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May 3, 2013

RECEIVED
5-3-13
SWRCB Hearing Unit

Mr. Paul Murphey
Division of Water Rights
State Water Resources Control Board
P.O. Box 2000
Sacramento, CA 95812-2000

RE: **Comments on MPWSP Draft Report**

Dear Mr. Murphey:

On behalf of the California American Water Company (Cal-Am), we would like to thank you and your colleagues for preparing the detailed and thoughtful *Draft Review of California American Water Company's Monterey Peninsula Water Supply Project*, dated April 3, 2013 ("Draft Review"). Overall, the Draft Review is consistent with Cal-Am's water rights position for the Monterey Peninsula Water Supply Project ("Project" or "MPWSP"), and comports with Cal-Am's understanding of the initial technical information concerning the potential effects of the Project. Cal-Am agrees that additional technical information, to be developed through the proposed test well and related study and monitoring program, is necessary to confirm and verify existing analysis and increase the certainty that the slant wells are not likely to adversely impact the Salinas Valley Groundwater Basin (SVGB) or cause injury to SVGB pumpers. This letter provides Cal-Am's comments on the Draft Review for your consideration. Our comments are intended to amplify or clarify points raised in the Draft Review.

<u>General Comments:</u>

- The primary recommendations in the Draft Review are for a robust study and monitoring program to determine aquifer conditions in the vicinity of the MPWSP, aquifer testing and hydrogeologic analysis, groundwater modeling, and monitoring. <u>See</u> Draft Review, pp. iii and 42-43. Cal-Am is proposing to undertake all of these analyses and investigations, and is currently in the process of obtaining permits and authorizations to complete this necessary work. Cal-Am also has an agreement with the Monterey County Water Resources Agency to implement and carry out a long-term monitoring plan associated with the MPWSP.

- The Draft Review notes that the "Dune Sand Aquifer" is a "near-surface water-bearing zone" that is "not regionally extensive" and is "poor quality" (due primarily to its direct influence from Monterey Bay). See Draft Review, p. 8. For these reasons, and in response to requests from certain stakeholders, Cal-Am is evaluating the feasibility and cost of completing the slant wells in the Dune Sand Aquifer, either partially or completely. This evaluation will be performed as part of Cal-Am's testing and monitoring program.

- The Draft Review (page 21) discusses the important distinction between the cone of depression (or zone of influence) and the capture zone that contributes water to a pumping well: "…not all the water in the cone of depression flows to the pumping well…." In particular, where significant boundary conditions exist – such as horizontal flow from a subsea aquifer outcropping and/or vertical leakage from the seabed – the boundary condition may provide an overriding factor relative to direction of groundwater flow in determining the dimensions of a capture zone and source(s) of water flowing to a well. (See also, Draft Review pp. 17-18). The recharge boundary conditions would also tend to affect (in this case, significantly increase) the proportion of seawater flowing to the project wells under existing landward gradients.

- The Draft Review (page 24) makes the point that the MPWSP project would appear to have the consequence of reducing the flow of seawater intrusion into the Salinas Valley. Related to this point, the term "capture zone" may be more accurate than "zone of influence" in describing the anticipated hydrogeologic effects of the MPWSP in the following sentence: "The MPWSP drawdown would change the groundwater gradient within the zone of influence causing a radial flow of groundwater toward the extraction wells."

- The Draft Review (page 26) does a good job of explaining one of the key and fundamental hydrogeologic concepts pertaining to the proposed MPWSP: "Because the ocean provides a constant source of nearby recharge to the extraction wells, the zone of influence for the extraction wells cannot expand much farther than the distance between the extraction wells and the ocean, or in the case of confined aquifer conditions, the distance between the extraction wells and the undersea outcrop of the confined aquifer."

- The Draft Review (page 28) states: "The reduction in the availability of fresh water would not be felt immediately; thus, replacement water could be provided after the MPWSP has been in operation and modeling information becomes available to evaluate the actual quantity of fresh water that needs to be returned to the system." The above concept is further discussed and developed on page 37 of the Draft Review. This is an important observation and the concept informs Cal-Am's commitment to return to the SVGB, through the Castroville Seawater Intrusion Project, any fresh water that is extracted by the MPWSP slant wells. This concept will also inform the development of Cal-Am's testing and monitoring plan.

- The Draft Review (page 38) states with respect to existing groundwater wells that have been identified in the general vicinity of the Project: "…it is unlikely the MPWSP would injure users of these wells as the wells are within a zone where water quality is significantly impacted from seawater intrusion." This is another key observation in the Draft Review and will help design the development of the study and monitoring plan and any mitigation measures that may be required for the MPWSP.

- The Draft Review mentions potential groundwater level "impacts" that may result from the MPWSP: "…pumped wells would have an impact to groundwater users within a 2-mile radius of the wells." (Draft Review, p. 20; see also, Draft Review, p. 24: "Once the zone of influence is estimated for each location and each pumping scenario then any wells within the zone of influence would be affected by project pumping and possibly cause injury"). The groundwater level effect described in this section of the Draft Report refers to the modeled drawdown estimates from the MPWSP; approximately 2.0 feet within one mile of the slant wells, less than 0.5 feet 1.5 miles from the well, and negligible influence at 2.0 miles and beyond. Elsewhere, the Draft Review acknowledges that the seawater intrusion front has extended more than five miles inland in the 180 foot aquifer (e.g., Draft Review p. 13), and that only 14 groundwater wells exist within a two mile radius of the proposed slant well location. The Draft Review further states that all of these wells are located within the seawater intruded zone, and on that basis concludes that "it is unlikely that the MPWSP would injure users of these wells…." (Draft Review, p. 38) Thus, Cal-Am interprets the Draft Review to conclude that groundwater level drawdown within the zone of influence attributable to the MPWSP wells may "affect" wells within that zone of influence, but such affects will not likely rise to the level of "legal injury" requiring remedial action or a physical solution unless there is a substantial impact to the use of those wells for beneficial purposes. See *Lodi v. East Bay Municipal Utilities District* (1936) 7 Cal.2d 316, 341. This is particularly true as it relates to wells that may be completed in the long-existing seawater intruded area of the SVGB.

- The Draft Review makes use of several terms to describe the water quality characteristics of the feed water that may be developed by the MPWSP, but does not provide precise definitions of those terms. In particular, the Draft Review uses the terms "seawater," "brackish" water, and "fresh" water. Based on the context in which these terms are used in the Draft Review, Cal-Am has discerned the following meanings:

  - "Seawater" appears to mean water that originates from the Pacific Ocean and Monterey Bay, and having the same general constituency of ocean waters found in Monterey Bay. See, e.g., Draft Review p. 28.
  - "Fresh" water appears to mean groundwater inland of the seawater intrusion front, which the Monterey County Water Resources Agency defines as the upper limit of the Secondary Drinking Water Standard, or 500 milligrams per liter (mg/L) concentration for chloride.[1] See, e.g., Draft Review, pp. 13-14 for definitional guidance, and e.g., pp. 28, 30, and 36-37 for usage.

[1] The Draft Review further cites to the Central Coast Regional Water Quality Control Board's Basin Plan, which states that water for agricultural use shall not contain concentrations of chemical constituents in amounts adversely

- "Brackish" water appears to mean (and include) all groundwater in the SVGB having a chloride level higher than "fresh" water (i.e., >500 mg/L concentration for chloride), and lower than the chloride and salinity levels in "seawater."

Based on these inferred definitions, Cal-Am questions the accuracy of the first part of the following statement on page 26 of the Draft Review (Cal-Am agrees with the second part of the statement): "Although this brackish water is of substantially better quality than seawater, it is likely degraded to the point that it is not suitable for any beneficial use other than feed water for desalination purposes." It is likely that brackish water in close enough proximity to be drawn into the proposed MPWSP slant wells would have salinity and chloride levels very similar to those levels found in "seawater." See also, Geoscience, September, 2008, attached. Conversely, brackish waters closer to the "fresh" water line in the SVGB are likely to have constituencies more similar to fresh waters.

- Page 38 of the Draft Review states: "If the MPWSP wells are located where unconfined aquifer conditions exist, project pumping likely would extract brackish groundwater. The majority of the source water would be from within the seawater-intruded portion of the Basin as the seawater intrusion front extends approximately 5 miles landward from the proposed well locations." Cal-Am interprets this statement to mean that, if the MPWSP source wells are located in an "unconfined" area of 180-foot aquifer of the SVGB, then the inland source of water, if any (because the vast majority of water would be sourced from the ocean), is likely to be "brackish" groundwater as opposed to "fresh" groundwater. Elsewhere the Draft Review acknowledges that in an "unconfined" aquifer – and Cal-Am submits the same would be true in a "semi-confined" aquifer – the vast majority of the source water to the proposed MPWSP will come from Monterey Bay/seawater. See Draft Review, p. 26. Under these conditions, "[i]t is unlikely that pumping from an unconfined aquifer would extract fresh groundwater since the seawater intrusion front is approximately 5 miles landward from the proposed pumps." See Draft Review, p. 26.

- Conversely, the Draft Review states that the inland groundwater level drawdown caused by the MPWSP is likely to be greater in a "confined" aquifer. See Draft Review, pp. 26-27. Cal-Am agrees with this basic hydrogeologic principle, but points out that even in a confined aquifer, "the zone of influence for the [slant] wells cannot expand much farther [inland] than the distance between…the extraction wells and the undersea outcrop of the confined aquifer." The distance between the undersea outcrop and the proposed MPWSP wells is 1.5 to 2 miles. See Draft Review, p. 26.

- The Draft Review cites a July 2008 Geoscience Report for the proposition that 87% of the water developed by the slant wells will come "from the ocean side wells," and 13% from the landward side. There is some uncertainty about the precise ratio of seawater that will be

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affecting the agricultural beneficial use. This standard is interpreted to exclude irrigation waters with chloride levels above 355 mg/L. (See Draft Review, pp. 13-14).

extracted by the MPWSP, as compared to brackish water. For example, a subsequent Geoscience report, dated September, 2008, concludes that approximately 96-97% of the water developed by the slant wells is seawater, and only 3-4% brackish water (see attached report, p. 23). The ratio of seawater vs. brackish water (vs. fresh water) that may be extracted by the proposed MPWSP will be better understood through the proposed aquifer testing and hydrogeologic analyses, groundwater modeling, and monitoring program that is described herein.

- Cal-Am believes that the MPWSP, as proposed, will not cause or result in injury to users of groundwater from the SVGB. As noted above, Cal-Am is developing and will implement an extensive study, testing, modeling and monitoring program for the proposed MPWSP wells, as recommended in the Draft Review. This information, together with the information developed by the California Public Utilities Commission in its comprehensive Environmental Impact Report for the MPWSP, will address the anticipated effects of the MPWSP on pumpers in the SVGB, and will provide substantial evidence to support the CPUC's approval of the Project. Cal-Am fully expects that the results of these analyses will confirm no significant unmitigated impact to the SVGB and SVGB pumpers; to the extent impacts may result to legal users of the SVGB from the MPWSP, such impacts will be addressed consistent with the physical solution principles discussed in the Draft Review. Any party that might challenge the MPWSP on the basis of injury to water rights in the SVGB would then have the burden of proving how such rights will be injured. See *City of Lodi v. East Bay Mun. Util. Dist.* (1936) 7 Cal.2d 316, 339; *Tulare Irr. Dist. v. Lindsay-Strathmore Irr. Dist.* (1935) 3 Cal.2d 489, 535.

- Several parties have suggested that the MPWSP is inconsistent with Section 21 of the Monterey County Water Resources Agency Act. These comments misinterpret the Agency Act. The MPWSP has been proposed consistent with the Agency Act. The "anti-export" language in Section 21 of the Agency Act is qualified by the statement "for the purpose of preserving [the] balance [in the SVGB resulting from the Agency's projects to balance extraction and recharge]." The MPWSP would, in a worst case scenario, incidentally extract relatively small quantities of contaminated brackish water from the SVGB without negatively affecting the balance of recharge and extraction of basin groundwater (and possibly it will improve that balance). To the extent the Project may in the future affect fresh groundwater resources, Cal-Am has proposed to return such water to the SVGB through the Castroville Seawater Intrusion Project, as noted in the Draft Review. Moreover, to the extent the statute may apply to the Project, the Agency Act vests sole discretion in the Monterey County Water Resources Agency to pursue appropriate remedies. Contrary to the assertions of several parties, the statute does not operate as an affirmative bar to the export of SVGB groundwater that may be enforced by third parties. Rather, the Agency would need to exercise its judgment and discretion to bring an action for injunctive relief, and only if the conditions for such injunction are present (i.e., a proposed export of groundwater upsetting the balance of recharge and extraction resulting from the Agency's projects).

Conclusion

On behalf of the California American Water Company, we thank the State Water Board for its thorough and thoughtful review of the technical and legal considerations concerning the proposed source water plan for the Monterey Peninsula Water Supply Project. As noted herein, Cal-Am fundamentally agrees with the overall conclusions reached in this Draft Review, and hopes that the above information assists the State Water Board in its efforts to finalize the Draft Review report. We would be pleased to provide the State Water Board with additional information, and certainly will keep the Board apprised of the development of the MPWSP.

Sincerely,

Robert E. Donlan

cc: Felicia Marcus, Chair, SWRCB
Fran Spivey-Weber, Vice Chair, SWRCB
Tam Dudoc, SWRCB
Steven Moore, SWRCB
Dorene D'Adamo, SWRCB
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Paul Clanon, Executive Director, CPUC
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Anthony Cerasuolo, Vice-President, Legal, California American Water
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Exhibit SV-6

North Marina Groundwater Model

Evaluation of Potential Projects

Prepared for: California American Water

CALIFORNIA
AMERICAN WATER

September 26, 2008

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NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

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FIGURES

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

1.0 INTRODUCTION

California American Water (CAW) faces a regulatory-driven need to replace most of its existing water supply, in order to meet long-term water demands of its Monterey Peninsula customers. The Monterey County Water Resources Agency (MCWRA) has a statutory obligation to reduce seawater intrusion in the lower Salinas Valley (see Figure 1). Thus, in order to respond to these water resource challenges, three potential projects have been proposed, the second and third of which are being jointly evaluated by CAW, MCWRA, Marina Coast Water District and Monterey Regional Water Pollution Control Agency, as alternatives to be included in CAW's Coastal Water Project (CWP) environmental impact report (EIR). The first CWP alternative is CAW's North Marina slant-well seawater desalination project. The second alternative is the Monterey Regional Water Supply Project Scenario 3a. The third alternative is the Monterey Regional Water Supply Project Scenario 4b. As part of assessing the feasibility and potential impacts of these three projects on groundwater levels and groundwater quality (i.e., seawater intrusion), groundwater modeling has been conducted. GEOSCIENCE was contracted by CAW to develop a groundwater flow and solute transport model to evaluate the various projects. The results of the modeling work will provide technical input for the CWP environmental impact report being prepared by ESA for the California Public Utilities Commission (CPUC), which is scheduled to be completed by December 2008.

In summary, the three CWP alternative projects evaluated in this modeling analysis are:

1. CAW's Coastal Water Project (CWP) is a plan to develop new water supplies to replace approximately three-fourths of its historical diversions from the Carmel River and Seaside Groundwater Basin. A central feature of the CWP is a proposed desalination

plant co-located at the Moss Landing electric power generation station that would use reverse osmosis (RO) to convert seawater into potable water. Because the California Environmental Quality Act (CEQA) requires that project alternatives be studied for inclusion in EIRs, CAW has also proposed for CPUC's consideration a seawater desalination facility with the feedwater intake system being six slant wells constructed at the Marina Coast Water District's former desalination well site on the north side of the Marina State Beach (see Figure 2).

2. The Monterey Regional Water Supply Project Scenario 3a is proposed to meet CAW's regulatory replacement and long-term regional water needs, improve seawater-intruded Salinas Basin groundwater, and expand agricultural deliveries. One component of the project would be a well field extraction system that pumps both saline and brackish water from the 180-Foot aquifer. The saline water wells will be located in a line approximately 1,000 ft away from and parallel to the coast, with the brackish water wells located approximately 2,600 ft inland of the saline water wells (see Figure 2).

3. The Monterey Regional Water Supply Project Scenario 4b is also proposed to meet CAW's regulatory replacement and long-term regional water needs, improve seawater-intruded Salinas Basin groundwater, and expand agricultural deliveries. The Monterey Regional Project Scenario 4b is a coastal well field extraction system (see Figure 2) as a source of both saline and brackish water from the 180-Foot Aquifer of the Salinas Valley Groundwater Basin for a regional desalination facility.

2.0 PURPOSE AND SCOPE

The purpose of this investigation was to evaluate impacts of potential water supply projects on groundwater levels and groundwater quality (i.e., seawater intrusion) using a calibrated groundwater flow and solute transport model. The effort included integrating the aquifer parameters, recharge and discharge terms, boundary conditions and predictive scenarios from the regional Salinas Valley Integrated Ground Water and Surface Model (SVIGSM) with the focused model. This method ensured that both regional impacts (using the SVIGSM) as well as detailed impacts (using the North Marina Model) could be evaluated.

To accomplish this, GEOSCIENCE worked closely with Water Resources & Information Management Engineering, Inc. (WRIME), RBF and RMC to ensure that the North Marina model mirrored the SVIGSM and provided the same overall results. However, the focused model included improved simulation of groundwater level changes (due to the finer model cell size), and capability for solute transport modeling (i.e., modeling of seawater intrusion). Specifically, the work included:

- Development of a focused, 100 ft square cell size MODFLOW groundwater flow and MT3D solute transport model based on inputs from the SVIGSM model;
- Evaluation of impacts from pumping six low angled subsea slant wells as a desalination feedwater intake supply as part of CAW's Coastal Water Project (CWP); and
- Evaluation of impacts from the Monterey Regional Water Supply Project as source water for a desalination plant at Armstrong Ranch.

The purpose of this report is to document the construction of the focused groundwater flow model (North Marina model) which included input and compatibility with the SVIGSM, and to present results of various predictive scenarios.

3.0 GEOHYDROLOGY

The Salinas Valley is filled with Tertiary and Quaternary marine and terrestrial sediments that include up to 2,000 ft of saturated alluvium (DWR, 2003). Groundwater recharge of the lower Salinas Valley is primarily from underflow originating in the upper valley. This is due to the existence of the Salinas Valley Aquitard which limits areal recharge of aquifers beneath. Seawater intrusion is an additional and more recent source of recharge to the groundwater basin (DWR, 2003).

Historically, groundwater flow was towards the ocean and discharged in the walls of the Monterey Submarine Canyon (see Figure 2). With increased pumping in the groundwater basin since the 1970’s, groundwater flow is dominantly northeastwards (DWR, 2003). Overpumping of the shallow aquifers, largely for agricultural use, has caused significant seawater intrusion.

3.1 Groundwater Basin Boundaries

The proposed projects are located at the northwestern boundary of the Salinas Valley Groundwater Basin (see Figure 1). The Salinas Valley Groundwater Basin extends approximately 100 miles from headwaters in the southeast to Monterey Bay in the northwest.

3.2 Aquifer Systems

Water-bearing materials in the vicinity of North Marina from oldest to youngest consist of:

- Pliocene marine Purisima Formation,
- Plio-Pleistocene Paso Robles Formation,
- Pleistocene Aromas Red Sands, and
- Holocene Valley Fill materials (Green, 1970).

In the Salinas Valley Groundwater Basin, the Valley Fill, Aromas Sands, and Paso Robles Formation comprise an upper aquifer system from 0 to 1,000 ft below ground level (bgs). The Pliocene Purisima Formation contains a deep aquifer system from approximately 1,000 to 2,000 ft bgs (Hanson et. al., 2002).

180-Foot, 400-Foot and Deeper Aquifers

Aquifers in the Salinas Valley Groundwater Basin have been named for the average depth at which they occur. The "180-Foot Aquifer" lies at an approximate depth of 50 to 250 ft, and has a thickness of 50 to 150 ft (Green, 1970). The 180-Foot Aquifer may correlate in part with older portions of Quaternary terrace deposits or the upper Aromas Red Sands, and underlies blue clay confining layer known as the Salinas Aquitard (DWR, 2003). The Salinas Aquitard varies in thickness from 25 ft to more than 100 ft thick near Nashua Road, 5 miles west of Salinas (DWR, 1973, Montgomery Watson, 1994). Zones of discontinuous aquifers and aquitards approximately 10 to 70 ft thick underlie the 180-Foot Aquifer (DWR, 1973). The 400-Foot Aquifer lies at an approximate depth of 270 to 470 ft bgs, has a thickness of 25 to 200 ft, and may correlate with the Aromas Red Sands and the upper part of the Paso Robles Formation (Green, 1970). The 400-Foot Aquifer is present as three beds near Castroville, two of which are 25 ft thick and one which is 100 ft thick (DWR, 1973). A deeper aquifer, also referred to as the "900-Foot Aquifer," is separated from the overlying 400-Foot Aquifer by a blue marine clay aquitard (DWR, 2003).

Existing published reports contain geohydrologic cross sections of varying detail and applicability to the proposed site – such as those available in Green (1970), DWR (1973), DWR (1977), Johnson (1983), Harding ESE (2001), Hanson (2003), Feeney and Rosenberg (2002), and Kennedy/Jenks Consultants (2004).

3.3 Water Quality and Seawater Intrusion

The 180-Foot aquifer, when not impacted by seawater, is a calcium sulfate to sodium bicarbonate sulfate groundwater (DWR, 2003). Where the aquifer has been intruded by seawater it typically changes to a sodium chloride to calcium chloride type water. Total dissolved solids (TDS) values range from 223 to 1,103 mg/L, with an average of 478 mg/L (DWR, 2003). TDS concentrations in the 400-Foot aquifer are generally lower than in the 180-Foot aquifer. The aquifers below the 180-Foot, 400-Foot and deeper aquifers can have high salinity that may be related to dissolution of salts from the saline marine clays (Hanson, et al., 2002).

In the North Marina area, seawater has intruded approximately 3 ¾ to 7 miles landward within the 180-Foot Aquifer, and ¼ to 3 ¼ miles landward within the 400-Foot Aquifer (see Figure 3)[1]. Seawater intrusion in the 180-Foot and 400-Foot Aquifers was estimated to be 8,900 acre-ft/yr in 1995 (MCWRA, 2001). It has been reported that between 1970 and 1992 the seawater intrusion was 11,300 acre-ft/yr in the 180-Foot Aquifer, 4,600 acre-ft/yr in the 400-Foot Aquifer, and 800 acre-ft/yr in the “Deep” Aquifer (Montgomery Watson, 1994).

The main sources of seawater intrusion are subsea outcrops of the 180-Foot and 400-Foot Aquifers on the bottom of Monterey Bay, discovered by the U.S. Geological Survey in 1970 (see Figure 2). There are also areas of active erosion along the south wall of the Monterey Submarine Canyon (see Figure 2) where the outcrops are located, representing new entrances for seawater intrusion (DWR, 1973; Green, 1970).

[1] http://www.mcwra.co.monterey.ca.us/SVWP/01swi180.pdf; http://www.mcwra.co.monterey.ca.us/SVWP/01swi400.pdf , Accessed 6-Jun-08.

4.0 POTENTIAL PROJECTS

The three potential projects that are the subject of this report include CAW's Coastal Water Project (CWP) North Marina Alternative (NMA) seawater slant-wells project, and Monterey Regional Water Supply Project (RWSP) Scenario 3a, and Regional Water Supply Project Scenario 4b. The NMA and RWSP both involve extraction of saline water as feedwater for desalination plants. These projects are described in more detail in the following sections.

Summary of Potential Projects

Potential Project	Project Purpose	Agency	Primary Project Facilities	Project Location
CAW Slant Well Desalination Feedwater Supply Project	Develop new water supplies to replace historical diversions from Carmel River	California American Water Company	Desalination plant using RO. Six slant wells to provide a feedwater supply of 22 mgd	Marina Coast Water District Facility (north end of Marina State Beach)
Monterey Regional Water Supply Project Scenario 3a	Meet regional needs, improve salinated groundwater and expand agricultural deliveries	Consortium of Several Agencies	Desalination plant at Armstrong Ranch using ten vertical wells extracting both saline and brackish water from the 180 ft aquifer at a total rate of 23.4 mgd	North and south of the Salinas River adjacent to the coast
Monterey Regional Water Supply Project Scenario 4b	Meet regional needs, improve salinated groundwater and expand agricultural deliveries	Consortium of Several Agencies	Desalination plant at Armstrong Ranch using five vertical wells extracting both saline and brackish water from the 180 ft aquifer at a total rate of 17.8 mgd	North and south of the Salinas River adjacent to the coast

4.1 CAW Slant Well Desalination Feedwater Supply Project

CAW's NMA is a CWP alternative project proposed to develop new water supplies in order to replace most of CAW's historical diversions from the Carmel River and Seaside Basin. A central feature of the NMA is a proposed desalination plant that would use reverse osmosis (RO) to convert seawater into potable water, with the feedwater intake system consisting of six slant wells[2] (RBF, 2008). The slant wells would be constructed on the site of Marina Coast Water District's former desalination intake wells on the north side of Marina State Beach at 11 Reservation Road, Marina, CA (see Figure 2). RBF's design for the CAW slant well project comprises six wells that would radiate out in three clusters of two wells per cluster towards and beneath the ocean (see Figure 4). The layout described above is a later refinement of the slant well layout that was modeled using the North Marina Model (see Section 6.0 for details of the modeled layout). Modeling results and impacts will not be expected to be much different between the two layouts. However, of the two layouts, the modeled layout represents a worst-case scenario due to shorter well lengths and steeper angle of the wells. The steeper angled wells and shorter lengths result in less ocean water extraction due to the greater distance between the ocean floor and screened interval. The combined amount of water that would be pumped by the slant wells for each layout would be the same, i.e., 22 mgd.

4.2 Monterey Regional Water Supply Project 3a

The RWSP Scenario 3a is designed to meet regional water supply needs, improve seawater intruded groundwater, and expand agricultural deliveries. There are a number of components that comprise the project, with regional desalination being one of them. Feedwater for a desalination plant at Armstrong Ranch will be obtained from a vertical well field extraction system that pumps both saline and brackish water from the 180-Foot aquifer. The saline water wells will be located in a line approximately 1,000 ft away from and parallel to the coast, with the brackish water wells located approximately 2,600 ft inland of the saline water wells (see Figure 2).

Initially, twelve wells were considered and modeled as Scenario 2e. These wells had variable pumping schedules that ranged from approximately 1.5 mgd to 3.1 mgd. Ultimately, based on

[2] Each well will be 20 degrees below horizontal, 700 lineal feet and completed with 12-inch diameter casing and perforated interval.

regional modeling by WRIME, a most likely scenario (3a) was developed. Under scenario 3a, the well field will produce saline water from five coastal or seaward wells, and brackish water from five inland wells. The five seaward wells would each pump constantly at 1,549 gpm, and the five inland wells each pump constantly at 1,697 gpm, for a combined total of 23.4 mgd

4.3 Monterey Regional Water Supply Project 4b

The RWSP Scenario 4b is also designed to meet regional water supply needs, improve seawater intruded groundwater, and expand agricultural deliveries. There are a number of components that comprise the project, with regional desalination being one of them. Feedwater for a desalination plant at Armstrong Ranch will be obtained from a vertical well field extraction system that pumps both saline and brackish water from the 180-Foot aquifer. Under Scenario 4b, five desalination (i.e., extraction) wells would each pump constantly at approximately 2,480 gallons per minute (gpm), for a combined total of approximately 17.8 million gallons per day (mgd).

5.0 NORTH MARINA GROUNDWATER FLOW AND SOLUTE TRANSPORT MODEL

5.1 General Description and Purpose of Model

The purpose of the North Marina groundwater flow and solute transport model (North Marina Model) was to evaluate impacts of various water supply projects on groundwater levels and seawater intrusion. Due to the established use of the regional model (SVIGSM) for groundwater management in the Salinas Valley, the focused North Marina Model was constructed by integrating the SVIGSM aquifer parameters, recharge and discharge terms, boundary conditions and predictive scenarios to ensure consistency between the two models. The North Marina model developed to specifically focus on the North Marina area has a much finer cell size to improve resolution in the vicinity of the proposed projects. It also includes a water quality component that the SVIGSM does not have.

5.2 Description of Model Codes

MODFLOW and MT3DMS are the model computer codes used for the North Marina Model. MODFLOW is a block-centered, three-dimensional, finite difference groundwater flow model developed by the USGS for the purpose of modeling groundwater flow. MT3DMS is a modular three-dimensional multispecies transport model for simulation of advection, dispersion, and chemical reactions of contaminants in groundwater systems (Zheng and Wang, 1998). The SEAWAT[3] program was also used to compare the results from the MODFLOW and MT3DMS. In general, MODFLOW and MT3DMS yield a very similar result compared to the SEAWAT with slight differences in water level elevation (approximately one foot).

3 The SEAWAT program was developed by the United States Geologic Survey (Guo and Langevin, 2002) to simulate three-dimensional, variable density, groundwater flow and solute transport in porous media. The source code for SEAWAT was developed by combining MODFLOW and MT3DMS into a single program that solves the coupled flow and solute transport equations.

5.3 Use of the Salinas Valley Integrated Ground Water and Surface Water Model

The SVIGSM is a regional model encompassing the entire Salinas Valley (approximately 650 square miles). It is a finite element model, with an average element size of approximately 0.4 square miles (Montgomery Watson, 1994). The North Marina Model is a detailed model with cell size of 200 ft by 200 ft covering an area of approximately 149 square miles (see Figure 5). Since the SVIGSM encompasses the entire North Marina Model, calibrated SVIGSM model data including the aquifer parameters, recharge and discharge terms, and boundary conditions in the North Marina model area were used to construct the North Marina Model. This procedure is similar to the telescopic mesh refinement method (Anderson and Woessner, 1992). The SVIGSM with its coarse grid network is the "Regional Model" and is used to model a large problem domain bounded by the physical limits of the aquifer system. The SVIGSM solution is used to define the "Local Model" (i.e., North Marina Model) boundaries, which define the smaller (focused) problem domain.

The pre-processing software "Groundwater Vistas"[4] was used to construct the MODFLOW groundwater flow model based on SVIGSM groundwater model files, and MT3DMS solute transport model. The recharge and discharge terms and water level data used for the boundary conditions cover the period from October 1979 to September 1994 on a monthly basis. This same period was used for the North Marina Model transient model calibration. For the model predictive scenarios, the monthly data from the SVIGSM for the period from October 1948 through September 2004 was used for the North Marina Model predictive scenarios.

[4] Environmental Simulations, Inc., 2005. Groundwater Vistas, Version 5.

Comparison of Focused North Marina Groundwater Model with Regional Groundwater Model

Groundwater Model	Model Purpose	Type of Model	Model Area, sq. mi.	Cell or Element Size	No of Layers	Total Model Layer Thickness (Average, ft)
Focused North Marina Model	Evaluate detailed projects in the vicinity of the North Marina coastal area- groundwater levels and quality	Flow and Solute Transport Finite Difference MODFLOW 2000, MT3DMS, SEAWAT 2000	149	Cell Size = 200 ft x 200 ft	6	1,570
Regional Groundwater Model (SVIGSM)	Evaluate regional projects and impacts on regional groundwater levels in the entire Salinas Valley	Finite Element Groundwater Flow Model – Groundwater and Surface Water	650	Element Size = 0.4 sq. mi.	3	1,570

5.4 Conceptual Model

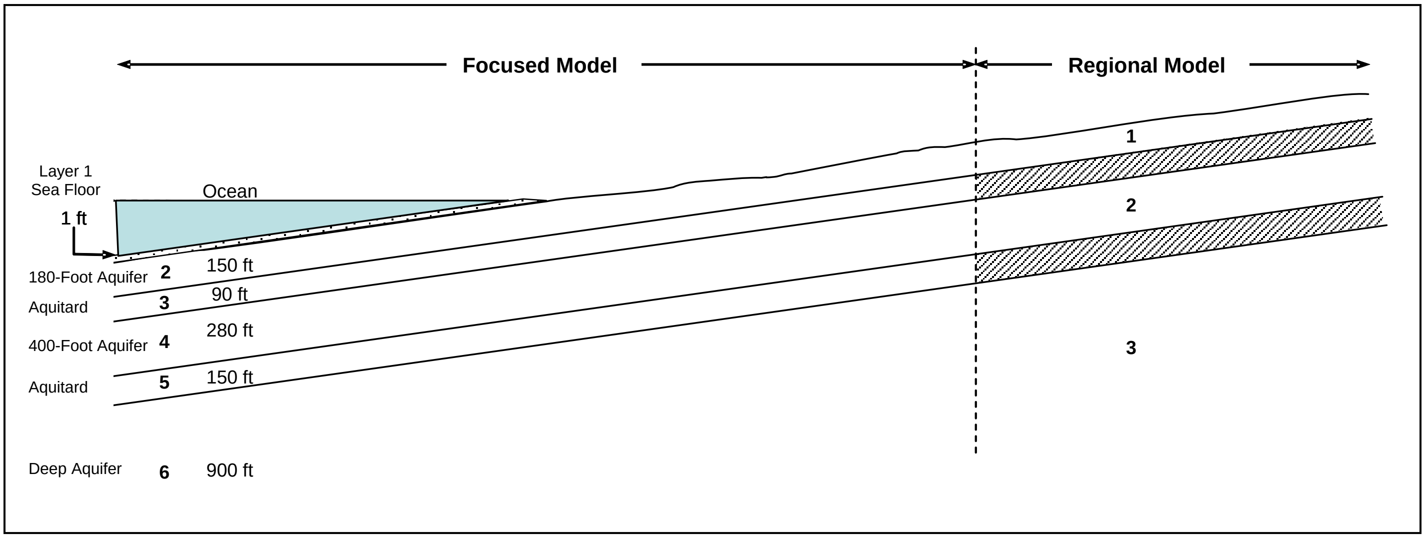
The North Marina Model was developed for the upper approximately 1,000 ft of unconsolidated to semi-consolidated sediments within the North Marina area of the Salinas Valley Groundwater Basin. This conceptual model is the same as that used for the SVIGSM (Montgomery Watson, 1994). The groundwater model consists of six model layers as summarized in the table below.

Summary of North Marina and SVIGSM Model Layers

Model Layer	North Marina Model	SVIGSM
1	Only active beneath the ocean and is assumed to be 1 ft thick[5]	Constant head boundary of Model Layer 1
2	180-Foot Aquifer	Model Layer 1
3	Aquitard	NA
4	400-Foot Aquifer	Model Layer 2
5	Aquitard	NA
6	Deep Aquifer	Model Layer 3

[5] The sole purpose of Model Layer 1 is to allow vertical leakage from the ocean into underlying aquifers.

**Schematic Diagram Showing Focused and Regional Model Layers
Showing Average Layer Thickness**



By definition, a boundary condition is any external influence or effect that either acts as a source or sink, adding to or removing water from the groundwater flow system. The boundary conditions used in the model are no-flow, constant head, river and general head boundary. No-flow cells were assigned to the non-alluvial or bedrock portions and portions of the open water of the Pacific Ocean of the model area. The constant head boundary of 0 ft above mean sea level (amsl) and constant TDS concentration of 35,000 mg/L were specified only in Model Layer 1 between the shoreline and the exposure of 180-Foot aquifer to allow vertical leakage from the ocean into the 180-Foot Aquifer (Model Layer 2). Similarly, the River Package was used to simulate the vertical leakage from the ocean into 400-Foot Aquifer (Model Layer 4). The eastern, northern, and southern edges of the active model area represent subsurface underflow and were simulated using the general head boundary package with a specified head based on the model simulated groundwater elevation from the SVIGSM.

5.6 Aquifer Parameters

The top and bottom elevations for Model Layer 2 through 6 were based on data from the SVIGSM. The top elevations for Model Layer 1 were assumed to be 1 ft above the top elevation of Model Layer 1 to allow vertical leakage from the ocean into the 180-Foot Aquifer (Model Layer 2).

Horizontal hydraulic conductivity for Model Layers 2 (180-Foot Aquifer), 4 (400-Foot Aquifer) and 6 (Deep Aquifer) and vertical hydraulic conductivity for Model Layers 3 and 5 (aquiclude) were obtained from SVIGSM. The vertical hydraulic conductivity for Model Layers 2, 4 and 6 was estimated assuming 1/20 of the horizontal hydraulic conductivity for Model Layers 2, 4 and 6 (i.e., ratio of horizontal hydraulic conductivity/vertical hydraulic conductivity = 20). The horizontal hydraulic conductivity for Model Layers 3 and 5 was estimated assuming 500 of the vertical hydraulic conductivity for Model Layers 3 and 5 (i.e., ratio of horizontal hydraulic conductivity/vertical hydraulic conductivity = 500). Typically, the ratios of horizontal hydraulic conductivity/vertical hydraulic conductivity fall in the range of 2 to 10 for alluvium and up to 100 or more occur where clay layers are present (Todd, 1980). A horizontal hydraulic conductivity of 500 ft/day and a vertical hydraulic conductivity of 25 ft/day was used for Model Layer 1 based on model calibration results.

The specific storativity and effective porosity values for Model Layers 2 through 6 were based on the SVIGSM. A specific yield (i.e., effective porosity) of 0.25 was used for Model Layer 1 based on the model calibration results. During the transport model calibration, in order to match the observed seawater intrusion front, the effective porosity of 0.06 for Model Layer 4 was increased to 0.1.

Longitudinal dispersivity was estimated initially from the relationship between longitudinal dispersivity and scale of observation (Zheng and Bennett, 2002) and adjusted during model calibration. A longitudinal dispersivity of 20 ft results in a good match between model-calculated and the observed seawater intrusion front. The ratio of horizontal transverse dispersivity to longitudinal dispersivity was assumed to be 0.1, while the ratio of vertical transverse dispersivity to longitudinal dispersivity was assumed to be 0.01.

The following table summarizes aquifer parameters used in the North Marina model.

Summary of Aquifer Parameters Used in the North Marina Groundwater Model

Model Layer	Horizontal Hydraulic Conductivity [ft/day]	Vertical Hydraulic Conductivity [ft/day]	Specific Storativity [ft^{-1}]	Specific Yield (Effective Porosity)	Dispersivity		
					Horizontal		Vertical
					Longitu-dinal [ft]	Transverse [ft]	Transverse [ft]
1	500	25	-	0.25	20	2	0.2
2 (180-Foot Aquifer)	25 to 250	1.25 to 12.5	0.000008 to 0.00006	0.08 to 0.16	20	2	0.2
3 (Aquiclude)	0.02 to 6.8	0.00004 to 0.0136	0.0000001 to 0.00005	0.02	20	2	0.2
4 (400-Foot Aquifer)	5 to 100	0.25 to 5	0.000001 to 0.00007	0.1	20	2	0.2
5 (Aquiclude)	1.8	0.0036	0.00000006 to 0.00002	0.02	20	2	0.2
6 (Deep Aquifer)	20 to 25	1 to 1.25	0.00000002 to 0.000005	0.06	20	2	0.2

5.7 Recharge and Discharge

Monthly data for deep percolation from precipitation and applied water (including return flow), stream recharge and groundwater pumping in the North Marina Model area for the model calibration period October 1979 to September 1994 were obtained from the SVIGSM. In addition, model simulated groundwater elevations during the same period of time in the north, south and east North Marina Model boundaries were also obtained from the SVIGSM. This allowed for calculation of subsurface inflow and outflow across the North Marina Model boundaries using a General Head Boundary Package. Vertical leakage from the ocean into Model Layer 2 (180-Foot Aquifer) and Model Layer 4 (400-Foot Aquifer) was simulated using a constant head boundary in Model Layer 1 and a River Package in Model Layer 4, respectively.

5.8 Model Calibration

5.8.1 Calibration Methodology

Model calibration was performed in order to compare model-simulated water levels and TDS concentrations to field-measured values. The method of calibration used by the groundwater model was the industry standard "history matching" technique. In this method, a transient calibration period from October 1979 to September 1994 were used based on the data obtained from the SVIGSM. The transient model calibration was simulated with a monthly stress period[6] for a total of 180 stress periods (i.e., 15 years).

Since the North Marina Model was developed based on the calibrated SVIGSM, the model calibration mainly focused on matching the observed seawater intrusion front in the 180-Foot Aquifer and 400-Foot Aquifer over time. The trial-and-error method was used to calibrate aquifer parameters. These aquifer parameters included horizontal hydraulic conductivity, vertical hydraulic conductivity, effective porosity and dispersivity.

5.8.2 Initial Conditions

Initial conditions for the transient calibration of the North Marina Model include groundwater elevations and TDS concentrations for October 1979. Groundwater elevation in October 1979 generated from the SVIGSM was provided by WRIME and was imported into the model using Groundwater Vistas. The initial TDS concentrations were estimated based on the observed seawater intrusion (500 mg/L chloride contour from Monterey County Water Resources Agency maps) and measured TDS concentration in wells. TDS concentration of seawater was assumed to be 35,000 mg/L. An empirical relationship between chloride and TDS for seawater (GEOSCIENCE, 1993) was used to convert estimated chloride contours to initial TDS contours.

[6] Stress period is the time length used to change model parameters such as groundwater pumping and stream recharge.

5.8.3 Calibration Results

For the model calibration, historical groundwater level data for 14 wells within the North Marina Model area were obtained from WRIME and compared with model-generated groundwater levels. Of the 14 wells, two wells are screened in the 180-Foot Aquifer (Model Layer 2), eight wells are screened in the 400-Foot Aquifer (Model Layer 4), and four wells are screened in the Deep Aquifer (Model Layer 6). The same 14 wells were also used for the SVIGSM calibration. Figures 6 through 8 show hydrographs of model-generated water levels compared to measured levels for the wells screened in the 180-Foot Aquifer, 400-Foot Aquifer, and Deep Aquifer, respectively. In general, the pattern of the model-generated and measured water levels are similar in that the model appears to capture the long- and short-term temporal trends in groundwater levels in most parts of the North Marina Model area.

A histogram of water level residuals (measured water level less model-generated water level) is shown on Figure 9. The histogram shows a bell shape with most of the residual[7] water level being in the range of +/- 10 ft (68% of 2,152 water level measurements), indicating an acceptable model calibration.

In order to evaluate the solute transport model calibration, the model-generated seawater intrusion front for the 180-Foot Aquifer and 400-Foot Aquifer in years 1985 and 1994 were plotted and compared to the observed seawater intrusion front (see Figures 10 and 11). In general, the model-generated seawater intrusion front matches the observed seawater intrusion front. The model-generated migration rate of the seawater intrusion front agrees with the rate estimated from observed data as can be seen by comparing the movement of the seawater intrusion front between 1985 and 1994.

[7] The residual is the difference between measured water levels and model-generated levels.

6.0 MODEL PREDICTIVE SCENARIOS

Four model predictive scenarios were run for a 56-year period from October 1948 through September 2004 with monthly stress periods. This hydrologic period is also the model calibration period for the SVIGSM and has been previously used for predictive scenarios for purposes of basin management.

The three predictive scenarios that were run using the North Marina model included:

- Baseline (developed by WRIME),
- Slant Well Desalination Feedwater Supply,
- Regional Project Scenario 3a (developed by WRIME), and
- Regional Project Scenario 4b (developed by WRIME).

The Baseline and Regional Project scenarios 3a and 4b were developed and run using the SVIGSM by WRIME. The recharge and discharge terms and model simulated water level elevations from each of the SVIGSM predictive scenarios for the period from October 1948 through September 2004 were used for North Marina Model predictive scenarios.

Initial groundwater elevations for the model predictive scenarios were the same as the SVIGSM and were provided by WRIME. The initial TDS concentrations were estimated based on the observed seawater intrusion (500 mg/L chloride contour) and TDS concentrations in wells measured in 2005.

Summary of Groundwater Model Predictive Scenarios Run Using the North Marina Model

Predictive Scenario	Initial and Boundary Conditions	Project Facilities
Baseline Scenario (No Project)	Baseline Boundary Conditions provided by Regional Model	Land and water use reflect estimated 2030 conditions
Slant Well Desalination Feedwater Supply	Baseline Boundary Conditions provided by Regional Model	Five slant wells producing 2,696 gpm ea. One Test Well producing 1,797 gpm for a total production of 22 mgd.
Regional Project 3a	Scenario 3a Boundary Conditions provided by Regional Model	Five seaward wells in the 180-Foot aquifer pump at a constant rate of 1,549 gpm ea. Five inland wells pump at constant rate of 1,697 gpm ea.. Total production from the 10 wells = 23.4 mgd
Regional Project 4b	Scenario 4b Boundary Conditions provided by Regional Model	Five seaward wells in the 180-Foot aquifer pump at a constant rate of 2,480 gpm ea. Total production from the 5 wells = 17.8 mgd

Assumptions made for each of the model scenarios are provided below:

1. <u>Baseline</u>
    - Boundary conditions were provided by WRIME,
    - Land use and water use indicative of 2030 conditions (WRIME, 2008), and
    - Refined version of the Future Conditions Baseline utilized by the EIR/EIS for the Salinas Valley Water Project (WRIME, 2008).

2. <u>CAW Slant Well Desalination Feedwater Supply Project</u>
    - Boundary conditions were the same as those provided by WRIME for the Baseline,
    - Five slant wells are constructed at 22 degrees from horizontal with a length of 600 lineal ft, and one test well is constructed at 36 degrees from horizontal with a length of 360 lineal ft. The wells do not extend deeper than 180 ft below sea level,

- Five full scale wells would produce approximately 2,696 gpm (3.88 mgd each), and the one test well would produce approximately 1,797 gpm (2.59 mgd) for a total production of 22 mgd, and
- Given the angle of the slant wells from the land surface (22 degrees), the length of the slant wells was limited so that they would be completed in the dune sand deposits and would remain above the theoretical 180-Foot aquifer (i.e., above 180 ft below sea level). However, in the vicinity of the slant wells, Model Layer 2 (180-Foot aquifer) comprises both the dune sand deposit and the 180-Foot aquifer as there is no Salinas Aquitard above the 180-Foot Aquifer (see Harding ESE cross-section D-D', Plate 6). Although the slant wells are supposed to be pumping from above the theoretical 180-Foot aquifer, due to the vertical distribution of the model layers, lithology, and cross-sections (WRIME, 1994), the model has the wells extracting water from both the dune sand deposits and 180-Foot aquifer (i.e., Model Layer 2).

3. Regional Project Scenario 3a
    - Boundary conditions were provided by WRIME,
    - Five seaward wells each pump constantly at 1,549 gpm,
    - Five inland wells each pump constantly at 1,697 gpm,
    - The combined total production for the well field would be 23.4 mgd, and
    - Wells are screened completely in the 180-Foot aquifer. Note: as the 180-Foot aquifer is one complete model layer, there is no discretization that would allow for apportioning extraction from a specific portion of the aquifer, as such, the model allows for an even distribution of pumping throughout the depth of the aquifer.

4. Regional Project Scenario 4b
    - Boundary conditions were provided by WRIME,
    - Five extraction wells each pump constantly at 2,480 gpm,
    - The combined total production for the well field would be 17.8 mgd, and
    - Wells are screened completely in the 180-Foot Aquifer.

7.0 GROUNDWATER FLOW AND SOLUTE TRANSPORT MODEL RESULTS

7.1 CAW Slant Well Desalination Feedwater Supply Project

The Slant Well scenario shows that the six slant wells pumping continuously would cause a slight change in groundwater flow directions and hydraulic gradients compared to Baseline (or No Project) conditions. Figures 12 and 13 show the difference in groundwater levels between Baseline (No Project) and the Slant Well Project. The general differences between scenarios are summarized below:

- In normal hydrologic years (precipitation is close to the long-term average), groundwater flow caused by the Slant Well Project remains similar to if there was no project (southwest to northeast), with the exception of the flattening out the northeastwards flow of groundwater and the development of a localized cone of depression that is up to 15 ft below sea level in close proximity to the slant wells.

- Under wet hydrologic conditions (precipitation is well above average), the effects of the Slant Well Project causes a slight steepening of the hydraulic gradient towards the slant wells. However, flow directions generally remain the same as Baseline flow directions outside of the slant well cone of depression[8]. Increased recharge to the 180-Foot aquifer from infiltration of precipitation and streamflow percolation during wet years allows for more groundwater outflow to the ocean.

- In dry years (precipitation well below average), the groundwater elevations in the model area for the Slant Well Project are very similar to Baseline (No Project) conditions. Flow is from the west to the east, with a localized depression formed around the slant wells.

[8] Due to complex spatial variations of the ground water elevation contours in the model area, a quantitative description of the difference between scenarios cannot be provided. Figures 12 and 13, however, show a direct comparison of contours for each scenario.

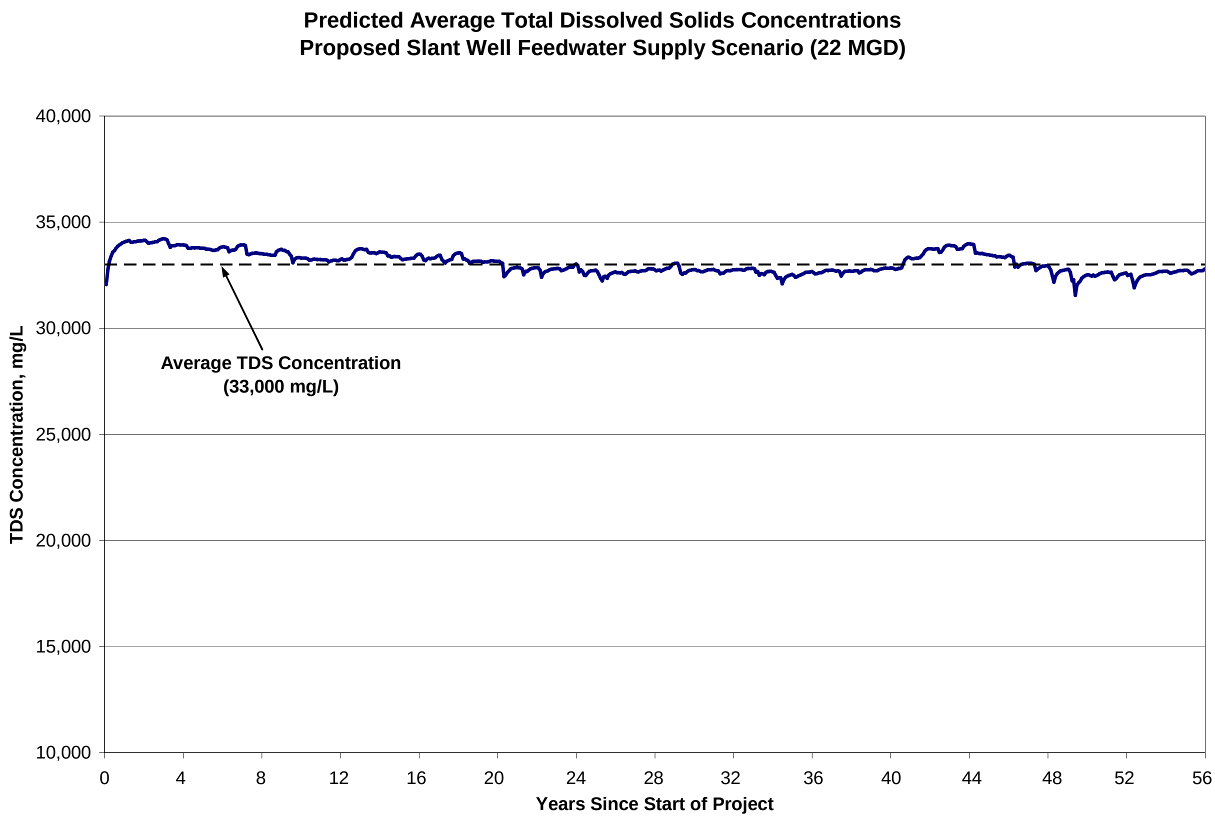
- After 56 years of operating the Slant Well Project, the inland groundwater elevations in the 180-Foot aquifer northeast of the slant wells would be slightly lower than under No Project conditions. For example, there is an approximate 1 ft lowering of groundwater levels in Marina Coast Water District Well 2 located one mile away from the slant wells after 56 years (see Figure 14). Groundwater flow directions would be similar to normal hydrologic year flow directions.

Selected hydrographs showing the Baseline (No Project) and Slant Well Project groundwater elevations over the 56 years of the predictive model are provided on Figure 14. It is shown that the decline in groundwater elevations at the slant well will be approximately 15 ft. The closest production well, Marina Coast Water District Well 2 would have just less than a 2 ft decline in levels due to the project (i.e., 5.3 ft amsl for baseline conditions less 3.4 ft amsl under project conditions). At 1.5 miles to the north, the impacts of water levels will cause less than a 0.5 ft decline (see location labeled 11 on Figure 14), with differences in water levels decreasing with distance from the slant wells.

Figure 15 shows the 500 mg/L chloride limit of the seawater intrusion in the 180-Foot aquifer at selected times over the 56 year model period. In general, the intrusion reduces at the same rate as No Project conditions, with the exception of the area in close proximity to the slant wells where the intrusion front reduces slightly slower than if the slant wells were not in operation.

The predicted TDS concentration for each of the six slant wells is shown on Figure 16. As can be seen, with the exception of the southernmost slant well and test slant well, the wells are extracting water with a concentration close to the assumed ocean water TDS of 35,000 mg/L. The test slant well has a lower TDS due to its larger angle from horizontal (i.e., 36 degrees) which results in more onshore groundwater being extracted because of its deeper depth below the sea floor. The southernmost slant well also has a lower TDS which indicates that it intercepts natural groundwater flow which moves from the southeast to the northwest (see Figure 12). In effect, this southernmost slant well protects the other wells from being recharged by onshore groundwater.

Over the 56 years, the blended TDS concentration of the feedwater extracted by the six slant wells will average approximately 33,000 mg/L. The chart below shows the modeled TDS concentrations over time.



The predicted TDS concentration of 33,000 mg/L for the feedwater extracted by the six slant wells is approximately 94 to 97 percent of the TDS concentration of seawater (34,000 to 35,000 mg/l). As the modeled layout represents a worse-case scenario (due to the steeper well angles), the most recent layout (six 700 ft wells with a 20 degree angle proposed by RBF, 2008) would most likely result in an even higher percentage of seawater in the extracted water.

The water budget presented in the table bellow shows all the model inflow and outflows as calculated using the model's cell-by-cell-budget. As can be seen in the table, operation of the slant wells as feedwater for the desalination plant generally increases the amount of ocean water flowing into the model and reduces the amount of groundwater flowing out into the ocean. Along the inland model boundaries (second column of the table, i.e., general head boundary), there will be a 762 acre-ft increase in the amount of water flowing into the model area from inland areas. This amount represents approximately 1 percent of total inflow to the model area (columns 2 through 4 in the table below), and as such would not have much of an impact on surface or groundwater resources outside of the focused model area. The amount of 762 acre-ft also represents only 3 percent of the project slant well pumping (column 6 in table below), which supports the mass balance estimation of the amount of groundwater being extracted by the slant wells.

Summary of Water Budget – Baseline and Three Project Scenarios
Annual Average Values for Hydrologic Year 1949-2004

Scenario	INFLOW			OUTFLOW				Change in Groundwater Storage
	Northern, Eastern and Southern Model Boundary (Underflow)	Stream Recharge and Deep Percolation from Precipitation and Applied Water (Irrigation)	Ocean Inflow	Non-Project Groundwater Pumping	Project Groundwater Pumping	Stream Discharge	Ocean Outflow	
	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]
Baseline (No Project)	12,398	36,783	4,032	35,850	0	1,971	15,220	172
Slant Well Project	13,160	36,783	23,938	35,850	24,631	1,971	11,643	-214
Regional Project Scenario 3a	11,809	34,958	22,363	27,643	26,200	1,676	13,429	182
Regional Project Scenario	11,005	34,033	19,302	27,779	20,000	2,270	13,976	315

7.2 Regional Project Scenario 3a

The Regional Project Scenario 3a shows that the ten seaward and inland wells pumping continuously in the 180-Foot aquifer would create an extraction barrier or trough parallel to the coast. This feature is formed as a result of seawater flowing inland towards the seawater wells (the five wells closest to the ocean, see Figure 17), while brackish water from seawater intruded groundwater flows seaward towards the five inland wells. Operating the wells continuously in this manner will maintain a barrier that would prevent future seawater intrusion of the 180-Foot aquifer.

Other changes in groundwater levels between Baseline (No Project) and the Regional Project Scenario 3a within the focused model area are shown on Figure 17 and summarized below:

- In normal hydrologic years (precipitation is close to the long-term average), groundwater flow caused by the Regional Project Scenario 3a remains similar to if there was no project (south west to northeast), with the exception of the pumping trough developed around the Regional Project Scenario 3a desalination wells. This locally alters the groundwater flow by drawing down groundwater by 10 ft more than would have occurred under No Project conditions near the coast.

- Under wet hydrologic condition (precipitation is well above average), the effects of the Regional Project Scenario 3a are less than under normal hydrologic conditions. In general, groundwater flow direction for No Project and Project conditions are quite similar, flowing southwest to northeast with a component also flowing towards the ocean. Although the pumping trough is still present, it has less of an effect south and east of the desalination wells compared to No Project conditions. Increased recharge to the 180-Foot aquifer from infiltration of precipitation and streamflow percolation during wet years allows for more groundwater outflow to the ocean.

- In dry years (precipitation well below average), the groundwater elevations east of the Regional Project Scenario 3a wells are higher than under Baseline (No Project) conditions. There is a strong component of groundwater flow from west to east (i.e., inland flow), which is reversed from flow in wet conditions (i.e., towards the ocean). The pumping trough developed by the Regional Project Scenario 3a in dry years will reduce the hydraulic gradient towards the east compared to No Project conditions. In effect, the Regional Project Scenario 3a would reduce the rate of seawater intrusion which would normally be more prevalent during dry years under No Project conditions.

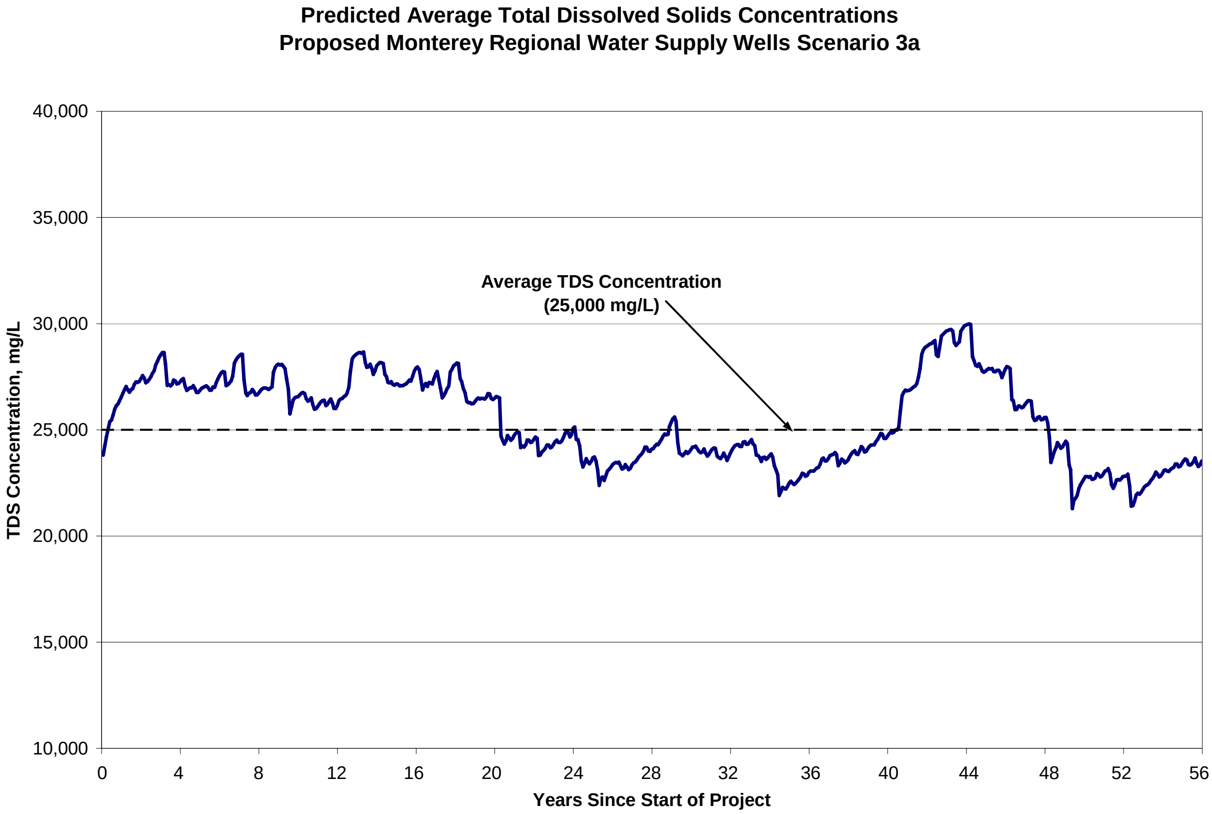
- After 56 years of operating the Regional Project Scenario 3a, the inland groundwater elevations in the 180-Foot aquifer would be higher than under No Project conditions. The area around the Project wells would have lower groundwater elevations due to the trough developed by continuous pumping. Groundwater flow directions would be similar to normal hydrologic year flow directions.

Selected hydrographs showing the Baseline (No Project) and Regional Project Scenario 3a groundwater elevations over the 56 years of the predictive model are provided on Figure 18. In general, the desalination wells of the Regional Project Scenario 3a show a decline in groundwater levels of approximately 10 ft or less. Inland of the Project wells, differences in groundwater levels between Baseline (No Project) and Project are minimal (less than 4 ft). This includes wells completed in the 400-Foot aquifer and Deep Aquifer underlying the 180-Foot aquifer. These deeper aquifers show almost no impacts from the Regional Project Scenario 3a pumping in the 180-Foot aquifer.

Figure 19 shows the 500 mg/L chloride limit of the seawater intrusion in the 180-Foot aquifer at selected times over the 56 year model period. In general, the intrusion is reduced at a faster rate when the Regional Project Scenario 3a is operating compared to Baseline (No Project) conditions. Only the area just south of the Salinas River mouth remains intruded longer than if there was no project. This is due to the trough that is designed to extract mostly seawater from the seawater wells of the Regional Project Scenario 3a.

The predicted TDS concentration from the ten extraction wells is shown on Figure 20. As can be seen, the seaward wells (1, 3, 4 and 5) all produce water with a TDS close to the assumed seawater concentration of 35,000 mg/L. The southernmost seaward extraction well has more fluctuating TDS concentrations, but still produces close to the 35,000 mg/L concentration. The TDS concentration of the inland wells indicates that the wells are producing a mixture of seawater and onshore groundwater. This suggests that the inland wells are effectively forming a barrier to onshore groundwater flowing towards the ocean (i.e., they intercept before it gets to the seaward wells). Thus, the seaward wells are able to extract more seawater than if the inland wells were not there.

Over the 56 years, the blended TDS concentration of the feedwater extracted by the ten Regional Project Scenario 3a wells will average approximately 25,000 mg/L. The chart below shows the modeled TDS concentrations over time. The predicted TDS concentration of 25,000 mg/L for the feedwater extracted by the ten Project wells is approximately 70 to 73 percent of the TDS concentration of seawater (34,000 to 35,000 mg/L).



The water budget (see Table in Section 7.1) for the Regional Project Scenario 3a shows that similarly to the CAW slant well scenario, there will be increased ocean water inflow and decreased outflow of onshore water to the ocean compared to the No Project (Baseline) conditions. However, due to changes in regional pumping (non-project pumping) and use of surface water for this scenario there would be a 589 acre-ft/yr decrease in the amount of water flowing into the model from the northern, eastern and southern model boundary areas as compared to No the Project (see column 2 of table in Section 7.1). This decrease in groundwater inflow would have a beneficial impact on groundwater resources outside of the focused model area (i.e. less impact on groundwater elevations). Inside the focused model area, the change in groundwater storage for the Regional Project Scenario 3a would increase 10 acre-ft/yr as compared to the No Project Scenario (see column 9 of table in Section 7.1). This would be a beneficial impact to groundwater resources within the focused model area.

7.3 Regional Project Scenario 4b

The Regional Project Scenario 4b shows that the five extraction wells pumping continuously in the 180-Foot Aquifer would create an extraction barrier or trough parallel to the coast. This feature is formed as the extraction wells pull in seawater (inland flow direction) and brackish water from the seawater-intruded Salinas Valley aquifer (seaward flow direction) (see Figure 21). Operating the wells continuously in this manner will maintain a barrier that would prevent future seawater intrusion of the 180-Foot Aquifer.

Other changes in groundwater levels between Baseline (No Project) and the Regional Project Scenario 4b within the focused model area are shown on Figure 21 and are summarized below:

- In normal hydrologic years (precipitation is close to the long-term average), groundwater flow caused by the Regional Project Scenario 4b remains similar to if there was no project (southwest to northeast), with the exception of the pumping trough developed around the Project extraction wells. This locally alters the groundwater flow by drawing down groundwater by 7 ft more than would have occurred under No Project conditions near the coast.

- Under wet hydrologic condition (precipitation is well above average), the effects of the Regional Project Scenario 4b are less than under normal hydrologic conditions. In general, groundwater flow direction for No Project and Project conditions are quite similar, flowing northwest to northeast with a component also flowing towards the ocean. Although the pumping trough is still present, it has less of an effect south and east of the desalination wells compared to No Project conditions. Increased recharge to the 180-Foot Aquifer from infiltration of precipitation and streamflow percolation during wet years allows for more groundwater outflow to the ocean.

- In dry years (precipitation well below average), the groundwater elevations east of the Project wells are higher than under Baseline (No Project) conditions. There is a strong component of groundwater flow from west to east (i.e., inland flow), which is reversed from flow in wet conditions (i.e., towards the ocean). The pumping trough developed by the Regional Project Scenario 4b in dry years will reduce the hydraulic gradient towards the east compared to No Project conditions. In effect, Scenario 4b would reduce the rate of seawater intrusion which would normally be more prevalent during dry years under No Project conditions.

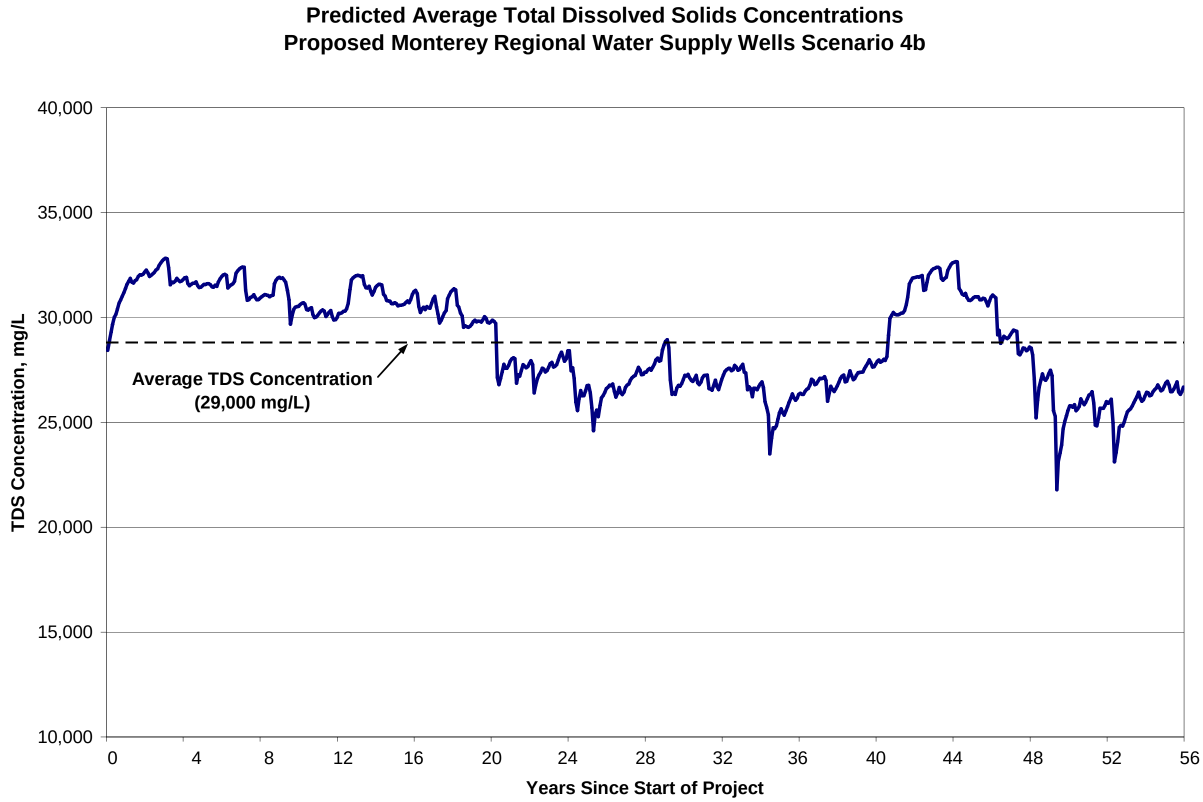
- After 56 years of operating the Regional Project Scenario 4b, the inland groundwater elevations in the 180-Foot Aquifer would be higher than under No Project conditions. For example, there is an average 0.5 ft rising of groundwater levels in the Observation Well No. 9 located four miles east from the Project wells during the 56 years model simulation period (see Figure 22). The area around the Project wells would have lower groundwater elevations due to the trough developed by continuous pumping. Groundwater flow directions would be similar to normal hydrologic year flow directions.

Selected hydrographs showing the Baseline (No Project) and Regional Project Scenario 4b groundwater elevations over the 56 years of the predictive model are provided on Figure 22. In general, the extraction wells of the Regional Project Scenario 4b show a decline in groundwater levels of approximately 10 ft or less. Inland of the Project desalination wells, differences in groundwater levels between Baseline (No Project) and Project are minimal (less than 7 ft). This includes wells completed in the 400-Foot Aquifer and Deep Aquifer underlying the 180-Foot Aquifer. Except for Observation Well 14, these deeper aquifers show almost no impacts from the Regional Project Scenario 4b pumping in the 180-Foot Aquifer.

Figure 23 shows the 500 mg/L chloride limit of the seawater intrusion in the 180-Foot Aquifer at selected times over the 56-year model period. In general, the intrusion is reduced at a faster rate when the Regional Project Scenario 4b is operating under Scenario 4b compared to Baseline (No Project) conditions. Only the area just south of the Salinas River mouth remains intruded longer than if there was no project. This is due to the trough that is designed to extract mostly seawater from the desalination wells of the Regional Project Scenario 4b.

The predicted TDS concentration from the five extraction wells is shown on Figure 24. As can be seen, the wells all produce water with fluctuating TDS concentrations (ranging from approximately 22,000 milligrams per liter (mg/L) to 33,000 mg/L) throughout the 56-year period. However, the TDS concentration is closer to the assumed seawater concentration of 35,000 mg/L during both normal and dry years than during wet years. The southernmost extraction well (Well 11) has more fluctuating TDS concentrations, but at times still produces close to the 35,000 mg/L concentration. During wet years, the TDS concentration of the extraction wells indicates that the wells are producing a mixture of seawater and onshore groundwater. This is due to the increase of groundwater, derived from infiltration of precipitation and streamflow percolation, flowing towards the ocean.

Over the 56 years, the average TDS concentration of the desalination feedwater extracted by the five Regional Project Scenario 4b wells will average approximately 29,000 mg/L. The chart below shows the modeled TDS concentrations over time. The predicted TDS concentration of 29,000 mg/L for the feedwater extracted by the five Project wells is approximately 82 to 85 percent of the TDS concentration of seawater (34,000 to 35,000 mg/L).



The water budget (see Table in Section 7.1) for the Regional Project Scenario 4b shows that similarly to the CAW slant well scenario, there will be increased ocean water inflow and decreased outflow of onshore water to the ocean compared to the No Project (Baseline) conditions. However, due to changes in regional pumping (non-project pumping) and use of surface water for this scenario there would be a 1,393 acre-ft/yr decrease in the amount of water flowing into the model from the northern, eastern and southern model boundary areas as compared to No the Project (see column 2 of table in Section 7.1). This decrease in groundwater inflow would have a beneficial impact on groundwater resources outside of the focused model area (i.e. less impact on groundwater elevations). Inside the focused model area, the change in groundwater storage for the Regional Project Scenario 4b would increase 143 acre-ft/yr as compared to the No Project Scenario (see column 9 of table in Section 7.1). This would be a beneficial impact to groundwater resources within the focused model area.

8.0 REFERENCES

Anderson, Mary P., and Woessner, William W., 1992. *Applied Groundwater Modeling – Simulation of Flow and Advective Transport*. New York: Academic Press, 1992.

California Department of Water Resources (DWR), 1973. *Sea Water Intrusion Lower Salinas Valley Monterey County*. Dated July 1973.

California Department of Water Resources, 1977. *North Monterey Water Resources Investigation*. Prepared pursuant to cooperative agreement between Department of Water Resources and Monterey County Flood Control and Water Conservation District, March 23, 1977.

California Department of Water Resources, 2003. *California's Groundwater - Bulletin 118, Update 2003.* Dated October, 1, 2003.

Feeney and Rosenberg, 2002. "*Deep Aquifer Investigation – Hydrogeologic Data Inventory, Review, Interpretation and Implications (TECHNICAL REVIEW DRAFT)*", Dated 23-Sep-02.

GEOSCIENCE Support Services, Inc., 1993. *Ground Water Model of the Talbert Gap Area, Orange County, California.* Prepared for the Orange County Water District, July 9, 1993.

GEOSCIENCE Support Services, Inc., 2005. *Feasibility of Using HDD Wells for Water Supply and Brine Discharge for the Coastal Water Project Desalination Plant, North Marina Site.* Prepared for RBF Consulting / California American Water, May 9, 2005.

Green, H. Gary, 1970. *Geology of Southern Monterey Bay and its Relationship to the Ground Water Basin and Salt Water Intrusion*. U.S.G.S. Open File Report, 1970.

Guo, W., and Langevin, C.D., 2002. *User's Guide to SEAWAT: A Computer Program for Simulation of Three-Dimensional Variable-Density Ground-Water Flow*. U.S. Geological Survey Techniques of Water-Resources Investigations 6-A7.

Hanson, R.T., R. Everett, M. Newhouse, S. Crawford, M.I. Pimental, and G. Smith, 2002. *Geohydrology of a Deep-Aquifer Monitoring-Well Site at Marina, Monterey County, California*. U.S.G.S. Water-Resources Investigations Report 02-4003. Prepared in cooperation with Monterey County Water Resources Agency.

Hanson, R.T., 2003. *Geohydrologic Framework of Recharge and Seawater Intrusion in the Pajaro Valley, Santa Cruz and Monterey Counties, California*. U.S.G.S. Water-Resources Investigations Report 03-4096. Prepared in cooperation with Pajaro Valley Water Management Agency.

Harding ESE, 2001. *Hydrogeologic Investigation of the Salinas Valley Basin in the Vicinity of Fort Ord and Marina Salinas Valley, California.* Prepared for Monterey County Water Resources Agency. April 28, 2001.

Johnson, M., 1983. *Ground Water in North Monterey County, California*, 1980. U.S.G.S. Water-Resources Investigations Report 83-4023. Prepared in cooperation with the Monterey County Flood Control and Water Conservation District. Dated July 1983.

Kennedy/Jenks consultant, 2004. *Hydrostratigraphic Analysis of the Northern Salinas Valley*. Prepared for Monterey County Water Resources Agency. May 14, 2004.

Monterey County Water Resources Agency (MCWRA), 2001. *Draft Environmental Impact Report/Environmental Impact Statement for the Salinas Valley Water Project*, Dated June 2001. Seawater intrusion is defined in the report as the average annual rate of subsurface flow from the Monterey Bay into the 180-Foot and 400-Foot Aquifers in the Pressure Subarea.

Monterey County Water Resources Agency (MCWRA), 2005. *Historic Seawater Intrusion Maps – 500 mg/L Chloride Areas* (pdf). Dated February 27, 2006. http://www.mcwra.co.monterey.ca.us/SVWP/01swi180.pdf;

http://www.mcwra.co.monterey.ca.us/SVWP/01swi400.pdf Accessed 6-Jun-08.

Montgomery Watson, 1994. *Salinas River Basin Water Resources Management Plan Task 1.09 Salinas Valley Ground Water Flow and Quality Model Report*. Prepared for Monterey County Water Resources Agency. Dated February 1994.

Montgomery Watson, 1997. *Final Report – Salinas Valley Integrated Ground Water and Surface Model Update*. Prepared for Monterey County Water Resources Agency. Dated May 1997.

RBF Consultants, 2008. Coastal Water Project Technical Memorandum Update. North Marina Alternative Desalination Plant. Revised July 8, 2008. Prepared for California American Water.

Todd, David K., 1980. *Groundwater Hydrology, Second Edition*. New York: John Wiley & Sons, 1980.

Zheng, C., and Wang, P., 1998. *MT3DMS, A modular three-dimensional multispecies transport model for simulation of advection, dispersion and chemical reactions of contaminants in groundwater systems*: Vicksburg, Miss., Waterways Experiment Station, U.S. Army Corps of Engineers.

Zheng, C., and Bennett, G., 2002. *Applied Contaminant Transport Modeling, Second Edition.* New York: John Wiley & Sons, 2002.

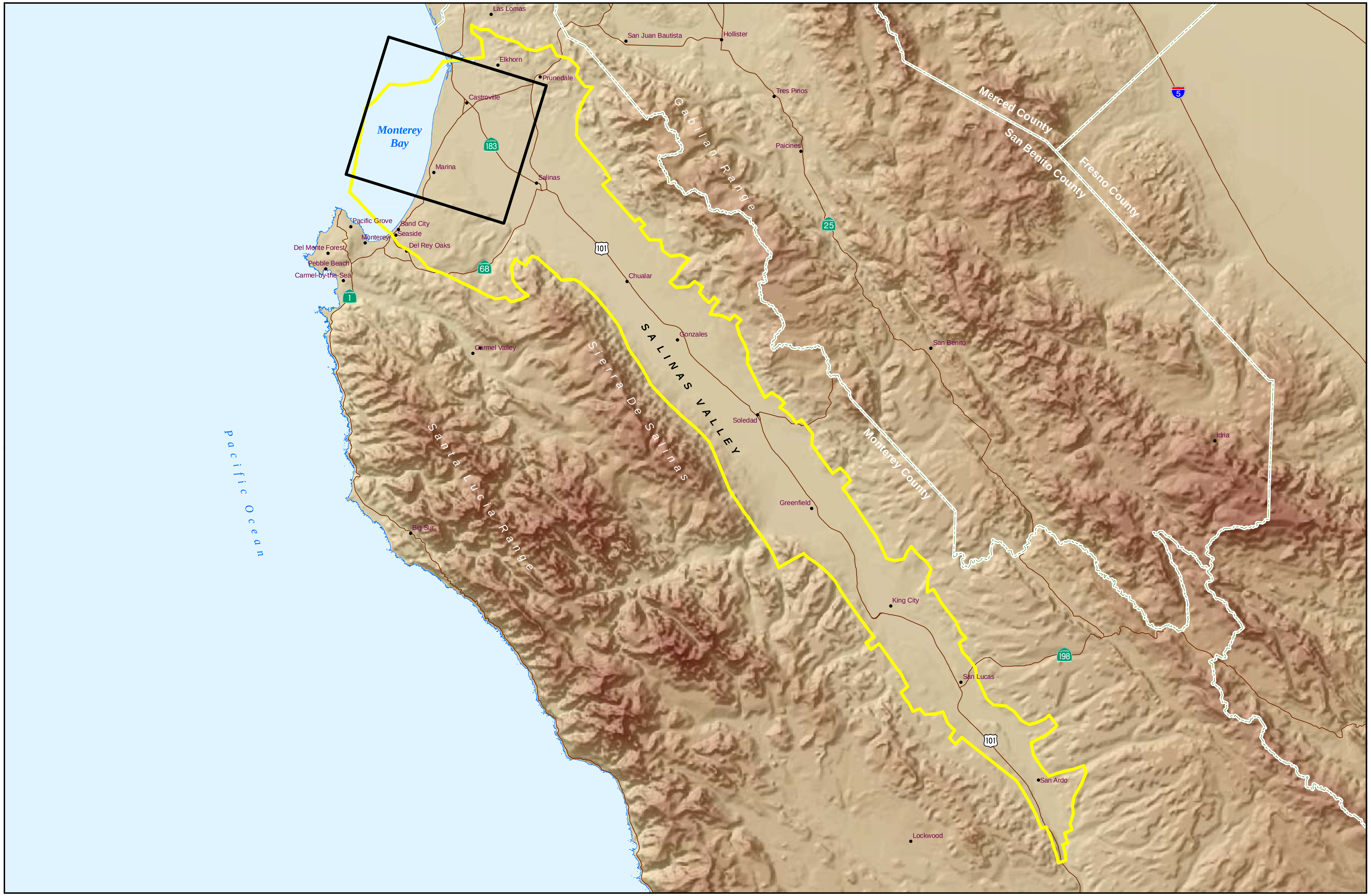
FIGURES

GEOSCIENCE Support Services, Inc.

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

GENERAL PROJECT LOCATION



EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- Salinas Valley Integrated Groundwater and Surface Water Model (SVIGSM) Boundary
- County Boundary
- Highway

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 10 20 Miles

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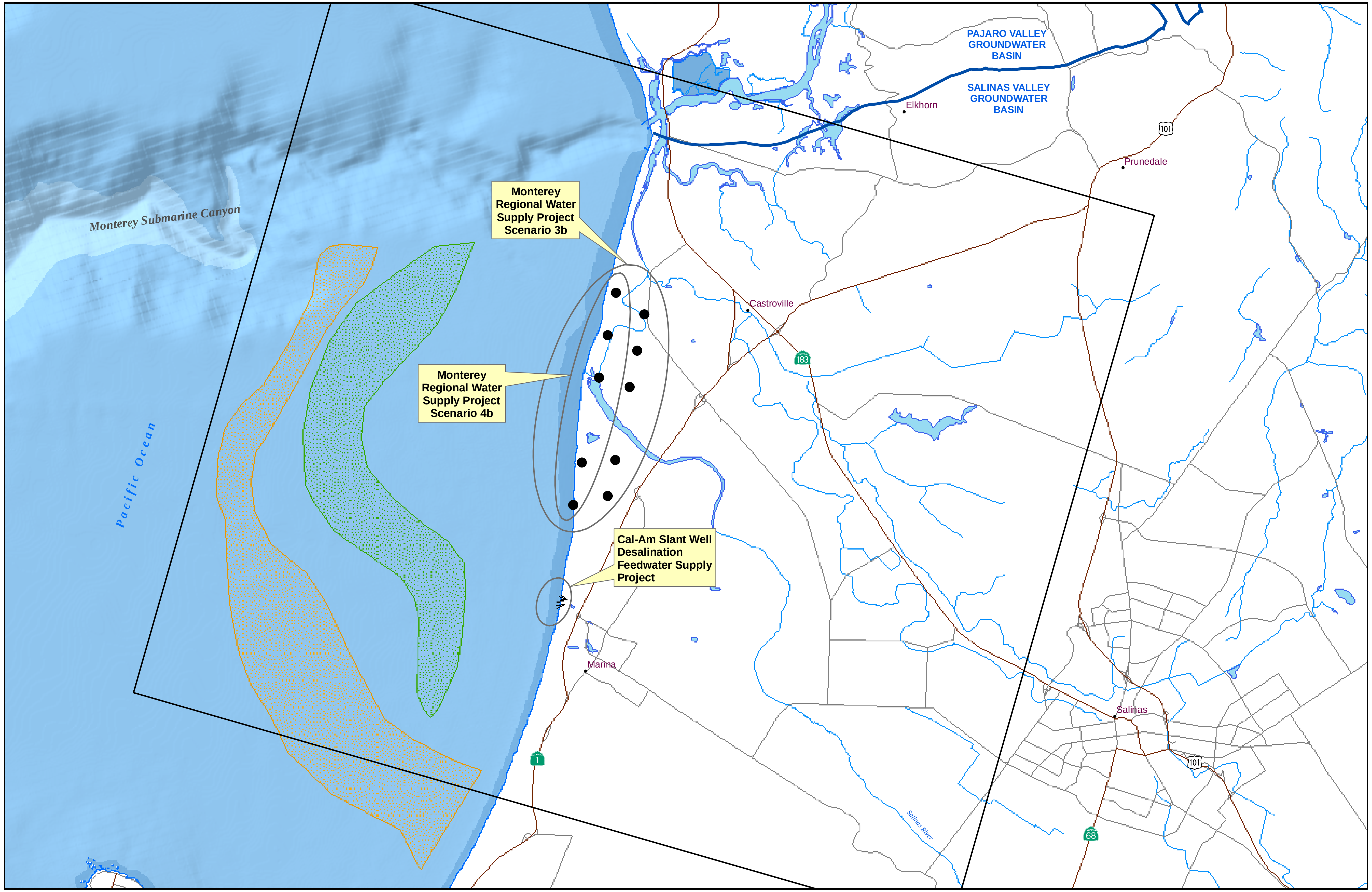
Figure 1

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_1_Slant_Wells_180ft_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



POTENTIAL PROJECTS

EXPLANATION

- Monterey Regional Project Well
- GEOSCIENCE Groundwater Model Boundary
- Groundwater Basin Boundary (DWR, 2003)

Offshore Aquifer Outcrop (Green, 1970; DWR, 1973)

- 180-Foot Aquifer
- 400-Foot Aquifer
- Slant Well
- Highway
- Major Roads
- Rivers and Creeks

NOTE:
Scenario 3b = 10 wells
Scenario 4b = 5 wells

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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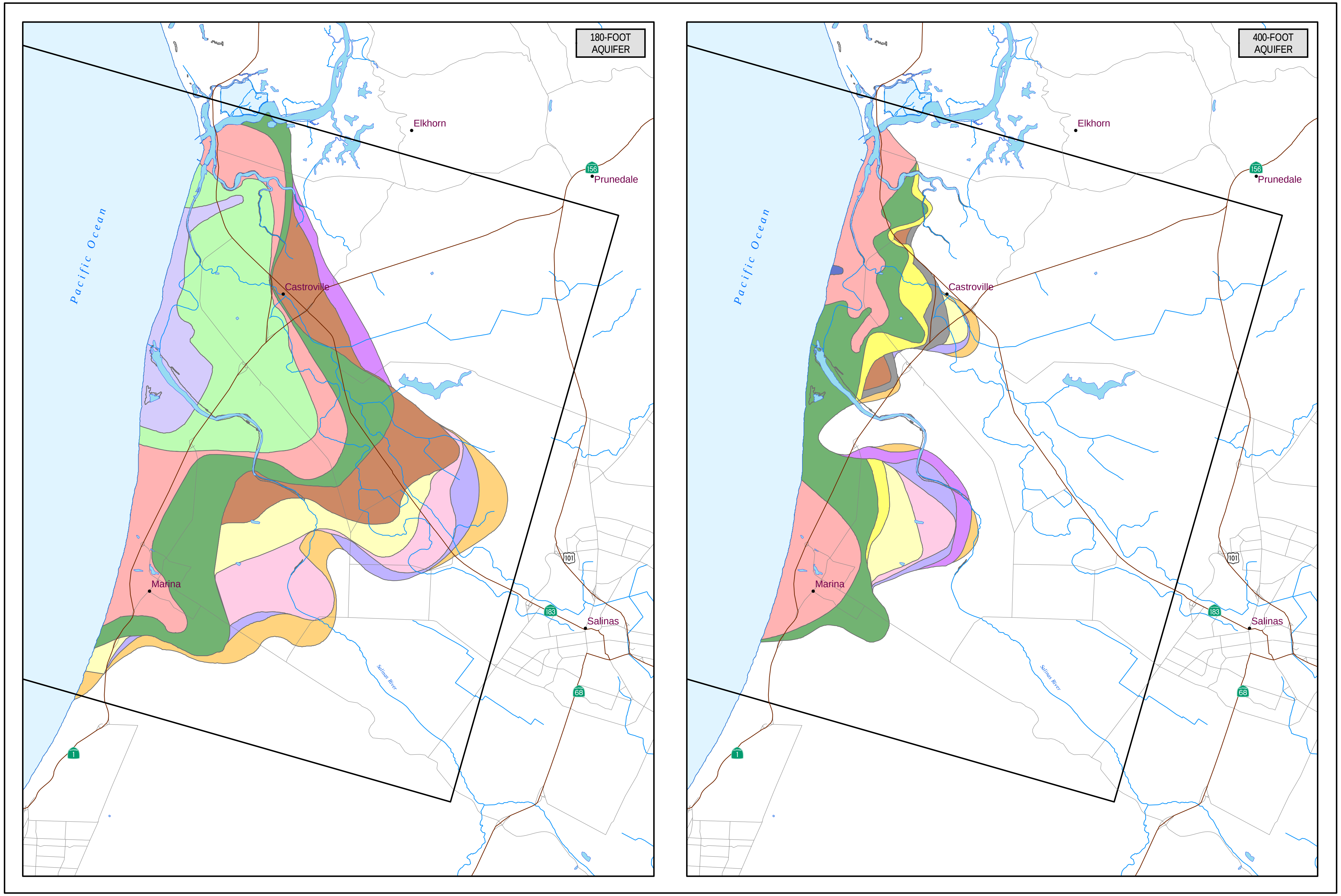
Figure 2

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_2_proposed_projects_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

HISTORICAL SEAWATER INTRUSION 180-FOOT AND 400-FOOT AQUIFERS



EXPLANATION

GEOSCIENCE Groundwater Model Boundary

Highway

Major Roads

Rivers and Creeks

Seawater Intrusion by Year
(Source: MCWRA, 2005)

1944, 1959, 1965, 1975, 1985, 1990, 1993, 1995, 1997, 1999, 2001, 2003, 2005

26-Sep-08

Prepared by: DWB

Map Projection:
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NORTH

0 2 4 Miles

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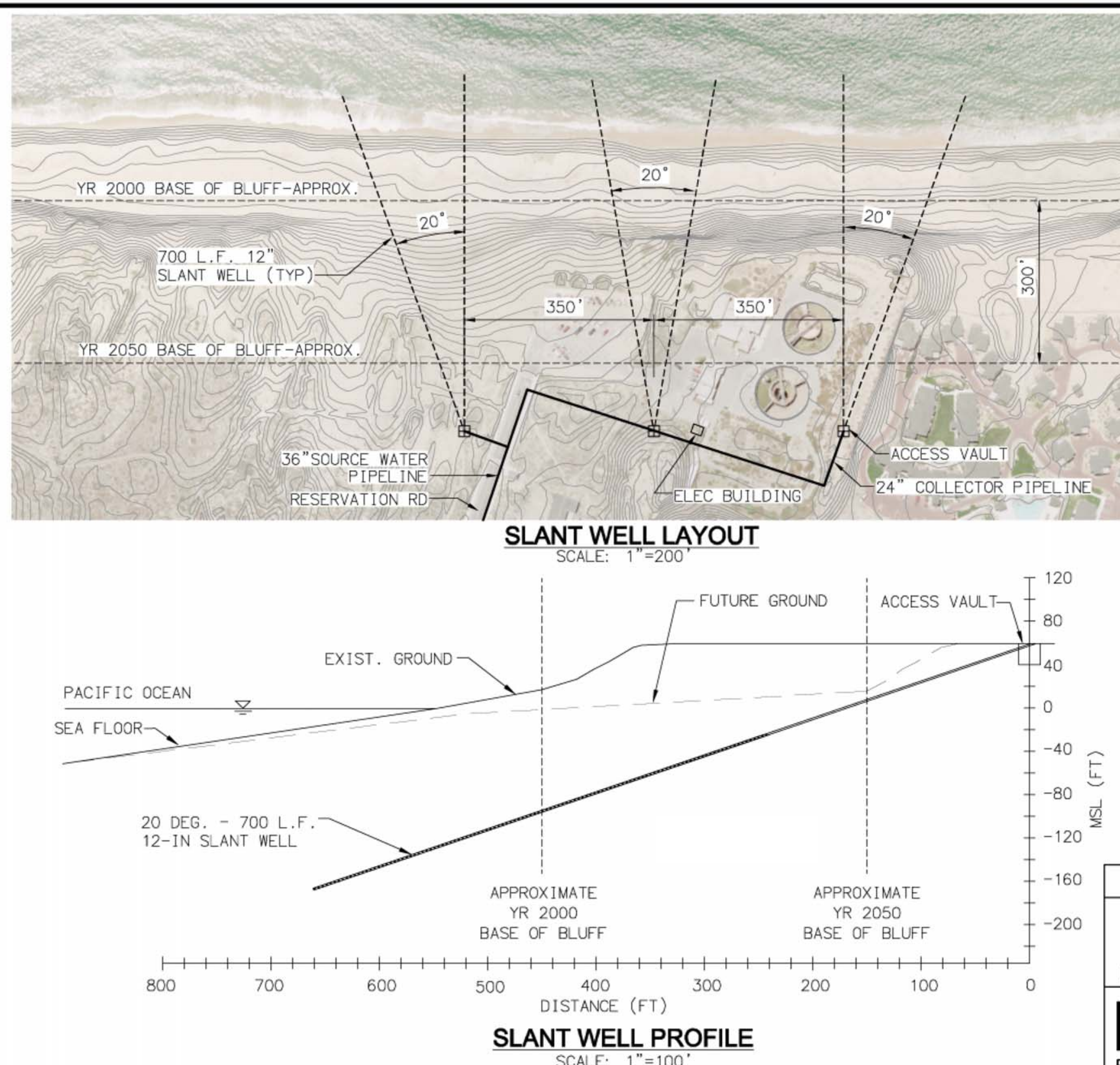
Figure 3

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_3_historic_swi_180ft_400ft_9-08.mxd

This layout was developed after model runs were completed. However, groundwater impacts are not expected to be much different between this layout and the layout modeled.



COASTAL WATER PROJECT

FIGURE 3
SLANT WELL SITE LAYOUT
NORTH MARINA ALTERNATIVE

RBF CONSULTING
PLANNING ■ DESIGN ■ CONSTRUCTION
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MARINA, CALIFORNIA 93933
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CALIFORNIA AMERICAN WATER

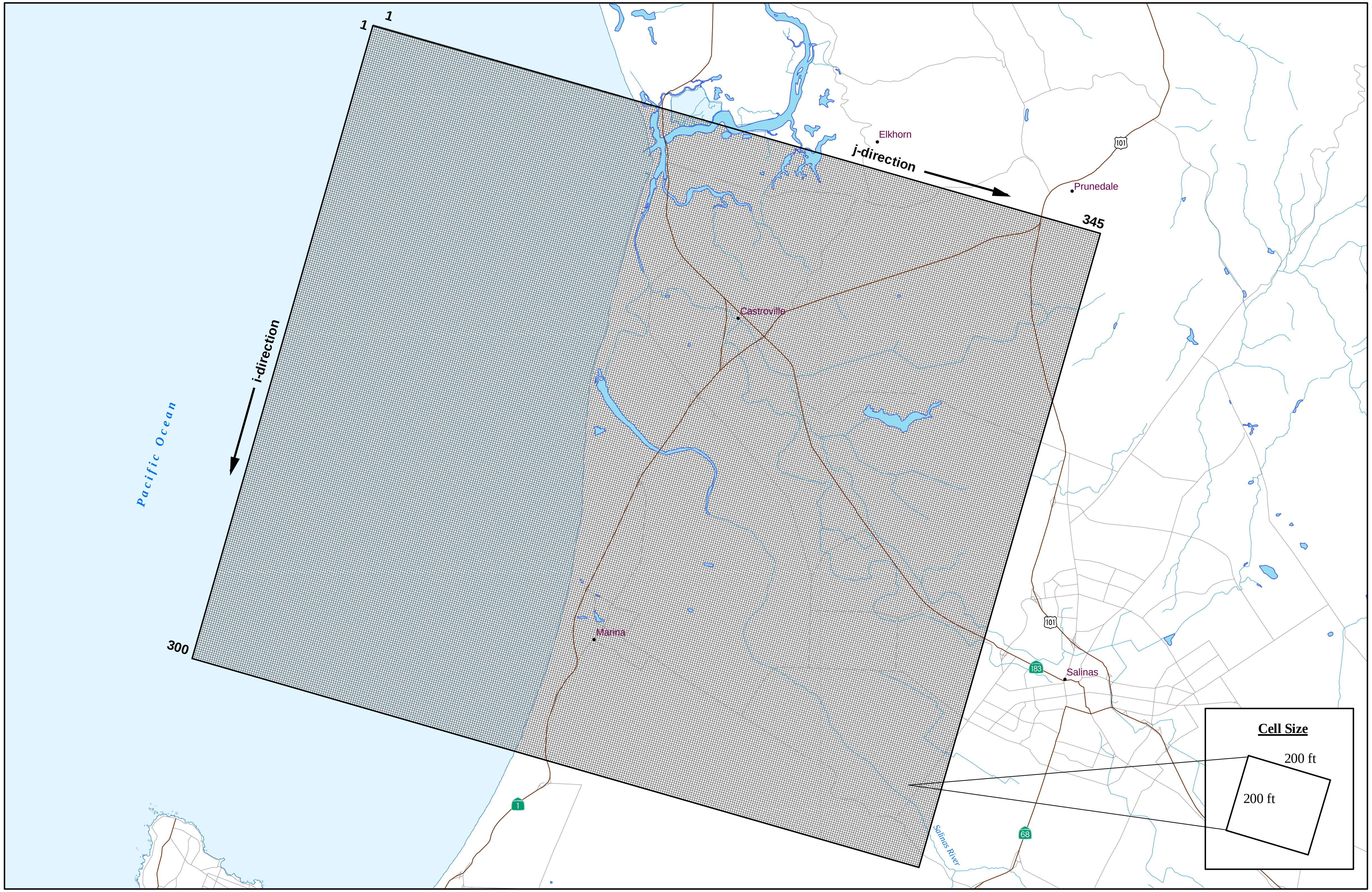
SLANT WELL LAYOUT

Drawn:
Checked:
Approved:
Date: 26-SEP-08

Figure 4

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



NORTH MARINA GROUNDWATER MODEL BOUNDARY

EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- Model Cell Size (200 ft x 200 ft)
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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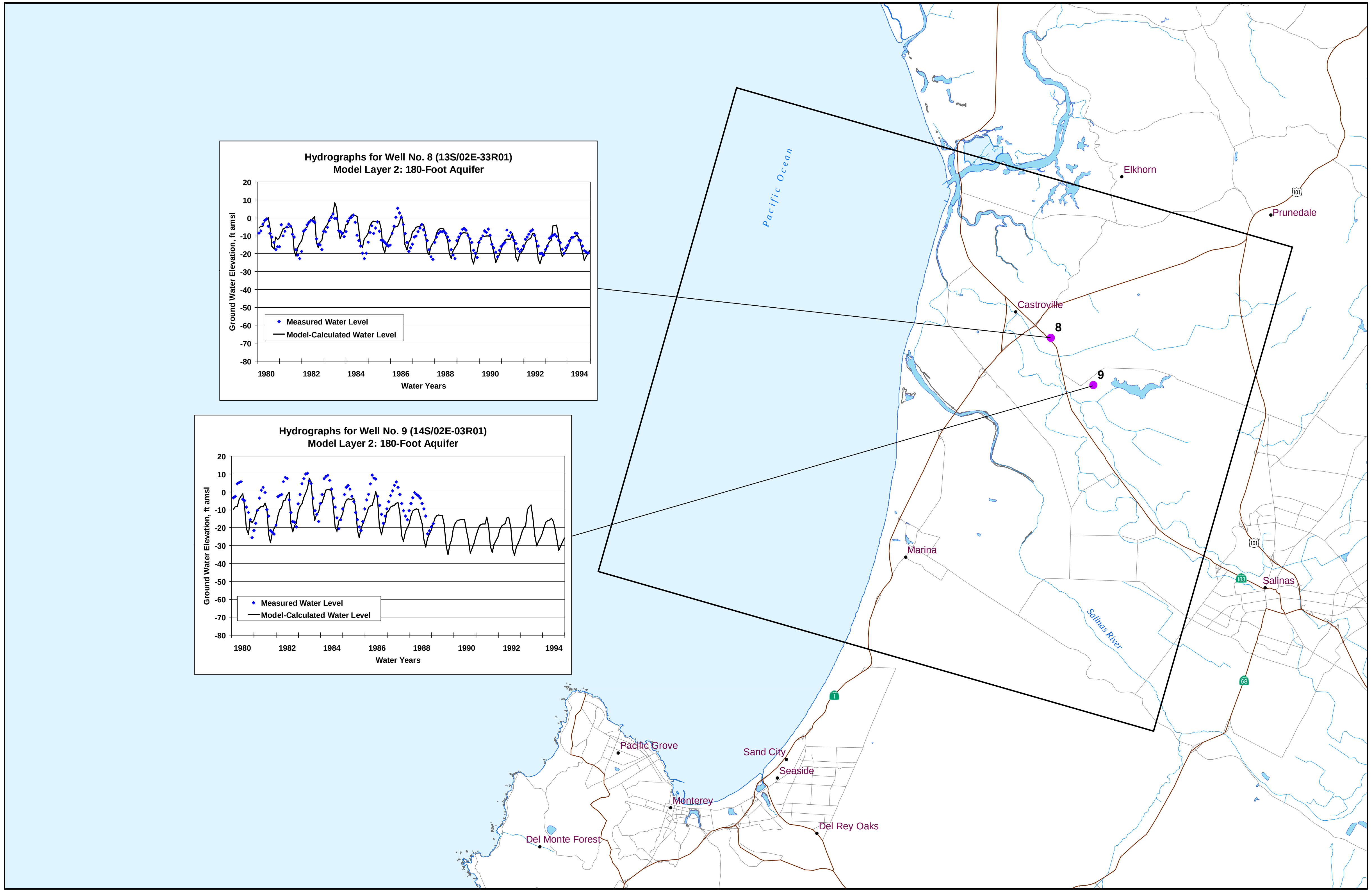
Figure 5

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_5_Model_Bouneary_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



FLOW MODEL CALIBRATION HYDROGRAPHS 180-FOOT AQUIFER

EXPLANATION

- WRIME Calibration Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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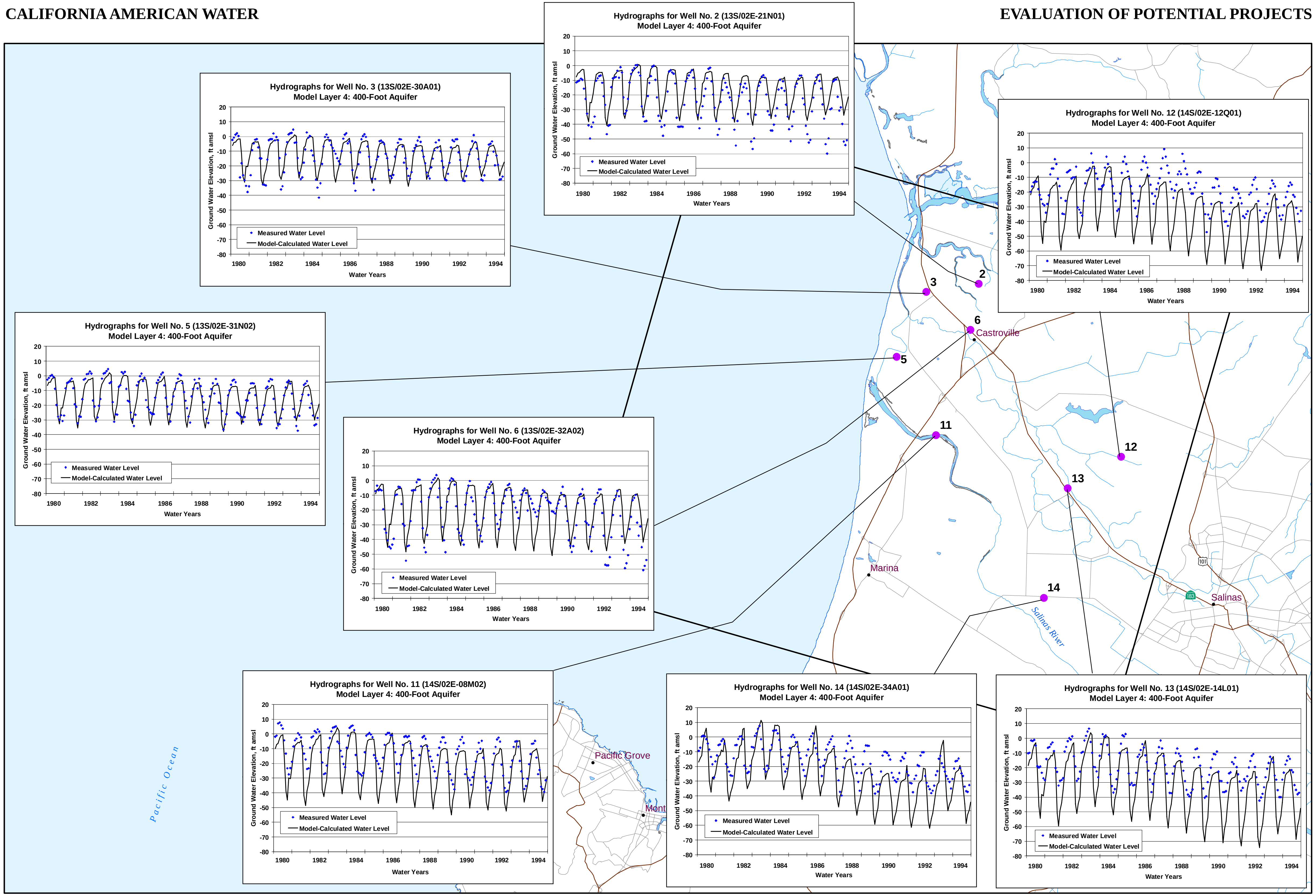
Figure 6

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

FLOW MODEL CALIBRATION HYDROGRAPHS 400-FOOT AQUIFER



EXPLANATION

- WRIME Calibration Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

NORTH

0 2 4 Miles

Map Projection:
State Plane 1983, California Zone IV

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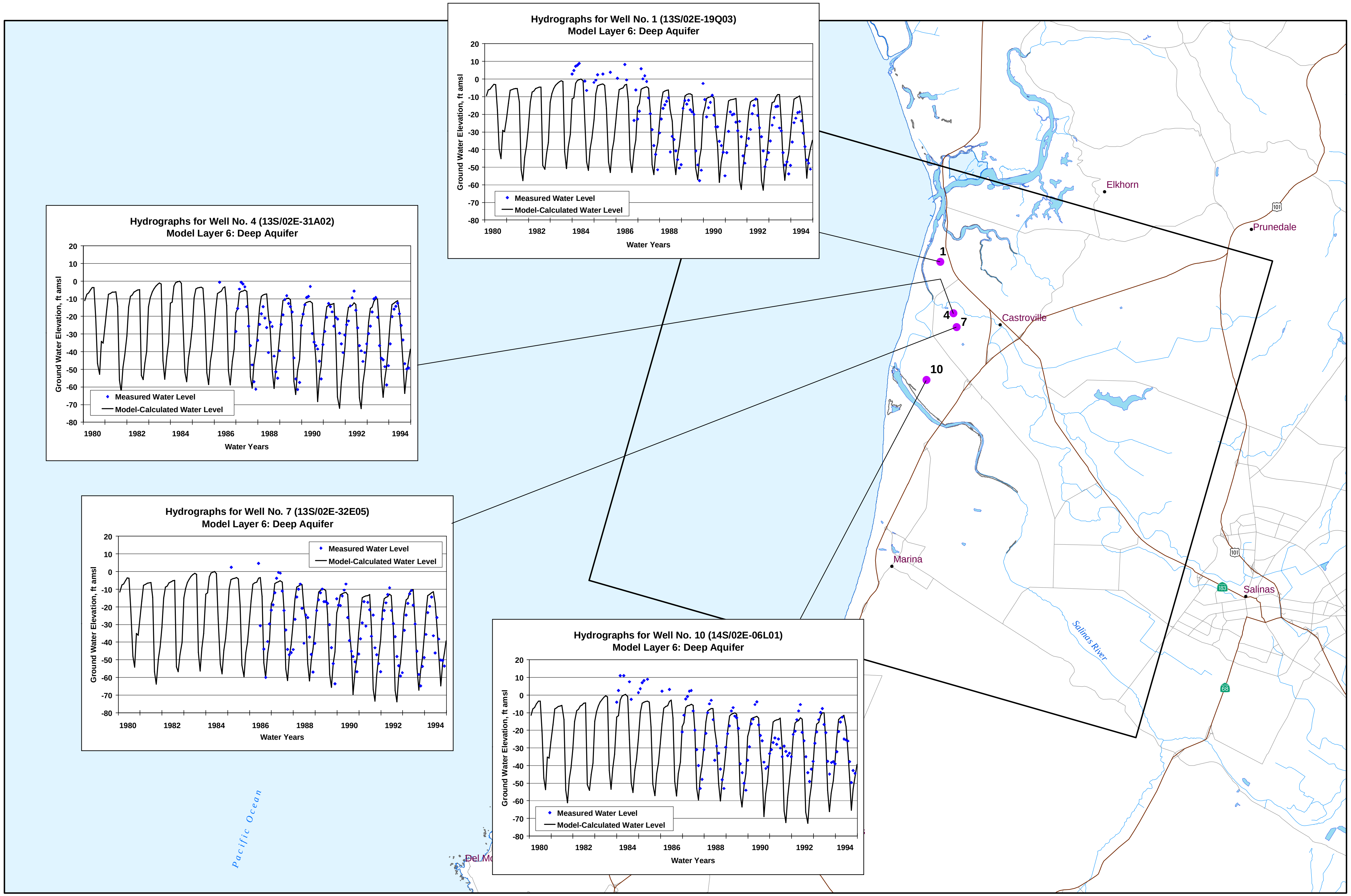
Figure 7

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_7_Hydrographs_400ft_aquifer_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

FLOW MODEL CALIBRATION HYDROGRAPHS DEEP AQUIFER



EXPLANATION

- WRIME Calibration Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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Figure 8

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_8_Hydrographs_deep_aquifer_9-08.mxd

Histogram of Groundwater Level Residuals* - Transient Model Calibration

(Model Calibration Period October 1979 Through September 1994)

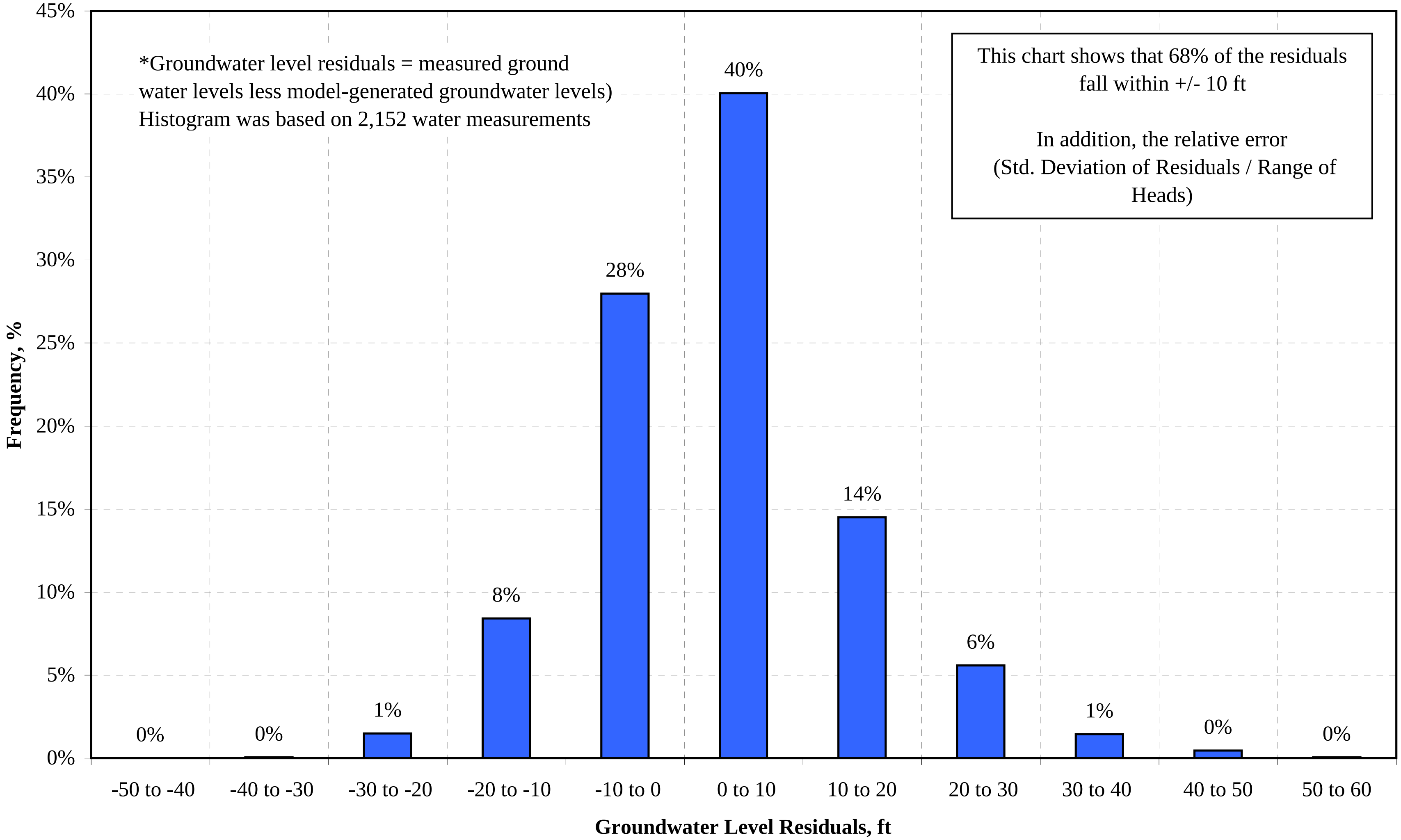
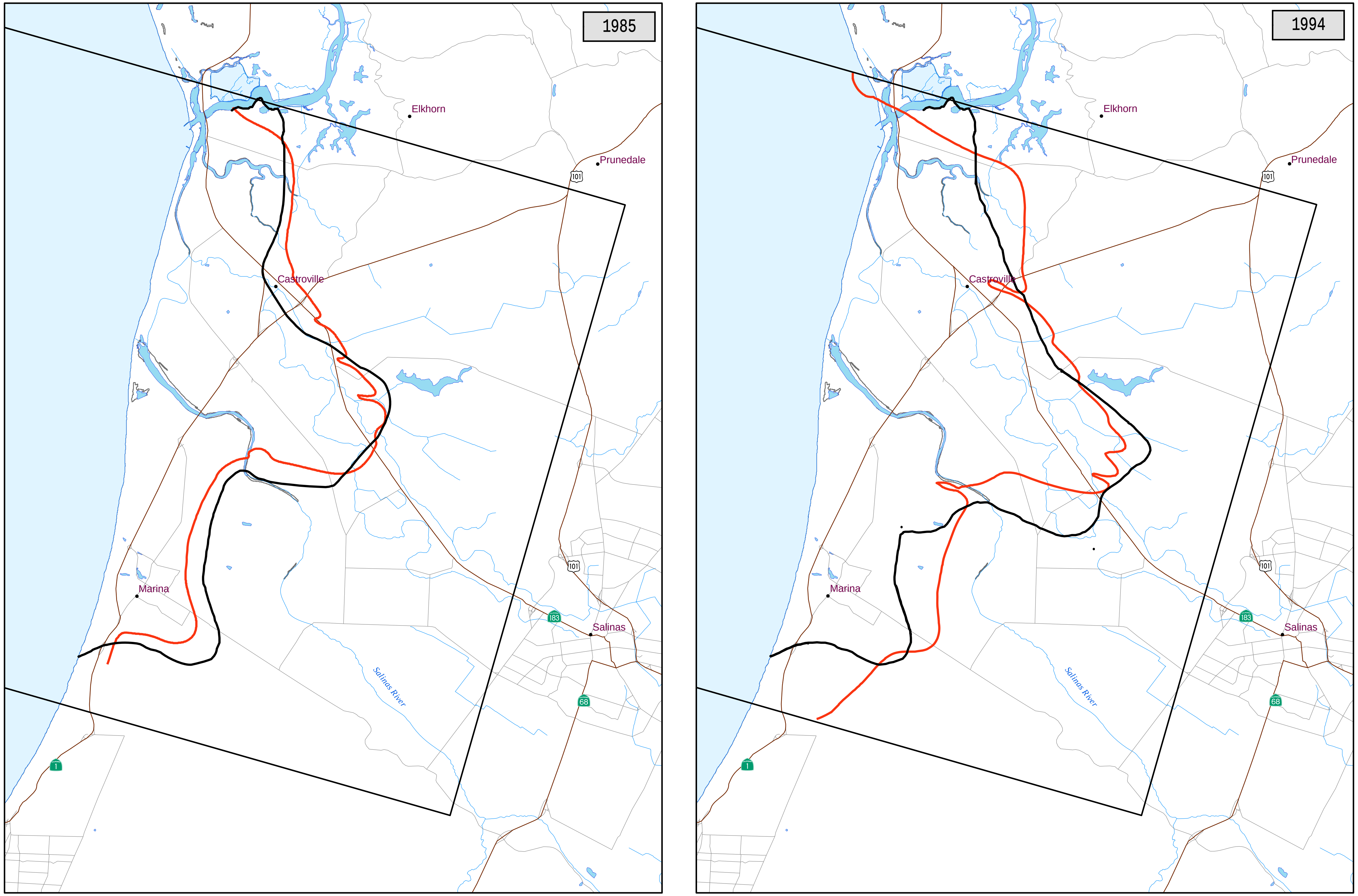


Figure 9

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



TRANSPORT MODEL CALIBRATION OF SEAWATER INTRUSION 180-FOOT AQUIFER

EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- MCWRA Seawater Intrusion Line (Chloride = 500 mg/L) (MCWRA, 2005)
- Model-Generated Seawater Intrusion Line (Chloride = 500 mg/L)
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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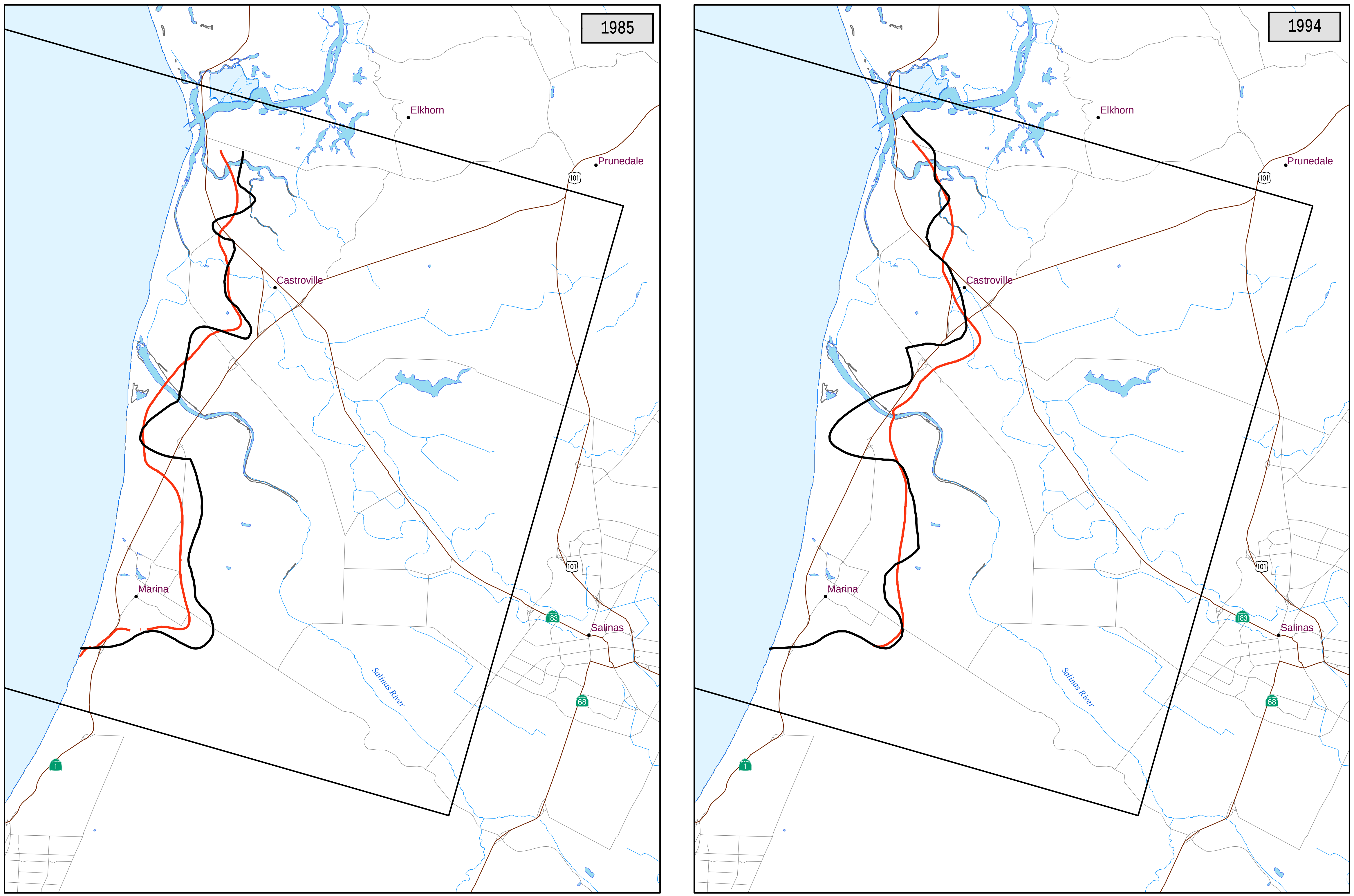
Figure 10

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_10_calibration_swi_180ft_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



TRANSPORT MODEL CALIBRATION OF SEAWATER INTRUSION 400-FOOT AQUIFER

EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- MCWRA Seawater Intrusion Line (Chloride = 500 mg/L) (MCWRA, 2003)
- Model-Generated Seawater Intrusion Line (Chloride = 500 mg/L)
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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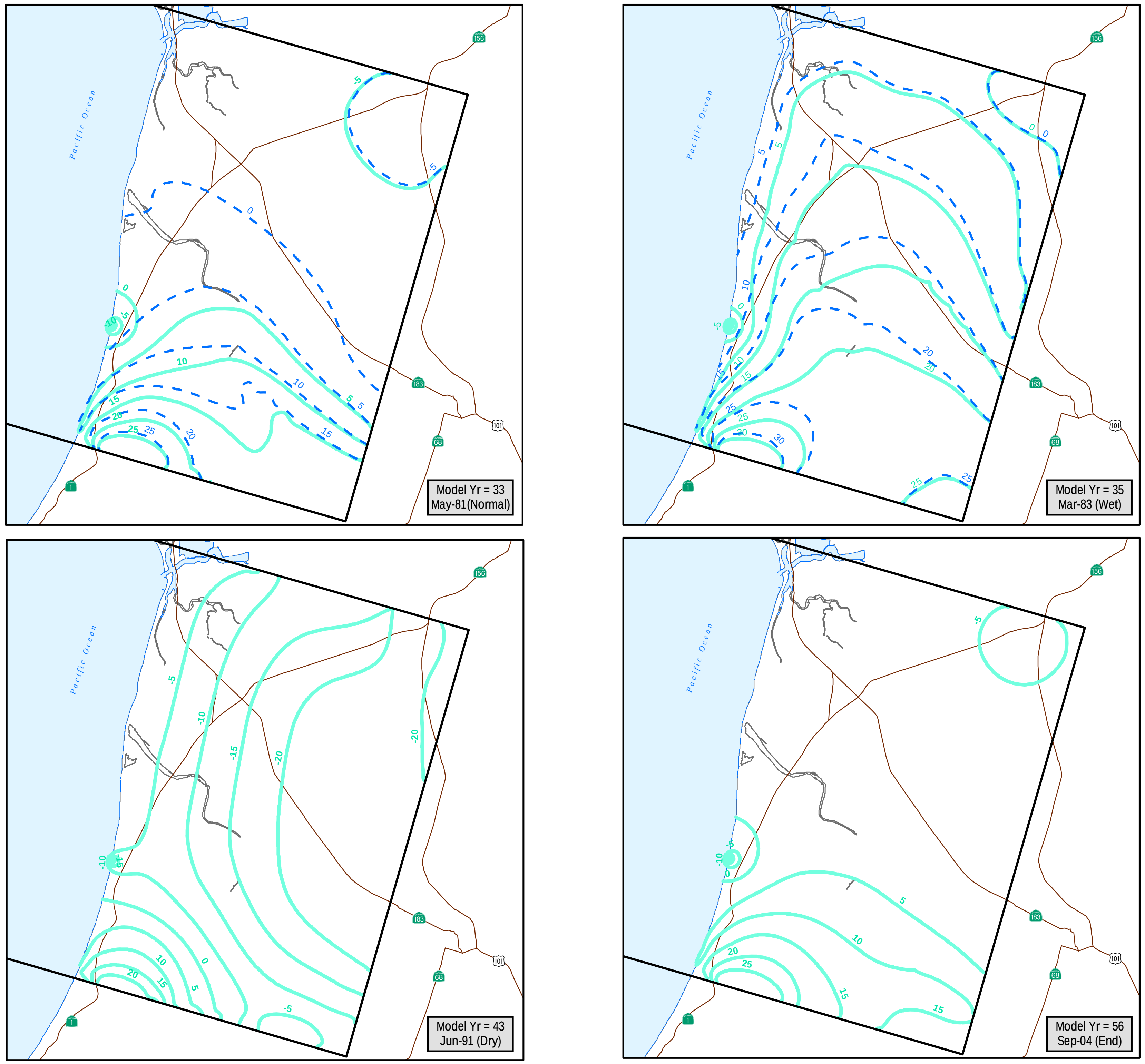
Figure 11

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_11_calibration_swi_400ft_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

180-FOOT AQUIFER BASELINE vs. SLANT WELL FEEDWATER SUPPLY SCENARIO (22 MGD) GROUNDWATER ELEVATIONS



EXPLANATION

GEOSCIENCE Groundwater Model Boundary

Baseline Groundwater Elevation, ft amsl

Slant Well Scenario Groundwater Elevation, ft amsl

Highway

Model Yr = 13 Jun-1961 (Dry) — Predictive Model Year* Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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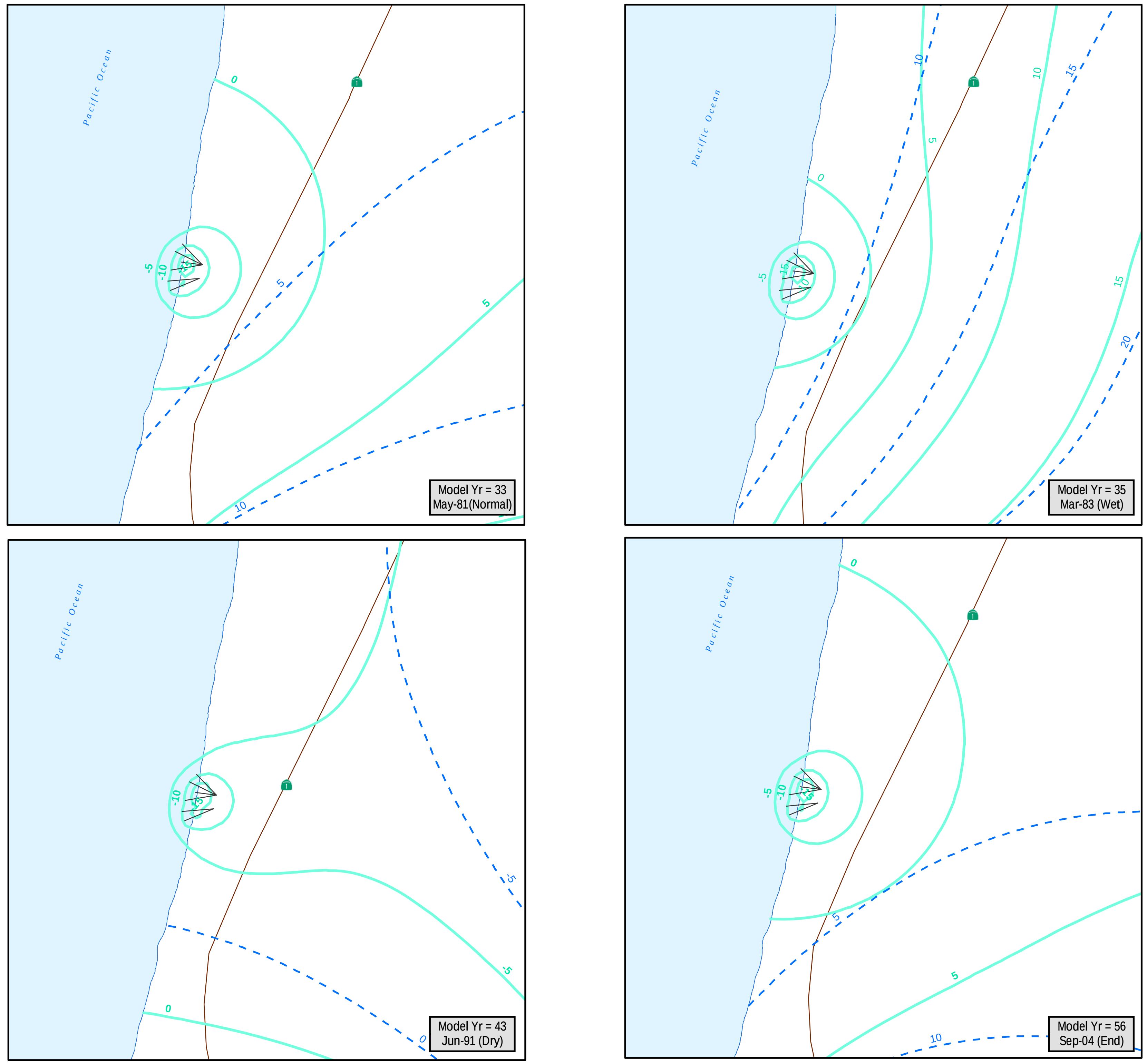
Figure 12

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_12_Slant_Wells_180ft_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



180-FOOT AQUIFER BASELINE vs. SLANT WELL FEEDWATER SUPPLY SCENARIO (22 MGD) GROUNDWATER ELEVATIONS (Close-Up)

EXPLANATION

Baseline Groundwater Elevation, ft amsl

Slant Wells

Slant Well Scenario Groundwater Elevation, ft amsl

Highway

Model Yr = 13 Jun-1961 (Dry) — Predictive Model Year* Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2,000 4,000 Feet

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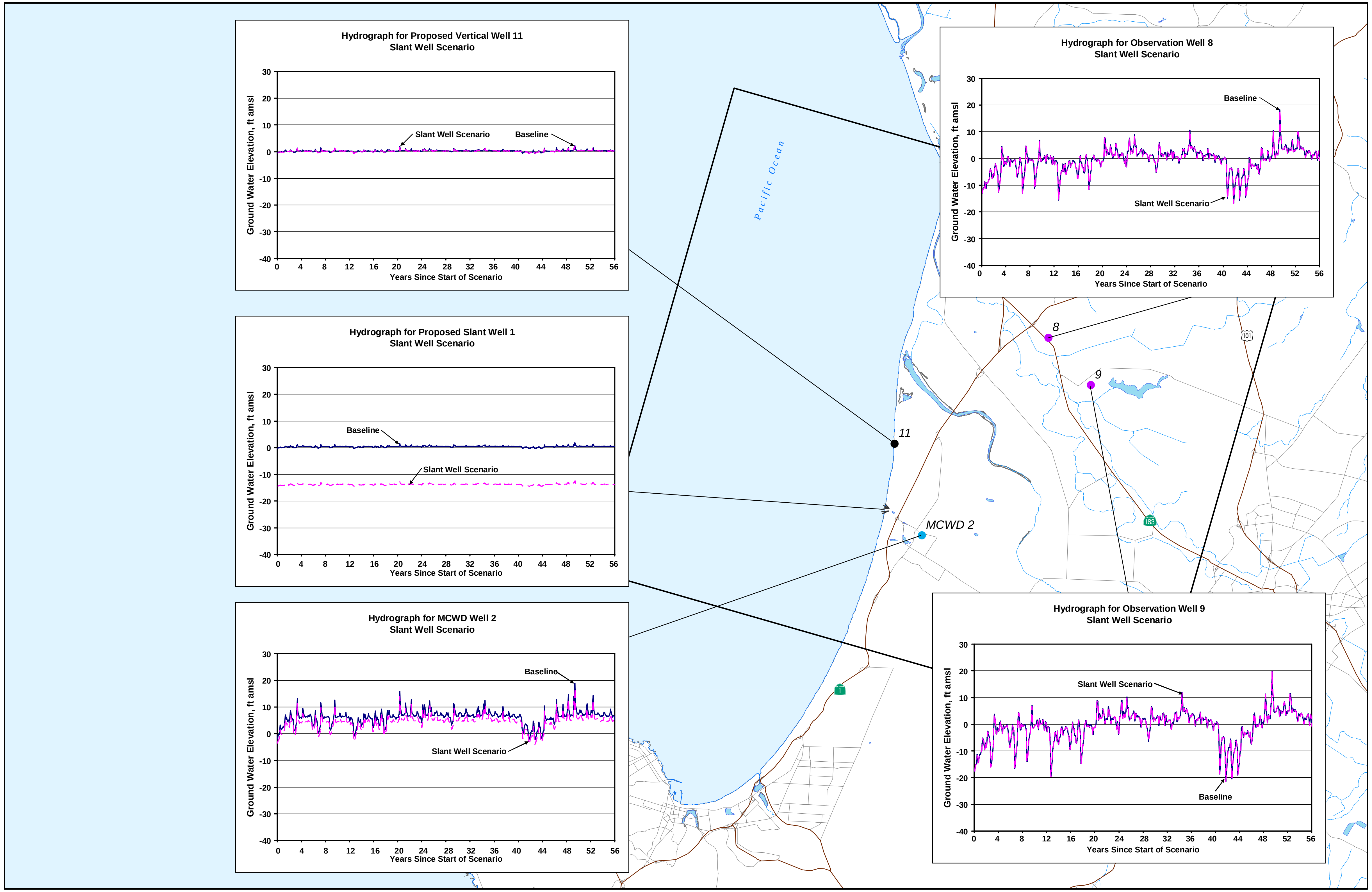
Figure 13

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_13_Slant_Wells_180ft_ZOOM_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

180-FOOT AQUIFER SLANT WELL FEEDWATER SUPPLY SCENARIO (22 MGD) HYDROGRAPHS



EXPLANATION

- Monterey Regional Project Well
- WRIME Calibration Well
- MCWD Well
- Slant Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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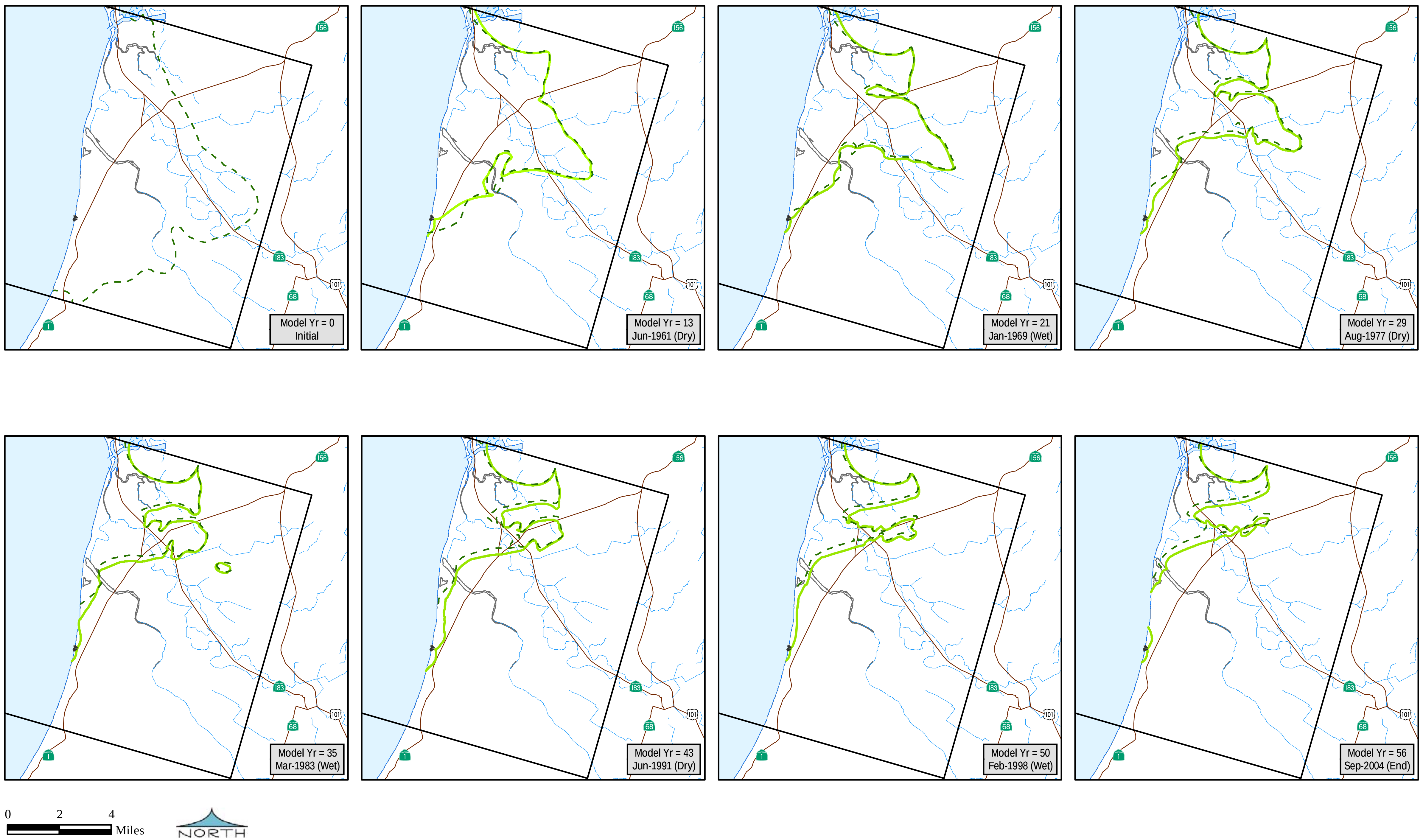
Figure 14

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_14_Slant_wells_Hydrographs_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

180-FOOT AQUIFER BASELINE vs. SLANT WELL FEEDWATER SUPPLY SCENARIO (22 MGD) SEAWATER INTRUSION



EXPLANATION

GEOSCIENCE Groundwater Model Boundary

Baseline Seawater Intrusion Chloride = 500 mg/L

Slant Well Scenario Seawater Intrusion, Chloride = 500 mg/L

Slant Well

Highway

Rivers and Creeks

Model Yr = 13 Jun-1961 (Dry) — Predictive Model Year* Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

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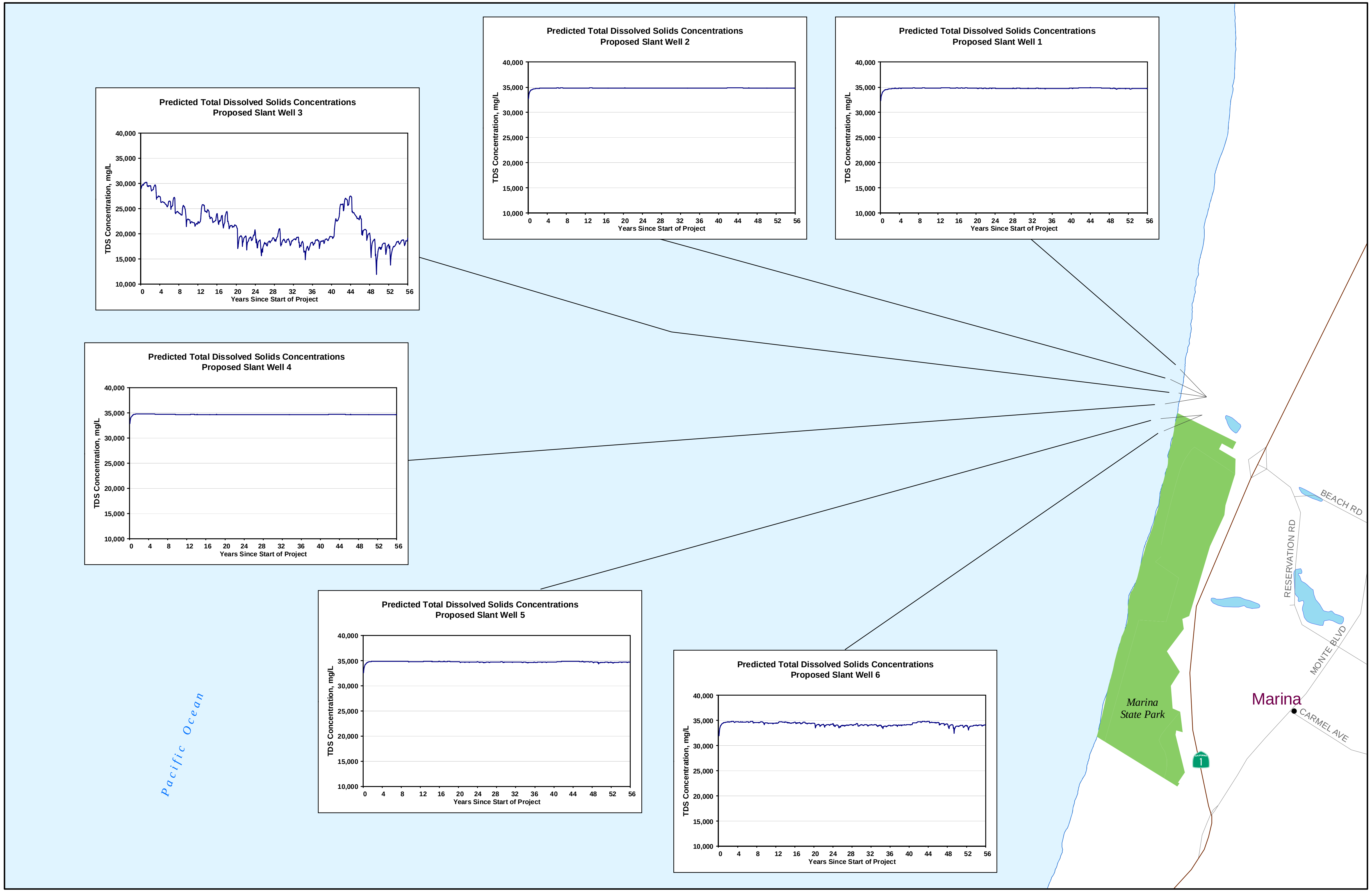
Figure 15

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_15_Slant_Wells_180ft_SWI_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

PREDICTED TDS CONCENTRATIONS FROM REGIONAL PROJECT SLANT WELLS



EXPLANATION

- Slant Wells
- Marina State Park
- Highway
- Major Roads

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2,000 4,000 Feet

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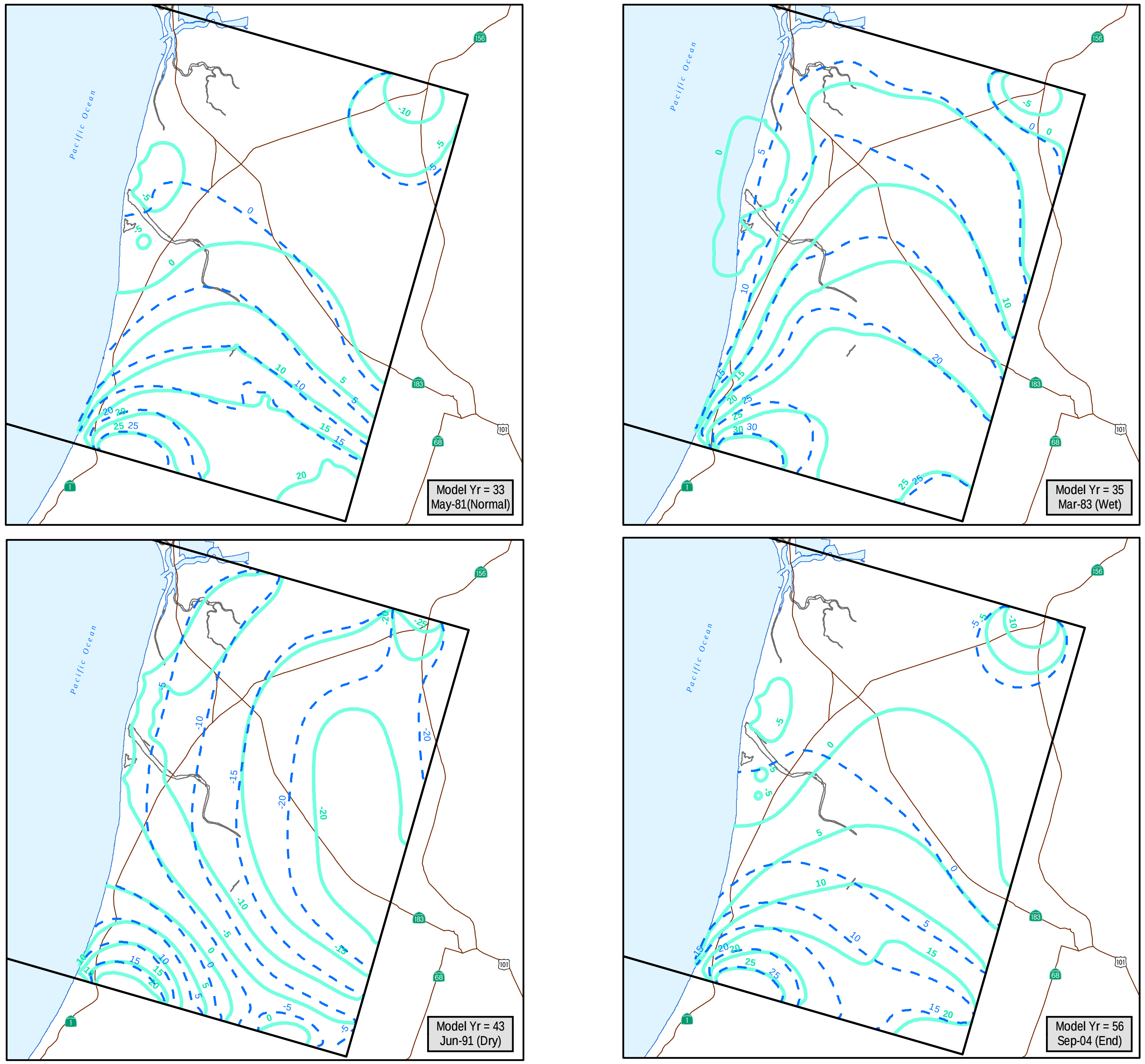
Figure 16

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_16_TDS_graphs_slant_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

180FT AQUIFER BASELINE vs. REGIONAL PROJECT SCENARIO 3a GROUNDWATER ELEVATIONS



EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- Baseline Groundwater Elevation, ft amsl
- Regional Project Scenario Groundwater Elevation, ft amsl
- Highway
- Model Yr = 13 Jun-1961 (Dry): Predictive Model Year* / Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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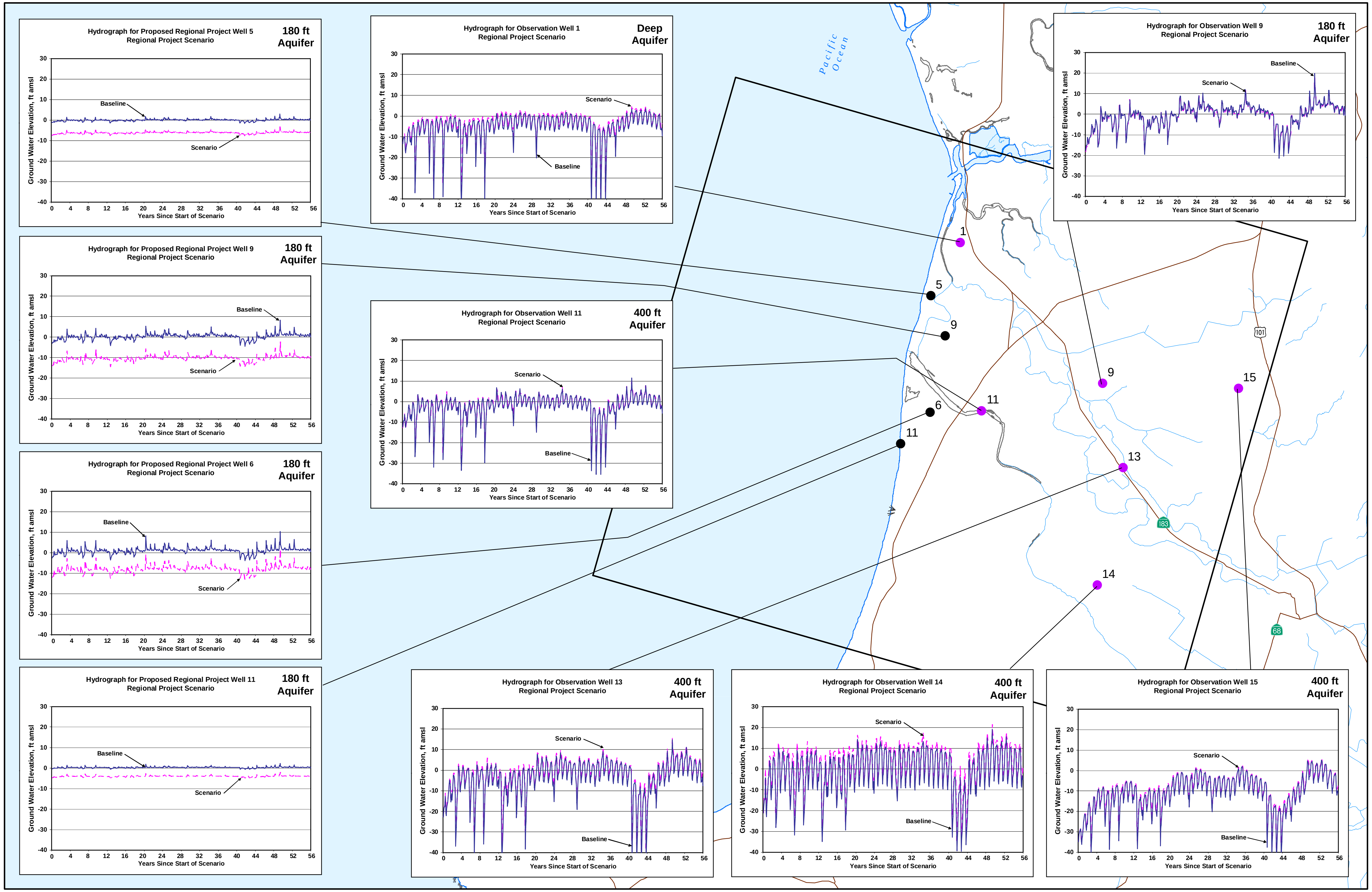
Figure 17

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_17_reg_proj_180ft_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

REGIONAL PROJECT SCENARIO 3a HYDROGRAPHS



EXPLANATION

Well Hydrograph Locations

- Monterey Regional Project Well
- WRIME Calibration Well
- Slant Wells
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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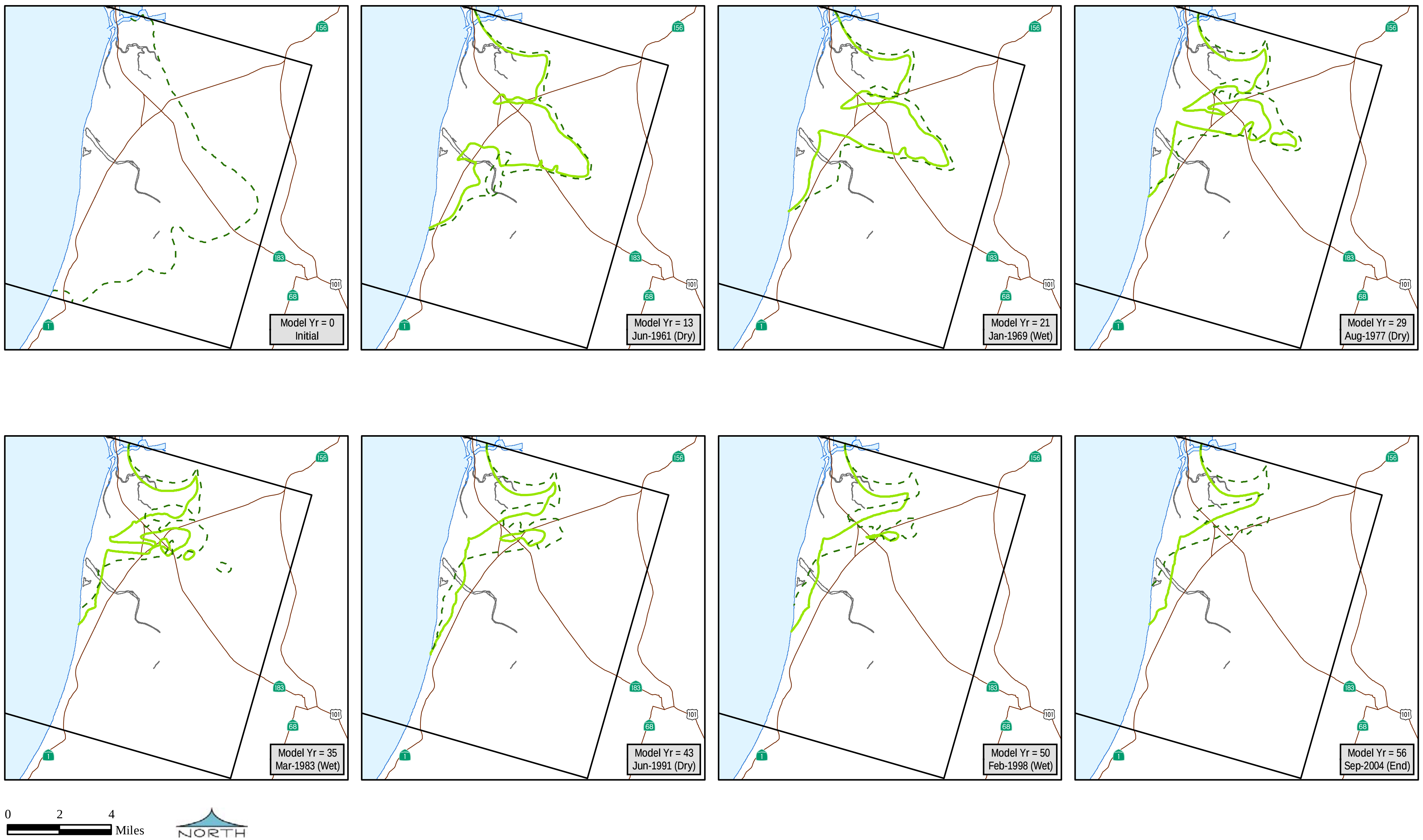
Figure 18

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_18_3a_reg_proj_Hydrographs_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



180-FOOT AQUIFER BASELINE vs. REGIONAL PROJECT SCENARIO 3a SEAWATER INTRUSION

EXPLANATION

GEOSCIENCE Groundwater Model Boundary

Baseline Seawater Intrusion Chloride = 500 mg/L

Regional Project Scenario Seawater Intrusion, Chloride = 500 mg/L

Highway

Model Yr = 13
Jun-1961 (Dry)

Predictive Model Year*
Hydrologic Year

* Years Since Start of Model Scenario

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Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

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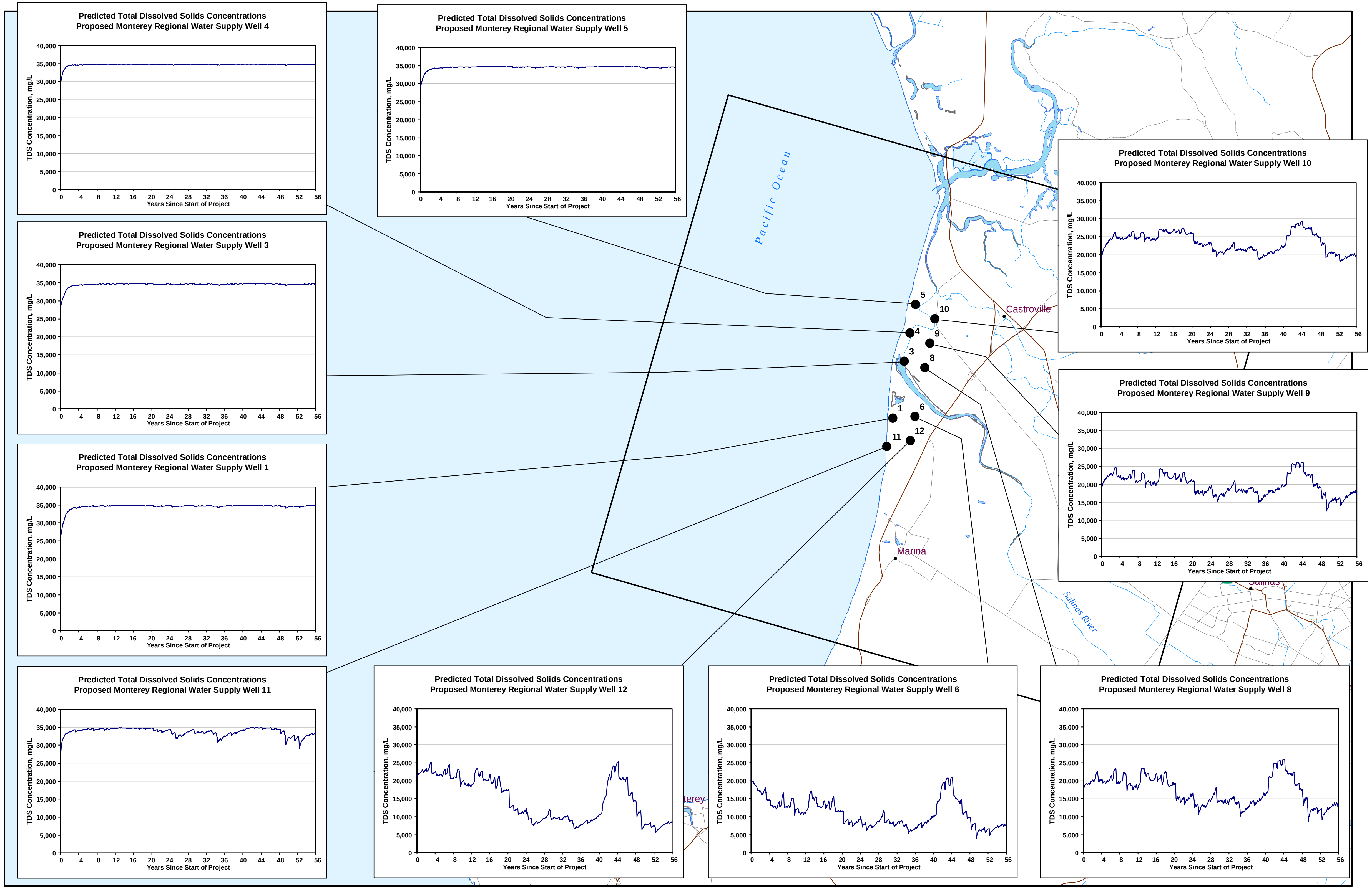
Figure 19

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_19_3a_reg_proj_180ft_SWI_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

PREDICTED TDS CONCENTRATIONS FROM REGIONAL PROJECT EXTRACTION WELLS



EXPLANATION

- Monterey Regional Project Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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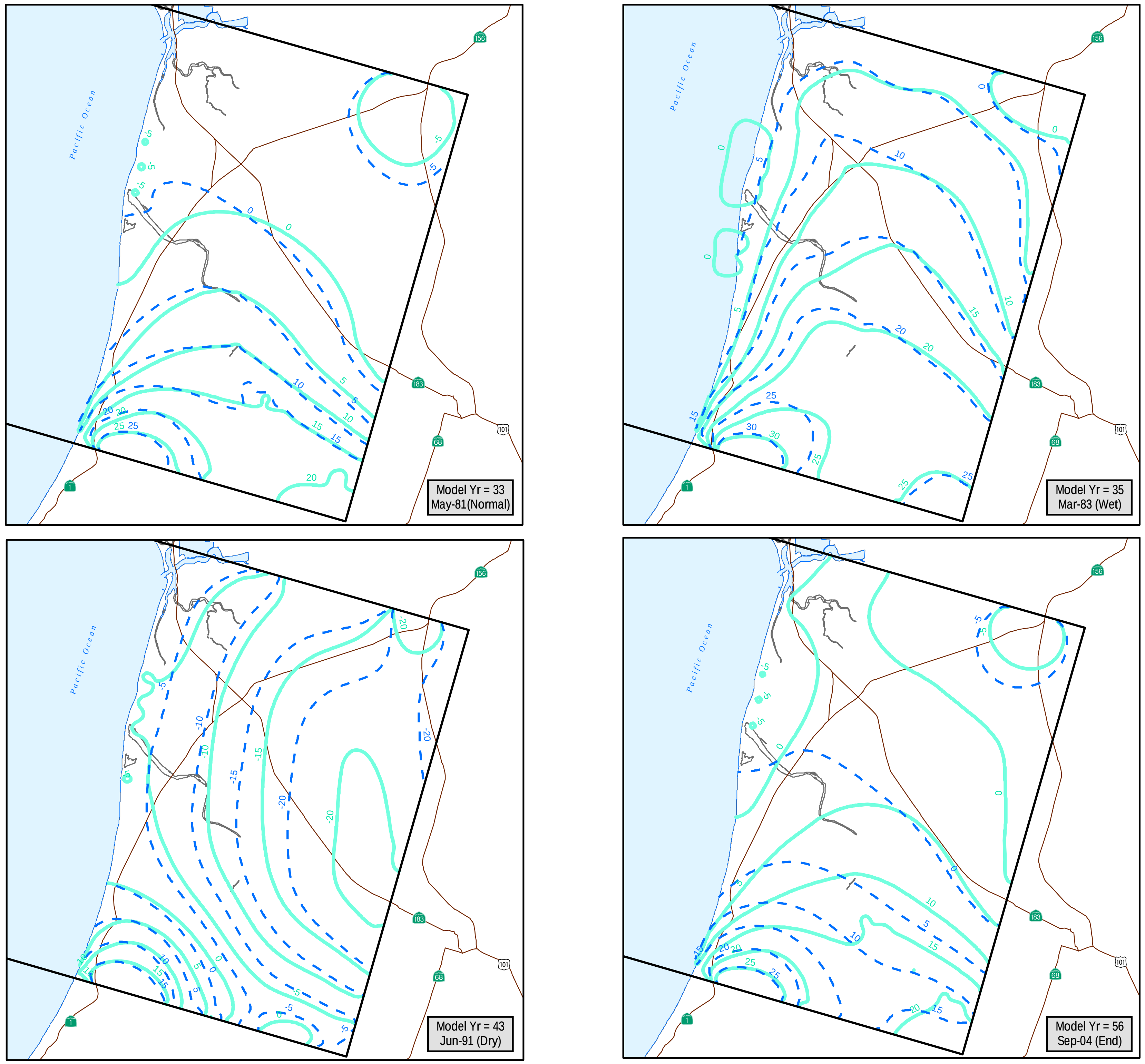
Figure 20

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_20_TDS_graphs_regional_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS



180-FOOT AQUIFER BASELINE vs. REGIONAL PROJECT SCENARIO 4b GROUNDWATER ELEVATIONS

EXPLANATION

GEOSCIENCE Groundwater Model Boundary

Baseline Groundwater Elevation, ft amsl

Regional Project Scenario 4b Grounwater Elevation, ft amsl

Highway

Model Yr = 13 Jun-1961 (Dry) — Predictive Model Year* Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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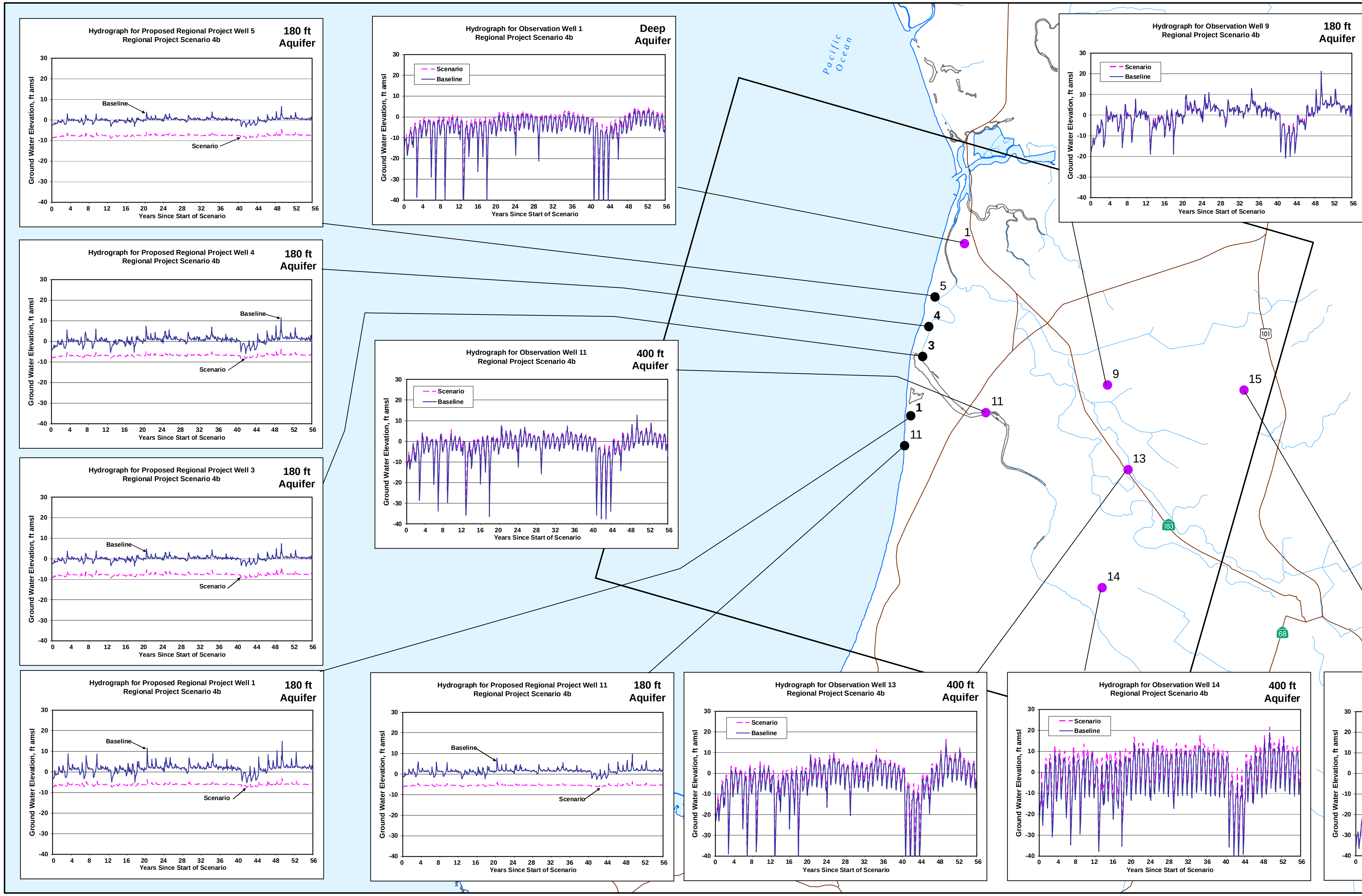
Figure 21

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

REGIONAL PROJECT SCENARIO 4b HYDROGRAPHS



EXPLANATION

Well Hydrograph Locations

- Monterey Regional Project Well
- WRIME Calibration Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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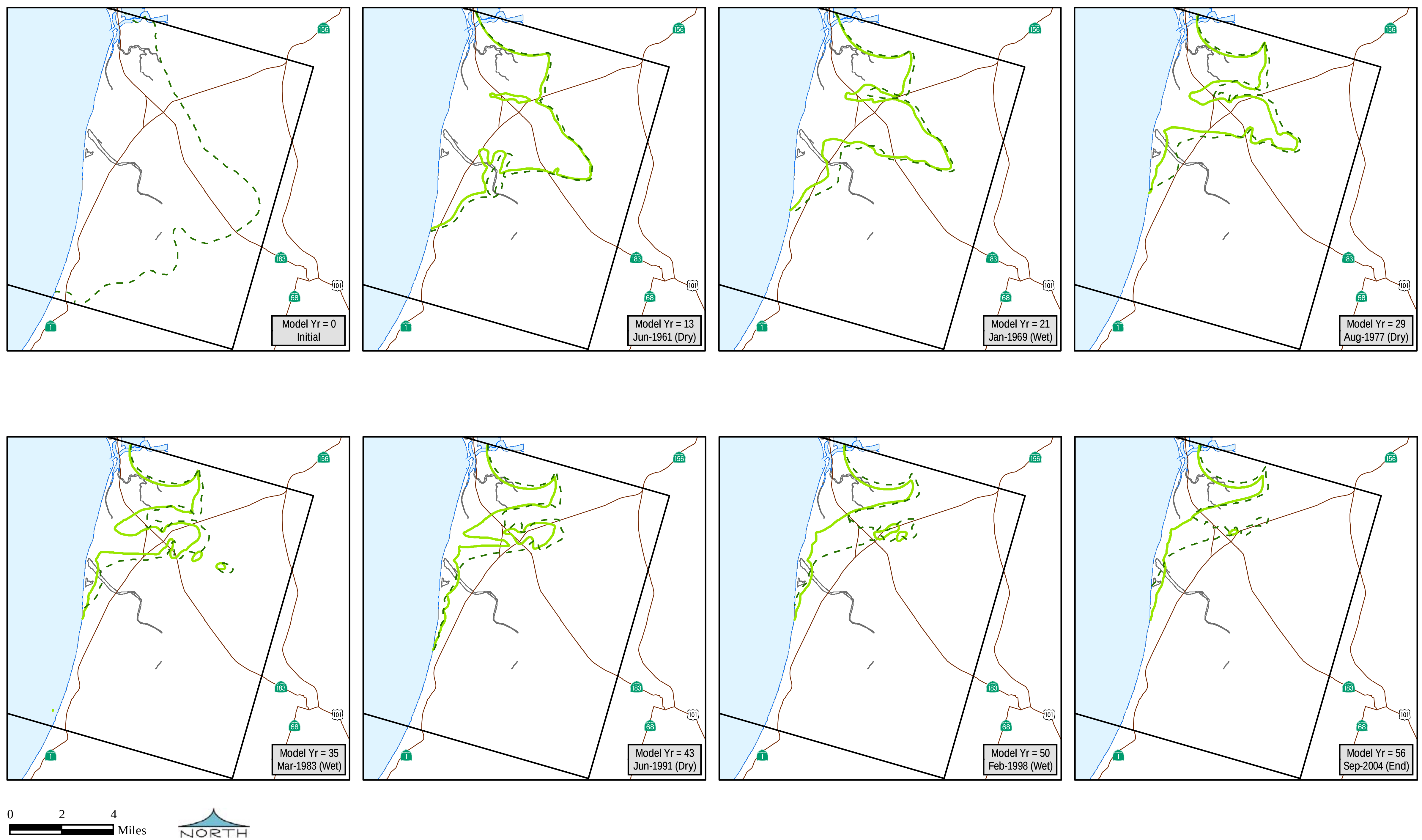
Figure 22

GIS_proj/cal_am_north_marina_modeling_9-08//0_Fig_22_4a_reg_proj_Hydrographs_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

180-FOOT AQUIFER BASELINE vs. REGIONAL PROJECT SCENARIO 4b SEAWATER INTRUSION



EXPLANATION

- GEOSCIENCE Groundwater Model Boundary
- Baseline Seawater Intrusion Chloride = 500 mg/L
- Regional Project Scenario Seawater Instrusion, Chloride = 500 mg/L
- Highway

Model Yr = 13 Jun-1961 (Dry) — Predictive Model Year* / Hydrologic Year

* Years Since Start of Model Scenario

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

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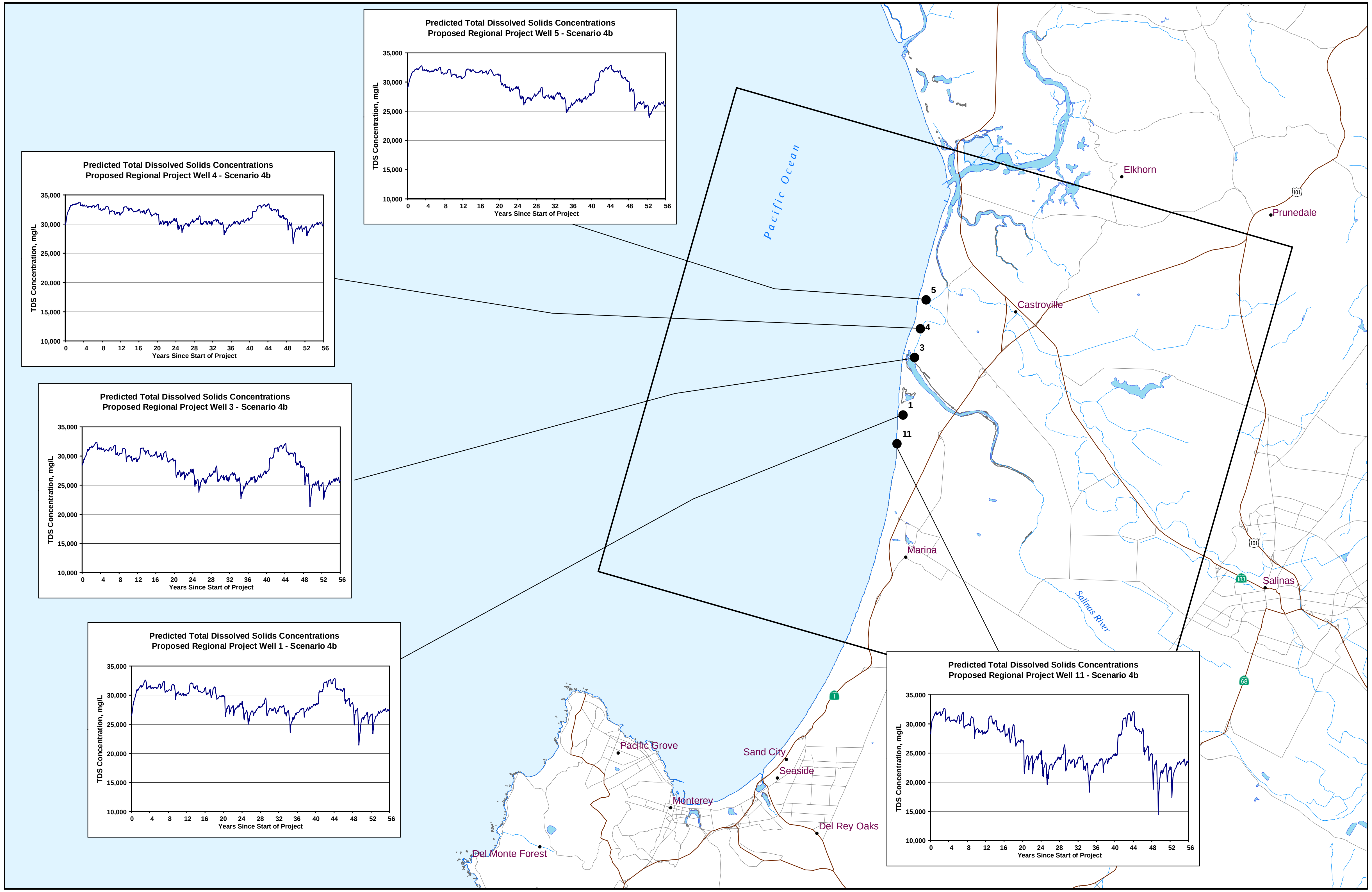
Figure 23

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_3_4a_reg_proj_180ft_SWI_9-08.mxd

CALIFORNIA AMERICAN WATER

NORTH MARINA GROUNDWATER MODEL
EVALUATION OF POTENTIAL PROJECTS

PREDICTED TDS CONCENTRATIONS FROM REGIONAL PROJECT SCENARIO 4b EXTRACTION WELLS



EXPLANATION

- Monterey Regional Project Well
- GEOSCIENCE Groundwater Model Boundary
- Highway
- Major Roads
- Rivers and Creeks

26-Sep-08

Prepared by: DWB

Map Projection:
State Plane 1983, California Zone IV

NORTH

0 2 4 Miles

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Figure 24

GIS_proj/cal_am_north_marina_modeling_9-08/0_Fig_24_TDS_graphs_regional_9-08.mxd