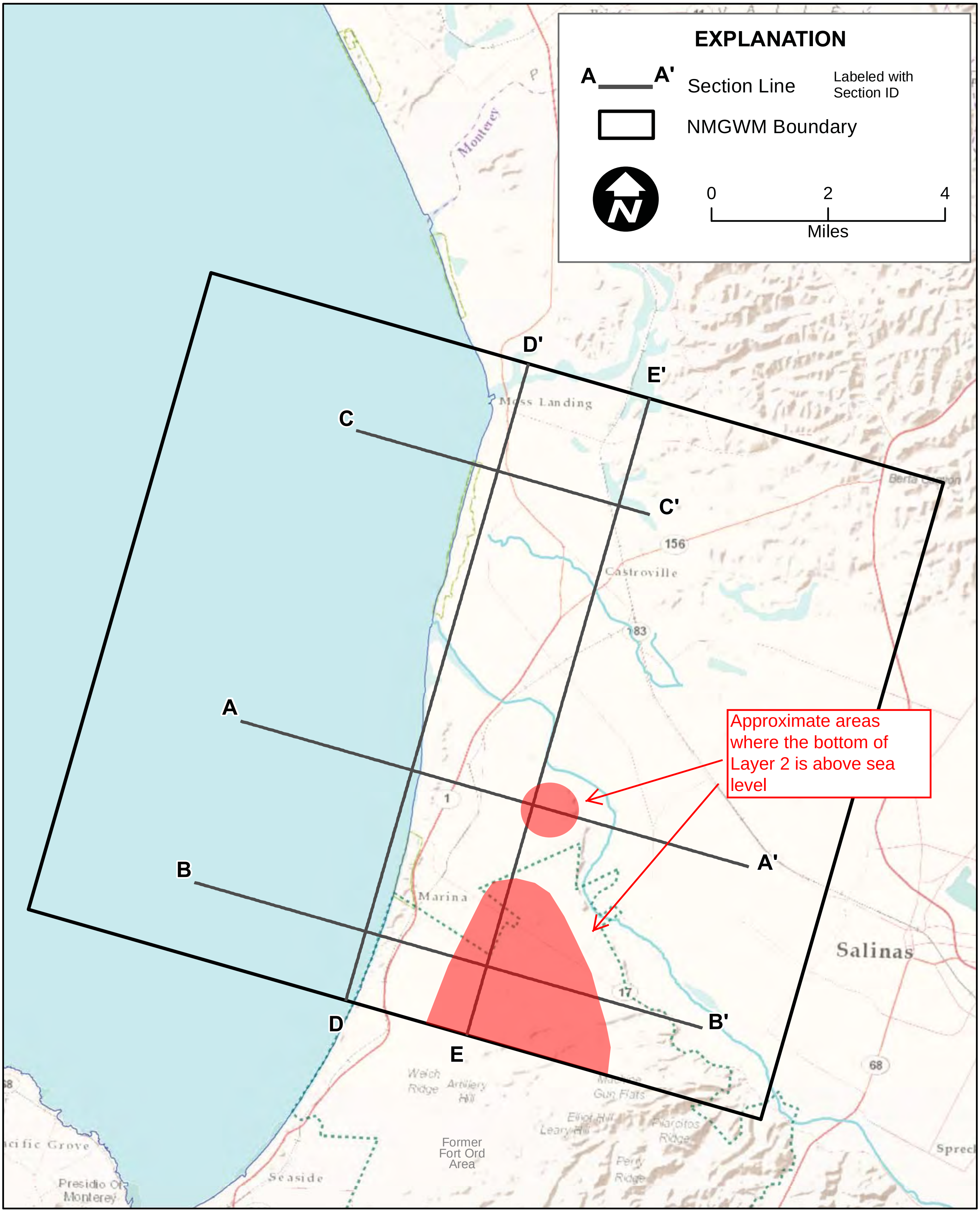

E
South
Cross-Section Along Model Column 207
E'
North
300 ft
200 ft
100 ft
Sea level
-100 ft
-200 ft
-300 ft
-400 ft
-500 ft
-600 ft
-700 ft
-800 ft
-900 ft
-1000 ft
-1100 ft
-1200 ft
-1300 ft
-1400 ft
-1500 ft
-1600 ft
-1700 ft
Cross Section B
Cross Section A
Cross Section C
Areas where the bottom of Layer 2 is above sea level
consolidated rock
Explanation
Hydraulic Conductivity Zones, Geologic, and Hydrogeologic Descriptors
Layer 2
Flood Plain and Basin Deposits
Terrace and Alluvial Fan Deposits
Older Dune Sand
Inactive cells
Layer 3
Salinas Valley Aquitard
Fort Ord-Salinas Valley Aquitard
Layer 4
Older Alluvim
Terrace Deposits, inland
Terrace Deposits, coastal
Layer 5
180/400-FT Aquitard
Layer 6
Aromas Sand
Layer 7
400/900-FT Aquitard
Layer 8
Paso Robles Formation
Notes:
See Figure 3.3 for map view of the conductivity zones.
Not all zones/geologic descriptions are in all cross sections.
5,000 ft
10,000 ft
15,000 ft
20,000 ft
25,000 ft
30,000 ft
35,000 ft
40,000 ft
45,000 ft
50,000 ft
55,000 ft
60,000 ft
HYDROFOCUS INC.
Solutions for Land and Water Resources
Section E-E', NMGWM2016 Layer 2 Elevation Issue
Figure 3.2f
PROJECT: 5073
DATE: 11/21/2016

Figure 32



HYDROFOCUS INC. Solutions for Land and Water Resources

NMGWM2016 section lines.

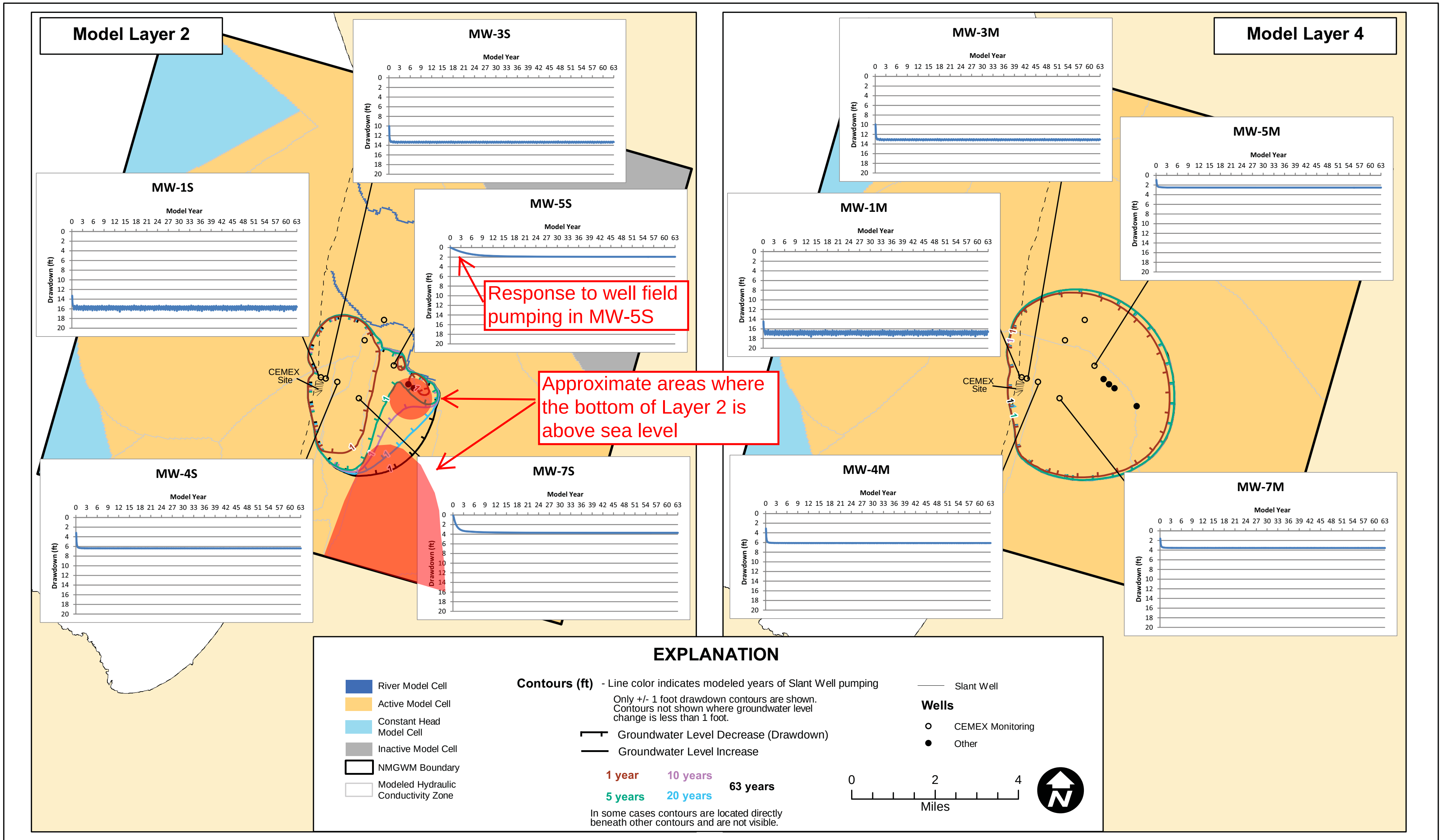
Layer 2 Elevation Issue

Figure 3.2a

PROJECT: 5073

DATE: 8/12/2016

Figure 33



HYDROFOCUS INC. Solutions for Land and Water Resources

Annual NMGWM[2016] calculated drawdown from slant well pumping (24.1 MGD), 44/56 Layer 2/Layer 4 distribution, 2012 sea level, with no return water, CEMEX site.

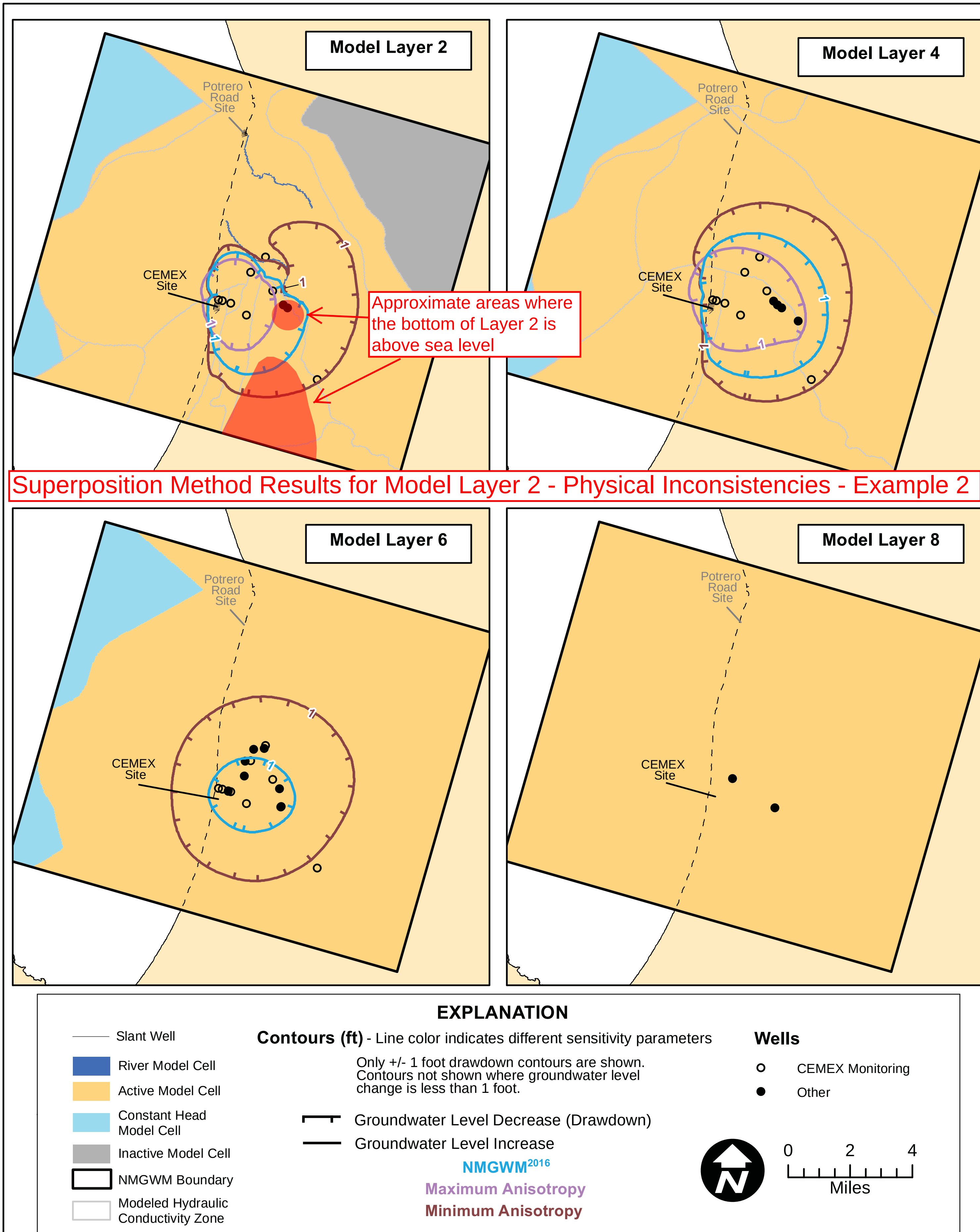
Figure 5.3

PROJECT: 5073

DATE: 7/11/2017

Superposition Method Results for Model Layer 2 - Physical Inconsistencies - Example 1

Figure 34



HYDROFOCUS INC
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Sensitivity of calculated drawdown to hydraulic conductivity after 63 years of slant well pumping (24.1 MGD), 44/56 Layer 2/Layer 4 distribution, 2012 sea level with no return water, CEMEX site.

Figure 6.2

PROJECT: 5073

DATE: 8/30/2016

Figure 35

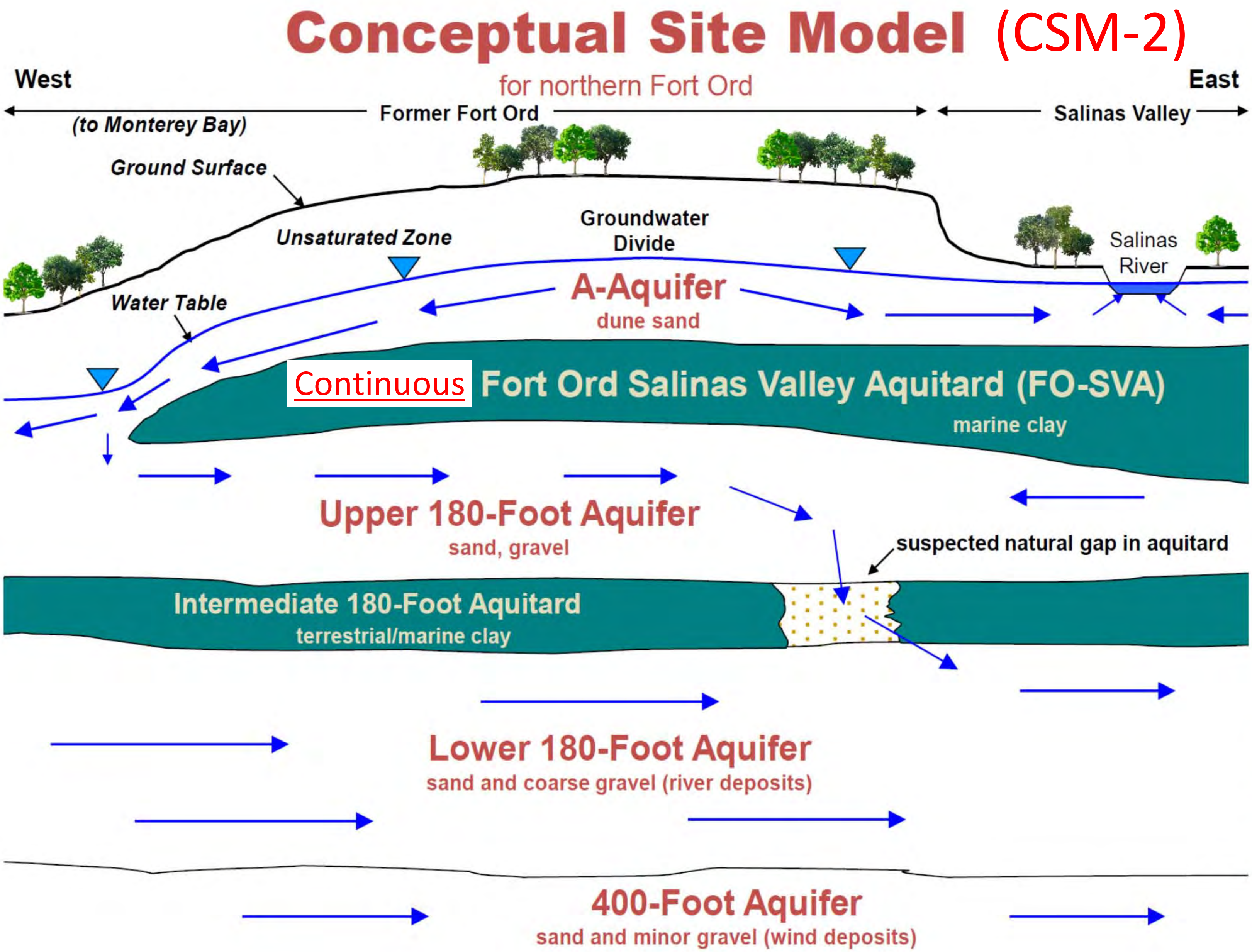


Figure 1: The Conceptual Site Model (Figure 1 at the left) describes groundwater conditions beneath former Fort Ord. Four aquifers are underlying former Fort Ord: A-Aquifer, Upper 180-Foot Aquifer, Lower 180-Foot Aquifer, and the 400-Foot Aquifer. Aquitards bound the A-, Upper 180-Foot Aquifer, Lower 180-Foot Aquifer, and 400-Foot Aquifers.

Groundwater flow in the A-Aquifer splits at a groundwater divide and goes toward the Salinas River and Monterey Bay, and enters the Upper 180-Foot Aquifer at the western edge of the FO-SVA. Groundwater may also be entering the Lower 180-Foot Aquifer through a suspected natural gap in the Intermediate 180-Foot aquitard.

Excerpted from Page 1 of http://docs.fortordcleanup.com/ar_pdfs/factsheets/03-09/; annotations in red

Figure 36

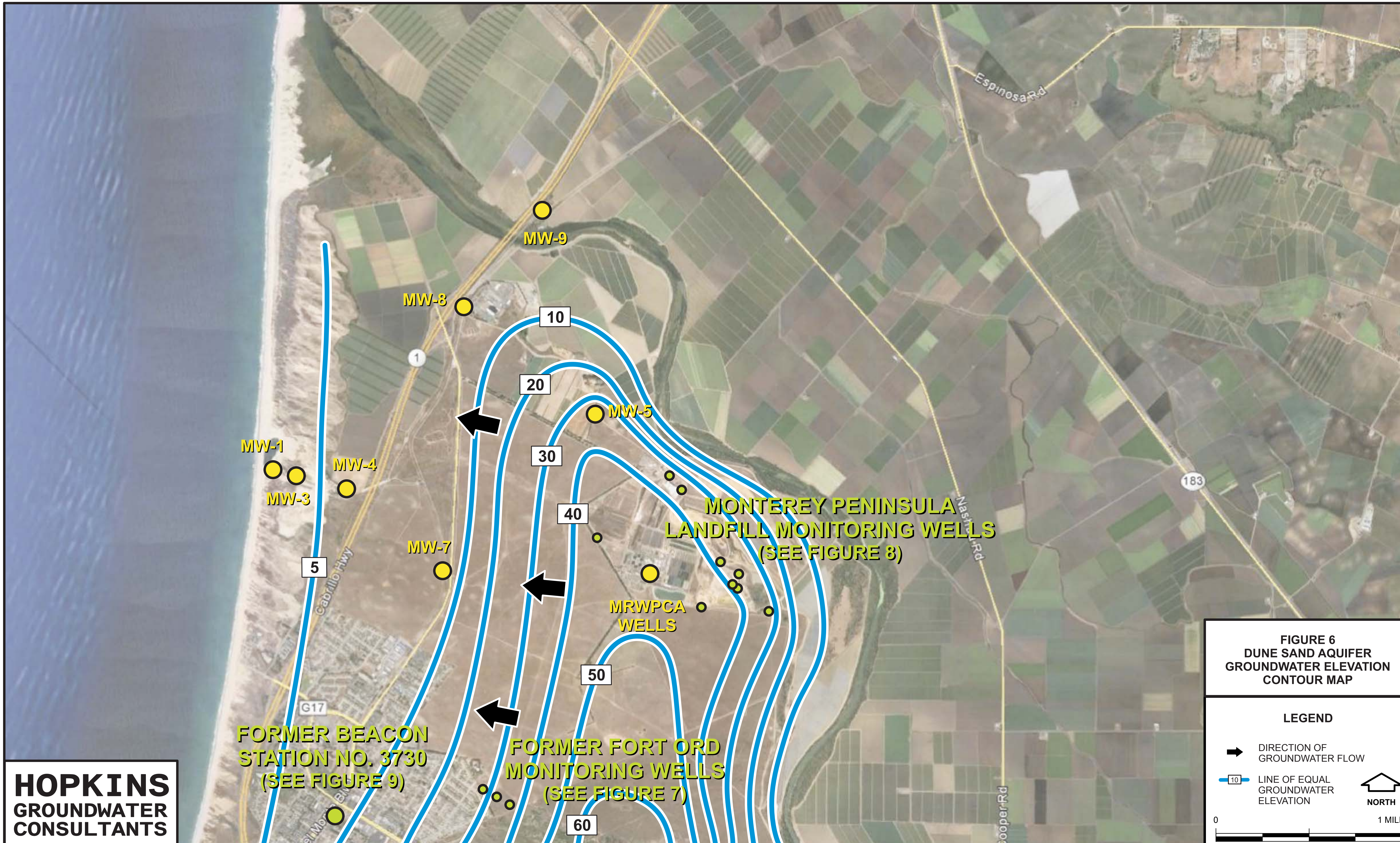
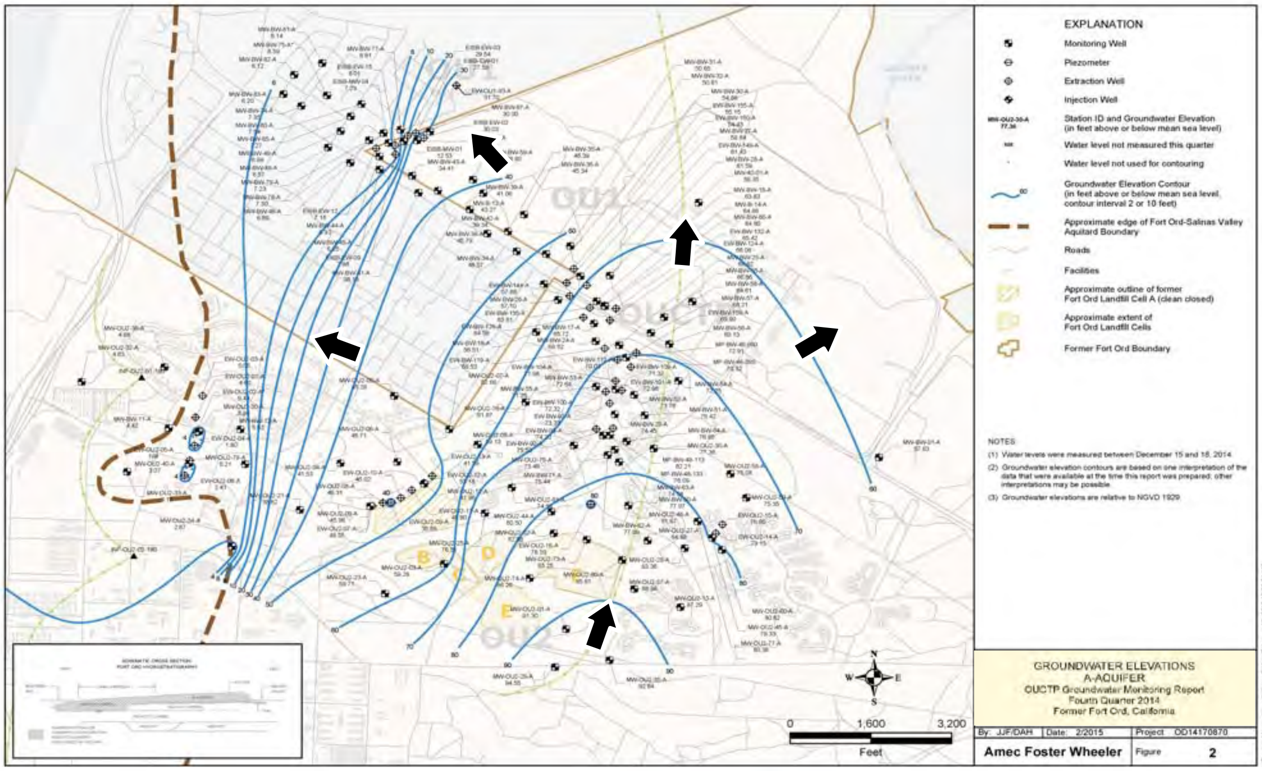
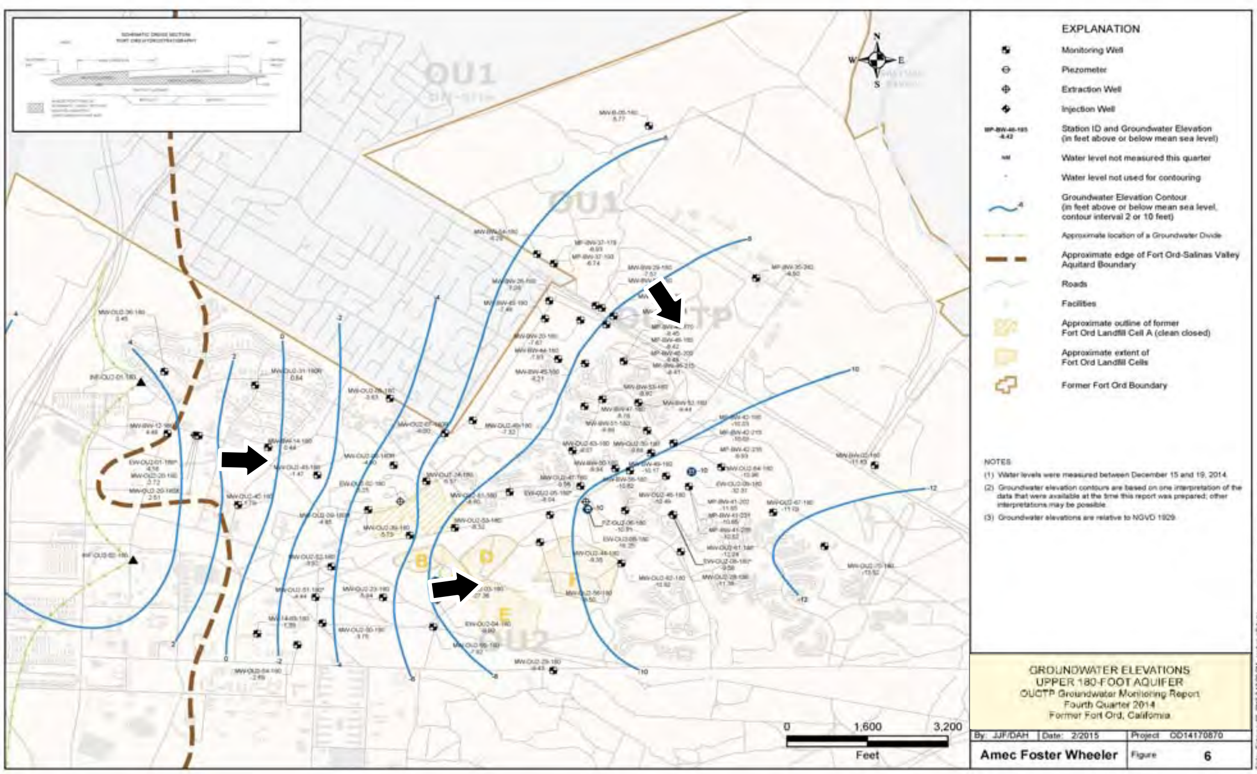

MW-9
MW-8
MW-5
MW-1
MW-4
MW-3
MW-7
10
20
30
40
50
60
5
MONTEREY PENINSULA LANDFILL MONITORING WELLS (SEE FIGURE 8)
MRWPCA WELLS
FORMER BEACON STATION NO. 3730 (SEE FIGURE 9)
FORMER FORT ORD MONITORING WELLS (SEE FIGURE 7)
Espinosa Rd
Nashua Rd
Cooper Rd
Cabrillo Hwy
183
G17
1
HOPKINS GROUNDWATER CONSULTANTS
FIGURE 6
DUNE SAND AQUIFER GROUNDWATER ELEVATION CONTOUR MAP
LEGEND
DIRECTION OF GROUNDWATER FLOW
LINE OF EQUAL GROUNDWATER ELEVATION
NORTH
0
1 MILE

Figure 37

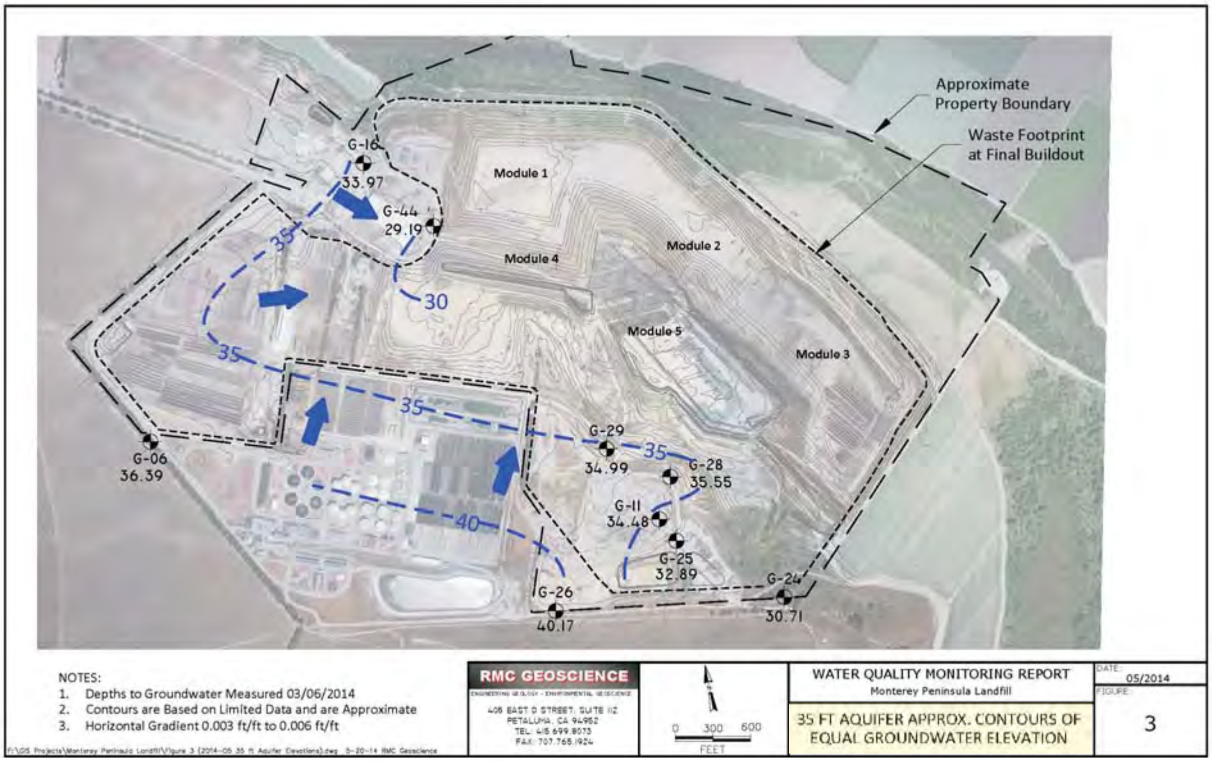




HOPKINS GROUNDWATER CONSULTANTS

FIGURE 7
FORT ORD CLEANUP SITE
GROUNDWATER ELEVATION DATA

Figure 38



HOPKINS GROUNDWATER CONSULTANTS

FIGURE 8
MONTEREY PENINSULA LANDFILL
GROUNDWATER ELEVATION DATA

Figure 39

Legend

- MCWD's Service Area
- DWR Groundwater Basin
- Armstrong Ranch
- Groundwater Divide
- Edge of Fort Ord-Salinas Valley Aquitard
- Groundwater Elevation Contour (2' Interval)
- Groundwater Elevation Contour (10' Interval)
- Cal Am Monitoring Well
- Fort Ord Monitoring Well

Well Labeling

MW-5S — Well ID
35 — Groundwater Elevation (ft MSL)

Path: X:\B60094\Maps\2017\02\Fig5_GWE_DuneSandAquifer.mxd

Abbreviations

Cal Am = California American Water
DWR = Department of Water Resources
ft MSL = feet mean sea level
MCWD = Marina Coast Water District
mg/L = milligram per liter
TDS = total dissolved solids

Notes

1. All locations are approximate.
2. Groundwater levels obtained from Reference 2 are measured in May 2016. Groundwater levels at Fort Ord are measured during June 2016 (Ahta, 2016. Final Operable Unit Carbon Tetrachloride Plume Second Quarter 2016 Groundwater Monitoring Report, Former Fort Ord, California, dated 29 August 2016). All groundwater levels are approximate.
3. Groundwater levels have been correlated for density, where TDS > 10,000 mg/L (see Reference 3).
4. Groundwater elevation contour dashed where approximate.

Sources

1. Aerial photograph provided by ESRI's ArcGIS Online, obtained 21 February 2017.
2. Cal Am Monterey Peninsula Water Supply Project Test Slant Well Long Term Pumping—Monitoring Report No. 55, released 24-May-2016.
3. Guo & Langevin, 2002. User's Guide to SEAWAT, U.S. Geological Survey Techniques of Water Resources Investigations 6-A7, released 2002.

Erler & Kalinowski, Inc.

Groundwater Elevations
Dune Sand Aquifer

Marina Coast Water District
Marina, CA
February 2017
EKI B60094.01
Figure 5

Figure 40

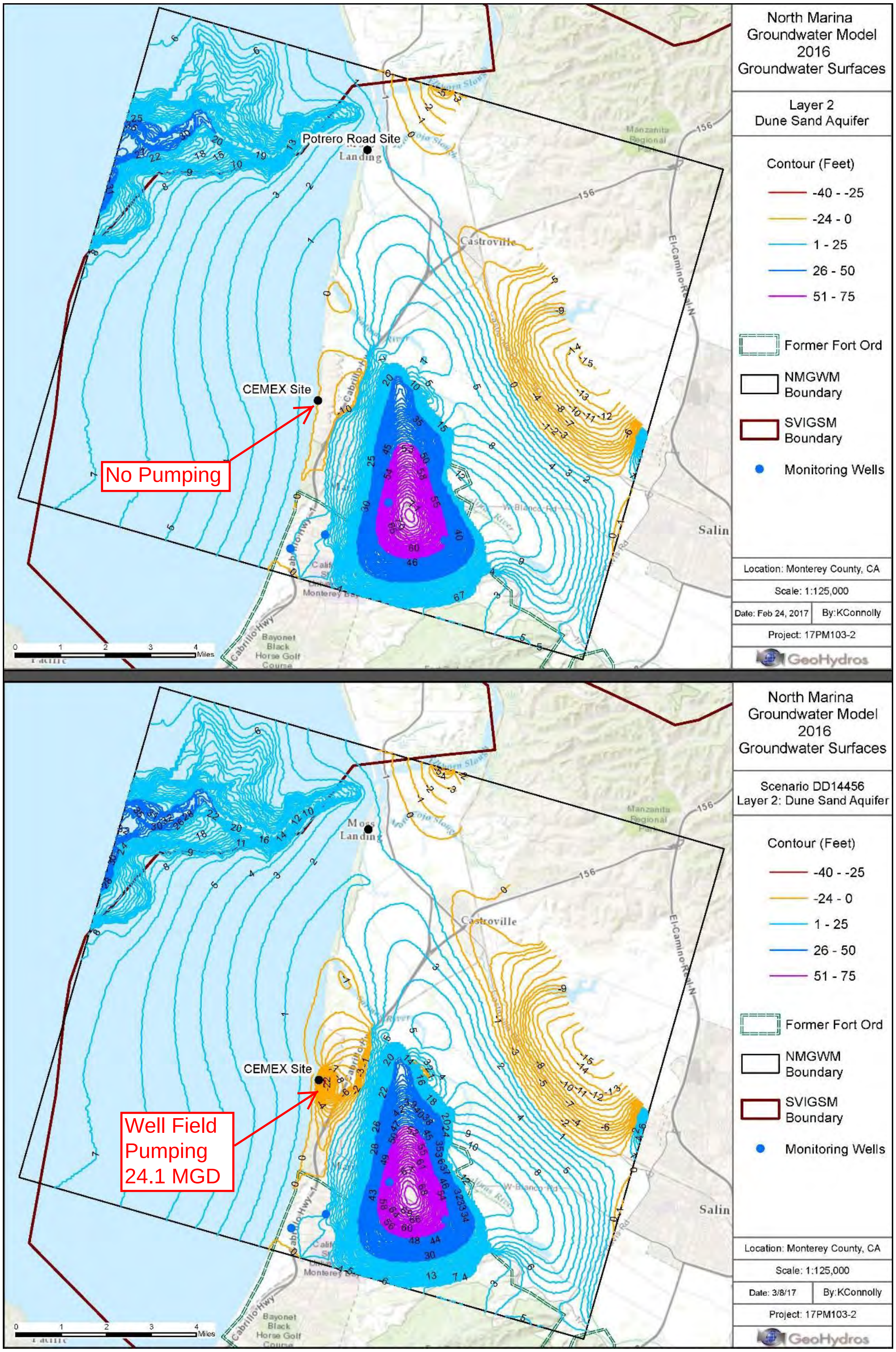


Figure 14. Simulated water table surface in the Dune Sand Aquifer (Layer 2) as portrayed by the calibrated version (top) and Scenario DD1-44/56 (bottom) showing mounding due to recharge in the Dune Sand Aquifer and equivalent fresh water heads assigned as constant values in the ocean resulting in a large eastward gradient across the model.

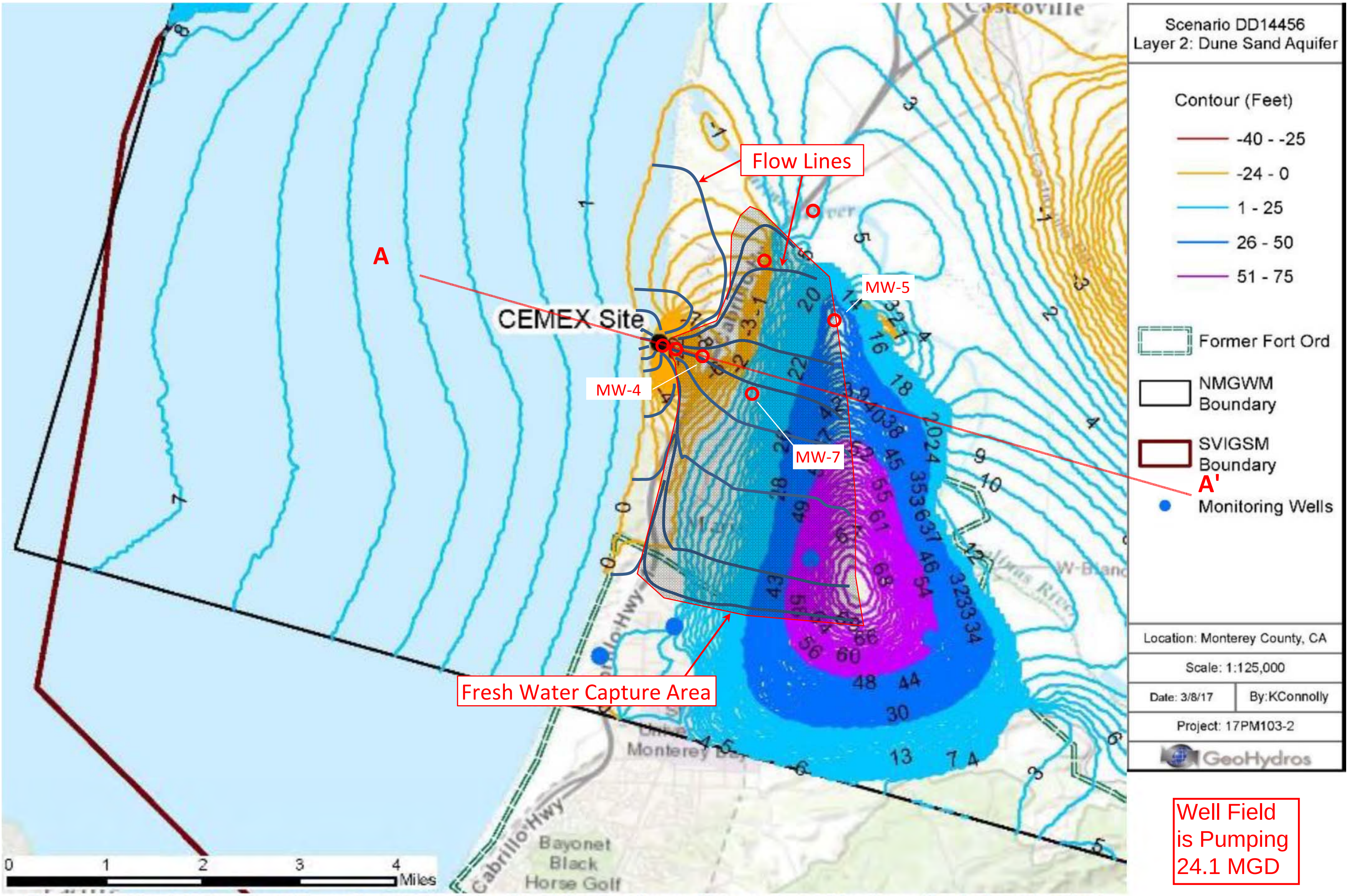


Figure 14. Simulated water table surface in the Dune Sand Aquifer (Layer 2) as portrayed by the calibrated version (top) and Scenario DD1-44/56 (bottom) showing mounding due to recharge in the Dune Sand Aquifer and equivalent fresh water heads assigned as constant values in the ocean resulting in a large eastward gradient across the model.

With Flow Net and Additional Fresh Water Capture Area (grey shading)

Figure 42

EXHIBIT 12

INDEPENDENT HYDROGEOLOGICAL REVIEW

JULY 2020

Weiss Associates *Environmental Science, Engineering, and Management*
2000 Powell Street, Suite 555, Emeryville, CA 94608 *Phone:* ***510-450-6000***

INDEPENDENT EVALUATION, MODIFICATION, AND USE OF THE NORTH MARINA GROUNDWATER MODEL TO ESTIMATE POTENTIAL AQUIFER IMPACTS

associated with the

PROPOSED MONTEREY PENINSULA WATER SUPPLY PROJECT

prepared for

California Marine Sanctuary Foundation
99 Pacific Street, Suite 455E
Monterey, California 93940

and

California Coastal Commission
45 Fremont Street, #2000
San Francisco, California 94105

July 10, 2020

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Weiss Associates
2000 Powell Street, Suite 555
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Job No. 466-2148.02

July 10, 2020

Weiss Associates work at the California-American Water test slant well site and vicinity was conducted under my supervision. To the best of my knowledge, the data contained herein is true and accurate, based on what can be reasonably understood as a result of this project while satisfying the scope of work prescribed by the client for this project. The data, findings, recommendations, specifications, and/or professional opinions were prepared under contract with the California Marine Sanctuary Foundation solely for the use of the California Coastal Commission in accordance with generally accepted professional engineering and geologic practice. We make no other warranty, either expressed or implied, and are not responsible for the interpretation by others of the contents herein.

William A. McIlvride 07/10/2020
William A. McIlvride, PG, CHG, CEG Date
Senior Project Hydrogeologist

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TABLES

ACRONYMS AND ABBREVIATIONS

Cal-Am	California American Water
Commission	California Coastal Commission
CPUC	California Public Utilities Commission
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
FO-SVA	Fort Ord/Salinas Valley Aquitard
FWP	fresh water percentage
GHB	general head boundary
gpm	gallons per minute
HWG	Hydrogeologic Working Group
K	hydraulic conductivity
KH	horizontal hydraulic conductivity
KV	vertical hydraulic conductivity
MGD	million gallons per day
MNW	multi-node well
MAW	multi-aquifer well
mg/L	milligrams per liter
MPWSP	Monterey Peninsula Water Supply Project
NAVD88	North American Vertical Datum of 1988
$NMGWM^{2016}$	North Marina Groundwater Model (2016 version)
OWP	ocean water percentage
Project	Monterey Peninsula Water Supply Project
RCH	recharge
RIV	river
SGMA	Sustainable Groundwater Management Act
SVIGSM	Salinas Valley Integrated Ground and Surface Water Model
TSW	Test Slant Well
TDS	total dissolved solids
USG	unstructured grid
USGS	U.S. Geological Survey
Weiss	Weiss Associates

1. INTRODUCTION

This report documents work performed by Weiss Associates (Weiss) to refine available estimates of the potential effects of California American Water's (Cal-Am's) proposed well field on aquifers in the vicinity of Cal-Am's proposed Monterey Peninsula Water Supply Project (MPWSP or Project) (Figure 1). The work employed a steady-state implementation of the 2016 North Marina Groundwater Model ($NMGWM^{2016}$) with uniform pre-pumping gradients to determine if key recommendations from Weiss's November 1, 2019 technical report (Weiss, 2019) can be addressed, or if it will be necessary to modify the transient implementation of $NMGWM^{2016}$ and possibly conduct a field investigation.

The objective of the work is to address the recommendations to the extent possible and improve upon the current modeling approach to better predict the percentage of ocean water ("ocean water percentage", or OWP) that will potentially be captured by the well field, and the percentage of fresh to brackish inland aquifer water (fresh water percentage, or FWP[1]) that will potentially be captured, and over what potential area the fresh water capture will occur. The predictions take into account potential ranges in groundwater gradient, recharge, well field pumping rates, extent of the Fort Ord/Salinas Valley Aquitard (FO-SVA), and Dune Sand Aquifer hydraulic conductivity (K). This provides an estimate of how the operating well field might affect the groundwater resource inland under current conditions, and under conditions of a seaward gradient in deeper aquifers that could potentially develop in response to proposed basin management changes being evaluated under the Sustainable Groundwater Management Act (SGMA).

Many of the figures included with this report are excerpted from documents developed for or associated with the MPWSP and have been renumbered for this document using red figure numbers. The numbering system from the document of origin has also been maintained so the reader can examine it from its original context, if desired. Some of the figures have been annotated for clarification in red but additional colors are used in annotation as noted on the figures and/or in text.

[1] In this report, the term "fresh" water includes groundwater with total dissolved solids (TDS) less than or equal to 3,000 milligrams per liter (mg/L). Modeled OWP results discussed throughout this report and shown on Tables 2 and 3 assume that fresh water has a TDS of 0.0 mg/L. For comparison, Tables 2a and 3a show OWPs for fresh water with assumed TDS of 500 mg/L (OWP^{500}); Tables 2b and 3b show OWPs for fresh water with assumed TDS of 3,000 mg/L ($OWP^{3,000}$).

2. BACKGROUND

The final environmental impact report/environmental impact statement (EIR/EIS) for the MPWSP was published on March 29, 2018 (ESA, 2018), and included results of the NMGWM^{2016}. The EIR/EIS includes comments on the Draft EIR/EIS and responses to those comments, which were extensive regarding potential impacts of the MPWSP on local fresh groundwater resources. These impacts occur primarily in the two uppermost aquifers at the MPWSP: the Dune Sand Aquifer (which is contiguous with the Perched/Mounded Aquifer on its east side), and the 180-Foot/180-Foot Equivalent Aquifer (180-Foot Aquifer).

This report assumes the reader is familiar with the hydrogeology of the MPWSP as described in the EIR/EIS, in particular Appendix E3. If the reader is unfamiliar with the MPWSP, it is recommended to refer to this document for background and context.

After publication of the EIR/EIS, further comments were submitted and responses provided regarding the potential fresh groundwater impacts, with differing scientific opinions, leading to the California Coastal Commission's (Commission) request for an independent review in support of their decision process.

2.1 Test Slant Well

As documented in the EIR/EIS (ESA, 2018) and more recent monitoring reports, a Test Slant Well (TSW) was constructed from December 2014 to March 2015 at the MPWSP site (Figure 2) so that pumping tests could be conducted to gather chemical and physical data required to estimate potential freshwater capture by the full-scale project. Weiss reviewed reports and data from initial pumping of the TSW at 2,000 gallons per minute (gpm) (2.88 million gallons per day [MGD]), and produced an independent hydrogeological review report dated September 23, 2015 (Weiss, 2015). This resolved an operating permit issue regarding the hydraulic influence of the TSW and led to permit modifications and long-term testing of the TSW at 2,000 gpm for 22 months, from May 2, 2016 through February 28, 2018.

2.2 Hydraulic Gradient in Dune Sand Aquifer

In the winter of 2016/2017, during the long-term TSW pumping test, heavier than average rainfall resulted in a seaward steepening of the groundwater gradient in the Dune Sand-Perched/Mounded Aquifer (Dune Sand Aquifer) in an area approximately 2,000 to 6,000 feet inland from the pumping well, based on data from key MPWSP monitoring well MW-7S (Geoscience, 2019). Accompanying this change was a decrease in TDS at the pumping well, indicating an increase in fresh water entering the well. These trends led to stakeholder comments that the EIR/EIS may not have accounted for these changes and potential additional post-2017 changes due to increased rainfall, and technical opinions differed on what those changes might represent. Weiss reviewed the EIR/EIS comments and documentation of the differing technical opinions and produced a technical report (Weiss, 2019) that addressed the Commission's study questions pertaining to the gradient changes.

The findings in that technical report included:

1. The steepening of the hydraulic gradient seaward in the Dune Sand Aquifer in 2017 will likely result in a limited to negligible effect on seawater intrusion, and will likely result in a decrease in OWP in water pumped, due to increased capture of fresh water from the aquifers tapped by the well field. The gradient change appears to result from local and regional aquifer recharge due to increased rainfall in 2016-2017 and 2018-2019. This is significant to the evaluation of the OWP resulting from the MPWSP since there are substantial data gaps with respect to groundwater flow paths in the Dune Sand Aquifer and the transfer of fresh water (TDS <3,000 mg/L) from the Dune Sand Aquifer to the 180-Foot Aquifer. Therefore, to be able to rely on $NMGWM^{2016}$ results to accurately predict OWP, Weiss recommended additional data collection to address these data gaps, development of a consensus conceptual site model and modifications to the $NMGWM^{2016}$ based on the revised conceptual model, and then calibration of the revised $NMGWM^{2016}$ to match the effects of these recent rainfall events.
2. The well field capture analysis presented in the EIR/EIS appeared to be flawed as it did not account for potential freshwater capture beyond the identified capture zone of the well field. This is because it relied on an assumed landward groundwater gradient and did not account for the seaward gradient in the Dune Sand Aquifer. If such capture is greater than what is already accounted for, it will decrease the OWP in water extracted by the well field. The uncertainty in the range of OWP depends on how the hydrogeology of the Dune Sand Aquifer and underlying FO-SVA is interpreted and modeled. The uncertainty could be reduced through adjustments to the $NMGWM^{2016}$ and applying it in a non-superposition mode to more accurately reflect the site hydrogeology and implications of the TSW pumping results.

2.3 Westward Extent of the Fort Ord-Salinas Valley Aquitard (FO-SVA)

A leading technical issue identified was the continuity and westward extent of the FO-SVA, the position of which would likely have a significant effect on predicted OWP and capture of fresh groundwater under different assumed groundwater gradient conditions. Comments and responses to the technical report were provided by the Hydrogeologic Working Group (HWG), the $NMGWM^{2016}$ modeling team, the City of Marina, and the Marina Coast Water District and their consultants in a series of written questions and responses and two teleconference calls. The EIR/EIS contained different interpretations of the continuity and extent of the FO-SVA (Weiss, 2019):

1. Appendix E3 of the EIR/EIS showed the western boundary of the FO-SVA to be approximately 6,000 feet inland of the Project well field and east of monitoring well MW-7S (Figure 3); and three of six geologic cross-sections in Appendix E3 (Figures 4, 5, and 6) showed the FO-SVA to be discontinuous north, south, and east of well MW-7S.
2. In contrast, Appendix E2 of the EIR/EIS showed the western boundary of the FO-SVA, depicted as the western extent of Layer 3 of the $NMGWM^{2016}$, to be approximately 2,000 feet inland of the Project well field and west of monitoring well MW-7S (Figure 7), with the FO-SVA modeled as being continuous (Layer 3) north, south, east, and west of well MW-7S.

The latter interpretation, which has the FO-SVA margin closer to the Project well field and assumes continuity of the FO-SVA, is potentially conservative from the standpoint of Project impacts; as stated by the HWG (February 20, 2020), *"If the FO-SVA is assumed to be continuous… then all the westward flowing groundwater within the Perched/Mounded* [Dune Sand] *Aquifer spills over the western edge of the FO-SVA (such as near MW-7) closer to the areas of potential influence from proposed MPWSP pumping."* By conservative, it is meant that the project impact will err on the side of low OWP in the groundwater captured by the Project well field, assuming all other factors are equal. The HWG has clarified this interpretation using geologic cross-sections (Figures 4, 5, and 6) by connecting what are shown as fragmented clay layers where the FO-SVA occurs in the vicinity of monitoring well MW-7S (HWG, 2020).

While this helped to resolve the recommended action in Weiss finding (1) above, there was still a need to account for potential fresh water capture under seaward gradient conditions in the Dune Sand Aquifer and reduce the uncertainty in the range of OWP estimates. It was proposed to accomplish this through adjustments to the $NMGWM^{2016}$, in conjunction with additional field data collection, and applying the $NMGWM^{2016}$ in a non-superposition mode to more accurately reflect the site hydrogeology and implications of the TSW pumping results. It was decided to implement modeling first, as described in Section 3.

As of the writing of this report, a pumping rate of 15.5 MGD has been approved for the MPWSP by the California Public Utilities Commission (CPUC). This pumping rate is used as the base rate for the different scenarios modeled in this report.

2.4 Ocean Water Percentage (OWP)

Predicting OWP in groundwater extracted from the MPWSP well field has been a key concern throughout the Project planning, design, and approval process, and is the primary goal of the work documented in this report. Preliminary review of the $NMGWM^{2016}$ (Weiss, 2019) indicated that the long-term (after the first few months of pumping) OWP should be in the range of 85 to 96 percent within the range of likely pumping rates from the Project well field. This OWP range is consistent with the TSW pumping results.

Weiss also reviewed the range of OWP estimates included in the EIR/EIS (ESA, 2018). The results of the different methods of determining OWP were summarized in a memorandum addressing comments on the analyses (HWG, 2017), as shown in Table 1 from that memorandum. The HWG also plotted TSW OWP field data versus time and compared the data to some different modeling approaches (Figure 8). Both of these depictions of the TSW data show a partial record, including both the 1- and 2-year OWP; these are in the range of 90 to 95 percent. However, the full record of TSW pumping (Figure 9) shows the OWP in the range of 84 to 90 percent during April through August 2017, which followed the very wet period from November 2016 through April 2017.

The HWG described the OWP trends (HWG, 2018, page 4), and their presumed causes, from the full record of TSW pumping. In their description (below), Weiss's statements describing accompanying gradient changes are inserted in bold text:

> *"An analysis of the actual field data shows that there are four distinct periods of time represented in the data. The first time period is the ramp up in TDS after start of pumping on April 22, 2015 until November 30, 2015 (with non-pumping period from June 5 to October 27). TDS concentrations started at 26,000 mg/L (OWP = 77) and ended at*

29,800 mg/L (OWP = 89) on November 30, 2015. The second time period from December 1, 2015 to February 1, 2017 (a 14 month period) represents a steady TDS mostly within a range from 30,000 to 32,000 mg/L (OWP = 90 to 95) **[before the seaward gradient steepened]**. *The third time period starts in February 2017 and extends to August 2017 (6 months)* **[seaward gradient steepened during this period]***, and represents a decline in TDS from an average of about 31,000 mg/L (OWP = 92) to about 29,000 mg/L (OWP = 86). The fourth time period starts in August 2017 and represents an increase in TDS from an average of about 29,000 mg/L (OWP = 86) to an average of about 30,500 mg/L (OWP = 91) as of end of October 2017* **[seaward gradient became slightly less steep during this period]**.

"The six month period from February to August 2017 reflects infiltration of rainfall (i.e., fresh water) during a record wet year from November 2016 to April 2017 **[It also represents a steepening of the seaward gradient]**. *The recharge from the record rainfall mixes with the ambient highly saline water in the TSW capture zone and is reflected in the observed TDS reduction (February to August 2017) – typically, rainfall recharge requires several days to a few months to be manifested as water level and quality changes in a given shallow aquifer. We understand that similar variations in intake water salinity related to differing rainfall amounts has been observed at the Sand City desalination plant intake wells.*

"Overall, the period of record for TSW TDS data provides an excellent long-term record that shows expected TDS concentrations following a below average (93% of normal) rainfall year (2014-2015) **[OWP 90-95%]***, an above average (141% of normal) rainfall year (2015-2016)* **[OWP 90-95%]***, and a record wet rainfall (174% of normal) year (2016-2017)* **[OWP 85-90%; and from Oct 2017 to Feb 2018, OWP was 87-93%]**. *The overall average rainfall is above average for the entire TSW pumping time period (126 percent of normal) and therefore can be considered conservative in terms of likely representing TSW TDS concentrations when freshwater recharge from rainfall is more abundant than normal (i.e., TSW TDS concentrations lower than normal)."*

To illustrate these trends, the OWP trend line is annotated and placed in corresponding position relative to the water level trends from 2015 through 2019 in monitoring wells MW-3S, MW-3M, MW-4S, MW-4M, MW-7S, and MW-7M (Figure 9). In performing the scope of work for this report, this data was compared to the model output values to inform making adjustments to model parameters to reflect conditions that were present during the Slant Well test.

As described in Weiss (2019), for wells pumping at the shoreline, the inland area can be considered for practical purposes to be the area where the cone of depression expands and at any given point water levels decrease over time, whereas in the seaward area a constant water level is maintained. Therefore, increasing pumping at the coast will create additive effects inland, expanding the cone of depression. Because the water level decrease associated with additional expansion of the cone of depression inland occurs over an area with already decreased water levels, the groundwater gradients from inland towards the pumping wells will increase at a slower rate in response to increased pumping relative to the gradients on the ocean side, which increase to a greater extent because sea level is not affected by pumping. This greater increase in the gradients on the ocean side in response to greater pumping will act to increase the OWP as pumping rates increase.

Thus, all else being equal, the OWP values shown in Table 1, and the OWP values shown on Figures 8 and 9, can be considered as minimums for any project that produces more than the TSW flow at the TSW location, under the rainfall/recharge conditions that occurred during TSW pumping. This principle was employed to do a "reality check" on the model outputs.

3. SCOPE OF WORK

To obtain more accurate and definitive OWP and groundwater capture zone estimates due to proposed pumping from the MPWSP well field, Weiss (2019) recommended the following:

1. Obtain additional hydrogeologic data from the 2 square-mile area east of monitoring well MW-7S to define the continuity of the FO-SVA;
2. Investigate the area west of monitoring well cluster MW-7 (between MW-4 and MW-7) to determine the potential extent of the FO-SVA westward from well cluster MW-7, and vertical groundwater gradients between the Dune Sand Aquifer and 180-Foot Aquifer; and
3. Incorporate the new data into $NMGWM^{2016}$ (Figures 10 through 13), which should be revised to reflect realistic values of horizontal and vertical hydraulic conductivity (KH and KV) (Figures 14 and 15) in the aquifers and aquitards proximal to the Project well field, and a FO-SVA configuration consistent with geological data east, north, and south of the Project well field area. The $NMGWM^{2016}$ is currently configured to allow most of the Dune Sand Aquifer (Perched/Mounded portion) water to flow vertically downward to the 180-Foot Aquifer well inland of the western margin of the FO-SVA, in the vicinity of monitoring well cluster MW-7 (Figure 16), which is not a conservative configuration.

To address the recommendations contained in the technical report in potentially less time than would be needed if the field work was included, it was decided that the $NMGWM^{2016}$ would be revised and implemented prior to the field work to see if a range of OWP and capture estimates could be calculated that would account for any reasonable variation in the range of possible aquitard configurations and discontinuities.

3.1 Tasks

For this work, Weiss employed the version of $NMGWM^{2016}$ used for the EIS/EIR to calculate ocean capture zones with variable regional groundwater gradients (ESA, 2018; Appendix E2, Figure E7) (Figure 17). This version of $NMGWM^{2016}$ was developed by assigning external water levels to the eastern-most general-head boundaries to approximately simulate the seasonal range in landward gradients observed in the Project area. It is a steady-state model; the modeling approach is described in Section 3.2.

This approach was judged to be potentially insensitive to the configuration of the FO-SVA and its westward extent, because it can include scenarios with pumping from both aquifers at similar and varying gradients. And these scenarios could be run with different simulated westward extent of the FO-SVA. Compared to using the transient version of the $NMGWM^{2016}$, the approach offered a relatively straightforward way to address certain model deficiencies, and to quickly estimate OWP and groundwater capture zones under a wide range of potential conditions and different pumping scenarios from the MPWSP well field.

Accordingly, the tasks performed for this project were as follows:

1. The model files to support the capture version of the NMGWM^{2016} were not available on the CPUC web site,[2] but were provided by Steve Deverel of HydroFocus on May 8, 2020. The model was run to reproduce the 0.0004, 0.0007, and 0.0011 capture scenarios from the EIS/EIR (ESA, 2018) to verify that the correct version of the model was being used and being used correctly, and to become familiar with the model itself. Scenarios for both non-pumping and pumping at 15.5 MGD were evaluated. For each of the gradient scenarios, the OWP of the simulated combined well discharge was calculated, and the size of the respective capture areas in the Dune Sand Aquifer and 180-foot Aquifer estimated using particle tracking, and compared with the modeled capture zones in the EIR/EIS (Figure 17).

2. The NMGWM^{2016} was modified to have a seaward gradient in the Dune Sand Aquifer, while keeping the same array of 0.0004, 0.0007, and 0.0011 landward gradients in the 180-Foot Aquifer. The KH east of monitoring well cluster MW-7 was maintained at the same values in the Dune Sand Aquifer as were employed in the original model.

3. The scenarios as described in task 2 above were repeated, but with a change for the 180-Foot Aquifer and deeper aquifer gradients to be flat to gently seaward, as could potentially occur under full implementation of SGMA by 2040. Differences in OWP were calculated for the different scenarios.

4. To create a seaward gradient in the Dune Sand Aquifer, recharge was added and varied to simulate the historical range of rainfall conditions. The original capture version of NMGWM^{2016} did not include a recharge component. The OWPs resulting from these runs were calculated and tabulated.

5. With recent revisions to water demand estimates, the project potentially may only need half of the approved 15.5 MGD desalinization facility capacity (CPUC, 2019). Therefore, model runs were included with half the pumping rate of runs described in tasks 2, 3, and 4 above; pumping rates in the six wells were reduced by half to achieve a total flow of 7.75 MGD.

6. Particle tracking was used to map out the capture areas in the Dune Sand Aquifer and 180-Foot Aquifer in key scenarios from tasks 1, 2, and 9.

7. A sensitivity analysis was performed for a range of conditions, including increasing KH east of MW-7 in zones KH16 and KH20 (Figure 14) from their current values of 2 and 4 feet per day to five times those values, and recalculating the OWP. This was a decision point for further modeling. The results to this point were reviewed and it was determined that the range of values was acceptable, and thus to continue with the subsequent modeling steps outlined below.

8. The results of the "wet" and "dry" season scenarios for 7.75 and 15.5 MGD pumping rates were used to estimate potential groundwater level changes in the vernal ponds under natural and pumping conditions. These are only relative changes since pond level data was not available to compare with the model results.

[2] See https://www.cpuc.ca.gov/Environment/info/esa/mpwsp/comms_n_docs.html,

9. The water levels specified at the southern boundary in Layer 2 were modified to constant, but much more realistic values. The southern boundary in the NMGWM^{2016} had groundwater elevation values in Layer 2 close to sea level; these differed from actual values by as much as 90 feet (Figure 18). Some of the stakeholders cautioned that this modification would create perched conditions that would likely crash the model. This might have been the case if the capture version of NMGWM^{2016} had been a transient model. However, the change did not cause stability problems for the steady-state model and the result was a much better agreement between the modeled and actual groundwater elevation contours in the southern portion of the model.
10. This report was prepared, describing the modeling implementation, results, and potential ranges in OWP and fresh groundwater capture by the Project.

3.2 Groundwater Modeling

The groundwater modeling was carried out with the assistance and collaboration of Eric Nichols of Substrata, LLC. The approach to NMGWM^{2016} modifications and model runs themselves were developed and performed by Vivek Bedekar of S.S. Papadopulos & Associates, Inc., with input from Mr. Nichols, and Mr. William McIlvride of Weiss. Mr. Bedekar also performed the post-processing and created the graphical results.

This work built on the work of those who developed the NMGWM^{2016} and its predecessors, as described in the Final EIR/EIS (ESA, 2018; Appendix E2); the methodology is briefly summarized here. The reader is referred to Appendix E2 of the EIR/EIS for a detailed description of the NMGWM^{2016} and how it has been used to support the MPWSP Final EIR/EIS.

The NMGWM^{2016} is composed of a uniform 200-by-200 foot grid with eight layers, 300 rows, and 345 columns at a rotation of 16 degrees (clockwise). Distance units are in feet and time units are in days. Three implementations of the model have been used to support the EIR/EIS:

1. ***Transient "calibration" version with 384 stress periods***, and calibrated to wells within the model domain. Its development resulted in the array of horizontal and vertical hydraulic conductivity zones within each model layer, and it serves as the basis for the following versions;
2. ***Transient, "superposition" version with 384 stress periods***, with all boundary conditions and initial heads set to zero. This was used to predict drawdown impacts from the Project over time; and
3. ***Steady-state "capture" version***, with landward gradients set by specifying heads at the eastern general head boundary. This was used to predict ocean water capture for different landward gradients and pumping rates. This version was adopted for the current work.

Of the model files supplied by HydroFocus, the "DD4" file with the 15.5 MGD pumping rate was used to implement the scenarios modeled for this work. This file was the version used to generate the estimated groundwater capture zones due to pumping at the proposed Project well field.

3.2.1 Groundwater Flow Simulation

As was done for the EIR/EIS (ESA, 2018), modeling to complete Tasks 1 through 9 for this study used input files run with the MODFLOW-2000 software that was developed by the U.S. Geological Survey (USGS) (Harbaugh et. al., 2000). The only modifications to the MODFLOW input files for NMGWM^{2016} that were made prior to performing Task 1 were:

- The parameter HCLOSE was adjusted from 10^{-4} to 10^{-5}, and RCLOSE was adjusted from 864 to 10^{-4} to achieve tighter solver convergence; and
- An LMT file was added to write to an FTL file, and create the inputs for MT3D.

The use of MODFLOW for running NMGWM^{2016} is well documented in Appendix E2 of the EIR/EIS (ESA, 2018) and is not repeated here; the reader is referred to that document for more information. Model outputs, including OWP visualizations, groundwater elevation contours, and groundwater flow pathlines were processed using the graphic user interface Groundwater Vistas version 7 (ESI, 2017).

3.2.2 Ocean Water Percentage Estimation and Visualization

MT3D-USGS (Bedekar, et al, 2016) is a finite-difference solute transport simulator that works in conjunction with the flow simulator MODFLOW. MT3D-USGS, developed by the USGS, is an updated version of MT3DMS. It simulates advection, dispersion, and reactions of solutes in the groundwater system, and was applied in this study as a 'tracer' to track the movement of ocean water within the modeling domain.

A unit plume approach[3] was used that: (1) 'tagged' ocean water entering the groundwater system from the constant head boundary that represents the ocean; (2) quantifies the OWP in water withdrawn by the pumping wells; and (3) provides a visual representation of the flow of ocean water within the groundwater system. The use of MT3D-USGS in this application was limited to advective transport, similar to how particle tracking is used to illustrate flow patterns within a groundwater system, and does not consider reactive transport processes, dispersion, diffusion, or the coupling of density-dependent flow and solute transport.

To implement the unit plume approach, a value of 1.0 (concentration of 100 percent ocean water) was assigned to water entering the groundwater system from the constant head (ocean) boundaries to represent ocean water. All other water entering the model and not originating from the ocean was assumed to be fresh water, and was assigned a value of 0.0 (concentration of zero percent, or fresh water). This applied to all other boundary conditions, including river (RIV), general head boundary (GHB), and recharge (RCH). Therefore, a concentration of 100 percent in water discharged from a pumping well signifies that 100 percent of the water in the well originated from the ocean, the same as OWP equals 100; and water with a concentration of 0.0 percent (OWP equals 0.0) discharged from the well is fresh water. A concentration between zero and 100 percent signifies a contribution of both fresh and ocean water, and OWP will be at a value intermediate between 0 and 100.

[3] In the "unit-plume" concept, a value of 1.0 is assigned at the unit source – in this case the ocean – denoting that the water at that location comprises 100% of the quantity of interest (i.e., it has not yet undergone any mixing with other water sources).

The OWP was calculated for the combined discharge from all slant wells pumped using a volume-weighted averaging approach as shown below:

$$OWP = \frac{\sum_{i=1}^{n}(Q_i C_i)}{\sum_{i=1}^{n}(Q_i)}$$

where:

n = the total number of model cells representing pumping wells;

Q_i = the flow rate at each model cell represented as a pumping well (ft^3/day); and

C_i = the concentration associated with respective model cells representing pumping wells (dimensionless unit plume).

For the 7.75 and 15.5 MGD pumping scenarios, the full slant well array (Figure 19) was used, with $n = 42$. For the 2.88 MGD TSW scenarios, only the original slant well used for testing was simulated, with $n = 5$.

To facilitate implementation of MT3D-USGS to calculate the OWP throughout the model, the model vertical datum was adjusted to an arbitrarily large negative value, in this case -1,000 feet, thereby avoiding any potential desaturation artifacts from the MODFLOW inputs to the MT3D model.

3.2.3 Flow Path Simulation

A subset of the scenarios generated using MODFLOW was processed with MODPATH version 6.0.01 (August 24, 2012) to illustrate groundwater flow paths. MODPATH works by delineating the flow path of "particles" of water moving through the modeled groundwater system, and computes the travel time for the simulated particles to reach their ending locations. For the scenarios processed with MODPATH, particles were "released" at every 10th cell in the center of the model, for an initial particle spacing of 2,000 feet. Each particle was released at the center of the model grid block corresponding to the particle release location, or at 0.5x the depth within the model cell. Points to consider when viewing and interpreting the figures that illustrate the MODPATH results include:

- A travel time of 63 years was specified for each particle, so the lines traced by the particles ("path lines") stop either at a groundwater sink or after 63 years of travel time[4];
- The rate of flow of the particles is indicated by the length of the path lines, and is dependent on what effective porosity is specified. A value of 0.1 was used, which is the same value used for the capture scenarios in the EIR/EIS (ESA, 2018). Short path lines indicate relatively slow flow and long path lines indicate relatively rapid flow;
- Path lines lengthen and extend further downgradient as flow velocity increases in response to steepening groundwater gradient;

[4] The 63-year period was used because 63-year pumping and 63-year recovery scenarios were simulated using NMGWM[2016] in the EIR/EIS (ESA, 2018), and this time period generates flow lines of an appropriate length to illustrate flow patterns while avoiding the output from becoming too cluttered.

- Path lines reside longer in Layer 2 due to horizontal gradients created by the RIV boundary; and
- A path line that is vertical will essentially be invisible on the model output, or show simply as a "dot".

The MODPATH results were converted to GIS shapefiles before plotting so that the path lines could be represented by a different color for each layer that a given particle travels through, to help illustrate the vertical component of flow. In the output presented in the figures with this report, the path lines are blue in Layer 2, green in Layer 4, and red in Layer 6 of the model; thus a path line that starts as blue, becomes green, and then red is tracing and illustrating not just horizontal flow, but also a vertical downward flow.

4. MODEL IMPLEMENTATION AND RESULTS

Input parameters and the results of each model run are described in this section. The OWPs in water from the pumping wells for each run are shown in Table 2. These OWP results are based on the assumption that fresh water has TDS of 0.0 mg/L, and for consistency the OWP results discussed in remainder of this report are based on this assumption. To provide comparison for different assumed fresh water TDS, Table 2a shows the OWPs based on the assumption that fresh water has TDS of 500 mg/L (OWP^{500}), and Table 2b shows the OWPs based on the assumption that fresh water has TDS of 3,000 mg/L ($OWP^{3,000}$).[5]

Some of the parameters in the original version of the $NMGWM^{2016}$ were adjusted to create the scenarios described below. Caution was used in selecting model parameters for adjustment, and in how they were adjusted, in keeping with the concept stated by HydroFocus (Appendix E2, page 19): *"the model-calculated water levels and groundwater volumetric budget terms should reasonably agree with the conceptual understanding of the groundwater system."* Therefore, whenever any aquifer zone KH or KV was adjusted for the MODFLOW runs, it was done so "in the direction of reasonableness", to bring the model more in alignment with physical reality. For example, the existing KH20 in Layer 2 set in $NMGWM^{2016}$ is 4 feet per day (Figure 14), which is at the bottom end of the 2 to 400 feet per day range in values reported from other sources. So, increasing the value from 4 to 40 feet per day is making it closer to its average value of 200 feet per day, thus changing it "in the direction of reasonableness".

4.1 Baseline – Replicate $NMGWM^{2016}$ Capture Results

After download of the capture version of the $NMGWM^{2016}$, it was reviewed and run as originally configured with landward gradients at 0.0004, 0.0007, and 0.0011 (Figures 20, 21, and 22) but initially with no pumping, to assess how the model was set up and allow for comparison with output from subsequent runs. There is also no rainfall recharge in the original configuration. Fresh water does enter the model from infiltration from rivers[6] and at the eastern GHB in Layer 2. All ocean water enters the model from the constant head boundary implemented on the western side of the model.

The results illustrate some key attributes of the original model configuration:

- The eastern GHB in Layer 2 was set at 0 feet in each of the three gradient scenarios;
- The eastern GHB in Layers 4 and 5 is set to -25, -50, and -75 feet, and in Layers 6, 7, and 8 is set to -15, -30, and -45 feet, to create the respective 0.0004, 0.0007, and 0.0011 inland gradients;
- The no-flow boundary in the northeastern corner of the model was removed from Layers 4 through 8, presumably to facilitate creation of a smooth landward gradient throughout the model. While this a departure from actual conditions in the north-eastern part of the model, it creates a more uniform and therefore realistic inland

[5] The effect on OWP of increasing the assumed TDS for fresh water is explained in detail on page 16 in Weiss (2019).
[6] Because of the presence of river boundaries in the original model, the original model is nonlinear and thus is not truly a "superposition model"(i.e., the capture extents will not be proportional to pumping rate or regional gradient).

gradient in the vicinity of the Project well field, which is the area of interest in evaluating groundwater capture due to pumping;

- Despite the eastern GHB setting of 0 feet in Layer 2, inland gradients were created in this layer for several miles inland of the Projects well field in response to the influence of heads in underlying Layer 4; and
- Fresh water enters the model at the river boundaries, and also in locations along the eastern boundary where heads are higher in the GHB for Layer 2 relative to the GHBs for Layers 4, 6, and 8.

The groundwater flow pattern that results from these conditions is depicted in the MODPATH outputs shown on Figures 23, 24, and 25.

All three gradient scenarios show inflow of fresh water from the rivers north of the Project well field. In an unpumped state, flow is to the east towards the GHB set to control the eastward gradients. As the gradient steepens from 0.0004 to 0.0011 (Figures 20, 21, and 22), the groundwater flow path lines lengthen, indicating increasing velocity of groundwater flow in response to the steeper gradients (Figures 23, 24, and 25).

Pumping at 15.5 MGD was then added, with flows allocated 44/56 percent between model Layers 2 and 4 to reproduce groundwater capture scenarios for comparison with those from the EIR/EIS (ESA, 2018; Figure 17). With increasing gradient, OWP in water captured by the slant wells increases (Figures 26, 27, and 28), and the capture area decreases (Figures 29, 30, and 31), as would be expected. The capture scenarios show good agreement with those from the EIR/EIS. The OWP exceeds 99 percent in all cases, reflecting that only landward gradients are present, even in Layer 2. Some aspects of the capture analysis include:

- Layer 4 particle tracks match the capture in the EIR/EIS (Figure 17).
- Captured particles in Layer 4 originate, travel, and are captured in Layer 4.
- The Layer 2 capture depicted in the EIR/EIS (Figure 17) is based on an ensemble of particles released at various depths within the model cell (0.1, 0.5, 0.9, and 1.0; 1.0 being at the water table).
- Particles in this analysis were released only at the midpoint of the model cells which show a more limited set of travel paths than the original model results.
- Most of the particles that originate south of the wells in Layer 2 travel downward into Layer 4, where they travel within Layer 4 for a majority of the time before getting captured in Layer 2 or 4.

In all of the scenarios, red path lines are crossing the shoreline south of the slant well field, and appear to defy/cross-over the capture zone boundaries. The red color of these path lines indicates particle travel through Layer 6, which is beneath the capture zones, thus passing below the capture area. After their initial release in Layers 2 or 4, these particles moved vertically downward to Layer 6 before moving laterally inland. The vertical flow segment of the particle flow path is not visible in the map view; the particles only become visible when they reach Layer 6 and begin to move horizontally; hence, they appear to originate in Layer 6.

4.2 Add Recharge to Create Layer 2 Seaward Gradient

As described in Section 2.2, the flat to very slight seaward groundwater gradient that was present in 2015 between wells MW-7S and MW-4S increased substantially, to approximately 0.001 beginning in 2016, and has remained elevated. A seaward gradient in Layer 2 was generated by adding recharge to the model, specifically, the annual average recharge of 5 inches per year referenced in the EIR/EIS (ESA, 2018). Recharge was applied to the model only on the land areas (Figure 32) and does not affect the Layer 1 ocean boundary. For the recharge scenario, the Layer 4 gradient was set at the intermediate value of 0.0007; slant well pumping was set at 15.5 MGD (Figure 33). This resulted in expected formation of a groundwater mound in the Dune Sand-Perched/Mounded Aquifer (Layer 2) inland of the slant wells, and a seaward gradient toward those wells. Due to more fresh water flowing toward the wells and capture of some of this water, the OWP dropped to 97.2 percent from the 99.97 percent baseline value. This is still higher that what was observed during TSW pumping (Figure 9). This is addressed by further modifications to the model described in Sections 4.7 and 4.8.

The sensitivity of OWP to variations in gradient was checked for the recharge scenario by running the model with 5 inches/year of recharge under the 0.0004, 0.0011, and 0.00 gradients. The results indicate that OWP becomes increasingly sensitive to recharge as the gradient flattens (Table 2). At a gradient of 0.0011, the OWP is 98.6 percent. Decreasing the gradient to 0.0007 decreases OWP by 1.4 percent, bringing it to a value of 97.2 percent. A further decrease in gradient to 0.0004 produces a much larger decrease in OWP of 5.7 percent, bringing it to a value of 91.5 percent. A further still gradient decrease to 0.00 produces the largest change of all in OWP: 12.1 percent, bringing it to a value of 74.9 percent.

It was noted that saline water upwells from Layer 4 to Layer 2 in the southeastern corner of the model (Figure 34), at the location of KV17 in Layer 2 and KV19 in Layer 3 (Figure 15). This is not likely to affect the OWP for this baseline scenario since it is far from the Project slant wells, and is on the other side of the groundwater divide created by recharge in Layer 2. However, it becomes important in further modifications to the model as described in Section 4.7.

4.3 Change 180-Foot Aquifer Gradient from Landward to Zero (SGMA Goal)

The baseline case developed with 5 inches of recharge, a hydraulic gradient of 0.0007, and well field pumping rate of 15.5 MGD described in Section 4.2 was used as the starting point to assess the effect of a zero groundwater gradient on OWP in water captured by the Project well field. The eastern GHB cells for Layers 4, 6, and 8 were set to +3 feet NAVD88 (same as the ocean boundary), the model was rerun, and OWP calculated. The resulting OWP of 74.9 percent is significantly lower than the baseline value of 92.7 percent (Table 2).

However, the 74.9 value generated by the steady-state model would not be seen for many decades or even centuries in real-world conditions. The steady-state model does not consider the large volume of saline water in storage in the 180-Foot Aquifer (Layer 4) that would have to be replaced by fresh water before the OWP at the Pumping well field would begin to decrease, and approach the 74.9 OWP calculated by the model.

Assuming that SGMA could create a flat gradient or even a pronounced seaward gradient,[7] for the initial decades after this condition is achieved the Project pumping wells would capture the existing saline water in the 180-Foot Aquifer (Layer 4) and OWP would likely be at or close to the 92.7 baseline value. After many decades or a few centuries when the 180-Foot Aquifer becomes filled with fresh water, this water would flow out to sea under non-pumping conditions, or would be captured by the Pumping well field if operating. Only under these conditions would the 74.9 OWP occur.

For comparison, it was decided to also check OWP for gradients of 0.0004 and 0.0011 in Layers 4, 6, and 8; these OWPs are 91.5 and 98.6 percent, respectively. This illustrates that when recharge is added to Layer 2, the OWP in water from the production wells becomes increasing sensitive to changes in the groundwater gradient in the deeper layers of the model (Layers 4, 6, and 8) as the gradient becomes gentler. A change in gradient by 0.0004, from 0.0011 to 0.0007, produces a decrease in OWP of 1.4 percent. But a reduction in gradient of the same magnitude starting with a shallower gradient, from 0.0004 to 0.00, produces a decrease in OWP of 12.1 percent. Presumably this is due to the increasing availability of fresh water for capture as the Layer 4 gradient flattens. Flattening the gradient decreases the flow of fresh water away from the pumping wells in Layer 4, until at zero gradient, there is no flow of fresh water away from the pumping wells.

4.4 Sensitivity to Variations in Recharge

The recharge amount of 5 inches per year in the baseline case was varied to determine the sensitivity of the model to variations in recharge. Values of 2.5, 10, and 15 inches per year were modeled.

The change in respective OWP calculated from these recharge values (Table 2) varies by about 7 to 23 percent, depending on the gradient specified in Layer 4. This indicates that OWP is quite sensitive to variations in recharge.

It should be pointed out that this steady-state model does not account for water storage variations in the aquifer, hence the OWPs calculated will not reflect the buffering effects of storage. In a transient situation as is the case in the real world, the actual OWP in a dry year will likely be lower than the calculated OWP due to residual water being present in storage from previous wetter years. In a like manner, the actual OWP in an abnormally wet year will likely be higher than the calculated OWP, as much of the extra water goes into storage and is not immediately available to the well. Therefore, the OWP represented by the sensitivity analysis from this steady-state model shows a narrower range in the OWP values than what would be expected in real-world conditions. To better identify the expected range in OWP, it is recommended to use the transient version of NMGWM^{2016} as discussed in Section 5.2.

4.5 Sensitivity to Variations in Pumping Rate

To determine the effect of changes in pumping rate on the OWP, the baseline scenario for all gradients was run with a pumping rate of half the baseline rate of 15.5 MGD, or 7.75 MGD (Table 1).

[7] The landward gradient due to inland pumping that has caused seawater intrusion into the 180-Foot Aquifer is quite steep and has been for more than 60 to 80 years. It is highly unlikely that a similarly steep seaward gradient could be achieved under SGMA. If it could, it would take a similar period of 60 to 80 years to reverse seawater intrusion impacts and bring fresh water from the 180-Foot Aquifer to the Project well field. Under a more realistic flat or gentle seaward gradient, it would take far longer than 60 to 80 years to reverse the seawater intrusion impacts.

This resulted in a relatively small change in OWP, on the order of approximately 1 percent or less for the non-zero percent gradient scenarios. Doubling the pumping rate to 31 MGD also had a relatively small effect on these scenarios. Under the 0 percent gradient scenario in Layer 4, OWP variations from baseline OWP were about -6 percent at 7.75 MGD and +5 percent at 31 MGD.

4.6 Sensitivity to Variations in Aquifer Zone Hydraulic Conductivities

Several aquifer zones in the vicinity of the pumping wells and western edge of the FO-SVA were selected for modification of KH and KV to determine the potential effects of the position and magnitude of these uncertain soil properties on the OWP. In particular, the values of Layer 2 Zones KH20/KV20 (Figures 14 and 16) and Layer 3 Zones KH21/KV21 (Figures 15 and 16) determine the effective modeled position of the western extent of the FO-SVA. In the unmodified NMGWM^{2016}, the FO-SVA, modeled by Layer 3 and represented by Zones KV18 and KV21 (Figure 15), is present between monitoring well clusters MW-7 and MW-4, with the western edge of KV21 closer to MW-4 (Figure 7). The combination of KH20 of 4 feet per day and KV21 of 0.0005 feet per day favors vertical groundwater flow downward from Layer 2 to Layer 4 through Zone KV21 (Figure 16), effectively negating KV21 as representative of the FO-SVA and therefore positioning the edge of the FO-SVA at the western edge of Layer 3 Zones KH18/KV18. This position is inland of MW-7 and corresponds to the red-dashed line shown on Figure 7 (purple-dashed line on Figure 3).

The KH and KV zones modified, degree of modification, and resulting OWPs are shown in Table 2. The OWP was relatively insensitive to most of the changes, varying less than 1 percent from baseline values. The exceptions involved decreasing KV21 from 0.0005 to 0.0000005 feet per day, which yielded a 1.5 percent decrease in OWP in the 0.0007 gradient scenario, and increasing KH20 from 4 to 625 feet per day, which yielded decreases in OWP ranging from 1.9 percent in the zero gradient scenario to 3.7 percent in the 0.0007 gradient scenario.

Awareness of the relative sensitivity of the OWP to changes in KV21 and KH20 informed the adjustment of model parameters to recreate water level conditions at well MW-7S during pumping of the TSW, as described in Section 4.8.

4.7 Southern Boundary Condition Revision in Layer 2

One of the key technical discrepancies in NMGWM^{2016} identified by stakeholders during Weiss's independent review (Weiss, 2019) is that the southern GHB groundwater elevation values for Layer 2 in the transient "calibration" version of the model were based on groundwater elevations from the Salinas Valley Integrated Ground and Surface Water Model (SVIGSM). These differ from the observed "perched" groundwater elevations by as much as 90 feet (Figures 18 and 34). Therefore, this condition was addressed before proceeding with further analysis of OWP and groundwater capture associated with the Project. A new GHB was created for Layer 2 with the configuration and head values shown on Figure 35. Heads for the GHB were set equal to projected groundwater elevation contours from measurements at Fort Ord, provided by EKI Environment and Water, Inc. Values between the contours were interpolated linearly. The GHB was only applied for cells with head greater than 50 feet to avoid generating artificial flows in and out of the model at lower elevations observed during initial model runs to evaluate the new GHB. Below 50 feet flow was mainly parallel to the southern edge of the model, so these portions of the Layer 2 southern boundary were assigned a no-flow condition.

Layers 3 through 8 were retained as no-flow boundaries, the same as in the unmodified capture version of NMGWM^{2016}.

During earlier model runs for the sensitivity analysis, another element of the unmodified model was discovered that exerted significant control of groundwater elevations along the southern margin. As mentioned in Section 4.2, there is an upwelling of saline water from Layer 4 to Layer 2 in the southeastern corner of the model (Figures 34 and 36) in the scenario with Layer 4 gradient at 0.0007. This location coincides with the location of KV17 in Layer 2 and KV19 in Layer 3 (Figure 15). The upwelling can be identified by an eastward bend, forming a point, in the -20 foot contour in Layer 4 at that location (Figure 33). Also, just west of that location, fresh water was entering Layer 4 from Layer 2, as indicated by the plume of lighter color moving downgradient from that spot. Essentially, KV19 was acting as a sink for fresh water from Layer 2 to flow vertically downward to Layer 4 (Figure 37).

The downward flow from Layer 2 to Layer 4 was much greater in the 0.0004 landward and 0.00 flat gradient scenarios, creating a groundwater mound in Layer 4 and warping the contours in Layer 2 (Figures 33 and 34). This truncated the groundwater mound formed in the Dune Sand Aquifer in the Fort Ord area. This had little effect on the unmodified model, as is shown in Figures 26, 27, and 28, mainly because there was no recharge, and the southern model boundary was a “no flow” boundary that was not putting any fresh water into the model. The problem at KV19 emerged due to its proximity to the newly-created Layer 2 GHB, which provides large quantities of fresh water in the adjacent model cells, creating a steep gradient between the Layer 2 GHB and Layer 3 at that location. The Layer 4 0.0011 and 0.0007 gradients are steep enough to drain this extra water away, in a landward direction away from the coast. But the 0.0004 gradient is not sufficient to drain away the water, hence the entire 180-foot Aquifer becomes unrealistically filled with fresh water, and under the 0.0004 and 0.00 gradients, an unrealistically large groundwater mound forms at the KV19 area. And, under all gradients, the Layer 2 groundwater elevation contours at Fort Ord were unrealistically truncated by the downward flow of groundwater from Layer 2 to Layer 4, as shown in Figures 33, 34, and 36.

The value of KV19 in the original NMGWM^{2016} was set at 8.7 feet per day (Figure 38), indicating the complete absence of the FO-SVA in that area. Note that KV in the adjoining zones is set orders of magnitude lower, where the FO-SVA is present. In Appendix E2 (page 17) of the EIR/EIS (ESA, 2018), it is stated,

> *“South of the Salinas River, the NMGWM^{2015} parameter zones were modified to represent reported hydrogeologic conditions in the Fort Ord Area. We modified the western extent of the FO-SVA delineated by Harding ESE (2001) based on the clay identified between the A-Aquifer and 180-FTE Aquifer in reported cross-sections (GSI, 2016). The **eastern boundary of the FO-SVA*** [emphasis added] *was delineated at the elevation difference between the upper dune sand and terrace deposits and the lower valley deposits.”*

This statement seems to indicate that the FO-SVA should be present in the KV19 zone, as it lies beneath the dune sand and terrace deposits, and its northeastern border coincides with the abovementioned elevation difference between the upper dune sand and terrace deposits and the lower valley deposits (Figure 38). And the FO-SVA is interpreted as being present in cross section 4-4’ (Figure 6) approximately 1 to 3 miles east of KV19. Cross-section 1-1’ (Figure 2a; Appendix E2; ESA, 2015) shows several aquitards in the subsurface near the “elevation difference” between the terrace deposits and lower valley deposits north of KV19, indicating the nature of the FO-SVA in that area.

In Appendix E2 of the EIR/EIS (page 18), it is stated:

> "*In **Figure 3.3a**, most (76%) of the NMGWM^{2016} horizontal conductivity values are within the range of previous studies with the exception of two zones representing the older dune sand deposits where the modeled values are noticeably greater (KH13+KH15 and KH17+KH19). The model-specified values for these older dune sand parameter zones reflect new information developed from analysis of the slant well pumping test data **collected from an observation well located in the older dune sand deposits** (HLA, 1995)* [emphasis added].

It is unknown from which observation well located in the older dune sand deposits this information originated. It does not appear from the MW-1 through MW-9 hydrographs that the TSW had any effect on water levels in wells screened in the older dune sands – or any well further than well MW-4 from the TSW. Zone KH19 is more than 4 miles away from the TSW, so it is not clear how its KH or KV were determined on the basis of TSW pumping test data.

Based on the likely presence of the FO-SVA in the KV19 area and the anomalously low water levels it was creating by allowing water from Layer 2 to move downward to Layer 4, the value of KV19 was changed from 8.7 to 0.0000005, to be in accord with the adjoining KV18 (Figure 38). The effects of this change can be seen in the southeastern corner of the model by comparing the groundwater contours in Layer 2 before the revision (Figure 33) to the contours after the revision (Figures 39 and 40). Groundwater elevations became some 20 to 40 feet higher in much of the southeast corner. To ensure this did not result in groundwater rising above the land surface, in particular the relatively low elevation Salinas Valley, the revised model groundwater elevations (Figures 39 and 40) were compared with land surface elevations in the Valley (Figure 41). The comparison showed the modeled groundwater elevations of 10 to 30 feet in this area remained below actual surface elevations in the range of 30 to 40 feet.

All subsequent model runs described below were performed with the revised southern boundary conditions. The initial run (Figure 39) employed these elements:

- KV19 was adjusted to be the same as KV18 at 0.0000005 feet per day;
- KH16 and KH18 were adjusted from 2 to 3.5 feet per day. This change was necessary because adding the new boundary brings more water into the model; this water needs to flow away from the boundary to maintain a match between the modeled and measured groundwater elevations (Figure 40);
- Recharge was set at 5 inches/year;
- Layer 4 inland gradient was set to 0.0007;
- Pumping from the slant wells at 15.5 MGD; and
- The reference heads at all model boundaries were raised by 3 feet so that heads are consistently expressed relative to the North American Vertical Datum of 1988 (NAVD88) for sea level:
  - Initial heads so that drawdown is still the same;
  - The constant head boundary representing ocean water;
  - GHB heads;
  - RIV heads; and
  - RIV bottom elevations adjusted to match results.

The results show a good match to the groundwater contours in Layer 2 in the south end of the model (Figure 40). The OWP from this initial run was 96.8 percent, 0.4 percent lower than without the adjustments to the south model boundary (Table 3)[8].

4.8 Adjust Model Parameters to Replicate Test Slant Well Conditions at MW-7S

Although not included in the list of tasks for this modeling implementation, to check results of the sensitivity analysis and southern boundary adjustments, the model was applied to see if it could replicate a limited set of conditions from the TSW testing period (Figure 9). These conditions were the OWP values for the dry period prior to the summer of 2016, the wet period following, corresponding groundwater elevations in well MW-7S, and pumping at 2,000 gpm (2.88 MGD). The remaining parameters were set as specified in Section 4.7, with the exception of the following:

- Only the northernmost slant well was used, corresponding to the TSW;
- Pumping was proportionally distributed over the model cells representing that well, based on the distribution of pumping rates assigned to the well for the 15.5 MGD simulations; and
- KH20 was changed from 4 to 40 feet per day, and KV21 was changed from 0.0005 to 0.0000005 feet per day, simulating an extension of the FO-SVA westward by 2,600 to 4,800 feet, bringing it west of well MW-7S and close to well MW-4S.

Two seasonal conditions were assessed: (1) "Wet" conditions represented by recharge of 6 inches per year and gradient of 0.0004; and (2) "Dry" conditions represented by recharge of 4 inches per year and gradient of 0.0011. In both scenarios, the OWP was calculated for the TSW and groundwater elevation was noted at well MW-7S; results are shown on Figures 42 and 43.

The "wet" scenario predicts an OWP of 85.8 percent and a water level in well MW-7S of 8.9 feet, very similar to the early- to mid-2017 values obtained in the TSW test (Figure 9). The "dry" scenario predicts an OWP of 99.6 percent, much higher than any of the "dry" periods during the TSW test, and a water level in well MW-7S of 0.7 feet, much lower than at any time during the TSW test (Figure 9). The latter is likely an artifact of steady state modeling, which is unable to draw on prior storage of fresh water in Layer 2 – essentially assuming that it has always been "dry" and always will remain dry. In the real world, the OWP and water levels in well MW-7S in the 2015 and early 2016 "dry" period likely reflect the influence of a large volume of storage of fresh water from previous wet years. The range in the OWP values from 85.8 to 99.6 percent derived from modeling TSW pumping conditions is similar to the range in the OWPs derived from modeling the full Project well flow, as discussed in Section 4.9.

In evaluating different combinations of recharge, KH, KV, and gradient to get the model to reproduce the "wet" season OWP and well MW-7S water levels from the TSW test, no combination was successful without extending the edge of the FO-SVA seaward as was done. As previously mentioned, this was accomplished through a combination of decreasing vertical K in Layer 3 Zone KV21 to the same value as KV18 (0.0000005 feet per day), and increasing horizontal K in Layer 2 Zone KH20 from 4 to 20 feet per day. This is good evidence that the FO-SVA is continuous,

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[8] To provide comparison for different assumed "fresh" water TDS, Table 3a shows the OWPs based on the assumption that "fresh" water has TDS of 500 mg/L (OWP^{500}), and Table 3b shows the OWPs based on the assumption that "fresh" water has TDS of 3,000 mg/L ($OWP^{3,000}$).

and indeed does extend west of well MW-7S. It is therefore unnecessary to conduct field work to establish the configuration and continuity of the FO-SVA; assuming it is continuous and extends west of well MW-7S produces conservatively low OWP estimates that match the TSW results.

4.9 Estimated Groundwater Capture in a Range of Scenarios

Building on the "wet" and "dry" scenarios described in Sections 4.7 and 4.8, both were run at slant well pumping rates of 7.75 and 15.5 MGD to obtain OWP estimates, and generate MODPATH plots to estimate the groundwater capture areas for these scenarios and pumping rates in Layers 2 and 4 (Figure 44 through 47).

Estimated fresh groundwater capture is greater in the "wet" scenarios due to the greater volume of fresh water coming into the system as recharge, and the reduced outflow from a gentler gradient in Layer 4 (Figures 44 and 45). For the 7.75 MGD Project pumping rate, the estimated capture areas are approximately 4 square miles in Layer 2, and 1.5 square miles in Layer 4. For the 15.5 MGD Project pumping rate, the capture areas are approximately 8 square miles in Layer 2, and 4 square miles in Layer 4.

Estimated fresh groundwater capture is less in the "dry" scenarios due to less availability of fresh water, and the steeper landward dry-season groundwater gradient in Layer 4. The steeper gradient induces greater fresh water flow inland, away from the Project well field. For the 7.75 MGD Project pumping rate, the estimated capture areas are approximately 0.75-square mile in Layer 2 and 0.5-square mile in Layer 4. For the 15.5 MGD Project pumping rate, the capture areas are approximately 2.5 square miles in Layer 2, and 0.75-square mile in Layer 4.

In addition, zero pumping and 7.75 and 15.5 MGD scenarios were run for a zero groundwater gradient set for Layers 4, 6, and 8 in the model (Table 3). The GHB for the eastern side of the model was set at +3 feet NAVD88 for all layers, creating a zero gradient from the eastern model boundary to the ocean. Recharge was set at 5 inches per year; this recharge and vertical downward flow from Layer 2 creates a gentle seaward gradient from several miles inland to the coast in these layers, in the region of the Pumping well field. MODPATH plots were generated for Layers 2 and 4 for each of these scenarios (Figures 48, 49, and 50).

The zero to slightly seaward groundwater gradient scenarios represent what may potentially occur following full implementation of the SGMA by 2040. In the no-pumping scenario (Figure 48), fresh groundwater flows from inland out to sea. Because the head differential between Layers 2 and 4 is eliminated in the zero to slightly seaward gradient scenarios, there is no spillover of fresh water from Layer 2 to Layer 4 at the edge of the FO-SVA – instead, all of the fresh water in both layers flows to the sea. In the pumping scenarios (Figures 49 and 50), much of the fresh water flowing toward the sea is captured by the Project well field. However, as discussed in Section 4.3, it would take many decades or even a few centuries before all of the sea water was flushed from the 180-foot aquifer and the OWPs of 66.6 for the 7.75 MGD pumping rate and 73.4 for the 15.5 MGD pumping rate were achieved.

4.10 Potential Impacts on Vernal Ponds

It is not known if the vernal ponds owe their existence to temporary perched water table conditions or are associated with temporary high overall groundwater elevations. Only in the latter case could the MPWSP pumping potentially impact the vernal ponds.

The potential impact of pumping on the vernal ponds located within the area of influence of the Project well field (Figure 51) was evaluated for both the "wet" and "dry" seasons. To serve as a baseline, the modeled groundwater elevations were compiled for the "wet" and "dry" season non-pumping model conditions for each pond (Table 4). Water level decreases (drawdown) at each pond due to pumping at rates of 7.75 and 15.5 MGD was also compiled and tabulated. The drawdowns for the "wet" and "dry" seasons are the same as a result of the principal of superposition; both seasons are tabulated to illustrate this principal.

As would be expected, baseline groundwater elevations are modeled to be lowest in the "dry" season and highest in the "wet" season, ranging from calculated lows of -2.8 to 0.29 feet NAVD88, to calculated highs of 2.7 to 6.9 feet NAVD88. These values are modeled estimates for comparison only, and are not a substitute for surveyed and measured groundwater elevations.

Model-predicted drawdowns are greatest in the ponds closest to the Project well field. Drawdowns range from 0.39 and 0.79 feet at the Lake Drive Pond for 7.75 and 15.5 MGD pumping rates, to 2.02 and 4.05 feet at the Armstrong Ranch Ponds for 7.75 and 15.5 MGD pumping rates, respectively.

4.11 Limitations of this Study

The numerical model used to simulate groundwater flow in this study is an approximate and non-unique representation of actual groundwater flow in the study area. As such, the study results are intended to be used strictly as a decision support tool. Due to a variety of known and unknown limitations, the results should not be considered as definitive representations of past, current, or future groundwater flow. The most important limitations that apply to the modeling conducted for this study are described below.

The subsurface hydrogeologic conditions within the study are not precisely defined and therefore hydrogeological features which are mathematically depicted in the numerical model are often based on extrapolation and assumptions by experienced professionals. While best practices have been used to establish valid model input parameters, the resulting solutions are not unique and the uncertainties in the model results cannot be quantified.

The model results are best applied to the area of the slant wells and vicinity, and become progressively less representative of actual conditions with increasing distance inland from the coast. The model should not be used to predict water levels or salinity in any area more than a few thousand feet from the Project well field. Such predictions would be approximations only, and should be augmented with information from other sources.

As described in Section 4.8, the steady-state model used in this study cannot reproduce "dry" season water levels accurately due to a lack of prior storage. The groundwater capture estimates discussed in Section 4.9 are based on steady-state modeling and do not account for groundwater storage, therefore the high and low ends of the range of estimates are not likely to occur and can be considered as “best-case” and “worst-case” estimates. Transient modeling is required to produce more realistic estimates of the capture areas likely to occur within this range.

Recharge is averaged over a year, when it actually takes place over a 4- to 6-month interval each year. This is good for determining general patterns and for comparing different scenarios, however it cannot be applied directly to predict specific circumstances, especially those with many variations.

Density differences between ocean water and fresh water are not accounted for. Compared with the single-density modeling performed for this study, the greater density of ocean water would have the effect that it would flow inland to a greater extent than what was modeled. This means that all else being equal, the OWP estimates from this single-density model will be in lower than actual values. An assessment of this issue in the EIR/EIS (ESA, 2018) indicated that the error in the OWP resulting from the single-density assumption is on the order of a few percent. However, this error appears to be largely offset by the specified inland gradients of 0.0004, 0.0007, and 0.0011 employed in the model (Figures 20, 21, 22, and 36) which create saline conditions in Layer 4. These gradients will partially account for saltwater intrusion in addition to the gradients induced by inland pumping alone.

The OWP and water level data obtained from the TSW (Figure 9) were used in this study and compared with model results. These data may have been impacted by adjacent CEMEX pond dredging sand washing with fresh water. The CEMEX operation moves large volumes of salt water and fresh water in dredging sand quarries (salt water) and washing sand (fresh water). These operations were active during the slant well testing, and the degree to which operations affected the results is unknown; opinions differ as to its significance (Hopkins, 2017). To the degree fresh water was discharged to the surface in the TSW vicinity from the sand washing operation, the OWP would be depressed. Discharges of saline dredge water would have the opposite effect.

It is important when interpreting the results of the steady-state version of the NMGWM^{2016} implemented for this study, to understand that the results represent equilibrium conditions not experienced in the real world where variables such as recharge and pumping rates are constantly changing. Each model implementation scenario assumes values for the hydrogeologic variables that do not change, in effect assuming that conditions have always been the way the parameters are set, and will never change in the future. Whereas in the real world there are seasonal changes, long-term weather trends, and variable anthropogenic effects such as land use changes, groundwater pumping and surface water diversions. The steady-state model therefore can represent an average condition, long-term average condition, or “worst case” end member condition, and the OWP calculated from each scenario must be interpreted accordingly. Especially important to the real-world value of the OWP is the flow of groundwater in and out of aquifer storage, which is not accounted for in the steady-state model, and provides a buffering effect.

Therefore, the OWP results are best understood as long-term averages, and differences between OWP values calculated indicate the relative effects of changing a particular variable, and will not necessarily be representative of, or predict, short-term OWP changes. For example, the annual average recharge value of 5 inches per year is distributed evenly over the entire year in the steady-state model; a transient model would assign the recharge proportionately to the 4- to 6-month period when it actually occurs. This should make seasonal changes in the OWP evident, whereas the steady-state model results will depict only the average tendencies of the system.

Also important is the effect of travel time. In calculating the OWP for the zero-gradient scenario, the length of time for existing salt water in the aquifers to be pushed back to the sea is likely to be decades to centuries. The OWP calculated for the Project well field output under the 0.00 gradient in Layers 4, 6, and 8 will only gradually be approached as that existing salt water flows seaward; it will not "instantaneously" reach the 65 to 75 percent range calculated by the model – that requires equilibrium to be reached.

The steady-state version of $NMGWM^{2016}$ does not account for the difference in density between fresh water and ocean water. The higher density of ocean water will induce flow inland, beneath the fresh water, in the absence of sufficient head in the inland fresh water aquifer(s). All else being equal, this would increase the OWP in the inland areas so impacted. Because this phenomenon is not modeled, the estimates of the OWP from the model err on the low side.

In both the original model and in the implementation for this study, the Dune Sand Aquifer (Layer 2) is modeled as confined. This results in zero change in transmissivity as water levels change, likely underestimating freshwater flow to the slant wells in wet conditions, and overestimating freshwater flow to the wells in dry conditions. And, the slant wells are modeled such that they withdraw a fixed proportion of water from each pumped layer, regardless of the actual layer transmissivity and gradient. The use of the multi-node well package (MNW) and/or multi-aquifer well package (MAW) in MODFLOW would rectify the latter.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The key conclusions from this study of OWP and fresh water capture under different conditions and assumed subsurface configurations are as follows:

1. OWP in water from the production wells becomes increasingly sensitive to changes in groundwater gradient in the deeper layers of the model (Layers 4, 6, and 8) as the gradient becomes gentler. A change in gradient by 0.0004, from 0.0011 to 0.0007 produces a decrease in the OWP of 1.4 percent. However, a reduction in gradient of the same magnitude starting with a shallower gradient, from 0.0004 to 0.00, produces a decrease in the OWP of 12.1 percent.

2. The OWP is relatively sensitive to changes in recharge and corresponding groundwater elevation differences inland from the Project well field.

3. The OWP is sensitive to the configuration/location of the western edge of the FO-SVA aquitard and the hydraulic conductivity of the overlying Dune Sand Aquifer under moderate inland gradient conditions (0.0004 to 0.0007). Moving the western edge of the FO-SVA 2,600 to 4,800 feet seaward from the original location assumed by the $NMGWM^{2016}$ reduces the OWP by 3.5 to 5 percent, depending on the gradient. There is little change in the OWP from moving the western edge of the FO-SVA under 0.00 gradient conditions, presumably because all the water in both Layers 2 and 4 inland from the coast is fresh.

4. The OWP and groundwater capture are not very sensitive to changes in aquifer zone KH and KV other than the changes mentioned above.

5. Potential fresh water capture by the MPWSP was estimated from particle tracking for "dry" and "wet" conditions, representing minimum and maximum likely capture areas. Under "dry" conditions, the MPWSP is calculated to potentially capture fresh groundwater from the Dune Sand Aquifer (Model Layer 2) over an area ranging from 0.75-square mile with pumping at 7.75 MGD to 2.5 square miles at 15.5 MGD. The range in the 180-Foot Aquifer (Model Layer 4) under these pumping conditions is 0.5- to 0.75-square mile. Under "wet" conditions, the corresponding capture areas increase in Layer 2 to range from 4 square miles with pumping at 7.75 MGD to 8 square miles at 15.5 MGD. In Layer 4, the "wet" conditions capture range is from 1.5 square miles with pumping at 7.75 MGD to 4 square miles at 15.5 MGD. These estimates are based on steady-state modeling and do not account for groundwater storage, therefore the high and low ends of the range are not likely to occur and can be considered "best-case" and "worst-case" estimates. Transient modeling would be required to produce more realistic estimates of the capture areas likely to occur within this range.

6. For zero gradient conditions in the 180-Foot Aquifer, potentially achievable by 2040 under SGMA, an OWP range of 66.6 to 73.4 was estimated for 7.75 MGD and 15.5 MGD pumping rates, respectively. However, as discussed in Section 4.3, it would

take many decades or even a few centuries for all of the sea water to be flushed from the 180-foot aquifer and for these OWPs to be achieved. Until that time, the Pumping well field would be capturing all of the saline water currently in storage in the 180-Foot Aquifer, resulting in average OWPs greater than 91.5.

7. If the vernal ponds do not owe their existence to perched groundwater conditions, they may be in hydraulic communication with shallow groundwater and subject to impact by the MPWSP pumping. In the latter case, model-predicted reductions in groundwater levels at the ponds range from 0.39 to 4.05 feet, depending on the location and the MPWSP pumping rate.

5.2 Recommendations

If more precise estimates of the OWP and groundwater capture and vernal pond impacts are necessary to support project decisions, it is recommended to employ the transient version of the NMGWM^{2016} ("calibrated model"). This will overcome the limitations of the steady-state implementation of NMGWM^{2016}, which does not account for groundwater storage and short-term difference on a scale of a few years or less. It is recommended that the transient version of NMGWM^{2016} be implemented as follows:

- Revise the starting heads file, possibly by importing the head file from one of the later or last stress periods, rather than relying on the SVIGSM starting heads.
- Revise the eastern model boundary conditions that are currently based on the SVIGSM, while retaining the adjustment to the Layer 2 GHB on the southern boundary and revision of KV19 made for this investigation. This will produce better model calibration with the calibration wells used in the NMGWM^{2016}; if this creates a perched condition for Layer 2 that MODFLOW-2000 will not work with, thicken Layer 3 from the bottom of Layer 2 to below sea level, with KV of Layer 3 set sufficiently low to keep it saturated, and provide hydraulic continuity between the bottom of Layer 2 and the top of Layer 4. Or, instead of MODFLOW-2000, use a Newton-Raphson formulation of MODFLOW such as MODFLOW-NWT (Niswonger et. al., 2011) or MODFLOW-USG (Panday et. al., 2013) that improves the solution of unconfined groundwater-flow problems.
- Keep sea level elevation at +3 feet relative to the NAVD-88 as was done for this investigation.
- Revise KH and KV in certain model zones as appropriate, using the values and results of the sensitivity analysis from this investigation as a guide.
- Specify that the Dune Sand Aquifer (Layer 2) is unconfined.
- Use the MNW or MAW packages in MODFLOW to model the slant wells so that they withdraw water from each pumped layer (Layers 2 and 4) in proportion to the actual layer transmissivity and gradient.
- Extend the model calibration period from 1980-2011 to 1980-2019; update recharge, evapotranspiration, boundary heads, and other model inputs accordingly.

- In addition to the existing group of wells used to calibrate the NMGWM^{2016} to the 1980-2011 period, extend the calibration period to include 2015-2020 data from the MW-series of monitoring wells and the TSW, which includes periods of below-average rainfall, much higher than average rainfall, and slightly above average rainfall. Also add key Fort Ord monitoring wells screened in Layer 2 that have a long period of record. Adjust model parameters to accurately predict the draw-downs in the MW-series of monitoring wells in response to the TSW pumping that occurred between April 15, 2015 and February 28, 2018, and the recovery period that followed.
- Estimate the potential impact of CEMEX operations that discharged water related to sand quarry dredging (salt water) and sand washing (fresh water) on slant well testing results. The degree to which these operations affected the TSW results is unknown. A sensitivity analysis covering the potential range of reasonable assumptions of salt water and fresh water discharge should be performed to determine the potential effect of these inputs on OWP calculations.
- Vernal pond bottom elevations should be surveyed and water levels monitored, both in the ponds themselves and adjacent shallow groundwater to determine if they exist because of perched water conditions or as a result of hydraulic communication with shallow groundwater.

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a. Chapter 4.4 (*Groundwater Resource*s)
b. Chapter 8.2 (*Master Responses 5-12*)
c. Chapters 8.5.1, 8.5.2 (*Comment letters of City of Marina and MCWD and Responses to Comments*)
d. Appendix E1, *Lawrence Berkeley National Laboratories Peer Review*
e. Appendix E2, *North Marina Groundwater Model Review, Revision, and Implementation for Slant Well Pumping Scenarios*
f. Appendix E3, *HWG Hydrogeologic Investigation Technical Report*
g. Appendix J, *Memorandum regarding Responses to Comments Received after Publication of MPWSP Final EIR/EIS*, File No. A. 12-04-019 Cal-Am MPWSP FEIR/EIS (September 12, 2018).

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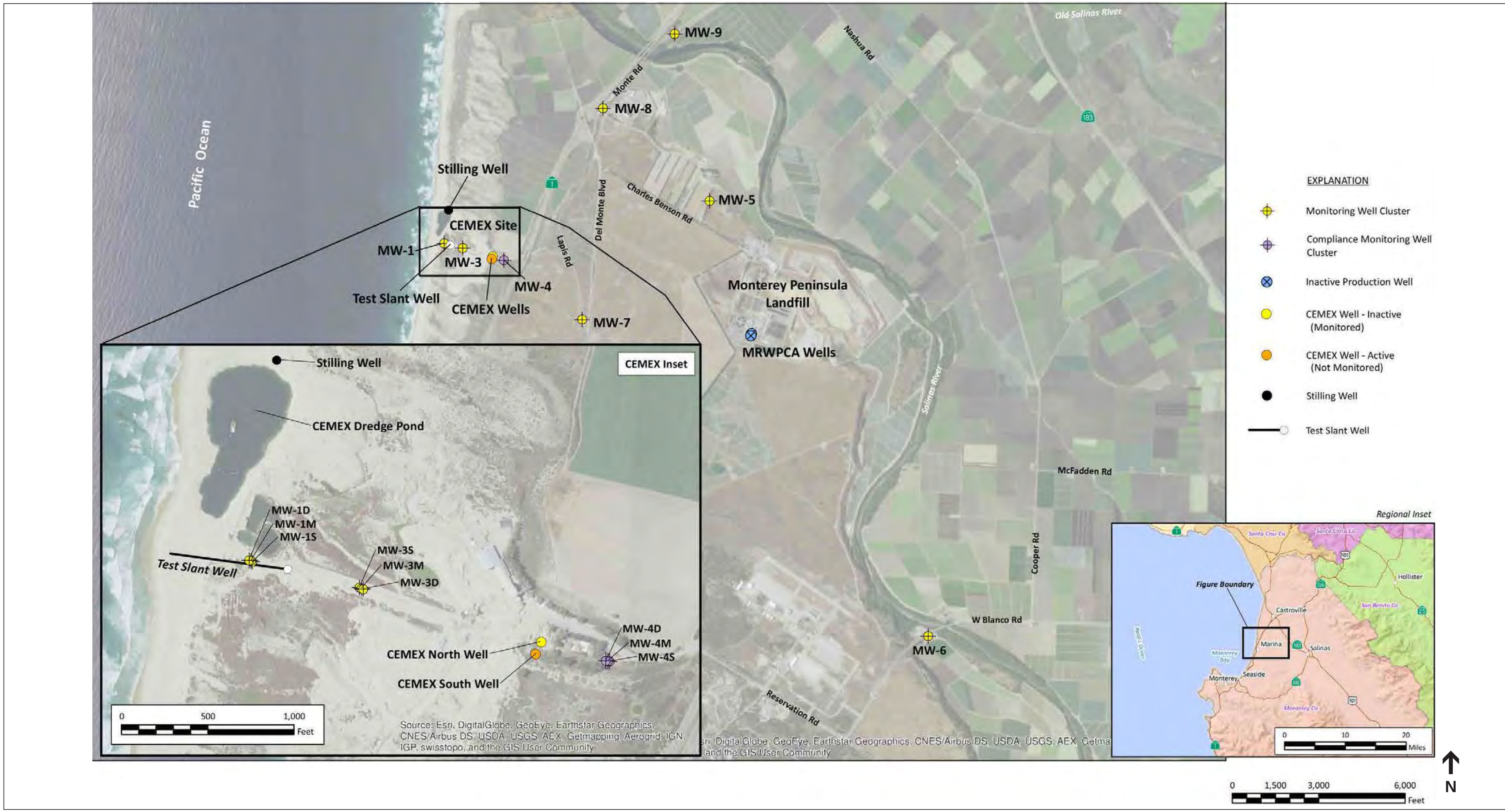
FIGURES



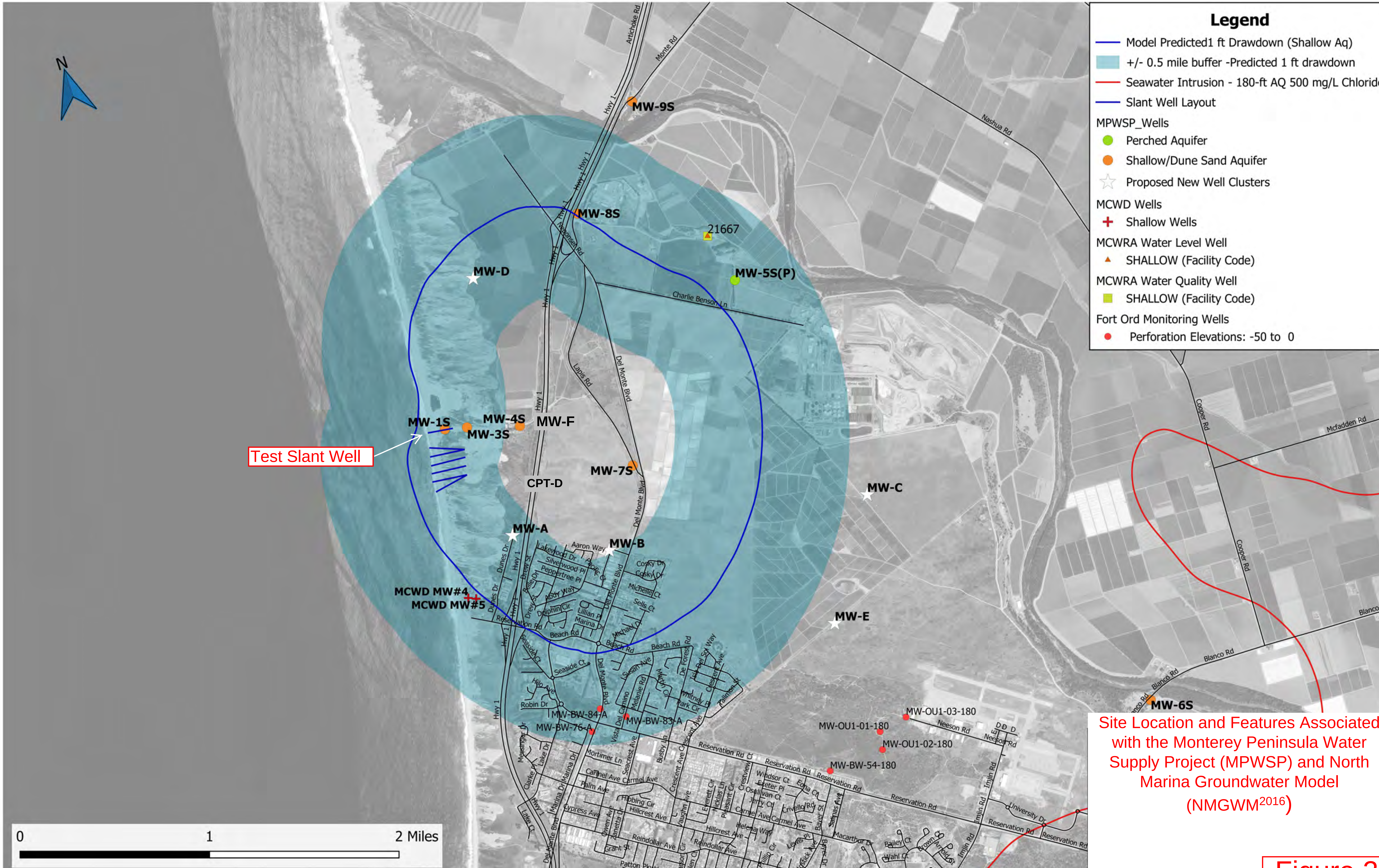
SOURCE: GeoScience, 2016

Monterey Peninsula Water Supply Project . 205335.01

Figure 4.4-9

Slant Well and Monitoring Well Locations

Figure 1

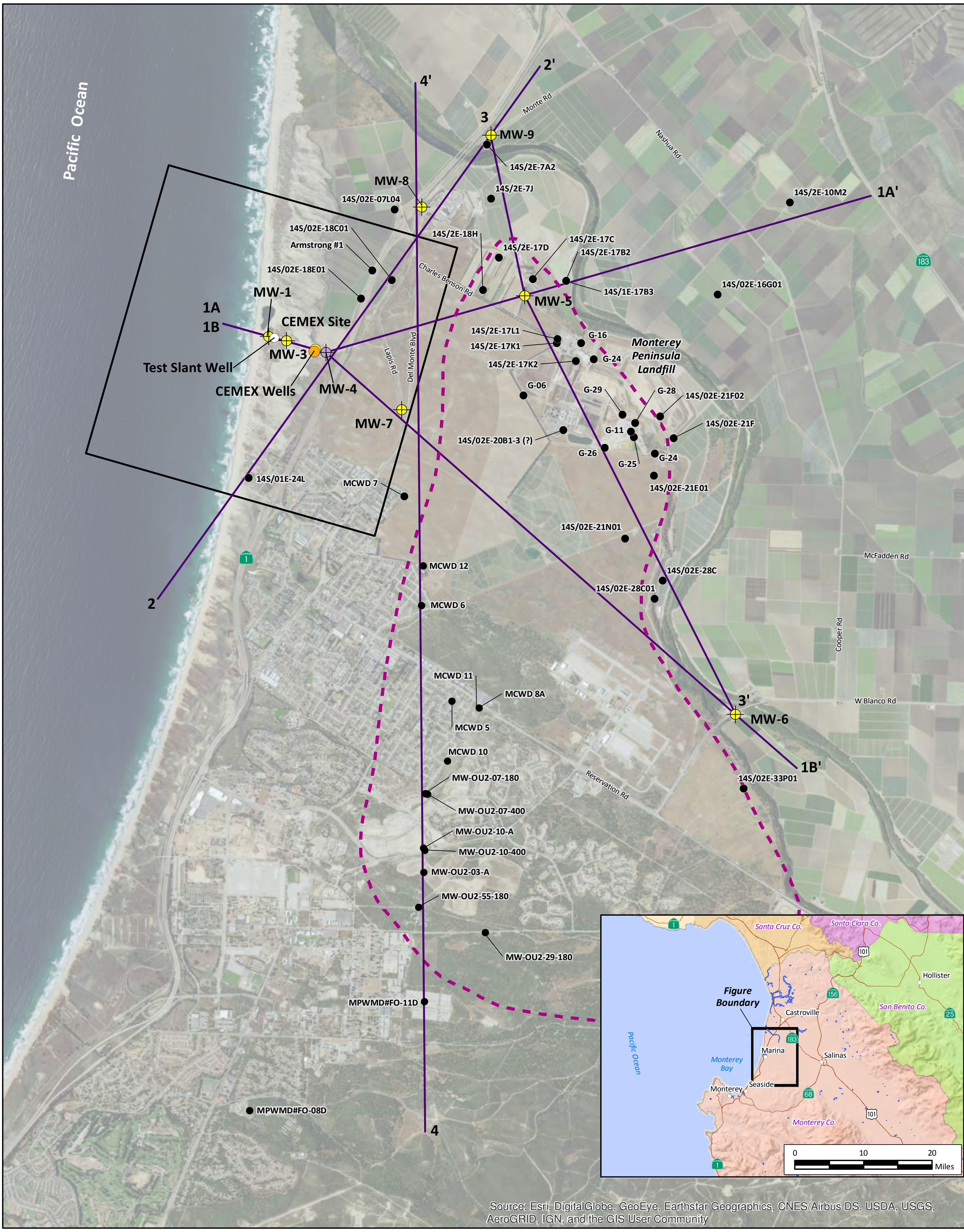


Site Location and Features Associated with the Monterey Peninsula Water Supply Project (MPWSP) and North Marina Groundwater Model (NMGWM2016)

Figure 2

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT
MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE



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EXPLANATION

- CEMEX Model Boundary
- 1 — 1' Cross-Section Location
- Fort Ord Salinas Valley Aquitard (FO-SVA) (GEOSCIENCE, 2016)
- Monitoring Well Cluster
- Compliance Monitoring Well Cluster
- CEMEX Well - Inactive (Monitored)
- CEMEX Well - Active (Not Monitored)
- Test Slant Well
- Other Well Used in Cross-Sections

NORTH

0 3,500 7,000 Feet

REGIONAL LOCATION MAP SHOWING WELL AND CROSS-SECTION LOCATIONS

8-Feb-17

Prepared by: DB. Map Projection: State Plane 1983, Zone IV.

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Figure 2

Figure 3

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE

GEOLOGIC CROSS-SECTION 1A-1A'

8-Feb-17

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Figure 3

X:\Projects\MONTEREY AREA DESAL STUDIES\01a) Test Slant Well Project\01) Monitoring Wells\4) TM Monitoring Well Completion\03) Final TM Feb_17\Figures

Figure 4


CALIFORNIA AMERICAN WATER
MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REORT AND CEMEX MODEL UPDATE
GEOLOGIC CROSS-SECTION 1B-1B'
1B W-NW
1B' E-SE
CEMEX Site
Dune Complex - Highland Area
Salinas Valley
Gap in FO-SVA East of MW-7?
Elevation, ft NAVD88
Pacific Ocean
Deltaic Deposits (Qf?)
Older Dune Sand (Qod)
Terrace Deposits (Qt)
180-Foot Equivalent Aquifer
180/400-Foot Aquitard
CEMEX North Well Screen Interval
CEMEX South Well Screen Interval
Aromas Sand (?) (Qar)
FO-SVA
Salinas River
Flood Plain Deposits (Qfl)
Perched "A" Aquifer
SVA
Valley Fill (Qo)
180-Foot Aquifer
400-Foot Aquifer
Paso Robles Formation (QT)
Explanation
Holocene
Pleistocene
Pliocene
SVA Clay Layer
Clay Layer
Geologic Contact (approximate)
Wells
MPWSP Monitoring Well Screened Interval
Screened Interval from DWR Well Log
Well Lithology
Conductivity Induction Log Deep (CILD) [mmho/m]
Groundwater Elevation, ft NAVD88 10-Sep-2015)
Shallow Completion
Middle Completion
Deep Completion
Water Quality (TDS) Measurement, mg/L (February, March, April, and August 2015)
Horizontal Approximate Scale Feet
Vertical Approximate Scale Feet
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Figure 4
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Figure 5

CALIFORNIA AMERICAN WATER

MONTEREY PENINSULA WATER SUPPLY PROJECT - MONITORING WELL COMPLETION REPORT AND CEMEX MODEL UPDATE

GEOLOGIC CROSS-SECTION 4-4'

8-Feb-17

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Figure 7

Figure 6

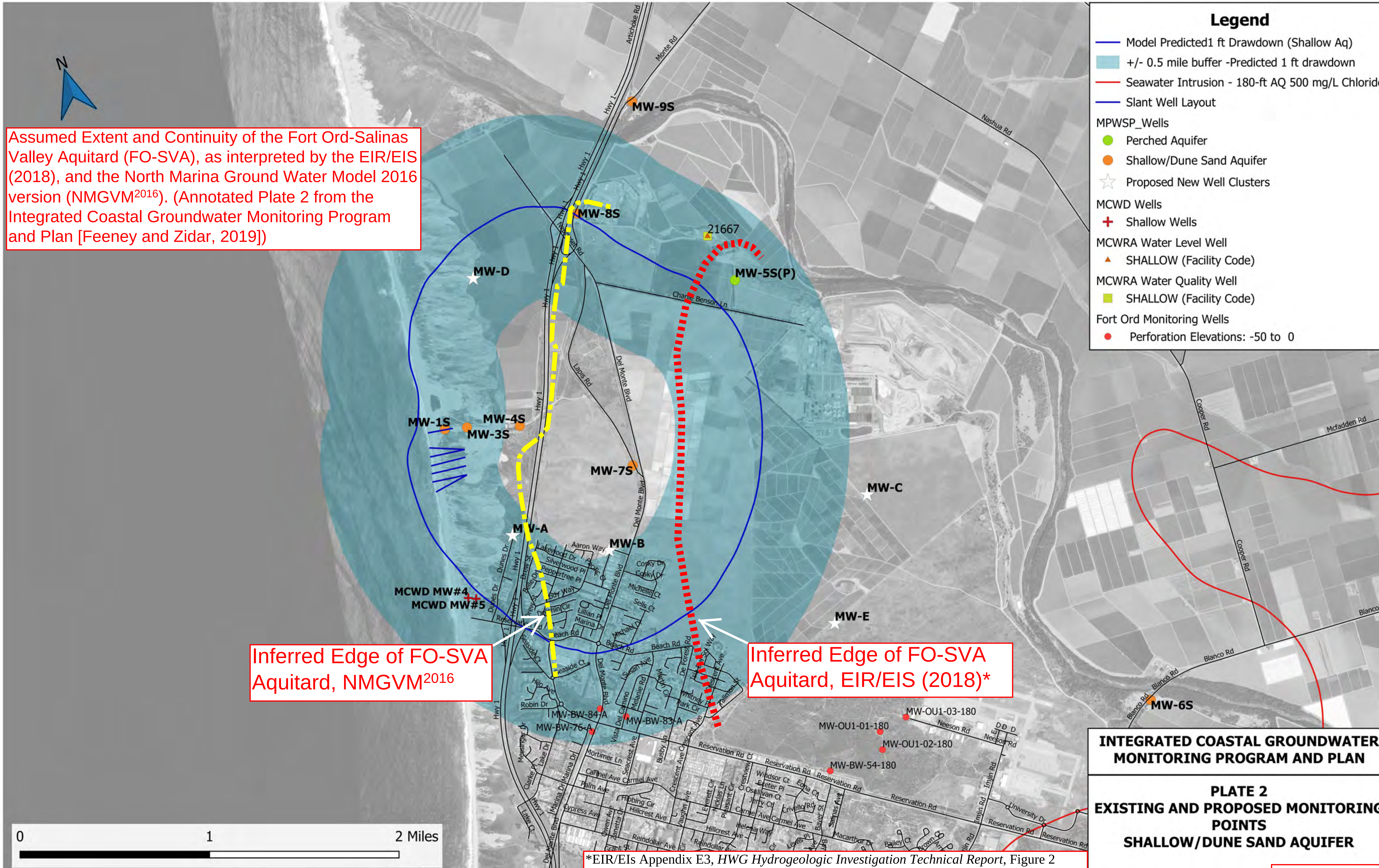

Assumed Extent and Continuity of the Fort Ord-Salinas Valley Aquitard (FO-SVA), as interpreted by the EIR/EIS (2018), and the North Marina Ground Water Model 2016 version (NMGVM2016). (Annotated Plate 2 from the Integrated Coastal Groundwater Monitoring Program and Plan [Feeney and Zidar, 2019])
Legend
Model Predicted1 ft Drawdown (Shallow Aq)
+/- 0.5 mile buffer -Predicted 1 ft drawdown
Seawater Intrusion - 180-ft AQ 500 mg/L Chloride
Slant Well Layout
MPWSP_Wells
Perched Aquifer
Shallow/Dune Sand Aquifer
Proposed New Well Clusters
MCWD Wells
Shallow Wells
MCWRA Water Level Well
SHALLOW (Facility Code)
MCWRA Water Quality Well
SHALLOW (Facility Code)
Fort Ord Monitoring Wells
Perforation Elevations: -50 to 0
N
MW-9S
MW-8S
21667
MW-5S(P)
MW-D
MW-1S
MW-4S
MW-3S
MW-7S
MW-C
MW-A
MW-B
MCWD MW#4
MCWD MW#5
MW-E
MW-6S
MW-BW-84-A
MW-BW-83-A
MW-BW-76-A
MW-OU1-03-180
MW-OU1-01-180
MW-OU1-02-180
MW-BW-54-180
Inferred Edge of FO-SVA Aquitard, NMGVM2016
Inferred Edge of FO-SVA Aquitard, EIR/EIS (2018)*
0
1
2 Miles
*EIR/EIs Appendix E3, HWG Hydrogeologic Investigation Technical Report, Figure 2
INTEGRATED COASTAL GROUNDWATER MONITORING PROGRAM AND PLAN
PLATE 2
EXISTING AND PROPOSED MONITORING POINTS
SHALLOW/DUNE SAND AQUIFER

Figure 7

A

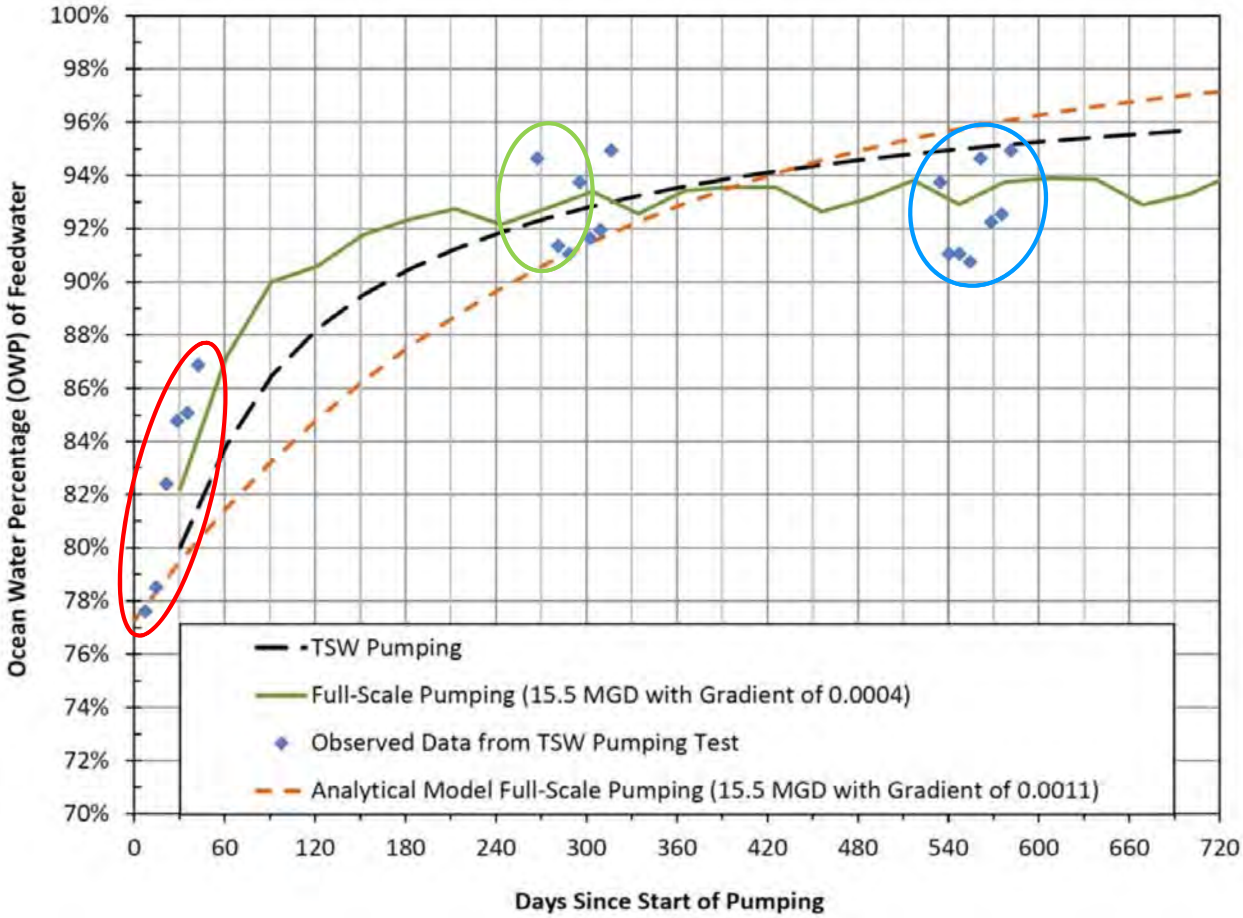
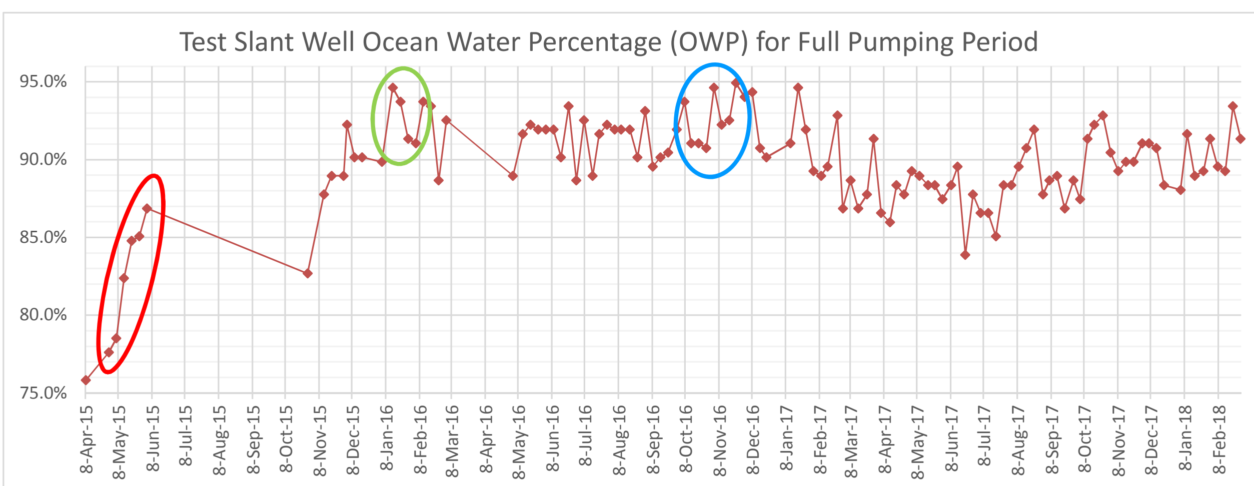


Figure 3.15 from the *MPWSP – HWG Hydrogeologic Investigation Technical Report* by the Hydrogeologic Working Group (November 6, 2017), EIR/EIS Appendix E3, Part 1

B

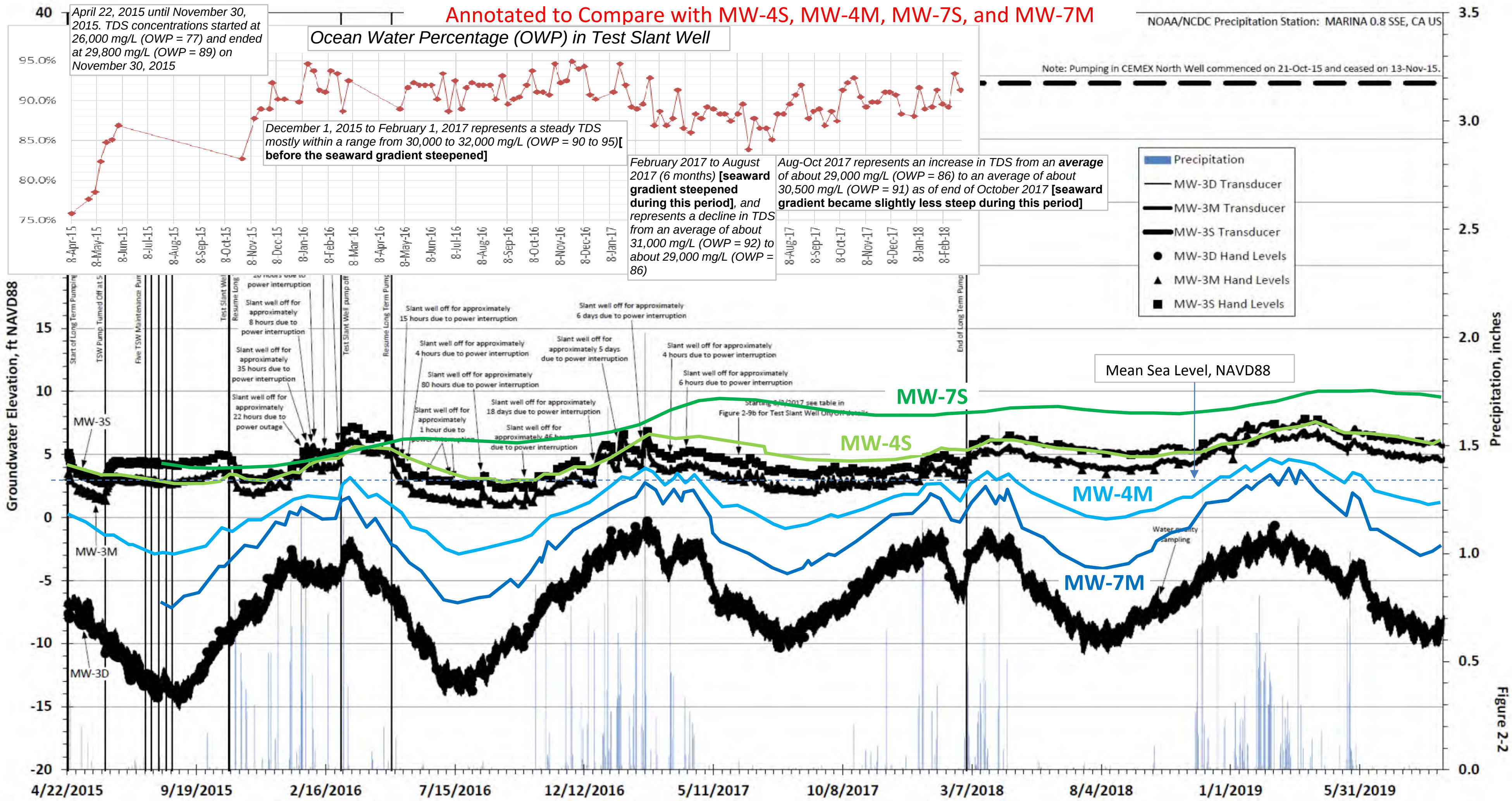


Comparison of Portions of the Test Slant Well OWP Record as Depicted in the EIR/EIS With OWP for the Full Pumping Record (Red, Green, and Blue Ovals Show Comparable Time Periods)

Figure 8

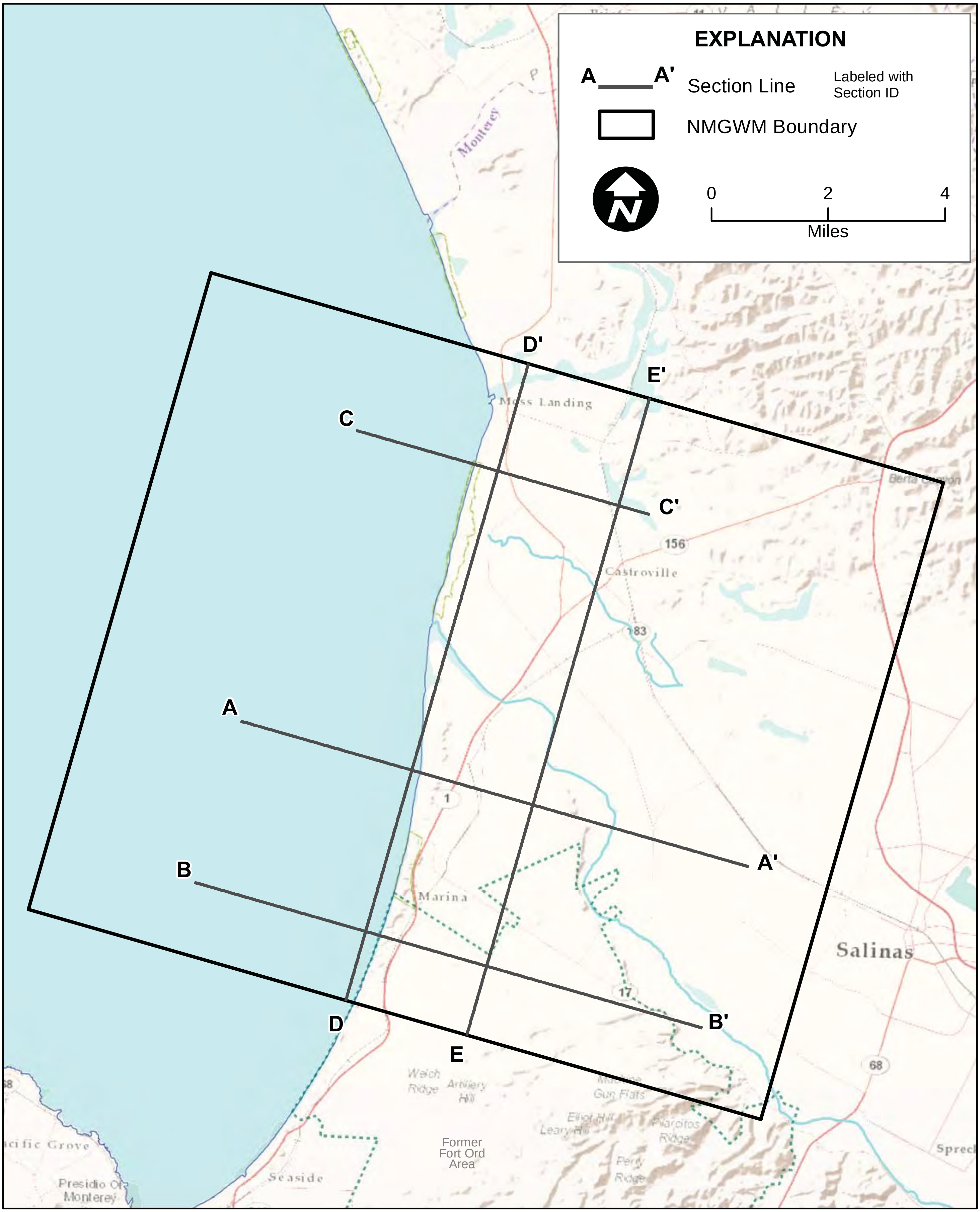
Groundwater Elevation in MPWSP MW-3

Annotated to Compare with MW-4S, MW-4M, MW-7S, and MW-7M



Test Slant Well Pumping - Comparison of OWP and Water Levels in MW-3, MW-4, and MW-7

Figure 9



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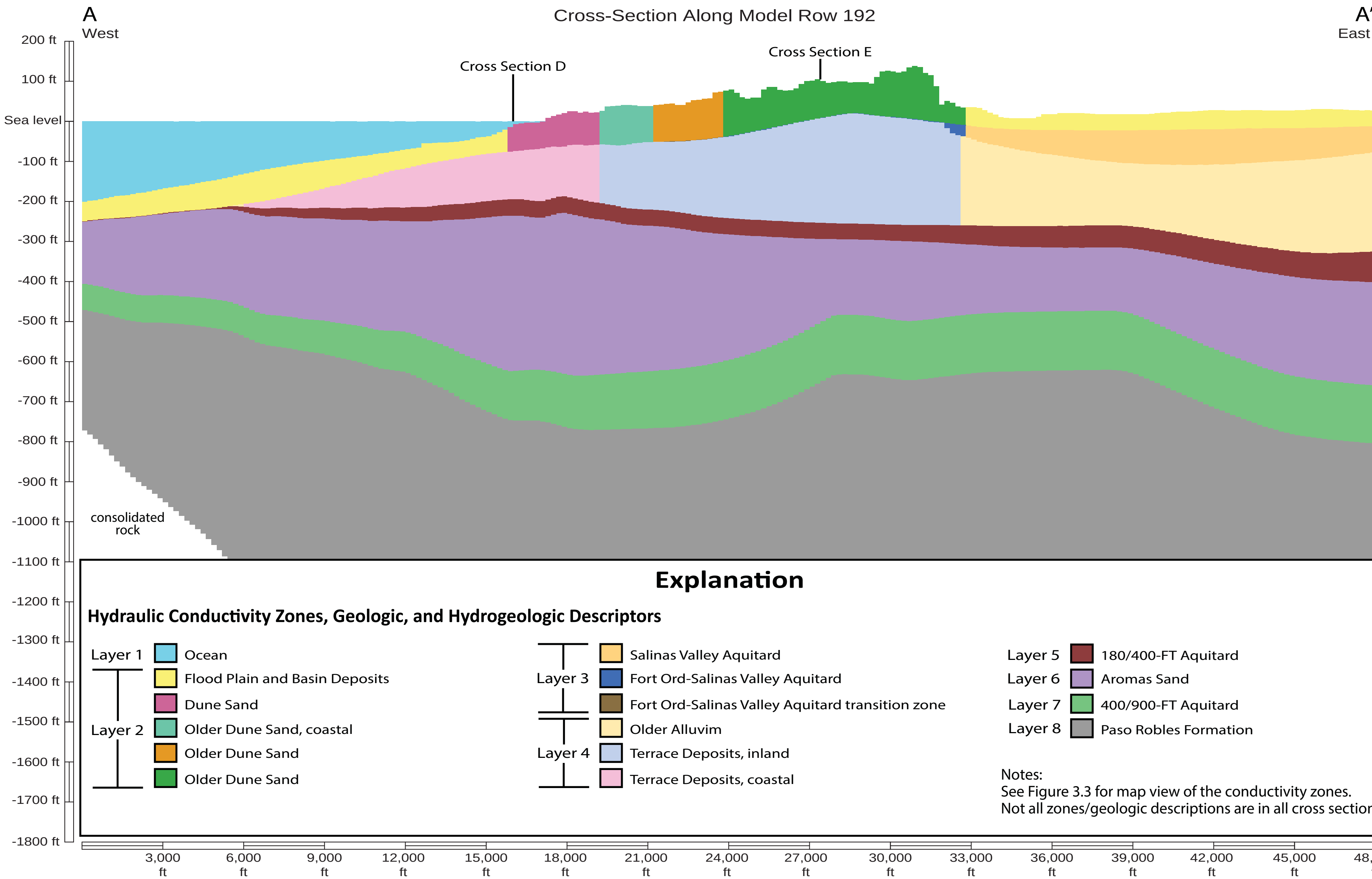
NMGWM[2016] section lines.

Figure 3.2a

PROJECT: 5073

DATE: 8/12/2016

Figure 10



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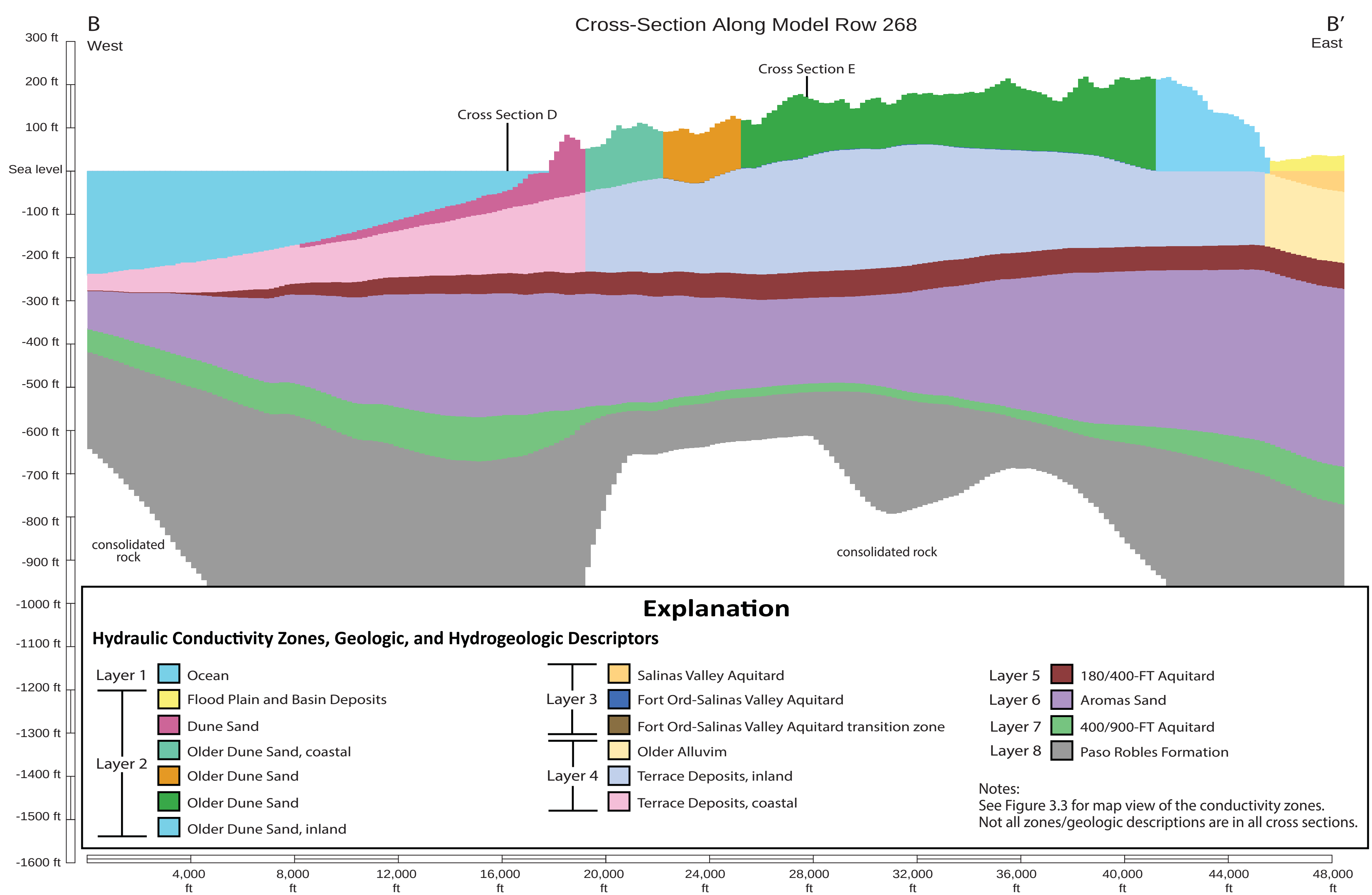
Section A-A′, NMGWM[2016].

Figure 3.2b

PROJECT: 5073

DATE: 11/8/2016

Figure 11



HYDROFOCUS INC.
Solutions for Land and Water Resources

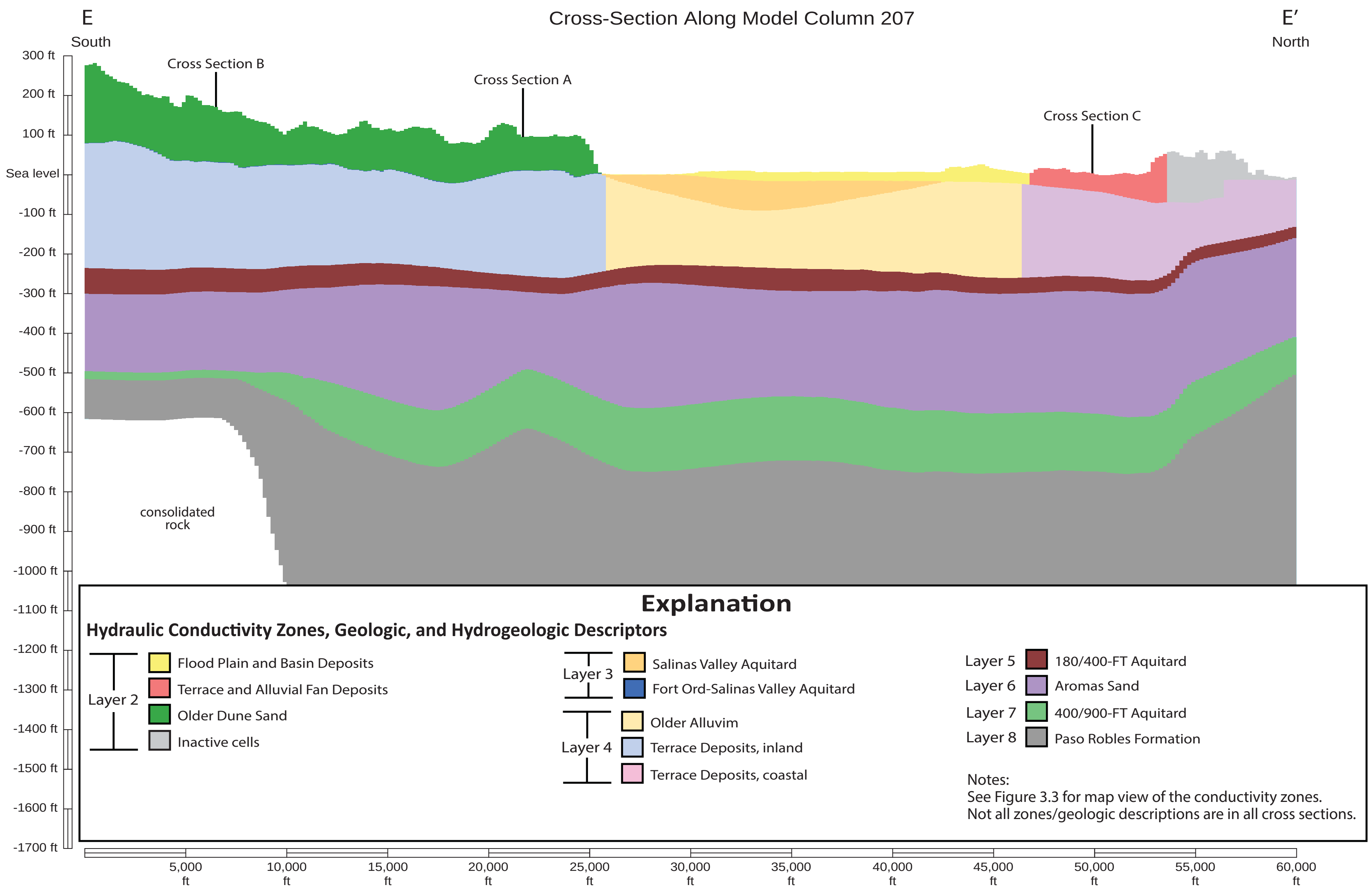
Section B-B', NMGWM[2016].

Figure 3.2c

PROJECT: 5073

DATE: 11/21/2016

Figure 12



HYDROFOCUS INC.
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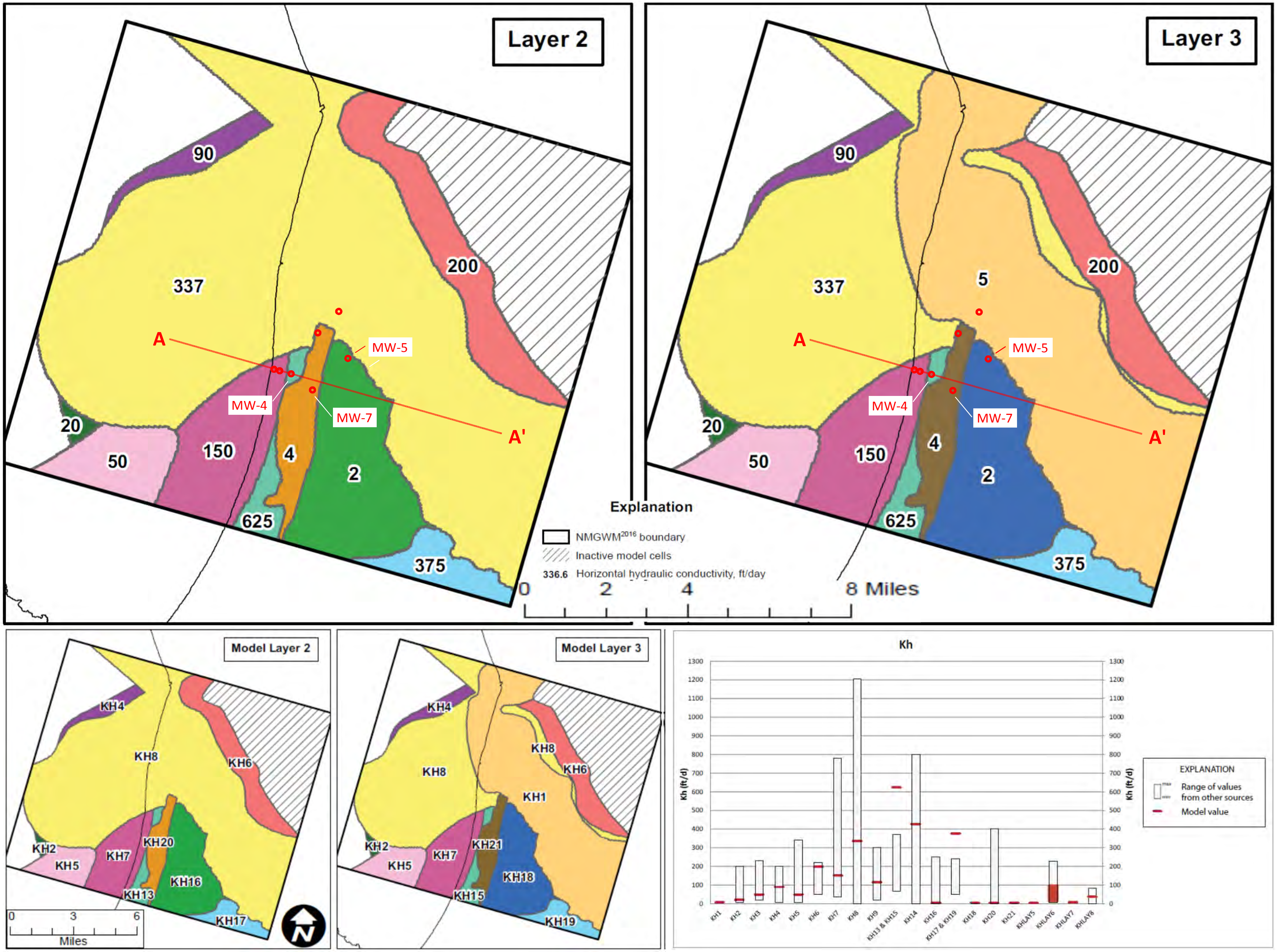
Section E-E', NMGWM[2016].

Figure 3.2f

PROJECT: 5073

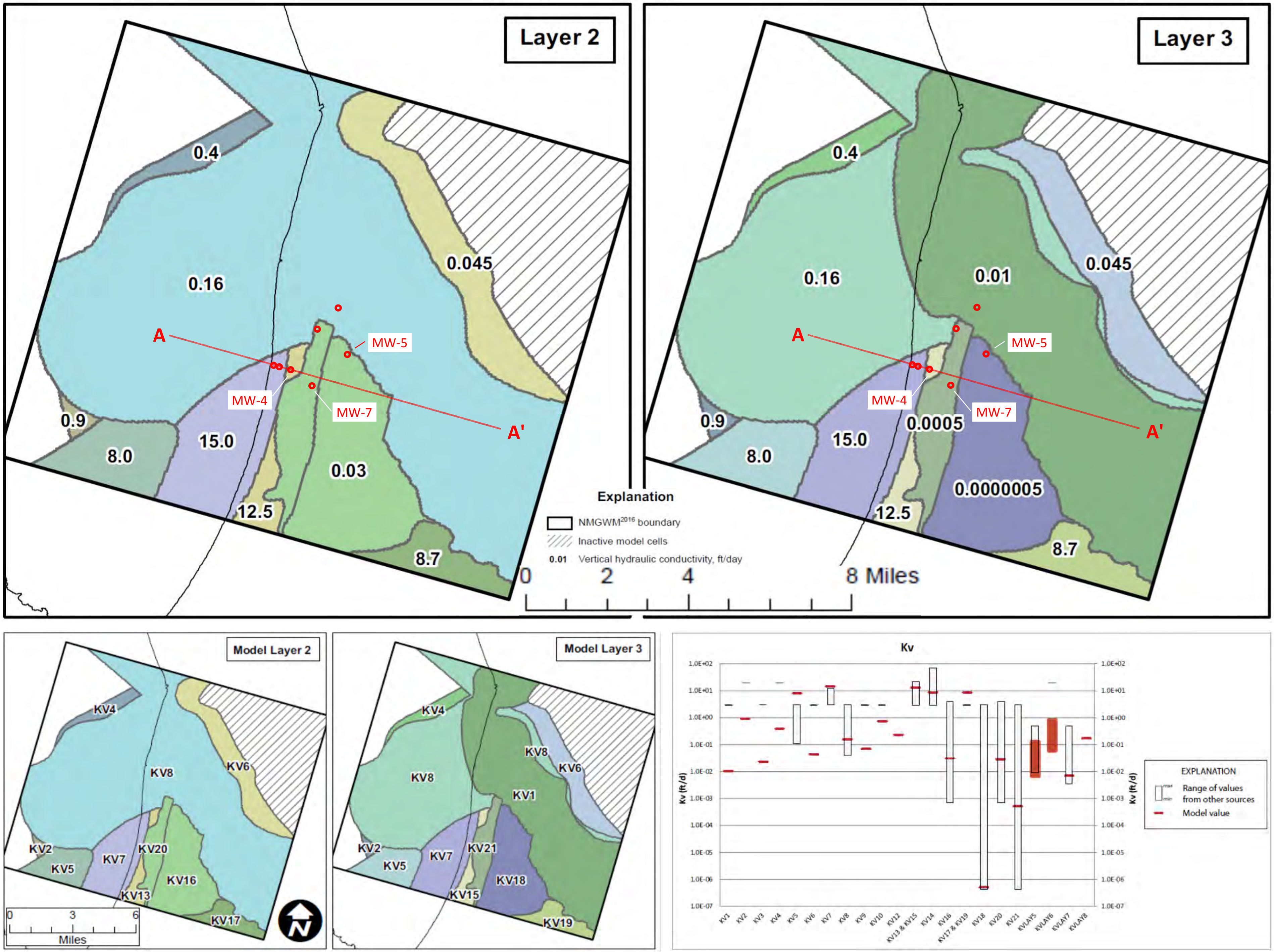
DATE: 11/21/2016

Figure 13



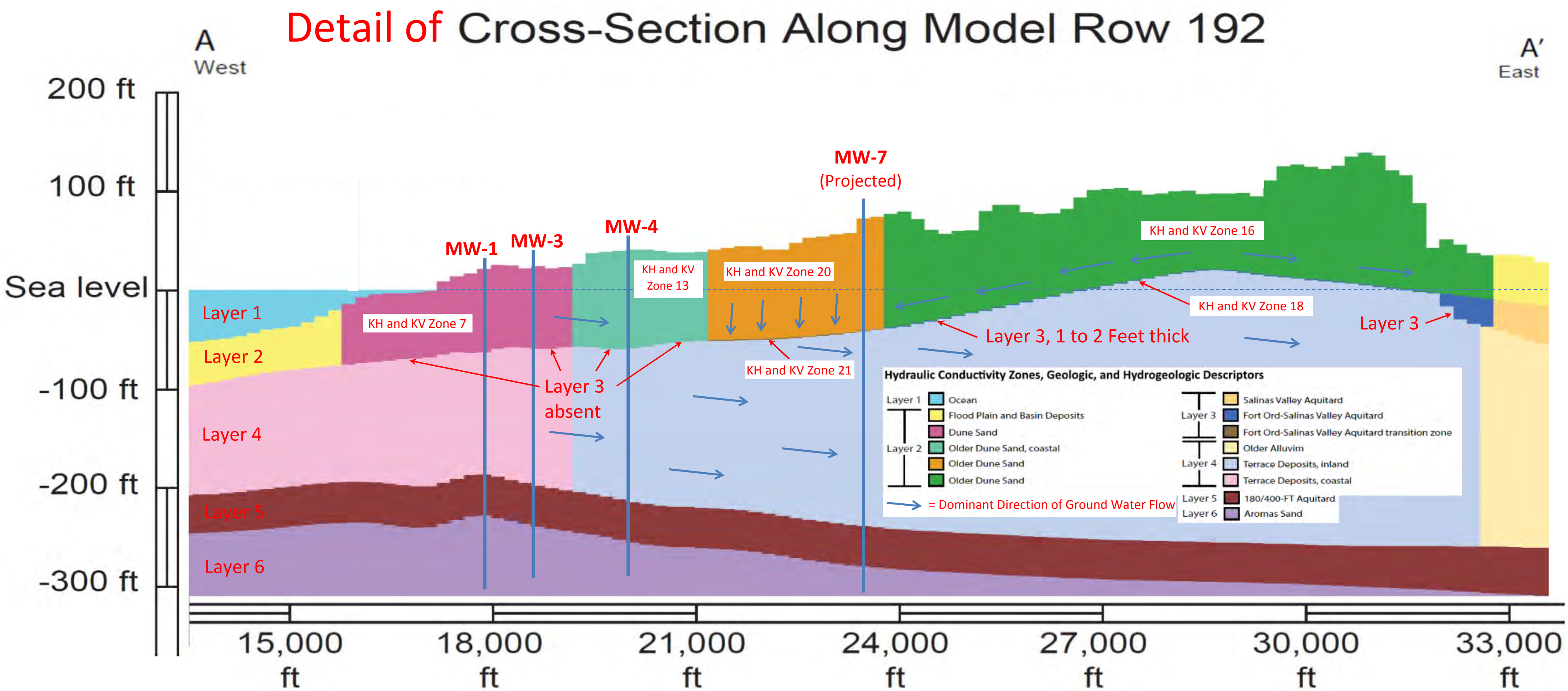
Horizontal Hydraulic Conductivity (KH) Parameter Zones and Values, Model Layers 2 and 3, NMGWM[2016], Excerpted from Figures 3.3a and 3.4a, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2* , March 28, 2018. Red lines and text are added based on other figures in Appendix E2

Figure 14



Vertical Hydraulic Conductivity (KV) Parameter Zones and Values, Model Layers 2 and 3, NMGWM[2016], Excerpted from Figures 3.3b and 3.4b, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2*, March 28, 2018. Red lines and text are added based on other figures in Appendix E2

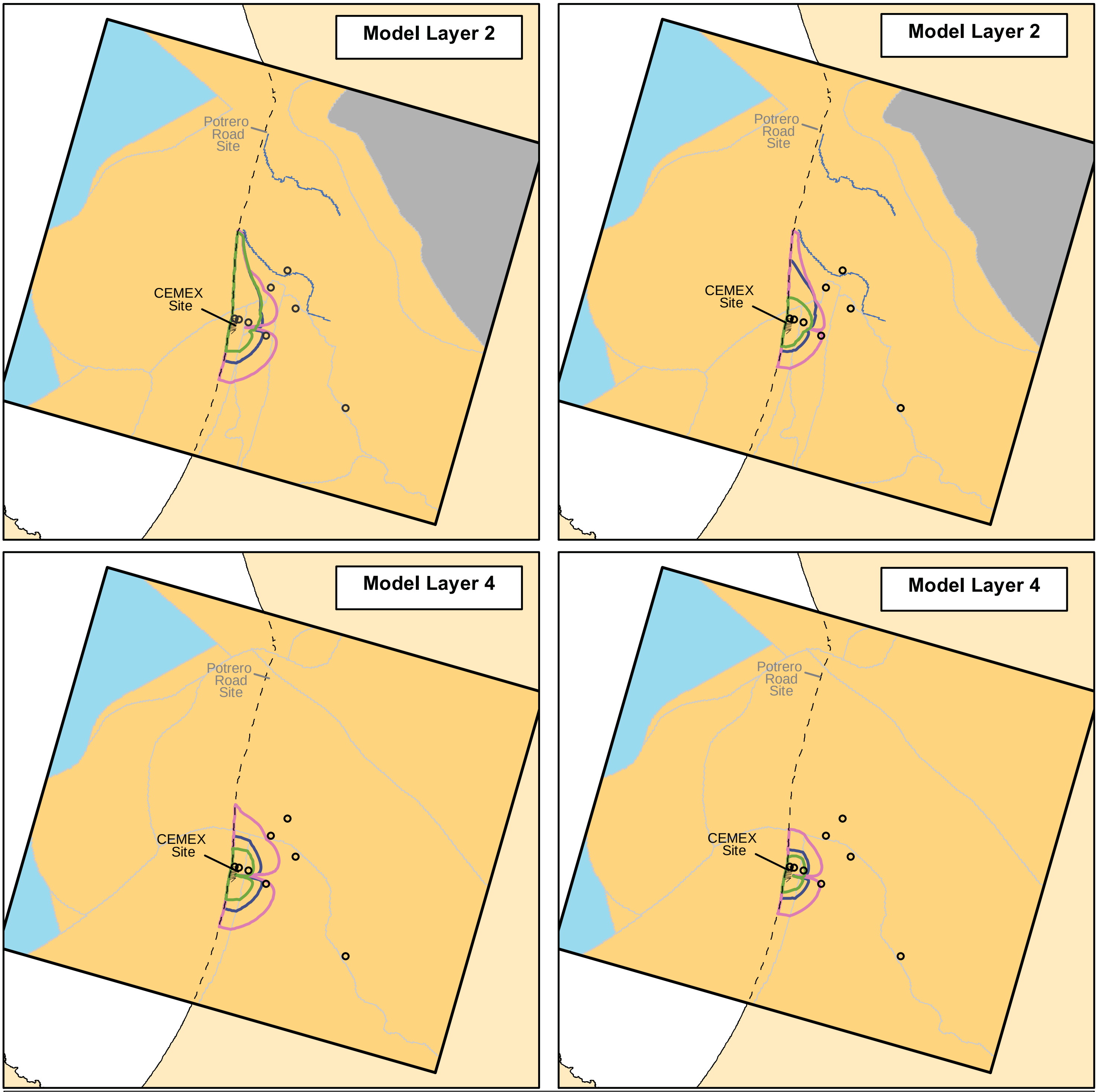
Figure 15



Hydraulic Conductivity Zones, Model Cross Section A-A', NMGWM[2016], excerpted from Figure 3.2b, *Final Environmental Impact Report/Environmental Impact Statement Appendix E2*, March 28, 2018. Well and Layer notations are added based on other figures in Appendix E2

Figure 16

CEMEX 24.1 MGD: | **CEMEX 15.5 MGD:**



EXPLANATION

- River Model Cell
- Active Model Cell
- Constant Head Model Cell
- Inactive Model Cell
- NMGWM Boundary
- Modeled Hydraulic Conductivity Zone
- CEMEX Monitoring Well
- Slant Well

Particle Tracking Ocean Capture Zones

- Ocean Capture Zone, porosity = 0.1, avg gradient = 0.0004
- Ocean Capture Zone, porosity = 0.1, avg gradient = 0.0007
- Ocean Capture Zone, porosity = 0.1, avg gradient = 0.0011

0 2 4
Miles

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NMGWM[2016] calculated ocean capture zone with variable regional gradients, 63 years of slant well pumping (24.1 and 15.5 MGD), 44/56 Layer 2/Layer 4 distribution, 2012 sea level, CEMEX site.

Figure E-7

PROJECT: 5073 | DATE: 11/15/2016

Figure 17

Legend

- MCWD's Service Area
- DWR Groundwater Basin
- Armstrong Ranch
- Groundwater Divide
- Edge of Fort Ord-Salinas Valley Aquitard
- Groundwater Elevation Contour (2' Interval)
- Groundwater Elevation Contour (10' Interval)
- Cal Am Monitoring Well
- Fort Ord Monitoring Well

Well Labeling

MW-5S — Well ID
35 — Groundwater Elevation (ft MSL)

Path: X:\B60094\Maps\2017\02\Fig5_GWE_DuneSandAquifer.mxd

Abbreviations

Cal Am = California American Water
DWR = Department of Water Resources
ft MSL = feet mean sea level
MCWD = Marina Coast Water District
mg/L = milligram per liter
TDS = total dissolved solids

Notes

1. All locations are approximate.
2. Groundwater levels obtained from Reference 2 are measured in May 2016. Groundwater levels at Fort Ord are measured during June 2016 (Ahta, 2016. Final Operable Unit Carbon Tetrachloride Plume Second Quarter 2016 Groundwater Monitoring Report, Former Fort Ord, California, dated 29 August 2016). All groundwater levels are approximate.
3. Groundwater levels have been correlated for density, where TDS > 10,000 mg/L (see Reference 3).
4. Groundwater elevation contour dashed where approximate.

Sources

1. Aerial photograph provided by ESRI's ArcGIS Online, obtained 21 February 2017.
2. Cal Am Monterey Peninsula Water Supply Project Test Slant Well Long Term Pumping—Monitoring Report No. 55, released 24-May-2016.
3. Guo & Langevin, 2002. User's Guide to SEAWAT, U.S. Geological Survey Techniques of Water Resources Investigations 6-A7, released 2002.

Erler & Kalinowski, Inc.

Groundwater Elevations
Dune Sand Aquifer

Marina Coast Water District
Marina, CA
February 2017
EKI B60094.01
Figure 5

Figure 18

Weiss Associates

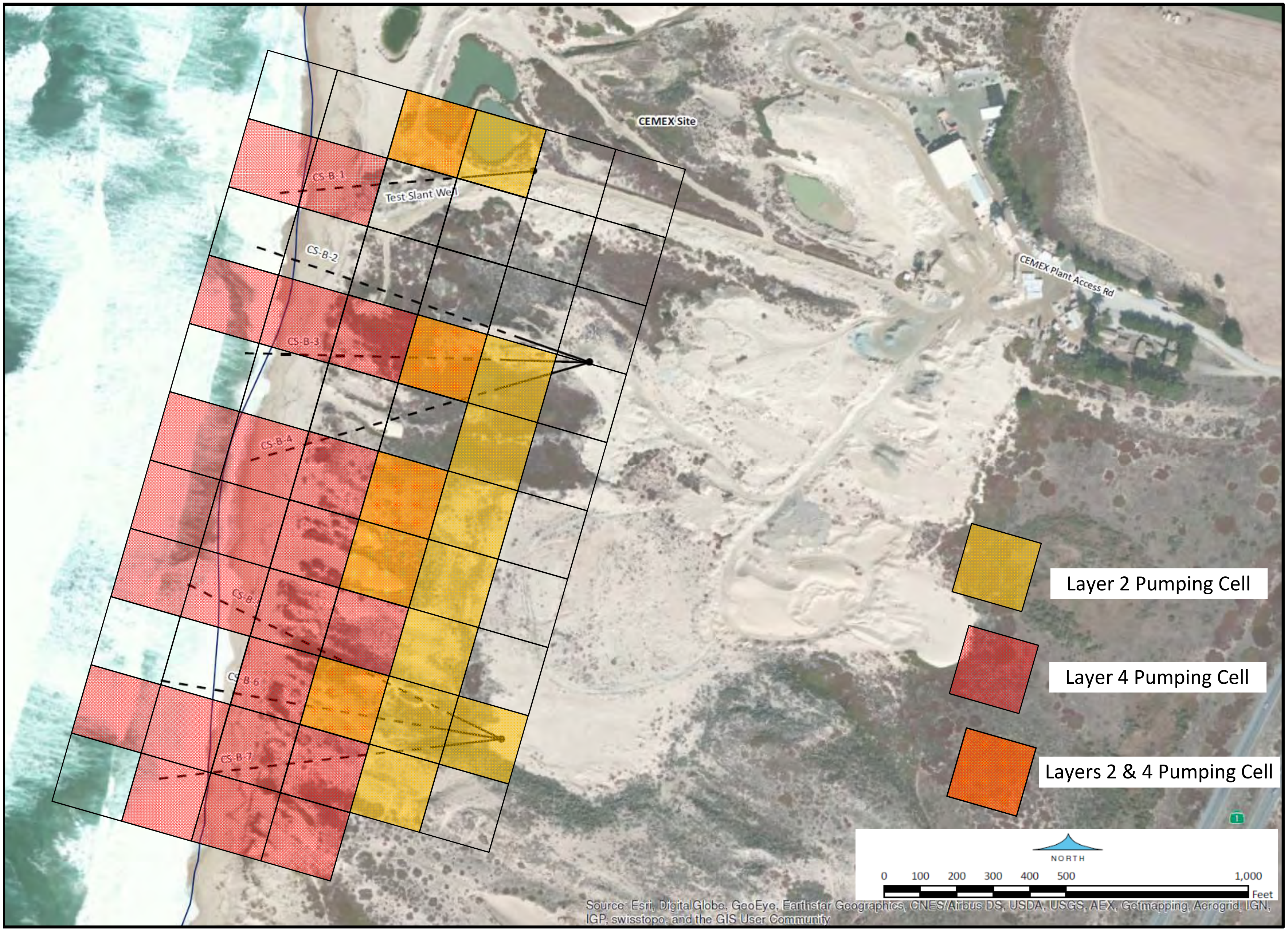
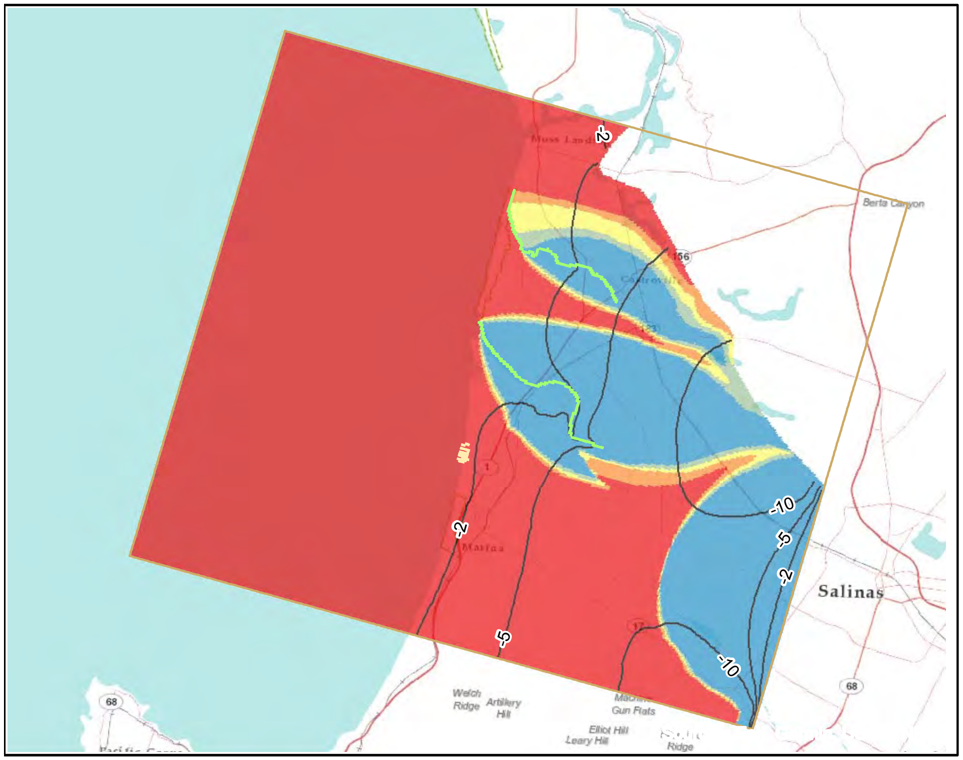
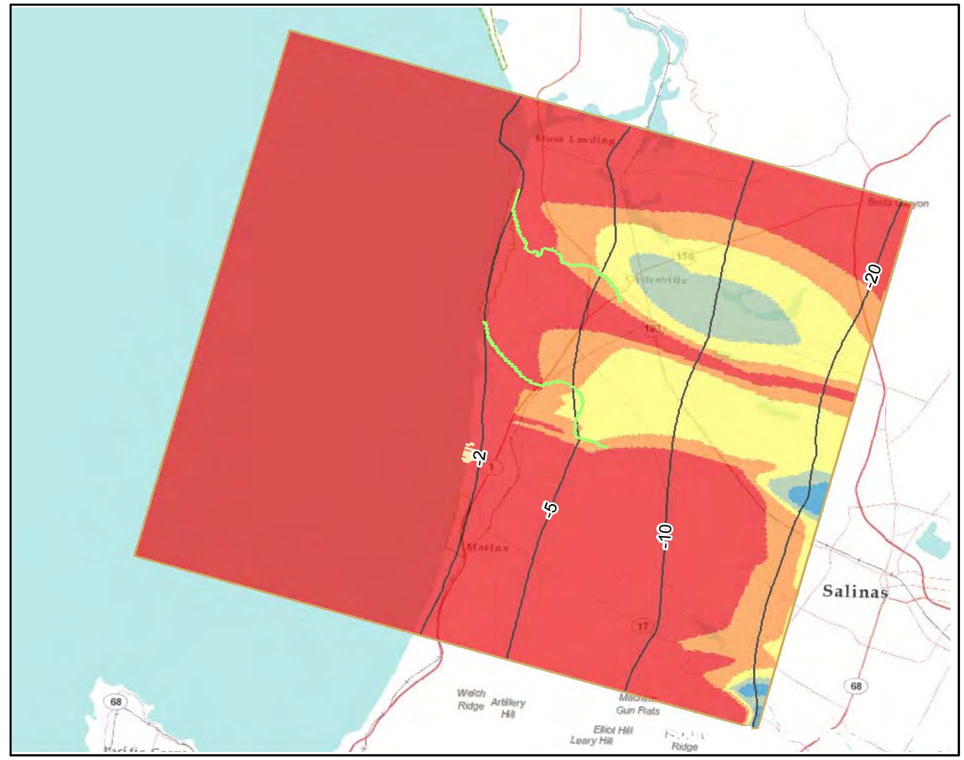


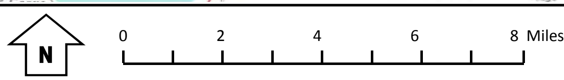
Figure 19. Slant Well Array and Model Cells Assigned to Pumping Wells

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)





Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments
Layer 4 Gradient:	0.0004	Landward

Figure 20. Baseline - NMGWM2016 With Inland Gradient = 0.0004; no Pumping

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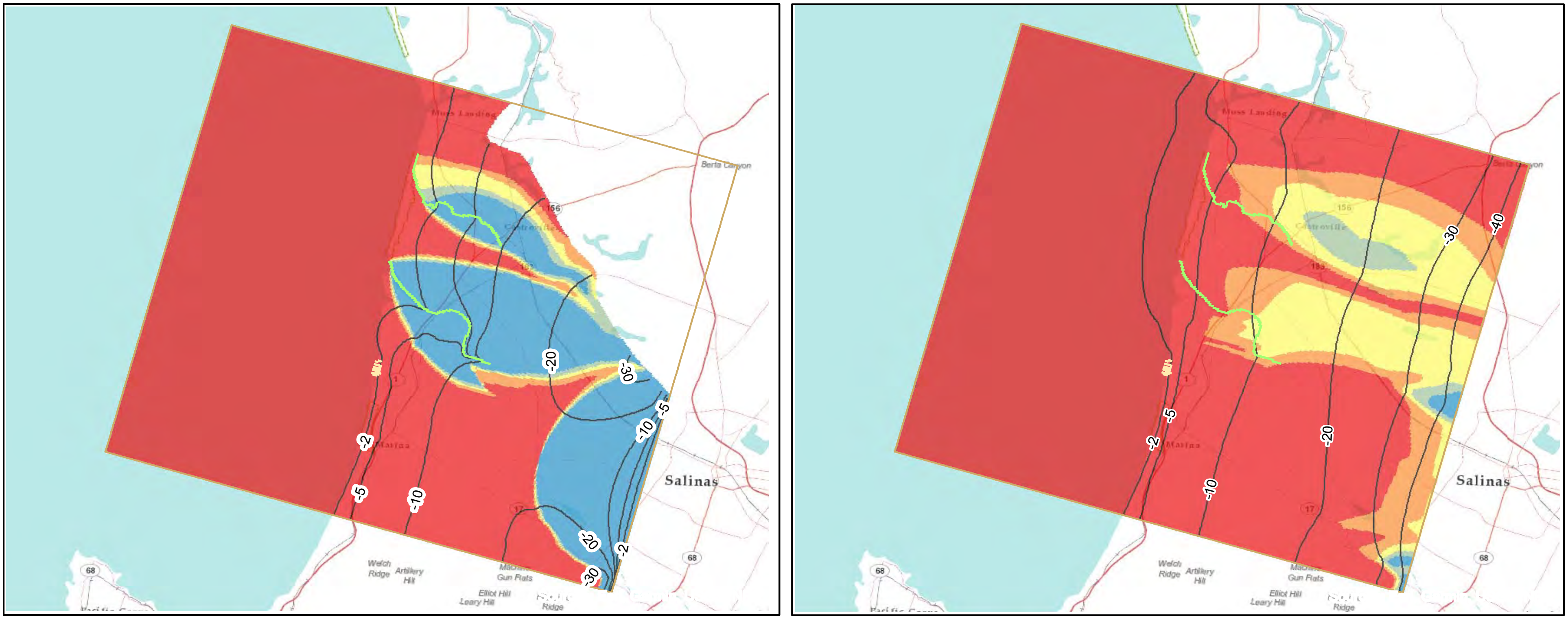
Layer 2 (Dune Sand Aquifer) / Layer 4 (180-Foot Aquifer)



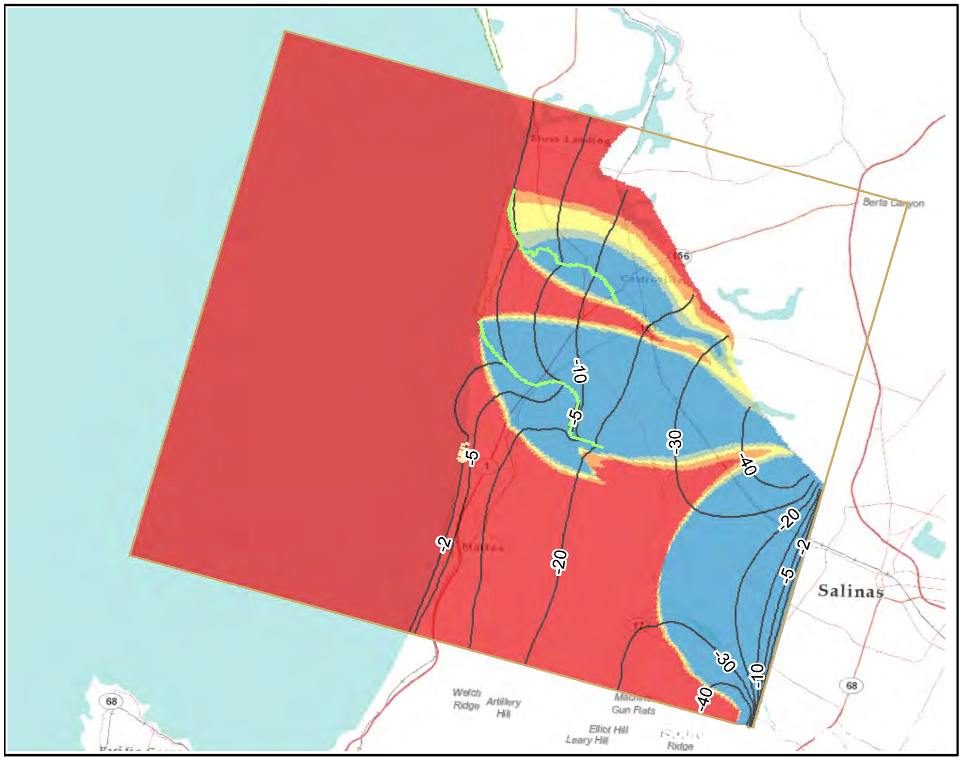
Salinity
Ocean Water Percent
(OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

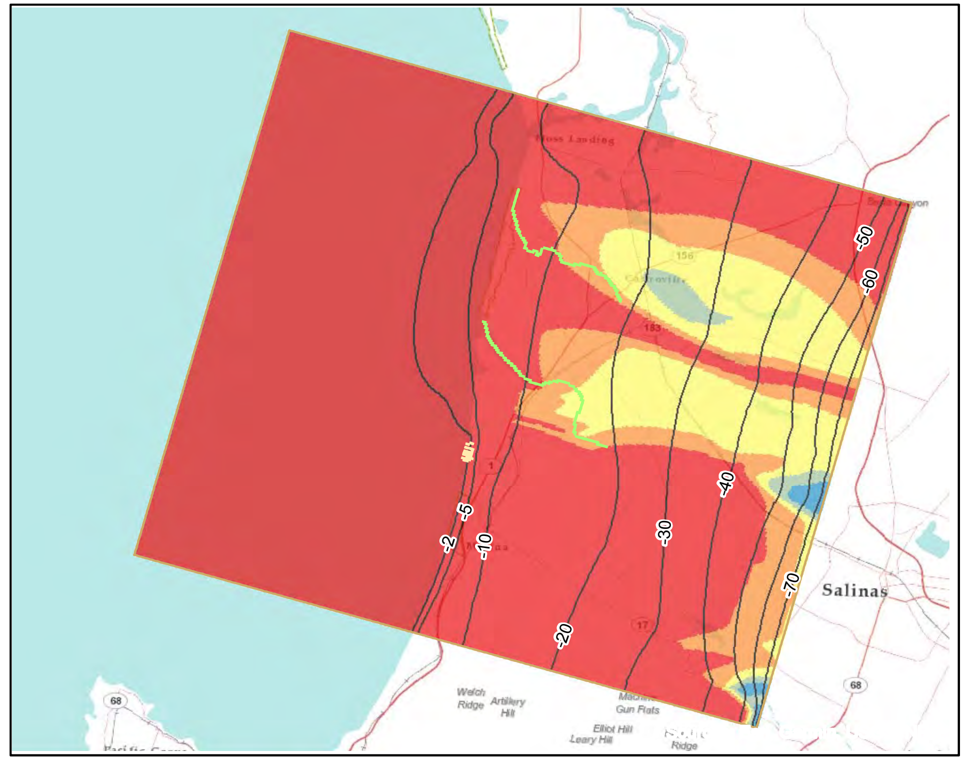
Model Parameter	Value	Comments
Layer 4 Gradient:	0.0007	Landward

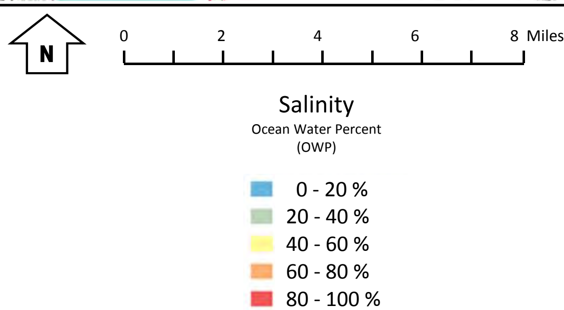
Figure 21. Baseline - NMGWM^{2016} With Inland Gradient = 0.0007; no Pumping

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)

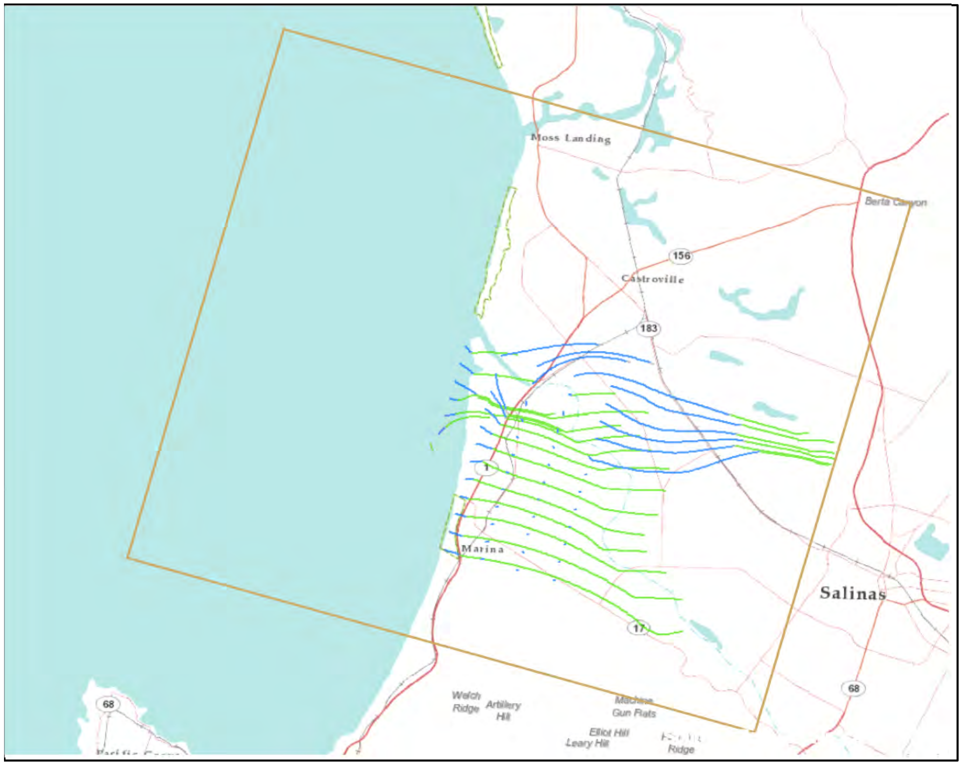




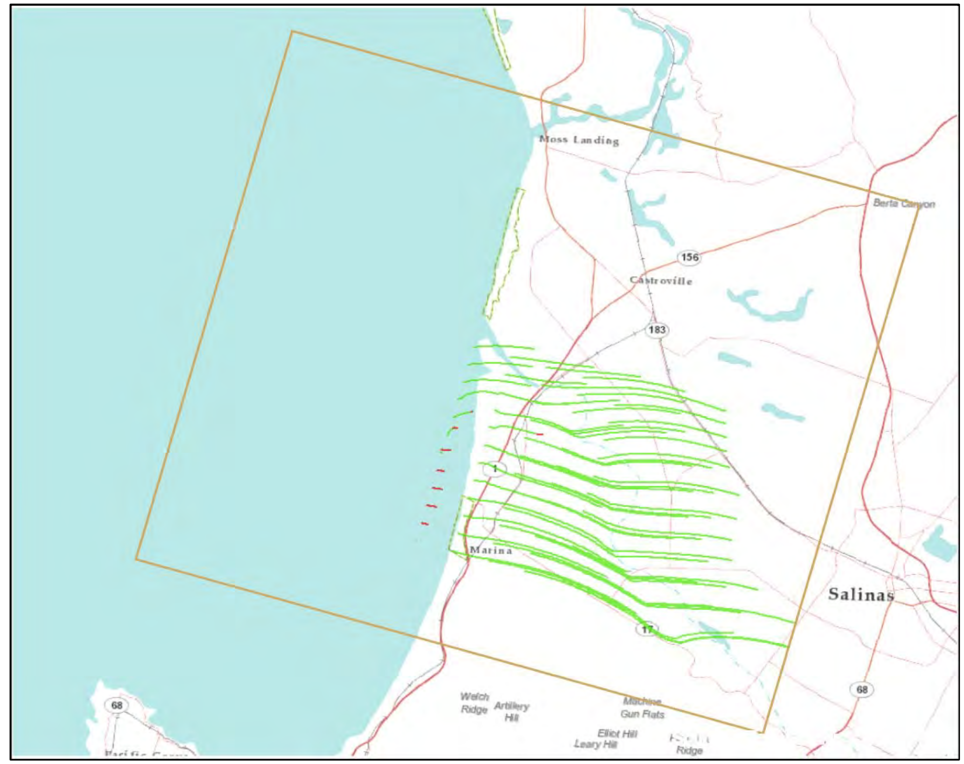
Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward

Figure 22. Baseline - NMGWM^{2016} With Inland Gradient = 0.0011; no Pumping

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

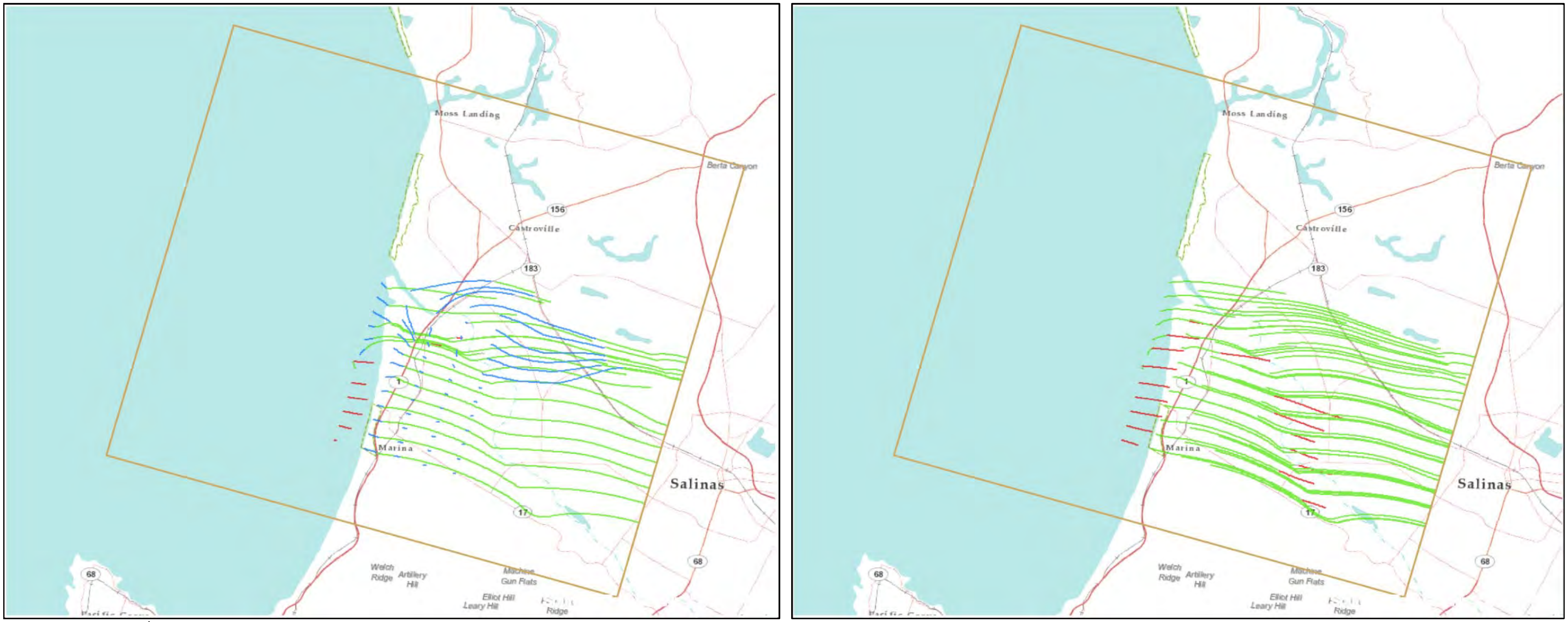
Flow Path within Model Layer

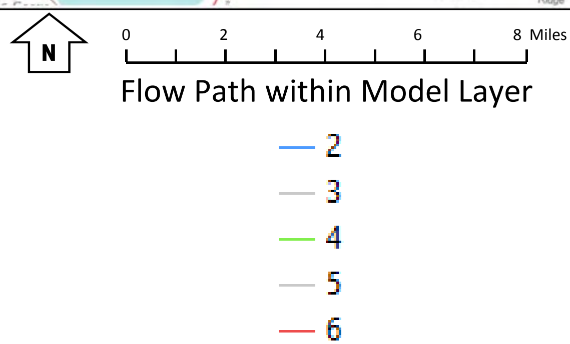
- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward

Figure 23. Baseline Groundwater Flow Paths - NMGWM^{2016} With Inland Gradient = 0.0004; no Pumping

Layer 2 (Dune Sand Aquifer) Layer 4 (180-Foot Aquifer)

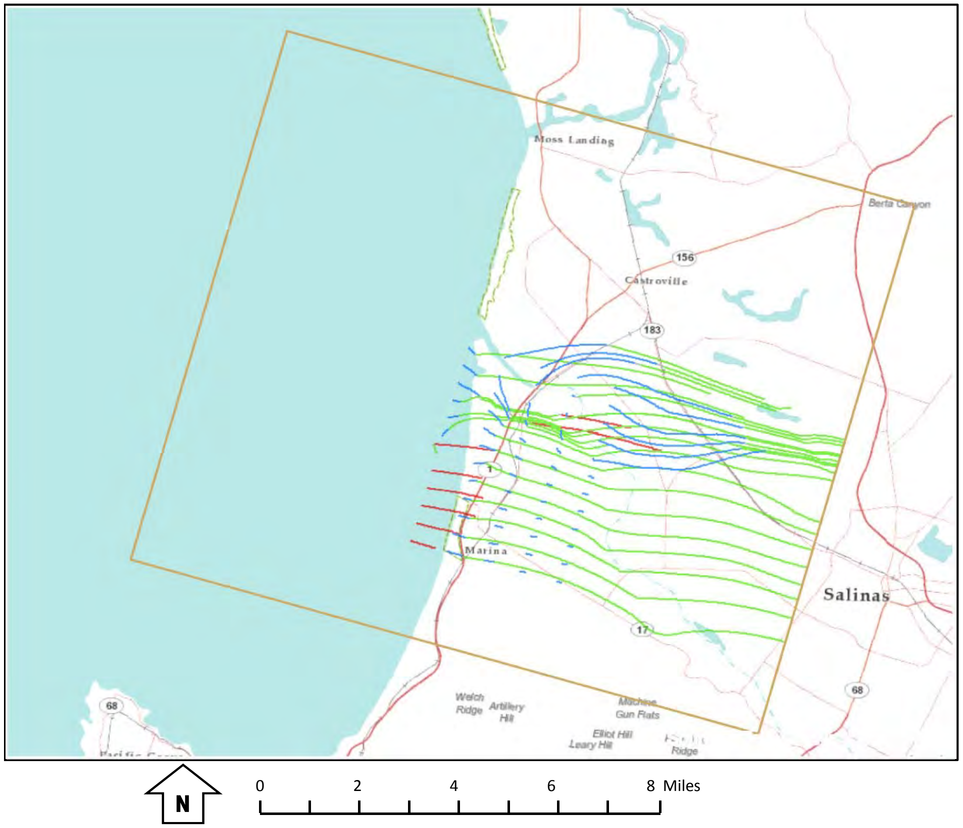




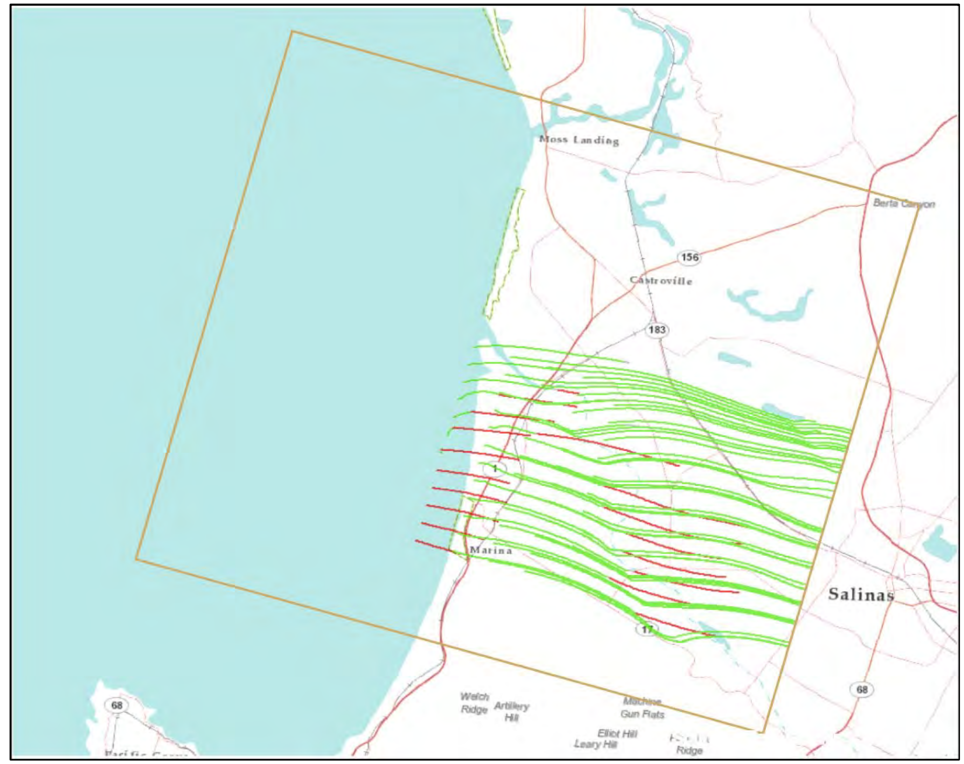
Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward

Figure 24. Baseline Groundwater Flow Paths - NMGWM^{2016} With Inland Gradient = 0.0007; no Pumping

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward

Figure 25. Baseline Groundwater Flow Paths - NMGWM2016 With Inland Gradient = 0.0011; no Pumping

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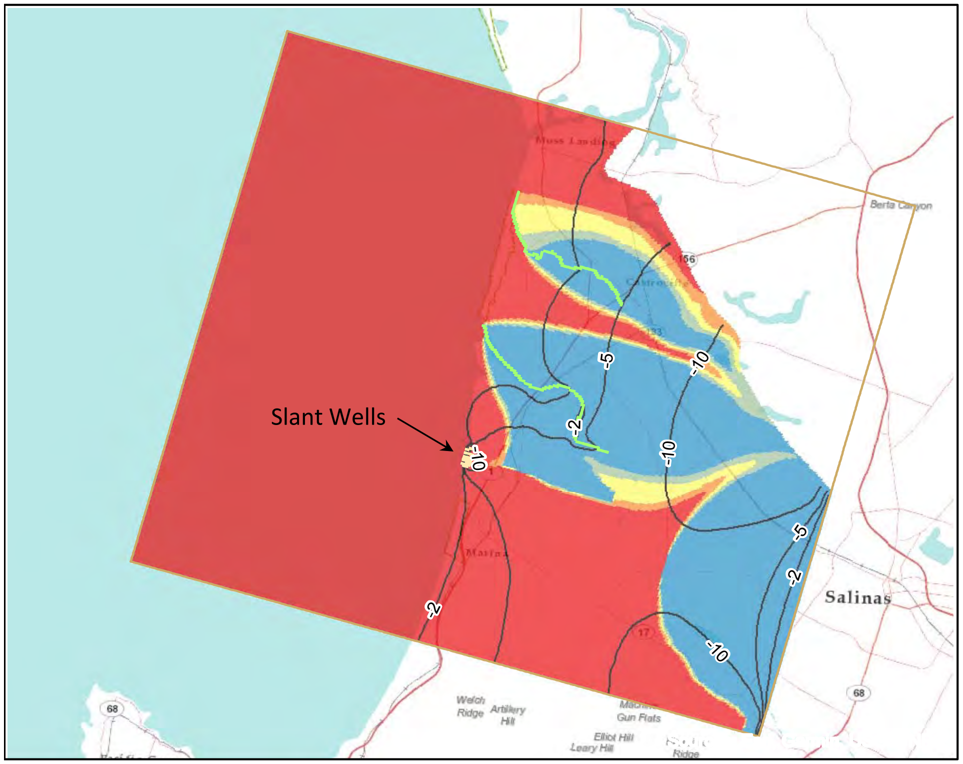
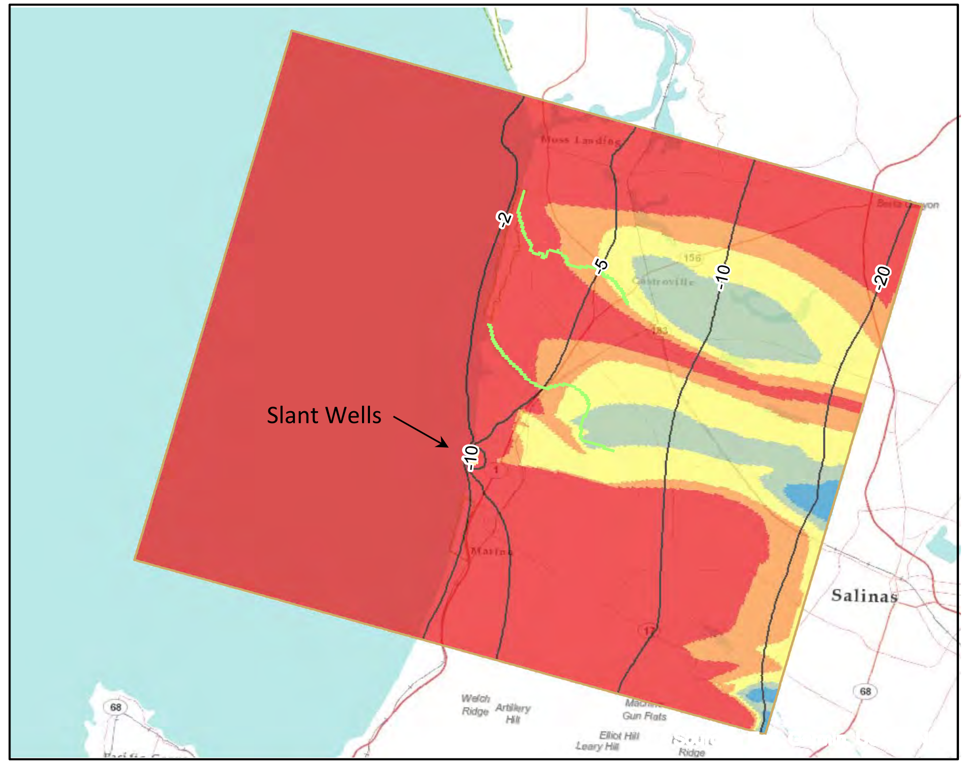
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

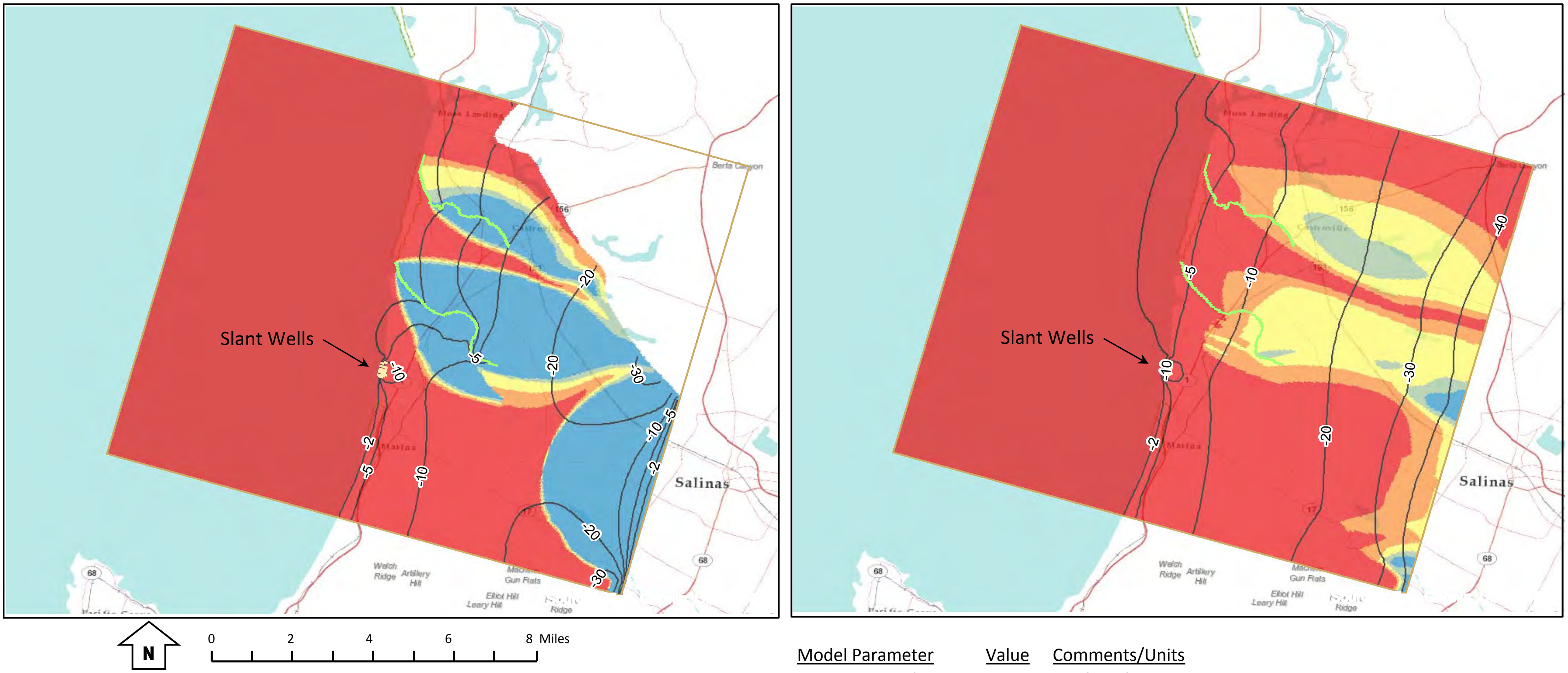
Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Well Discharge OWP:	99.3%	(Ocean Water Percentage)

Figure 26. Baseline - NMGWM^{2016} With Inland Gradient = 0.0004; Slant Wells Pumping 15.5 MGD

Layer 2 (Dune Sand Aquifer) / Layer 4 (180-Foot Aquifer)



Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward
Slant Wells Pumping Rate:	15.5	MGD

Well Discharge OWP: 99.97% (Ocean Water Percentage)

Figure 27. Baseline - NMGWM^{2016} With Inland Gradient = 0.0007; Slant Wells Pumping 15.5 MGD

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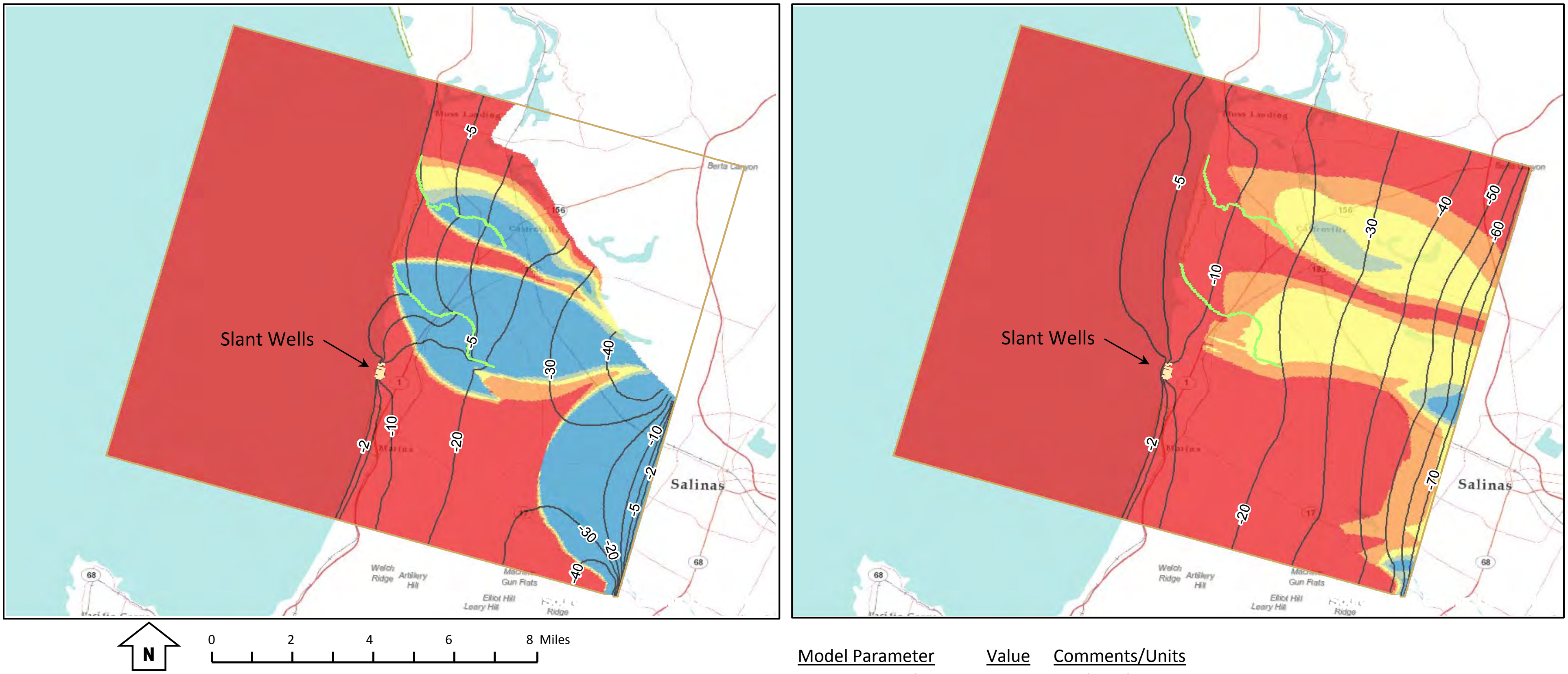
Layer 2 (Dune Sand Aquifer) Layer 4 (180-Foot Aquifer)



Salinity
Ocean Water Percent
(OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward
Slant Wells Pumping Rate:	15.5	MGD

Well Discharge OWP: 99.99% (Ocean Water Percentage)

Figure 28. Baseline - NMGWM2016 With Inland Gradient = 0.0011; Slant Wells Pumping 15.5 MGD

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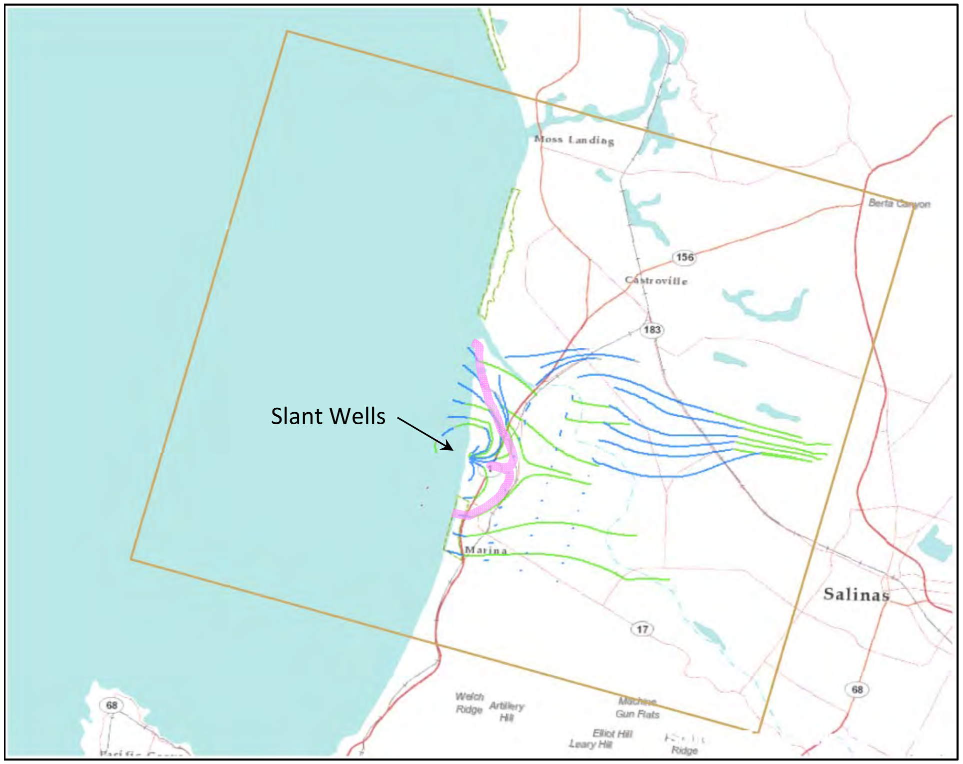
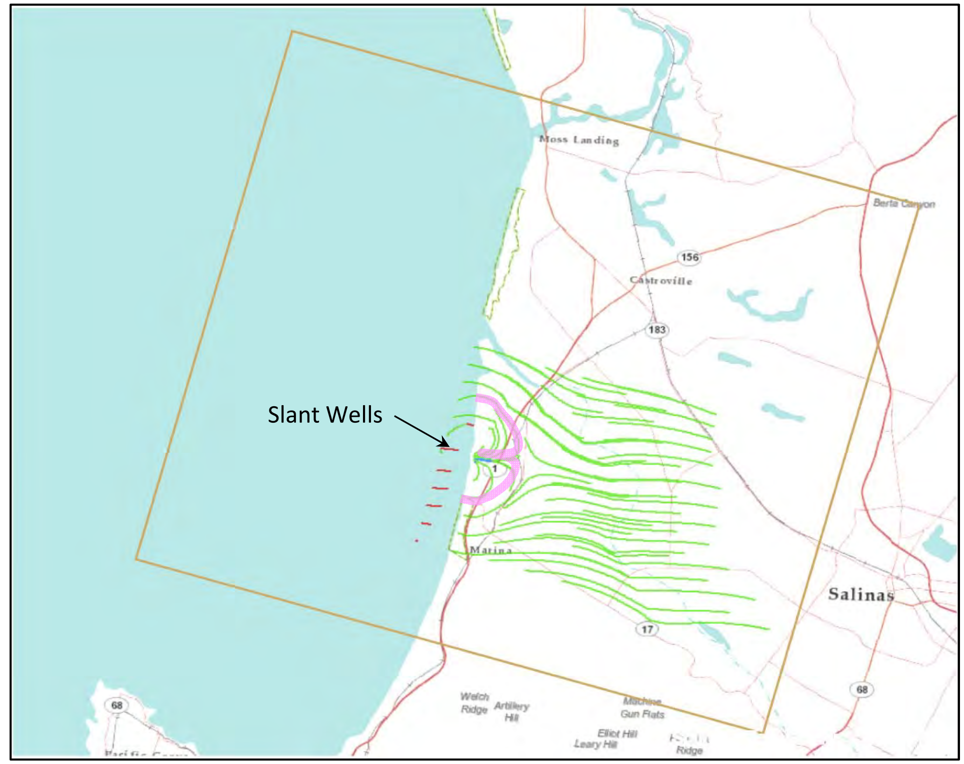
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

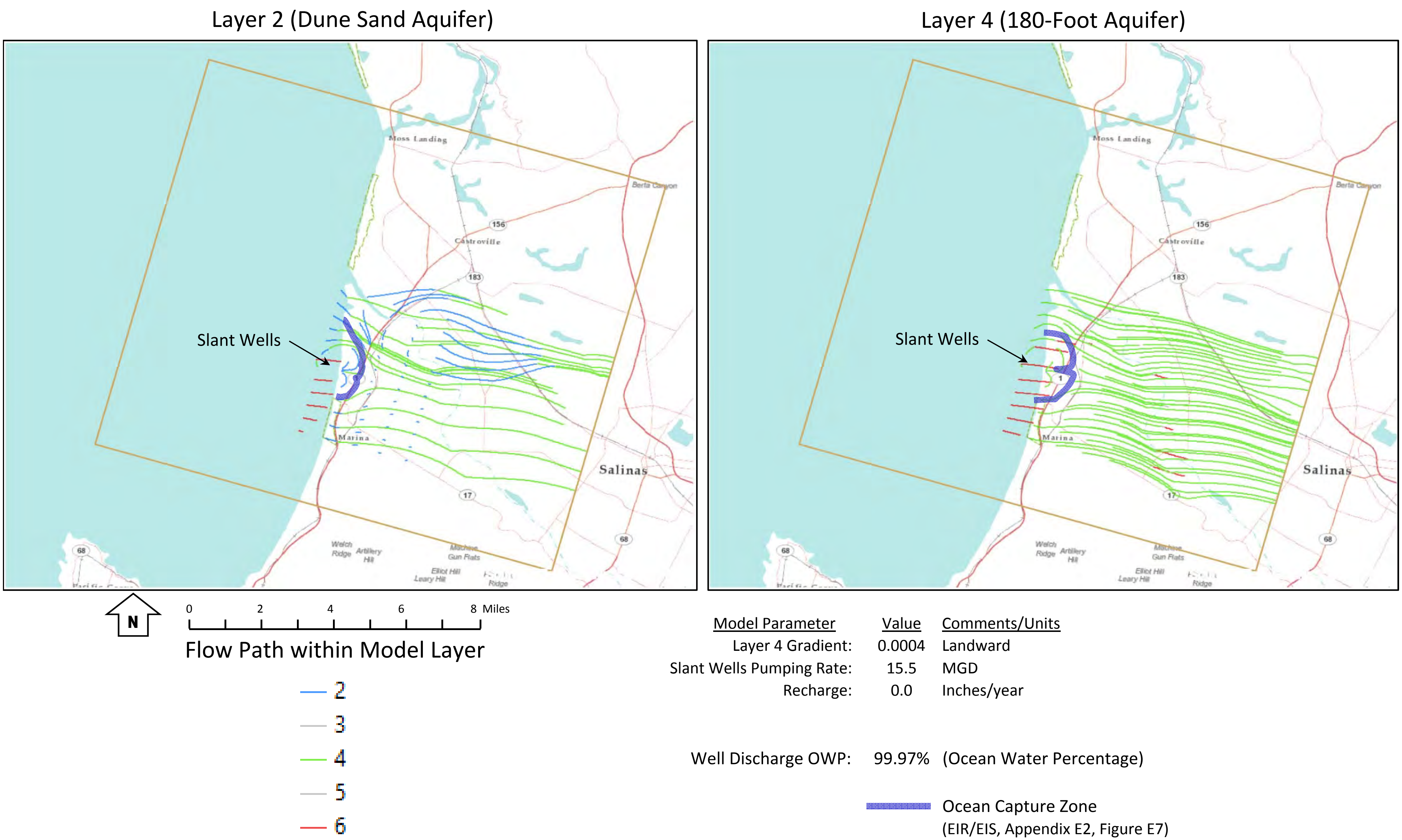
Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	0.0	Inches/year
Well Discharge OWP:	99.3%	(Ocean Water Percentage)

Ocean Capture Zone (EIR/EIS, Appendix E2, Figure E7)

Figure 29. Baseline Groundwater Flow Paths - NMGWM^{2016} With Inland Gradient = 0.0004; Slant Wells Pumping 15.5 MGD



Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	0.0	Inches/year
Well Discharge OWP:	99.97%	(Ocean Water Percentage)

Ocean Capture Zone
(EIR/EIS, Appendix E2, Figure E7)

Figure 30. Baseline Groundwater Flow Paths - NMGWM^{2016} With Inland Gradient = 0.0007; Slant Wells Pumping 15.5 MGD

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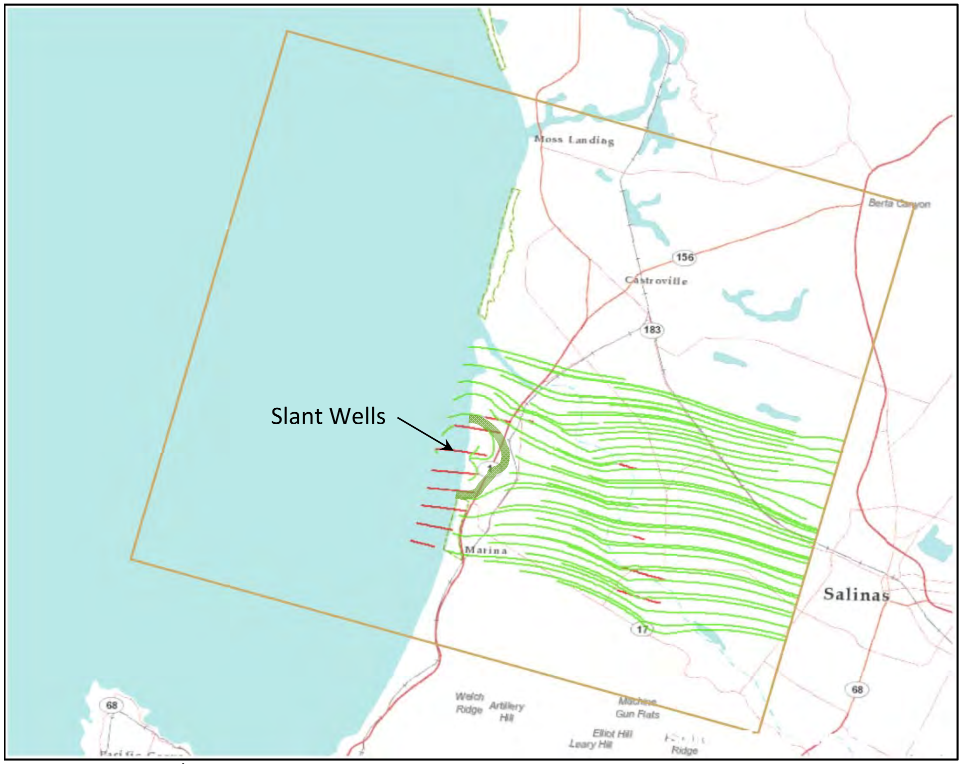
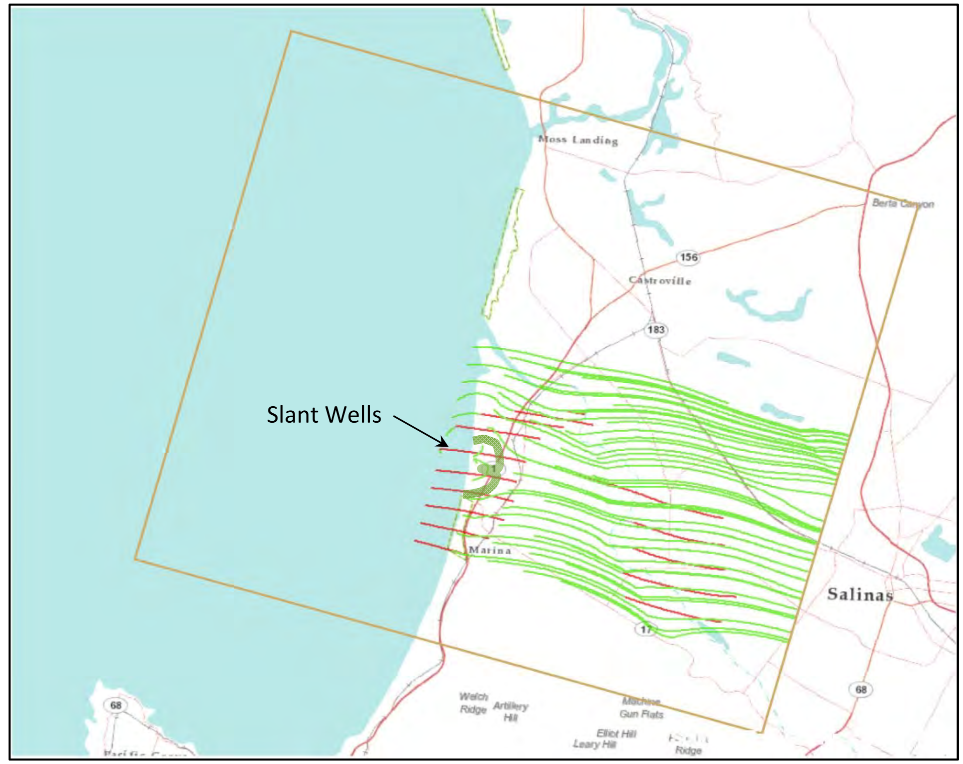
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	0.0	Inches/year
Well Discharge OWP:	99.99%	(Ocean Water Percentage)

Ocean Capture Zone
(EIR/EIS, Appendix E2, Figure E7)

Figure 31. Baseline Groundwater Flow Paths - NMGWM^{2016} With Inland Gradient = 0.0011; Slant Wells Pumping 15.5 MGD

Layer 2 (Dune Sand Aquifer)

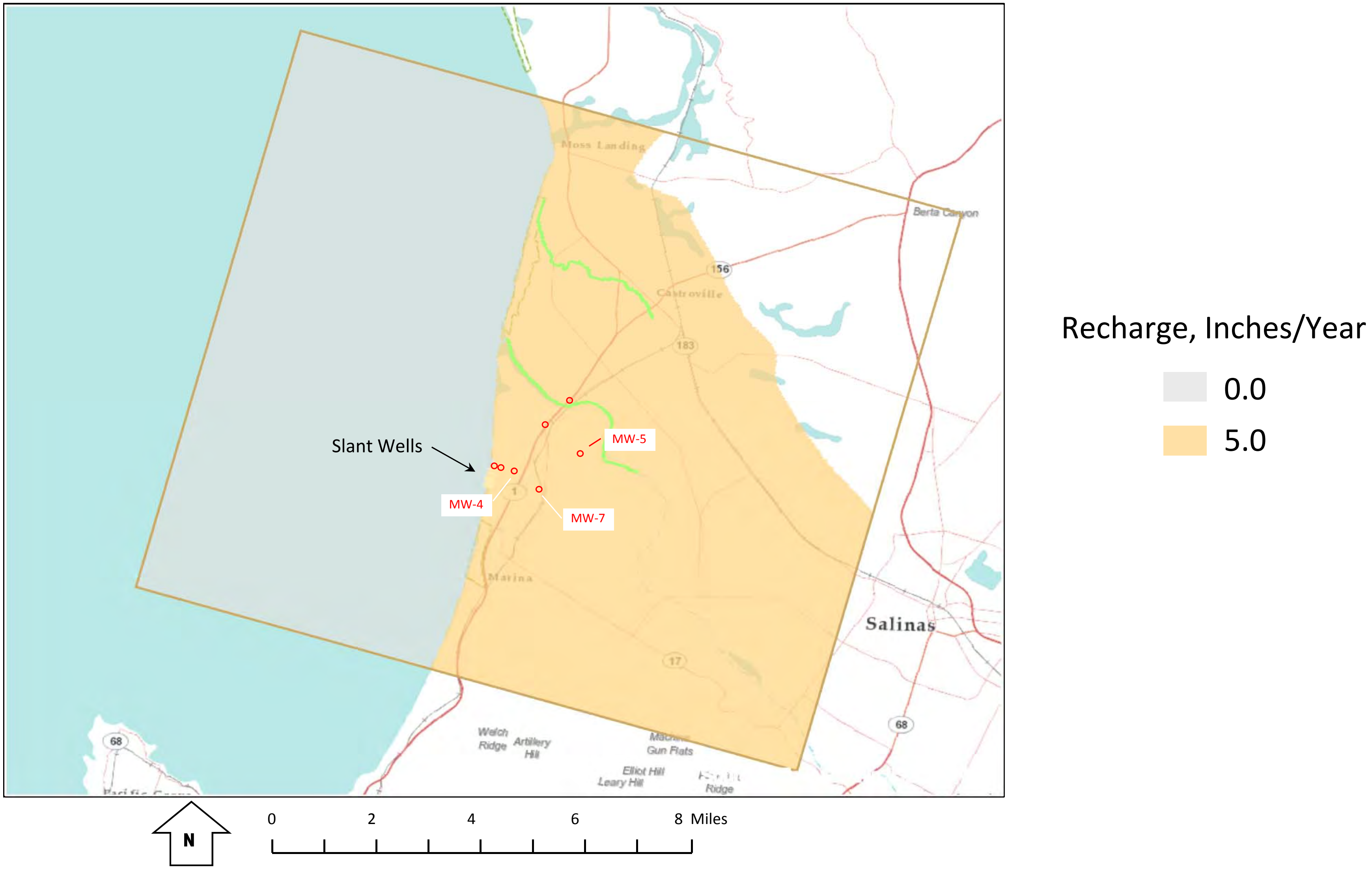
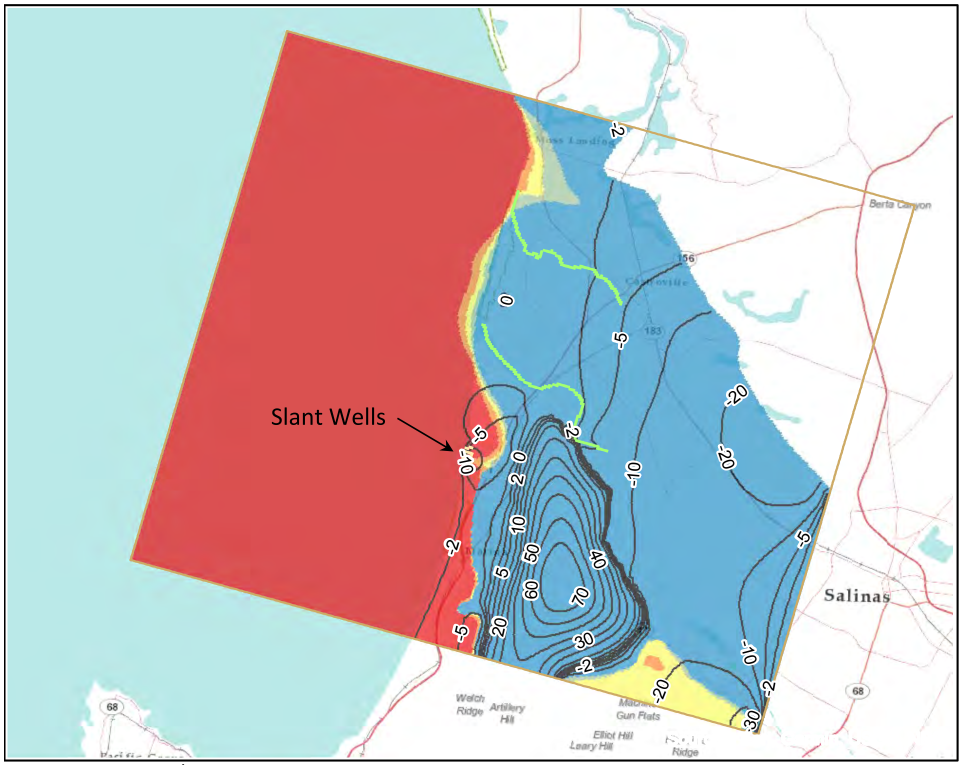


Figure 32. Area Where Recharge was Added to Layer 2 of NMGWM2016

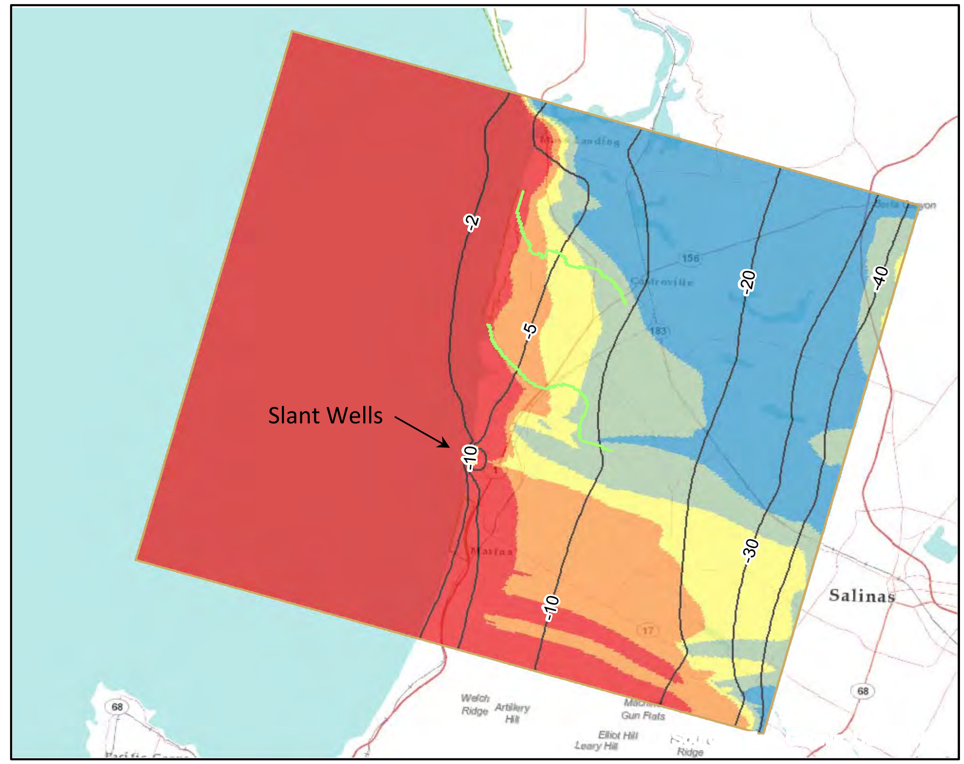
NMGWM2016 Modification - Recharge Added

Weiss Associates

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

-5

Groundwater Elevation Contour

Salinity

Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	5.0	Inches/year
KH16 and KH18:	4 and 2	Feet/day
Well Discharge OWP:	97.2%	(Ocean Water Percentage)

Figure 33. Recharge Added - NMGWM2016 With Layer 4 Inland Gradient = 0.0007; Slant Wells Pumping 15.5 MGD

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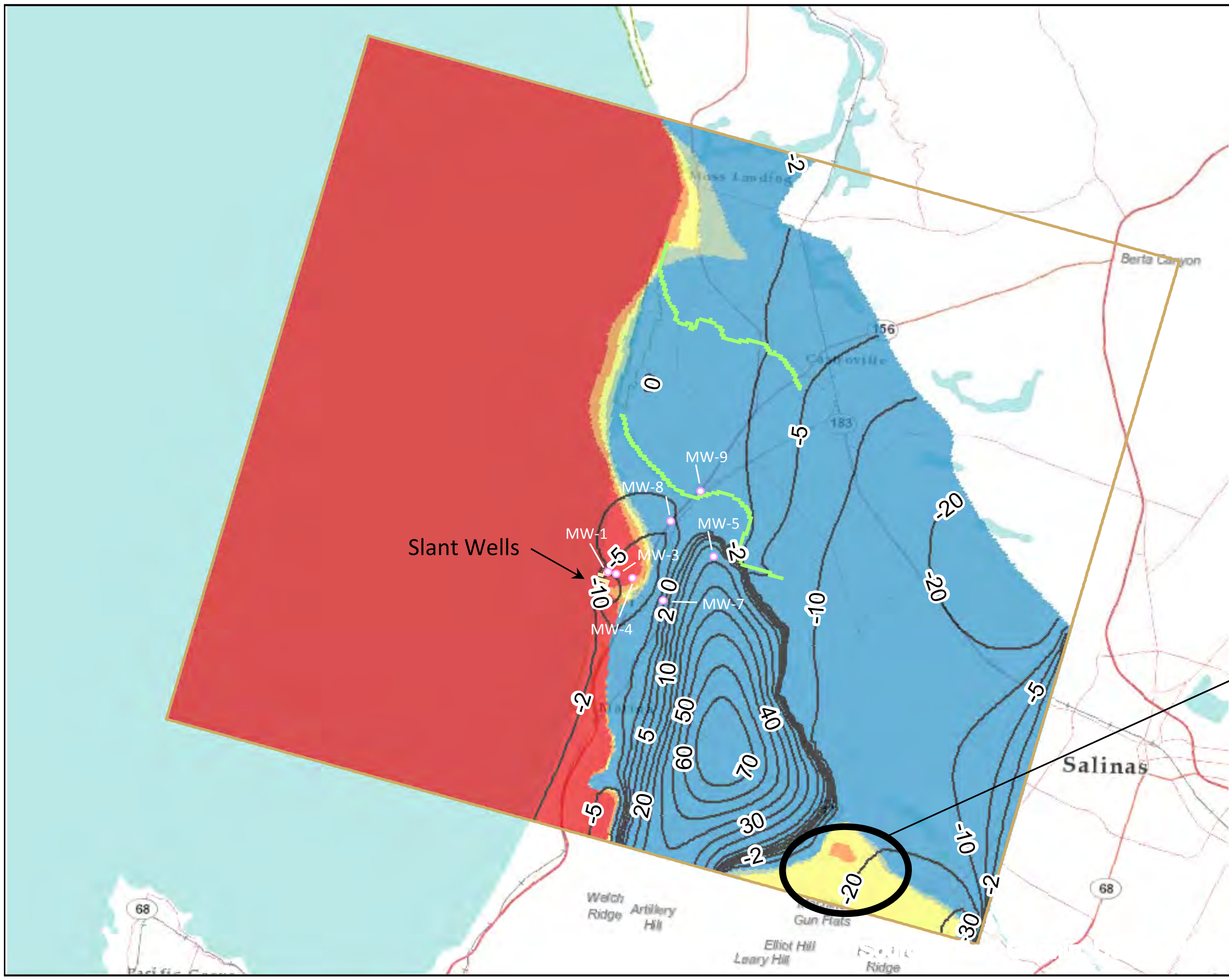
Layer 2 (Dune Sand Aquifer)



-5 Groundwater Elevation Contour

Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Salinity in Layer 2 caused by upwelling of saline water from Layer 4, through Aquifer Zone KV19

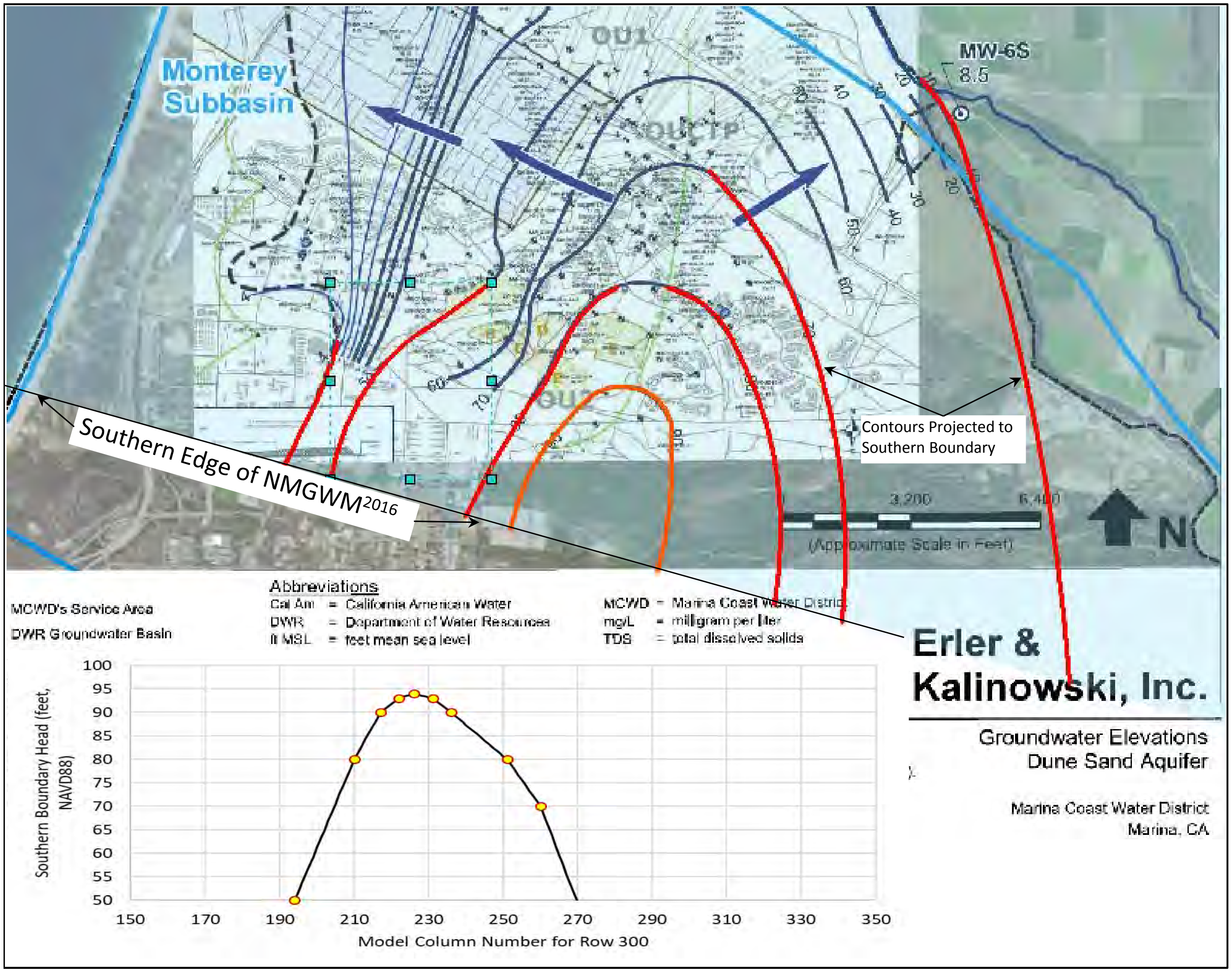
N

0 2 4 6 8 Miles

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge, Inches/Year:	5.0	Inches/year
Well Discharge OWP:	97.2%	(Ocean Water Percentage)

Figure 34. Saline Water Upwelling from Layer 4 to Layer 2

Layer 2 (Dune Sand Aquifer) Groundwater Elevations



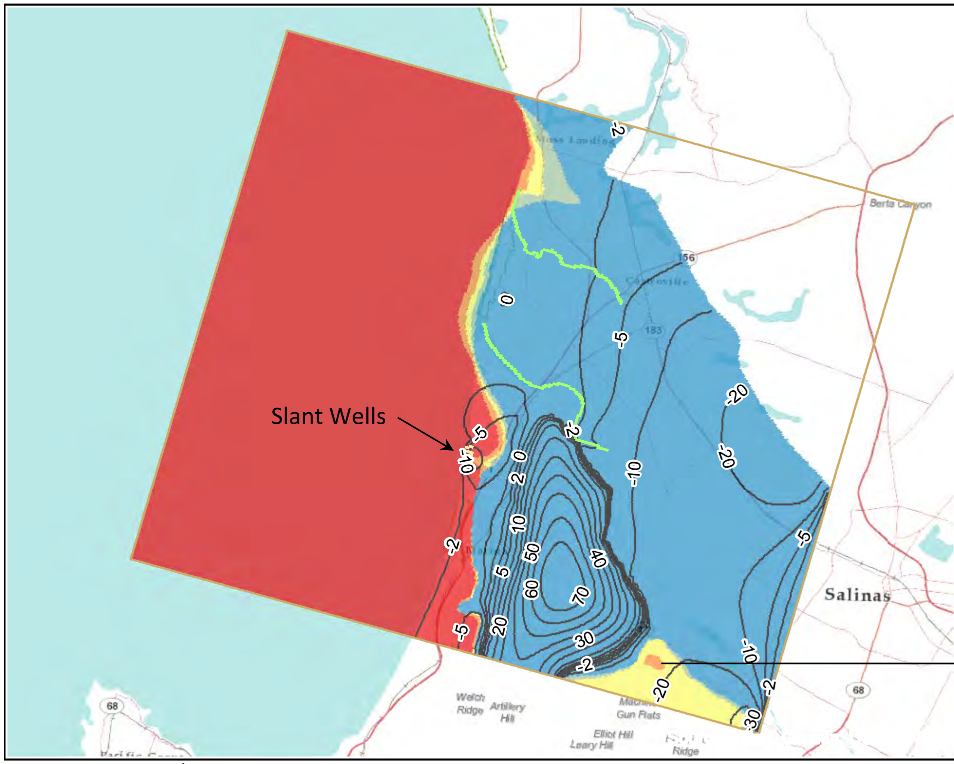
Southern boundary imposed as a general head boundary with heads equal to projected groundwater elevation contours

Piecewise linear interpolation between contours

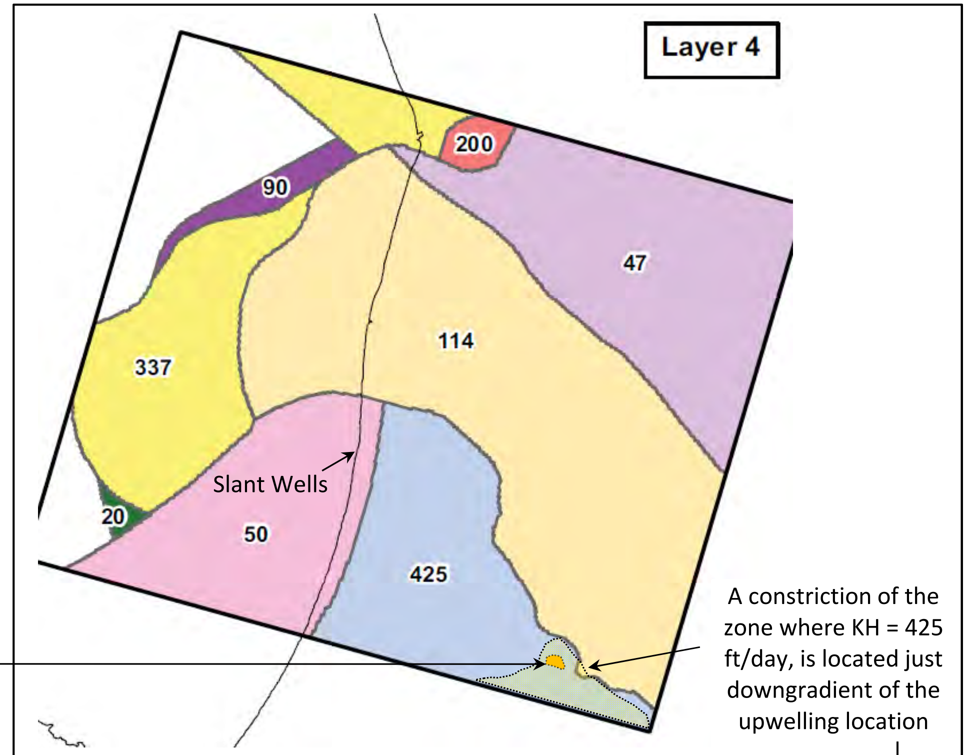
The general head boundary is only applied for cells with head greater than 50 feet

Figure 35. Modification of Southern Boundary of NMGWM^{2016} in Layer 2

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer) KH Zone Values (Feet/Day)



N

0 2 4 6 8 Miles

-5

Groundwater Elevation Contour

Salinity
Ocean Water Percent
(OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	5.0	Inches/year
Well Discharge OWP:	97.2%	(Ocean Water Percentage)

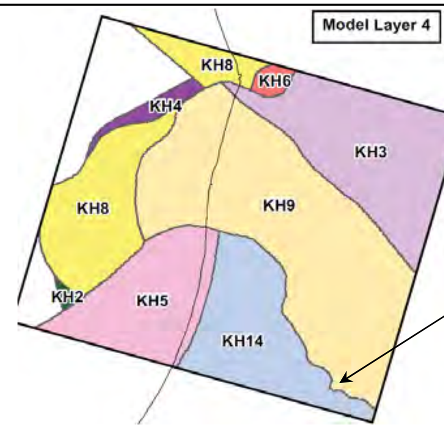


Figure 36. Comparison of Upwelling Location With Layer 4 KH Zone Configuration and Values (Feet/Day)

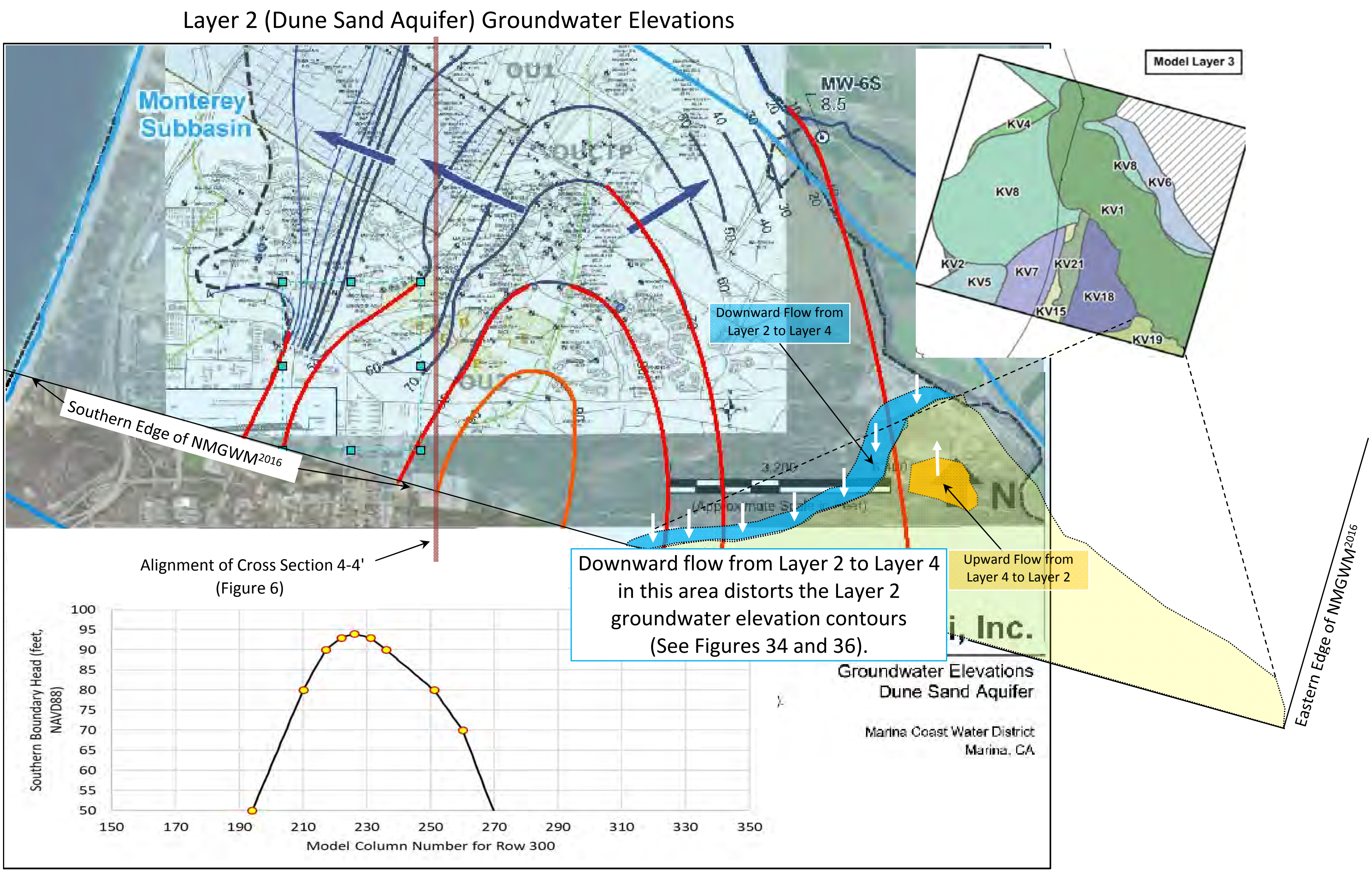
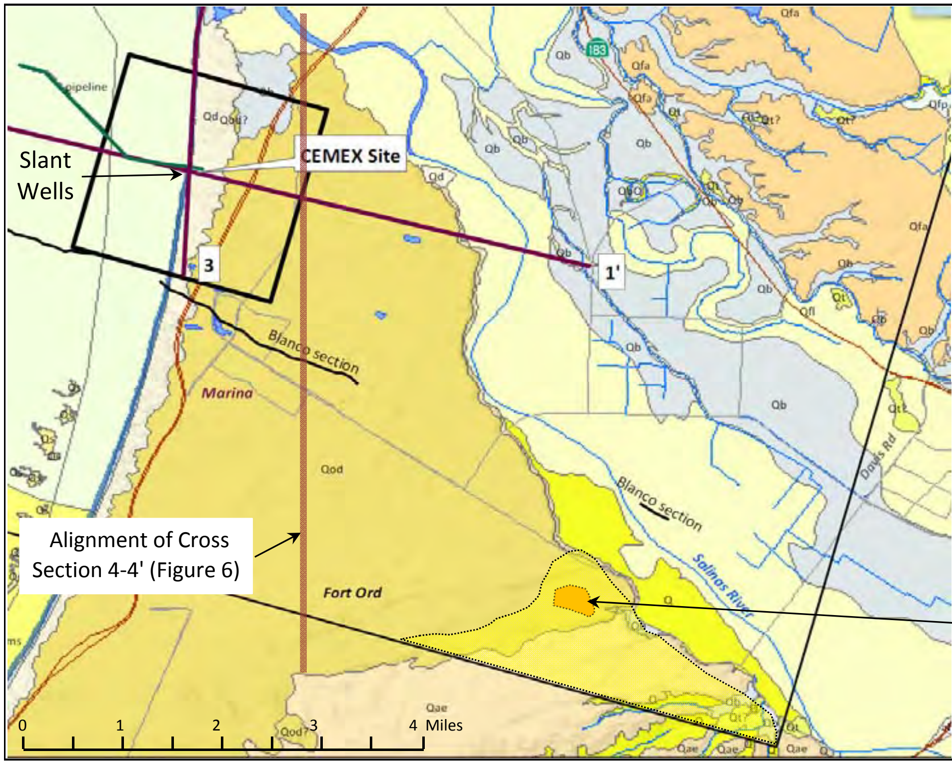
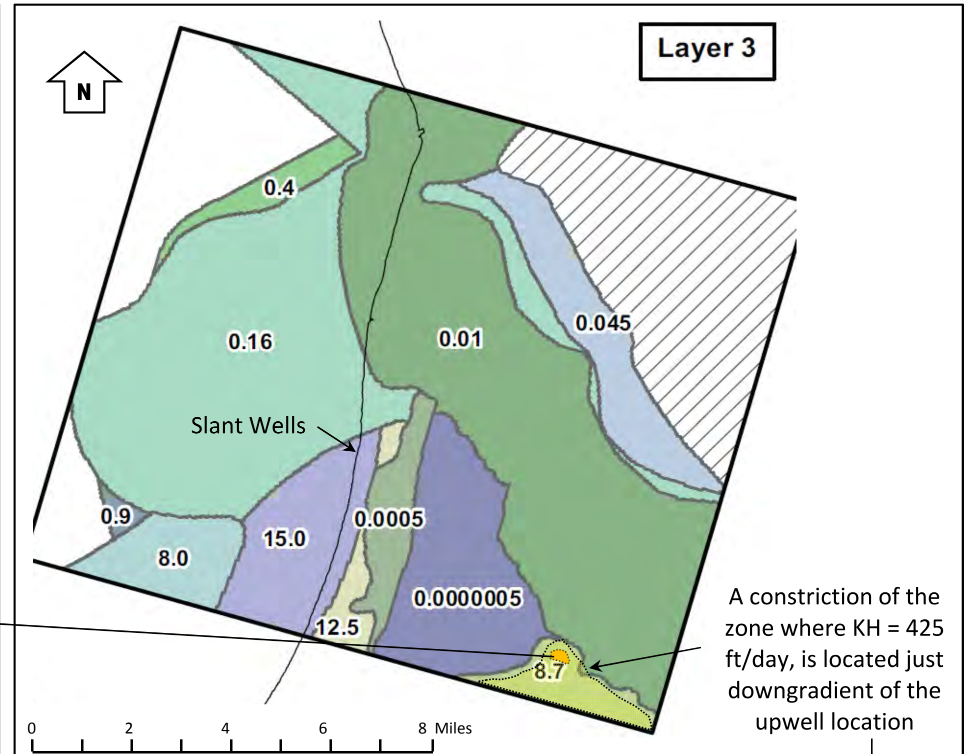


Figure 37. Vertical Groundwater Flow Through Layer 3, KV19

Geologic Map (Dune Sand Aquifer)

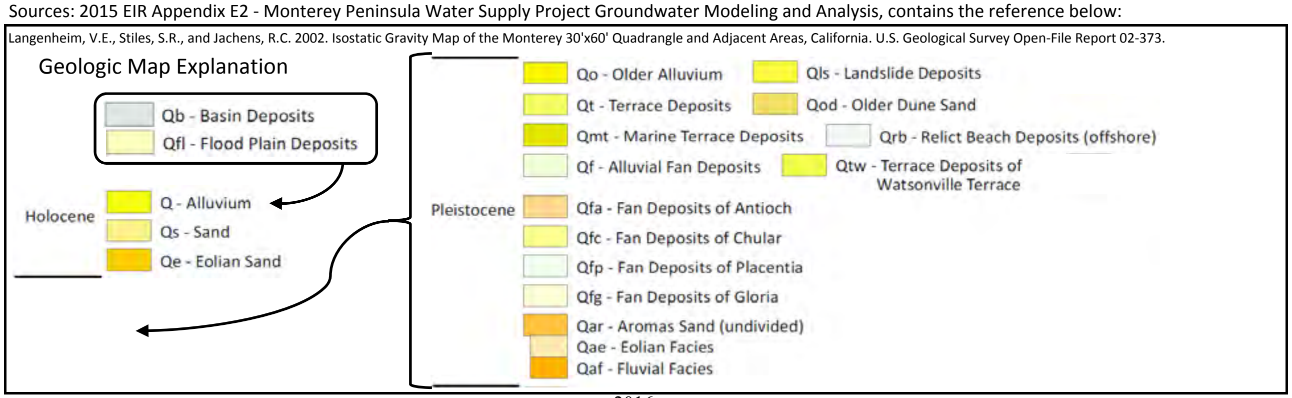


Layer 3 (FO-SVA Aquitard) KV Zone Values (Feet/Day)



Sources: 2015 EIR Appendix E2 - Monterey Peninsula Water Supply Project Groundwater Modeling and Analysis, contains the reference below:

Langenheim, V.E., Stiles, S.R., and Jachens, R.C. 2002. Isostatic Gravity Map of the Monterey 30'x60' Quadrangle and Adjacent Areas, California. U.S. Geological Survey Open-File Report 02-373.



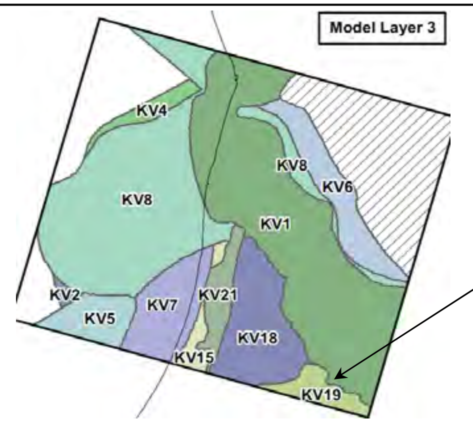
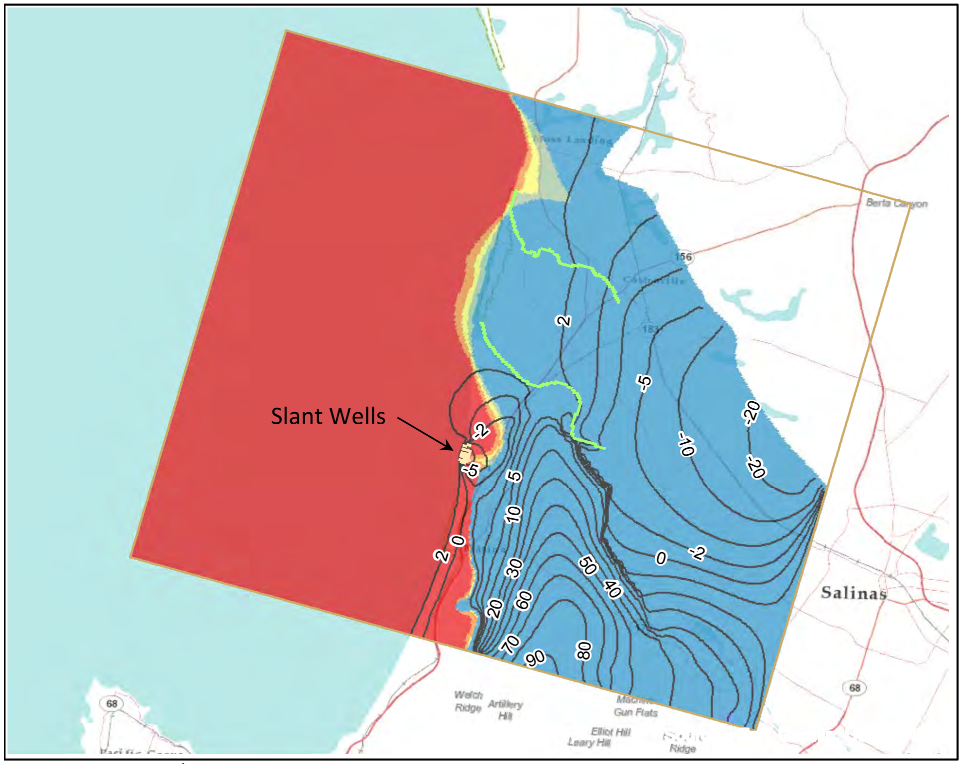


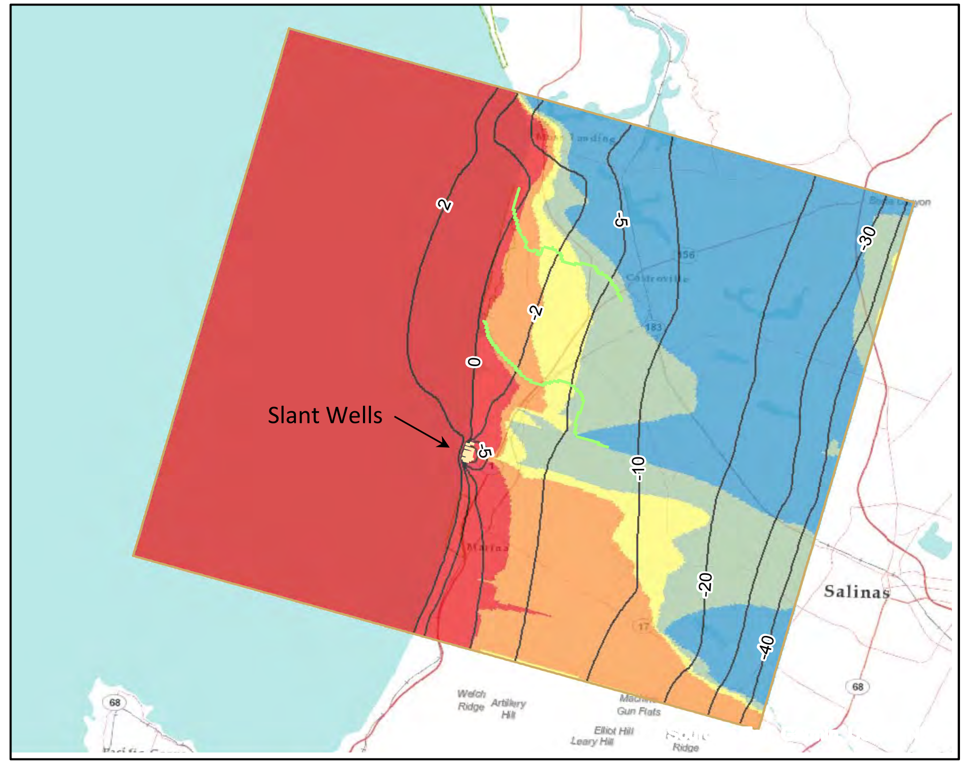
Figure 38. Comparison of Geology and NMGWM^{2016} Layer 3 KV Zone Values (Feet/Day)

NMGWM[2016] Modification - Southern Boundary Revised

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

-5 Groundwater Elevation Contour

Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0007	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	5.0	Inches/year
KH16 and KH18:	4 and 2	Feet/day
Well Discharge OWP:	96.8%	(Ocean Water Percentage)

Figure 39. Southern Boundary Revised - NMGWM[2016] With Layer 4 Inland Gradient = 0.0007; Slant Wells Pumping 15.5 MGD

Layer 2 (Dune Sand Aquifer)

Groundwater Elevation Contours Based on Field Measurements are Shown in Blue.

Model-Generated Contours are Shown in Orange.

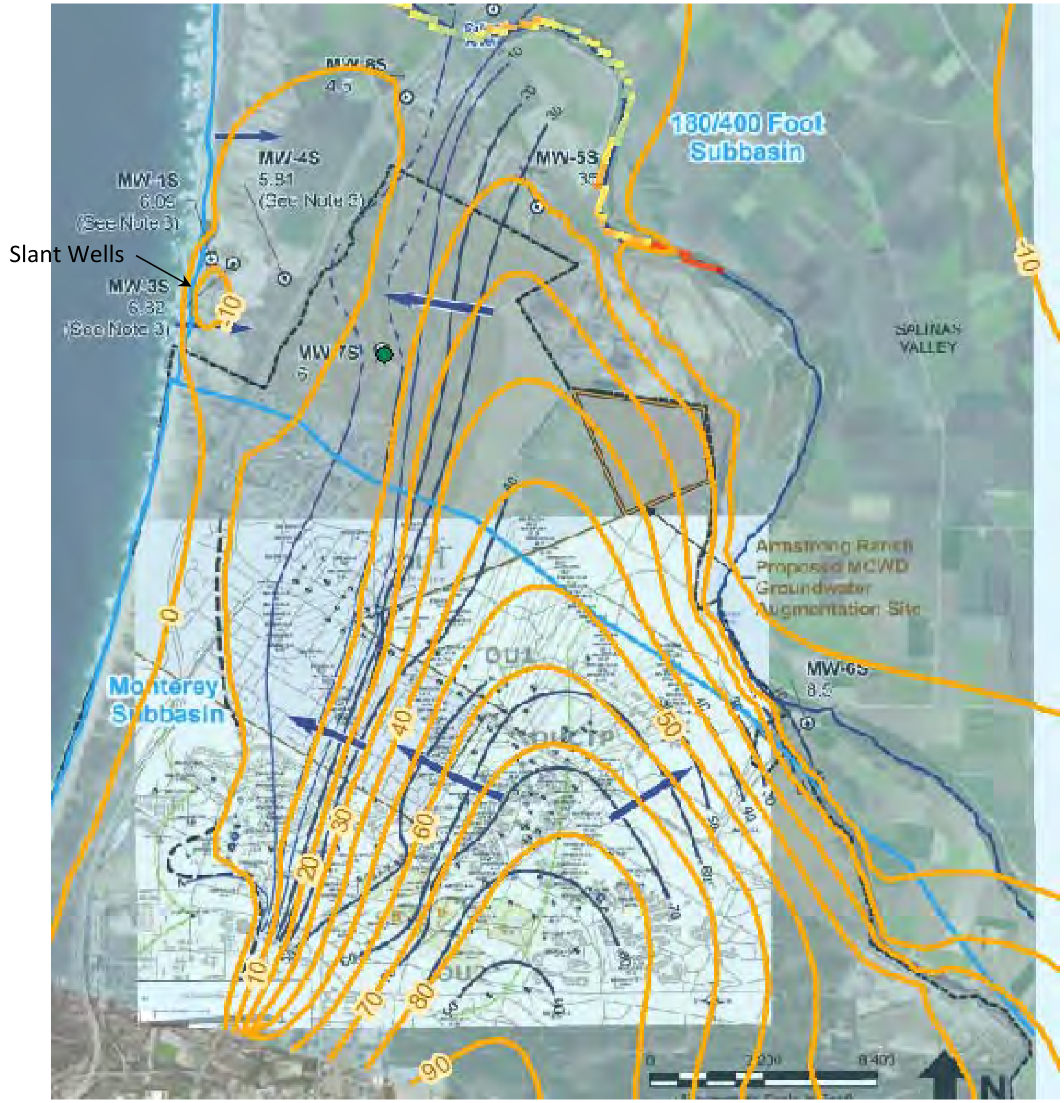


Figure 40. Revised Southern Boundary - Comparison of Modeled and Measured Groundwater Elevation Contours

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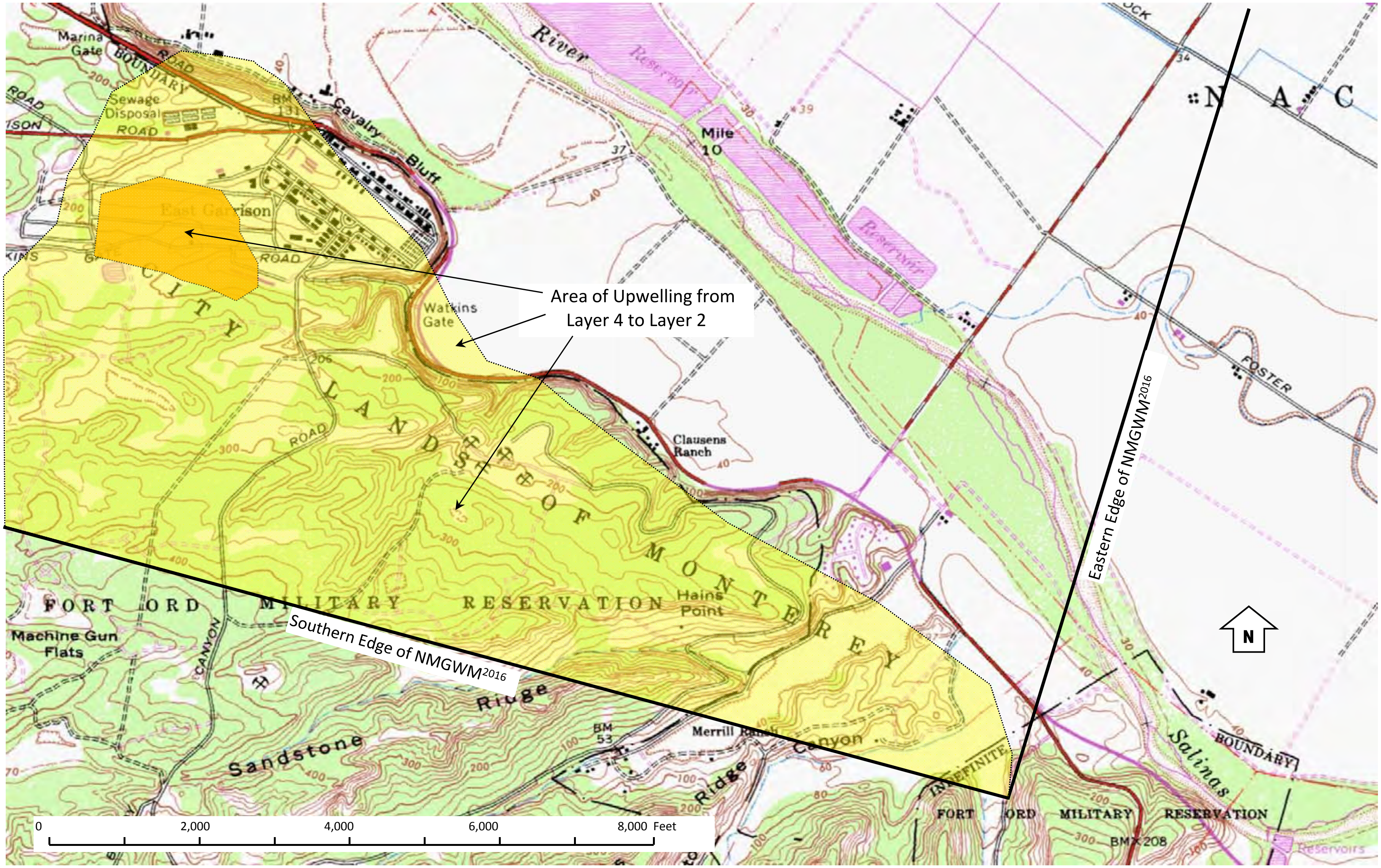

Figure 41. Revised Southern Boundary - Topography in the Southeast Corner of NMGWM^{2016}

NMGWM^{2016} Results - "Wet" Season TSW Comparison

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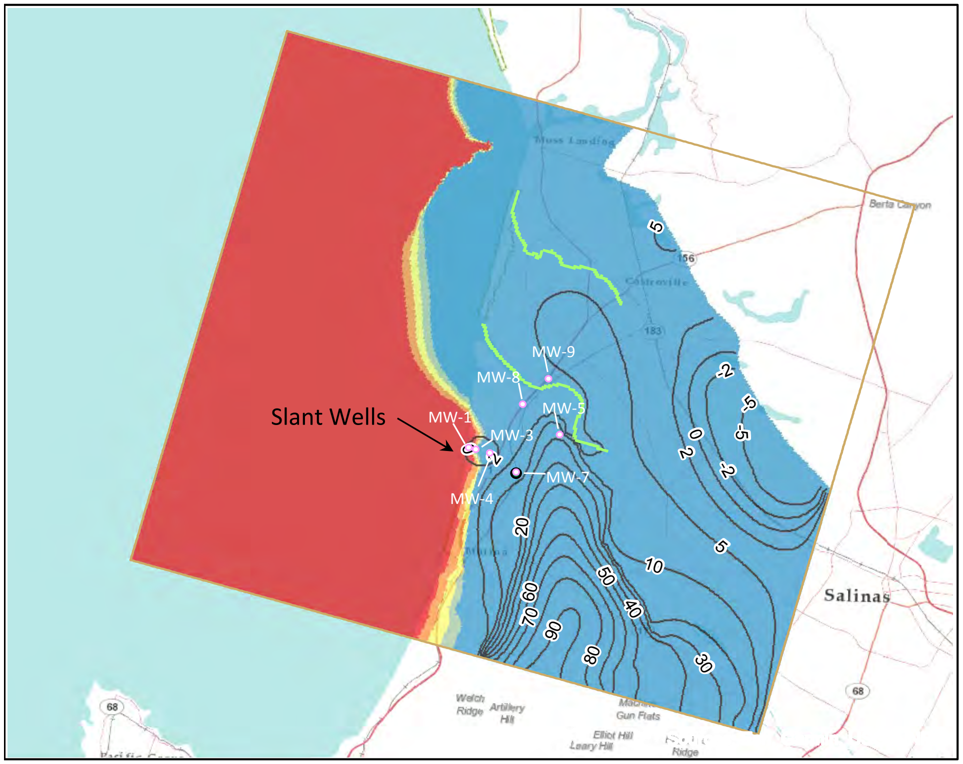
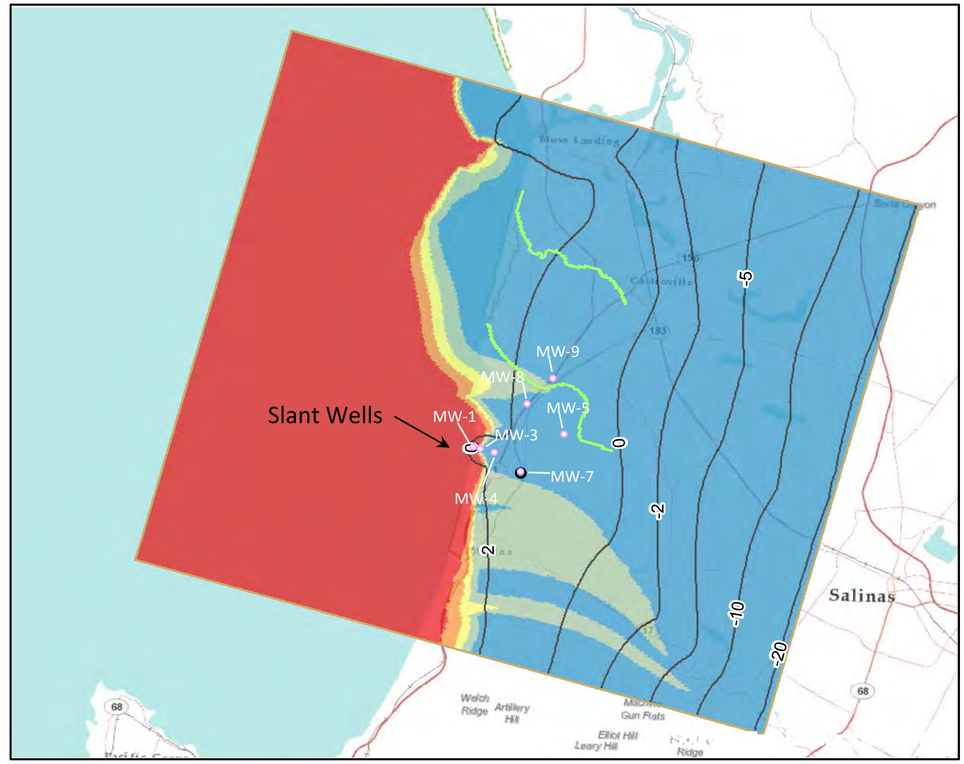
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Salinity
Ocean Water Percent (OWP)

- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	6.0	Inches/year
KH16 and KH18:	3.5	Feet/day
Well Discharge OWP:	85.8%	(Ocean Water Percentage)
Groundwater Elevation in MW-7S:	8.9	Feet

Figure 42. "Wet" Season TSW Results Comparison - NMGWM^{2016}, Layer 4 Gradient = 0.0004; Slant Wells Pumping 2.88 MGD, Recharge = 6 inches/year

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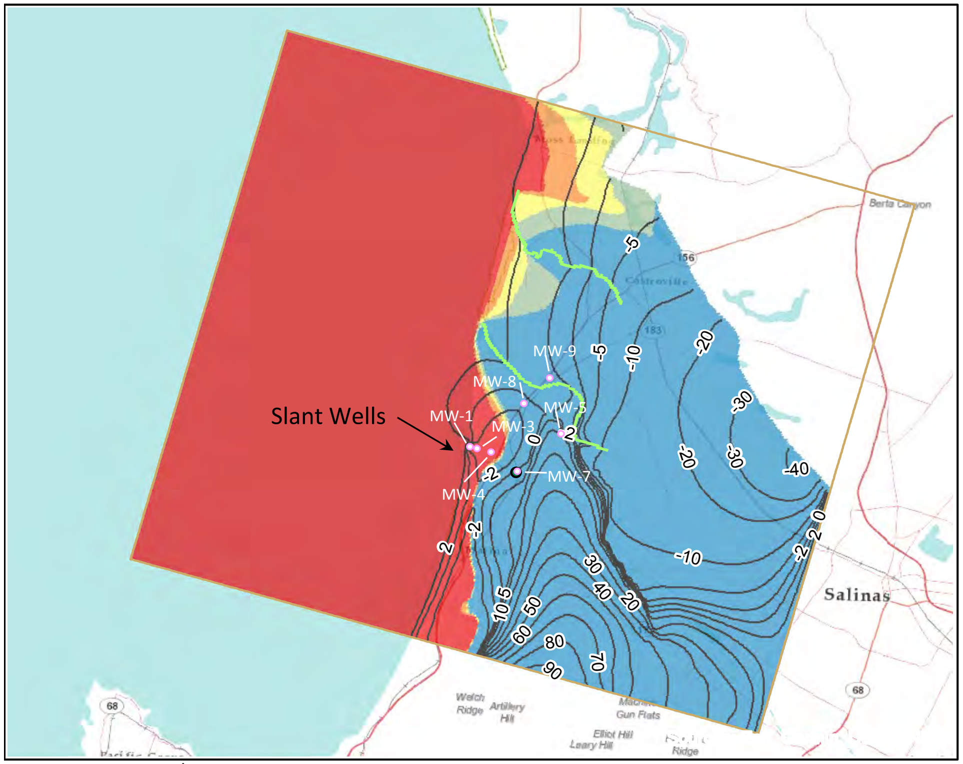
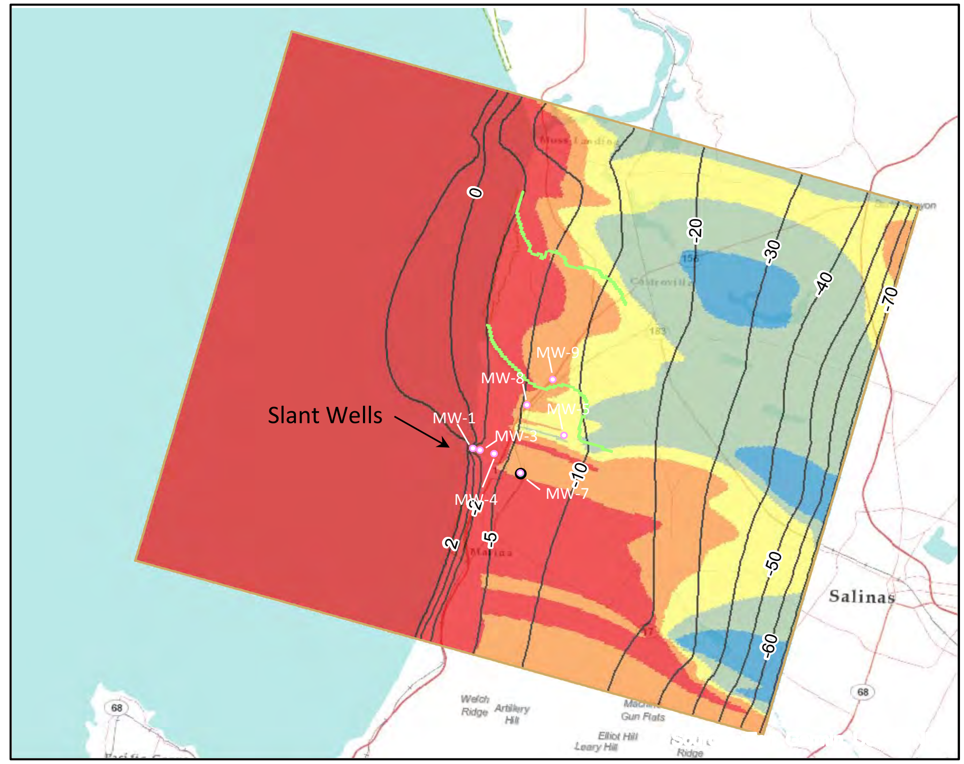
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Salinity
Ocean Water Percent
(OWP)

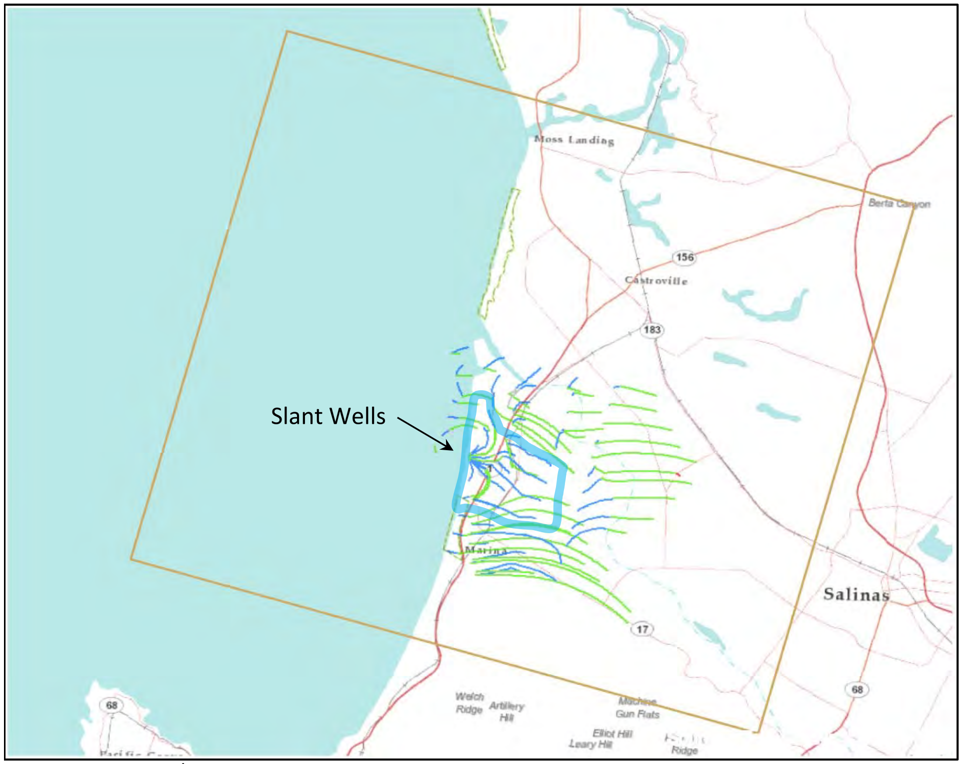
- 0 - 20 %
- 20 - 40 %
- 40 - 60 %
- 60 - 80 %
- 80 - 100 %

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	4.0	Inches/year
KH16 and KH18:	3.5	Feet/day
Well Discharge OWP:	99.6%	(Ocean Water Percentage)
Groundwater Elevation in MW-7S:	0.7	Feet

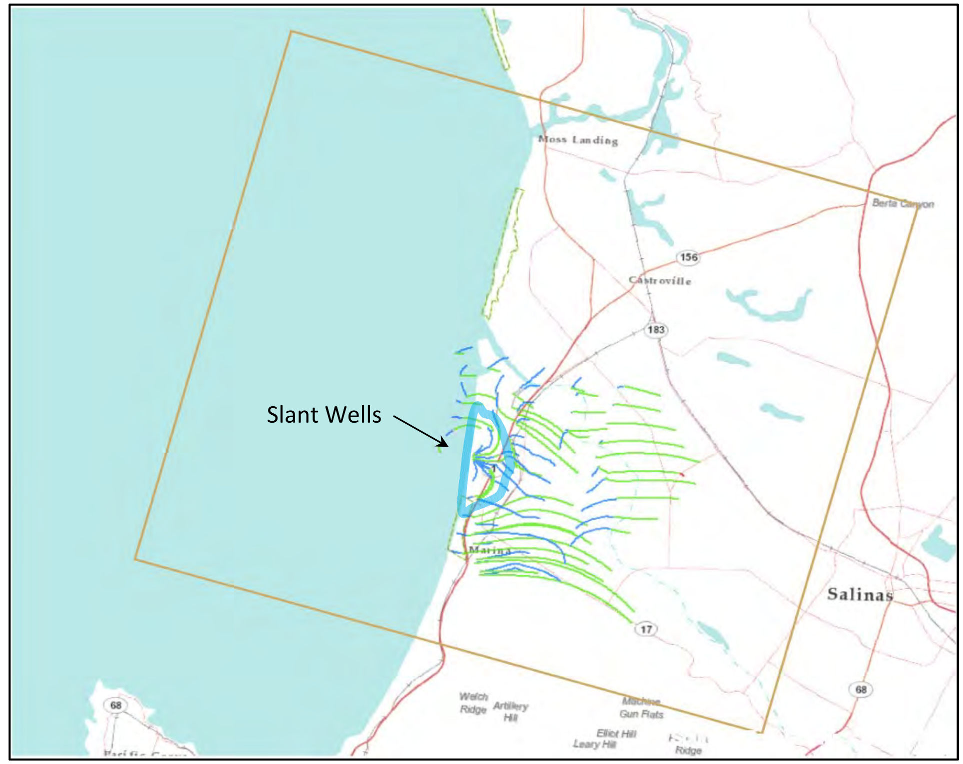
Figure 43. "Dry" Season TSW Results Comparison - NMGWM^2016, Layer 4 Gradient = 0.0011; Slant Wells Pumping 2.88 MGD, Recharge = 4 inches/year

NMGWM^{2016} Results - "Wet" Season, 7.75 MGD

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	7.75	MGD
Recharge:	6.0	Inches/year
Well Discharge OWP:	84.7%	(Ocean Water Percentage)

"Fresh" Water Capture Zone

Figure 44. "Wet" Season Groundwater Capture - NMGWM^{2016}; Slant Wells Pumping 7.75 MGD

NMGWM2016 Results - "Wet" Season, 15.5 MGD

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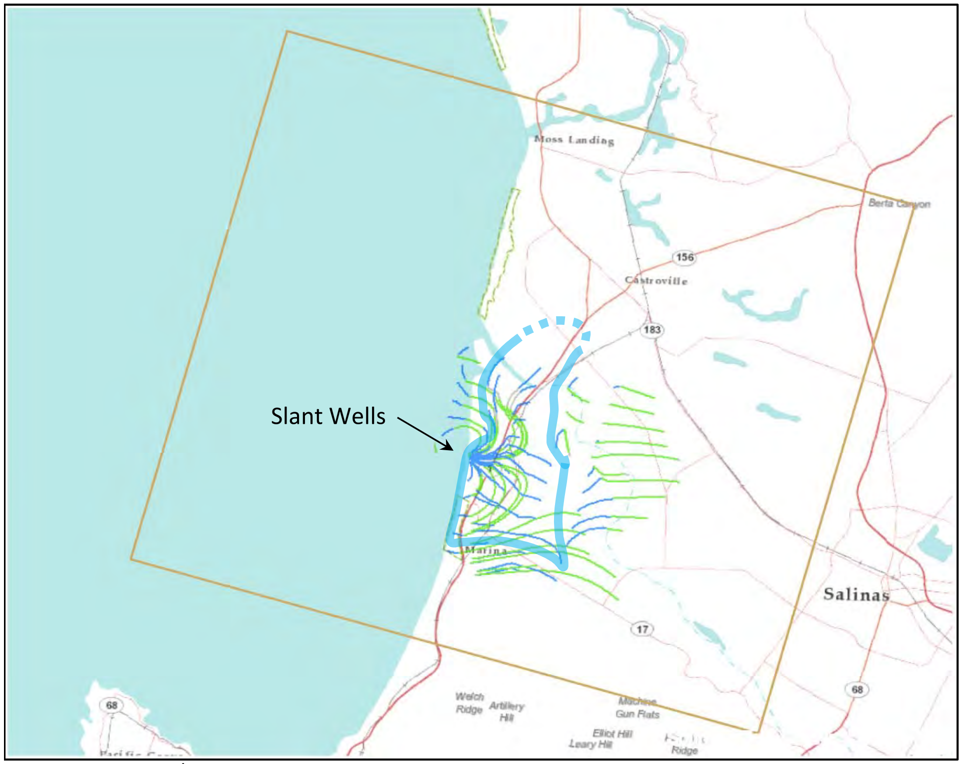
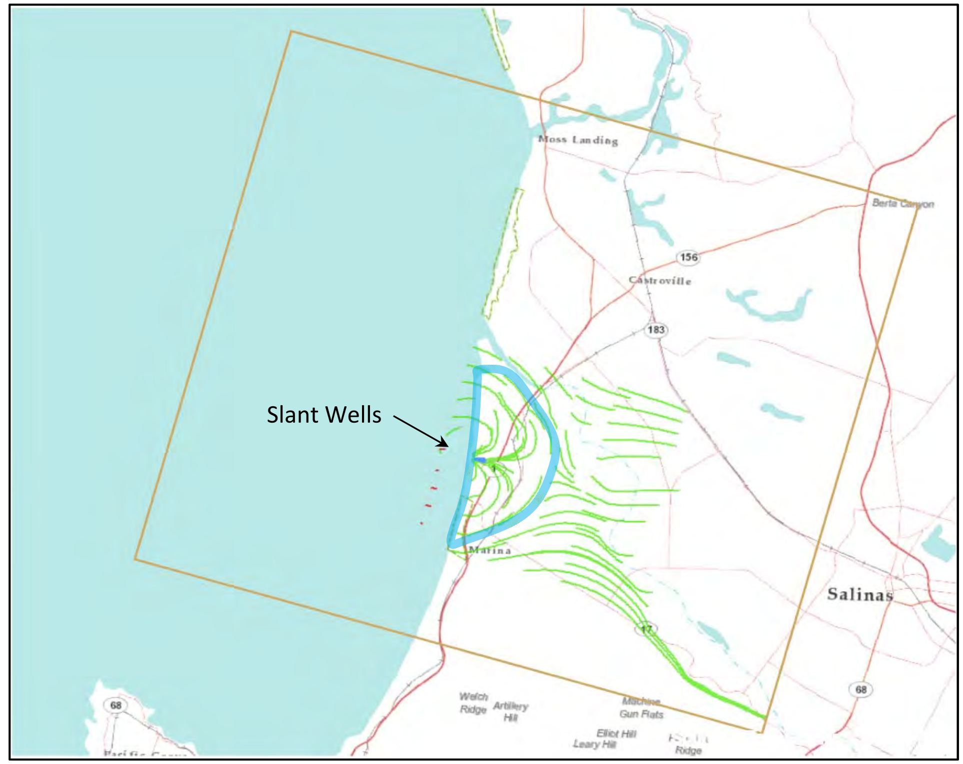
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

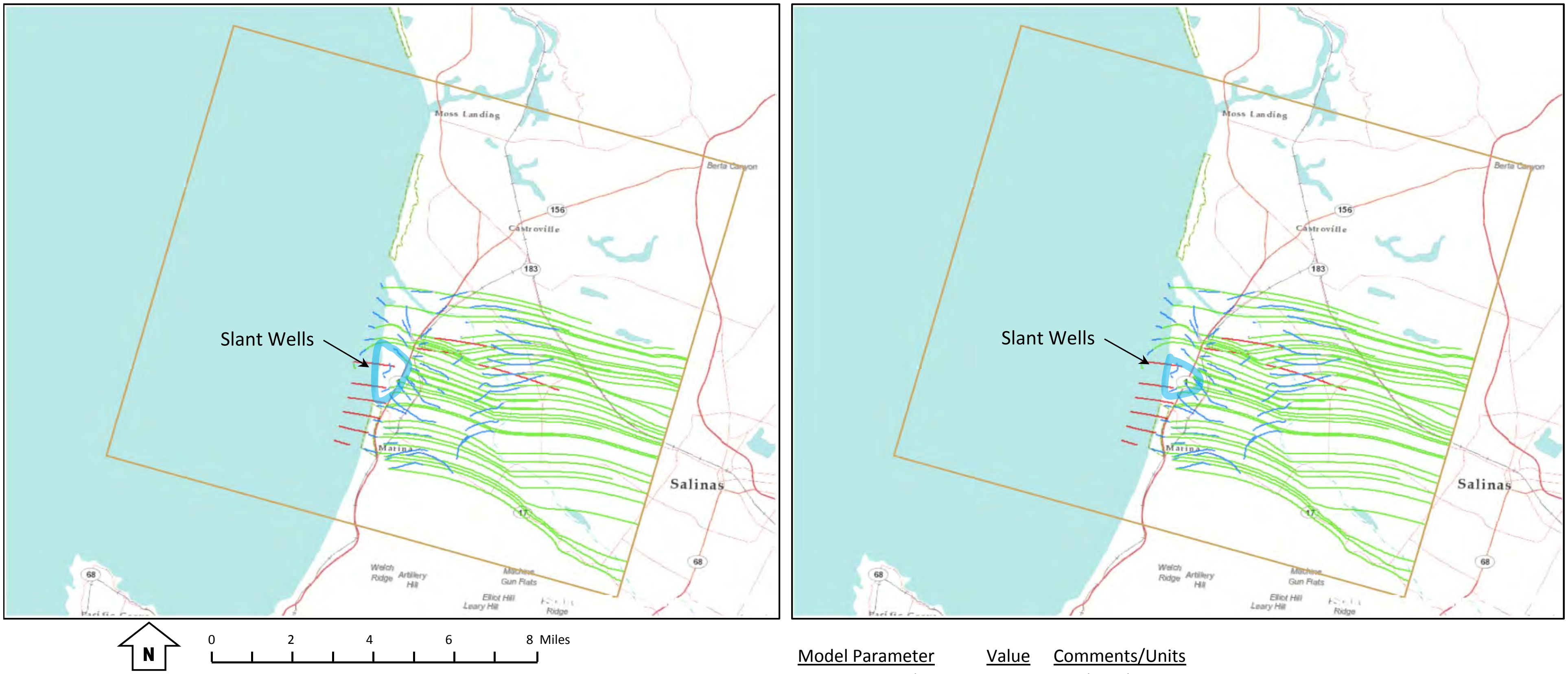
- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0004	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	6.0	Inches/year
Well Discharge OWP:	87.3%	(Ocean Water Percentage)

"Fresh" Water Capture Zone

Figure 45. "Wet" Season Groundwater Capture - NMGWM2016; Slant Wells Pumping 15.5 MGD

Layer 2 (Dune Sand Aquifer) | Layer 4 (180-Foot Aquifer)



Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward
Slant Wells Pumping Rate:	7.75	MGD
Recharge:	4.0	Inches/year
Well Discharge OWP:	98.9%	(Ocean Water Percentage)

"Fresh" Water Capture Zone

Figure 46. "Dry" Season Groundwater Capture - NMGWM[2016]; Slant Wells Pumping 7.75 MGD

NMGWM^{2016} Results - "Dry" Season, 15.5 MGD

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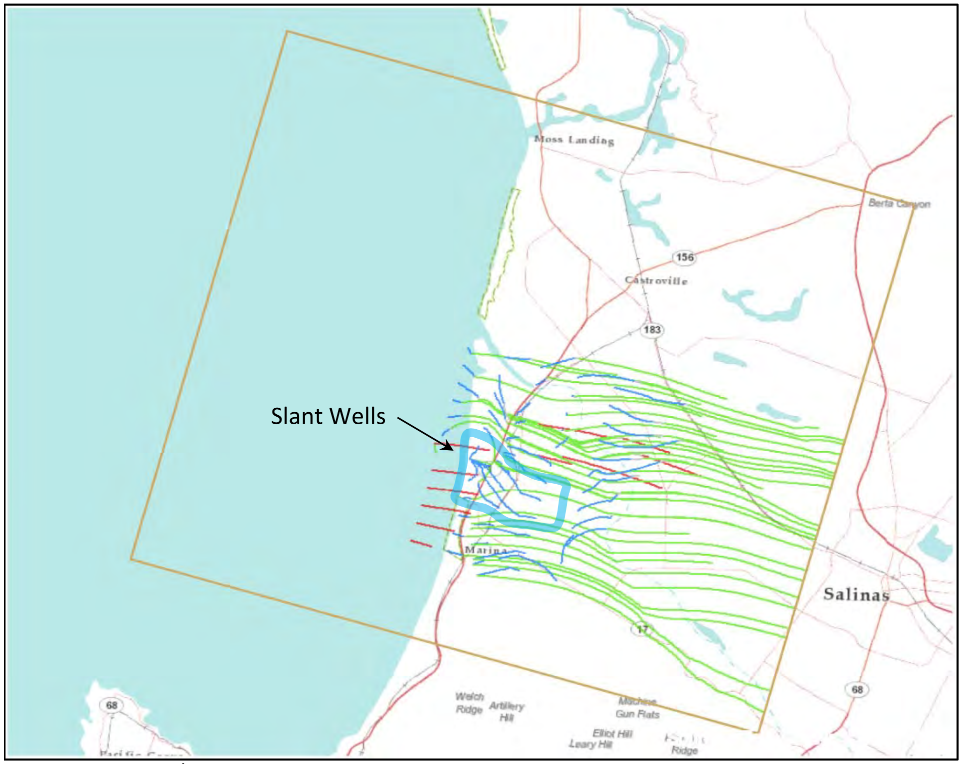
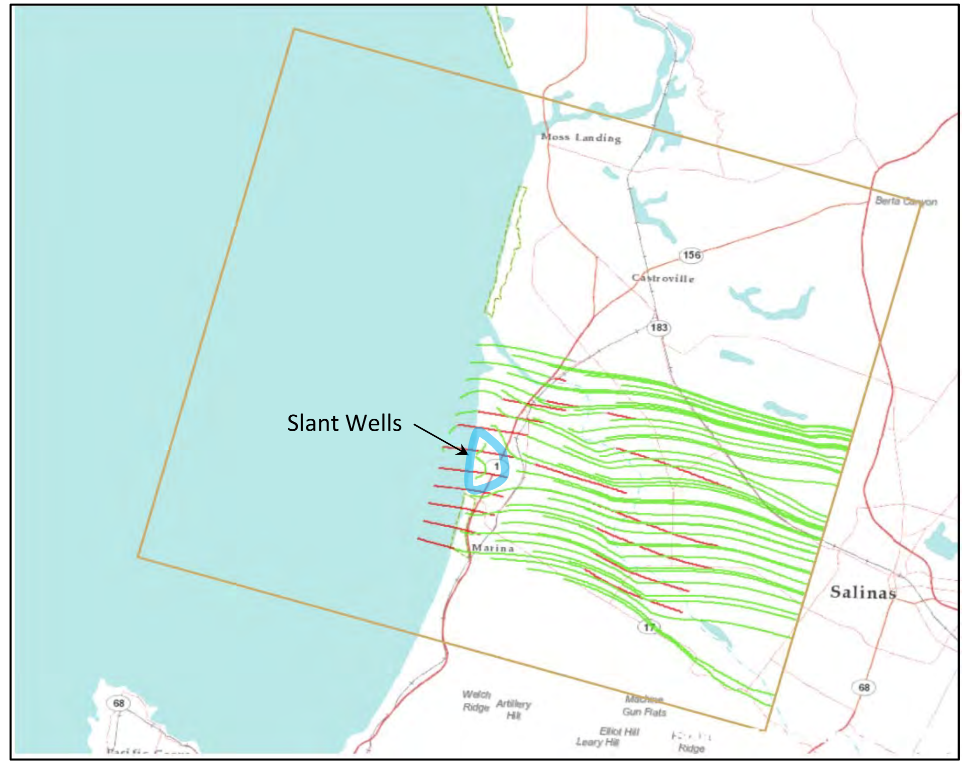
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.0011	Landward
Slant Wells Pumping Rate:	15.5	MGD
Recharge:	4.0	Inches/year
Well Discharge OWP:	97.6%	(Ocean Water Percentage)

"Fresh" Water Capture Zone

Figure 47. "Dry" Season Groundwater Capture - NMGWM^{2016}; Slant Wells Pumping 15.5 MGD

NMGWM^{2016} Results - Zero* Gradient

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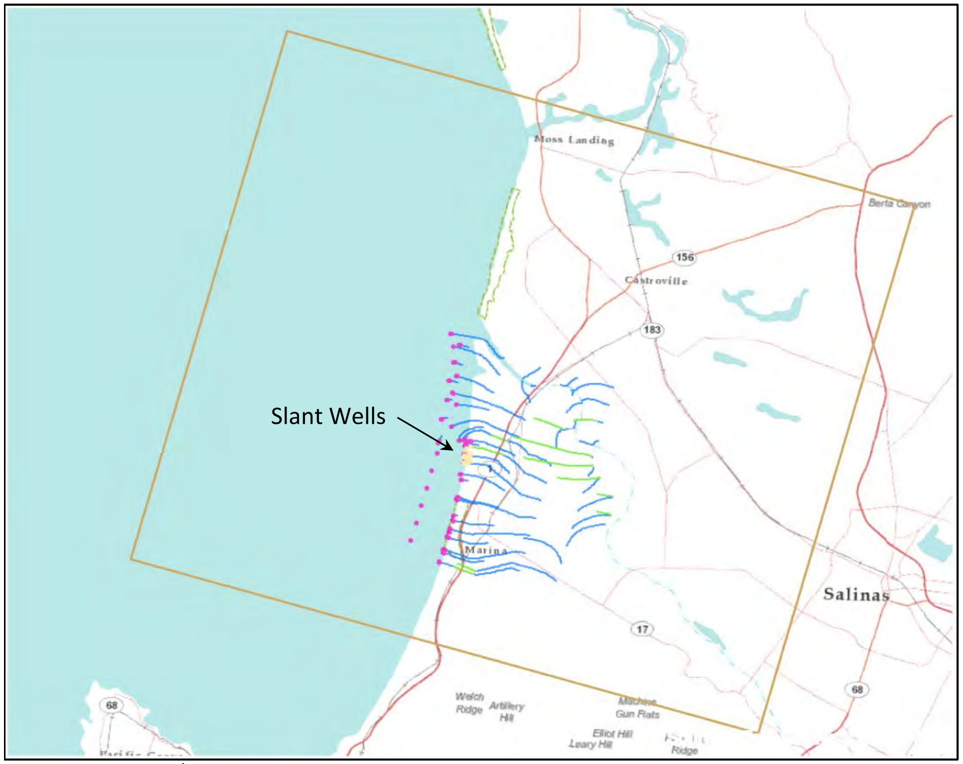
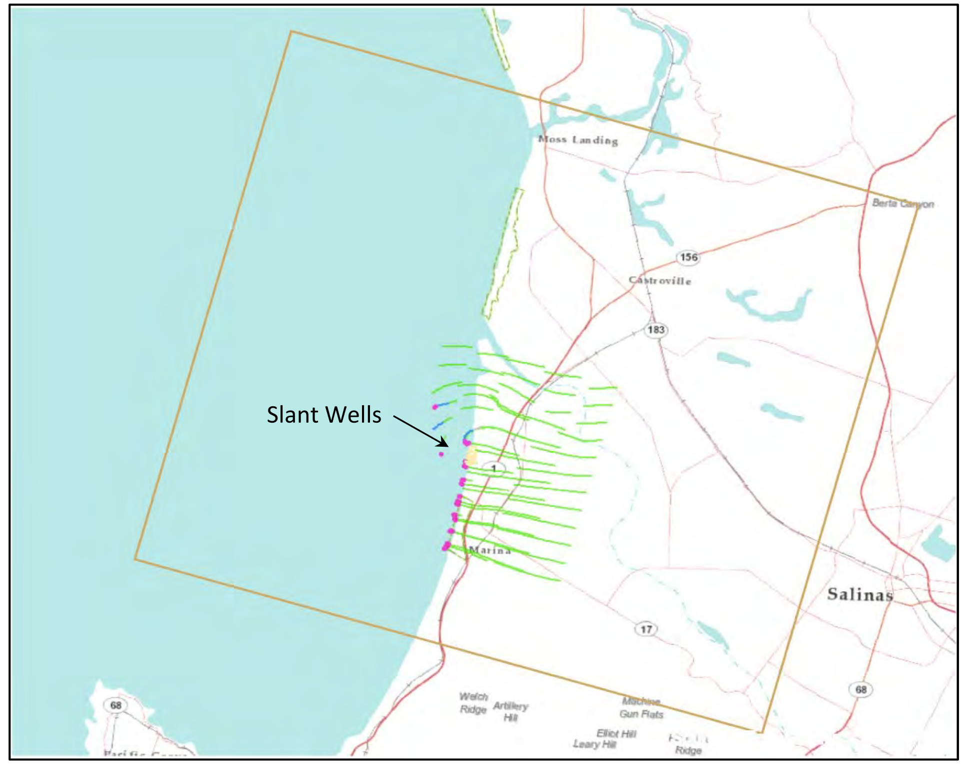
Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.00	Landward
Slant Wells Pumping Rate:	0.00	MGD
Recharge:	5.0	Inches/year

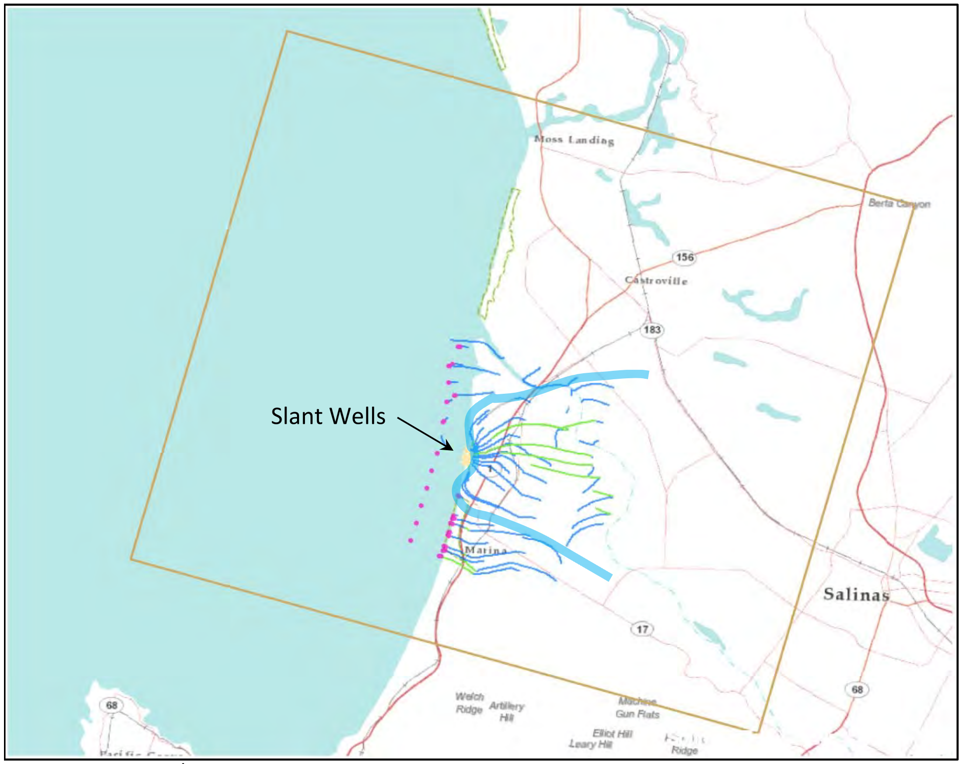
*Although the eastern general head boundary in Layers 2, 4, 6, and 8 is set to +3 NAVD88, creating a zero gradient from the eastern model boundary to the ocean, recharge and vertical downward flow from Layer 2 creates a gentle seaward gradient from several miles inland to the coast in these layers.

Well Discharge OWP: 0.0% (Ocean Water Percentage)

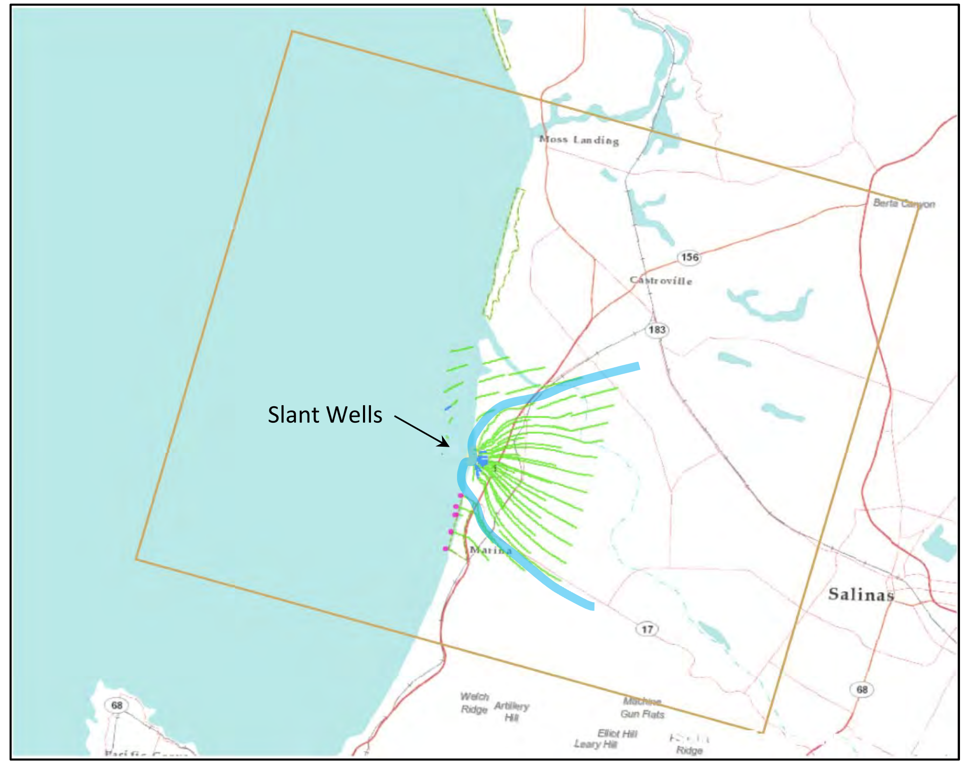
"Fresh" Water Capture Zone

Figure 48. Zero Gradient Groundwater Flow - NMGWM^{2016}; No Pumping, No Capture

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.00	Landward
Slant Wells Pumping Rate:	7.75	MGD
Recharge:	5.0	Inches/year

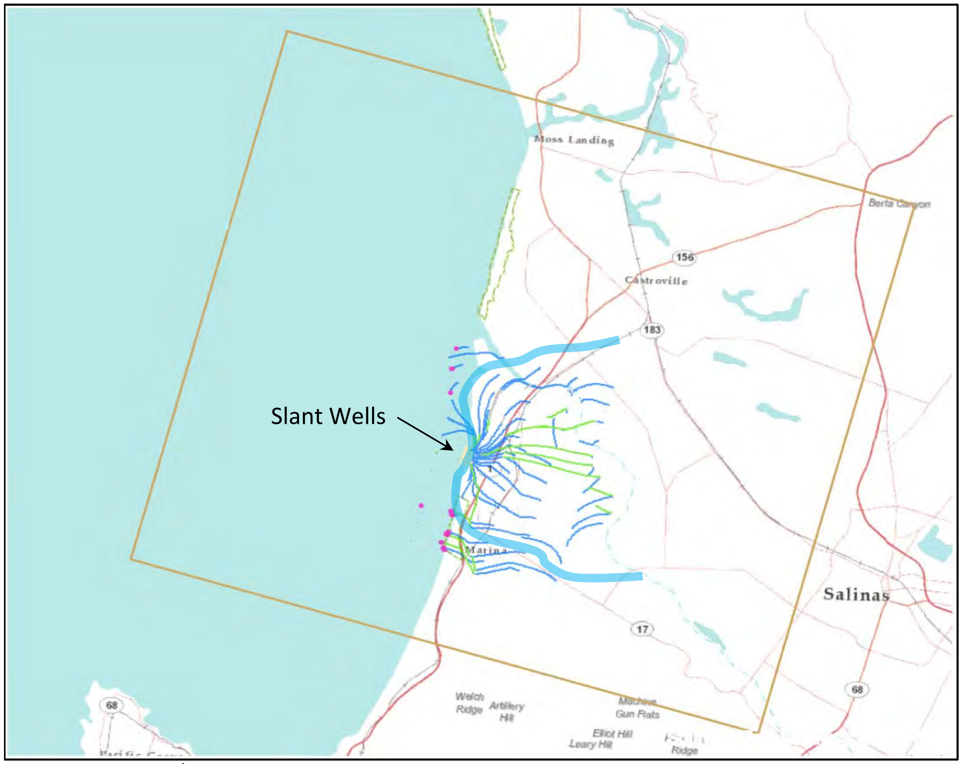
*Although the eastern general head boundary in Layers 2, 4, 6, and 8 is set to +3 NAVD88, creating a zero gradient from the eastern model boundary to the ocean, recharge and vertical downward flow from Layer 2 creates a gentle seaward gradient from several miles inland to the coast in these layers.

Well Discharge OWP: 66.6% (Ocean Water Percentage)

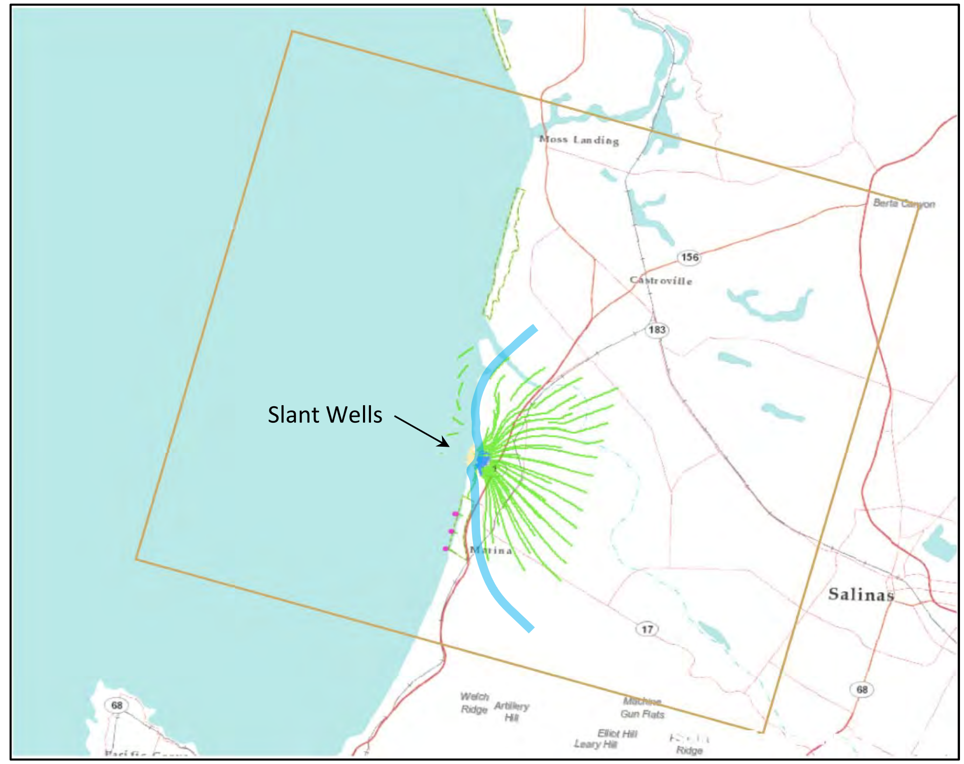
"Fresh" Water Capture Zone

Figure 49. Zero Gradient Groundwater Capture - NMGWM2016; Slant Wells Pumping 7.75 MGD

Layer 2 (Dune Sand Aquifer)



Layer 4 (180-Foot Aquifer)



N

0 2 4 6 8 Miles

Flow Path within Model Layer

- 2
- 3
- 4
- 5
- 6

Model Parameter	Value	Comments/Units
Layer 4 Gradient:	0.00	Landward
Slant Wells Pumping Rate:	15.50	MGD
Recharge:	5.0	Inches/year

*Although the eastern general head boundary in Layers 2, 4, 6, and 8 is set to +3 NAVD88, creating a zero gradient from the eastern model boundary to the ocean, recharge and vertical downward flow from Layer 2 creates a gentle seaward gradient from several miles inland to the coast in these layers.

Well Discharge OWP: 73.4% (Ocean Water Percentage)

"Fresh" Water Capture Zone

Figure 50. Zero Gradient Groundwater Capture - NMGWM2016; Slant Wells Pumping 15.5 MGD

NMGWM2016 Results - "Wet" Season, 15.5 MGD

- Two seasonal conditions ('wet' and 'dry') were assessed for
  - No pumping
  - Total pumping rate of 7.75 MGD
  - Total pumping rate of 15.5 MGD
- Average drawdown calculated (pumping minus no pumping) over the cells (blue model cells in figure) representing vernal pond locations
- Drawdowns at model cells associated with each vernal pond are calculated and the values for averaged for each pond

Figure 51. Location of Vernal Ponds Relative to Slant Wells

TABLES

Table 1. Summary of Ocean Water Percentage (OWP) Analyses

Source	1-month OWP	1-year OWP	2-years OWP	Long-term OWP	Method
2015 Draft EIR	--	89 – 92	93 – 96	93 – 96	Variable Density Solute Transport Model
MCWD/GeoHydros	69	89	90	90	Model Water Balance
TSW Field Data	85	92 – 95	90 – 92	--	Field Data
HWG Analytical	78 – 79	88 – 93	93 – 97	96+	Analytical Mixing Model
HWG Numerical	82	93	93 – 94	94	Variable Density Solute Transport Model
Overall Range	69 – 85	89 – 95	90 – 96	90 – 96+	Various

Abbreviations:
EIR – Environmental Impact Report
HWG – Hydrogeological Working Group
MCWD – Marina Coast Water District
OWP – Ocean Water Percentage
TSW – Test Slant Well

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Table 2. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations, With Fresh Water TDS = 0.0 mg/L

Scenario	OWP Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Original (No recharge with 15.5 MGD Pumping)	99.30%	99.97%	99.99%	---
Base Case for Sensitivity Analysis (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD	**91.5%**	**97.2%**	**98.6%**	**74.9%**
Sensitivity Analysis				
Recharge Sensitivity (15 in/yr)	72.5%	84.6%	92.5%	63.8%
Recharge Sensitivity (10 in/yr)	81.0%	91.9%	96.4%	68.7%
Recharge Sensitivity (2.5 in/yr)	95.8%	98.8%	99.4%	79.9%
Recharge (5 in/yr); Well Pumping Sensitivity (7.75 MGD)	91.9%	97.9%	99.1%	68.7%
Recharge (5 in/yr); Well Pumping Sensitivity (31 MGD)	92.2%	95.8%	97.9%	79.9%
Layer 2 Sensitivity at Pumping Wells KH7 x 0.2 (150 changed to 30 ft/day)	89.6%	95.7%	97.8%	72.8%
Layer 2 Sensitivity at Pumping Wells KH7 x 5 (150 changed to 750 ft/day)	95.0%	99.0%	99.6%	78.7%
Variations in Hydraulic Conductivity, Margin of FO-SVA				
Increase Dune Sand KH (KH20 and KH16) x 5 (4 and 2 changed to 20 and 10 ft/day)	91.1%	96.6%	---	74.7%
Expand Moderate-K FO-SVA margin (KV15 = KV21 = 0.0005 and KV13 = KV20 = 0.03 ft/day)	91.9%	96.4%	97.3%	76.0%
Reduce Effectiveness (KV) of FO-SVA (KV21 = KV15 = 12.5 and KV20 = KV13 = 12.5 ft/day)	91.8%	97.5%	---	74.8%
Extend Low-K margin of FO-SVA west of Well 7 (KV21 = KV18 = 0.0000005 and KV20 = KV16 = 0.03 ft/day)	91.0%	96.0%	---	74.8%
Expand Area of Low-K Dune Sand Aquifer Westward (KH15 = KH21 = 4 and KH13 = KH20 = 4 ft/day)	92.3%	97.8%	---	76.5%
Expand Area of High-K Dune Sand Aquifer Eastward (KH21 = KH15 = 625 and KH20 = KH13 = 625 ft/day)	88.3%	93.5%	---	73.0%

Notes
FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day
KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity
--- = value not determined

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Table 2a. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations, With Fresh Water TDS = 500 mg/L

Scenario	OWP[500] Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Original (No recharge with 15.5 MGD Pumping)	99.29%	99.97%	99.99%	---
Base Case for Sensitivity Analysis (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD	**91.4%**	**97.2%**	**98.6%**	**74.5%**
Sensitivity Analysis				
Recharge Sensitivity (15 in/yr)	72.1%	84.4%	92.4%	63.3%
Recharge Sensitivity (10 in/yr)	80.7%	91.8%	96.3%	68.2%
Recharge Sensitivity (2.5 in/yr)	95.7%	98.8%	99.4%	79.6%
Recharge (5 in/yr); Well Pumping Sensitivity (7.75 MGD)	91.8%	97.9%	99.1%	68.2%
Recharge (5 in/yr); Well Pumping Sensitivity (31 MGD)	92.1%	95.7%	97.9%	79.6%
Layer 2 Sensitivity at Pumping Wells KH7 x 0.2 (150 changed to 30 ft/day)	89.4%	95.6%	97.8%	72.4%
Layer 2 Sensitivity at Pumping Wells KH7 x 5 (150 changed to 750 ft/day)	94.9%	99.0%	99.6%	78.4%
Variations in Hydraulic Conductivity, Margin of FO-SVA				
Increase Dune Sand KH (KH20 and KH16) x 5 (4 and 2 changed to 20 and 10 ft/day)	91.0%	96.5%	---	74.3%
Expand Moderate-K FO-SVA margin (KV15 = KV21 = 0.0005 and KV13 = KV20 = 0.03 ft/day)	91.8%	96.3%	97.3%	75.6%
Reduce Effectiveness (KV) of FO-SVA (KV21 = KV15 = 12.5 and KV20 = KV13 = 12.5 ft/day)	91.7%	97.5%	---	74.4%
Extend Low-K margin of FO-SVA west of Well 7 (KV21 = KV18 = 0.0000005 and KV20 = KV16 = 0.03 ft/day)	90.9%	95.9%	---	74.4%
Expand Area of Low-K Dune Sand Aquifer Westward (KH15 = KH21 = 4 and KH13 = KH20 = 4 ft/day)	92.2%	97.8%	---	76.1%
Expand Area of High-K Dune Sand Aquifer Eastward (KH21 = KH15 = 625 and KH20 = KH13 = 625 ft/day)	88.1%	93.4%	---	72.6%

Notes

FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day
KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity
mg/L = milligrams per liter
TDS = total dissolved solids
--- = value not determined

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Table 2b. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations, With Fresh Water TDS = 3,000 mg/L

Scenario	$OWP^{3,000}$ Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Original (No recharge with 15.5 MGD Pumping)	99.23%	99.97%	99.99%	---
Base Case for Sensitivity Analysis (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD	**90.7%**	**96.9%**	**98.5%**	**72.4%**
Sensitivity Analysis				
Recharge Sensitivity (15 in/yr)	69.8%	83.1%	91.8%	60.2%
Recharge Sensitivity (10 in/yr)	79.1%	91.1%	96.0%	65.6%
Recharge Sensitivity (2.5 in/yr)	95.4%	98.7%	99.3%	77.9%
Recharge (5 in/yr); Well Pumping Sensitivity (7.75 MGD)	91.1%	97.7%	99.0%	65.6%
Recharge (5 in/yr); Well Pumping Sensitivity (31 MGD)	91.4%	95.4%	97.7%	77.9%
Layer 2 Sensitivity at Pumping Wells KH7 x 0.2 (150 changed to 30 ft/day)	88.6%	95.3%	97.6%	70.1%
Layer 2 Sensitivity at Pumping Wells KH7 x 5 (150 changed to 750 ft/day)	94.5%	98.9%	99.6%	76.6%
Variations in Hydraulic Conductivity, Margin of FO-SVA				
Increase Dune Sand KH (KH20 and KH16) x 5 (4 and 2 changed to 20 and 10 ft/day)	90.2%	96.3%	---	72.2%
Expand Moderate-K FO-SVA margin (KV15 = KV21 = 0.0005 and KV13 = KV20 = 0.03 ft/day)	91.1%	96.0%	97.0%	73.6%
Reduce Effectiveness (KV) of FO-SVA (KV21 = KV15 = 12.5 and KV20 = KV13 = 12.5 ft/day)	91.0%	97.3%	---	72.3%
Extend Low-K margin of FO-SVA west of Well 7 (KV21 = KV18 = 0.0000005 and KV20 = KV16 = 0.03 ft/day)	90.1%	95.6%	---	72.3%
Expand Area of Low-K Dune Sand Aquifer Westward (KH15 = KH21 = 4 and KH13 = KH20 = 4 ft/day)	91.5%	97.6%	---	74.2%
Expand Area of High-K Dune Sand Aquifer Eastward (KH21 = KH15 = 625 and KH20 = KH13 = 625 ft/day)	87.1%	92.9%	---	70.3%

Notes

FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day
KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity
mg/L = milligrams per liter
TDS = total dissolved solids
--- = value not determined

Table 3. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations - South Model Boundary Adjusted, With Fresh Water TDS = 0.0 mg/L

Scenario	OWP Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Base Case - No South Model Boundary Adjustment (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = 4; KH16 = 2 ft/day	**91.5%**	**97.2%**	**98.6%**	**74.9%**
South Model Boundary Adjusted				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = KH16 = 3.5 ft/day	---	96.8%	---	---
Seasonal Differences				
Test Slant Well Comparison - "Wet": Recharge (6 in/yr); Well Pumping 2.88 MGD	85.8%	---	---	---
Test Slant Well Comparison - "Dry": Recharge (4 in/yr); Well Pumping 2.88 MGD	---	---	99.6%	---
1/2 Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 7.75 MGD	84.7%	---	---	---
Full Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 15.5 MGD	87.3%	---	---	---
1/2 Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 7.75 MGD	---	---	98.9%	---
Full Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 15.5 MGD	---	---	97.6%	---
Zero Gradient Simulations				
No Pumping, Recharge (5 in/yr)	---	---	---	n/a
Wells Pumping 7.75 MGD, Recharge (5 in/yr)	---	---	---	66.6%
Wells Pumping 15.5 MGD, Recharge (5 in/yr)	---	---	---	73.4%

Notes

FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day

KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity

n/a = not applicable
--- = value not determined

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Table 3a. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations - South Model Boundary Adjusted, With Fresh Water TDS = 500 mg/L

Scenario	OWP^{500} Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Base Case - No South Model Boundary Adjustment (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = 4; KH16 = 2 ft/day	**91.4%**	**97.2%**	**98.6%**	**74.5%**
South Model Boundary Adjusted				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = KH16 = 3.5 ft/day	---	96.8%	---	---
Seasonal Differences				
Test Slant Well Comparison - "Wet": Recharge (6 in/yr); Well Pumping 2.88 MGD	85.6%	---	---	---
Test Slant Well Comparison - "Dry": Recharge (4 in/yr); Well Pumping 2.88 MGD	---	---	99.6%	---
1/2 Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 7.75 MGD	84.5%	---	---	---
Full Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 15.5 MGD	87.1%	---	---	---
1/2 Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 7.75 MGD	---	---	98.9%	---
Full Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 15.5 MGD	---	---	97.6%	---
Zero Gradient Simulations				
No Pumping, Recharge (5 in/yr)	---	---	---	n/a
Wells Pumping 7.75 MGD, Recharge (5 in/yr)	---	---	---	66.1%
Wells Pumping 15.5 MGD, Recharge (5 in/yr)	---	---	---	73.0%

Notes

FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day
KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity
mg/L = milligrams per liter
TDS = total dissolved solids
n/a = not applicable
--- = value not determined

Weiss Associates

Table 3b. Ocean Water Percentages (OWP) From Slant Well Pumping Simulations - South Model Boundary Adjusted, With Fresh Water TDS = 3,000 mg/L

Scenario	$OWP^{3,000}$ Results by Layer 4 Gradient			
	0.0004	0.0007	0.0011	0.00
Base Case - No South Model Boundary Adjustment (Point of Comparison)				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = 4; KH16 = 2 ft/day	**90.7%**	**96.9%**	**98.5%**	**72.4%**
South Model Boundary Adjusted				
Recharge (5 in/yr); Wells Pumping 15.5 MGD; KH20 = KH16 = 3.5 ft/day	---	96.5%	---	---
Seasonal Differences				
Test Slant Well Comparison - "Wet": Recharge (6 in/yr); Well Pumping 2.88 MGD	84.4%	---	---	---
Test Slant Well Comparison - "Dry": Recharge (4 in/yr); Well Pumping 2.88 MGD	---	---	99.6%	---
1/2 Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 7.75 MGD	83.2%	---	---	---
Full Project Well Flow - "Wet": Recharge (6 in/yr); Wells Pumping 15.5 MGD	86.1%	---	---	---
1/2 Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 7.75 MGD	---	---	98.8%	---
Full Project Well Flow - "Dry": Recharge (4 in/yr); Wells Pumping 15.5 MGD	---	---	97.4%	---
Zero Gradient Simulations				
No Pumping, Recharge (5 in/yr)	---	---	---	n/a
Wells Pumping 7.75 MGD, Recharge (5 in/yr)	---	---	---	63.3%
Wells Pumping 15.5 MGD, Recharge (5 in/yr)	---	---	---	70.8%

Notes

FO-SVA = Fort Ord-Salinas Valley Aquitard
MGD = million gallons per day
KH = horizontal hydraulic conductivity
KV = vertical hydraulic conductivity
mg/L = milligrams per liter
TDS = total dissolved solids
n/a = not applicable
--- = value not determined

Table 4. Simulated Water Level Changes at Vernal Ponds Due to Seasonal Effects and Proposed Slant Well Pumping

Pond Number	Pond Name	"Dry"			"Wet"		
		No-Pumping Groundwater Elevation	7.75 MGD Drawdown	15.5 MGD Drawdown	No-Pumping Groundwater Elevation	7.75 MGD Drawdown	15.5 MGD Drawdown
		<------------------------ *Feet* ------------------------>					
1	Robin Drive Pond	-2.08	0.40	0.80	2.70	0.40	0.80
2	Locke-Paddon Park	0.29	0.54	1.09	6.88	0.54	1.09
3	Marina Landing Pond	-0.01	0.75	1.50	5.93	0.75	1.49
4	Marina Coast Water District Pond	-0.08	0.57	1.15	2.89	0.57	1.15
5	Marina State Beach Pond	-0.48	0.42	0.84	2.84	0.42	0.84
6	Armstrong Ranch Ponds	-2.8	2.02	4.05	3.42	2.02	4.05
7	Lake Drive Pond	-2.47	0.39	0.79	2.72	0.39	0.79

Note
MGD = million gallons per day

EXHIBIT 13

HWG COMMENTS ON

INDEPENDENT HYDROGEOLOGICAL REVIEW

JULY 2020

August 13, 2020

California Coastal Commission
45 Fremont Street, #2000
San Francisco, CA 94105
Attn: Tom Luster
Tom.Luster@coastal.ca.gov

SUBJECT: HWG COMMENTS ON WEISS REPORT: INDEPENDENT EVALUATION, MODIFICATION, AND USE OF THE NORTH MARINA GROUNDWATER MODEL TO ESTIMATE POTENTIAL AQUIFER IMPACTS, DATED JULY 10, 2020

Dear Mr. Luster:

This letter provides the comments of the Hydrogeologic Working Group (HWG) on the Weiss Associates Report entitled: Independent Evaluation, Modification, and Use of the North Marina Groundwater Model to Estimate Potential Aquifer Impacts, associated with the Proposed Monterey Peninsula Water Supply Project, dated July 10, 2020 (Weiss 2020 Report). Overall, the Weiss 2020 Report modeling results generally appear to be valid and reasonable with the exception of the flat gradient and excessive rainfall recharge scenarios. Our comments are divided into three types: key conclusions not stated in Conclusions Section of the Weiss 2020 Report but which can be reached based on the Report's analysis, comments on Weiss 2020 Report recommendations, and areas of disagreement with the Weiss 2020 Report's assumptions/methods/findings. We present a brief summary of our main points below, followed by a more detailed description of our comments.

KEY CONCLUSIONS SUMMARY

The following are key conclusions that are either not stated or not clearly stated in the Weiss 2020 Report, but which the HWG has reached based on the analysis provided in the Report:

1 Assumed seaward gradients in the Dune Sand Aquifer <u>do not result in any significant difference</u> in OWP results.

2 The Weiss Report's hypothetical construction of a flat to seaward gradient in the 180-Foot and 400-Foot Aquifer (based on an incorrect assumption about SGMA) <u>is inconsistent with</u> the groundwater elevation minimum thresholds and measurable objectives in the 180/400 Foot Aquifer Subbasin Groundwater Sustainability Plan (GSP).

3 The 180-Foot Aquifer flat gradient scenario (even if it did occur despite not being required in the GSP) <u>would take decades to centuries after 2040 to occur</u>. This hypothetical scenario is not applicable to the permit being considered by the Coastal Commission as the life of the proposed slant wells being permitted is only 25 years.

4 The previously proposed field work to investigate the extent and continuity of the FO-SVA is not necessary.

5 The Weiss model results demonstrate that occurrence of elevated rainfall recharge in a wet year explains the observed temporary decline in OWP (as observed in TSW field data during late Spring/early Summer 2017) associated with the record wet year of 2016-17.

6 The 2020 Weiss Report model sensitivity runs demonstrate that predicted OWP is greater than 88% for any reasonable set of assumptions applied.

7 Previous and current modeling results are consistent with field data collected during pumping of the Test Slant Well.

8 There is no need to further refine estimates of OWP within a range of 88 to 99%.

DETAILED COMMENTS

The HWG comments from our review of the modeling scenarios and results provided in the Weiss 2020 Report are provided below for the three comment types described above in the introduction.

The following are key conclusions to note that are relevant to the purpose of the work, which are not specifically stated in Weiss' Conclusion Section of the Report:

1) The Weiss model results demonstrate that the assumption of a seaward gradient (instead of a landward gradient) in the Dune Sand Aquifer does not result in any significant difference in OWP results. Weiss Table 2 demonstrates OWP exceeds 88% for the assumed seaward gradient in the DSA using reasonable assumptions for other model inputs. The current results are consistent with Weiss' previous findings, previous HWG work, and the EIR/EIS (see Weiss Table 1).
2) The hypothetical construction of a flat to seaward gradient in the 180-Foot Aquifer (and 400-Foot Aquifer) is not consistent with the groundwater elevation minimum thresholds and measurable objectives provided in the 180/400 Foot Aquifer Subbasin Groundwater Sustainability Plan (GSP), which demonstrate an inland gradient from the ocean shoreline to more than five miles inland even under sustainable conditions after 2040 (**Figures 1, 2, 3, and 4**). The GSP groundwater elevation contour maps for minimum thresholds and measurable objective groundwater elevations show an inland gradient in the 180-Foot and 400-Foot Aquifers ranging from 0.00025 to 0.0016. Accordingly, Weiss modeling results for the flat (actually seaward) gradient case should be removed from the Weiss 2020 Report because they are inconsistent with the GSP and not required by SGMA (see **Appendix A**).

3) The model assumption of a flat gradient in the 180-Foot Aquifer is not possible without assuming extreme reductions in agricultural pumping and retirement of agricultural lands in the Eastside and Pressure subareas. Even if farmers were willing or compelled to implement major pumping reductions, which is not a component of the GSP, a flat gradient would not be achieved as indicated in the GSP (**Figures 1, 2, 3, and 4**). Weiss correctly opines that the OWP estimates provided in the model results for a flat to seaward gradient (which, as noted, is not required in the GSP) in the 180-Foot Aquifer (and 400-Foot Aquifer) would take decades to centuries to occur after a flat/seaward gradient is initially achieved in 2040 under SGMA (which is presumably what the Weiss 2020 Report assumes as the start date for a flat gradient given the planning horizon under SGMA). The Weiss Report states it would take more than 80 years to reverse seawater intrusion impacts after a seaward gradient is achieved, so the OWP provided in Weiss Table 2 do not apply until after 2120 (at a minimum, and more likely to be long after 2120) for their hypothetical flat/seaward gradient model scenario. The life of proposed slant wells being permitted is 25 years; thus, these scenario results for a flat gradient are not applicable to the permit being considered.
4) Weiss Table 2 demonstrates OWP exceeds 88% for the assumed seaward gradient in the DSA using reasonable assumptions for other model inputs (e.g., landward gradient in 180-Foot Aquifer, which represents current, historical, and projected future conditions; rainfall recharge that is less than 50% of average annual total rainfall).
5) The Weiss model results demonstrate (and Weiss states in the main body of the Weiss 2020 Report) that previously proposed field work to investigate the extent and continuity of the FO-SVA is not necessary. While the HWG disagree with the Weiss evaluation and conclusions regarding the western extent of the FO-SVA, HWG does agree that modeling results demonstrate no further investigation is necessary.
6) The Weiss model results demonstrate that occurrence of elevated rainfall recharge in a wet year explains the observed short-term temporary decline in OWP observed in TSW field data during late Spring/early Summer of 2017 immediately following the record wet year that occurred in 2016-17.
7) The Weiss model results demonstrate that a wide range of model sensitivity assumptions (e.g., changes in horizontal/vertical K values in different areas of the model domain, changes in western extent of FO-SVA) all result in OWP estimates greater than 88%. The only OWP estimate less than 88% required unreasonable/unsubstantiated rainfall recharge over the long-term or flat/seaward hydraulic gradients in the 180-Foot Aquifer (an unrealistic future conditions assumption that is not consistent with the GSP) that would require decades to centuries to reduce OWP.

With regard to Weiss 2020 Report recommendations, HWG believes that additional modeling work using a transient model is not needed from Weiss because:

1) The conclusions of the Weiss 2020 Report demonstrate that predicted OWP is greater than 88% for scenarios where a reasonable set of assumptions is applied (even including seaward gradients in the Dune Sand Aquifer).

2) Previous and current modeling results are consistent with field data collected during pumping of the Test Slant Well over a three-year period from April 2015 to February 2018, which was a time period of wide-ranging annual rainfall.
3) There is no need to further refine estimates of OWP within a range of 88 to 99%.

While it is apparent that current Weiss model results further support conclusions and previous work completed by the FEIR/FEIS Project Team and the HWG, the HWG notes the following areas of disagreement with the Weiss model assumptions/methods and the Weiss 2020 Report conclusions:

1) Model results for a flat/seaward gradient assumption in the 180-Foot Aquifer should not be presented because this is an unreasonable/unsubstantiated assumption (that is inconsistent with the GSP), but more importantly for this purpose, they represent a time frame well beyond that being considered for the MPWSP slant well permit. We also note that:
   a) The claim made by others (e.g., EKI) that SGMA requires or will lead to a flat gradient is erroneous and misleading; the 180/400-Foot Aquifer Subbasin GSP does not specify a flat gradient requirement (**Figures 1, 2, 3, and 4**), and SGMA does not require this assumption. Neither EKI nor Weiss explain how a flat gradient would be achieved.
   b) A flat gradient is no more likely (and probably less likely) than an extraction barrier to be the selected solution for halting seawater intrusion, and flat gradient model results (if presented at all given that GSP does not require or suggest this will occur) should not be included without companion model results for an extraction barrier.
   c) A previous USGS modeling report for the Salinas Valley Basin (Yates, 1988) demonstrates that even a 30% reduction (72,000 AFY) in groundwater pumping in the Pressure and Eastside Subareas will be inadequate to create a flat gradient and halt seawater intrusion (suggesting pumping reductions on the order of 50% or around 100,000 AFY may be necessary). As this would require fallowing more than 30,000 acres of prime agricultural land, such pumping reductions are unlikely to be the selected solution.
2) Rainfall recharge to groundwater is typically only a fraction of total rainfall (previous site-specific evaluation by HWG indicates an average of 30 percent of the 14.8 inches of average annual total rainfall or 5 inches for rainfall recharge in this area). Weiss model results for long-term average annual rainfall recharge of 10 and 15 inches/year should not be presented in the Weiss 2020 Report, because such amounts of rainfall recharge are not realistic or possible over the long-term given that average long-term rainfall recharge is approximately 5 inches/year. Weiss' rainfall recharge amounts may apply on rare occasions in individual wet years like 2016-2017 or 1997-98 (in which total rainfall was 23.3 to 34.7 inches), but not as the long-term averages that were actually simulated by Weiss and presented in the Weiss 2020 Report.
3) Weiss Table 2 shows "0.00" to represent model results for a flat gradient in the 180-Foot and 400-Foot Aquifers. Although the other assumed gradients are cited to four decimals, the "Flat" gradient scenario is only reported to two decimals (i.e. 0.00) while the actual "flat" gradient simulated by Weiss is seaward at 0.0001 (0.53 ft/mi). The reason for this is noted on Weiss Figure 50: "Although the eastern general head boundary in layers 2, 4, 6, and 8 is set to +3 NAVD88, creating a zero gradient from the eastern model boundary to the ocean, recharge and vertical downward flow from Layer 2 creates a gentle seaward gradient from several miles inland to the coast in these layers." HWG calculated this gradient to be 0.0001 ft/ft (0.53 ft/mi)

seaward for the 180-Ft Aquifer. The seaward hydraulic gradient in 180-Ft Aquifer would result in a lower OWP in water extracted by the well field as compared to the real "Flat" hydraulic gradient. Regardless, even more important is to note this flat/seaward gradient assumption and simulation by Weiss is far different than the landward gradient along the coast shown in the GSP for future conditions (**Figures 1, 2, 3, and 4**).

4) Under "No Project" (no slant well pumping) conditions and the Weiss assumption of a "Flat" gradient in the 180-Foot and 400-Foot Aquifers that actually has a seaward direction, the outflow to the ocean was calculated as approximately 5,600 acre-ft/yr in the 180-Foot Aquifer. Aside from the fact that it would be extremely unlikely to have major pumping reductions in the Eastside and Pressure subareas by retiring significant acreages of agricultural lands, this magnitude of outflow suggests that whatever fresh water that could be conserved would be lost to ocean outflow. MPWSP pumping along with an extraction barrier, as contemplated in the GSP, would be a much more effective and efficient seawater intrusion management option, and it would protect current land uses and water use in the region by conserving and putting brackish and seawater intruded groundwater to beneficial use.
5) The Weiss 2020 Report discussion of the potential occurrence of a seaward gradient in the Dune Sand Aquifer ignores key evidence for an inland gradient in the Dune Sand Aquifer including:
    a) Monitoring well MW-8S is further inland and has lower groundwater elevations that MW-1S, MW-3S, and MW-4S; therefore, the assumption of a seaward gradient in the Dune Sand Aquifer certainly does not apply everywhere in the vicinity of the proposed wellfield (even without considering equivalent freshwater heads);
    b) Accounting for density differences results in equivalent freshwater heads that show a persistent inland gradient between MW-1S, MW-3S, and MW-4S over the time frame of available data without test slant well pumping from 2015 to 2019 (**Figure 5**);
    c) The overall time frame from 2015 to 2018 had above-average rainfall; therefore, the measured TSW discharge salinity is likely lower than long-term average results.
    d) Geochemistry data for Dune Sand Aquifer wells demonstrate seawater intrusion is occurring; indicating that overall net average historical gradient has been inland for seawater intrusion to occur (HWG, 2017).
    e) A large area of agricultural development and agricultural return flows near MW-7S (and MW-4S) was introduced after 2016. This has contributed to creating higher groundwater elevations at MW-7S, yet there remains a consistently inland gradient towards MW-8.
6) The so-called "Fresh Water Capture Zones" (FWCZ) presented in the Weiss 2020 Report are misleading for the following reasons:
    a) Graphics presenting FWCZ (e.g., Weiss Figures 48 and 49) imply most of the water flowing into the wells is coming from inland, whereas the reality is that most of the water is still coming from the ocean;
    b) Some graphics (e.g., Figures 44-47) show FWCZ where the area contained within the capture zones will be primarily water coming from the ocean.
    c) Overall, the FWCZ graphics are misleading and should not be presented without showing that the majority of water is coming from the ocean; this might be accomplished using backward tracking of particles placed around the slant wells.
7) The Conclusions Section of the Weiss 2020 Report is unclear and potentially misleading for the following reasons:

a) Weiss did not verify the claim made by others (e.g., EKI) that SGMA requires a flat gradient – SGMA does not require a flat gradient and the claim is actually inconsistent with the Final GSP prepared for the 180/400-Foot Aquifer Subbasin, which shows an inland gradient for both the 180-Foot and 400-Foot Aquifers after 2040 (**Figures 1, 2, 3, and 4**);
b) Key conclusions are not stated (e.g., assumed DSA gradients have negligible effects on OWP; additional field work is not needed), especially those related to the Weiss November 2019 report that were the stated reasons to pursue this additional modeling effort;
c) Conclusions state OWP is sensitive to changes in recharge, but this is only when using unreasonable/unsubstantiated assumptions and model inputs for long-term recharge;
d) Conclusions state OWP is sensitive to changes in configuration/location of the western edge of the FO-SVA, yet OWP estimates for a wide range of such conditions are greater than 88%;
e) Conclusions regarding potential freshwater capture are confusing and misleading; the figures may be perceived to imply more freshwater capture than supported based on the OWP estimates;
f) Evaluating and highlighting only 180-Foot Aquifer flat (actually seaward) gradient results as a potential SVBGSA GSP and SGMA consequence when an extraction/pumping barrier program is more feasible, efficient, and protective as a management measure and much more likely to be implemented;
g) Highlighting the OWP flat gradient estimates of 66.6 to 73.4% in the conclusions section misrepresents and is likely to cause misunderstanding of what these model results mean, particularly in light of the fact that GSP management criteria for groundwater elevations are not based on a flat or seaward gradient in the 180-Foot and 400-Foot Aquifers, which are the only scenarios under which these lower OWP estimates would occur;
h) Weiss' modeling results demonstrate that short-term OWP changes observed in Test Slant Well field data were related to rainfall recharge but not DSA gradients.

Sincerely,

The Hydrogeologic Working Group (Dennis Williams, Tim Durbin, Martin Feeney, Peter Leffler)

Dennis Williams

Tim Durbin

Martin Feeney

Peter Leffler

Attachments:

Appendix A Review of SGMA Requirements and the 180/400-Foot Aquifer Subbasin GSP.

Figure 1 GSP Figure 8-2: Groundwater Elevation Minimum Threshold Contour Map for the 180-Foot Aquifer.

Figure 2 GSP Figure 8-3: Groundwater Elevation Minimum Threshold Contour Map for the 400-Foot Aquifer.

Figure 3 GSP Figure 8-4: Groundwater Elevation Measurable Objective Contour Map for the 180-Foot Aquifer.

Figure 4 GSP Figure 8-5: Groundwater Elevation Measurable Objective Contour Map for the 400-Foot Aquifer.

Figure 5 Equivalent Freshwater Head Hydrographs

REFERENCES

Hydrogeologic Working Group, *Salinas HWG Hydrogeologic Investigation Technical Report,* prepared for Monterey Peninsula Water Supply Project, 2017.

Montgomery & Associates, *Salinas Valley Groundwater Basin 180/400-Foot Aquifer Subbasin Groundwater Sustainability Plan*, prepared for Salinas Valley Groundwater Sustainability Agency, 2020.

Weiss Associates, *Independent Evaluation, Modification, and Use of the North Marina Groundwater Model to Estimate Potential Aquifer Impacts associated with the Proposed Monterey Peninsula Water Supply Project*, prepared for California Marin Sanctuary Foundation and California Coastal Commission, 2020.

Yates, Eugene B., *Simulated Effects of Ground-Water Management Alternatives for the Salinas Valley, California*, United States Geological Survey (USGS) Water-Resources Investigations Report 87-4066, 1988.

APPENDIX A: REVIEW OF SGMA REQUIREMENTS AND THE 180/400-FOOT AQUIFER SUBBASIN GSP

The Sustainable Groundwater Management Act (SGMA) requires that overdrafted groundwater subbasins submit a Groundwater Sustainability Plan (GSP) by January 2020 that demonstrates how they will become sustainable by 2040. Sustainability is to be measured and determined by meeting sustainable management criteria (SMC) for the six sustainability indicators: groundwater levels, groundwater storage, seawater intrusion, subsidence, groundwater quality, and stream depletion. Each sustainability indicator that is applicable to a given subbasin is required to have assigned minimum thresholds and measurable objectives that will apply after 2040. Minimum thresholds represent the minimum values that must always be maintained for a given SMC (e.g., lowest allowable groundwater elevations), and measurable objectives represent the average values for a given SMC that are expected to be maintained after 2040 (e.g., average groundwater elevations).

The occurrence of seawater intrusion in the Salinas Valley has been the main concern over the past 60 to 80 years, and continues to have a detrimental impact on the Salinas Valley under current conditions. The 180/400-Foot Aquifer Subbasin has experienced the greatest impacts from seawater intrusion in Salinas Valley, particularly in that portion of the subbasin located between the ocean shoreline and City of Salinas. SGMA requires that the extent and magnitude of seawater intrusion not be exacerbated compared to current conditions, but does not require that existing seawater intrusion be mitigated/remediated.

SGMA makes no mention of a flat (or seaward) gradient being required in areas currently experiencing seawater intrusion, but rather only requires that there be no further inland movement of the seawater intrusion front. Review of the Final GSP for the 180/400-Foot Aquifer Subbasin also makes no mention of a flat gradient, nor does it require that a flat gradient be achieved before or after 2040. The GSP does not require that pumping reductions have to occur, but rather developed a list of priority projects and management actions intended to serve as a list of options (or a “toolbox”) that basin stakeholders may select from to achieve sustainability. There is no expectation stated in the GSP that the group of projects and management actions ultimately selected by basin stakeholders will lead to a flat gradient. For example, historical and current advancement of the seawater intrusion front may be stopped with implementation of an extraction barrier near the ocean shoreline, as outlined in Priority Project 6 in the GSP.

In summary, the occurrence or implementation of conditions leading to a flat to seaward hydraulic gradient in the 180-Foot and 400-Foot Aquifers is neither required under SGMA nor specified in the 180-400-Foot Aquifer Subbasin GSP. The Weiss assumption of the need to conduct model simulations to calculate OWP under a flat to seaward gradient in the 180-Foot Aquifer is not supported by the 180/400-Foot Aquifer Subbasin GSP.

Figures

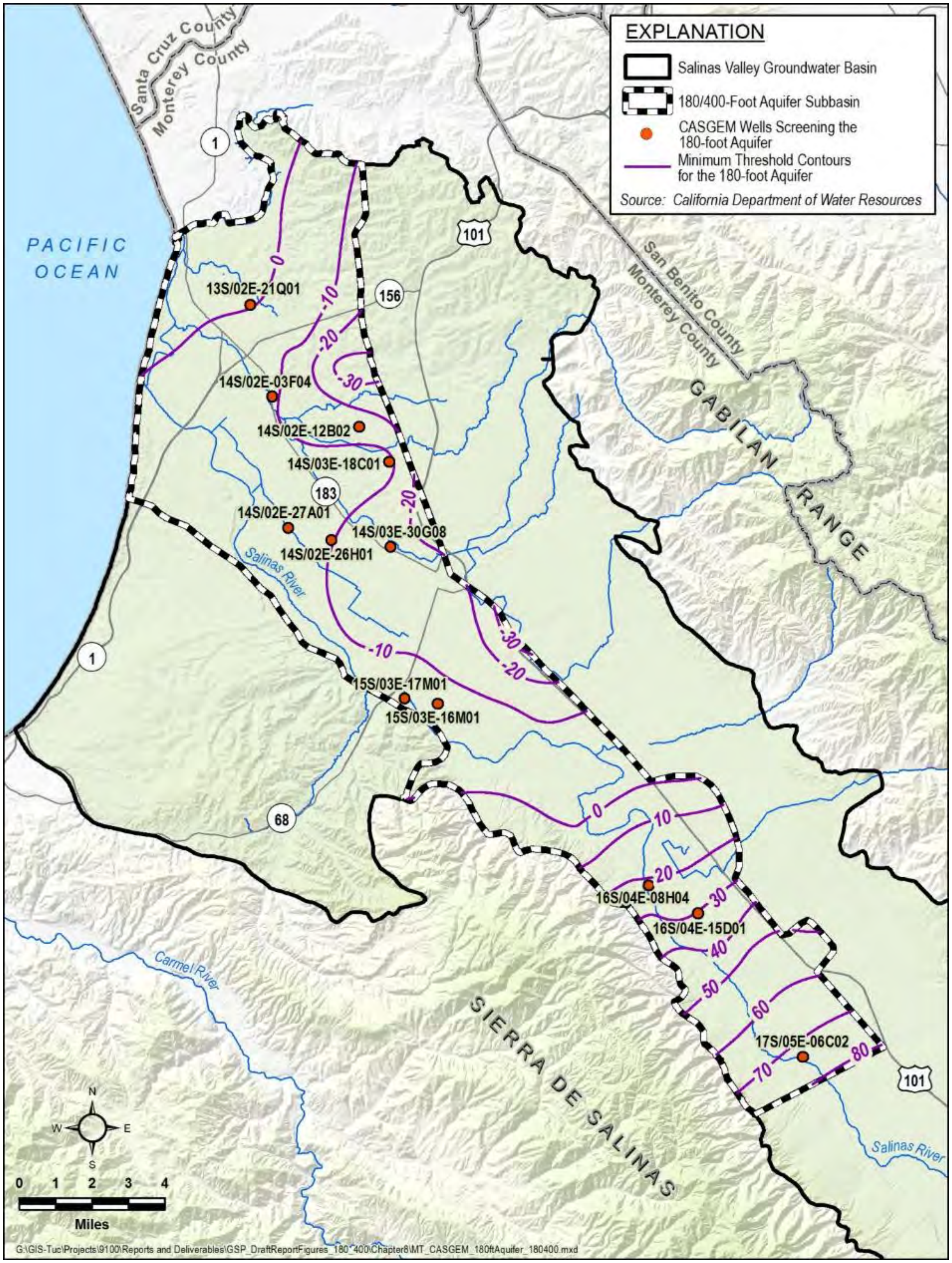

Figure 1 (Figure 8-2 in GSP). Groundwater Elevation Minimum Threshold Contour Map for the 180-Foot Aquifer

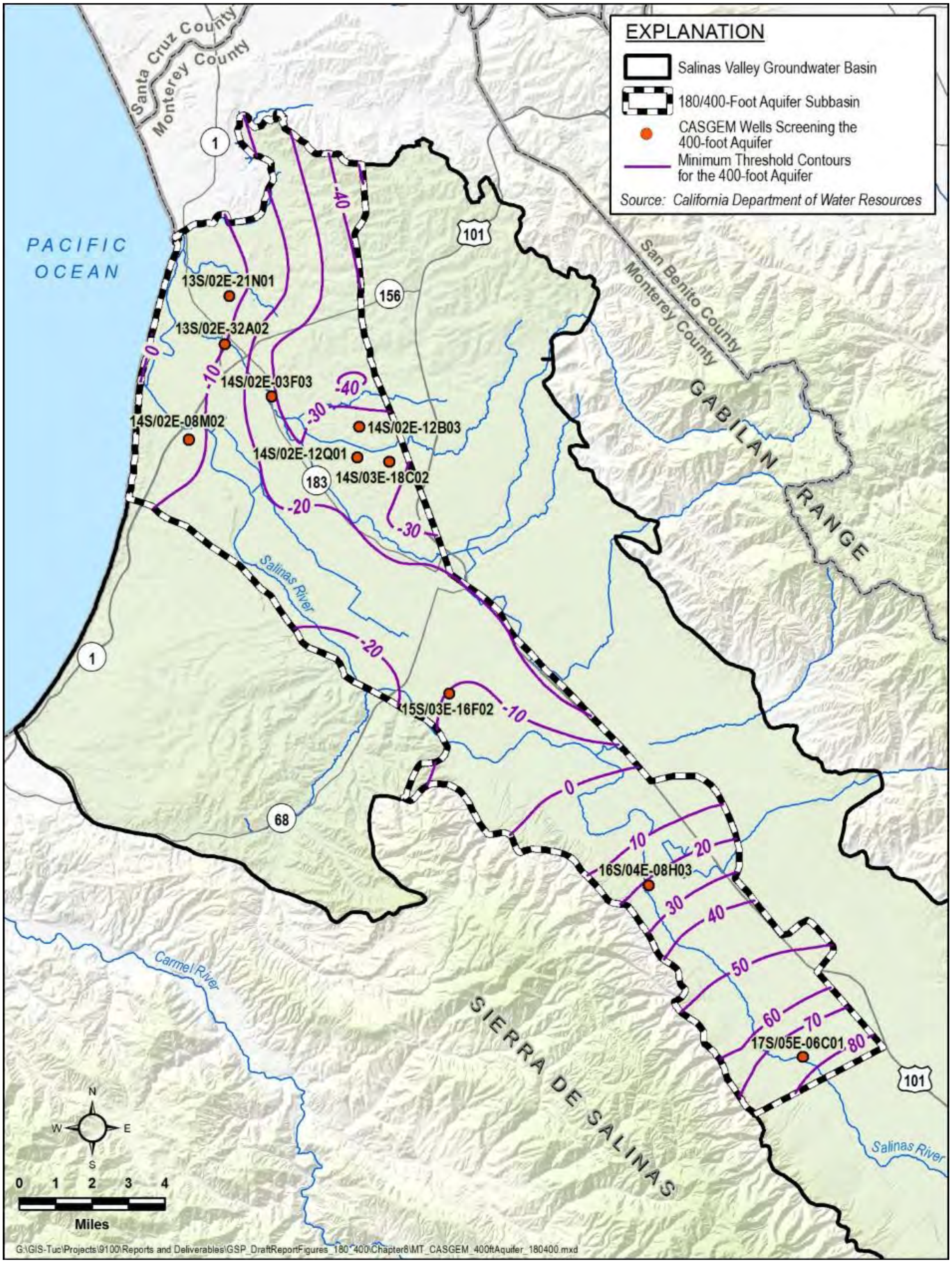

Figure 2 (Figure 8-3 in GSP). Groundwater Elevation Minimum Threshold Contour Map for the 400 Foot Aquifer

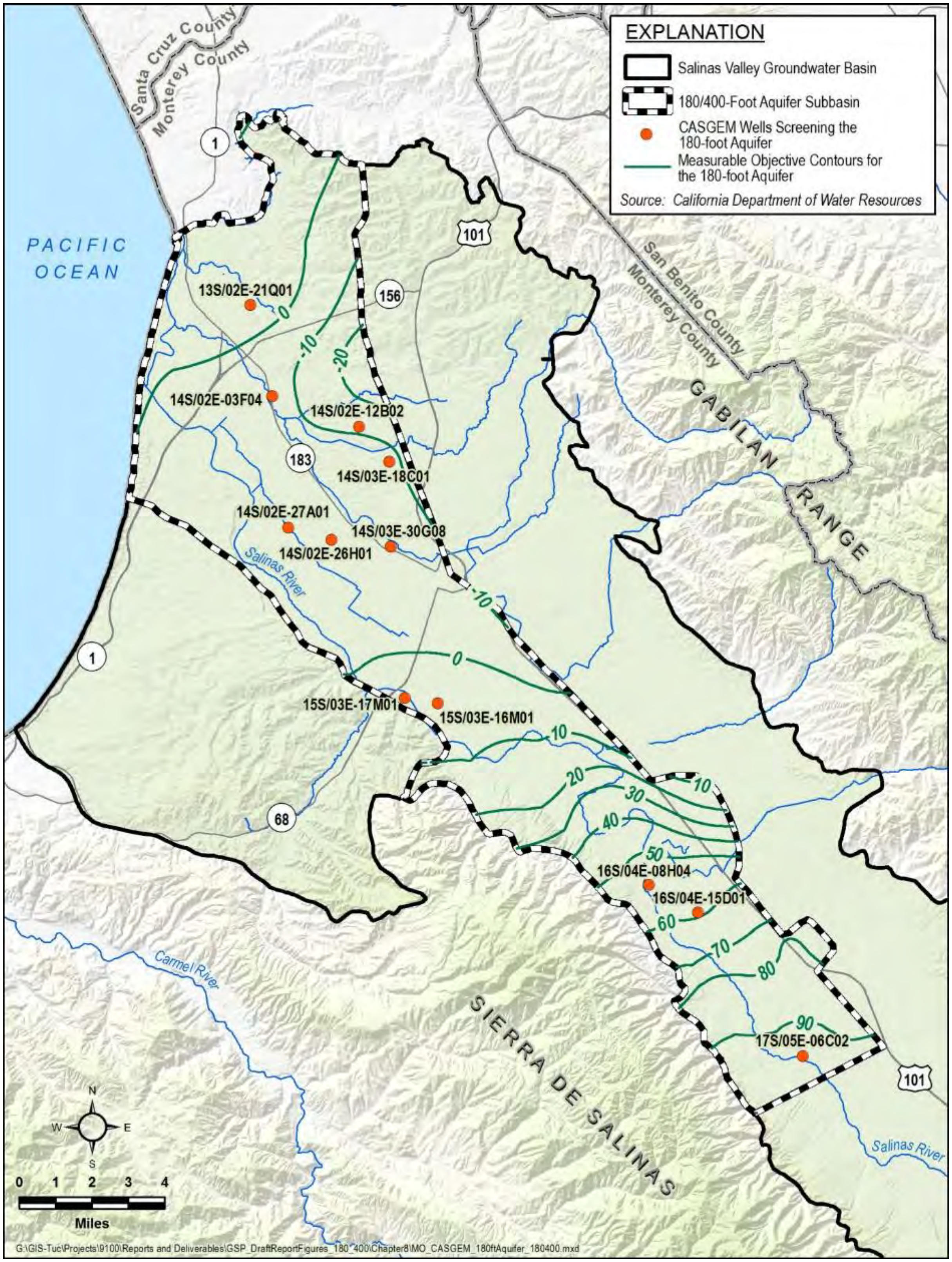

Figure 3 (Figure 8-4 in GSP). Groundwater Elevation Measurable Objective Contour Map for the 180-Foot Aquifer

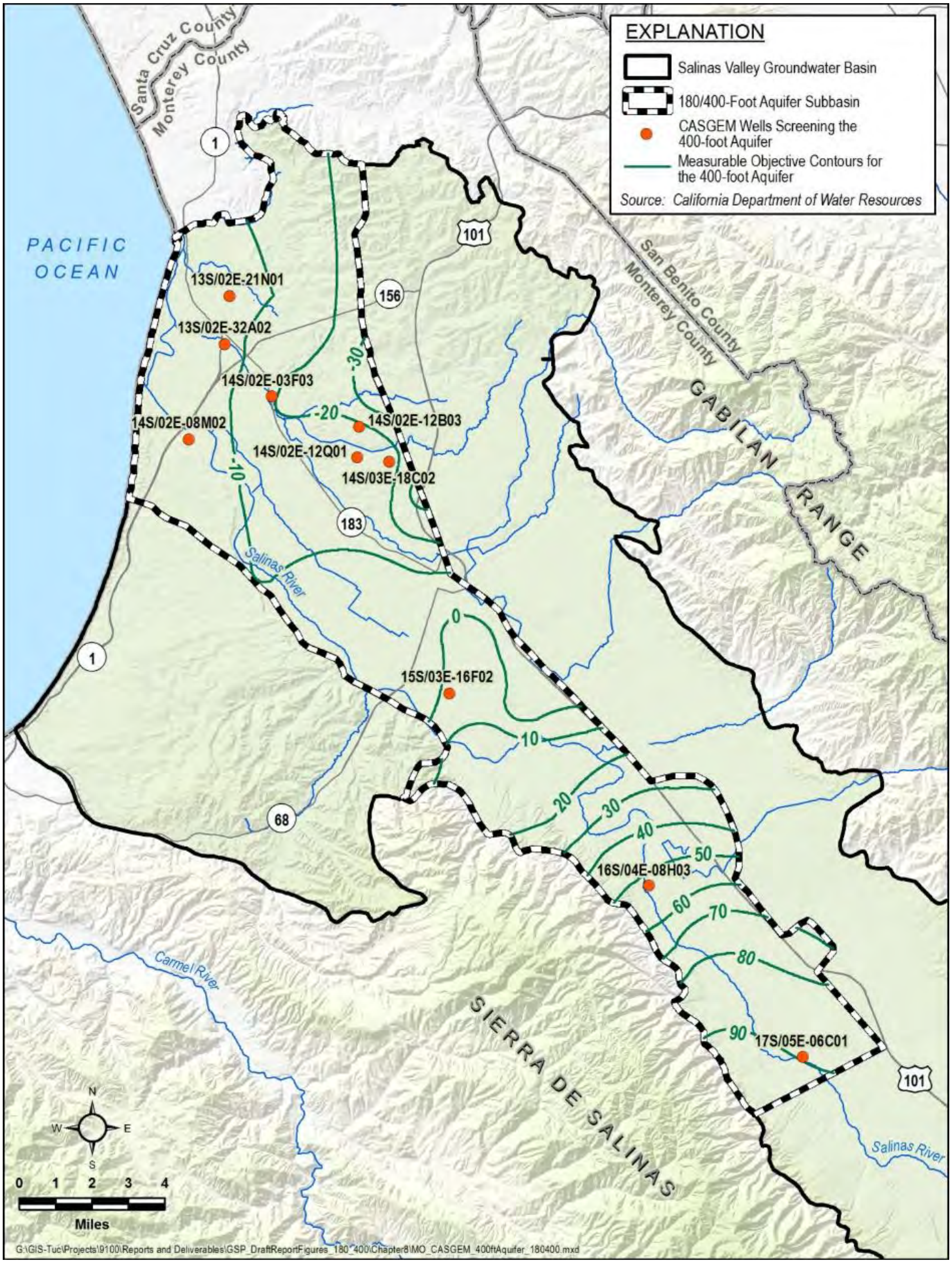

Figure 4 (Figure 8-5 in GSP). Groundwater Elevation Measurable Objective Contour Map for the 400-Foot Aquifer

Figure 5. Freshwater Equivalent Head Hydrographs: MW-1S, MW-3S, and MW-4S