

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING

**RIVERSIDE CORONA FEEDER PROJECT
CONJUNCTIVE USE SCENARIOS**

PREPARED FOR:

**WESTERN MUNICIPAL
WATER DISTRICT**

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SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

1.0 EXECUTIVE SUMMARY

Western Municipal Water District (Western) is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and to meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County. Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), to store that water in the SBBA when it is available, and to extract water from the basin when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

The RCF is supported by, and fully consistent with, MWD's Integrated Resource Plan, the Santa Ana Watershed Project Authority's Integrated Watershed Plan, and the regional water planning efforts for the cities of Riverside, Norco, and Corona, Elsinore Valley Municipal Water District, Jurupa Community Services District, Home Gardens County Water District, Lee Lake Water

District, and the March Air Reserve Base.

In order to address the comments to the Notice of Preparation for the RCF Realignment Supplemental EIR made by the City of San Bernardino Municipal Water District (SBMWD) and the City of Colton, groundwater modeling was performed to assess potential groundwater impacts due to the RCF including impacts to the Western Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods were addressed. Results of the model predictive runs were summarized in the reports entitled “Groundwater Modeling of Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated October 23, 2009 and “Groundwater Modeling of TDS and Nitrate-Nitrogen Concentrations Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated December 23, 2009.

The purpose of this groundwater modeling was to conduct a sensitivity analysis of the RCF conjunctives use scenarios under prolonged dry base period conditions and to evaluate potential impacts of the RCF conjunctive use scenarios on the land subsidence in the SBBA. The scope of work included:

- Select a prolonged dry base period for the predictive model runs;
- Develop Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios;
- Run groundwater flow model for the Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios;
- Augment the SBBA Refined Basin Flow Model (RBFM) by incorporating the land subsidence simulation capability so that the land subsidence potential can be evaluated;

- Run the groundwater flow model with the subsidence simulation for Baseline Run and RCF conjunctive use scenarios as well as the Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios; and
- Prepare a report summarizing the modeling results.

In the previous modeling report, the 26-year period from January 1979 through December 2004 was selected for the hydrologic base period for the Baseline Run and RCF conjunctive use Scenarios 1 through 3 based on monthly data availability and analyses of historical precipitation and streamflow. This base period covers both wet and dry hydrologic cycles and the average precipitation and streamflow are approximately the same as the long-term average. For the sensitivity predictive runs, a prolonged dry hydrologic base period from January 1945 through December 1968 was assumed to represent future conditions for the 24-year period from January 2007 through December 2030. During this period, the average annual precipitation was 14.00 inches at the San Bernardino County Hospital Station compared to a long term average of 16.19 inches. The average annual streamflow at the Santa Ana River (SAR) near Mentone gaging station was 36,400 acre-ft compared to the long term average of 57,000 acre-ft during the same period of time.

A total of four predictive model runs was made using the RBFM to assess the potential impacts of the RCF on groundwater levels and groundwater storage. These model runs are:

- Prolonged Dry Baseline Run (No Project)
- Prolonged Dry RCF Scenario 1
- Prolonged Dry RCF Scenario 2
- Prolonged Dry RCF Scenario 3

In order to simulate the subsidence potential (i.e., elastic compaction and expansion and inelastic compaction of compressible aquifers), the RBFM was augmented by incorporating the Subsidence and Aquifer-System Compaction (SUB) Package into the model. The SUB package is used in conjunction with MODFLOW to simulate time-dependent drainage and compaction of compressible aquifer strata. The model was calibrated using 41 observed land subsidence data during the period 1945 to 2000 at 10 selected target sites. The model calibration is acceptable with a relative error of 9.3 % (below the recommended error of 10%).

A total of eight predictive model runs was made using the RBFM integrated with SUB package to assess the potential subsidence impacts of the RCF, including four model runs using the average base period (1979 to 2004) and four model runs using the prolonged dry base period (1945 to 1968). These model runs are:

- Average Base Period (1979 to 2004)
 - Baseline Run (No Project)
 - RCF Scenario 1
 - RCF Scenario 2
 - RCF Scenario 3
- Prolonged Dry Base Period (1945 to 1968)
 - Prolonged Dry Baseline Run (No Project)
 - Prolonged Dry RCF Scenario 1
 - Prolonged Dry RCF Scenario 2
 - Prolonged Dry RCF Scenario 3

Based on results of the sensitivity of the prolonged dry base period and land subsidence modeling, the following conclusions have been made for the RCF Conjunctive Use scenarios:

- For RCF Prolonged Dry Scenario 1, there is no change in water level from the Prolonged Dry Baseline Run (No Project) due to no Project artificial recharge or groundwater pumping. Water level changes range from zero (no change) to a rise of 32 ft for RCF Prolonged Dry Scenario 2 as compared to the Prolonged Dry Baseline Run (No Project). For RCF Prolonged Dry Scenario 3, these changes range from a decline of one foot to a rise of 38 ft. Water levels in most of the wells would increase due to the artificial recharge from the RCF.
- Based on results from iterative model runs, RCF Prolonged Dry Scenario 1 consists of no artificial recharge or groundwater pumping during the 24 years from 2007 through 2030 (see Figure 8). RCF Prolonged Dry Scenario 2 includes artificial recharge of 203,200 acre-ft and groundwater pumping of 140,000 acre-ft (see Figure 9). RCF Prolonged Dry Scenario 3 includes artificial recharge of 300,000 acre-ft and groundwater pumping of 205,000 acre-ft (see Figure 10).
- Groundwater storage in the SBBA declines by 747,490 acre-ft during the period 2007 through 2030 under Prolonged Dry Baseline Run (No Project) conditions (see Table 2). Groundwater storage decline for RCF Prolonged Dry Scenario 1 would be the same as the Prolonged Dry Baseline Run (No Project) conditions due to no RCF artificial recharge or groundwater pumping (see Table 3). Groundwater storage decline for RCF Prolonged Dry Scenarios 2 and 3 would be less than under Prolonged Dry Baseline Run (No Project) conditions, which are estimated be negative (“-“) 702,419 acre-ft and negative 682,313 acre-ft (see Tables 4 and 5, respectively). These results indicate that more water (45,071 acre-ft for Prolonged Dry Scenario 2 and 65,177 acre-ft for Prolonged Dry Scenario 3) was recharged over the 24 years than what was necessary to maintain a total recharge equal to the Prolonged Dry Baseline Run (No Project) conditions.

- The annual average underflow outflow across the San Jacinto Fault near the SAR to the Rialto-Colton Groundwater Basin for the period 2007 to 2030 was estimated to be 245 acre-ft/yr under Prolonged Dry Baseline Run (No Project) conditions. The underflow outflow was estimated to be 245 acre-ft/yr, 246 acre-ft/yr, and 248 acre-ft/yr for the RCF Prolonged Dry Scenarios 1 through 3, respectively (see Table 6). These changes in underflow outflow are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project).
- For purpose of this report, the efficiency of the Conjunctive Use project was calculated as the ratio of the amount of additional groundwater pumping plus the increase in groundwater storage to the amount of additional artificial recharge. The efficiency is 91% for Prolonged Dry Scenario 2 and 90% for Prolonged Dry Scenario 3. The efficiency was optimized based on iterative model runs by varying the timing and amount of artificial recharge and groundwater pumping. The major loss of water for the conjunctive use model runs would be due to the increase in evapotranspiration as well as the reduction of recharge from streamflow due to increases in water levels as a result of additional artificial recharge at the spreading grounds in the forebay area.
- The changes in land subsidence are minimal for the RCF scenarios as compared to the Baseline Run (No Project) under the average base period conditions (1979 to 2004). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under RCF Scenarios 2 and 3 conditions ranging from a total of 0.01 ft to 0.03 ft during the 26 years (i.e., approximately 0.0004 ft/yr to 0.0012 ft/yr). These sites are located in the vicinity or hydraulically downgradient of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), there would be no change or decrease in land subsidence.
- The changes in land subsidence are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project) under the prolonged dry base

period conditions (1945 to 1968). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under Prolonged Dry Scenario 3 conditions ranging from a total of 0.01 ft to 0.02 ft during the 24 years (i.e., approximately 0.0004 ft/yr to 0.0008 ft/yr). These sites are located in the vicinity of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), there would be no change or decrease in land subsidence.

The SBBA RBFM and RBFM integrated with SUB Package are useful tools for evaluating water levels, groundwater storage and land subsidence. However, it is a simplified approximation of a complex hydrogeologic system. The accuracy of model predictions is dependent on the assumptions used for the model prediction.

The purpose of this Prolonged Dry Baseline Run was to establish the no project conditions so that the potential groundwater storage and land subsidence impacts from the RCF conjunctive use scenarios under the prolonged dry base period conditions can be compared to. To prevent decline in groundwater storage and land subsidence under the prolonged dry conditions, specific water management strategies would need to be implemented to make up for the decline in water levels.

2.0 INTRODUCTION

2.1 Background

Western Municipal Water District (Western) is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and to meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County (see Figure 1). Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells as shown in Figure 2. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), to store that water in the SBBA when it is available, and to extract water from the basin when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

The RCF is supported by, and fully consistent with, MWD's Integrated Resource Plan, the Santa Ana Watershed Project Authority's Integrated Watershed Plan, and the regional water planning efforts for the cities of Riverside, Norco, and Corona, Elsinore Valley Municipal Water District, Jurupa Community Services District, Home Gardens County Water District, Lee Lake Water District, and the March Air Reserve Base.

In order to address the comments to the Notice of Preparation for the RCF Realignment Supplemental EIR made by the City of San Bernardino Municipal Water District (SBMWD)

(2008) and the City of Colton (2008), groundwater modeling was performed to assess potential groundwater impacts due to the RCF including impacts to the Western Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods were addressed. Results of the model predictive runs were summarized in the reports entitled “Groundwater Modeling of Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated October 23, 2009 (GEOSCIENCE, 2009a) and “Groundwater Modeling of TDS and Nitrate-Nitrogen Concentrations Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated December 23, 2009 (GEOSCIENCE, 2009b).

2.2 Purpose and Scope

The purpose of this groundwater modeling was to conduct a sensitivity analysis of the RCF conjunctives use scenarios under prolonged dry base period conditions and to evaluate potential impacts of the RCF conjunctive use scenarios on the land subsidence in the SBBA. The scope of work included:

- Select a prolonged dry base period for the predictive model runs;
- Develop Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios;
- Run groundwater flow model for the Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios;
- Augment the SBBA Refined Basin Flow Model (RBFM) by incorporating the land subsidence simulation capability so that the land subsidence potential can be evaluated;
- Run the groundwater flow model with the subsidence simulation for Baseline Run and RCF conjunctive use scenarios as well as the Prolonged Dry Baseline Run and RCF prolonged dry conjunctive use scenarios; and

- Prepare a report summarizing the modeling results.

2.3 Sources of Data

Data used for this study was obtained from multiple sources. The primary sources and the types of data provided by them are summarized as follows:

- Metropolitan Water District of Southern California (2009): Availability of SWP water for hydrology years 1922 through 2003.
- Albert A. Webb Associates (2009): Proposed locations of RCF facilities, pipelines, and groundwater pumping wells.
- United States Geological Survey (USGS): Electronic file of unpublished land subsidence data.

A complete list of references is included in Section 7.0 of this report.

3.0 SENSITIVITY TO PROLONGED DRY BASE PERIOD

Groundwater flow models have been used in the SBBA over the past two decades. The latest refinement process was a cooperative technical effort involving representatives of SBMWD and Valley District, their respective consultants at Stantec Consulting (Stantec) and GEOSCIENCE, and Mr. Wes Danskin of the USGS. The cooperative effort was initiated to avoid the development of two different models and to develop one model that would be compatible and defensible. The USGS Basin Flow Model was collaboratively refined by Stantec and GEOSCIENCE and is known as the Newmark Groundwater Flow Model/Refined Basin Flow Model (NGFM/RBFM) (GEOSCIENCE, 2009c and Stantec, 2008). RBFM was used to conduct sensitivity analysis for Baseline Run (No Project) RCF conjunctive use scenarios under prolonged dry base period conditions.

3.1 Prolonged Dry Base Period Model Scenarios

In the previous report (GEOSCIENCE, 2009a), the 26-year period from January 1979 through December 2004 was selected for the hydrologic base period for the Baseline Run and RCF conjunctive use Scenarios 1 through 3 based on monthly data availability and analyses of historical precipitation and streamflow. This base period covers both wet and dry hydrologic cycles and the average precipitation and streamflow are approximately the same as the long-term average. For the sensitivity predictive runs, a prolonged dry hydrologic base period from January 1945 through December 1968 was assumed to represent future conditions for the 24-year period from January 2007 through December 2030. During this period, the average annual precipitation was 14.00 inches at the San Bernardino County Hospital Station compared to a long term average of 16.19 inches (see Figure 3). The average annual streamflow at the Santa Ana River (SAR) near Mentone gaging station was 36,400 acre-ft compared to the long term average of 57,000 acre-ft (see Figure 4) during the same period of time.

A total of four predictive model runs was made using the RBFM to assess the potential impacts of the RCF on groundwater levels and groundwater storage. These model runs are:

- Prolonged Dry Baseline Run (No Project)
- Prolonged Dry RCF Scenario 1
- Prolonged Dry RCF Scenario 2
- Prolonged Dry RCF Scenario 3

The RCF Prolonged Dry Scenarios includes two “bookend” scenarios (Scenarios 1 and 3) and one “most likely” scenario (Scenario 2). “Bookend” conditions are generally described as conditions that result from artificial recharge and groundwater pumping schedules that are likely to cause the most environmentally stressful conditions (Scenario 3) and conditions that are the least stressful (Scenario 1) than those encountered under the “most likely” scenario. Results from the RCF Prolonged Dry Scenarios were compared to the Prolonged Dry Baseline Run (No Project). The following sections discuss the modeling assumptions for the model scenarios.

3.2 Model Assumptions for Prolonged Dry Baseline Run (No Project)

The original Baseline Run was conducted by GEOSCIENCE for the Upper Santa Ana River Watershed Integrated Regional Water Management Plan (IRWMP) (GEI Consultants, SAIC, and GEOSCIENCE, 2007). The IRWMP Baseline Run 1 was updated by Stantec and GEOSCIENCE in June 2009 to include changes to the IRWMP Baseline Run 1. This updated Baseline Run is named as the Baseline Run in the previous groundwater modeling report (GEOSCIENCE, 2009a). The Prolonged Dry Baseline Run uses the same projected water demands as the Baseline Run with a prolonged dry base period from January 1945 through December 1968 instead of an average base period from January 1979 through December 2004.

3.2.1 Groundwater Pumping

The Prolonged Dry Baseline Run groundwater pumping was determined based on future water demands obtained from 2005 Urban Water Management Plans and updated information presented by City of Colton, City of Redlands, SBMWD, East Valley Water District, and West Valley Water District at the 7-Nov-08 meeting. Figure 5 shows the projected groundwater

pumping for the Prolonged Dry Baseline Run. During the model period 2007 to 2030, the groundwater pumping ranges from 210,500 acre-ft in 2008 (hydrologic year 1946) to 289,800 acre-ft in 2025 (hydrologic year 1963) with an average of 250,300 acre-ft/yr.

3.2.2 Artificial Recharge

The Prolonged Dry Baseline artificial recharge consists of Santa Ana River diversions and the Valley District's Replenishment Obligation. The following table summarizes the assumptions for the Santa Ana River diversion.

Assumptions of Santa Ana River Diversion for Prolonged Dry Baseline Run

Santa Ana River Diversion	Diversion by SBVWCD	SBVWCD's Licensed Rights
	Diversion by Senior Water Rights Claimants	Seven Oaks Accord
	Valley District/Western	SAR Water Right Applications

For purposes of this sensitivity analysis, the assumption for the Valley District's artificial recharge was based on the availability of the amount of SWP water. Figure 6 shows the final amount of artificial recharge for the Prolonged Dry Baseline Run. As shown for the Prolonged Dry Baseline Run, the artificial recharge ranges from 15,800 acre-ft in year 2017 (hydrologic year 1955) to 131,500 acre-ft in year 2029 (hydrologic year 1967) with an average of 74,700 acre-ft/yr. Figure 7 shows the spreading grounds used for artificial recharge.

3.3 Model Assumptions for Riverside-Corona Feeder Project Prolonged Dry Scenarios

Three model predictive scenarios were run for a 24-year period (2007 through 2030) with monthly stress periods. The RCF Prolonged Dry Scenarios use the same assumptions as the Prolonged Dry Baseline Run (No Project), except these RCF prolonged dry conjunctive use

scenarios include additional project artificial recharge and groundwater pumping. The actual amount of RCF artificial recharge and pumping will vary year to year, depending upon natural hydrologic conditions that may affect the timing of available surplus water, spreading ground capacity, and basin groundwater levels (i.e., storage). The artificial recharge and pumping schedules for the RCF Prolonged Dry Scenarios have been quantified through iterative model runs so that total project extraction (i.e., pumping) is lower than total project replenishment (see Figures 8 through 10). As a result, the SBBA storage for each RCF Prolonged Dry Scenario will always be equal to or above the storage for the Prolonged Dry Baseline Run (No Project). The following sections discuss the modeling assumptions for the RCF prolonged dry scenarios.

3.3.1 Riverside-Corona Feeder Project Artificial Recharge

An artificial recharge schedule for each of the three RCF Prolonged Dry Scenarios was developed from surplus water availability data for the period from 1922 through 2003 (MWD, 2009). This is the same approach used in the previous groundwater modeling report (GEOSCIENCE, 2009a). Surplus water is available when the combined total of MWD's Table A and Article 21 allocations exceed 1,330,000 acre-ft/yr¹. Water is available for the RCF when surplus water for MWD exceeds 250,000 acre-ft (see Figure 11). Based on 2008 surplus water availability projections, it is assumed that surplus water will be available for the RCF approximately 28% of the time (see Figure 11).

The initial artificial recharge schedules for each RCF Prolonged Dry Scenario are based on availability of surplus water that are likely to cause the most environmentally stressful conditions (at 28% exceedance level) and conditions less stressful (at 2.8% exceedance level) than those encountered under the "most likely" condition (at 20% exceedance level). Those are the same exceedance levels used in the previous report (GEOSCIENCE, 2009a). The artificial recharge schedules for each RCF Prolonged Dry Scenario are:

- Prolonged Dry Scenario 1 simulates RCF artificial recharge to occur when MWD surplus

¹ SWP deliveries in excess of 70% of MWD's contracted amount of 1.9 million acre-ft/yr.

water is equal to or exceeds 718,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 2.8% or less of the time.

- Prolonged Dry Scenario 2 simulates RCF artificial recharge to occur when MWD surplus water is equal to or exceeds 485,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 20% or less of the time.
- Prolonged Dry Scenario 3 simulates RCF artificial recharge to occur when MWD surplus water is equal to or exceeds 250,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 28% or less of the time.

These forecasts are based on the long-term general increase in water demand associated with growth and the availability of imported water for direct delivery by MWD.

Based on results from iterative model runs, RCF Prolonged Dry Scenario 1 consists of no artificial recharge during the 24 years from 2007 through 2030 (i.e., hydrologic years from 1945 through 1968) (see Figure 8). RCF Prolonged Dry Scenario 2 includes artificial recharge of 203,200 acre-ft (see Figure 9). RCF Prolonged Dry Scenario 3 includes artificial recharge of 300,000 acre-ft (see Figure 10).

3.3.2 Riverside-Corona Feeder Project Groundwater Pumping

Five new wells are to be located within the Redlands-Crafton plume at the eastern end of the proposed Riverside-Corona Feeder Pipeline (see Figure 2). The maximum capacity for each well is estimated to be 3,000 acre-ft/yr (total of 15,000 acre-ft/yr) based on local geohydrologic conditions.

Based on results from iterative model runs, RCF Prolonged Dry Scenario 1 consists of no groundwater pumping during the 24 years from 2007 through 2030 (i.e., hydrologic years from 1945 through 1968; see Figure 8). RCF Prolonged Dry Scenario 2 includes pumping a total of

140,000 acre-ft (see Figure 9). RCF Prolonged Dry Scenario 3 includes pumping a total of 205,000 acre-ft (see Figure 10).

3.4 Initial Groundwater Elevations for Predicted Model Scenarios

Groundwater elevations obtained from the end of the RBFM model calibration results (i.e., December 2006) were used as initial groundwater elevations for the Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios 1 through 3.

3.5 Model Results

3.5.1 Groundwater Elevation

Groundwater elevation contours for the Prolonged Dry Baseline Run (No Project) in year 2030 (end of model simulation, hydrologic year 1968) are shown on Figure 12. In general, the model-generated groundwater flow direction is similar to historical directions with groundwater flowing west from the SAR and Mill Creek Spreading Grounds, and southeast from Lytle Creek and Cajon Creek (i.e., flowing to the Pressure Zone area). However, groundwater elevations in the Pressure Zone would be approximately 100 ft lower at the end of model simulation for the Prolonged Dry Baseline Run (under prolonged dry conditions from 1945 to 1968, see Figure 12) compared to the Baseline Run (under average hydrologic conditions from 1979 to 2004, see Figure 20 of GEOSCIENCE 2009a report).

Groundwater elevations in the year 2030 are shown in Figures 13 through 15 for RCF Prolonged Dry Scenarios 1 through 3, respectively. Groundwater flow directions and general patterns of fluctuations for the three RCF prolonged dry scenarios are similar to the Prolonged Dry Baseline Run (No Project).

Hydrographs at selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/Riverside Agreement) for the Prolonged Dry

Baseline Run (No Project) and the RCF Prolonged Dry Scenarios 1 through 3 are provided in Appendix A. The approximate locations of these wells are shown as insets on the hydrographs in Appendix A. These hydrographs show the temporal variations in groundwater levels reflecting the hydrologic conditions, artificial recharge, and groundwater pumping assumed for the Prolonged Dry Baseline Run (No Project) and the RCF prolonged dry scenarios.

For each of the selected wells in Appendix A, the average simulated groundwater elevations and the difference between the average groundwater elevations for the Prolonged Dry Baseline Run (No Project) with respect to the RCF prolonged dry scenarios are summarized in Table 1. As shown, for RCF Prolonged Dry Scenario 1, there is no change in water level from the Prolonged Dry Baseline Run (No Project) due to no additional recharge or groundwater pumping. Water level changes range from zero (no change) to a rise of 32 ft for RCF Prolonged Dry Scenario 2 as compared to the Prolonged Dry Baseline Run (No Project). For RCF Prolonged Dry Scenario 3, these changes range from a decline of one foot to a rise of 38 ft. Water levels in most of the wells would increase due to the artificial recharge from the RCF.

3.5.2 Groundwater Budget

The overall water budgets for each of the model runs were compiled to evaluate the RCF prolonged dry scenarios. The inflow terms for the model include recharge to groundwater from gaged streamflow, artificial recharge, local runoff generated by precipitation, infiltration from direct precipitation, return flow from groundwater pumping, ungaged mountain front runoff, and underflow. The outflow terms comprise evapotranspiration, groundwater pumping, and underflow. The difference between the total inflow and total outflow is the change in groundwater storage. Annual groundwater budgets for each scenario are shown in Tables 2 through 5 for the Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios 1 through 3, respectively. The average annual groundwater budgets for these model runs during the period from 2007 to 2030 are shown in Figure 16. The groundwater budgets for the period 2007 to 2030 for these model runs are shown in the following table:

Summary Water Budgets – 2007 to 2030

Prolonged Dry Scenarios

Flux Terms			Prolonged Dry Baseline Run (No Project) [acre-ft]	RCF Prolonged Dry Scenario 1 [acre-ft]	RCF Prolonged Dry Scenario 2 [acre-ft]	RCF Prolonged Dry Scenario 3 [acre-ft]
Inflow	Recharge from Gaged Streamflow		1,988,509	1,988,509	1,988,509	1,988,509
	Artificial Recharge	Others	1,792,214	1,792,214	1,792,214	1,792,214
		RCF	0	0	203,196	300,000
	Recharge from Local Runoff Generated by Precipitation		110,248	110,248	110,248	110,248
	Infiltration from Direct Precipitation		25,991	25,991	25,991	25,991
	Return Flow from Groundwater Pumping		1,164,025	1,164,025	1,164,025	1,164,025
	Recharge from Ungaged Mountain Front Runoff		264,001	264,001	264,001	264,001
	Underflow Recharge		88,008	88,008	88,008	88,008
	Total Inflow		5,432,997	5,432,997	5,635,577	5,731,003
Outflow	Evapotranspiration		118,813	118,813	136,280	146,553
	Groundwater Pumping	Others	6,008,285	6,008,285	6,008,285	6,008,285
		RCF	0	0	140,000	205,000
	Underflow Discharge		53,388	53,388	53,430	53,479
	Total Outflow		6,180,486	6,180,486	6,337,995	6,413,316
Change in Groundwater Storage (Total Inflow – Total Outflow)			-747,490	-747,490	-702,419	-682,313

Groundwater storage in the SBBA declines by 747,490 acre-ft during the period 2007 through 2030 under Prolonged Dry Baseline Run (No Project) conditions. It is important to note that the purpose of this Prolonged Dry Baseline Run was to establish the no project conditions so that the potential groundwater storage impacts from the RCF conjunctive use scenarios under the prolonged dry base period conditions can be compared to. To prevent a decline of groundwater storage, specific water management strategies would need to be implemented to make up for the

loss under the prolonged dry conditions.

Groundwater storage decline for RCF Prolonged Dry Scenario 1 would be the same as the Prolonged Dry Baseline Run (No Project) conditions due to no RCF artificial recharge or groundwater pumping. Groundwater storage decline for RCF Prolonged Dry Scenarios 2 and 3 would be less than under Prolonged Dry Baseline Run (No Project) conditions, which are estimated be negative (“-“) 702,419 acre-ft and negative 682,313 acre-ft. These results indicate that more water (45,071 acre-ft for Prolonged Dry Scenario 2 and 65,177 acre-ft for Prolonged Dry Scenario 3) was recharged over the 24 years than what was necessary to maintain a total recharge equal to the Prolonged Dry Baseline Run (No Project) conditions.

The cumulative changes in groundwater storage for the historical period 1934 through 2006 (calculated based on groundwater levels) and for the predictive model runs 2007 to 2030 are shown in Figure 17. In general, the patterns of the cumulative changes in groundwater storage for the Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios 1 through 3 during the period 2007 to 2030 are similar to the historical prolonged dry base period from 1945 to 1968.

3.5.3 Underflow Outflow to Rialto-Colton Groundwater Basin

Groundwater underflow flows from the SBBA across the San Jacinto Fault near the SAR to the Rialto-Colton Groundwater Basin. The amount of underflow was quantified based on the model-predicted water levels in the Heap Well using the following equation (Danskin, et. al, 2006):

$$Q_{underflow} = 10^{(WL_{heap}-663.136)/96.876}$$

where:

$Q_{underflow}$ = Underflow across the San Jacinto Fault near the SAR, acre-ft/yr
 WL_{heap} = Groundwater elevation in the Heap Well, ft amsl

Based on the predicted water levels in the Heap Well, the amount of underflow across the San Jacinto Fault near the SAR for the period 2007 to 2030 for each model run is summarized in Table 6. As shown, the underflow outflow ranges from 46 acre-ft to 433 acre-ft with an annual average of 245 acre-ft/yr under Prolonged Dry Baseline Run (No Project) conditions. For RCF Prolonged Dry Scenario 1, the underflow would be the same as the Prolonged Dry Baseline Run during the same period of time. The underflow would range from 51 acre-ft to 433 acre-ft with an annual average of 246 acre-ft/yr for RCF Prolonged Dry Scenario 2 and range from 52 acre-ft to 433 acre-ft with an annual average of 248 acre-ft/yr for RCF Prolonged Dry Scenario 3. These changes in underflow outflow are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project).

Groundwater underflow also flows from the Lytle Basin of the SBBA across Barrier E to the Rialto-Colton Groundwater Basin. The amount of underflow was quantified based on the historical trend used for the model calibration and validation periods from 1945 to 2006. The average amount of underflow across Barrier E would be 1,980 acre-ft/yr for the Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios 1 through 3.

The following table summarizes the annual average underflow outflow from the SBBA to the Rialto-Colton Groundwater Basin for the 24-year period from 2007 to 2030:

**Summary of Annual Average Underflow Outflow
From SBBA to Rialto-Colton Groundwater Basin
2007 to 2030**

Outflow	Prolonged Dry Baseline Run (No Project)	RCF Prolonged Dry Scenario 1	RCF Prolonged Dry Scenario 2	RCF Prolonged Dry Scenario 3
Across San Jacinto Fault near SAR to Rialto-Colton Groundwater Basin	245	245	246	248
Across Barrier E to Rialto-Colton Groundwater Basin	1,980	1,980	1,980	1,980
Total	2,225	2,225	2,226	2,228

3.5.4 Efficiency of Conjunctive Use Scenarios

The water losses for the RCF Prolonged Dry Scenarios 1 through 3 as compared to the Prolonged Dry Baseline Run were calculated based on the water budgets. The water losses include reduction of recharge from gaged streamflow, increase in evapotranspiration and increase in underflow outflow. The following table summarizes these changes compared to the Prolonged Dry Baseline Run (No Project).

Summary of Water Losses

Flux Term	RCF Prolonged Dry Scenario 1 [acre-ft/yr]	RCF Prolonged Dry Scenario 2 [acre-ft/yr]	RCF Prolonged Dry Scenario 3 [acre-ft/yr]
Reduction in Recharge from Gaged Streamflow	0	26	84
Increase in Evapotranspiration	0	727	1,155
Increase in Underflow Outflow	0	1	3
Total	0	754	1,242

As shown in the table above, the major loss of recharge water of the conjunctive use project is from the evapotranspiration. These losses are 727 acre-ft/yr, and 1,115 acre-ft/yr for RCF Prolonged Dry Scenarios 2 and 3, respectively. These losses are due to high water levels in the forebay area as a result of the artificial recharge from the RCF.

For purposes of this report, the efficiency² of RCF conjunctive use was calculated as the ratio of the amount of additional groundwater pumping plus an increase in groundwater storage to the amount of additional artificial recharge. The efficiency was not calculated for the Prolonged Dry Scenario 1 due to no additional recharge/pumping. The efficiency is 91% for the Prolonged Dry Scenario 2 to 90% for the Prolonged Dry Scenario 3. The efficiency was optimized through varying the timing and amount of artificial recharge and groundwater pumping. The following table summarizes the conjunctive use efficiency:

² The efficiencies are based on the artificial recharge amount as well as groundwater pumping rates. These efficiencies can be higher if different pattern rates of recharge and pumping are applied.

Summary of Conjunctive Use Efficiency

Flux Term		RCF Prolonged Dry Scenario 1 [acre-ft/yr]	RCF Prolonged Dry Scenario 2 [acre-ft/yr]	RCF Prolonged Dry Scenario 3 [acre-ft/yr]
[1]	Artificial Recharge	0	8,467	12,500
[2]	Groundwater Pumping	0	5,833	8,542
[3]	Increase in Groundwater Storage	0	1,878	2,715
([2]+[3])/[1]		Not Applicable	91 %	90 %

4.0 LAND SUBSIDENCE MODELING

4.1 Historical Land Subsidence in the SBBA

Land subsidence as a result of groundwater, or other subsurface fluid, withdrawal has been recognized in many parts of California (Meade, 1968, Helm, 1975, Ireland et al., 1984, Poland and Ireland, 1988, Sneed and Galloway, 2000). In all cases, the measured subsidence is a function of excessive lowering of groundwater levels in areas where a significant portion of the subsurface consists of very fine-grained sediments (i.e., clay). In many cases, subsidence can be correlated with areas that historically were flowing artesian (the groundwater level was at or above the land surface).

Land subsidence due to declining groundwater levels has historically been reported in the SBBA (Lofgren, 1971; Miller and Singer, 1971; and Fife, 1976). These reports show that there was an average annual subsidence ranging from 0.015 ft/yr to 0.04 ft/yr during the period from 1944 to 1956 (see Figure 18). During the period from 1944 to 1969, at least one foot of subsidence had occurred in the Pressure Zone near the Raub well field and immediately north of Loma Linda between the San Jacinto and Loma Linda faults (Miller and Singer, 1971).

4.2 Description of Land Subsidence Model

In order to simulate the subsidence potential (i.e., elastic compaction and expansion and inelastic compaction of compressible aquifers), the RBFM was augmented by incorporating the Subsidence and Aquifer-System Compaction (SUB) Package (Hoffmann, et. al, 2003) into the model. The SUB package is used in conjunction with MODFLOW to simulate time-dependent drainage and compaction of compressible aquifer strata. The amount of stress imparted on the beds due to pumping, along with bed thickness and vertical hydraulic diffusivity determine whether the deformation is elastic (recoverable) or inelastic (permanent).

4.3 Land Subsidence Model Calibration

The method of calibration used by the land subsidence calibration was the standard “history matching” technique. In this method, a transient calibration period from 1945 to 2000 was chosen based on availability of observed land subsidence data. Model-generated land subsidence values were compared with measured land subsidence for sites both in the Pressure Zone and in the forebay area of the SBBA. Adjustments in model parameters such as elastic storativity, inelastic storativity and preconsolidation heads were then made within tolerable limits until a satisfactory match was obtained. Parameter changes during model calibration were assigned to groups of cells. Adjustment of individual parameters for individual model cells was not considered. The final calibrated elastic storage coefficient and inelastic storage coefficient values are shown in Figures 19 and 20, respectively. The calibrated preconsolidation heads were 50 ft below the 1945 groundwater elevations.

A graphical comparison between measured and model predicted land subsidence (from 10 target sites) for the subsidence calibration is shown in Figure 21. In Figure 21, the closer the land subsidence falls on the straight line, the better the "goodness-of-fit". Apart from the calibration evaluation of “goodness of fit”, another more qualitative approach is to calculate the relative error of the residuals (i.e., standard deviation of the residuals divided by the observed land subsidence range). Common modeling practice is to consider a good fit between historical and model predicted data if the relative error is below 10% (Spitz and Moreno, 1996; and Environmental Simulations, Inc., 1999). As seen in Figure 21, the relative error for 41 land subsidence measurements from 10 target sites is 9.3 %, which is below the recommended error of 10%.

4.4 Land Subsidence Model Scenarios

A total of eight predictive model runs was made using the RBFM integrated with SUB package to assess the potential subsidence impacts of the RCF, including four model runs using the average base period (1979 to 2004) and four model runs using the prolonged dry base period

(1945 to 1968). These model runs are:

- Average Base Period (1979 to 2004)
 - Baseline Run (No Project)
 - RCF Scenario 1
 - RCF Scenario 2
 - RCF Scenario 3
- Prolonged Dry Base Period (1945 to 1968)
 - Prolonged Dry Baseline Run (No Project)
 - Prolonged Dry RCF Scenario 1
 - Prolonged Dry RCF Scenario 2
 - Prolonged Dry RCF Scenario 3

Modeling assumptions for the first model scenarios can be found in Section 4 of the groundwater modeling report prepared by GEOSCIENCE (2009a). Modeling assumptions for the prolonged dry model runs can be found in Sections 3.1 through 3.3 of this report.

Preconsolidation heads for the predictive model runs were obtained from model calibrations results and are shown in Figure 22.

4.5 Land Subsidence Model Results

4.5.1 Model Runs Under Average Base Period Conditions (1979-2004)

Model predicted land subsidence over the model simulation period at selected locations (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/Riverside Agreement) for the Baseline Run (No Project) and the RCF Scenarios

1 through 3 under average base period conditions (1979 to 2004) are provided (see Appendix B). The approximate locations of these sites are shown as insets on the graphs in Appendix B.

For each of the selected sites in Appendix B, the simulated total land subsidence and the difference between the simulated land subsidence for the Baseline Run (No Project) with respect to the RCF scenarios are summarized in Table 7. As shown in Table 7, the total land subsidence at the end of model simulation (i.e., year 2032) under the Baseline Run conditions would be negative 0.02 ft (i.e., rebound) at the forebay area to 0.29 ft (0.01 ft/yr) at the Pressure Zone area.

The changes in land subsidence are minimal for the RCF scenarios as compared to the Baseline Run (No Project) under the average base period conditions (1979 to 2004). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under RCF Scenarios 2 and 3 conditions ranging from a total of 0.01 ft to 0.03 ft during the 26 years (i.e., approximately 0.0004 ft/yr to 0.0012 ft/yr). These sites are located in the vicinity or hydraulically downgradient of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), there would be no change or decrease in land subsidence. The following table summarizes these changes:

**Summary of Changes in Land Subsidence
RCF Scenarios as Compared to Baseline Run (No Project)
Average Base Period (1979 to 2004)**

Compared to Prolonged Dry Baseline Run	RCF Prolonged Dry Scenario 1		RCF Prolonged Dry Scenario 2		RCF Prolonged Dry Scenario 3	
	Number of Sites	Ranges ft	Number of Sites	Ranges ft	Number of Sites	Ranges ft
No Change in Land Subsidence	26	0	20	0	20	0
Decrease in Land Subsidence	0	0	3	0.01	3	0.01
Increase in Land Subsidence	0	0	3	0.01 to 0.02	3	0.02 to 0.03

4.5.2 Model Runs Under Prolonged Dry Base Period Conditions (1945-1968)

Model predicted land subsidence over the model simulation period at selected locations (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/Riverside Agreement) for the Prolonged Dry Baseline Run (No Project) and the RCF Prolonged Dry Scenarios 1 through 3 under prolonged dry base period conditions (1945 to 1968) are also provided (see Appendix C). The approximate locations of these sites are shown as insets on the graphs in Appendix C.

For each of the selected sites in Appendix C, the simulated total land subsidence and the difference between the simulated land subsidence for the Prolonged Dry Baseline Run (No Project) with respect to the RCF prolonged dry scenarios are summarized in Table 8. As shown in Table 8, the total land subsidence at the end of model simulation (i.e., year 2030) under the

Prolonged Dry Baseline Run conditions would be negative 0.01 ft (i.e., rebound) at City of San Bernardino Newmark 3 Well and East Valley Water District Cone Camp Well to 0.87 ft (0.036 ft/yr) at the City of Riverside Raub 1 Well. It is important to note that the purpose of this Prolonged Dry Baseline Run was to establish the no project conditions so that the potential land subsidence impacts from the RCF conjunctive use scenarios under the prolonged dry base period conditions can be compared to. To prevent land subsidence, specific water management strategies would need to be implemented to make up for the decline in water levels under the prolonged dry conditions.

The changes in land subsidence are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project) under the prolonged dry base period conditions (1945 to 1968). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under Prolonged Dry Scenario 3 conditions ranging from a total of 0.01 ft to 0.02 ft during the 24 years (i.e., approximately 0.0004 ft/yr to 0.0008 ft/yr). These sites are located in the vicinity of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), there would be no change or decrease in land subsidence. The following table summarizes these changes:

Summary of Changes in Land Subsidence
RCF Prolonged Dry Scenarios as Compared to Prolonged Dry Baseline Run
Prolonged Dry Base Period (1945 to 1968)

Compared to Prolonged Dry Baseline Run	RCF Prolonged Dry Scenario 1		RCF Prolonged Dry Scenario 2		RCF Prolonged Dry Scenario 3	
	Number of Sites	Ranges ft	Number of Sites	Ranges ft	Number of Sites	Ranges ft
No Change in Land Subsidence	26	0	9	0	10	0
Decrease in Land Subsidence	0	0	17	0.01 to 0.03	13	0.01 to 0.03
Increase in Land Subsidence	0	0	0	0	3	0.01 to 0.02

5.0 CONCLUSIONS

Based on results of the sensitivity to prolonged dry base period and land subsidence modeling, the following conclusions have been made for the RCF Conjunctive Use scenarios:

- For RCF Prolonged Dry Scenario 1, there is no change in water level from the Prolonged Dry Baseline Run (No Project) due to no Project artificial recharge or groundwater pumping. Water level changes range from zero (no change) to a rise of 32 ft for RCF Prolonged Dry Scenario 2 as compared to the Prolonged Dry Baseline Run (No Project). For RCF Prolonged Dry Scenario 3, these changes range from a decline of one foot to a rise of 38 ft. Water levels in most of the wells would increase due to the artificial recharge from the RCF.
- Based on results from iterative model runs, RCF Prolonged Dry Scenario 1 consists of no artificial recharge or groundwater pumping during the 24 years from 2007 through 2030. RCF Prolonged Dry Scenario 2 includes artificial recharge of 203,200 acre-ft and groundwater pumping a total of 140,000 acre-ft. RCF Prolonged Dry Scenario 3 includes artificial recharge of 300,000 acre-ft and groundwater pumping a total of 205,000 acre-ft.
- Groundwater storage in the SBBA declines by 747,490 acre-ft during the period 2007 through 2030 under Prolonged Dry Baseline Run (No Project) conditions (see Table 2). Groundwater storage decline for RCF Prolonged Dry Scenario 1 would be the same as the Prolonged Dry Baseline Run (No Project) conditions due to no RCF artificial recharge or groundwater pumping. Groundwater storage decline for RCF Prolonged Dry Scenarios 2 and 3 would be less than under Prolonged Dry Baseline Run (No Project) conditions, which are estimated to be negative (“-“) 702,419 acre-ft and negative 682,313 acre-ft (see Table 2). These results indicate that more water (45,071 acre-ft for Prolonged Dry Scenario 2 and 65,177 acre-ft for Prolonged Dry Scenario 3) was recharged over the 24 years than what was necessary to maintain a total recharge equal to the Prolonged Dry Baseline Run (No Project) conditions.

- The annual average underflow outflow across the San Jacinto Fault near the SAR to the Rialto-Colton Groundwater Basin for the period 2007 to 2030 was estimated to be 245 acre-ft/yr under Prolonged Dry Baseline Run (No Project) conditions. The underflow outflow was estimated to be 245 acre-ft/yr, 246 acre-ft/yr, and 248 acre-ft/yr for the RCF Prolonged Dry Scenarios 1 through 3, respectively. These changes in underflow outflow are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project).
- For purposes of this report, the efficiency of the Conjunctive Use project was calculated as the ratio of the amount of additional groundwater pumping plus the increase in groundwater storage to the amount of additional artificial recharge. The efficiency was not calculated for Prolonged Dry Scenario 1 due to no additional recharge/pumping. The efficiency is 91% for Prolonged Dry Scenario 2 and 90% for Prolonged Dry Scenario 3. The efficiency was optimized based on iterative model runs by varying the timing and amount of artificial recharge and groundwater pumping. The major loss of water for the conjunctive use model runs would be the increase in evapotranspiration, as well as the reduction of recharge from streamflow due to increases in water levels as a result of additional artificial recharge at the spreading grounds in the forebay area.
- The changes in land subsidence are minimal for the RCF scenarios as compared to the Baseline Run (No Project) under the average base period conditions (1979 to 2004). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under RCF Scenarios 2 and 3 conditions ranging from a total of 0.01 ft to 0.03 ft during the 26 years (i.e., approximately 0.0004 ft/yr to 0.0012 ft/yr). These sites are located in the vicinity or hydraulically downgradient of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), there would be no change or decrease in land subsidence.

- The changes in land subsidence are minimal for the RCF prolonged dry scenarios as compared to the Prolonged Dry Baseline Run (No Project) under the prolonged dry base period conditions (1945 to 1968). Increase in land subsidence due to the RCF would be minimal and would only occur in three wells under Prolonged Dry Scenario 3 conditions ranging from a total of 0.01 ft to 0.02 ft during the 24 years (i.e., approximately 0.0004 ft/yr to 0.0008 ft/yr). These sites are located in the vicinity of the proposed RCF wellfield. For the majority of the sites (i.e., 23 of 26), it would be no change or decrease in land subsidence.

6.0 MODEL LIMITATIONS AND UNCERTAINTY

The SBBA RBFM and RBFM integrated with SUB Package are useful tools for evaluating water levels, groundwater storage and land subsidence. However, it is a simplified approximation of a complex hydrogeologic system. The accuracy of model predictions is dependent on the assumptions used for the model prediction.

It is important to note that the purpose of this Prolonged Dry Baseline Run was to establish the no project conditions so that the potential groundwater storage and land subsidence impacts from the RCF conjunctive use scenarios under the prolonged dry base period conditions can be compared to. To prevent decline in groundwater storage and land subsidence under the prolonged dry conditions, specific water management strategies would need to be implemented to make up for the decline in water levels.

7.0 REFERENCES

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FIGURES

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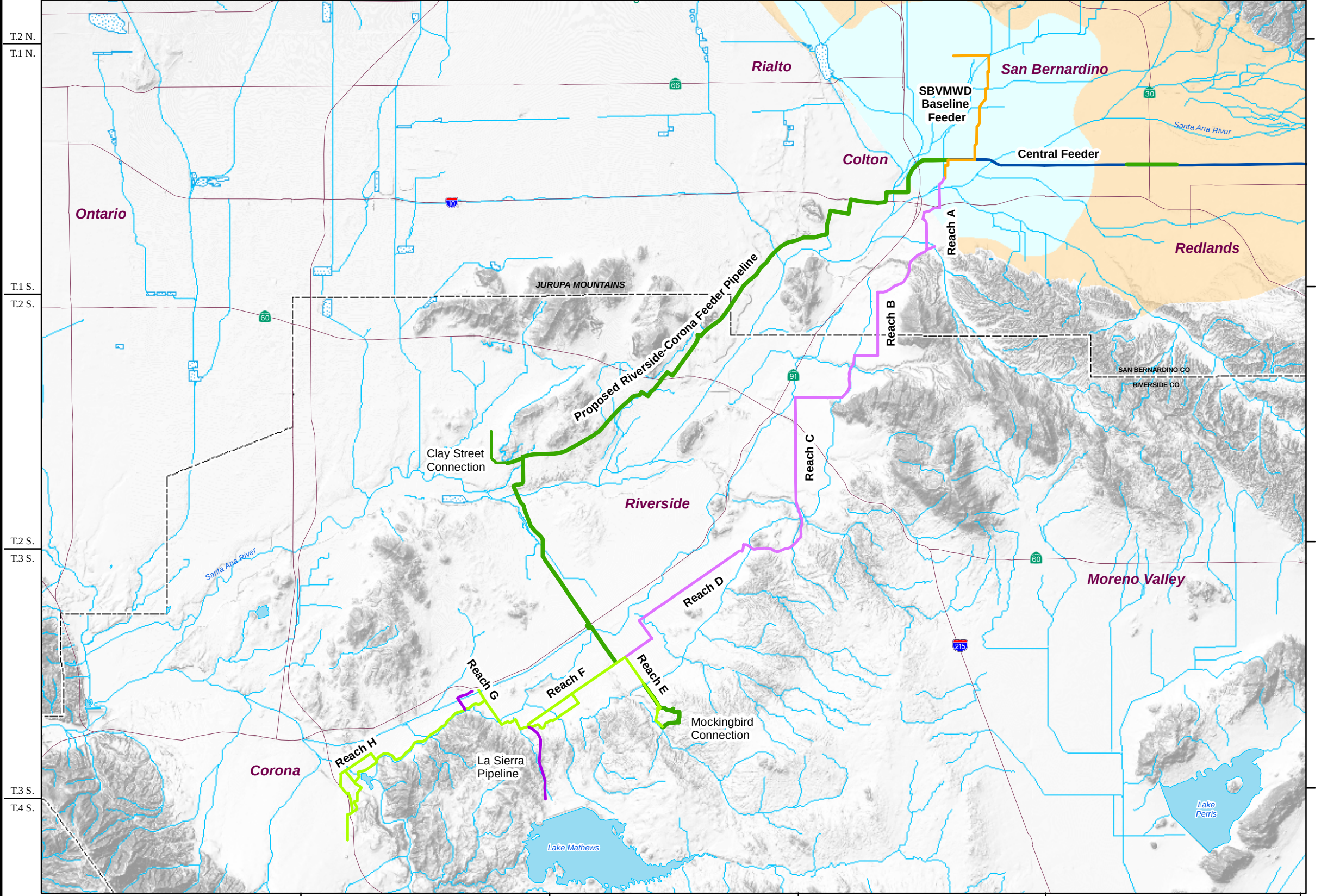


GENERAL
RIVERSIDE-CORONA
FEEDER PROJECT
LOCATION

EXPLANATION

- Proposed Riverside-Corona Feeder Realignment
- R-C Feeder Alignment (Reaches E-H)
- Original R-C Feeder Alignment (Reaches A-D)
- Central Feeder Pipeline
- SBVMWD Pipeline
- Riverside-Corona Feeder - La Sierra Pipeline
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary

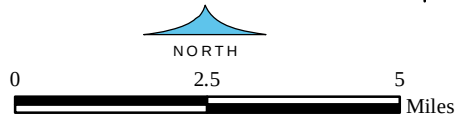
Source of Pipelines:
Albert A. Webb Associates, 2009.
SBVMWD, 2005.



12-Mar-10

Prepared by: DWB

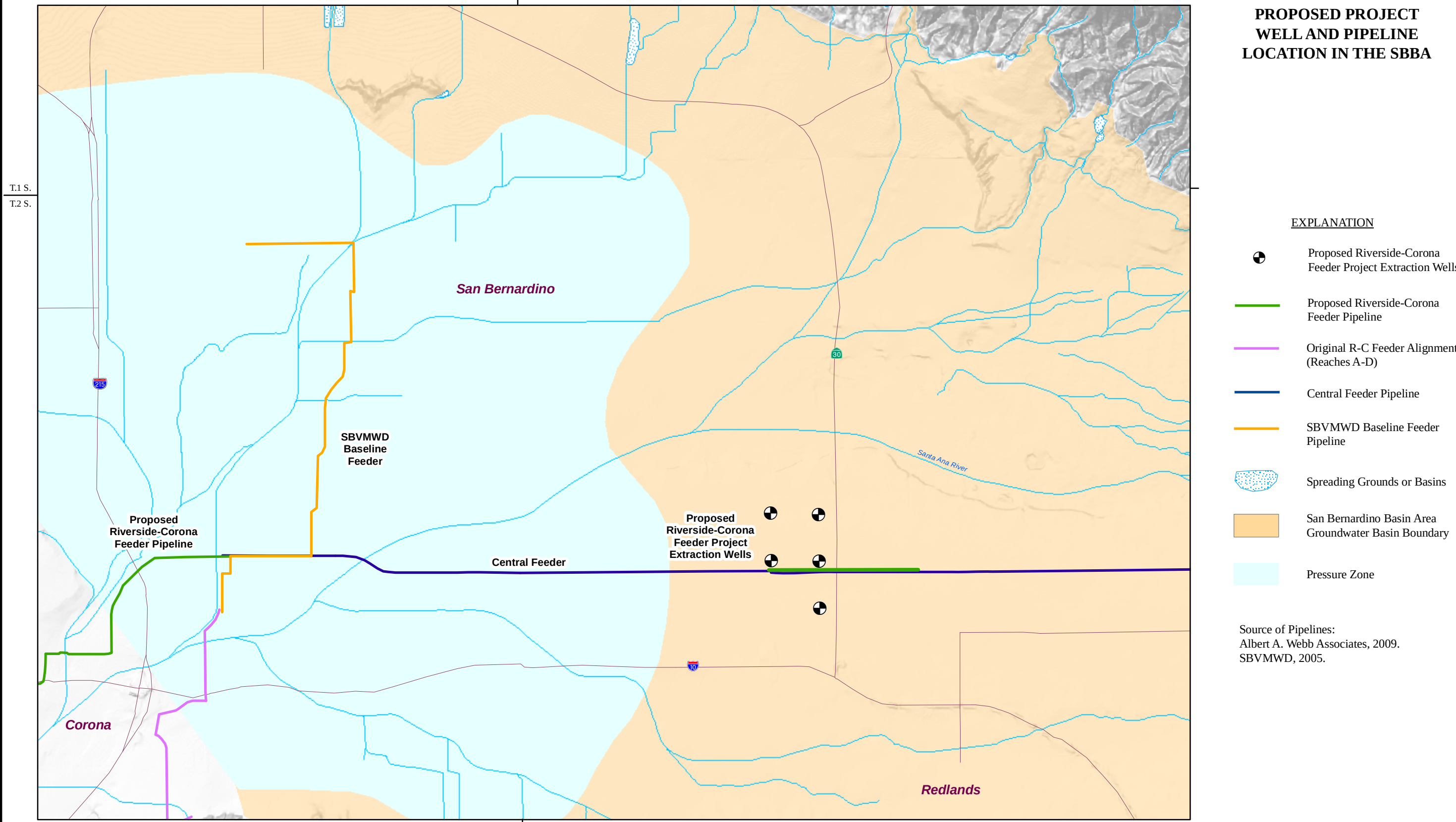
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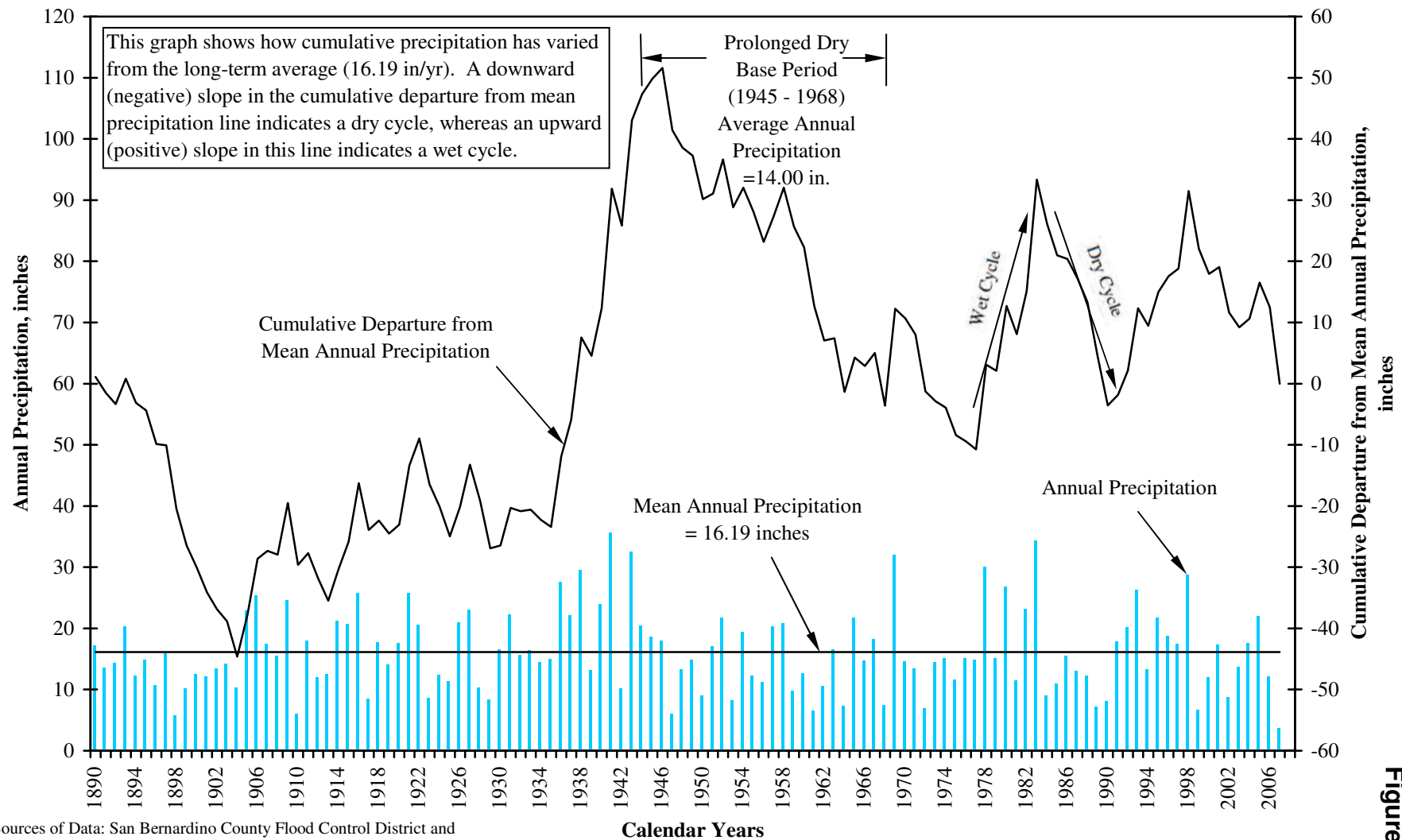
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Figure 1

**PROPOSED PROJECT
WELL AND PIPELINE
LOCATION IN THE SBBA**



Cumulative Departure from Mean Annual Precipitation San Bernardino County Hospital Station 1890 to 2007



Sources of Data: San Bernardino County Flood Control District and Santa Ana River Watermaster Annual Reports

Figure 3

Cumulative Departure from Mean Annual Streamflow Santa Ana River Near Mentone Gaging Station (Combined) 1913 to 2005

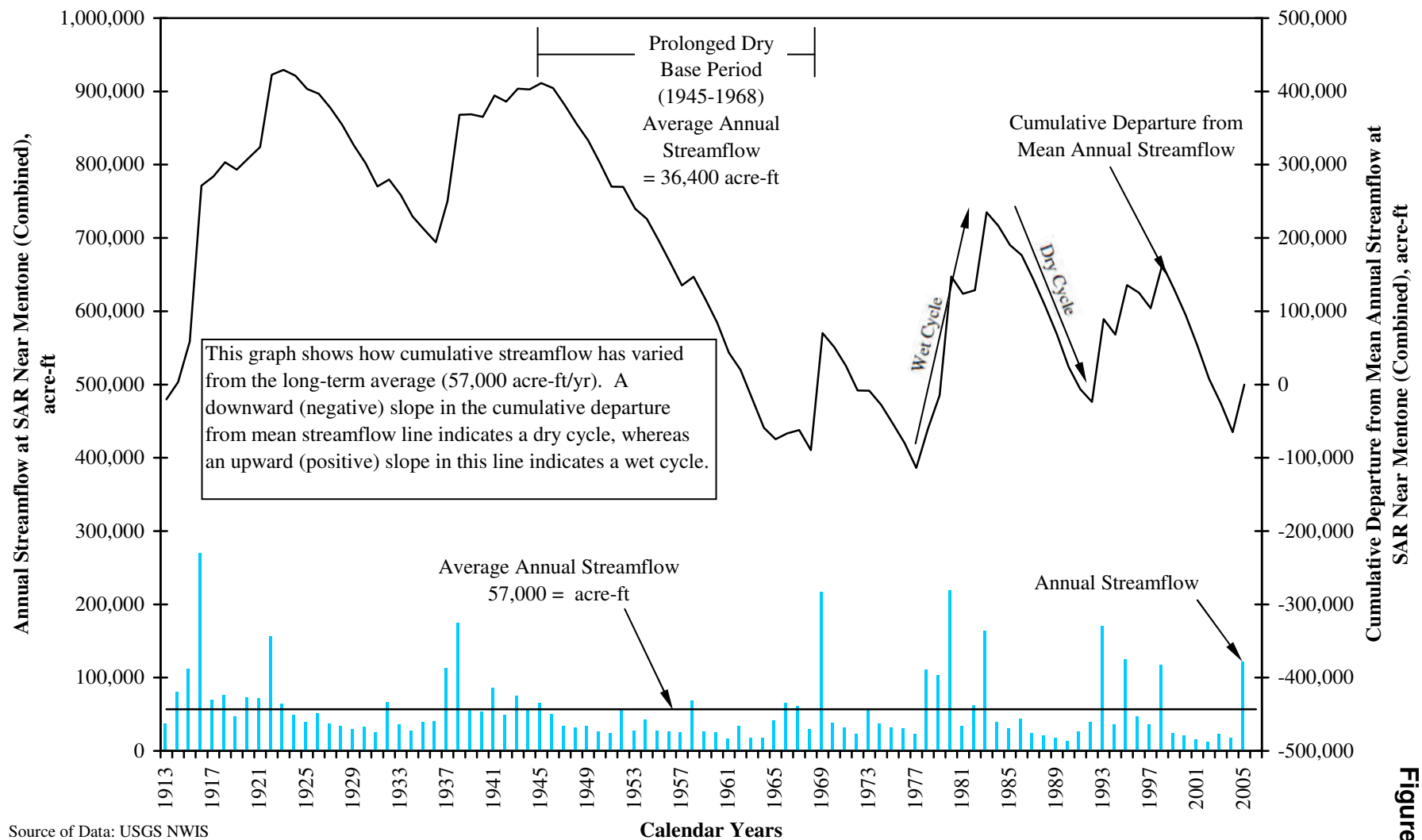


Figure 4

Groundwater Pumping for the Prolonged Dry Baseline Run (No Project) - 2007 to 2030

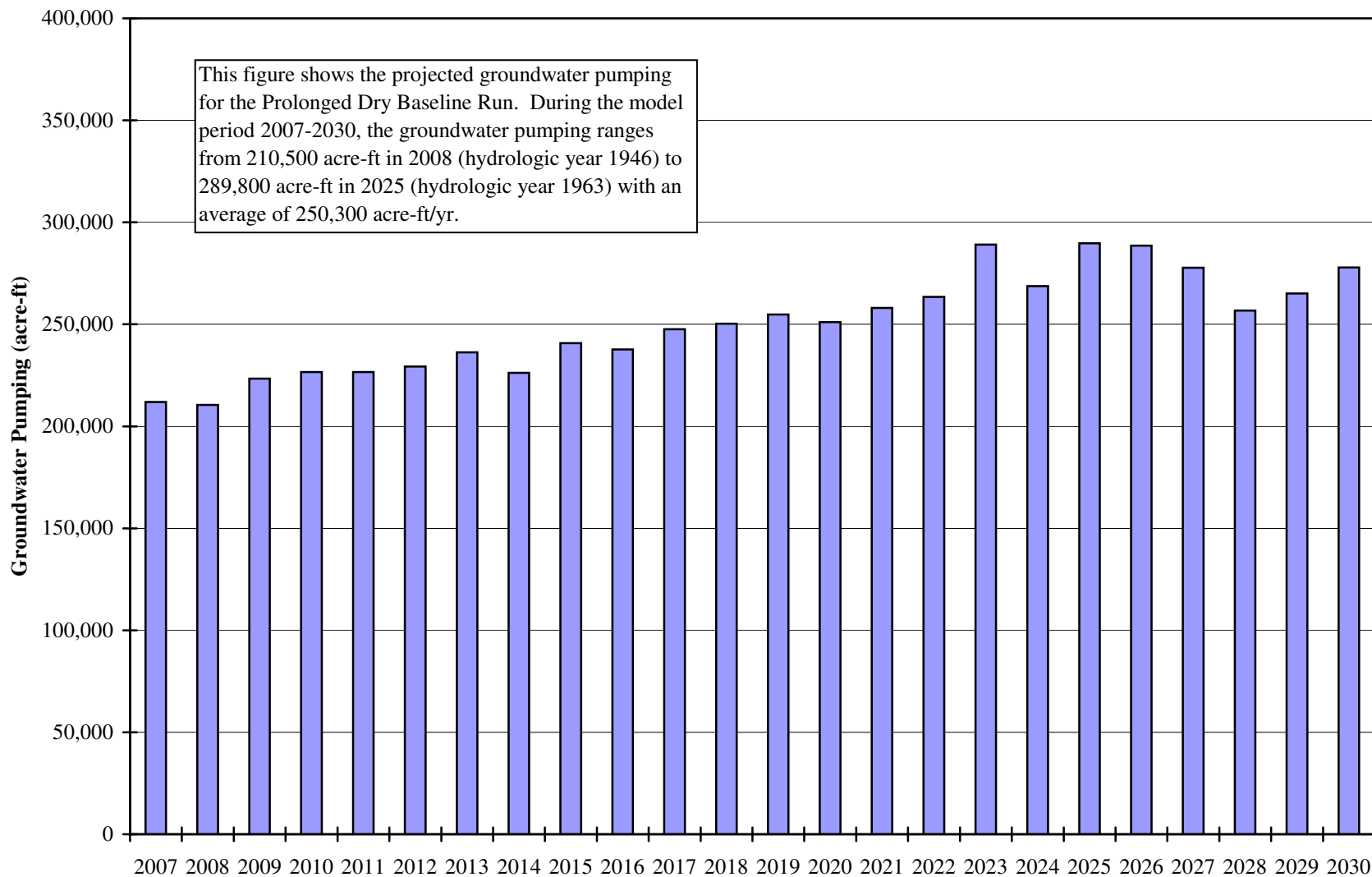


Figure 5

Artificial Recharge for the Prolonged Dry Baseline Run (No Project) - 2007 to 2030

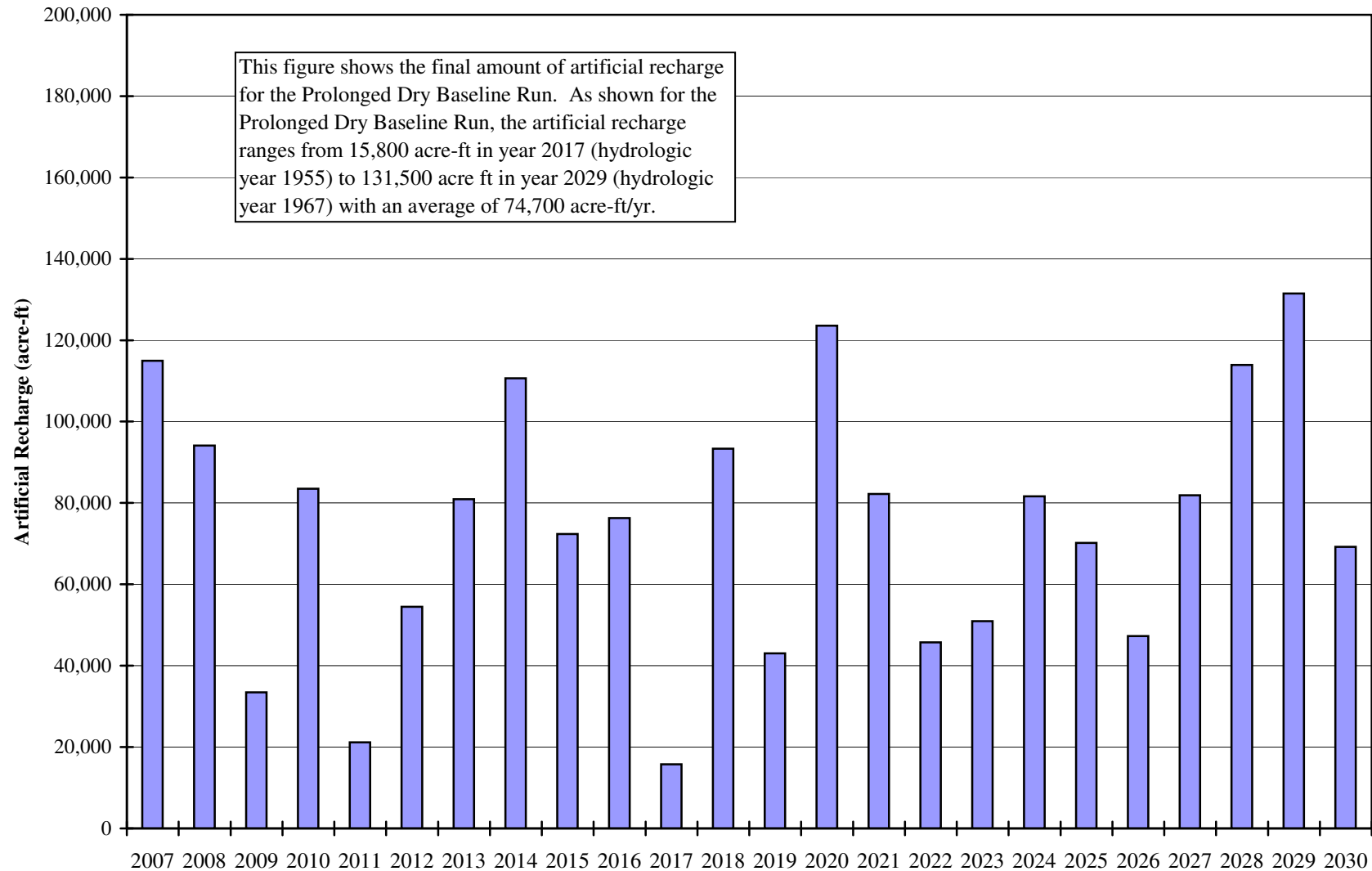


Figure 6

LOCATIONS OF
SPREADING GROUNDS
FOR ARTIFICIAL RECHARGE

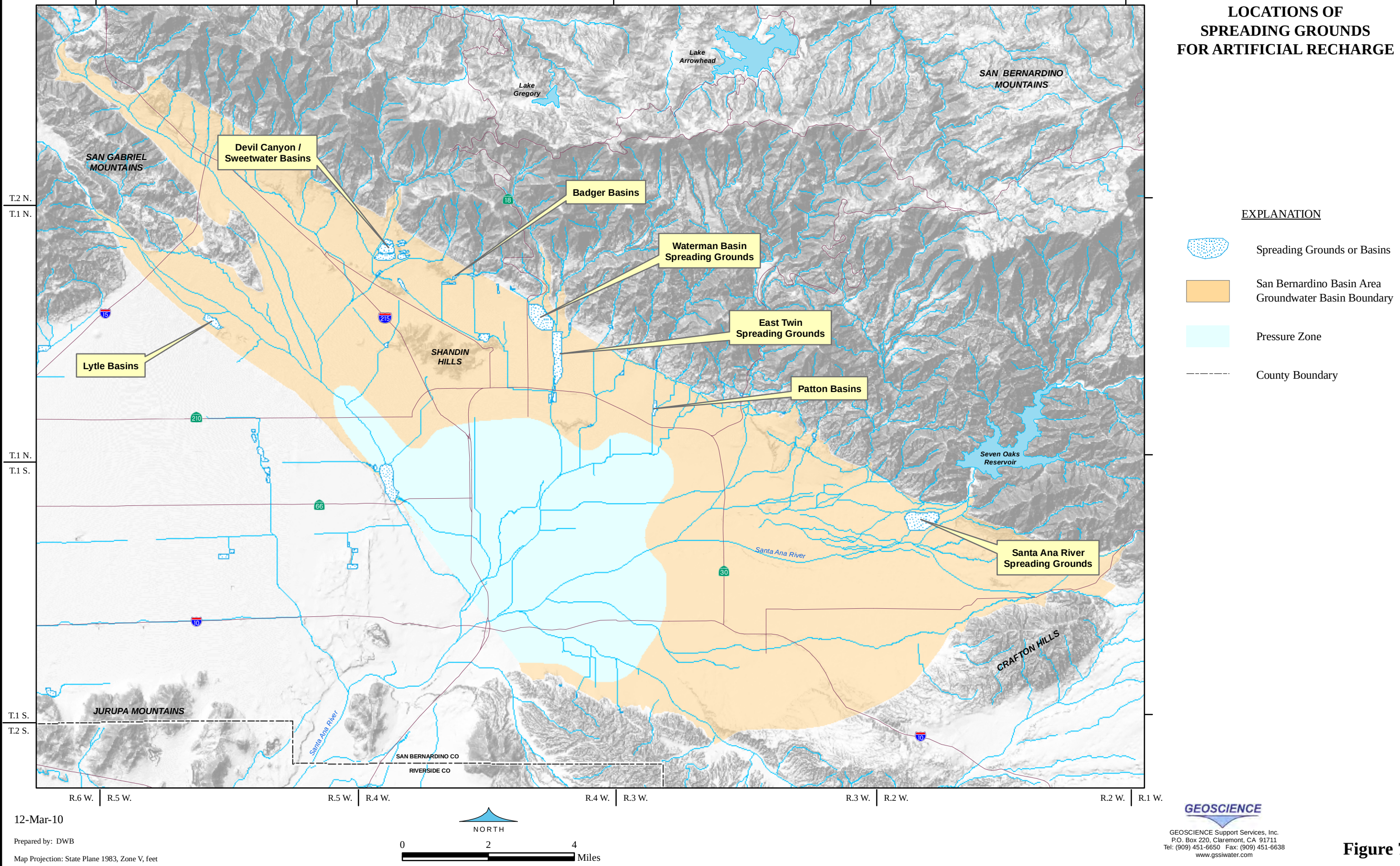


Figure 7

Artificial Recharge and Groundwater Pumping for Riverside-Corona Feeder Project Prolonged Dry Scenario 1 - 2007 to 2030

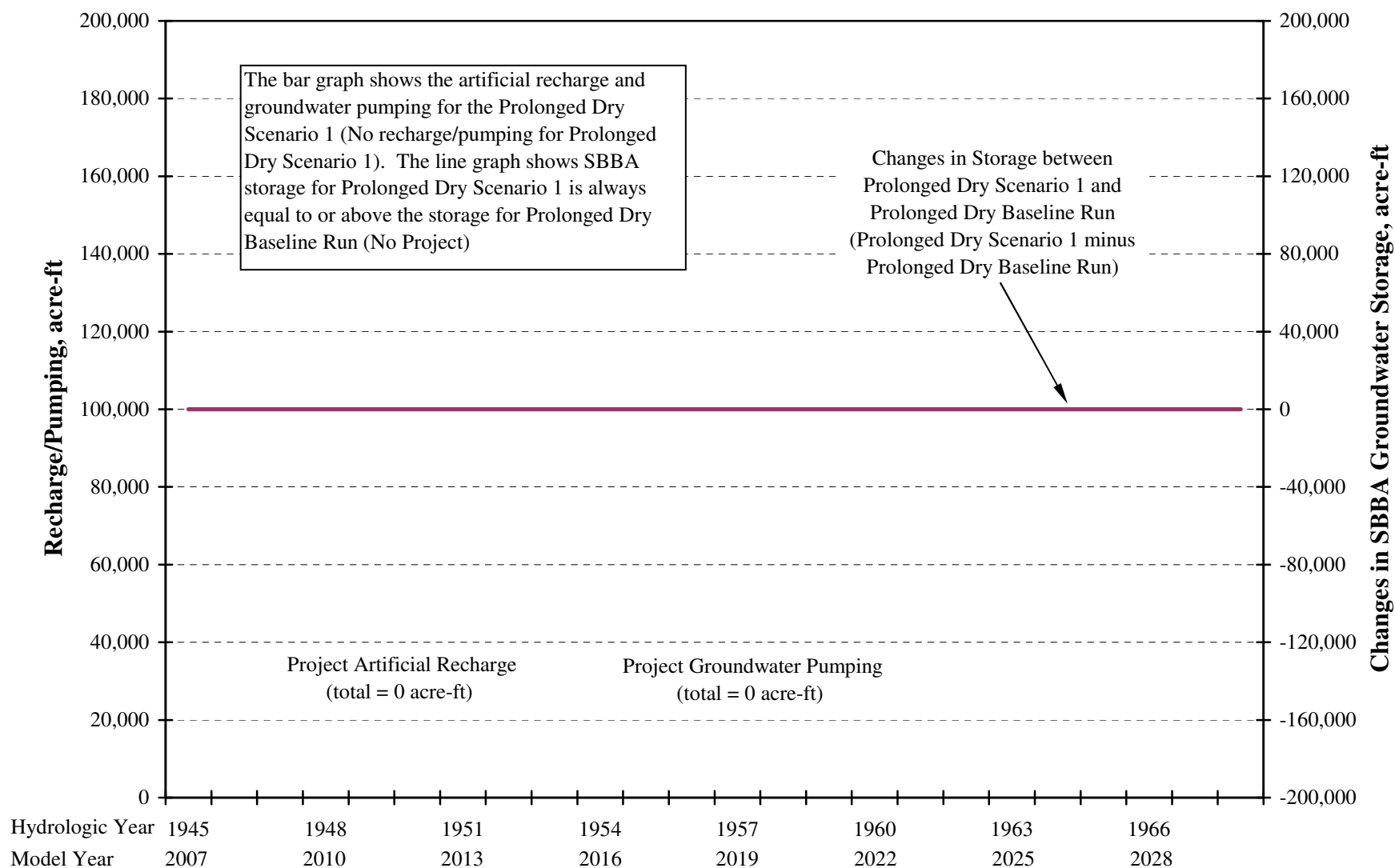


Figure 8

Artificial Recharge and Groundwater Pumping for Riverside-Corona Feeder Project Prolonged Dry Scenario 2 - 2007 to 2032

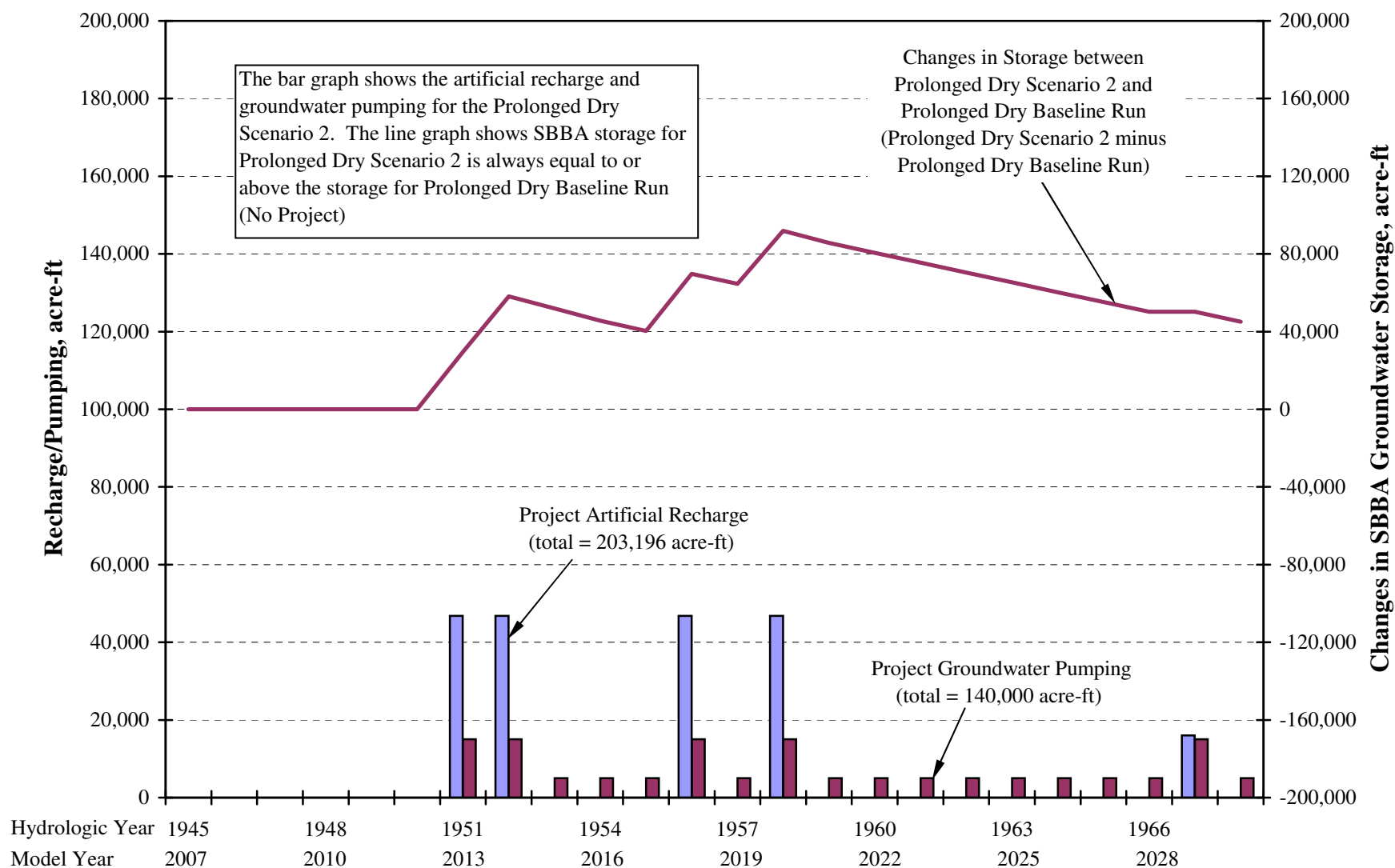


Figure 9

Artificial Recharge and Groundwater Pumping for Riverside-Corona Feeder Project Prolonged Dry Scenario 3 - 2007 to 2030

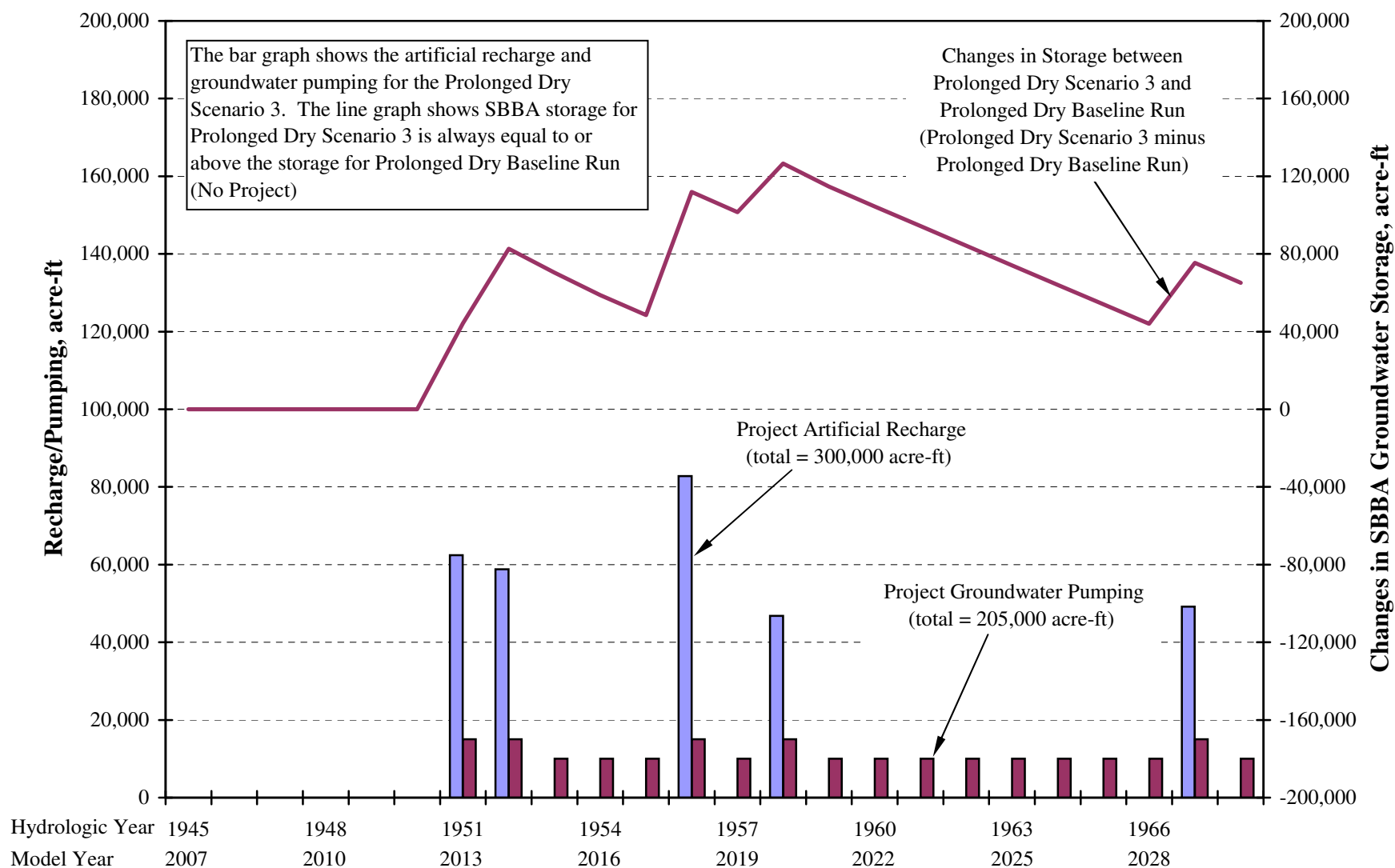


Figure 10

Exceedance Probability of Surplus Water Available for Riverside-Corona Feeder Project

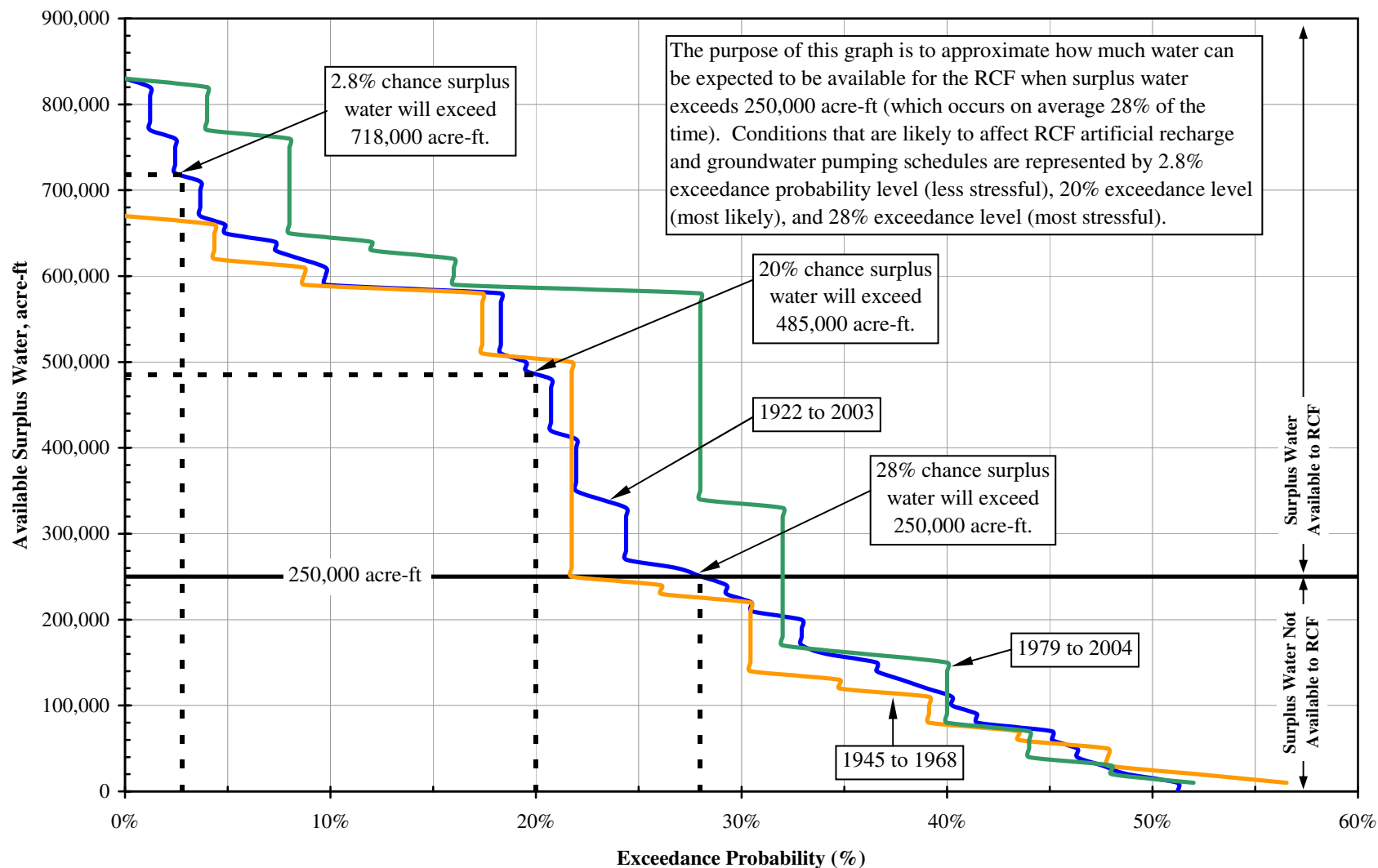
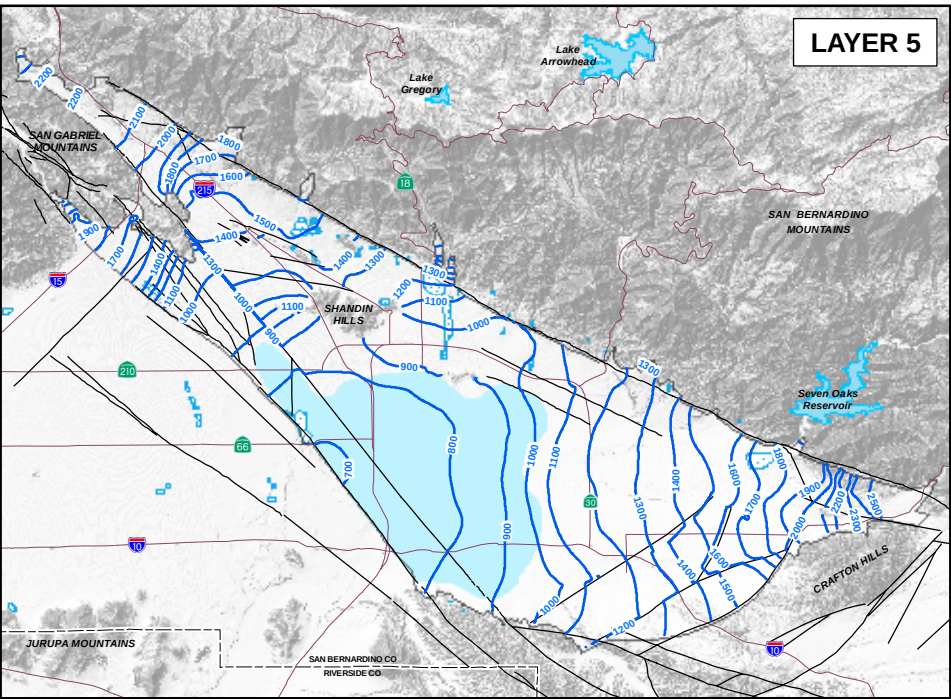
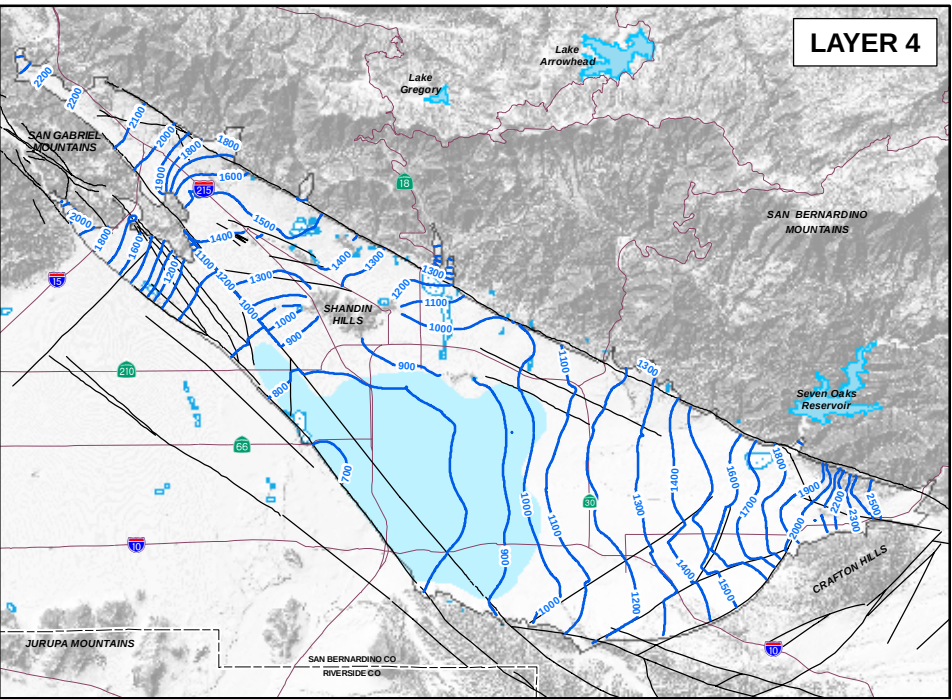
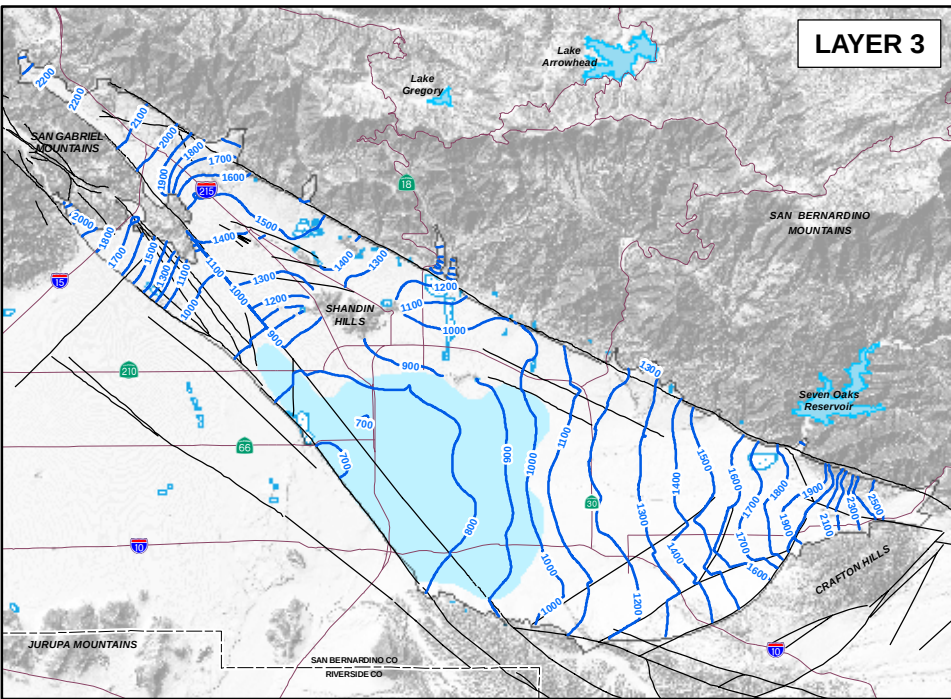
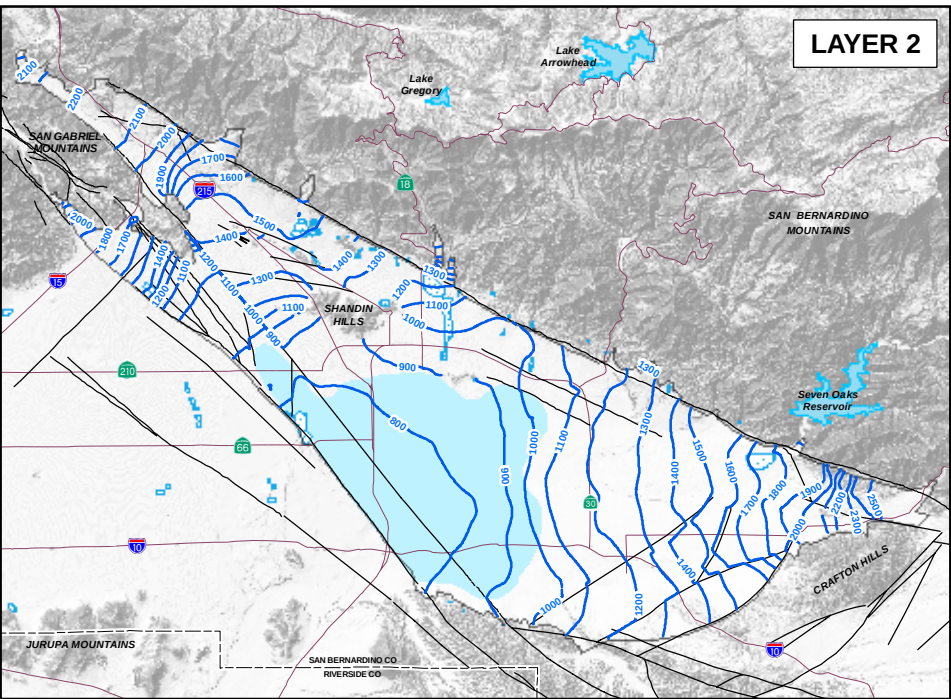
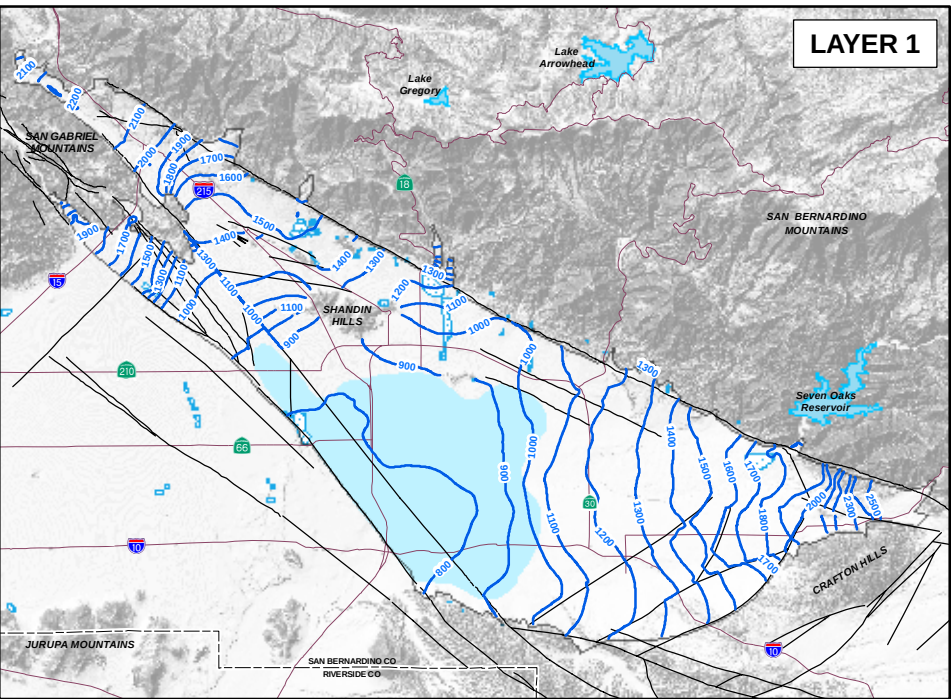


Figure 11

WESTERN MUNICIPAL WATER DISTRICT



EXPLANATION

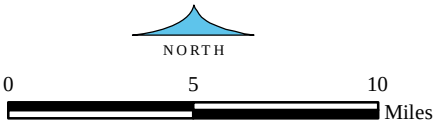
- 1100— Groundwater Elevations (feet above mean sea level) in Year 2030
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

**GROUNDWATER ELEVATIONS
FOR PROLONGED DRY
BASELINE RUN
(NO PROJECT)
IN YEAR 2030**

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

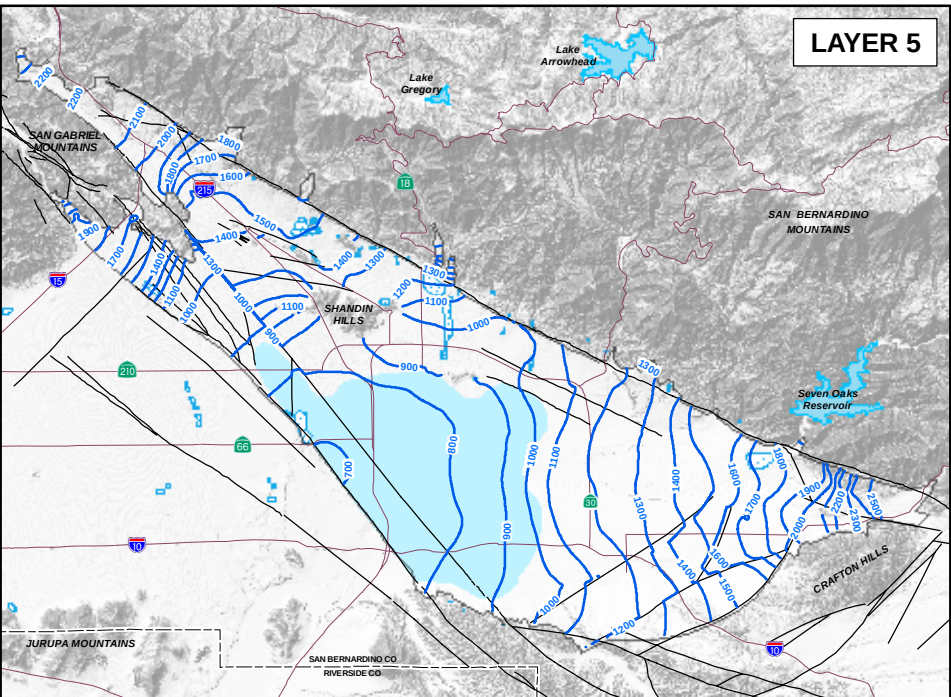
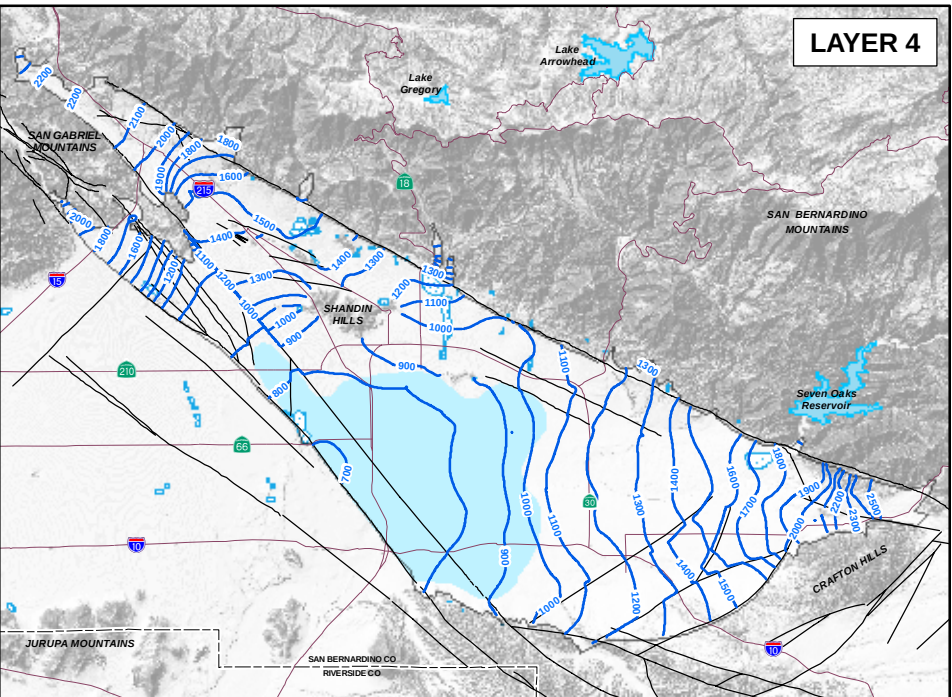
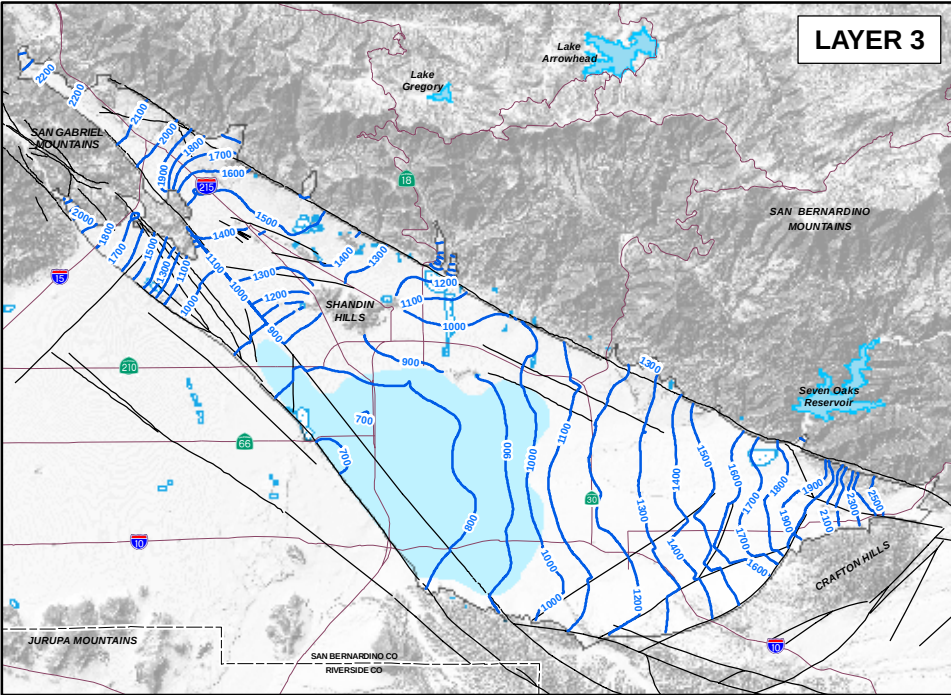
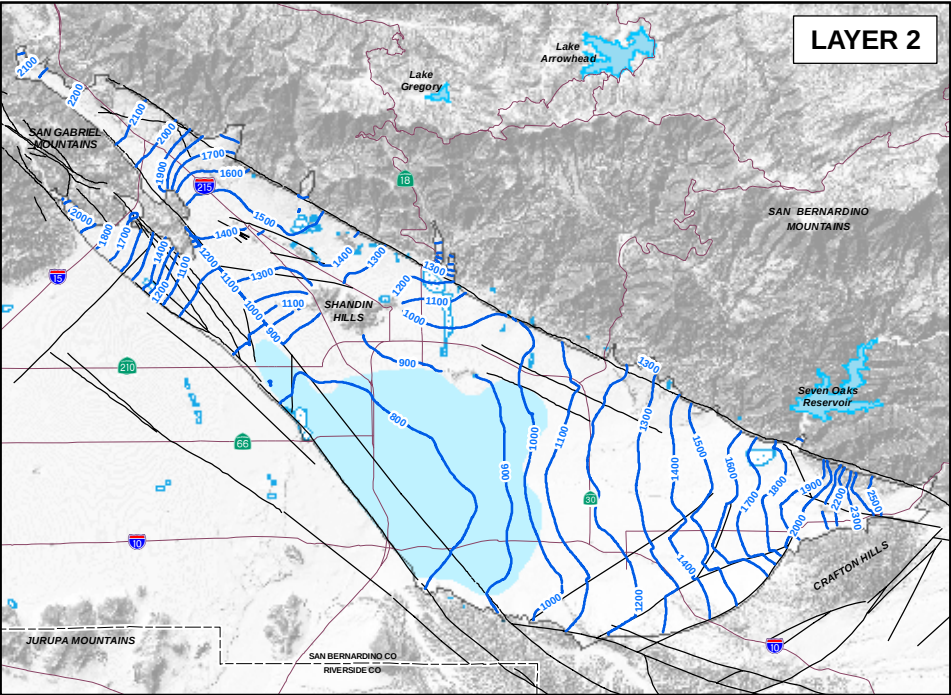
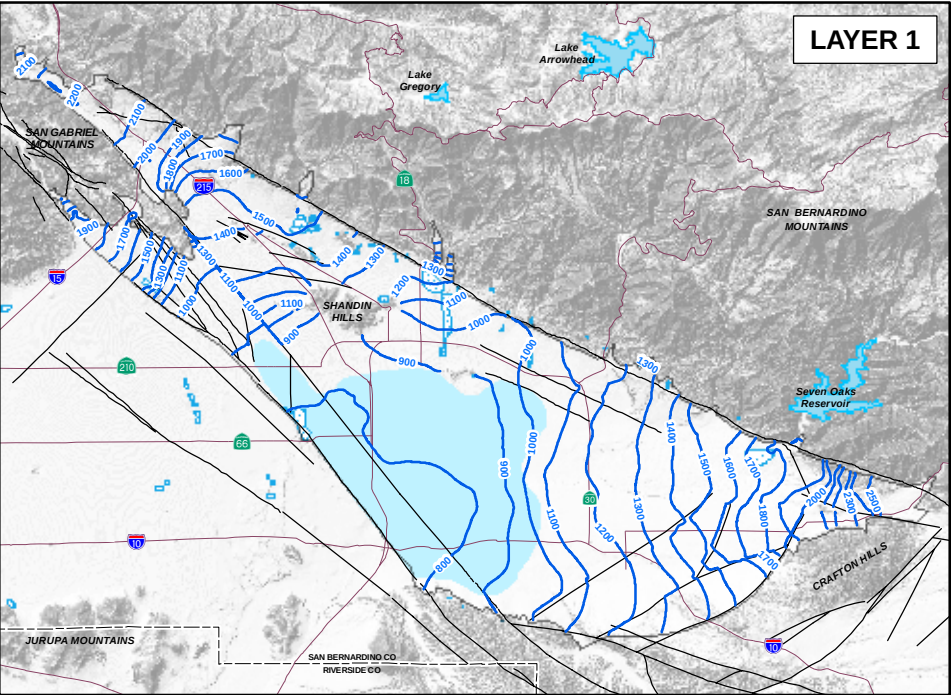


GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
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Figure 12

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

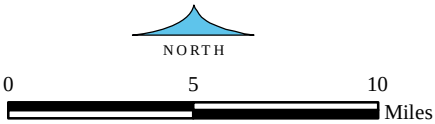
- 1100— Groundwater Elevations (feet above mean sea level) in Year 2030
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
PROLONGED DRY
SCENARIO 1
IN YEAR 2030

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



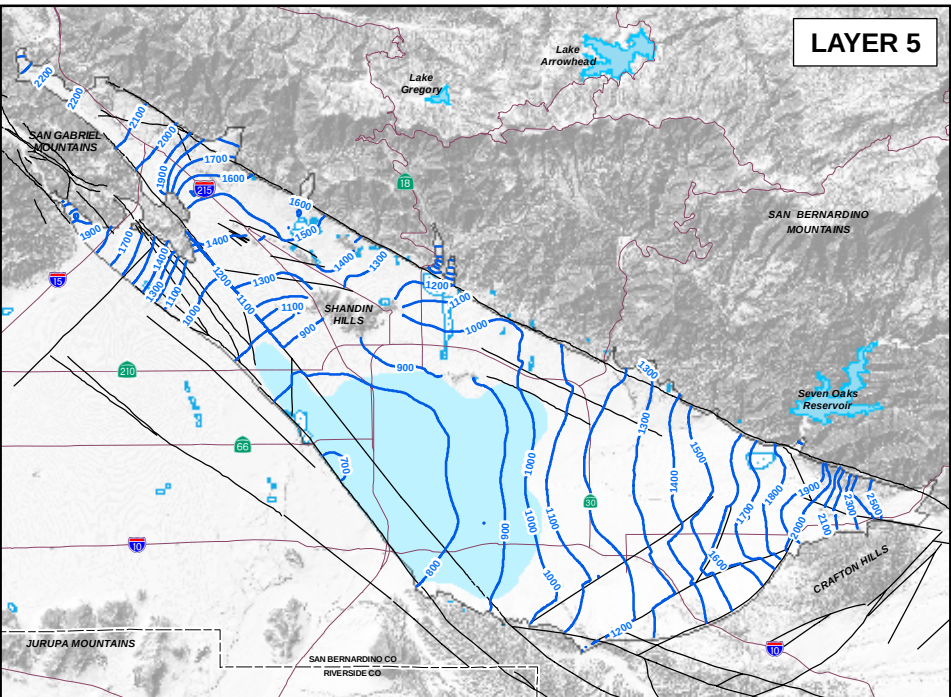
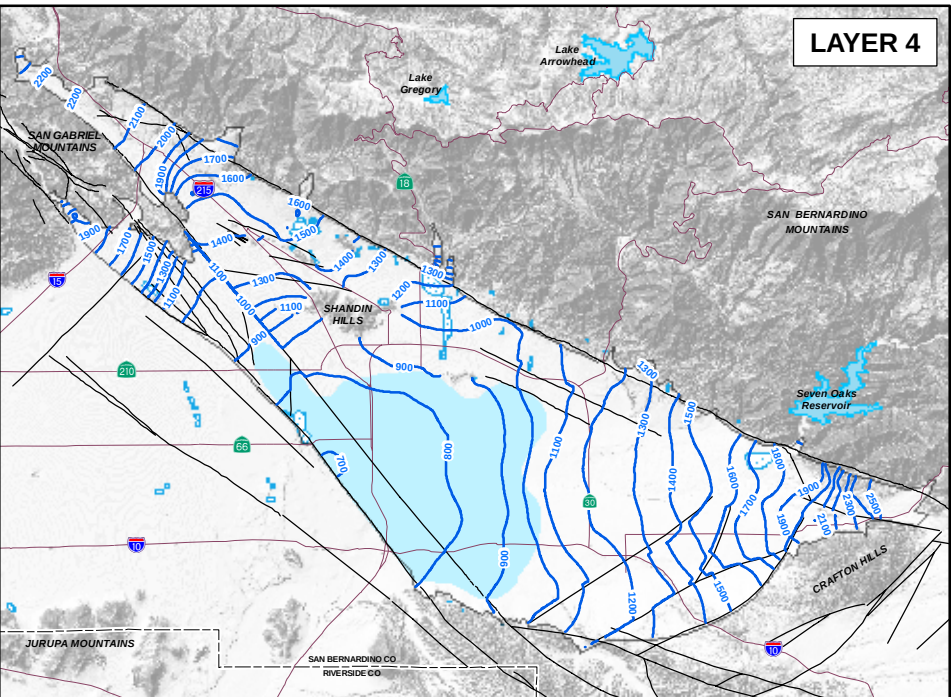
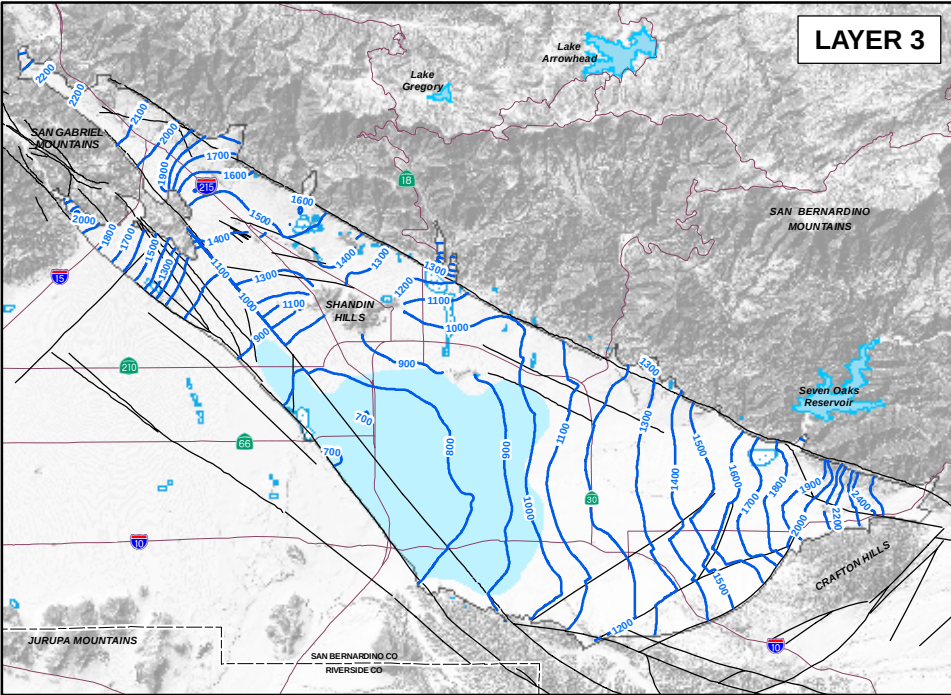
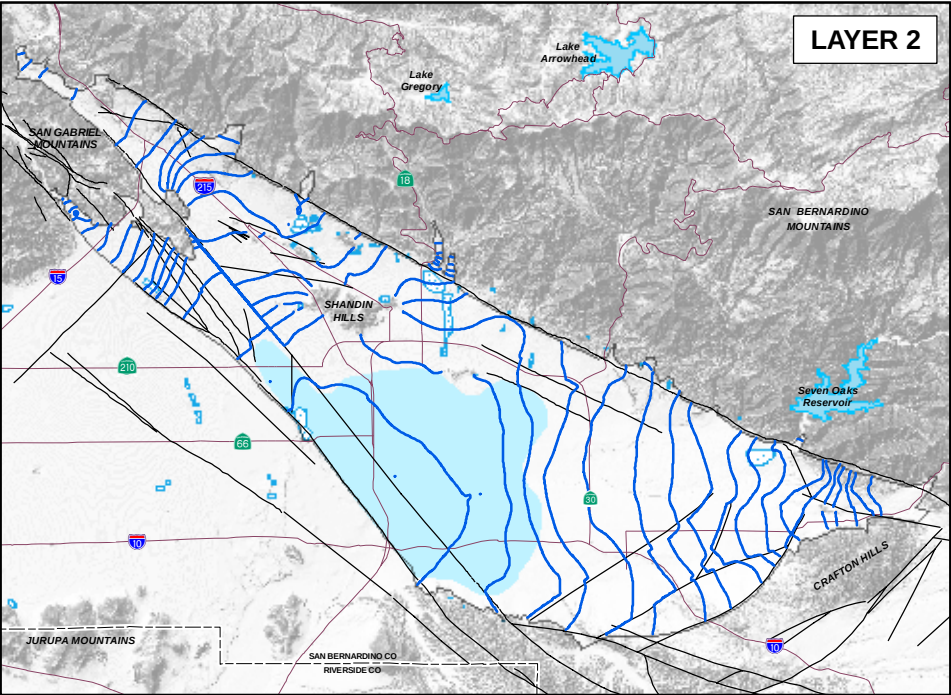
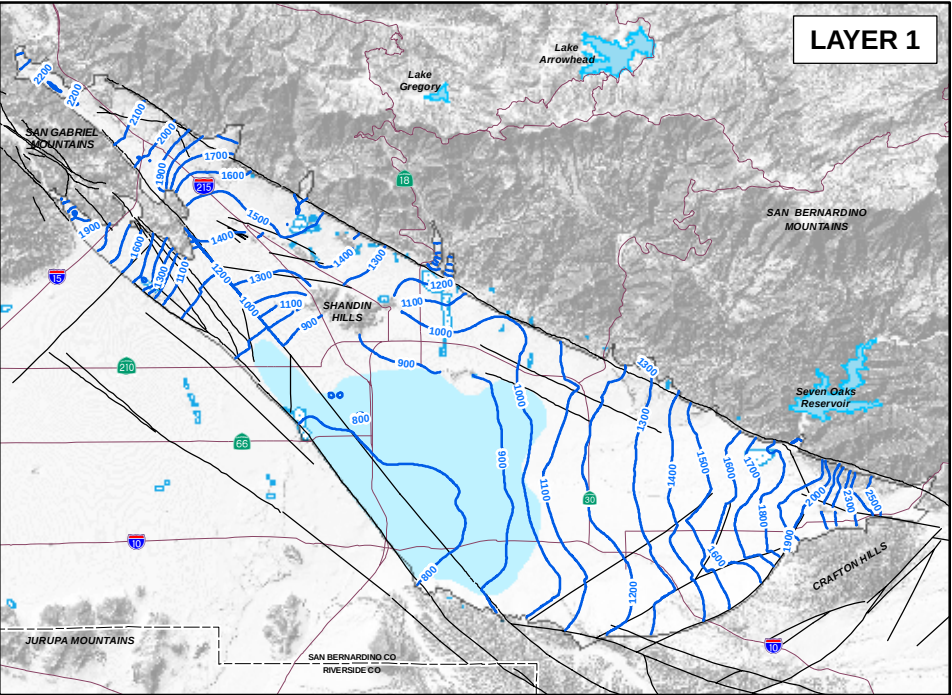
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Figure 13

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

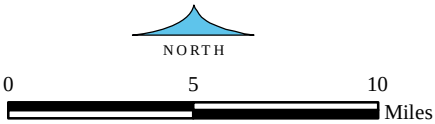
- 1100— Groundwater Elevations (feet above mean sea level) in Year 2030
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
PROLONGED DRY
SCENARIO 2
IN YEAR 2030

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

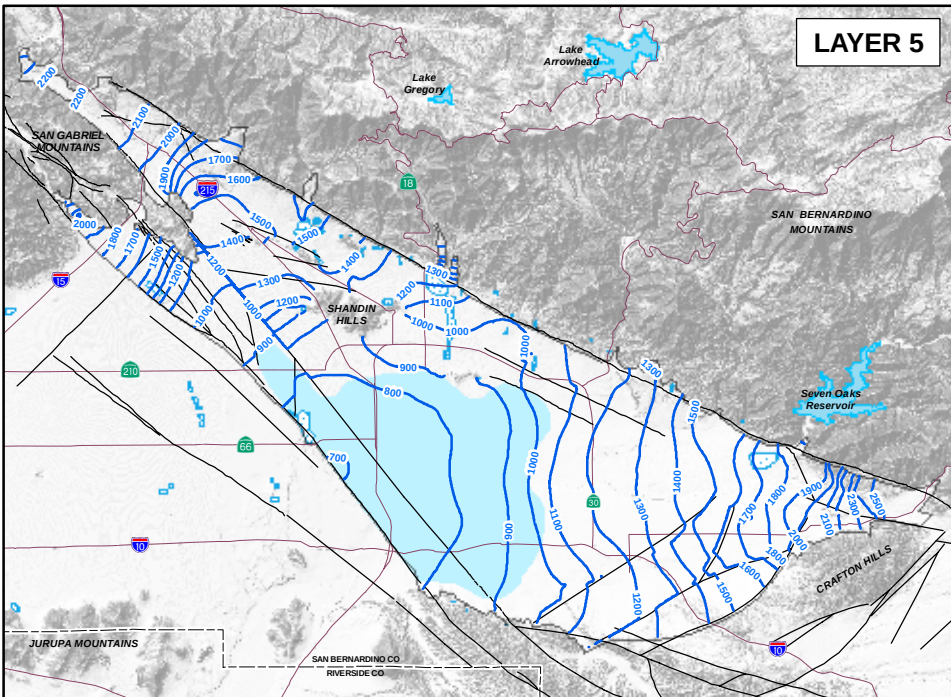
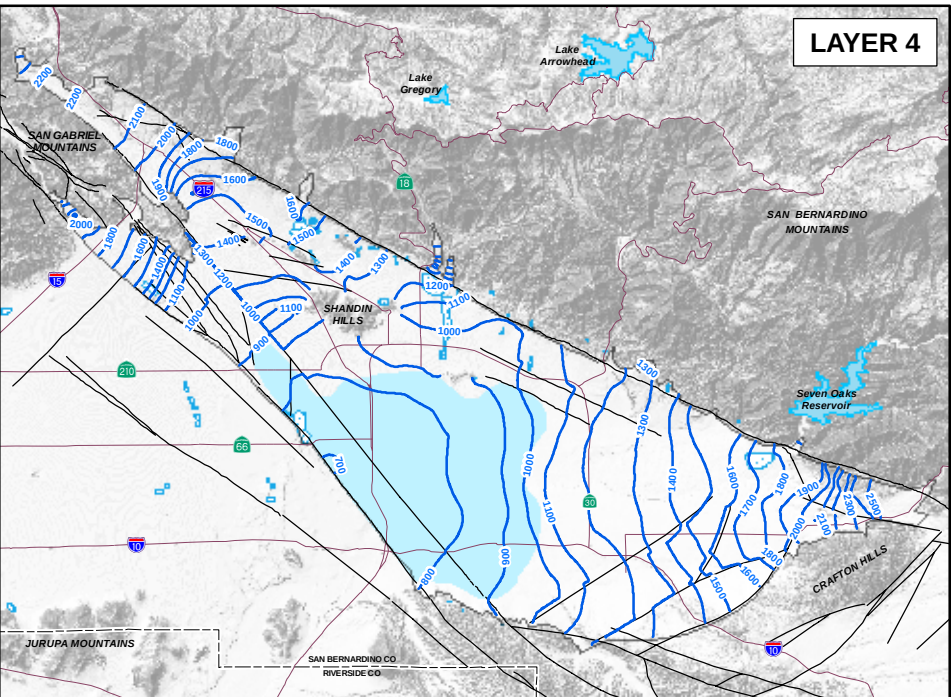
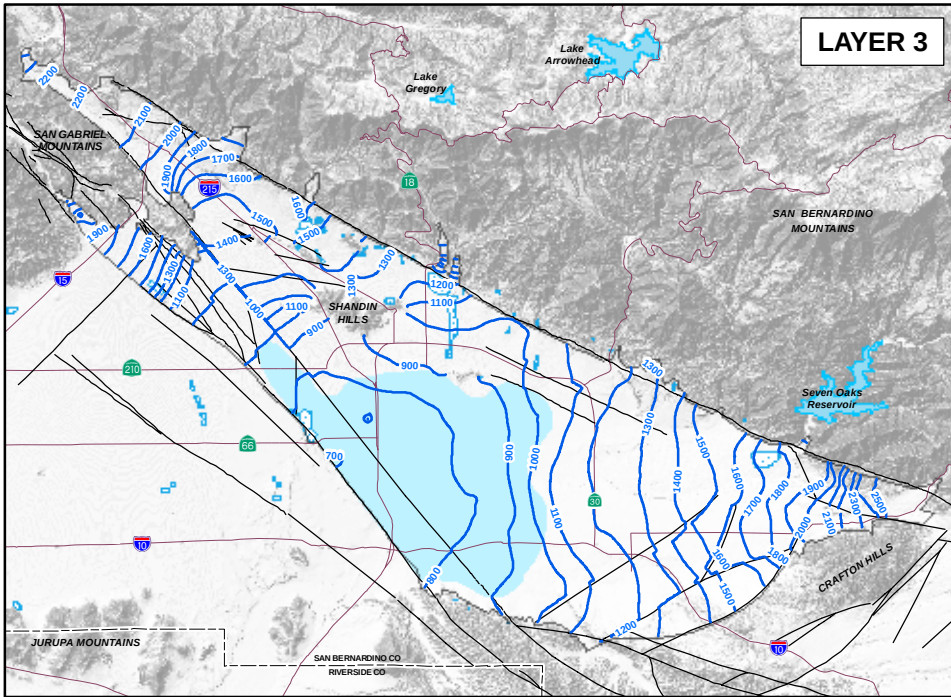
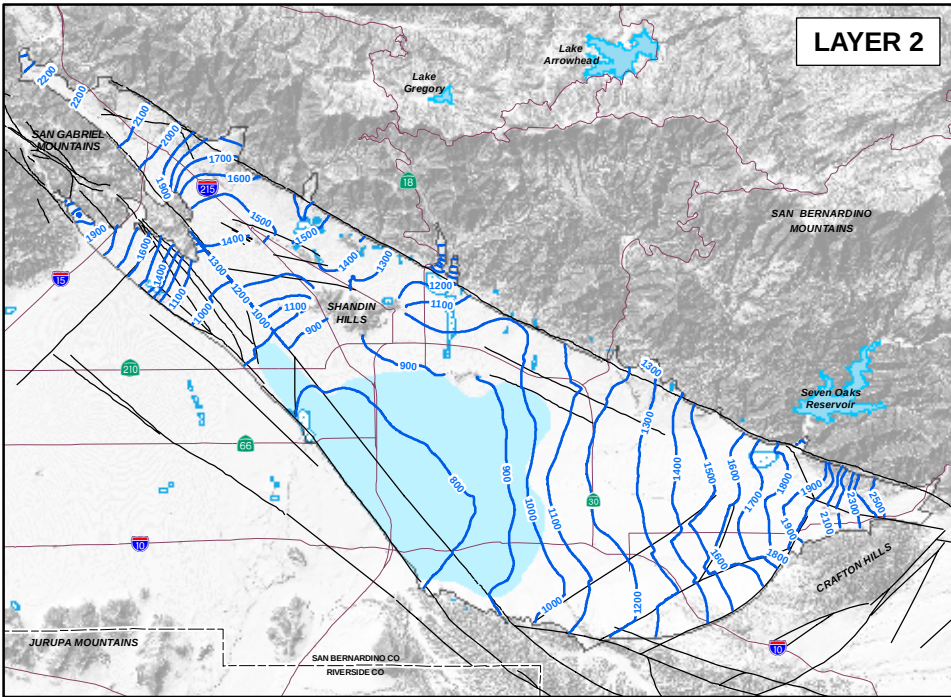
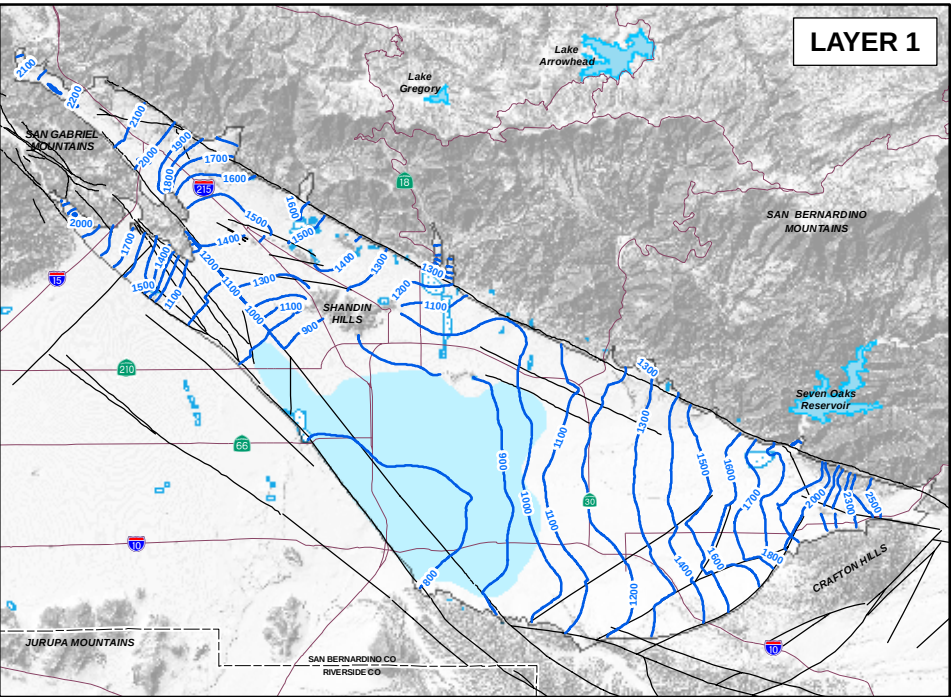


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Figure 14

WESTERN MUNICIPAL WATER DISTRICT



EXPLANATION

—1100— Groundwater Elevations
(feet above mean sea level)
in Year 2030



Spreading Grounds or Basins



San Bernardino Basin Area
Groundwater Basin Boundary



Pressure Zone



Fault



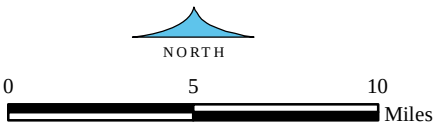
County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
PROLONGED DRY
SCENARIO 3
IN YEAR 2030

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



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Figure 15

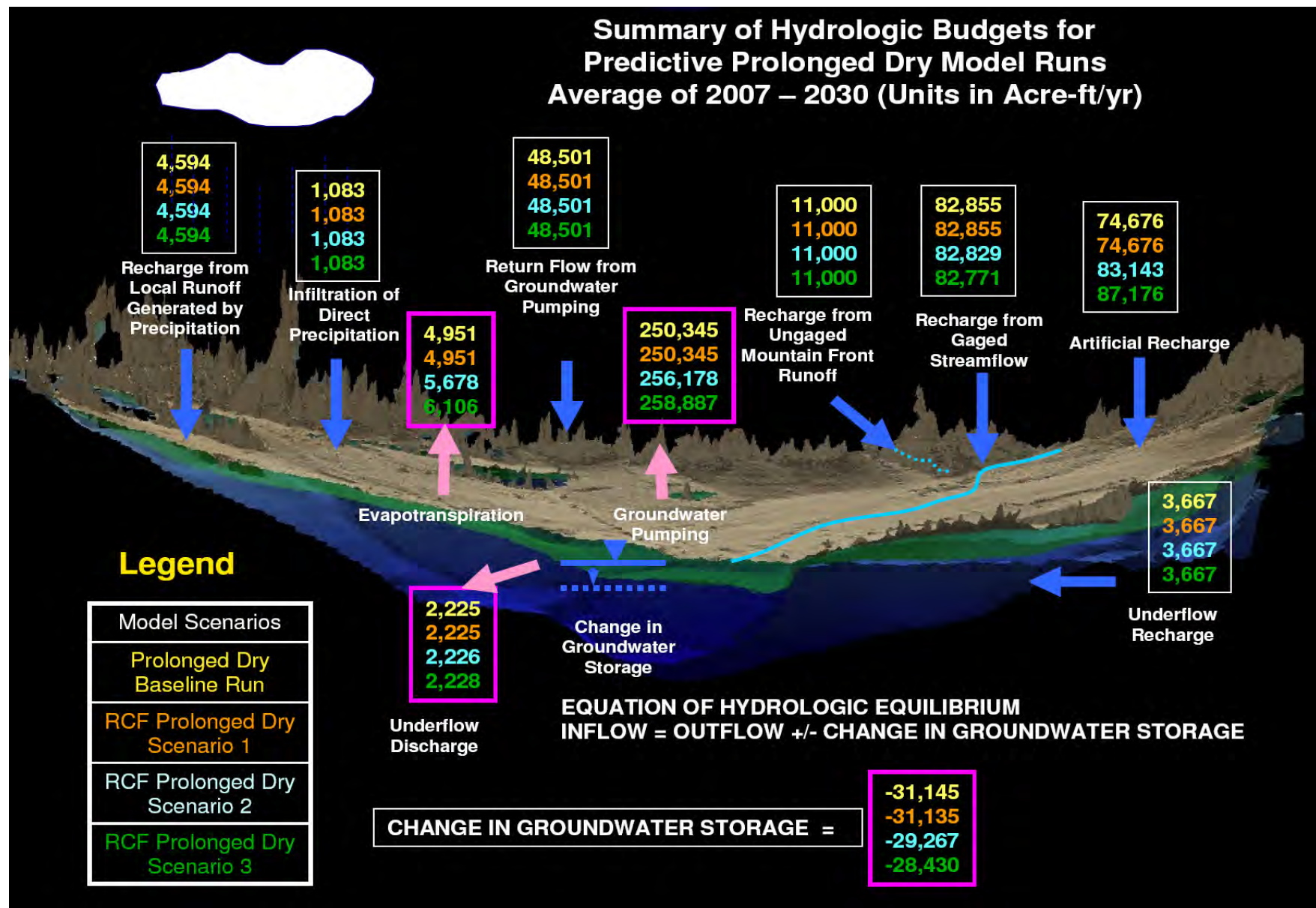


Figure 16

Cumulative Annual Changes in Groundwater Storage for Predictive Prolonged Dry Model Scenarios 2007 to 2030

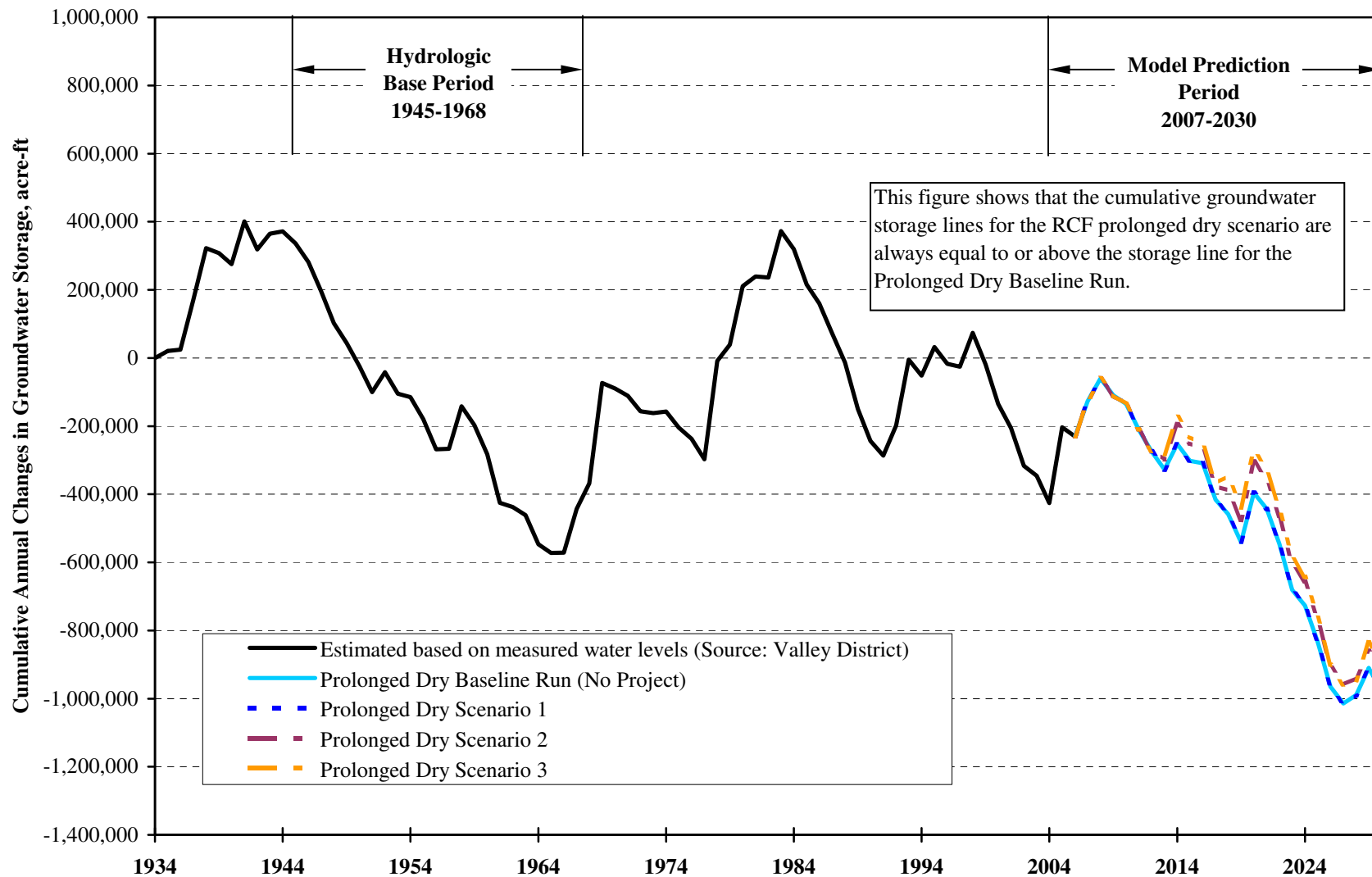


Figure 17

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

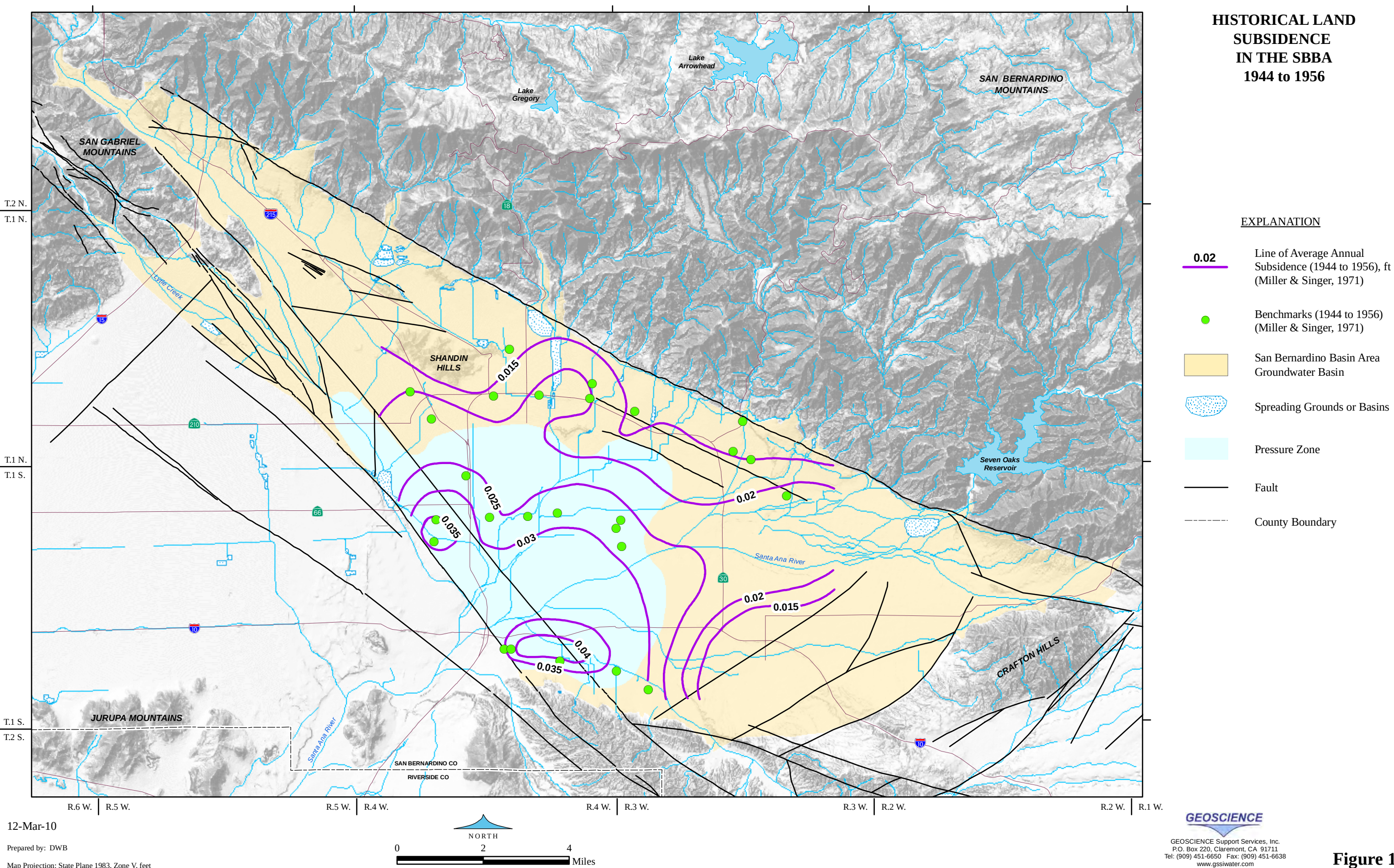
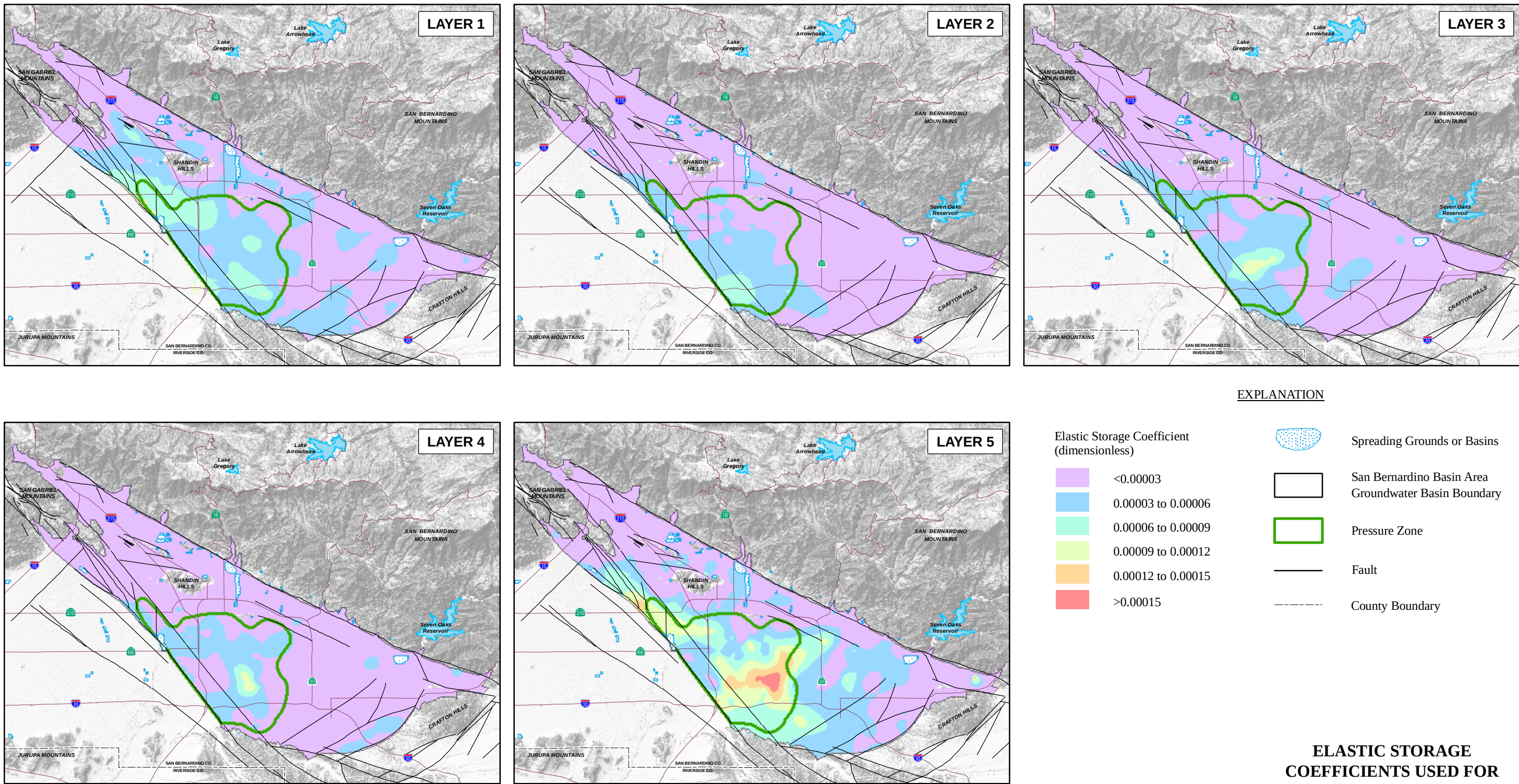


Figure 18

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

GIS_proj/wmwd_riv-corona_feeder_drybase_subsidence_1-10/0_Fig_19_elastic_storage_3-10.mxd

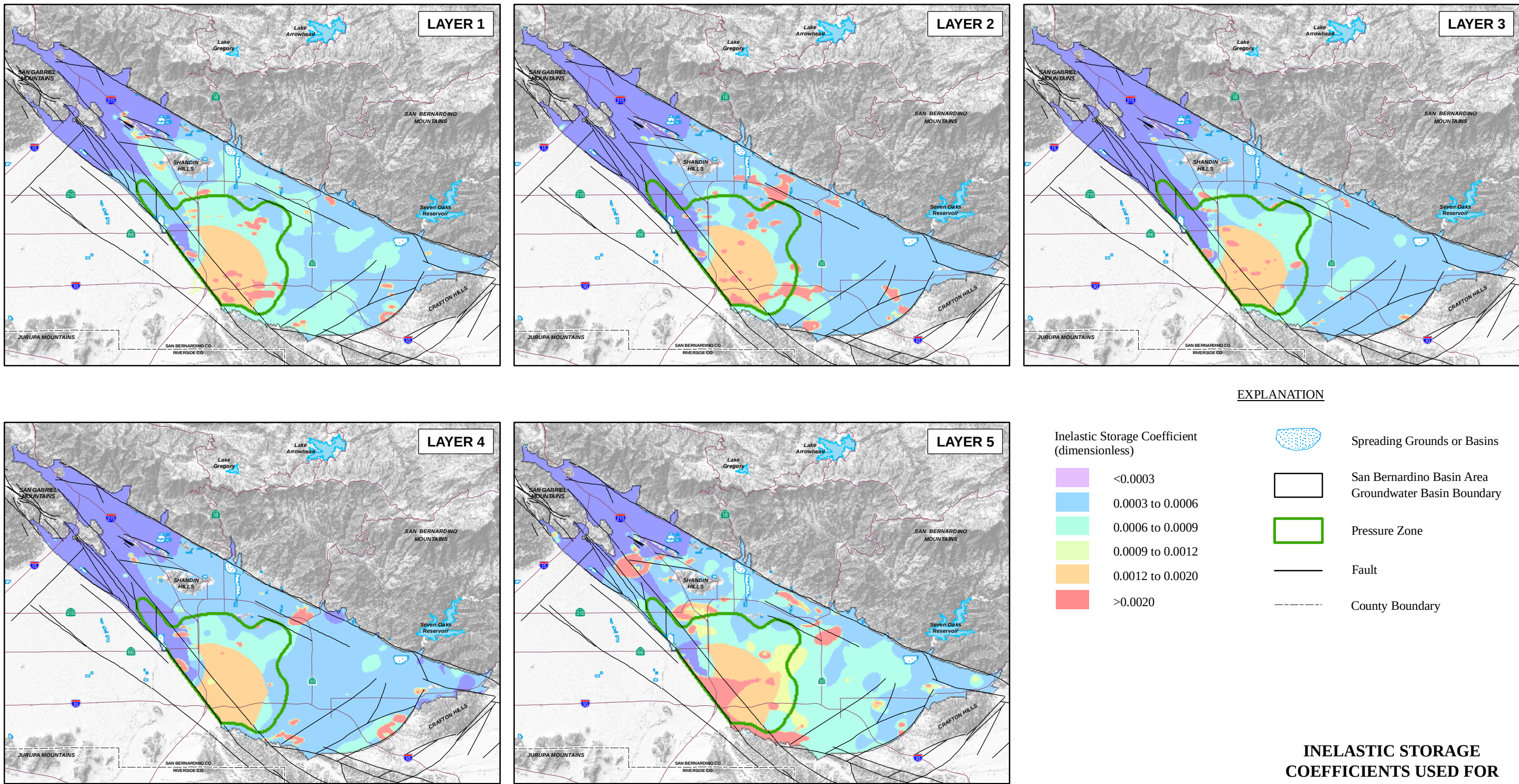
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Figure 19

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

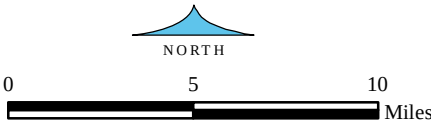


INELASTIC STORAGE
COEFFICIENTS USED FOR
LAND SUBSIDENCE MODEL

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



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Figure 20

Measured Land Subsidence versus Model-Calculated Land Subsidence Model Calibration 1945 to 2000

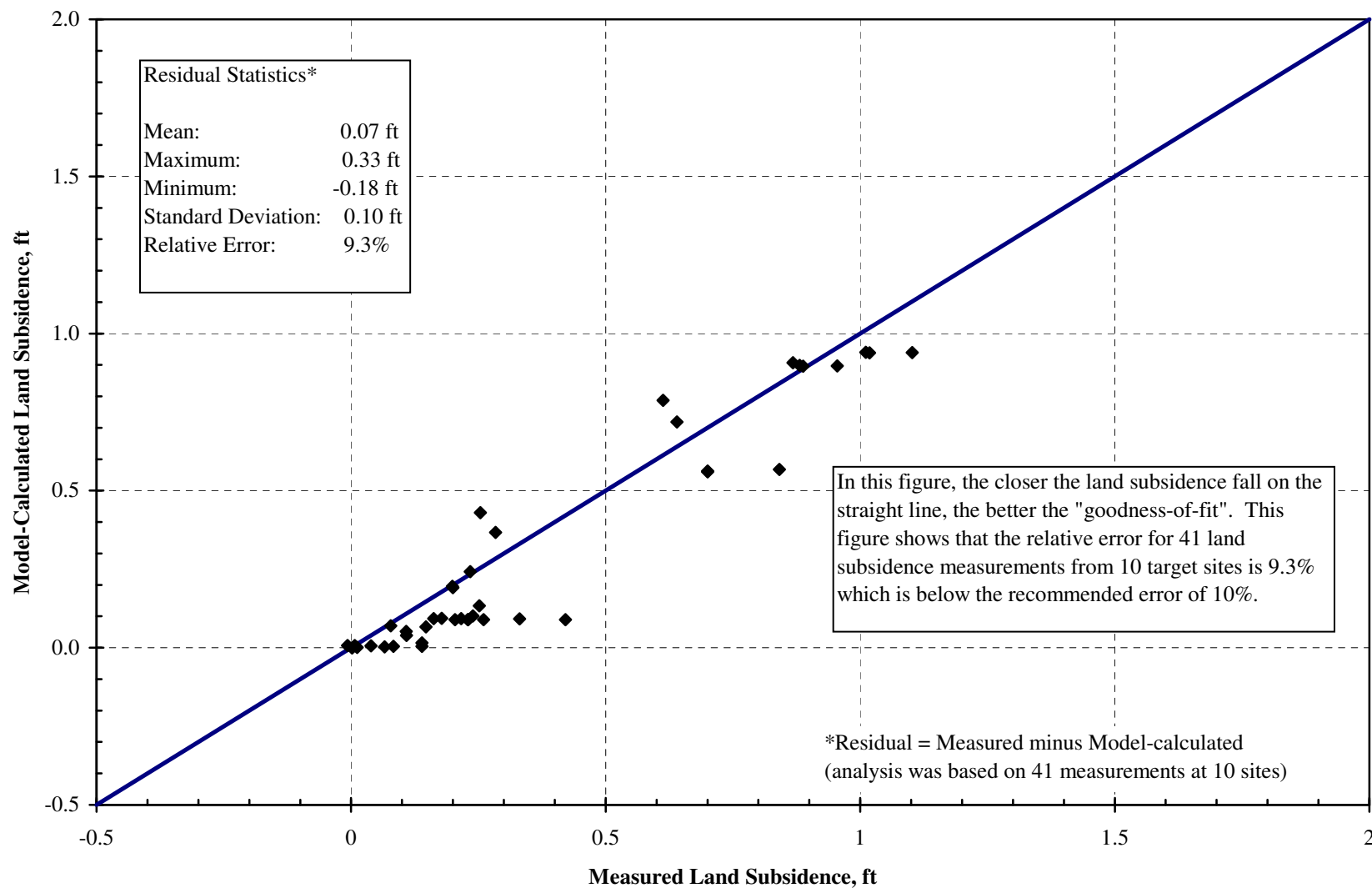
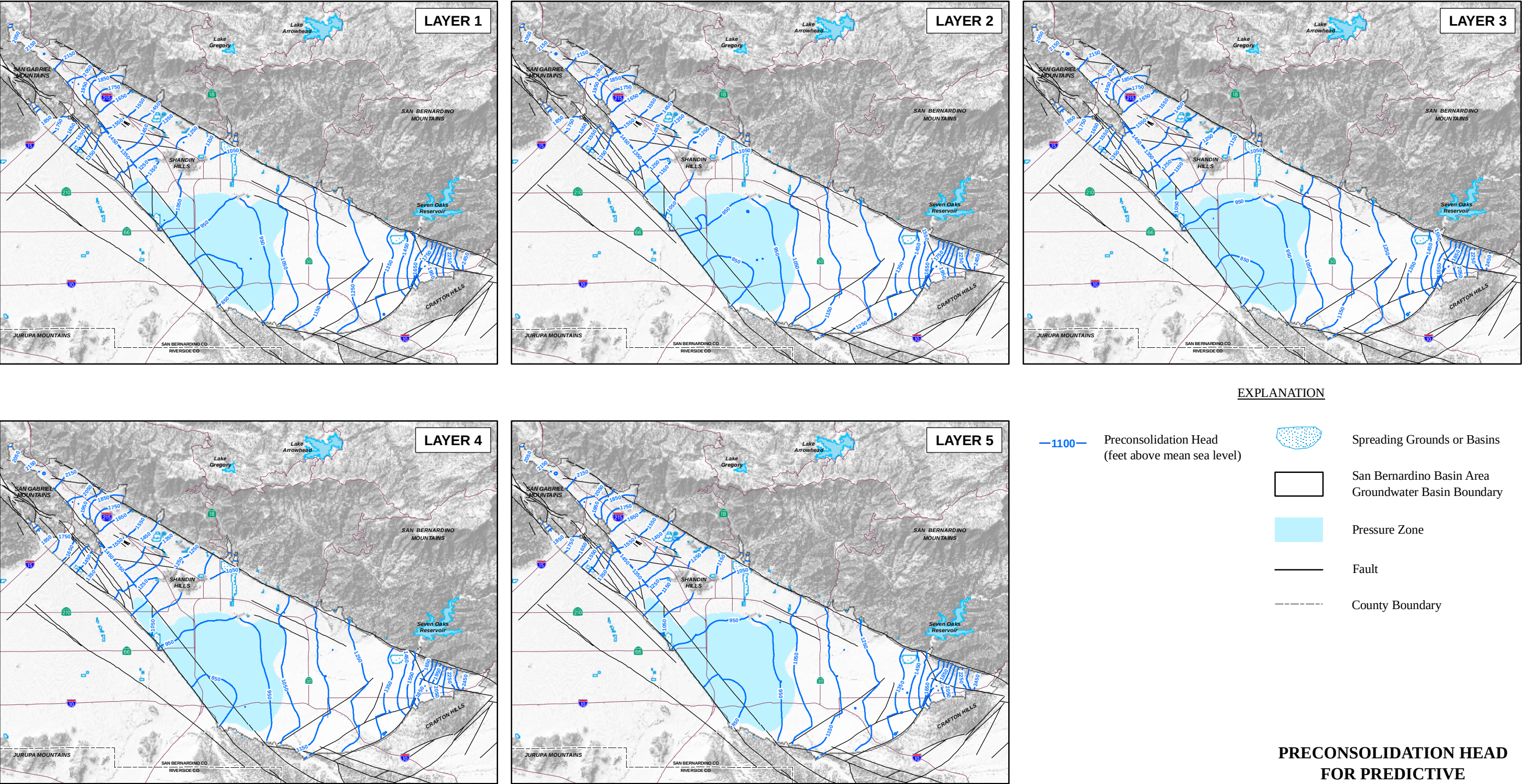


Figure 21

WESTERN MUNICIPAL WATER DISTRICT

SENSITIVITY TO PROLONGED DRY BASE PERIOD AND LAND SUBSIDENCE MODELING
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



TABLES

GEOSCIENCE Support Services, Inc.



Comparisons of Groundwater Elevation for Prolonged Dry Baseline Run (No Project) and Riverside-Corona Feeder Project Prolonged Dry Scenarios 1 through 3 Annual Average from 2007 to 2030

Well Name	Average Groundwater Elevation from 2007 to 2030				Difference in Average Groundwater Elevation between Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios			Hydrograph Page Number in Appendix A
	Prolonged Dry Baseline Run (No Project)	RCF Prolonged Dry Scenario 1	RCF Prolonged Dry Scenario 2	RCF Prolonged Dry Scenario 3	Prolonged Dry Scenario 1 minus Prolonged Dry Baseline Run	Prolonged Dry Scenario 2 minus Prolonged Dry Baseline Run	Prolonged Dry Scenario 3 minus Prolonged Dry Baseline Run	
	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	
SBVMWD San Bernardino Ave. Well	1,411	1,411	1,432	1,436	0	21	26	A-1
City of San Bernardino Mt. Vernon Well	950	950	954	956	0	3	5	A-2
East Valley Water District Well 62	1,029	1,029	1,030	1,030	0	1	2	A-3
Fontana Union Well 13	1,073	1,073	1,083	1,091	0	9	17	A-4
Fontana Union Well 26	1,657	1,657	1,669	1,679	0	12	22	A-5
Fontana Union Well 27	2,061	2,061	2,064	2,067	0	3	6	A-6
East Valley Water District Well 120	1,329	1,329	1,343	1,346	0	14	16	A-7
City of San Bernardino Vincent Well	2,086	2,086	2,086	2,086	0	0	0	A-8
City of San Bernardino Devil Canyon Well No. 1	1,372	1,372	1,381	1,385	0	9	13	A-9
City of San Bernardino Newmark 3 Well	1,274	1,274	1,282	1,284	0	7	10	A-10
West Valley Water District Lord 7 Well	943	943	949	953	0	5	9	A-11
City of Riverside Raub 1 Well	820	820	821	821	0	1	1	A-12
City of Redlands Well 32	1,184	1,184	1,185	1,183	0	1	-1	A-13
City of Redlands Orange Street Well	1,212	1,212	1,216	1,216	0	4	4	A-14
East Valley Water District Well 24A	1,009	1,009	1,011	1,011	0	2	3	A-15
City of San Bernardino Cajon Well No. 1	1,614	1,614	1,617	1,618	0	2	3	A-16
East Valley Water District Well 40	1,134	1,134	1,136	1,135	0	2	1	A-17
City of San Bernardino Devil Canyon Well No. 3	1,498	1,498	1,508	1,511	0	10	13	A-18
City of San Bernardino Leroy Street Well	1,000	1,000	1,002	1,003	0	2	3	A-19
City of Redlands Agate 2 Well	1,496	1,496	1,527	1,533	0	32	38	A-20
East Valley Water District Cone Camp Well	1,476	1,476	1,502	1,508	0	25	32	A-21
Bear Valley Mutual Water Company Nelson Street Well	1,314	1,314	1,327	1,330	0	13	15	A-22
Gage Canal Company Lower Kelly Well	836	836	836	836	0	1	0	A-23
City of Redlands Airport Well No. 2	1,312	1,312	1,325	1,328	0	14	16	A-24
East Valley Water District Well 146A	1,260	1,260	1,269	1,270	0	9	10	A-25
SBVMWD Backyard Well	815	815	816	816	0	1	1	A-26

Groundwater Budgets for Prolonged Dry Baseline Run (No Project) - 2007 to 2030

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1945	136,359	114,950	0	6,081	1,083	44,274	19,848	3,667	326,261	8,193	211,893	0	2,413	222,499	103,762
2008	1946	124,799	94,144	0	5,846	1,083	44,275	15,148	3,667	288,961	9,687	210,493	0	2,390	222,570	66,391
2009	1947	90,360	33,439	0	1,944	1,083	44,276	10,077	3,667	184,846	8,179	223,345	0	2,384	233,907	-49,062
2010	1948	65,158	83,479	0	4,324	1,083	44,277	9,618	3,667	211,606	7,722	226,652	0	2,389	236,763	-25,158
2011	1949	70,881	21,168	0	4,850	1,083	44,278	10,283	3,667	156,210	3,262	226,582	0	2,382	232,226	-76,016
2012	1950	57,299	54,462	0	2,940	1,083	44,279	8,061	3,667	171,791	3,815	229,246	0	2,358	235,419	-63,628
2013	1951	47,260	80,900	0	5,564	1,083	44,280	7,240	3,667	189,994	4,299	236,314	0	2,329	242,942	-52,948
2014	1952	129,583	110,643	0	7,085	1,083	40,208	17,081	3,667	309,349	6,485	226,207	0	2,308	235,000	74,349
2015	1953	64,281	72,373	0	2,408	1,083	46,261	8,184	3,667	198,257	4,237	240,778	0	2,296	247,311	-49,054
2016	1954	92,857	76,313	0	6,320	1,083	44,451	12,964	3,667	237,656	4,630	237,692	0	2,285	244,607	-6,951
2017	1955	64,090	15,762	0	3,995	1,083	46,925	8,361	3,667	143,884	1,044	247,661	0	2,265	250,971	-107,087
2018	1956	57,461	93,336	0	3,662	1,083	47,426	8,046	3,667	214,681	4,745	250,304	0	2,243	257,291	-42,610
2019	1957	65,831	43,060	0	6,679	1,083	48,921	7,733	3,667	176,973	2,176	254,836	0	2,218	259,230	-82,257
2020	1958	201,124	123,565	0	6,803	1,083	49,115	20,862	3,667	406,219	7,966	251,087	0	2,195	261,248	144,971
2021	1959	68,823	82,244	0	3,169	1,083	50,955	8,073	3,667	218,014	4,847	258,043	0	2,172	265,061	-47,047
2022	1960	53,820	45,723	0	4,146	1,083	50,363	7,443	3,667	166,245	2,604	263,442	0	2,155	268,201	-101,956
2023	1961	37,201	50,947	0	2,137	1,083	58,493	4,771	3,667	158,299	2,683	289,108	0	2,139	293,930	-135,632
2024	1962	75,617	81,663	0	3,440	1,083	52,903	10,371	3,667	228,744	4,142	268,711	0	2,120	274,972	-46,228
2025	1963	45,762	70,210	0	5,666	1,083	57,779	5,291	3,667	189,458	3,531	289,787	0	2,100	295,418	-105,960
2026	1964	42,219	47,252	0	3,228	1,083	57,932	5,302	3,667	160,682	2,364	288,559	0	2,080	293,004	-132,321
2027	1965	73,696	81,922	0	7,094	1,083	54,548	12,450	3,667	234,460	4,104	277,792	0	2,061	283,958	-49,498
2028	1966	98,827	113,958	0	4,820	1,083	47,634	19,389	3,667	289,379	5,733	256,798	0	2,046	264,577	24,802
2029	1967	146,782	131,502	0	5,598	1,083	47,969	18,440	3,667	355,041	8,251	265,120	0	2,035	275,406	79,635
2030	1968	78,418	69,197	0	2,450	1,083	52,204	8,967	3,667	215,987	4,113	277,836	0	2,026	283,975	-67,988
Total		1,988,509	1,792,214	0	110,248	25,991	1,164,025	264,001	88,008	5,432,997	118,813	6,008,285	0	53,388	6,180,486	-747,490
Average		82,855	74,676	0	4,594	1,083	48,501	11,000	3,667	226,375	4,951	250,345	0	2,225	257,520	-31,145

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Prolonged Dry Scenario 1 - 2007 to 2030

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1945	136,359	114,950	0	6,081	1,083	44,274	19,848	3,667	326,261	8,193	211,893	0	2,413	222,499	103,762
2008	1946	124,799	94,144	0	5,846	1,083	44,275	15,148	3,667	288,961	9,687	210,493	0	2,390	222,570	66,391
2009	1947	90,360	33,439	0	1,944	1,083	44,276	10,077	3,667	184,846	8,179	223,345	0	2,384	233,907	-49,062
2010	1948	65,158	83,479	0	4,324	1,083	44,277	9,618	3,667	211,606	7,722	226,652	0	2,389	236,763	-25,158
2011	1949	70,881	21,168	0	4,850	1,083	44,278	10,283	3,667	156,210	3,262	226,582	0	2,382	232,226	-76,016
2012	1950	57,299	54,462	0	2,940	1,083	44,279	8,061	3,667	171,791	3,815	229,246	0	2,358	235,419	-63,628
2013	1951	47,260	80,900	0	5,564	1,083	44,280	7,240	3,667	189,994	4,299	236,314	0	2,329	242,942	-52,948
2014	1952	129,583	110,643	0	7,085	1,083	40,208	17,081	3,667	309,349	6,485	226,207	0	2,308	235,000	74,349
2015	1953	64,281	72,373	0	2,408	1,083	46,261	8,184	3,667	198,257	4,237	240,778	0	2,296	247,311	-49,054
2016	1954	92,857	76,313	0	6,320	1,083	44,451	12,964	3,667	237,656	4,630	237,692	0	2,285	244,607	-6,951
2017	1955	64,090	15,762	0	3,995	1,083	46,925	8,361	3,667	143,884	1,044	247,661	0	2,265	250,971	-107,087
2018	1956	57,461	93,336	0	3,662	1,083	47,426	8,046	3,667	214,681	4,745	250,304	0	2,243	257,291	-42,610
2019	1957	65,831	43,060	0	6,679	1,083	48,921	7,733	3,667	176,973	2,176	254,836	0	2,218	259,230	-82,257
2020	1958	201,124	123,565	0	6,803	1,083	49,115	20,862	3,667	406,219	7,966	251,087	0	2,195	261,248	144,971
2021	1959	68,823	82,244	0	3,169	1,083	50,955	8,073	3,667	218,014	4,847	258,043	0	2,172	265,061	-47,047
2022	1960	53,820	45,723	0	4,146	1,083	50,363	7,443	3,667	166,245	2,604	263,442	0	2,155	268,201	-101,956
2023	1961	37,201	50,947	0	2,137	1,083	58,493	4,771	3,667	158,299	2,683	289,108	0	2,139	293,930	-135,632
2024	1962	75,617	81,663	0	3,440	1,083	52,903	10,371	3,667	228,744	4,142	268,711	0	2,120	274,972	-46,228
2025	1963	45,762	70,210	0	5,666	1,083	57,779	5,291	3,667	189,458	3,531	289,787	0	2,100	295,418	-105,960
2026	1964	42,219	47,252	0	3,228	1,083	57,932	5,302	3,667	160,682	2,364	288,559	0	2,080	293,004	-132,321
2027	1965	73,696	81,922	0	7,094	1,083	54,548	12,450	3,667	234,460	4,104	277,792	0	2,061	283,958	-49,498
2028	1966	98,827	113,958	0	4,820	1,083	47,634	19,389	3,667	289,379	5,733	256,798	0	2,046	264,577	24,802
2029	1967	146,782	131,502	0	5,598	1,083	47,969	18,440	3,667	355,041	8,251	265,120	0	2,035	275,406	79,635
2030	1968	78,418	69,197	0	2,450	1,083	52,204	8,967	3,667	215,987	4,113	277,836	0	2,026	283,975	-67,988
Total		1,988,509	1,792,214	0	110,248	25,991	1,164,025	264,001	88,008	5,432,997	118,813	6,008,285	0	53,388	6,180,486	-747,490
Average		82,855	74,676	0	4,594	1,083	48,501	11,000	3,667	226,375	4,951	250,345	0	2,225	257,520	-31,145

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Prolonged Dry Scenario 2 - 2007 to 2030

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1945	136,359	114,950	0	6,081	1,083	44,274	19,848	3,667	326,261	8,193	211,893	0	2,413	222,499	103,762
2008	1946	124,799	94,144	0	5,846	1,083	44,275	15,148	3,667	288,961	9,687	210,493	0	2,390	222,570	66,391
2009	1947	90,360	33,439	0	1,944	1,083	44,276	10,077	3,667	184,846	8,179	223,345	0	2,384	233,907	-49,062
2010	1948	65,158	83,479	0	4,324	1,083	44,277	9,618	3,667	211,606	7,722	226,652	0	2,389	236,763	-25,158
2011	1949	70,881	21,168	0	4,850	1,083	44,278	10,283	3,667	156,210	3,262	226,582	0	2,382	232,226	-76,016
2012	1950	57,299	54,462	0	2,940	1,083	44,279	8,061	3,667	171,791	3,815	229,246	0	2,358	235,419	-63,628
2013	1951	47,260	80,900	46,800	5,564	1,083	44,280	7,240	3,667	236,794	6,567	236,314	15,000	2,329	260,211	-23,416
2014	1952	129,597	110,643	46,800	7,085	1,083	40,208	17,081	3,667	356,163	9,641	226,207	15,000	2,307	253,154	103,009
2015	1953	64,282	72,373	0	2,408	1,083	46,261	8,184	3,667	198,257	5,510	240,778	5,000	2,292	253,580	-55,323
2016	1954	92,693	76,313	0	6,320	1,083	44,451	12,964	3,667	237,492	5,765	237,692	5,000	2,280	250,736	-13,244
2017	1955	64,090	15,762	0	3,995	1,083	46,925	8,361	3,667	143,884	1,317	247,661	5,000	2,260	256,239	-112,355
2018	1956	57,461	93,336	46,800	3,662	1,083	47,426	8,046	3,667	261,481	7,179	250,304	15,000	2,240	274,723	-13,242
2019	1957	65,831	43,060	0	6,679	1,083	48,921	7,733	3,667	176,973	2,271	254,836	5,000	2,217	264,324	-87,351
2020	1958	200,675	123,565	46,800	6,803	1,083	49,115	20,862	3,667	452,570	12,004	251,087	15,000	2,195	280,286	172,283
2021	1959	68,823	82,244	0	3,169	1,083	50,955	8,073	3,667	218,014	6,049	258,043	5,000	2,173	271,265	-53,251
2022	1960	53,819	45,723	0	4,146	1,083	50,363	7,443	3,667	166,245	2,751	263,442	5,000	2,158	273,351	-107,107
2023	1961	37,201	50,947	0	2,137	1,083	58,493	4,771	3,667	158,299	2,761	289,108	5,000	2,144	299,013	-140,715
2024	1962	75,617	81,663	0	3,440	1,083	52,903	10,371	3,667	228,744	4,226	268,711	5,000	2,127	280,064	-51,320
2025	1963	45,761	70,210	0	5,666	1,083	57,779	5,291	3,667	189,458	3,605	289,787	5,000	2,108	300,500	-111,043
2026	1964	42,219	47,252	0	3,228	1,083	57,932	5,302	3,667	160,682	2,390	288,559	5,000	2,089	298,038	-137,356
2027	1965	73,694	81,922	0	7,094	1,083	54,548	12,450	3,667	234,457	4,107	277,792	5,000	2,069	288,968	-54,511
2028	1966	98,814	113,958	0	4,820	1,083	47,634	19,389	3,667	289,365	5,742	256,798	5,000	2,053	269,593	19,772
2029	1967	146,782	131,502	15,996	5,598	1,083	47,969	18,440	3,667	371,037	9,320	265,120	15,000	2,041	291,481	79,555
2030	1968	78,418	69,197	0	2,450	1,083	52,204	8,967	3,667	215,987	4,215	277,836	5,000	2,031	289,083	-73,095
Total		1,987,893	1,792,214	203,196	110,248	25,991	1,164,025	264,001	88,008	5,635,577	136,280	6,008,285	140,000	53,430	6,337,995	-702,419
Average		82,829	74,676	8,467	4,594	1,083	48,501	11,000	3,667	234,816	5,678	250,345	5,833	2,226	264,083	-29,267

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Prolonged Dry Scenario 3 - 2007 to 2030

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1945	136,359	114,950	0	6,081	1,083	44,274	19,848	3,667	326,261	8,193	211,893	0	2,413	222,499	103,762
2008	1946	124,799	94,144	0	5,846	1,083	44,275	15,148	3,667	288,961	9,687	210,493	0	2,390	222,570	66,391
2009	1947	90,360	33,439	0	1,944	1,083	44,276	10,077	3,667	184,846	8,179	223,345	0	2,384	233,907	-49,062
2010	1948	65,158	83,479	0	4,324	1,083	44,277	9,618	3,667	211,606	7,722	226,652	0	2,389	236,763	-25,158
2011	1949	70,881	21,168	0	4,850	1,083	44,278	10,283	3,667	156,210	3,262	226,582	0	2,382	232,226	-76,016
2012	1950	57,299	54,462	0	2,940	1,083	44,279	8,061	3,667	171,791	3,815	229,246	0	2,358	235,419	-63,628
2013	1951	47,260	80,900	62,400	5,564	1,083	44,280	7,240	3,667	252,394	7,349	236,314	15,000	2,329	260,992	-8,598
2014	1952	129,104	110,643	58,800	7,085	1,083	40,208	17,081	3,667	367,670	11,524	226,207	15,000	2,307	255,038	112,632
2015	1953	64,281	72,373	0	2,408	1,083	46,261	8,184	3,667	198,257	6,498	240,778	10,000	2,293	259,569	-61,312
2016	1954	92,595	76,313	0	6,320	1,083	44,451	12,964	3,667	237,394	6,006	237,692	10,000	2,282	255,979	-18,585
2017	1955	64,091	15,762	0	3,995	1,083	46,925	8,361	3,667	143,884	1,253	247,661	10,000	2,263	261,178	-117,294
2018	1956	57,461	93,336	82,800	3,662	1,083	47,426	8,046	3,667	297,481	9,204	250,304	15,000	2,243	276,750	20,731
2019	1957	65,831	43,060	0	6,679	1,083	48,921	7,733	3,667	176,973	2,512	254,836	10,000	2,219	269,567	-92,594
2020	1958	199,900	123,565	46,800	6,803	1,083	49,115	20,862	3,667	451,795	13,461	251,087	15,000	2,198	281,746	170,049
2021	1959	68,822	82,244	0	3,169	1,083	50,955	8,073	3,667	218,013	6,736	258,043	10,000	2,177	276,955	-58,942
2022	1960	53,819	45,723	0	4,146	1,083	50,363	7,443	3,667	166,245	2,853	263,442	10,000	2,163	278,458	-112,213
2023	1961	37,200	50,947	0	2,137	1,083	58,493	4,771	3,667	158,298	2,771	289,108	10,000	2,150	304,029	-145,730
2024	1962	75,616	81,663	0	3,440	1,083	52,903	10,371	3,667	228,743	4,237	268,711	10,000	2,133	285,080	-56,337
2025	1963	45,761	70,210	0	5,666	1,083	57,779	5,291	3,667	189,457	3,615	289,787	10,000	2,113	305,516	-116,058
2026	1964	42,219	47,252	0	3,228	1,083	57,932	5,302	3,667	160,682	2,398	288,559	10,000	2,093	303,050	-142,368
2027	1965	73,691	81,922	0	7,094	1,083	54,548	12,450	3,667	234,455	4,109	277,792	10,000	2,072	293,973	-59,518
2028	1966	98,806	113,958	0	4,820	1,083	47,634	19,389	3,667	289,358	5,745	256,798	10,000	2,054	274,598	14,760
2029	1967	146,782	131,502	49,200	5,598	1,083	47,969	18,440	3,667	404,241	11,135	265,120	15,000	2,042	293,297	110,944
2030	1968	78,418	69,197	0	2,450	1,083	52,204	8,967	3,667	215,987	4,290	277,836	10,000	2,032	294,157	-78,170
Total		1,986,516	1,792,214	300,000	110,248	25,991	1,164,025	264,001	88,008	5,731,003	146,553	6,008,285	205,000	53,479	6,413,316	-682,313
Average		82,771	74,676	12,500	4,594	1,083	48,501	11,000	3,667	238,792	6,106	250,345	8,542	2,228	267,222	-28,430

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
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[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

**Underflow Outflow from SBBA Across San Jacinto Fault near Santa Ana River to
Rialto-Colton Groundwater Basin for Predictive Prolonged Dry Model Scenarios - 2007 to 2030**

Model Year	Hydrologic Year	Underflow Outflow Across San Jacinto Fault near SAR to Rialto-Colton Groundwater Basin			
		Prolonged Dry Baseline Run (No Project)	RCF Prolonged Dry Scenario 1	RCF Prolonged Dry Scenario 2	RCF Prolonged Dry Scenario 3
		[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]
2007	1945	433	433	433	433
2008	1946	410	410	410	410
2009	1947	404	404	404	404
2010	1948	409	409	409	409
2011	1949	402	402	402	402
2012	1950	378	378	378	378
2013	1951	349	349	349	349
2014	1952	328	328	327	327
2015	1953	316	316	312	313
2016	1954	305	305	300	302
2017	1955	285	285	280	283
2018	1956	263	263	260	263
2019	1957	238	238	237	239
2020	1958	215	215	215	218
2021	1959	192	192	193	197
2022	1960	175	175	178	183
2023	1961	159	159	164	170
2024	1962	140	140	147	153
2025	1963	120	120	128	133
2026	1964	100	100	109	113
2027	1965	81	81	89	92
2028	1966	66	66	73	74
2029	1967	55	55	61	62
2030	1968	46	46	51	52
Maximum		433	433	433	433
Minimum		46	46	51	52
Average		245	245	246	248

Table 6

Comparisons of Land Subsidence from 2007 to 2032 for Baseline Run (No Project) and Riverside-Corona Feeder Project Scenarios 1 through 3

Well Name	Total Land Subsidence from 2007 to 2032				Difference in Total Land Subsidence between Baseline Run (No Project) and RCF Scenarios			Graph Page Number in Appendix B
	Baseline Run (No Project) [ft]	RCF Scenario 1 [ft]	RCF Scenario 2 [ft]	RCF Scenario 3 [ft]	Scenario 1 minus Baseline Run [ft]	Scenario 2 minus Baseline Run [ft]	Scenario 3 minus Baseline Run [ft]	
SBVMWD San Bernardino Ave. Well	-0.02	-0.02	-0.02	-0.02	0.00	0.00	0.00	B-1
City of San Bernardino Mt. Vernon Well	0.25	0.25	0.24	0.24	0.00	-0.01	-0.01	B-2
East Valley Water District Well 62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-3
Fontana Union Well 13	0.17	0.17	0.17	0.16	0.00	0.00	0.00	B-4
Fontana Union Well 26	0.12	0.12	0.12	0.12	0.00	-0.01	-0.01	B-5
Fontana Union Well 27	0.04	0.04	0.04	0.04	0.00	0.00	0.00	B-6
East Valley Water District Well 120	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	B-7
City of San Bernardino Vincent Well	0.03	0.03	0.03	0.03	0.00	0.00	0.00	B-8
City of San Bernardino Devil Canyon Well No. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-9
City of San Bernardino Newmark 3 Well	-0.02	-0.02	-0.02	-0.02	0.00	0.00	0.00	B-10
West Valley Water District Lord 7 Well	0.29	0.29	0.29	0.29	0.00	-0.01	-0.01	B-11
City of Riverside Raub 1 Well	0.24	0.24	0.26	0.27	0.00	0.02	0.03	B-12
City of Redlands Well 32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-13
City of Redlands Orange Street Well	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-14
East Valley Water District Well 24A	-0.02	-0.02	-0.02	-0.02	0.00	0.00	0.00	B-15
City of San Bernardino Cajon Well No. 1	0.04	0.04	0.03	0.03	0.00	0.00	0.00	B-16
East Valley Water District Well 40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-17
City of San Bernardino Devil Canyon Well No. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-18
City of San Bernardino Leroy Street Well	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	B-19
City of Redlands Agate 2 Well	0.05	0.05	0.05	0.05	0.00	0.00	0.00	B-20
East Valley Water District Cone Camp Well	-0.02	-0.02	-0.02	-0.02	0.00	0.00	0.00	B-21
Bear Valley Mutual Water Company Nelson Street Well	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	B-22
Gage Canal Company Lower Kelly Well	0.06	0.05	0.07	0.08	0.00	0.02	0.03	B-23
City of Redlands Airport Well No. 2	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	B-24
East Valley Water District Well 146A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	B-25
SBVMWD Backyard Well	0.21	0.21	0.22	0.23	0.00	0.01	0.02	B-26

Comparisons of Land Subsidence from 2007 to 2030 for Prolonged Dry Baseline Run (No Project) and Riverside-Corona Feeder Project Prolonged Dry Scenarios 1 through 3

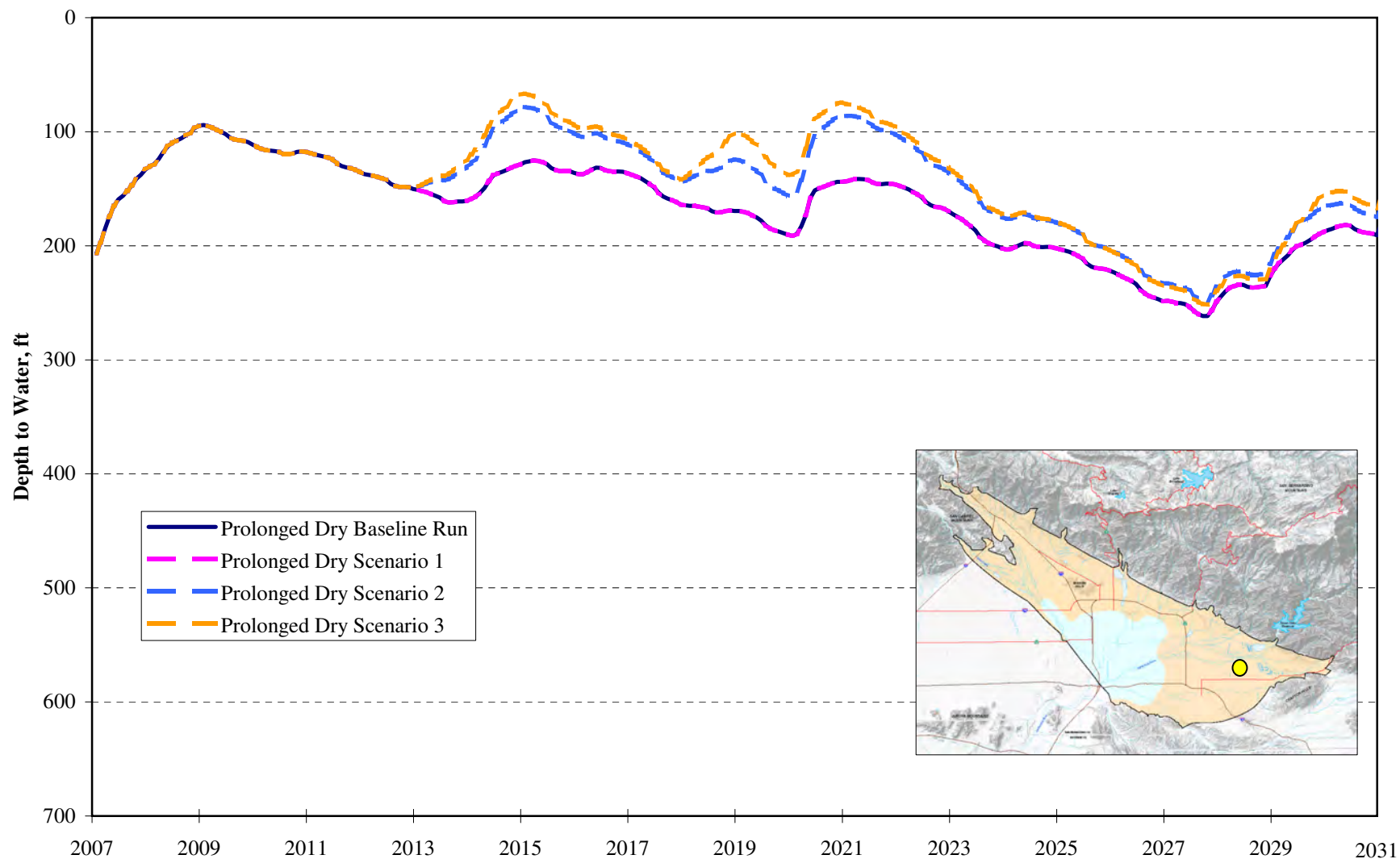
Well Name	Total Land Subsidence from 2007 to 2030				Difference in Total Land Subsidence between Prolonged Dry Baseline Run (No Project) and RCF Prolonged Dry Scenarios			Graph Page Number in Appendix C
	Prolonged Dry Baseline Run (No Project)	RCF Prolonged Dry Scenario 1	RCF Prolonged Dry Scenario 2	RCF Prolonged Dry Scenario 3	Prolonged Dry Scenario 1 minus Prolonged Dry Baseline Run	Prolonged Dry Scenario 2 minus Prolonged Dry Baseline Run	Prolonged Dry Scenario 3 minus Prolonged Dry Baseline Run	
	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	[ft]	
SBVMWD San Bernardino Ave. Well	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	C-1
City of San Bernardino Mt. Vernon Well	0.56	0.56	0.54	0.53	0.00	-0.02	-0.03	C-2
East Valley Water District Well 62	0.10	0.10	0.07	0.07	0.00	-0.03	-0.03	C-3
Fontana Union Well 13	0.30	0.30	0.29	0.28	0.00	-0.01	-0.03	C-4
Fontana Union Well 26	0.29	0.29	0.28	0.27	0.00	-0.01	-0.02	C-5
Fontana Union Well 27	0.07	0.07	0.07	0.07	0.00	0.00	-0.01	C-6
East Valley Water District Well 120	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	C-7
City of San Bernardino Vincent Well	0.05	0.05	0.05	0.05	0.00	0.00	0.00	C-8
City of San Bernardino Devil Canyon Well No. 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C-9
City of San Bernardino Newmark 3 Well	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	C-10
West Valley Water District Lord 7 Well	0.51	0.51	0.50	0.48	0.00	-0.01	-0.03	C-11
City of Riverside Raub 1 Well	0.87	0.87	0.85	0.87	0.00	-0.02	0.00	C-12
City of Redlands Well 32	0.03	0.03	0.02	0.05	0.00	-0.01	0.02	C-13
City of Redlands Orange Street Well	0.07	0.07	0.05	0.07	0.00	-0.01	0.01	C-14
East Valley Water District Well 24A	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	C-15
City of San Bernardino Cajon Well No. 1	0.08	0.08	0.08	0.08	0.00	0.00	0.00	C-16
East Valley Water District Well 40	0.13	0.13	0.12	0.14	0.00	-0.01	0.01	C-17
City of San Bernardino Devil Canyon Well No. 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C-18
City of San Bernardino Leroy Street Well	0.00	0.00	0.00	0.00	0.00	0.00	0.00	C-19
City of Redlands Agate 2 Well	0.08	0.08	0.06	0.06	0.00	-0.02	-0.02	C-20
East Valley Water District Cone Camp Well	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	C-21
Bear Valley Mutual Water Company Nelson Street Well	0.01	0.01	0.00	0.00	0.00	0.00	0.00	C-22
Gage Canal Company Lower Kelly Well	0.59	0.59	0.57	0.59	0.00	-0.02	0.00	C-23
City of Redlands Airport Well No. 2	0.04	0.04	0.03	0.03	0.00	-0.01	-0.01	C-24
East Valley Water District Well 146A	0.05	0.05	0.03	0.04	0.00	-0.02	-0.01	C-25
SBVMWD Backyard Well	0.74	0.74	0.72	0.73	0.00	-0.02	-0.01	C-26

APPENDIX A
Selected Hydrographs for Predictive Prolonged Dry Model Scenarios
2007 to 2030

GEOSCIENCE Support Services, Inc.

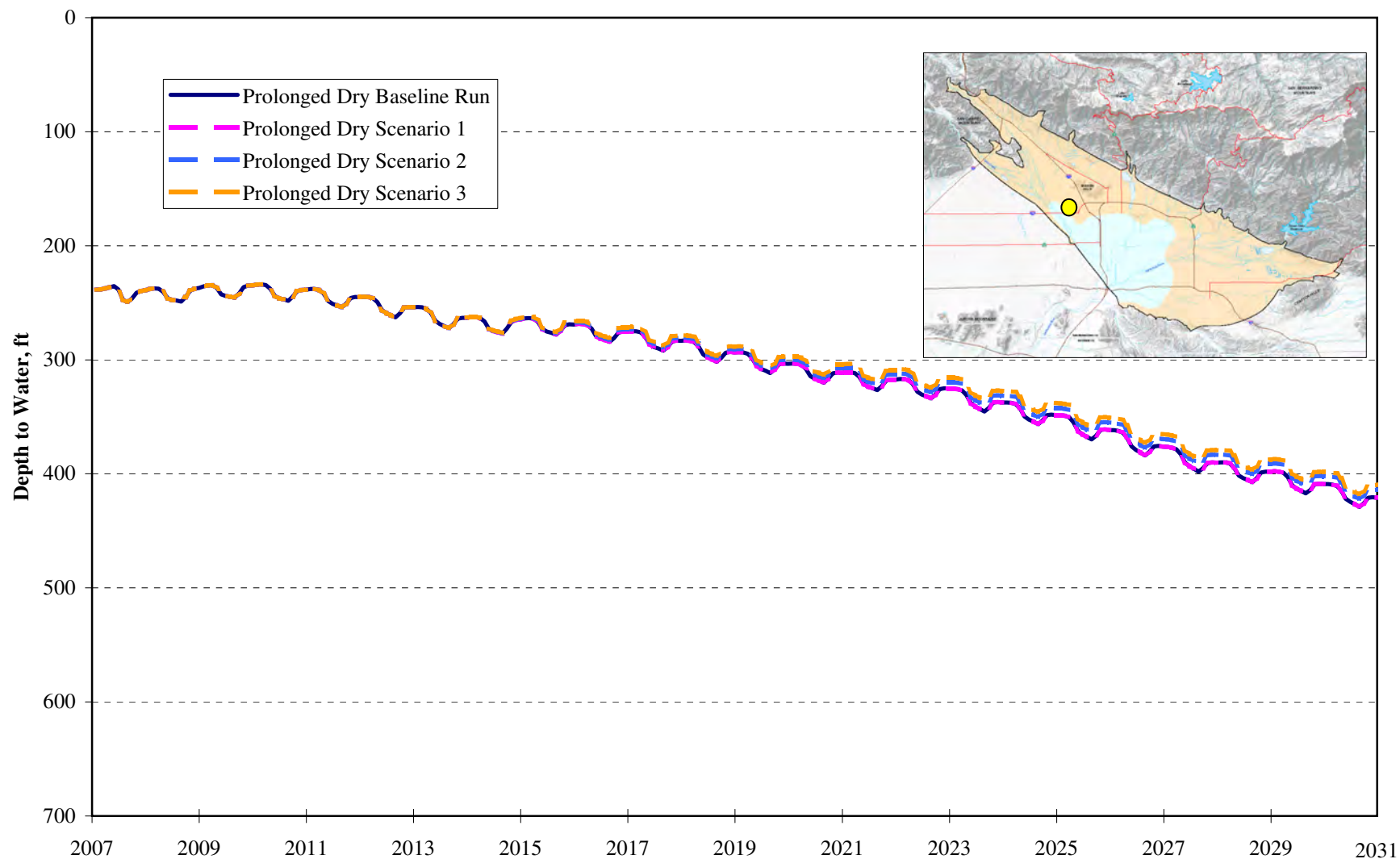


Depth to Water for SBVMWD San Bernardino Ave. Well Model Runs 2007-2030



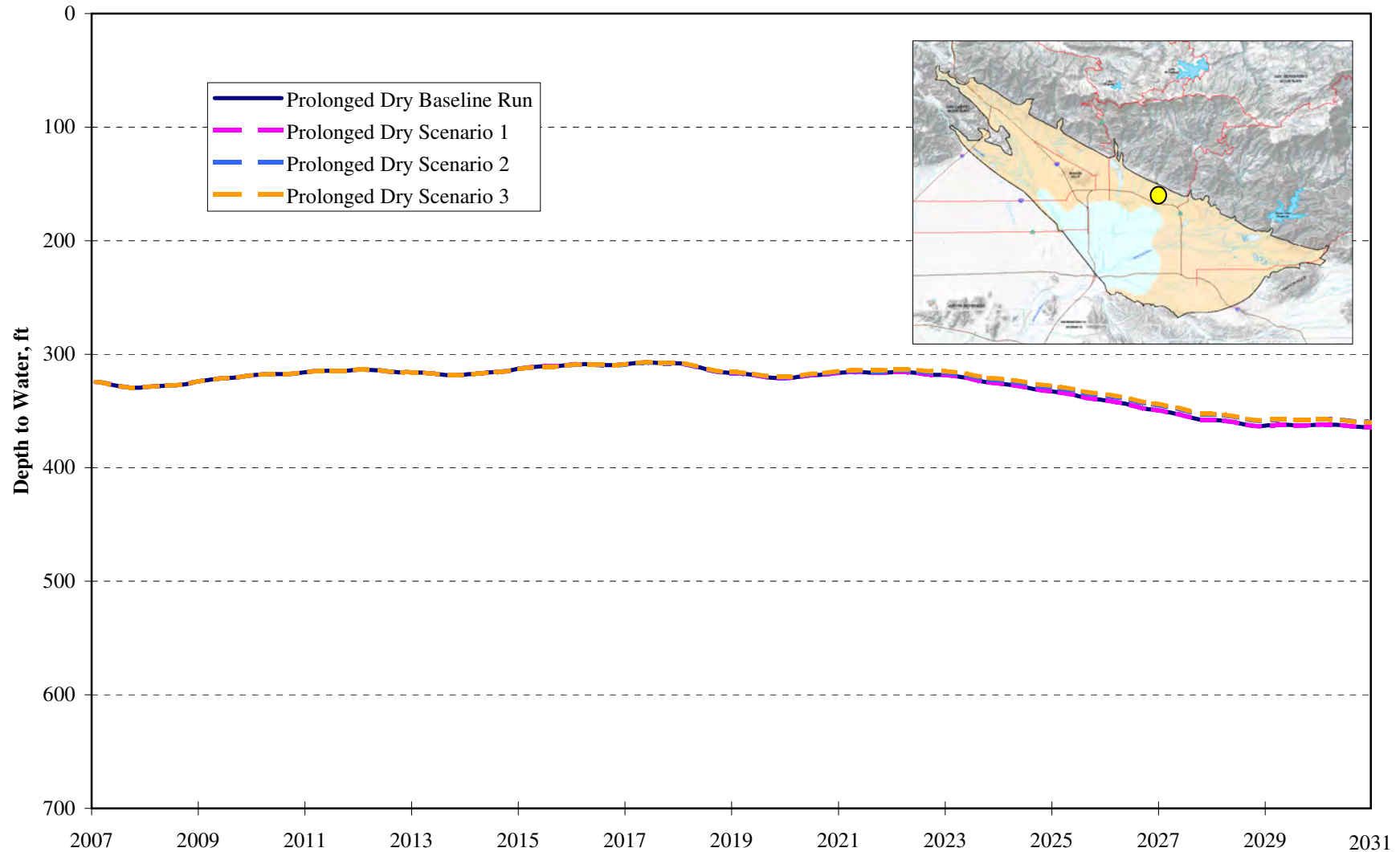
Appendix A

Depth to Water for City of San Bernardino Mt. Vernon Well Model Runs 2007-2030

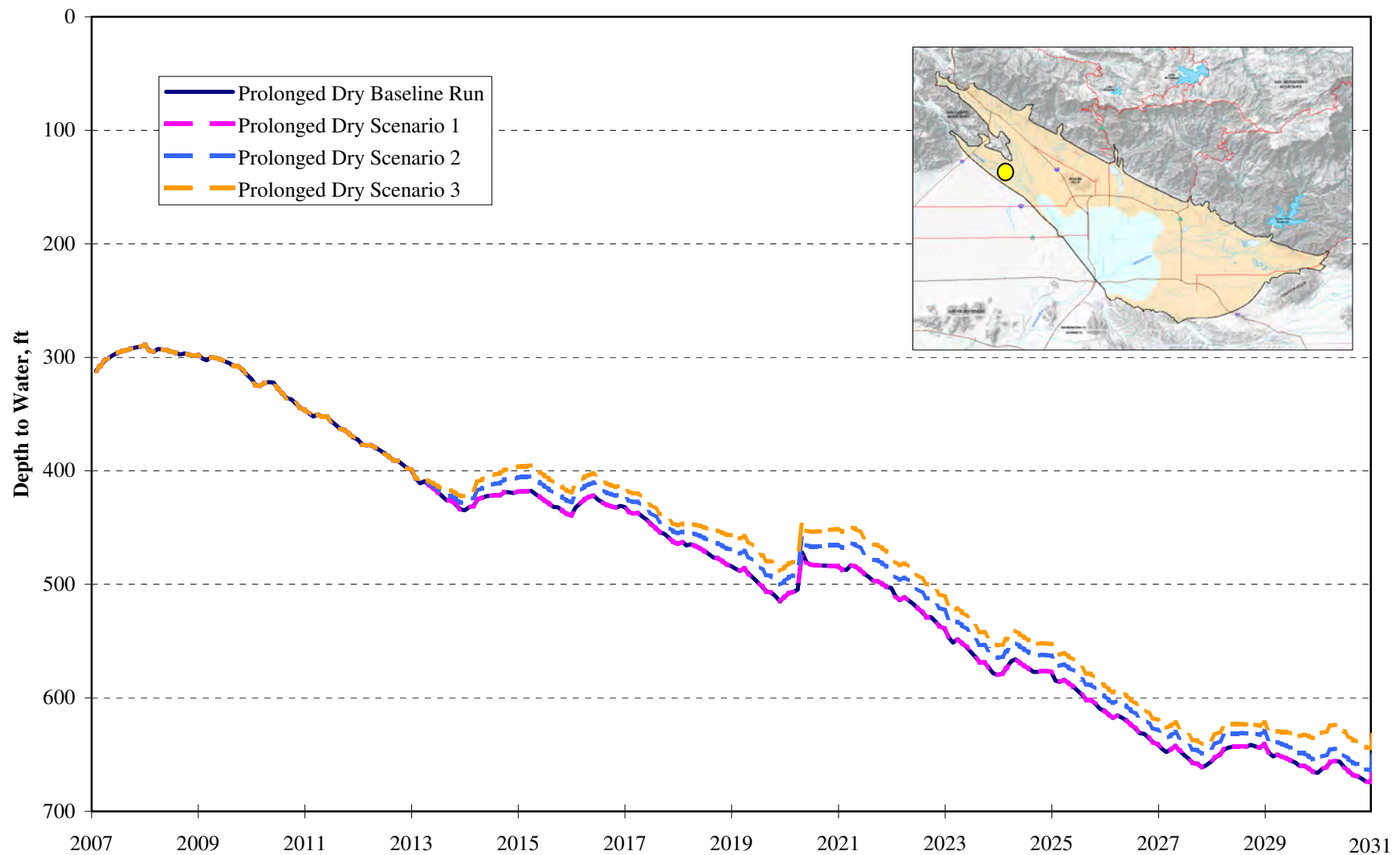


Appendix A

Depth to Water for East Valley Water District Well 62 Model Runs 2007-2030

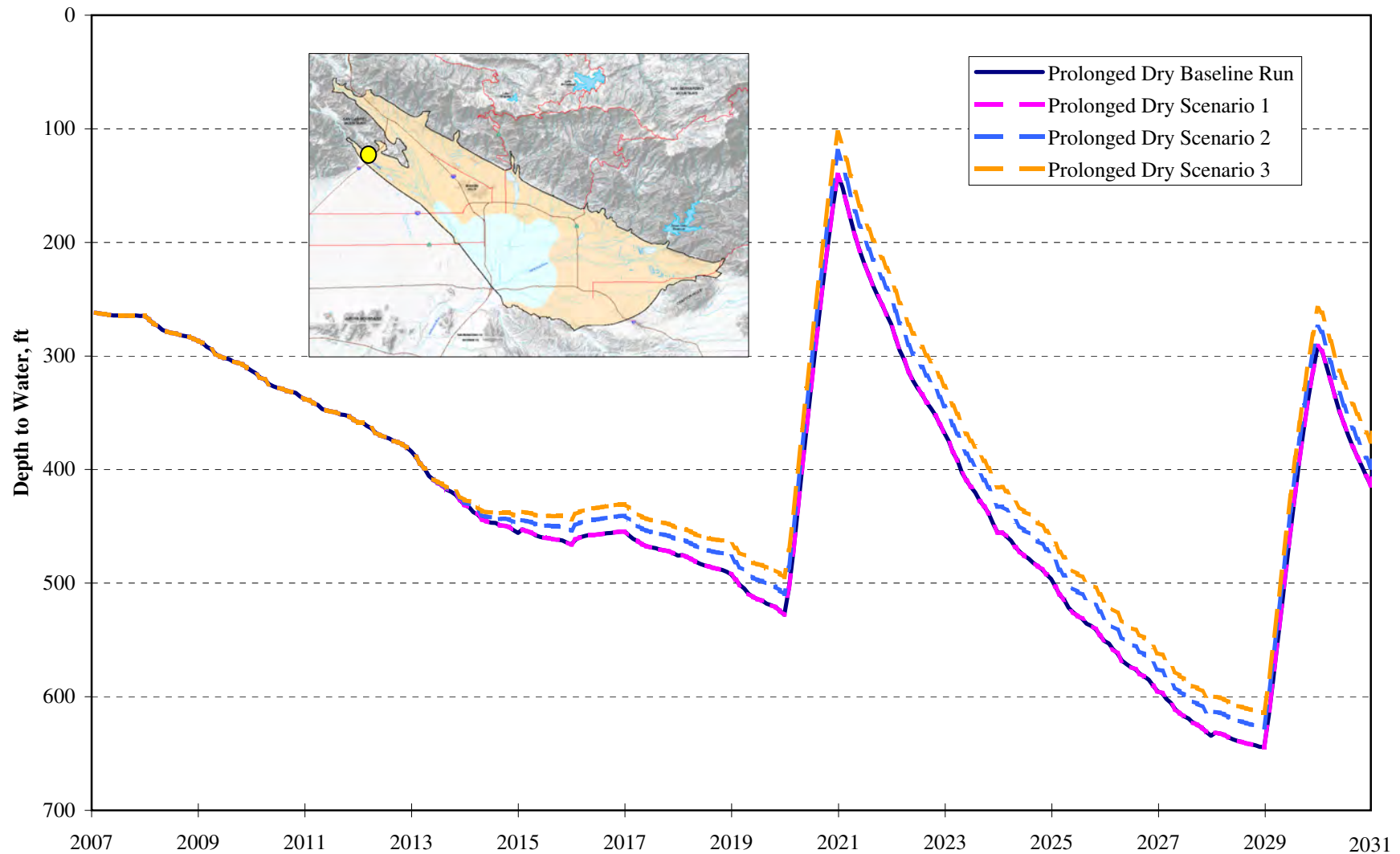


Depth to Water for Fontana Union Water Company Well 13 Model Runs 2007-2030



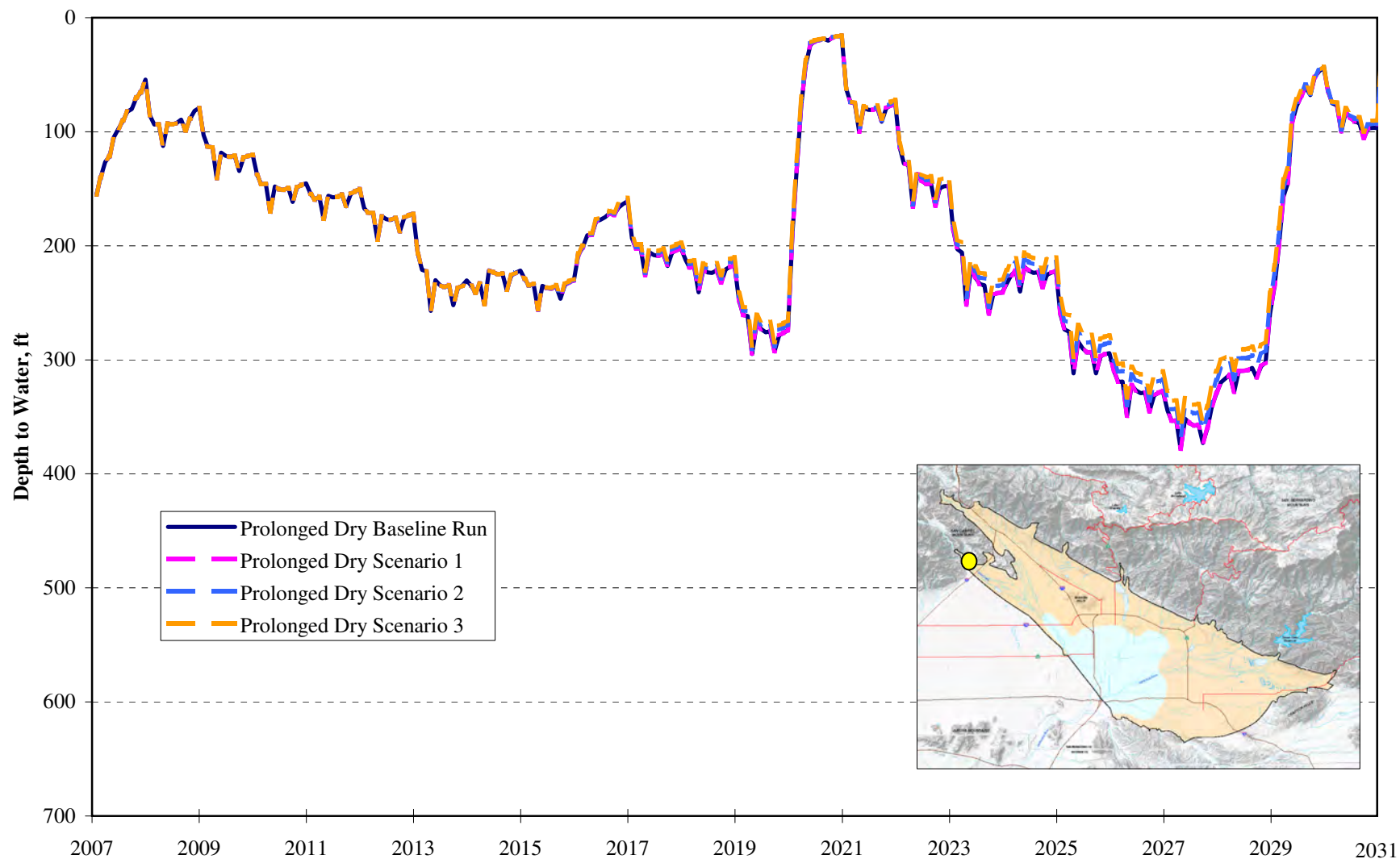
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Depth to Water for Fontana Union Water Company Well 26 Model Runs 2007-2030

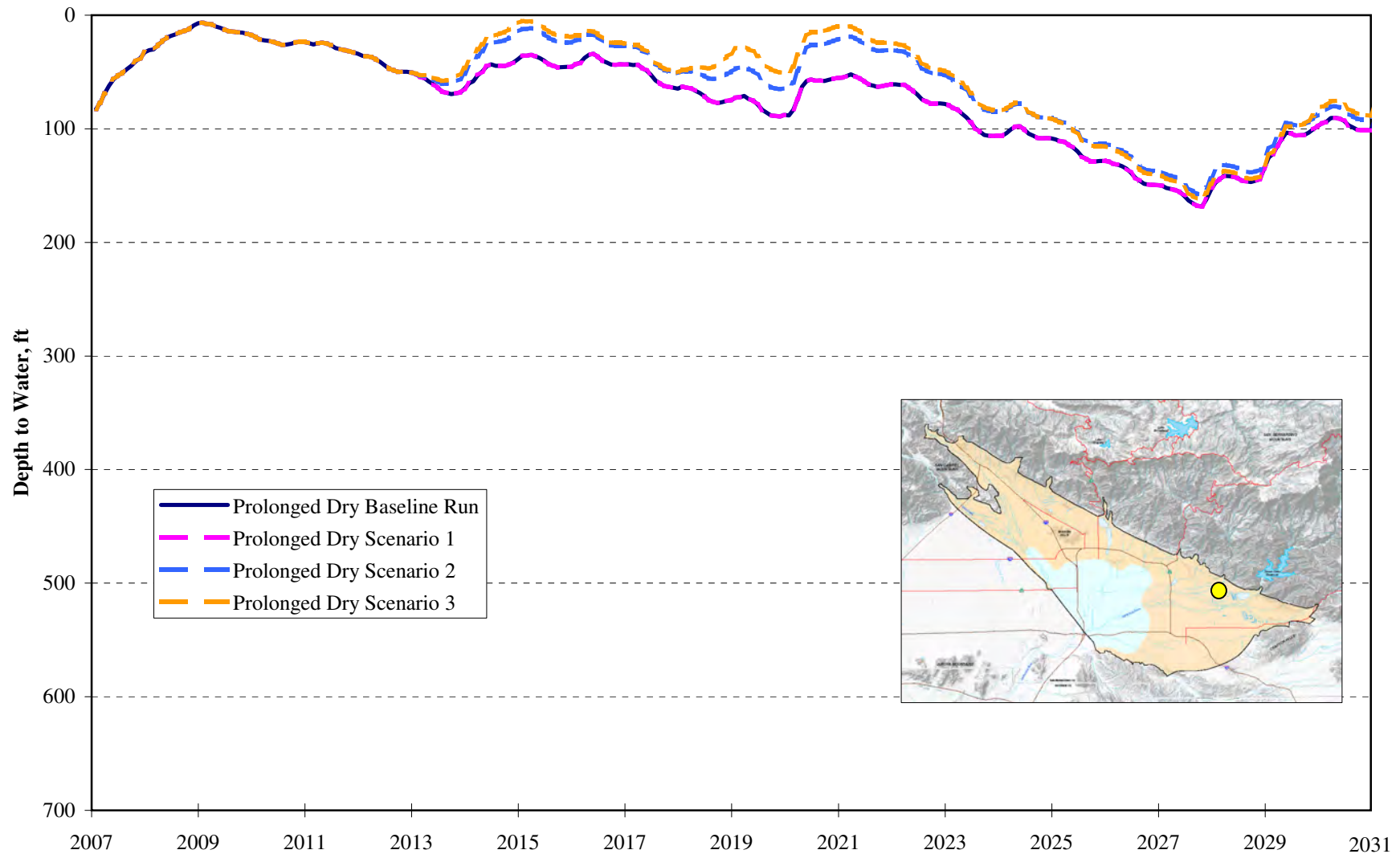


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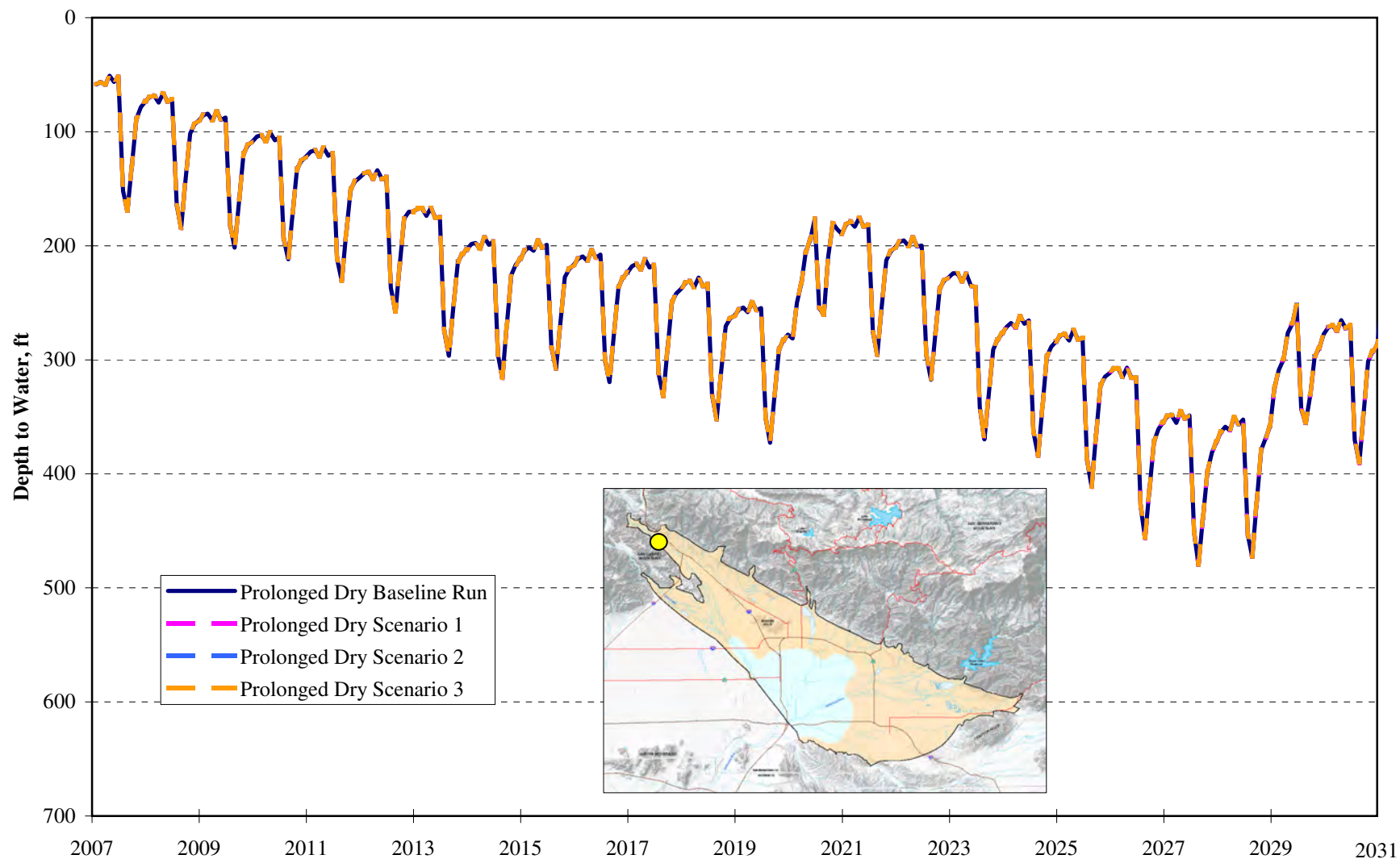
Depth to Water for Fontana Union Water Company Well 27 Model Runs 2007-2030



Depth to Water for East Valley Water District Well 120 Model Runs 2007-2030

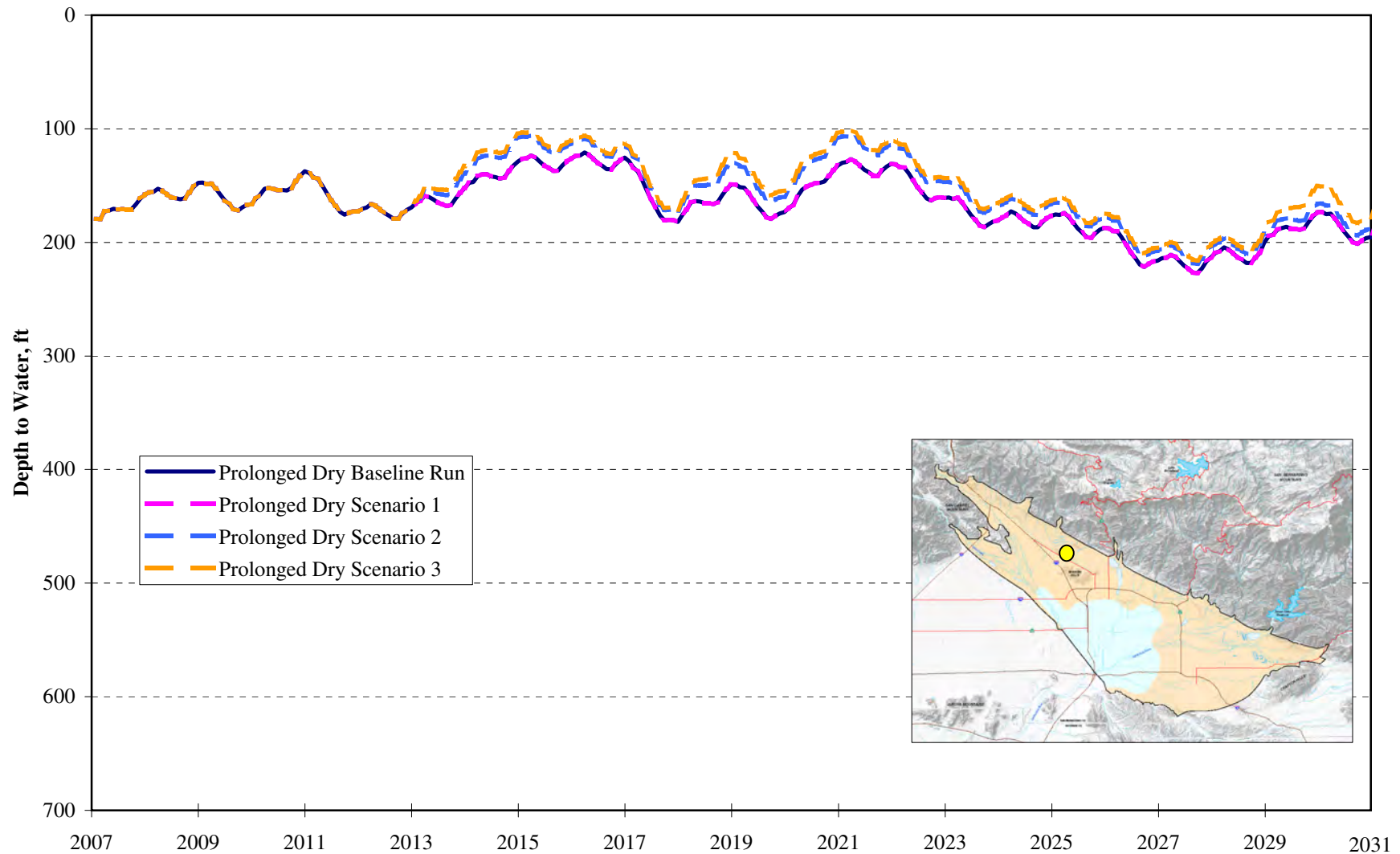


Depth to Water for City of San Bernardino Vincent Well Model Runs 2007-2030

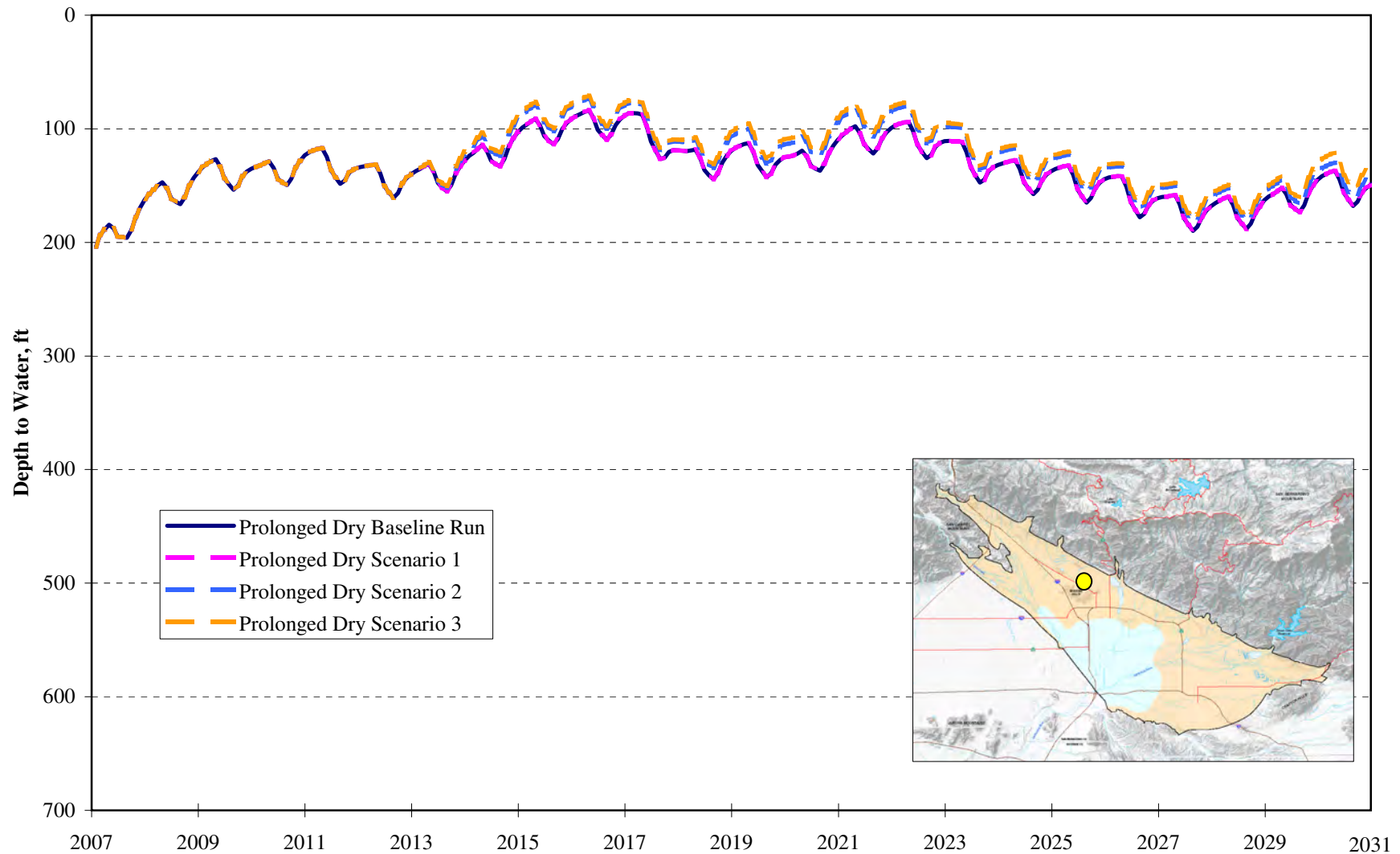


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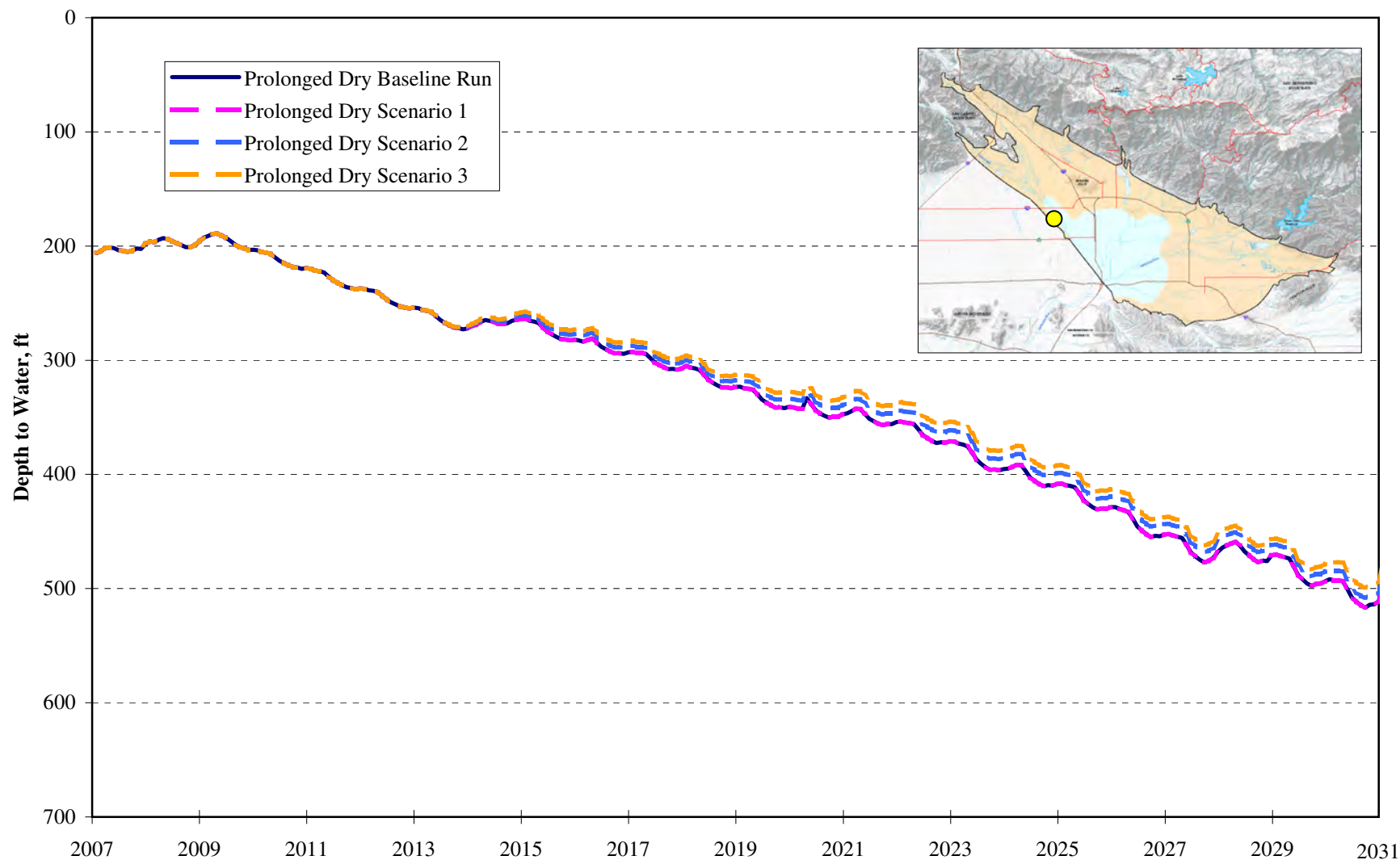
Depth to Water for City of San Bernardino Devil Canyon Well No. 1 Model Runs 2007-2030



Depth to Water for City of San Bernardino Newmark 3 Well Model Runs 2007-2030

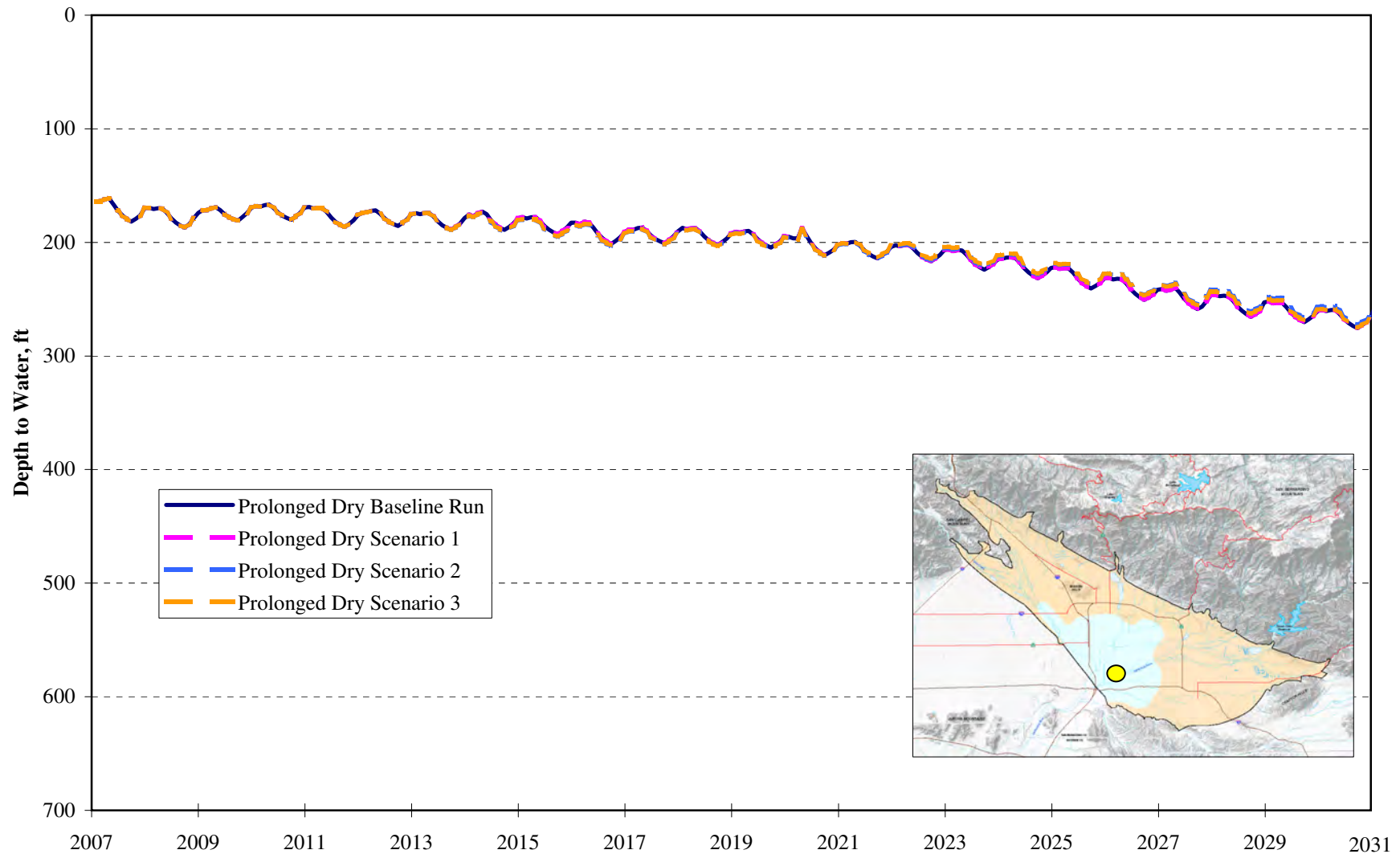


Depth to Water for West Valley Water District Lord 7 Well Model Runs 2007-2030

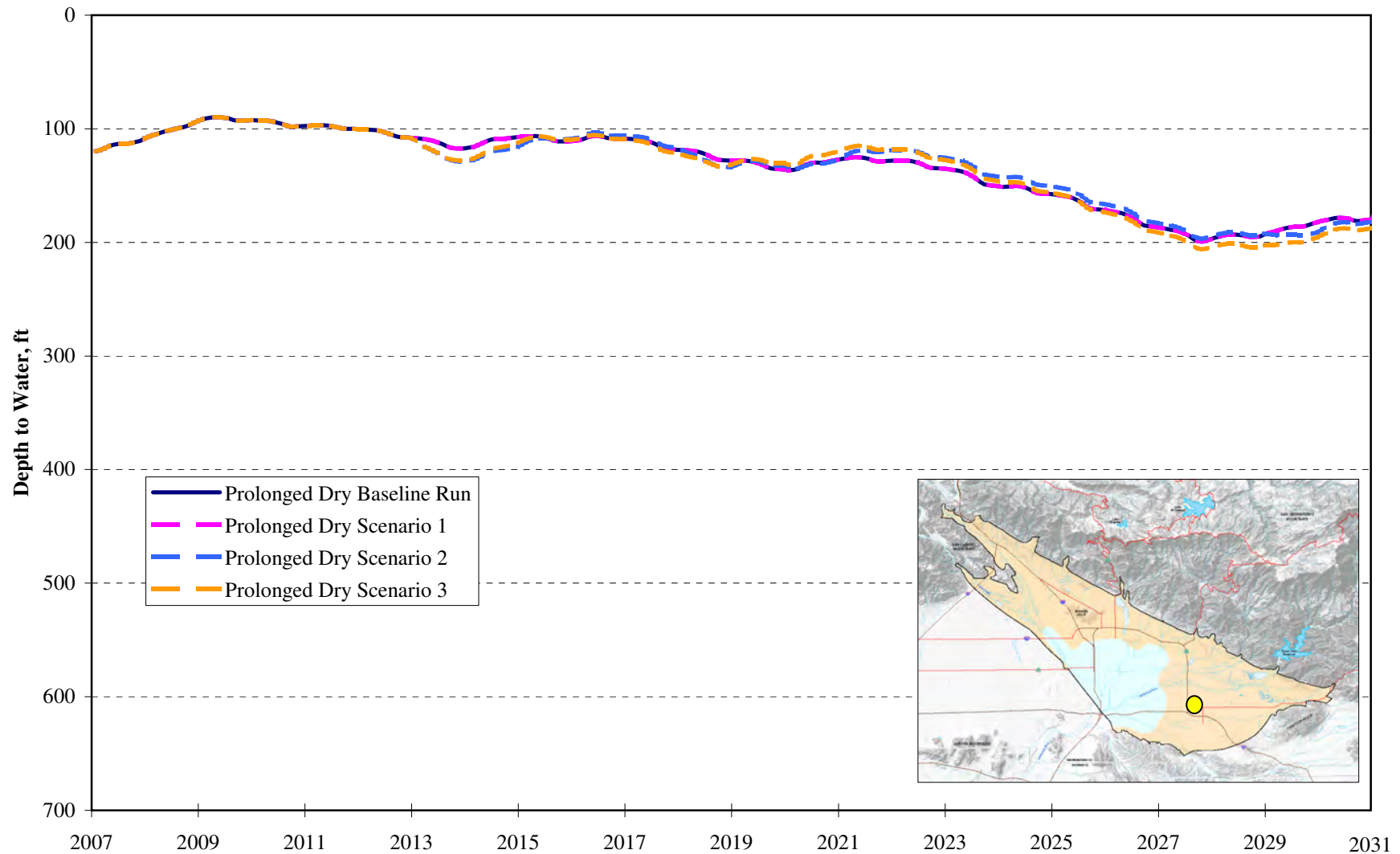


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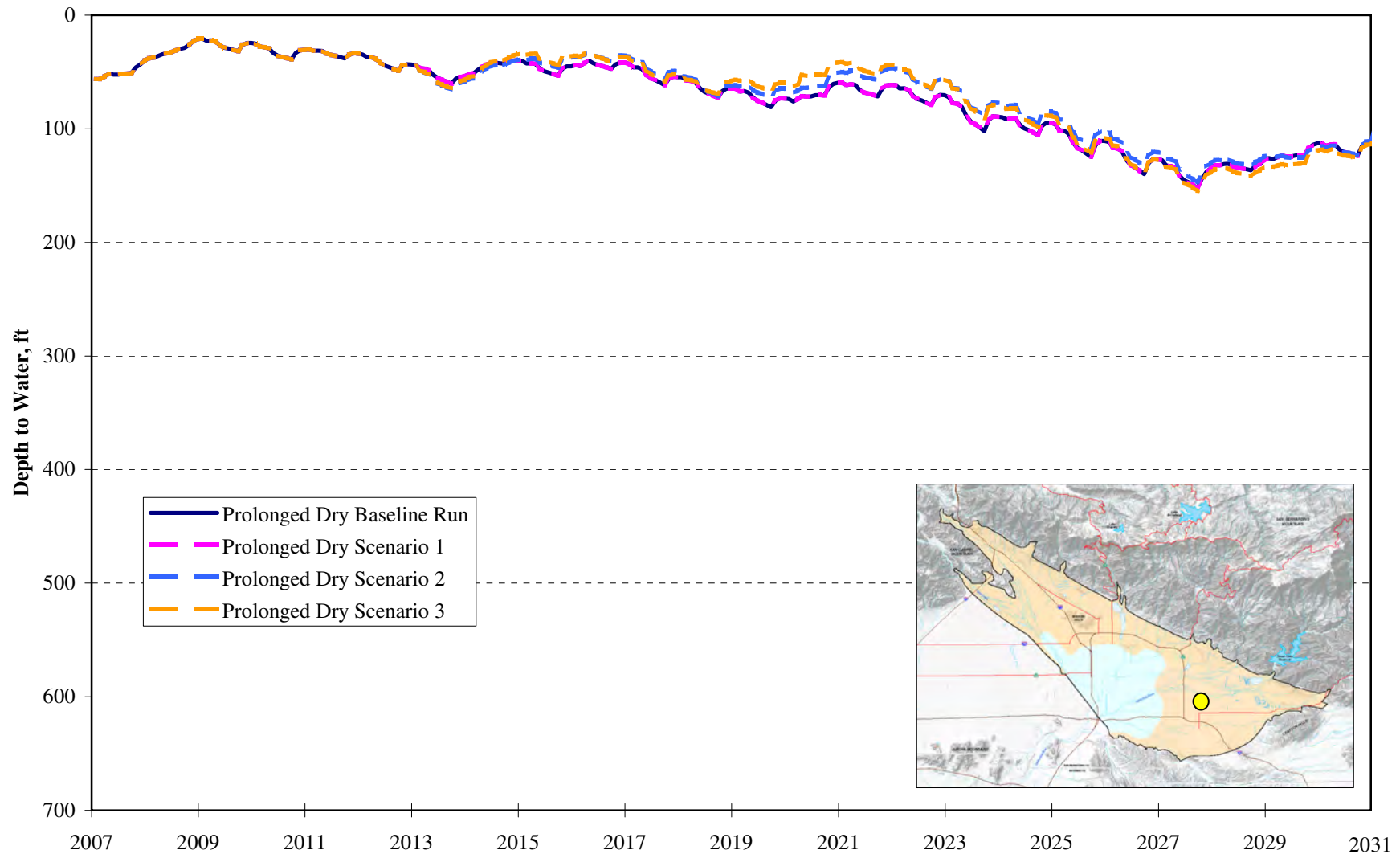
Depth to Water for City of Riverside Raub 1 Well Model Runs 2007-2030



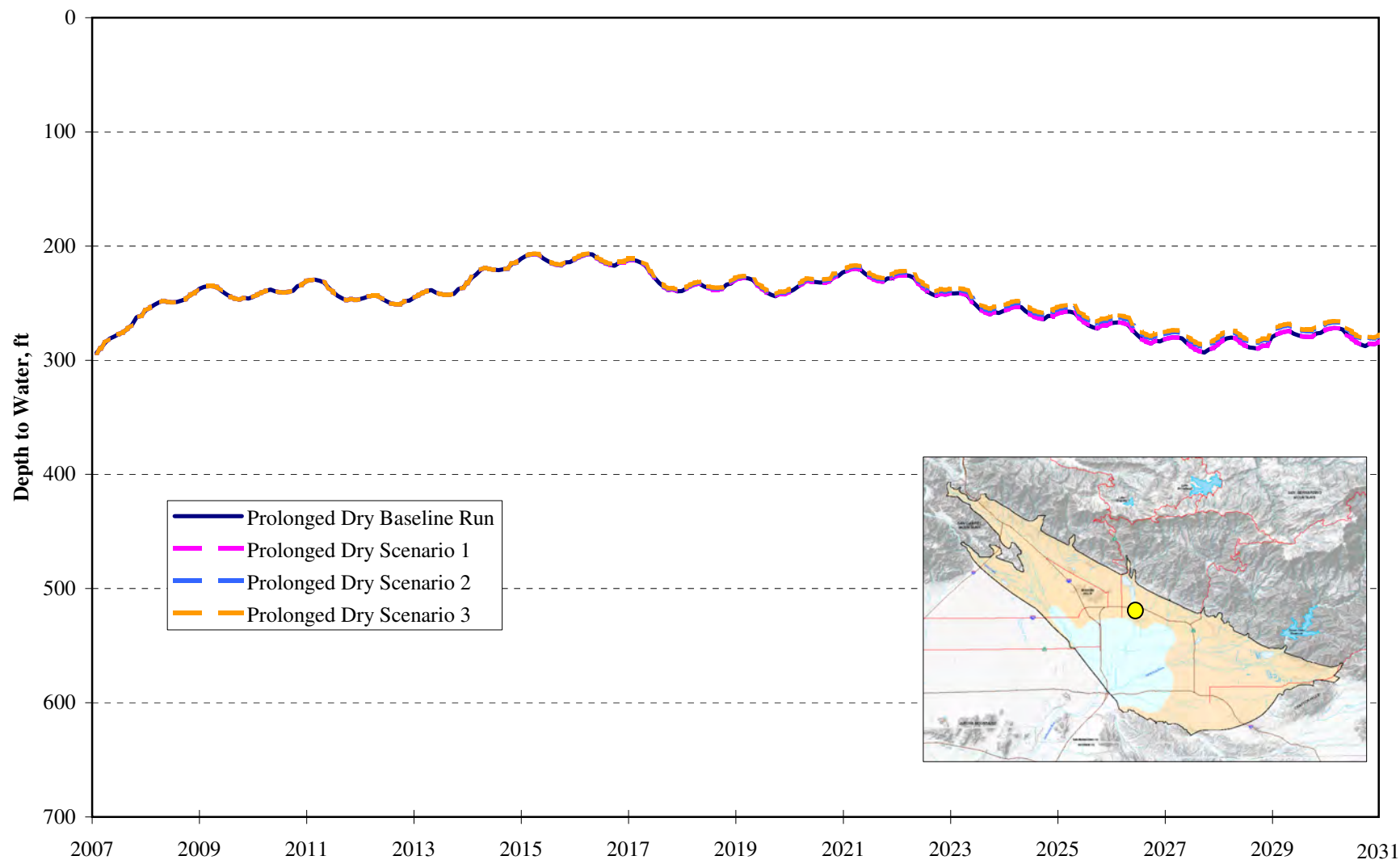
Depth to Water for City of Redlands Well 32 Model Runs 2007-2030



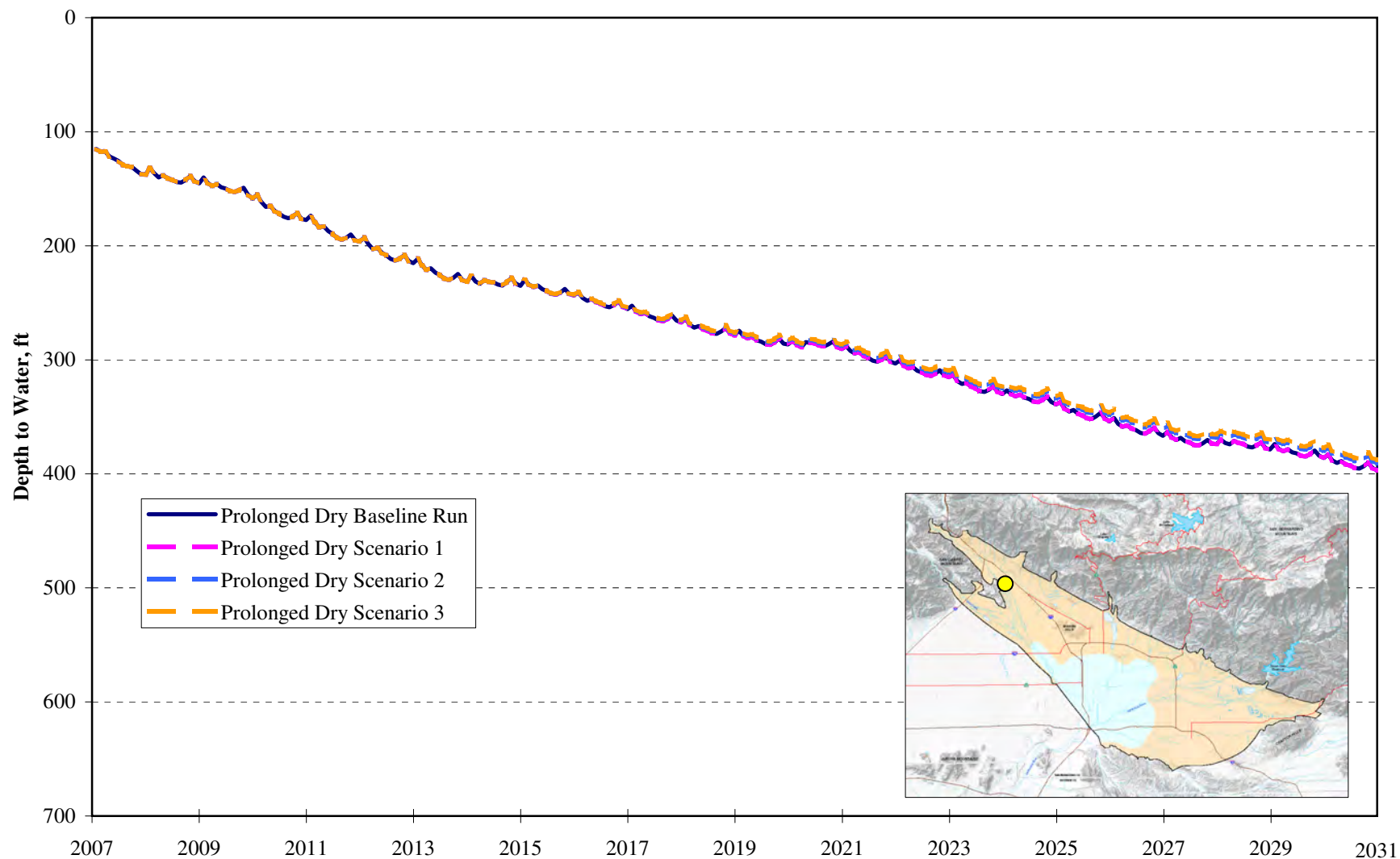
Depth to Water City of Redlands Orange Street Well Model Runs 2007-2030



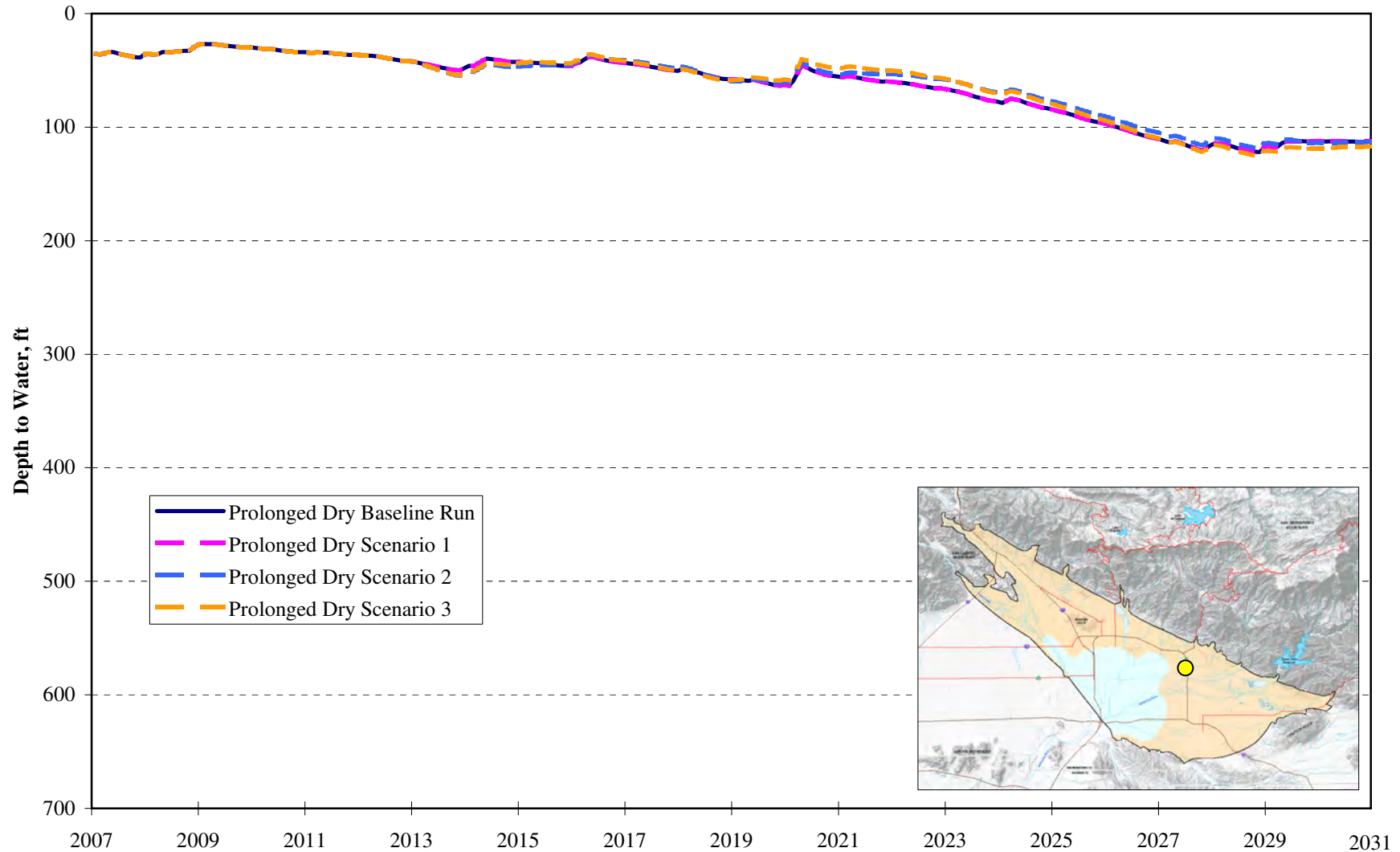
Depth to Water for East Valley Water District Well 24A Model Runs 2007-2030



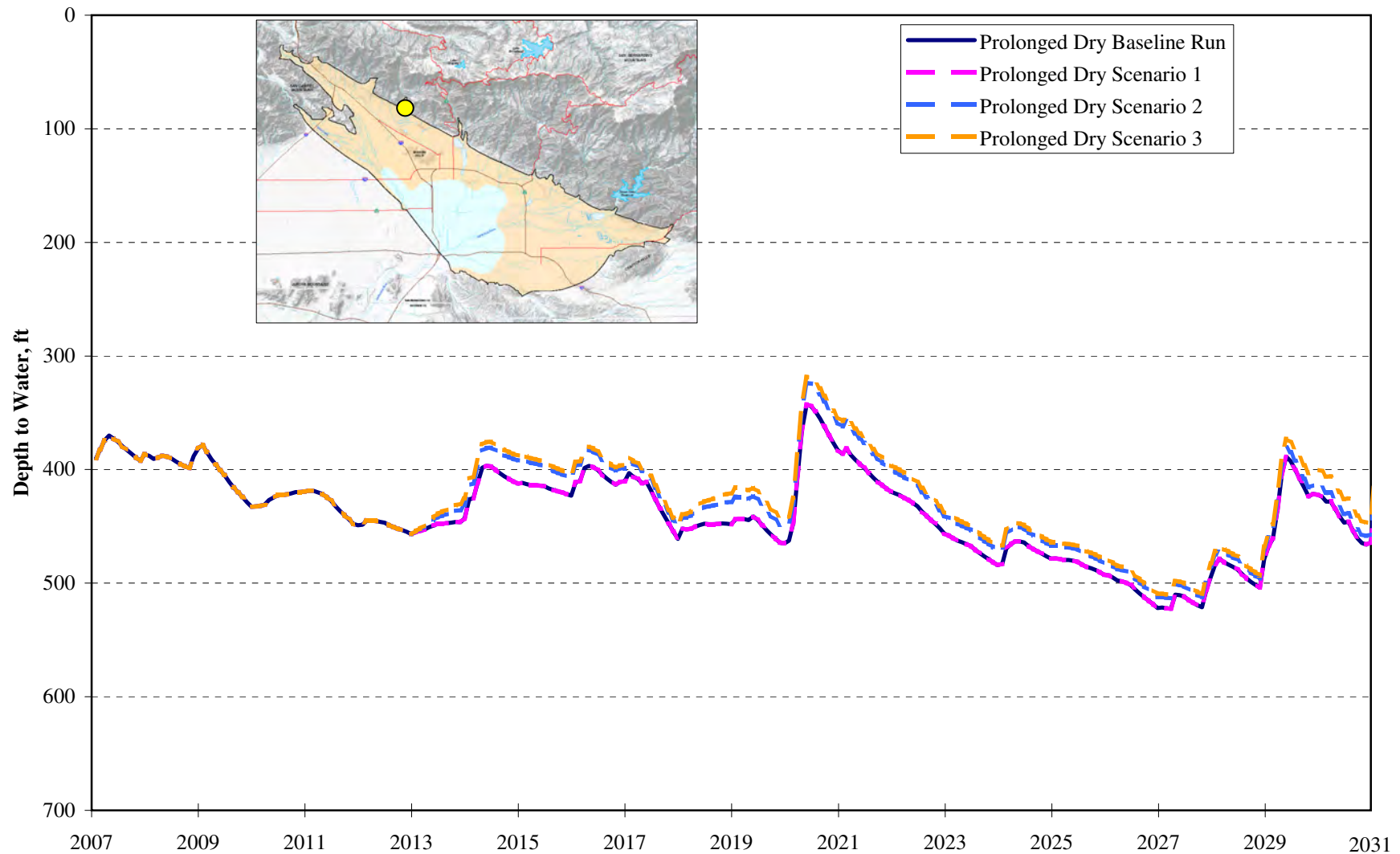
Depth to Water for City of San Bernardino Cajon Well No. 1 Model Runs 2007-2030



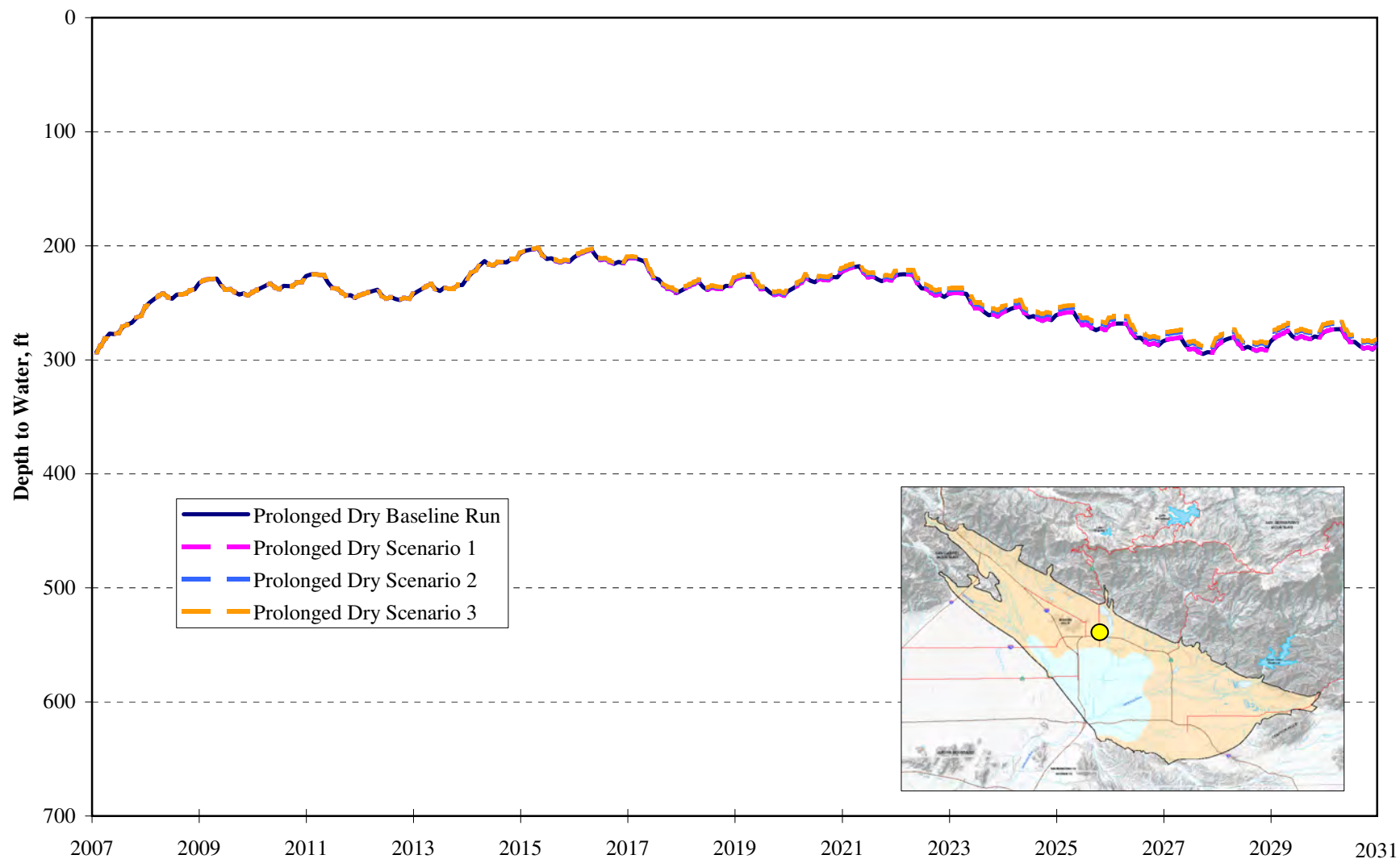
Depth to Water for East Valley Water District Well 40 Model Runs 2007-2030



Depth to Water for City of San Bernardino Devil Canyon Well No. 3 Model Runs 2007-2030

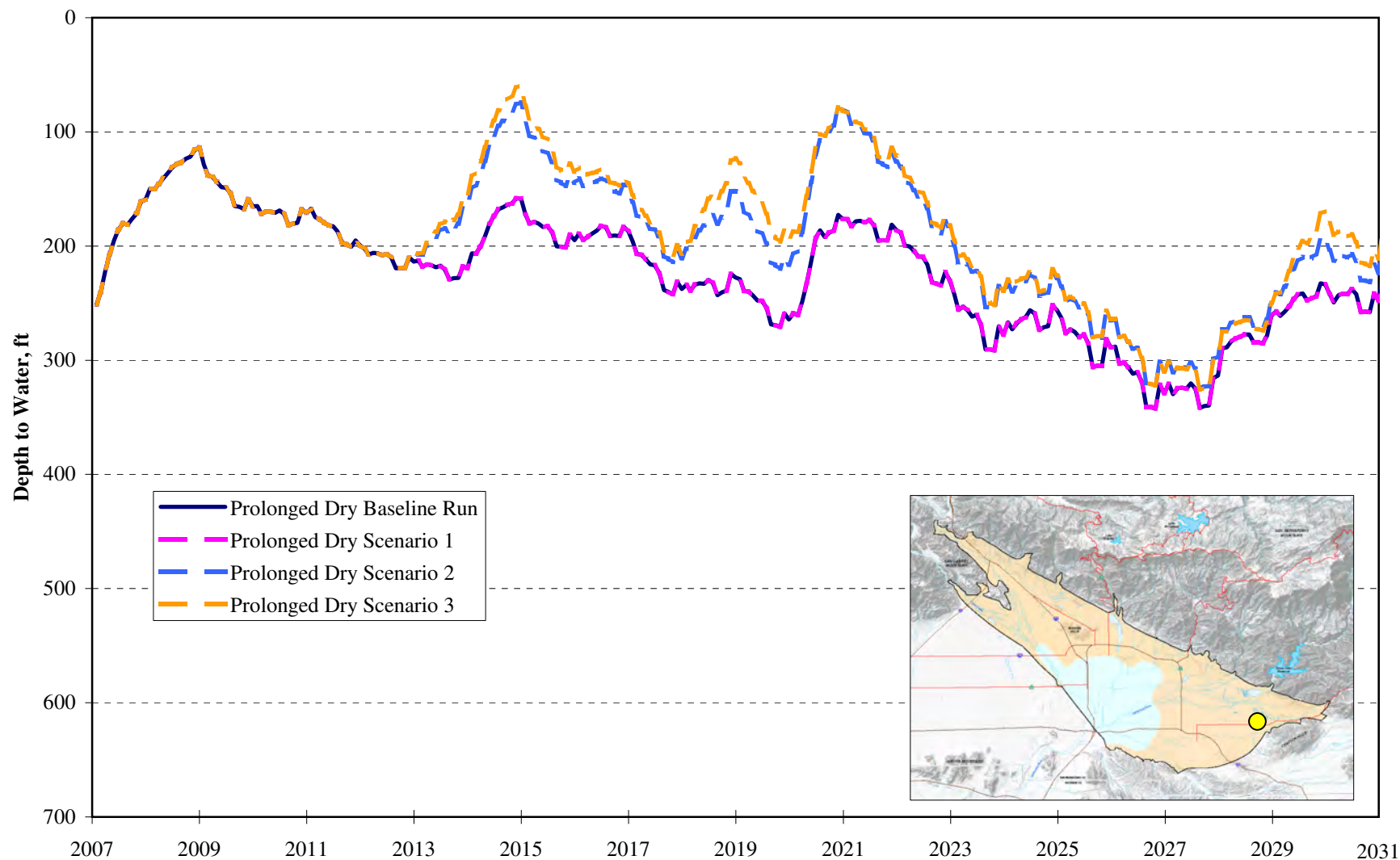


Depth to Water for City of San Bernardino Leroy Street Well Model Runs 2007-2030



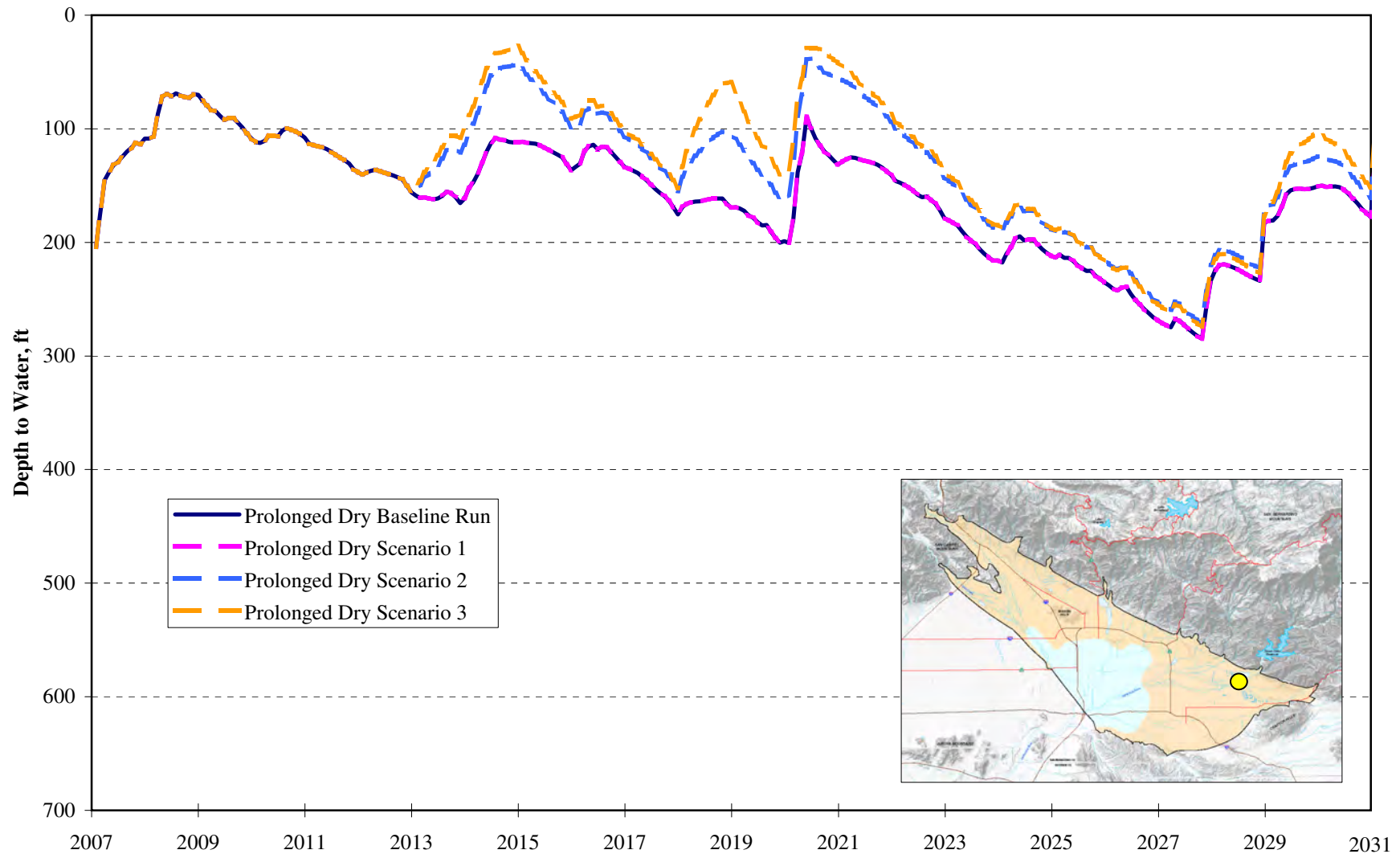
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Depth to Water for City of Redlands Agate 2 Well Model Runs 2007-2030

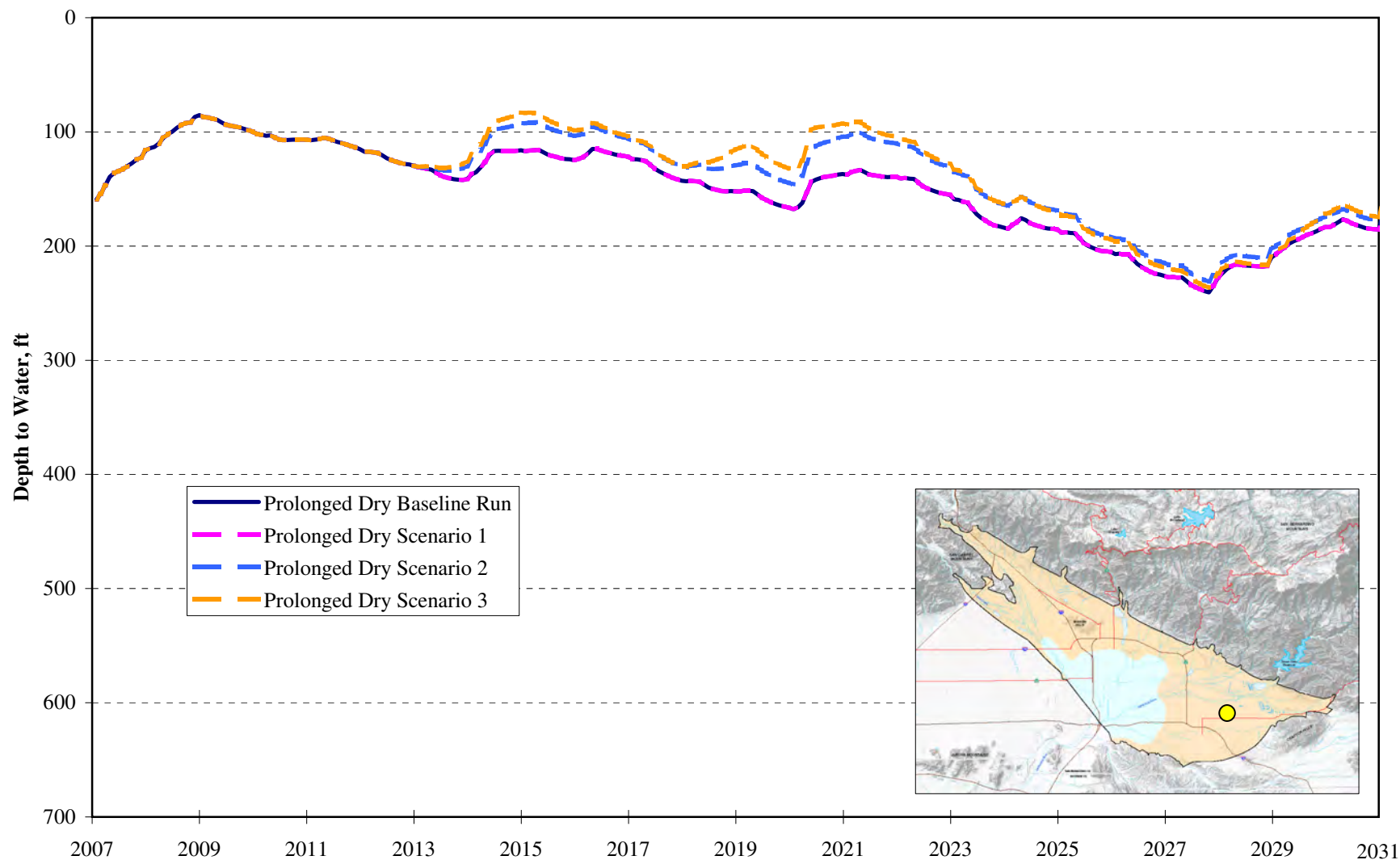


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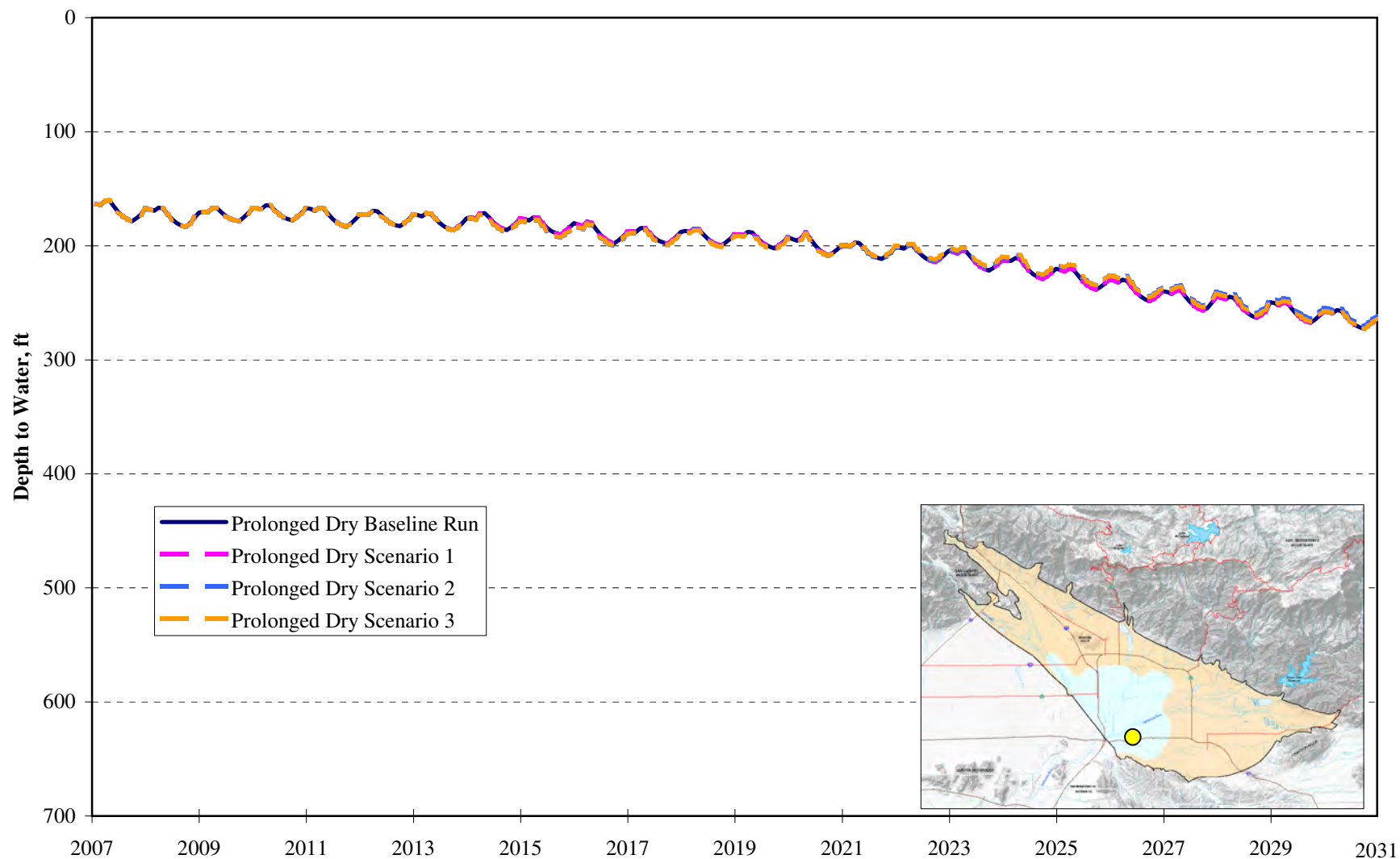
Depth to Water for East Valley Water District Cone Camp Well Model Runs 2007-2030



Depth to Water for Bear Valley Mutual Water Company Nelson Street Well Model Runs 2007-2030

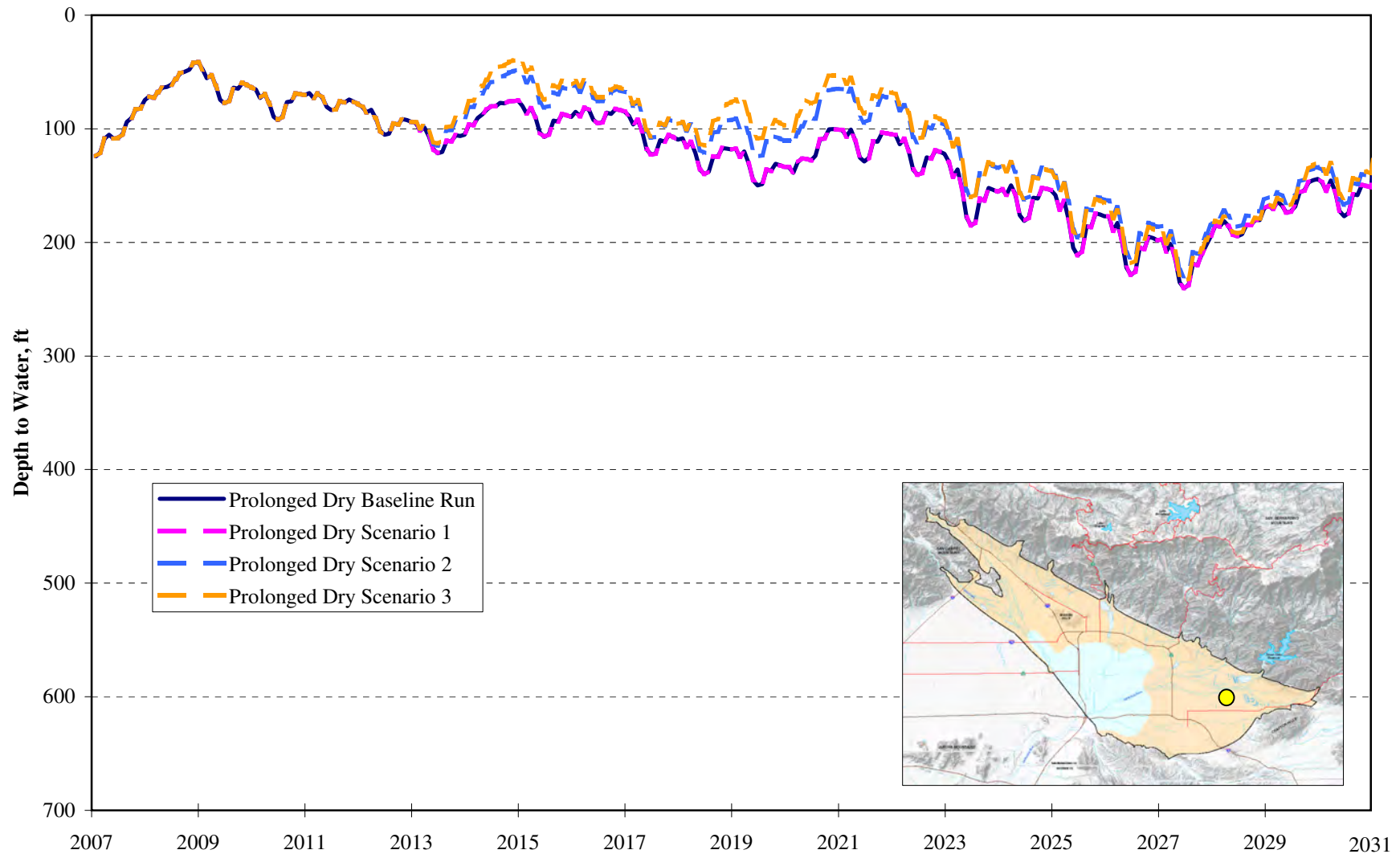


Depth to Water for Gage Canal Company Lower Kelly Well Model Runs 2007-2030



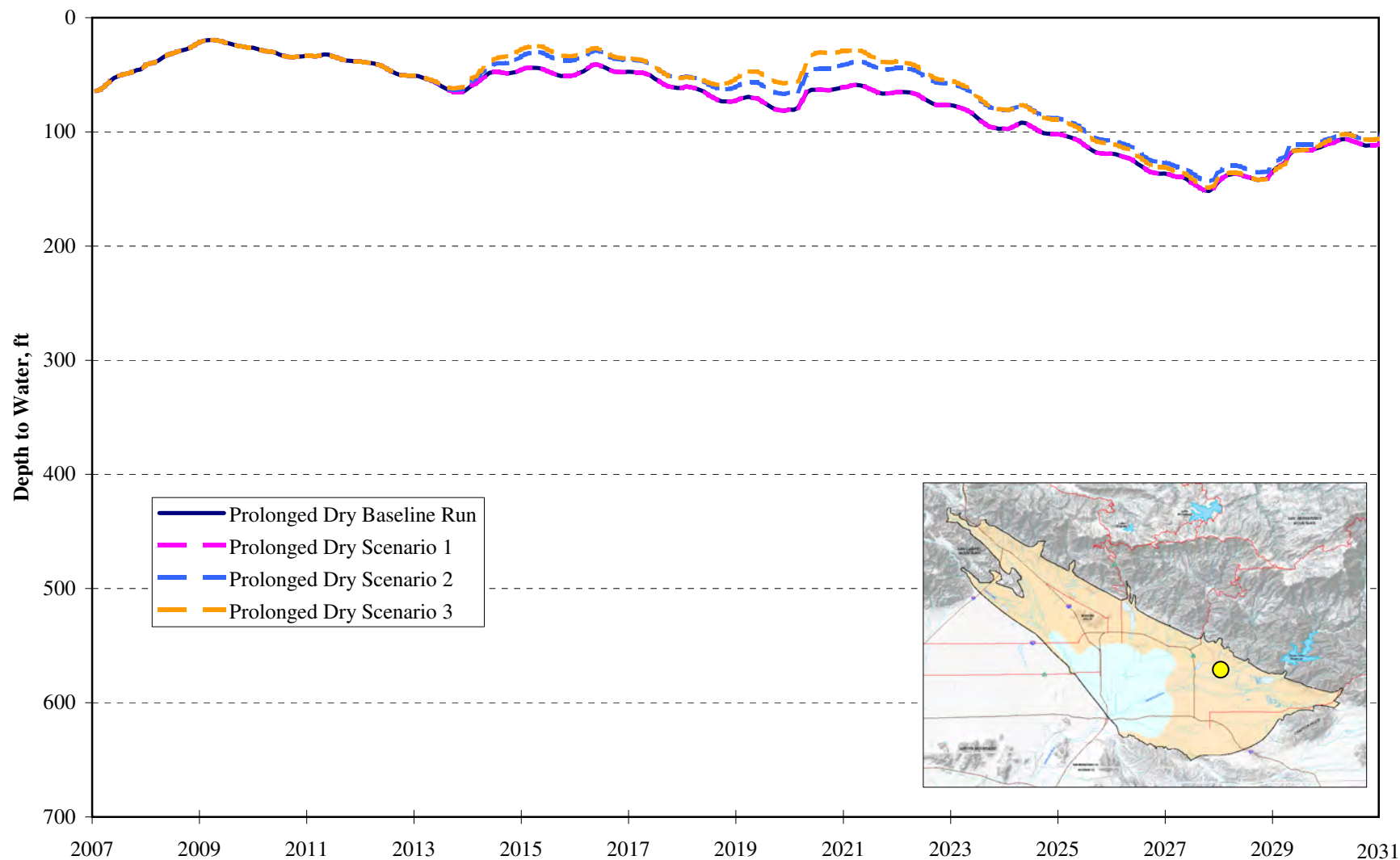
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Depth to Water for City of Redlands Airport Well No. 2 Model Runs 2007-2030

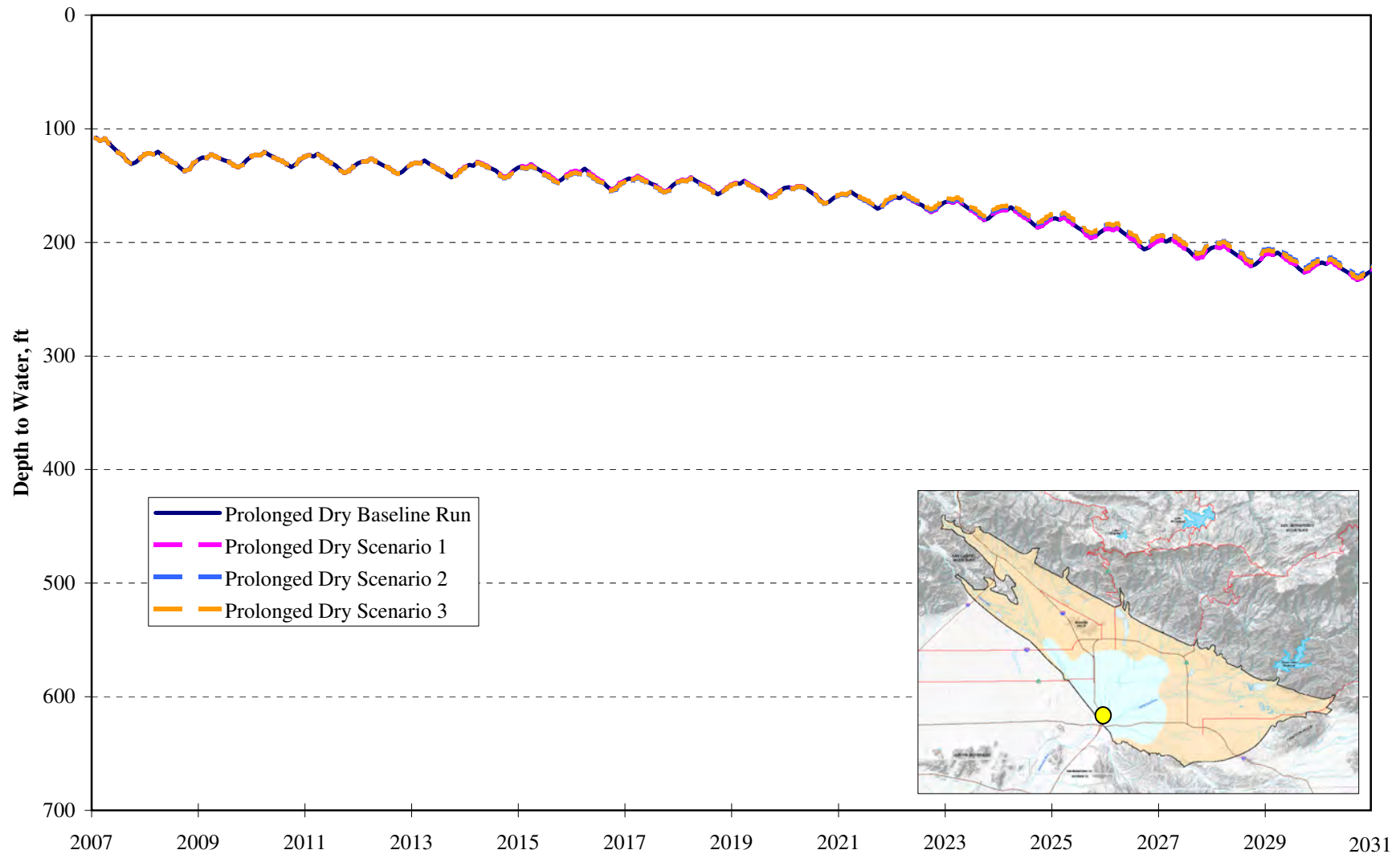


Appendix A

Depth to Water for East Valley Water District Well 146A Model Runs 2007-2030



Depth to Water for SBVMWD Backyard Well Model Runs 2007-2030

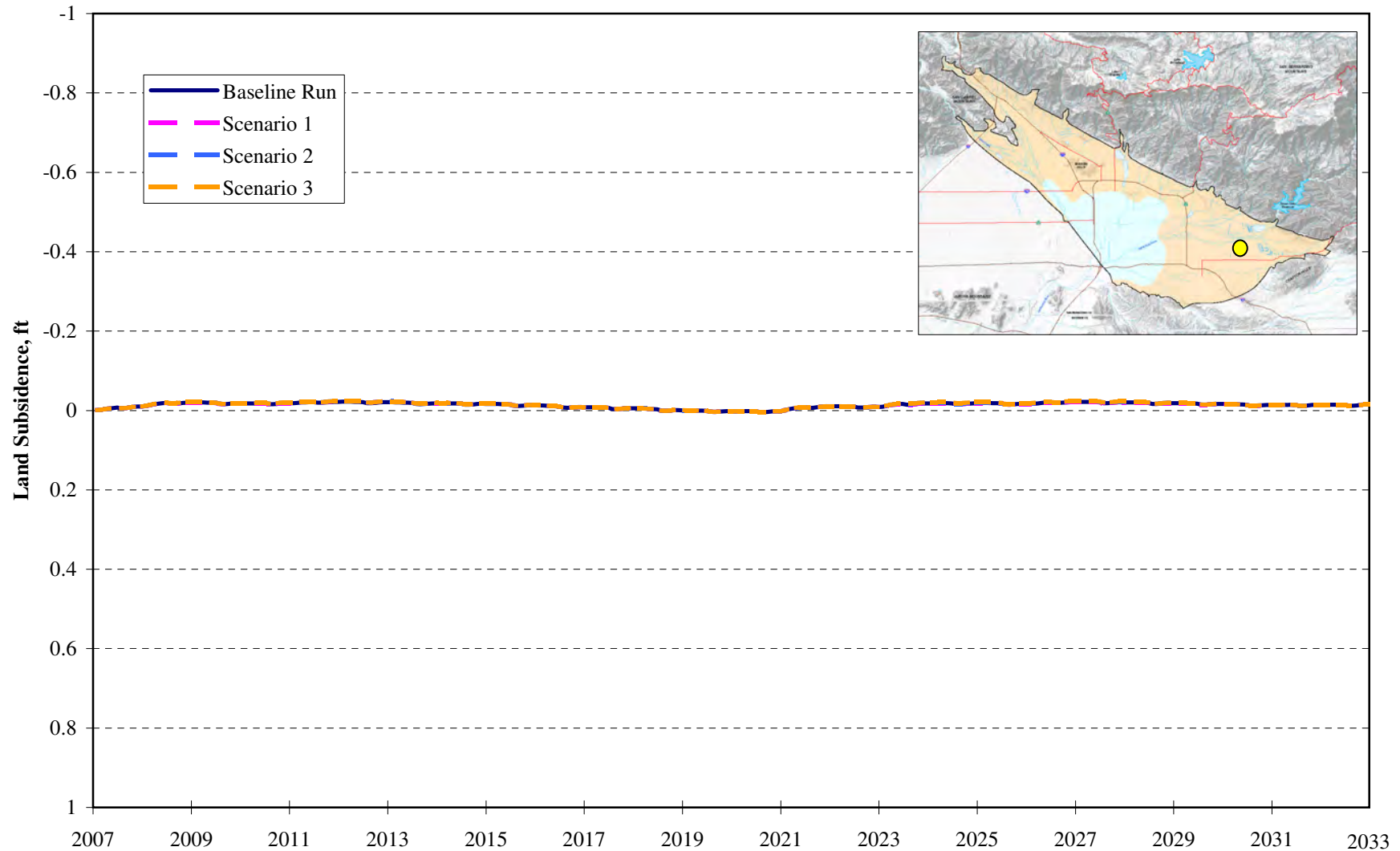


APPENDIX B
Land Subsidence at Selected Sites for Predictive Model Scenarios
2007 to 2032

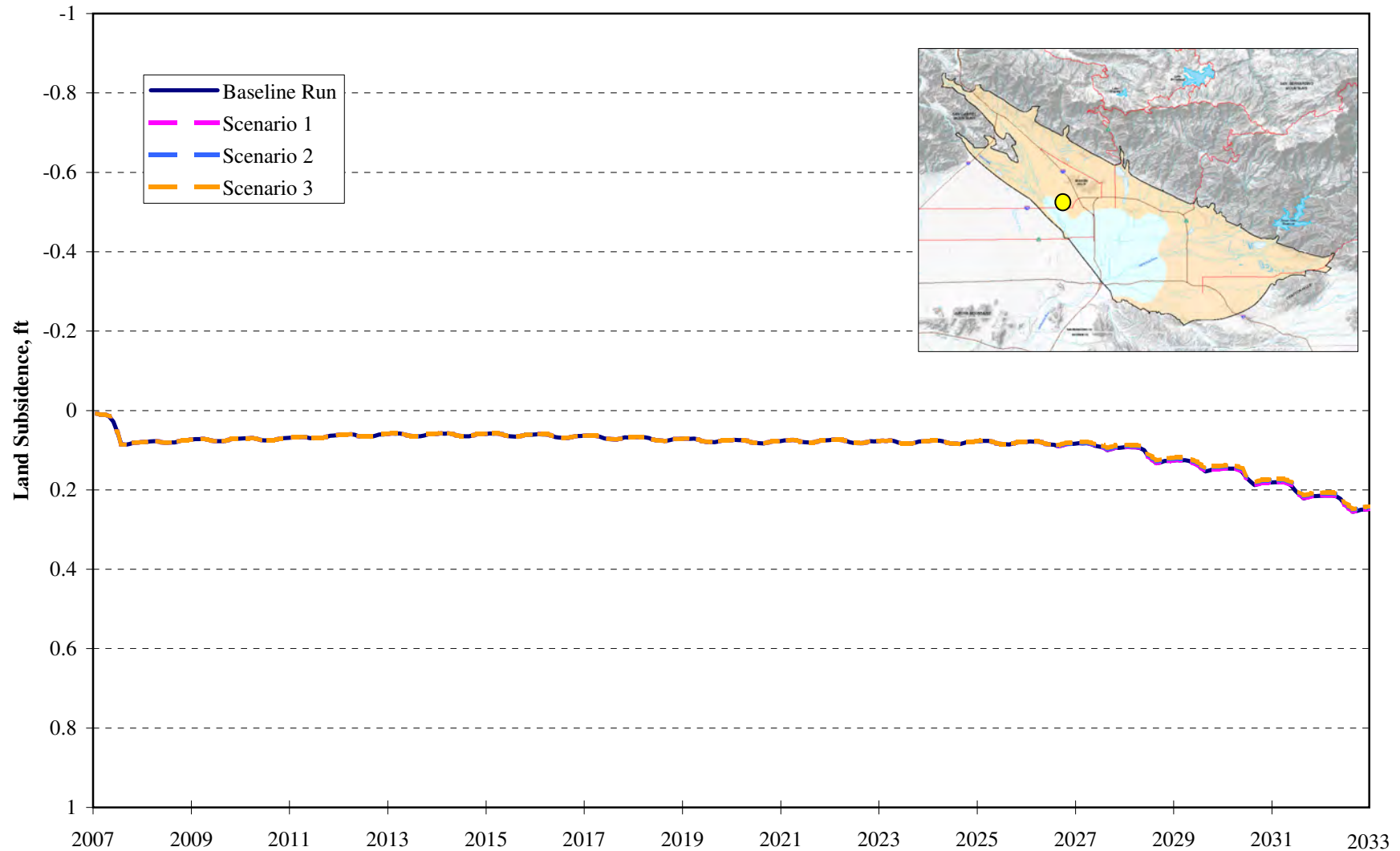
GEOSCIENCE Support Services, Inc.



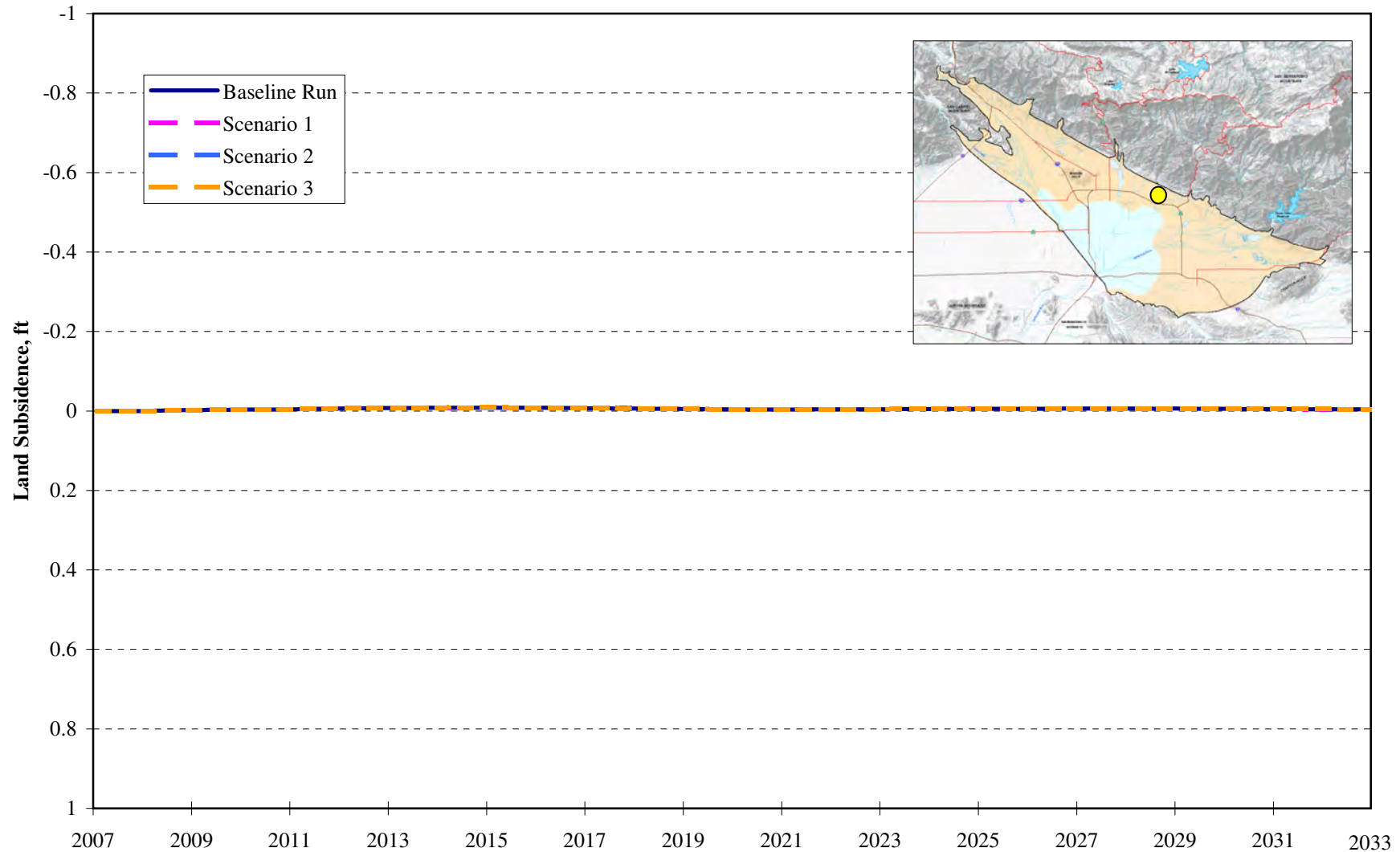
**Land Subsidence at SBVMWD San Bernardino Ave. Well
Model Runs 2007-2032**



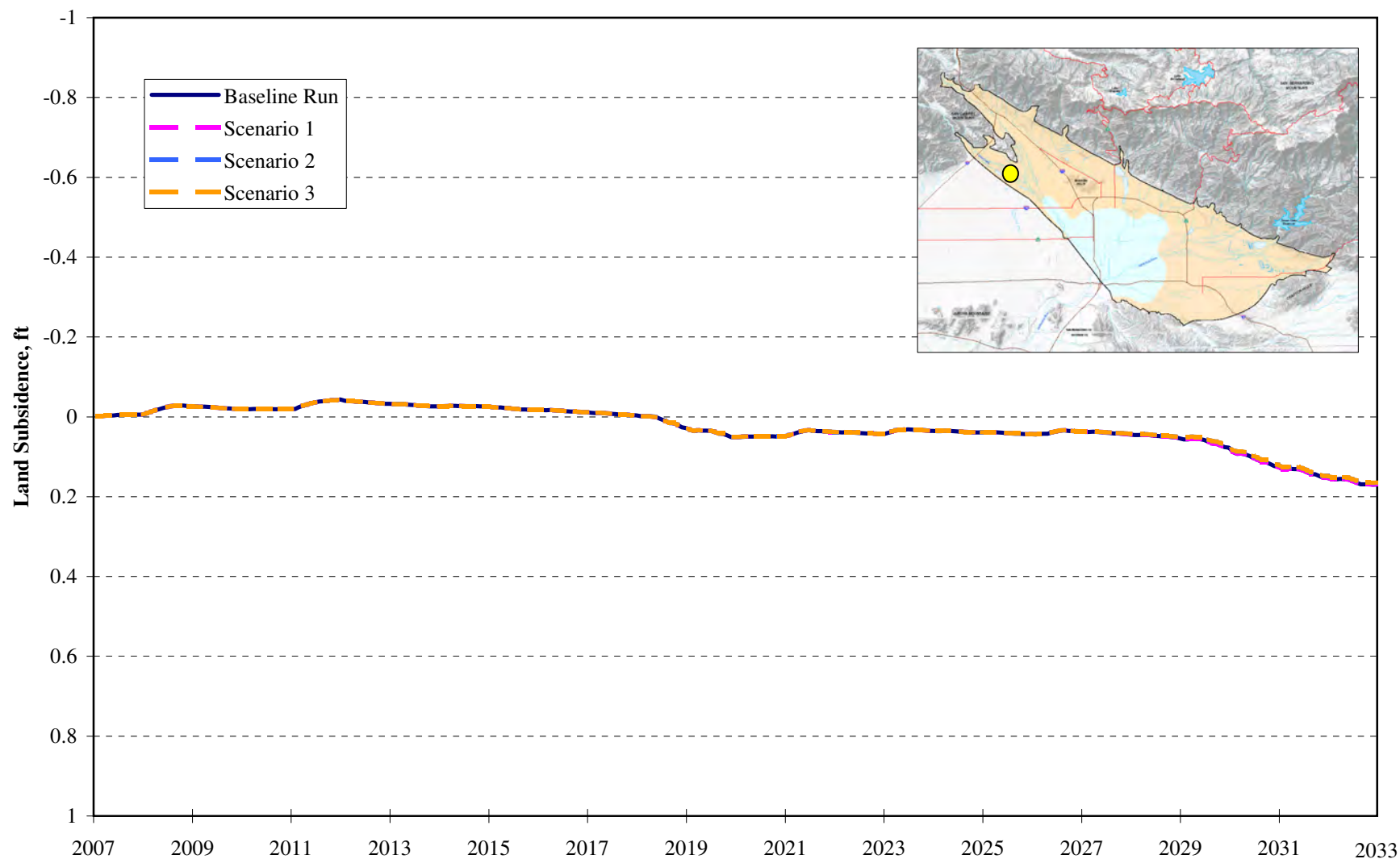
**Land Subsidence at City of San Bernardino Mt. Vernon Well
Model Runs 2007-2032**



Land Subsidence at East Valley Water District Well 62 Model Runs 2007-2032

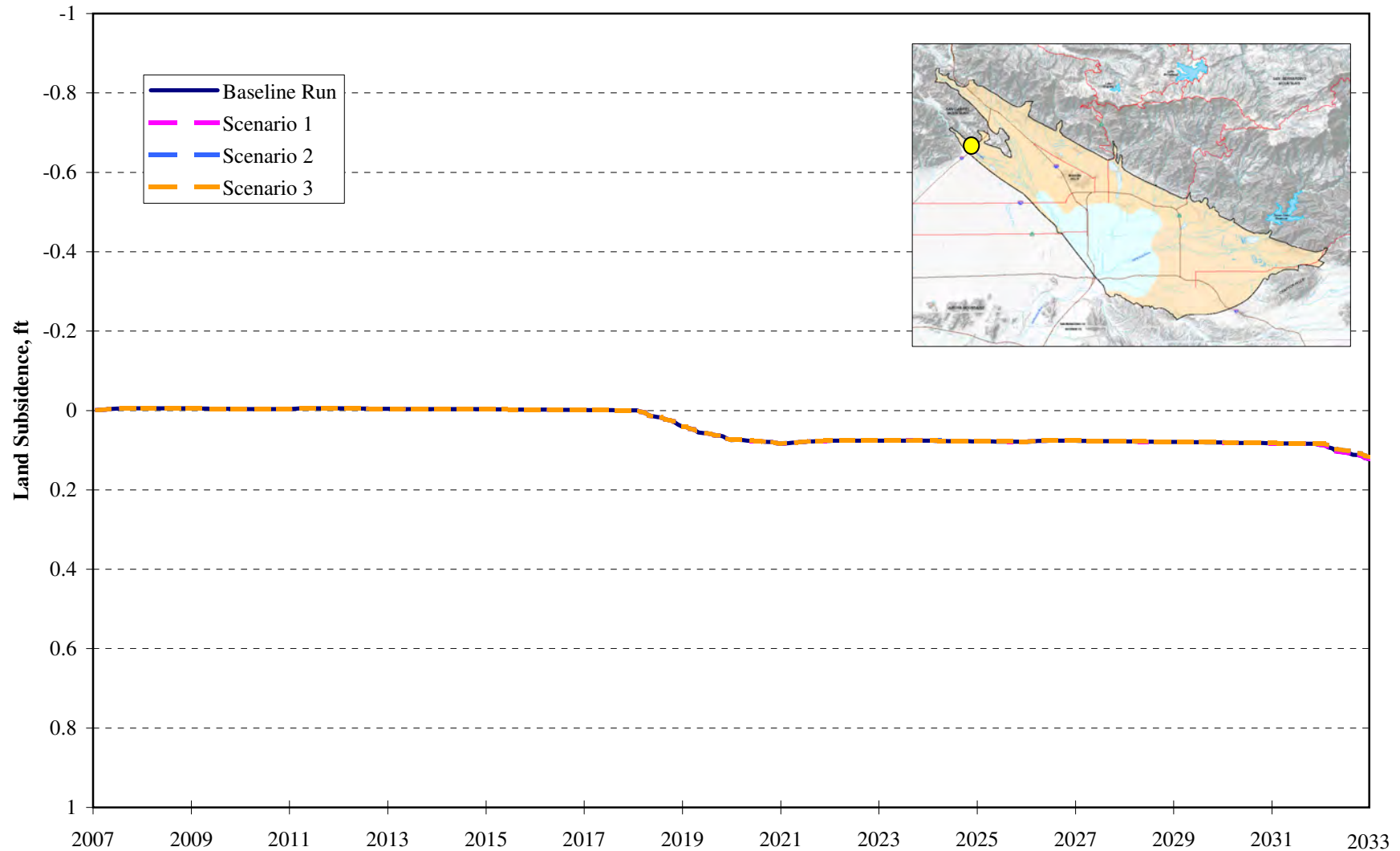


Land Subsidence at Fontana Union Water Company Well 13 Model Runs 2007-2032

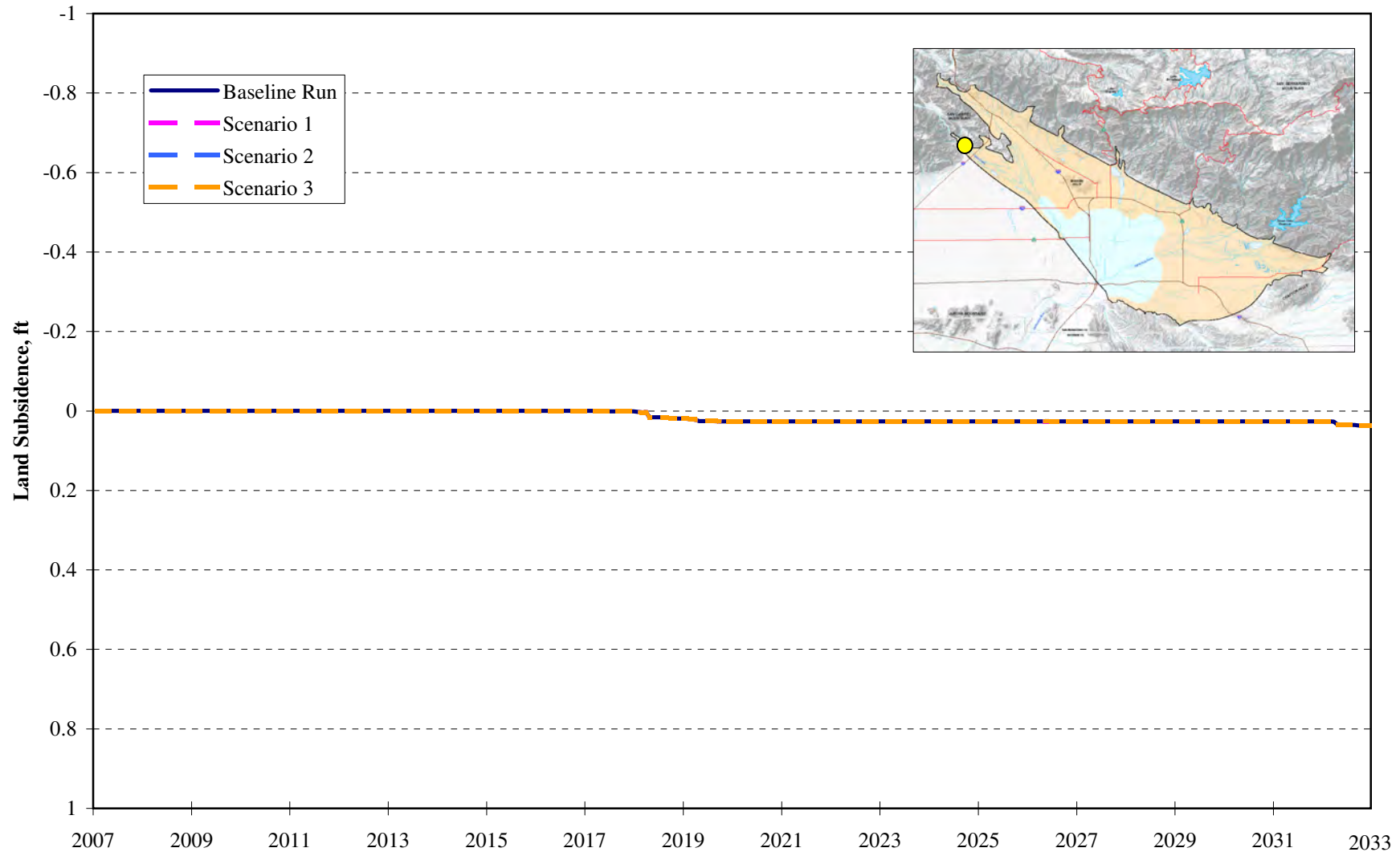


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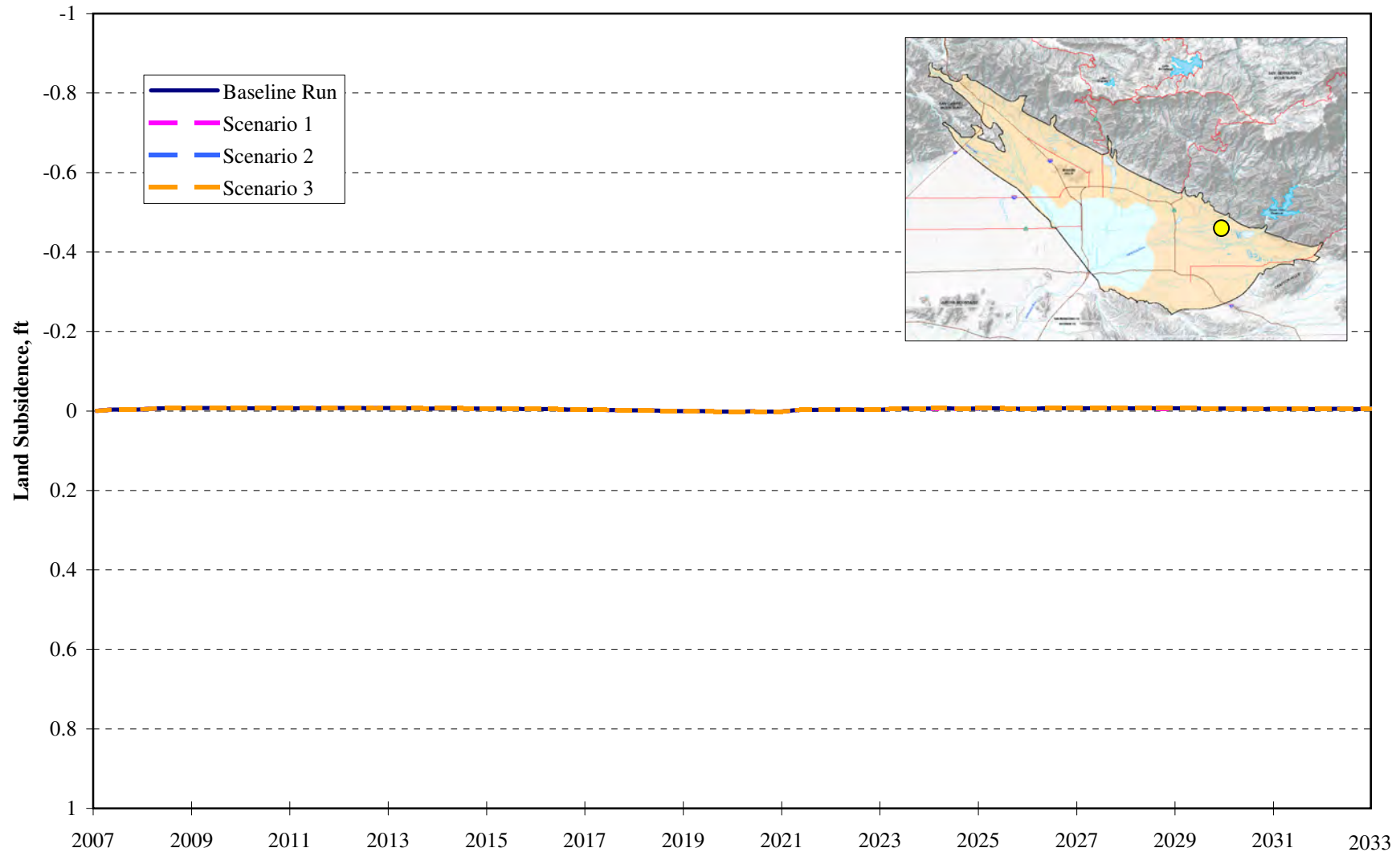
Land Subsidence at Fontana Union Water Company Well 26 Model Runs 2007-2032



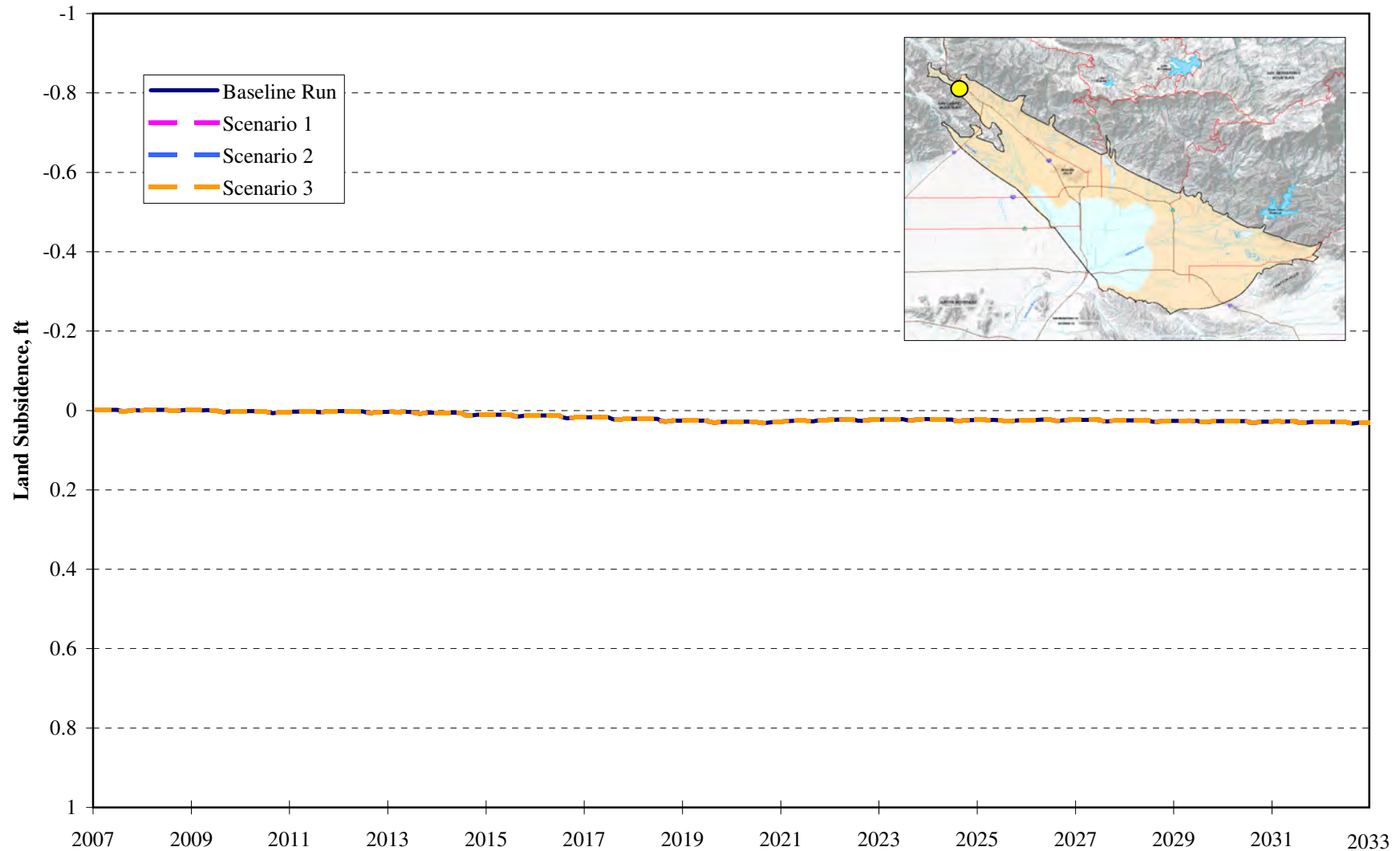
**Land Subsidence at Fontana Union Water Company Well 27
Model Runs 2007-2032**



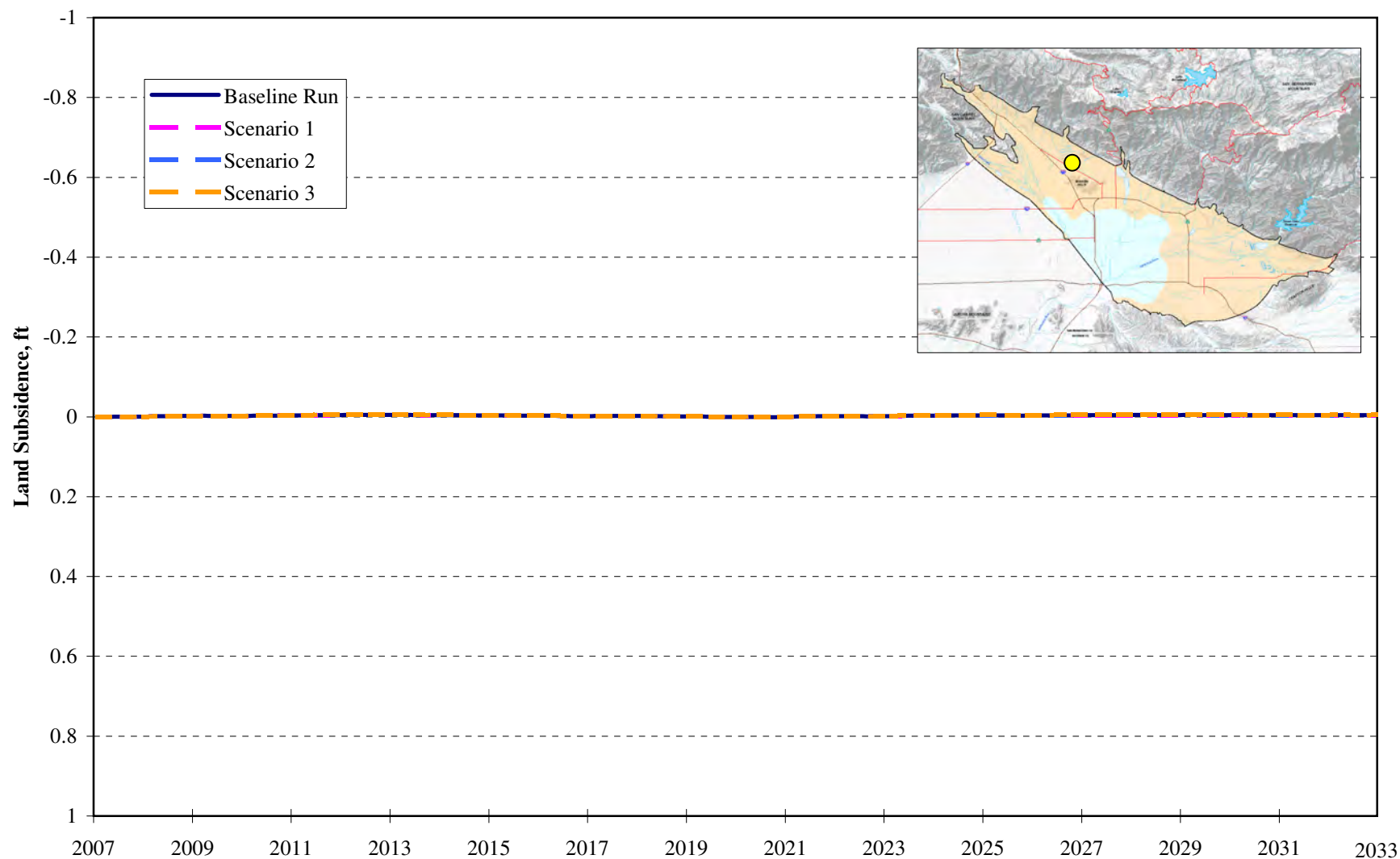
**Land Subsidence at East Valley Water District Well 120
Model Runs 2007-2032**



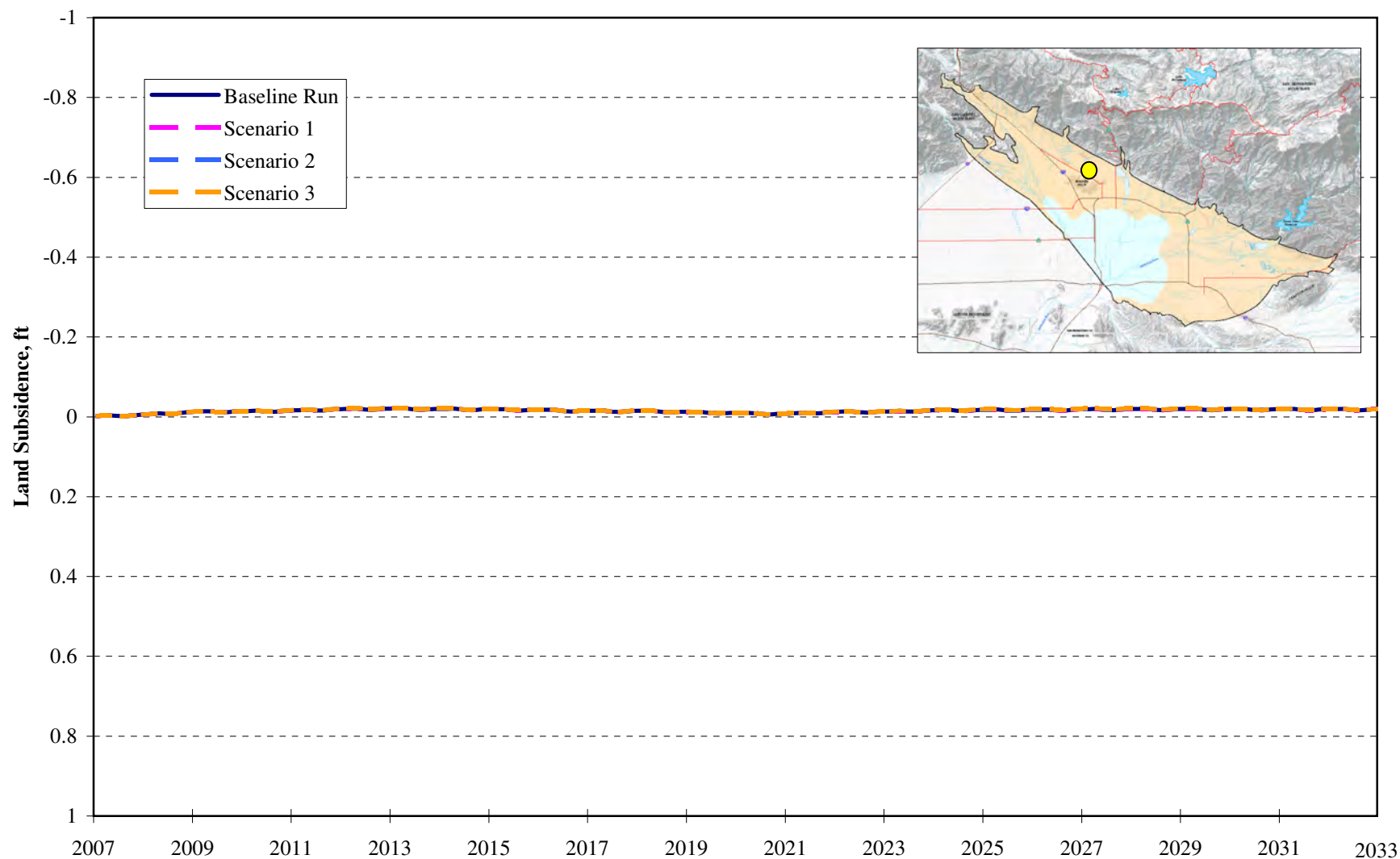
**Land Subsidence at City of San Bernardino Vincent Well
Model Runs 2007-2032**



Land Subsidence at City of San Bernardino Devil Canyon Well No. 1 Model Runs 2007-2032

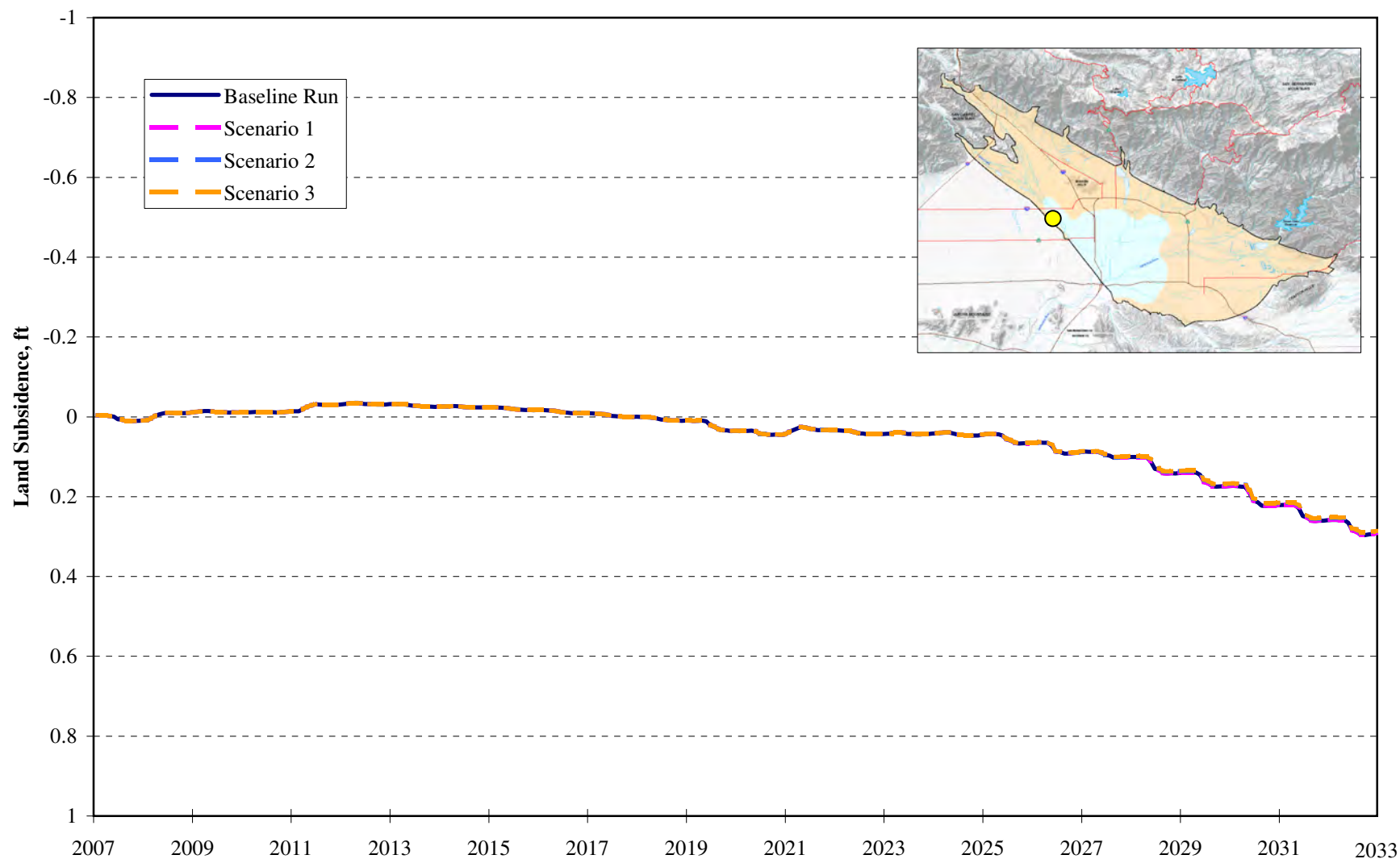


Land Subsidence at City of San Bernardino Newmark 3 Well Model Runs 2007-2032



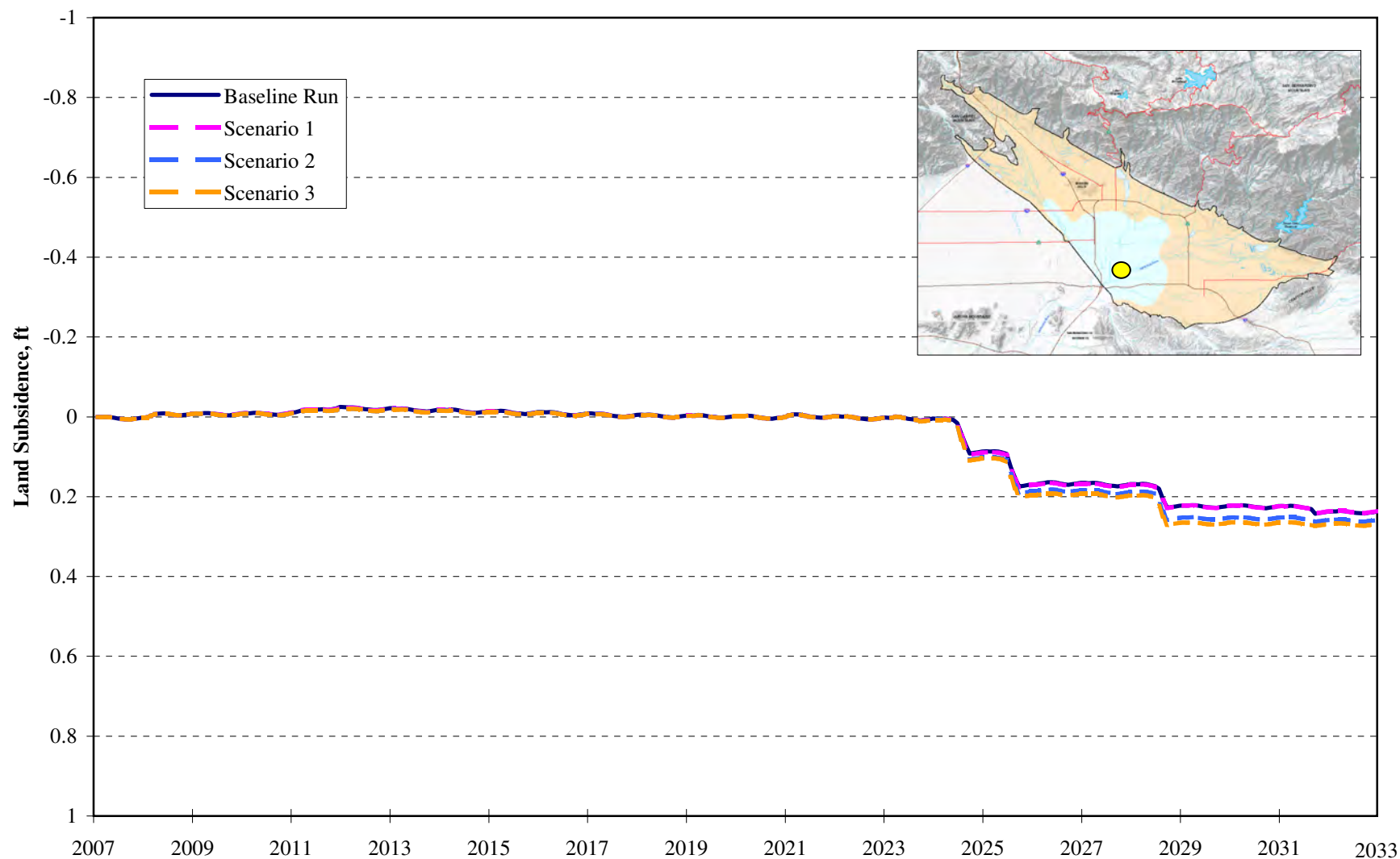
Appendix B

Land Subsidence at West Valley Water District Lord 7 Well Model Runs 2007-2032



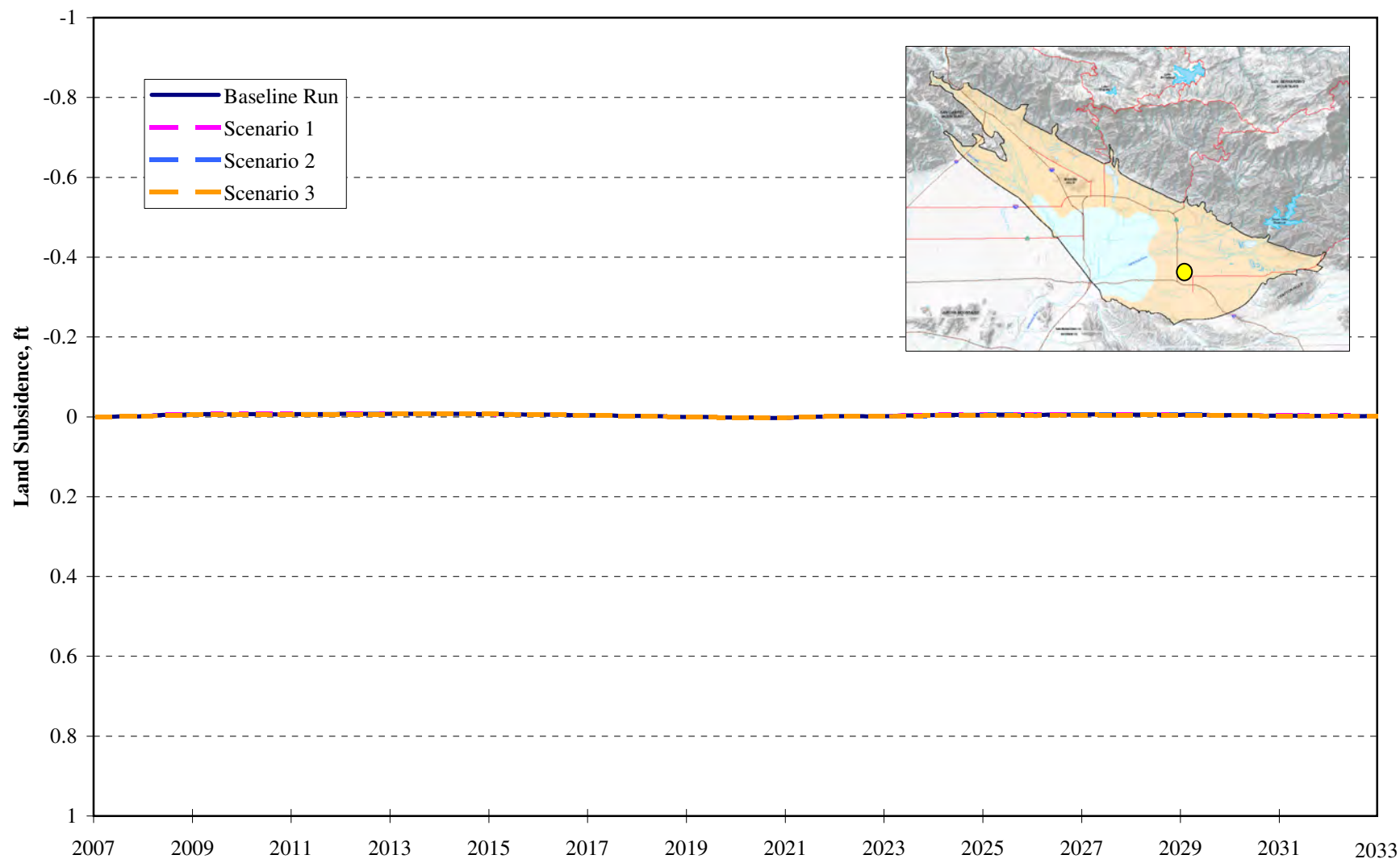
Appendix B

Land Subsidence at City of Riverside Raub 1 Well Model Runs 2007-2032

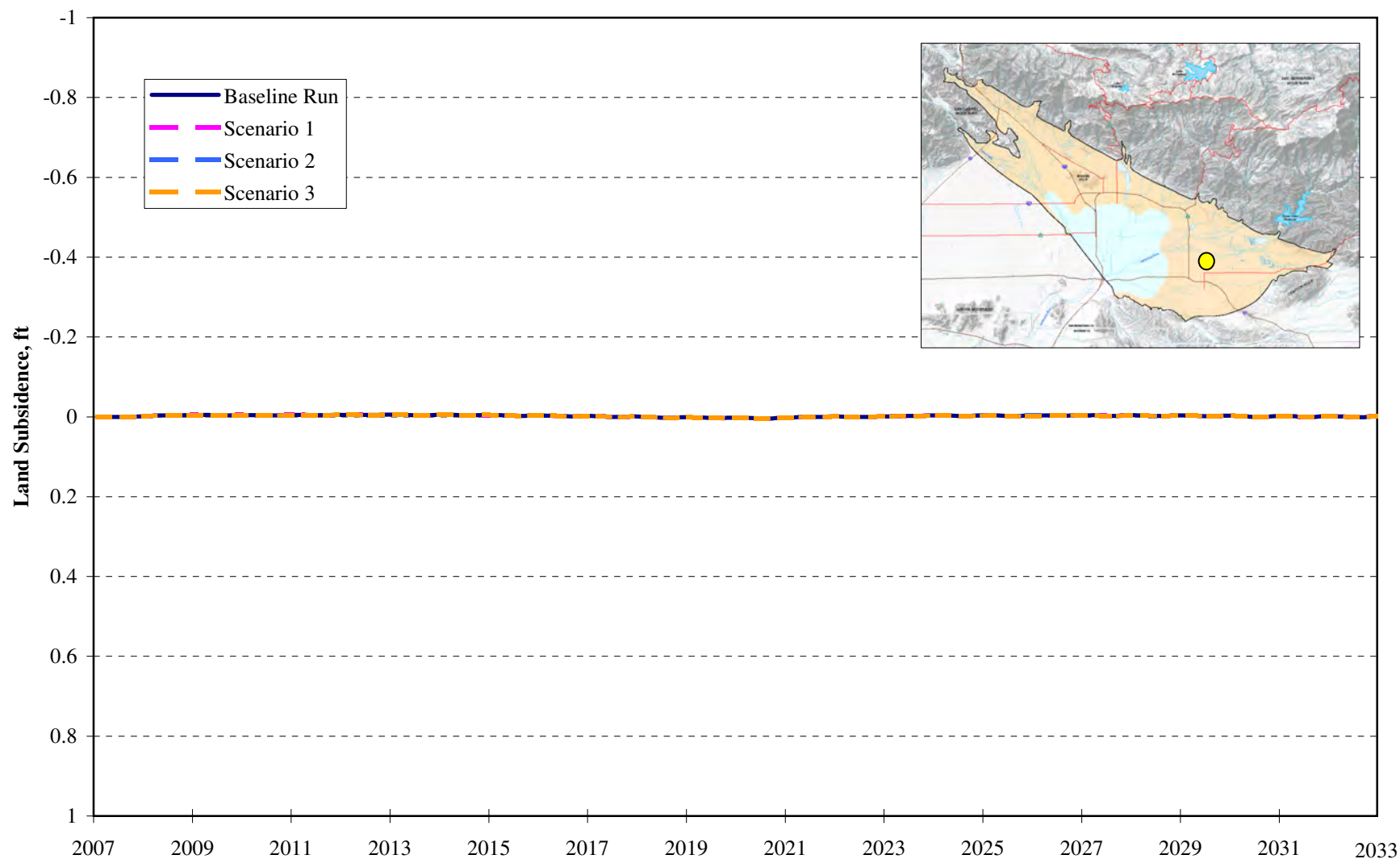


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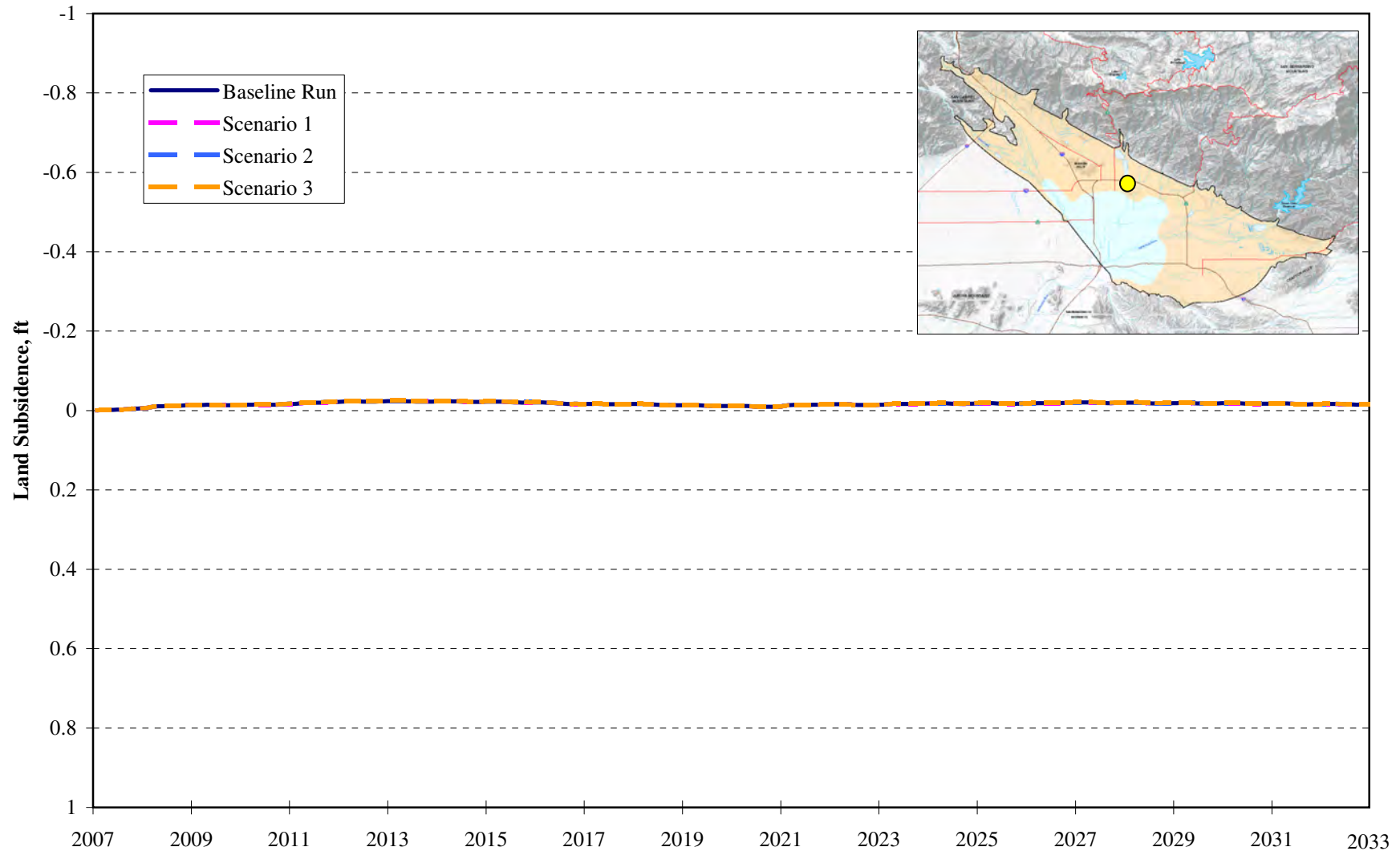
**Land Subsidence at City of Redlands Well 32
Model Runs 2007-2032**



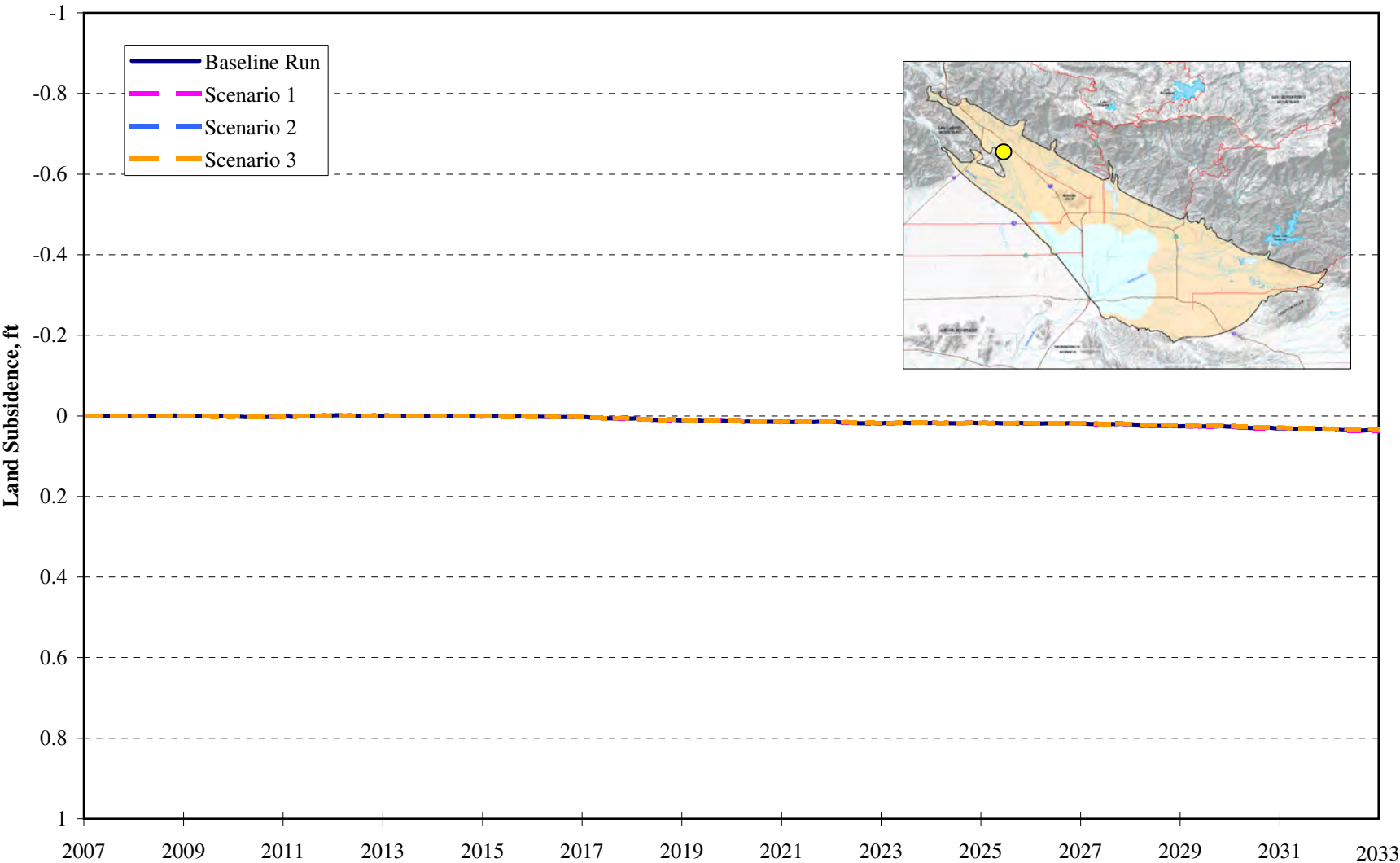
**Land Subsidence at City of Redlands Orange Street Well
Model Runs 2007-2032**



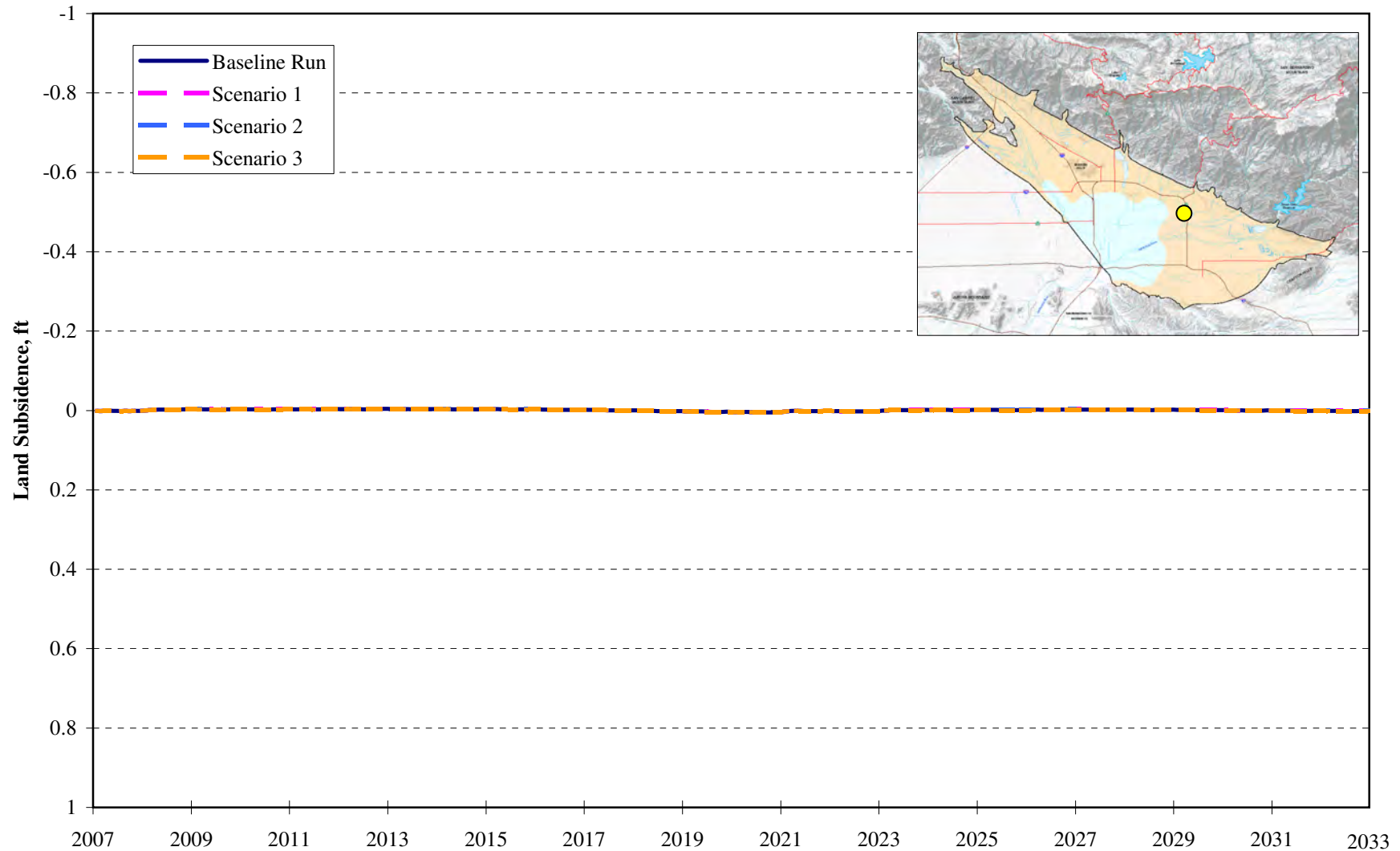
**Land Subsidence at East Valley Water District Well 24A
Model Runs 2007-2032**



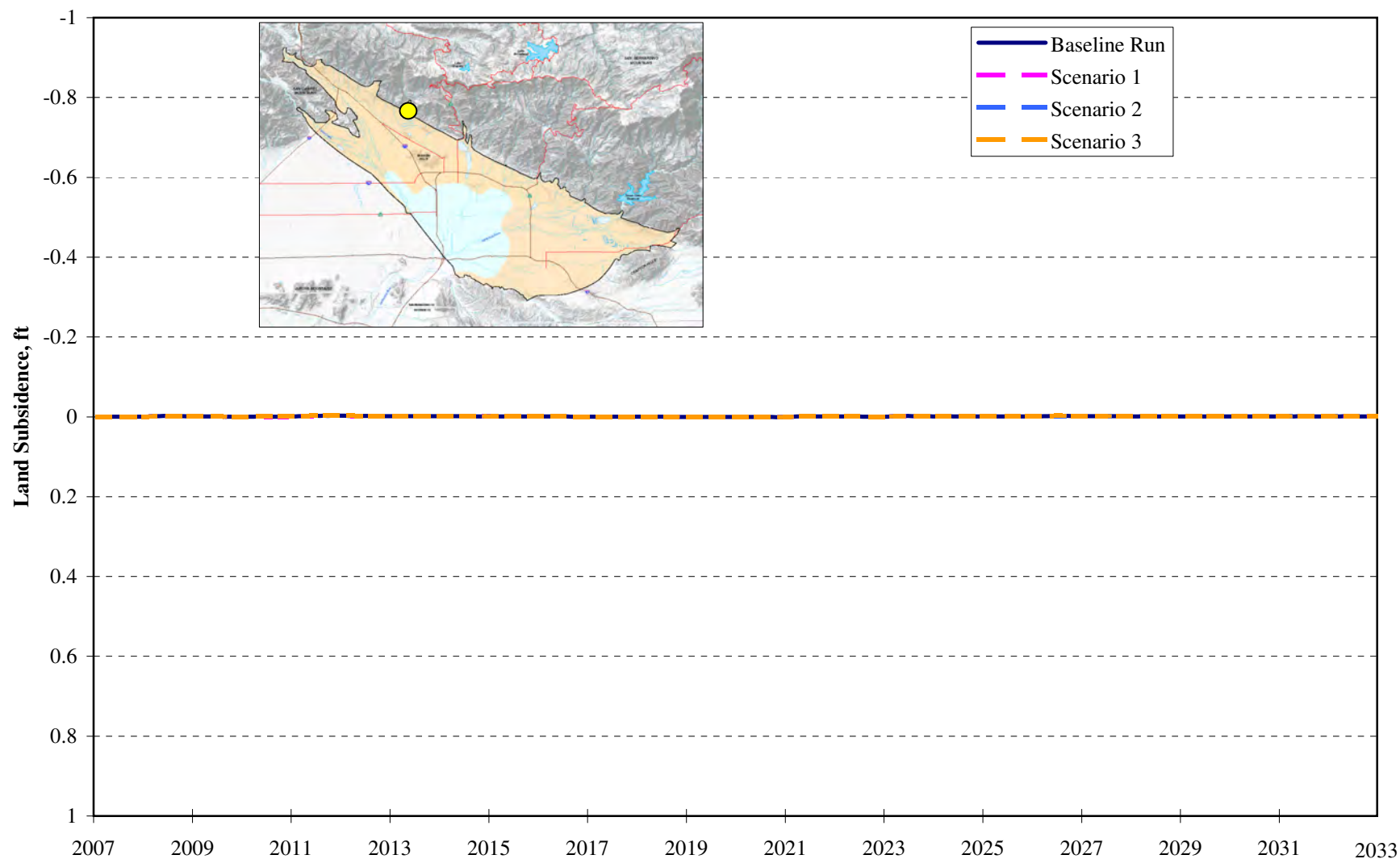
Land Subsidence at City of San Bernardino Cajon Well No. 1
Model Runs 2007-2032



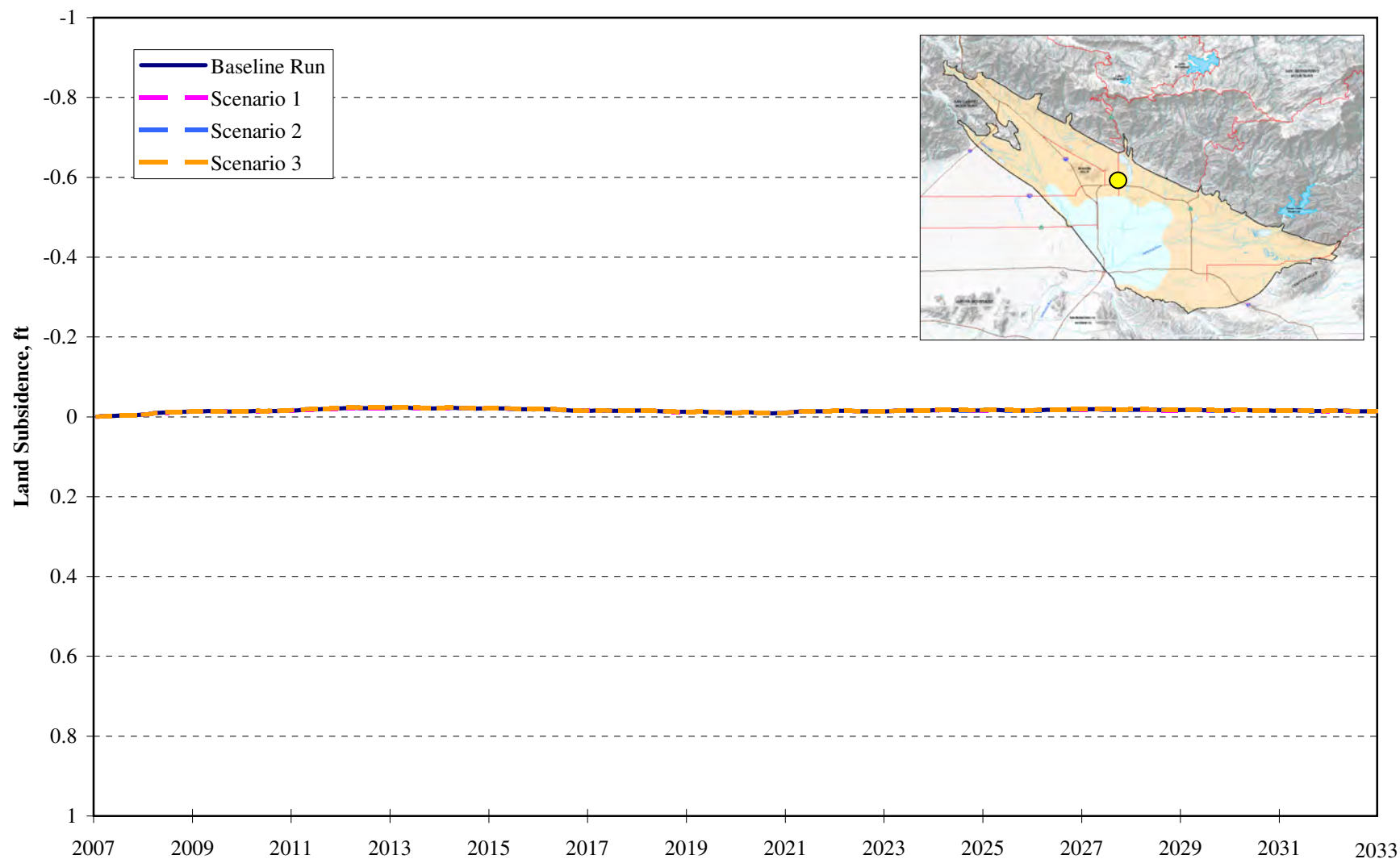
**Land Subsidence at East Valley Water District Well 40
Model Runs 2007-2032**



Land Subsidence at City of San Bernardino Devil Canyon Well No. 3 Model Runs 2007-2032

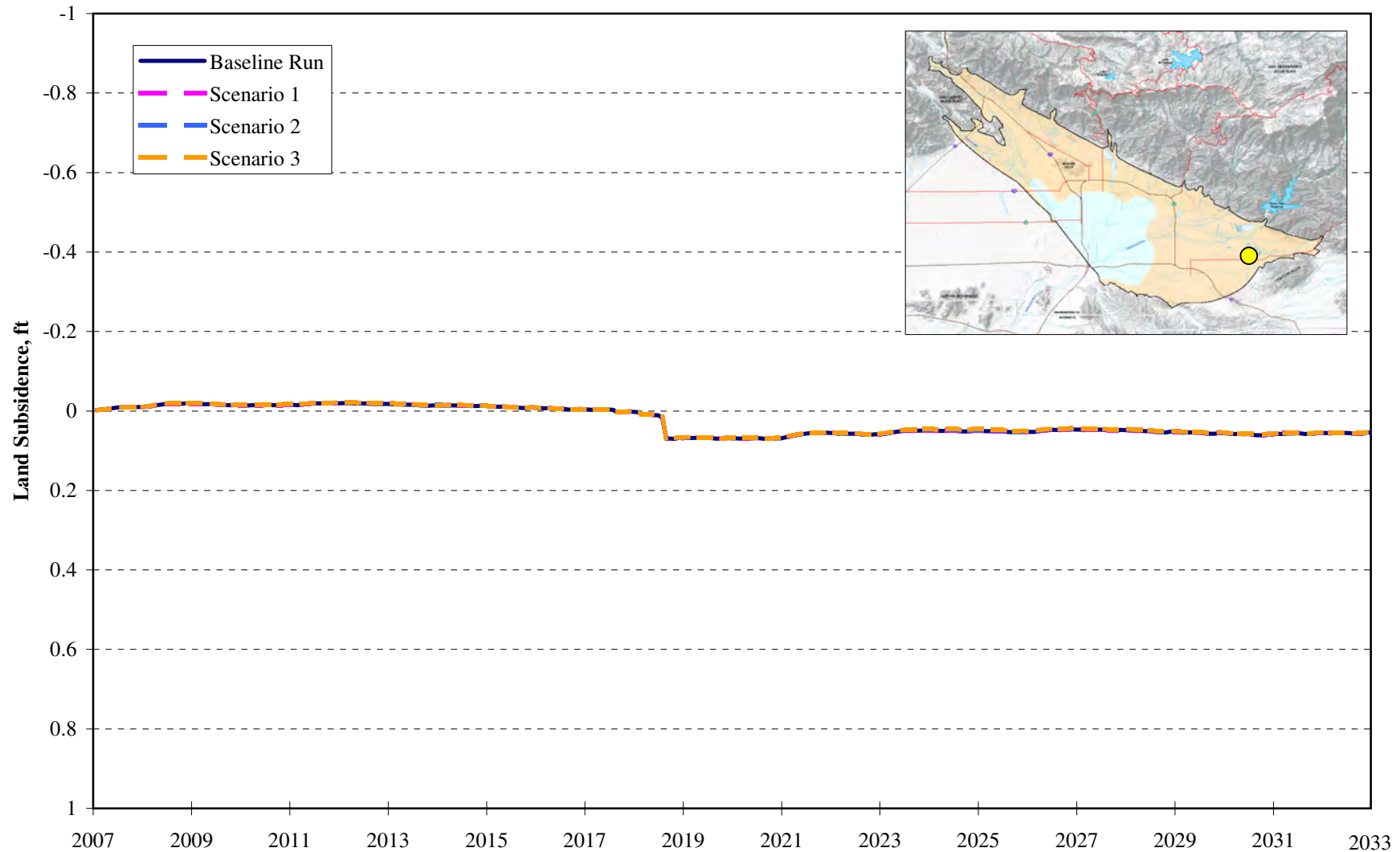


Land Subsidence at City of San Bernardino Leroy Street Well Model Runs 2007-2032

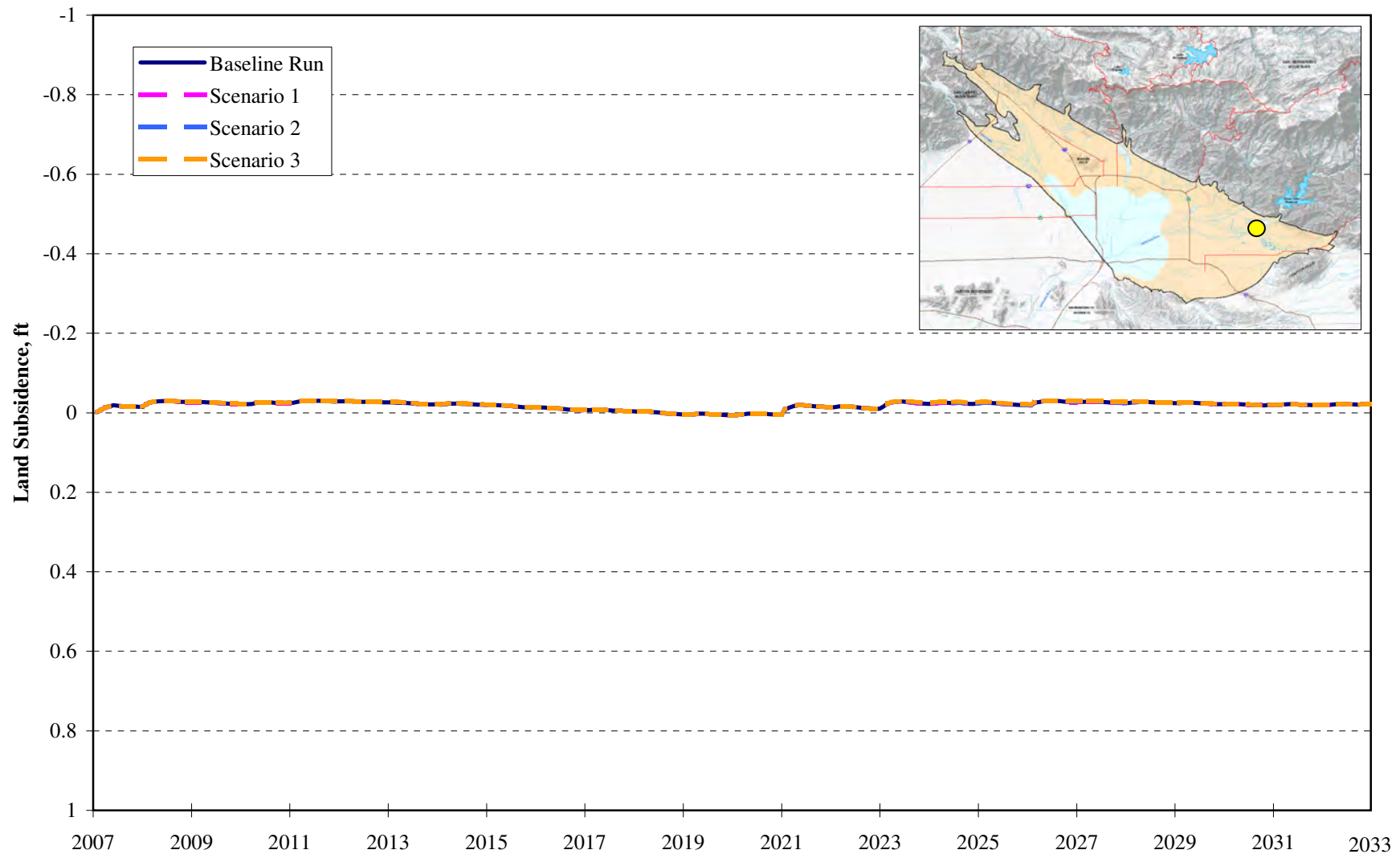


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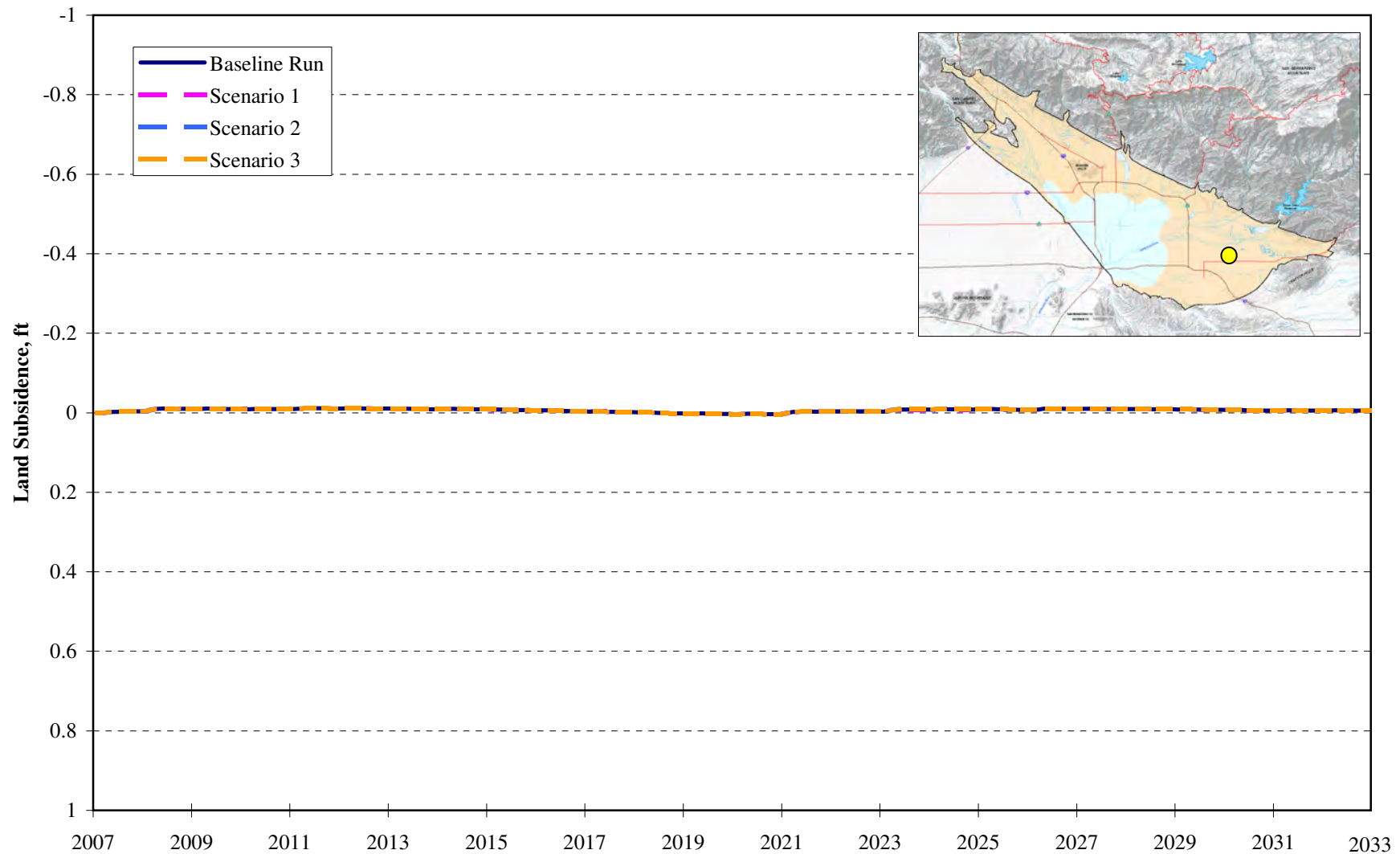
Land Subsidence at City of Redlands Agate 2 Well Model Runs 2007-2032



**Land Subsidence at East Valley Water District Cone Camp Well
Model Runs 2007-2032**

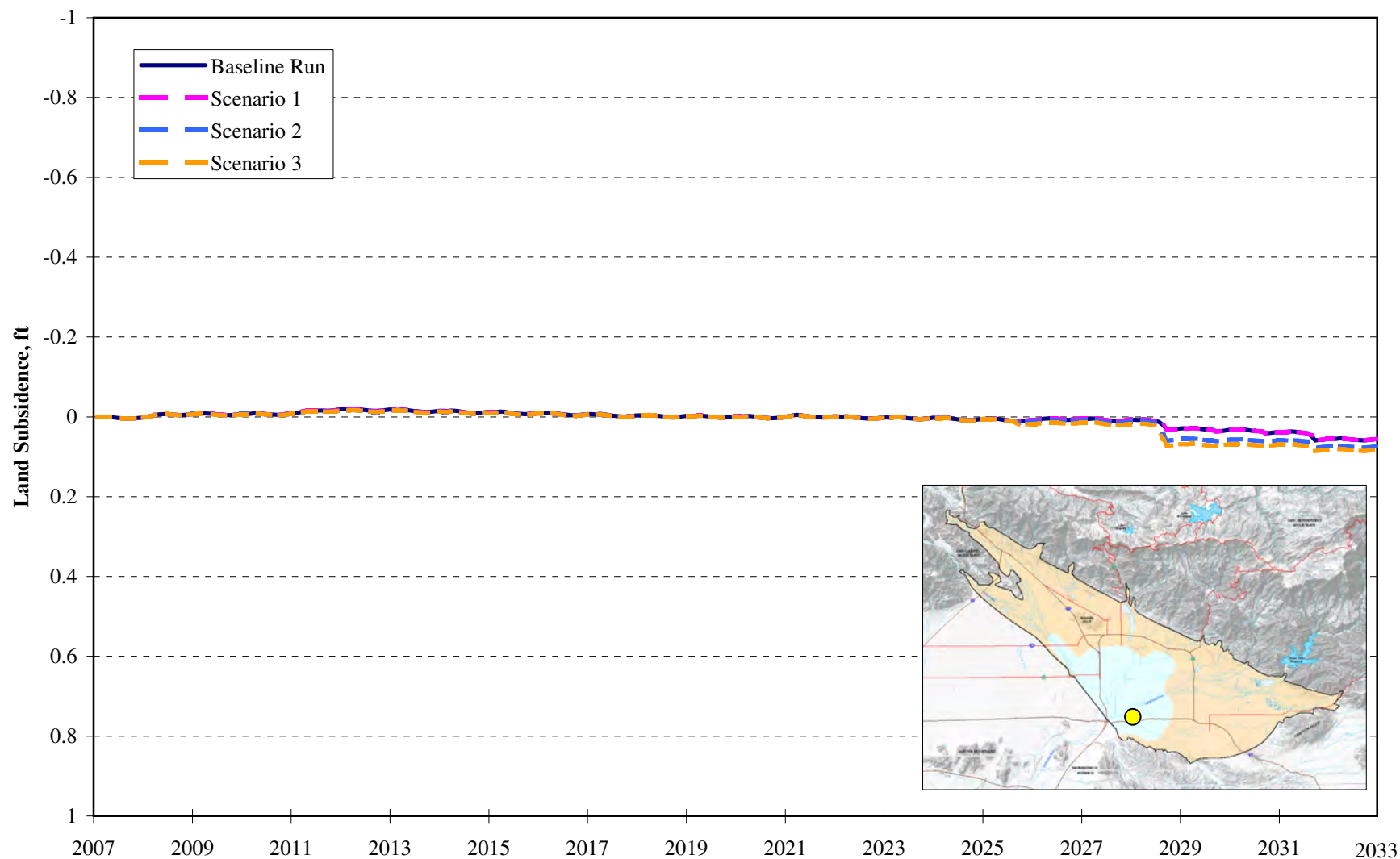


Land Subsidence at Bear Valley Mutual Water Company Nelson Street Well Model Runs 2007-2032



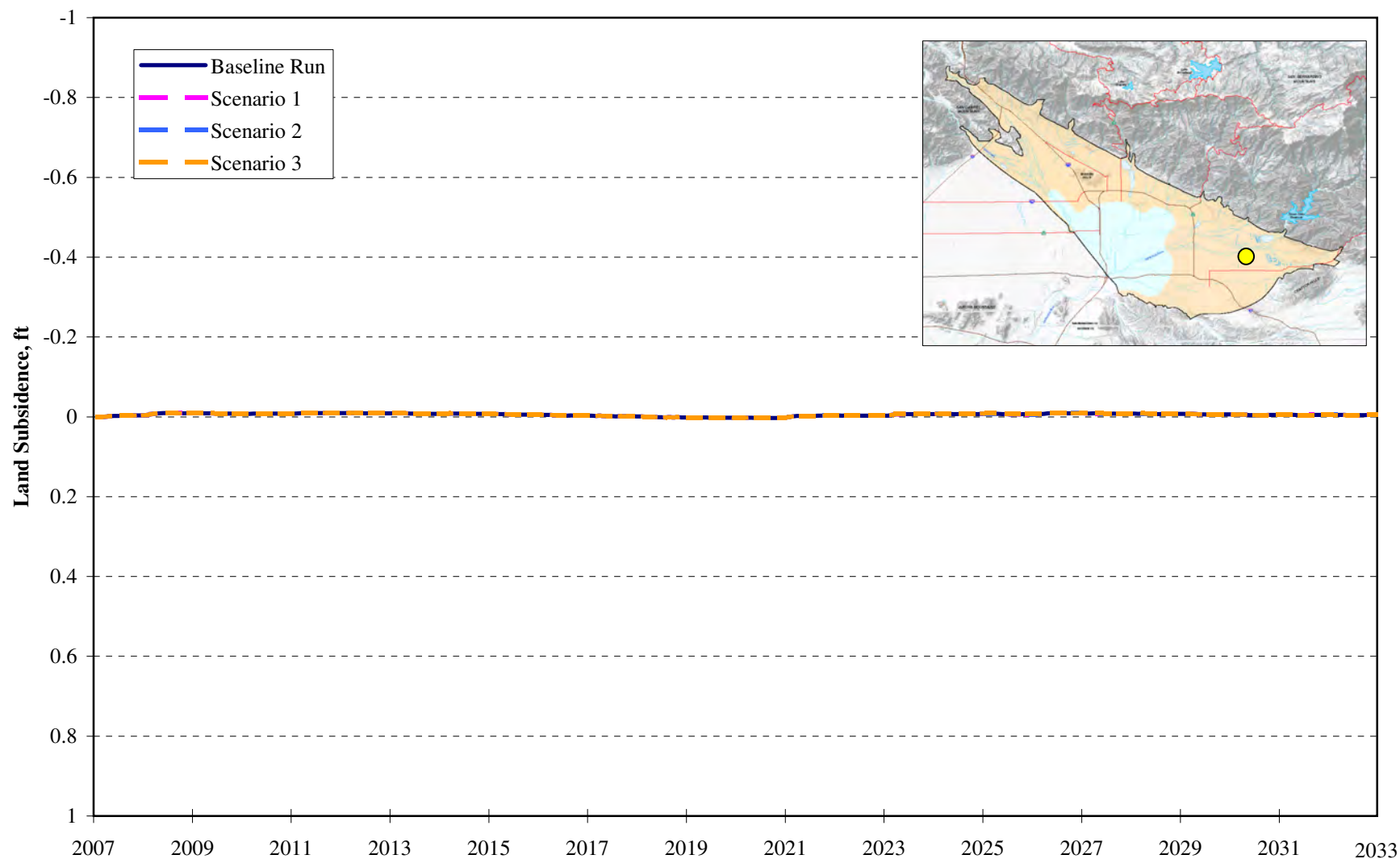
Appendix B

Land Subsidence at Gage Canal Company Lower Kelly Well Model Runs 2007-2032

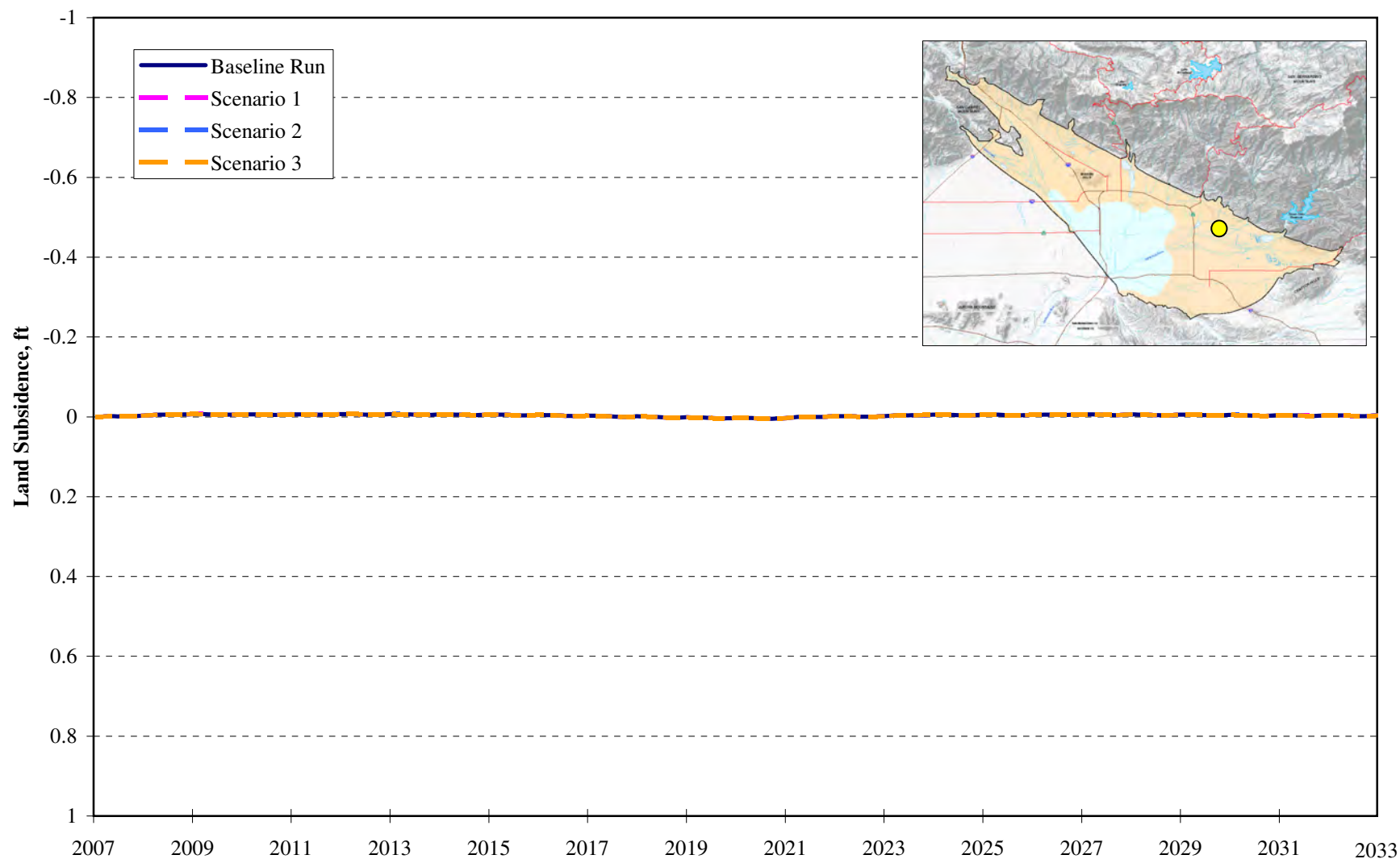


Appendix B

**Land Subsidence at City of Redlands Airport Well No. 2
Model Runs 2007-2032**

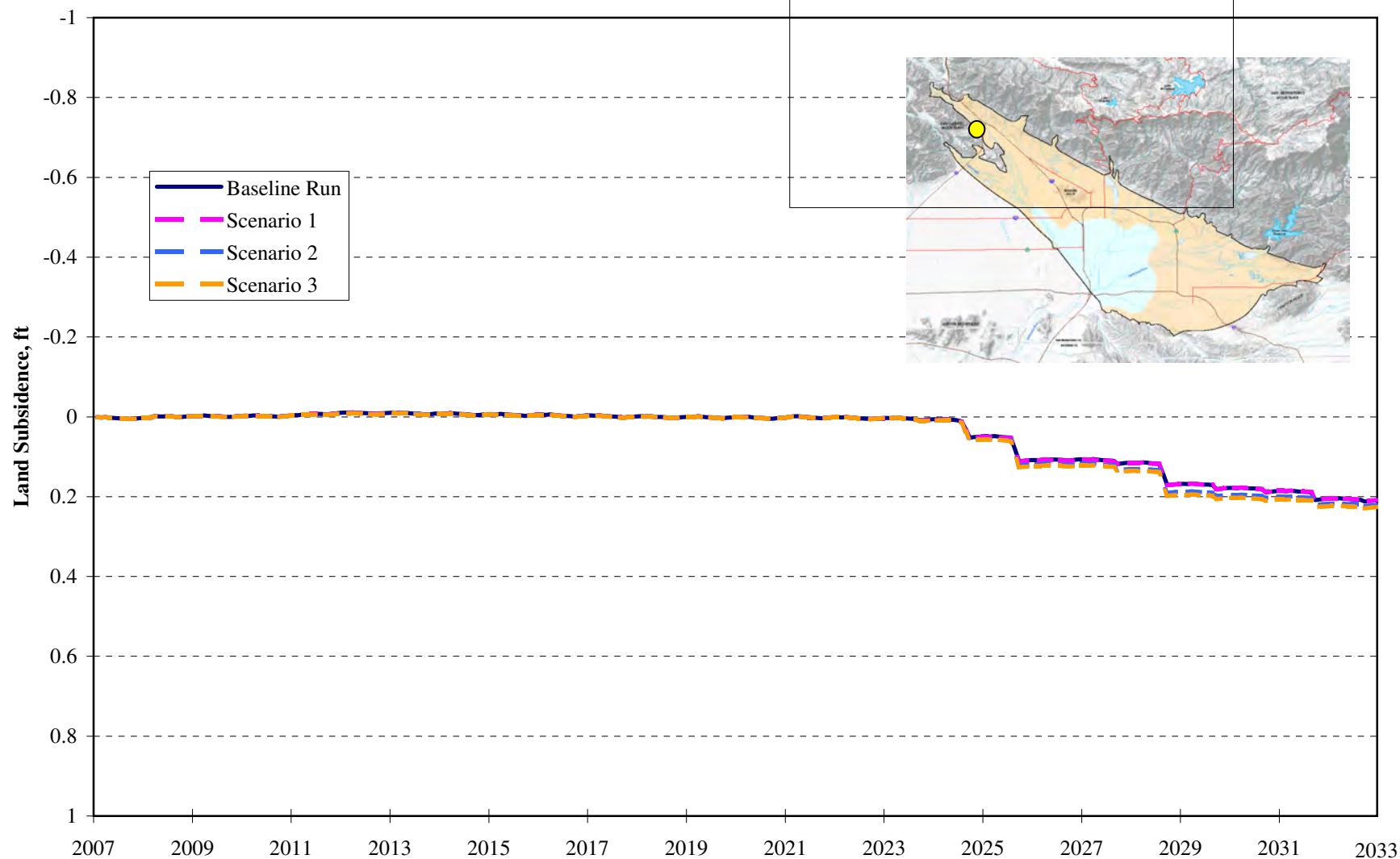


Land Subsidence at East Valley Water District Well 146A Model Runs 2007-2032



Appendix B

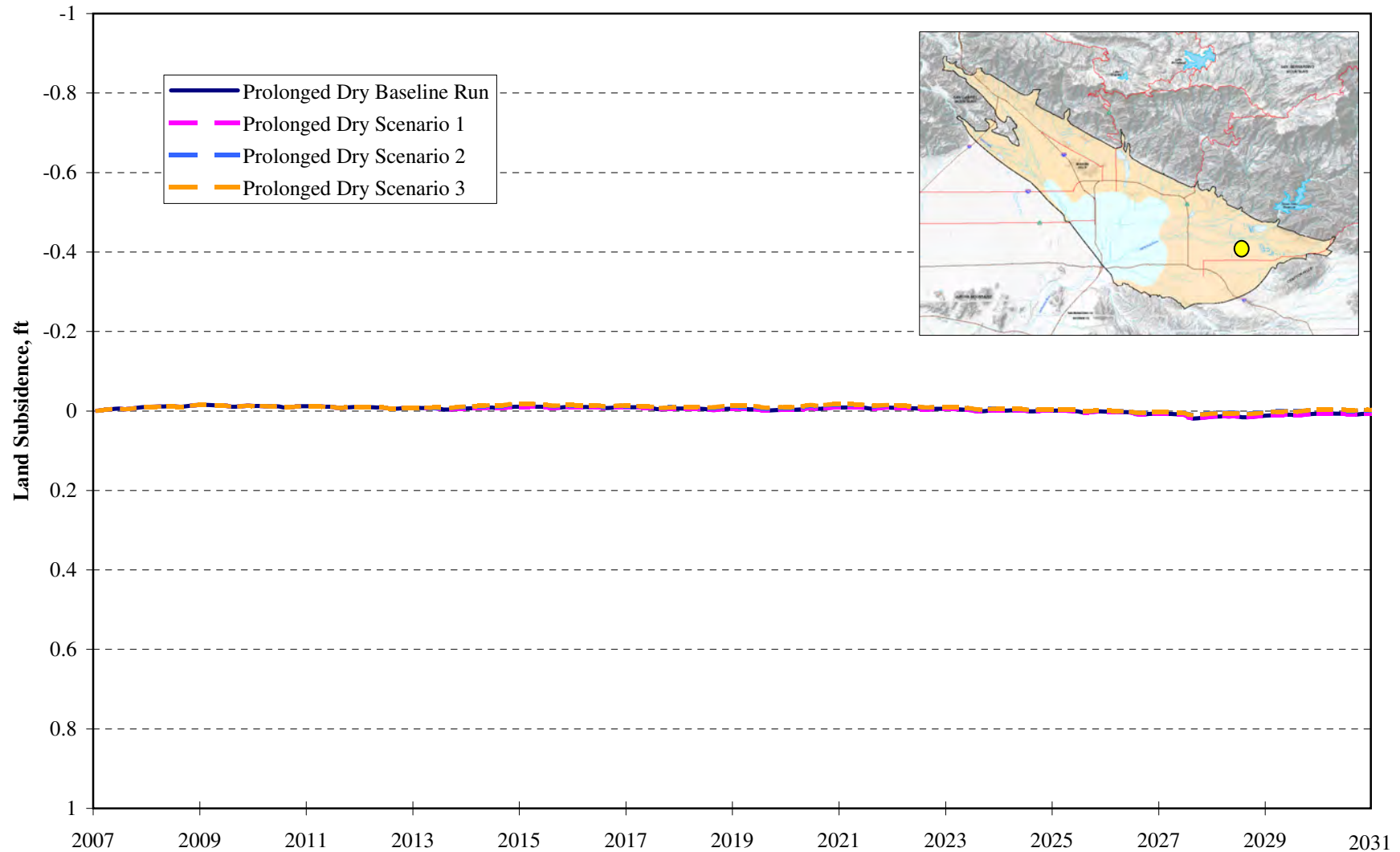
Land Subsidence at SBVMWD Backyard Well Model Runs 2007-2032



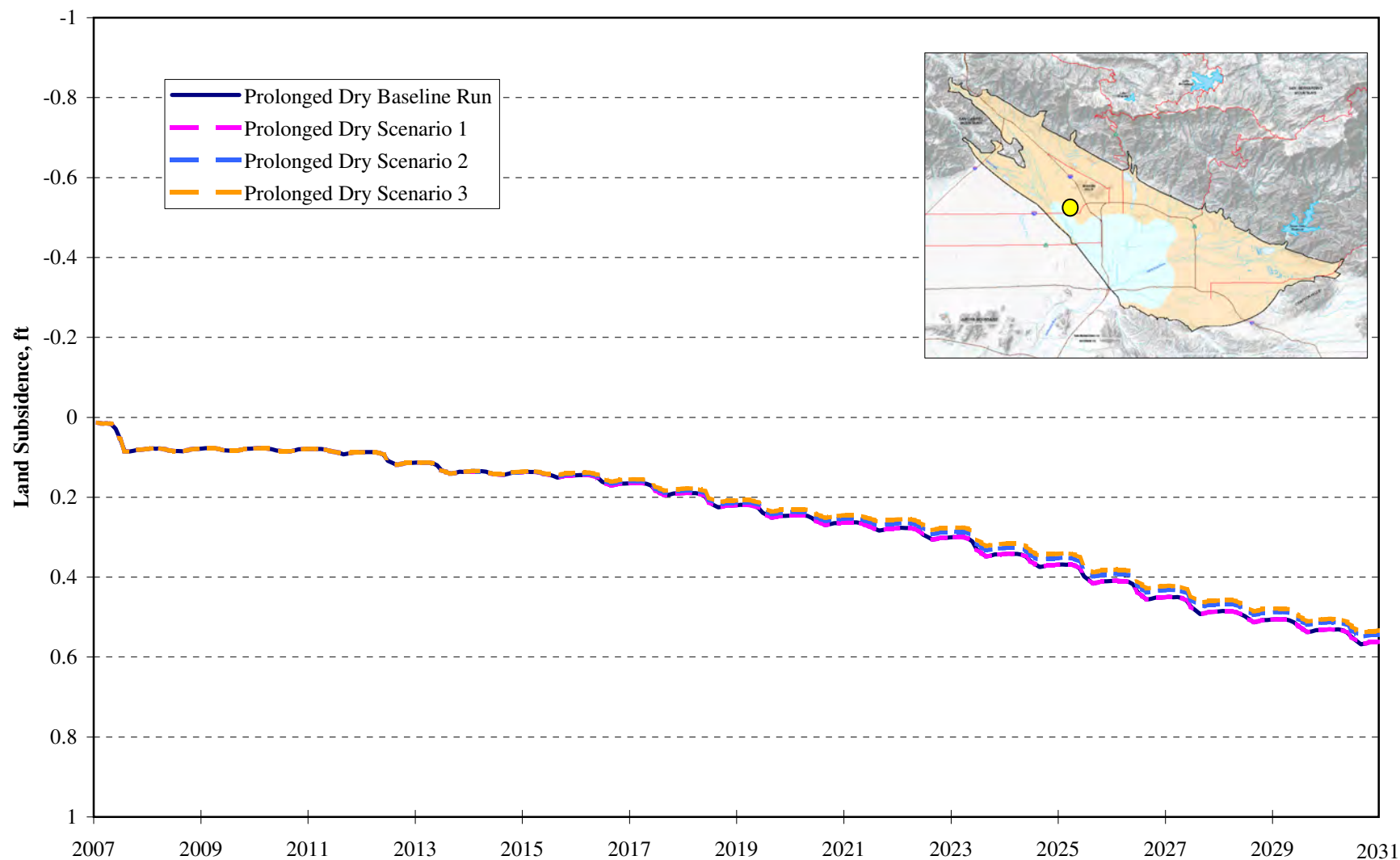
Appendix B

APPENDIX C
Land Subsidence at Selected Sites for
Predicted Prolonged Dry Model Scenarios
2007 to 2030

Land Subsidence at SBVMWD San Bernardino Ave. Well Model Runs 2007-2030

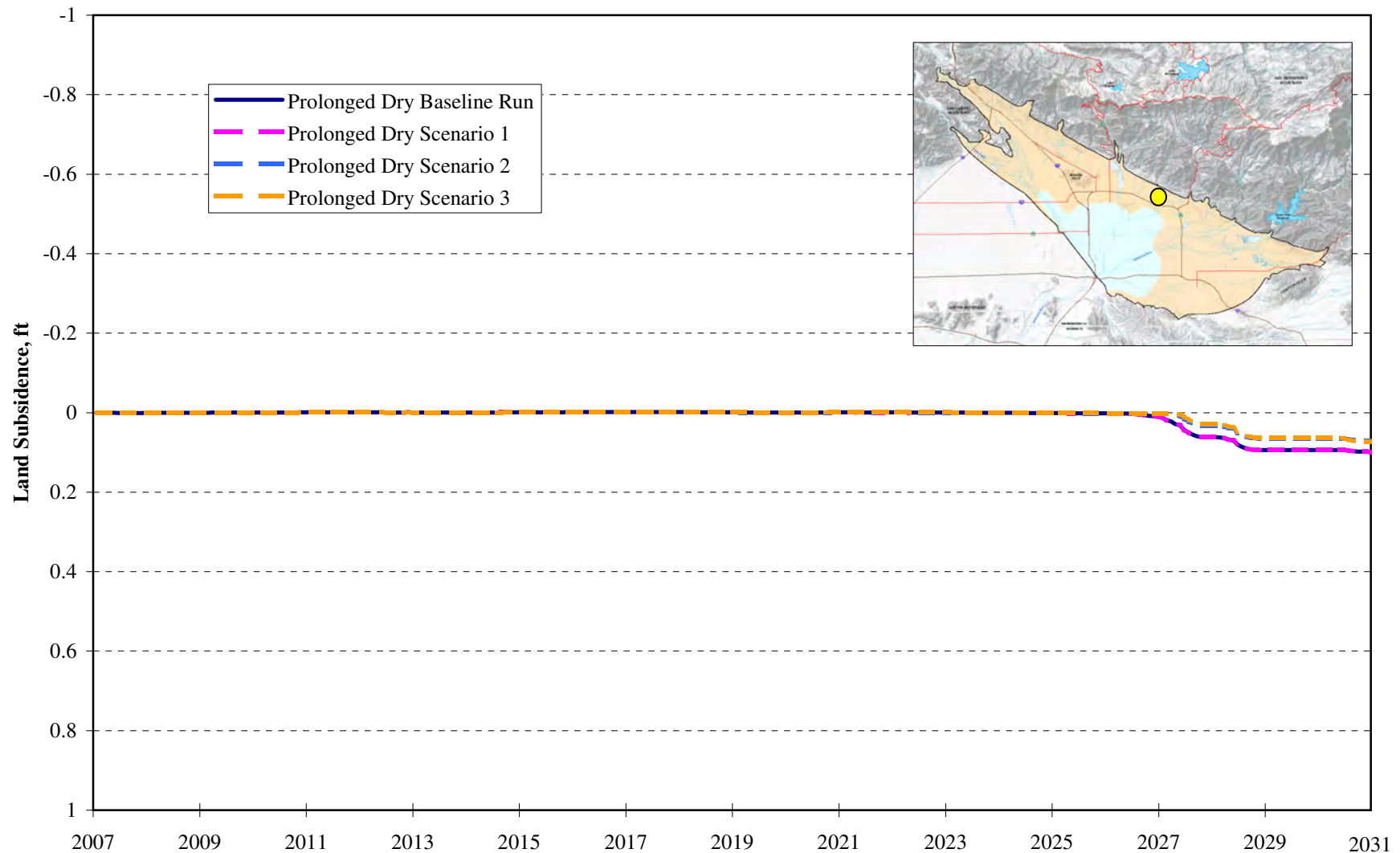


Land Subsidence at City of San Bernardino Mt. Vernon Well Model Runs 2007-2030

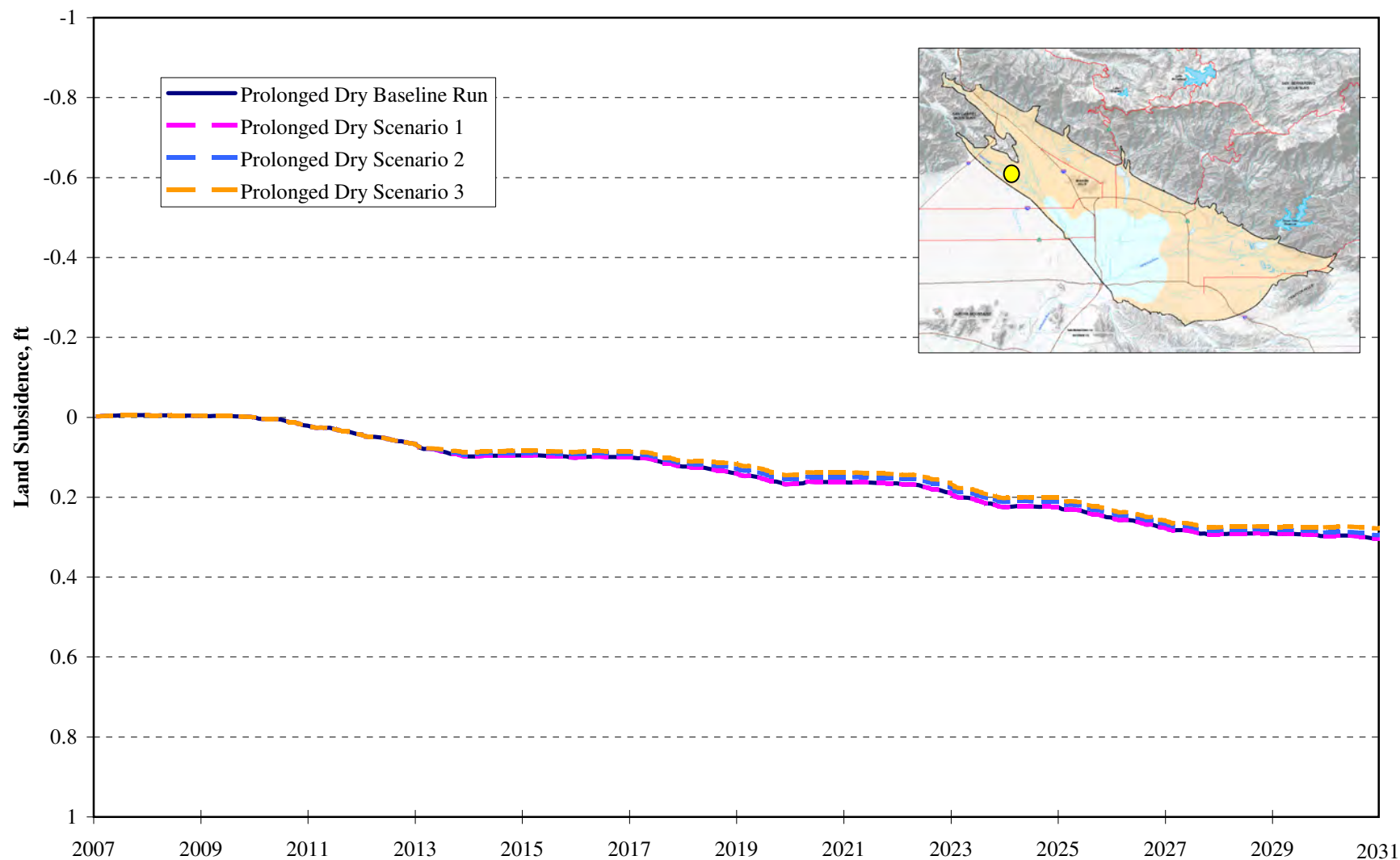


Appendix C

Land Subsidence at East Valley Water District Well 62 Model Runs 2007-2030

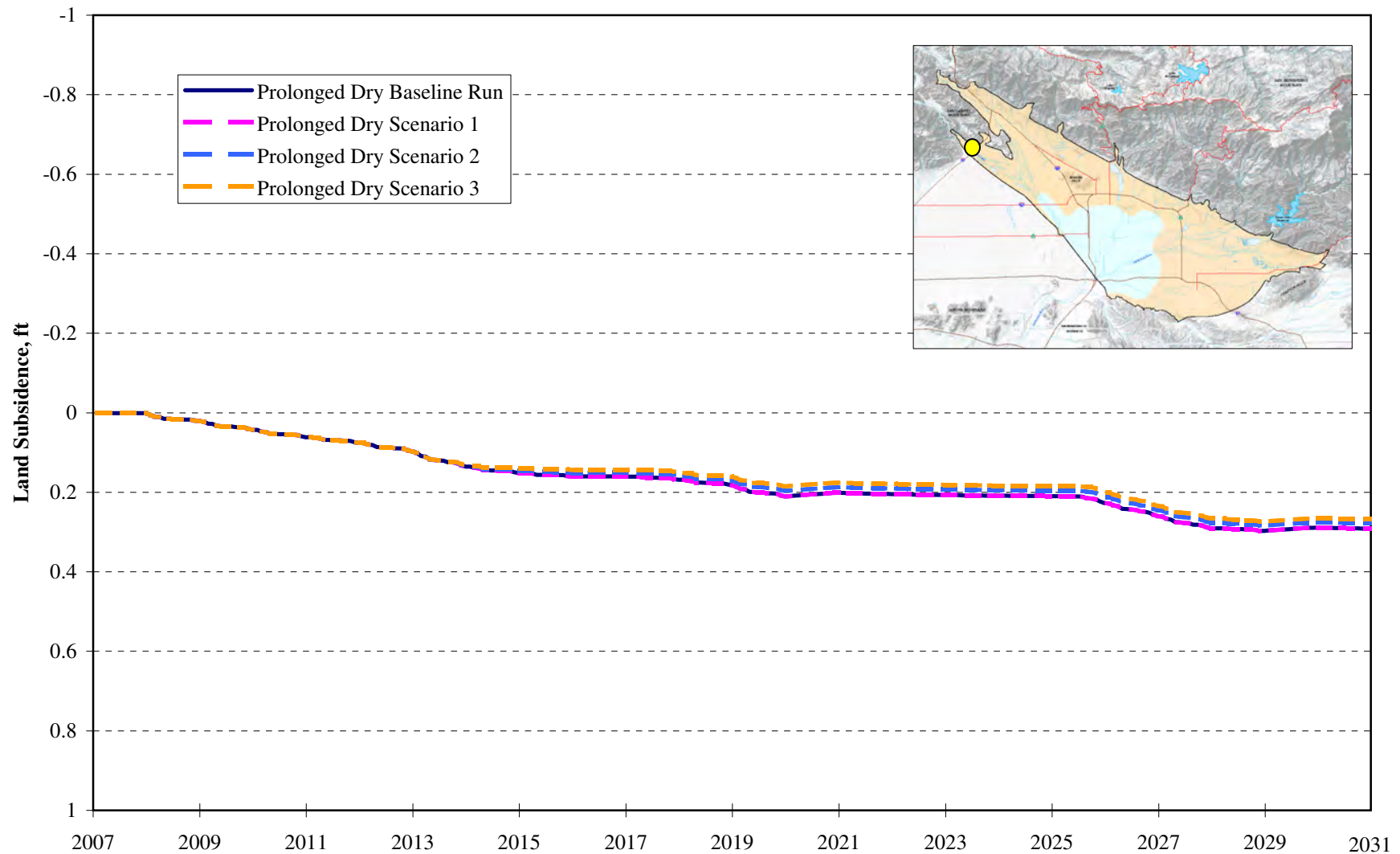


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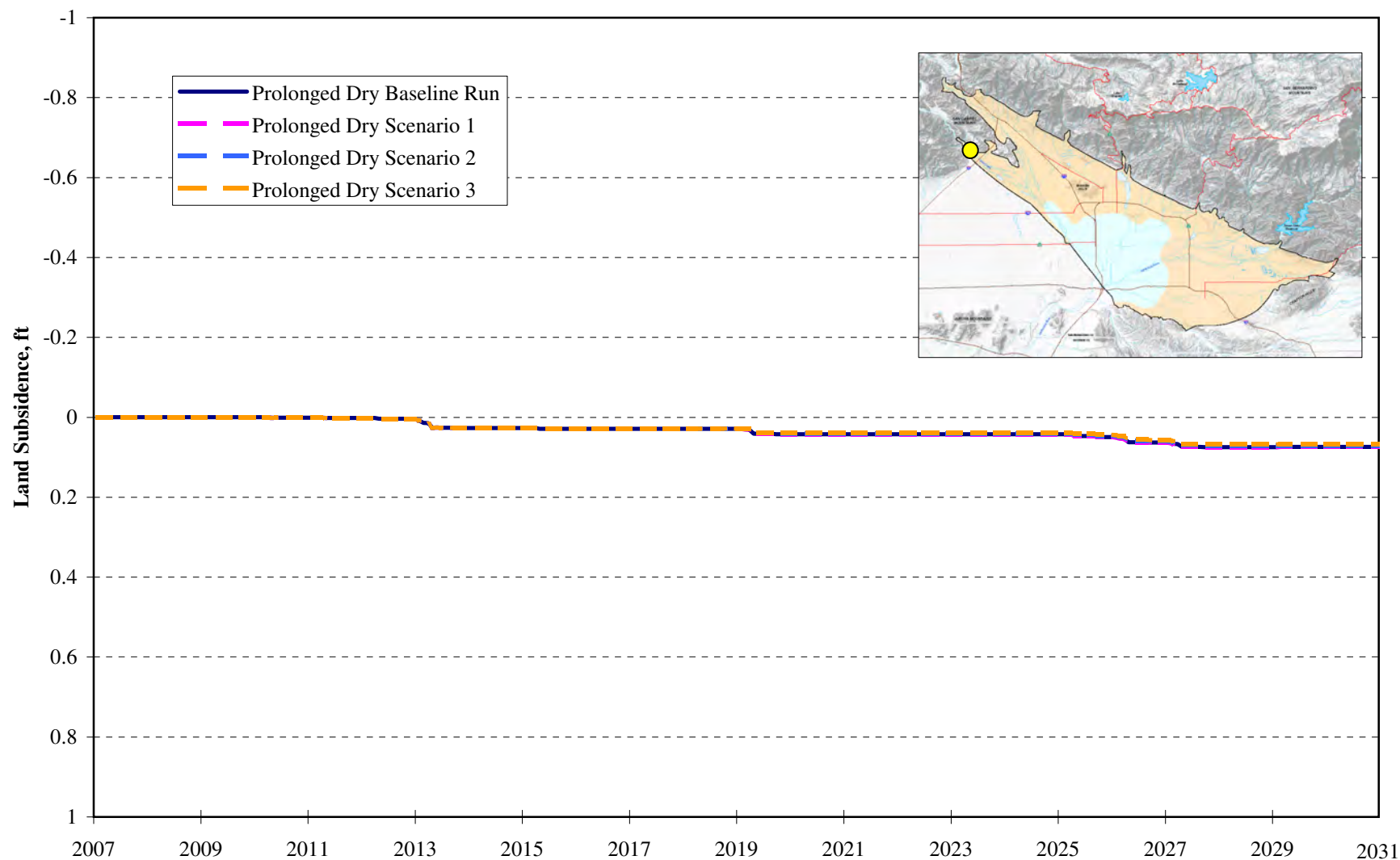


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Land Subsidence at Fontana Union Water Company Well 26 Model Runs 2007-2030

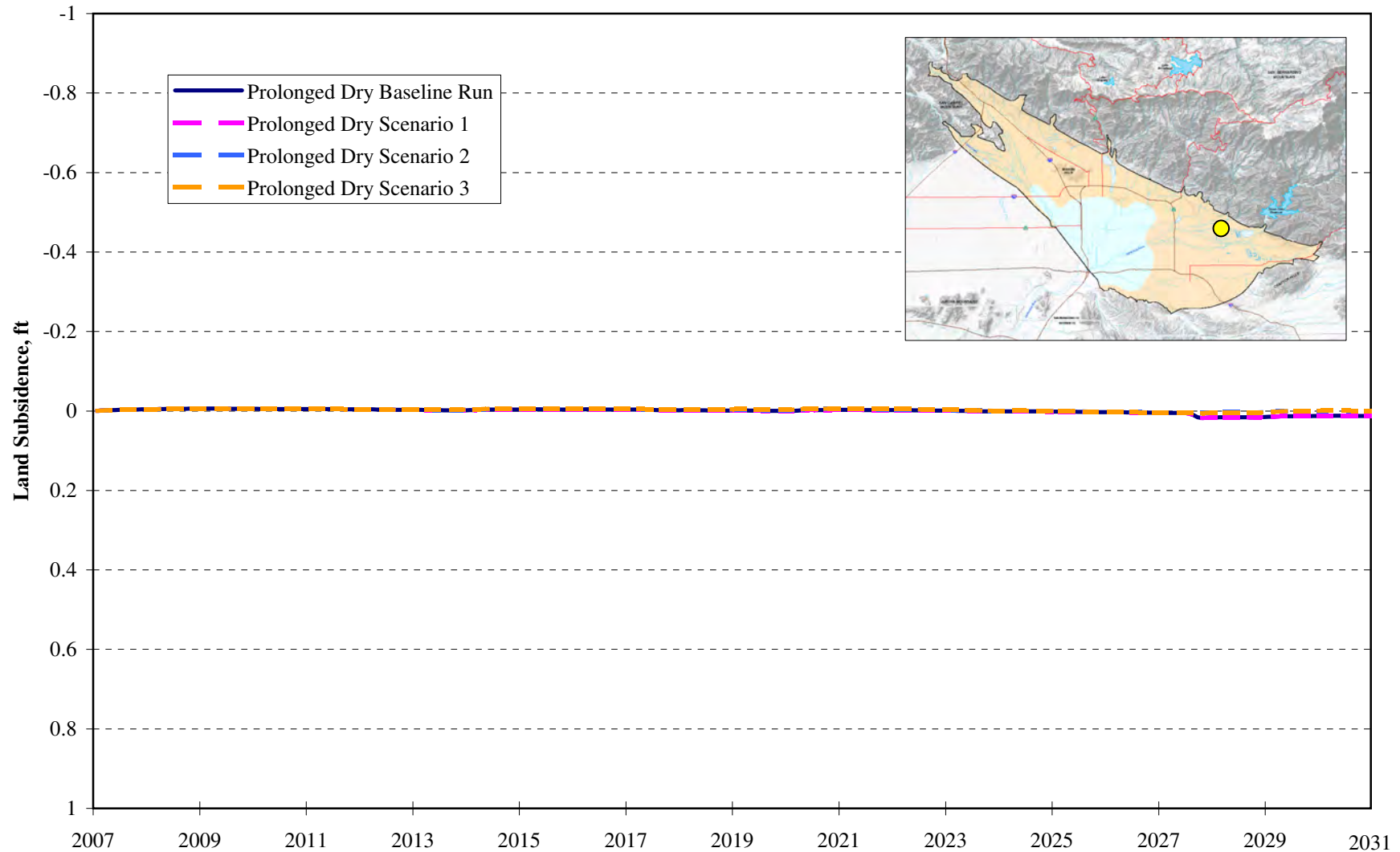


Land Subsidence at Fontana Union Water Company Well 27 Model Runs 2007-2030

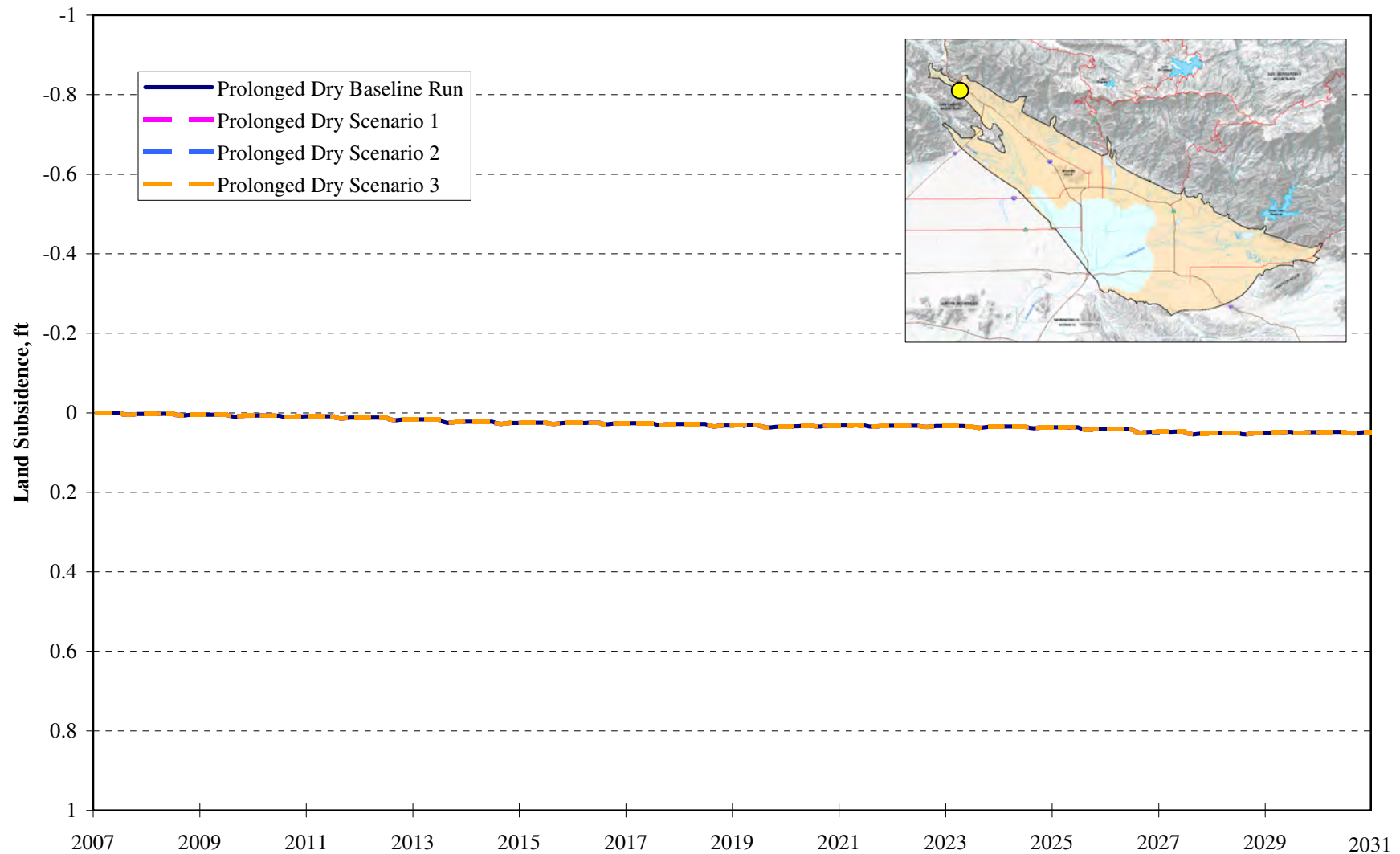


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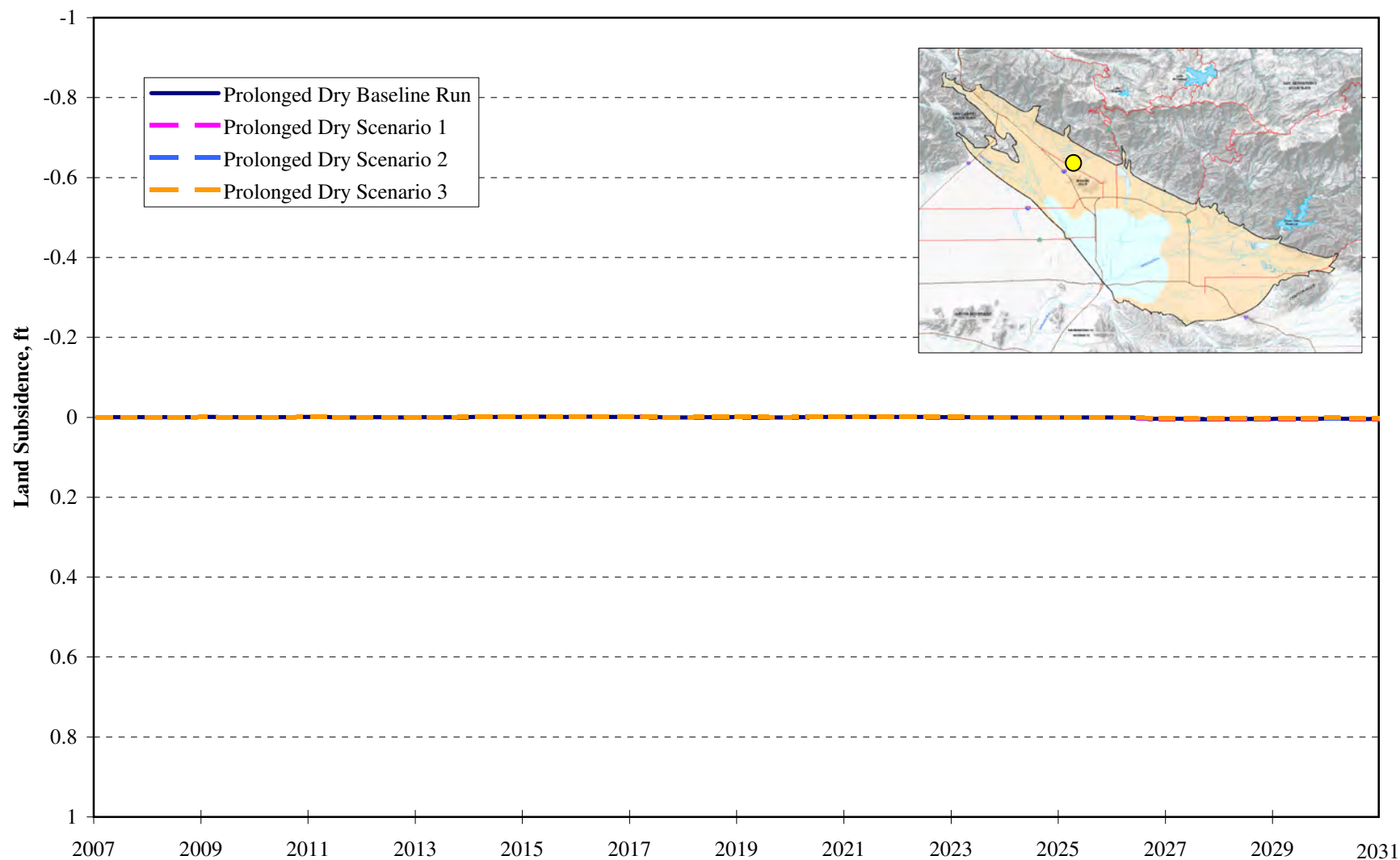
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Model Runs 2007-2030**



Land Subsidence at City of San Bernardino Vincent Well Model Runs 2007-2030

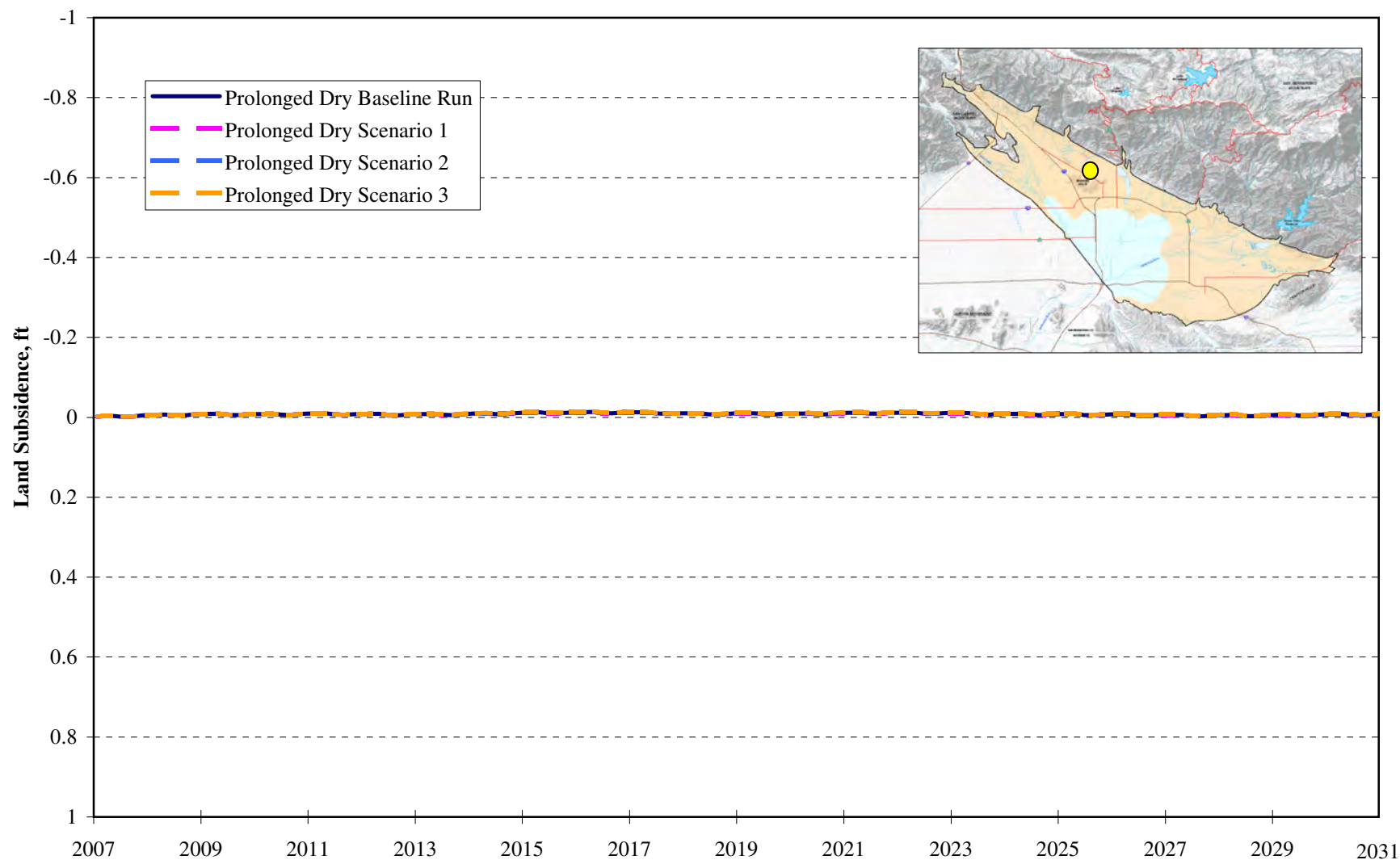


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Model Runs 2007-2030**

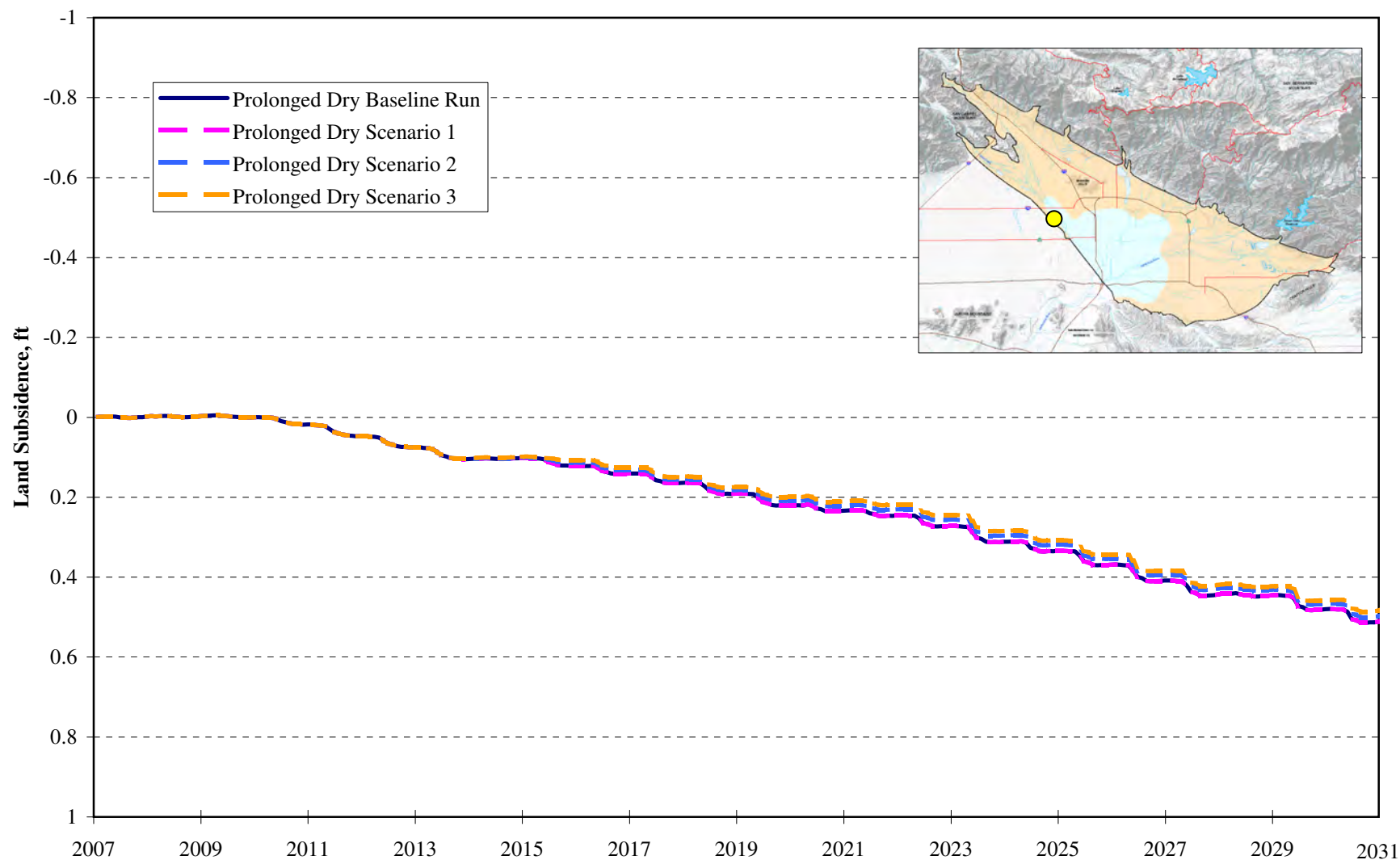


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Land Subsidence at City of San Bernardino Newmark 3 Well Model Runs 2007-2030

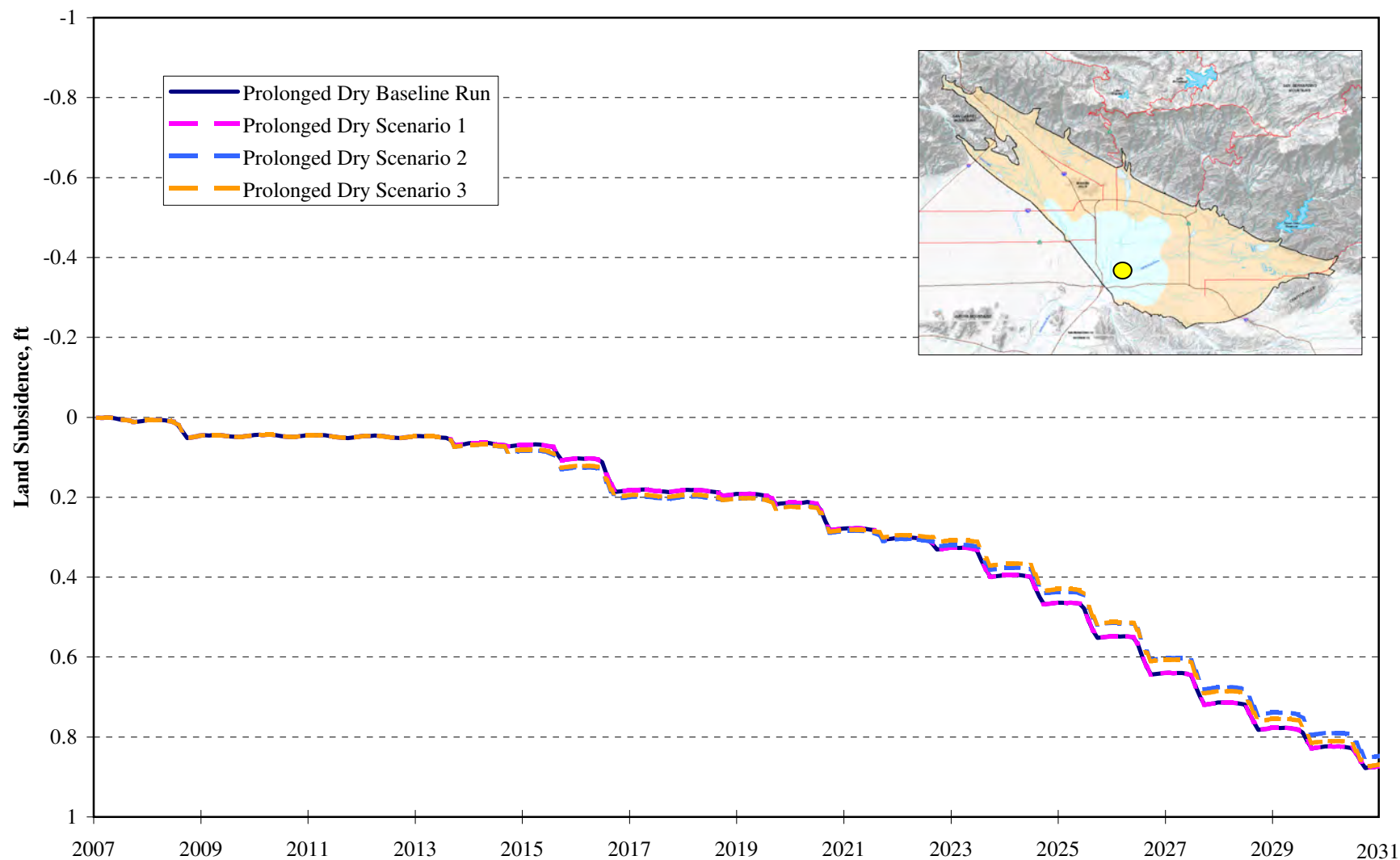


Land Subsidence at West Valley Water District Lord 7 Well Model Runs 2007-2030



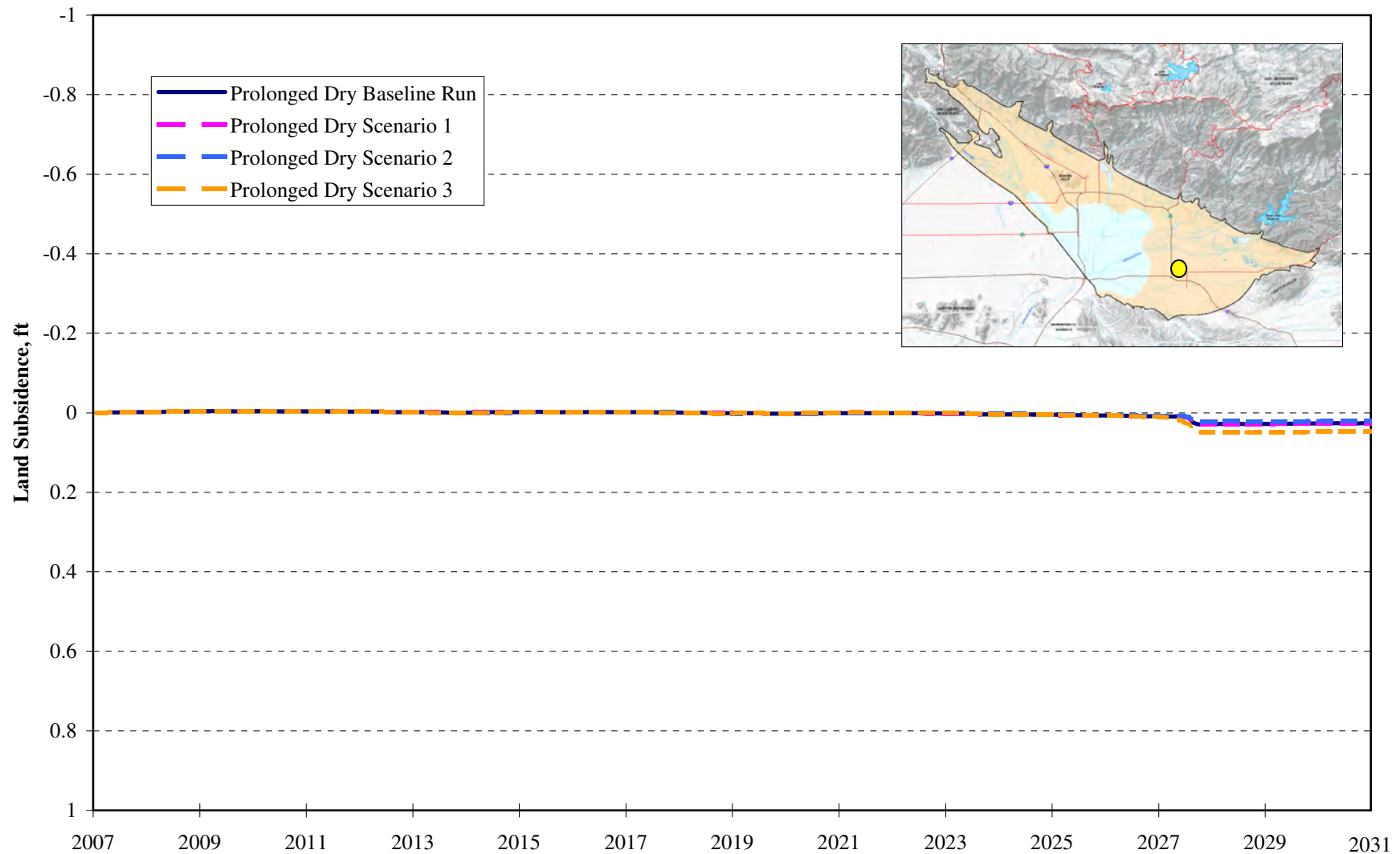
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Land Subsidence at City of Riverside Raub 1 Well Model Runs 2007-2030

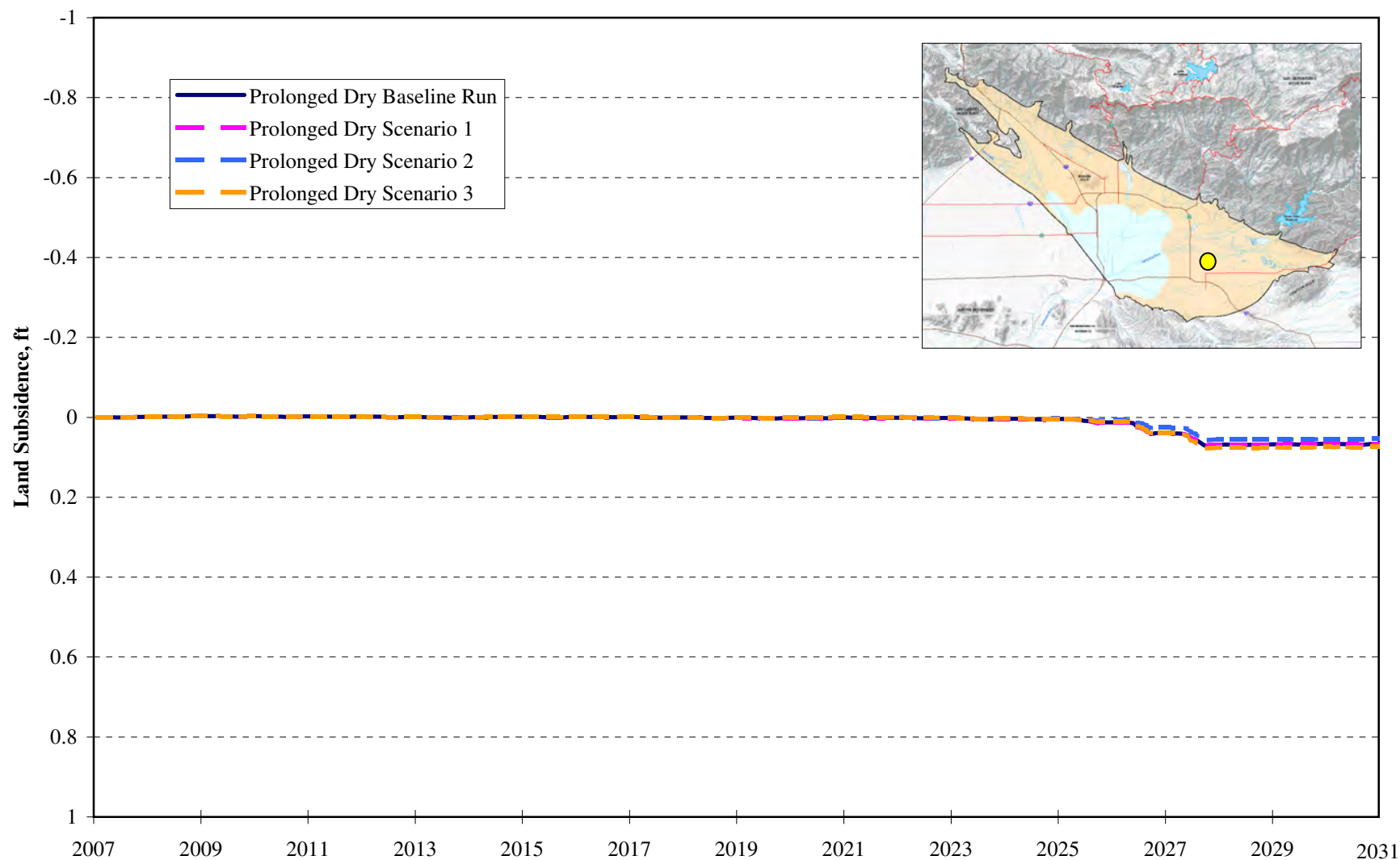


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**Land Subsidence at City of Redlands Well 32
Model Runs 2007-2030**

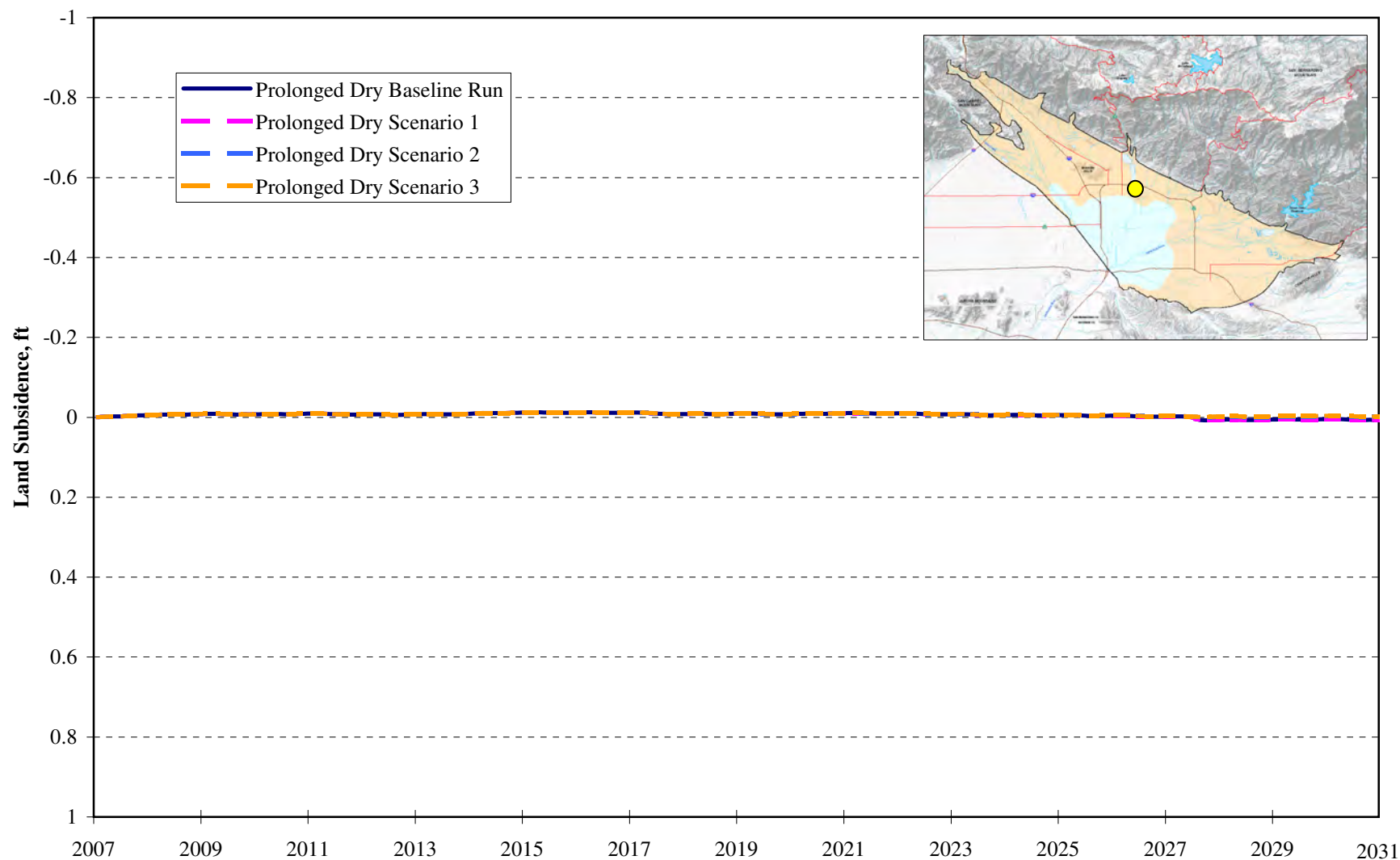


Land Subsidence at City of Redlands Orange Street Well Model Runs 2007-2030

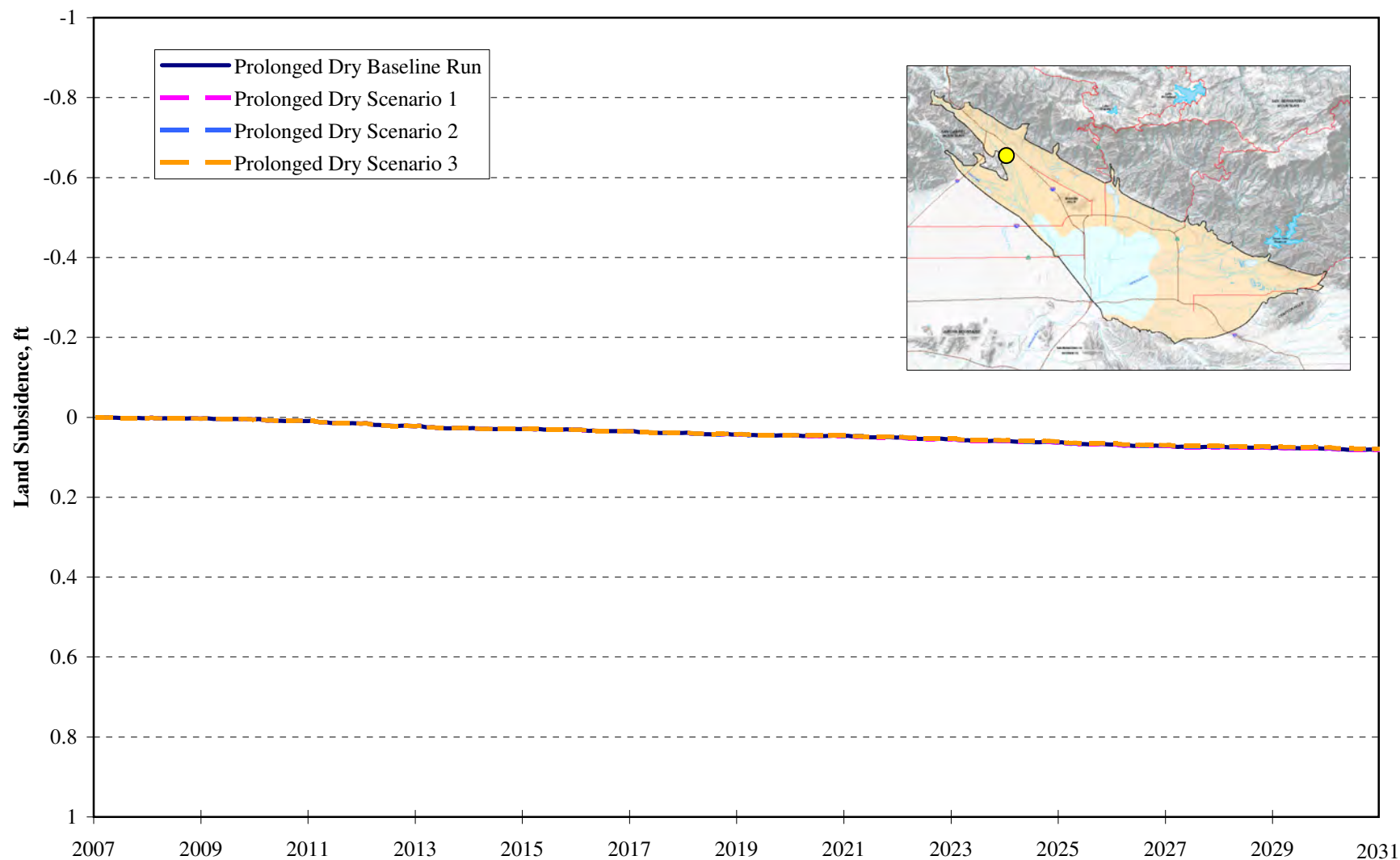


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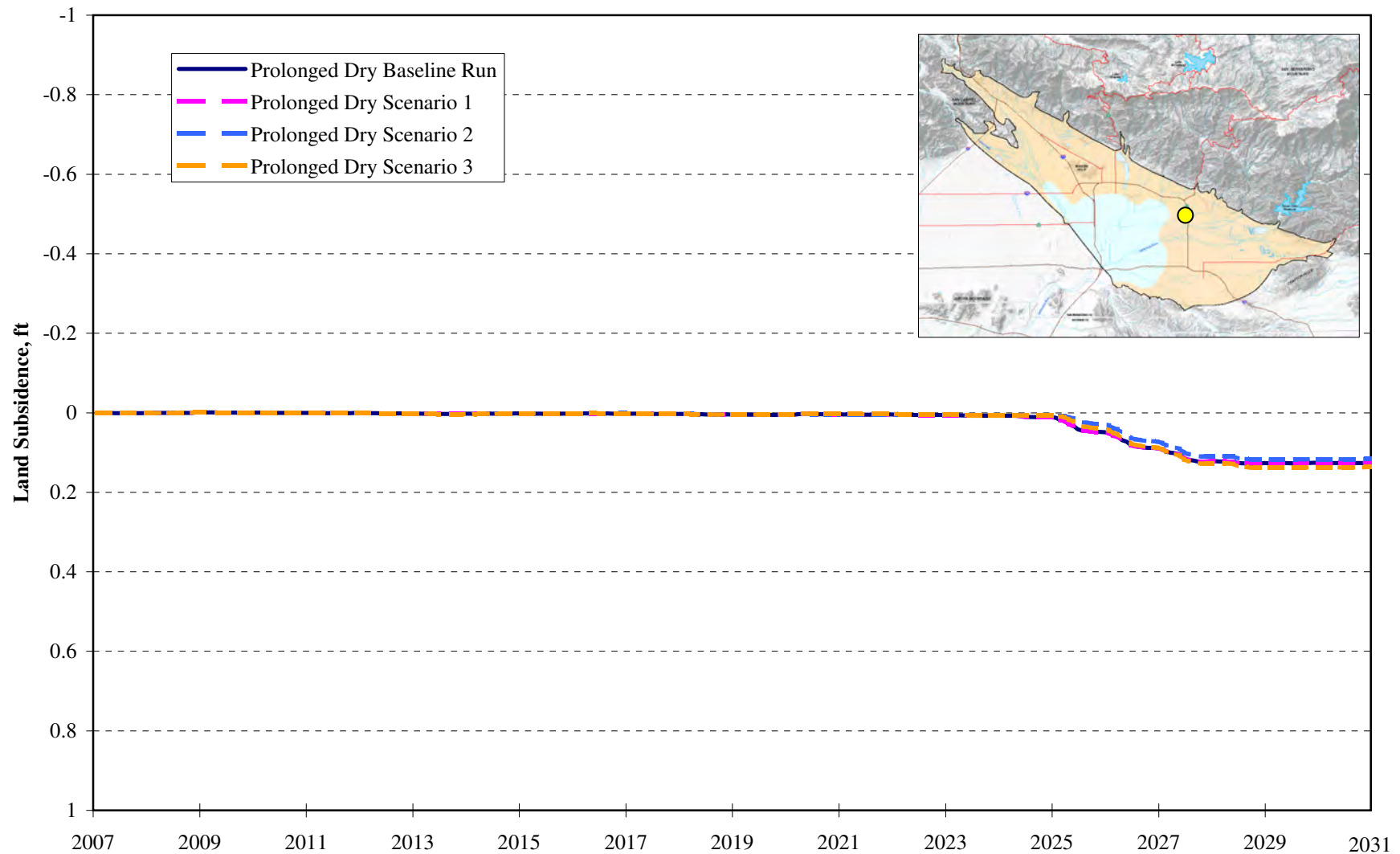
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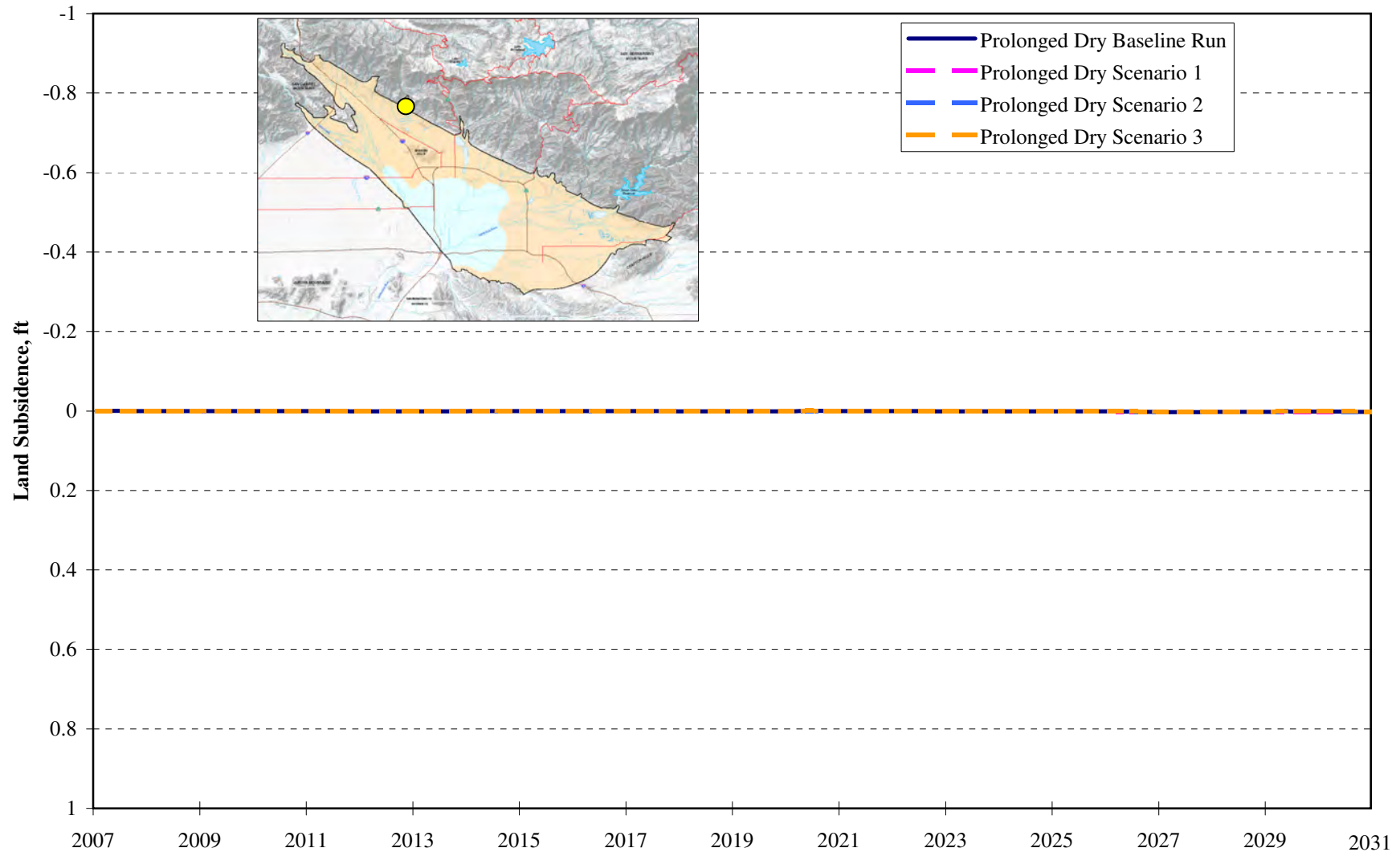
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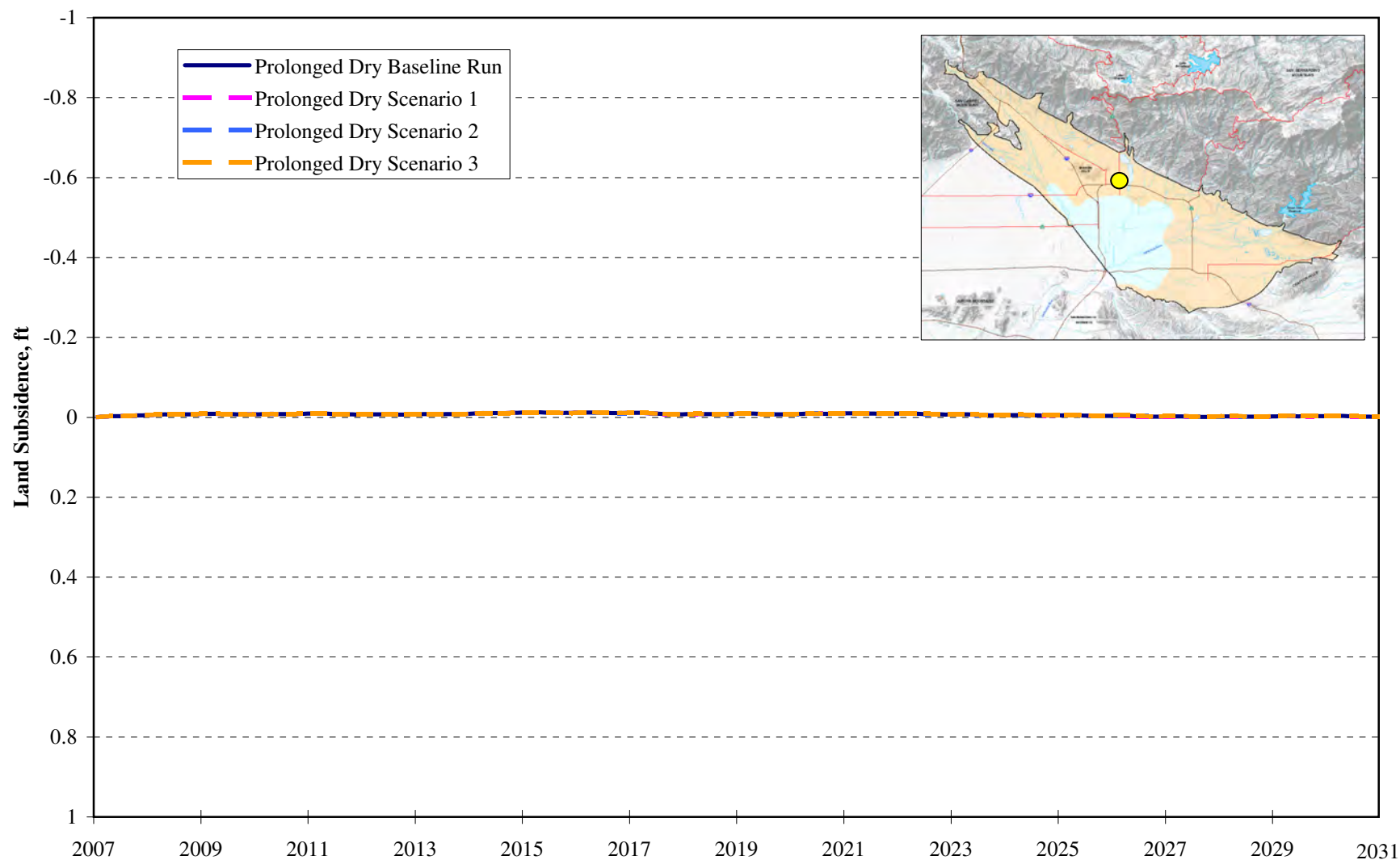
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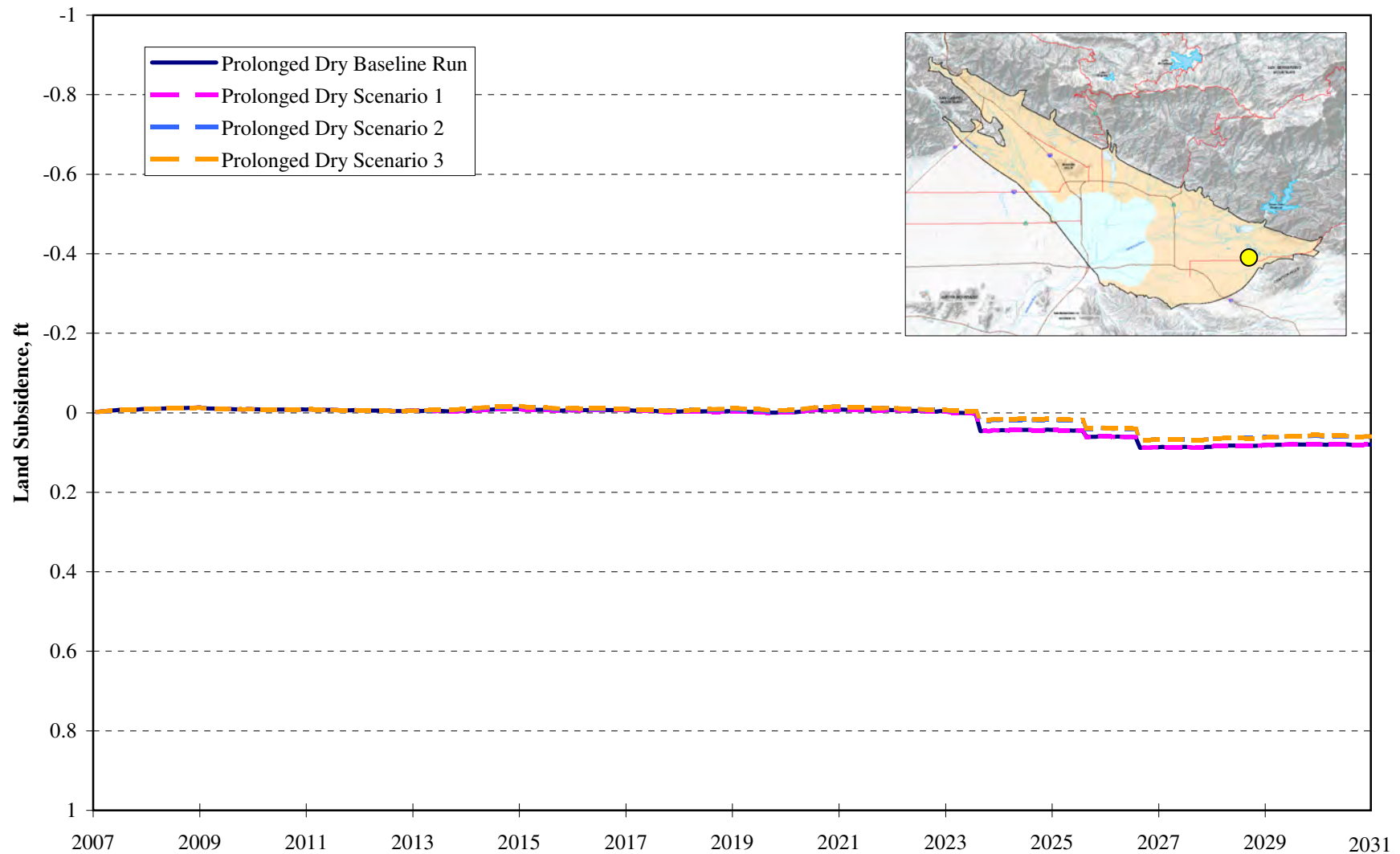
**Land Subsidence at City of San Bernardino Devil Canyon Well No. 3
Model Runs 2007-2030**



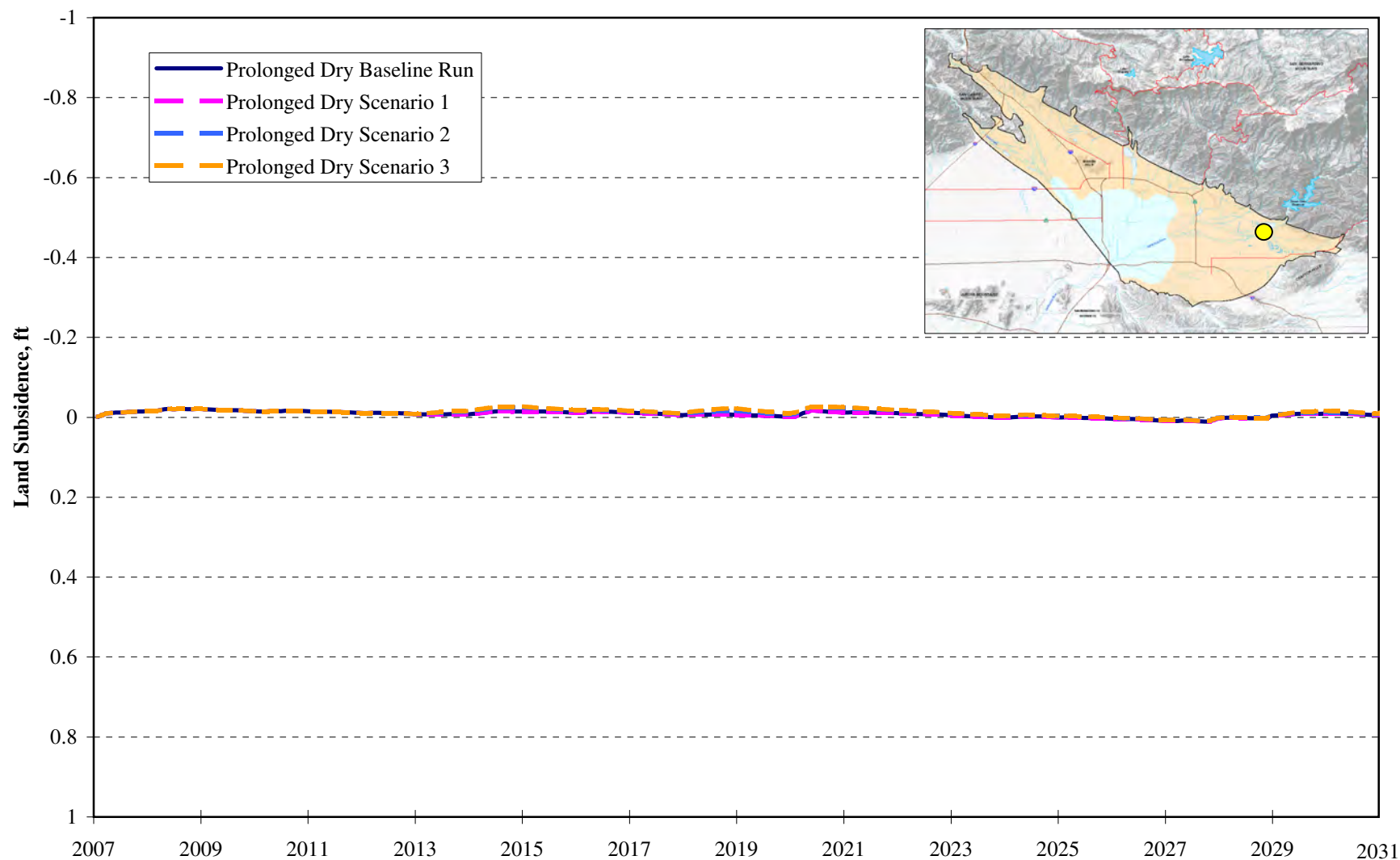
**Land Subsidence at City of San Bernardino Leroy Street Well
Model Runs 2007-2030**



Land Subsidence at City of Redlands Agate 2 Well Model Runs 2007-2030

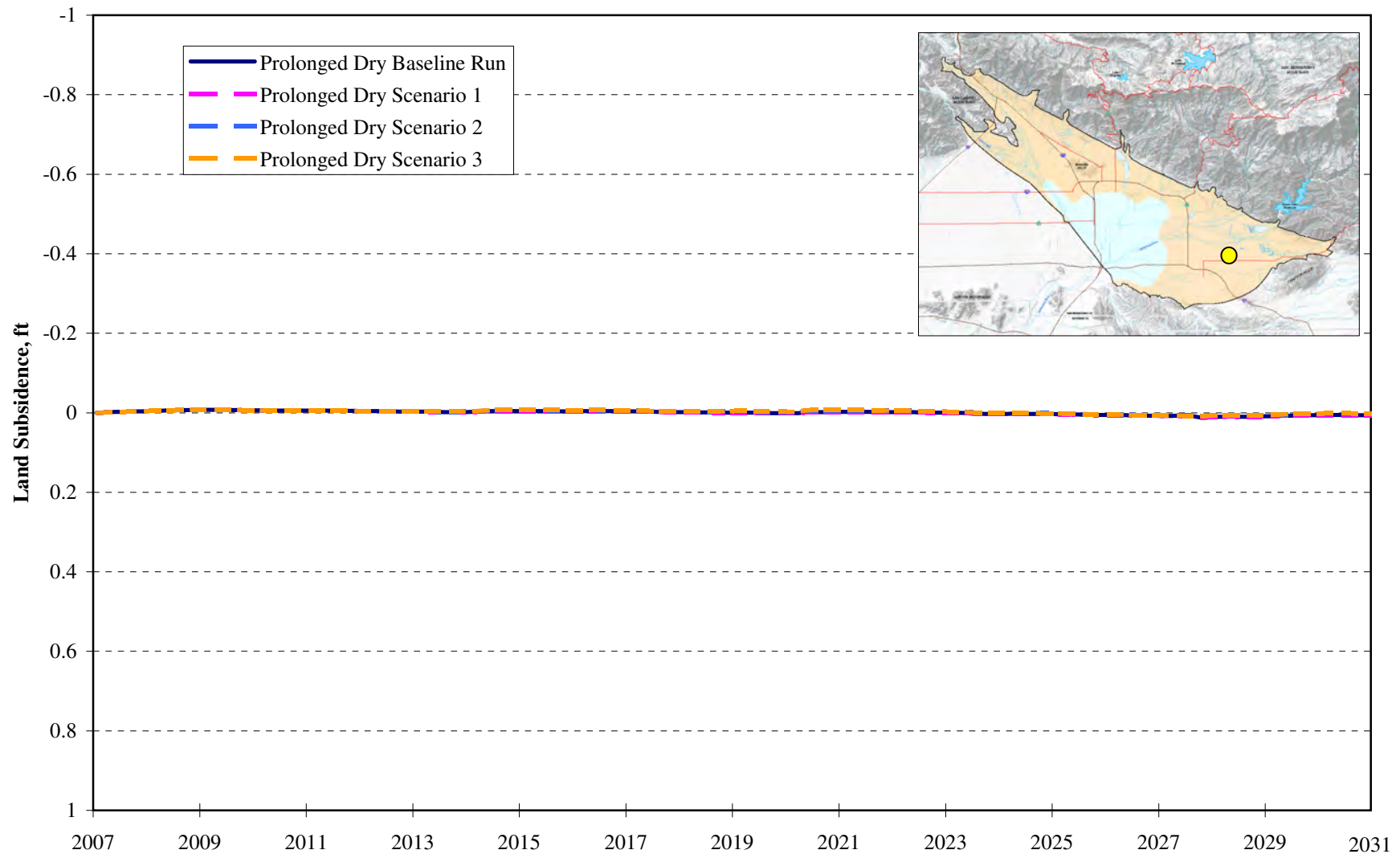


Land Subsidence at East Valley Water District Cone Camp Well Model Runs 2007-2030

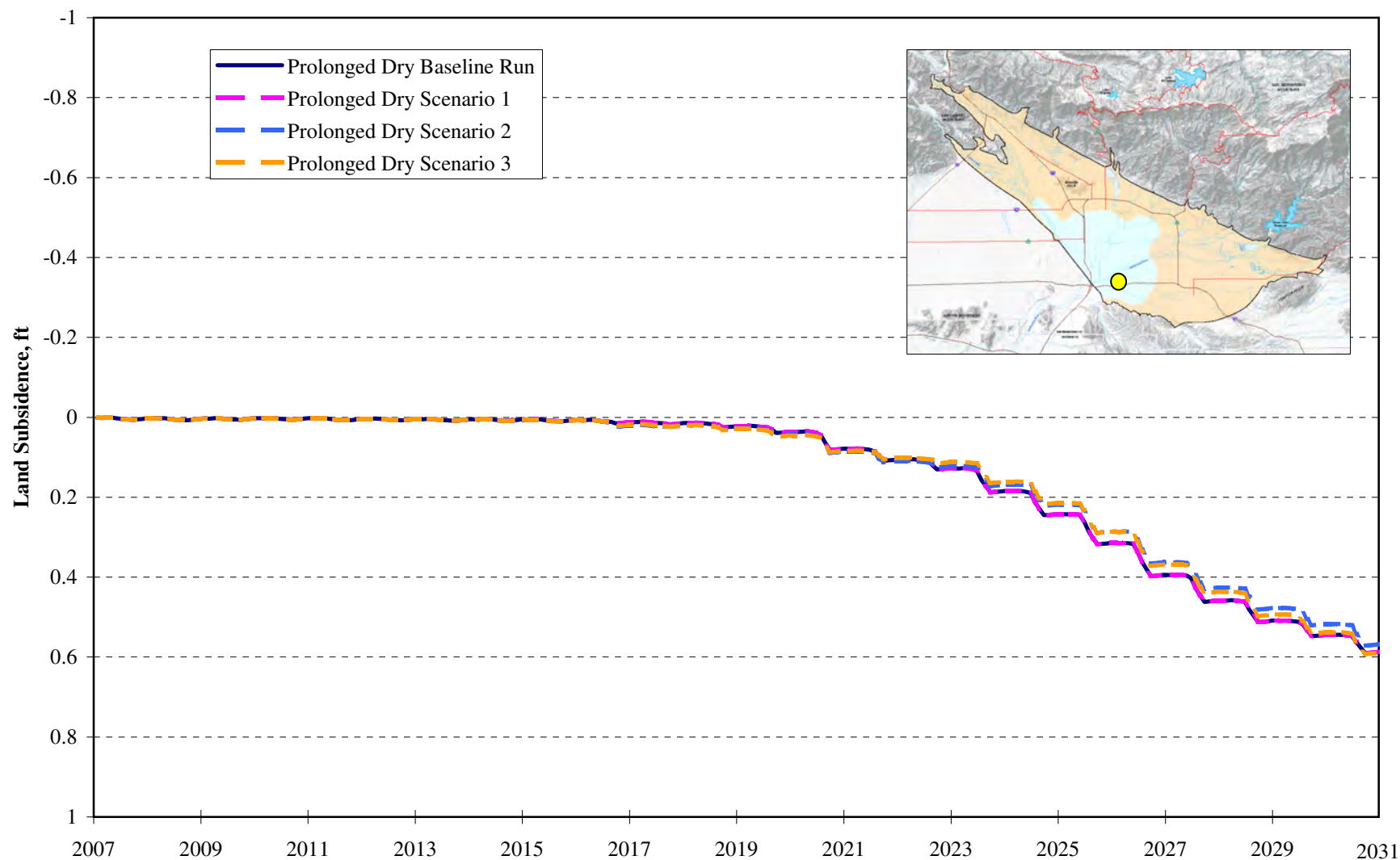


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**Land Subsidence at Bear Valley Mutual Water Company Nelson Street Well
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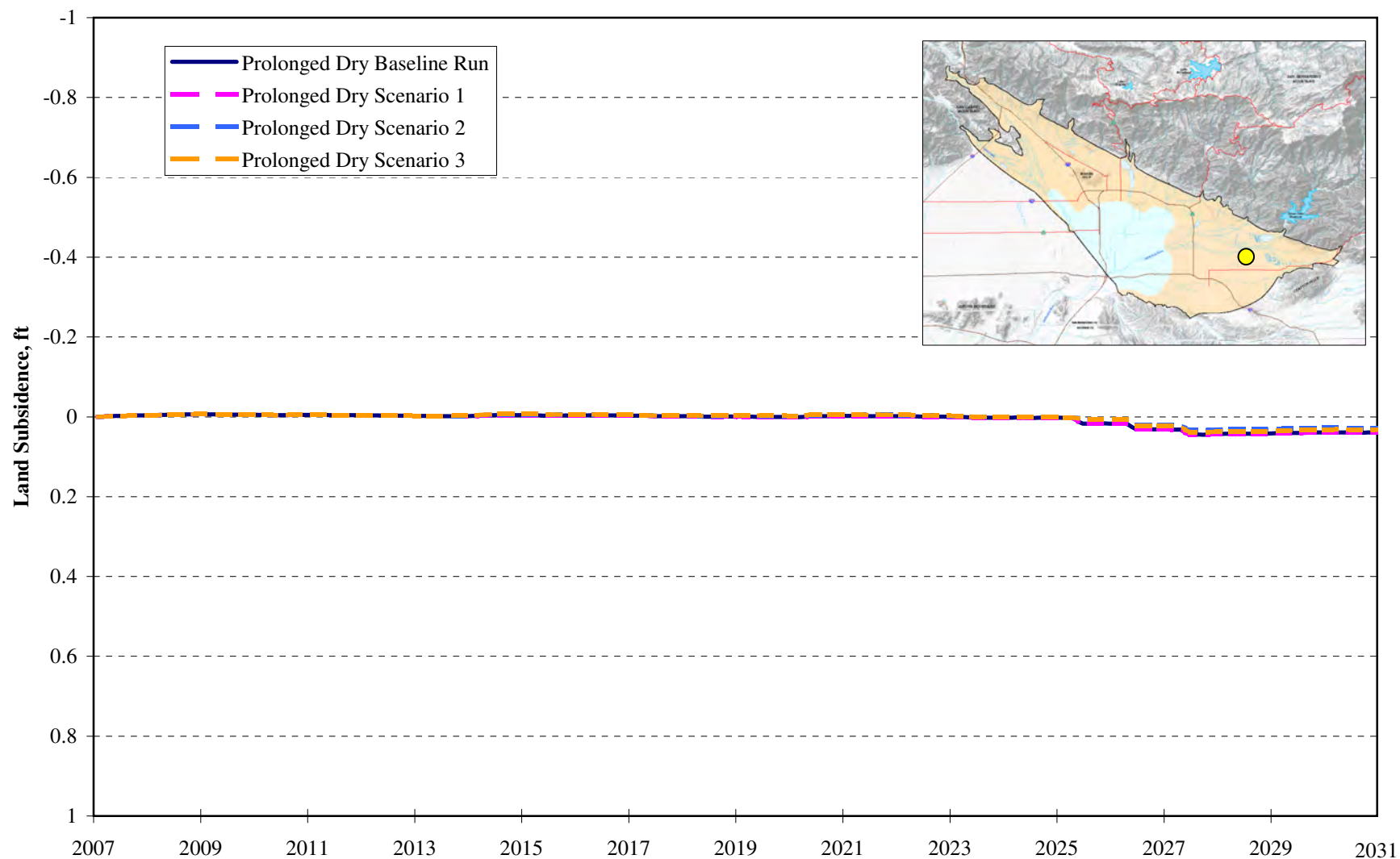


Land Subsidence at Gage Canal Company Lower Kelly Well Model Runs 2007-2030



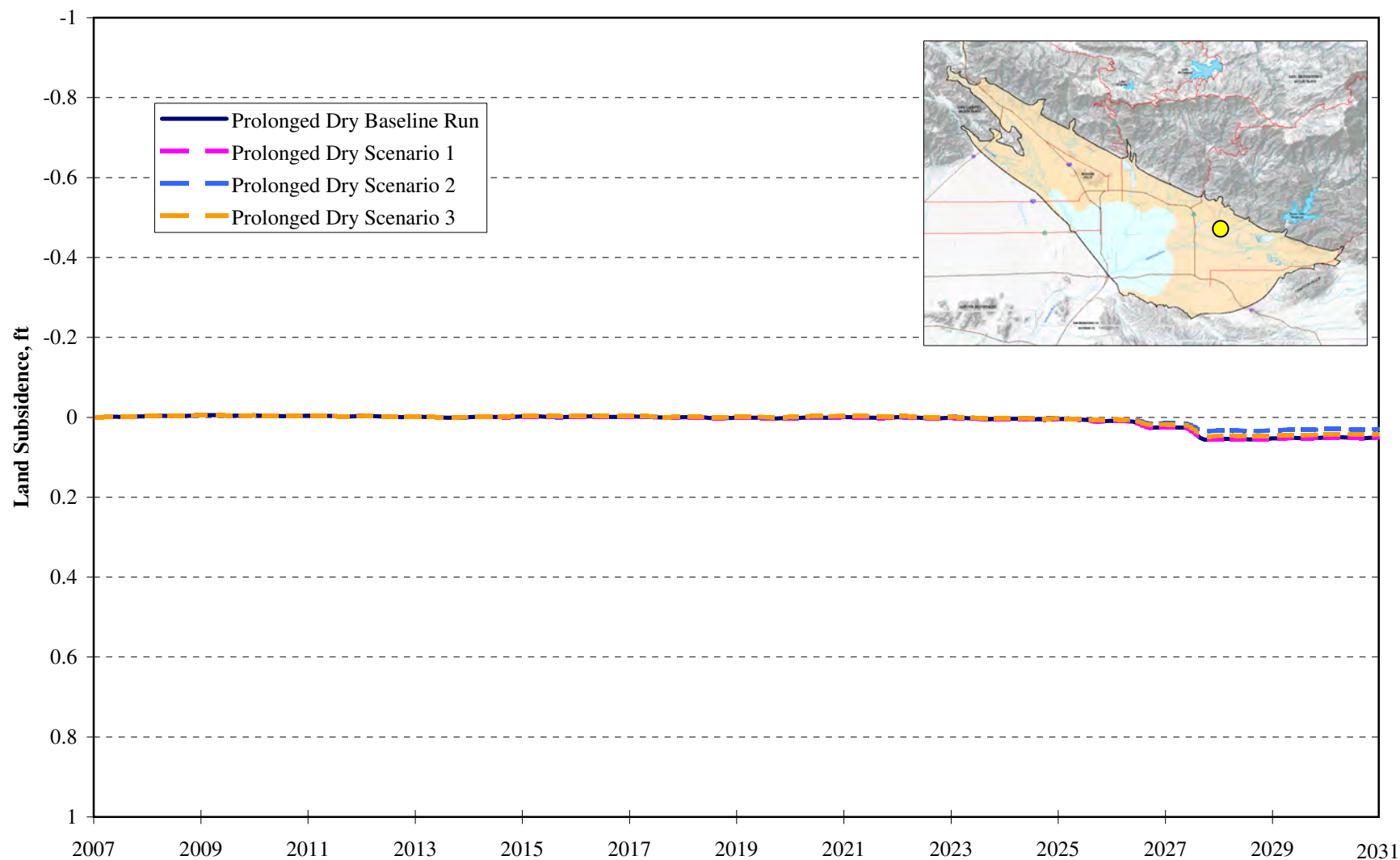
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Land Subsidence at City of Redlands Airport Well No. 2 Model Runs 2007-2030

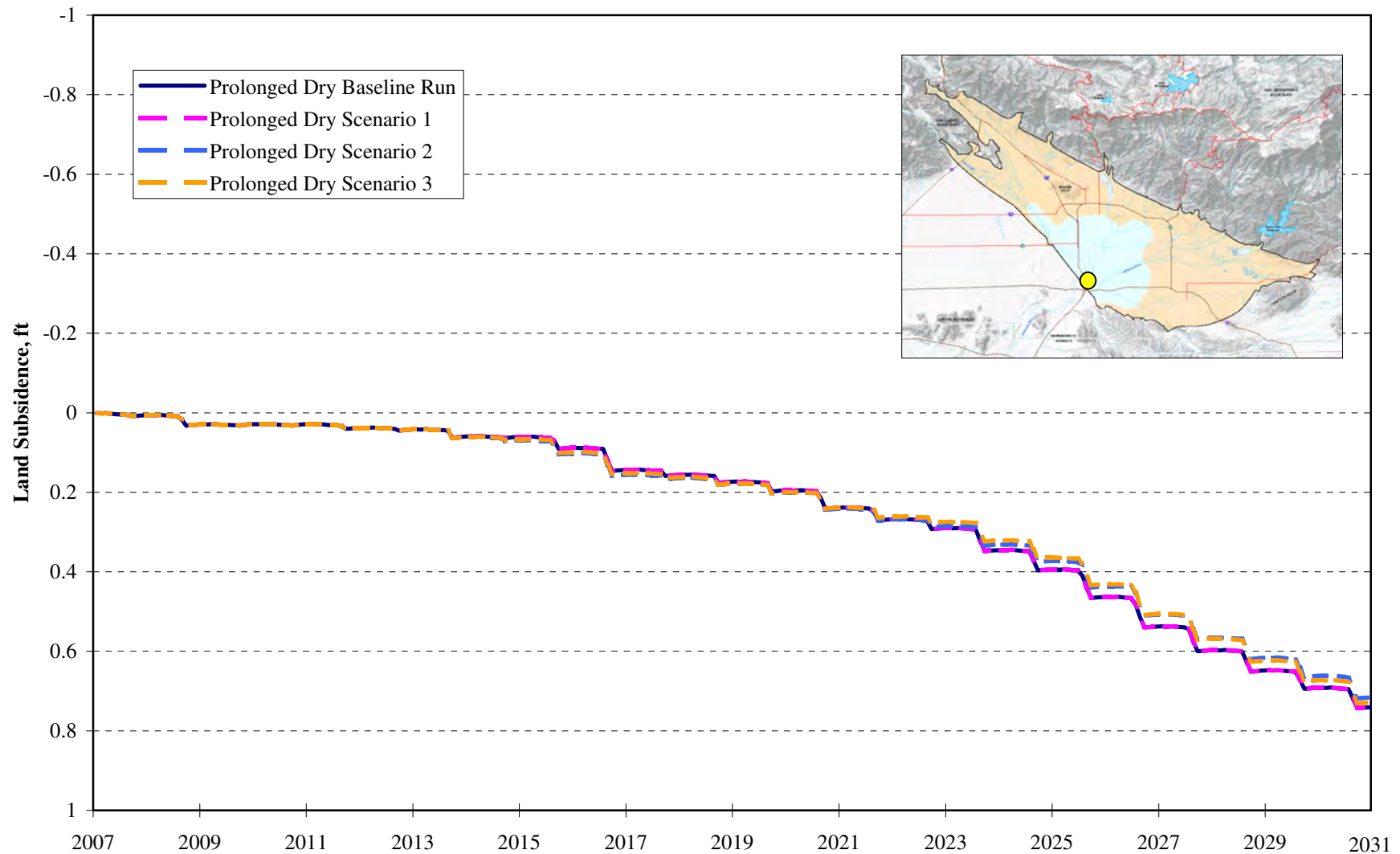


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Land Subsidence at East Valley Water District Well 146A Model Runs 2007-2030



Land Subsidence at SBVMWD Backyard Well Model Runs 2007-2030



Appendix C

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS

**RIVERSIDE CORONA FEEDER PROJECT
CONJUNCTIVE USE SCENARIOS**

PREPARED FOR:

**WESTERN MUNICIPAL
WATER DISTRICT**

MARCH 12, 2010



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**GROUNDWATER MODELING OF
TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT
CONJUNCTIVE USE SCENARIOS**

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**GROUNDWATER MODELING OF
TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT
CONJUNCTIVE USE SCENARIOS**

1.0 EXECUTIVE SUMMARY

Western is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and to meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County. Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), to store that water in the SBBA when it is available, and to extract water from the basin when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

In order to address the comments to the Notice of Preparation for the RCF Realignment Supplemental Environmental Impact Report made by the City of San Bernardino Municipal Water District (SBMWD) and the City of Colton, groundwater modeling was performed in order to assess potential groundwater impacts due to the RCF including impacts to the Western

Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods were addressed. Results of the model predictive runs were summarized in the report entitled “Groundwater Modeling of Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated October 23, 2009.

The purpose of this groundwater modeling was to evaluate potential impact of the RCF conjunctive use scenarios on the total dissolved solids (TDS) and nitrate-nitrogen concentrations in the SBBA. The groundwater management zones in the SBBA include Bunker Hill-A, Bunker Hill-B, and Lytle. The scope of the work included:

- Compare the projected TDS and Nitrate-Nitrogen concentrations of each management zones for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions;
- Compare the projected TDS and Nitrate-Nitrogen concentrations in selected wells for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions;
- Compare the projected TDS and Nitrate-Nitrogen concentrations of the underflow outflow to the Rialto and Colton Management Zones for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions; and
- Prepare a report summarizing the modeling results.

The Refined Basin Solute Transport Model (RBSTM) was used to evaluate water quality changes for Baseline Run (No Project) and RCF conjunctive use scenarios.

A total of four predictive model runs was made using the RBSTM to assess the potential impacts

of the RCF on TDS and nitrate-nitrogen concentrations. These model runs are:

- Baseline Run (No Project)
- RCF Scenario 1
- RCF Scenario 2
- RCF Scenario 3

The RCF Scenarios includes two “bookend” scenarios (Scenarios 1 and 3) and one “most likely” scenario (Scenario 2). “Bookend” conditions are generally described as conditions that result from artificial recharge and groundwater pumping schedules that are likely to cause the most environmentally stressful conditions (Scenario 3) and conditions that are the least stressful (Scenario 1) than those encountered under the “most likely” scenario. Results from the RCF Scenarios were compared to the Baseline Run (No Project).

The sources for TDS and nitrate-nitrogen input concentrations were specified according to the flow input source defined in the flow model. A summary of the source, type, and the TDS and nitrate-nitrogen concentrations used is shown in the following table:

Summary of Source Concentrations
Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones

Flow Source	MODFLOW Package	Concentration Used
Direct Infiltration from Precipitation	Recharge	Same as precipitation concentrations plus an urban increment of 250 mg/L for TDS for the urban area and adjusted by a factor of 4 for concentrating effect
Recharge from Local Runoff Generated by Precipitation	Recharge	
Artificial Recharge	Recharge	Flow-weighted average of recharge water source concentrations (SAR water, SWP water and recycled water) and adjusted by a factor of 1.05 to account for evaporation effect
Return Flow from Non-Plaintiff Groundwater Pumping	Recharge	Same as Ambient Concentrations and adjusted by a factor of 3.33 for irrigation efficiency effect
Recharge from Ungaged Mountain Front Runoff	Well	Same as Ambient Concentrations
Return Flow from Plaintiff Groundwater Pumping (Export)	Recharge	Same as Ambient Concentrations
Underflow Recharge	Well	Same as Ambient Concentrations
Gaged Streamflow	Streamflow Routing	Gaged streamflow and flow-weighted average

Based on results of the modeling, the following conclusions have been made regarding predicted TDS and nitrate-nitrogen concentrations and underflow outflow for the RCF Conjunctive Use scenarios:

- Model predicted TDS concentrations in Year 2032 under Baseline Run (No Project) conditions would be 463 milligrams per liter (mg/L), 346 mg/L and 274 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted TDS concentration would be the same or decrease by 1 to 2 mg/L under the RCF Scenarios in the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones.

- The difference between the average TDS concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios was calculated for 26 selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/City of Riverside Agreement). For RCF Scenario 1, the changes in TDS concentration from the Baseline Run (No Project) range from a decline of 5 mg/L to a rise of 2 mg/L. TDS concentration changes range from a decline of 19 mg/L to a rise of 7 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 24 mg/L to a rise of 9 mg/L. In general, the wells with an increase in TDS concentration are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., SBVMWD Backyard Well and City of Riverside Raub 1 Well). Wells with decreases in TDS concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.
- Model predicted nitrate-nitrogen concentrations in year 2032 under Baseline Run (No Project) conditions would be 4.9 mg/L, 5.2 mg/L and 2.8 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted nitrate-nitrogen concentrations would be the same or increase by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-A Management Zone. The model predicted nitrate-nitrogen concentrations would be the same or decrease by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-B Management Zone. The model predicted nitrate-nitrogen concentrations would be the same under the RCF Scenarios in the Lytle Management Zone.
- The difference between the average nitrate-nitrogen concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios was calculated for 26 selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/City of Riverside Agreement). For RCF Scenario 1, the changes in nitrate-nitrogen concentrations from the Baseline Run (No Project) range from a decline of 0.2 mg/L to a rise of 0.1 mg/L. Concentration changes range from a decline of

0.4 mg/L to a rise of 0.2 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 0.5 mg/L to a rise of 0.2 mg/L. The well with greatest increase in nitrate-nitrogen concentrations is the City of Riverside Raub 1 Well, which is located downgradient of the proposed RCF wellfield. Wells with decreases in nitrate-nitrogen concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.

- The predicted average TDS concentration of underflow outflow across the San Jacinto Fault near the SAR to the Colton Management Zone during the 26 year predictive period would be 319 mg/L to 698 mg/L with an average of 520 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 12,398 tons. The predicted TDS concentrations of the underflow for the RCF Scenarios would be approximately the same with an average ranging from 519 mg/L to 522 mg/L. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 12,106 tons to 12,317 tons.
- The predicted average TDS concentration of underflow outflow from the Lytle Management Zone across Barrier E to the Rialto Management Zone during the 26 year predictive period would be 186 mg/L to 222 mg/L with an average of 201 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 14,066 tons. The predicted TDS concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).
- The predicted average nitrate-nitrogen concentration of underflow outflow across the San Jacinto Fault near the SAR to the Colton Management Zone during the 26 year predictive period would be 5.0 mg/L to 9.7 mg/L with an average of 7.4 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 177 tons. The predicted nitrate-nitrogen concentrations of the underflow for the RCF Scenarios

would be the same. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 172 tons to 175 tons due to slightly less underflow outflow.

- The predicted average nitrate-nitrogen concentrations of underflow outflow from the Lytle Management Zone across Barrier E to the Rialto Management Zone during the 26 year predictive period would be 2.6 mg/L to 2.7 mg/L with an average of 2.7 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 187 tons. The predicted nitrate-nitrogen concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).

The SBBA RBFM and RBSTM are useful tools for evaluating water levels and water quality of the aquifer systems. However, it is a simplified approximation of a complex hydrogeologic system. The accuracy of model predictions is dependent on the assumptions used for the model prediction. More conservative mass loading assumptions were used for modeling of the TDS and nitrate-nitrogen, including:

- Local runoff generated from precipitation from urban areas may have an increase in TDS of 250 mg/L,
- Salt concentration due to evaporation should be considered, and
- Return flows should have higher concentrations of TDS and nitrate-nitrogen than ambient concentrations due to salt concentration through evapotranspiration.

These conservative mass-loading assumptions may not represent actual conditions due to the fact that these mass loading assumptions have not been calibrated to historical conditions. The model simulations were not expected to predict the future TDS and nitrate-nitrogen concentrations with a high degree of accuracy. Rather, they were intended to allow relative comparisons between the Baseline Run (No Project) and RCF conjunctive use scenarios.

2.0 INTRODUCTION

2.1 Background

Western is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and to meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County (see Figure 1). Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells as shown in Figure 2. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), to store that water in the SBBA when it is available, and to extract water from the basin when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

The RCF is supported by, and fully consistent with, MWD's Integrated Resource Plan, the Santa Ana Watershed Project Authority's Integrated Watershed Plan, and the regional water planning efforts for the cities of Riverside, Norco, and Corona, Elsinore Valley Municipal Water District, Jurupa Community Services District, Home Gardens County Water District, Lee Lake Water District, and the March Air Reserve Base.

In order to address the comments to the Notice of Preparation for the RCF Realignment Supplemental Environmental Impact Report made by the City of San Bernardino Municipal

Water District (SBMWD) (2008) and the City of Colton (2008), groundwater modeling was performed in order to assess potential groundwater impacts due to the RCF including impacts to the Western Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods were addressed. Results of the model predictive runs were summarized in the report entitled “Groundwater Modeling of Riverside-Corona Feeder Project Conjunctive Use Scenarios” dated October 23, 2009 (GEOSCIENCE, 2009a).

2.2 Purpose and Scope

The purpose of this groundwater modeling was to evaluate potential impact of the RCF conjunctive use scenarios on the total dissolved solids (TDS) and nitrate-nitrogen concentrations in the SBBA. The groundwater management zones in the SBBA include Bunker Hill-A, Bunker Hill-B, and Lytle (see Figure 3). The scope of the work included:

- Compare the projected TDS and Nitrate-Nitrogen concentrations of each management zones for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions;
- Compare the projected TDS and Nitrate-Nitrogen concentrations in selected wells for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions;
- Compare the projected TDS and Nitrate-Nitrogen concentrations of the underflow outflow to the Rialto and Colton Management Zones for the RCF conjunctive use scenarios to the projected concentrations under Baseline Run (No Project) conditions; and
- Prepare a report summarizing the modeling results.

2.3 Sources of Data

Data used for this study was obtained from multiple sources. The primary sources and the types of data provided by them are summarized as follows:

- Metropolitan Water District of Southern California: Electronic files of historical TDS and nitrate-nitrogen concentrations of SWP water for Silverwood Lake at Devil Canyon;
- United States Geological Survey (USGS): Electronic file of streamflow and water quality data for gaging stations in the study area; and
- Wildermuth Environmental, Inc. (WEI): Electronic files of current ambient TDS and nitrate-nitrogen concentrations for management zones.

A complete list of references is included in Section 6.0 of this report.

3.0 GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS

Groundwater flow models have been used in the SBBA over the past two decades. The latest refinement process was a cooperative technical effort involving representatives of SBMWD and Valley District, their respective consultants at Stantec Consulting (Stantec) and GEOSCIENCE, and Mr. Wes Danskin of the USGS. The cooperative effort was initiated to avoid the development of two different models and to develop one model that would be compatible and defensible. The USGS Basin Flow Model was collaboratively refined by Stantec and GEOSCIENCE and is known as the Newmark Groundwater Flow Model/Refined Basin Flow Model (NGFM/RBFM) (GEOSCIENCE, 2006; GEOSCIENCE, 2007; GEOSCIENCE, 2009b; and Stantec, 2008).

A water quality component was added to the RBFM by GEOSCIENCE for Valley District under USEPA Grant X-97957701-0 (GEOSCIENCE, 2009b) using computer code MT3DMS (Zheng and Wang, 1999). The Refined Basin Solute Transport Model (RBSTM) was calibrated against the observed PCE and TCE data for the period 1986 through 2000. The model relative error¹ is 7.7% and 3.4% for PCE and TCE concentrations, respectively. It is common modeling practice to consider a relative error of less than 10% to be a good fit. Therefore, these results are considered reasonable.

RBSTM was used to evaluate water quality changes for Baseline Run (No Project) and RCF conjunctive use scenarios.

3.1 Description of Predictive Model Scenarios

A total of four predictive model runs was made using the RBSTM to assess the potential impacts

¹ Relative error is the standard deviation of the PCE and TCE concentration residuals divided by the range of measured concentrations. A residual is the difference between a measured concentration and a model-generated concentration.

of the RCF on TDS and nitrate-nitrogen concentrations. These model runs are:

- Baseline Run (No Project)
- RCF Scenario 1
- RCF Scenario 2
- RCF Scenario 3

The RCF Scenarios includes two “bookend” scenarios (Scenarios 1 and 3) and one “most likely” scenario (Scenario 2). “Bookend” conditions are generally described as conditions that result from artificial recharge and groundwater pumping schedules that are likely to cause the most environmentally stressful conditions (Scenario 3) and conditions that are the least stressful (Scenario 1) than those encountered under the “most likely” scenario. Results from the RCF Scenarios were compared to the Baseline Run (No Project). Modeling assumptions for these model scenarios can be found in the Section 4 of the groundwater modeling report prepared by GEOSCIENCE (2009a).

3.2 Source and Sink Concentrations

The sources for TDS and nitrate-nitrogen input concentrations were specified according to the flow input source defined in the flow model. The sources of flow for the model are described in Section 4 of the groundwater modeling report prepared by GEOSCIENCE (2009a), and a summary of the source, type, and the TDS and nitrate-nitrogen concentrations used is shown in the following table.

Summary of Source Concentrations
Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones

Flow Source	MODFLOW Package	Concentration Used
Direct Infiltration from Precipitation	Recharge	Same as precipitation concentrations plus an urban increment of 250 mg/L for TDS for the urban area and adjusted by a factor of 4 for concentrating effect
Recharge from Local Runoff Generated by Precipitation	Recharge	
Artificial Recharge	Recharge	Flow-weighted average of recharge water source concentrations (SAR water, SWP water and recycled water) and adjusted by a factor of 1.05 to account for evaporation effect
Return Flow from Non-Plaintiff Groundwater Pumping	Recharge	Same as Ambient Concentrations and adjusted by a factor of 3.33 for irrigation efficiency effect
Recharge from Ungaged Mountain Front Runoff	Well	Same as Ambient Concentrations
Return Flow from Plaintiff Groundwater Pumping (Export)	Recharge	Same as Ambient Concentrations
Underflow Recharge	Well	Same as Ambient Concentrations
Gaged Streamflow	Streamflow Routing	Gaged streamflow and flow-weighted average

The TDS concentration for direct recharge from precipitation and recharge from local runoff generated by precipitation was assumed to be 650 milligrams per liter (mg/L). This is the weighted average for urban and non-urban areas. For urban areas, the TDS concentration was assumed to be 25 mg/L (precipitation's concentration; Dastane, 1978) plus an urban increment of 250 mg/L (Wildermuth, 1999 and California Regional Water Quality Control Board, 2004) and then adjusted by a factor of four for concentrating effects (Wildermuth, 1999). For non-urban areas, the TDS concentration was assumed to be 25 mg/L and then adjusted by a factor of four for concentrating effects. The nitrate-nitrogen concentration for direct recharge from precipitation and recharge from local runoff generated by precipitation was assumed to be 2 mg/L. This was based on a concentration of 0.5 mg/L for the precipitation (Miller et al., 2000)

and then adjusted by a factor of four for concentrating effects.

The concentrations for artificial recharge was calculated as the weighted average concentrations of SAR water, SWP water and recycled water and then adjusted by a factor of 1.05 to account for the assumed 5% evaporation. The measured TDS concentration for SAR water is summarized in Table 1. The 50% exceedance probability of the TDS and nitrate-nitrogen concentrations for SWP water were used for the solute transport model simulations. As shown in Figure 4, a TDS of 255 mg/L represents a 50% exceedance probability of TDS concentrations from Silverwood Lake at Devil Canyon (the source of SWP water used for artificial recharge in the SBBA). In other words, 50% of the time, the TDS concentration of SWP water is equal to or will exceed 255 mg/L. For nitrate-nitrogen, the 50% exceedance probability is 0.65 mg/L (see Figure 5). The TDS and nitrate-nitrogen concentrations for recycled water were assumed to be 100 mg/L and 2 mg/L, respectively (WMI, 2008).

The TDS and nitrate-nitrogen concentrations for return flow were assumed to be the ambient concentrations and then adjusted by a factor of 3.33 for irrigation efficiency effect (Wildermuth, 1999). The adjustment factor is the reciprocal of the one minus irrigation efficiency. For example, the ambient TDS concentration of the Bunker Hill-A Management Zone is 330 mg/L and the irrigation efficiency is 70%, the concentration of return flow is calculated as 1,099 mg/L ($1,099 = 330 \times 1 / (1-0.7)$).

Figure 6 shows the ambient TDS and nitrate-nitrogen concentrations for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones. Measured TDS and nitrate-nitrogen concentrations at streamflow gaging stations are shown on Figures 7 and 8, respectively. Table 2 shows the TDS and nitrate-nitrogen concentrations used for each segment of the Streamflow-Routing package based on measured data and flow-weighted averages. TDS and nitrate-nitrogen concentrations assumed for the recharge from mountain front runoff are illustrated on Figure 9. TDS and nitrate-nitrogen concentrations assumed for recharge from underflow are presented in Figure 10.

The concentrations for the outflow terms including groundwater pumping, evapotranspiration and underflow were based on concentrations in the aquifer systems.

3.3 Initial Model TDS and Nitrate-Nitrogen Concentrations

Initial concentrations for TDS and nitrate-nitrogen were based on the 1987-2006 ambient concentrations calculated by Wildermuth Environmental, Inc. (2008) (see Figure 6).

3.4 Model Results

3.4.1 TDS Concentrations of the SBBA

The model predicted TDS concentrations at the end of model simulation (i.e., 2032) for the Baseline Run (No Project) and RCF conjunctive use scenarios 1 through 3 are shown on Figures 11 through 14. The average TDS concentrations, in year 2032, for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones for each model scenario are summarized on Figure 15. As shown on Figure 15, model predicted TDS concentrations in year 2032 under Baseline Run (No Project) conditions would be 463 mg/L, 346 mg/L and 274 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted TDS concentrations would be the same or decrease by 1 to 2 mg/L under the RCF Scenarios in the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones. The following table summarizes model predicted TDS concentrations in year 2032 for each model run.

Comparisons of Model Predicted TDS Concentrations in Year 2032
Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones

	TDS Concentrations, mg/L			
	Baseline Run (No Project)	RCF Scenario 1	RCF Scenario 2	RCF Scenario 3
Bunker Hill-A	463	463	461	462
Bunker Hill-B	346	346	345	346
Lytle	274	274	274	274

TDS concentrations over time in selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/City of Riverside Agreement) for the Baseline Run (No Project) and the RCF Scenarios 1 through 3 are provided in Appendix A. The approximate locations of these wells are shown as insets on the charts in Appendix A. These charts show the temporal variations in TDS concentrations reflecting the hydrologic conditions, artificial recharge, and groundwater pumping assumed for the Baseline Run (No Project) and the RCF Scenarios.

For each of the selected wells in Appendix A, the average simulated TDS concentrations and the difference between the average TDS concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios are summarized in Table 3. As shown, for RCF Scenario 1, the changes in TDS concentration from the Baseline Run (No Project) range from a decline of 5 mg/L to a rise of 2 mg/L. TDS concentration changes range from a decline of 19 mg/L to a rise of 7 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 24 mg/L to a rise of 9 mg/L. In general, the wells with an increase in TDS concentration are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., SBVMWD Backyard Well and City of Riverside Raub 1 Well). Wells with decreases in TDS concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.

3.4.2 Nitrate-Nitrogen Concentrations of the SBBA

The model predicted nitrate-nitrogen concentrations at the end of model simulation (i.e., 2032) for the Baseline Run (No Project) and RCF conjunctive use scenarios 1 through 3 are shown on Figures 16 through 19. The average nitrate-nitrogen concentrations, in year 2032, for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones for each model scenario are summarized on Figure 20. As shown on Figure 20, model predicted nitrate-nitrogen concentrations in year 2032 under Baseline Run (No Project) conditions would be 4.9 mg/L, 5.2 mg/L and 2.8 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted nitrate-nitrogen concentrations would be the same or increase by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-A Management Zone. The model predicted nitrate-nitrogen concentrations would be the same or decrease by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-B Management Zone. The model predicted nitrate-nitrogen concentrations would be the same under the RCF Scenarios in the Lytle Management Zone. The following table summarizes model predicted nitrate-nitrogen concentrations in year 2032 for each model run.

**Comparisons of Model Predicted Nitrate-Nitrogen Concentrations in Year 2032
Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones**

	Nitrate-Nitrogen Concentrations, mg/L			
	Baseline Run (No Project)	RCF Scenario 1	RCF Scenario 2	RCF Scenario 3
Bunker Hill-A	4.9	5.0	4.9	4.9
Bunker Hill-B	5.2	5.2	5.2	5.1
Lytle	2.8	2.8	2.8	2.8

Nitrate-nitrogen concentrations over time in selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/Riverside Agreement) for the Baseline Run (No Project) and the RCF Scenarios 1 through 3 are also provided (see Appendix B). The approximate locations of these wells are shown as insets on the

charts in Appendix B. These charts show the temporal variations in nitrate-nitrogen concentrations reflecting the hydrologic conditions, artificial recharge, and groundwater pumping assumed for the Baseline Run (No Project) and the RCF Scenarios.

For each of the selected wells in Appendix B, the average simulated nitrate-nitrogen concentration and the difference between the average nitrate-nitrogen concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios are summarized in Table 4. As shown, for RCF Scenario 1, the changes in nitrate-nitrogen concentrations from the Baseline Run (No Project) range from a decline of 0.2 mg/L to a rise of 0.1 mg/L. Concentration changes range from a decline of 0.4 mg/L to a rise of 0.2 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 0.5 mg/L to a rise of 0.2 mg/L. The well with greatest increase in nitrate-nitrogen concentrations is the City of Riverside Raub 1 Well, which is located downgradient of the proposed RCF wellfield. Wells with decreases in nitrate-nitrogen concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.

3.4.3 TDS Concentrations of Underflow Outflow

Groundwater underflow flows from the SBBA across the San Jacinto Fault near SAR to the Colton Management Zone. The solute transport model shows the predicted TDS concentrations of the underflow during the 26 years would be 319 mg/L to 698 mg/L with an average of 520 mg/L under Baseline Run (No Project) conditions (see Table 5). The total mass of the underflow outflow would be 12,398 tons for TDS during the 26 year period (see Table 5). The predicted TDS concentrations of the underflow for RCF Scenarios would be approximately the same with an average ranging from 519 mg/L to 522 mg/L. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 12,106 tons to 12,317 tons.

Groundwater underflow also flows from the Lytle Management Zone across the Barrier E to the Rialto Management Zone. The amount of underflow was quantified based on the historical trend used for the model calibration and validation periods from 1945-2006. The solute transport

model shows the predicted TDS concentrations of the underflow during the 26 years would be 186 mg/L to 222 mg/L with an average of 201 mg/L under Baseline Run (No Project) conditions (see Table 6). The total mass of the underflow outflow would be 14,066 tons for TDS during the 26 year period (see Table 6). The predicted TDS concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).

The following table summarizes the average volume and concentration and total mass of the underflow outflow for the 26 year period from 2007-2032:

**Predicted TDS Flow, Concentration, and Total Mass for Underflow Outflow
from Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones
to Rialto and Colton Management Zones (2007-2032)**

Outflow	Baseline Run (No Project)			RCF Scenarios 1 through 3		
	Average Volume [acre-ft/yr]	Average Concentration [mg/L]	Cumulative Total Mass [Tons]	Average Volume [acre-ft/yr]	Average Concentration [mg/L]	Cumulative Total Mass [Tons]
Across San Jacinto Fault near SAR to Colton Management Zone	712	520	12,398	691-707	519 to 522	12,106 to 12,317
Across Barrier E to Rialto Management Zone	1,980	201	14,066	1,980	201	14,066

As shown, these changes in TDS concentrations and total mass of underflow outflow are minimal for the RCF Scenarios as compared to the Baseline Run (No Project).

3.4.4 Nitrate-Nitrogen Concentrations of Underflow Outflow

The solute transport model shows the predicted nitrate-nitrogen concentrations of the underflow from the SBBA across the San Jacinto Fault near SAR to the Colton Management Zone during

the 26 years would be 5.0 mg/L to 9.7 mg/L with an average of 7.4 mg/L under Baseline Run (No Project) conditions (see Table 7). The total mass of the underflow outflow would be 177 tons for nitrate-nitrogen during the 26 year period (see Table 7). The predicted nitrate-nitrogen concentrations of the underflow for RCF Scenarios would be the same. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 172 tons to 175 tons due to slightly less underflow outflow.

The solute transport model shows the predicted nitrate-nitrogen concentrations of the underflow from the Lytle Management Zone across the Barrier E to the Rialto Management Zone during the 26 years would be 2.6 mg/L to 2.7 mg/L with an average of 2.7 mg/L under Baseline Run (No Project) conditions (see Table 8). The total mass of the underflow outflow would be 187 tons for nitrate-nitrogen during the 26 year period (see Table 8). The predicted nitrate-nitrogen concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).

The following table summarizes the average volume and concentration and total mass of the underflow outflow for the 26 year period from 2007-2032:

**Predicted Nitrate-Nitrogen Flow, Concentration, and Total Mass for Underflow Outflow
from Bunker Hill-A, Bunker Hill-B, and Lytle Management Zones
to Rialto and Colton Management Zones (2007-2032)**

Outflow	Baseline Run (No Project)			RCF Scenarios 1 through 3		
	Average Volume [acre-ft/yr]	Average Concentration [mg/L]	Cumulative Total Mass [Tons]	Average Volume [acre-ft/yr]	Average Concentration [mg/L]	Cumulative Total Mass [Tons]
Across San Jacinto Fault near SAR to Colton Management Zone	712	7.4	177	691-707	7.4	172 to 175
Across Barrier E to Rialto Management Zone	1,980	2.7	187	1,980	2.7	187

As shown, these changes in nitrate-nitrogen concentrations and total mass of underflow outflow are minimal for the RCF Scenarios as compared to the Baseline Run (No Project).

4.0 CONCLUSIONS

Based on results of the modeling, the following conclusions have been made regarding predicted TDS and nitrate-nitrogen concentrations and underflow outflow for the RCF Conjunctive Use scenarios:

- Model predicted TDS concentrations in Year 2032 under Baseline Run (No Project) conditions would be 463 mg/L, 346 mg/L and 274 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted TDS concentration would be the same or decrease by 1 to 2 mg/L under the RCF Scenarios in the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones.
- The difference between the average TDS concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios was calculated for 26 selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/City of Riverside Agreement). For RCF Scenario 1, the changes in TDS concentration from the Baseline Run (No Project) range from a decline of 5 mg/L to a rise of 2 mg/L. TDS concentration changes range from a decline of 19 mg/L to a rise of 7 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 24 mg/L to a rise of 9 mg/L. In general, the wells with an increase in TDS concentration are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., SBVMWD Backyard Well and City of Riverside Raub 1 Well). Wells with decreases in TDS concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.
- Model predicted nitrate-nitrogen concentrations in year 2032 under Baseline Run (No Project) conditions would be 4.9 mg/L, 5.2 mg/L and 2.8 mg/L for the Bunker Hill-A, Bunker Hill-B and Lytle Management Zones, respectively. The model predicted nitrate-nitrogen concentrations would be the same or increase by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-A Management Zone. The model predicted nitrate-nitrogen

concentrations would be the same or decrease by 0.1 mg/L under the RCF Scenarios in the Bunker Hill-B Management Zone. The model predicted nitrate-nitrogen concentrations would be the same under the RCF Scenarios in the Lytle Management Zone.

- The difference between the average nitrate-nitrogen concentrations for the Baseline Run (No Project) with respect to the RCF Scenarios was calculated for 26 selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/City of Riverside Agreement). For RCF Scenario 1, the changes in nitrate-nitrogen concentrations from the Baseline Run (No Project) range from a decline of 0.2 mg/L to a rise of 0.1 mg/L. Concentration changes range from a decline of 0.4 mg/L to a rise of 0.2 mg/L for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of 0.5 mg/L to a rise of 0.2 mg/L. The well with greatest increase in nitrate-nitrogen concentrations is the City of Riverside Raub 1 Well, which is located downgradient of the proposed RCF wellfield. Wells with decreases in nitrate-nitrogen concentrations are primarily located in the forebay recharge areas due to artificial recharge from the RCF.
- The predicted average TDS concentration of underflow outflow across the San Jacinto Fault near the SAR to the Colton Management Zone during the 26 year predictive period would be 319 mg/L to 698 mg/L with an average of 520 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 12,398 tons. The predicted TDS concentrations of the underflow for the RCF Scenarios would be approximately the same with an average ranging from 519 mg/L to 522 mg/L. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 12,106 tons to 12,317 tons.
- The predicted average TDS concentration of underflow outflow from the Lytle Management Zone across Barrier E to the Rialto Management Zone during the 26 year

predictive period would be 186 mg/L to 222 mg/L with an average of 201 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 14,066 tons. The predicted TDS concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).

- The predicted average nitrate-nitrogen concentration of underflow outflow across the San Jacinto Fault near the SAR to the Colton Management Zone during the 26 year predictive period would be 5.0 mg/L to 9.7 mg/L with an average of 7.4 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 177 tons. The predicted nitrate-nitrogen concentrations of the underflow for the RCF Scenarios would be the same. The total mass of the underflow would be slightly less for the RCF Scenarios ranging from 172 tons to 175 tons due to slightly less underflow outflow.
- The predicted average nitrate-nitrogen concentrations of underflow outflow from the Lytle Management Zone across Barrier E to the Rialto Management Zone during the 26 year predictive period would be 2.6 mg/L to 2.7 mg/L with an average of 2.7 mg/L under Baseline Run (No Project) conditions. The total mass of the underflow outflow would be 187 tons. The predicted nitrate-nitrogen concentrations and total mass of the underflow for RCF Scenarios would be the same as compared to the Baseline Run (No Project).

5.0 MODEL LIMITATIONS AND UNCERTAINTY

The SBBA RBFM and RBSTM are useful tools for evaluating water levels and water quality of the aquifer systems. However, it is a simplified approximation of a complex hydrogeologic system. The accuracy of model predictions is dependent on the assumptions used for the model prediction. More conservative mass loading assumptions were used for modeling of the TDS and nitrate-nitrogen, including:

- Local runoff generated from precipitation from urban areas may have an increase in TDS of 250 mg/L,
- Salt concentration due to evaporation should be considered, and
- Return flows should have higher concentrations of TDS and nitrate-nitrogen than ambient concentrations due to salt concentration through evapotranspiration.

These conservative mass-loading assumptions may not represent actual conditions due to the fact that these mass loading assumptions have not been calibrated to historical conditions. The model simulations were not expected to predict the future TDS and nitrate-nitrogen concentrations with a high degree of accuracy. Rather, they were intended to allow relative comparisons between the Baseline Run (No Project) and RCF conjunctive use scenarios.

6.0 REFERENCES

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FIGURES

GEOSCIENCE Support Services, Inc.

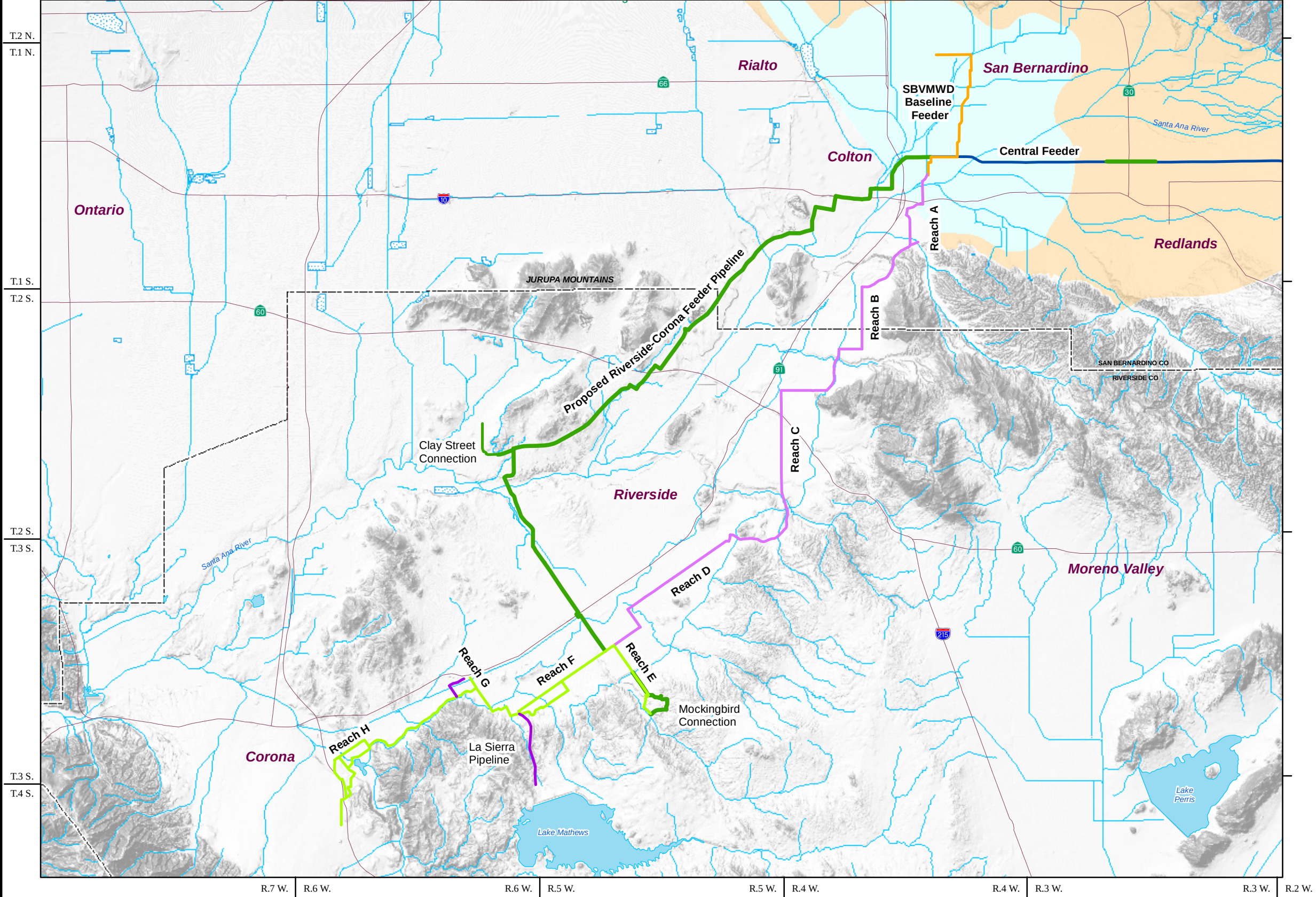


GENERAL
RIVERSIDE-CORONA
FEEDER PROJECT
LOCATION

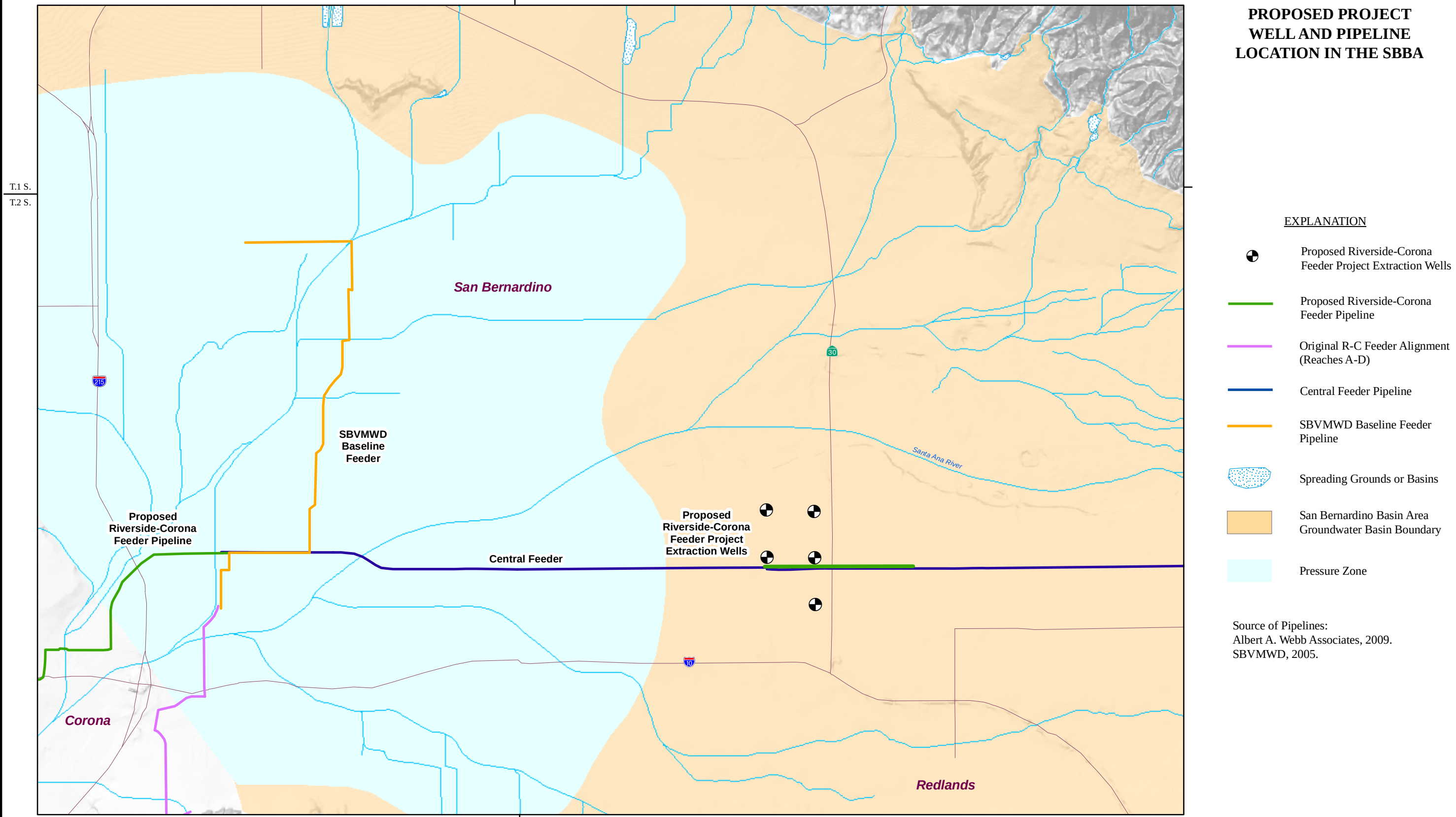
EXPLANATION

- Proposed Riverside-Corona Feeder Realignment
- R-C Feeder Alignment (Reaches E-H)
- Original R-C Feeder Alignment (Reaches A-D)
- Central Feeder Pipeline
- SBVMWD Pipeline
- Riverside-Corona Feeder - La Sierra Pipeline
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary

Source of Pipelines:
Albert A. Webb Associates, 2009.
SBVMWD, 2005.



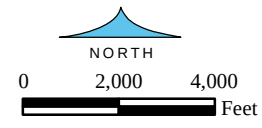
**PROPOSED PROJECT
WELL AND PIPELINE
LOCATION IN THE SBBA**



12-Mar-10

Prepared by: DWB

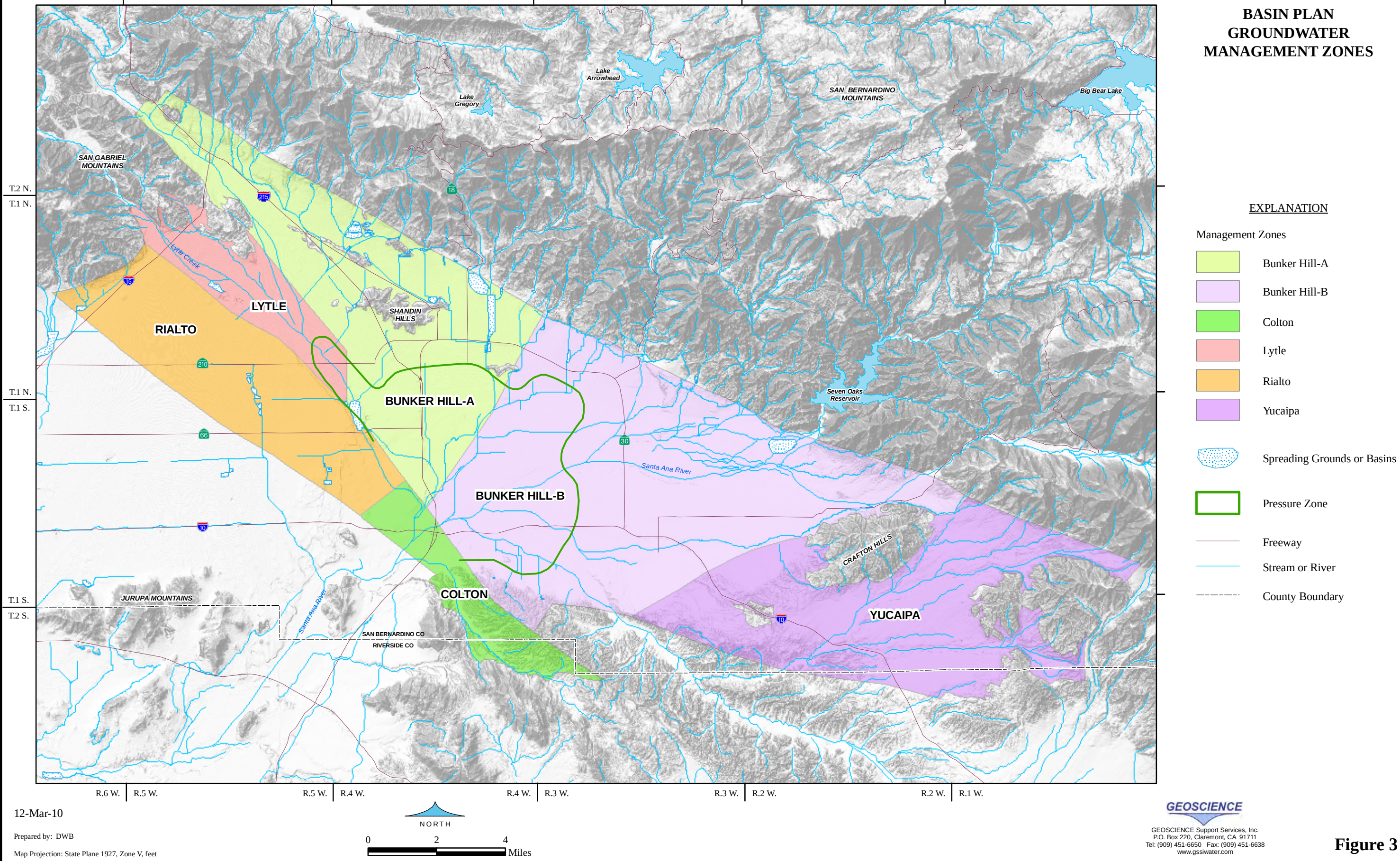
Map Projection: State Plane 1983, Zone V, feet



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Figure 2

BASIN PLAN
GROUNDWATER
MANAGEMENT ZONES



12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1927, Zone V, feet

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Figure 3

SWP Water TDS Concentrations Exceedance Probability Curve

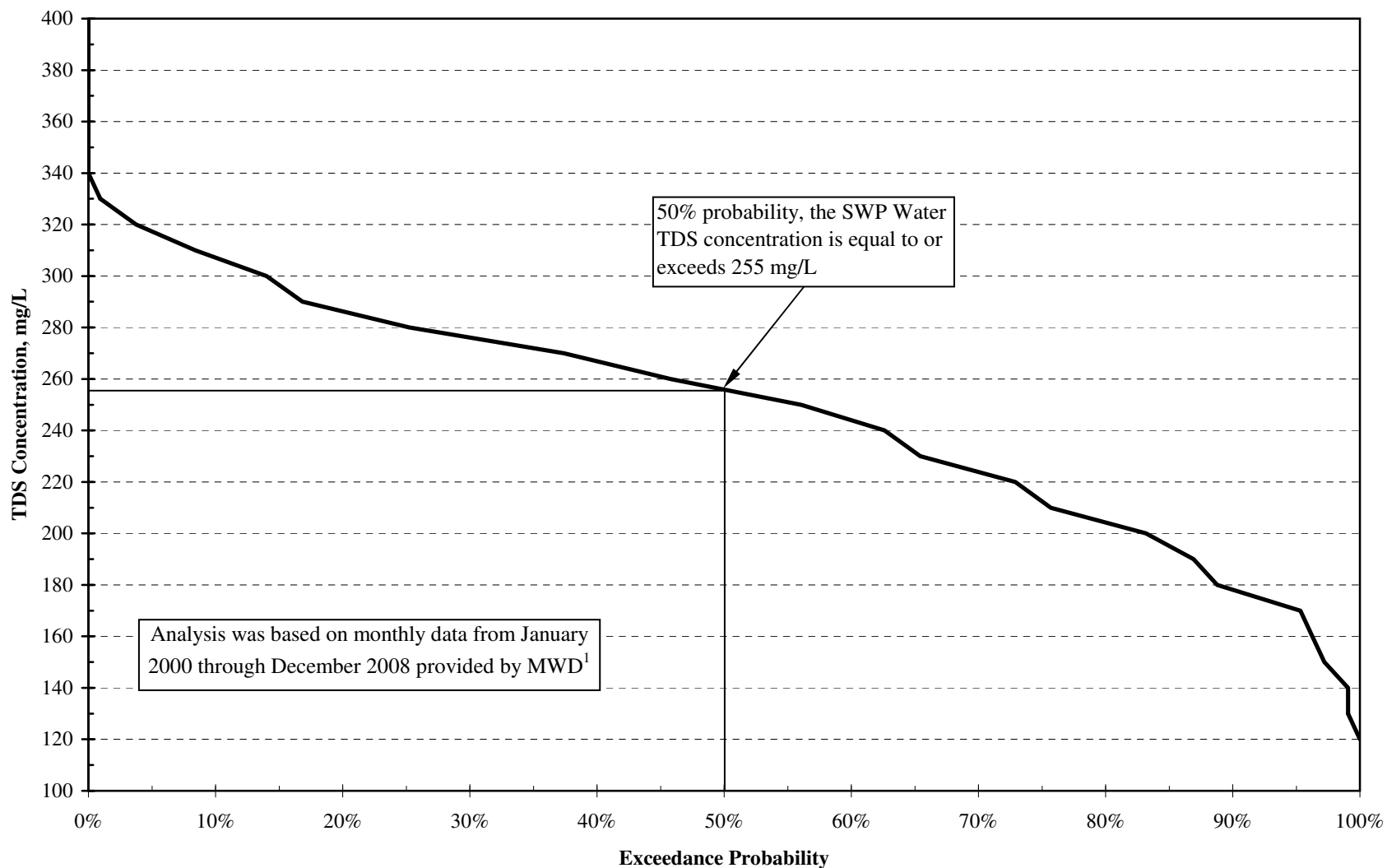


Figure 4

¹Metropolitan Water District of Southern California

SWP Water Nitrate-Nitrogen Concentrations Exceedance Probability Curve

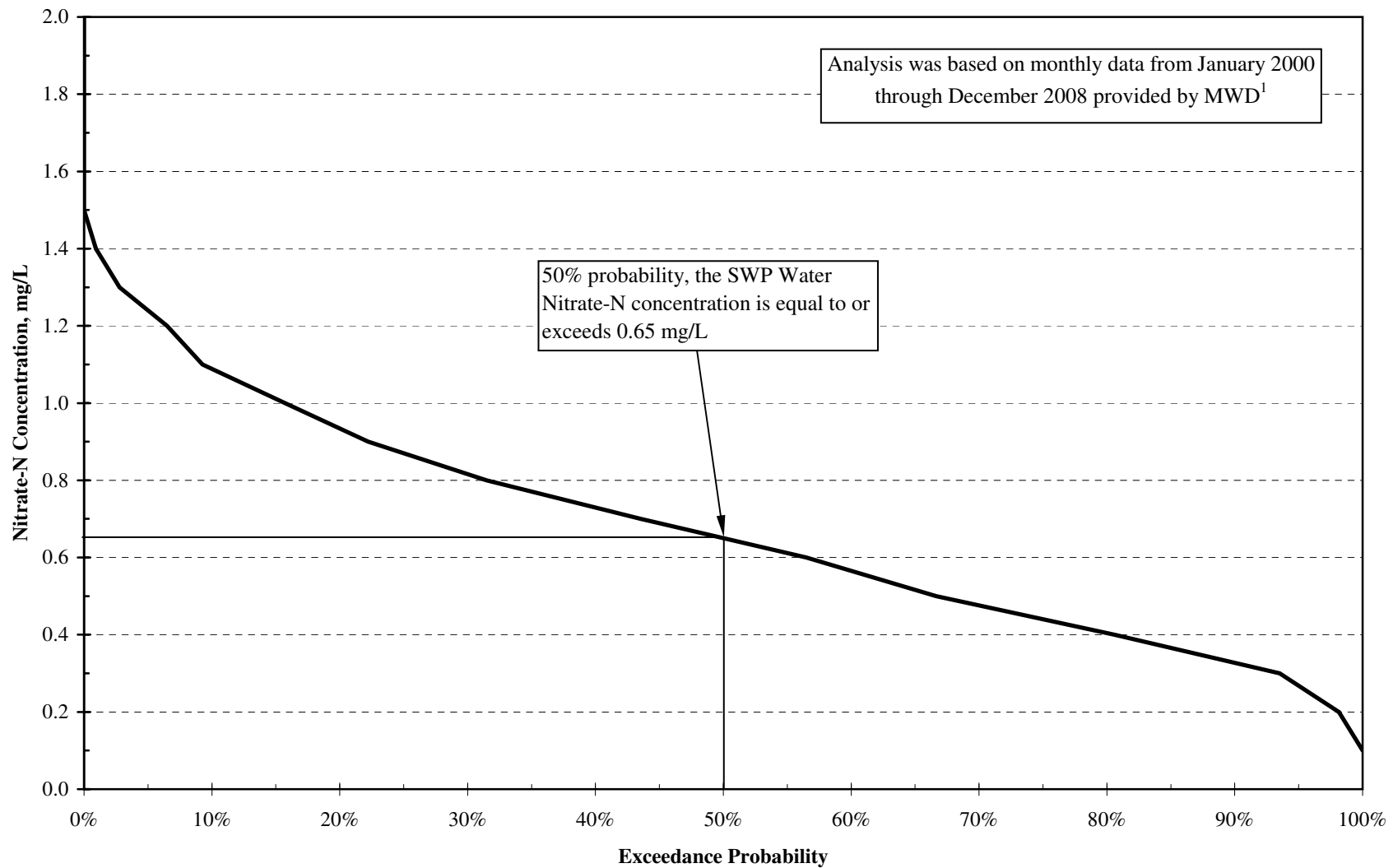


Figure 5

¹Metropolitan Water District of Southern California

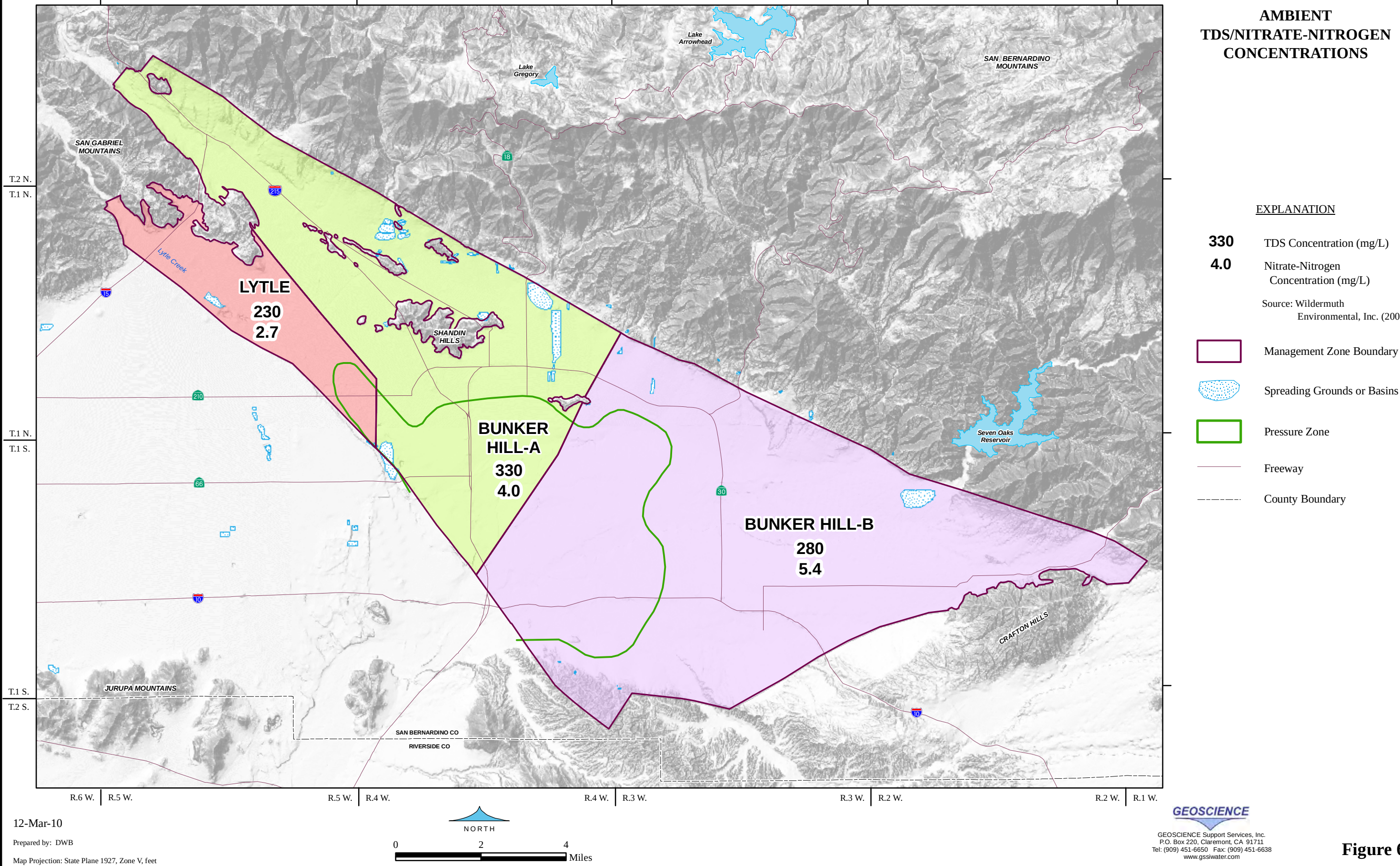
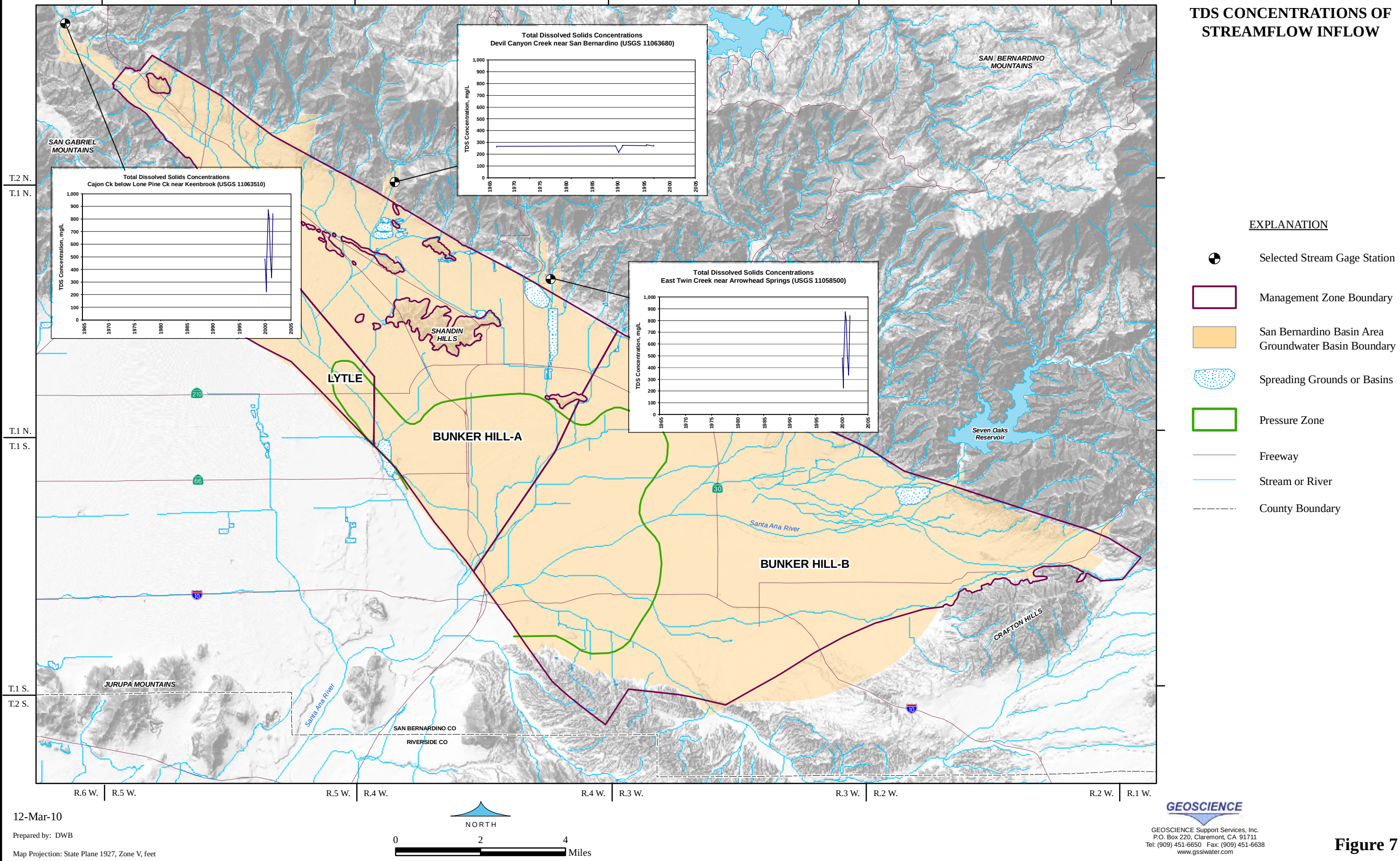
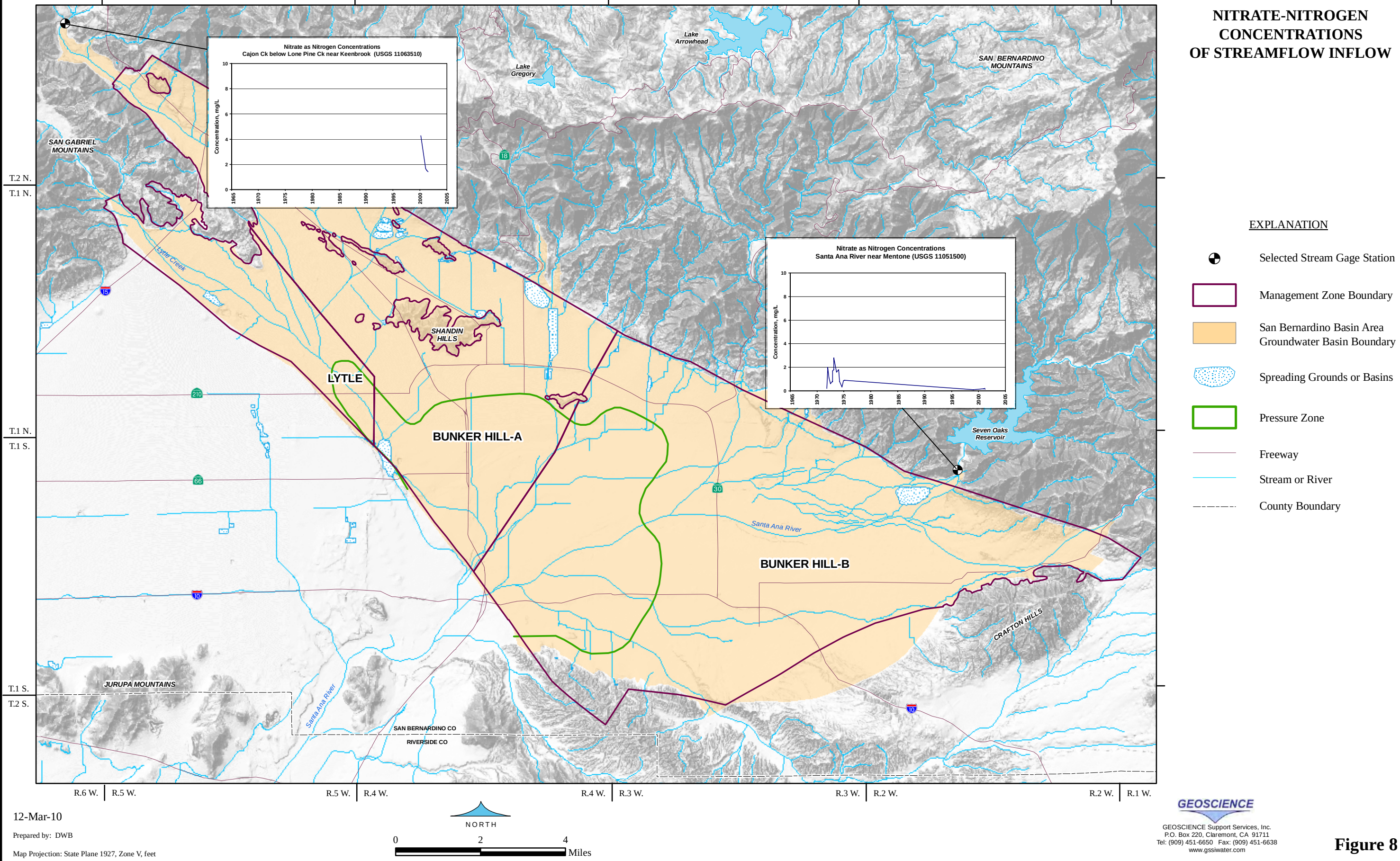


Figure 6

TDS CONCENTRATIONS OF
STREAMFLOW INFLOW



NITRATE-NITROGEN
CONCENTRATIONS
OF STREAMFLOW INFLOW



TDS/NITRATE-NITROGEN
CONCENTRATIONS OF
MOUNTAIN FRONT RUNOFF

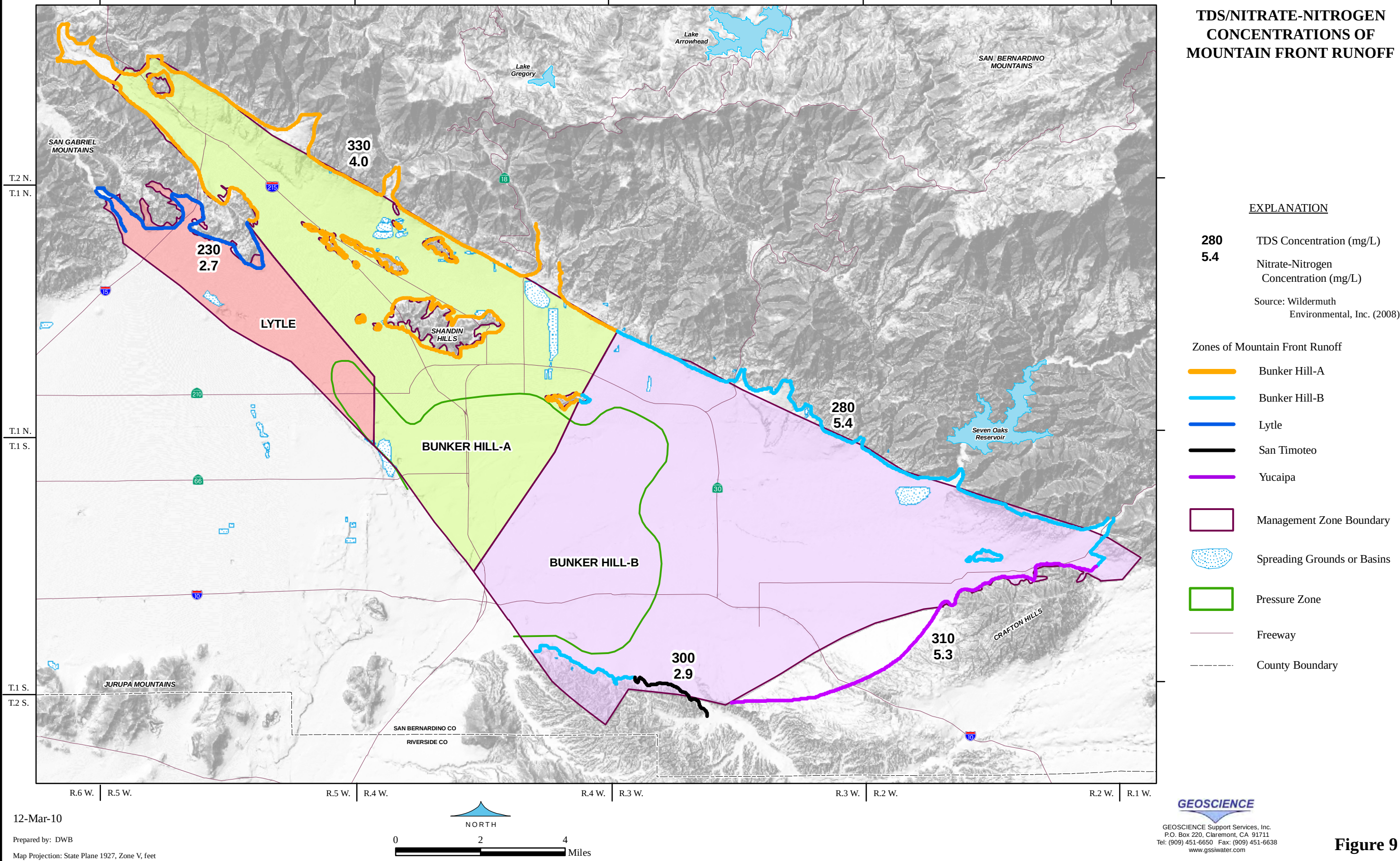
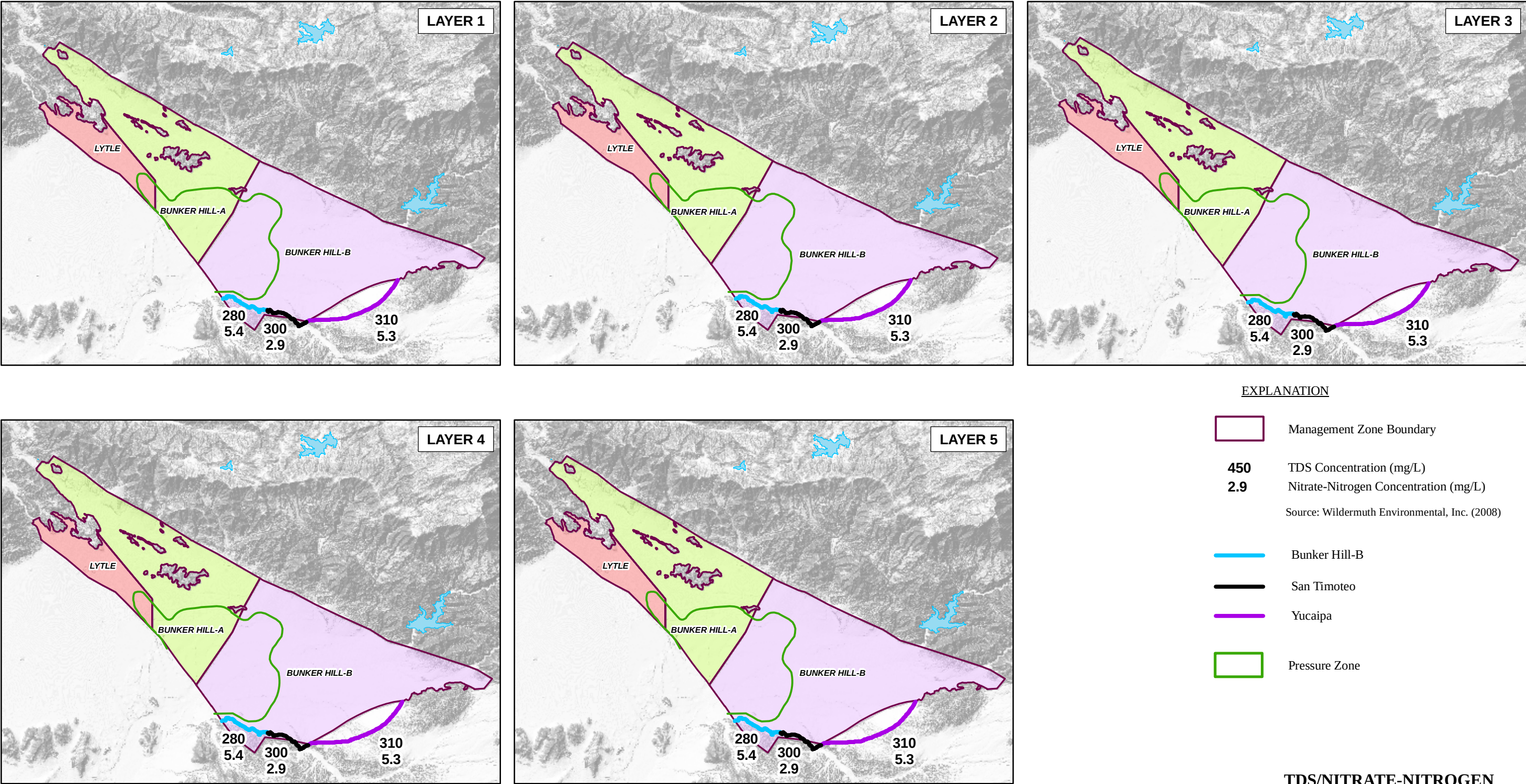


Figure 9



EXPLANATION

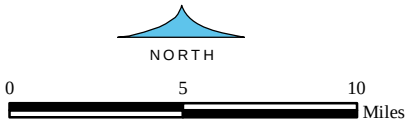
- Management Zone Boundary
- 450 TDS Concentration (mg/L)
- 2.9 Nitrate-Nitrogen Concentration (mg/L)
- Source: Wildermuth Environmental, Inc. (2008)
- Bunker Hill-B
- San Timoteo
- Yucaipa
- Pressure Zone

TDS/NITRATE-NITROGEN
CONCENTRATIONS
OF UNDERFLOW INFLOW

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



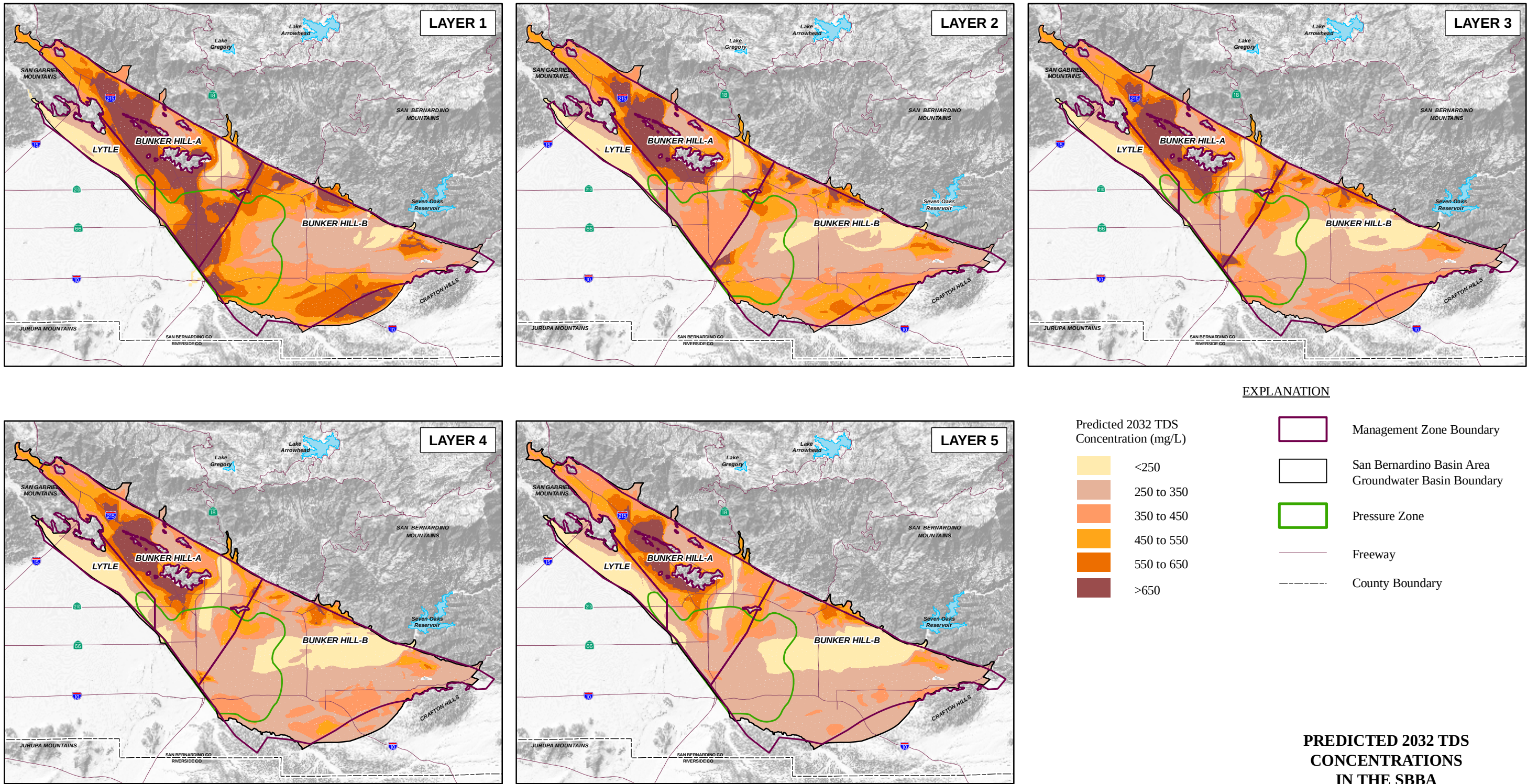
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Figure 10

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



**PREDICTED 2032 TDS
CONCENTRATIONS
IN THE SBBA
BASELINE RUN
(NO PROJECT)**

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



0 5 10
Miles

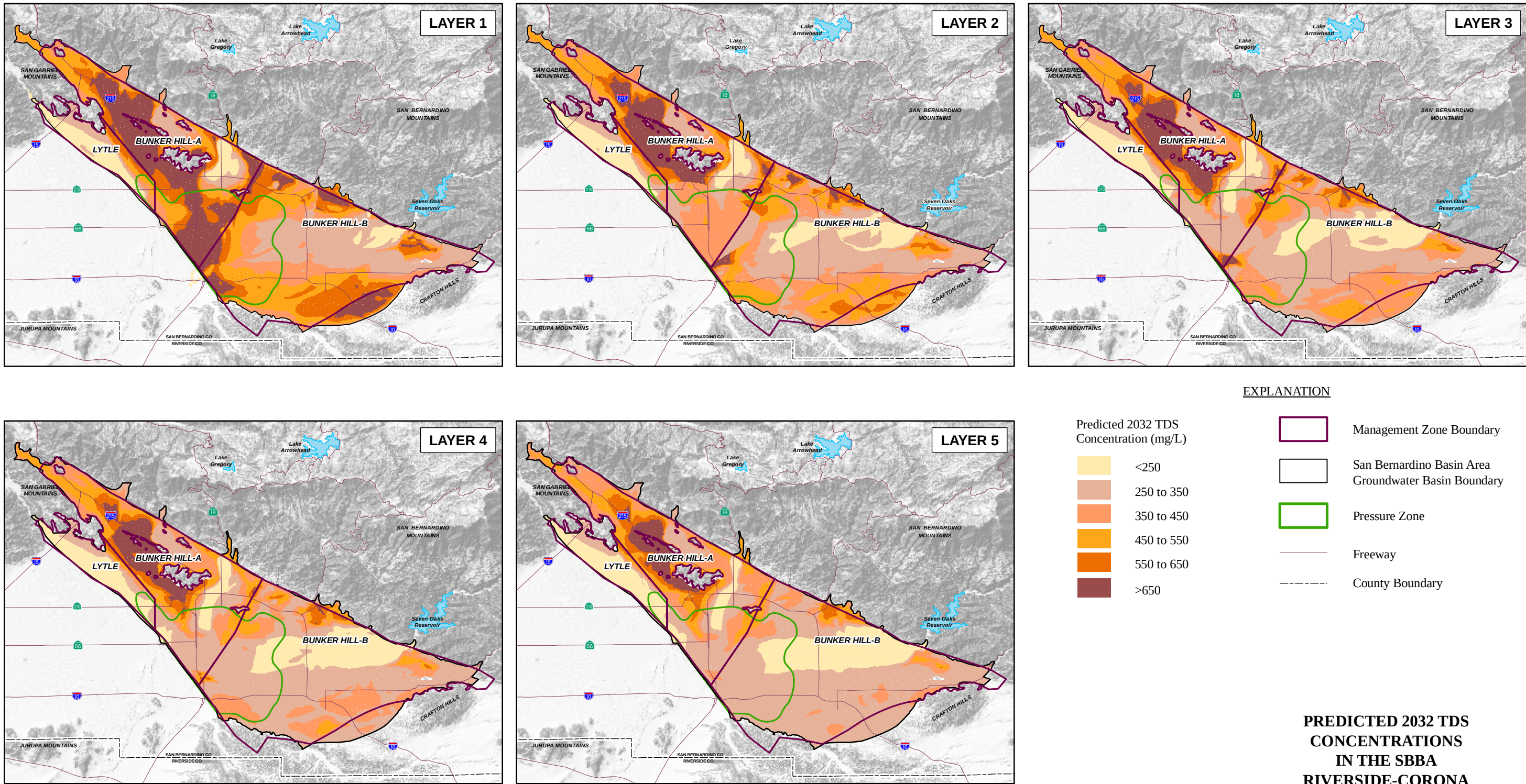
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Figure 11

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



PREDICTED 2032 TDS
CONCENTRATIONS
IN THE SBBA
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



0 5 10
Miles

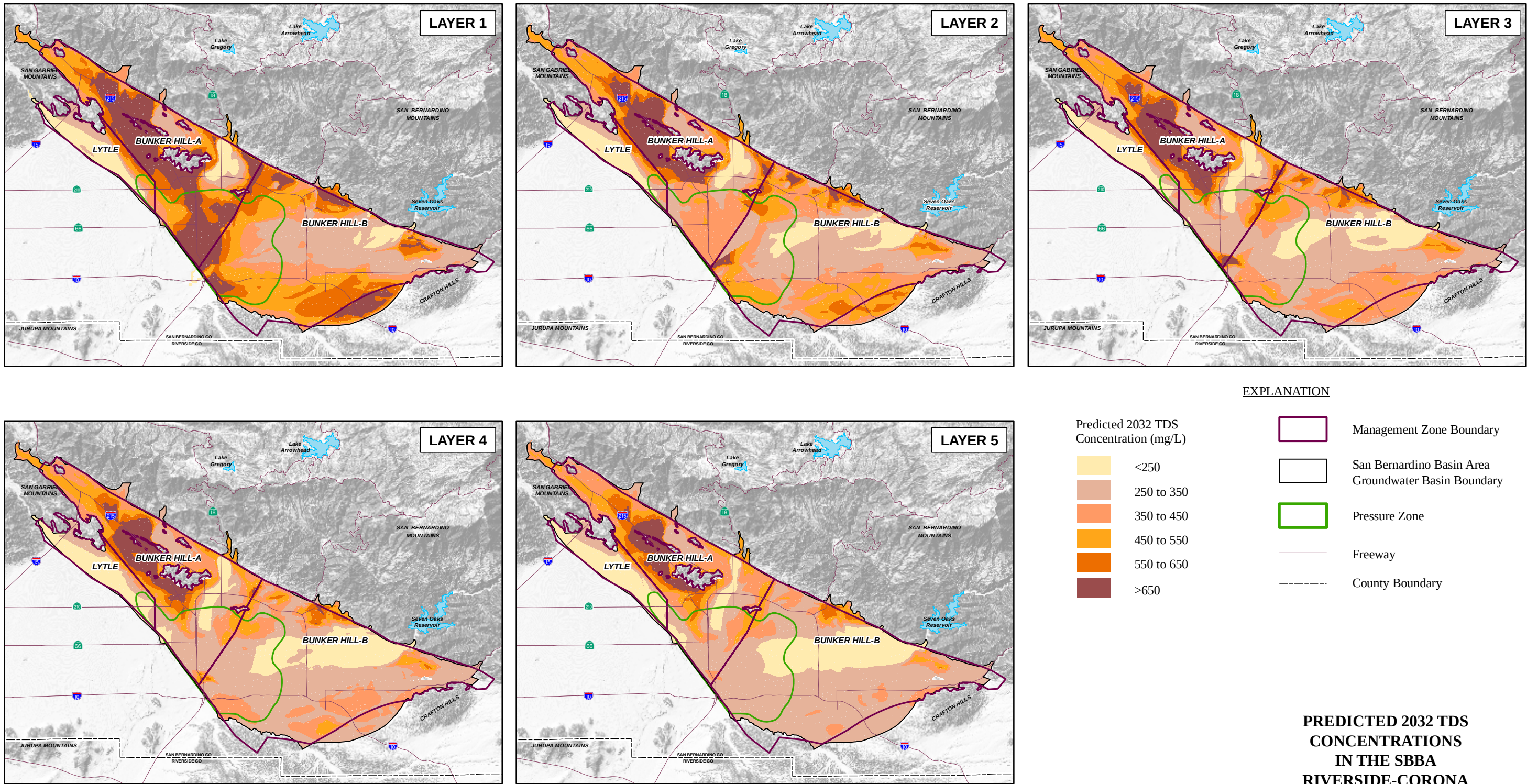
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Figure 12

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



**PREDICTED 2032 TDS
CONCENTRATIONS
IN THE SBBA
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2**

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



0 5 10
Miles

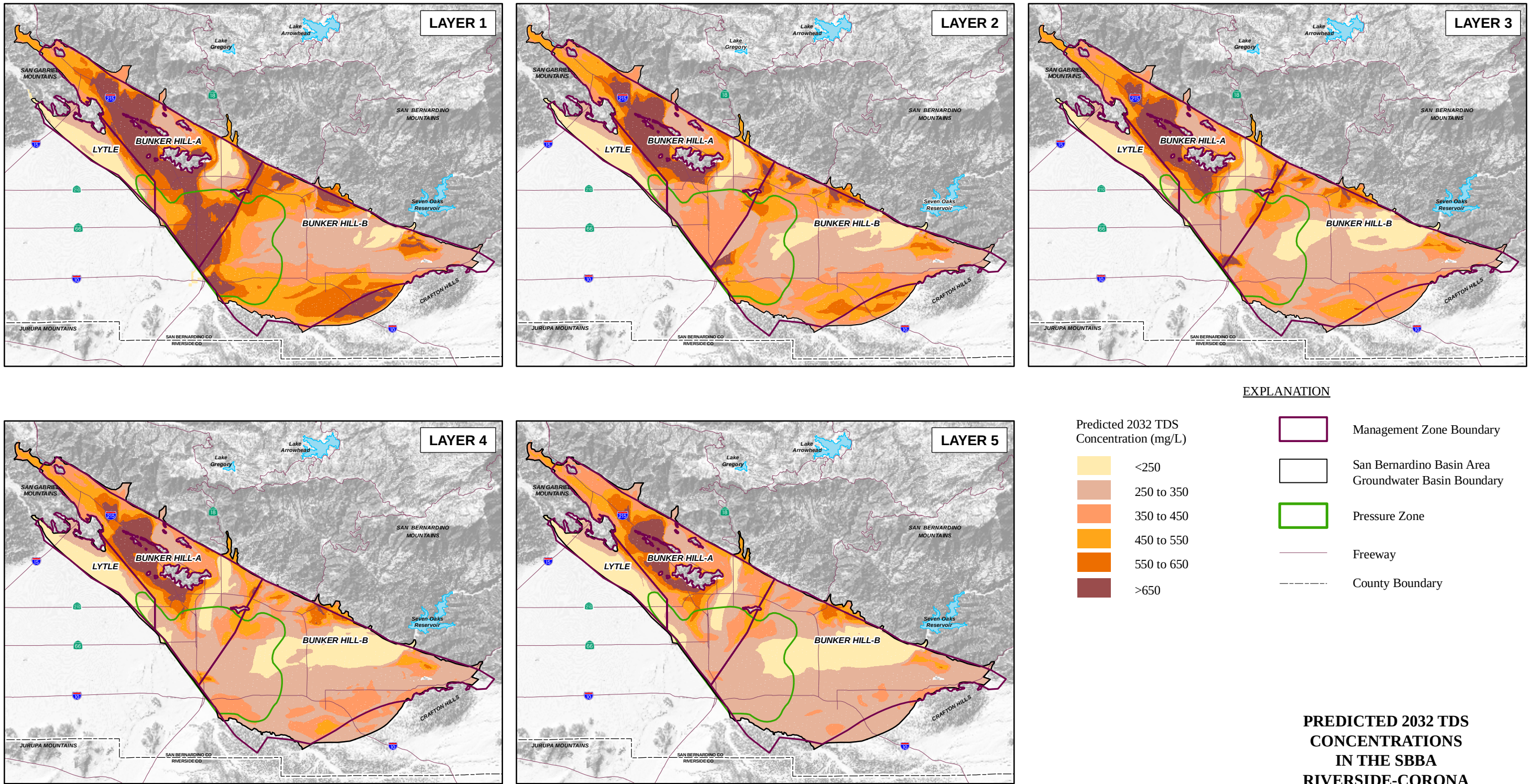
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Figure 13

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

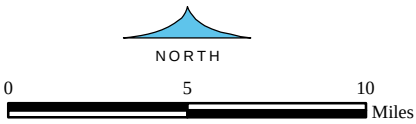


PREDICTED 2032 TDS
CONCENTRATIONS
IN THE SBBA
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



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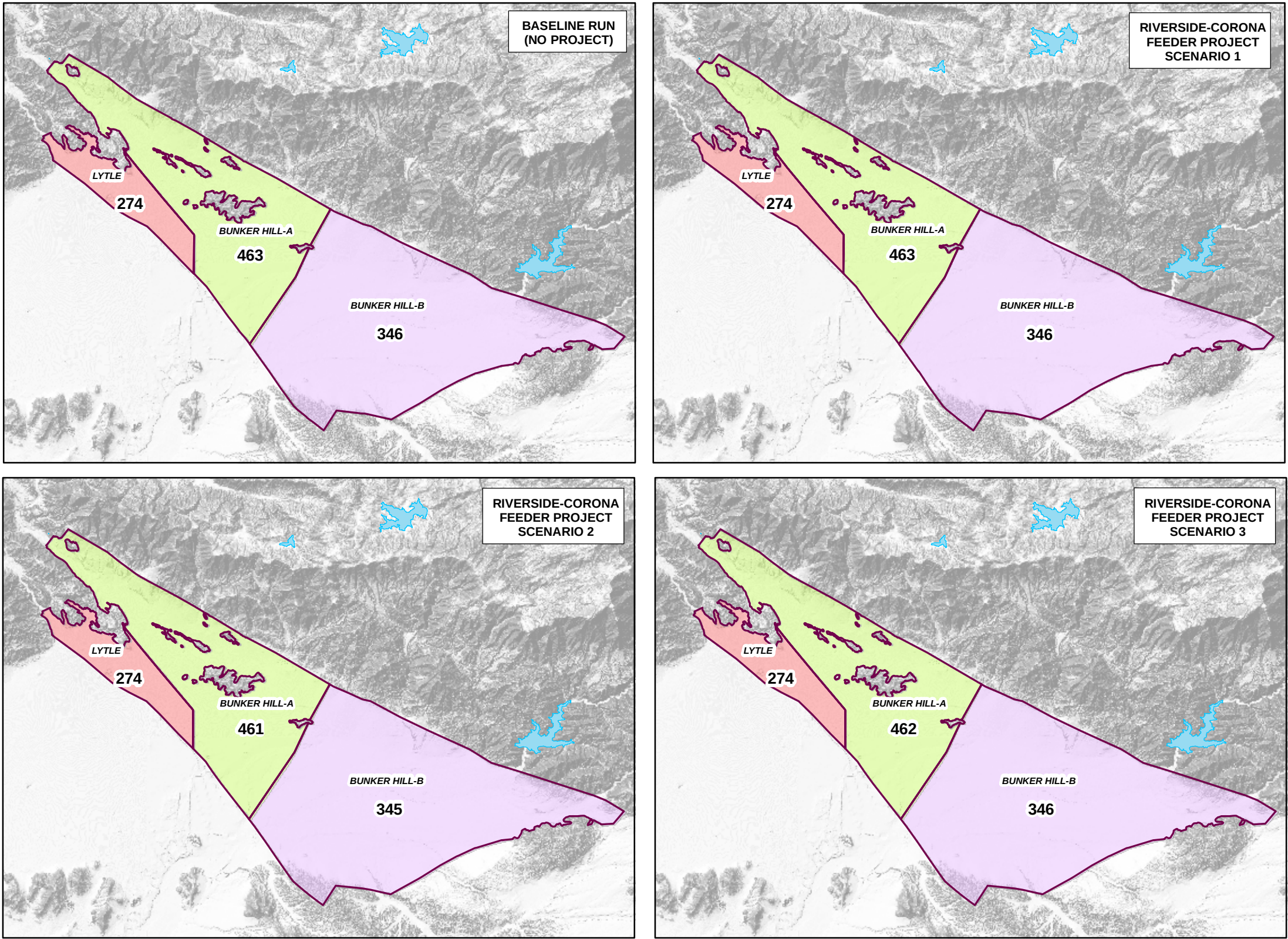
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Figure 14

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

PREDICTED 2032 AVERAGE
TDS CONCENTRATIONS
IN THE BUNKER HILL-A,
BUNKER HILL-B & LYTLE
MANAGEMENT ZONES
BASELINE RUN (NO PROJECT)
AND RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIOS 1 THROUGH 3

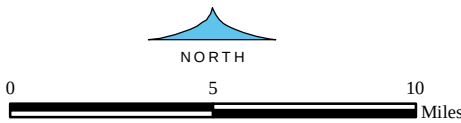


EXPLANATION

274 Predicted 2032 Average TDS Concentration (mg/L)

Management Zones

- Bunker Hill-A
- Bunker Hill-B
- Lytle



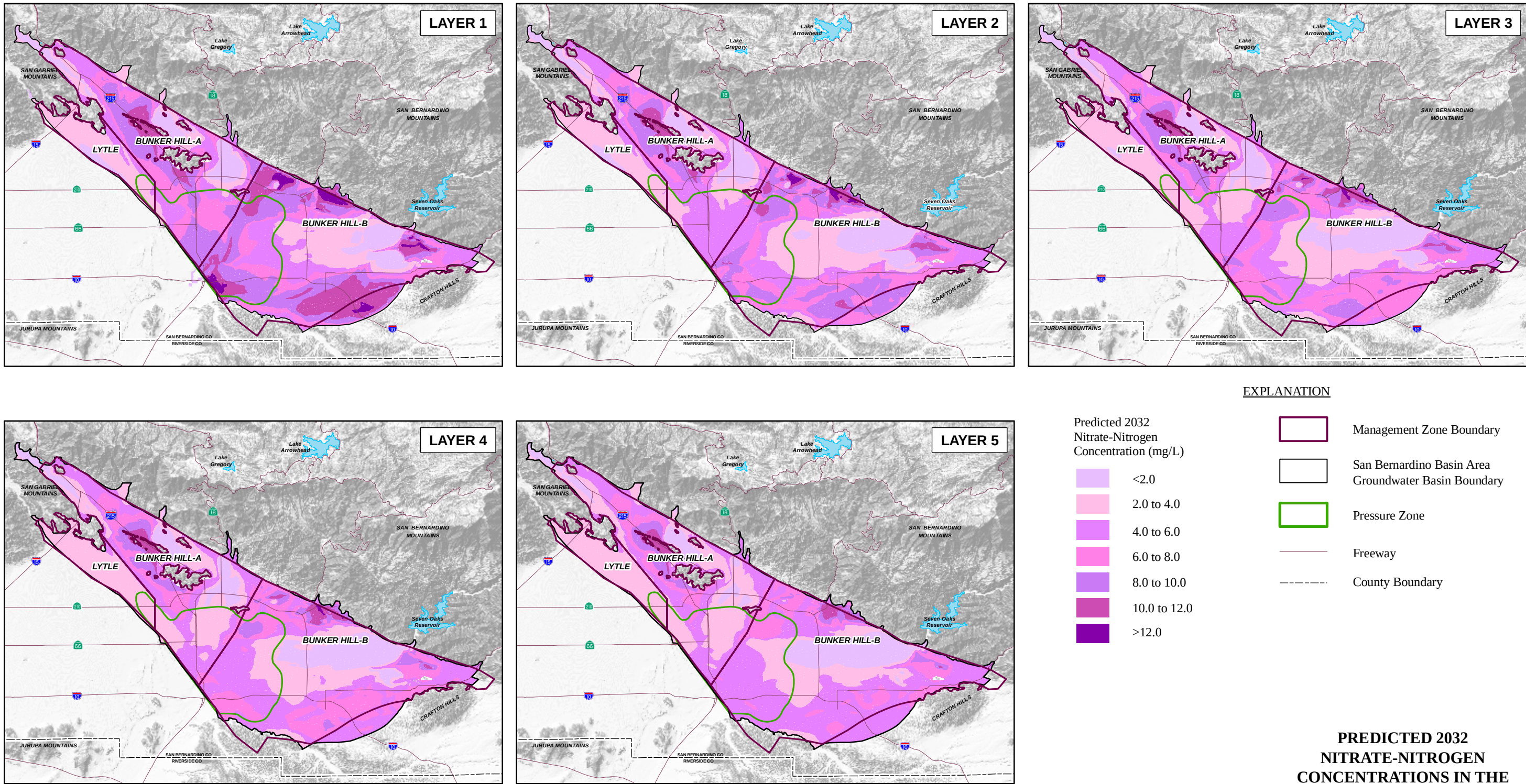
12-Mar-10
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

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Figure 15

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



NORTH

0 5 10 Miles



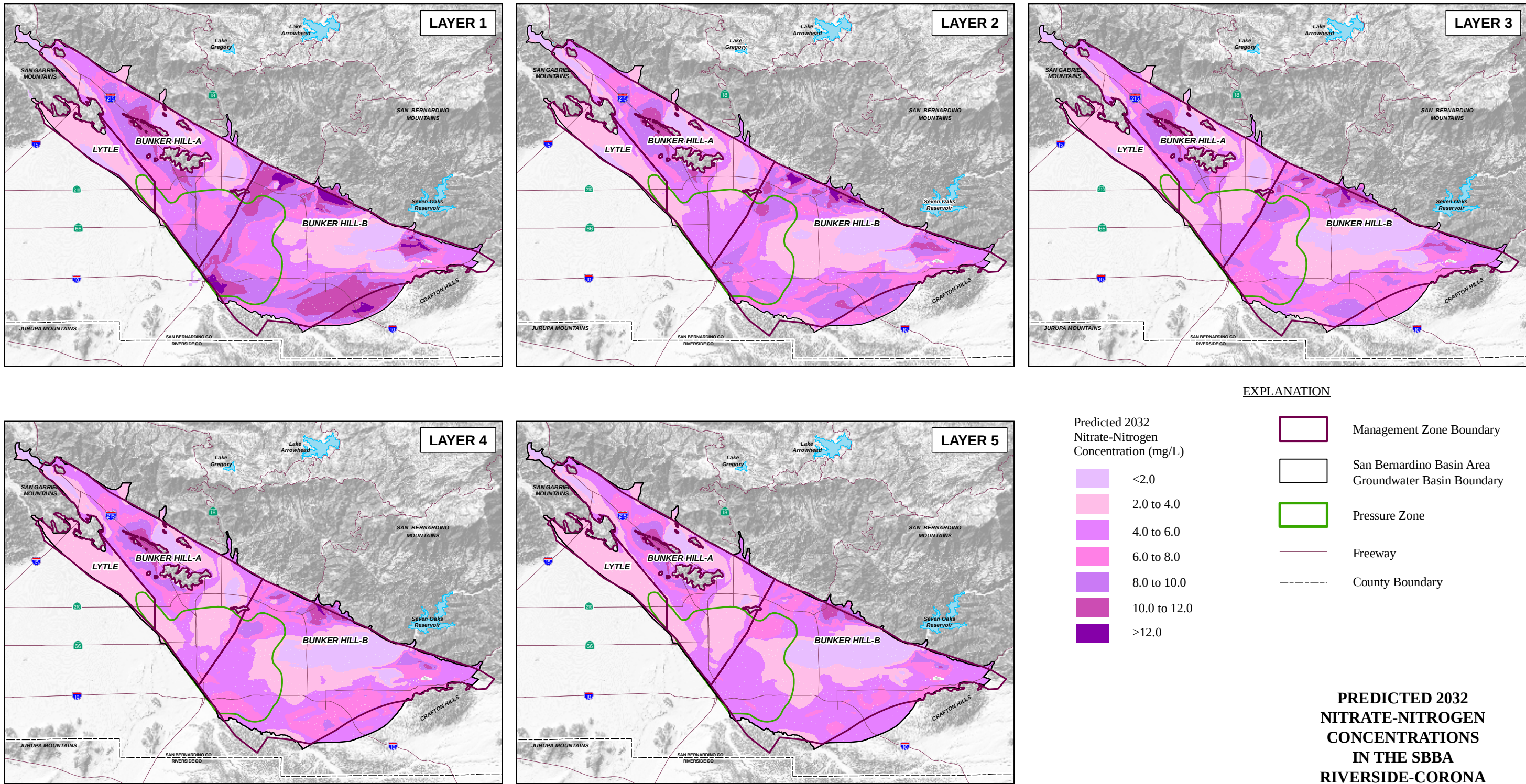
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PREDICTED 2032
NITRATE-NITROGEN
CONCENTRATIONS IN THE
SBBA - BASELINE RUN
(NO PROJECT)

Figure 16

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



**PREDICTED 2032
NITRATE-NITROGEN
CONCENTRATIONS
IN THE SBBA
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1**

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



0 5 10
Miles

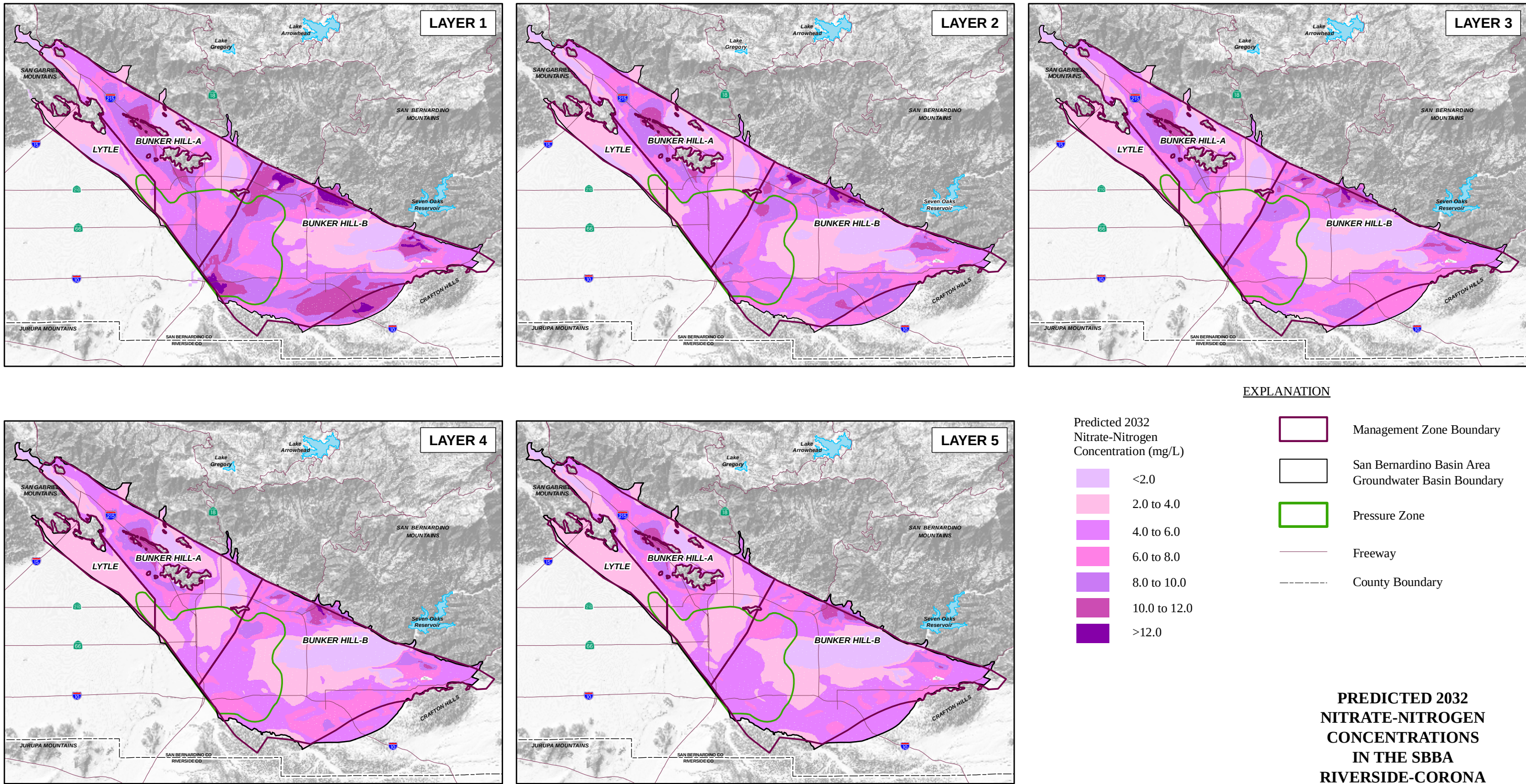
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Figure 17

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



**PREDICTED 2032
NITRATE-NITROGEN
CONCENTRATIONS
IN THE SBBA
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2**

12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



0 5 10
Miles

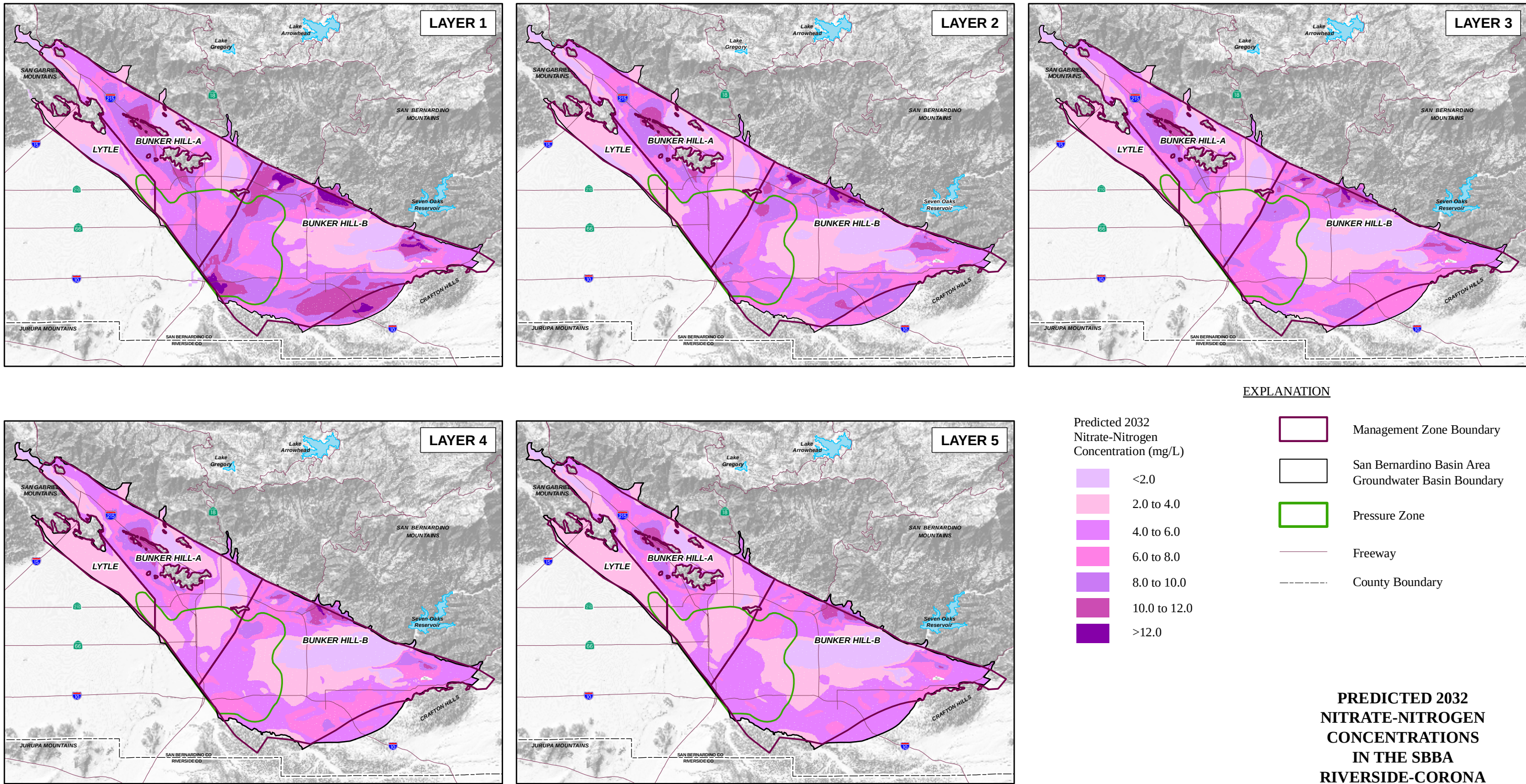
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Figure 18

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



NORTH

0 5 10 Miles

GEOSCIENCE

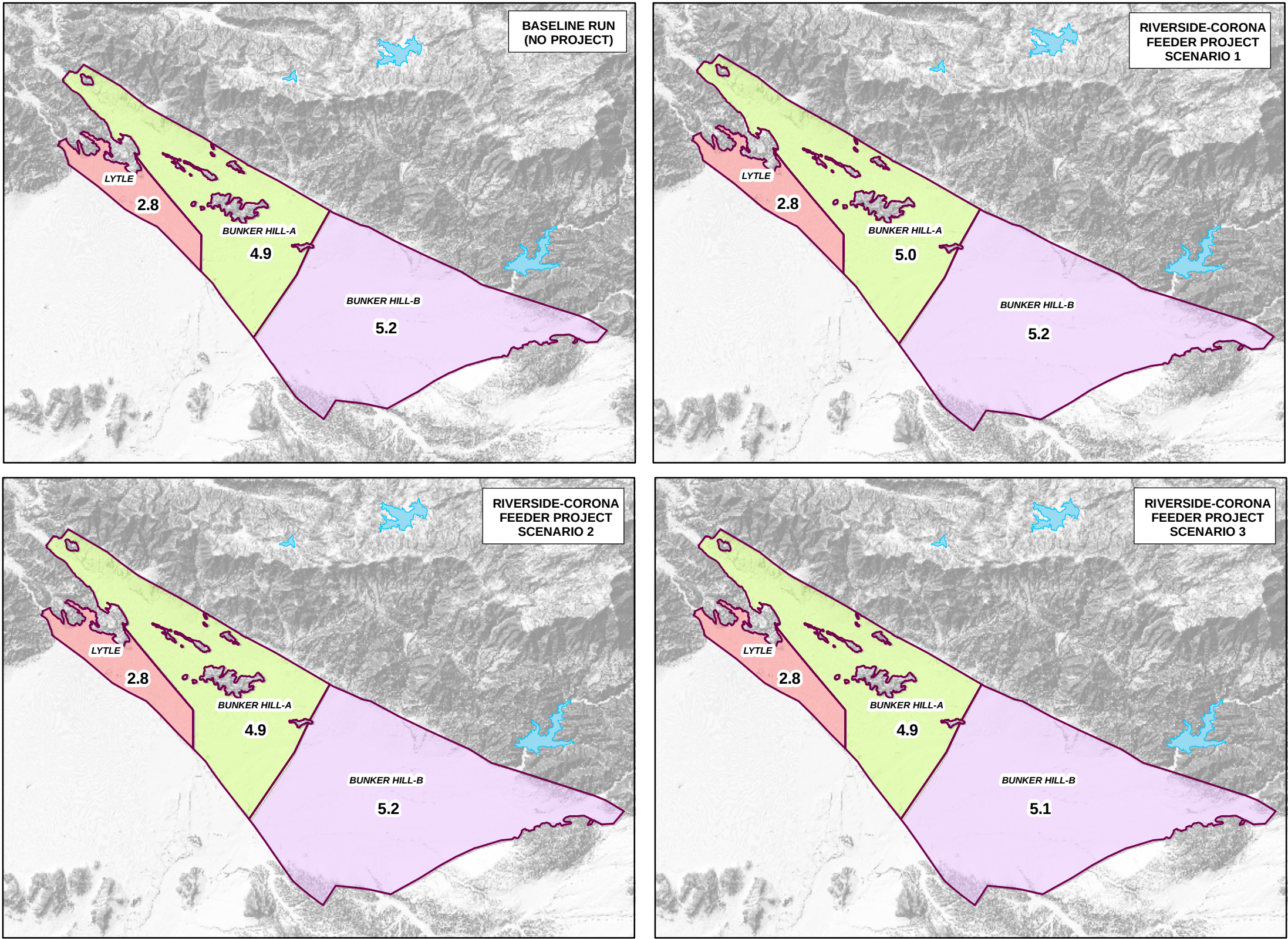
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Figure 19

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF TDS AND NITRATE-NITROGEN CONCENTRATIONS
RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

PREDICTED 2032 AVERAGE
NITRATE-NITROGEN
CONCENTRATIONS
IN THE BUNKER HILL-A,
BUNKER HILL-B & LYTLE
MANAGEMENT ZONES
BASELINE RUN (NO PROJECT)
AND RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIOS 1 THROUGH 3

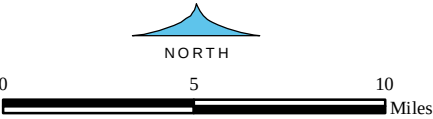


EXPLANATION

2.8 Predicted 2032 Average
Nitrate-Nitrogen
Concentration (mg/L)

Management Zones

- Bunker Hill-A
- Bunker Hill-B
- Lytle



12-Mar-10

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

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Figure 20

TABLES

GEOSCIENCE Support Services, Inc.



Measured TDS Concentrations of SAR Water (1993-2005)

Sample Location	Parameter	Sample Date	TDS Concentration [mg/L]
Hinckley WTP	TDS	4/6/1993	94.5
Hinckley WTP	TDS	6/25/1993	104
Hinckley WTP	TDS	7/28/1993	110
Hinckley WTP	TDS	8/19/1993	116
Hinckley WTP	TDS	12/27/1994	157
Hinckley WTP	TDS	2/28/1995	151
Hinckley WTP	TDS	2/28/1995	114
Hinckley WTP	TDS	4/19/1995	125
Hinckley WTP	TDS	5/22/1995	134
Hinckley WTP	TDS	2/11/1997	122
Hinckley WTP	TDS	2/11/1997	122
Hinckley WTP	TDS	1/16/1998	128
Hinckley WTP	TDS	1/12/1999	132
Hinckley WTP	TDS	1/12/1999	132
Redlands Tunnel	TDS	1/21/1999	167
Santa Ana River	TDS	1/21/1999	127
Santa Ana Edison #3	TDS	2/1/1999	122
Plant 134	TDS	4/27/1999	144
Plant 134	TDS	4/27/2000	123
Plant 134	TDS	5/4/2000	224
Hinckley WTP	TDS	2/7/2001	150
Plant 134	TDS	7/12/2001	160
Plant 134	TDS	7/12/2001	160
North Fork Ditch	TDS	9/5/2001	340
North Fork Ditch	TDS	6/20/2003	180
Hinckley WTP	TDS	1/14/2004	170
Hinckley WTP	TDS	4/12/2004	160
Plunge Pool	TDS	11/19/2004	210
Plunge Pool	TDS	11/19/2004	210
Power Plant #1 W2239	TDS	11/29/2004	160
Plant 134	TDS	11/29/2004	210
Plunge Pool	TDS	11/29/2004	200
North Fork Intake	TDS	11/29/2004	200
River Pick Up	TDS	11/29/2004	200
North Face of SOD	TDS	5/20/2005	160
Plunge Pool	TDS	5/20/2005	170
SOD Res Inlet	TDS	5/20/2005	360
Average			163

Sources of Data: City of Redlands and East Valley Water District

TDS and Nitrate-Nitrogen Concentrations of Streamflow Segments

Model Stream Segment	Segment Name	TDS [mg/L]	Nitrate-Nitrogen [mg/L]
1	Lytle Creek, gaged inflow	180	2.7
2	Cajon Creek, gaged inflow	456	1.6
3	Cable Canyon Creek, estimated inflow	456	1.6
4	Cable Canyon Creek, below recharge basin	456	1.6
5	Devil Canyon Creek, gaged inflow	269	1.6
6	Devil Canyon spreading basin	269	1.6
7	Devil Canyon diversion channel, below spreading basins	269	1.6
8	Devil Canyon diversion channel, at Wiggins #1	269	1.6
9	Devil Canyon diversion channel, below Wiggins #1	269	1.6
10	Devil Canyon diversion channel, below Cable Canyon Creek	363	1.6
11	Cajon Creek, below Devil Canyon Creek	409	1.6
12	Lytle Creek, below Cajon Creek	295	2.2
13	Lytle-Cajon basin	295	2.2
14	Lytle Creek, east branch	295	2.2
15	Warm Creek, natural channel, diverted inflow	330	4.0
16	Warm Creek, below Lytle Creek	312	3.1
17	Waterman Creek, gaged inflow	484	4.0
18	Waterman spreading basin	484	4.0
19	East Twin Creek, gaged inflow	484	4.0
20	East Twin spreading basin	484	4.0
21	East Twin Creek, below spreading basin	484	4.0
22	Sand Creek, estimated inflow	280	5.4
23	Patton spreading basin	280	5.4
24	Warm Creek, below Patton spreading basin	280	5.4
25	Warm Creek, below East Twin Creek	382	4.7
26	Warm Creek bypass	382	4.7
27	City Creek, diverted inflow	280	5.4
28	Warm Creek bypass, below City Creek	331	5.1
29	Warm Creek bybass	331	5.1
30	City Creek, gaged inflow	280	5.4

TDS and Nitrate-Nitrogen Concentrations of Streamflow Segments

Model Stream Segment	Segment Name	TDS [mg/L]	Nitrate-Nitrogen [mg/L]
31	City Creek spreading basin	280	5.4
32	City Creek, below City Creek spreading basin	280	5.4
33	Plunge Creek, gaged inflow	163	1.3
34	Plunge Creek, above SAR	222	3.4
35	Santa Ana River, gaged inflow	163	1.3
36	Santa Ana River spreading basin, diverted flow	163	1.3
37	Santa Ana River spreading basins, upper	163	1.3
38	Santa Ana River spreading basins, channel	163	1.3
39	Santa Ana River spreading basins, lower	163	1.3
40	Santa Ana River spreading basins, channel	163	1.3
41	Santa Ana River, undiverted flow	163	1.3
42	Mill Creek, gaged inflow	280	5.4
43	Mill Creek, below Zanja	280	5.4
44	Mill Creek spreading basin	280	5.4
45	Mill Creek spreading basin channel	280	5.4
46	Mill Creek, undiverted flow	280	5.4
47	Mill Creek, below spreading basin	280	5.4
48	Santa Ana River, below Mill Creek	222	3.4
49	Santa Ana River, below spreading basin	192	2.3
50	Santa Ana River, below Plunge Creek	207	2.8
51	Zanja, diverted flow	310	5.3
52	Santa Ana River, below Zanja	258	4.1
53	San Timoteo, gaged inflow	300	2.9
54	Santa Ana River, below San Timoteo	279	3.5
55	Santa Ana River, below Warm Creek bypass	305	4.3
56	Santa Ana River, gaged outflow	309	3.7

Comparisons of TDS Concentration for Baseline Run (No Project) and Riverside-Corona Feeder Project Scenarios 1 through 3 Annual Average between 2007 to 2032

Well Name	Average TDS Concentration 2007 to 2032				Difference in Average TDS Concentration between Baseline Run (No Project) and RCF Scenarios			Concentration Over Time Page Number in Appendix A
	Baseline Run (No Project) [mg/L]	RCF Scenario 1 [mg/L]	RCF Scenario 2 [mg/L]	RCF Scneario 3 [mg/L]	Scenario 1 minus Baseline Run [mg/L]	Scenario 2 minus Baseline Run [mg/L]	Scenario 3 minus Baseline Run [mg/L]	
SBVMWD San Bernardino Ave. Well	342	342	340	341	-1	-2	-1	A-1
City of San Bernardino Mt. Vernon Well	393	393	394	396	0	0	3	A-2
East Valley Water District Well 62	441	442	443	445	1	2	4	A-3
Fontana Union Well 13	190	190	190	190	0	0	0	A-4
Fontana Union Well 26	221	221	221	221	0	0	0	A-5
Fontana Union Well 27	203	203	203	203	0	0	0	A-6
East Valley Water District Well 120	239	239	240	240	0	0	1	A-7
City of San Bernardino Vincent Well	457	457	457	457	0	0	0	A-8
City of San Bernardino Devil Canyon Well No. 1	498	493	479	474	-5	-19	-24	A-9
City of San Bernardino Newmark 3 Well	387	386	382	380	-1	-4	-7	A-10
West Valley Water District Lord 7 Well	211	211	210	211	0	0	0	A-11
City of Riverside Raub 1 Well	382	384	388	391	2	7	9	A-12
City of Redlands Well 32	372	370	368	366	-2	-4	-5	A-13
City of Redlands Orange Street Well	279	280	280	283	1	1	4	A-14
East Valley Water District Well 24A	312	311	310	310	-1	-2	-2	A-15
City of San Bernardino Cajon Well No. 1	717	717	718	718	0	1	2	A-16
East Valley Water District Well 40	275	275	272	272	0	-3	-3	A-17
City of San Bernardino Devil Canyon Well No. 3	393	393	392	391	0	0	-1	A-18
City of San Bernardino Leroy Street Well	239	238	238	238	-1	-1	-1	A-19
City of Redlands Agate 2 Well	290	290	289	288	0	-1	-2	A-20
East Valley Water District Cone Camp Well	205	205	206	206	0	2	1	A-21
Bear Valley Mutual Water Company Nelson Street Well	293	293	293	293	0	-1	-1	A-22
Gage Canal Company Lower Kelly Well	428	428	429	430	0	0	2	A-23
City of Redlands Airport Well No. 2	286	287	287	288	0	1	1	A-24
East Valley Water District Well 146A	296	295	295	296	0	0	1	A-25
SBVMWD Backyard Well	593	593	594	597	0	1	4	A-26

Comparisons of Nitrate-Nitrogen Concentration for Baseline Run (No Project) and Riverside-Corona Feeder Project Scenarios 1 through 3 Annual Average between 2007 to 2032

Well Name	Average Nitrate-Nitrogen Concentration 2007 to 2032				Difference in Average Nitrate-Nitrogen Concentration between Baseline Run (No Project) and RCF Scenarios			Concentration Over Time Page Number in Appendix B
	Baseline Run (No Project) [mg/L]	RCF Scenario 1 [mg/L]	RCF Scenario 2 [mg/L]	RCF Scneario 3 [mg/L]	Scenario 1 minus Baseline Run [mg/L]	Scenario 2 minus Baseline Run [mg/L]	Scenario 3 minus Baseline Run [mg/L]	
SBVMWD San Bernardino Ave. Well	5.7	5.6	5.5	5.4	-0.1	-0.3	-0.3	B-1
City of San Bernardino Mt. Vernon Well	4.4	4.4	4.4	4.4	0.0	0.0	0.0	B-2
East Valley Water District Well 62	6.1	6.1	6.2	6.2	0.0	0.1	0.1	B-3
Fontana Union Well 13	2.7	2.7	2.7	2.7	0.0	0.0	0.0	B-4
Fontana Union Well 26	2.7	2.7	2.7	2.7	0.0	0.0	0.0	B-5
Fontana Union Well 27	2.7	2.7	2.7	2.7	0.0	0.0	0.0	B-6
East Valley Water District Well 120	2.7	2.7	2.7	2.6	0.0	0.0	-0.1	B-7
City of San Bernardino Vincent Well	1.6	1.6	1.6	1.6	0.0	0.0	0.0	B-8
City of San Bernardino Devil Canyon Well No. 1	4.7	4.6	4.4	4.3	-0.1	-0.3	-0.4	B-9
City of San Bernardino Newmark 3 Well	2.9	2.9	2.8	2.8	0.0	-0.1	-0.1	B-10
West Valley Water District Lord 7 Well	2.5	2.5	2.5	2.5	0.0	0.0	0.0	B-11
City of Riverside Raub 1 Well	6.8	6.8	6.9	6.9	0.0	0.2	0.2	B-12
City of Redlands Well 32	5.9	5.7	5.5	5.4	-0.2	-0.4	-0.5	B-13
City of Redlands Orange Street Well	3.7	3.7	3.7	3.7	0.0	0.0	0.0	B-14
East Valley Water District Well 24A	1.9	1.9	1.9	1.9	0.0	0.0	0.0	B-15
City of San Bernardino Cajon Well No. 1	7.8	7.8	7.8	7.8	0.0	0.0	0.0	B-16
East Valley Water District Well 40	4.0	4.0	3.9	3.9	0.0	-0.1	-0.1	B-17
City of San Bernardino Devil Canyon Well No. 3	3.5	3.5	3.5	3.5	0.0	0.0	0.0	B-18
City of San Bernardino Leroy Street Well	2.2	2.3	2.3	2.3	0.1	0.1	0.1	B-19
City of Redlands Agate 2 Well	4.1	4.0	3.9	3.8	-0.1	-0.2	-0.3	B-20
East Valley Water District Cone Camp Well	1.4	1.4	1.4	1.4	0.0	0.0	0.0	B-21
Bear Valley Mutual Water Company Nelson Street Well	4.4	4.3	4.2	4.2	-0.1	-0.2	-0.3	B-22
Gage Canal Company Lower Kelly Well	7.8	7.8	7.8	7.8	0.0	0.0	0.0	B-23
City of Redlands Airport Well No. 2	4.0	3.9	3.8	3.7	-0.1	-0.2	-0.2	B-24
East Valley Water District Well 146A	4.0	4.0	4.0	4.0	0.0	0.0	-0.1	B-25
SBVMWD Backyard Well	7.3	7.3	7.3	7.3	0.0	0.0	0.0	B-26

**Predicted Flow and TDS Concentrations for Underflow from Bunker Hill-A and Bunker Hill-B Management Zones
Across San Jacinto Fault near SAR to Colton Management Zone (2007-2032)**

Year	Baseline Run (No Project)			RCF Scenario 1			RCF Scenario 2			RCF Scenario 3		
	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]
2007	319	433	188	319	433	188	319	433	188	319	433	188
2008	338	423	194	338	423	194	338	423	194	338	423	194
2009	352	490	234	352	490	234	353	488	234	353	488	234
2010	367	593	296	367	593	296	368	586	293	368	585	292
2011	380	712	367	380	711	367	381	695	360	381	693	358
2012	391	944	501	391	938	498	392	906	483	393	902	482
2013	406	1,218	672	408	1,209	669	408	1,163	645	409	1,157	643
2014	423	1,411	811	426	1,403	812	427	1,355	787	428	1,345	783
2015	448	1,478	899	450	1,468	897	452	1,426	875	453	1,415	870
2016	471	1,433	917	472	1,418	910	474	1,387	893	476	1,376	890
2017	493	1,280	857	494	1,263	847	494	1,243	834	499	1,233	837
2018	513	1,074	749	513	1,059	738	513	1,046	729	518	1,040	732
2019	529	890	639	528	878	630	528	870	624	533	865	626
2020	547	736	547	546	727	540	546	722	535	550	719	538
2021	554	632	476	553	626	470	552	622	466	557	620	469
2022	574	585	456	573	579	451	572	577	448	577	575	451
2023	586	545	434	585	541	430	584	539	428	589	537	430
2024	597	507	411	596	504	408	595	501	405	600	500	407
2025	612	476	396	610	474	393	610	470	389	613	470	392
2026	610	450	373	609	448	371	609	442	366	612	443	369
2027	636	438	378	634	436	376	625	429	365	627	430	366
2028	648	420	369	646	419	368	644	410	359	646	411	361
2029	665	384	347	663	383	345	662	375	337	664	375	338
2030	678	348	320	676	348	319	676	341	313	678	340	313
2031	689	317	297	688	317	296	688	312	291	690	311	291
2032	698	284	270	697	284	269	698	280	266	701	279	266
Average	520	712	477	520	707	474	519	694	466	522	691	466
Total Mass [tons]	12,398			12,317			12,106			12,119		

**Predicted Flow and TDS Concentrations for Underflow from Lytle Management Zone
Across Barrier E to Rialto Management Zone (2007-2032)**

Year	Baseline Run (No Project)			RCF Scenario 1			RCF Scenario 2			RCF Scenario 3		
	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]
2007	222	1,980	597	222	1,980	597	222	1,980	597	222	1,980	597
2008	217	1,980	585	217	1,980	585	217	1,980	585	217	1,980	585
2009	212	1,980	571	212	1,980	571	212	1,980	571	212	1,980	571
2010	208	1,980	559	208	1,980	559	208	1,980	559	208	1,980	558
2011	204	1,980	550	204	1,980	550	204	1,980	550	204	1,980	550
2012	204	1,980	549	204	1,980	549	204	1,980	549	204	1,980	549
2013	203	1,980	545	202	1,980	545	202	1,980	545	202	1,980	545
2014	200	1,980	539	200	1,980	539	200	1,980	539	200	1,980	539
2015	199	1,980	536	199	1,980	536	199	1,980	536	199	1,980	536
2016	199	1,980	537	199	1,980	537	199	1,980	537	200	1,980	538
2017	200	1,980	538	200	1,980	538	200	1,980	538	200	1,980	539
2018	199	1,980	535	199	1,980	535	199	1,980	535	199	1,980	534
2019	199	1,980	536	199	1,980	536	199	1,980	536	199	1,980	535
2020	199	1,980	536	199	1,980	536	199	1,980	536	199	1,980	535
2021	190	1,980	512	190	1,980	512	190	1,980	512	190	1,980	512
2022	186	1,980	500	186	1,980	500	186	1,980	500	186	1,980	500
2023	197	1,980	530	197	1,980	530	197	1,980	530	197	1,980	530
2024	199	1,980	535	199	1,980	535	199	1,980	535	199	1,980	535
2025	202	1,980	543	202	1,980	543	202	1,980	543	202	1,980	543
2026	197	1,980	531	197	1,980	530	197	1,980	530	197	1,980	531
2027	197	1,980	529	197	1,980	529	198	1,980	534	199	1,980	534
2028	199	1,980	535	199	1,980	535	200	1,980	538	200	1,980	538
2029	198	1,980	532	198	1,980	532	198	1,980	532	198	1,980	532
2030	196	1,980	528	196	1,980	528	196	1,980	528	196	1,980	528
2031	200	1,980	537	200	1,980	537	200	1,980	537	200	1,980	537
2032	200	1,980	539	200	1,980	539	200	1,980	539	200	1,980	539
Average	201	1,980	541	201	1,980	541	201	1,980	541	201	1,980	541
Total Mass [tons]	14,066			14,066			14,066			14,066		

**Predicted Flow and Nitrate-Nitrogen Concentrations for Underflow from Bunker Hill-A and Bunker Hill-B
Management Zones Across San Jacinto Fault near SAR to Colton Management Zone (2007-2032)**

Year	Baseline Run (No Project)			RCF Scenario 1			RCF Scenario 2			RCF Scenario 3		
	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]
2007	5.0	433	3.0	5.0	433	3.0	5.0	433	3.0	5.0	433	3.0
2008	5.1	423	2.9	5.1	423	2.9	5.1	423	2.9	5.1	423	2.9
2009	5.4	490	3.6	5.4	490	3.6	5.5	488	3.6	5.4	488	3.6
2010	5.6	593	4.5	5.6	593	4.5	5.6	586	4.4	5.6	585	4.4
2011	5.6	712	5.5	5.6	711	5.4	5.6	695	5.3	5.6	693	5.3
2012	5.8	944	7.4	5.7	938	7.3	5.8	906	7.2	5.9	902	7.2
2013	6.0	1,218	10.0	6.1	1,209	10.0	6.1	1,163	9.6	6.1	1,157	9.6
2014	6.3	1,411	12.0	6.3	1,403	12.0	6.3	1,355	11.6	6.3	1,345	11.5
2015	6.6	1,478	13.2	6.6	1,468	13.1	6.5	1,426	12.7	6.5	1,415	12.6
2016	6.7	1,433	13.1	6.7	1,418	13.0	6.7	1,387	12.7	6.7	1,376	12.6
2017	7.0	1,280	12.1	7.0	1,263	11.9	7.0	1,243	11.8	7.0	1,233	11.7
2018	7.2	1,074	10.5	7.2	1,059	10.4	7.2	1,046	10.3	7.2	1,040	10.2
2019	7.4	890	8.9	7.4	878	8.8	7.4	870	8.7	7.4	865	8.7
2020	7.6	736	7.6	7.6	727	7.5	7.6	722	7.5	7.6	719	7.5
2021	7.6	632	6.6	7.6	626	6.5	7.6	622	6.4	7.6	620	6.4
2022	8.0	585	6.3	8.0	579	6.3	8.0	577	6.2	8.0	575	6.2
2023	8.1	545	6.0	8.1	541	5.9	8.1	539	5.9	8.1	537	5.9
2024	8.2	507	5.6	8.2	504	5.6	8.2	501	5.6	8.2	500	5.6
2025	8.4	476	5.4	8.4	474	5.4	8.4	470	5.3	8.4	470	5.3
2026	8.3	450	5.1	8.3	448	5.0	8.3	442	5.0	8.2	443	5.0
2027	8.8	438	5.2	8.8	436	5.2	8.6	429	5.0	8.5	430	5.0
2028	8.9	420	5.1	8.9	419	5.1	8.9	410	4.9	8.8	411	4.9
2029	9.2	384	4.8	9.2	383	4.8	9.2	375	4.7	9.1	375	4.7
2030	9.4	348	4.5	9.4	348	4.4	9.4	341	4.3	9.4	340	4.3
2031	9.6	317	4.1	9.6	317	4.1	9.6	312	4.0	9.6	311	4.0
2032	9.7	284	3.8	9.7	284	3.8	9.7	280	3.7	9.7	279	3.7
Average	7.4	712	6.8	7.4	707	6.7	7.4	694	6.6	7.4	691	6.6
Total Mass [tons]	177			175			172			172		

**Predicted Flow and Nitrate-Nitrogen Concentrations for Underflow from Lytle Management Zone
Across Barrier E to Rialto Management Zone (2007-2032)**

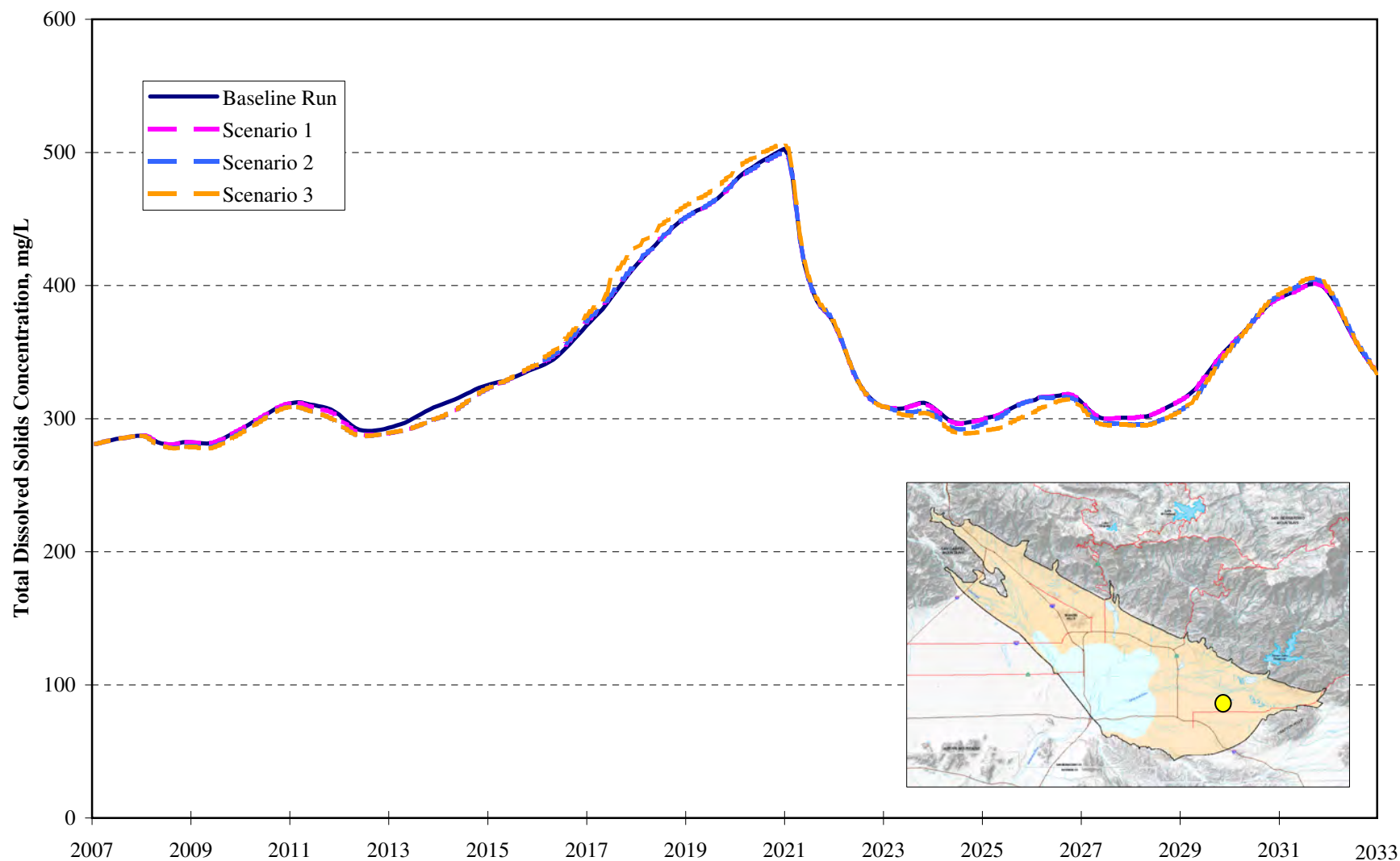
Year	Baseline Run (No Project)			RCF Scenario 1			RCF Scenario 2			RCF Scenario 3		
	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]	Concentration [mg/L]	Volume [acre-ft]	Mass [tons]
2007	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2008	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2009	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2010	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2011	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2012	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1
2013	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2014	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2015	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2016	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2017	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2018	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2019	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2020	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2021	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1
2022	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2023	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1
2024	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2025	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2026	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1
2027	2.7	1,980	7.2	2.7	1,980	7.2	2.6	1,980	7.0	2.6	1,980	7.0
2028	2.7	1,980	7.2	2.7	1,980	7.2	2.6	1,980	7.1	2.6	1,980	7.1
2029	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2030	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
2031	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1	2.7	1,980	7.1
2032	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1	2.6	1,980	7.1
Average	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2	2.7	1,980	7.2
Total Mass [tons]	187			187			187			187		

APPENDIX A
TDS Concentrations for Predictive Model Scenarios in
Selected Wells – 2007 to 2032

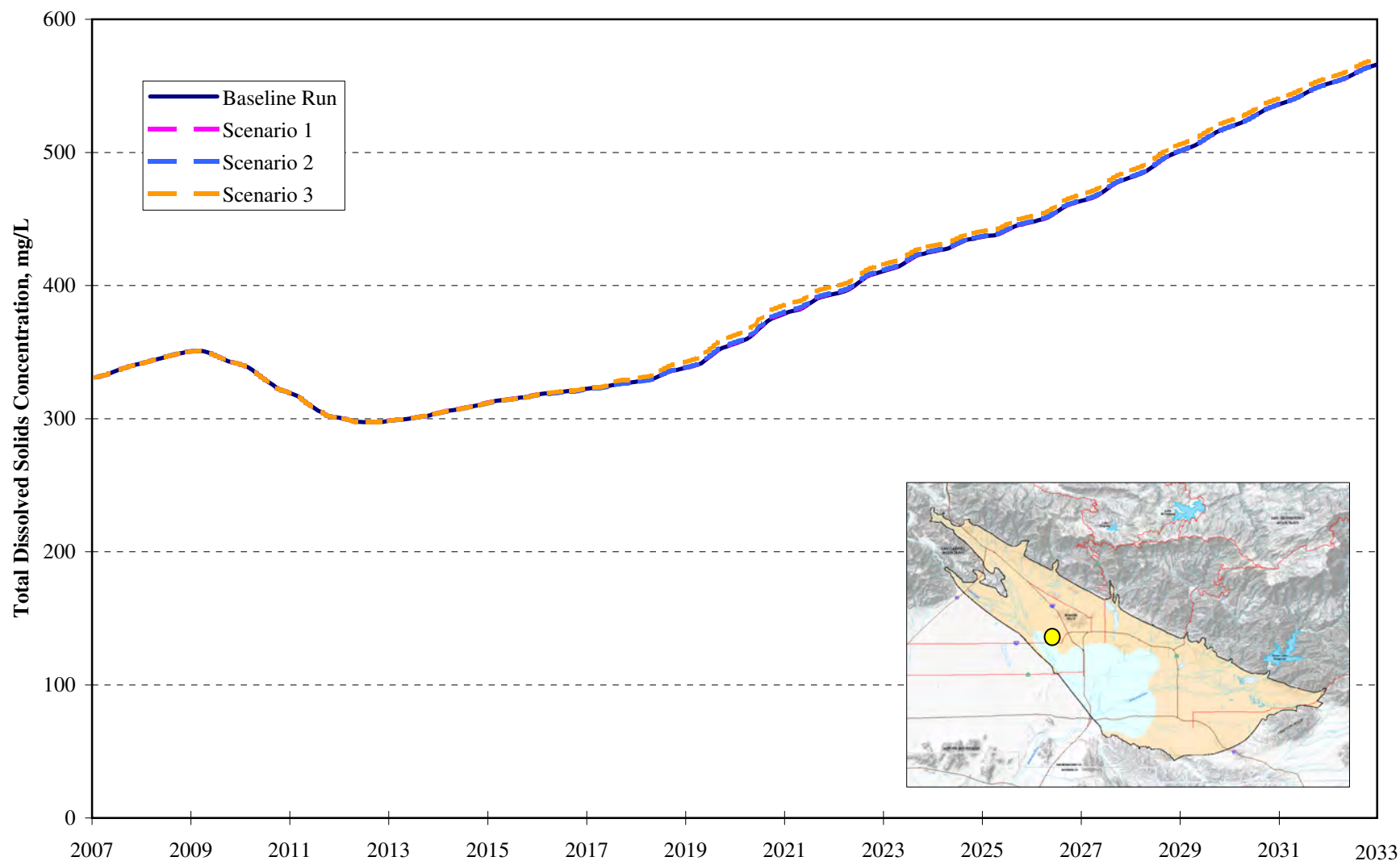
GEOSCIENCE Support Services, Inc.



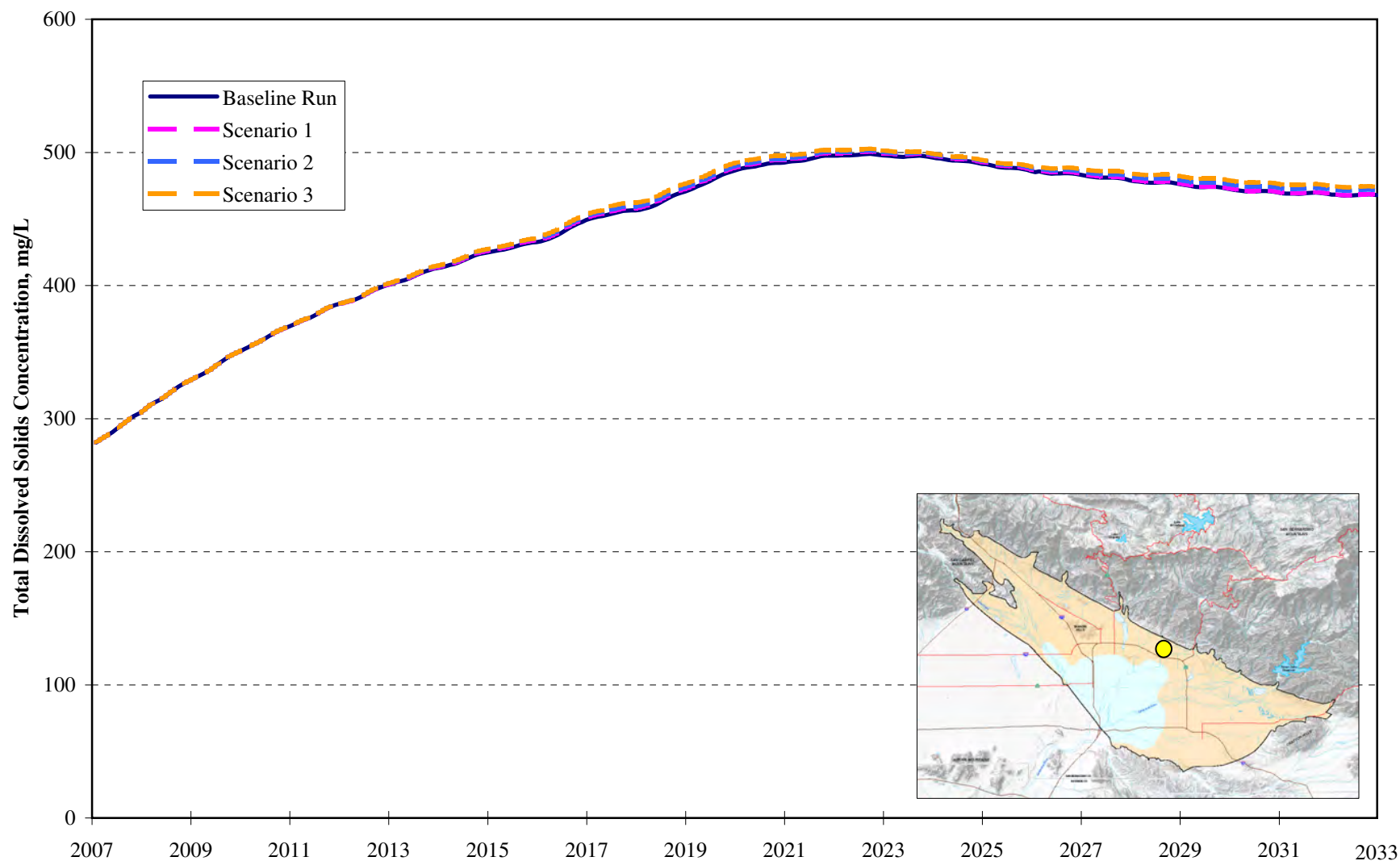
**Total Dissolved Solids for SBVMWD San Bernardino Ave. Well
Model Runs 2007-2032**



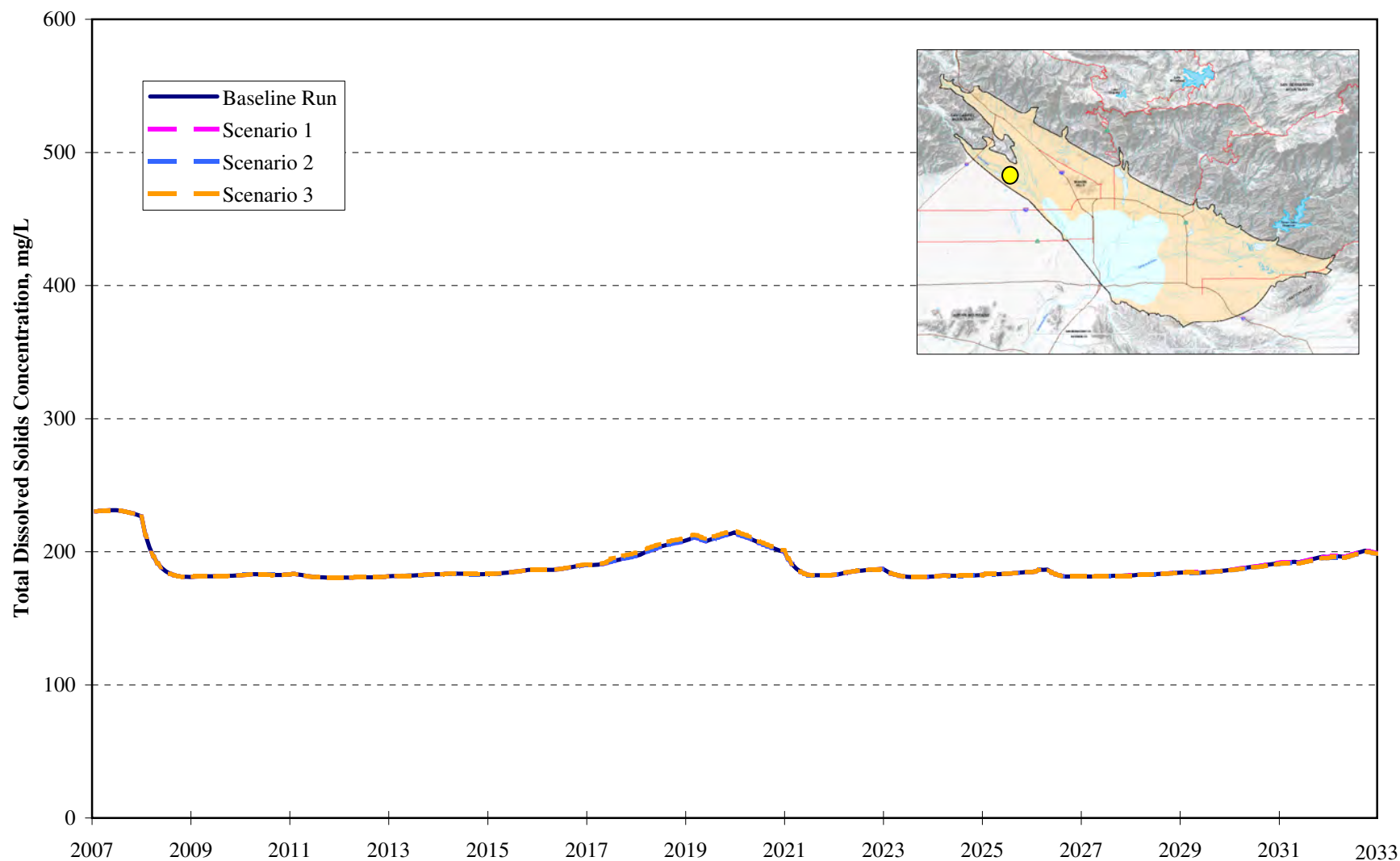
Total Dissolved Solids for City of San Bernardino Mt. Vernon Well Model Runs 2007-2032



Total Dissolved Solids for East Valley Water District Well 62 Model Runs 2007-2032

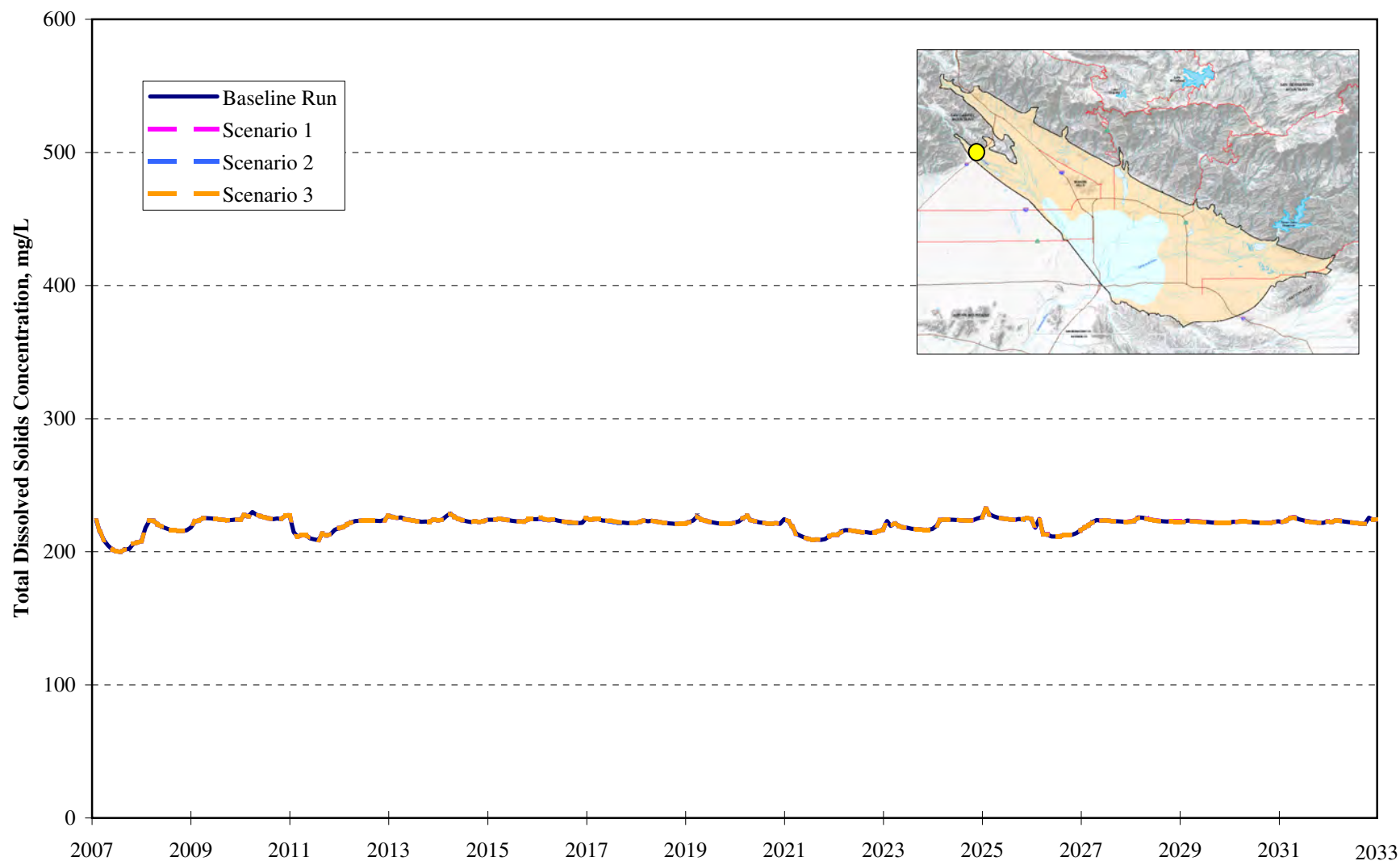


Total Dissolved Solids for Fontana Union Water Company Well 13 Model Runs 2007-2032

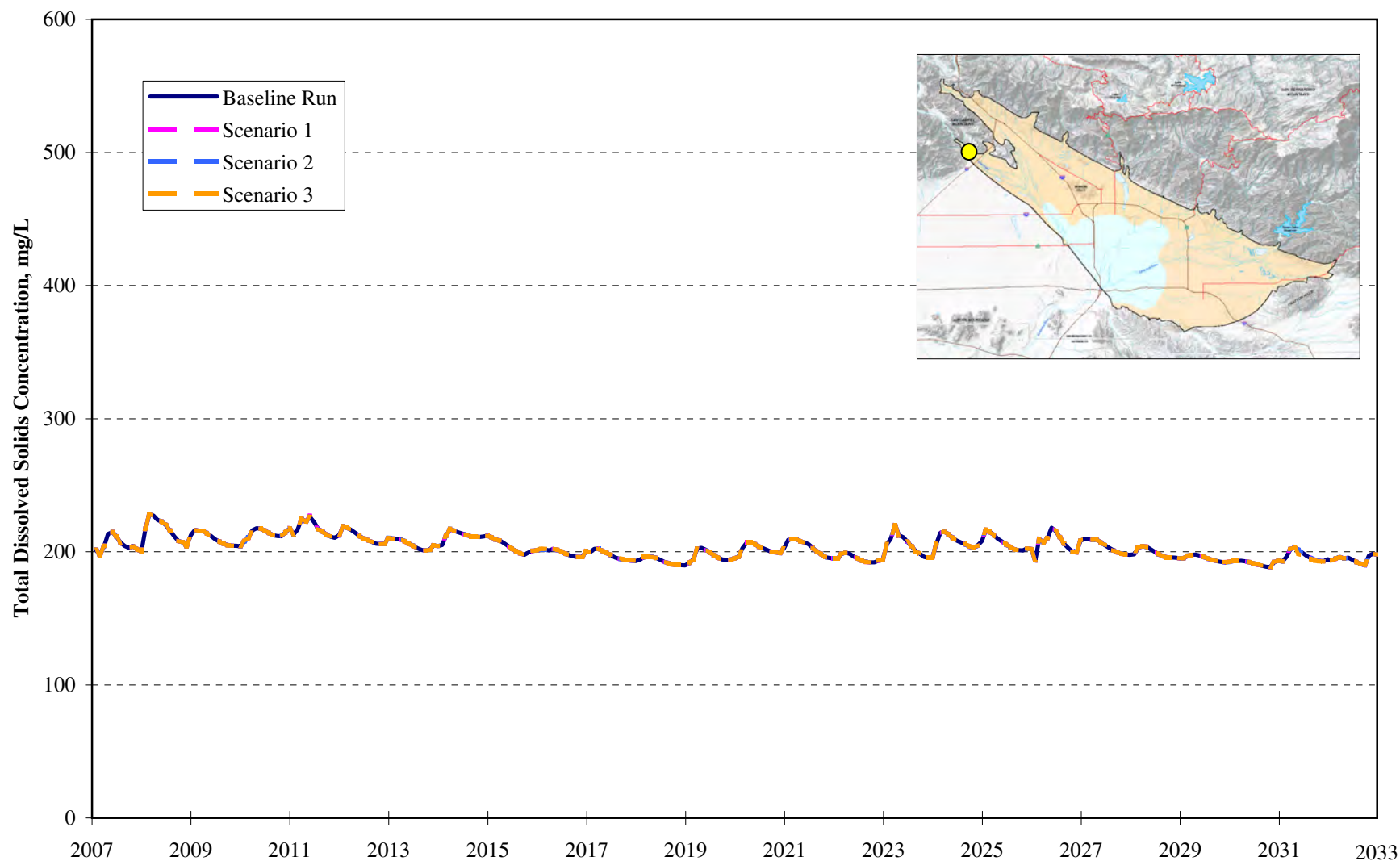


Appendix A

Total Dissolved Solids for Fontana Union Water Company Well 26 Model Runs 2007-2032

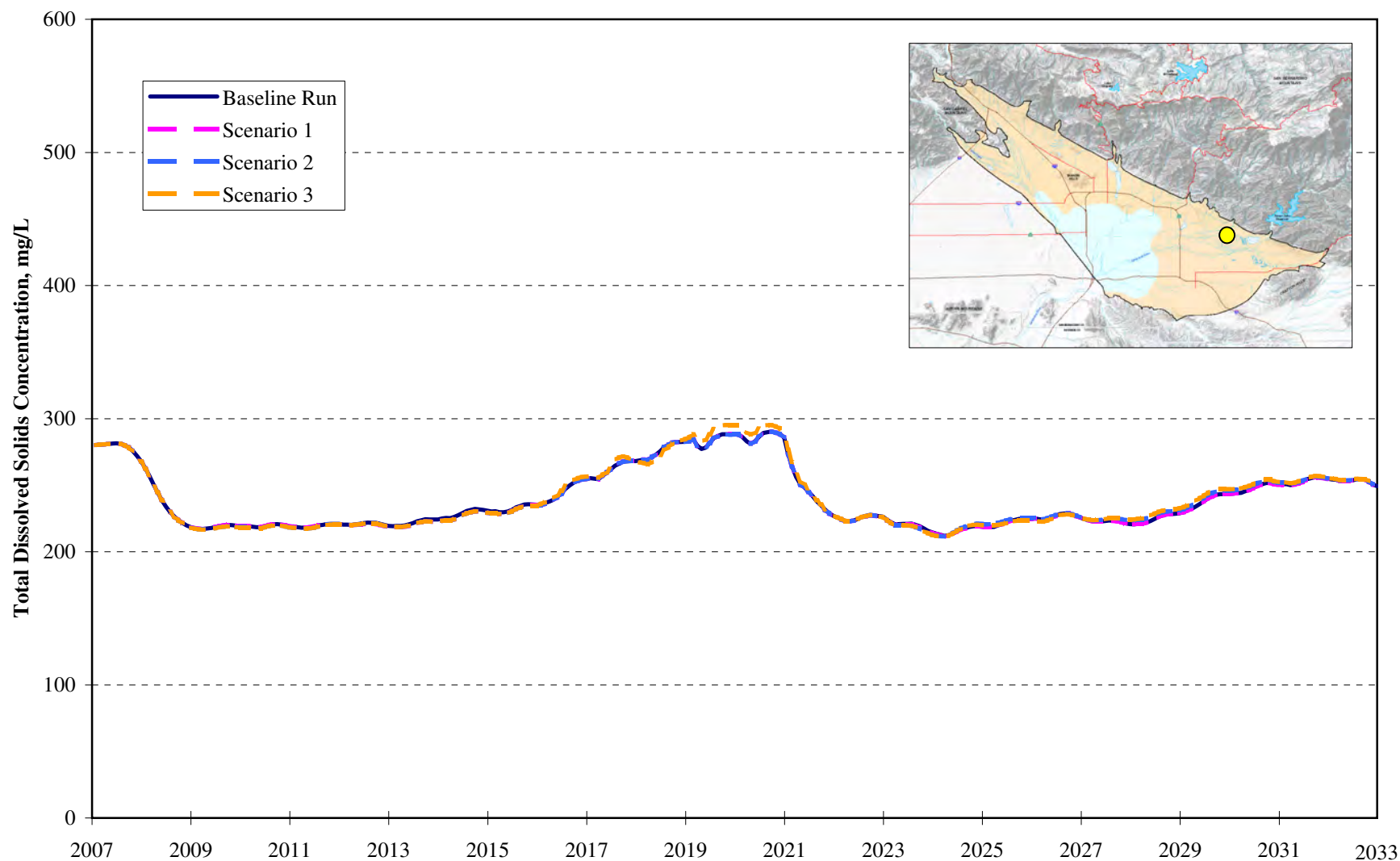


**Total Dissolved Solids for Fontana Union Water Company Well 27
Model Runs 2007-2032**



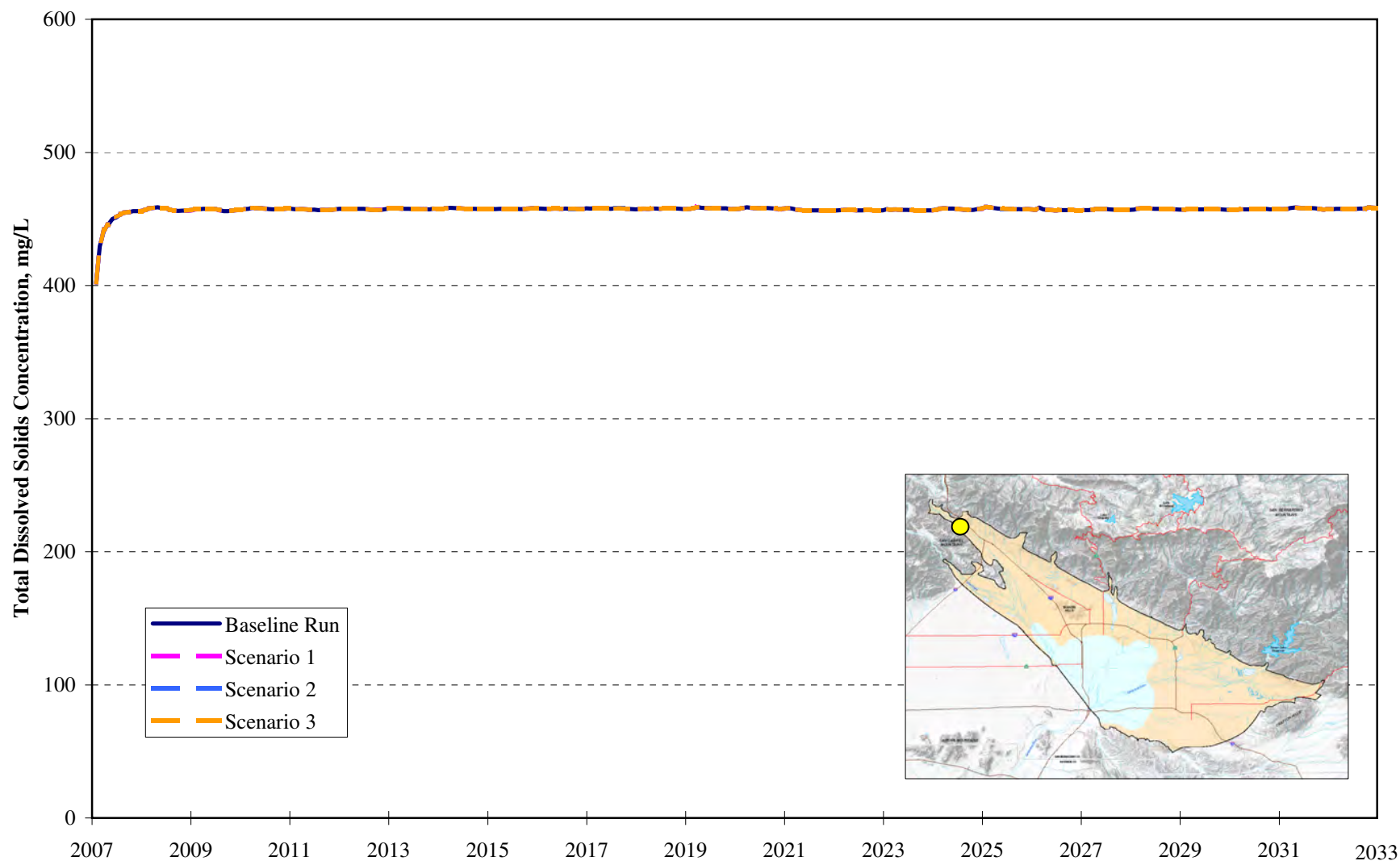
Appendix A

Total Dissolved Solids for East Valley Water District Well 120 Model Runs 2007-2032

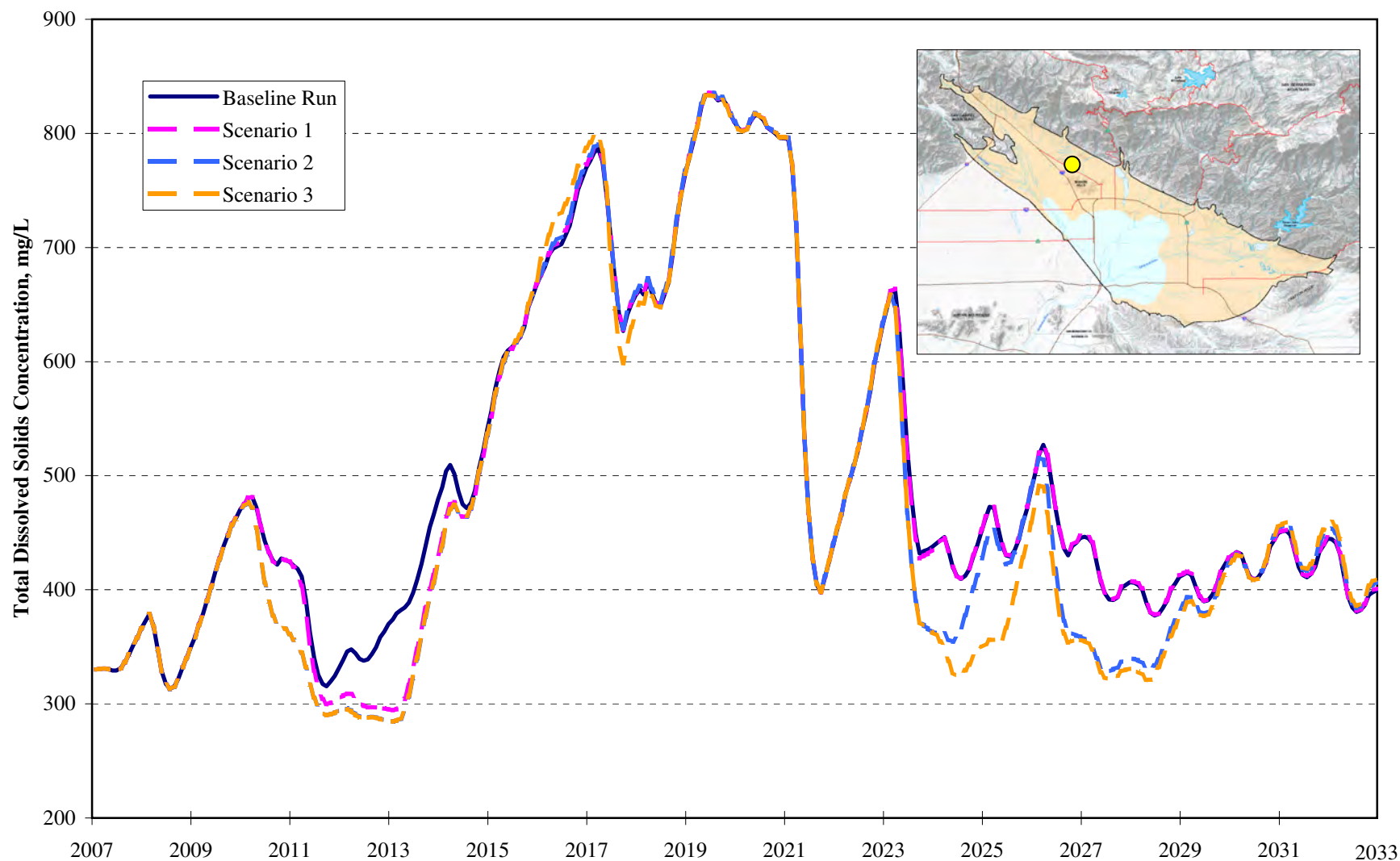


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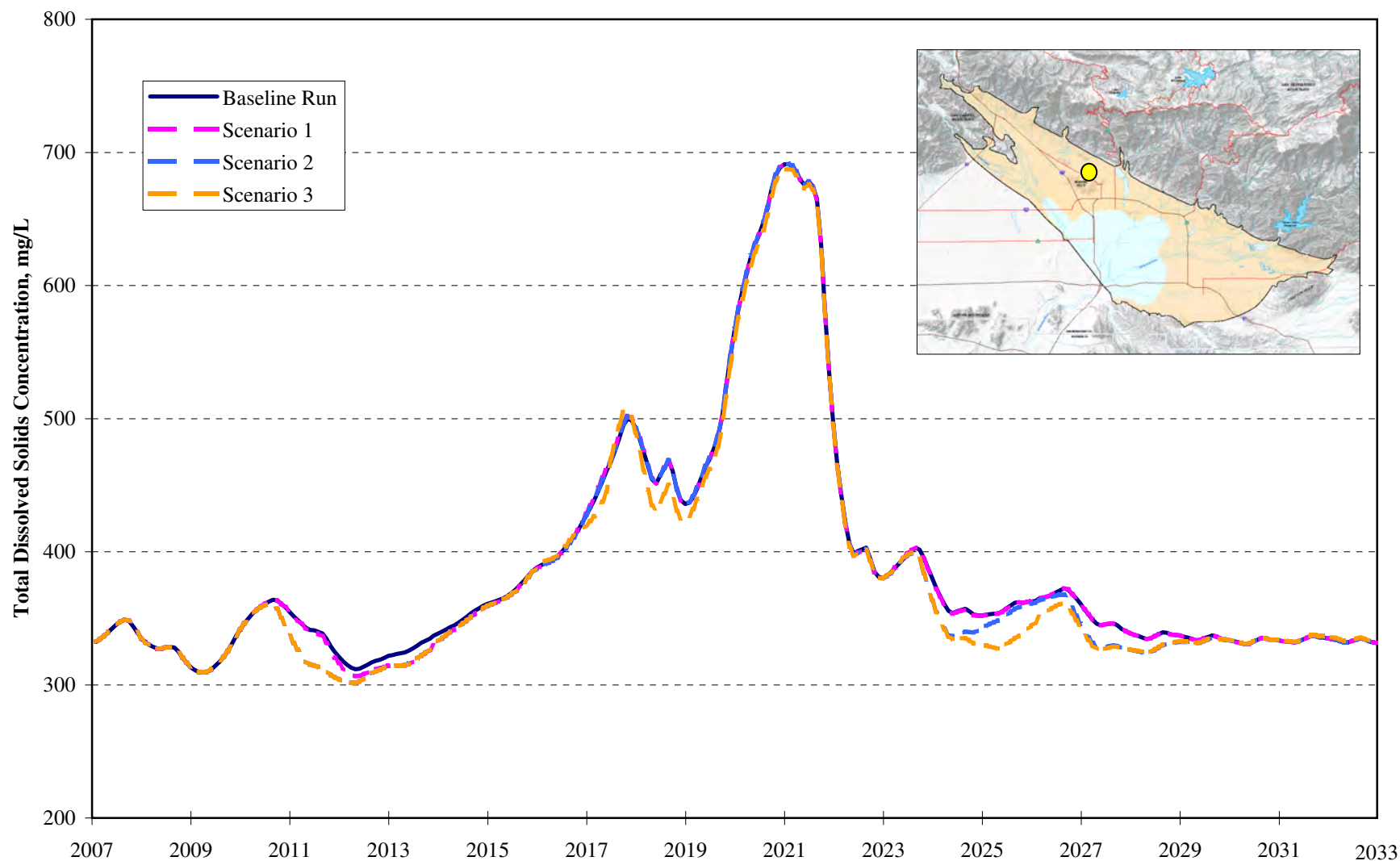
**Total Dissolved Solids for City of San Bernardino Vincent Well
Model Runs 2007-2032**



Total Dissolved Solids for City of San Bernardino Devil Canyon Well No. 1 Model Runs 2007-2032

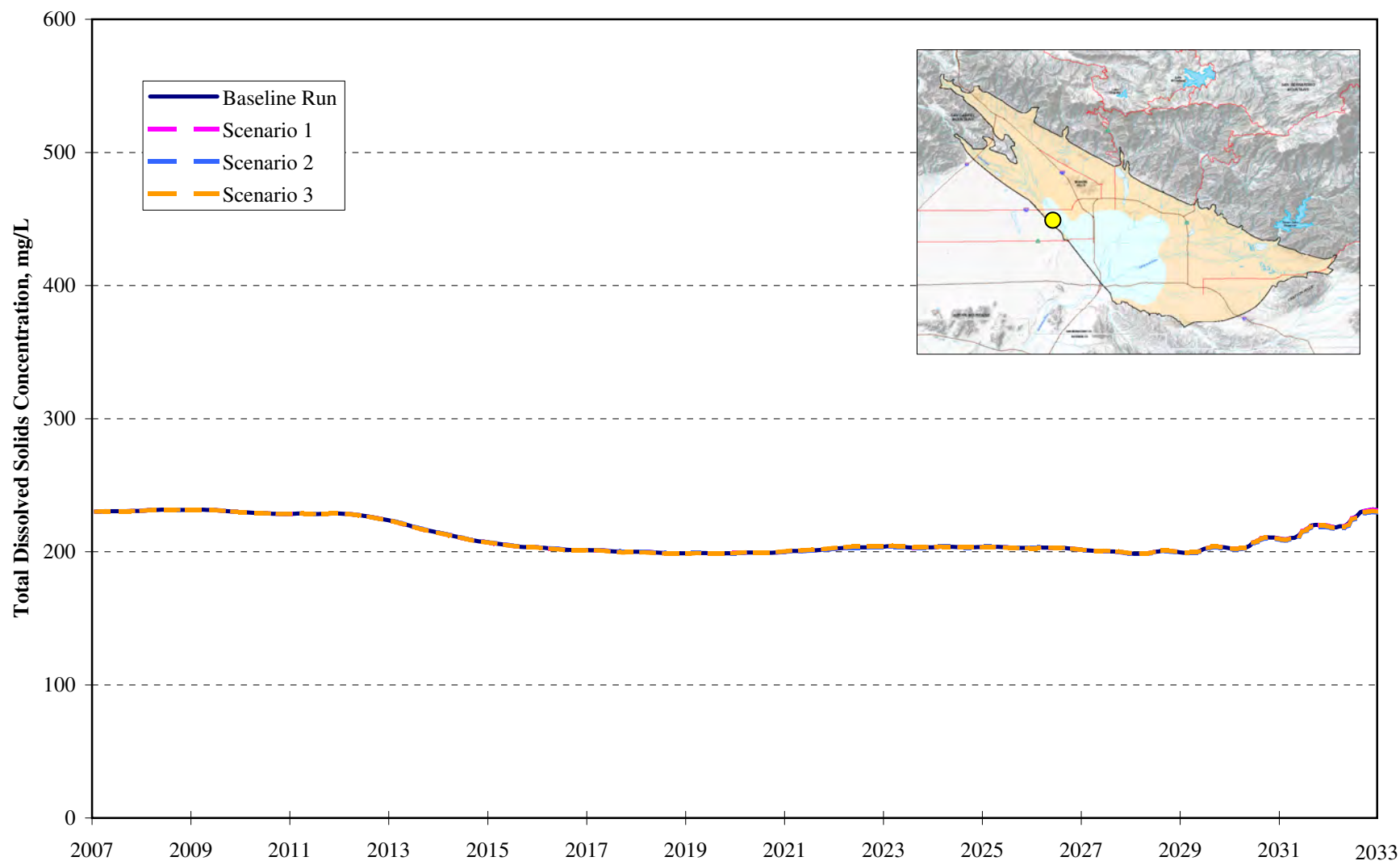


Total Dissolved Solids for City of San Bernardino Newmark 3 Well Model Runs 2007-2032



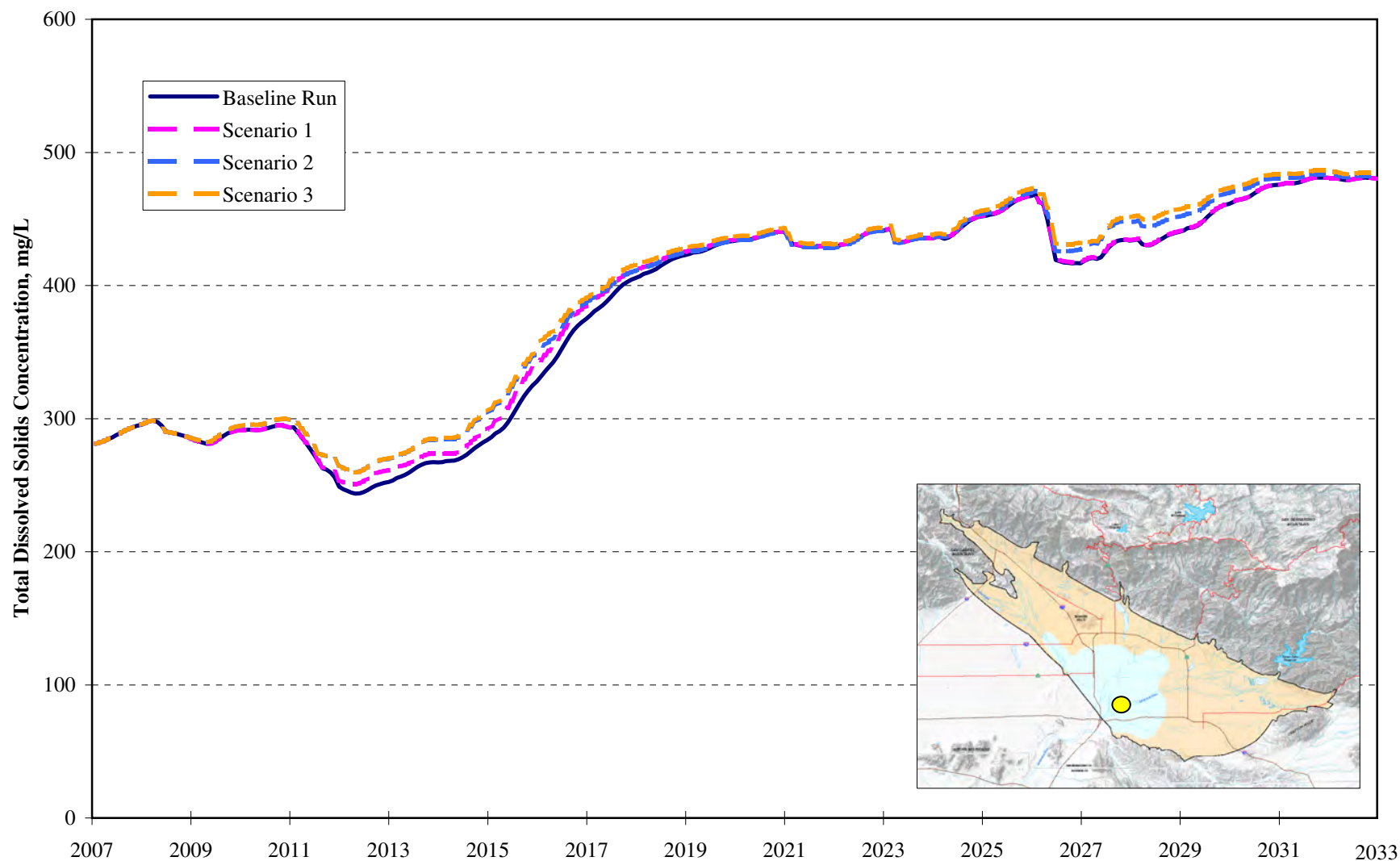
Appendix A

Total Dissolved Solids for West Valley Water District Lord 7 Well Model Runs 2007-2032

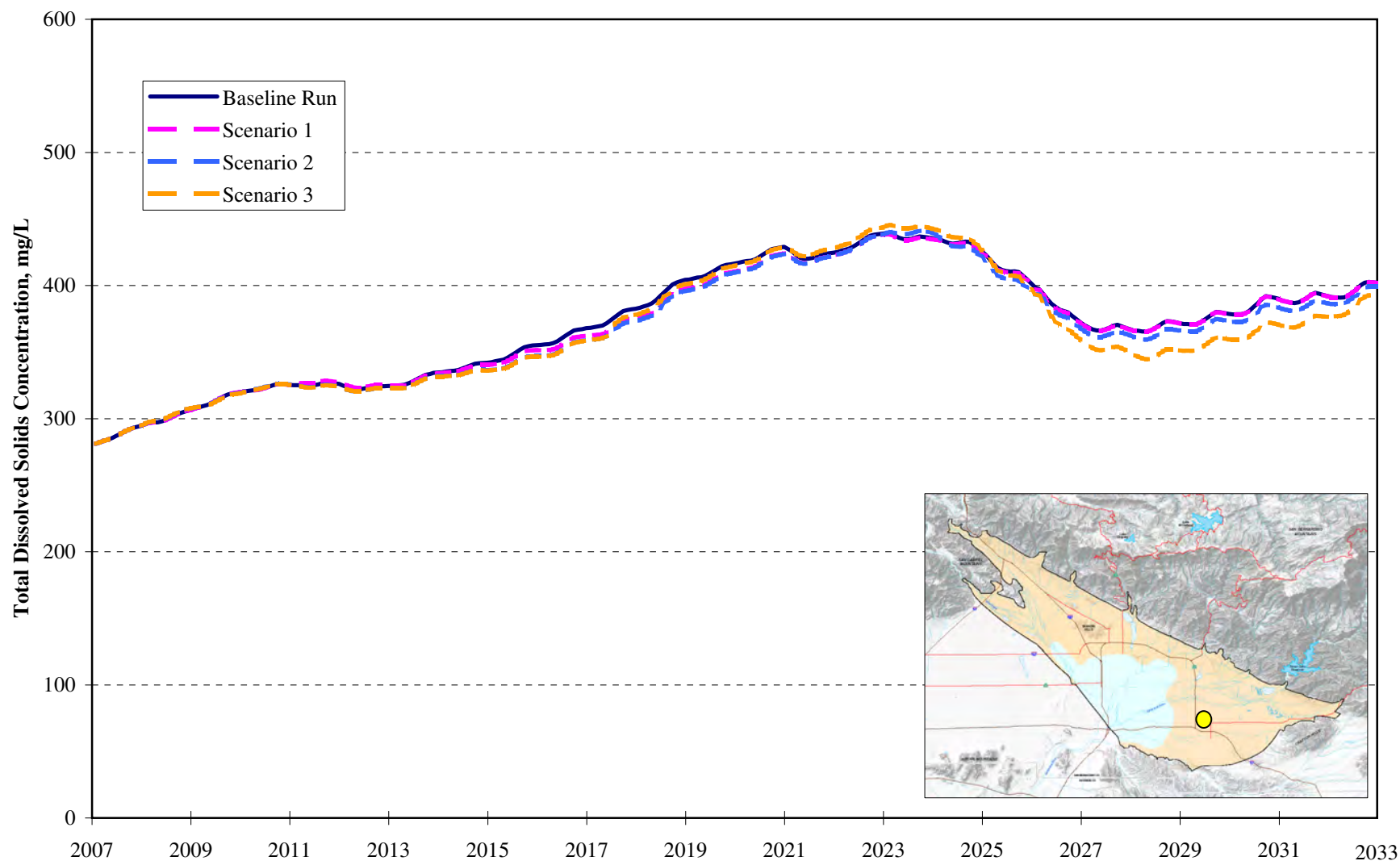


Appendix A

Total Dissolved Solids for City of Riverside Raub 1 Well Model Runs 2007-2032

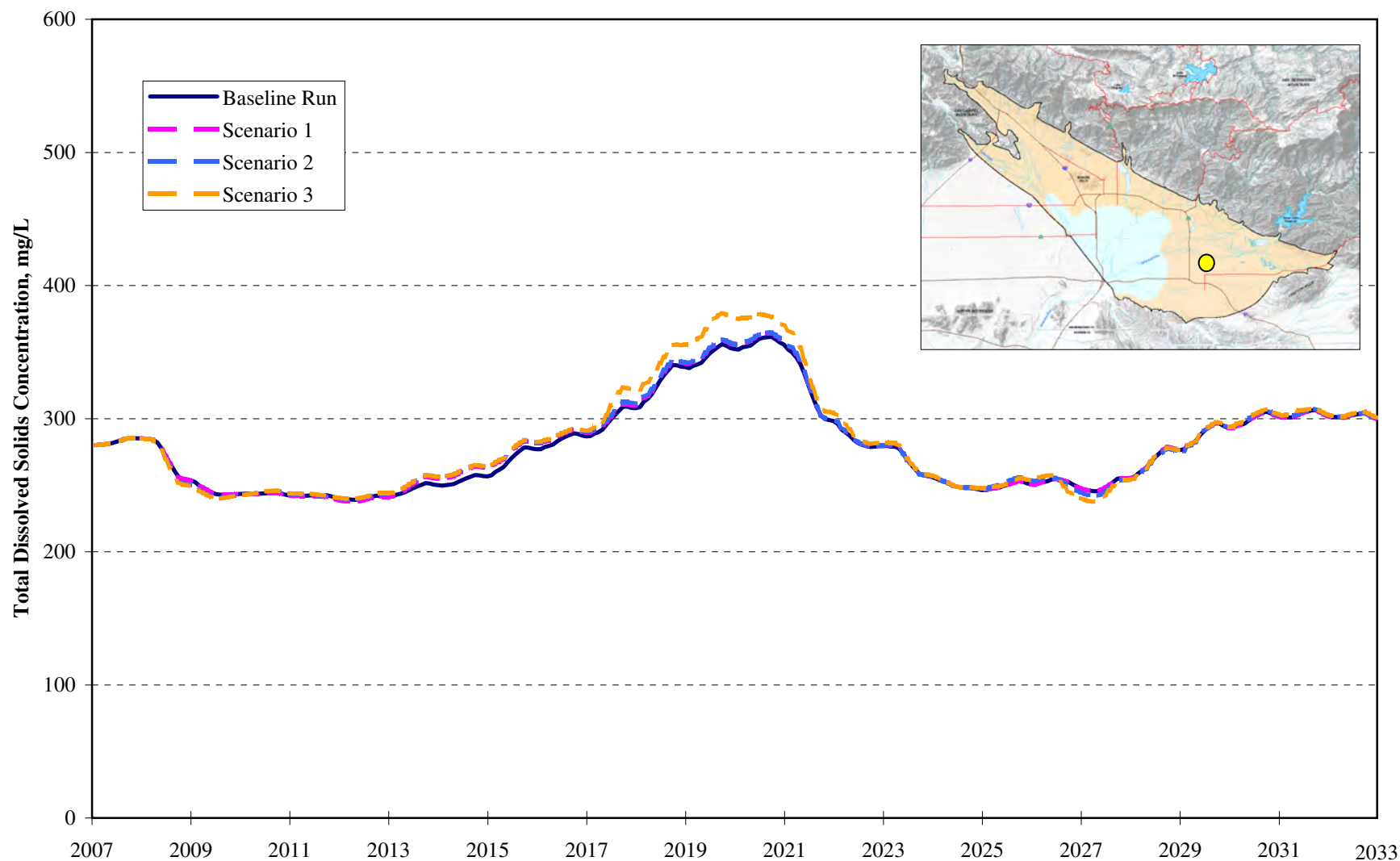


Total Dissolved Solids for City of Redlands Well 32 Model Runs 2007-2032

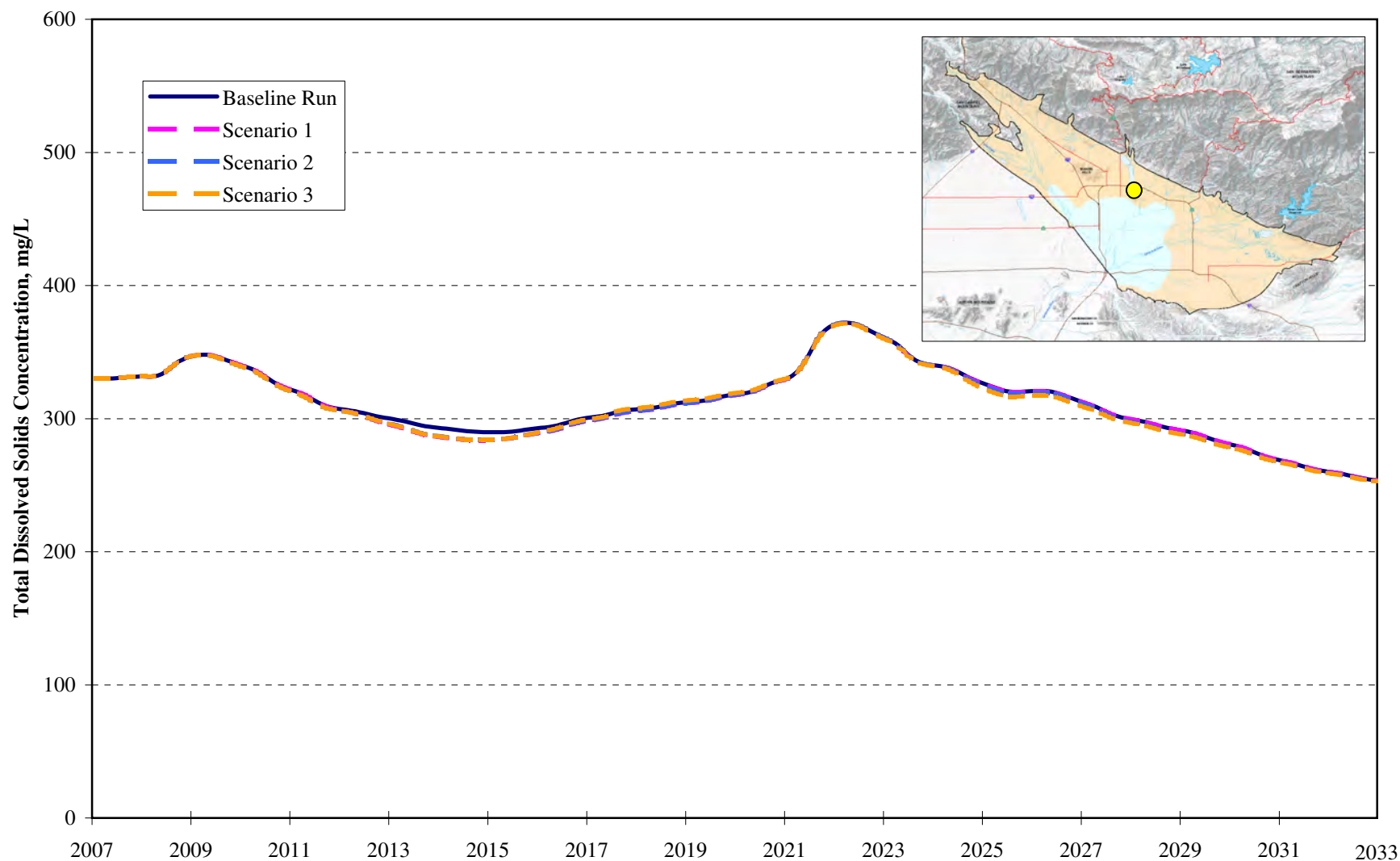


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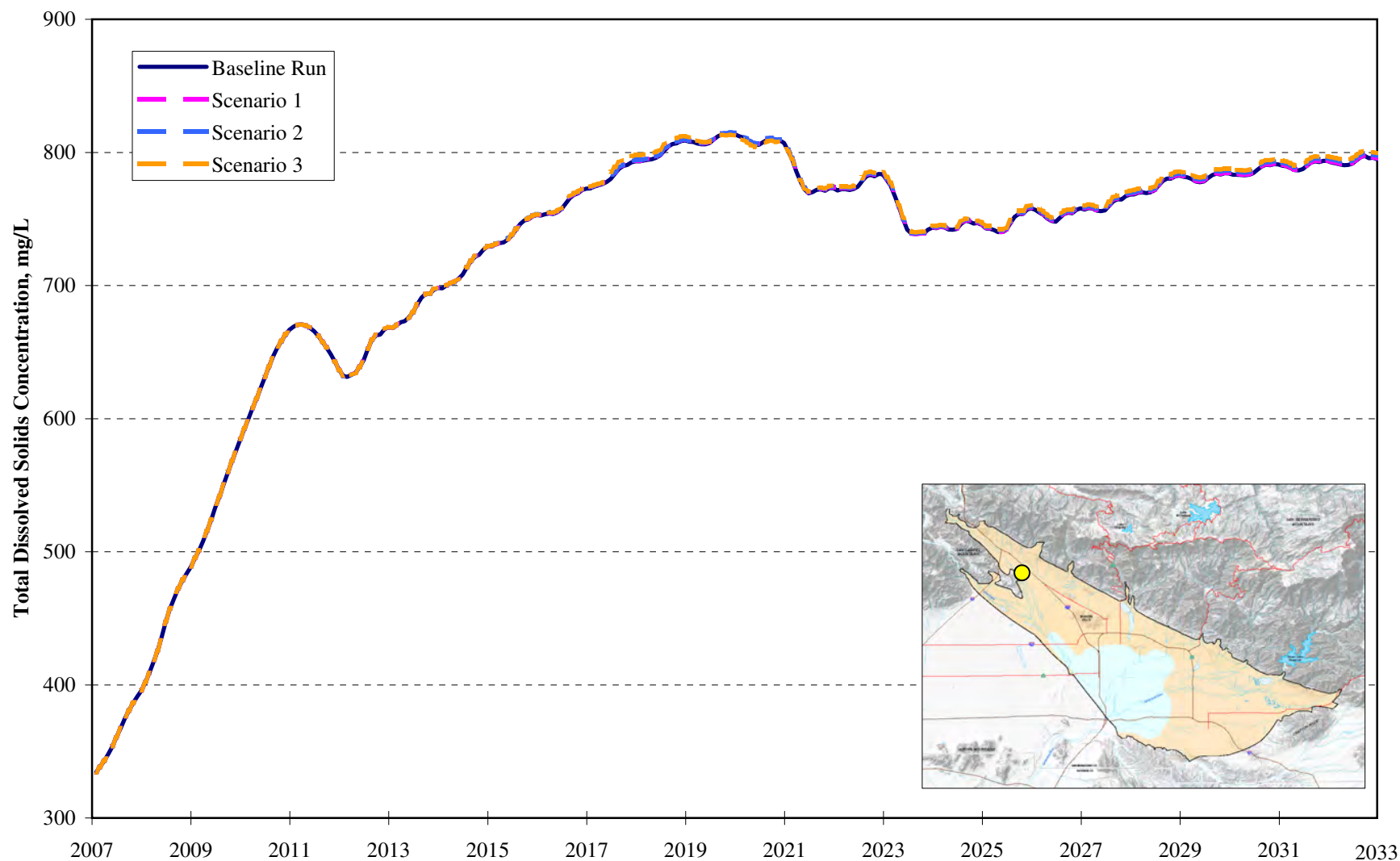
Total Dissolved Solids for City of Redlands Orange Street Well Model Runs 2007-2032



Total Dissolved Solids for East Valley Water District Well 24A Model Runs 2007-2032

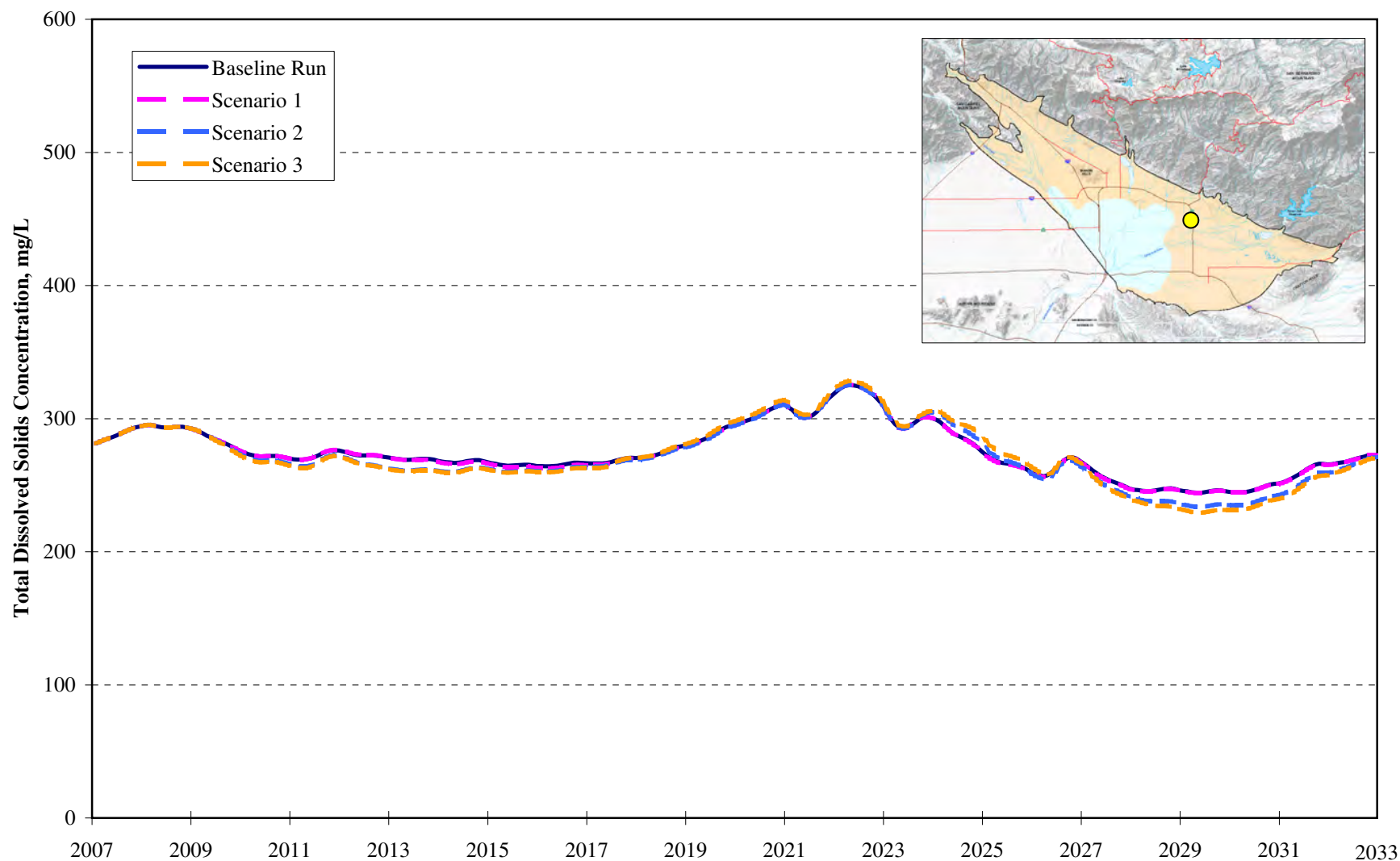


Total Dissolved Solids for City of San Bernardino Cajon Well No. 1 Model Runs 2007-2032

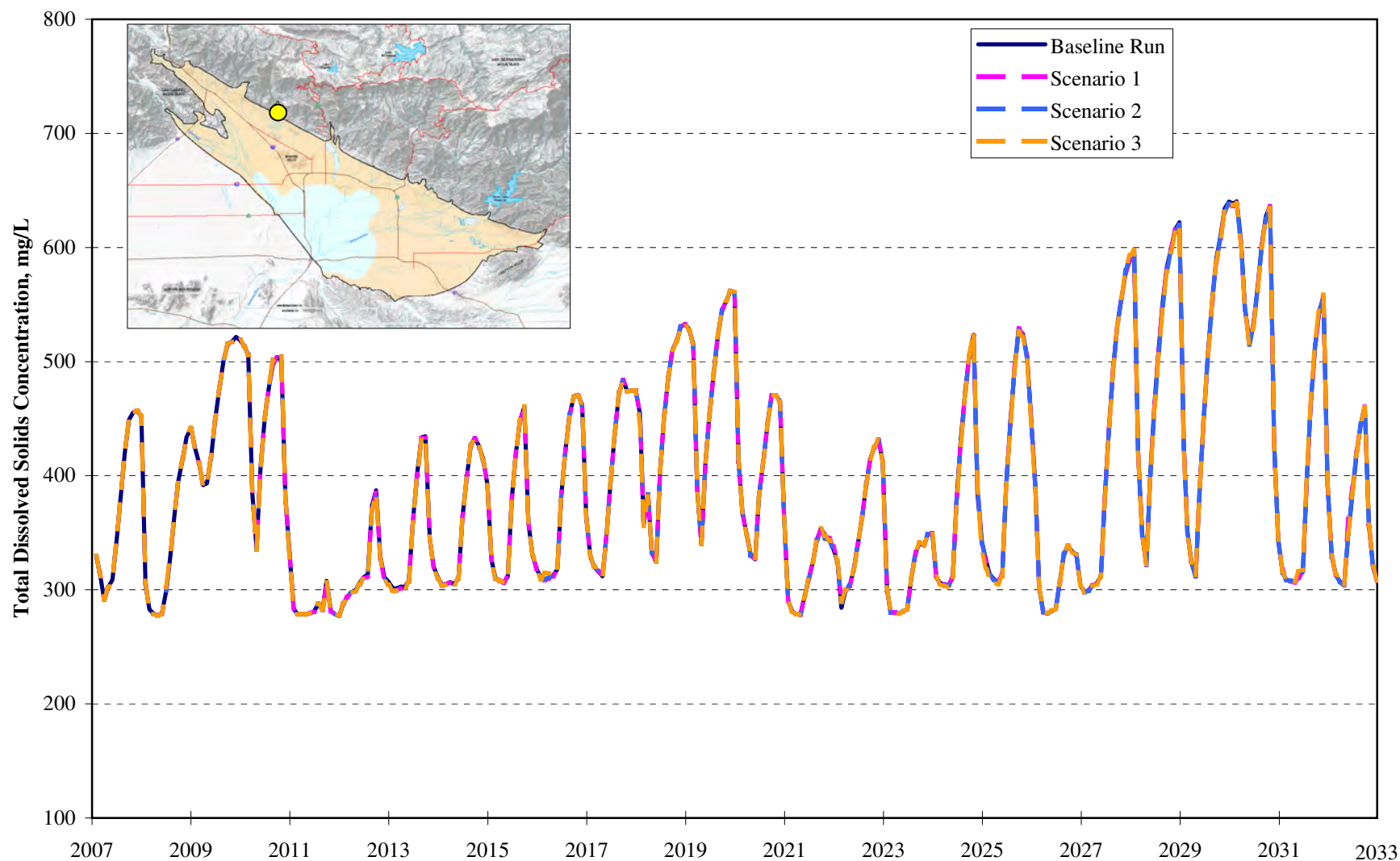


Appendix A

Total Dissolved Solids for East Valley Water District Well 40 Model Runs 2007-2032

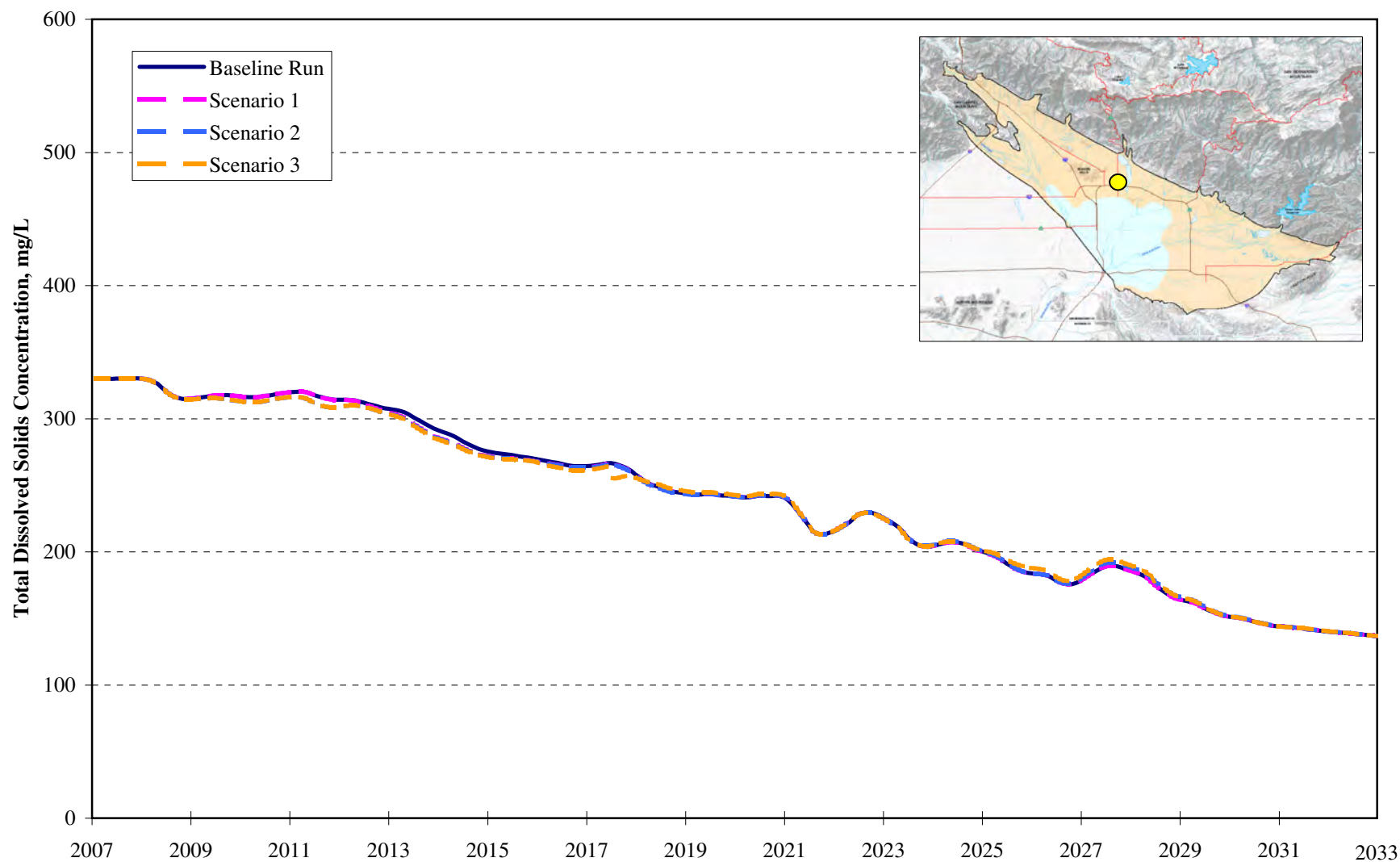


Total Dissolved Solids for City of San Bernardino Devil Canyon Well No. 3 Model Runs 2007-2032



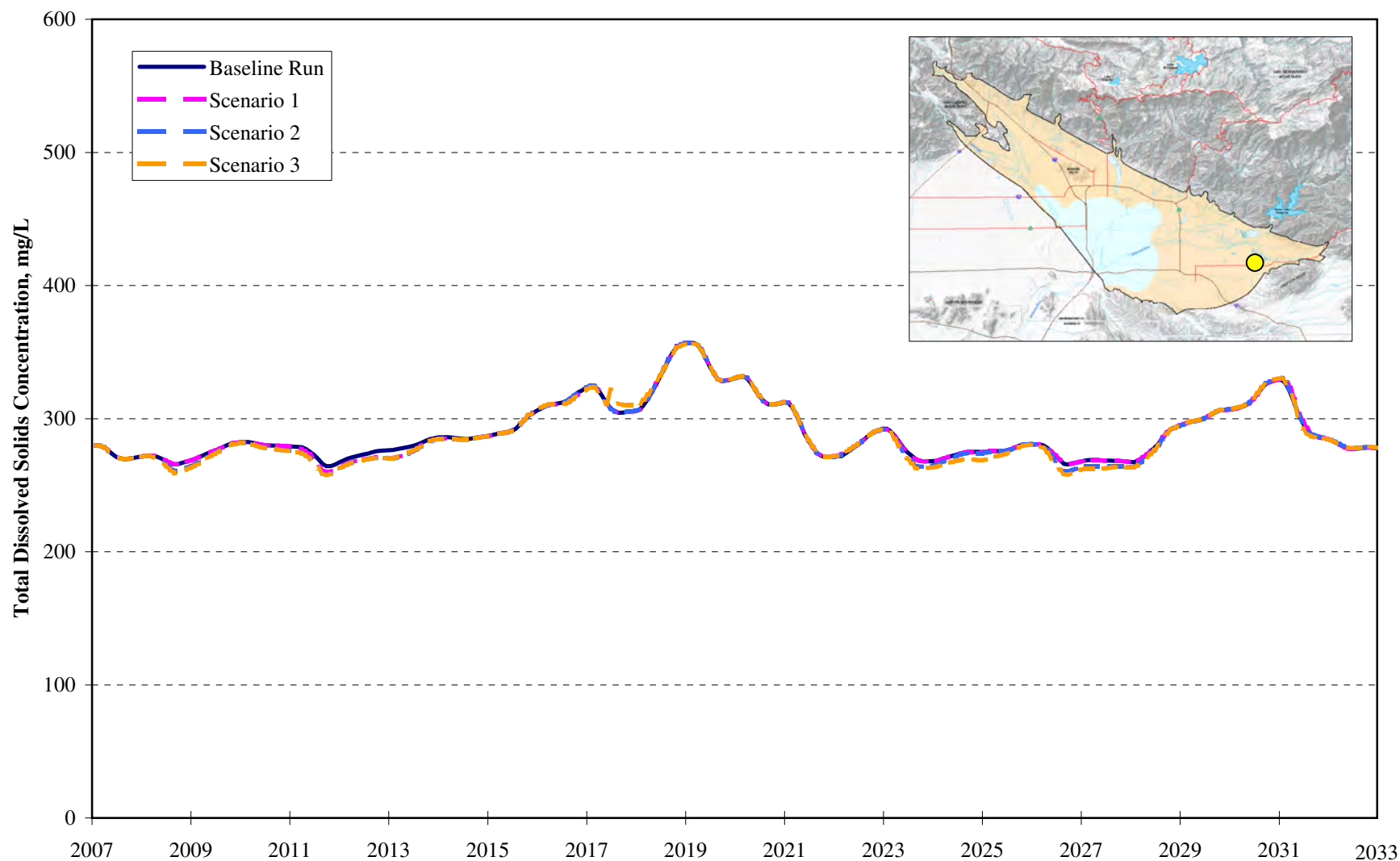
Appendix A

Total Dissolved Solids for City of San Bernardino Leroy Street Well Model Runs 2007-2032

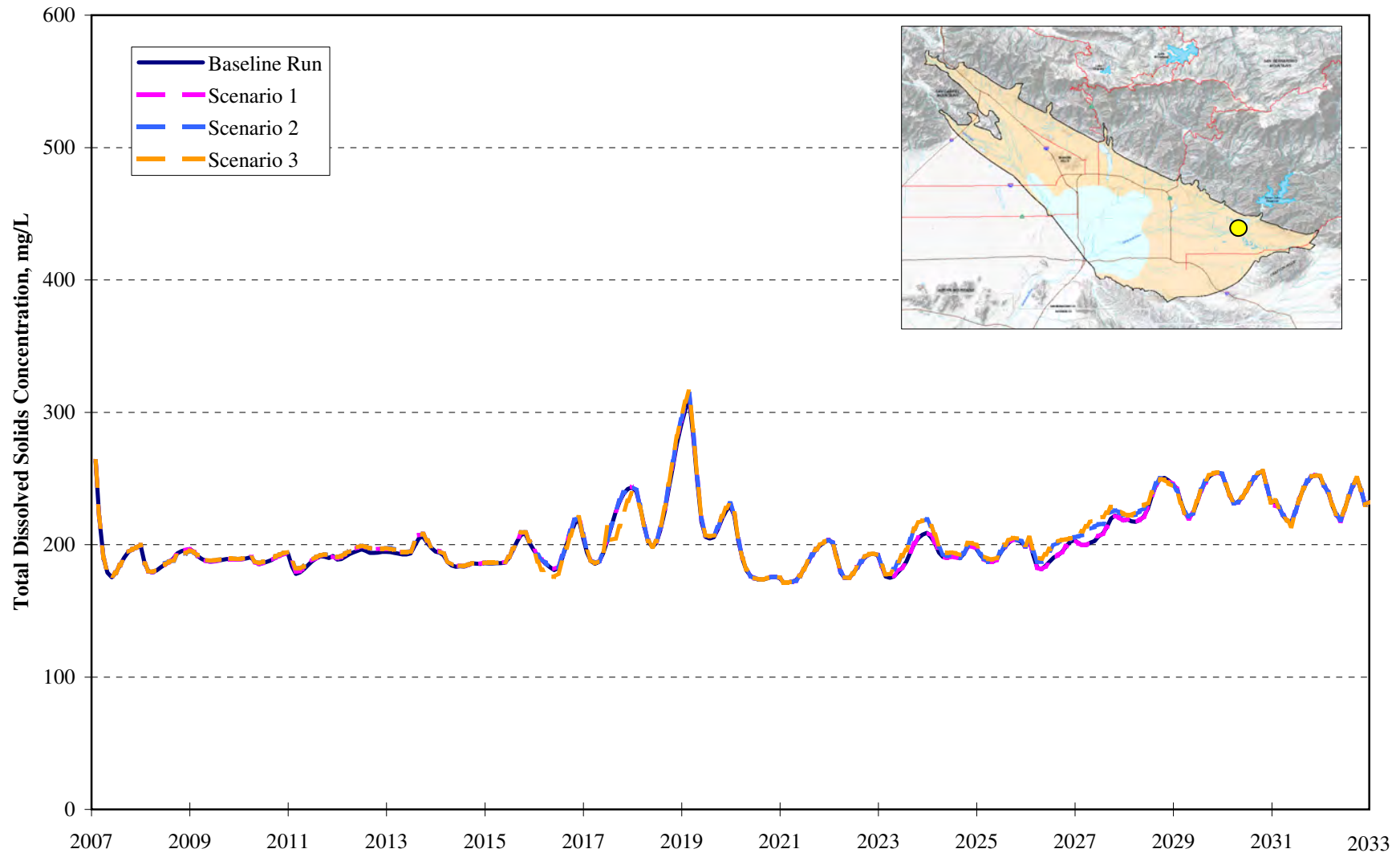


Appendix A

Total Dissolved Solids for City of Redlands Agate 2 Well Model Runs 2007-2032

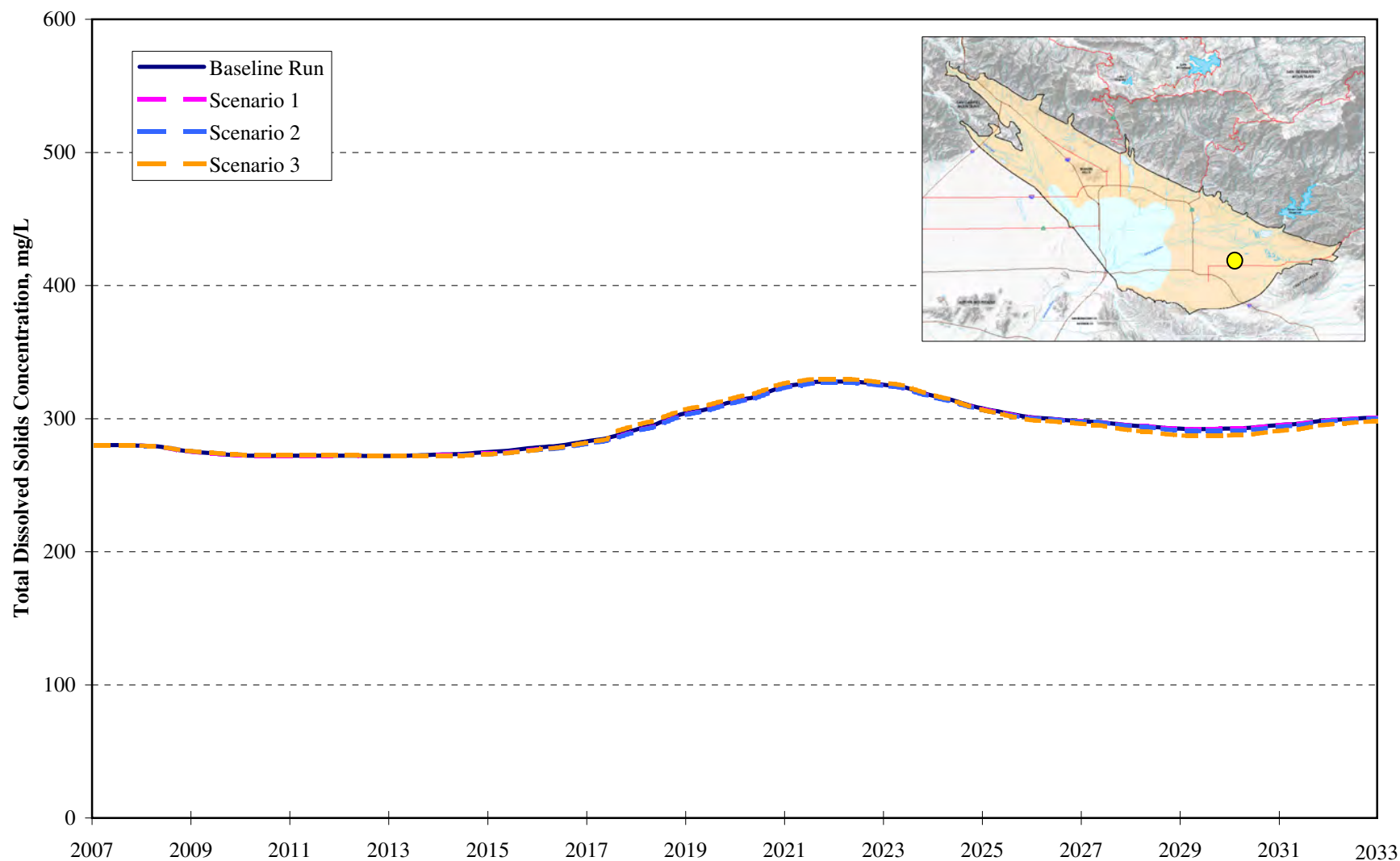


Total Dissolved Solids for East Valley Water District Cone Camp Well Model Runs 2007-2032



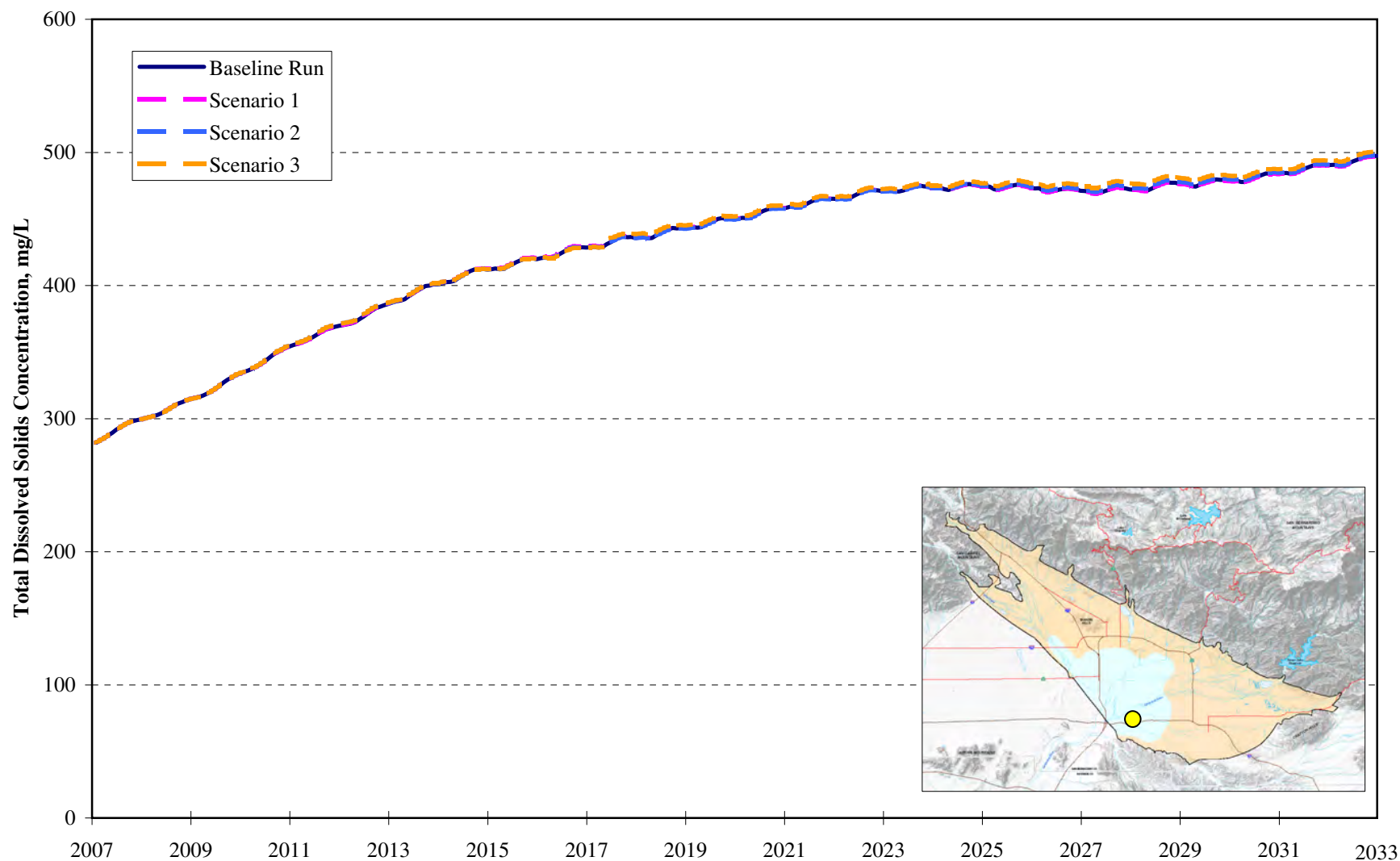
Appendix A

Total Dissolved Solids for Bear Valley Mutual Water Company Nelson Street Well Model Runs 2007-2032

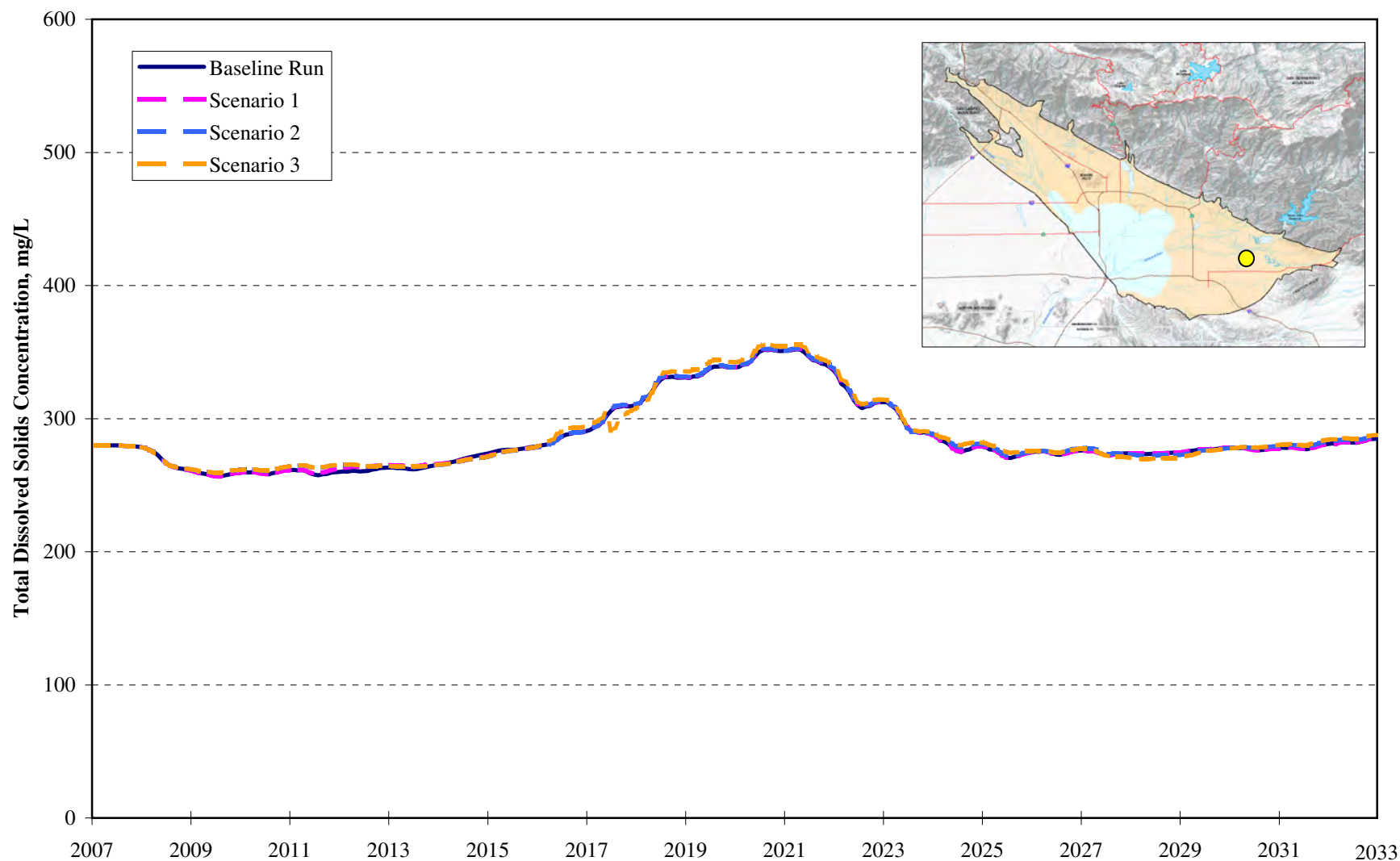


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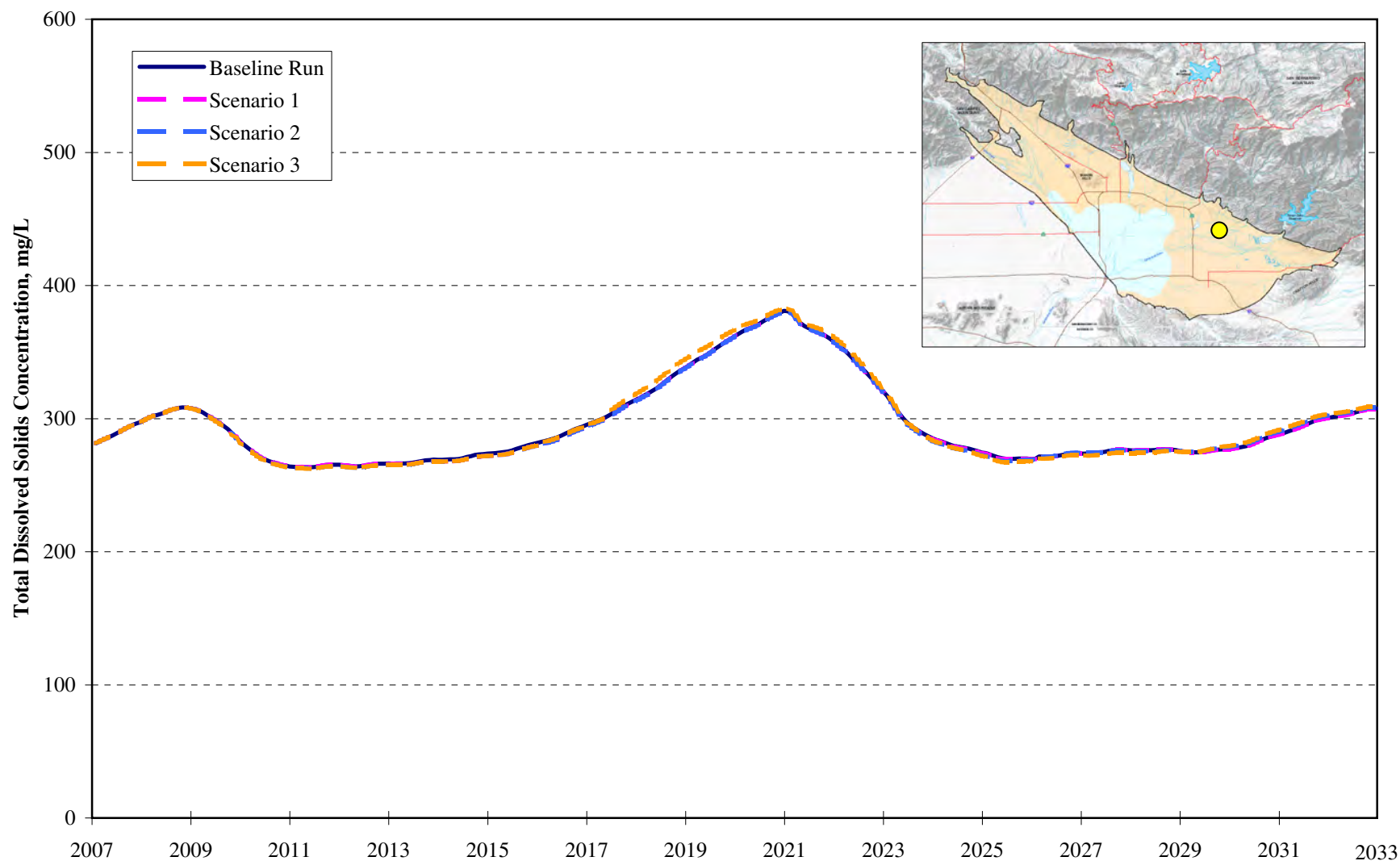
Total Dissolved Solids for Gage Canal Company Lower Kelly Well Model Runs 2007-2032



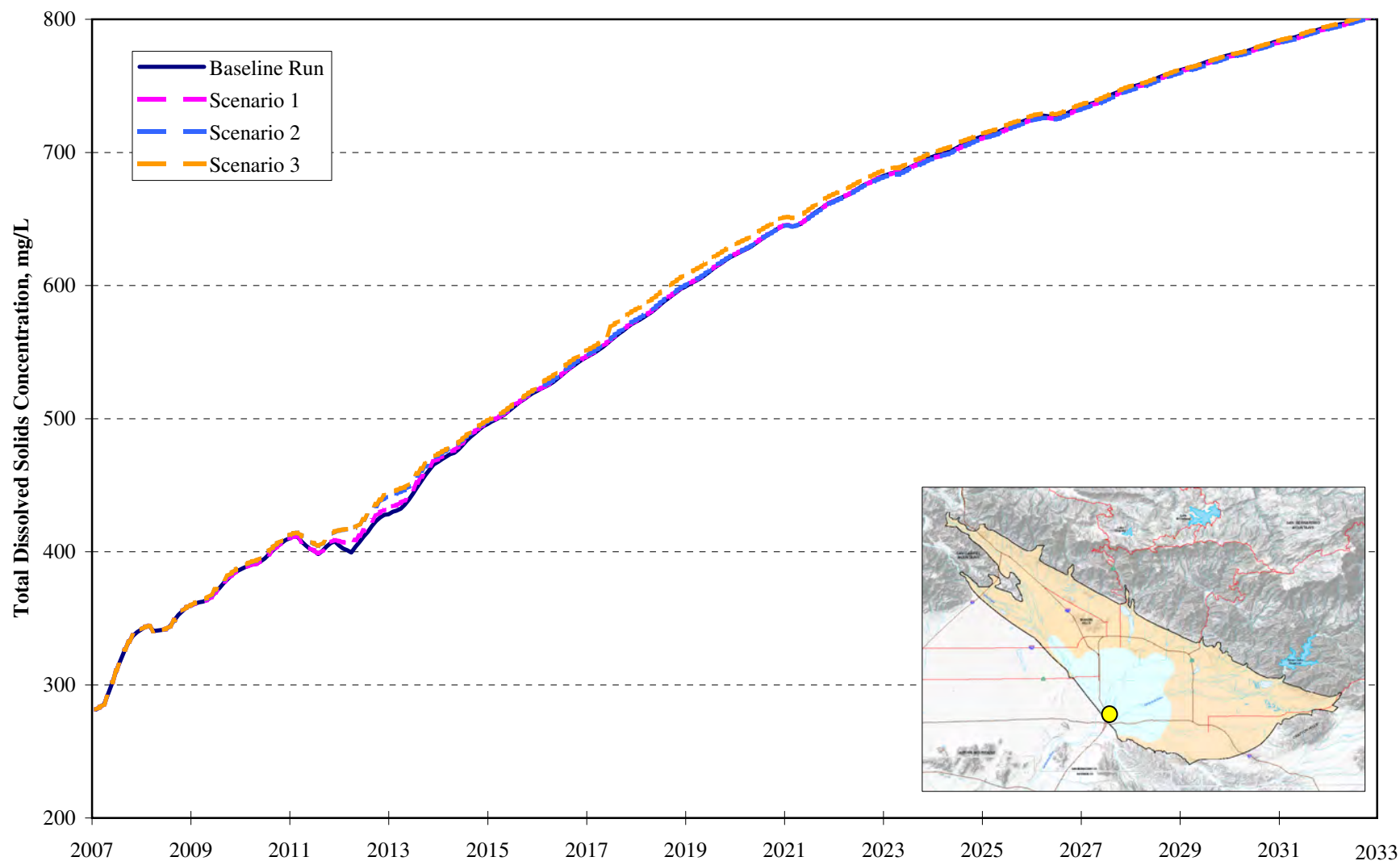
Total Dissolved Solids for City of Redlands Airport Well No. 2 Model Runs 2007-2032



Total Dissolved Solids for East Valley Water District Well 146A Model Runs 2007-2032



Total Dissolved Solids for SBVMWD Backyard Well Model Runs 2007-2032

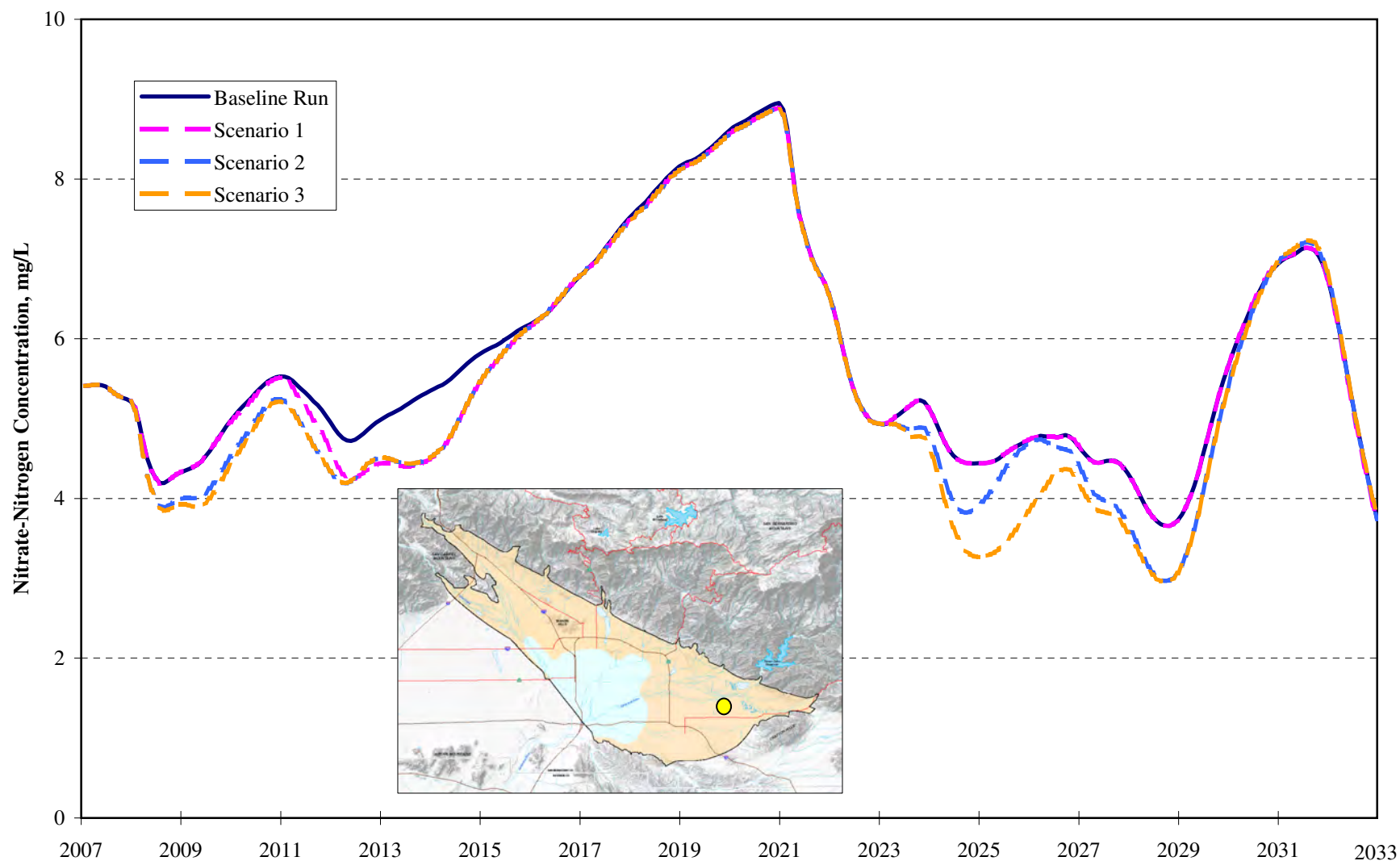


APPENDIX B
Nitrate-Nitrogen Concentrations for Predictive Model Scenarios in
Selected Wells – 2007 to 2032

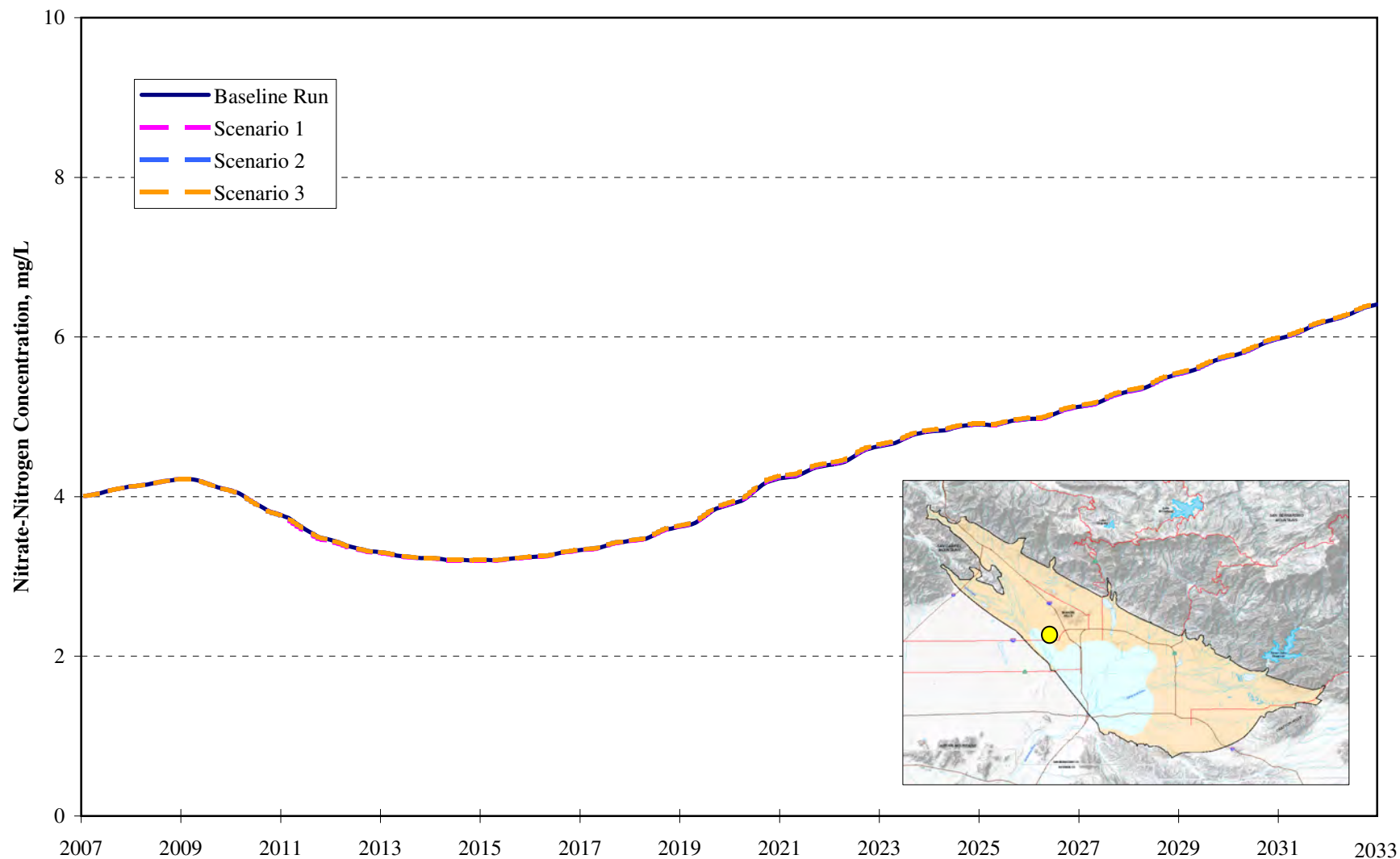
GEOSCIENCE Support Services, Inc.



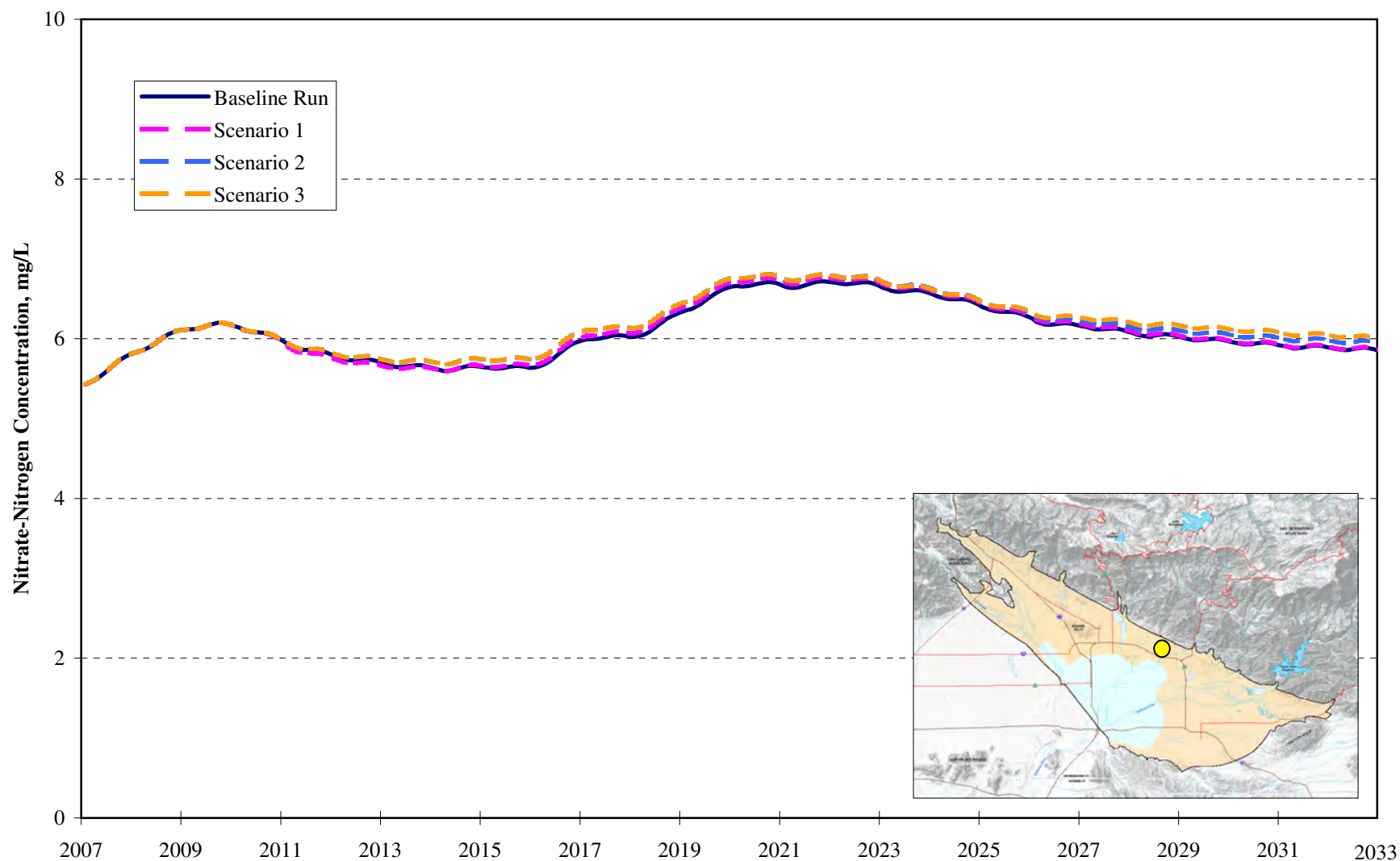
**Nitrate-Nitrogen for SBVMWD San Bernardino Ave. Well
Model Runs 2007-2032**



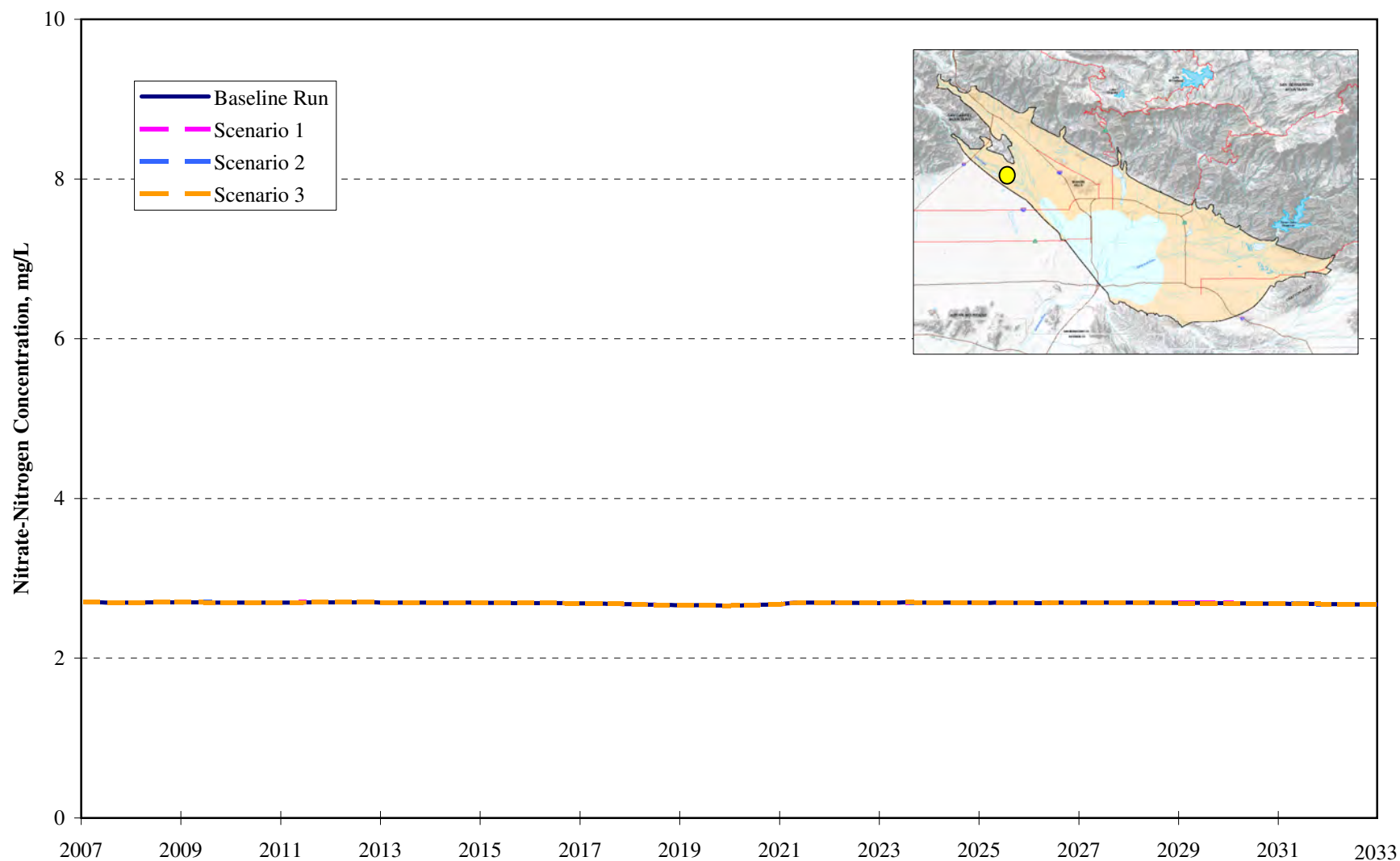
**Nitrate-Nitrogen for City of San Bernardino Mt. Vernon Well
Model Runs 2007-2032**



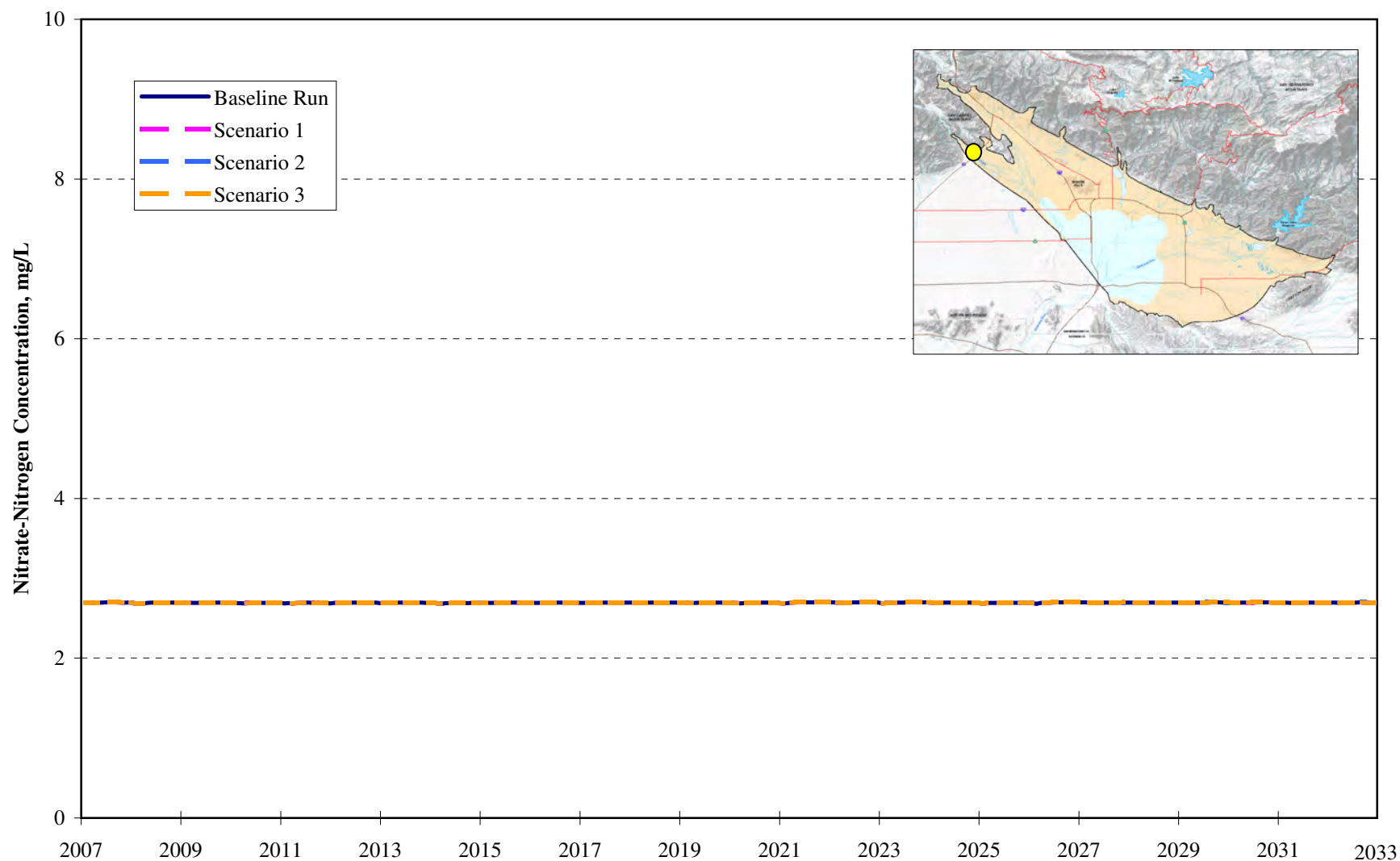
**Nitrate-Nitrogen for East Valley Water District Well 62
Model Runs 2007-2032**



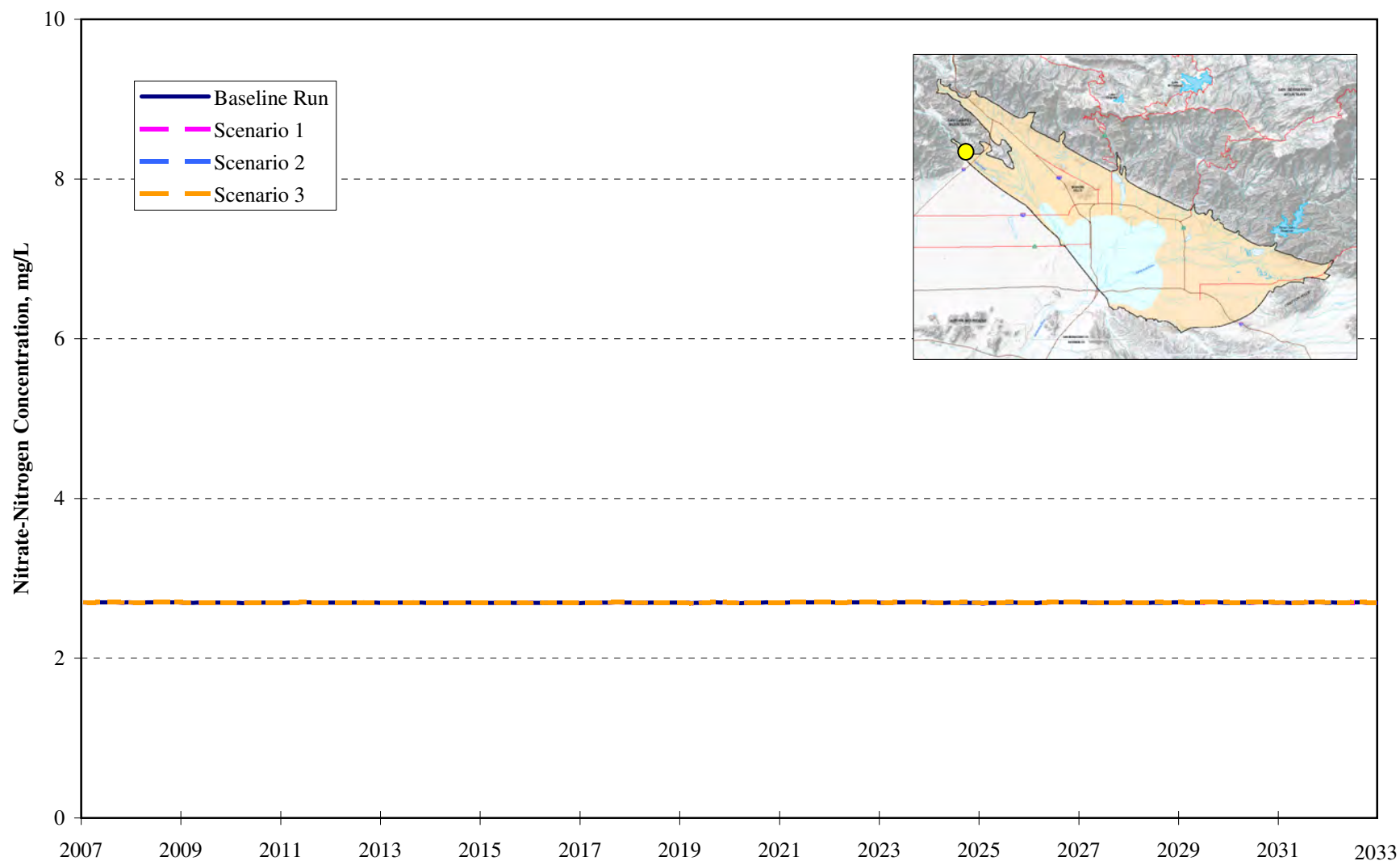
**Nitrate-Nitrogen for Fontana Union Water Company Well 13
Model Runs 2007-2032**



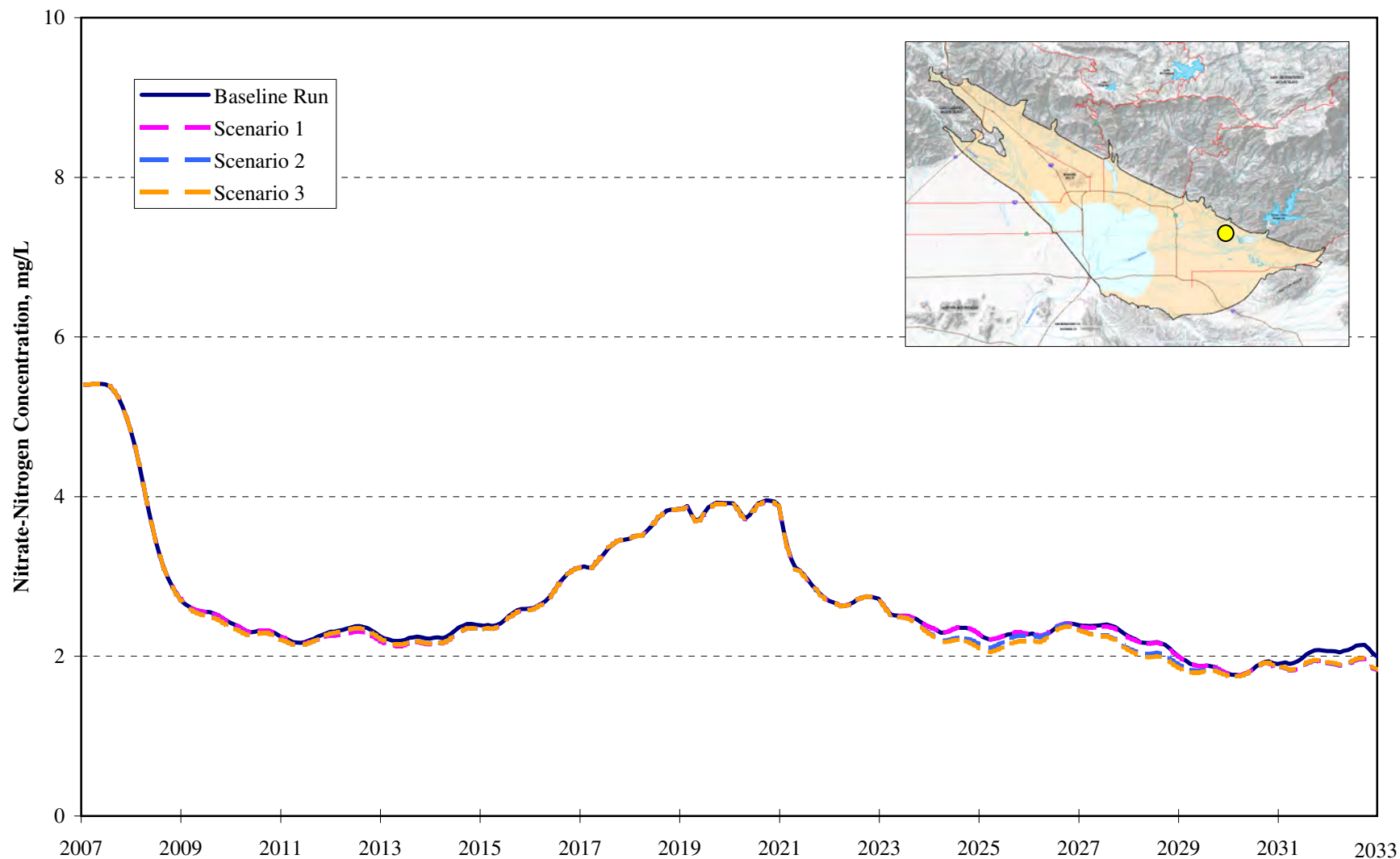
**Nitrate-Nitrogen for Fontana Union Water Company Well 26
Model Runs 2007-2032**



**Nitrate-Nitrogen for Fontana Union Water Company Well 27
Model Runs 2007-2032**

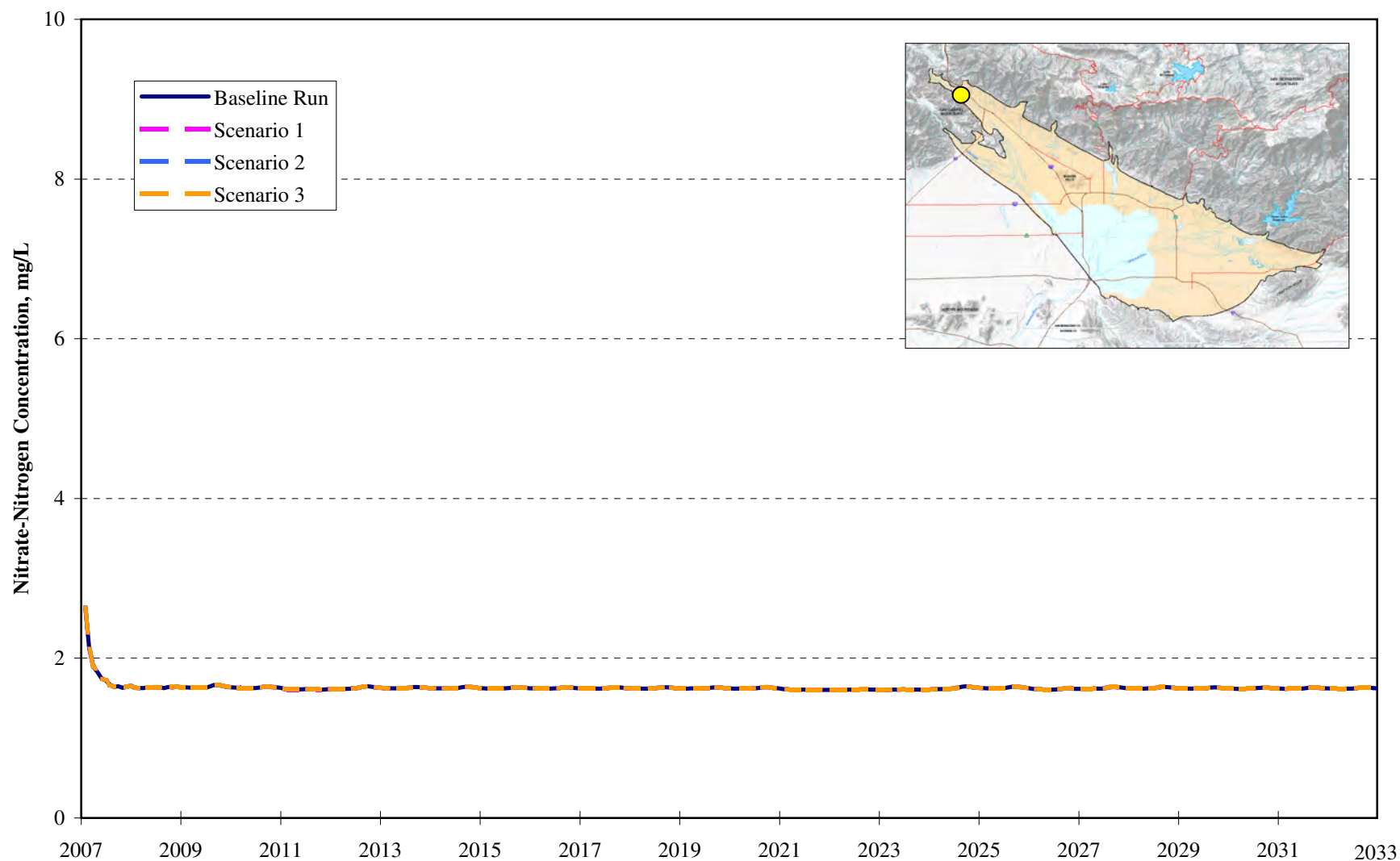


Nitrate-Nitrogen for East Valley Water District Well 120 Model Runs 2007-2032

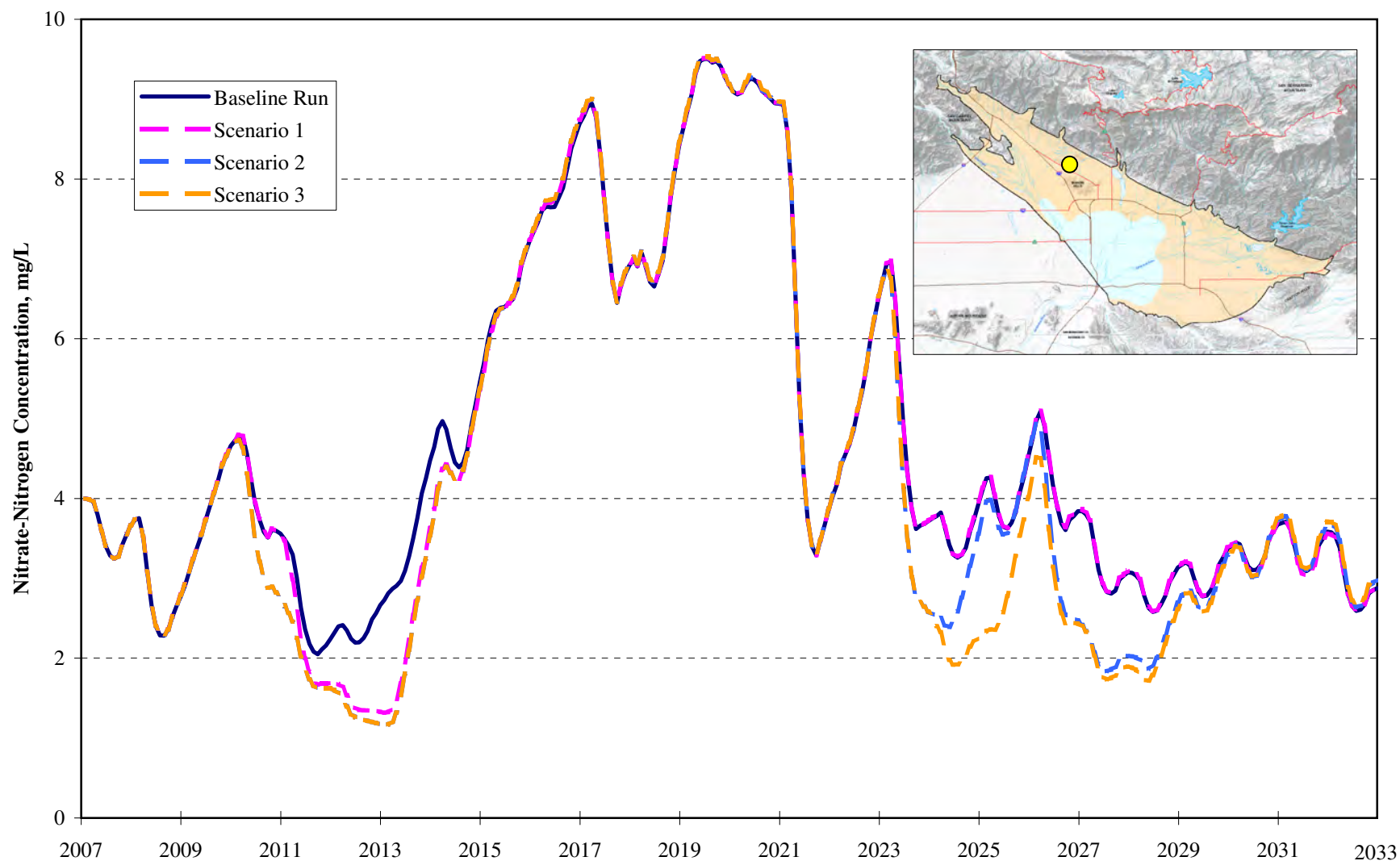


Appendix B

**Nitrate-Nitrogen for City of San Bernardino Vincent Well
Model Runs 2007-2032**

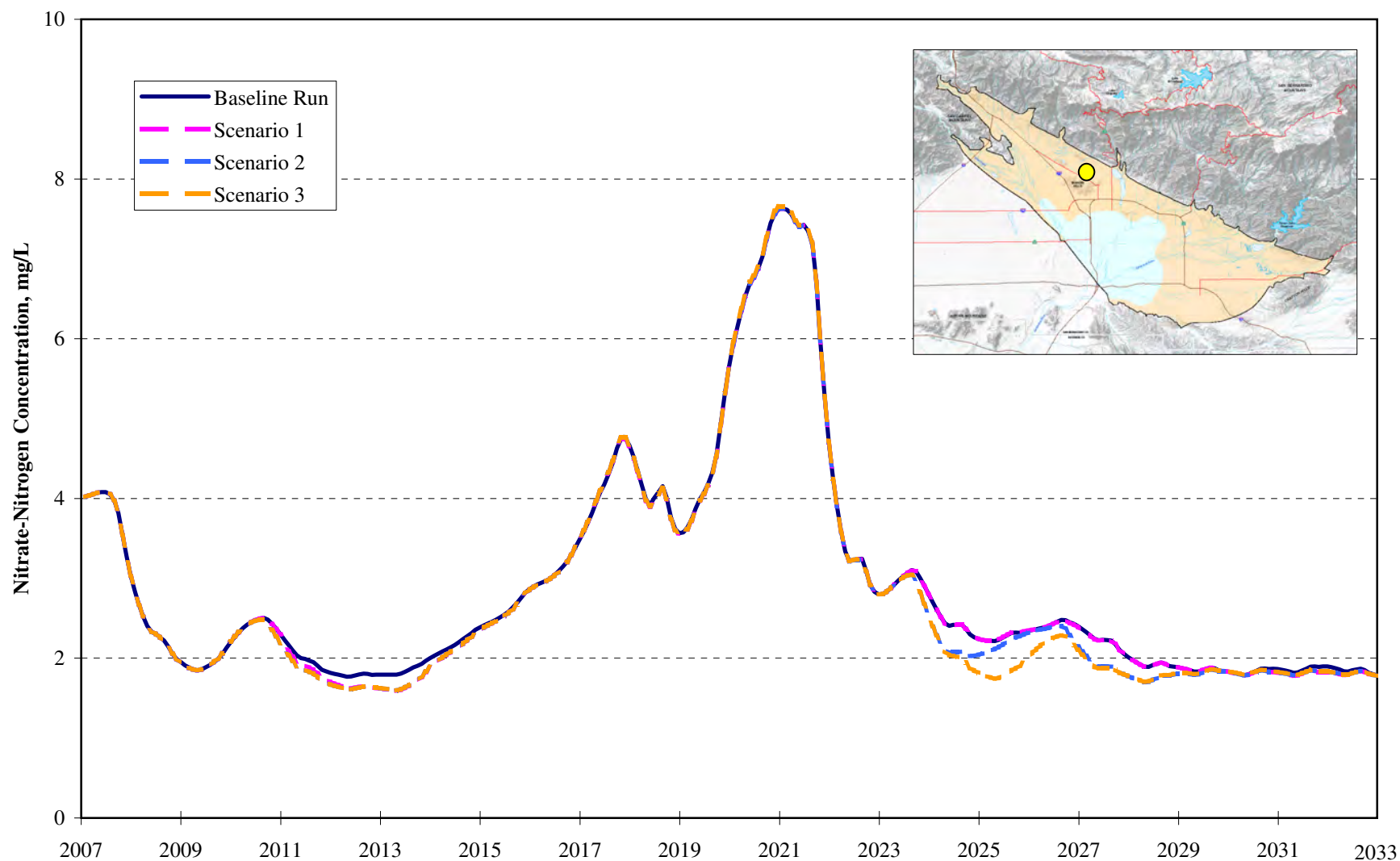


Nitrate-Nitrogen for City of San Bernardino Devil Canyon Well No. 1 Model Runs 2007-2032



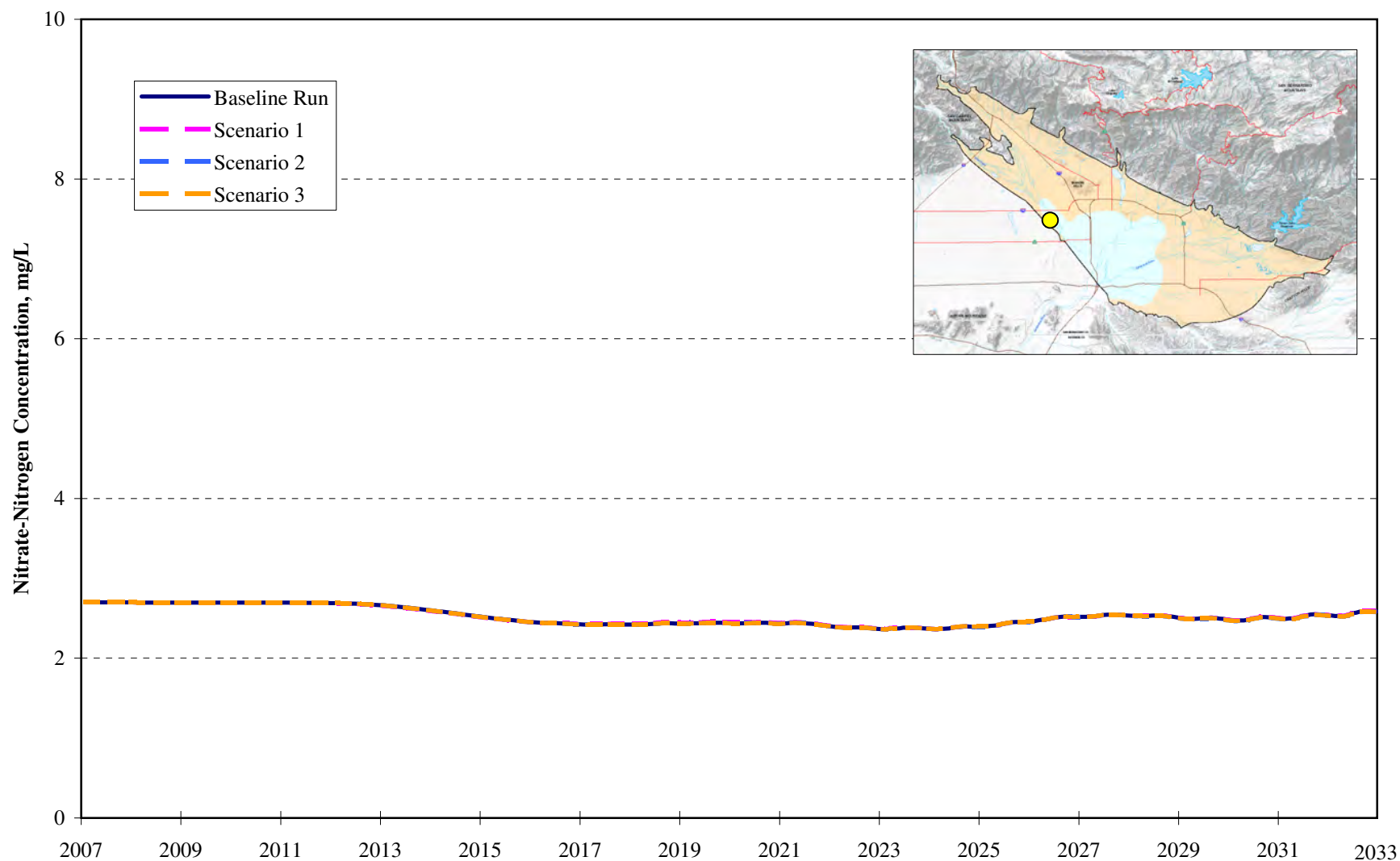
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Nitrate-Nitrogen for City of San Bernardino Newmark 3 Well Model Runs 2007-2032

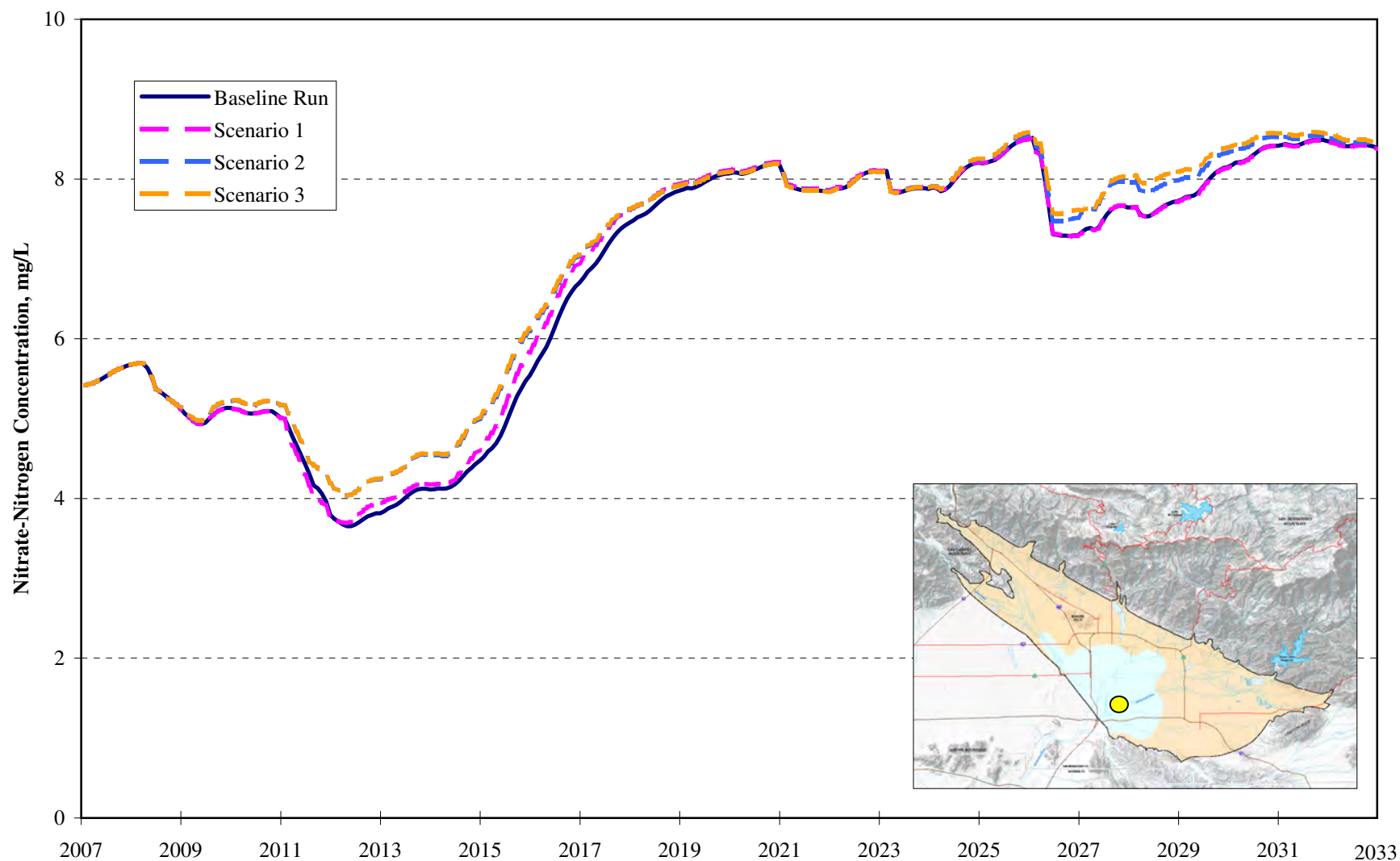


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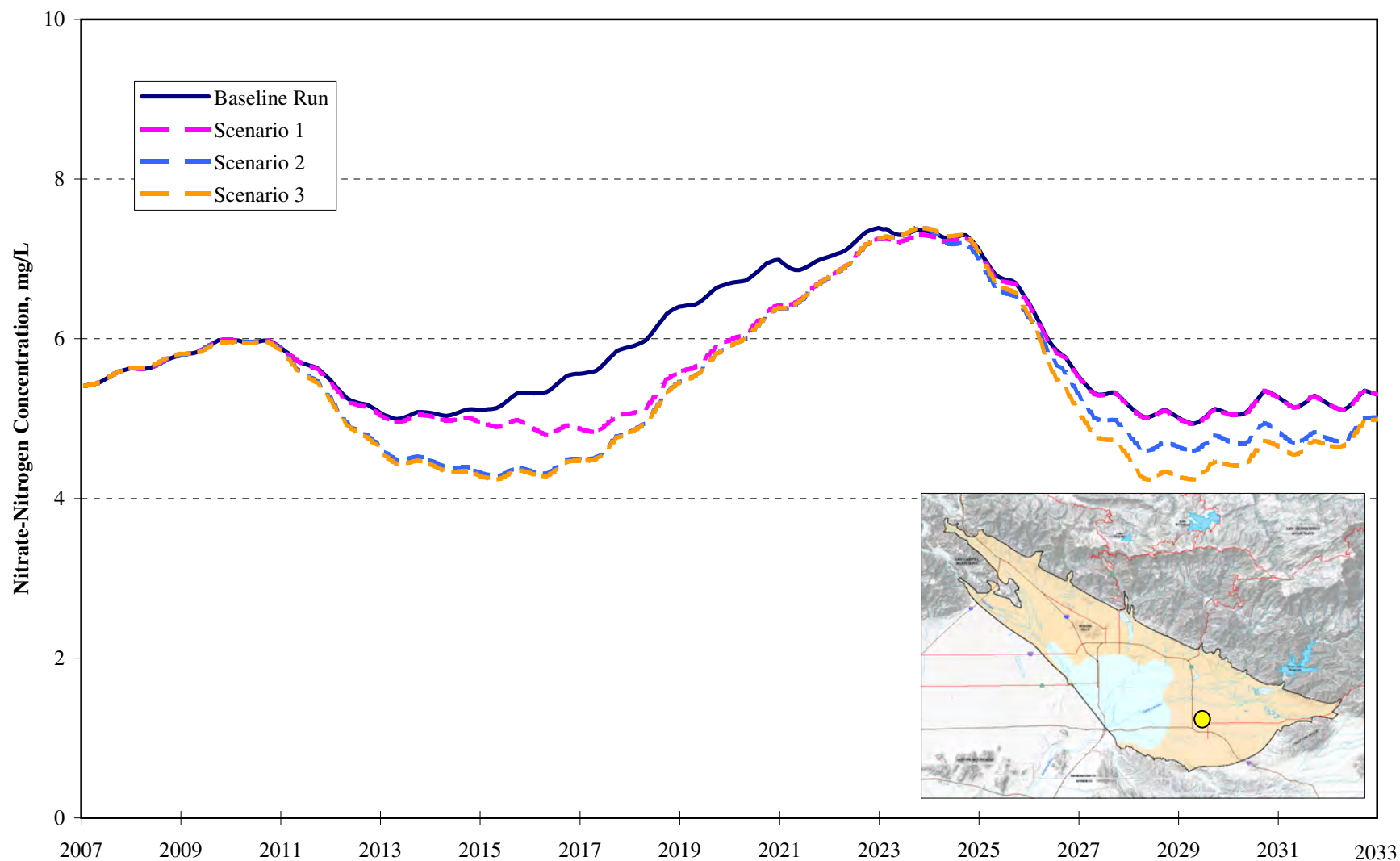
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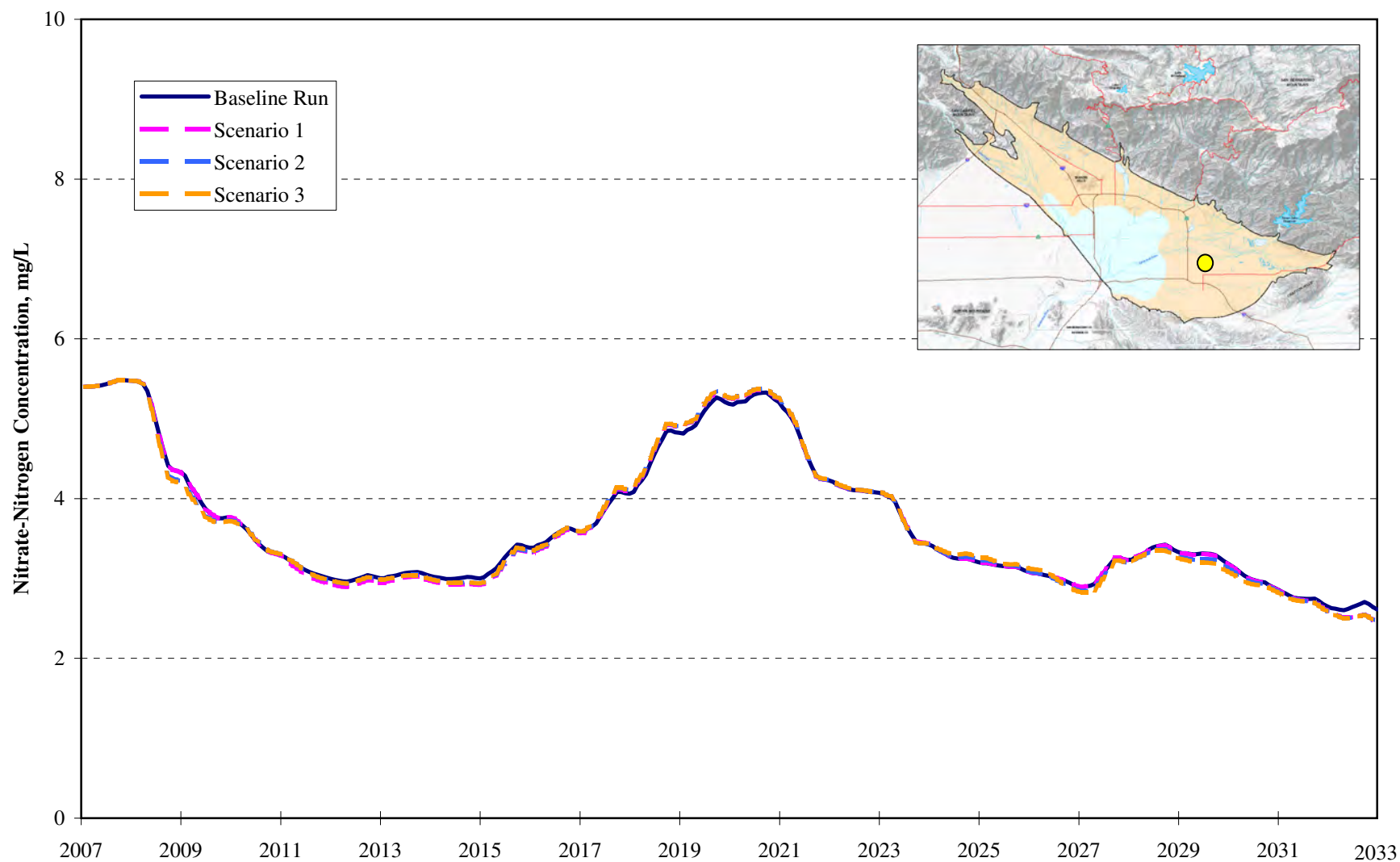
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Nitrate-Nitrogen for City of Redlands Well 32 Model Runs 2007-2032

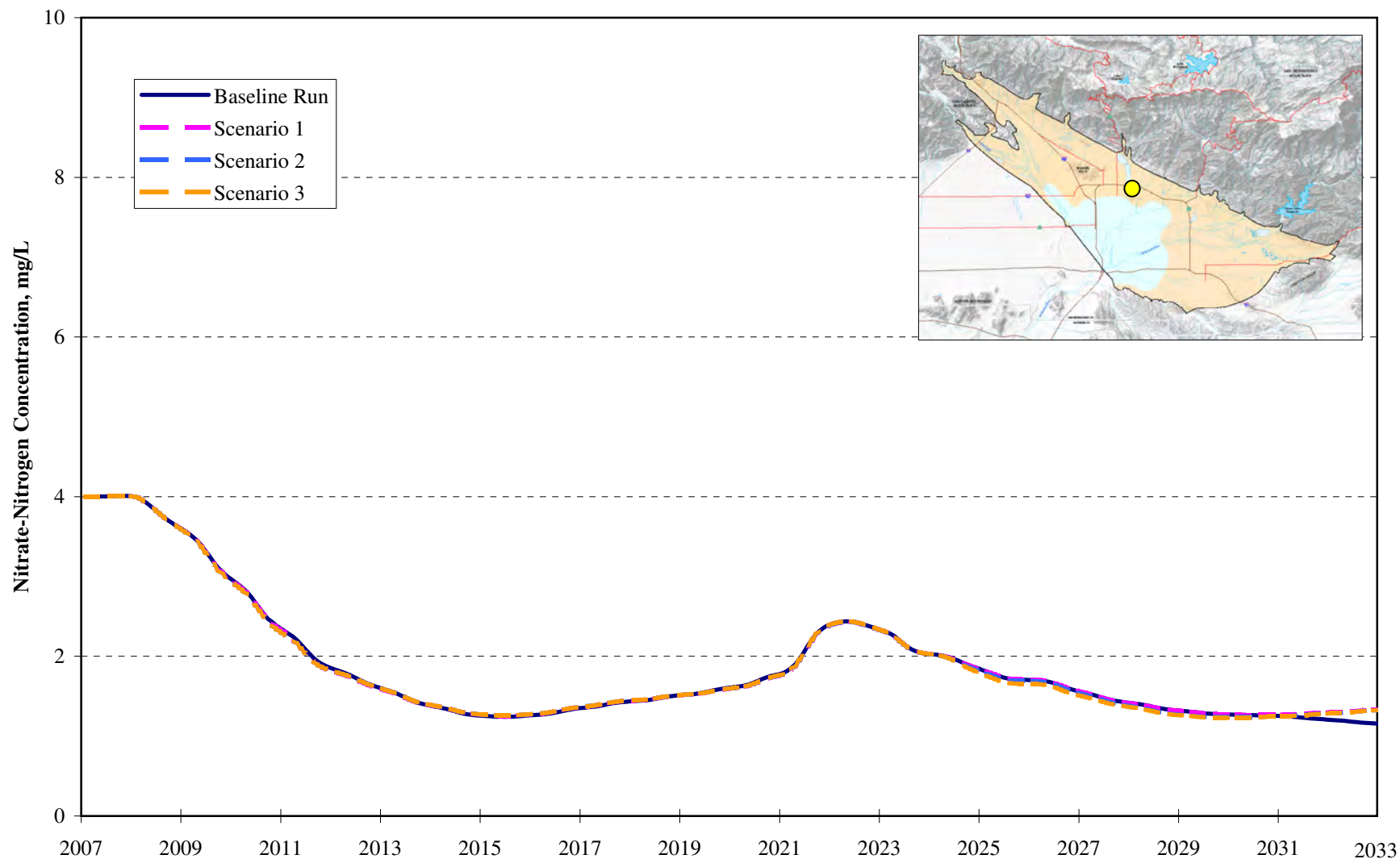


Nitrate-Nitrogen for City of Redlands Orange Street Well Model Runs 2007-2032



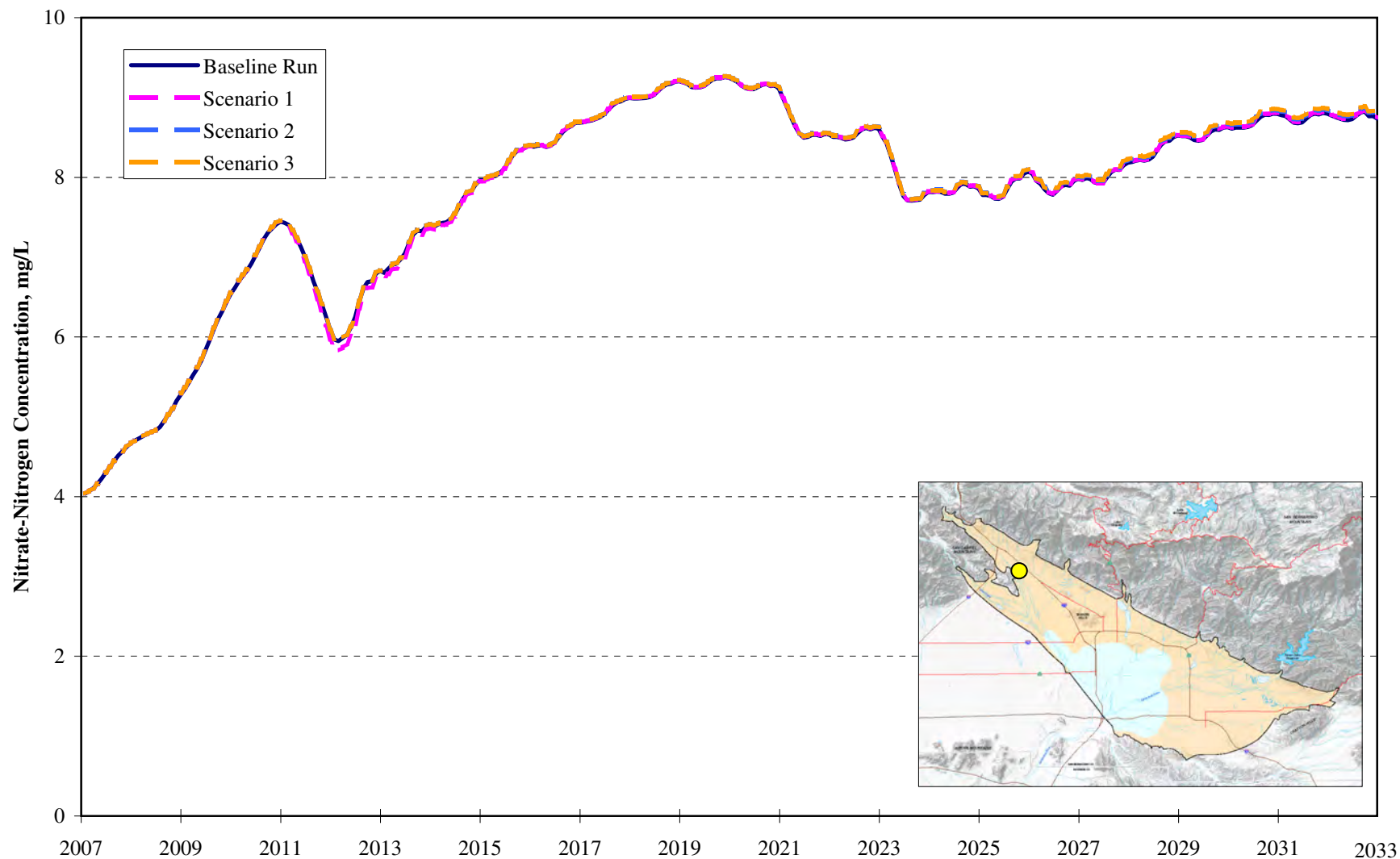
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Nitrate-Nitrogen for East Valley Water District Well 24A Model Runs 2007-2032

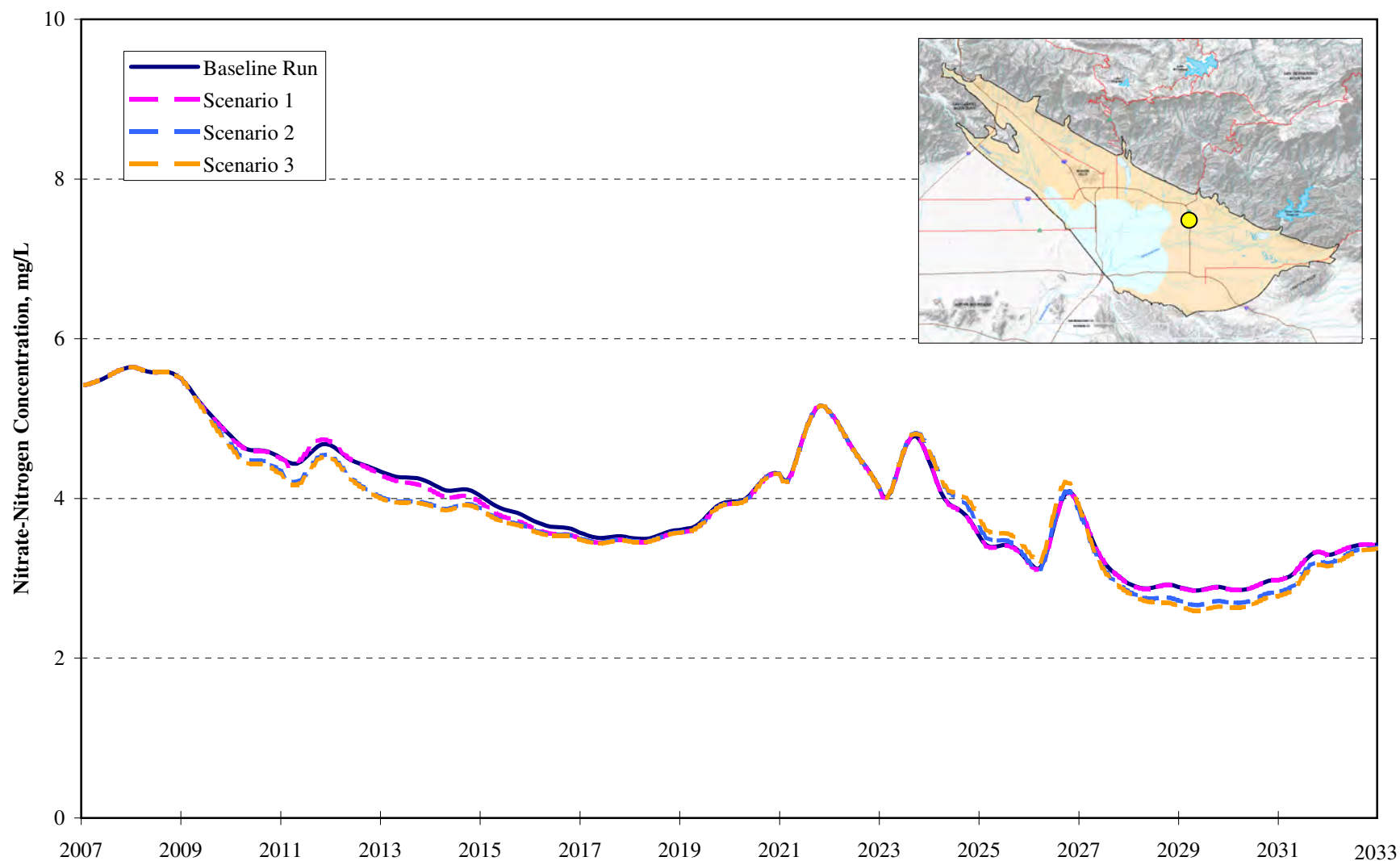


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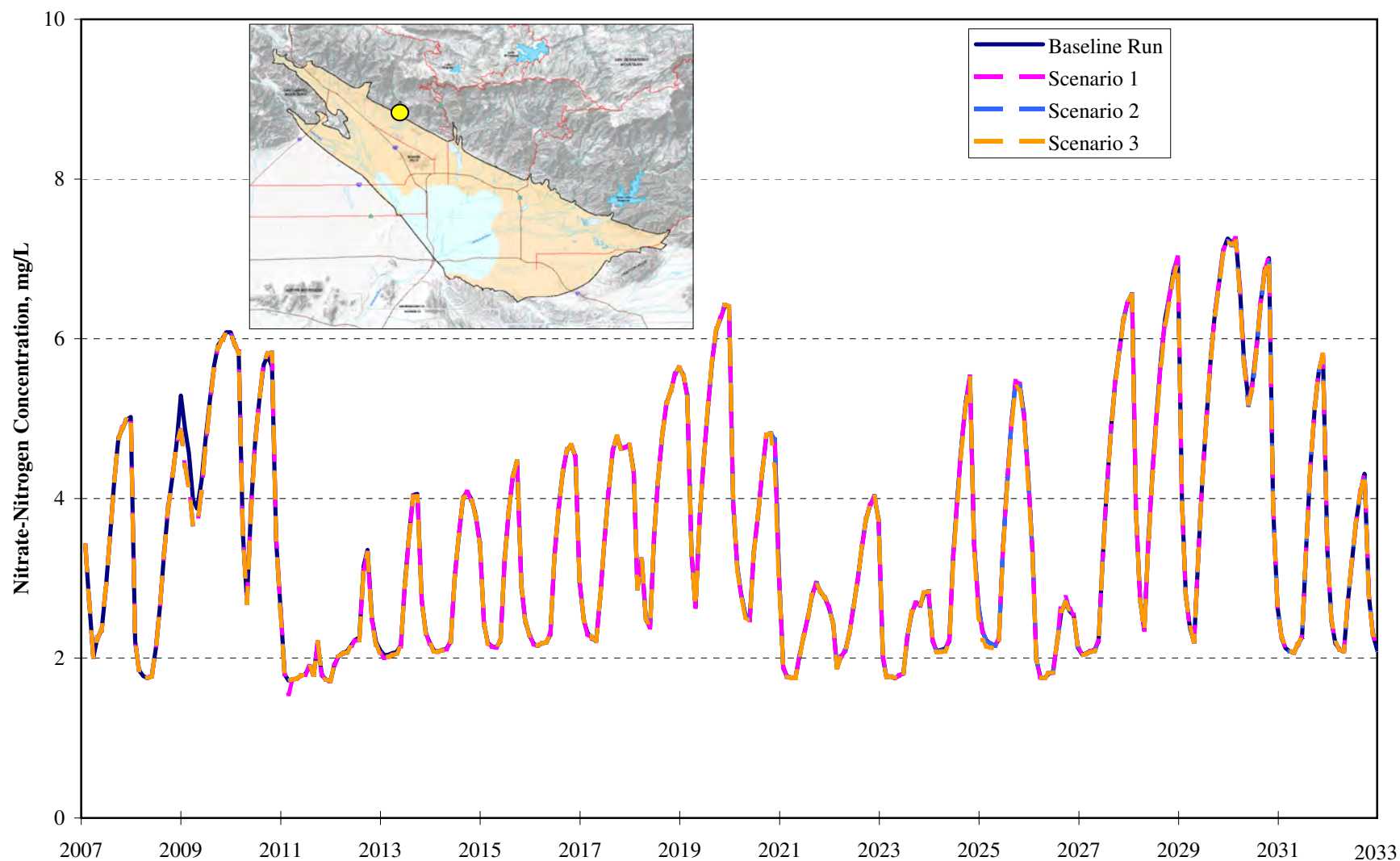
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Model Runs 2007-2032**



Nitrate-Nitrogen for East Valley Water District Well 40 Model Runs 2007-2032

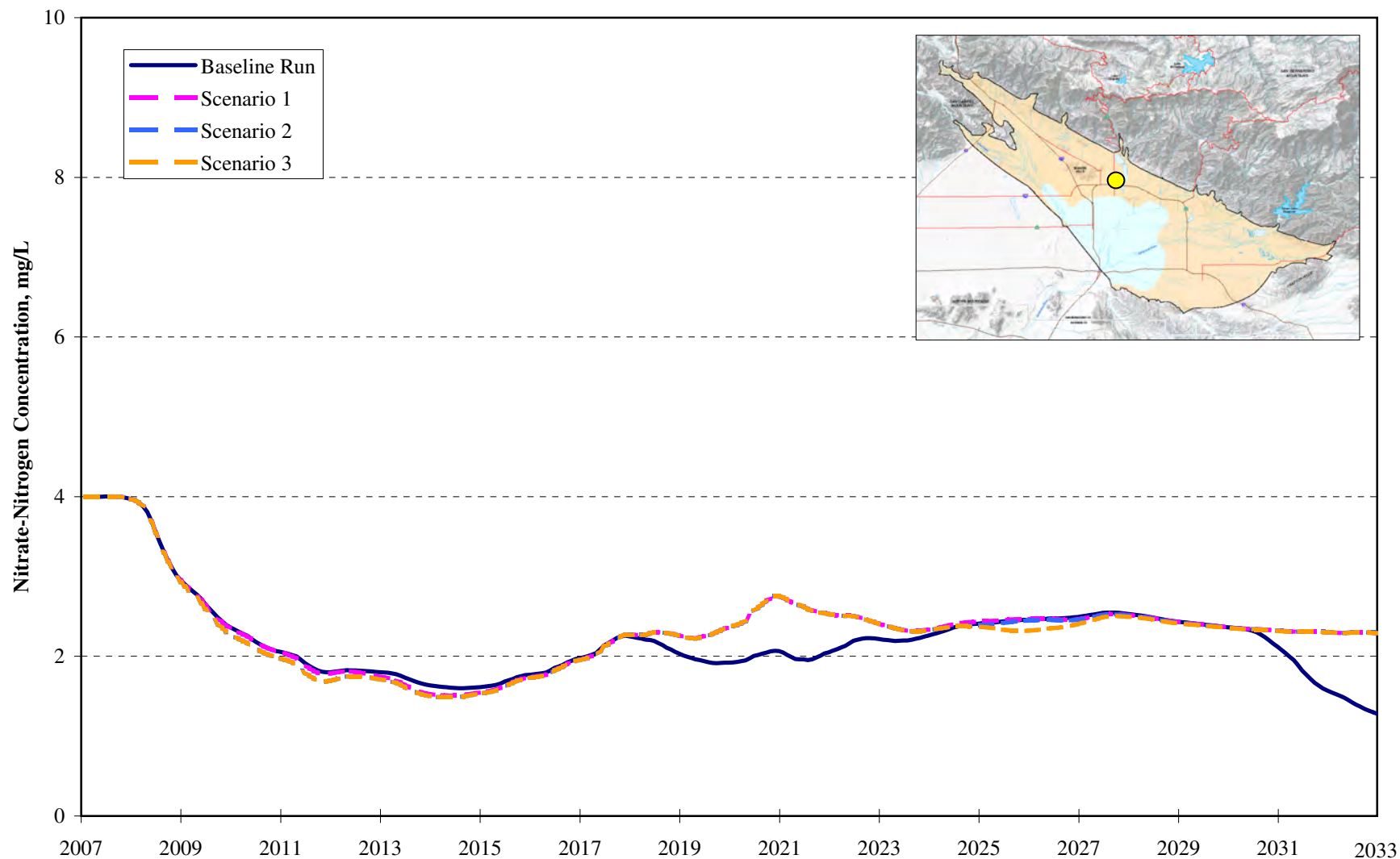


Nitrate-Nitrogen for City of San Bernardino Devil Canyon Well No. 3 Model Runs 2007-2032



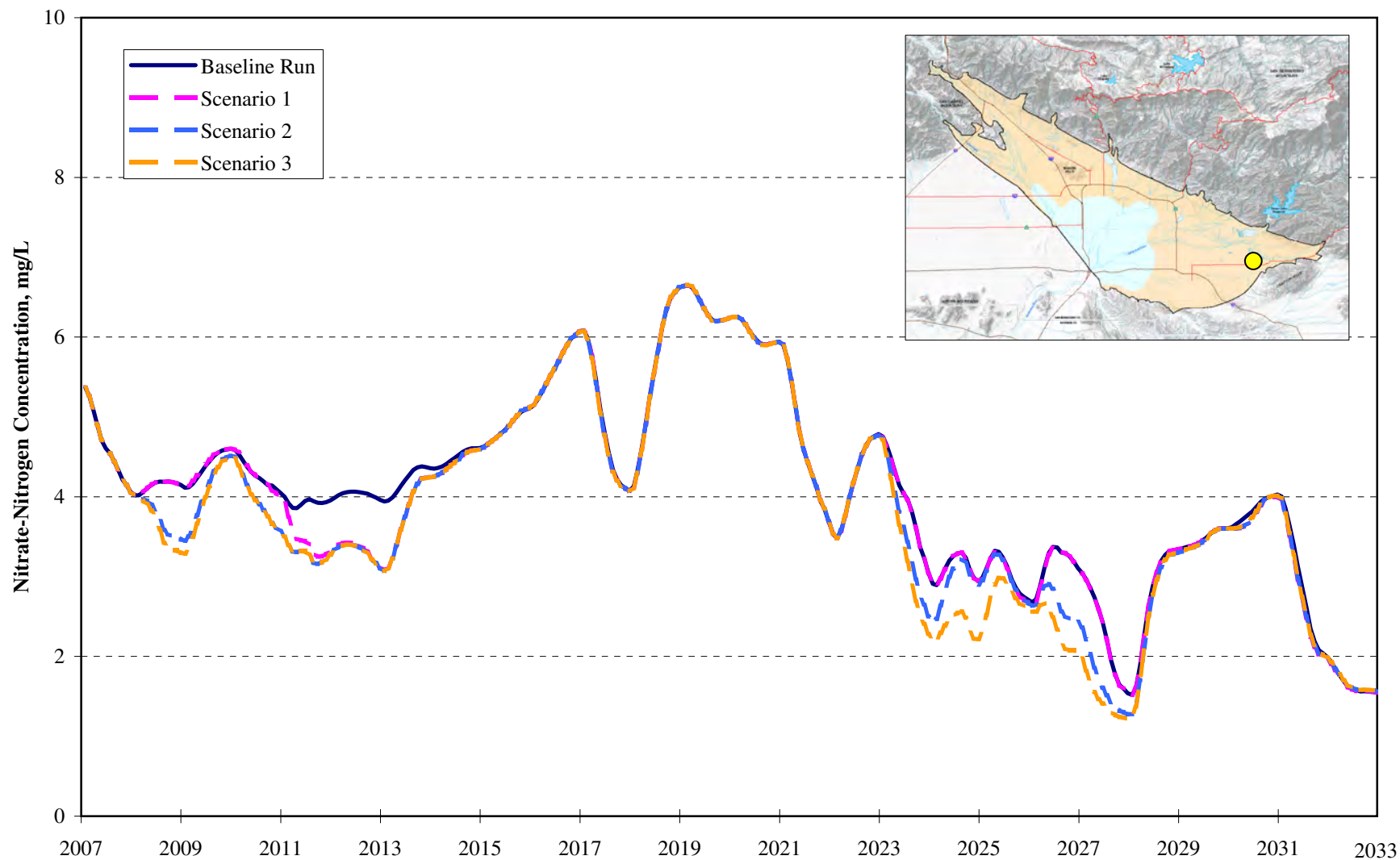
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**Nitrate-Nitrogen for City of San Bernardino Leroy Street Well
Model Runs 2007-2032**



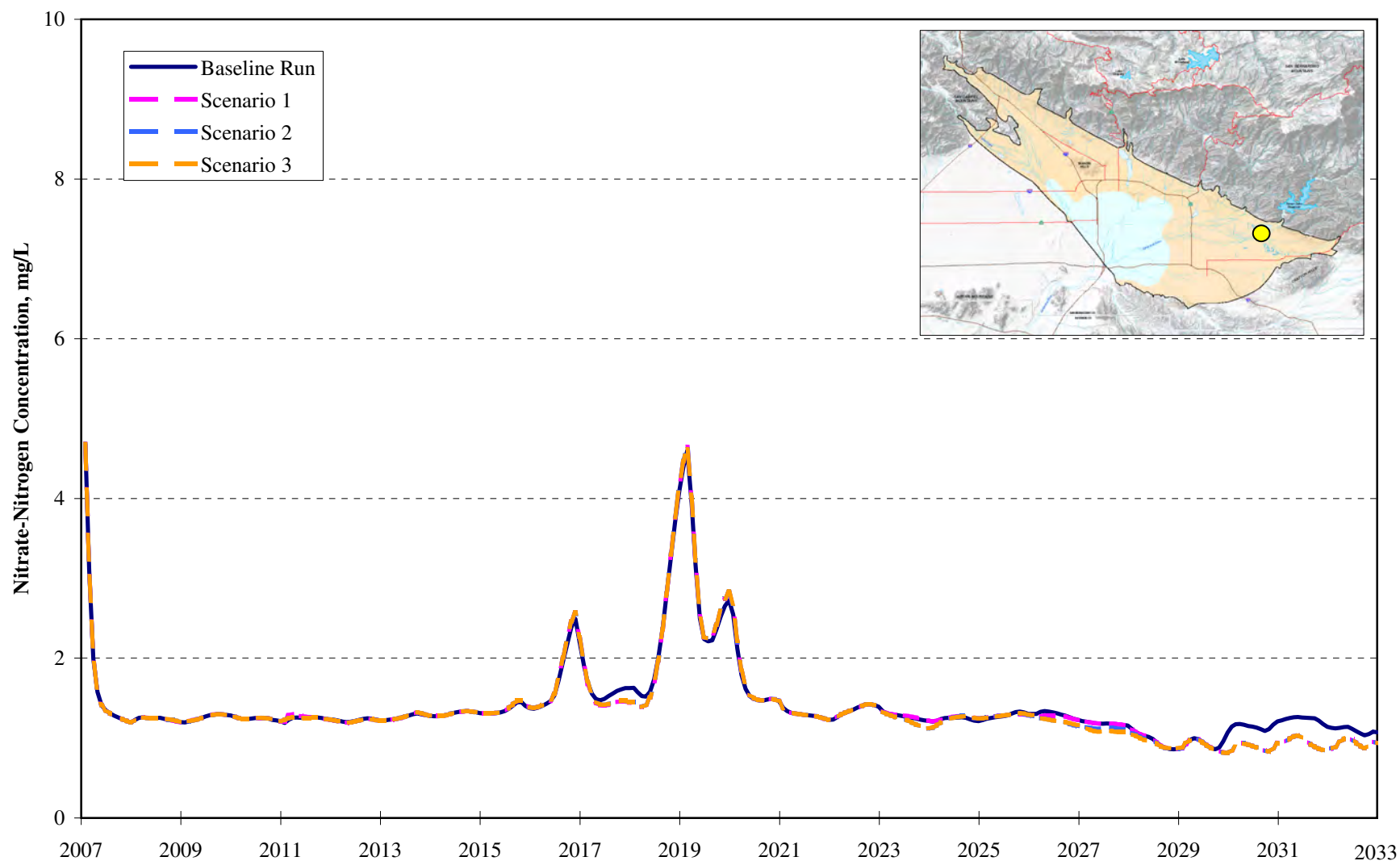
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Nitrate-Nitrogen for City of Redlands Agate 2 Well Model Runs 2007-2032



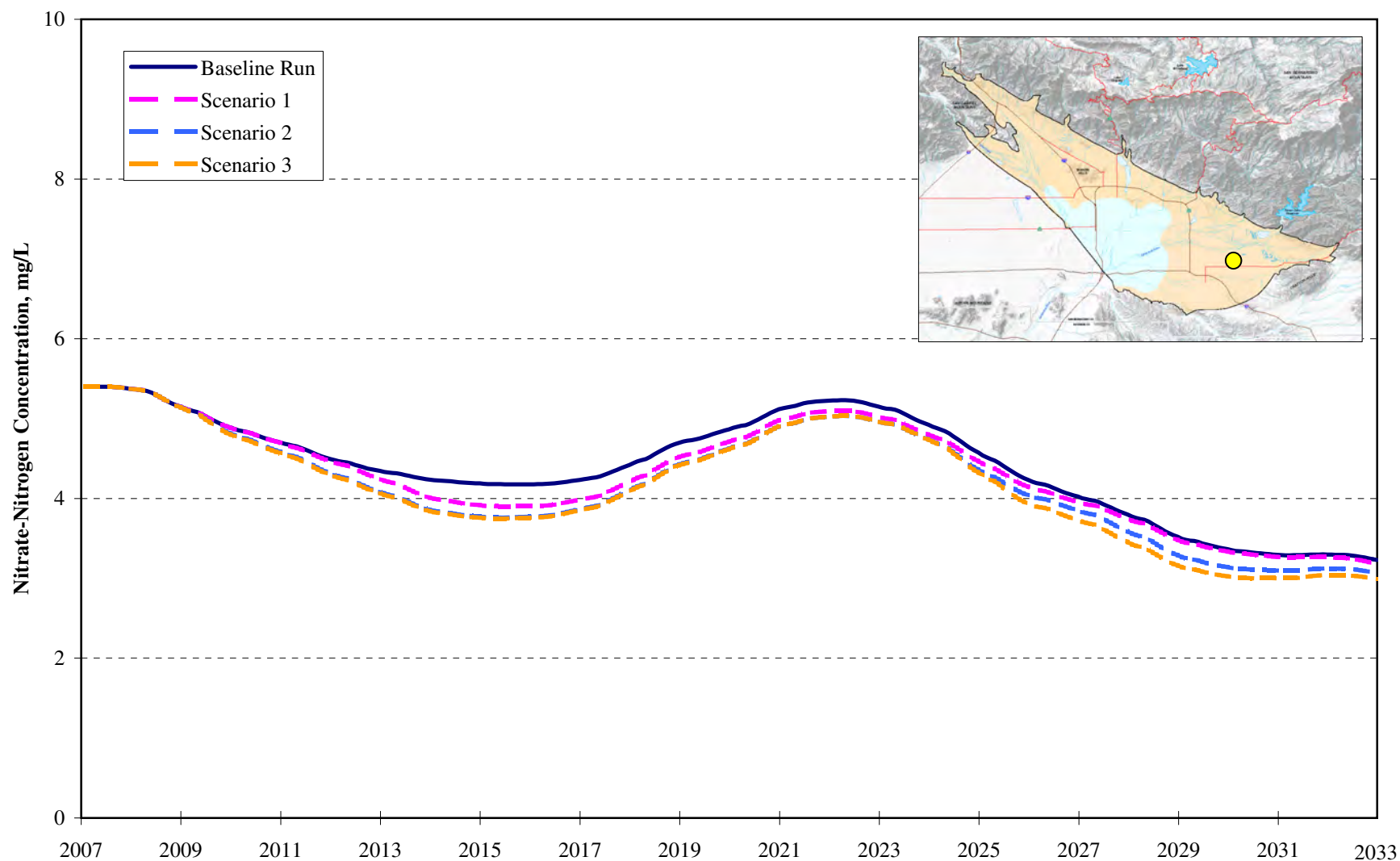
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**Nitrate-Nitrogen for East Valley Water District Cone Camp Well
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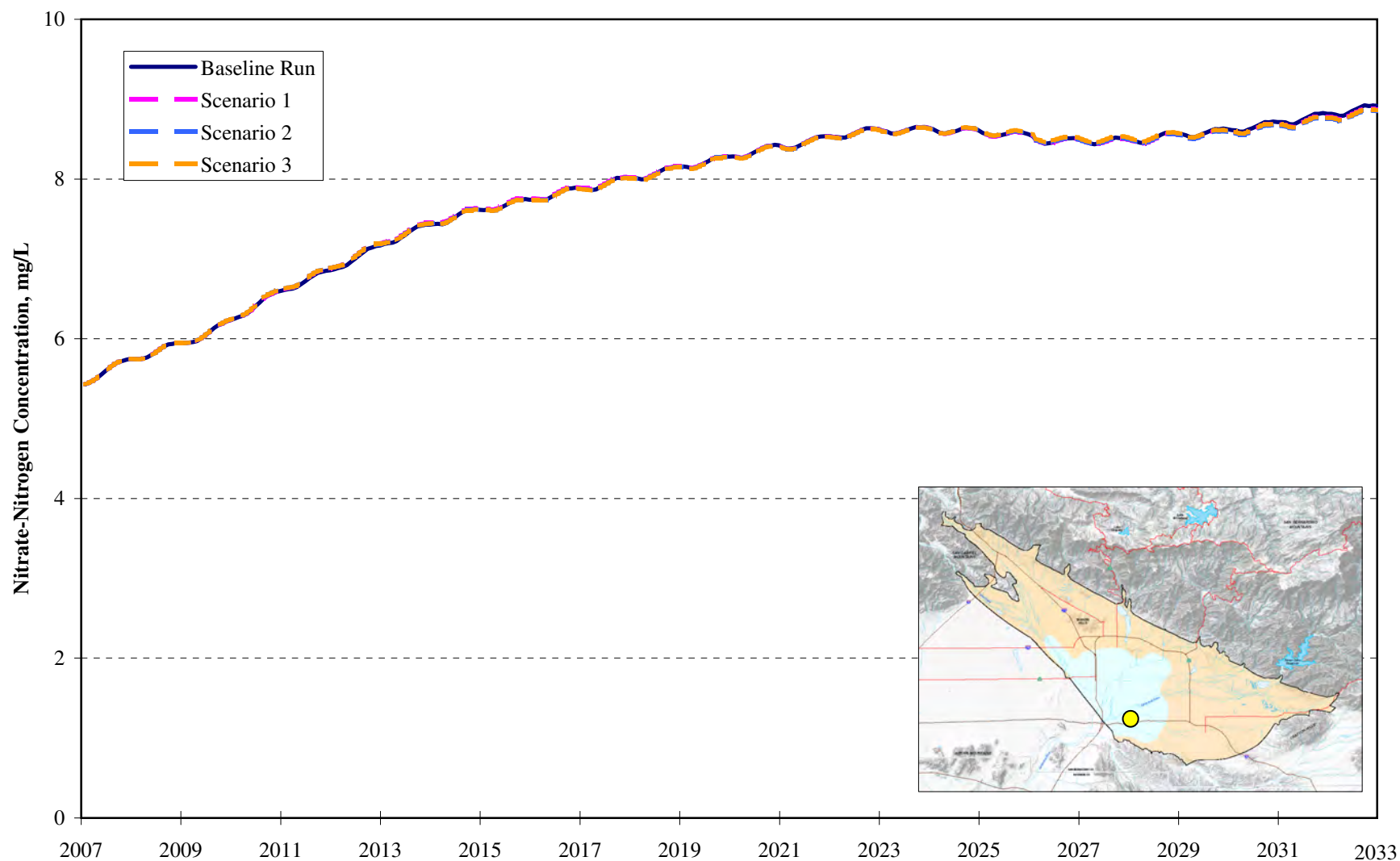
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Nitrate-Nitrogen for Bear Valley Mutual Water Company Nelson Street Well Model Runs 2007-2032

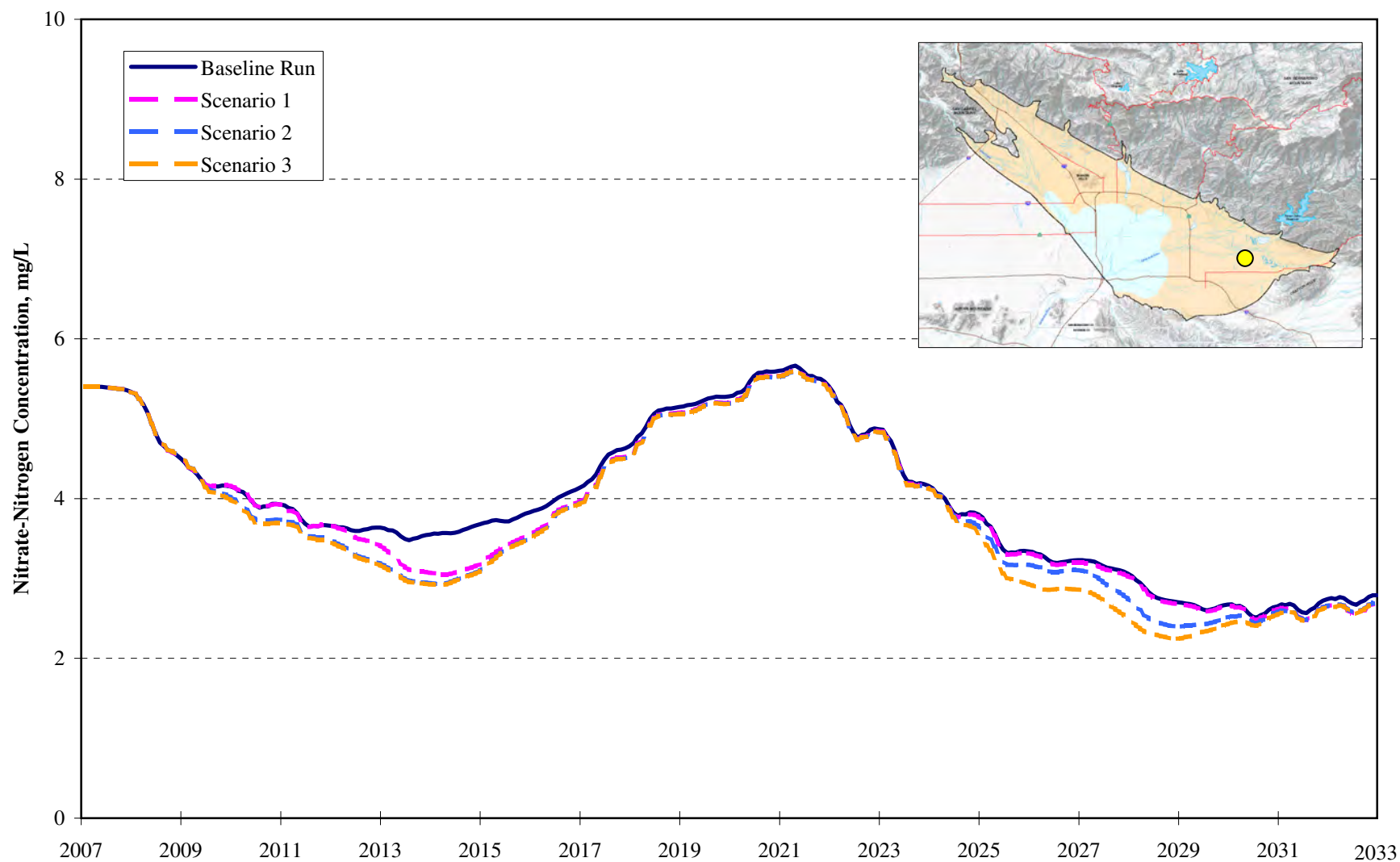


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Nitrate-Nitrogen for Gage Canal Company Lower Kelly Well Model Runs 2007-2032

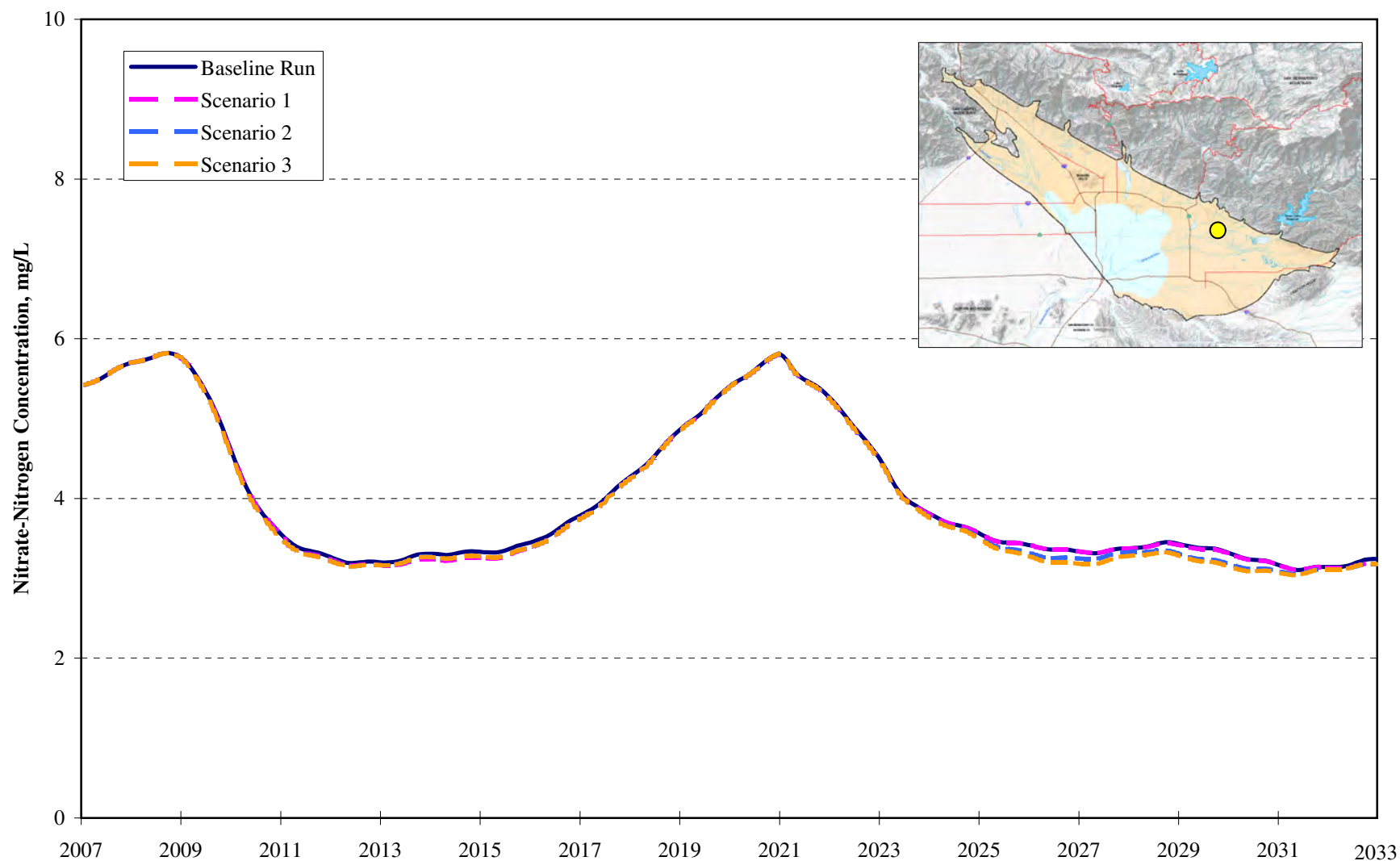


Nitrate-Nitrogen for City of Redlands Airport Well No. 2 Model Runs 2007-2032

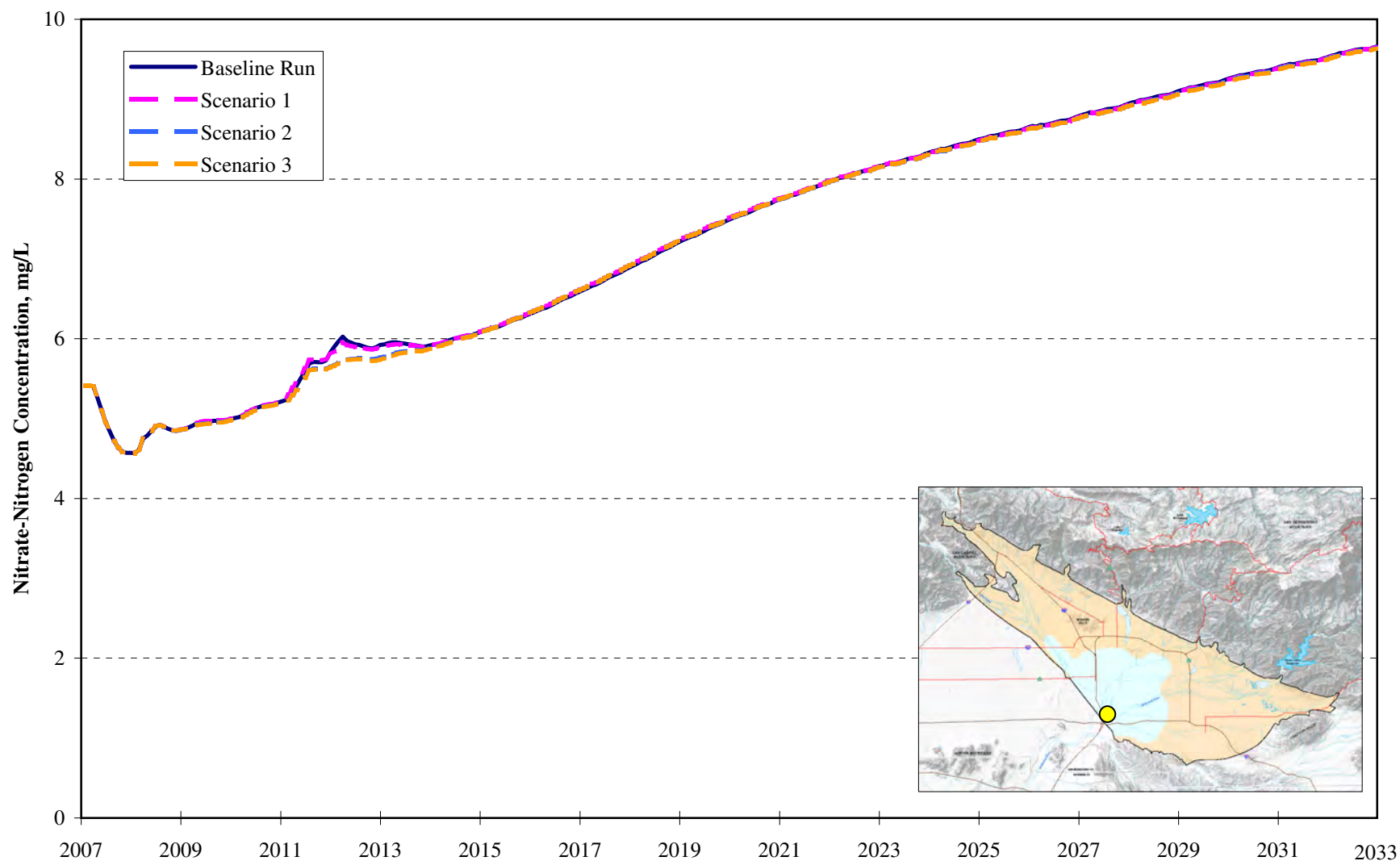


Appendix B

Nitrate-Nitrogen for East Valley Water District Well 146A Model Runs 2007-2032

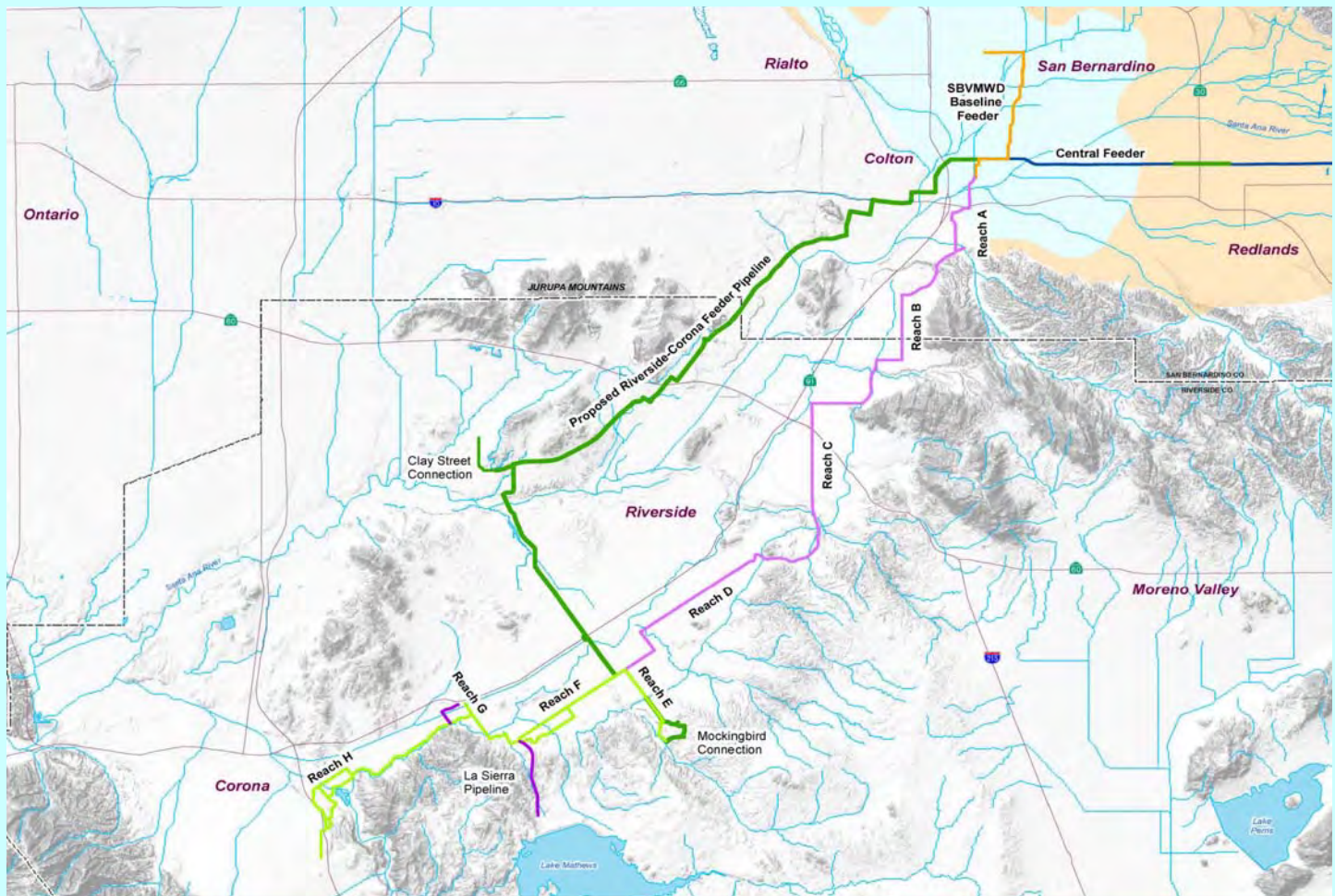


**Nitrate-Nitrogen for SBVMWD Backyard Well
Model Runs 2007-2032**



Groundwater Modeling of Riverside-Corona Feeder Project Conjunctive Use Scenarios

October 23, 2009



Prepared for:



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GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

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GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

1.0 EXECUTIVE SUMMARY

Western Municipal Water District (Western) is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County. Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), and to store that water in the SBBA when it is available and to extract water from the basins when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

The purpose of this work is to address the comments to the Draft Environmental Impact Report (DEIR) made by the City of San Bernardino Municipal Water District and the City of Colton. The modeling was performed in order to assess potential groundwater impacts due to the RCF, including impacts to the Western Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods are addressed. Results of the model predictive runs are used to determine the best locations and

amounts of additional replenishment by Western with SWP water from the MWD.

Two previous investigations have been performed to evaluate potential future impacts of initial operational scenarios for the RCF on the groundwater levels and groundwater quality in the SBBA. Both investigations used the same groundwater flow MODFLOW and solute transport MT3DMS models¹ that were used for the Valley District/Western Santa Ana River (SAR) Water Right Applications DEIR.

In the 2005 “Riverside-Corona Feeder Project – Phase I Groundwater Modeling Results,” a wellfield consisting of 20 new wells was delineated in the vicinity of Riverside-Corona Feeder, Baseline Feeder Extension South, and Central Feeder Pipeline. The total extraction during the period from 2001 through 2039 is 685,000 acre-ft. The total replenishment during the period from 2001 through 2039 is 757,000 acre-ft.

The 2006 “Riverside-Corona Feeder Well Field Siting and Basin Response Study” used the same assumptions as the 2005 study except for well locations. For the 2006 study, these 20 wells are to be located within the Newmark, Norton, and Redlands-Crafton plumes in the vicinity of Riverside-Corona Feeder, Baseline Feeder Extension South, and Central Feeder Pipeline. The total extraction during the period from 2001 through 2039 is 685,000 acre-ft. The total replenishment during the period from 2001 through 2039 is 776,000 acre-ft.

The MODFLOW groundwater flow model of the SBBA Refined Basin Flow Model was used to evaluate water level changes for various project alternatives. MODPATH particle tracking was utilized to evaluate potential impacts of the proposed project on remediation (i.e., cleanup) efforts by evaluating groundwater flow paths seepage velocities and travel times. The Refined Basin Solute Transport Model was used to simulate the groundwater quality for PCE (Newmark

¹ For descriptions of these models, refer to the Santa Ana River Water Right Applications for Supplemental Water Supply Draft Environmental Impact Report (San Bernardino Valley Municipal Water District and Western Municipal Water District, 2004).

and Muscoy plumes), TCE (Norton and Redlands-Crafton plumes), and perchlorate in the SBBA.

A total of four predictive model runs was made using the Refined Basin Flow Model and Refined Basin Solute Transport Model to assess the potential impacts of the RCF on groundwater levels and water quality. These model runs are:

- Baseline Run (No Project)
- RCF Scenario 1
- RCF Scenario 2
- RCF Scenario 3

The original Baseline Run was conducted by GEOSCIENCE for the Upper Santa Ana River Watershed Integrated Regional Water Management Plan (IRWMP). The IRWMP Baseline Run 1 was updated by Stantec and GEOSCIENCE in June 2009 to include changes to the IRWMP Baseline Run 1. The following table compares the assumptions used for the Baseline Run and IRWMP Baseline Run 1.

**Comparisons of Model Assumptions for
Baseline Run and IRWMP Baseline Run 1**

Model Assumptions		IRWMP Baseline Run 1	Baseline Run
Hydrologic Base Period		1962-2000 with Annual Stress Period	1979-2004 with Monthly Stress Period
Groundwater Pumping		2005 Urban Water Management Plans	2005 Urban Water Management Plans with 2008 Update
Artificial Recharge	Valley District's Replenishment Obligation	Western Judgment	Western Judgment
	Diversion by SBVWCD	Agreement between SBVWCD and Valley District/Western	SBVWCD's Licensed Rights
	Diversion by Senior Water Rights Claimants	Seven Oaks Accord	Seven Oaks Accord
	Valley District/Western	SAR Water Right Applications	SAR Water Right Applications

The RCF Scenarios use the same assumptions as the Baseline Run (No Project), except these RCF conjunctive use scenarios include additional project artificial recharge and groundwater pumping. The actual amount of RCF water replenishment and extraction will vary year to year, depending upon natural hydrologic conditions that may affect the timing of available surplus water, spreading ground capacity and basin groundwater levels (i.e., storage). The replenishment and extraction schedules for the RCF Scenarios have been quantified through iterative model runs so that total project extraction is lower than total project replenishment. As a result, the SBBA storage for each RCF Scenario will always be equal to or above the storage for the Baseline Run (No Project).

The initial replenishment schedules for each RCF Scenario are based on availability of surplus water that are likely to cause the most environmentally stressful conditions (at 28% exceedance level) and conditions less stressful (at 2.8% exceedance level) than those encountered under the “most likely” condition (at 20% exceedance level). Based on results from iterative model runs, RCF Scenario 1 consists of artificial recharge of 42,000 acre-ft during the 26 years from 2007

through 2032. RCF Scenario 2 includes artificial recharge of 150,000 acre-ft. RCF Scenario 3 includes artificial recharge of 198,000 acre-ft.

Five new wells are to be located within the Redlands-Crafton plume at the eastern end of the proposed Riverside-Corona Feeder Pipeline. The maximum capacity for each well is estimated to be 3,000 acre-ft/yr (total of 15,000 acre-ft/yr) based on local geohydrologic conditions. Based on results from iterative model runs, RCF Scenario 1 consists of extraction of 34,500 acre-ft during the 26 years from 2007 through 2032. RCF Scenario 2 includes extraction of 125,800 acre-ft. RCF Scenario 3 includes extraction of 163,300 acre-ft.

Based on results of the modeling, the following conclusions have been made for the RCF conjunctive use scenarios:

- For RCF Scenario 1, the changes in water level from the Baseline Run (No Project) range from a decline of one ft to a rise of three ft. Water level changes range from a decline of four ft to a rise of 11 ft for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of six ft to a rise of 13 ft. In general, the wells with declines in water levels are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., City of Redlands Well No. 32 and City of Riverside Raub 1 Well). Wells with increases in groundwater elevations are located in the forebay recharge areas due to artificial recharge from the RCF.
- Based on results from iterative model runs, RCF Scenario 1 consists of artificial recharge of 42,000 acre-ft and extraction of 34,500 acre-ft during the 26 years from 2007 through 2032. RCF Scenario 2 includes artificial recharge of 150,000 acre-ft and extraction of 125,800 acre-ft. RCF Scenario 3 includes artificial recharge of 198,000 acre-ft and extraction of 163,300 acre-ft.

- The acreage of the potential liquefaction area in the Pressure Zone is approximately 720 acres for the year 2001 (year with the greatest potential liquefaction area) and is approximately 3.7% of total Pressure Zone area of 19,320 acres for the Baseline Run (No Project). The potential liquefaction area was estimated to be approximately 690 acres, 540 acres, and 600 acres for RCF Scenarios 1 through 3, respectively. The slight reduction in potential liquefaction area in the Pressure Zone was due to extraction occurring in the proposed RCF wellfield near the Pressure Zone area.
- Groundwater storage in the SBBA declines by 32,181 acre-ft during the period 2007 through 2032 under Baseline Run (No Project) conditions. Groundwater storage decline for RCF Scenarios 1 through 3 was less than under Baseline Run (No Project) conditions, which are estimated be negative (“-“) 31,496 acre-ft, negative 30,909 acre-ft, and negative 31,358 acre-ft, respectively. These results indicate that slightly more water (685 acre-ft for Scenario 1, 1,272 acre-ft for Scenario 2, and 823 acre-ft for Scenario 3) was recharged over the 26 years than what was necessary to maintain a total recharge equal to the Baseline Run (No Project) conditions.
- The annual average underflow outflow across the San Jacinto Fault near the SAR to the Rialto-Colton Groundwater Basin for the period 2007 to 2032 was estimated to be 712 acre-ft/yr under Baseline Run (No Project) conditions. The underflow outflow was estimated to be 707 acre-ft/yr, 694 acre-ft/yr, and 691 acre-ft/yr for the RCF Scenarios 1 through 3, respectively. These changes in underflow outflow are minimal for the RCF scenarios as compared to the Baseline Run (No Project).
- For purposes of this report, the efficiency² of RCF conjunctive use was calculated as the ratio of the amount of additional groundwater pumping to the amount of additional artificial recharge. The efficiency ranges from 82% for Scenarios 1 and 3 to 84% for Scenario 2. The efficiency was optimized through varying the timing and amount of

² The efficiencies are based on the recharge amount as well as extraction rates. These efficiencies can be higher if different pattern rates of recharge and extraction was applied.

artificial recharge and groundwater pumping. The major loss of the conjunctive use recharge was by evapotranspiration and discharging water to the stream due to increases in groundwater levels.

- Results of recharge and extraction show that the RCF conjunctive scenarios have no impact on groundwater resources.
- Solute transport model results show no change in the Newmark and Muscoy PCE Plume areas for all the RCF scenarios as compared to plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the PCE plume (approximately 1,910 acres) is reduced to approximately 670 acres for all of the RCF scenarios.
- Solute transport model results show no change in the TCE Plume areas for all the RCF scenarios as compared to plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the TCE plume (approximately 2,030 acres) is reduced to approximately 260 acres for all of the RCF scenarios.
- Solute transport model results show that the perchlorate plume dissipates slightly faster for the RCF scenarios as compared to the Baseline Run (No Project) as a result of increased extraction from the proposed RCF wellfield. Under Baseline Run (No Project) conditions, the overall initial area of the perchlorate plume (approximately 7,820 acres) is reduced to approximately 480 acres by the end of the predictive run (2032). By the end of the predictive run (2032), the perchlorate plume area would be 470 acres, 460 acres and 450 acres for RCF Scenarios 1 through 3, respectively.
- Particle tracking results show that the particle recovery for the Newmark Plume is 91% to 92% for the RCF scenarios as compared to a particle recovery of 93% for the Baseline Run (No Project). The particle recovery for the Muscoy Plume is 97% for all RCF

scenarios and the Baseline Run (No Project). The Newmark and Muscoy Operable Units Statement of Work (Appendix D of Consent Decree) specifies a minimum particle recovery of 85% for the Newmark Plume Front extraction well network and the Muscoy Plume Front extraction well network when these extraction wells are set equivalent to or above the design extraction rates. Results of the particle tracking from the Newmark and Muscoy Plumes show that the RCF conjunctive use scenarios would not impact the contamination plumes.

2.0 INTRODUCTION

2.1 Background

Western is a regional water wholesaler within the County of Riverside and is obligated to address long-term water demand and to meet the future water needs of a rapidly growing service area. Current efforts to maintain this obligation include the Riverside-Corona Feeder Project (RCF). The RCF is designed to convey potable water from the San Bernardino Basin Area (SBBA) to communities throughout western Riverside County (see Figure 1). Water conveyance will be performed using a major pipeline with several turnouts, a pump station, and up to five new wells as shown in Figure 2. The proposed infrastructure will allow Western to purchase water when it is available from the State Water Project (SWP), to and store that water in the SBBA when it is available, and to extract water from the basins when it is needed. This realignment also allows Western to address the reduced potential for SWP water availability for groundwater replenishment purposes. If appropriate agreements can be reached, additional native water may, at times, also be available. The facilities may also be used to obtain and convey native water pursuant to rights held by other agencies, such as the City of Riverside, Jurupa Community Services District, Rubidoux Community Services District, the Chino Basin Desalter Authority, San Bernardino Valley Municipal Water District (Valley District), and Elsinore Valley Municipal Water District. This project will make Western less dependent on the direct delivery of water from the Metropolitan Water District of Southern California (MWD).

The RCF is supported by, and fully consistent with, MWD's Integrated Resource Plan, the Santa Ana Watershed Project Authority's Integrated Watershed Plan, and the regional water planning efforts for the cities of Riverside, Norco, and Corona, Elsinore Valley Municipal Water District, Jurupa Community Services District, Home Gardens County Water District, Lee Lake Water District, and the March Air Reserve Base.

2.2 Purpose and Scope

The purpose of this work is to address the comments to the Draft Environmental Impact Report (DEIR) made by the City of San Bernardino Municipal Water District (SBMWD, 2008) and the City of Colton (2008). The modeling was performed in order to assess potential groundwater impacts due to the RCF including impacts to the Western Judgment and the Newmark Groundwater Superfund Site. Particularly, potential groundwater impacts during periods of drought and emergency periods are addressed. Results of the model predictive runs are used to determine the best locations and amounts of additional replenishment and extraction by Western with SWP water from the MWD.

2.3 Previous Investigations

Two previous investigations have been performed to evaluate potential future impacts of initial operational scenarios for the RCF on the groundwater levels and groundwater quality in the SBBA. Both investigations used the same groundwater flow MODFLOW and solute transport MT3DMS models³ that were used for the Valley District/Western Santa Ana River (SAR) Water Right Applications DEIR. The modeling assumptions are provided in the following sections.

2.3.1 Riverside-Corona Feeder Project – 2005 Study

In the 2005 “Riverside-Corona Feeder Project – Phase I Groundwater Modeling Results”, a wellfield consisting of 20 new wells was delineated in the vicinity of Riverside-Corona Feeder, Baseline Feeder Extension South, and Central Feeder Pipeline. The maximum capacity for each well was estimated to be 2,400 acre-ft. A forecast from 2001 through 2039 of the extraction and delivery of water through the Riverside-Corona Feeder Project was provided by Western. This forecast was based on the long-term general increase in water demand associated with growth

³ For descriptions of these models, refer to the Santa Ana River Water Right Applications for Supplemental Water Supply Draft Environmental Impact Report (San Bernardino Valley Municipal Water District and Western Municipal Water District, 2004).

and the availability of imported water for direct delivery by MWD. The Project starts with a 5,000 acre-ft extraction in 2006 (no extraction for years 2001-2005) and increases to 10,000 acre-ft in 2007. From 2008, the following extraction rules are applied:

- In years that the MWD Water Surplus and Drought Management Plan (WSDM Plan) calls for interruption of replenishment, the extractions for Riverside Corona Feeder Project are maximized at 40,000 acre-ft/yr.
- In years that the MWD WSDM Plan calls for reduction in storage at Diamond Valley Lake or the SWP storage programs, the extractions for Riverside-Corona Feeder Project are 30,000 acre-ft/yr.
- In years that the MWD water budget forecast shows a “remaining surplus” of greater than 200,000 acre-feet, the extractions for Riverside-Corona Feeder Project are 10,000 acre-ft/yr.
- In all other years, Riverside-Corona Feeder Project extractions for the first Phase I study are 20,000 acre-ft when local hydrology is normal, 25,000 acre-ft when local hydrology is dry and 15,000 acre-ft when local hydrology is wet⁴.

The total extraction during the period from 2001 through 2039 is 685,000 acre-ft.

A forecast from 2001 through 2039 for the availability of MWD replenishment water was provided by Western. In years that the MWD WSDM Plan calls for interruption of replenishment, the replenishment for the Riverside-Corona Feeder Project is zero (i.e., years 2016, 2029, 2030, and 2031). The replenishment for other years was determined through iterative modeling to meet the following criteria:

- There is no rejected replenishment.
- Water is not extracted without having been previously spread in the basin for replenishment.

The total replenishment during the period from 2001 through 2039 is 757,000 acre-ft.

⁴ For purposes of this study, annual hydrology is referred to in terms of “normal”, “dry,” and “wet”, which corresponds with the total annual precipitation for the base period (1979 – 2004). Total annual precipitation for “normal” years ranges from 14 to 18 inches, 7 to 14 inches for “dry” years, and 18 to 34 inches for “wet” years.

2.3.2 Riverside-Corona Feeder Project – 2006 Study

The 2006 “Riverside-Corona Feeder Well Field Siting and Basin Response Study” used the same assumptions used for the 2005 study except for well locations. For the 2006 study, these 20 wells are to be located within the Newmark, Norton, and Redlands-Crafton plumes in the vicinity of Riverside-Corona Feeder, Baseline Feeder Extension South, and Central Feeder Pipeline. The maximum capacity for each well is estimated to be 2,400 acre-ft based on local geohydrologic conditions.

The total extraction during the period from 2001 through 2039 is 685,000 acre-ft. The total replenishment during the period from 2001 through 2039 is 776,000 acre-ft.

2.4 Sources of Data

The primary sources and types of data used to evaluate the RCF are summarized below:

- Metropolitan Water District of Southern California (2009): Availability of SWP water for hydrology years 1922 through 2003.
- Albert A. Webb Associates (2009): Proposed locations of RCF facilities, pipelines, and extraction wells.

A complete list of references is included at the end of the written portion of this report.

3.0 MODELING APPROACH

This section describes the tools and methodology used to identify potential groundwater level and quality impacts associated with the RCF. Both groundwater flow and solute transport distributed parameters were used in the analyses.

3.1 MODFLOW Groundwater Flow Model

The MODFLOW groundwater flow model of the SBBA Refined Basin Flow Model (RBFM) was used to evaluate water level changes for various project scenarios. Groundwater flow models have been used in the SBBA over the past two decades. The latest refinement process was a cooperative technical effort involving representatives of SBMWD and Valley District, their respective consultants at Stantec Consulting (Stantec) and GEOSCIENCE, and Mr. Wes Danskin of USGS. The cooperative effort was initiated to avoid the development of two different models and to develop one model that would be compatible and defensible. The USGS Basin Flow Model was collaboratively refined by Stantec and GEOSCIENCE and is known as the Refined Basin Flow Model (GEOSCIENCE, 2006; GEOSCIENCE, 2007; GEOSCIENCE, 2009; and Stantec, 2008).

The various groundwater flow models that have formed part of the evolution of the current RBFM include:

- The first numerical model of the area (1966/1967) by Tyson, Weber, and Frankel of the California Department of Water Resources (personal communication, Reiter, 2005);
- A simplified well-response model by the USGS's Durbin (1974), and Durbin and Morgan (1978);
- A more complex groundwater flow model by the USGS's Hardt and Hutchinson (1980), developed to simulate aquifer response to natural and artificial recharge and production. This model was also used by Hardt and Freckleton in 1987 to predict

changes in groundwater levels based on projected recharge and production to the year 2025; and

- The USGS Basin Flow Model prepared by Danskin, et al., (2006). This model formed the basis for the current model refinement.

The original USGS Basin Flow Model covers an area of approximately 524 square miles and is a two-layer finite difference model with a cell size of 820 feet x 820 feet. The RBFM is a five-layered finite difference model and covers the same area as the original USGS Basin Flow Model. Each model cell of the original USGS Basin Flow Model was rediscritized to 64 model cells with a cell size of 102.5 feet x 102.5 feet. The refined model consists of 944 nodes⁵ in the north-to-south direction (i-direction) and 1,472 nodes in the west-to-east direction (j-direction), for a total of 6,947,840 nodes (see Figure 3).

The RBFM was appropriately calibrated for steady-state calibration of 1945, annual transient for 1945-2000, monthly transient for January 1983–December 2000, and monthly verified for January 2001–December 2006. In general, steady-state model calibration is acceptable with a relative error of 7.1% and mean residual of 11.29 feet based on the measured water level in 120 wells in 1945. For the annual transient model calibration, historical groundwater level data for 141 wells within the SBBA were compared with model-generated groundwater levels. In general, the pattern of the model-generated and measured 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 basin. The relative error of the model-generated groundwater levels between 1945 and 2000 is approximately 4.6%. Common modeling practice is to consider a good fit between historical and model-predicted data if the relative error is below 10%. The model also provided a good match with the gaged surface runoff within the SBBA. For the monthly transient calibration January 1983–December 2000, the relative error of water level residuals is approximately 4.3% with an average water level residual of -6.6 feet. For the monthly model validation (January 2001 through December 2006), the relative error of water level residuals is

⁵ A model “node” is the center of a model “cell.” The model cells are square with a side of 102.5 ft. The network of model cells forms a “grid” or “mesh” covering the entire model area.

approximately 4.6% with an average water level residual of 3.2 feet. This water level residual statistic indicates that the SBBA RBFM accurately simulates water levels in most of the model area.

3.2 MODPATH Particle Tracking

The purpose of the MODPATH model was to evaluate potential impacts of the proposed project on remediation (i.e., cleanup) efforts by evaluating groundwater flow path seepage velocities, and travel times. MODPATH is a post-processing package developed to compute three-dimensional flow paths (i.e., particle tracking) using output from the groundwater flow model. MODPATH uses a semi-analytical particle-tracking scheme that allows an analytical expression of the particle's⁶ flow path to be obtained within each finite-difference grid cell. Particle paths are computed by tracking particles from one cell to the next until the particle reaches a boundary, an internal sink/source, or satisfies some other termination criterion.

MODPATH does not take into account dispersion, retardation, or half-life decay. The results of MODPATH simply provide an indication of the direction and rate of groundwater flow.

3.3 MT3DMS Solute Transport Model

A water quality component was added to the RBFM by GEOSCIENCE for Valley District under USEPA Grant X-97957701-0 (GEOSCIENCE, 2009). The Refined Basin Solute Transport Model (RBSTM) was calibrated against the observed PCE and TCE data for the period 1986 through 2000. The model relative error⁷ is 7.7% and 3.4% for PCE and TCE concentrations, respectively. It is common modeling practice to consider a relative error of less than 10% to be a good fit. Therefore, these results are considered reasonable. MT3DMS was the computer code

⁶ A “particle track” would represent the flow path taken by groundwater through model time and influenced by any relevant recharge or discharge component (e.g., pumping or spreading).

⁷ Relative error is the standard deviation of the PCE and TCE concentration residuals divided by the range of measured concentrations. A residual is the difference between a measured concentration and a model-generated concentration.

used to simulate the groundwater quality for PCE (Newmark and Muscoy plumes), TCE (Norton and Redlands-Crafton plumes), and perchlorate in the SBBA.

4.0 PREDICTIVE MODEL SCENARIOS

A total of four predictive model runs was made using the RBFM and RBSTM to assess the potential impacts of the RCF on groundwater levels and water quality. These model runs are:

- Baseline Run (No Project)
- RCF Scenario 1
- RCF Scenario 2
- RCF Scenario 3

The RCF Scenarios includes two “bookend” scenarios (Scenarios 1 and 3) and one “most likely” scenario (Scenario 2). “Bookend” conditions are generally described as conditions that result from extraction and replenishment schedules that are likely to cause the most environmentally stressful conditions (Scenario 3) and conditions that are the least stressful (Scenario 1) than those encountered under the “most likely” scenario. Results from the RCF scenarios were compared to the Baseline Run (No Project). The following sections discuss the modeling assumptions for the model scenarios.

4.1 Model Assumptions for Baseline Run (No Project)

The original Baseline Run was conducted by GEOSCIENCE for the Upper Santa Ana River Watershed Integrated Regional Water Management Plan (IRWMP) (GEI Consultants, SAIC, and GEOSCIENCE, 2007). The IRWMP Baseline Run 1 was updated by Stantec and GEOSCIENCE in June 2009 to include changes to the IRWMP Baseline Run 1. This updated Baseline Run is named as the Baseline Run in this report. These changes include the following:

- A monthly stress period instead of annual,
- New base period from 1979 through 2004 instead of 1962 through 2000,
- Changes in projected groundwater pumping as submitted by some of the retail water agencies during a technical workshop in November 2008,

- Surplus water availability projection for 2008⁸ instead of surplus water availability projection for 2005⁹, and
- SAR diversions by SBVWCD's licensed rights¹⁰ instead of Agreement between SBVWCD and Valley District/Western.

The following table compares the assumptions used for the Baseline Run and IRWMP Baseline Run 1.

⁸ 2008 DWR State Water Project Reliability Report: High Fisheries Impact – No Climate Change Scenario provided by MWD.

⁹ 2005 SWP Surplus Water Availability provided by SAIC.

¹⁰ This is due to the SBVWCD withdrew their water rights application that they had submitted to the State Water Resources Control Board which was a condition of their settlement agreement with Valley District. As a result, the SBVWCD diversion amounts provided in the settlement agreement no longer apply and SBVWCD's rights continue to be their two seasonal permits of License No. 2831 (January 1 to May 31) and License No. 2832 (October 1 to December 31).

**Comparisons of Model Assumptions for
Baseline Run and IRWMP Baseline Run 1**

Model Assumptions		IRWMP Baseline Run 1	Baseline Run
Hydrologic Base Period		1962-2000 with Annual Stress Period	1979-2004 with Monthly Stress Period
Groundwater Pumping		2005 Urban Water Management Plans	2005 Urban Water Management Plans with 2008 Update
Artificial Recharge	Valley District's Replenishment Obligation	Western Judgment (2005 SWP Water Availability Projections) ¹¹	Western Judgment (2008 SWP Water Availability Projections) ¹²
	Diversion by SBVWCD	Agreement between SBVWCD and Valley District/Western	SBVWCD's Licensed Rights
	Diversion by Senior Water Rights Claimants	Seven Oaks Accord	Seven Oaks Accord
	Valley District/Western	SAR Water Right Applications	SAR Water Right Applications

¹¹ SAIC¹² DWR, 2009

4.1.1 Hydrologic Base Period

Based on monthly data availability and analyses of historical precipitation and streamflow, the 26-year period from January 1979 through December 2004 was selected for the hydrologic base period of the Baseline Run. This base period covers both wet and dry hydrologic cycles and the average precipitation and streamflow are approximately the same as the long-term average (see Figures 4 and 5). For model prediction runs, the hydrologic base period was assumed to represent future conditions for the 26-year period from January 2007 through December 2032.

4.1.2 Groundwater Pumping

The Baseline groundwater pumping was determined based on future water demands obtained from 2005 Urban Water Management Plans and updated information presented by City of Colton, City of Redlands, SBMWD, East Valley Water District, and West Valley Water District at the 7-Nov-08 meeting. Figure 6 shows the projected groundwater pumping estimated for the Baseline Run. During the model period 2007-2032, the groundwater pumping ranges from 206,100 acre-ft in 2007 (hydrologic year 1979) to 308,300 acre-ft in 2032 (hydrologic year 2002) with an average of 258,600 acre-ft/yr.

4.1.3 Artificial Recharge

The Baseline artificial recharge consists of Santa Ana River diversions and the Valley District's Replenishment Obligation, as summarized in the following table.

Artificial Recharge for Baseline Run

Santa Ana River Diversion	Diversion by SBVWCD	SBVWCD's Licensed Rights
	Diversion by Senior Water Rights Claimants	Seven Oaks Accord
	Valley District/Western	SAR Water Right Applications
Valley District's Replenishment Obligation		Western Judgment

The final amount of artificial recharge for the Baseline Run was the result of iterative model runs. Figure 7 shows the adjusted total amount of artificial recharge. As shown for the Updated Baseline Run, the adjusted artificial recharge ranges from 8,200 acre-ft in year 2016 (hydrologic year 1988) to 144,000 acre-ft in year 2032 (hydrologic year 2004) with an average of 87,700 acre-ft. Figure 8 shows the spreading grounds used for artificial recharge.

4.2 Model Assumptions for Riverside-Corona Feeder Project Conjunctive Use Scenarios

Three model predictive scenarios were run for a 26-year period (2007 through 2032) with monthly stress periods. The RCF Scenarios use the same assumptions as the Baseline Run (No Project), except these RCF conjunctive use scenarios include additional project artificial recharge and groundwater pumping. The actual amount of RCF water replenishment and extraction will vary year to year, depending upon natural hydrologic conditions that may affect the timing of available surplus water, spreading ground capacity, and basin groundwater levels (i.e., storage). The replenishment and extraction schedules for the RCF Scenarios have been quantified through iterative model runs so that total project extraction is lower than total project replenishment (see Figures 9 through 11). As a result, the SBBA storage for each RCF Scenario will always be equal to or above the storage for the Baseline Run (No Project). The following sections discuss the modeling assumptions for the RCF scenarios.

4.2.1 Riverside-Corona Feeder Project Replenishment

A replenishment schedule for each of the three RCF Scenarios was developed from surplus water availability data for the period from 1922 through 2003 (MWD, 2009). These surplus forecasts are based on the statistical analysis of the data that were obtained from MWD¹³ (see Appendix A). Surplus water is available when the combined total of MWD's Table A and Article 21 allocations exceed 1,330,000 acre-ft/yr¹⁴. Water is available for the RCF when surplus water for MWD exceeds 250,000 acre-ft (see Figure 12). Based on 2008 surplus water availability projections, it is assumed that surplus water will be available for the RCF approximately 28% of the time (see Figure 13).

¹³ A 2005 surplus water availability projection was provided by SAIC, and a 2008 surplus water availability projection was provided by MWD. These projections are derived from the SWP Delivery Reliability Reports that are developed by the California Department of Water Resources (DWR) to provide updated estimates of current and future SWP delivery reliability. The 2008 projections were used to develop the RCF Scenarios. The 2008 data differs from the 2005 data because it includes estimates of reduction to SWP delivery reliability.

¹⁴ SWP deliveries in excess of 70% of MWD's contracted amount of 1.9 million acre-ft/yr.

The initial replenishment schedules for each RCF Scenario are based on availability of surplus water that are likely to cause the most environmentally stressful conditions (at 28% exceedance level) and conditions less stressful (at 2.8% exceedance level) than those encountered under the “most likely” condition (at 20% exceedance level). The replenishment schedules for each RCF Scenario are:

- Scenario 1 simulates RCF replenishment to occur when MWD surplus water is equal to or exceeds 718,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 2.8% or less of the time.
- Scenario 2 simulates RCF replenishment to occur when MWD surplus water is equal to or exceeds 485,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 20% or less of the time.
- Scenario 3 simulates RCF replenishment to occur when MWD surplus water is equal to or exceeds 250,000 acre-ft. Based on historic data for available MWD surplus water, this condition occurs approximately 28% or less of the time.

These forecasts are based on the long-term general increase in water demand associated with growth and the availability of imported water for direct delivery by MWD (see Appendix A).

Based on results from iterative model runs, RCF Scenario 1 consists of artificial recharge of 42,000 acre-ft during the 26 years from 2007 through 2032 (i.e., hydrologic years from 1979 through 2004) (see Figure 9). RCF Scenario 2 includes artificial recharge of 150,000 acre-ft (see Figure 10). RCF Scenario 3 includes artificial recharge of 198,000 acre-ft (see Figure 11).

4.2.2 Riverside-Corona Feeder Project Extraction

Five new wells are to be located within the Redlands-Crafton plume at the eastern end of the proposed Riverside-Corona Feeder Pipeline (see Figure 2). The maximum capacity for each well

is estimated to be 3,000 acre-ft/yr (total of 15,000 acre-ft/yr) based on local geohydrologic conditions.

Based on results from iterative model runs, RCF Scenario 1 consists of extraction of 34,500 acre-ft during the 26 years from 2007 through 2032 (i.e., hydrologic years from 1979 through 2004) (see Figure 9). RCF Scenario 2 includes extraction of 125,800 acre-ft (see Figure 10). RCF Scenario 3 includes extraction of 163,300 acre-ft (see Figure 11).

4.3 Initial Model Groundwater Elevations and Concentrations

Groundwater elevations obtained from the end of the RBFM model calibration results (i.e., December 2006) were used as initial groundwater elevations for the Baseline Run (No Project) and RCFP Scenarios 1 through 3. The initial concentrations used for the PCE, TCE, and perchlorate transport models were derived from 2006 measured concentrations. Due to the limited quantity of measured PCE, TCE, and perchlorate data available for 2006, historical PCE, TCE, and perchlorate concentrations measured around 2006 were also used. For example, PCE concentrations measured in May 2007¹⁵ are shown for the Newmark-Muscoy area in Figure 14. Figures 15, 16, and 17 show the initial concentrations used for the model runs for PCE, TCE, and perchlorate, respectively.

4.4 Model Results

4.4.1 Groundwater Elevation

Groundwater elevation contours for the Baseline Run (No Project) in the years 2011 (highest level, hydrologic year 1983), 2020 (lowest level, hydrologic year 1992), and 2032 (end of model simulation, hydrologic year 2004) are shown on Figures 18 through 20. In general, the model-generated groundwater flow direction is similar to historical directions with groundwater flowing west from the SAR and Mill Creek Spreading Grounds, and southeast from the Lytle Creek and

¹⁵ Secor, 2008.

Cajon Creek (i.e., flowing to the Pressure Zone area).

Groundwater level fluctuations reflect hydrological wet and dry cycles. For example, a change in groundwater level of 50 feet to 100 feet occurs in the Pressure Zone between model years 2011 (equivalent to 1983 – end of a wet year cycle) and 2020 (end of a dry cycle, historical year 1992). Groundwater elevations in the years 2011, 2020, and 2032 are shown in Figures 21 through 23, Figures 24 through 26 and Figures 27 through 29 for RCF Scenarios 1 through 3, respectively. Groundwater flow directions and general patterns of fluctuations for the three RCF scenarios are similar to the Baseline Run (No Project).

Hydrographs at selected wells (including 25 index wells of the Seven Oaks Accord and the Backyard Well for the Valley District/Western/Riverside Agreement) for the Baseline Run (No Project) and the RCF Scenarios 1 through 3 are provided in Appendix B. The approximate locations of these wells are shown as insets on the hydrographs in Appendix B. These hydrographs show the temporal variations in groundwater levels reflecting the hydrologic conditions, artificial recharge, and groundwater pumping assumed for the Baseline Run (No Project) and the RCF scenarios.

For each of the selected wells in Appendix B, the average simulated groundwater elevations and the difference between the average groundwater elevations for the Baseline Run (No Project) with respect to the RCF scenarios are summarized in Table 1. As shown, for RCF Scenario 1, the changes in water levels from the Baseline Run (No Project) range from a decline of one ft to a rise of three ft. Water level changes range from a decline of four ft to a rise of 11 ft for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of six ft to a rise of 13 ft. In general, the wells with declines in water levels are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., City of Redlands Well No. 32 and City of Riverside Raub 1 Well). Wells with increases in groundwater elevations are located in the forebay recharge areas due to artificial recharge from the RCF.

4.4.2 Potential Liquefaction Area in the Pressure Zone

Liquefaction typically occurs in recent (Holocene to late Pleistocene) deposits of silt, sand, and gravel. Most liquefaction occurs where the depth to groundwater is less than 50 feet; this depth is traditionally considered adequate for most investigations of liquefaction potential (Martin and Lew, 1999). Soil liquefaction is a major cause of damage during earthquakes. For purposes of this report, areas with depth to groundwater of less than 50 feet in the Pressure Zone were evaluated for each model operational run.

Figure 30 shows the potential liquefaction in the Pressure Zone in year 2011 (year with the greatest potential liquefaction area). As shown, the acreage of the potential liquefaction area is approximately 720 acres and is approximately 3.7% of total Pressure Zone area of 19,320 acres. The primary potential liquefaction area is located in the eastern portion of the Pressure Zone near the Santa Ana River and City Creek areas and is away from the City of San Bernardino. Therefore, potential liquefaction is considered minimal.

The potential liquefaction area in the Pressure Zone in year 2011 (year with the greatest potential liquefaction area) for RCF Scenarios 1 through 3 were shown in Figures 31, 32, and 33, respectively. The acreage of the potential liquefaction area is approximately 690, 540, and 600 acres for RCF Scenarios 1 through 3, respectively. The slight reduction in potential liquefaction area in the Pressure Zone was due to extraction occurring in the proposed RCF wellfield near the Pressure Zone area.

4.4.3 Groundwater Budget

The overall water budgets for each of the model runs were compiled to evaluate the RCF Conjunctive Use scenarios. The inflow terms for the model include recharge to groundwater from gaged streamflow, artificial recharge, local runoff generated by precipitation, infiltration from direct precipitation, return flow from groundwater pumping, ungaged mountain front runoff, and underflow. The outflow terms comprise evapotranspiration, groundwater pumping,

and underflow. The difference between the total inflow and total outflow is the change in groundwater storage. Annual groundwater budgets for each scenario are shown in Tables 2 through 5 for the Baseline Run (No Project) and RCF Scenarios 1 through 3, respectively. The average annual groundwater budgets for the period 2007-2032 for these model runs are shown in Figure 34 and are also shown in the following table.

Summary Water Budgets – 2007 to 2032

Flux Terms			Baseline Run (No Project) [acre-ft]	RCF Scenario 1 [acre-ft]	RCF Scenario 2 [acre-ft]	RCF Scenario 3 [acre-ft]
Inflow	Recharge from Gaged Streamflow		2,943,402	2,942,776	2,939,856	2,937,168
	Artificial Recharge	Others	2,281,278	2,281,278	2,281,278	2,281,278
		RCF	0	42,000	150,000	198,000
	Recharge from Local Runoff Generated by Precipitation		135,751	135,751	135,751	135,751
	Infiltration from Direct Precipitation		28,157	28,157	28,157	28,157
	Return Flow from Groundwater Pumping		1,268,982	1,268,982	1,268,982	1,268,982
	Recharge from Ungaged Mountain Front Runoff		446,433	446,433	446,433	446,433
	Underflow Recharge		95,342	95,342	95,342	95,342
	Total Inflow		7,199,345	7,240,719	7,345,799	7,391,111
Outflow	Evapotranspiration		438,262	444,580	458,103	466,439
	Groundwater Pumping	Others	6,723,285	6,723,285	6,723,285	6,723,285
		RCF	0	34,500	125,800	163,300
	Underflow Discharge		69,979	69,852	69,520	69,445
	Total Outflow		7,231,526	7,272,216	7,376,708	7,422,469
Change in Groundwater Storage (Total Inflow – Total Outflow)			-32,181	-31,496	-30,909	-31,358

Groundwater storage in the SBBA declines by 32,181 acre-ft during the period 2007 through 2032 under Baseline Run (No Project) conditions. Groundwater storage decline for RCF Scenarios 1 through 3 was less than under Baseline Run (No Project) conditions, which are

estimated be negative (“-“) 31,496 acre-ft, negative 30,909 acre-ft, and negative 31,358 acre-ft, respectively. These results indicate that slightly more water (685 acre-ft for Scenario 1, 1,272 acre-ft for Scenario 2, and 823 acre-ft for Scenario 3) was recharged over the 26 years than what was necessary to maintain a total recharge equal to the Baseline Run (No Project) conditions.

The cumulative changes in groundwater storage for the historical period 1934 through 2006 (calculated based on groundwater levels) and for the predictive model runs 2007-2032 are shown in Figure 35. In general, the patterns of the cumulative changes in groundwater storage for the Baseline Run (No Project) and RCF Scenarios 1 through 3 during the period 2007-2032 are similar to the historical period from 1979-2004.

4.4.4 Underflow Outflow to Rialto-Colton Groundwater Basin

Groundwater underflow flows from the SBBA across the San Jacinto Fault near SAR to the Rialto-Colton Groundwater Basin. The amount of underflow was quantified based on the model-predicted water levels in the Heap well using the following equation (Danskin, et. al, 2006):

$$Q_{\text{underflow}} = 10^{(WL_{\text{heap}} - 663.136) / 96.876}$$

where:

$$\begin{aligned} Q_{\text{underflow}} &= \text{Underflow across the San Jacinto Fault near the SAR, acre-ft/yr} \\ WL_{\text{heap}} &= \text{Groundwater elevation in the Heap Well, ft amsl} \end{aligned}$$

Based on the predicted water levels in the Heap Well, the amount of underflow across the San Jacinto Fault near the SAR for the period 2007 to 2032 for each of model runs was summarized in Table 6. As shown, the underflow outflow ranges from 284 acre-ft to 1,478 acre-ft with an annual average of 712 acre-ft/yr under Baseline Run (No Project) conditions. For RCF Scenario 1, the underflow would range from 284 acre-ft to 1,468 acre-ft with an annual average

of 707 acre-ft/yr during the same period of time. The underflow would range from 280 acre-ft to 1,426 acre-ft with an annual average of 694 acre-ft/yr for RCF Scenario 2 and range from 279 acre-ft to 1,415 acre-ft with an annual average of 691 acre-ft/yr for RCF Scenario 3. These changes in underflow outflow are minimal for the RCF scenarios as compared to the Baseline Run (No Project).

Groundwater underflow also flows from the Lytle Basin of the SBBA across Barrier E to the Rialto-Colton Groundwater Basin. The amount of underflow was quantified based on the historical trend used for the model calibration and validation periods from 1945-2006. The average amount of underflow across Barrier E would be 1,980 acre-ft/yr for the Baseline Run (No Project) and RCF Scenarios 1 through 3.

The following table summarizes the annual average underflow outflow from the SBBA to the Rialto-Colton Groundwater Basin for the 26-year period from 2007-2032.

**Summary of Annual Average Underflow Outflow
From SBBA to Rialto-Colton Groundwater Basin
2007 to 2032**

Outflow	Baseline Run (No Project)	RCF Scenario 1	RCF Scenario 2	RCF Scenario 3
Across San Jacinto Fault near SAR to Rialto-Colton Groundwater Basin	712	707	694	691
Across Barrier E to Rialto-Colton Groundwater Basin	1,980	1,980	1,980	1,980
Total	2,692	2,687	2,674	2,671

4.4.5 Efficiency of Conjunctive Use Scenarios

Based on the water budgets from the RCF Scenarios 1 through 3, the efficiency of conjunctive use was evaluated. For Scenarios 1 through 3, the additional amounts of artificial recharge compared to Baseline Run (No Project) are 1,615 acre-ft/yr, 5,769 acre-ft/yr and 7,615 acre-ft/yr, respectively. Groundwater storage for each of the three scenarios also changes due to artificial recharge, the amounts of recharge from gaged streamflow, evapotranspiration, groundwater pumping, and underflow outflow. The following table summarizes these changes compared to the Baseline Run (No Project).

Summary of Efficiency of Conjunctive Use

Flux Term		RCF Scenario 1 [acre-ft/yr]	RCF Scenario 2 [acre-ft/yr]	RCF Scenario 3 [acre-ft/yr]
Inflow	Artificial Recharge	+1,615	+5,769	+7,615
	Recharge from Gaged Streamflow	-24	-137	-240
	Subtotal	+1,591	+5,632	+7,375
Outflow	Groundwater Pumping	+1,327	+4,838	+6,281
	Evapotranspiration	+243	+763	+1,084
	Underflow Outflow	-5	-18	-21
	Changes in Groundwater Storage	+27	+49	+32
	Subtotal	+1,592	+5,632	+7,376

As shown in the table above, the major loss of recharge water of the conjunctive use project is from the evapotranspiration. These losses are 243 acre-ft/yr, 763 acre-ft/yr, and 1,084 acre-ft/yr for RCF Scenarios 1 through 3, respectively. These losses are due to high water levels in the forebay area as a result of the artificial recharge from the RCF Conjunctive Use project. The losses of the Conjunctive Use recharge water were caused by evapotranspiration and discharging

water to the stream channel¹⁶ due to increase in groundwater levels.

For purposes of this report, the efficiency of conjunctive use was calculated as the ratio of the amount of additional groundwater pumping to the amount of additional artificial recharge.

4.4.6 PCE Plumes

Results for the PCE transport model are shown in Figures 36 through 39. These figures show the modeled MCL (5 µg/L) plume boundary of the Newmark and Muscoy PCE plumes in selected years for the Baseline Run (No Project) and RCF Scenarios 1 through 3, respectively. Results show no change in the Newmark and Muscoy PCE Plume areas for all the RCF scenarios as compared to the plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the PCE plume (approximately 1,910 acres) is reduced to approximately 670 acres for all of the RCF scenarios.

4.4.7 TCE Plumes

Results for the TCE transport model are shown in Figures 40 through 43. These figures show the modeled MCL (5 µg/L) plume boundary of the Norton and Redland-Crafton TCE plumes in selected years for the Baseline Run (No Project) and RCF Scenarios 1 through 3, respectively. Results show no change in the TCE Plume areas for all the RCF scenarios as compared to plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the TCE plume (approximately 2,030 acres) is reduced to approximately 260 acres for all of the RCF scenarios.

¹⁶ When the groundwater level in the aquifer is above the stage of the stream channel, there is no percolation from the stream channel and the groundwater flows from the aquifer to the stream channel.

4.4.8 Perchlorate Plume

Results for the perchlorate transport model are shown in Figures 44 through 47. These figures show the modeled MCL (6 µg/L) plume boundary of the perchlorate plume in selected years for the Baseline Run (No Project) and RCF Scenarios 1 through 3, respectively. Results show that perchlorate plume dissipates slightly faster for RCF scenarios as compared to the Baseline Run (No Project) as a result of increased extraction from the proposed RCF wellfield. Under Baseline Run (No Project) conditions, the overall initial area of the perchlorate plume (approximately 7,820 acres) is reduced to approximately 480 acres by the end of the predictive run (2032). By the end of the predictive run (2032), the perchlorate plume area would be 470 acres, 460 acres, and 450 acres for the RCF Scenarios 1 through 3, respectively.

4.4.9 Particle Tracking of the Newmark and Muscoy Plumes

The purpose of the MODPATH model was to evaluate potential impacts of the production from the RCF conjunctive use scenarios on remediation (i.e., cleanup) efforts in the Newmark and Muscoy plumes by evaluating directions of groundwater flow paths and travel times.

The particles were released at four section lines within the Newmark plume, and three section lines within the Muscoy plume (see Figure 48). The section lines are perpendicular to the groundwater flow directions. Twenty particles were released at model layers 3, 4, and 5 at each section line of the Newmark plume. Therefore, a total of 240 particles were released in the Newmark plume area. For the Muscoy plume area, 20 particles were released at model layers 1 and 3 at each section line with a total of 120 particles released. The following table summarizes the percent of particle recovery (i.e., either captured by the EPA plume front extraction wells, or wells upgradient of the extraction wells) under the Baseline Run (No Project) and RCF Scenarios 1 through 3 conditions.

Results of Particle Recovery from Newmark and Muscoy Plumes

Plume	Scenario	Number of Particle Released	Number of Particles Captured by EPA Extraction Wells or Upgradient Wells of EPA Extraction Wells	Percent of Particle Recovery
Newmark Plume	Baseline Run (No Project)	240	222	93%
	RCF Scenario 1		221	92%
	RCF Scenario 2		218	91%
	RCF Scenario 3		218	91%
Muscoy Plume	Baseline Run (No Project)	120	116	97%
	RCF Scenario 1		116	97%
	RCF Scenario 2		116	97%
	RCF Scenario 3		116	97%

As shown in the table, the particle recovery for the Newmark Plume is 91% to 92% for the RCF scenarios as compared to a particle recovery of 93% for the Baseline Run (No Project). The particle recovery for the Muscoy Plume is 97% for the all RCF scenarios and the Baseline Run (No Project). The Newmark and Muscoy Operable Units Statement of Work (Appendix D of Consent Decree) specifies a minimum particle recovery of 85% for the Newmark Plume Front extraction well network and the Muscoy Plume Front extraction well network when these extraction wells are set equivalent to or above the design extraction rates. Results of the particle tracking from the Newmark and Muscoy Plumes show that the RCF Conjunctive Use project would not impact the contamination plumes.

5.0 CONCLUSIONS

Based on results of the modeling, the following conclusions have been made for the RCF Conjunctive Use scenarios:

- For RCF Scenario 1, the changes in water level from the Baseline Run (No Project) range from a decline of one ft to a rise of three ft. Water level changes range from a decline of four ft to a rise of 11 ft for RCF Scenario 2 as compared to the Baseline Run (No Project). For RCF Scenario 3, these changes range from a decline of six ft to a rise of 13 ft. In general, the wells with declines in water levels are located in the vicinity or downgradient of the proposed RCF wellfield (e.g., City of Redlands Well No. 32 and City of Riverside Raub 1 Well). Wells with increases in groundwater elevations are located in the forebay recharge areas due to artificial recharge from the RCF.
- Based on results from iterative model runs, RCF Scenario 1 consists of artificial recharge of 42,000 acre-ft and extraction of 34,500 acre-ft during the 26 years from 2007 through 2032. RCF Scenario 2 includes artificial recharge of 150,000 acre-ft and extraction of 125,800 acre-ft. RCF Scenario 3 includes artificial recharge of 198,000 acre-ft and extraction of 163,300 acre-ft.
- The acreage of the potential liquefaction area in the Pressure Zone is approximately 720 acres in year 2001 (year with the greatest potential liquefaction area) and is approximately 3.7% of total Pressure Zone area of 19,320 acres for the Baseline Run (No Project). The potential liquefaction area was estimated to be approximately 690 acres, 540 acres, and 600 acres for RCF Scenarios 1 through 3, respectively. The slight reduction in potential liquefaction area in the Pressure Zone was due to extraction occurring in the proposed RCF wellfield near the Pressure Zone area.
- Groundwater storage in the SBBA declines by 32,181 acre-ft during the period 2007 through 2032 under Baseline Run (No Project) conditions. Groundwater storage decline

for RCF Scenarios 1 through 3 was less than under Baseline Run (No Project) conditions, which are estimated be negative 31,496 acre-ft, negative 30,909 acre-ft, and negative 31,358 acre-ft, respectively. These results indicate that slightly more water (685 acre-ft for Scenario 1, 1,272 acre-ft for Scenario 2, and 823 acre-ft for Scenario 3) was recharged over the 26 years than what was necessary to maintain a total recharge equal to the Baseline Run (No Project) conditions.

- The annual average underflow outflow across the San Jacinto Fault near the SAR to the Rialto-Colton Groundwater Basin for the period 2007 to 2032 was estimated to be 712 acre-ft/yr under Baseline Run (No Project) conditions. The underflow outflow was estimated to be 707 acre-ft/yr, 694 acre-ft/yr, and 691 acre-ft/yr for the RCF Scenarios 1 through 3, respectively. These changes in underflow outflow are minimal for the RCF scenarios as compared to the Baseline Run (No Project).
- Storage results indicated that the Conjunctive Use project has no potential groundwater impacts.
- For purpose of this report, the efficiency of Conjunctive Use project was calculated as the ratio of the amount of additional groundwater pumping to the amount of additional artificial recharge. The efficiency ranges from 82% for Scenarios 1 and 3 to 84% for Scenario 2. The efficiency was optimized based on iterative model runs by varying the timing and amount of artificial recharge and groundwater pumping. The major loss of water for the conjunctive use model runs would be the increase in evapotranspiration as well as the reduction of recharge from streamflow due to increases in water levels as a result of additional artificial recharge at the spreading grounds in the forebay area.
- Solute transport model results show no change in the Newmark and Muscoy PCE Plume areas for all the RCF scenarios as compared to plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the

PCE plume (approximately 1,910 acres) is reduced to approximately 670 acres for all of the RCF scenarios.

- Solute transport model results show no change in the TCE Plume areas for all the RCF scenarios as compared to plume area under Baseline Run (No Project) conditions. By the end of the predictive run (2032), the overall initial area of the TCE plume (approximately 2,030 acres) is reduced to approximately 260 acres for all of the RCF scenarios.
- Solute transport model results show that the perchlorate plume dissipates slightly faster for the RCF scenarios as compared to the Baseline Run (No Project) as a result of increased extraction from the proposed RCF wellfield. Under Baseline Run (No Project) conditions, the overall initial area of the perchlorate plume (approximately 7,820 acres) is reduced to approximately 480 acres by the end of the predictive run (2032). By the end of the predictive run (2032), the perchlorate plume area would be 470 acres, 460 acres, and 450 acres for RCF Scenarios 1 through 3, respectively.
- Particle tracking results show that the particle recovery for the Newmark Plume is 91% to 92% for the RCF scenarios as compared to a particle recovery of 93% for the Baseline Run (No Project). The particle recovery for the Muscoy Plume is 97% for all RCF scenarios and the Baseline Run (No Project). The Newmark and Muscoy Operable Units Statement of Work (Appendix D of Consent Decree) specifies a minimum particle recovery of 85% for the Newmark Plume Front extraction well network and the Muscoy Plume Front extraction well network when these extraction wells are set equivalent to or above the design extraction rates. Results of the particle tracking from the Newmark and Muscoy Plumes show that the RCF conjunctive use scenarios would not impact the contamination plumes.

6.0 MODEL LIMITATIONS AND UNCERTAINTY

The SBBA RBFM and RBSTM are useful tools for evaluating water levels and water quality of the aquifer systems. However, it is a simplified approximation of a complex hydrogeologic system. The accuracy of model predictions is dependent on the assumptions used for the model prediction. As an example, simplifications and uncertainty of the estimation mass loading for the contaminants (i.e., PCE, TCE, and perchlorate) may have effects on model results.

Models have a number of limitations that must be understood if they are to be used effectively. These limitations are related to:

- Discretization effects;
- Uncertainty in aquifer parameters;
- Uncertainty in boundary conditions; and
- Underlying assumptions for modeling scenarios.

Model accuracy can always be improved with new geohydrologic data.

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FIGURES

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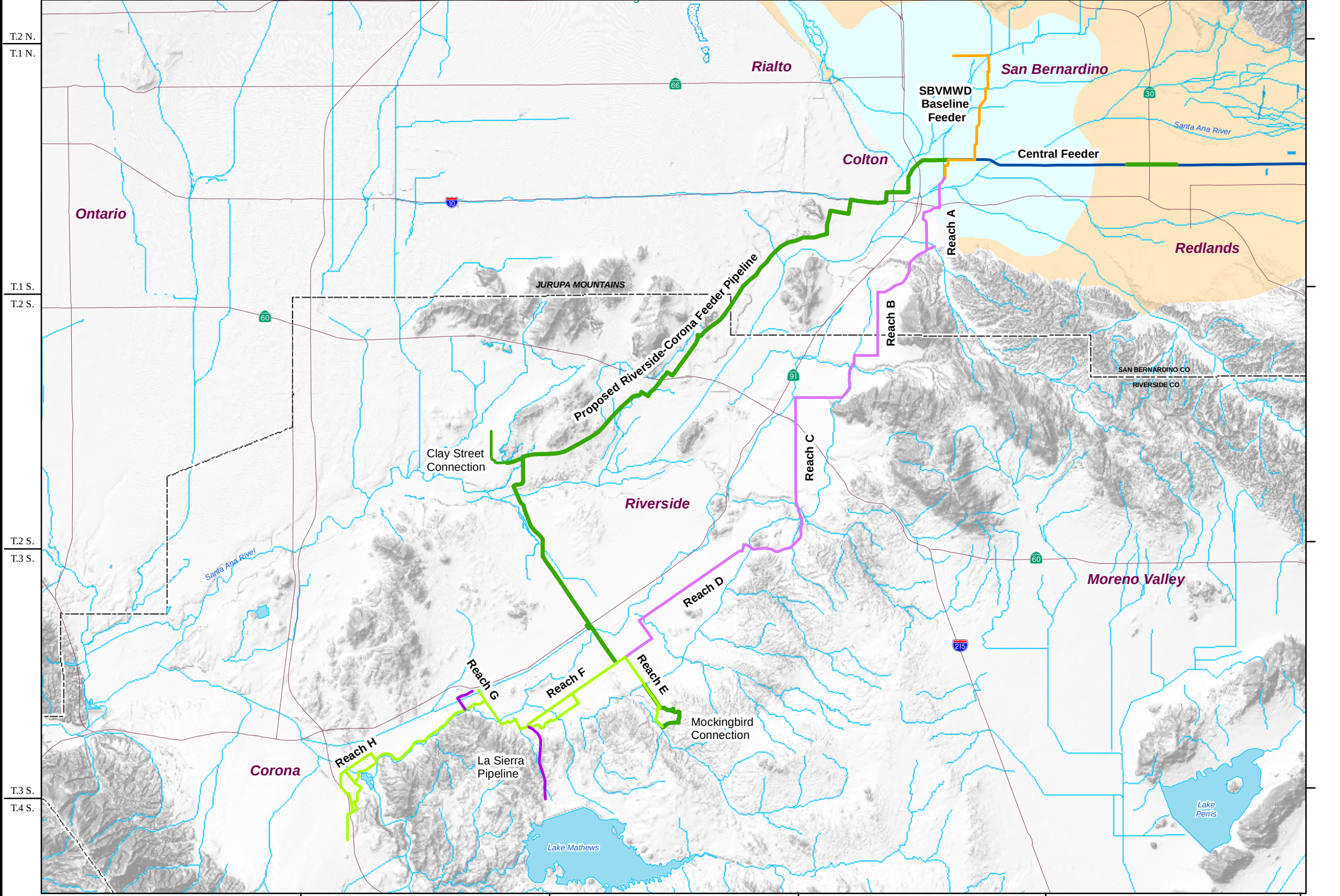


GENERAL
RIVERSIDE-CORONA
FEEDER PROJECT
LOCATION

EXPLANATION

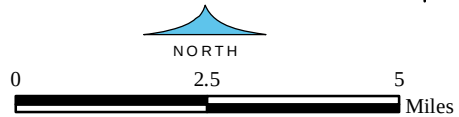
- Proposed Riverside-Corona Feeder Realignment
- R-C Feeder Alignment (Reaches E-H)
- Original R-C Feeder Alignment (Reaches A-D)
- Central Feeder Pipeline
- SBVMWD Pipeline
- Riverside-Corona Feeder - La Sierra Pipeline
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary

Source of Pipelines:
Albert A. Webb Associates, 2009.
SBVMWD, 2005.



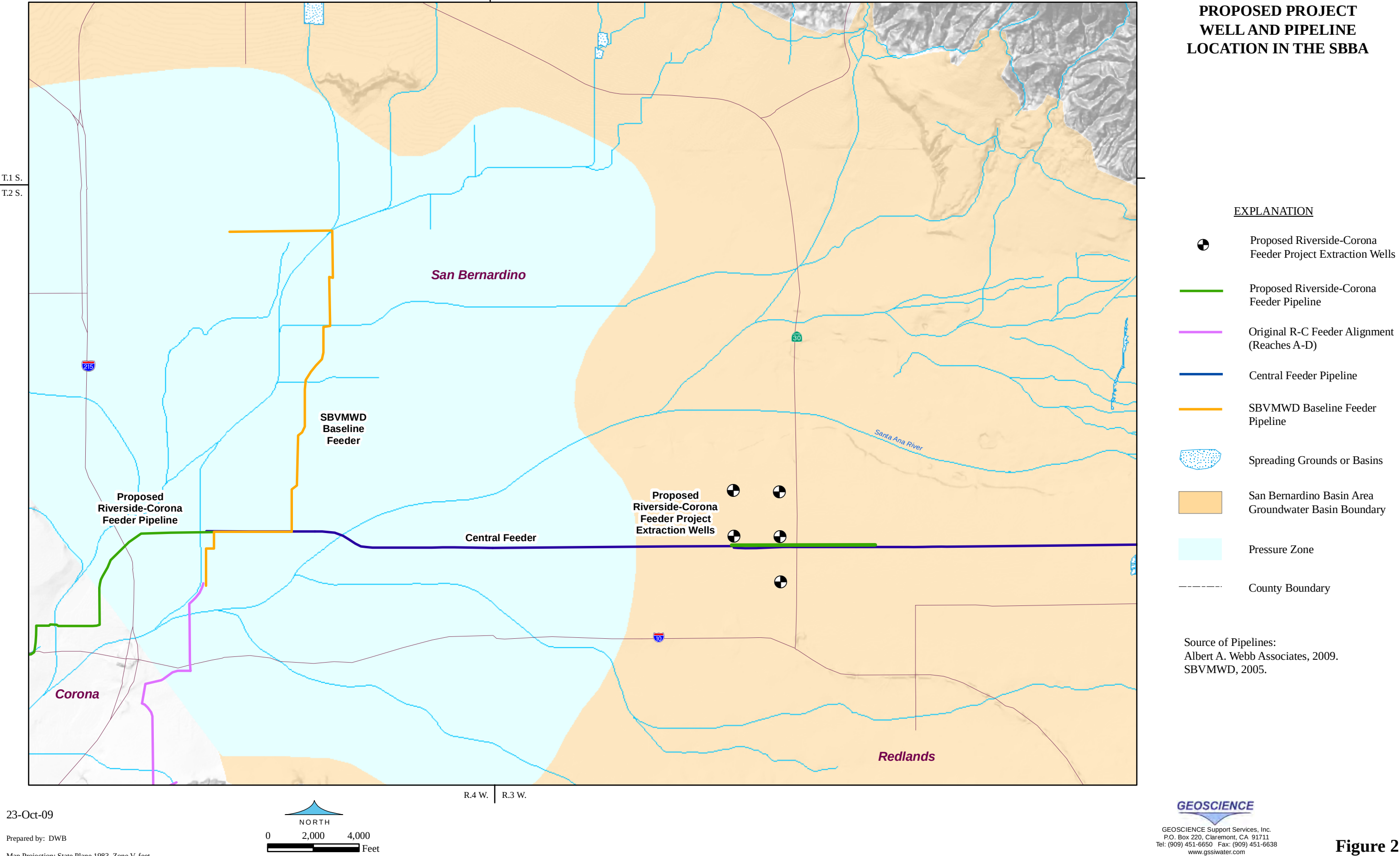
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Map Projection: State Plane 1983, Zone V, feet



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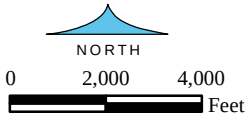
Figure 1



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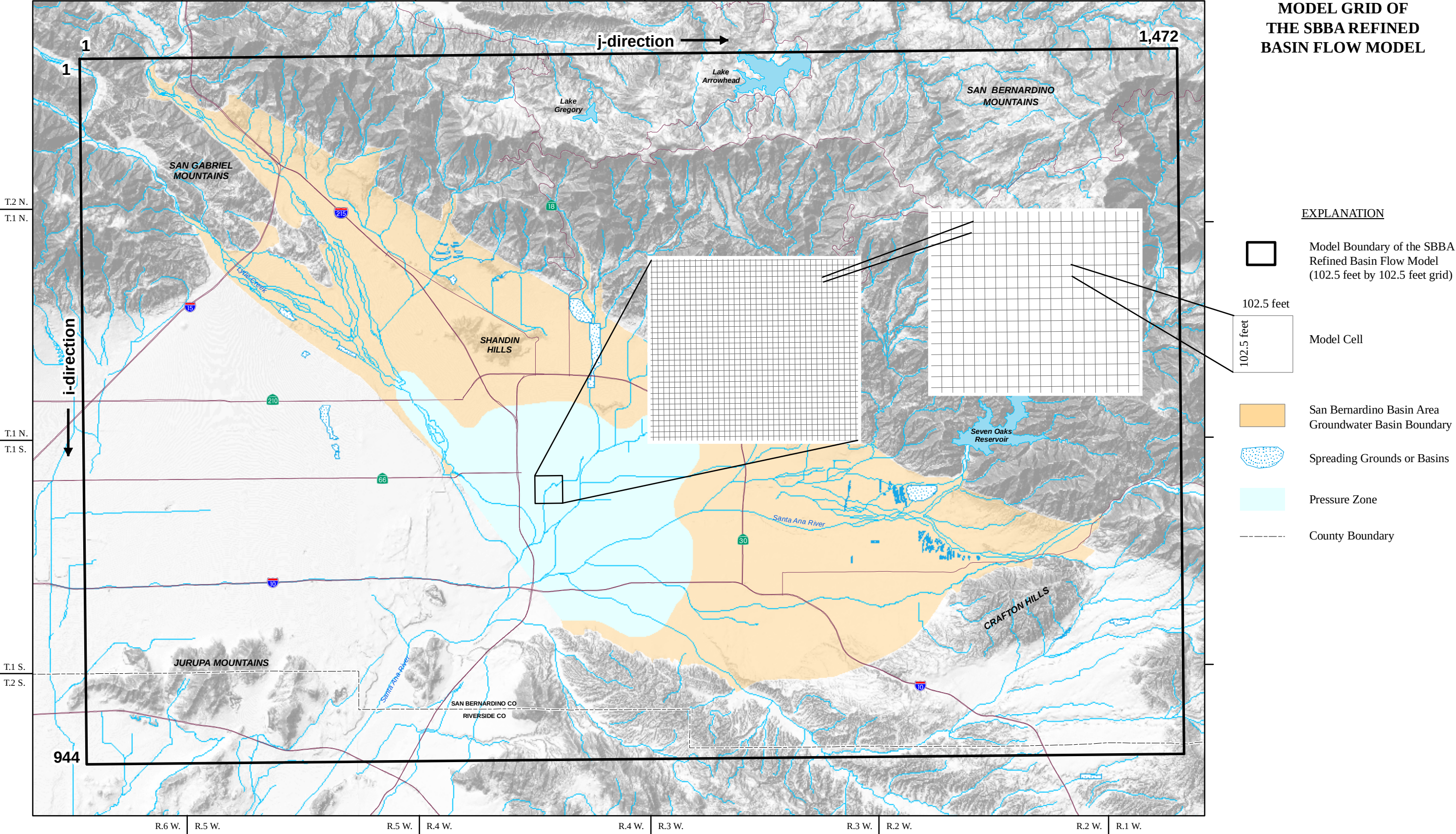
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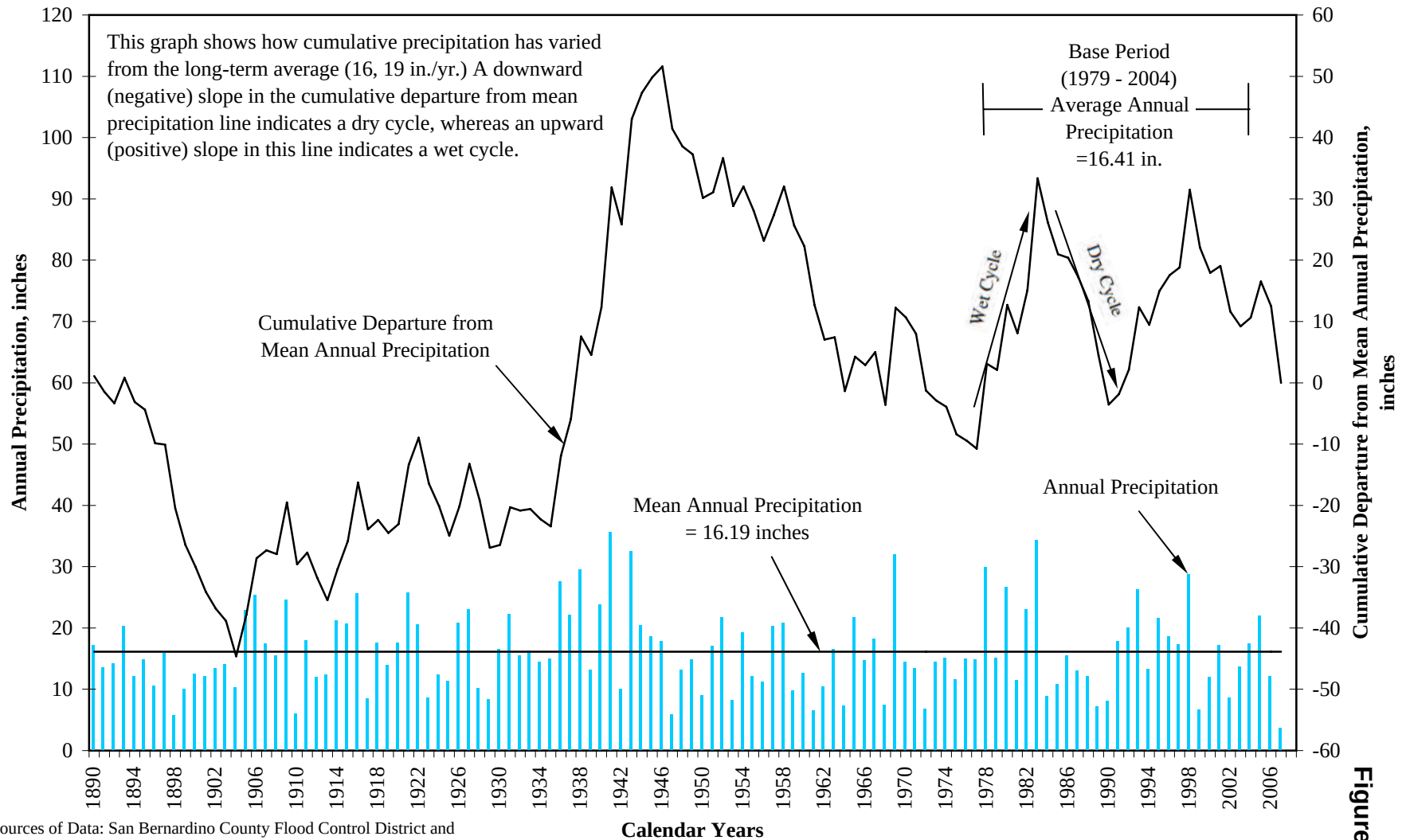
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Figure 2

MODEL GRID OF
THE SBBA REFINED
BASIN FLOW MODEL



Cumulative Departure from Mean Annual Precipitation San Bernardino County Hospital Station 1890 - 2007



Sources of Data: San Bernardino County Flood Control District and Santa Ana River Watermaster Annual Reports

Figure 4

Cumulative Departure from Mean Annual Streamflow Santa Ana River Near Mentone Gaging Station (Combined) 1913-2005

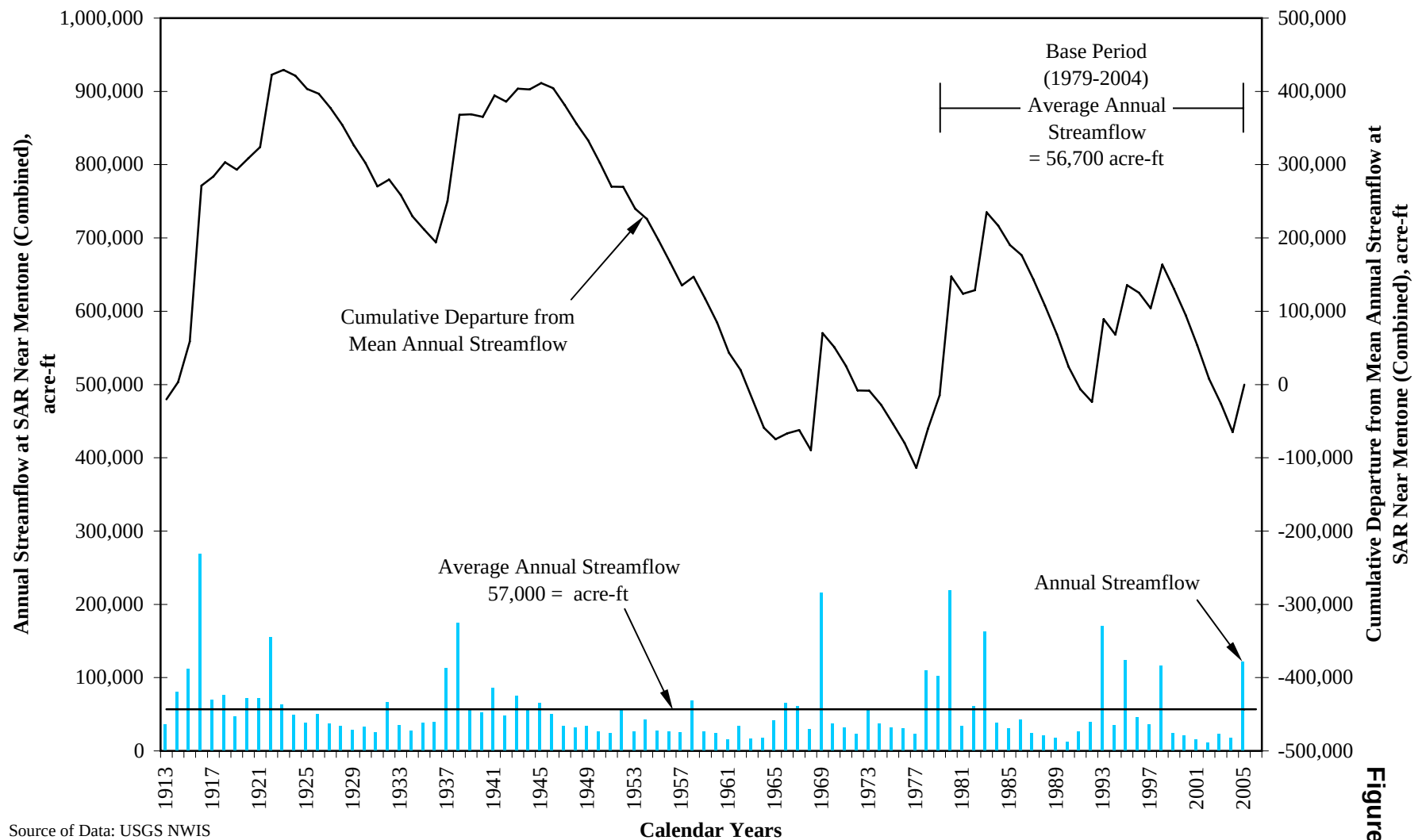


Figure 5

Groundwater Pumping for the Baseline Run (No Project) - 2007 to 2032

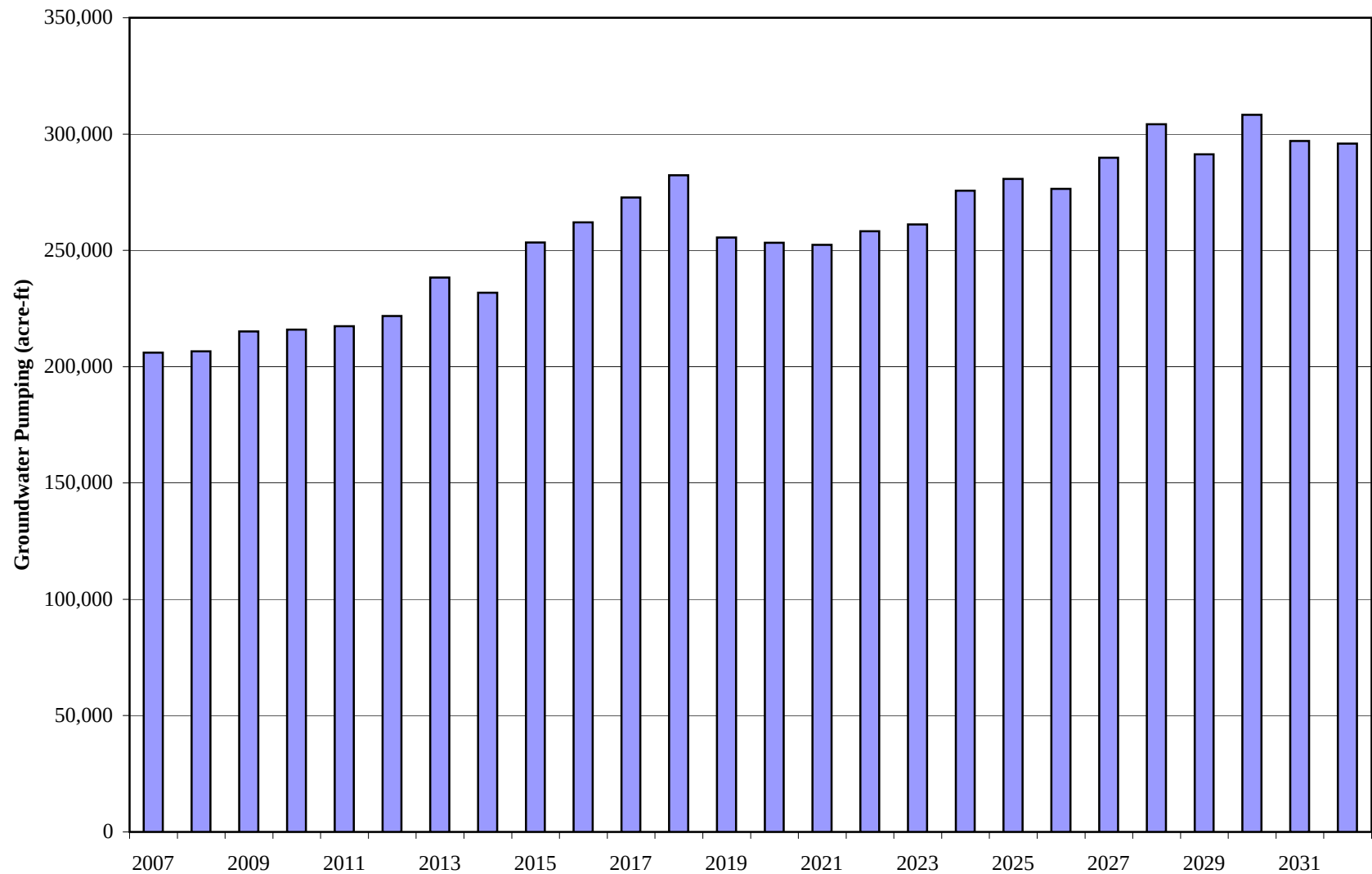


Figure 6

Artificial Recharge for the Baseline Run (No Project) - 2007 to 2032

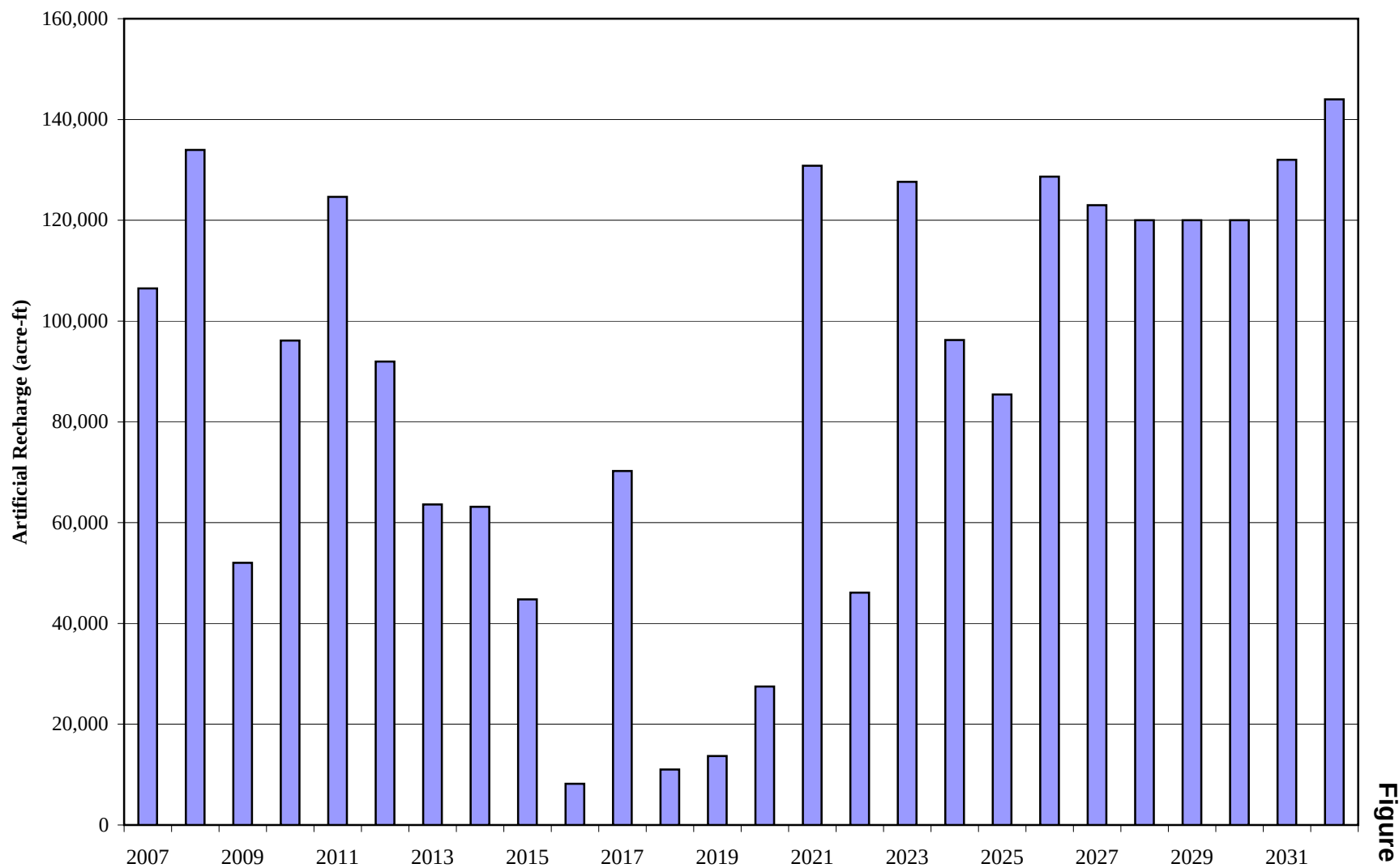
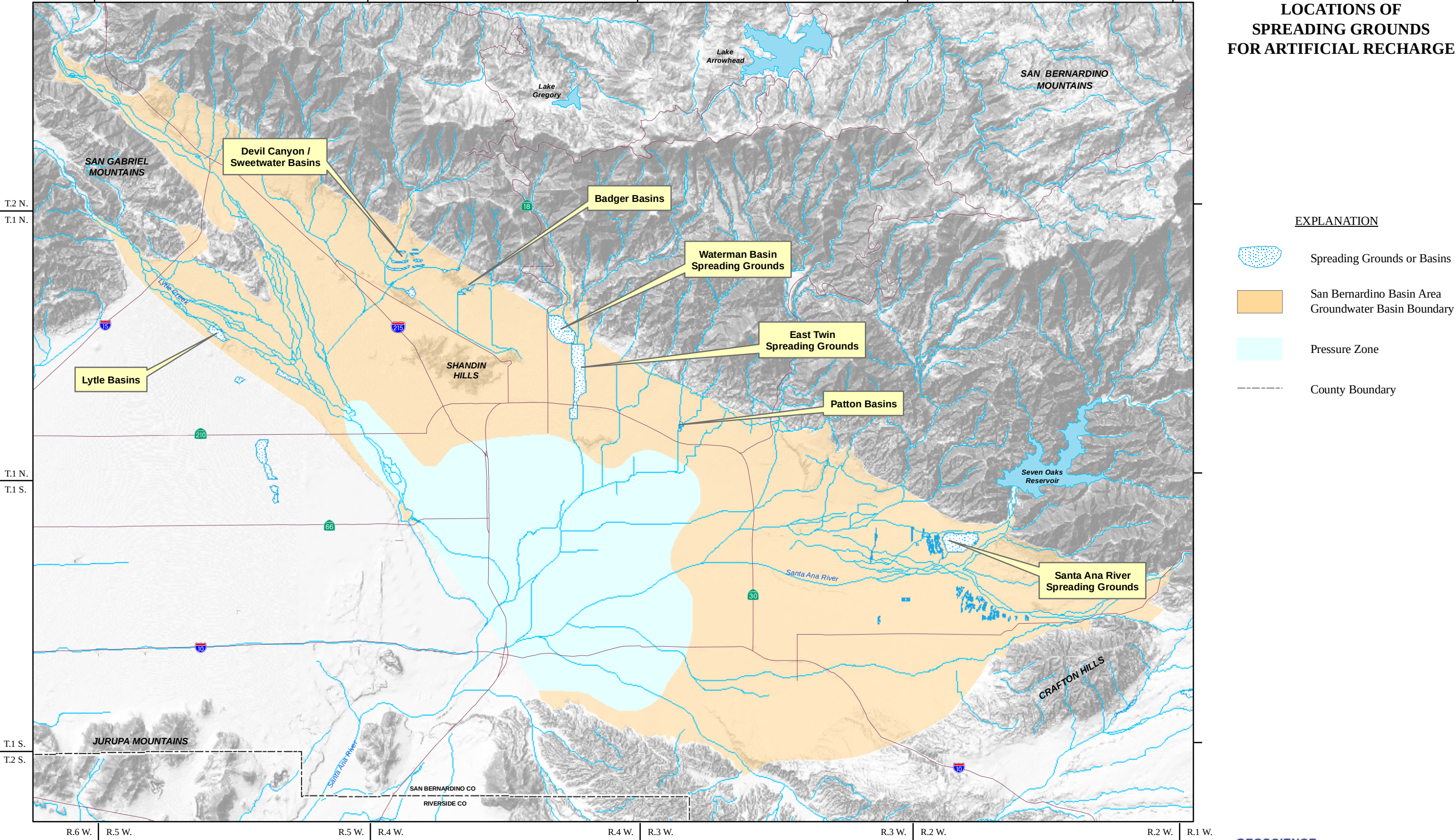


Figure 7

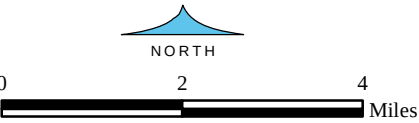
LOCATIONS OF
SPREADING GROUNDS
FOR ARTIFICIAL RECHARGE



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Map Projection: State Plane 1983, Zone V, feet



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Figure 8

Replenishment and Extraction for Riverside-Corona Feeder Project Scenario 1 2007 to 2032

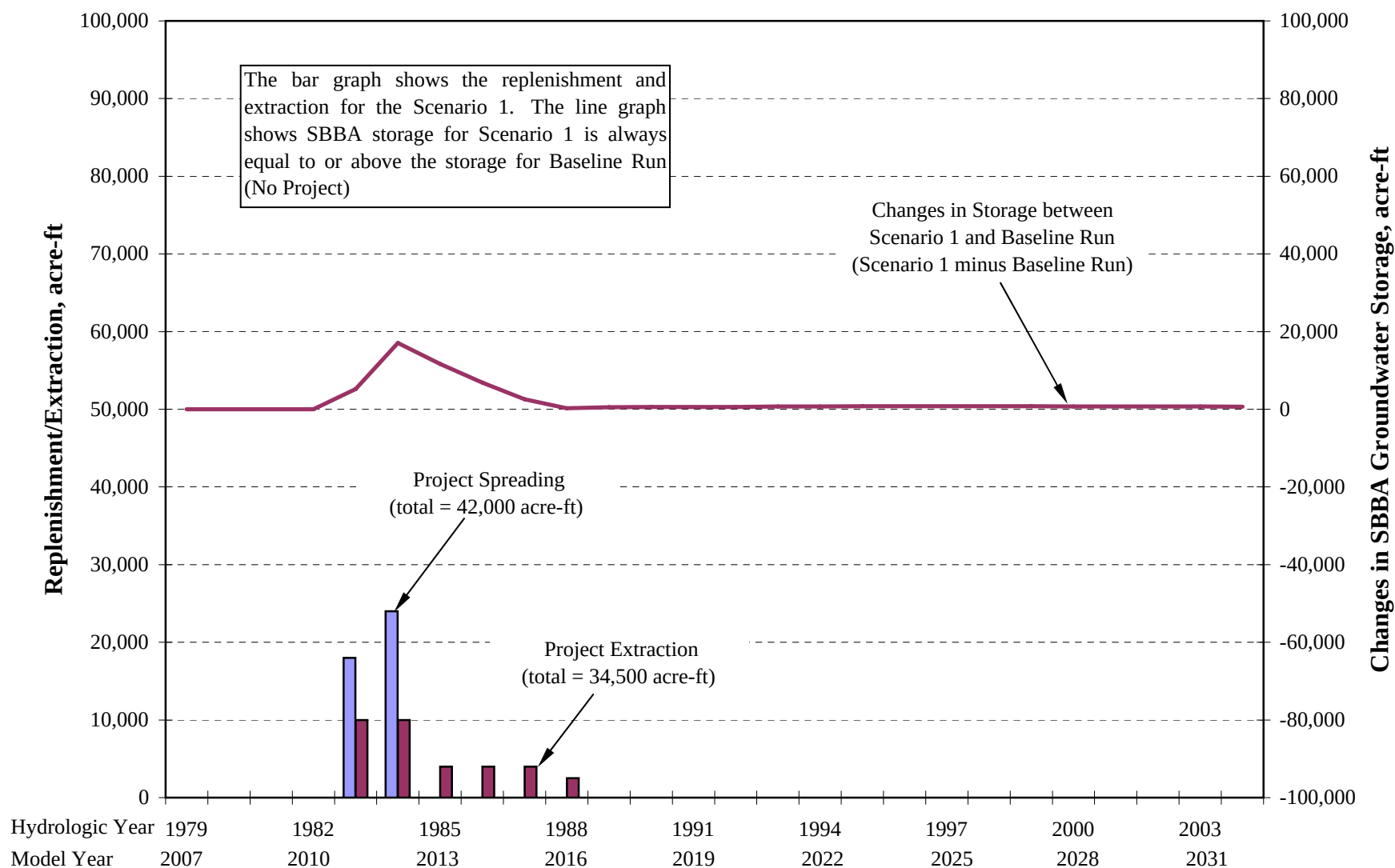


Figure 9

Replenishment and Extraction for Riverside-Corona Feeder Project Scenario 2 2007 to 2032

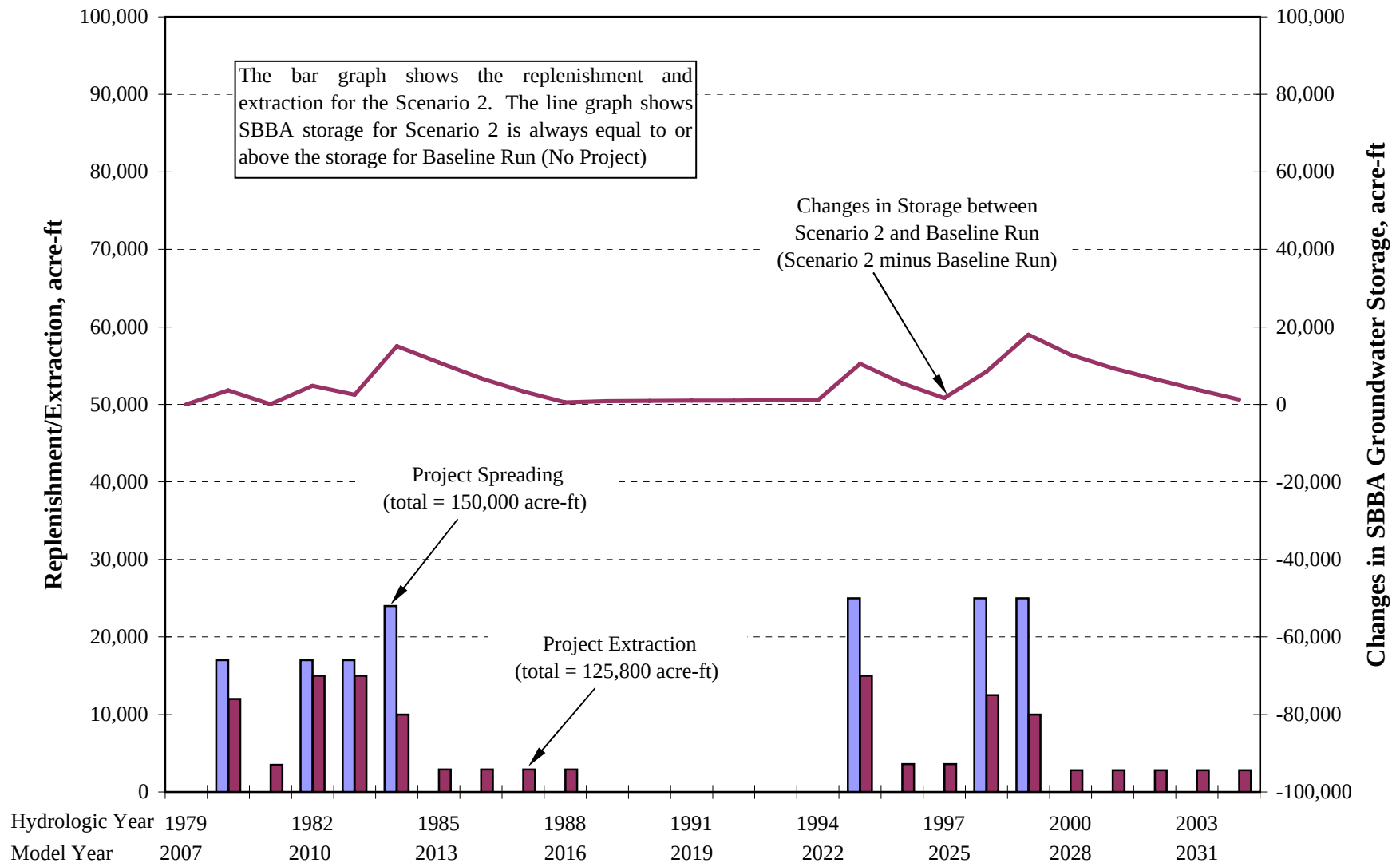


Figure 10

Replenishment and Extraction for Riverside-Corona Feeder Project Scenario 3 2007 to 2032

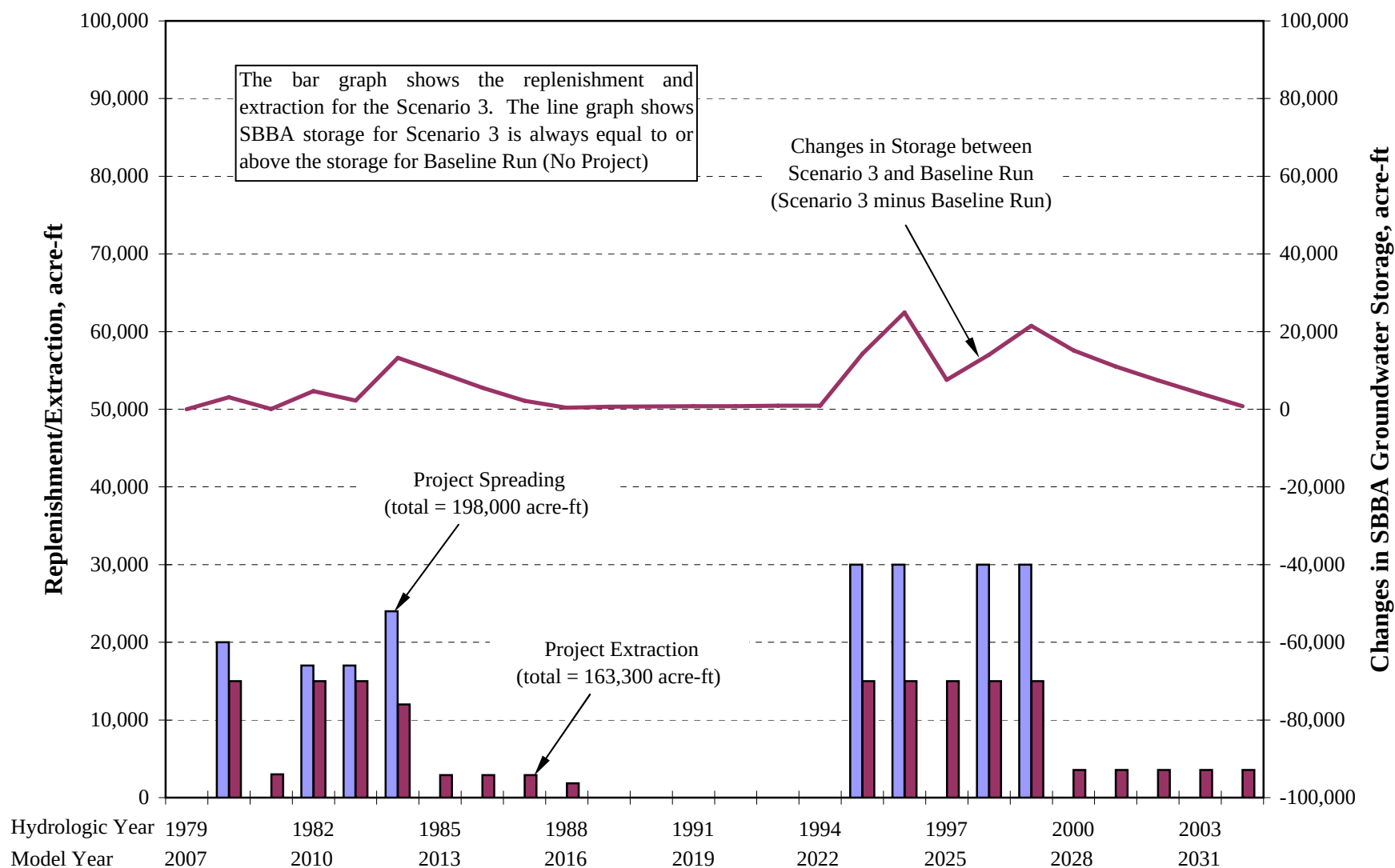


Figure 11

Comparison of 2005 and 2008 Surplus Water Reliability

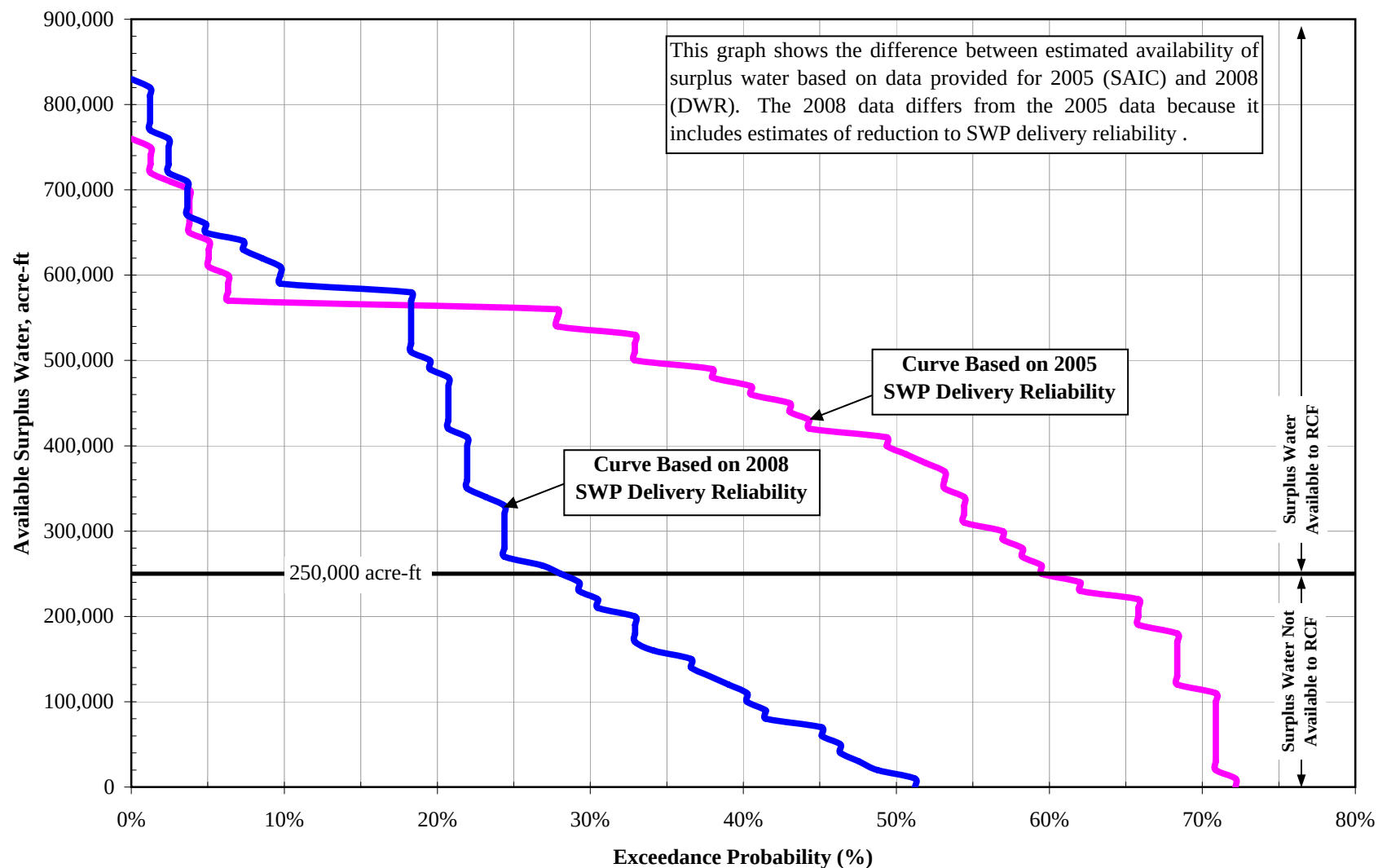


Figure 12

Exceedance Probability of Surplus Water Available for Riverside-Corona Feeder Project

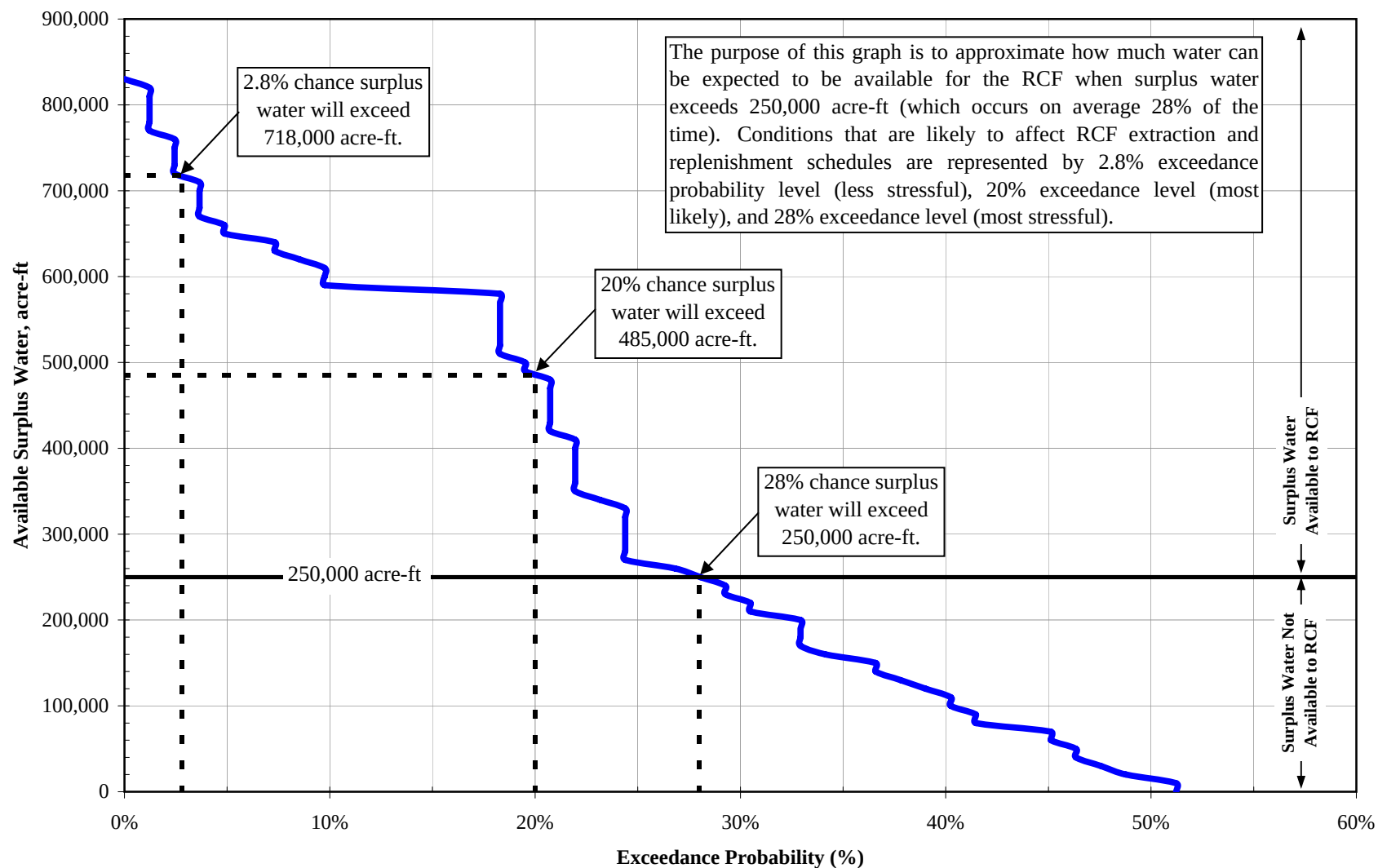
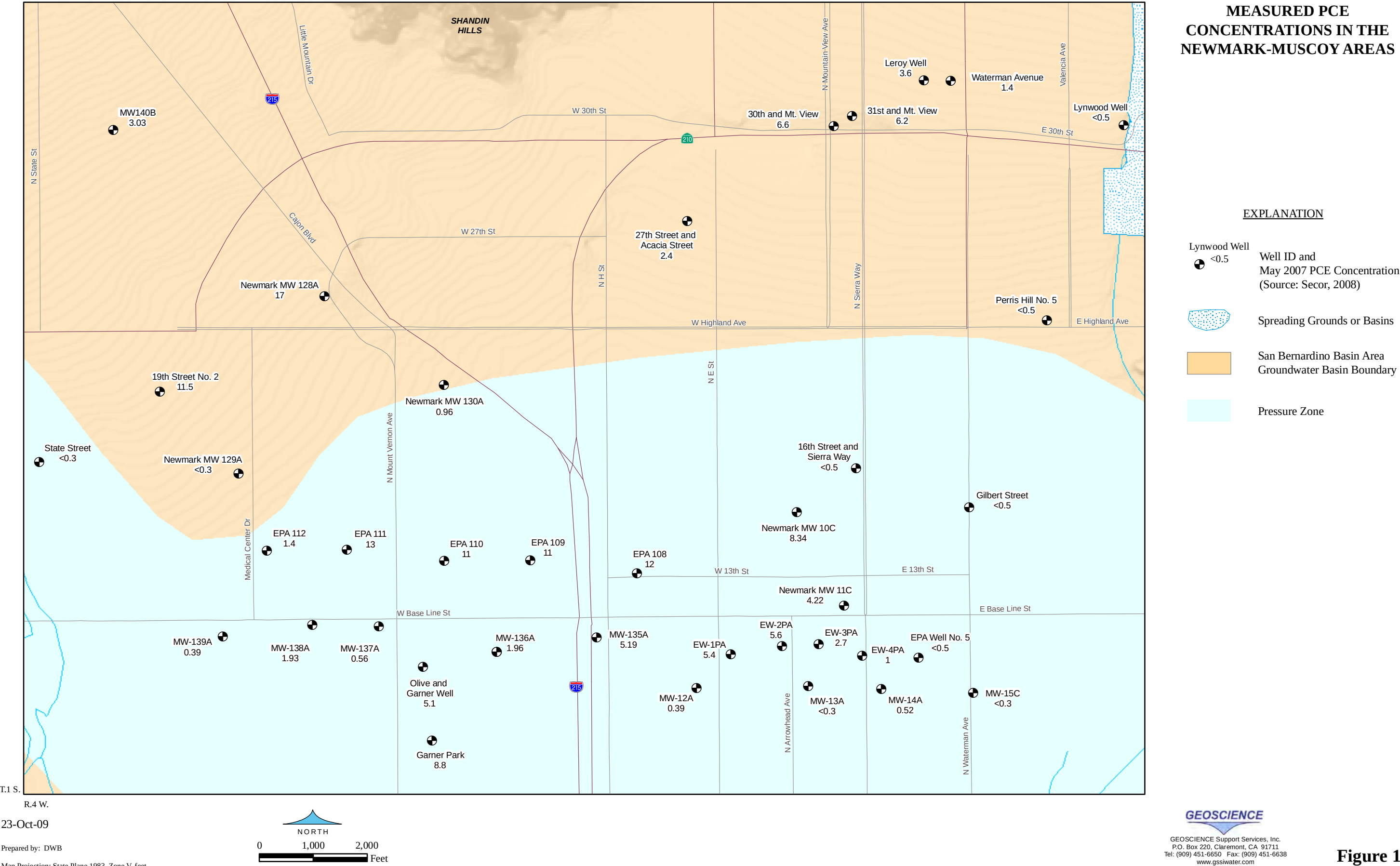
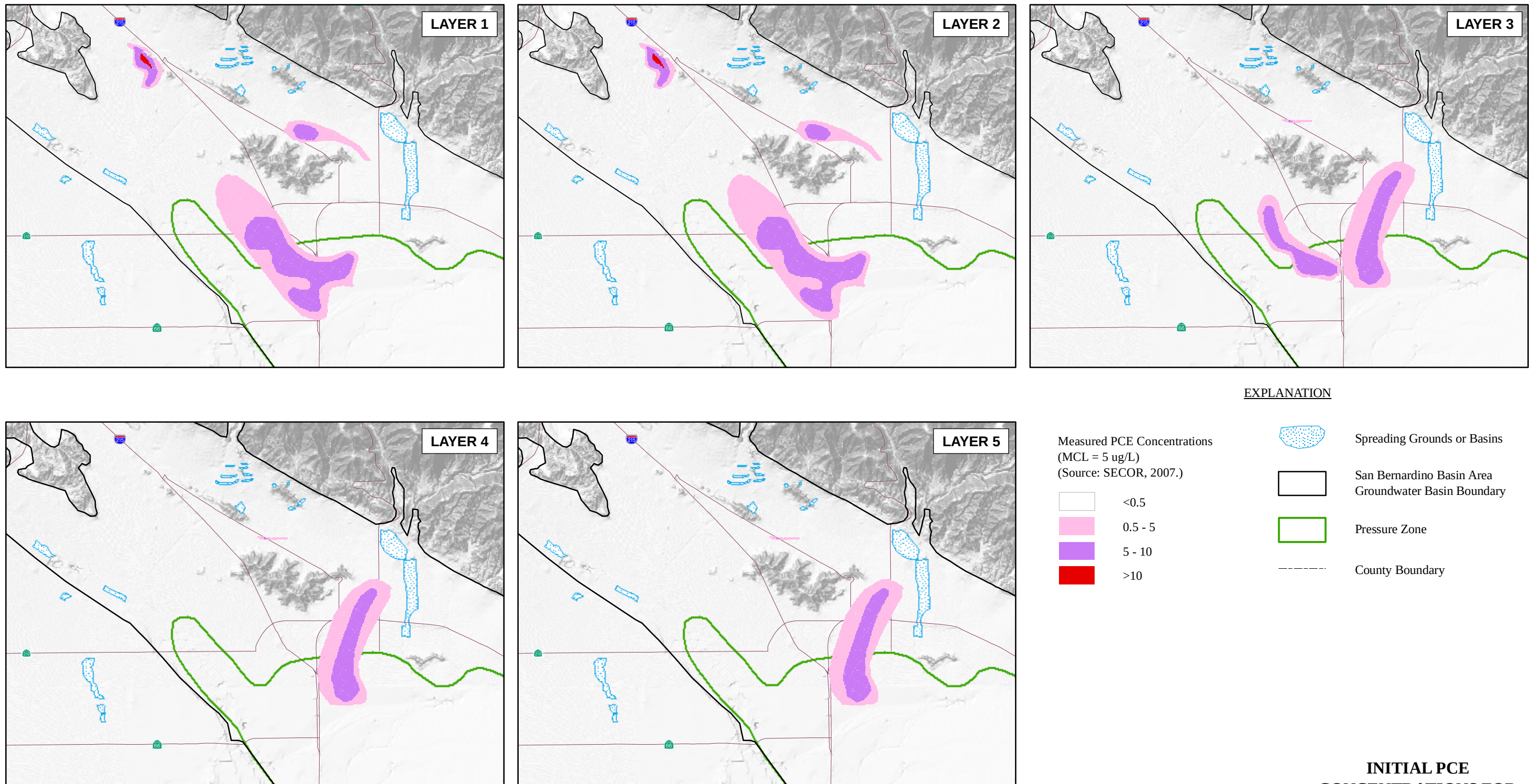


Figure 13



WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

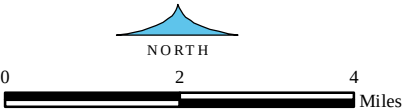


INITIAL PCE
CONCENTRATIONS FOR
MODEL PREDICTIVE
SCENARIOS

23-Oct-09

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Map Projection: State Plane 1983, Zone V, feet



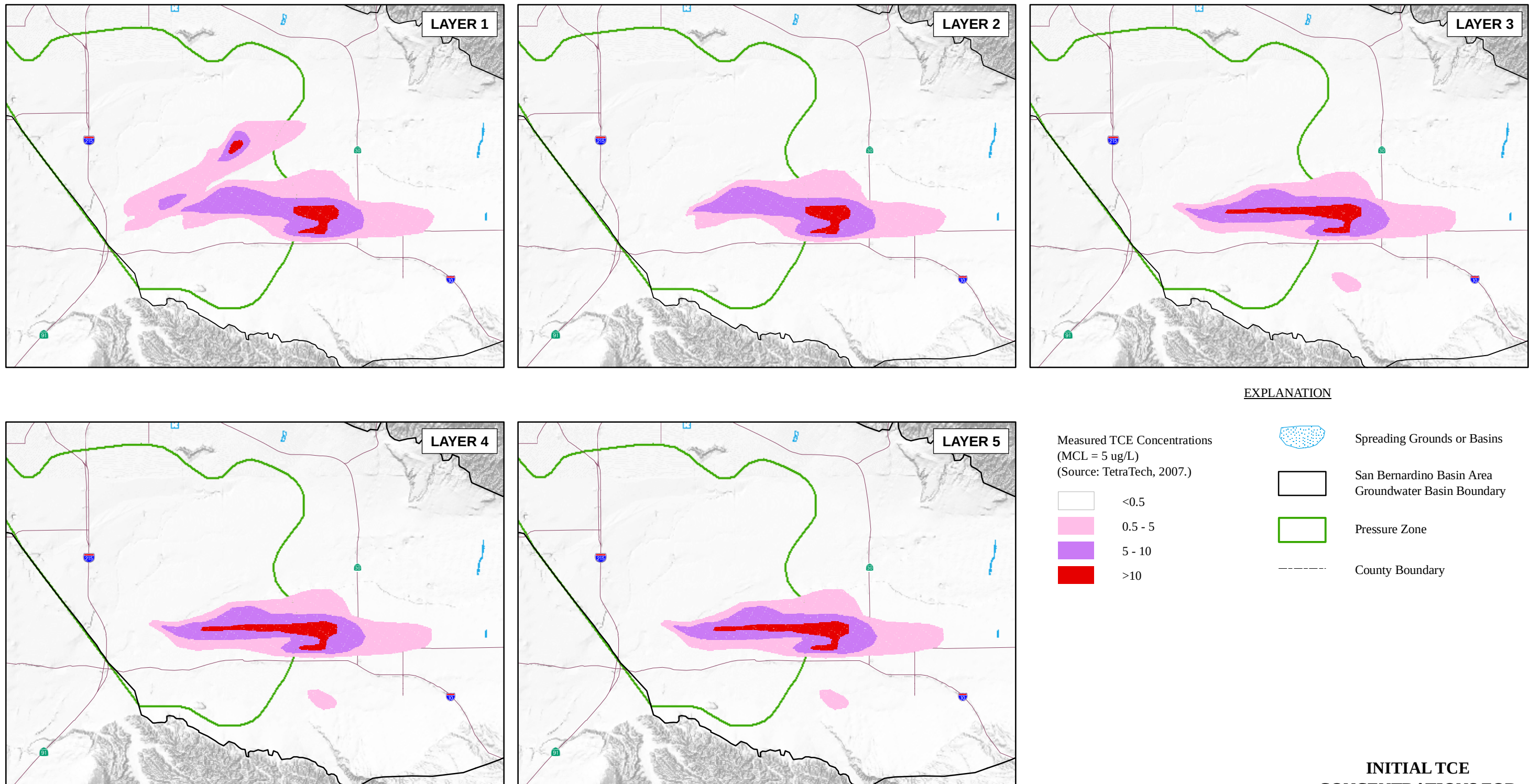
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Figure 15

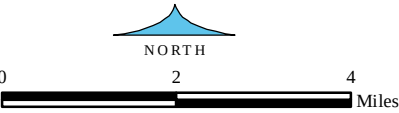
WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



INITIAL TCE
CONCENTRATIONS FOR
MODEL PREDICTIVE
SCENARIOS

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Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

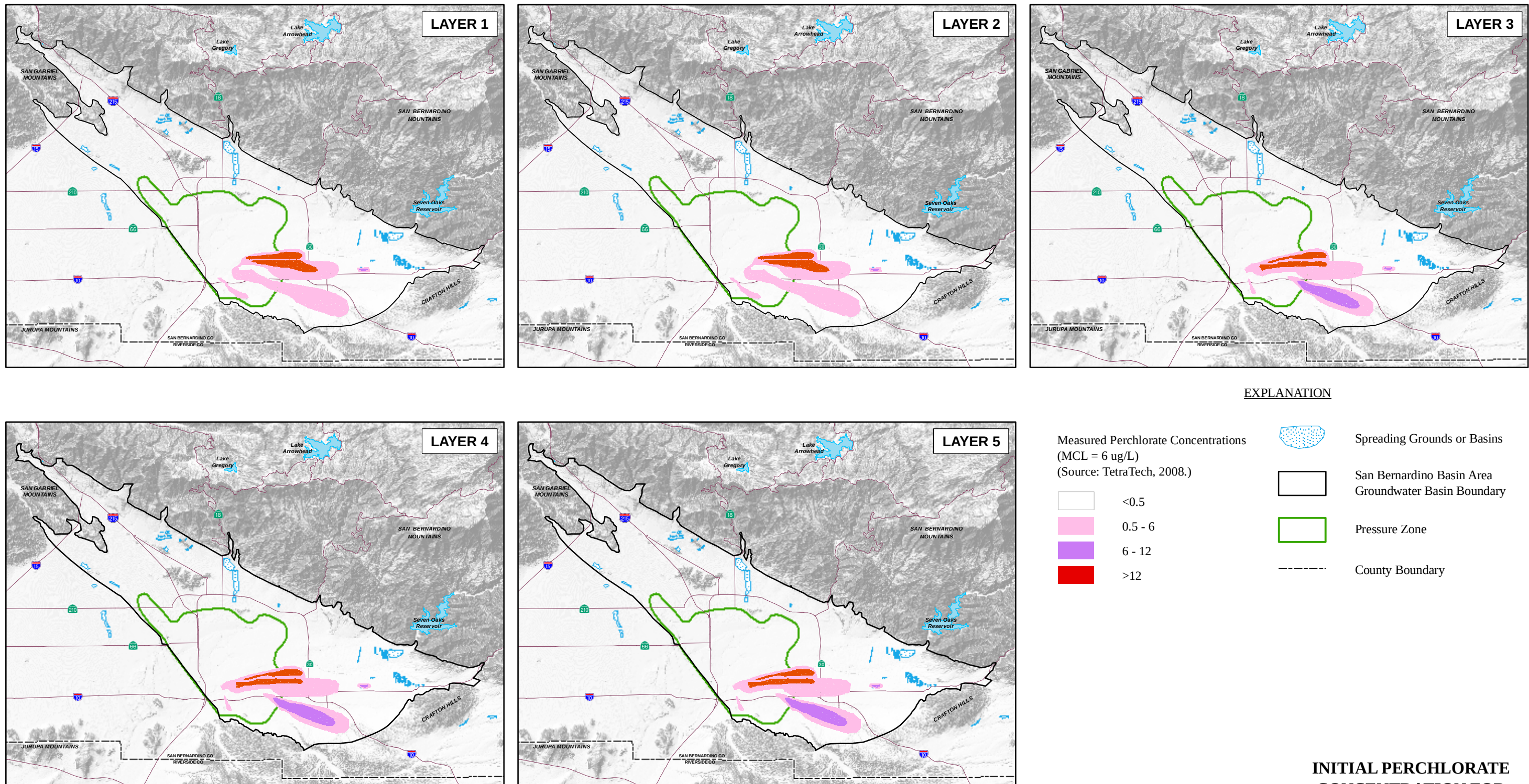


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Figure 16

WESTERN MUNICIPAL WATER DISTRICT

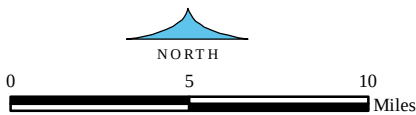
GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



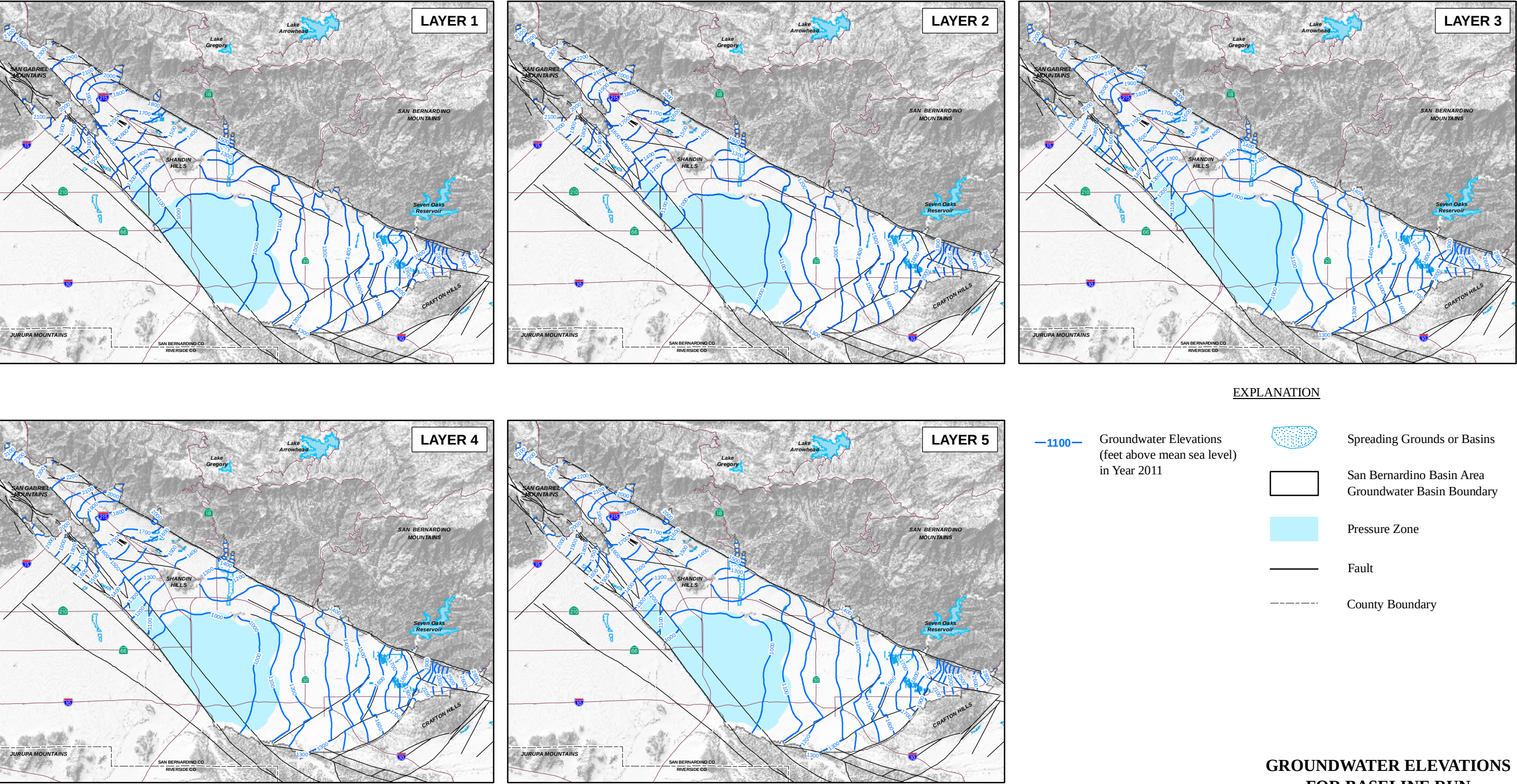
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**INITIAL PERCHLORATE
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MODEL PREDICTIVE
SCENARIOS**

Figure 17

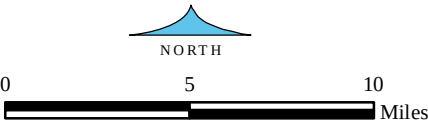
WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



GROUNDWATER ELEVATIONS
FOR BASELINE RUN
(NO PROJECT)
IN YEAR 2011

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet



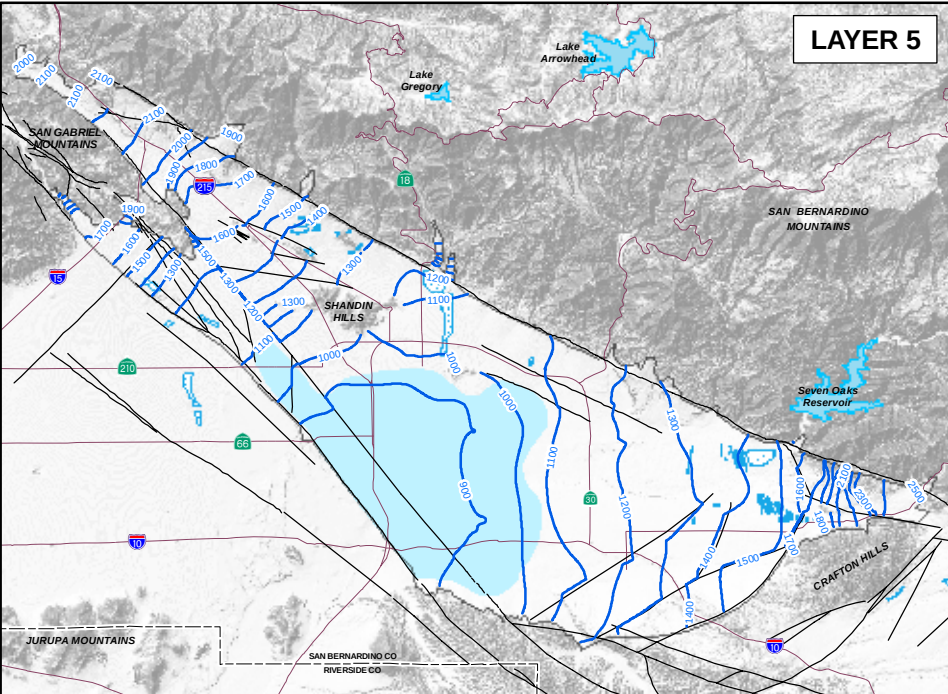
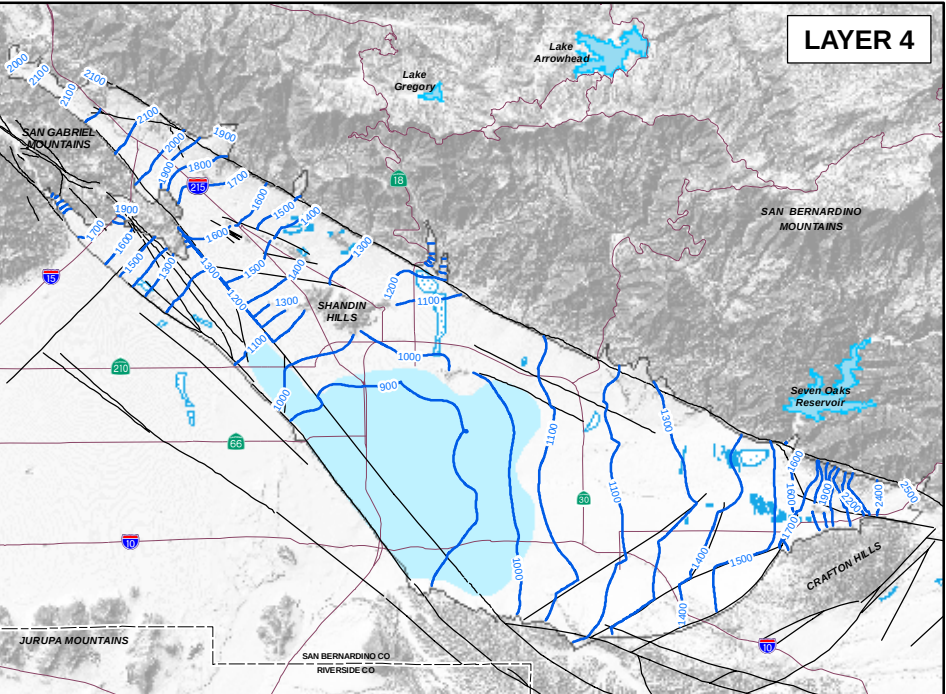
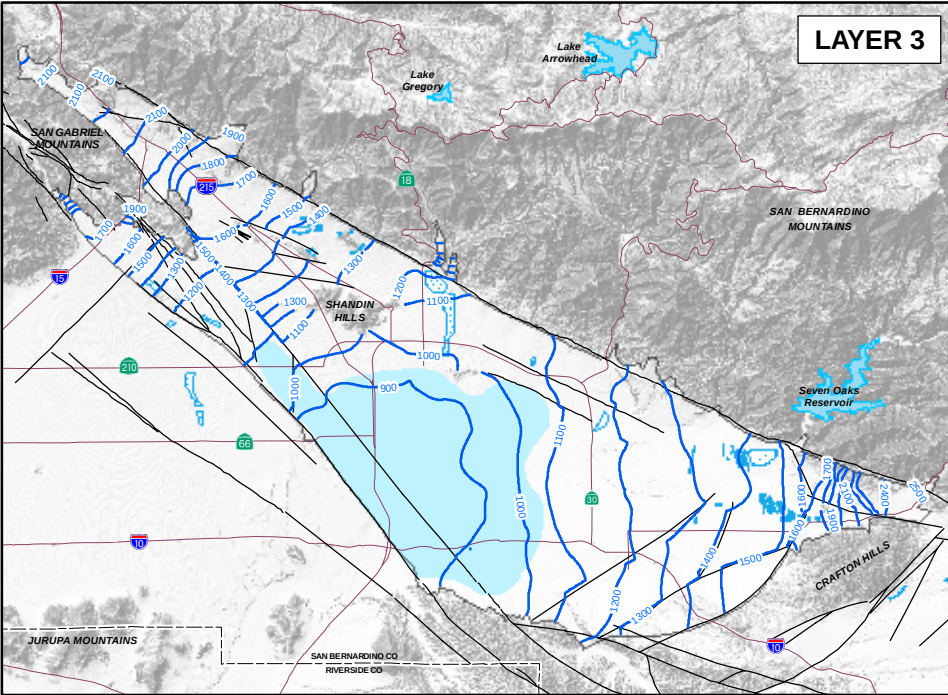
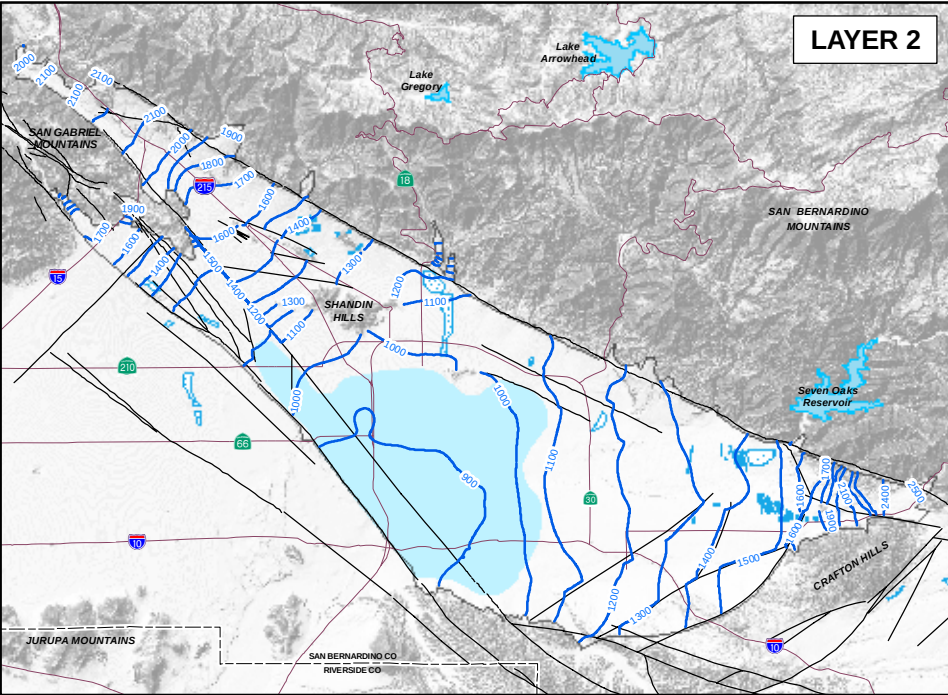
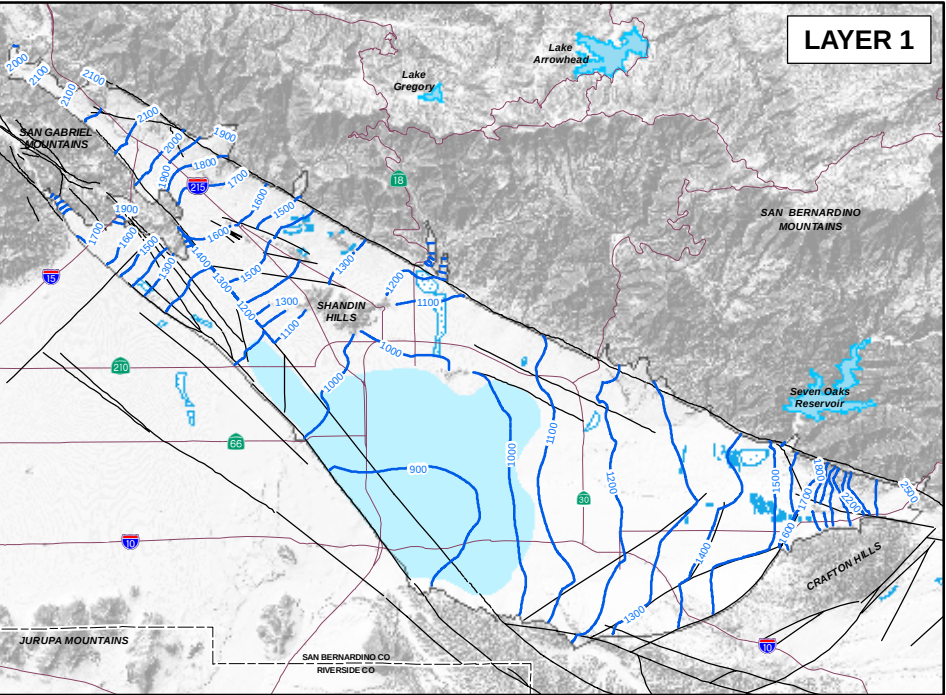
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Figure 18

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

—1100— Groundwater Elevations
(feet above mean sea level)
in Year 2020



Spreading Grounds or Basins



San Bernardino Basin Area
Groundwater Basin Boundary



Pressure Zone



Fault



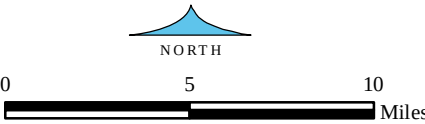
County Boundary

GROUNDWATER ELEVATIONS
FOR BASELINE RUN
(NO PROJECT)
IN YEAR 2020

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



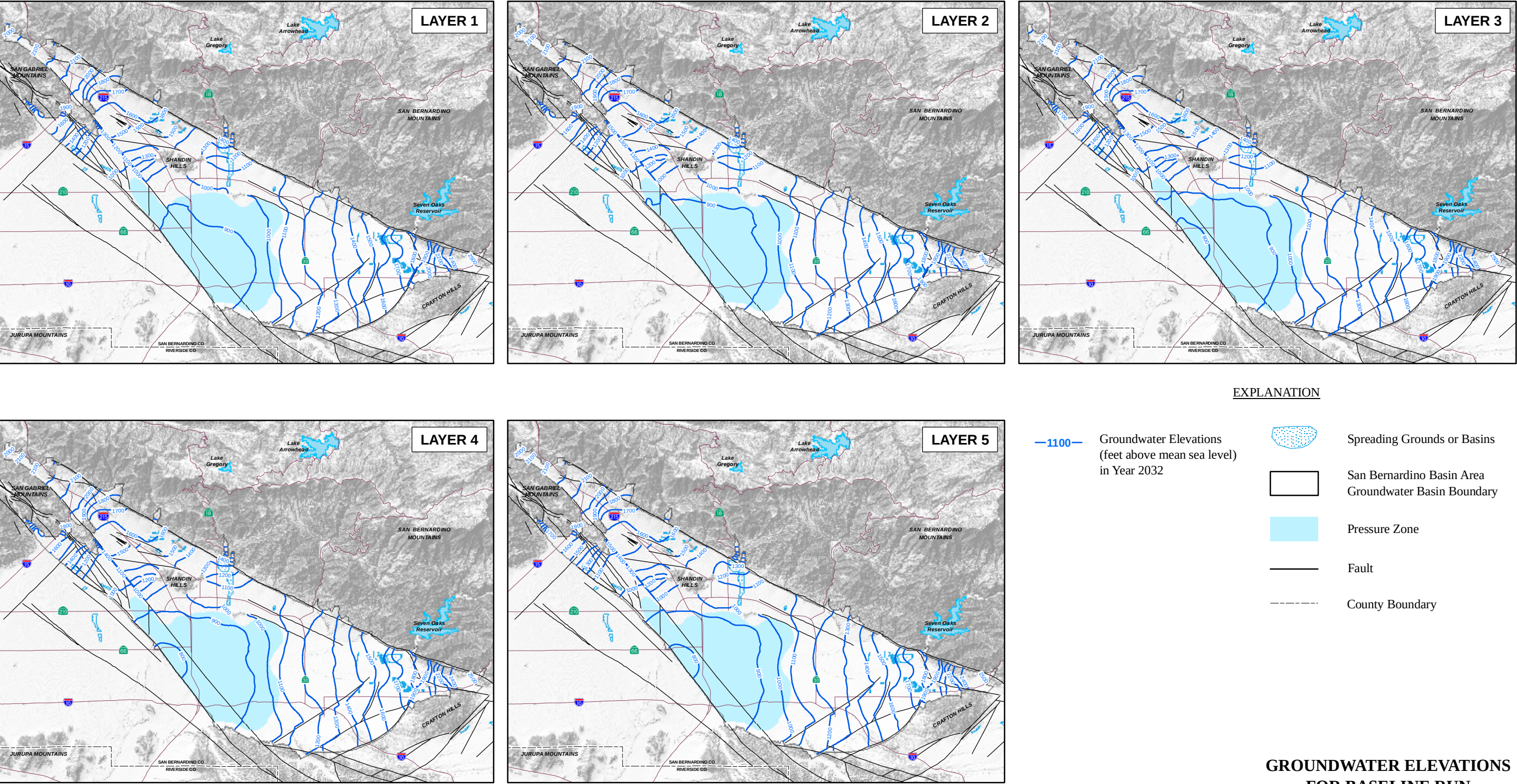
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Figure 19

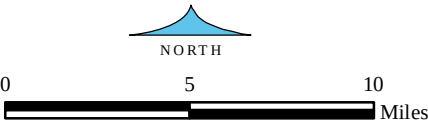
WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



GROUNDWATER ELEVATIONS
FOR BASELINE RUN
(NO PROJECT)
IN YEAR 2032

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet



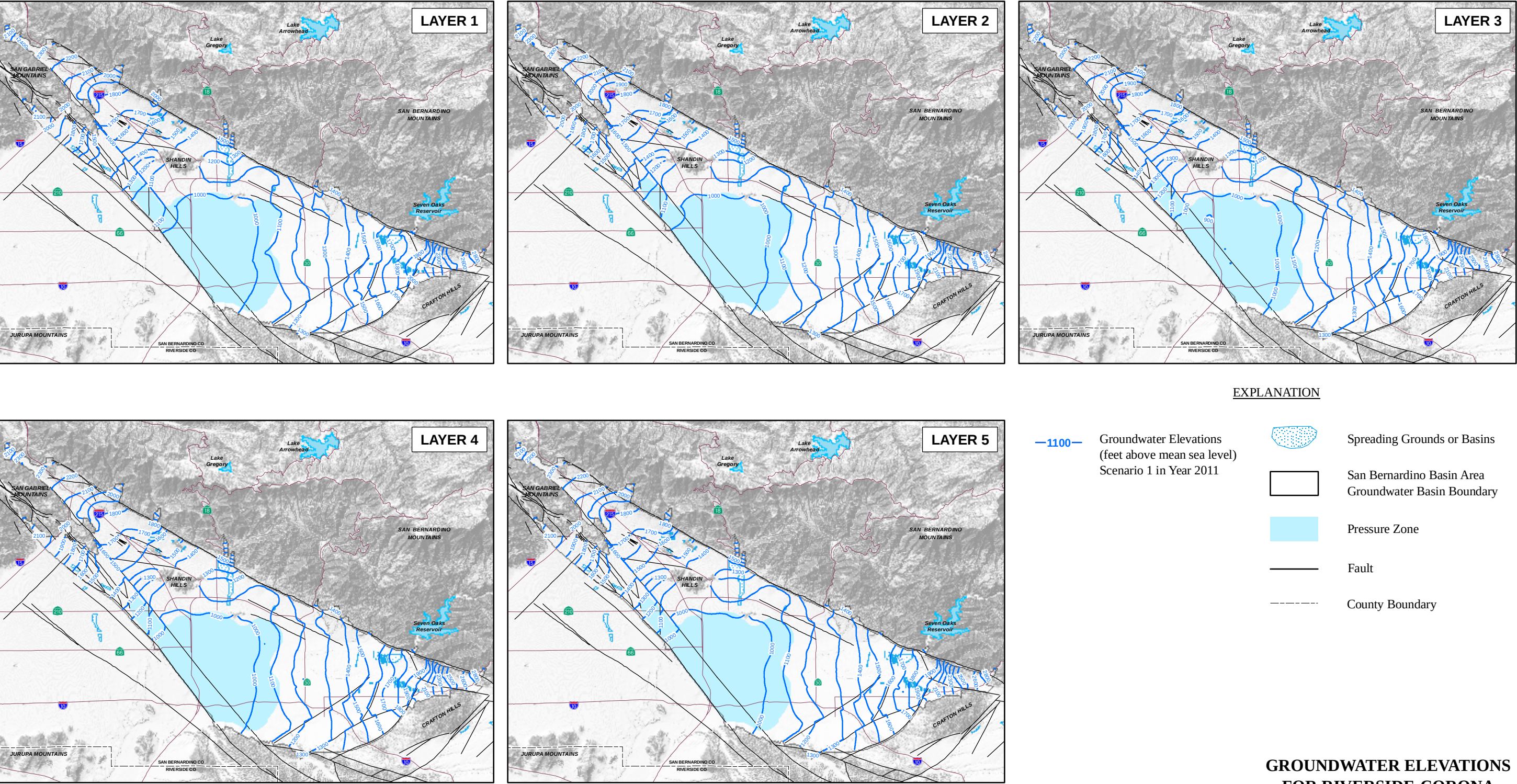
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Figure 20

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

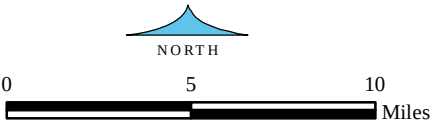


EXPLANATION

- 1100— Groundwater Elevations (feet above mean sea level) Scenario 1 in Year 2011
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1 IN YEAR 2011

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet



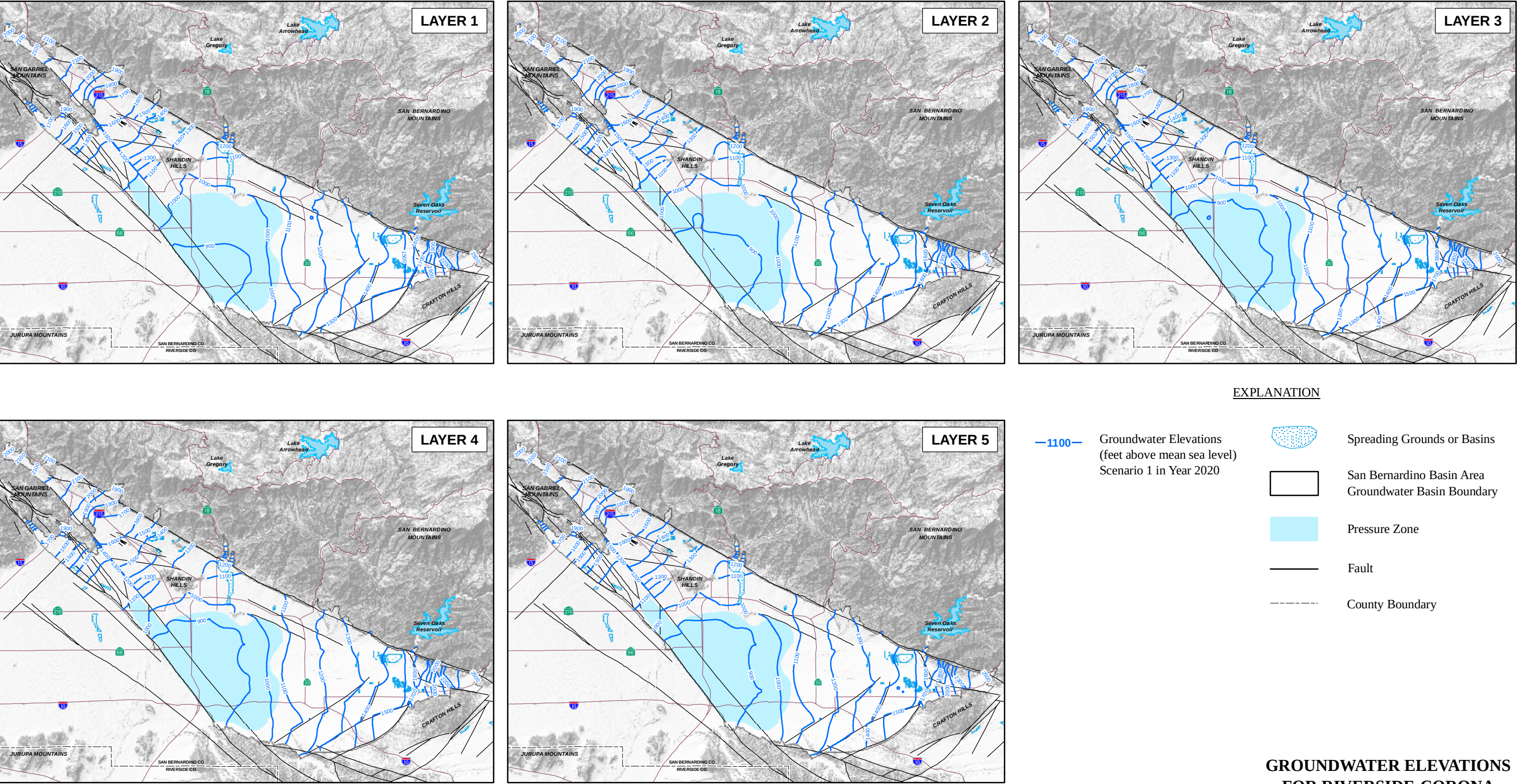
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Figure 21

WESTERN MUNICIPAL WATER DISTRICT

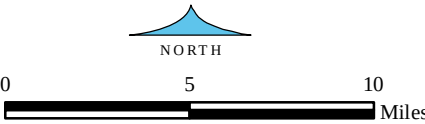
GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



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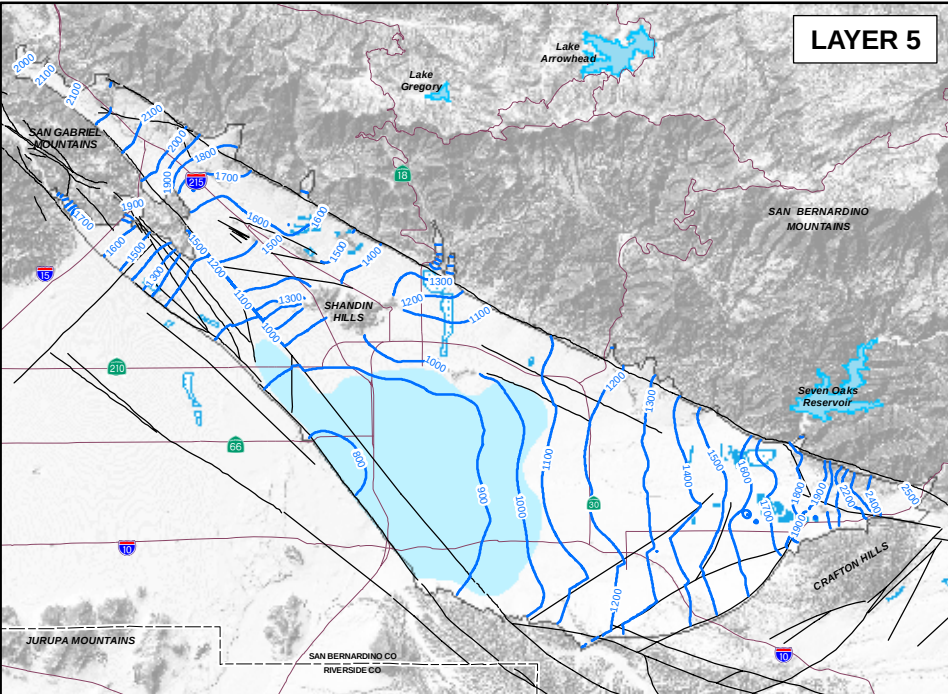
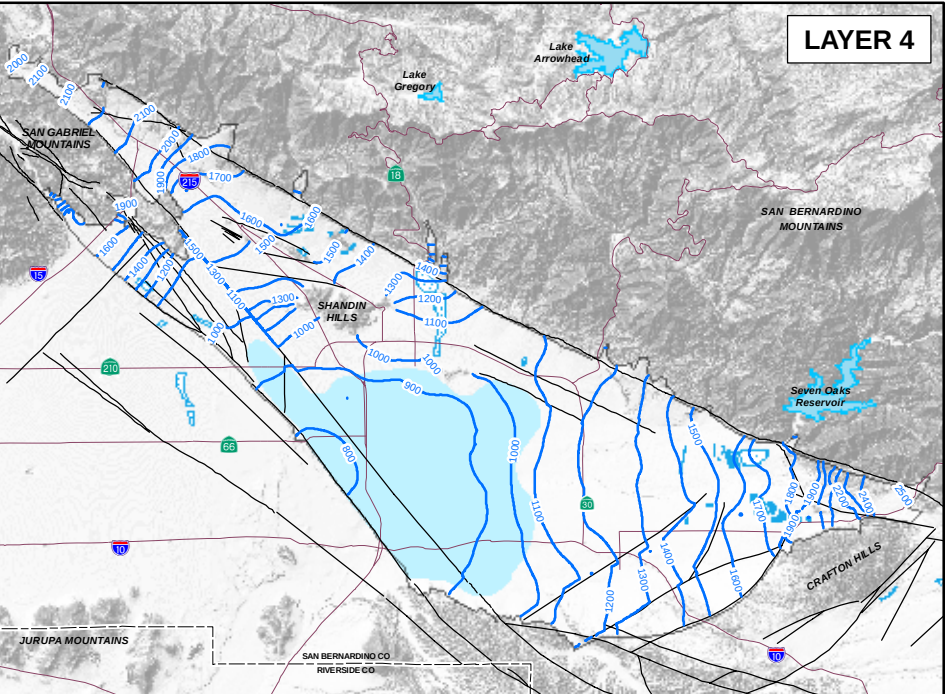
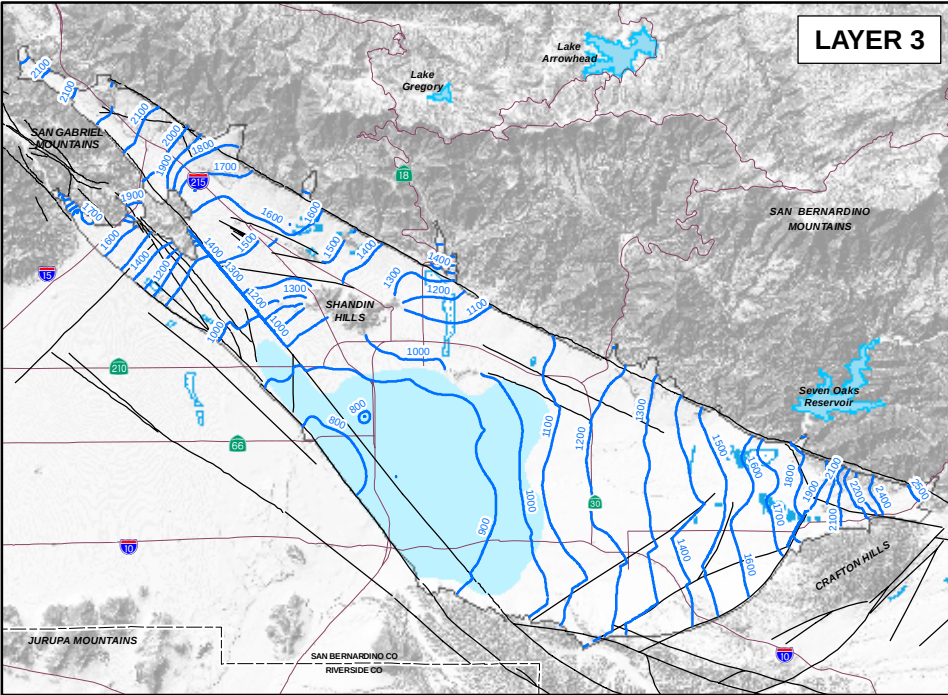
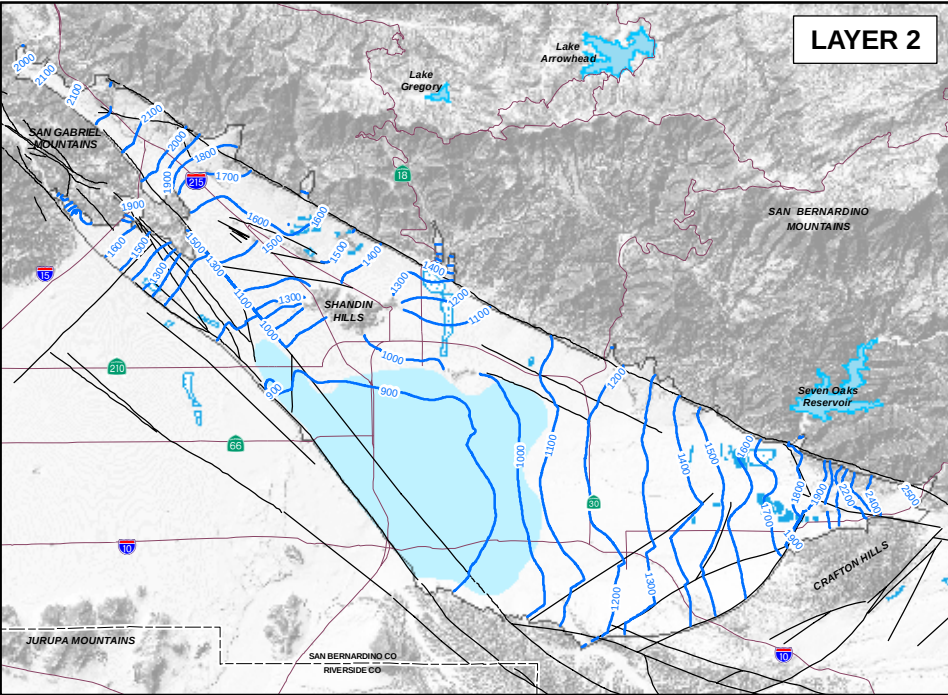
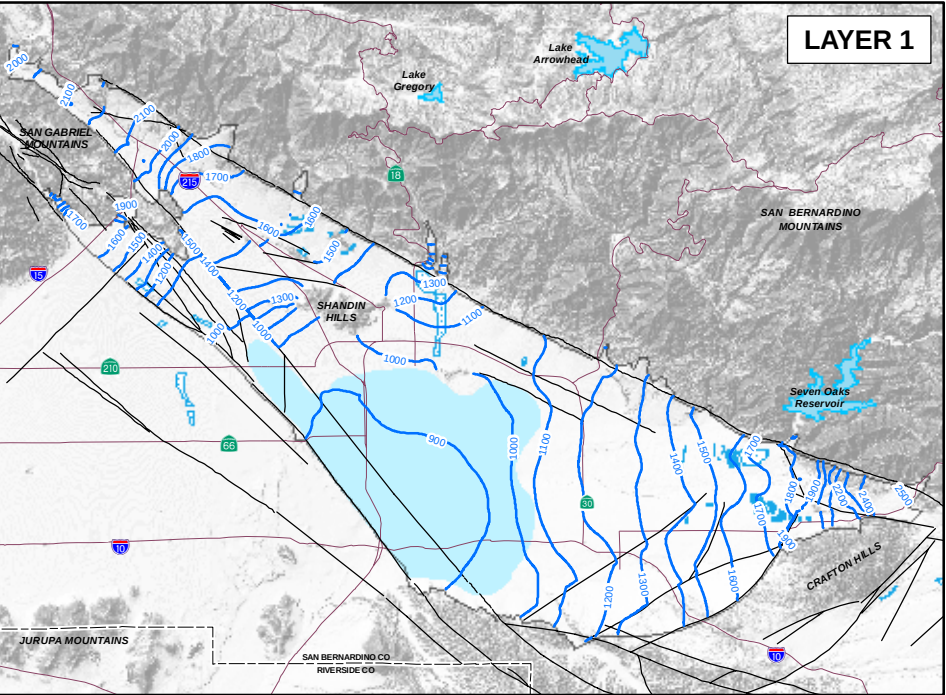
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GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1 IN YEAR 2020

Figure 22

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

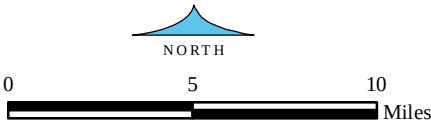
- 1100— Groundwater Elevations (feet above mean sea level) Scenario 1 in Year 2032
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1 IN YEAR 2032

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



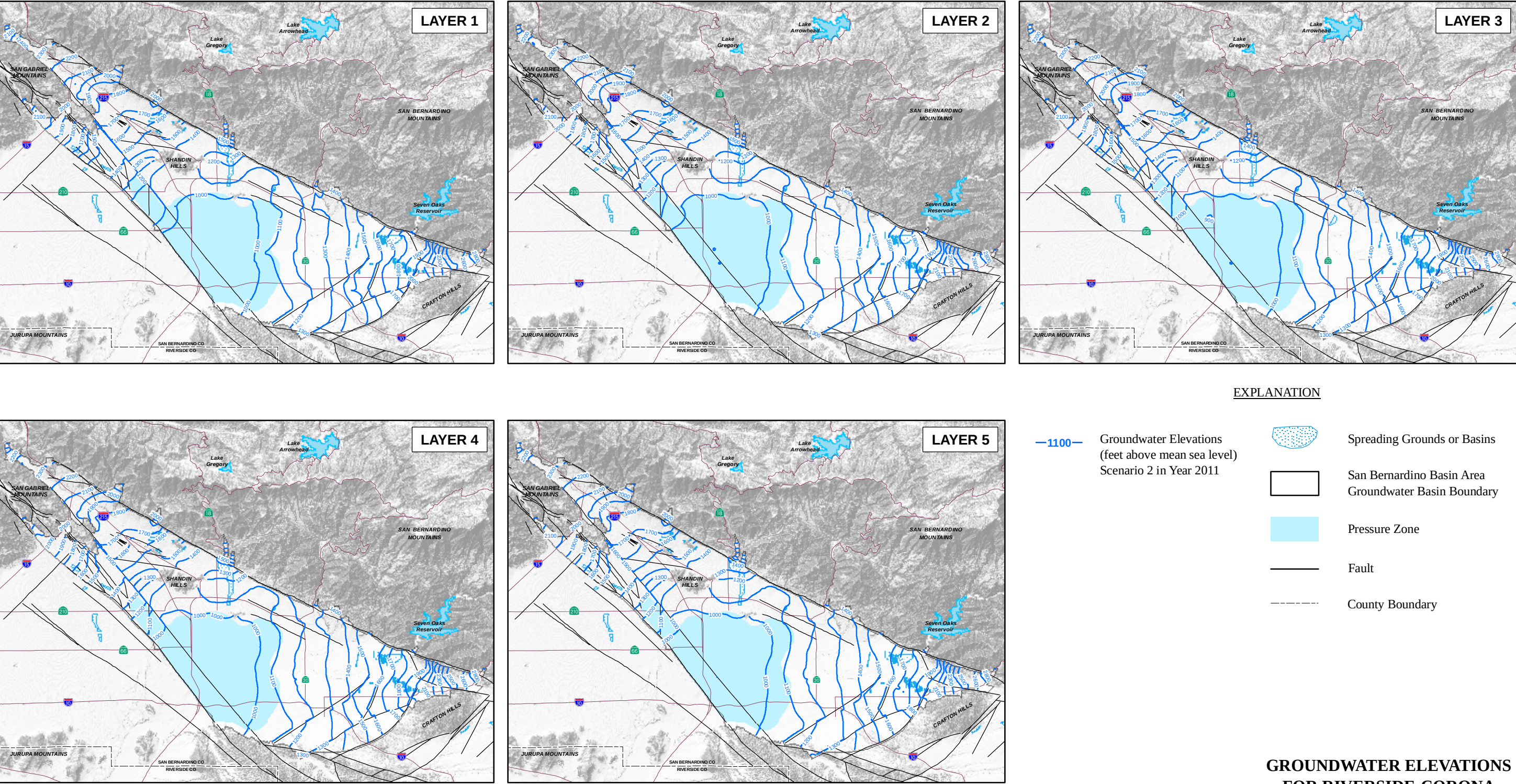
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Figure 23

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

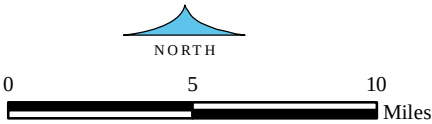


GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2 IN YEAR 2011

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



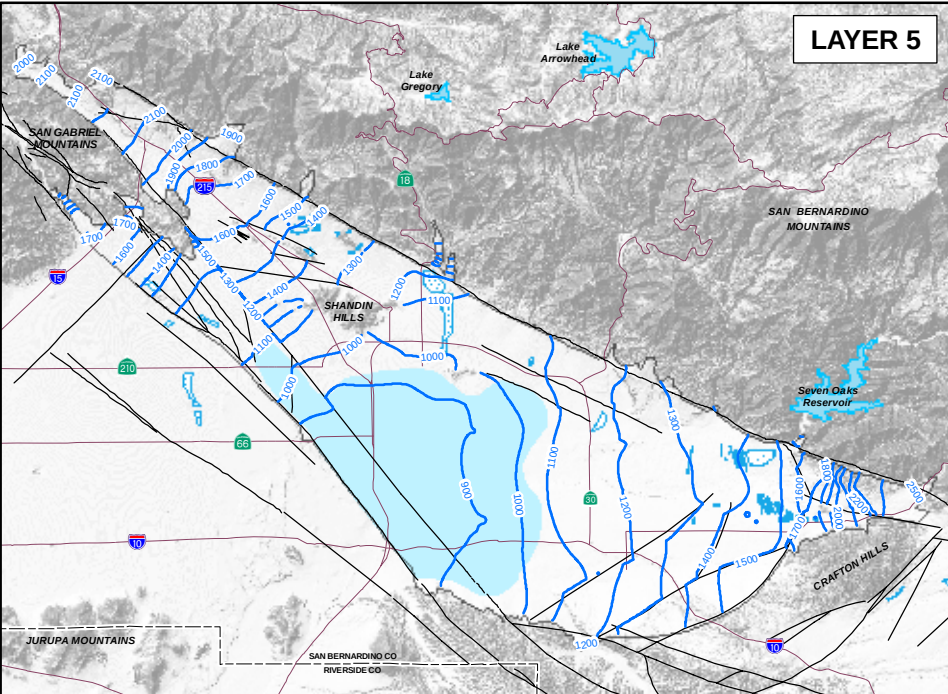
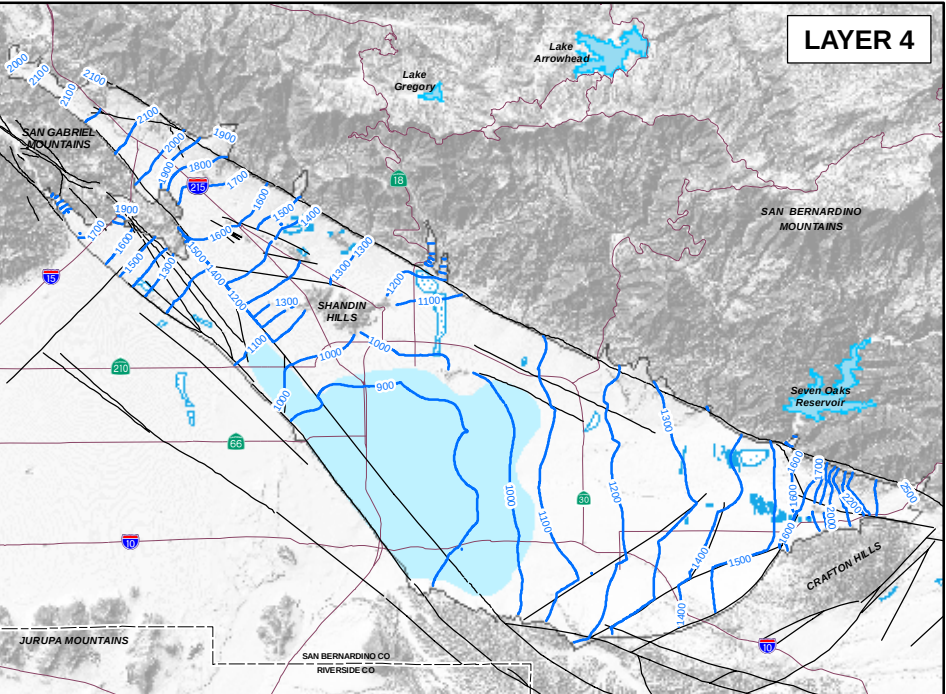
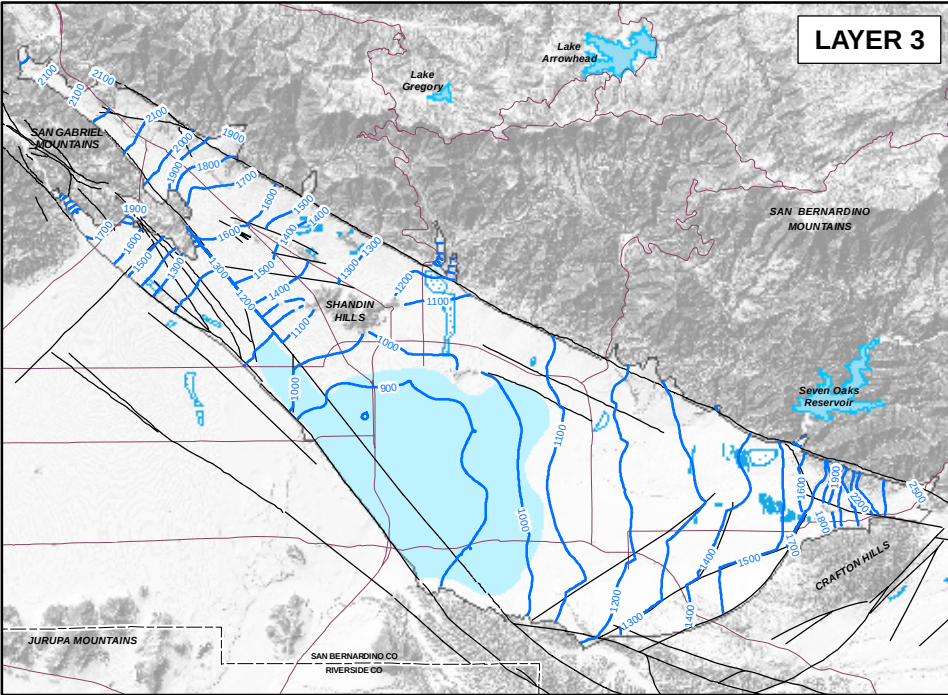
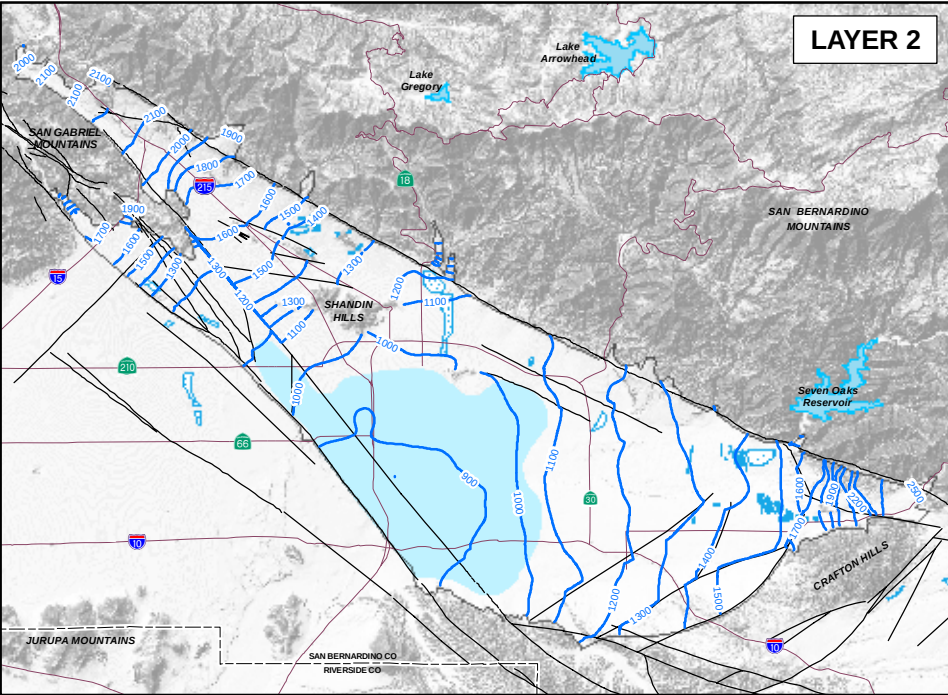
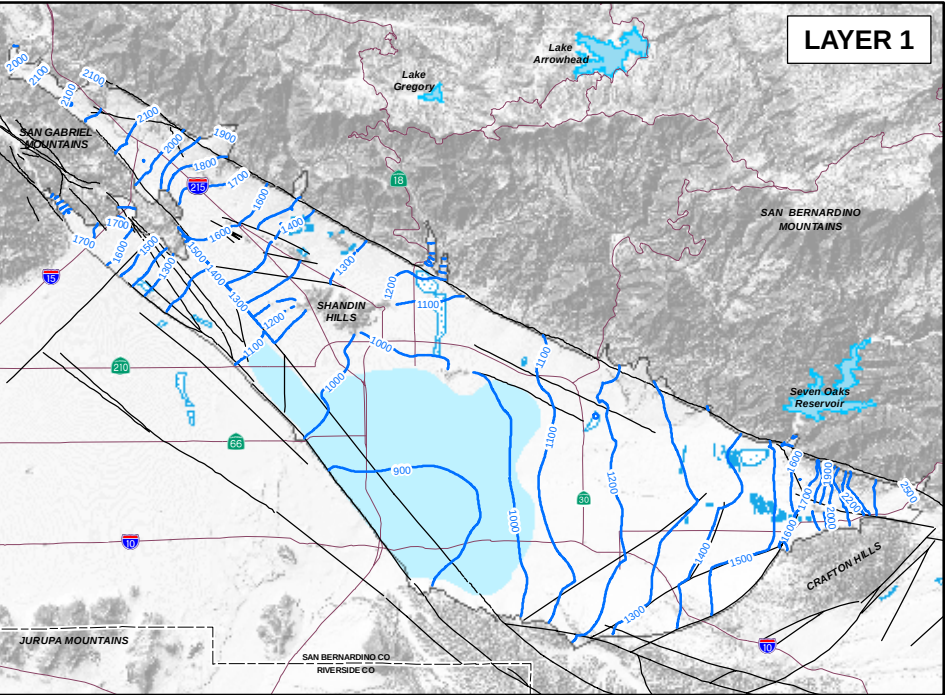
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Figure 24

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

—1100— Groundwater Elevations
(feet above mean sea level)
Scenario 2 in Year 2020



Spreading Grounds or Basins



San Bernardino Basin Area
Groundwater Basin Boundary



Pressure Zone



Fault



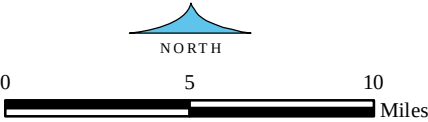
County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2 IN YEAR 2020

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

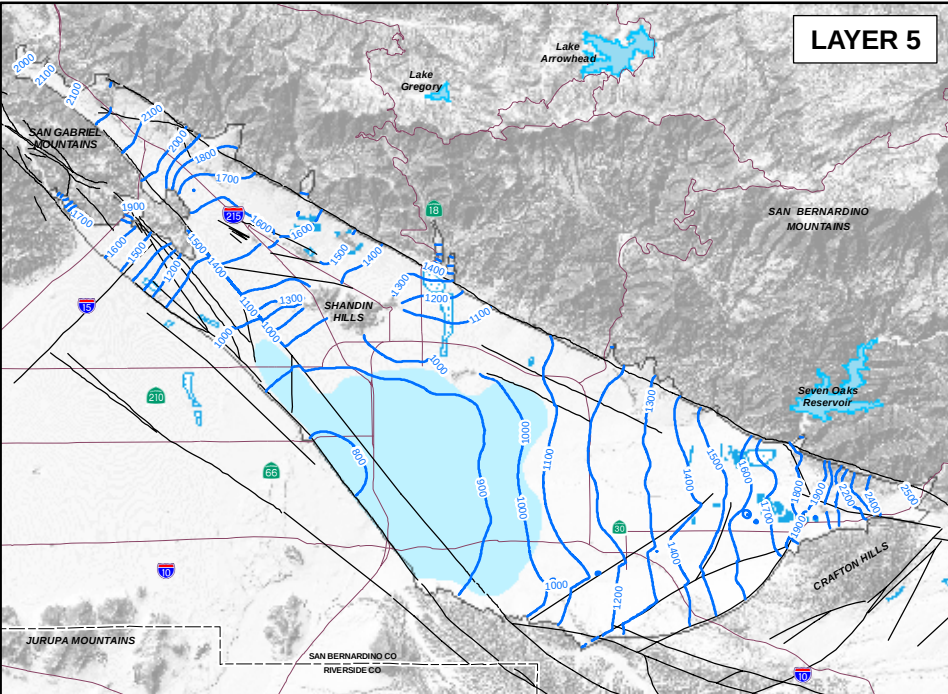
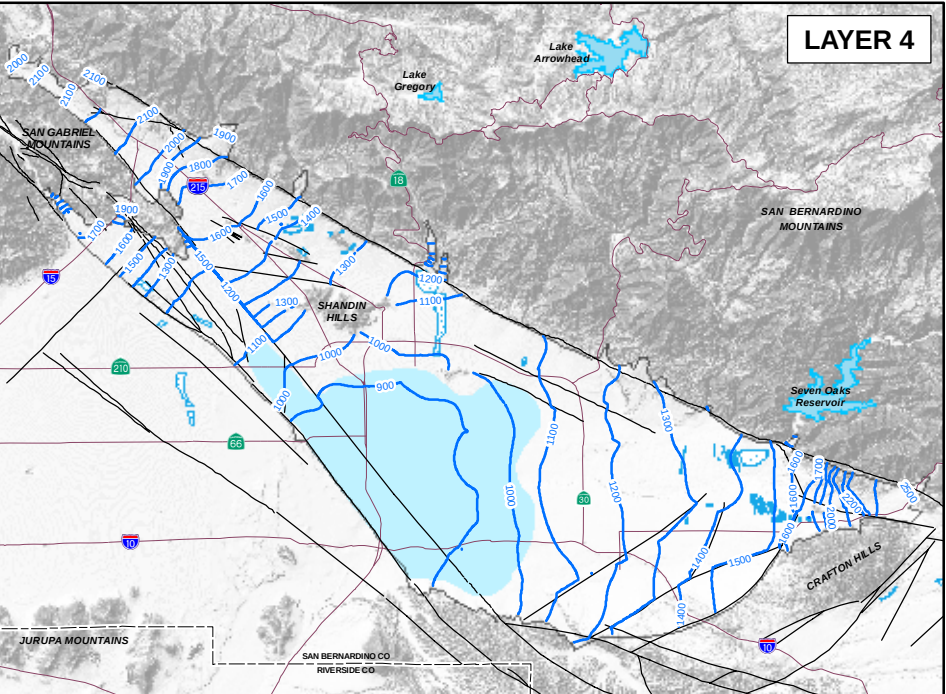
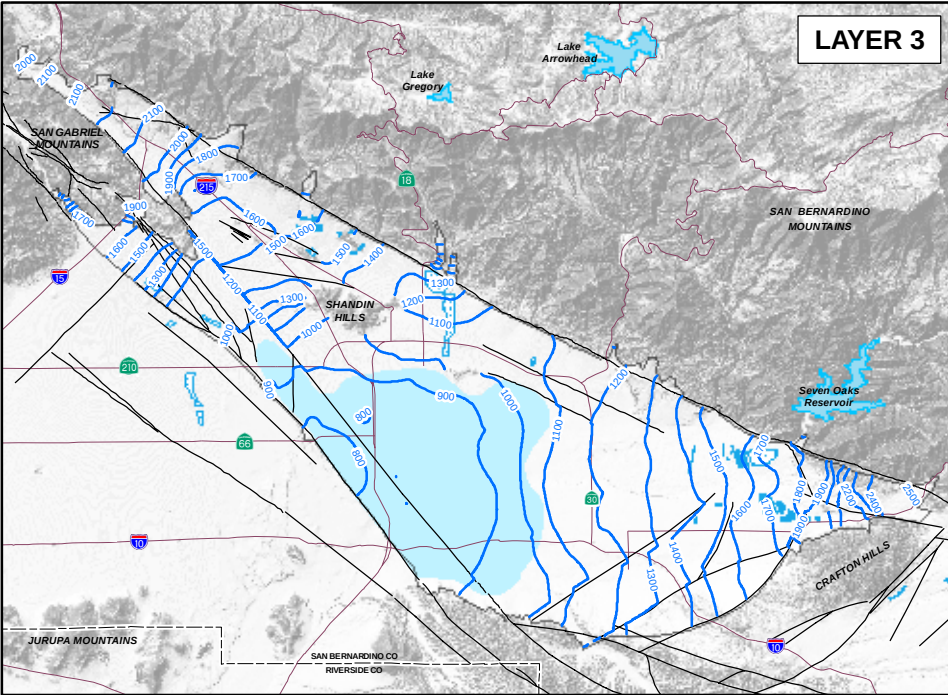
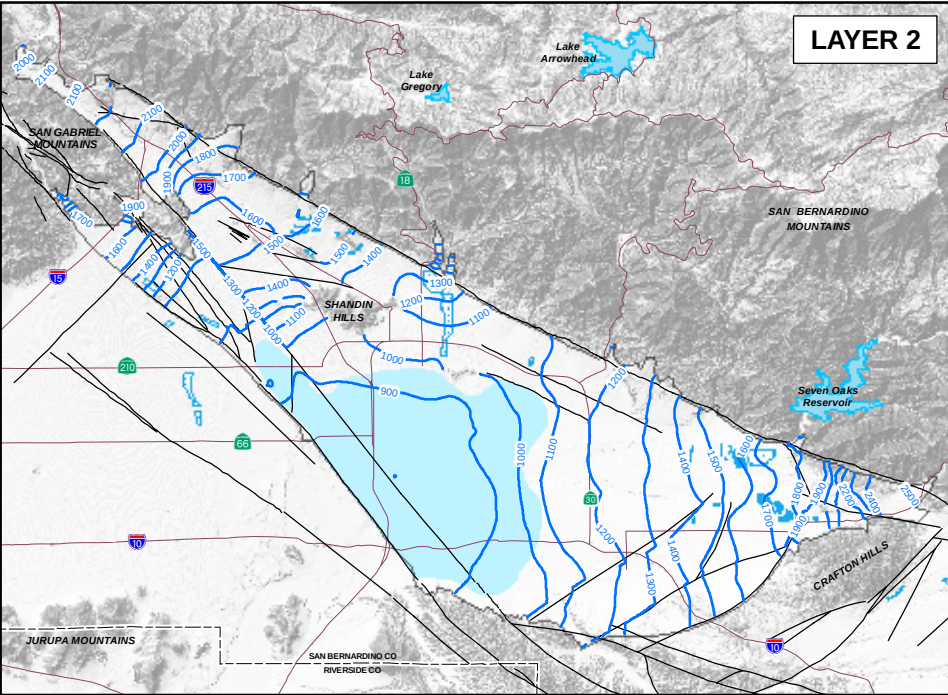
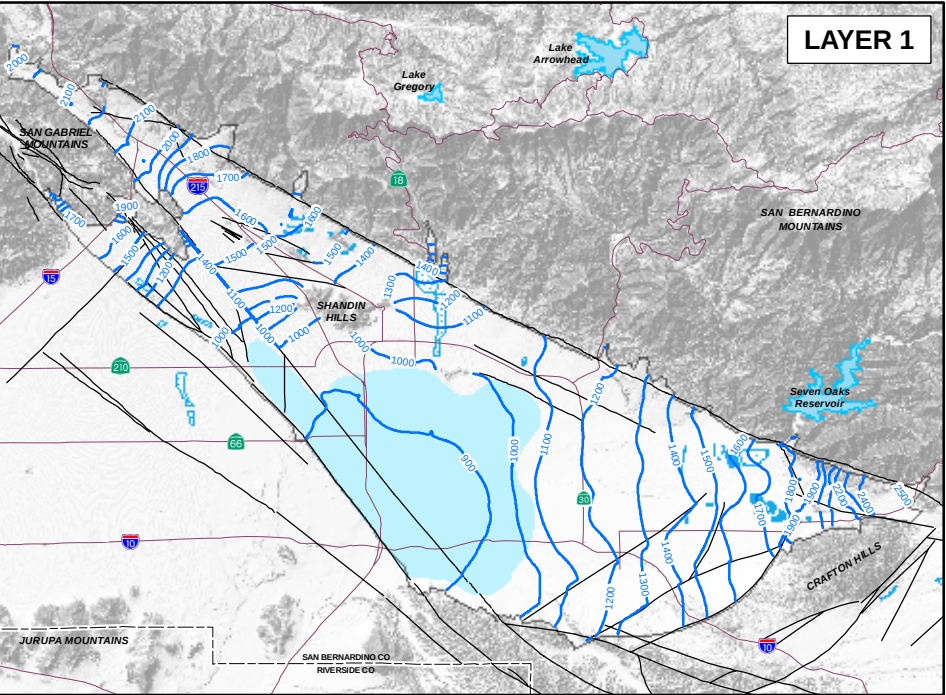


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Figure 25

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



EXPLANATION

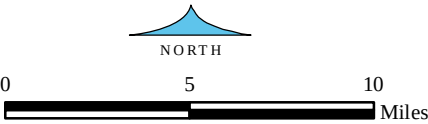
- 1100— Groundwater Elevations (feet above mean sea level) Scenario 2 in Year 2032
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2 IN YEAR 2032

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



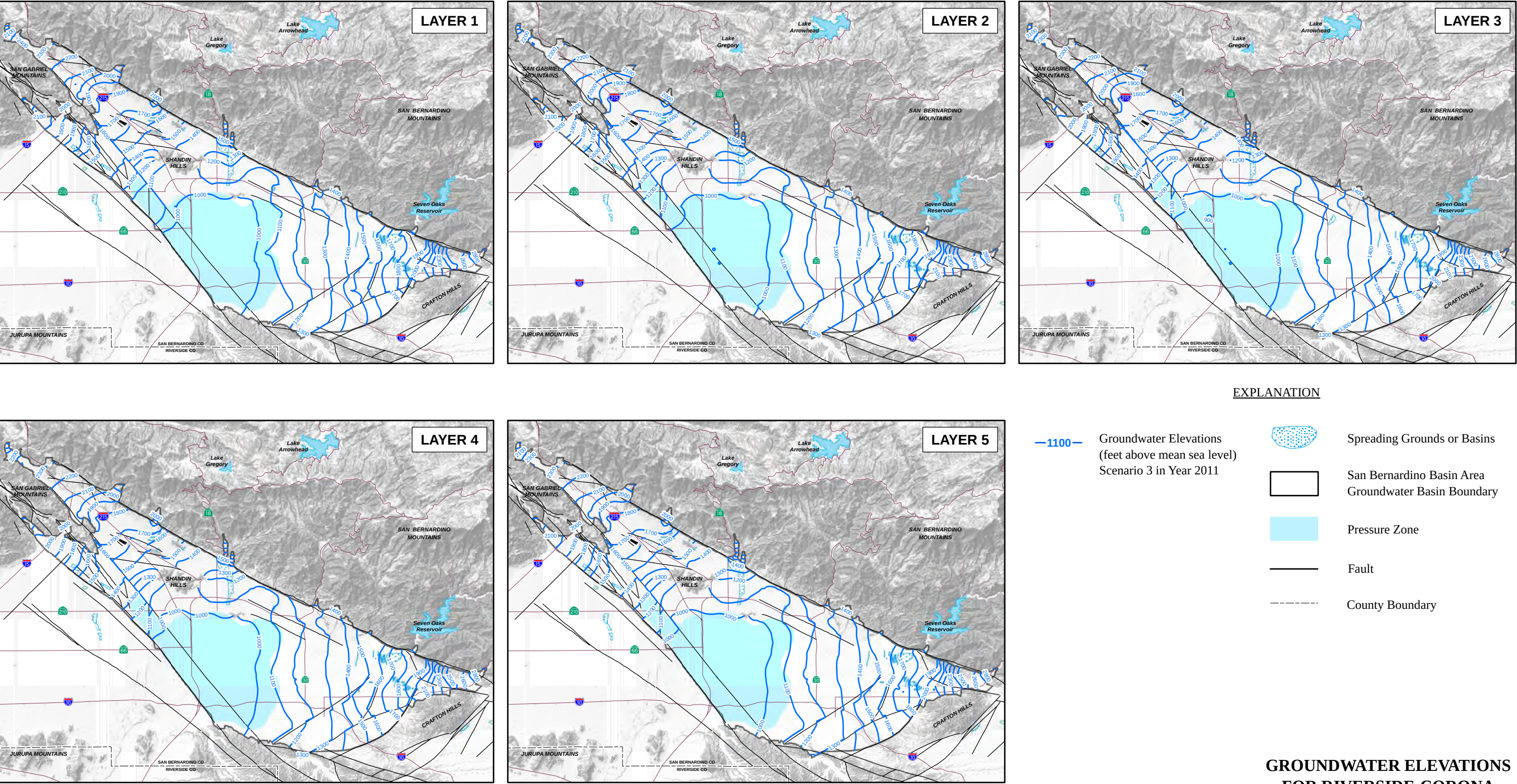
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Figure 26

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS

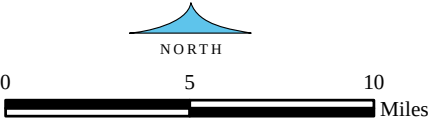


EXPLANATION

- 1100— Groundwater Elevations (feet above mean sea level) Scenario 3 in Year 2011
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3 IN YEAR 2011

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet



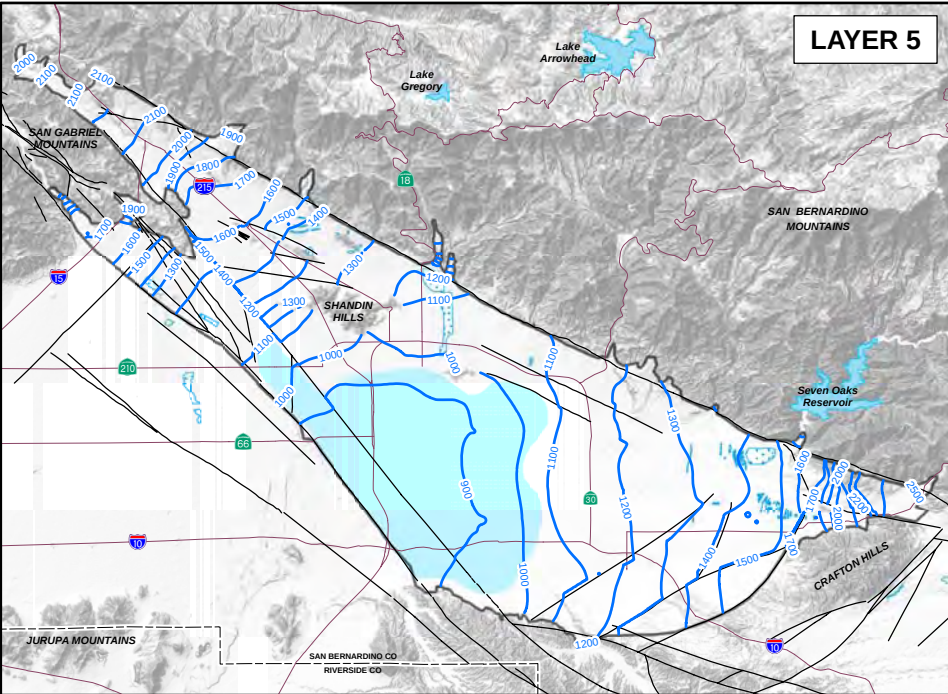
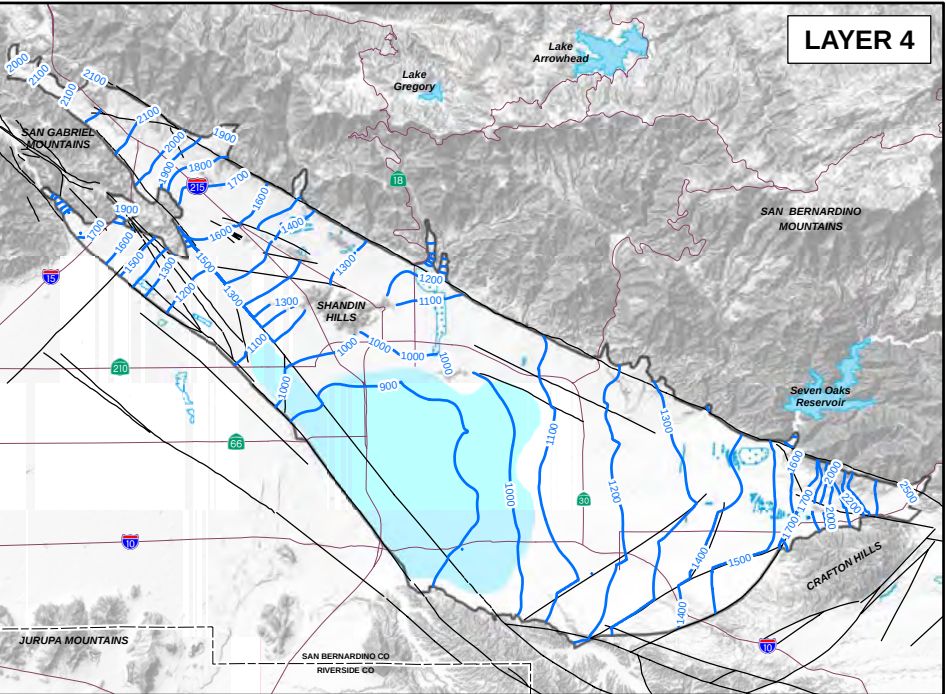
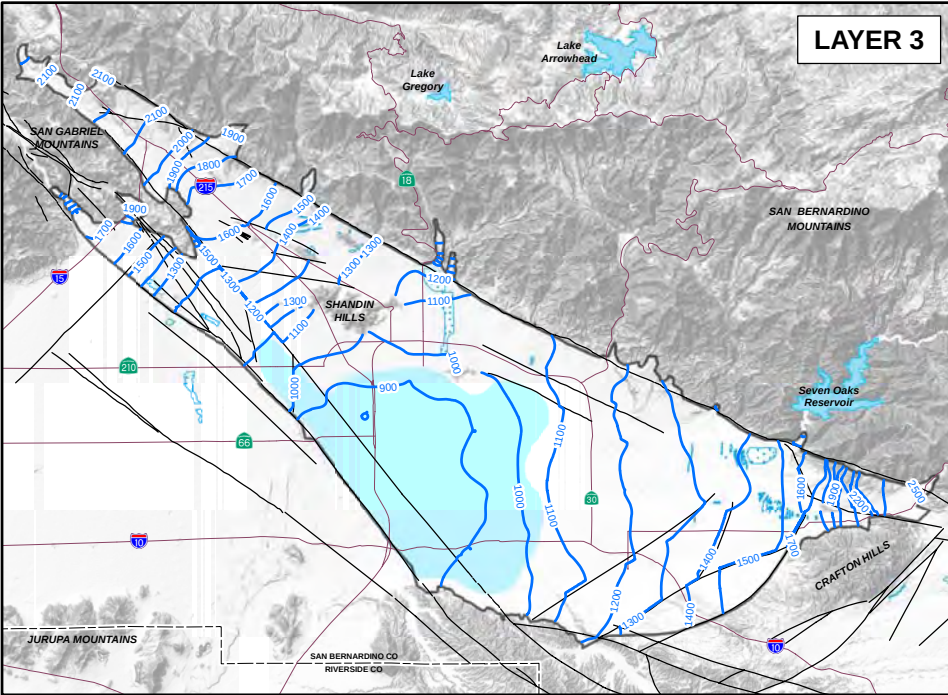
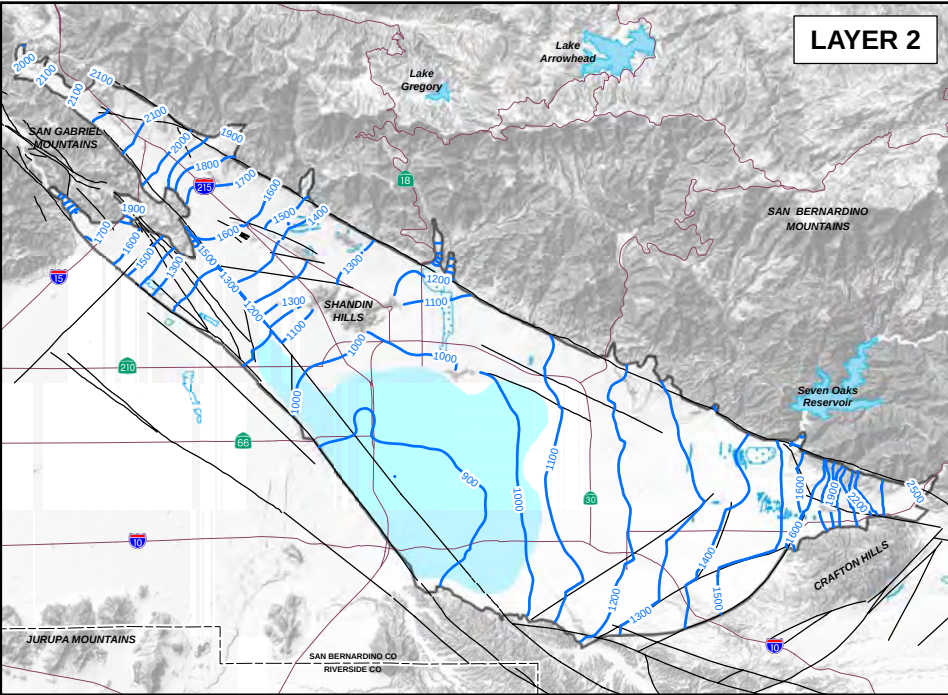
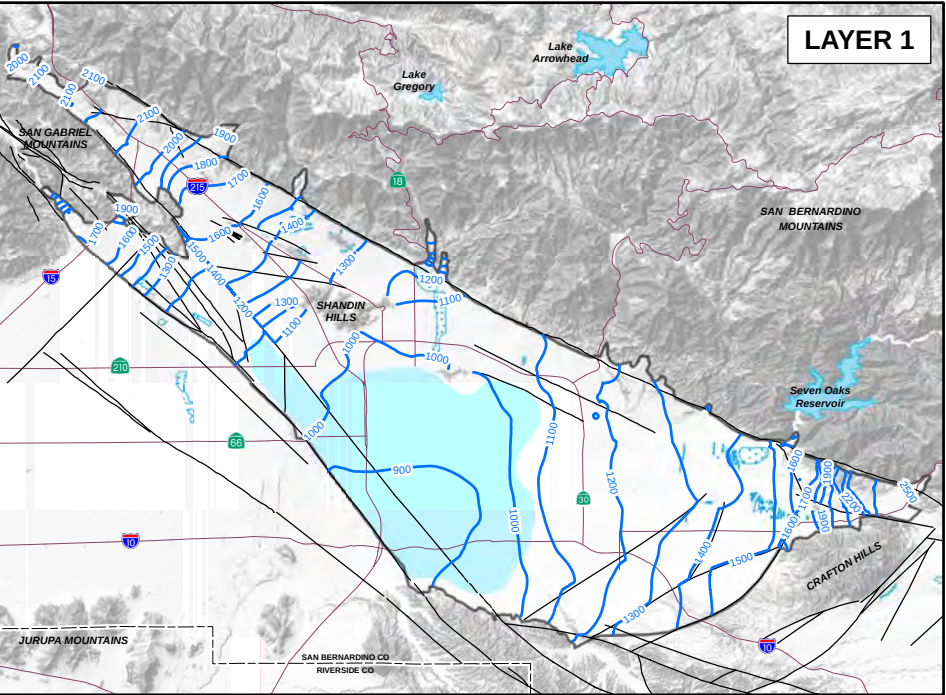
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Figure 27

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



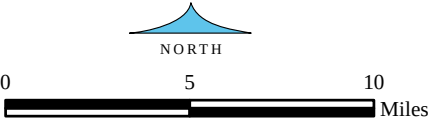
EXPLANATION

—1100— Groundwater Elevations
(feet above mean sea level)
Scenario 3 in Year 2020

- Spreading Grounds or Basins
- San Bernardino Basin Area
Groundwater Basin Boundary
- Pressure Zone
- Fault
- County Boundary

GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3 IN YEAR 2020

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet



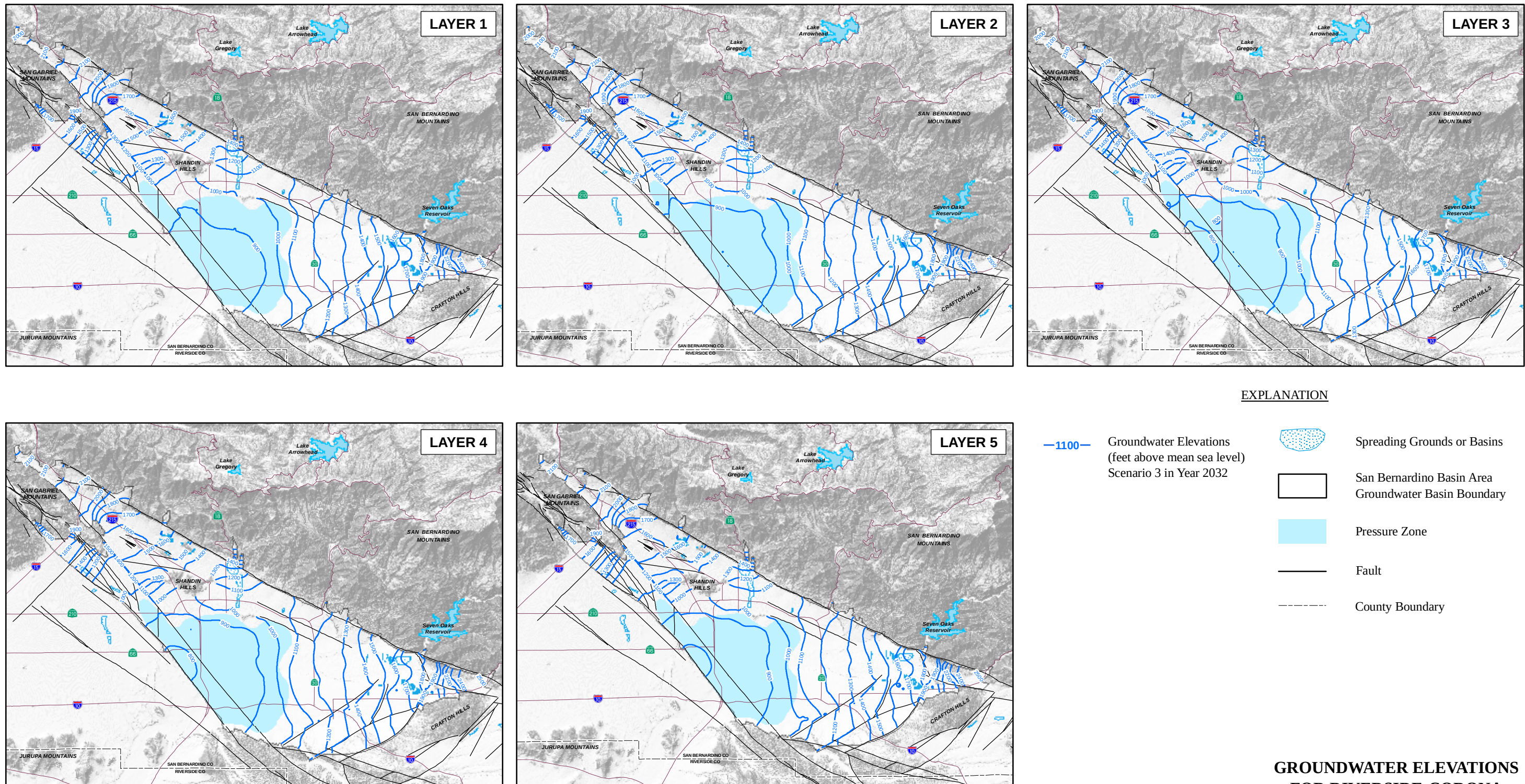
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Figure 28

WESTERN MUNICIPAL WATER DISTRICT

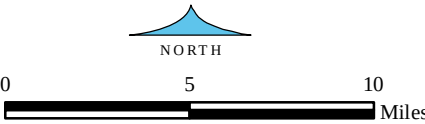
GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

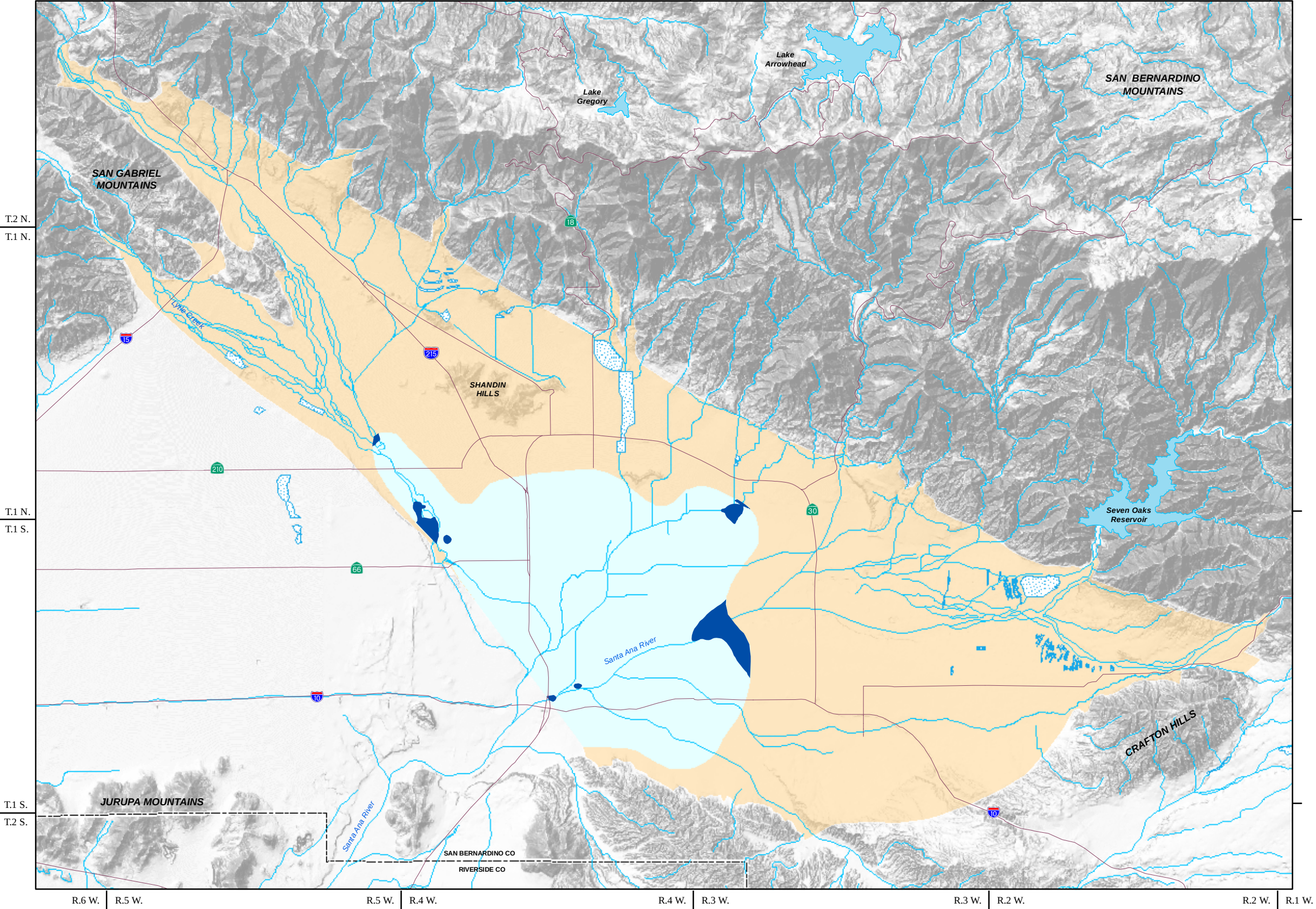


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GROUNDWATER ELEVATIONS
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3 IN YEAR 2032

Figure 29

POTENTIAL LIQUEFACTION
AREA IN 2011 FOR
BASELINE RUN
(NO PROJECT)



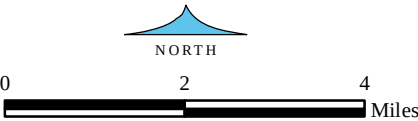
EXPLANATION

- Potential Liquefaction Area in 2011 for Baseline Run (No Project)
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

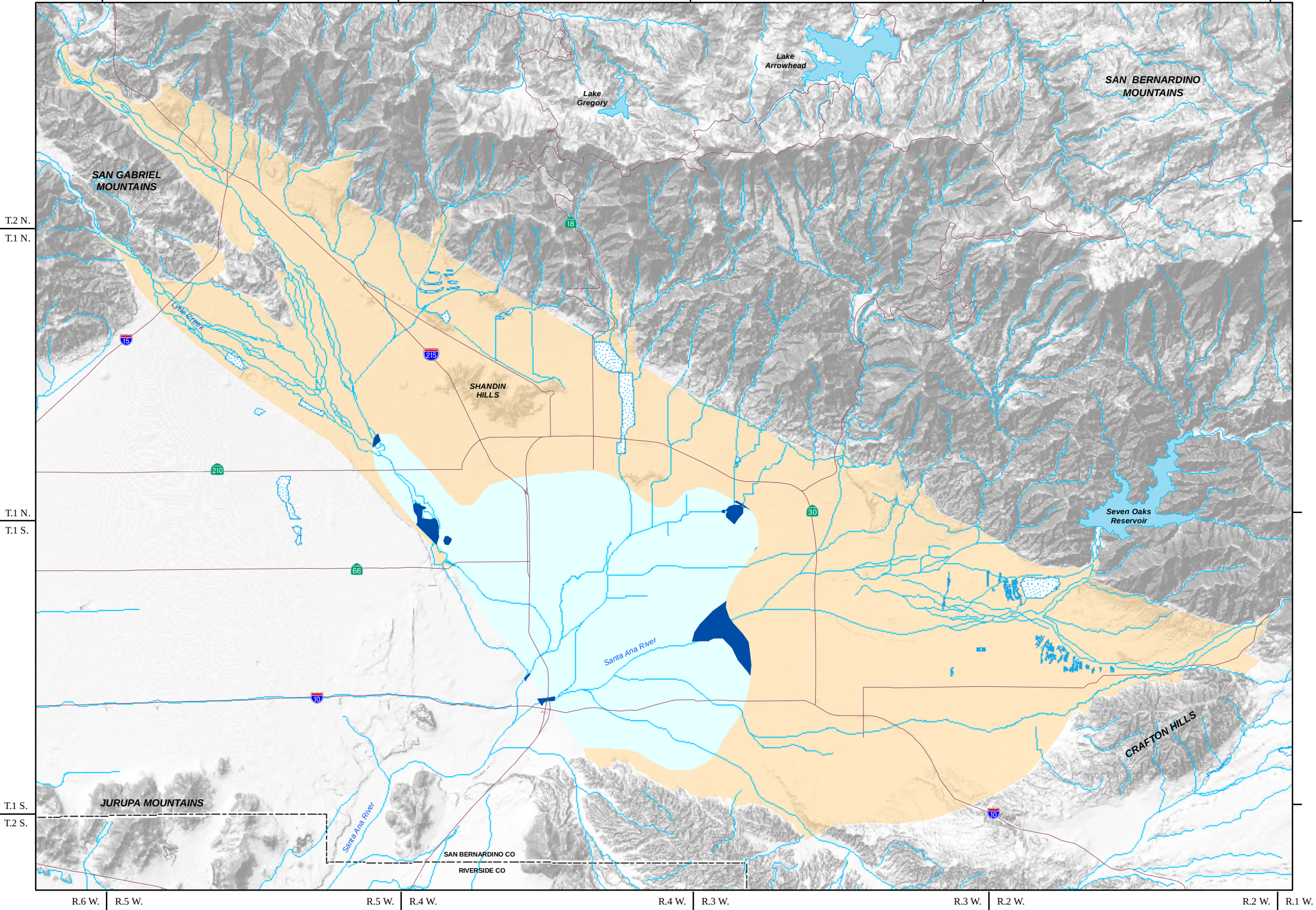


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Figure 30

POTENTIAL LIQUEFACTION
AREA IN 2011 FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1



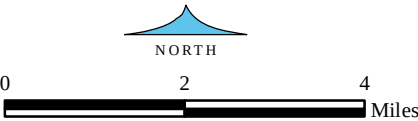
EXPLANATION

- Potential Liquefaction Area in 2011 for Riverside-Corona Feeder Project (Scenario 1)
- Spreading Grounds or Basins
- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

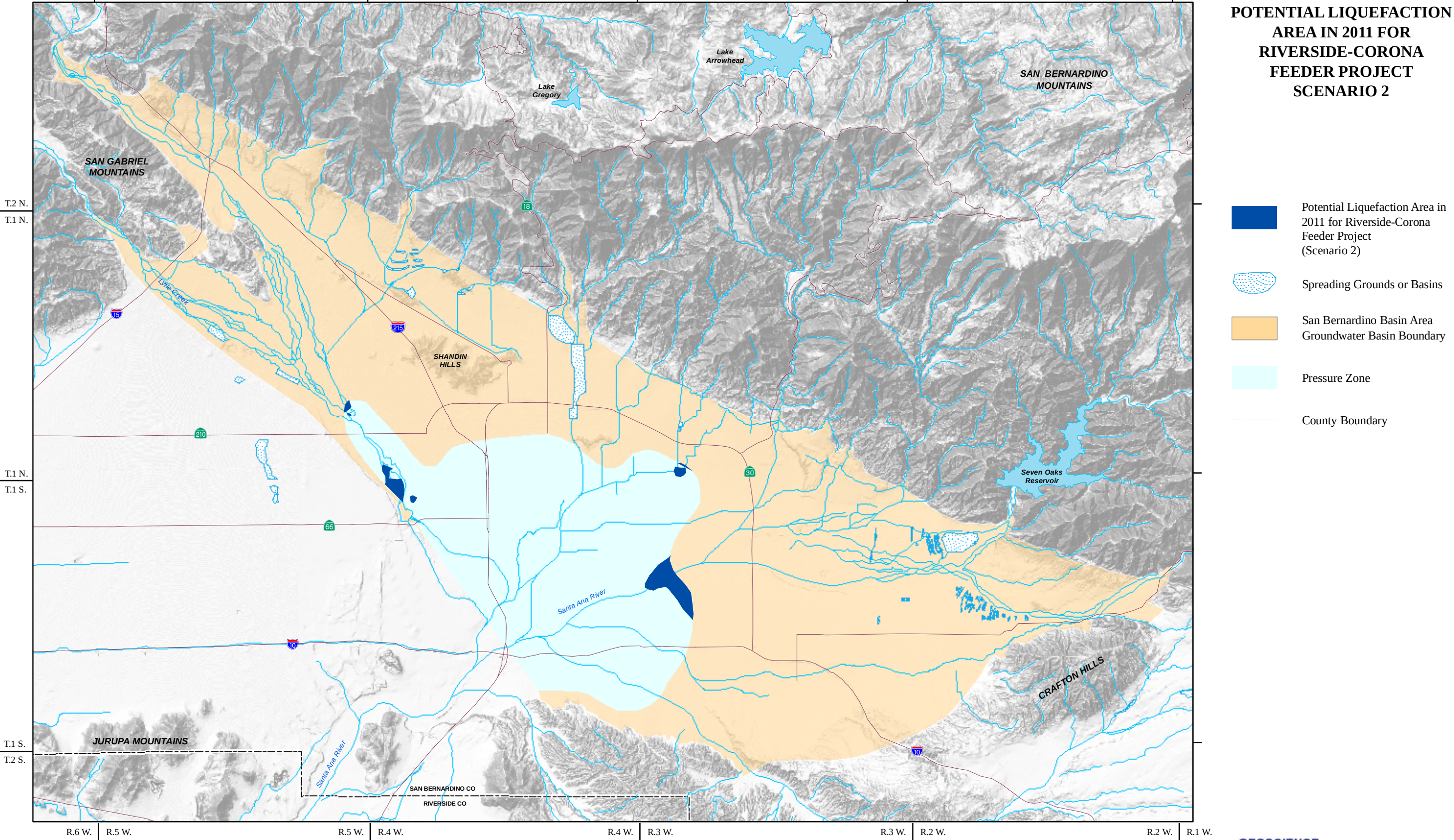


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Figure 31

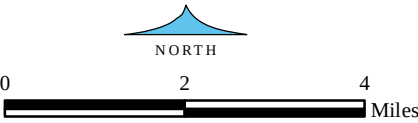
POTENTIAL LIQUEFACTION
AREA IN 2011 FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2



23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

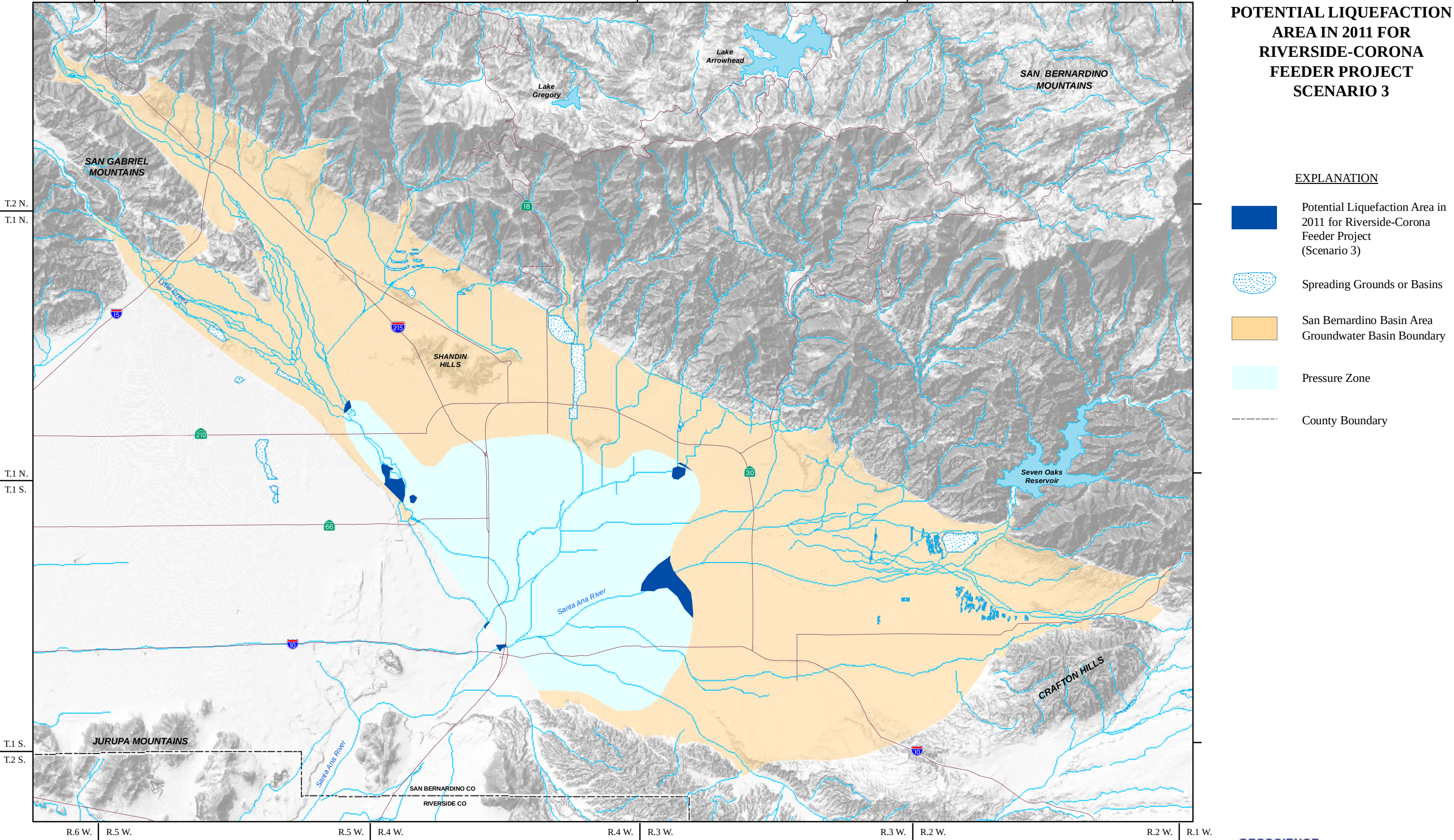


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Figure 32

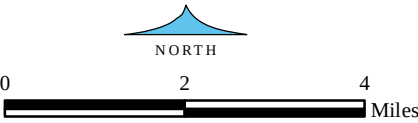
POTENTIAL LIQUEFACTION
AREA IN 2011 FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3



23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet



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Figure 33

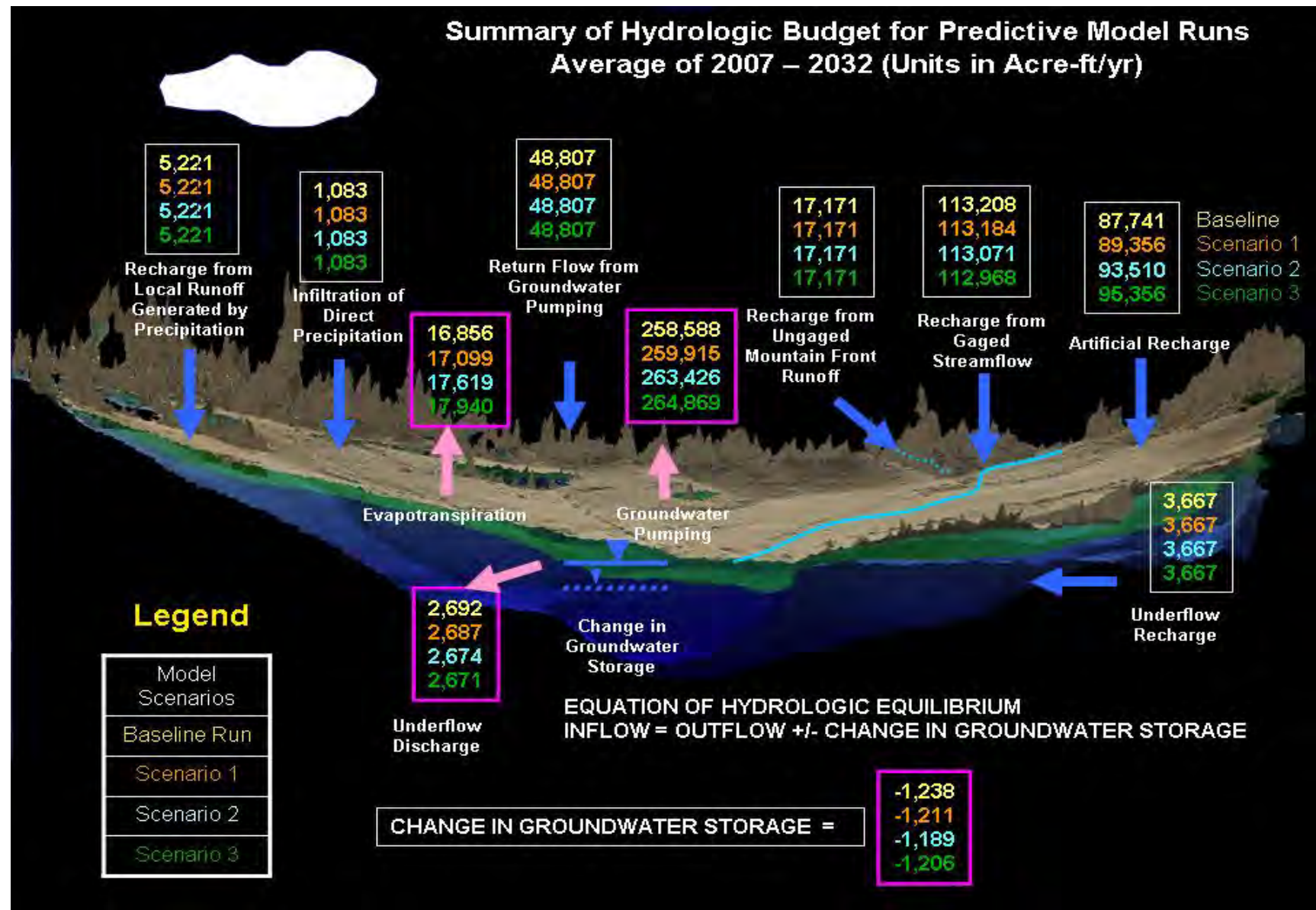


Figure 34

Cumulative Annual Changes in Groundwater Storage for Predictive Model Scenarios 2007 to 2032

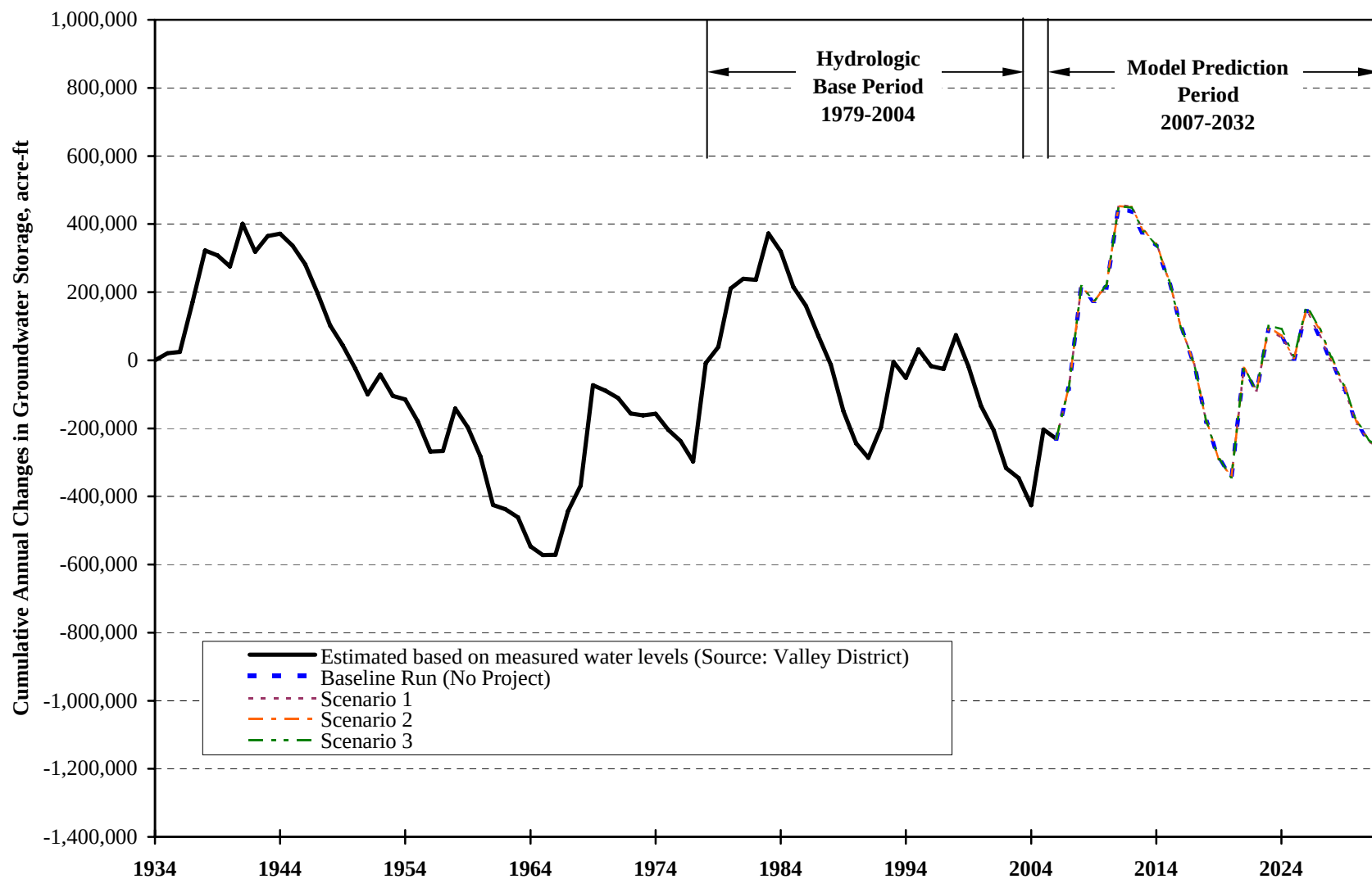
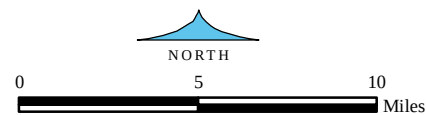
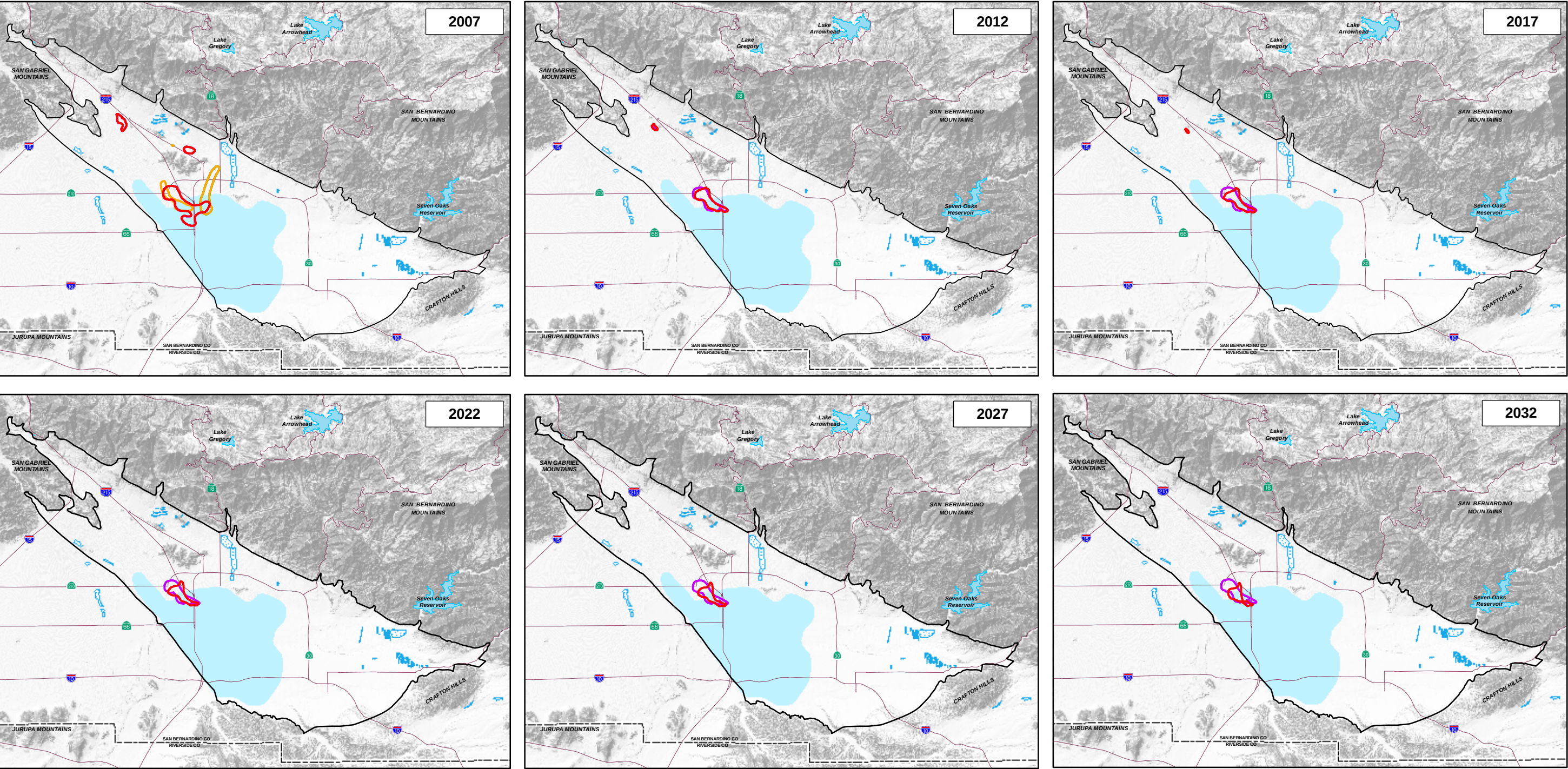


Figure 35

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated PCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
- Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

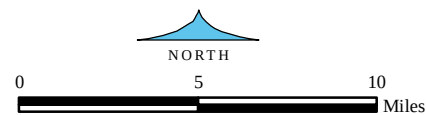
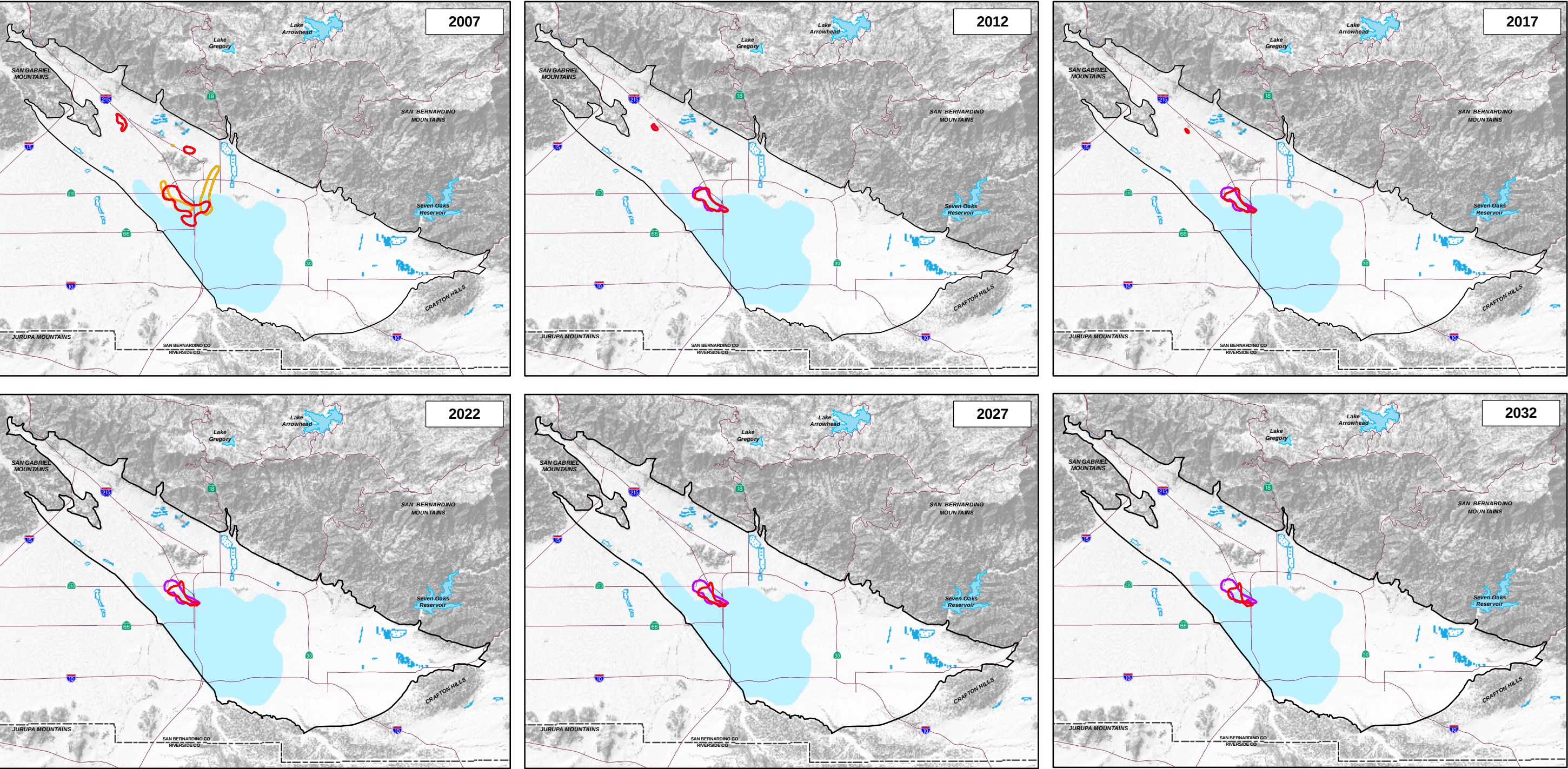
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**MODEL-GENERATED
PCE PLUME BOUNDARIES
FOR BASELINE RUN
NO PROJECT**

Figure 36

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated PCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
- Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

MODEL-GENERATED
PCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1

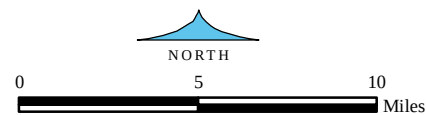
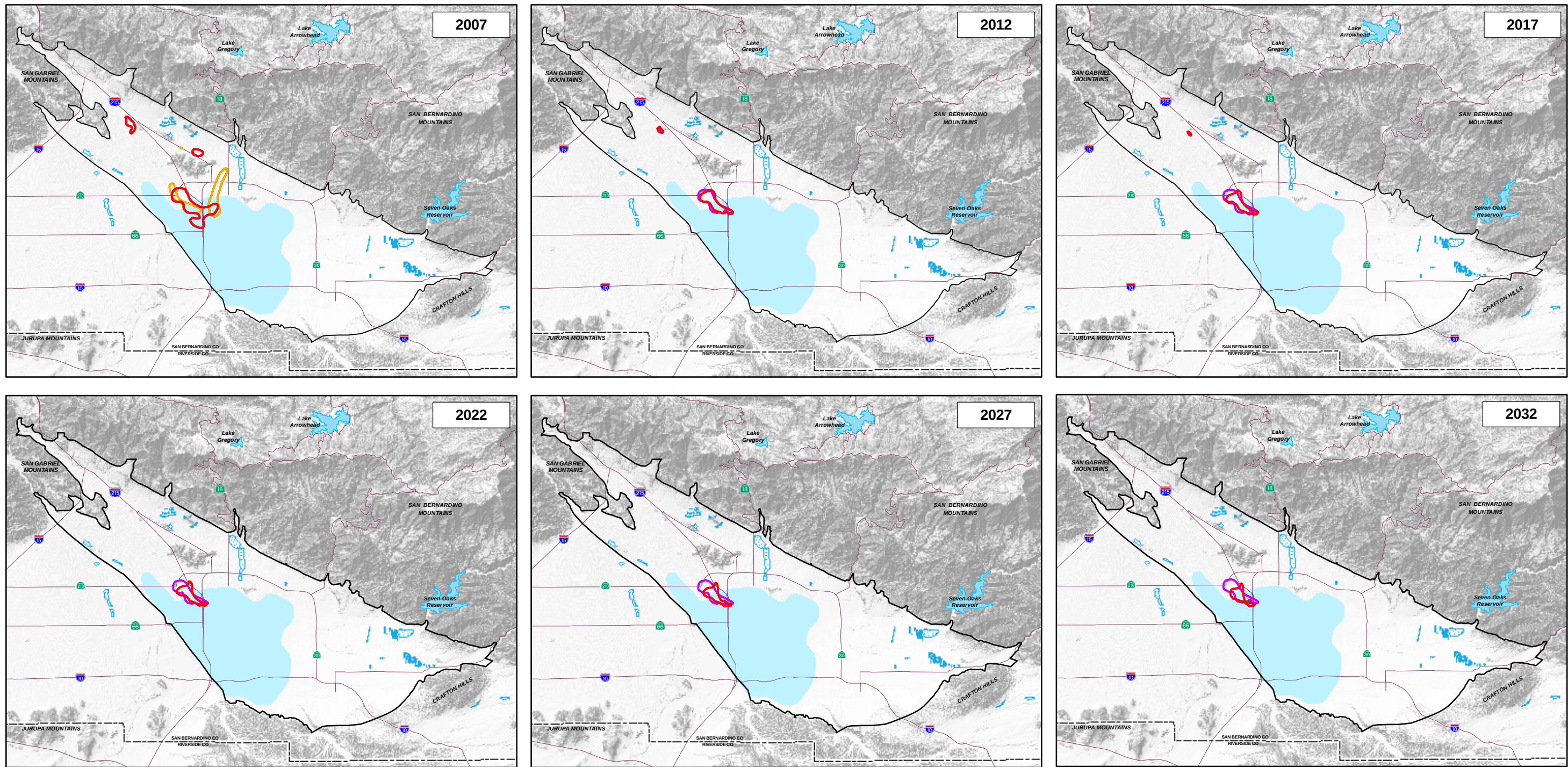
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Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

Figure 37

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated PCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
- Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

MODEL-GENERATED
PCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2

GEOSCIENCE

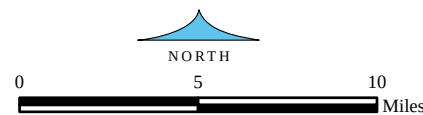
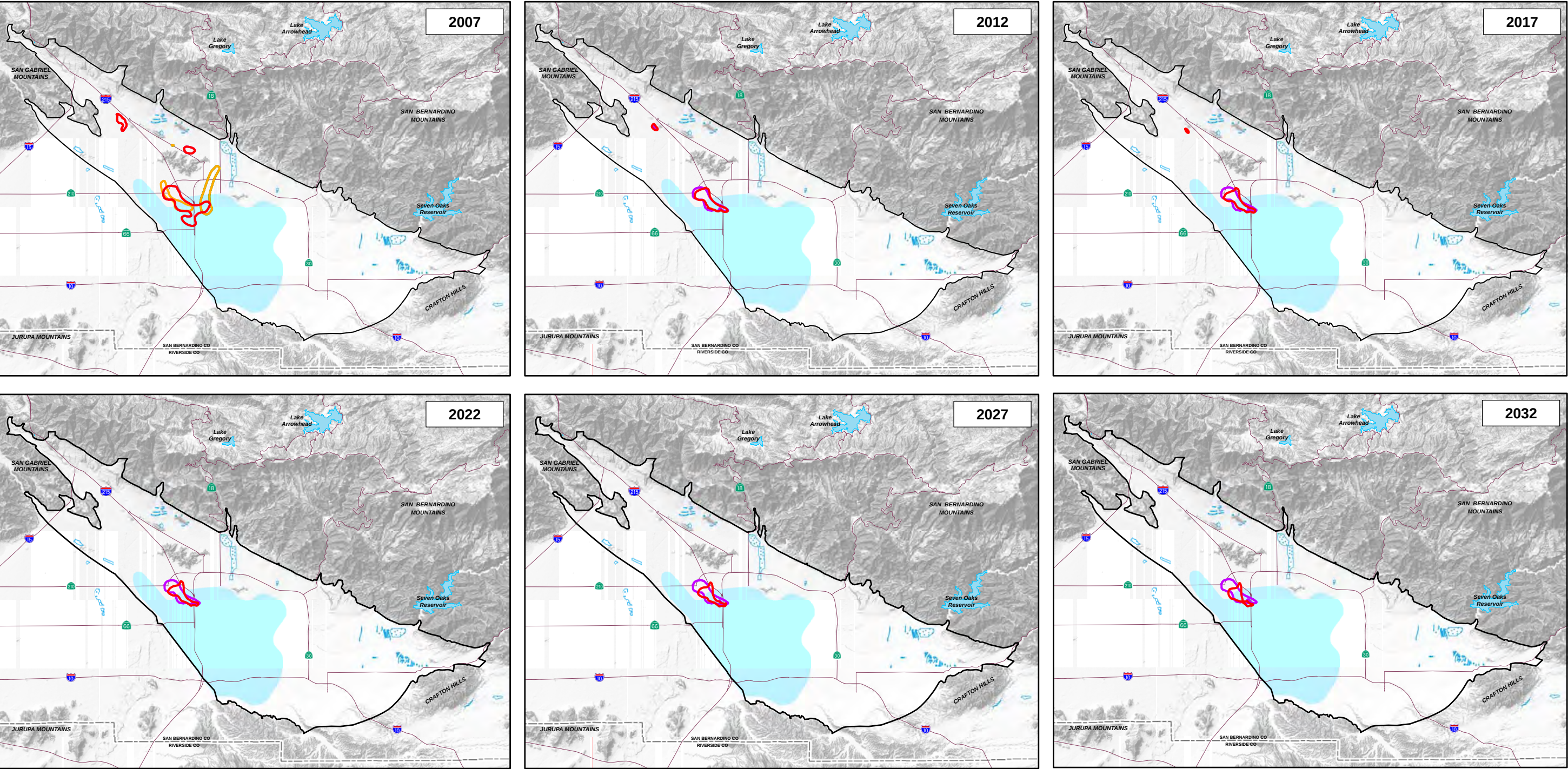
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Figure 38

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Map Projection: State Plane 1983, Zone V, feet

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated PCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

MODEL-GENERATED
PCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3

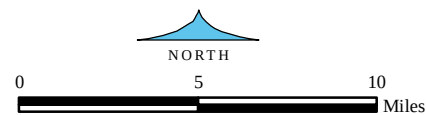
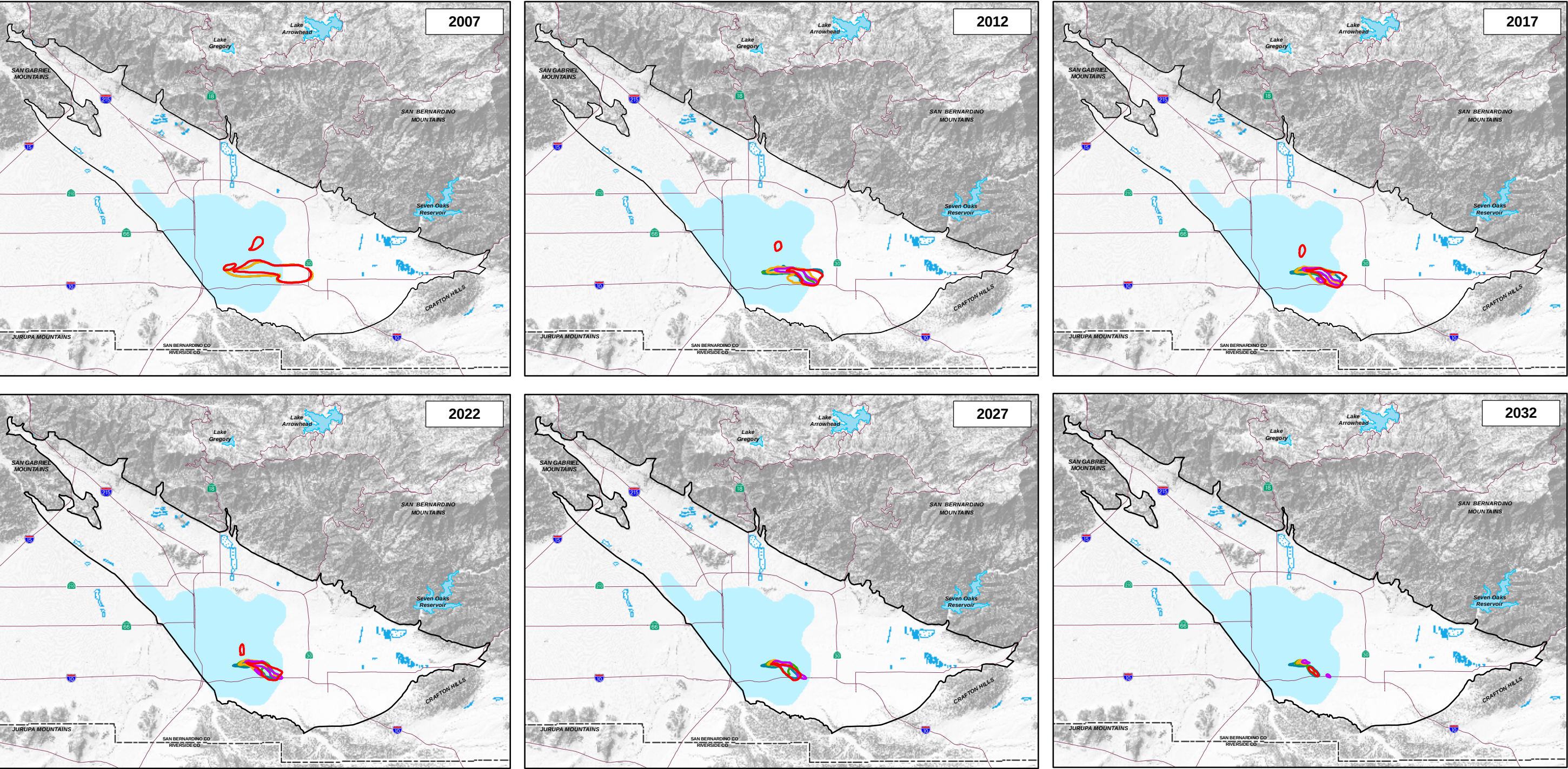
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Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

Figure 39

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated TCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
- Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

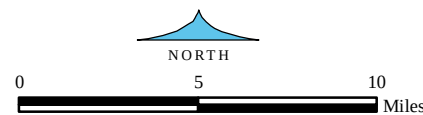
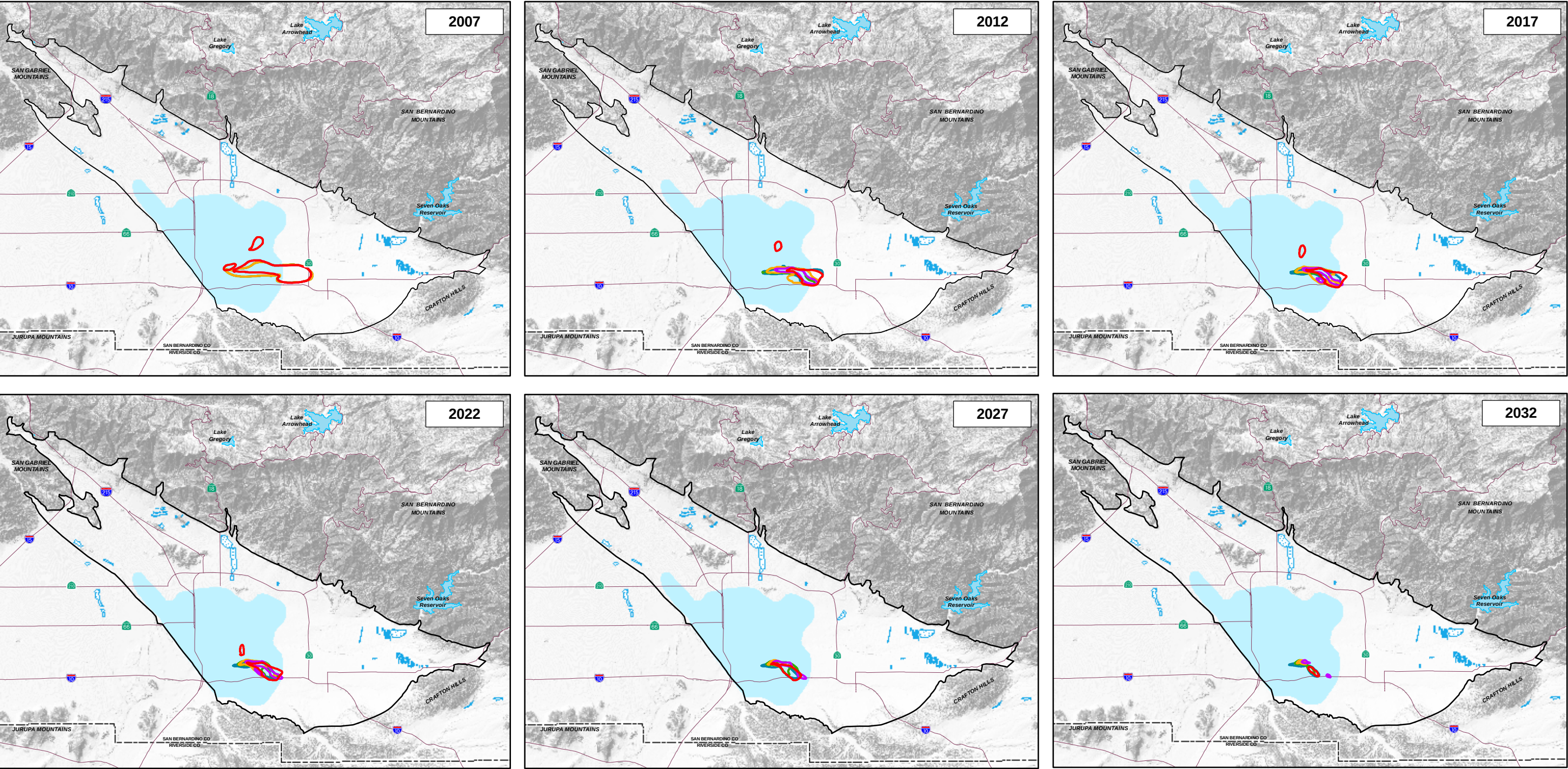
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**MODEL-GENERATED
TCE PLUME BOUNDARIES
FOR BASELINE RUN
NO PROJECT**

Figure 40

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated TCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

MODEL-GENERATED
TCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1

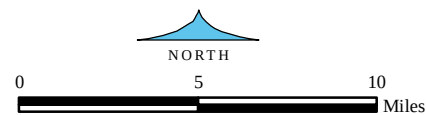
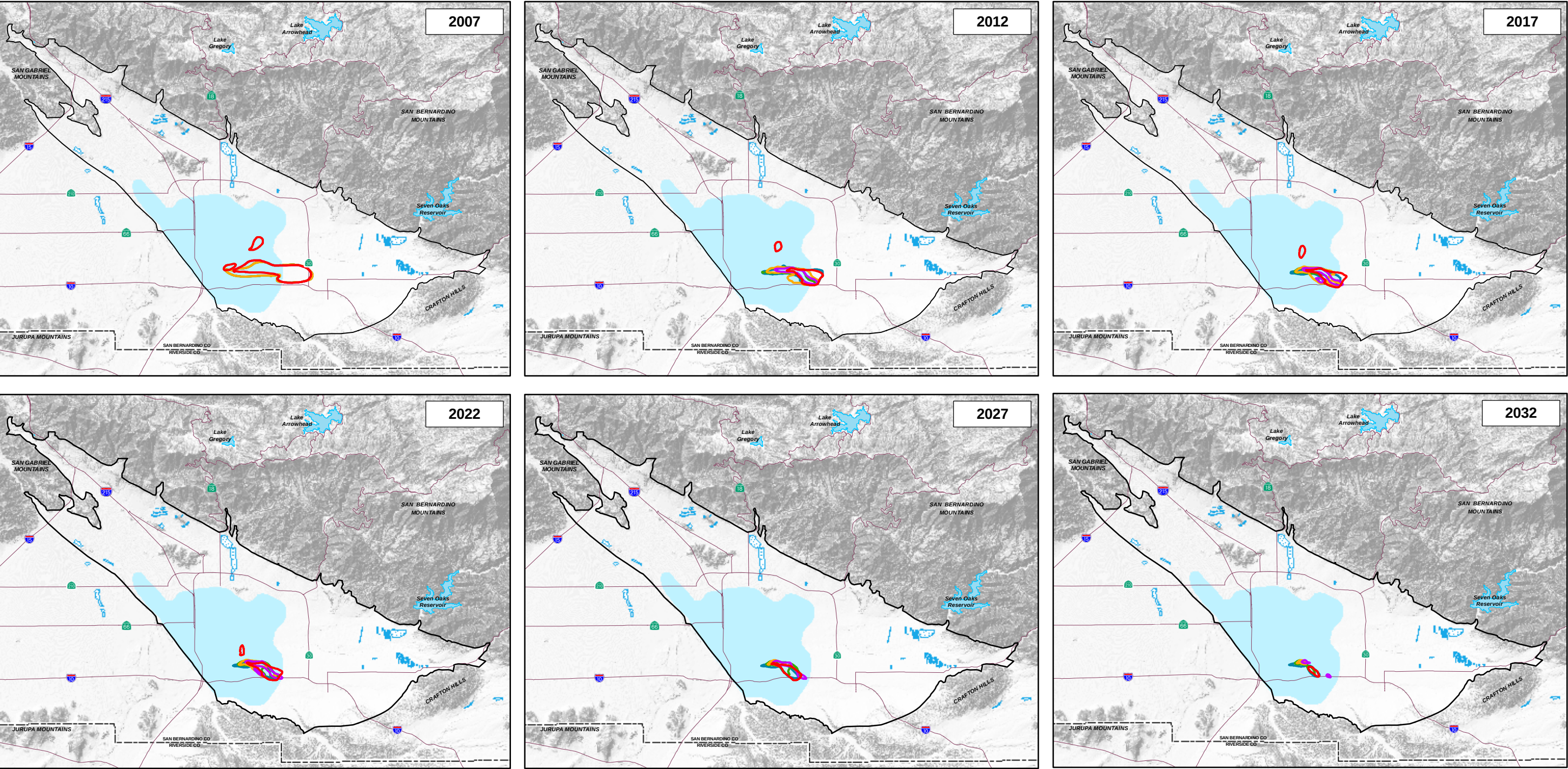
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Figure 41

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated TCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

23-Oct-09
Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

MODEL-GENERATED
TCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2

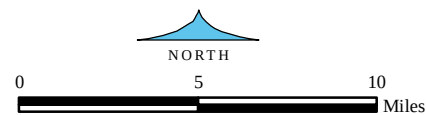
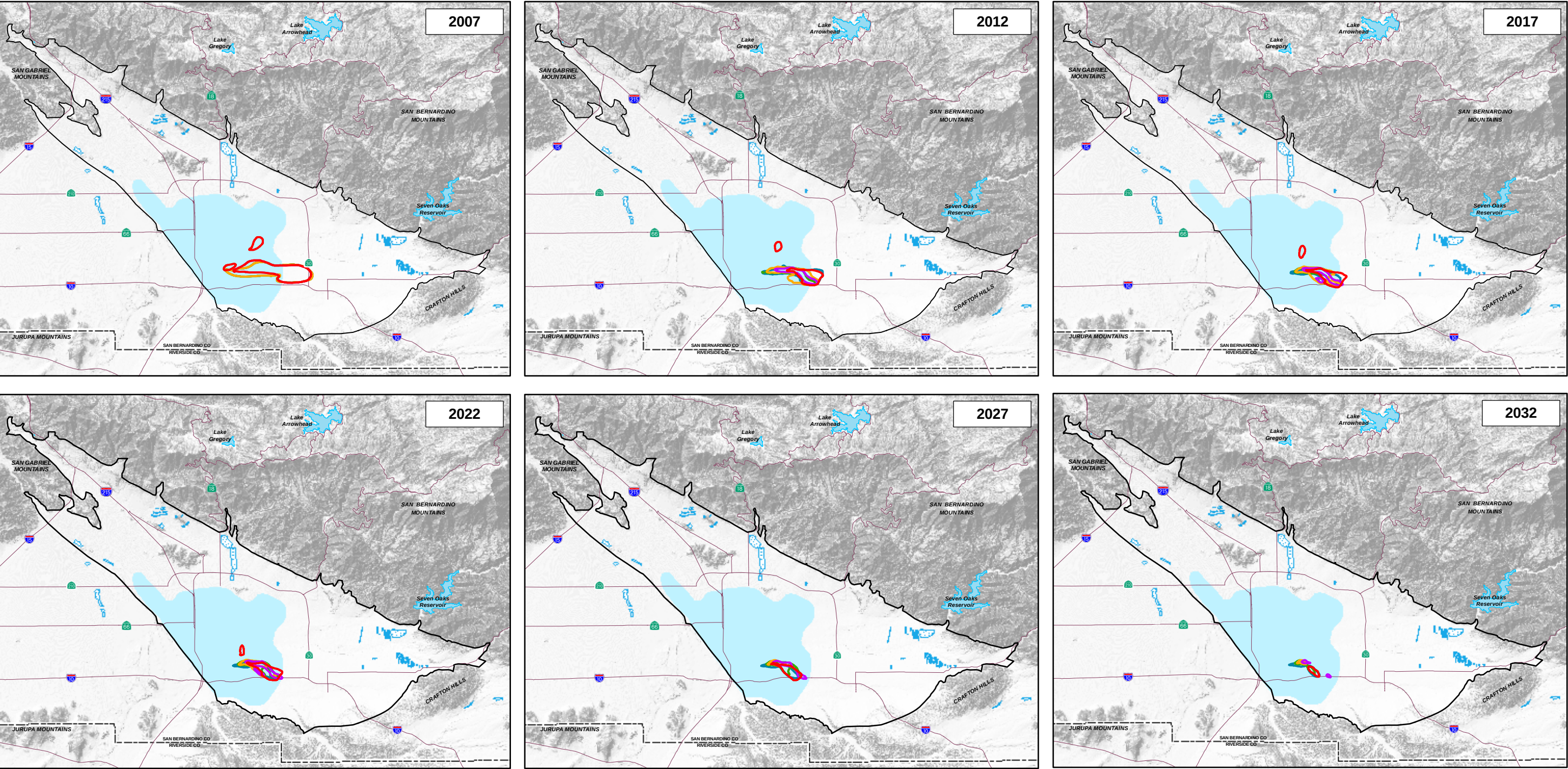
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Figure 42

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated TCE Plume (MCL = 5 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V, feet

MODEL-GENERATED
TCE PLUME BOUNDARIES
FOR RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3

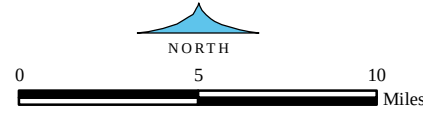
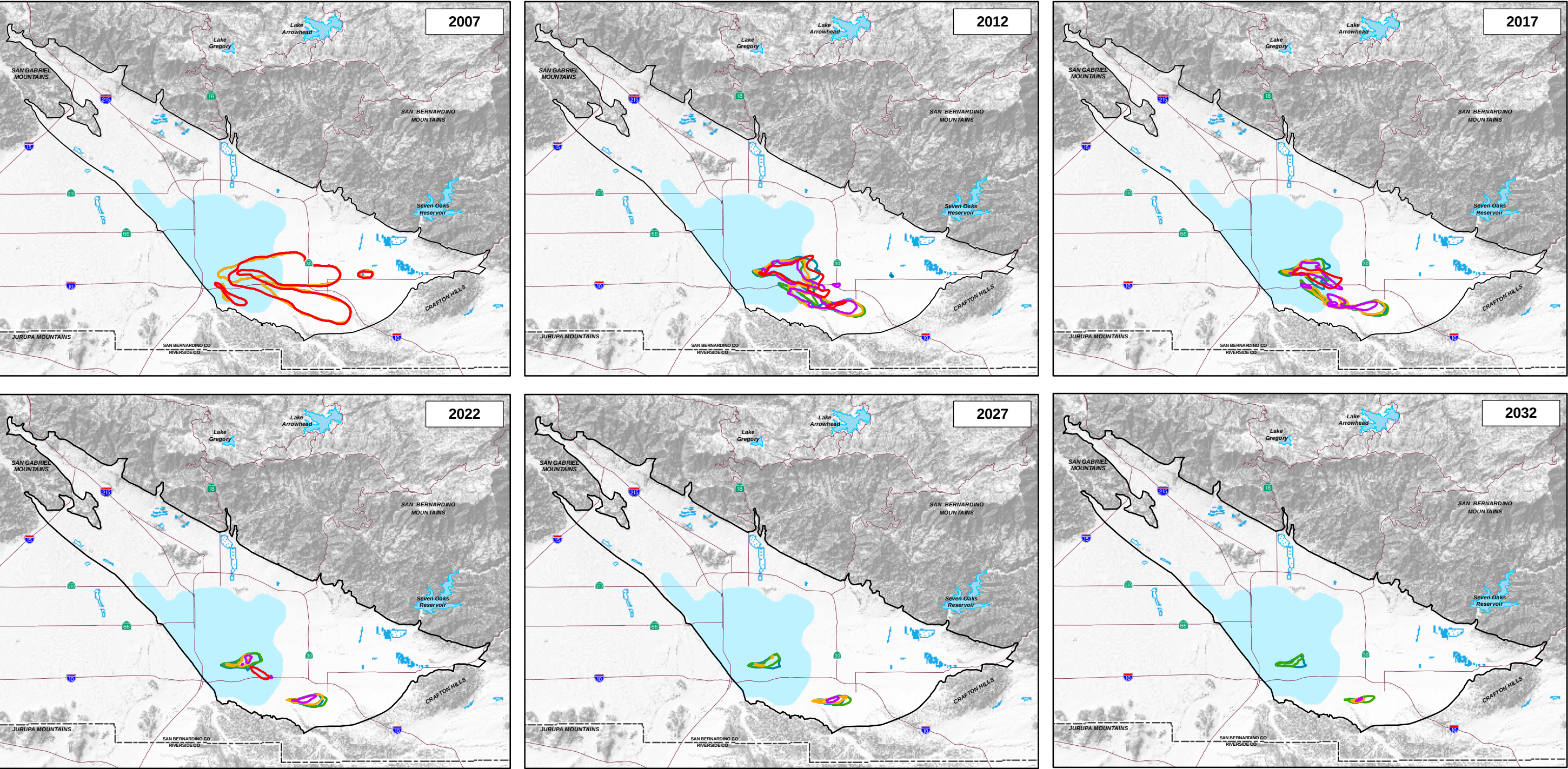
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Figure 43

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated Perchlorate Plume
(MCL = 6 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

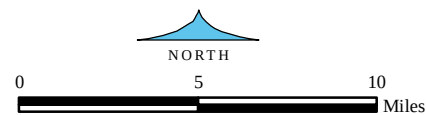
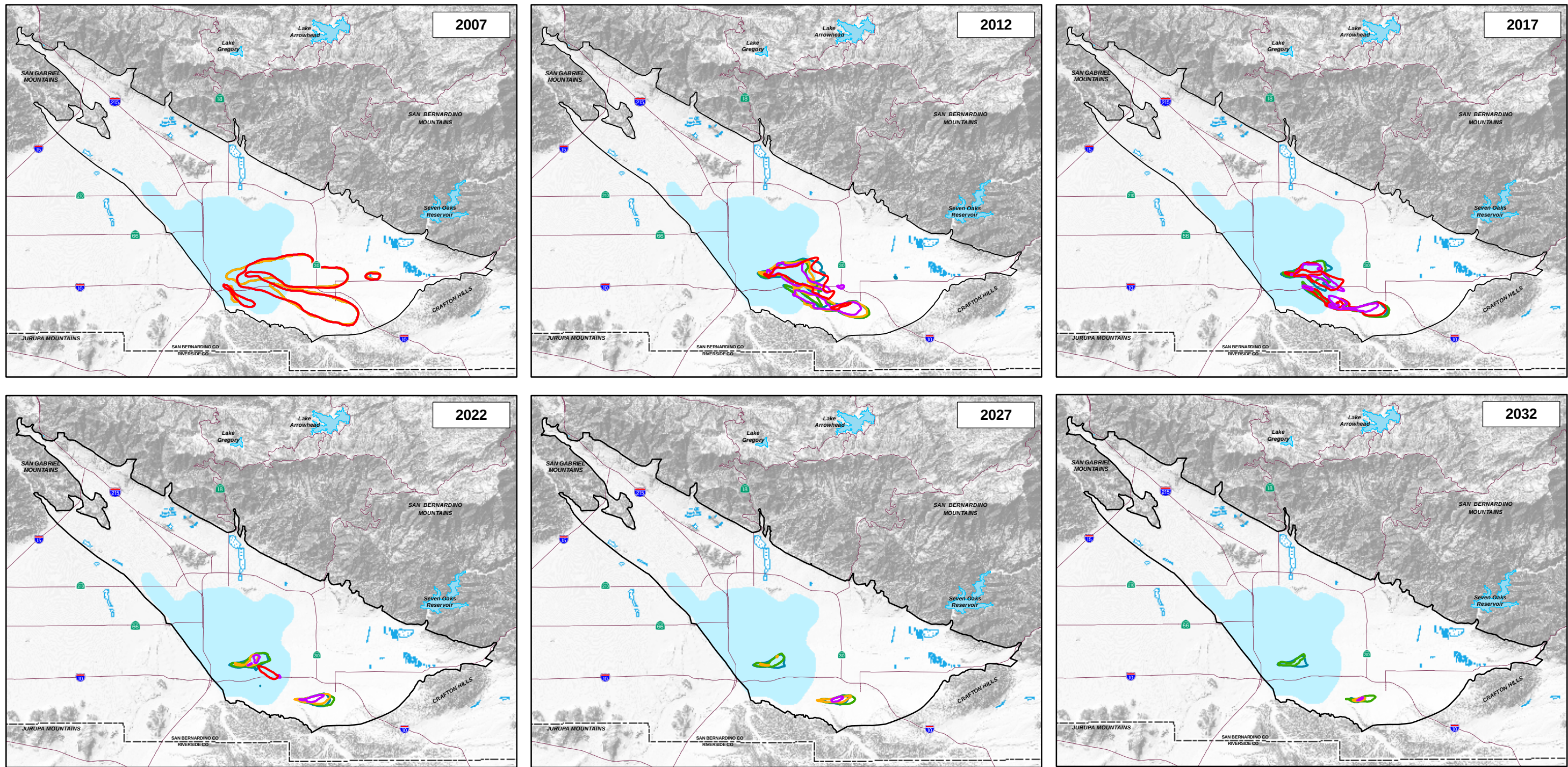
MODEL-GENERATED
PERCHLORATE PLUME
BOUNDARIES FOR
BASELINE RUN
NO PROJECT

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Figure 44

WESTERN MUNICIPAL WATER DISTRICT

GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



Model-Generated Perchlorate Plume
(MCL = 6 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

- San Bernardino Basin Area
Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

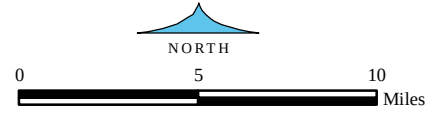
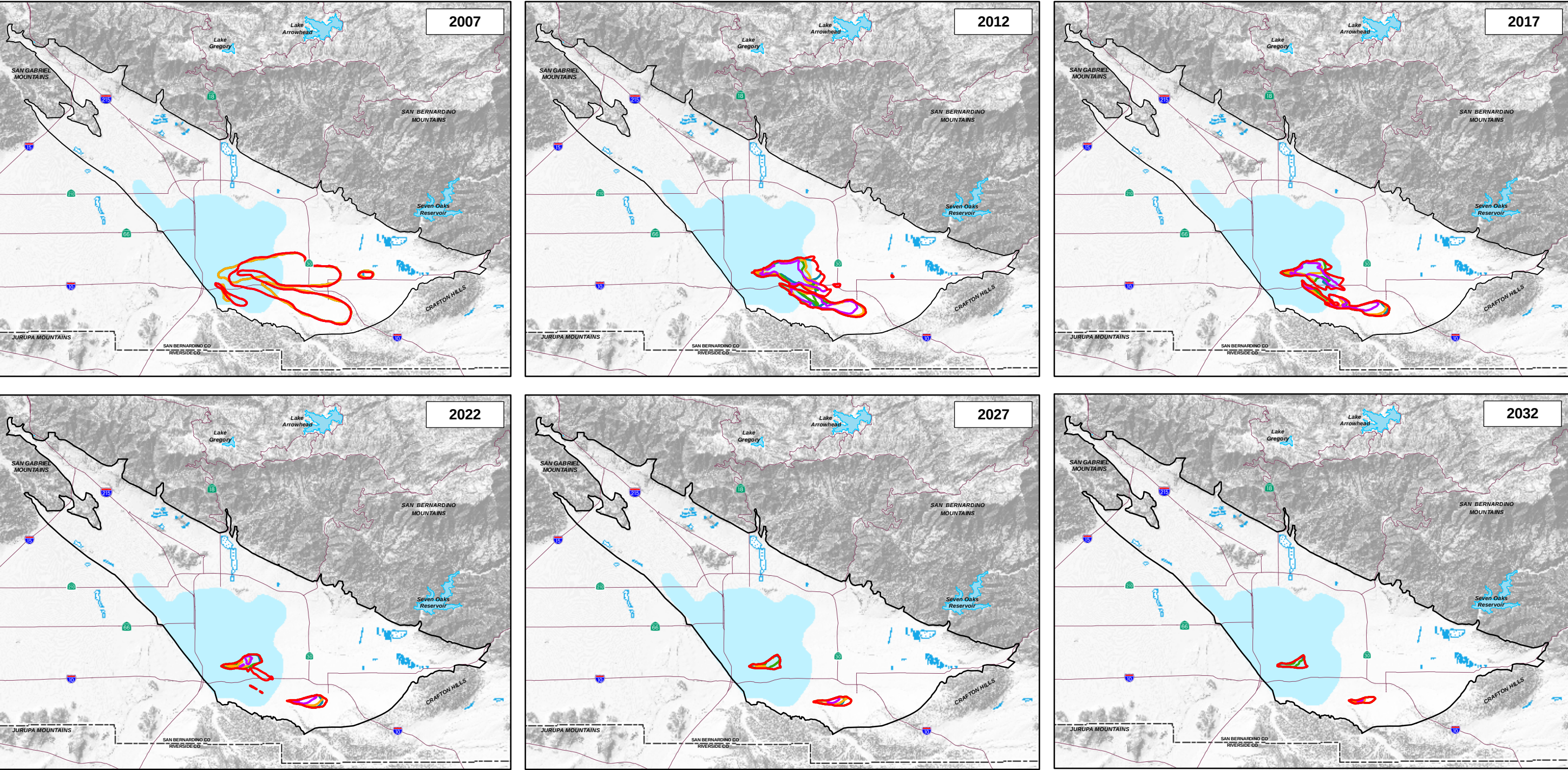
MODEL-GENERATED
PERCHLORATE PLUME
BOUNDARIES FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 1

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Prepared by: DWB
Map Projection: State Plane 1983, Zone V, feet

Figure 45



Model-Generated Perchlorate Plume
(MCL = 6 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

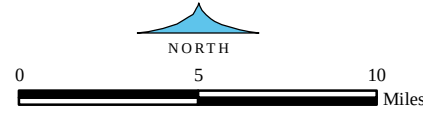
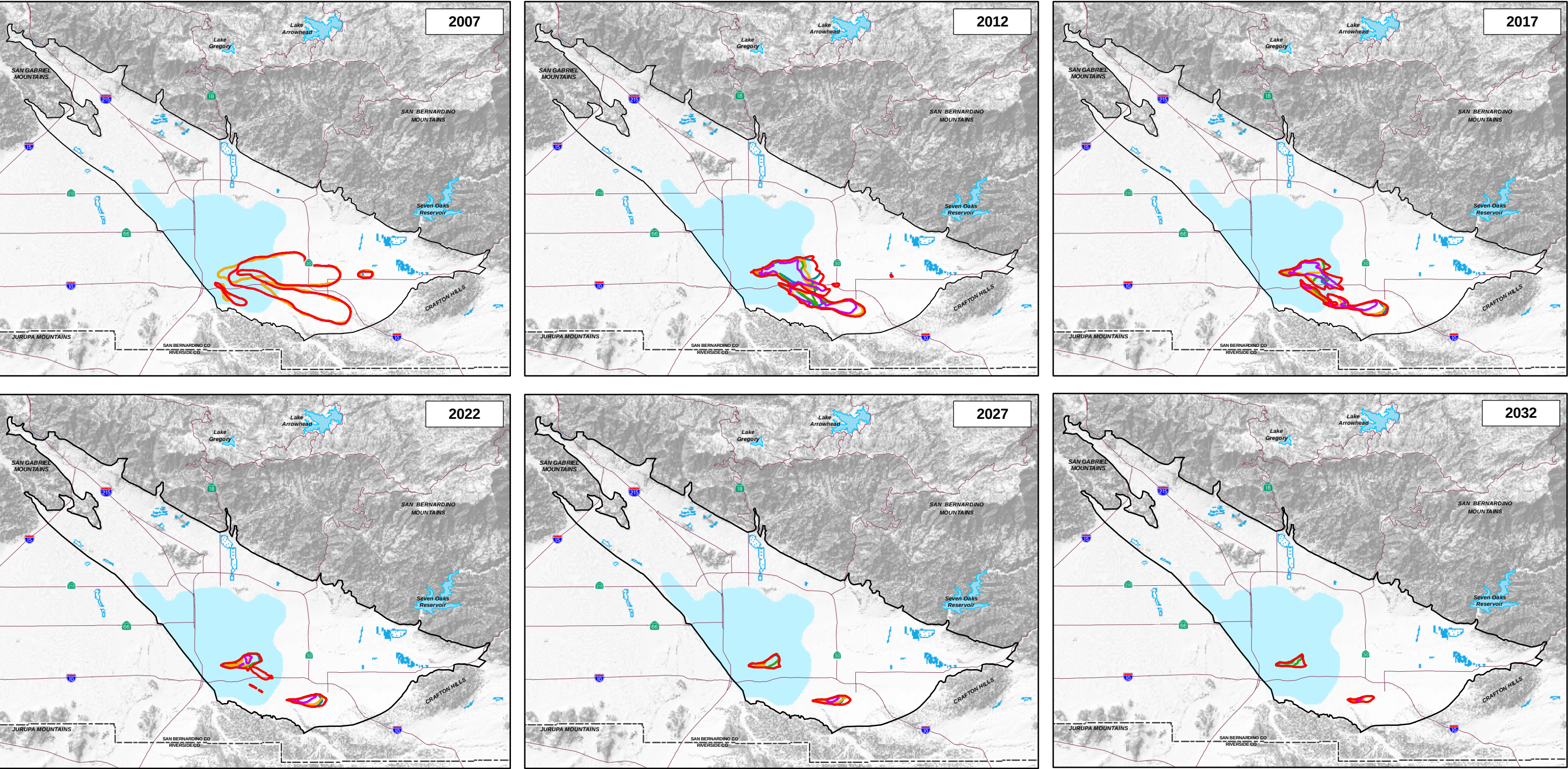
- San Bernardino Basin Area
Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

MODEL-GENERATED
PERCHLORATE PLUME
BOUNDARIES FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 2

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Map Projection: State Plane 1983, Zone V, feet

Figure 46



Model-Generated Perchlorate Plume
(MCL = 6 ug/L)

- Layer 1
- Layer 2
- Layer 3
- Layer 4
- Layer 5

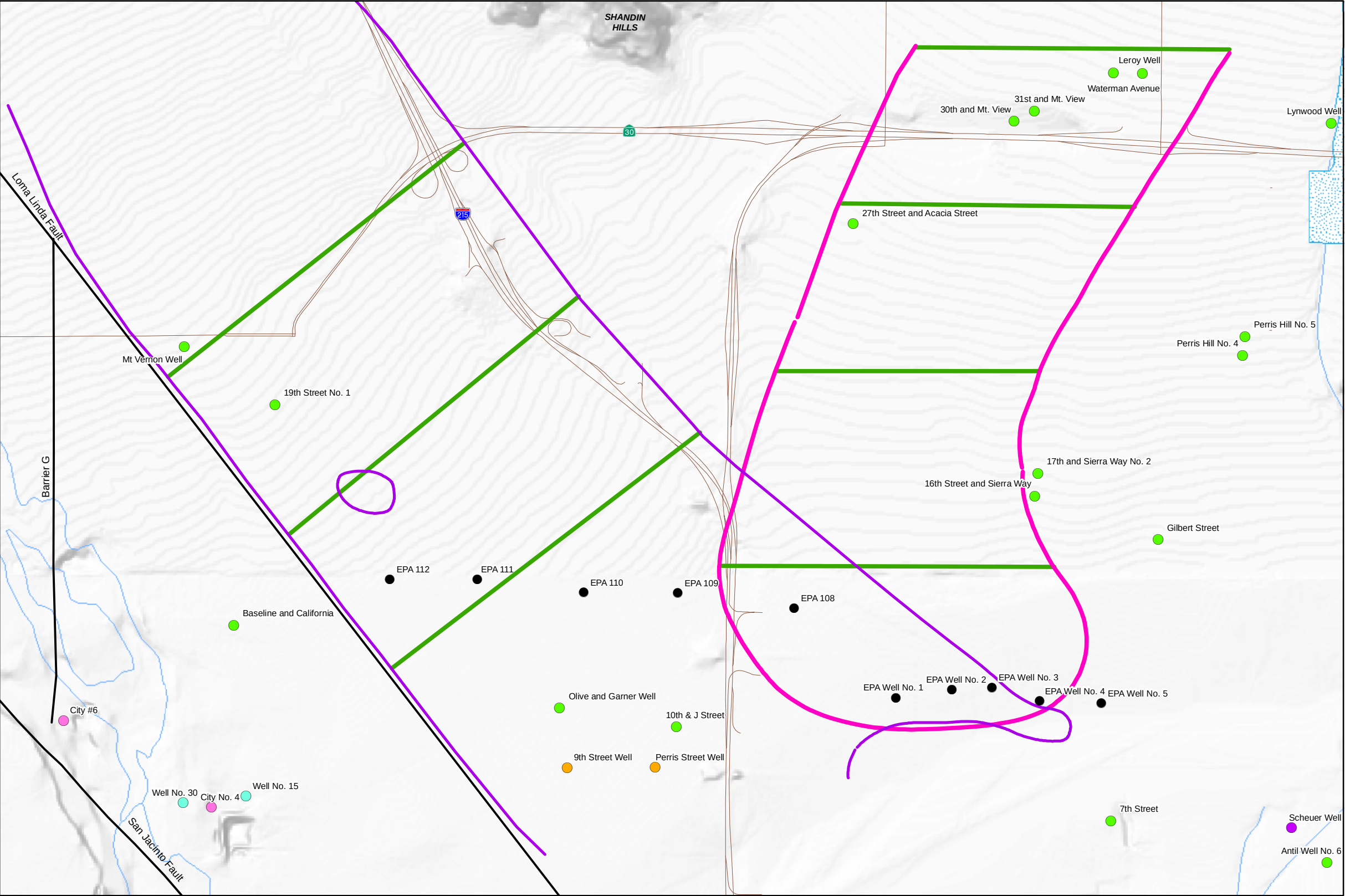
- San Bernardino Basin Area
Groundwater Basin Boundary
- Pressure Zone
- County Boundary
- Spreading Grounds or Basins

MODEL-GENERATED
PERCHLORATE PLUME
BOUNDARIES FOR
RIVERSIDE-CORONA
FEEDER PROJECT
SCENARIO 3

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Map Projection: State Plane 1983, Zone V, feet

Figure 47



**PARTICLE RELEASE
LOCATIONS AT
NEWMARK AND
MUSCOY PLUMES**

EXPLANATION

Particle Release Locations

Well Classification

- City of Rialto
- City of Riverside
- City of San Bernardino
- Newmark Muscoy EPA
- San Bernardino Valley Municipal Water District
- West Valley Water District

Muscoy PCE Plume
(0.5 ug/L)
(Source: Stantec, May 2008)

Newmark PCE Plume
(0.5 ug/L)
(Source: Stantec, May 2008)

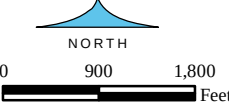
Fault

Spreading Grounds or
Basins

23-Oct-09

Prepared by: DWB

Map Projection: State Plane 1983, Zone V



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Figure 48

TABLES

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Table 1

Comparisons of Groundwater Elevation for Baseline Run (No Project) and Riverside-Corona Feeder Project Scenarios 1 through 3 Annual Average between 2007 to 2032

Well Name	Average Groundwater Elevations 2007 to 2032				Difference in Average Groundwater Elevation between Baseline Run (No Project) and RCF Scenarios			Hydrograph Page Number in Appendix A
	Baseline Run (No Project) [ft amsl]	RCF Scenario 1 [ft amsl]	RCF Scenario 2 [ft amsl]	RCF Scneario 3 [ft amsl]	Scenario 1 minus Baseline Run [ft]	Scenario 2 minus Baseline Run [ft]	Scenario 3 minus Baseline Run [ft]	
SBVMWD San Bernardino Ave. Well	1,476	1,477	1,481	1,482	2	5	7	A-1
City of San Bernardino Mt. Vernon Well	1,038	1,038	1,039	1,039	0	1	1	A-2
East Valley Water District Well 62	1,084	1,084	1,085	1,085	0	1	1	A-3
Fontana Union Well 13	1,266	1,267	1,268	1,268	0	2	2	A-4
Fontana Union Well 26	1,920	1,920	1,921	1,921	0	1	1	A-5
Fontana Union Well 27	2,152	2,152	2,152	2,152	0	0	0	A-6
East Valley Water District Well 120	1,376	1,376	1,377	1,377	0	1	1	A-7
City of San Bernardino Vincent Well	2,190	2,190	2,190	2,190	0	0	0	A-8
City of San Bernardino Devil Canyon Well No. 1	1,464	1,467	1,473	1,475	3	9	11	A-9
City of San Bernardino Newmark 3 Well	1,351	1,353	1,357	1,359	2	6	8	A-10
West Valley Water District Lord 7 Well	1,071	1,071	1,072	1,072	0	1	1	A-11
City of Riverside Raub 1 Well	866	865	863	862	-1	-3	-3	A-12
City of Redlands Well 32	1,226	1,224	1,221	1,220	-1	-4	-6	A-13
City of Redlands Orange Street Well	1,254	1,253	1,252	1,251	-1	-2	-3	A-14
East Valley Water District Well 24A	1,077	1,078	1,080	1,081	1	3	4	A-15
City of San Bernardino Cajon Well No. 1	1,717	1,718	1,718	1,719	1	2	2	A-16
East Valley Water District Well 40	1,173	1,173	1,172	1,171	0	-2	-2	A-17
City of San Bernardino Devil Canyon Well No. 3	1,649	1,653	1,660	1,663	3	11	13	A-18
City of San Bernardino Leroy Street Well	1,069	1,070	1,072	1,073	1	3	4	A-19
City of Redlands Agate 2 Well	1,580	1,583	1,588	1,591	3	9	11	A-20
East Valley Water District Cone Camp Well	1,549	1,550	1,553	1,554	1	4	5	A-21
Bear Valley Mutual Water Company Nelson Street Well	1,367	1,367	1,368	1,368	0	1	1	A-22
Gage Canal Company Lower Kelly Well	881	880	878	877	-1	-3	-4	A-23
City of Redlands Airport Well No. 2	1,364	1,364	1,365	1,365	0	1	2	A-24
East Valley Water District Well 146A	1,303	1,303	1,302	1,302	0	0	0	A-25
SBVMWD Backyard Well	863	862	860	860	-1	-2	-3	A-26

Groundwater Budgets for Baseline Run (No Project) - 2007 to 2032

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1979	181,023	106,486	0	5,376	1,083	38,194	31,030	3,667	366,858	11,373	206,079	0	2,413	219,865	146,993
2008	1980	282,923	133,937	0	8,680	1,083	38,770	66,632	3,667	535,693	28,923	206,644	0	2,403	237,970	297,723
2009	1981	86,405	52,046	0	3,761	1,083	39,517	10,125	3,667	196,604	18,451	215,193	0	2,470	236,114	-39,510
2010	1982	108,673	96,150	0	7,488	1,083	40,493	18,593	3,667	276,147	19,304	215,930	0	2,573	237,807	38,340
2011	1983	263,117	124,636	0	11,231	1,083	41,248	49,131	3,667	494,114	36,606	217,363	0	2,692	256,661	237,453
2012	1984	88,843	91,971	0	2,918	1,083	41,643	11,637	3,667	241,761	32,931	221,773	0	2,924	257,628	-15,866
2013	1985	74,588	63,619	0	3,561	1,083	44,563	9,235	3,667	200,317	25,240	238,329	0	3,198	266,768	-66,450
2014	1986	94,056	63,133	0	5,073	1,083	43,164	13,106	3,667	223,282	22,221	231,828	0	3,391	257,440	-34,158
2015	1987	62,870	44,778	0	4,258	1,083	48,115	7,249	3,667	172,019	15,509	253,435	0	3,458	272,402	-100,382
2016	1988	59,314	8,202	0	3,980	1,083	50,292	6,389	3,667	132,925	7,399	262,069	0	3,413	272,882	-139,956
2017	1989	46,371	70,247	0	2,362	1,083	51,875	5,388	3,667	180,993	6,550	272,692	0	3,260	282,502	-101,510
2018	1990	36,166	10,996	0	2,676	1,083	55,177	3,866	3,667	113,631	1,357	282,283	0	3,054	286,694	-173,063
2019	1991	66,839	13,712	0	5,829	1,083	48,920	7,958	3,667	148,010	887	255,474	0	2,870	259,231	-111,221
2020	1992	104,925	27,482	0	6,569	1,083	49,845	11,878	3,667	205,450	1,615	253,332	0	2,716	257,663	-52,214
2021	1993	342,743	130,812	0	8,590	1,083	47,561	51,496	3,667	585,952	10,783	252,345	0	2,612	265,740	320,212
2022	1994	85,901	46,093	0	4,530	1,083	49,550	10,829	3,667	201,653	6,361	258,263	0	2,565	267,189	-65,536
2023	1995	237,122	127,647	0	7,069	1,083	48,612	37,558	3,667	462,757	20,327	261,107	0	2,525	283,959	178,797
2024	1996	100,322	96,251	0	6,111	1,083	51,842	14,036	3,667	273,313	18,002	275,637	0	2,487	296,125	-22,812
2025	1997	80,067	85,438	0	5,671	1,083	52,515	10,847	3,667	239,288	16,995	280,685	0	2,456	300,136	-60,849
2026	1998	218,584	128,634	0	9,475	1,083	50,240	35,275	3,667	446,959	30,319	276,413	0	2,430	309,162	137,797
2027	1999	62,827	123,007	0	2,222	1,083	54,663	7,189	3,667	254,658	27,640	289,810	0	2,418	319,869	-65,210
2028	2000	53,038	120,000	0	4,114	1,083	56,575	6,383	3,667	244,860	22,693	304,172	0	2,400	329,265	-84,405
2029	2001	48,468	120,000	0	1,235	1,083	54,735	4,708	3,667	233,896	18,121	291,241	0	2,364	311,726	-77,830
2030	2002	31,560	120,000	0	2,052	1,083	58,526	3,519	3,667	220,407	13,368	308,311	0	2,328	324,007	-103,601
2031	2003	58,434	132,000	0	5,192	1,083	55,408	6,920	3,667	262,704	12,605	296,989	0	2,297	311,891	-49,186
2032	2004	68,222	144,000	0	5,728	1,083	56,939	5,457	3,667	285,096	12,678	295,889	0	2,264	310,832	-25,737
Total		2,943,402	2,281,278	0	135,751	28,157	1,268,982	446,433	95,342	7,199,345	438,262	6,723,285	0	69,979	7,231,526	-32,181
Average		113,208	87,741	0	5,221	1,083	48,807	17,171	3,667	276,898	16,856	258,588	0	2,692	278,136	-1,238

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Scenario 1 - 2007 to 2032

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1979	181,023	106,486	0	5,376	1,083	38,194	31,030	3,667	366,858	11,373	206,079	0	2,413	219,865	146,993
2008	1980	282,923	133,937	0	8,680	1,083	38,770	66,632	3,667	535,693	28,923	206,644	0	2,403	237,970	297,723
2009	1981	86,405	52,046	0	3,761	1,083	39,517	10,125	3,667	196,604	18,451	215,193	0	2,470	236,114	-39,510
2010	1982	108,673	96,150	0	7,488	1,083	40,493	18,593	3,667	276,147	19,304	215,930	0	2,573	237,807	38,340
2011	1983	260,800	124,636	18,000	11,231	1,083	41,248	49,131	3,667	509,797	37,071	217,363	10,000	2,691	267,125	242,671
2012	1984	89,452	91,971	24,000	2,918	1,083	41,643	11,637	3,667	266,371	35,717	221,773	10,000	2,918	270,407	-4,037
2013	1985	75,405	63,619	0	3,561	1,083	44,563	9,235	3,667	201,135	27,422	238,329	4,000	3,189	272,940	-71,806
2014	1986	94,038	63,133	0	5,073	1,083	43,164	13,106	3,667	223,264	23,075	231,828	4,000	3,383	262,286	-39,022
2015	1987	62,870	44,778	0	4,258	1,083	48,115	7,249	3,667	172,019	15,784	253,435	4,000	3,448	276,666	-104,647
2016	1988	59,314	8,202	0	3,980	1,083	50,292	6,389	3,667	132,925	7,224	262,069	2,500	3,398	275,191	-142,266
2017	1989	46,371	70,247	0	2,362	1,083	51,875	5,388	3,667	180,993	6,306	272,692	0	3,243	282,241	-101,248
2018	1990	36,166	10,996	0	2,676	1,083	55,177	3,866	3,667	113,631	1,285	282,283	0	3,039	286,607	-172,976
2019	1991	66,839	13,712	0	5,829	1,083	48,920	7,958	3,667	148,009	885	255,474	0	2,858	259,217	-111,208
2020	1992	104,925	27,482	0	6,569	1,083	49,845	11,878	3,667	205,449	1,619	253,332	0	2,707	257,658	-52,209
2021	1993	342,818	130,812	0	8,590	1,083	47,561	51,496	3,667	586,026	10,770	252,345	0	2,606	265,720	320,306
2022	1994	85,900	46,093	0	4,530	1,083	49,550	10,829	3,667	201,652	6,351	258,263	0	2,559	267,173	-65,521
2023	1995	237,194	127,647	0	7,069	1,083	48,612	37,558	3,667	462,829	20,319	261,107	0	2,521	283,947	178,882
2024	1996	100,362	96,251	0	6,111	1,083	51,842	14,036	3,667	273,353	18,060	275,637	0	2,484	296,180	-22,827
2025	1997	80,096	85,438	0	5,671	1,083	52,515	10,847	3,667	239,317	17,037	280,685	0	2,454	300,176	-60,859
2026	1998	218,646	128,634	0	9,475	1,083	50,240	35,275	3,667	447,021	30,373	276,413	0	2,428	309,214	137,806
2027	1999	62,829	123,007	0	2,222	1,083	54,663	7,189	3,667	254,660	27,683	289,810	0	2,416	319,910	-65,250
2028	2000	53,040	120,000	0	4,114	1,083	56,575	6,383	3,667	244,862	22,719	304,172	0	2,399	329,290	-84,427
2029	2001	48,468	120,000	0	1,235	1,083	54,735	4,708	3,667	233,896	18,138	291,241	0	2,363	311,742	-77,846
2030	2002	31,562	120,000	0	2,052	1,083	58,526	3,519	3,667	220,408	13,383	308,311	0	2,328	324,021	-103,613
2031	2003	58,435	132,000	0	5,192	1,083	55,408	6,920	3,667	262,705	12,616	296,989	0	2,297	311,902	-49,197
2032	2004	68,222	144,000	0	5,728	1,083	56,939	5,457	3,667	285,096	12,692	295,889	0	2,264	310,846	-25,749
Total		2,942,776	2,281,278	42,000	135,751	28,157	1,268,982	446,433	95,342	7,240,719	444,580	6,723,285	34,500	69,852	7,272,216	-31,496
Average		113,184	87,741	1,615	5,221	1,083	48,807	17,171	3,667	278,489	17,099	258,588	1,327	2,687	279,701	-1,211

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Scenario 2 - 2007 to 2032

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1979	181,023	106,486	0	5,376	1,083	38,194	31,030	3,667	366,858	11,373	206,079	0	2,413	219,865	146,993
2008	1980	281,216	133,937	17,000	8,680	1,083	38,770	66,632	3,667	550,985	28,608	206,644	12,000	2,403	249,654	301,331
2009	1981	86,760	52,046	0	3,761	1,083	39,517	10,125	3,667	196,959	18,821	215,193	3,500	2,468	239,982	-43,023
2010	1982	110,244	96,150	17,000	7,488	1,083	40,493	18,593	3,667	294,717	18,144	215,930	15,000	2,566	251,640	43,077
2011	1983	260,859	124,636	17,000	11,231	1,083	41,248	49,131	3,667	508,855	38,675	217,363	15,000	2,675	273,713	235,142
2012	1984	90,556	91,971	24,000	2,918	1,083	41,643	11,637	3,667	267,474	36,185	221,773	10,000	2,886	270,843	-3,369
2013	1985	75,674	63,619	0	3,561	1,083	44,563	9,235	3,667	201,403	27,711	238,329	2,900	3,143	272,083	-70,680
2014	1986	94,001	63,133	0	5,073	1,083	43,164	13,106	3,667	223,227	23,356	231,828	2,900	3,335	261,419	-38,192
2015	1987	62,870	44,778	0	4,258	1,083	48,115	7,249	3,667	172,019	16,064	253,435	2,900	3,406	275,805	-103,786
2016	1988	59,314	8,202	0	3,980	1,083	50,292	6,389	3,667	132,926	7,337	262,069	2,900	3,367	275,674	-142,748
2017	1989	46,371	70,247	0	2,362	1,083	51,875	5,388	3,667	180,993	6,302	272,692	0	3,223	282,217	-101,223
2018	1990	36,166	10,996	0	2,676	1,083	55,177	3,866	3,667	113,631	1,282	282,283	0	3,026	286,590	-172,960
2019	1991	66,839	13,712	0	5,829	1,083	48,920	7,958	3,667	148,009	886	255,474	0	2,850	259,209	-111,200
2020	1992	104,924	27,482	0	6,569	1,083	49,845	11,878	3,667	205,449	1,621	253,332	0	2,702	257,655	-52,206
2021	1993	342,834	130,812	0	8,590	1,083	47,561	51,496	3,667	586,042	10,764	252,345	0	2,602	265,711	320,331
2022	1994	85,901	46,093	0	4,530	1,083	49,550	10,829	3,667	201,653	6,347	258,263	0	2,557	267,167	-65,513
2023	1995	236,682	127,647	25,000	7,069	1,083	48,612	37,558	3,667	487,317	20,514	261,107	15,000	2,519	299,140	188,177
2024	1996	100,252	96,251	0	6,111	1,083	51,842	14,036	3,667	273,243	19,343	275,637	3,600	2,481	301,060	-27,817
2025	1997	80,289	85,438	0	5,671	1,083	52,515	10,847	3,667	239,510	17,488	280,685	3,600	2,450	304,223	-64,713
2026	1998	214,952	128,634	25,000	9,475	1,083	50,240	35,275	3,667	468,326	32,382	276,413	12,500	2,422	323,718	144,609
2027	1999	62,271	123,007	25,000	2,222	1,083	54,663	7,189	3,667	279,102	32,528	289,810	10,000	2,409	334,747	-55,645
2028	2000	53,177	120,000	0	4,114	1,083	56,575	6,383	3,667	244,998	25,228	304,172	2,800	2,390	334,591	-89,592
2029	2001	48,470	120,000	0	1,235	1,083	54,735	4,708	3,667	233,898	18,782	291,241	2,800	2,355	315,178	-81,280
2030	2002	31,559	120,000	0	2,052	1,083	58,526	3,519	3,667	220,406	13,449	308,311	2,800	2,321	326,881	-106,475
2031	2003	58,434	132,000	0	5,192	1,083	55,408	6,920	3,667	262,704	12,450	296,989	2,800	2,292	314,531	-51,827
2032	2004	68,220	144,000	0	5,728	1,083	56,939	5,457	3,667	285,094	12,463	295,889	2,800	2,260	313,413	-28,319
Total		2,939,856	2,281,278	150,000	135,751	28,157	1,268,982	446,433	95,342	7,345,799	458,103	6,723,285	125,800	69,520	7,376,708	-30,909
Average		113,071	87,741	5,769	5,221	1,083	48,807	17,171	3,667	282,531	17,619	258,588	4,838	2,674	283,720	-1,189

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Groundwater Budgets for Riverside-Corona Feeder Project Scenario 3 - 2007 to 2032

Model Year	Hydrologic Year	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
		INFLOW									OUTFLOW					CHANGE IN GROUNDWATER STORAGE
		Recharge from Gaged Streamflow	Artificial Recharge		Recharge from Local Runoff Generated by Precipitation	Infiltration from Direct Precipitation	Return Flow from Groundwater Pumping	Recharge from Ungaged Mountain Front Runoff	Underflow Recharge	Total Inflow	Evapo- transpiration	Groundwater Pumping		Underflow Discharge	Total Outflow	
			Others	Riverside-Corona Feeder Project								Others	Riverside-Corona Feeder Project			
		[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]	[acre-ft]
2007	1979	181,023	106,486	0	5,376	1,083	38,194	31,030	3,667	366,858	11,373	206,079	0	2,413	219,865	146,993
2008	1980	281,030	133,937	20,000	8,680	1,083	38,770	66,632	3,667	553,799	28,915	206,644	15,000	2,403	252,962	300,837
2009	1981	86,834	52,046	0	3,761	1,083	39,517	10,125	3,667	197,032	18,901	215,193	3,000	2,468	239,562	-42,529
2010	1982	110,157	96,150	17,000	7,488	1,083	40,493	18,593	3,667	294,631	18,192	215,930	15,000	2,565	251,687	42,943
2011	1983	260,743	124,636	17,000	11,231	1,083	41,248	49,131	3,667	508,739	38,706	217,363	15,000	2,673	273,741	234,998
2012	1984	90,960	91,971	24,000	2,918	1,083	41,643	11,637	3,667	267,878	36,085	221,773	12,000	2,882	272,740	-4,862
2013	1985	75,961	63,619	0	3,561	1,083	44,563	9,235	3,667	201,691	27,610	238,329	2,900	3,137	271,977	-70,286
2014	1986	94,071	63,133	0	5,073	1,083	43,164	13,106	3,667	223,297	23,305	231,828	2,900	3,325	261,358	-38,061
2015	1987	62,870	44,778	0	4,258	1,083	48,115	7,249	3,667	172,019	16,020	253,435	2,900	3,395	275,749	-103,730
2016	1988	59,314	8,202	0	3,980	1,083	50,292	6,389	3,667	132,926	7,373	262,069	1,850	3,356	274,648	-141,722
2017	1989	46,371	70,247	0	2,362	1,083	51,875	5,388	3,667	180,993	6,349	272,692	0	3,213	282,254	-101,261
2018	1990	36,166	10,996	0	2,676	1,083	55,177	3,866	3,667	113,630	1,290	282,283	0	3,020	286,593	-172,962
2019	1991	66,839	13,712	0	5,829	1,083	48,920	7,958	3,667	148,009	886	255,474	0	2,845	259,205	-111,196
2020	1992	104,924	27,482	0	6,569	1,083	49,845	11,878	3,667	205,449	1,621	253,332	0	2,699	257,652	-52,203
2021	1993	342,833	130,812	0	8,590	1,083	47,561	51,496	3,667	586,041	10,772	252,345	0	2,600	265,717	320,324
2022	1994	85,899	46,093	0	4,530	1,083	49,550	10,829	3,667	201,651	6,350	258,263	0	2,555	267,168	-65,517
2023	1995	236,527	127,647	30,000	7,069	1,083	48,612	37,558	3,667	492,162	21,363	261,107	15,000	2,517	299,988	192,175
2024	1996	99,355	96,251	30,000	6,111	1,083	51,842	14,036	3,667	302,346	21,400	275,637	15,000	2,480	314,516	-12,171
2025	1997	79,803	85,438	0	5,671	1,083	52,515	10,847	3,667	239,025	19,118	280,685	15,000	2,450	317,253	-78,228
2026	1998	214,080	128,634	30,000	9,475	1,083	50,240	35,275	3,667	472,455	34,356	276,413	15,000	2,423	328,192	144,263
2027	1999	61,601	123,007	30,000	2,222	1,083	54,663	7,189	3,667	283,433	33,933	289,810	15,000	2,410	341,153	-57,720
2028	2000	53,123	120,000	0	4,114	1,083	56,575	6,383	3,667	244,945	25,578	304,172	3,550	2,391	335,691	-90,746
2029	2001	48,469	120,000	0	1,235	1,083	54,735	4,708	3,667	233,897	18,753	291,241	3,550	2,355	315,898	-82,001
2030	2002	31,560	120,000	0	2,052	1,083	58,526	3,519	3,667	220,406	13,390	308,311	3,550	2,320	327,571	-107,165
2031	2003	58,434	132,000	0	5,192	1,083	55,408	6,920	3,667	262,704	12,385	296,989	3,550	2,291	315,215	-52,511
2032	2004	68,220	144,000	0	5,728	1,083	56,939	5,457	3,667	285,094	12,416	295,889	3,550	2,259	314,114	-29,020
Total		2,937,168	2,281,278	198,000	135,751	28,157	1,268,982	446,433	95,342	7,391,111	466,439	6,723,285	163,300	69,445	7,422,469	-31,358
Average		112,968	87,741	7,615	5,221	1,083	48,807	17,171	3,667	284,273	17,940	258,588	6,281	2,671	285,480	-1,206

[1] Model-Calculated
[2] Model input data estimated based on model iterative runs
[3] Model input data estimated based on model iterative runs
[4] Model input data estimated based on historical conditions
[5] Model input data estimated based on historical conditions
[6] Model input data estimated based on pumping data
[7] Model input data estimated based on historical conditions
[8] Model input data estimated based on historical conditions
[9] = sum of [1] through [8]
[10] Model-Calculated
[11] Model input data estimated based on water demands
[12] Model input data estimated based on model iterative runs
[13] Model input based on historical conditions and model-calculated water levels in Heap Well
[14] = sum of [10] through [13]
[15] = [9]-[14]

Western Municipal Water District
Groundwater Modeling of Riverside-Corona Feeder Project
Conjunctive Use Scenarios

**Underflow Outflow from SBBA Across San Jacinto Fault near Santa Ana River to
Rialto-Colton Groundwater Basin 2007 to 2032**

Model Year	Hydrologic Year	Underflow Outflow Across San Jacinto Fault near SAR to Rialto-Colton Groundwater Basin			
		Baseline Run (No Project)	RCF Scenario 1	RCF Scenario 2	RCF Scenario 3
		[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]	[acre-ft/yr]
2007	1979	433	433	433	433
2008	1980	423	423	423	423
2009	1981	490	490	488	488
2010	1982	593	593	586	585
2011	1983	712	711	695	693
2012	1984	944	938	906	902
2013	1985	1,218	1,209	1,163	1,157
2014	1986	1,411	1,403	1,355	1,345
2015	1987	1,478	1,468	1,426	1,415
2016	1988	1,433	1,418	1,387	1,376
2017	1989	1,280	1,263	1,243	1,233
2018	1990	1,074	1,059	1,046	1,040
2019	1991	890	878	870	865
2020	1992	736	727	722	719
2021	1993	632	626	622	620
2022	1994	585	579	577	575
2023	1995	545	541	539	537
2024	1996	507	504	501	500
2025	1997	476	474	470	470
2026	1998	450	448	442	443
2027	1999	438	436	429	430
2028	2000	420	419	410	411
2029	2001	384	383	375	375
2030	2002	348	348	341	340
2031	2003	317	317	312	311
2032	2004	284	284	280	279
Maximum		1,478	1,468	1,426	1,415
Minimum		284	284	280	279
Average		712	707	694	691

Table 6

APPENDIX A
2005 and 2008 SWP Surplus Water Availability Reports

GEOSCIENCE Support Services, Inc.



Western Municipal Water District
Groundwater Modeling of Riverside-Corona Feeder Project
Conjunctive Use Scenarios

2005 SWP Surplus Water Availability

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1922	1,900,000	100%	0	1,900,000	570,000
1923	1,900,000	100%	0	1,900,000	570,000
1924	171,000	9%	0	171,000	0
1925	684,000	36%	0	684,000	0
1926	1,254,000	66%	0	1,254,000	0
1927	1,900,000	100%	0	1,900,000	570,000
1928	1,558,000	82%	0	1,558,000	228,000
1929	513,000	27%	0	513,000	0
1930	1,254,000	66%	0	1,254,000	0
1931	494,000	26%	0	494,000	0
1932	722,000	38%	0	722,000	0
1933	608,000	32%	0	608,000	0
1934	684,000	36%	0	684,000	0
1935	1,862,000	98%	0	1,862,000	532,000
1936	1,710,000	90%	0	1,710,000	380,000
1937	1,558,000	82%	0	1,558,000	228,000
1938	1,900,000	100%	0	1,900,000	570,000
1939	1,577,000	83%	0	1,577,000	247,000
1940	1,900,000	100%	0	1,900,000	570,000
1941	1,805,000	95%	0	1,805,000	475,000
1942	1,900,000	100%	0	1,900,000	570,000
1943	1,748,000	92%	0	1,748,000	418,000
1944	1,634,000	86%	0	1,634,000	304,000
1945	1,786,000	94%	0	1,786,000	456,000
1946	1,767,000	93%	0	1,767,000	437,000
1947	1,273,000	67%	0	1,273,000	0
1948	1,349,000	71%	0	1,349,000	19,000
1949	931,000	49%	0	931,000	0
1950	1,558,000	82%	0	1,558,000	228,000
1951	1,900,000	100%	36,558	1,936,558	606,558
1952	1,805,000	95%	0	1,805,000	475,000
1953	1,900,000	100%	0	1,900,000	570,000
1954	1,900,000	100%	0	1,900,000	570,000
1955	684,000	36%	0	684,000	0

Western Municipal Water District
Groundwater Modeling of Riverside-Corona Feeder Project
Conjunctive Use Scenarios

2005 SWP Surplus Water Availability

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1956	1,900,000	100%	79,287	1,979,287	649,287
1957	1,634,000	86%	0	1,634,000	304,000
1958	1,900,000	100%	0	1,900,000	570,000
1959	1,748,000	92%	0	1,748,000	418,000
1960	741,000	39%	0	741,000	0
1961	1,254,000	66%	0	1,254,000	0
1962	1,520,000	80%	0	1,520,000	190,000
1963	1,900,000	100%	0	1,900,000	570,000
1964	1,330,000	70%	0	1,330,000	0
1965	1,596,000	84%	0	1,596,000	266,000
1966	1,900,000	100%	0	1,900,000	570,000
1967	1,900,000	100%	0	1,900,000	570,000
1968	1,748,000	92%	0	1,748,000	418,000
1969	1,805,000	95%	61,695	1,866,695	536,695
1970	1,900,000	100%	137,670	2,037,670	707,670
1971	1,900,000	100%	0	1,900,000	570,000
1972	1,254,000	66%	0	1,254,000	0
1973	1,862,000	98%	0	1,862,000	532,000
1974	1,900,000	100%	0	1,900,000	570,000
1975	1,900,000	100%	0	1,900,000	570,000
1976	1,444,000	76%	0	1,444,000	114,000
1977	95,000	5%	0	95,000	0
1978	1,786,000	94%	0	1,786,000	456,000
1979	1,729,000	91%	0	1,729,000	399,000
1980	1,615,000	85%	62,733	1,677,733	347,733
1981	1,748,000	92%	0	1,748,000	418,000
1982	1,900,000	100%	0	1,900,000	570,000
1983	1,805,000	95%	241,105	2,046,105	716,105
1984	1,900,000	100%	185,216	2,085,216	755,216
1985	1,577,000	83%	0	1,577,000	247,000
1986	1,311,000	69%	0	1,311,000	0
1987	1,520,000	80%	0	1,520,000	190,000
1988	190,000	10%	0	190,000	0
1989	1,615,000	85%	0	1,615,000	285,000

2005 SWP Surplus Water Availability

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1990	399,000	21%	0	399,000	0
1991	399,000	21%	0	399,000	0
1992	665,000	35%	0	665,000	0
1993	1,900,000	100%	0	1,900,000	570,000
1994	1,444,000	76%	0	1,444,000	114,000
1995	1,824,000	96%	0	1,824,000	494,000
1996	1,824,000	96%	0	1,824,000	494,000
1997	1,824,000	96%	0	1,824,000	494,000
1998	1,824,000	96%	0	1,824,000	494,000
1999	1,824,000	96%	38,850	1,862,850	532,850
2000	1,713,800	90%	0	1,713,800	383,800

Note:

[1] Table A water is water delivered according to the portion of available supply to be delivered to MWD.

1995-2000 values were estimated based on the average value during the period 1922-1994 with similar water year types using the Sacramento Valley Water Year Hydrologic Classification Indices.

[2] Percent SWP delivered of MWD's contracted amount of 1.9 million acre-ft

[3] Article 21 of the contract permits delivery of water excess to delivery of Table A and some other water types

[4] = [1] + [3]

[5] Total SWP Deliveries [4] that exceeds 70% of 1.9 million acre-ft (1,330,000 acre-ft)

Data provided by SAIC

**2008 SWP Reliability Delivery Report
High Fisheries Impact - No Climate Change Scenario**

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1922	1,485,256	78%	0	1,485,256	155,256
1923	1,265,336	66%	0	1,265,336	0
1924	57,878	3%	0	57,878	0
1925	722,603	38%	0	722,603	0
1926	909,034	48%	0	909,034	0
1927	1,537,873	80%	0	1,537,873	207,873
1928	875,065	46%	0	875,065	0
1929	298,736	16%	0	298,736	0
1930	977,924	51%	0	977,924	0
1931	484,148	25%	0	484,148	0
1932	538,798	28%	0	538,798	0
1933	886,148	46%	0	886,148	0
1934	660,561	35%	0	660,561	0
1935	1,173,687	61%	0	1,173,687	0
1936	1,246,617	65%	0	1,246,617	0
1937	1,745,399	91%	0	1,745,399	415,399
1938	1,911,500	100%	0	1,911,500	581,500
1939	1,459,921	76%	0	1,459,921	129,921
1940	1,286,216	67%	0	1,286,216	0
1941	1,819,105	95%	0	1,819,105	489,105
1942	1,675,071	88%	0	1,675,071	345,071
1943	1,599,339	84%	0	1,599,339	269,339
1944	1,180,721	62%	0	1,180,721	0
1945	1,534,032	80%	0	1,534,032	204,032
1946	1,579,753	83%	0	1,579,753	249,753
1947	841,873	44%	0	841,873	0
1948	1,340,674	70%	0	1,340,674	10,674
1949	507,322	27%	0	507,322	0
1950	1,031,888	54%	0	1,031,888	0
1951	1,911,500	100%	36,558	1,948,058	618,058
1952	1,911,500	100%	0	1,911,500	581,500
1953	1,461,303	76%	0	1,461,303	131,303
1954	1,402,934	73%	0	1,402,934	72,934

2008 SWP Reliability Delivery Report
High Fisheries Impact - No Climate Change Scenario

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1955	461,342	24%	0	461,342	0
1956	1,911,500	100%	79,287	1,990,787	660,787
1957	919,547	48%	0	919,547	0
1958	1,911,500	100%	0	1,911,500	581,500
1959	1,358,376	71%	0	1,358,376	28,376
1960	573,382	30%	0	573,382	0
1961	1,152,646	60%	0	1,152,646	0
1962	1,445,945	76%	0	1,445,945	115,945
1963	1,290,551	68%	0	1,290,551	0
1964	1,012,946	53%	0	1,012,946	0
1965	1,381,959	72%	0	1,381,959	51,959
1966	1,559,608	82%	0	1,559,608	229,608
1967	1,831,538	96%	0	1,831,538	501,538
1968	1,093,417	57%	0	1,093,417	0
1969	1,911,500	100%	61,695	1,973,195	643,195
1970	1,911,500	100%	137,670	2,049,170	719,170
1971	994,279	52%	0	994,279	0
1972	688,991	36%	0	688,991	0
1973	1,597,207	84%	0	1,597,207	267,207
1974	1,580,515	83%	0	1,580,515	250,515
1975	1,428,419	75%	0	1,428,419	98,419
1976	755,751	40%	0	755,751	0
1977	128,342	7%	0	128,342	0
1978	1,911,500	100%	0	1,911,500	581,500
1979	1,404,603	73%	0	1,404,603	74,603
1980	1,911,500	100%	62,733	1,974,233	644,233
1981	1,174,678	61%	0	1,174,678	0
1982	1,911,500	100%	0	1,911,500	581,500
1983	1,911,500	100%	241,105	2,152,605	822,605
1984	1,911,500	100%	185,216	2,096,716	766,716
1985	1,366,185	71%	0	1,366,185	36,185
1986	1,314,512	69%	0	1,314,512	0
1987	1,054,557	55%	0	1,054,557	0

**2008 SWP Reliability Delivery Report
High Fisheries Impact - No Climate Change Scenario**

	[1]	[2]	[3]	[4]	[5]
Year	Table A Delivery [acre-ft]	Percent of Maximum Table A	Article 21 Deliveries [acre-ft]	Total SWP Deliveries (Table A + Article 21) [acre-ft]	Available MWD Surplus [acre-ft]
1988	199,713	10%	0	199,713	0
1989	1,406,087	74%	0	1,406,087	76,087
1990	88,289	5%	0	88,289	0
1991	338,758	18%	0	338,758	0
1992	507,944	27%	0	507,944	0
1993	1,345,868	70%	0	1,345,868	15,868
1994	1,057,173	55%	0	1,057,173	0
1995	1,911,500	100%	0	1,911,500	581,500
1996	1,662,995	87%	0	1,662,995	332,995
1997	1,492,594	78%	0	1,492,594	162,594
1998	1,911,500	100%	0	1,911,500	581,500
1999	1,911,500	100%	38,850	1,950,350	620,350
2000	1,481,749	78%	0	1,481,749	151,749
2001	454,015	24%	0	454,015	0
2002	952,550	50%	0	952,550	0
2003	802,392	42%	0	802,392	0

Note:

[1] Table A water is water delivered according to the portion of available supply to be delivered to MWD

[2] Percent SWP delivered of MWD's contracted amount of 1.9 million acre-ft

[3] Article 21 of the contract permits delivery of water excess to delivery of Table A and some other water types

[4] = [1] + [3]

[5] Total SWP Deliveries [4] that exceeds 70% of 1.9 million acre-ft (1,330,000 acre-ft)

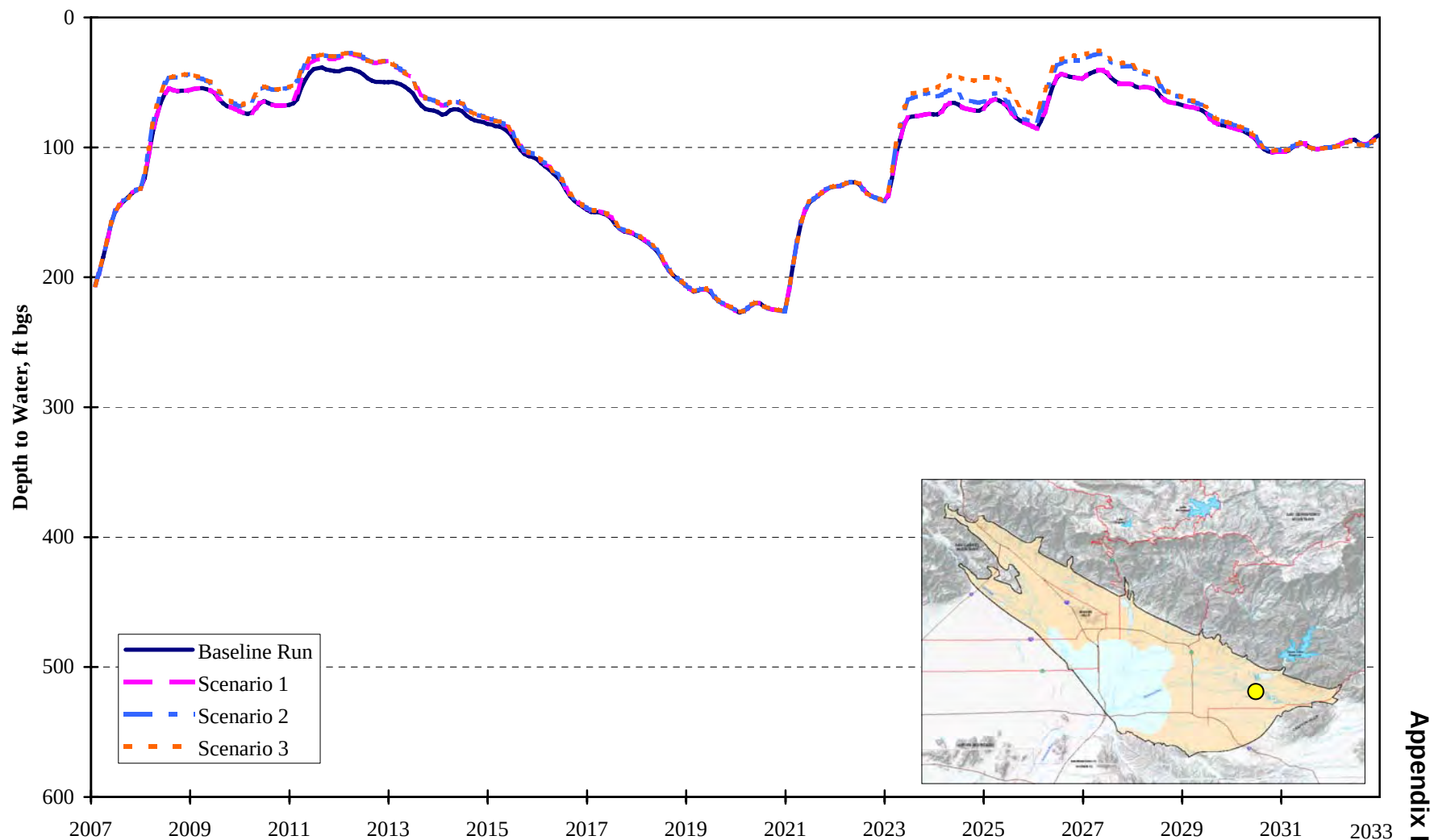
Data provided by MWD (2009)

APPENDIX B
Selected Hydrographs for Predictive Model Scenarios
2007 to 2032

GEOSCIENCE Support Services, Inc.

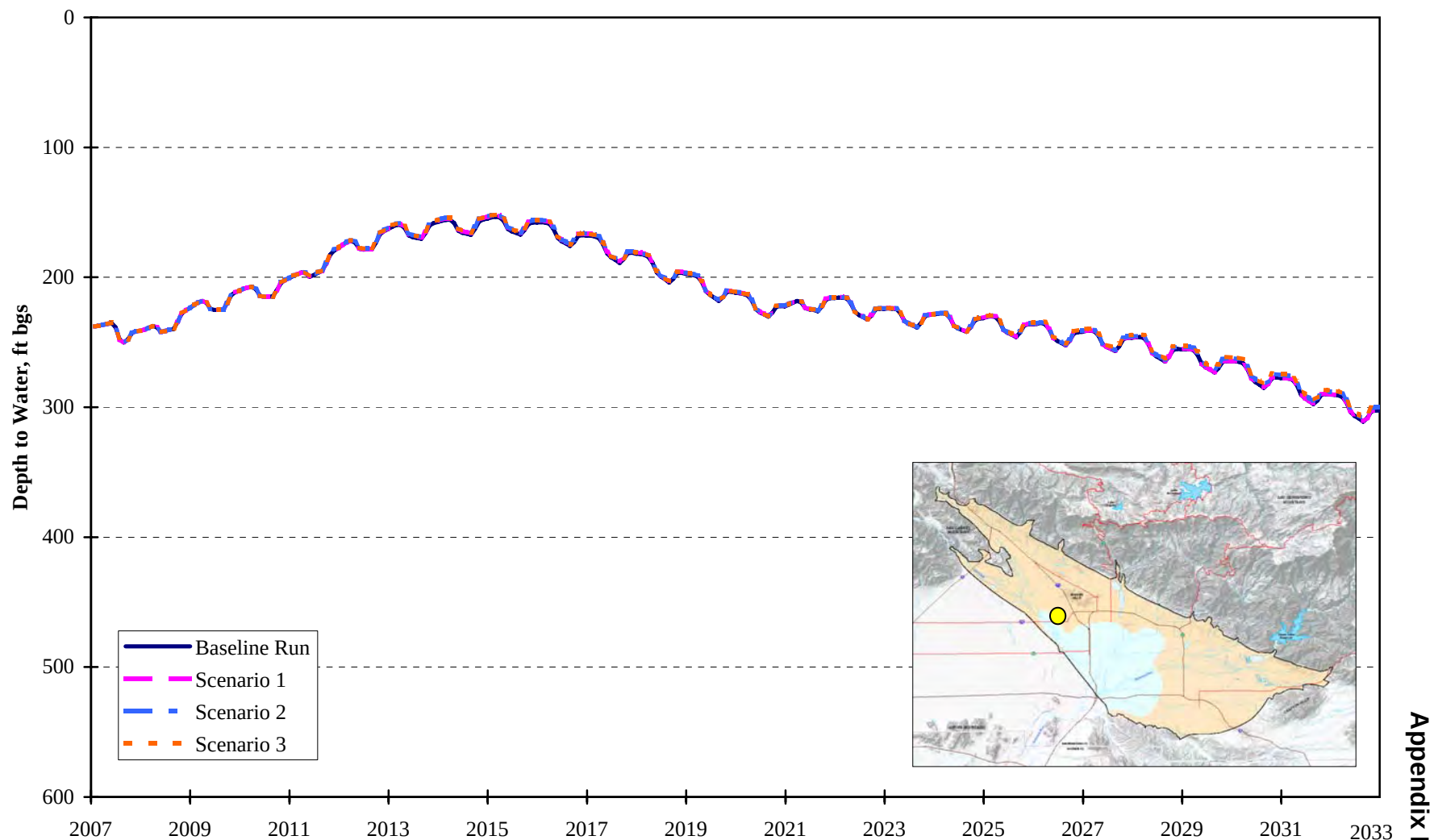


Depth to Water for SBVMWD San Bernardino Ave. Well Model Runs 2007-2032



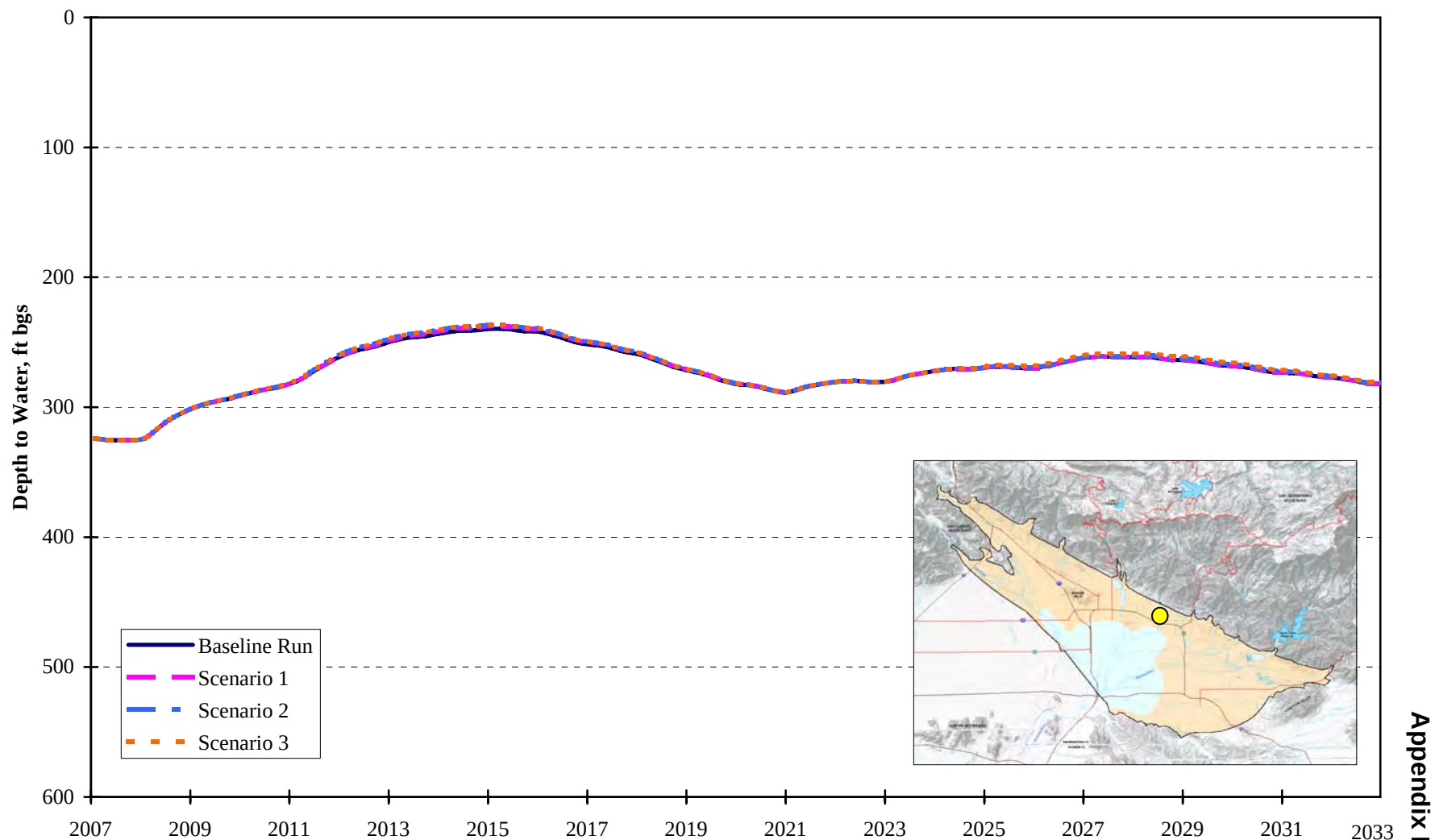
Appendix B

Depth to Water for City of San Bernardino Mt. Vernon Well Model Runs 2007-2032



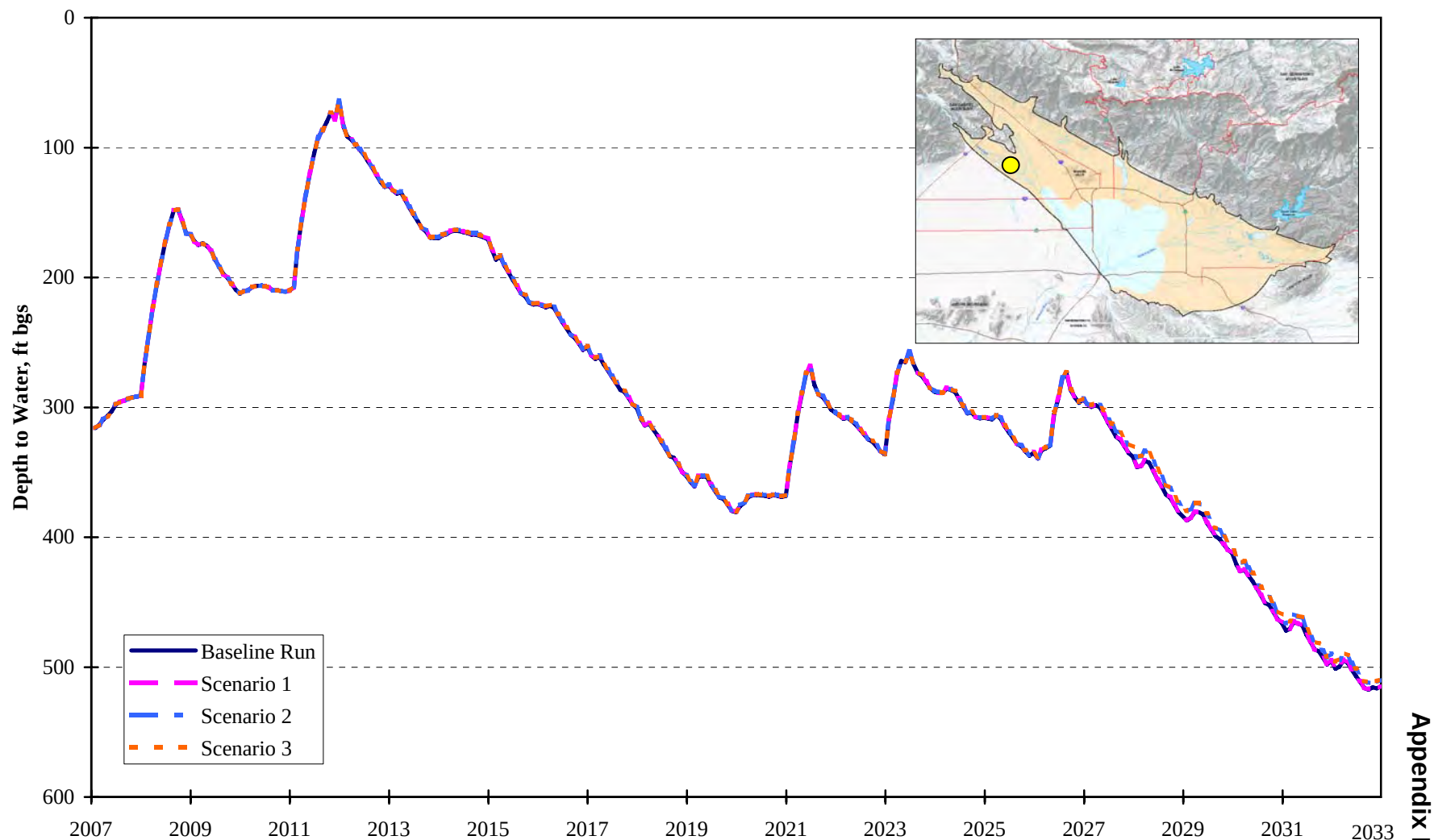
Appendix B

Depth to Water for East Valley Water District Well 62
Model Runs 2007-2032

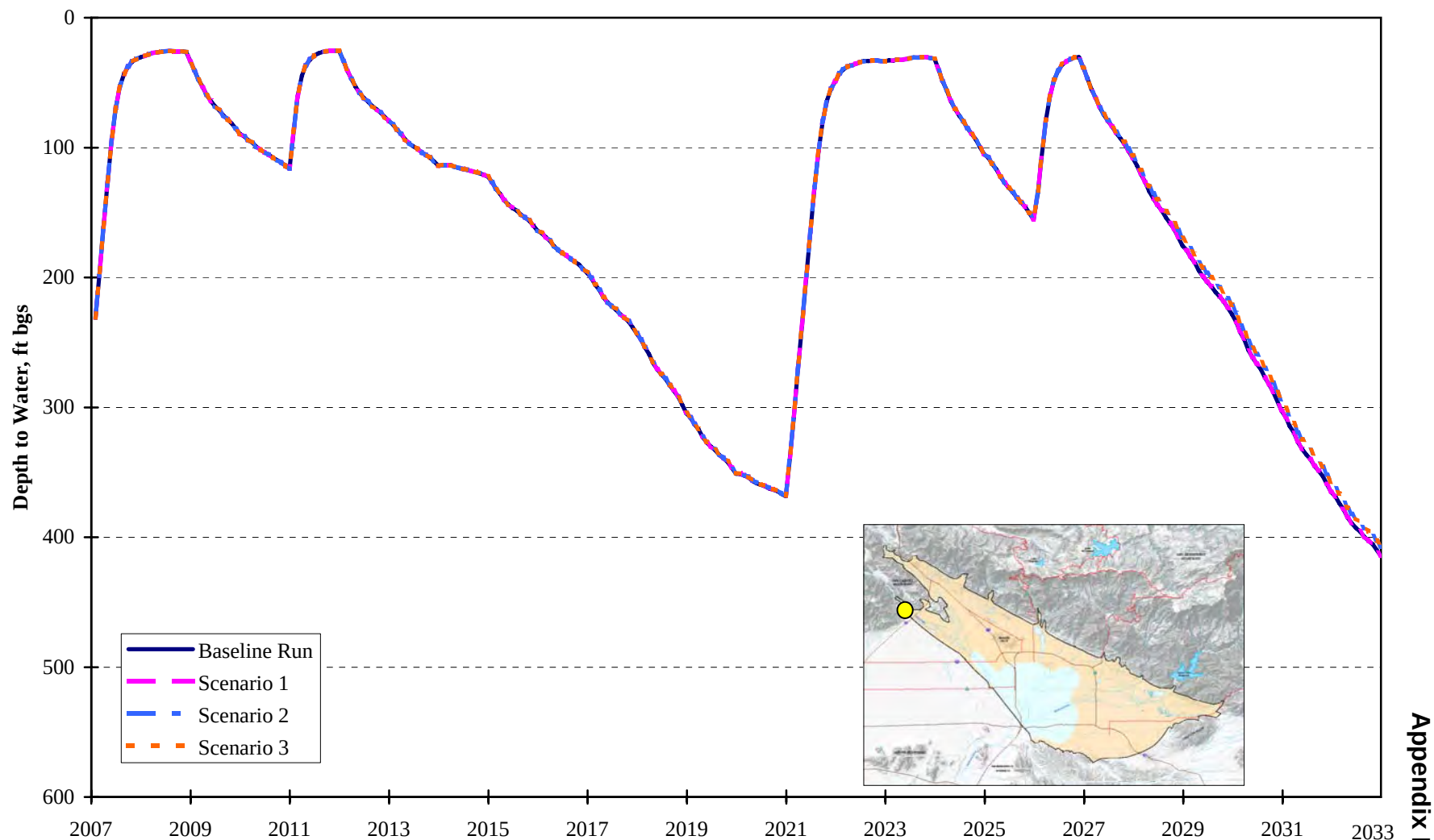


Appendix B

Depth to Water for Fontana Union Water Company Well 13 Model Runs 2007-2032



Depth to Water for Fontana Union Water Company Well 26 Model Runs 2007-2032



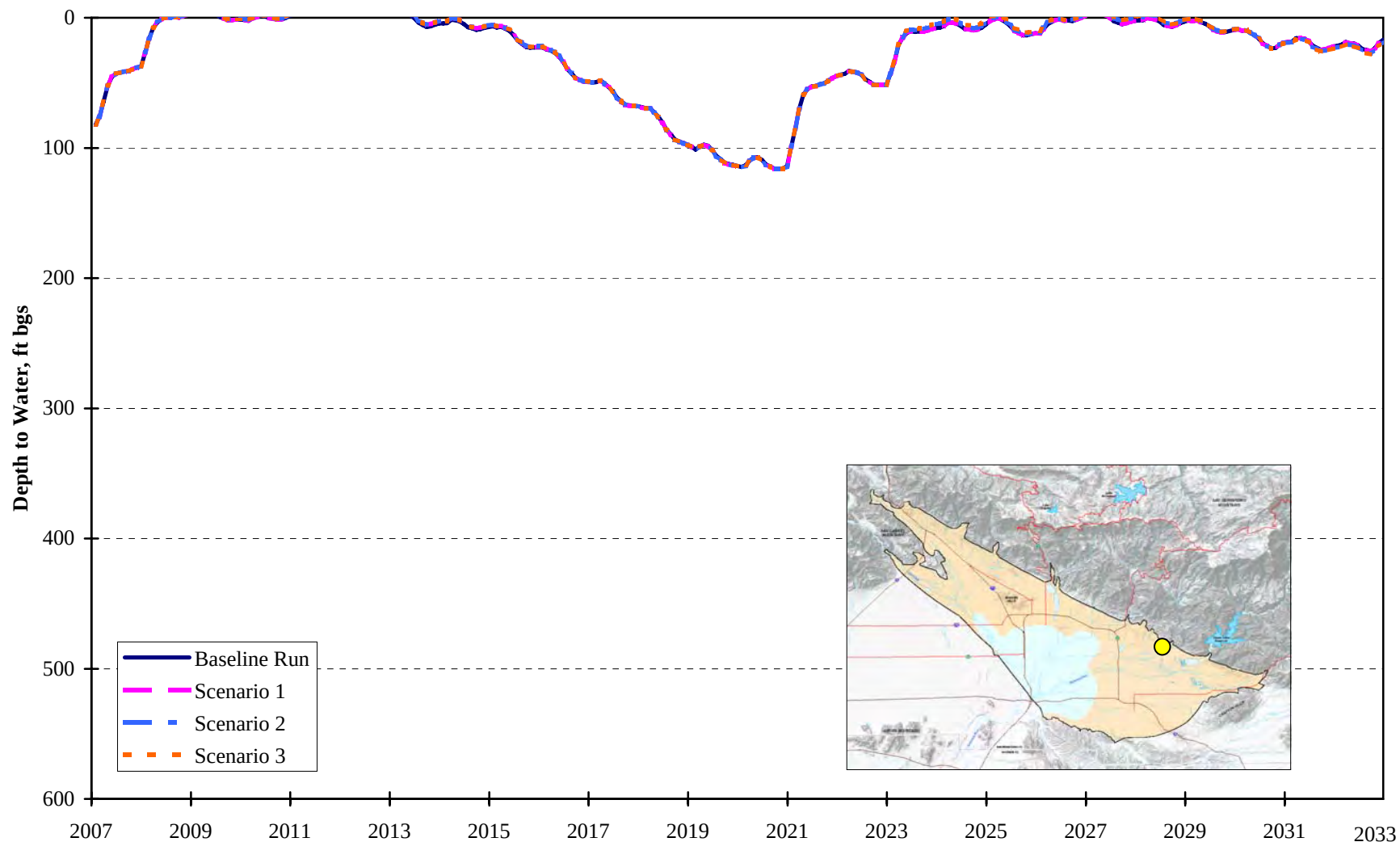
Appendix B

Depth to Water for Fontana Union Water Company Well 27 Model Runs 2007-2032



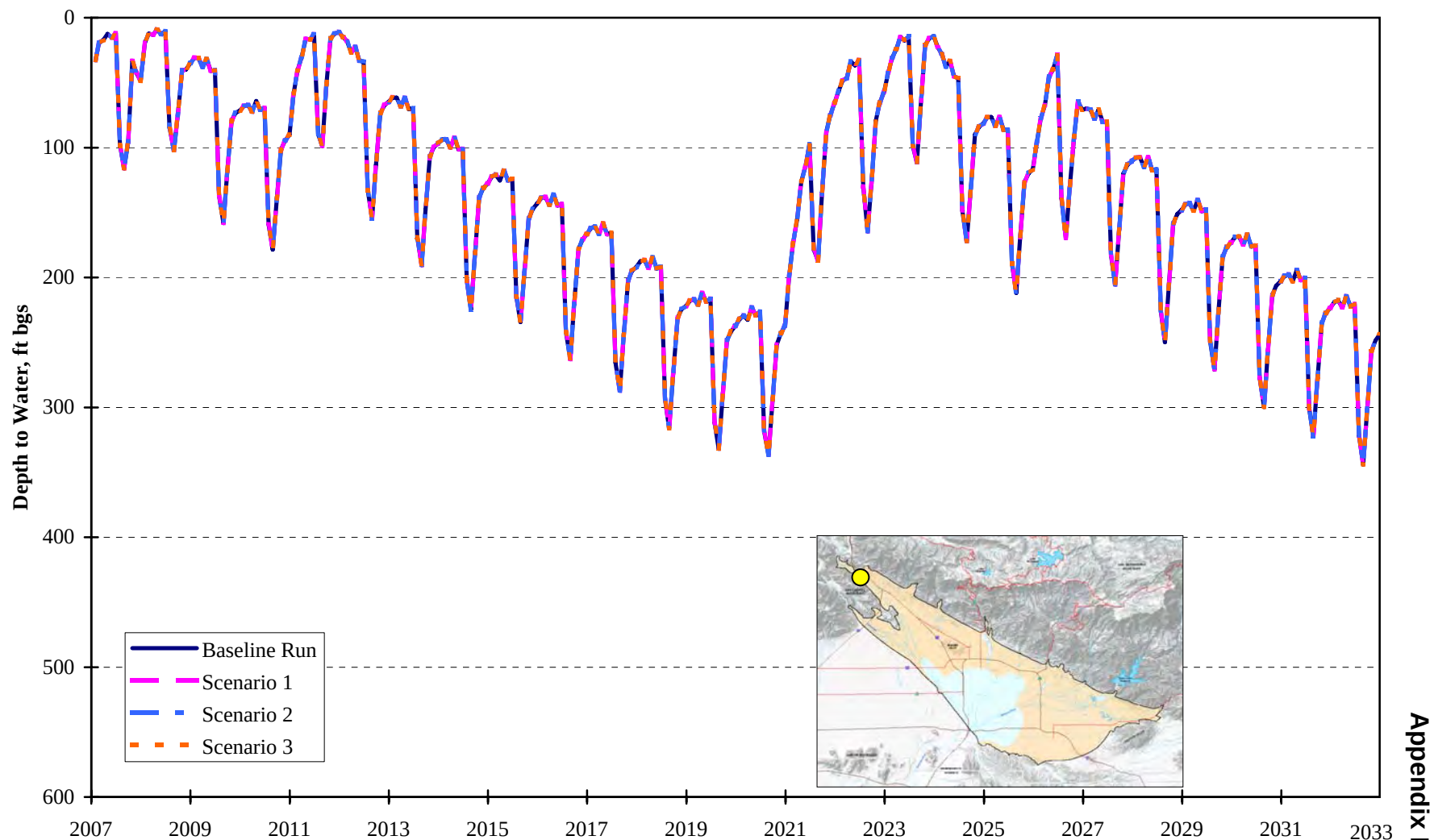
Appendix B

Depth to Water for East Valley Water District Well 120 Model Runs 2007-2032



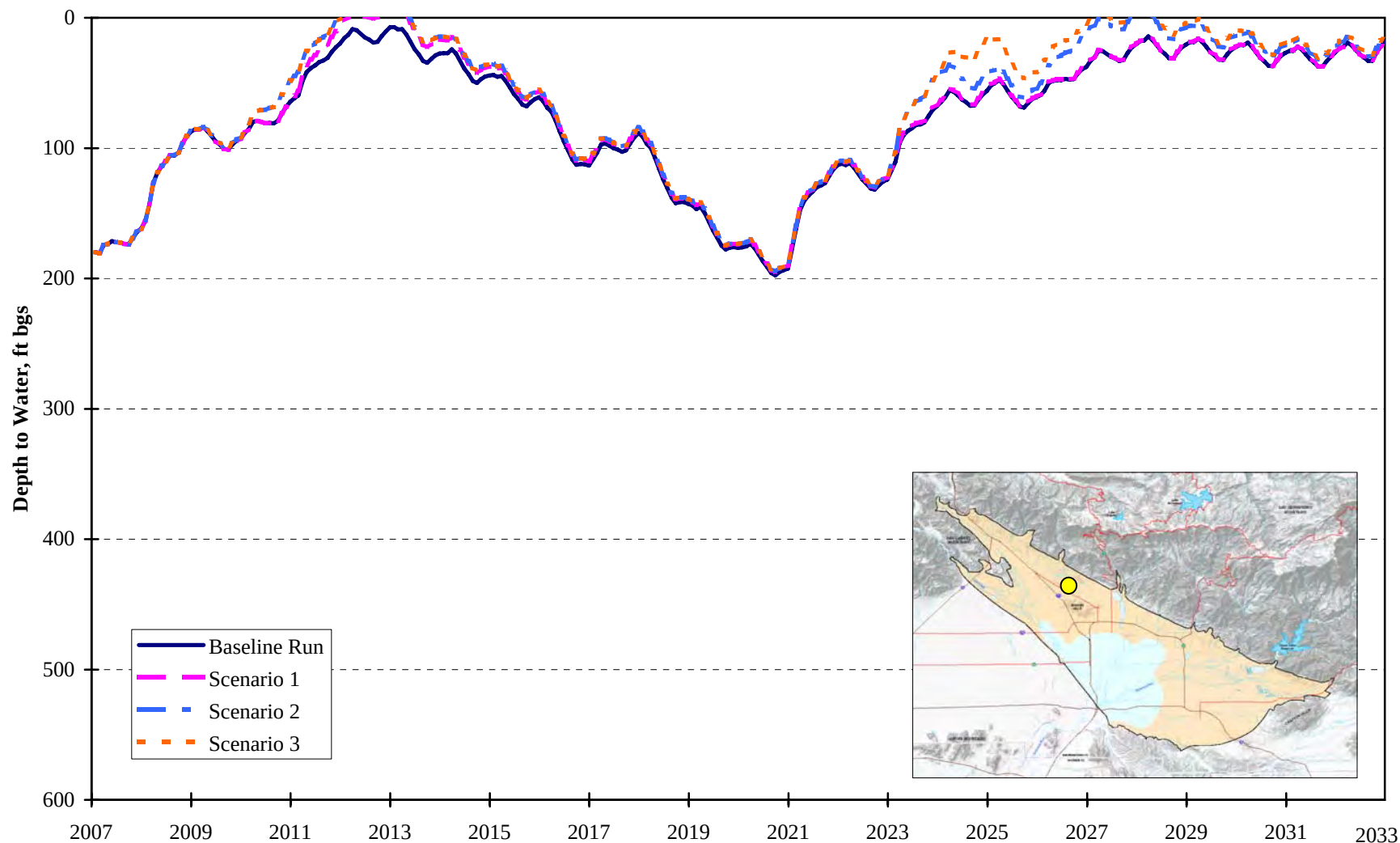
Appendix B

Depth to Water for City of San Bernardino Vincent Well Model Runs 2007-2032



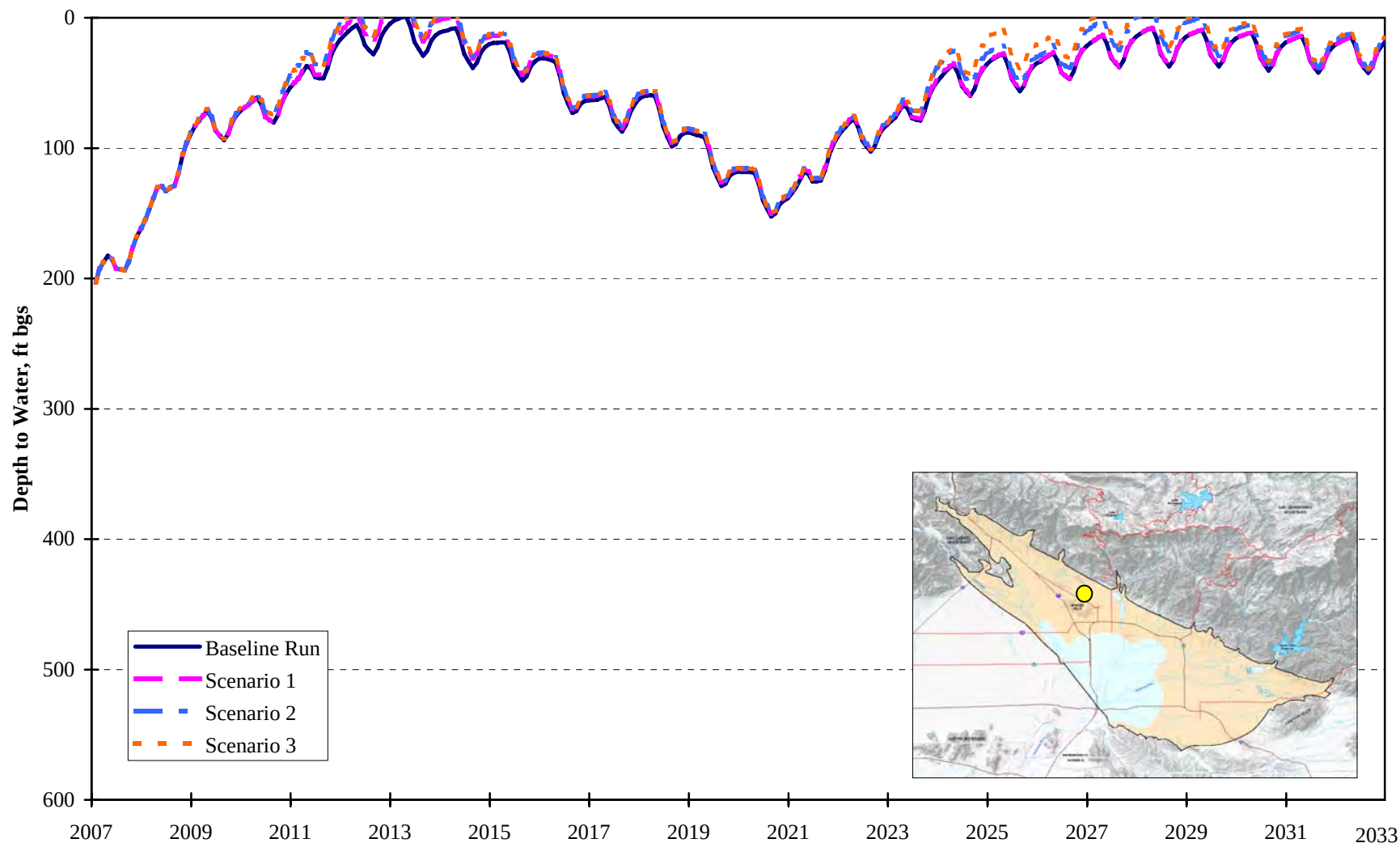
Appendix B

Depth to Water for City of San Bernardino Devil Canyon Well No. 1 Model Runs 2007-2032



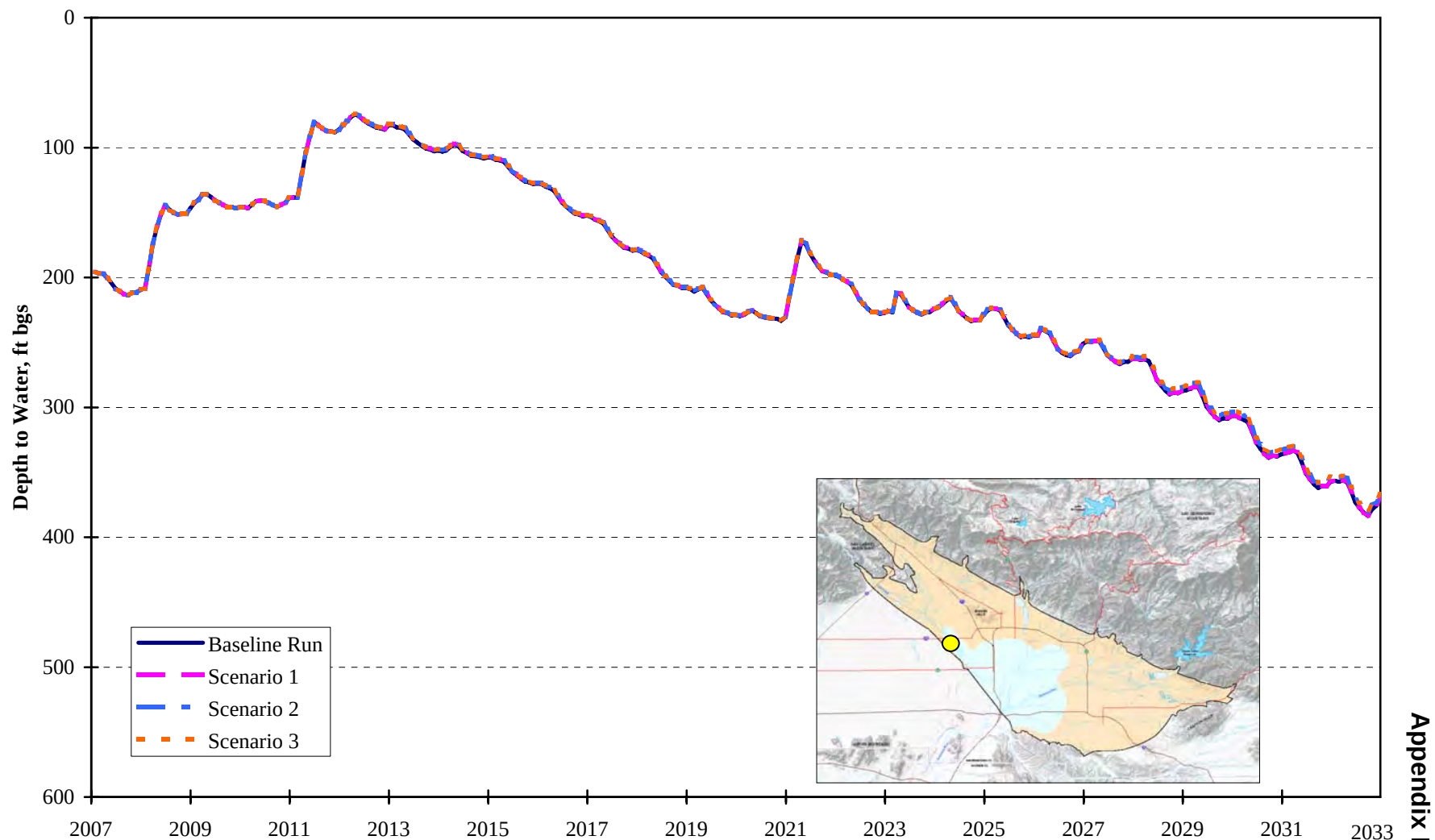
Appendix B

Depth to Water for City of San Bernardino Newmark 3 Well Model Runs 2007-2032



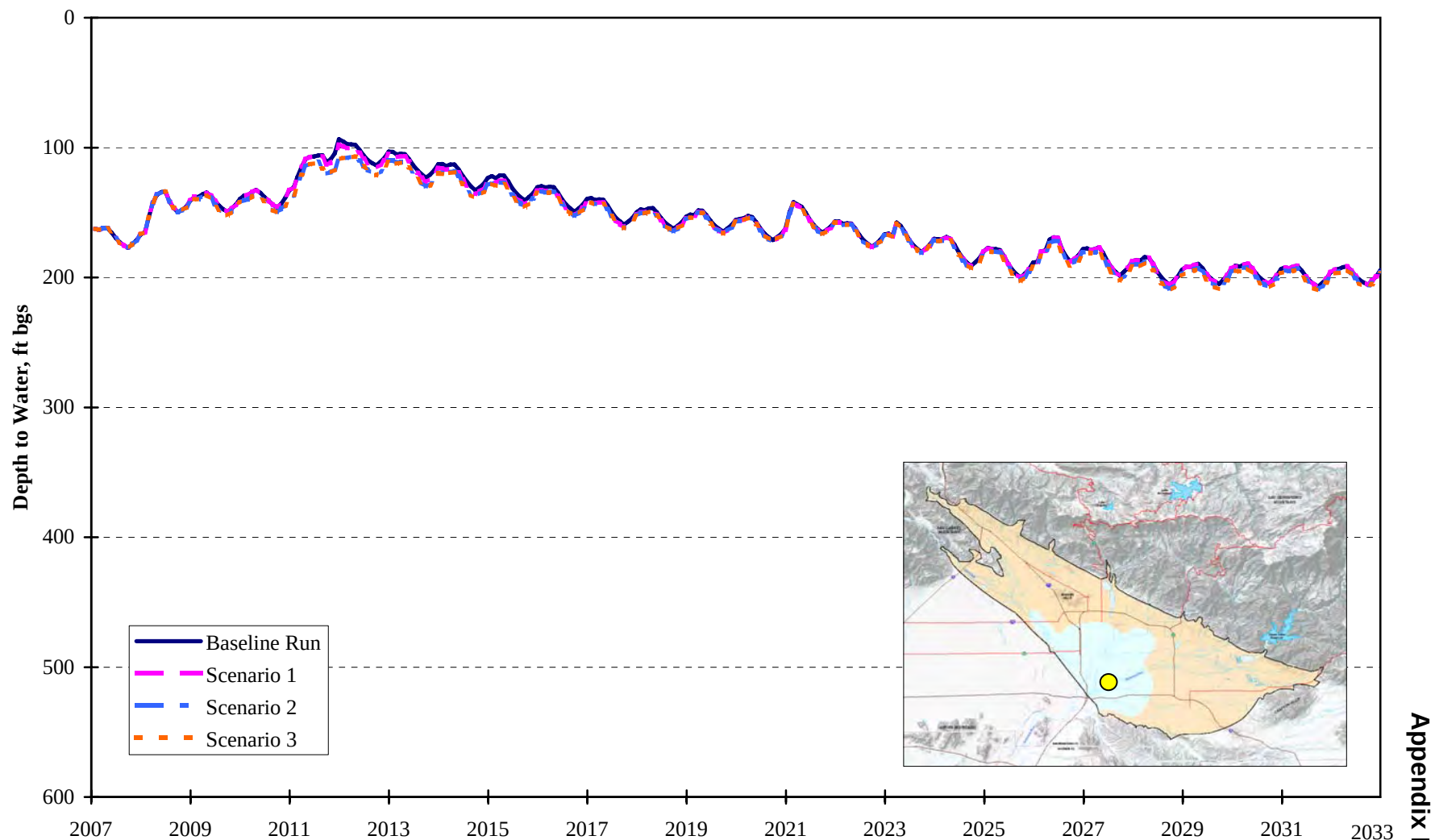
Appendix B

Depth to Water for West Valley Water District Lord 7 Well Model Runs 2007-2032



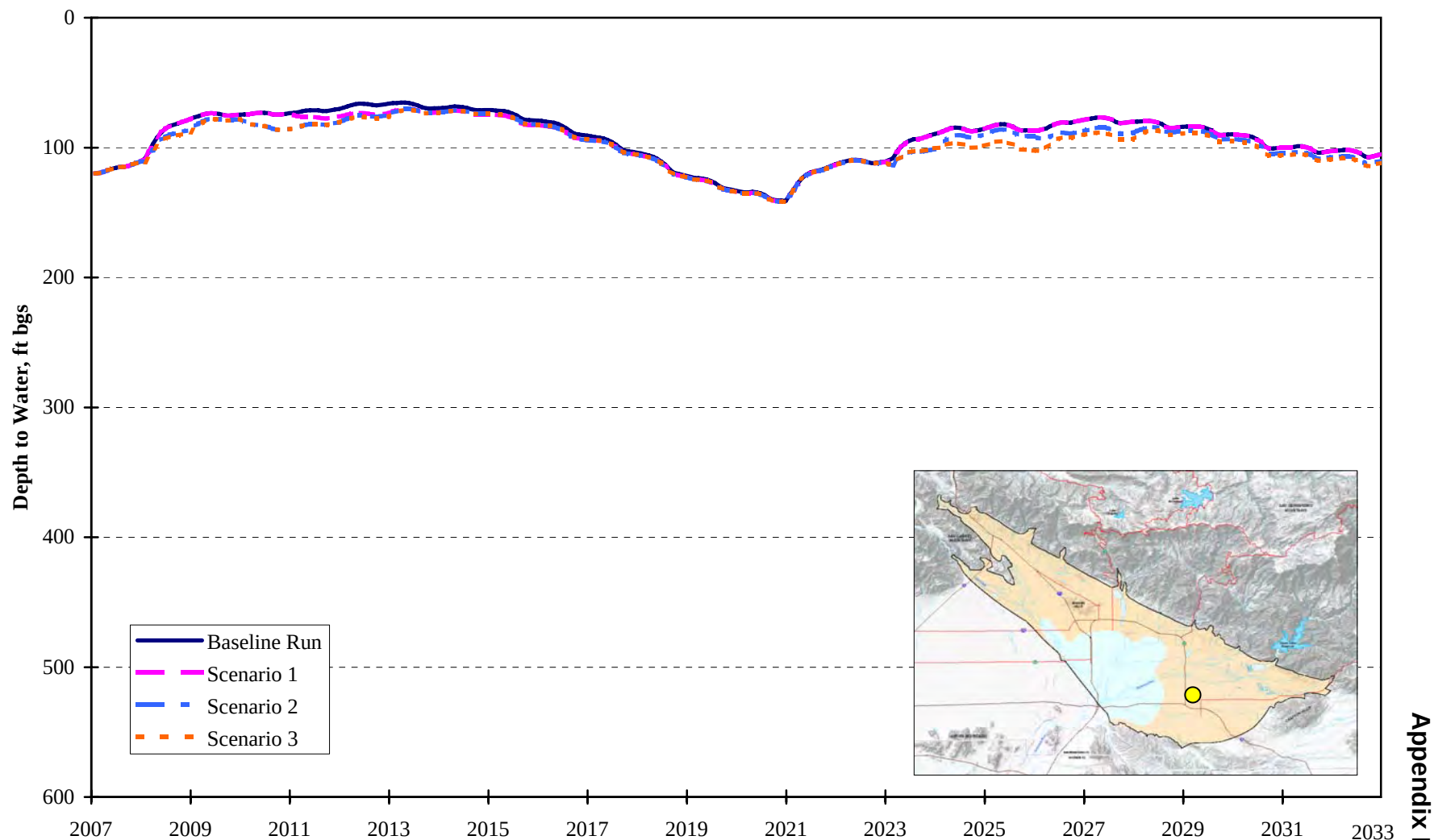
Appendix B

Depth to Water for City of Riverside Raub 1 Well Model Runs 2007-2032



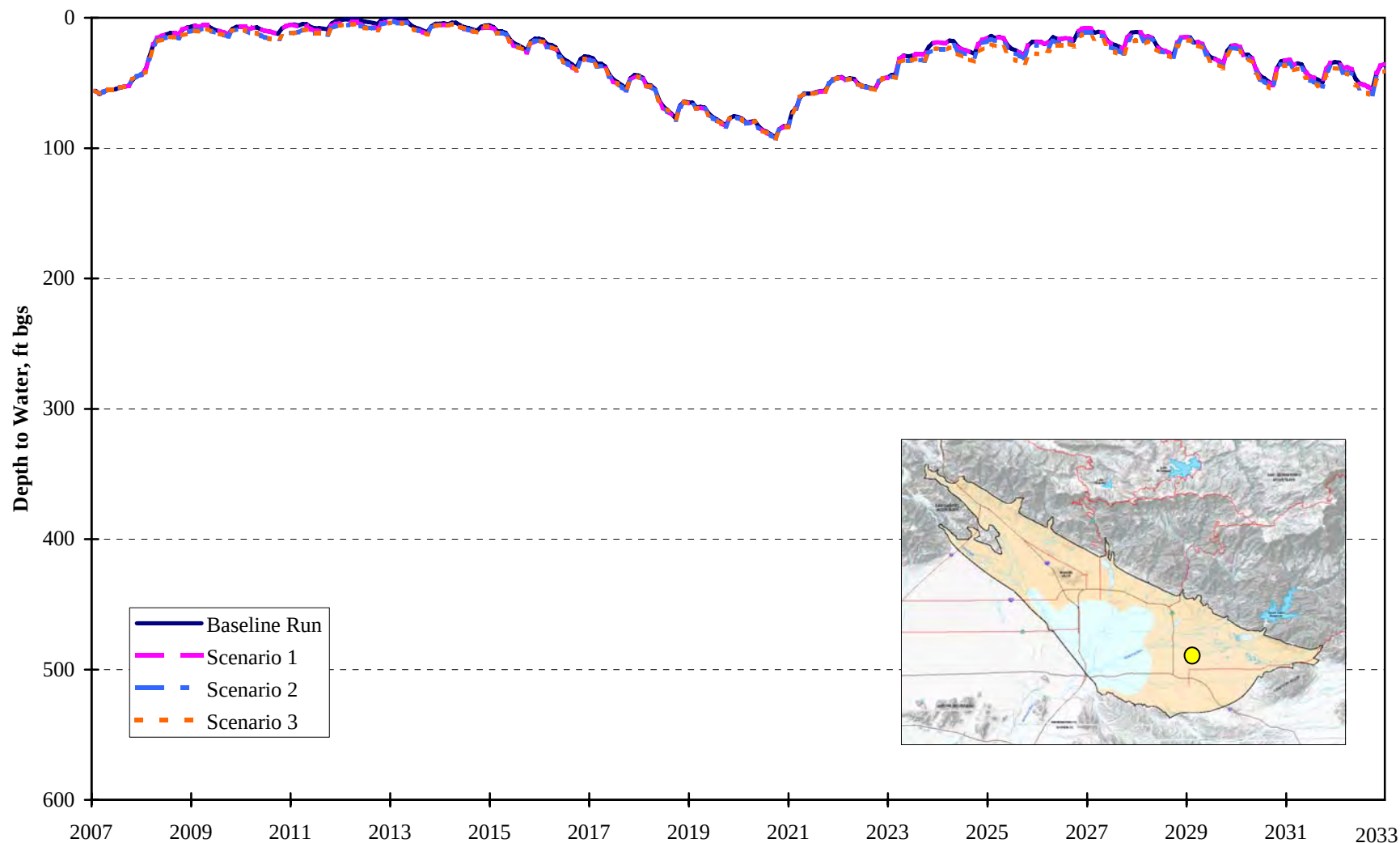
Appendix B

Depth to Water for City of Redlands Well 32 Model Runs 2007-2032



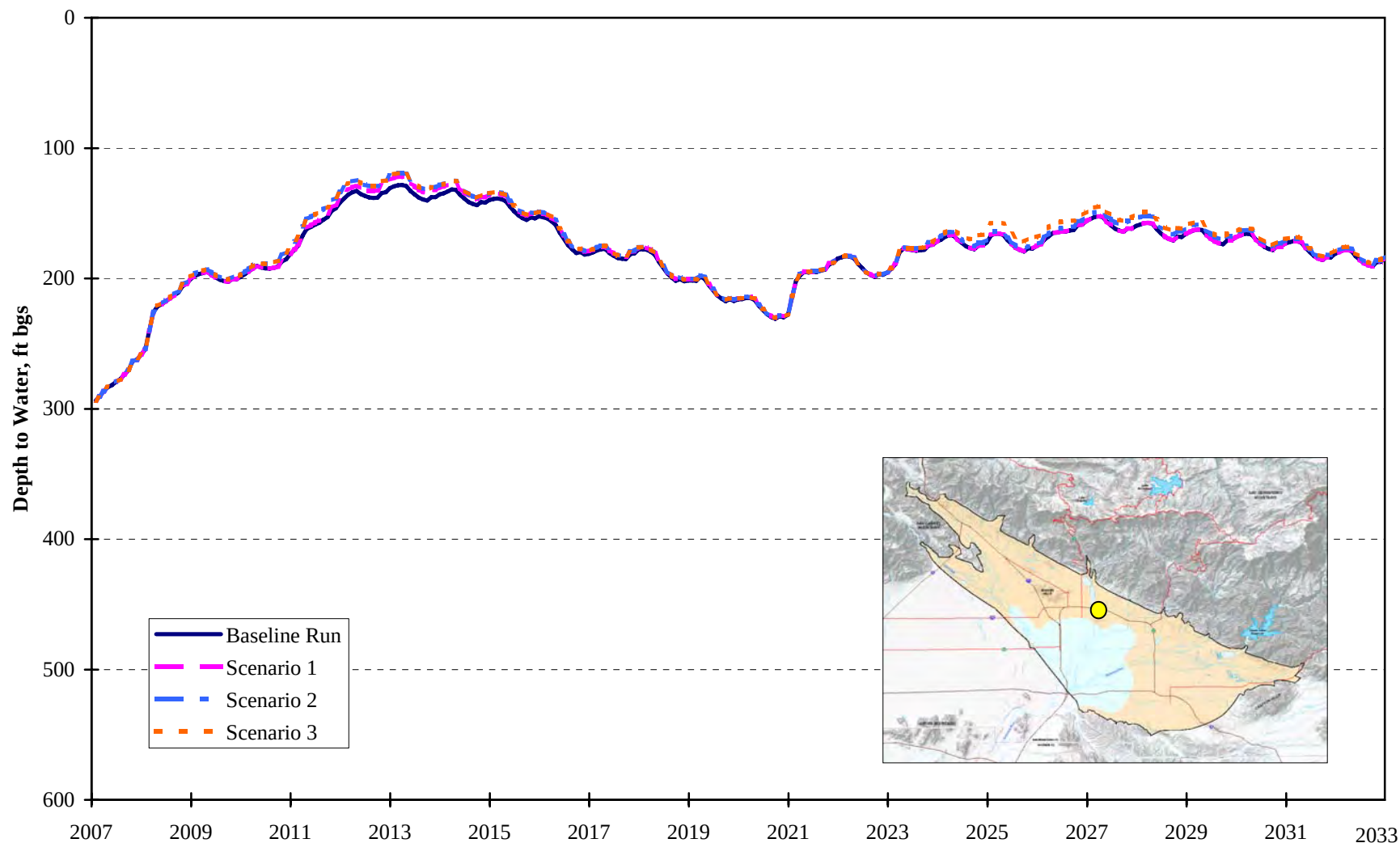
Appendix B

Depth to Water for City of Redlands Orange Street Well Model Runs 2007-2032



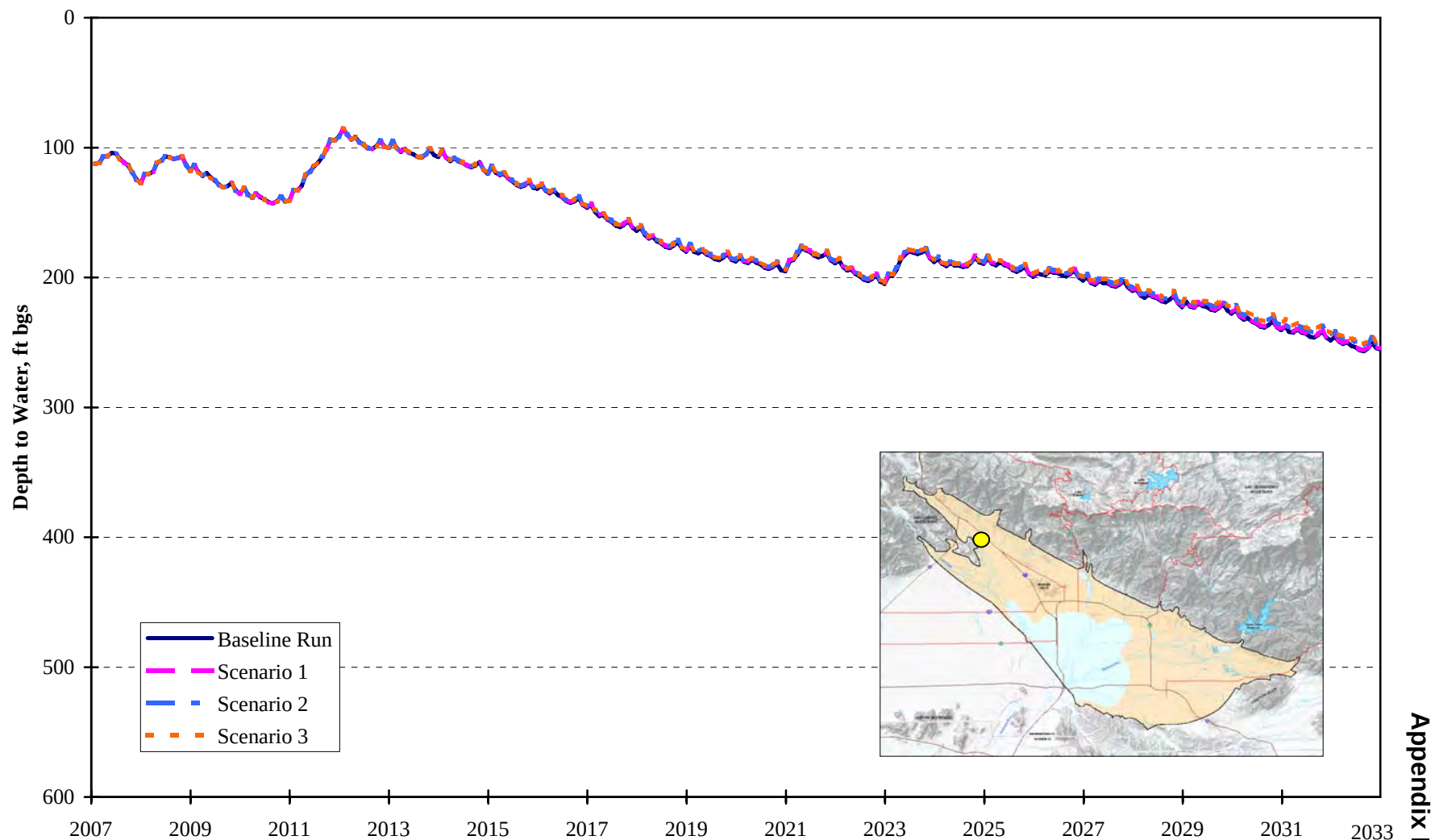
Appendix B

Depth to Water for East Valley Water District Well 24A Model Runs 2007-2032



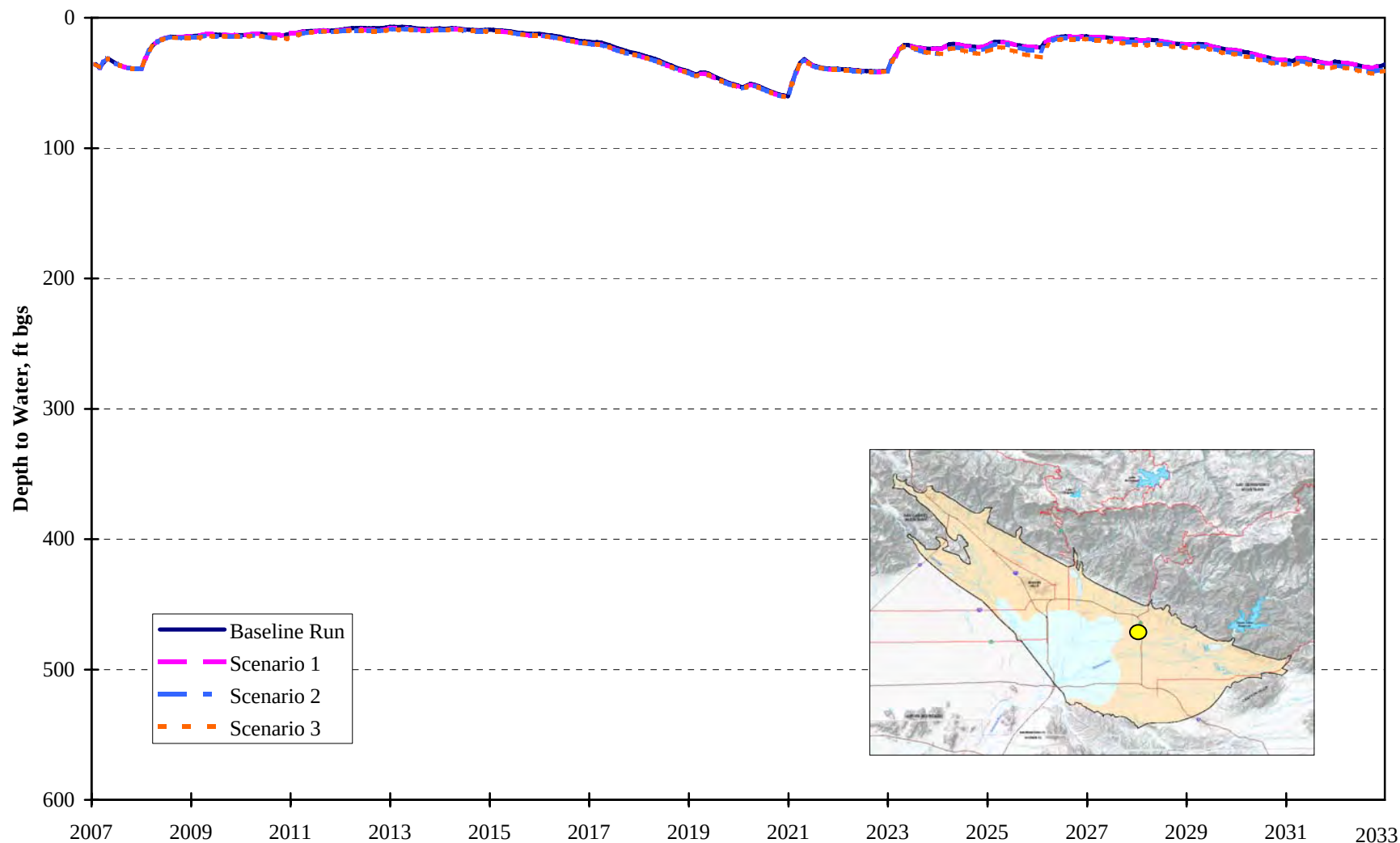
Appendix B

Depth to Water for City of San Bernardino Cajon Well No. 1 Model Runs 2007-2032



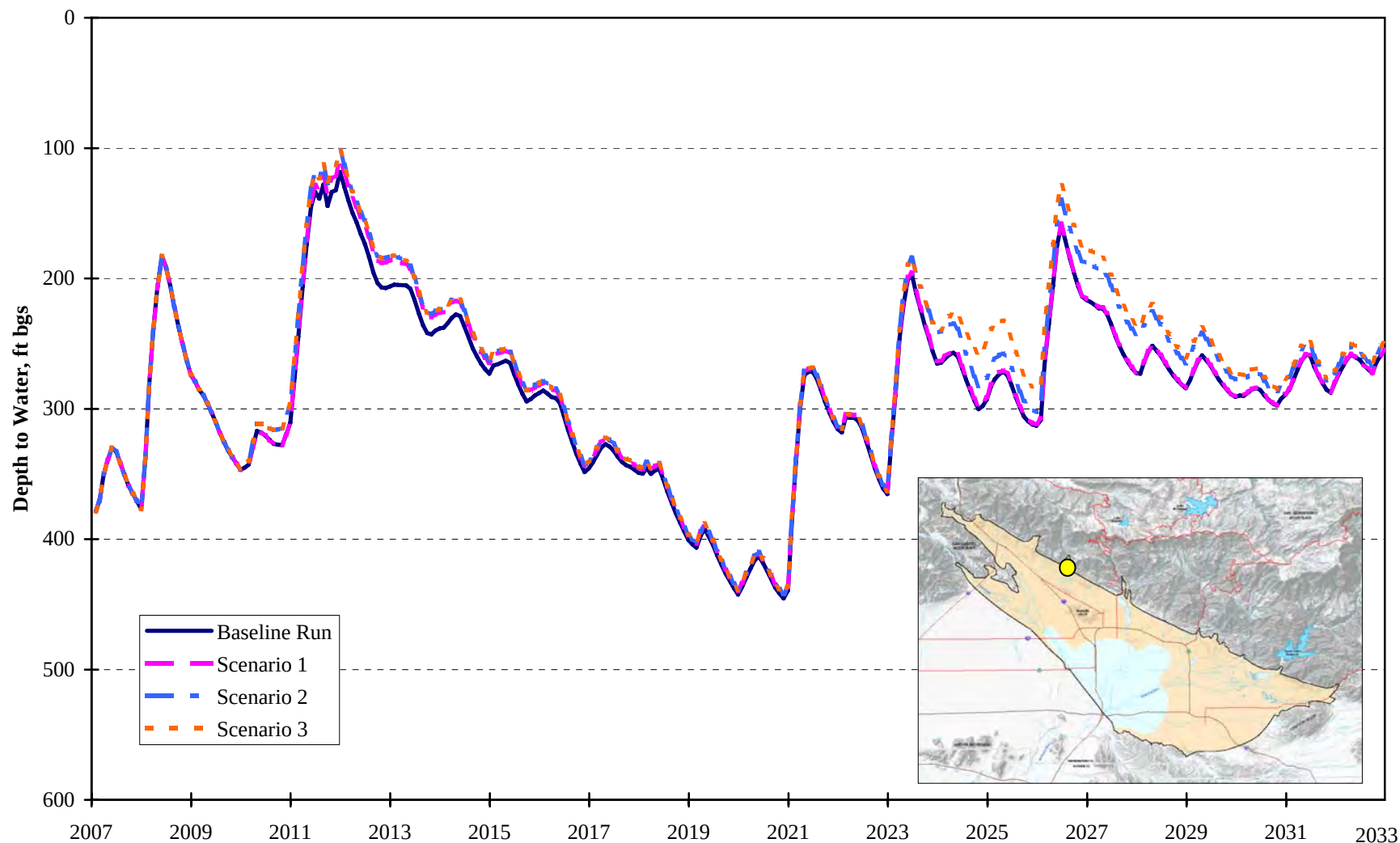
Appendix B

Depth to Water for East Valley Water District Well 40 Model Runs 2007-2032



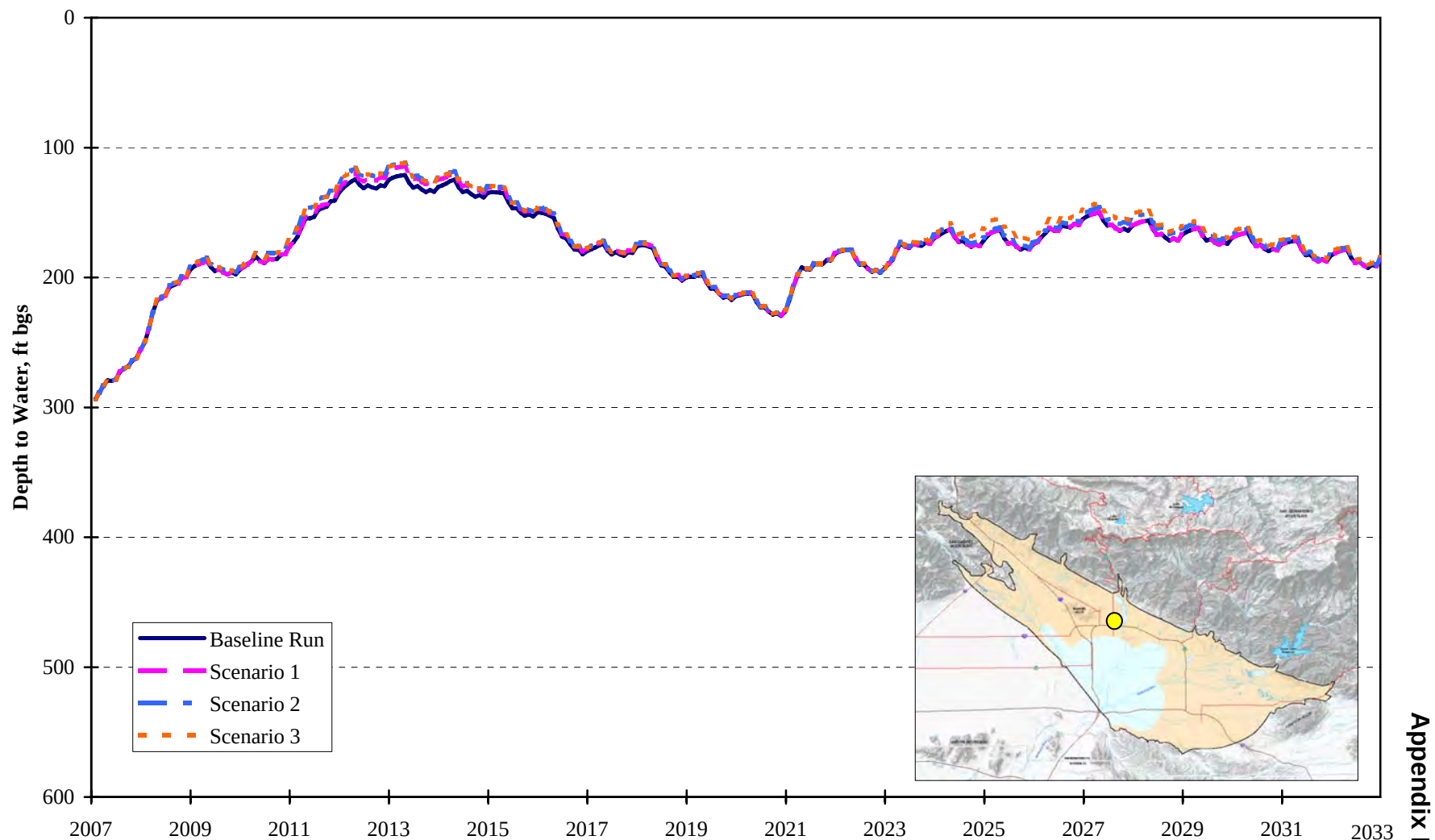
Appendix B

Depth to Water for City of San Bernardino Devil Canyon Well No. 3 Model Runs 2007-2032



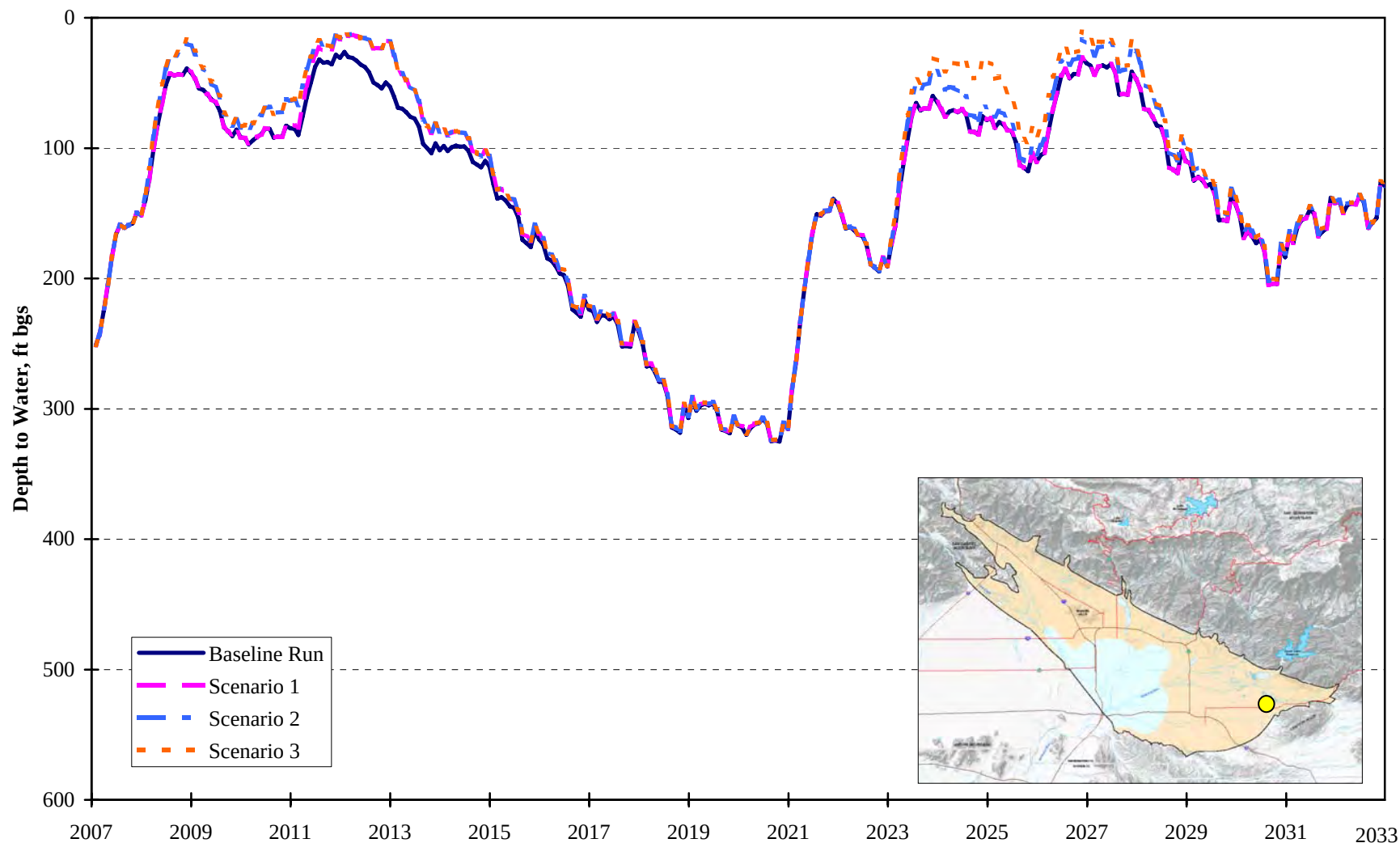
Appendix B

Depth to Water for City of San Bernardino Leroy Street Well Model Runs 2007-2032



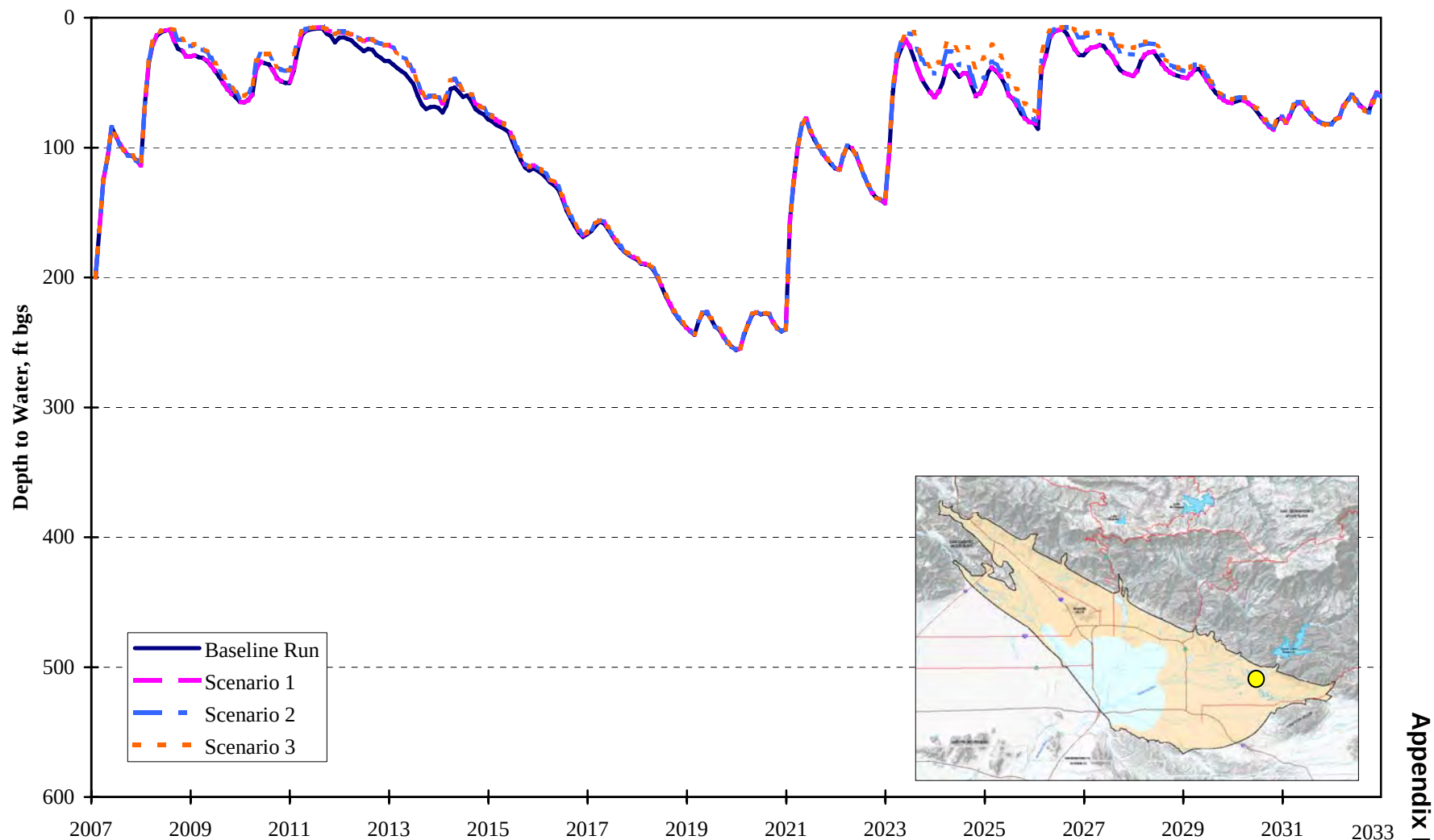
Appendix B

Depth to Water for City of Redlands Agate 2 Well Model Runs 2007-2032



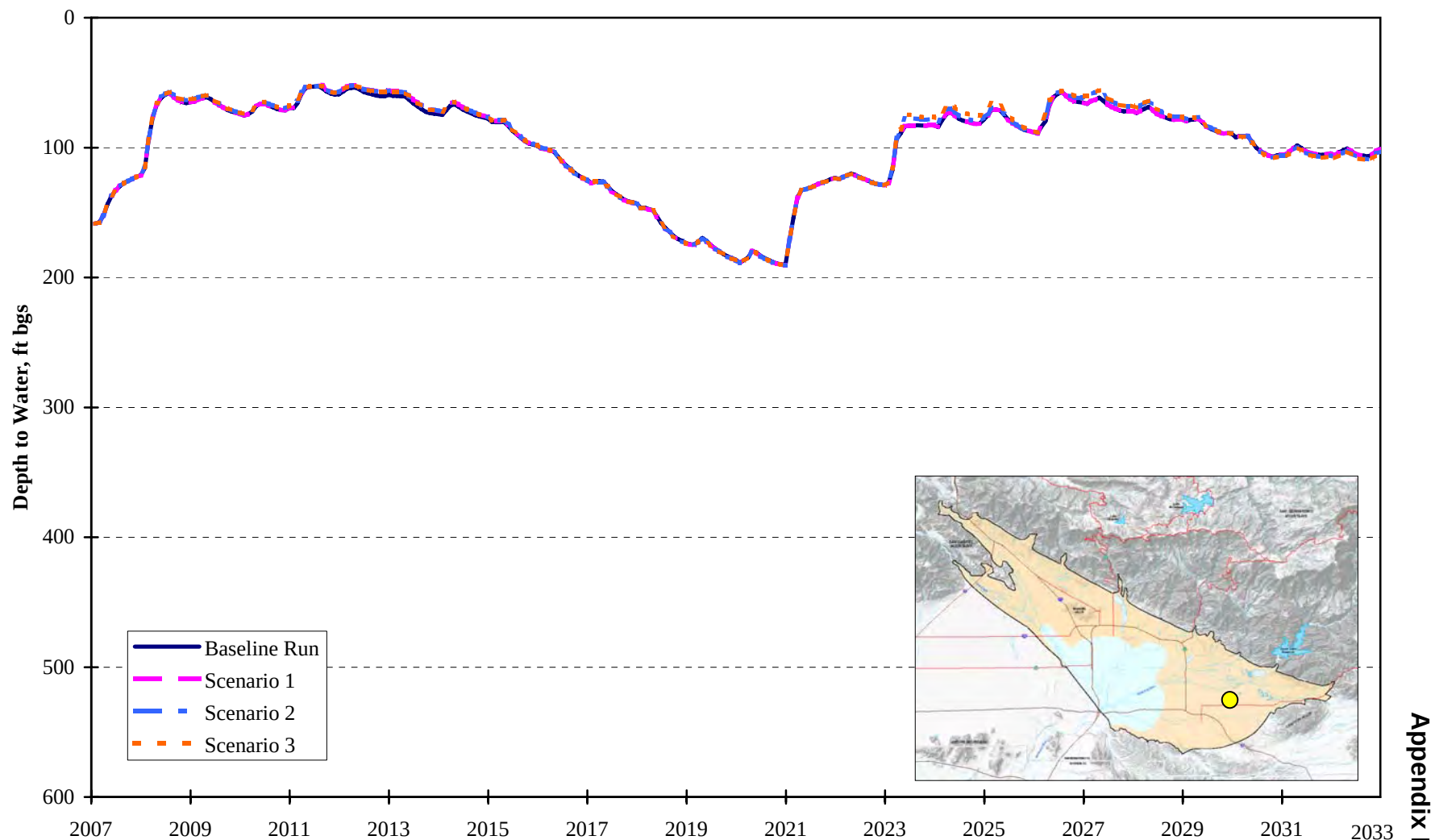
Appendix B

Depth to Water for East Valley Water District Cone Camp Well Model Runs 2007-2032



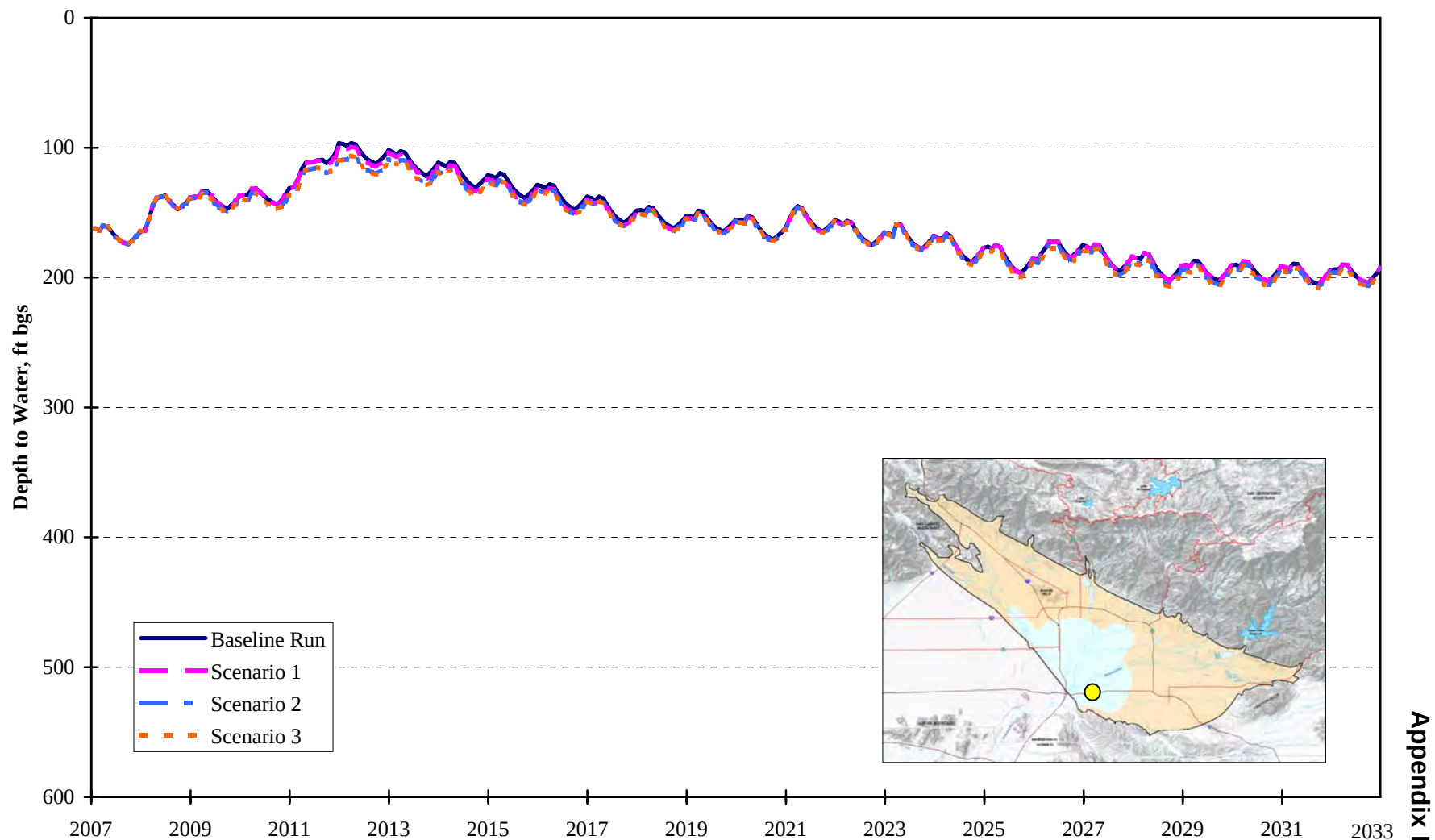
Appendix B

Depth to Water for Bear Valley Mutual Water Company Nelson Street Well Model Runs 2007-2032



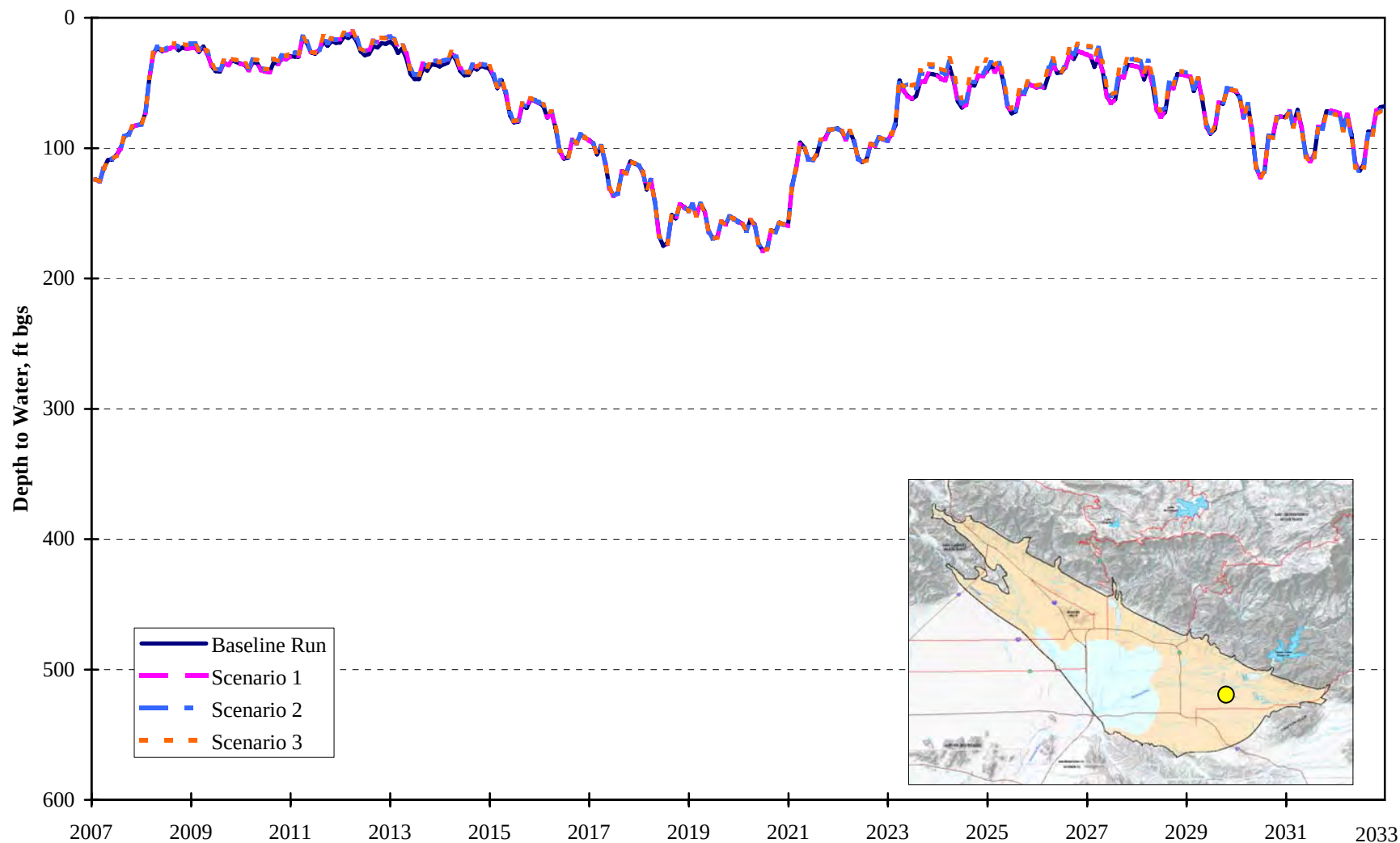
Appendix B

Depth to Water for Gage Canal Company Lower Kelly Well Model Runs 2007-2032



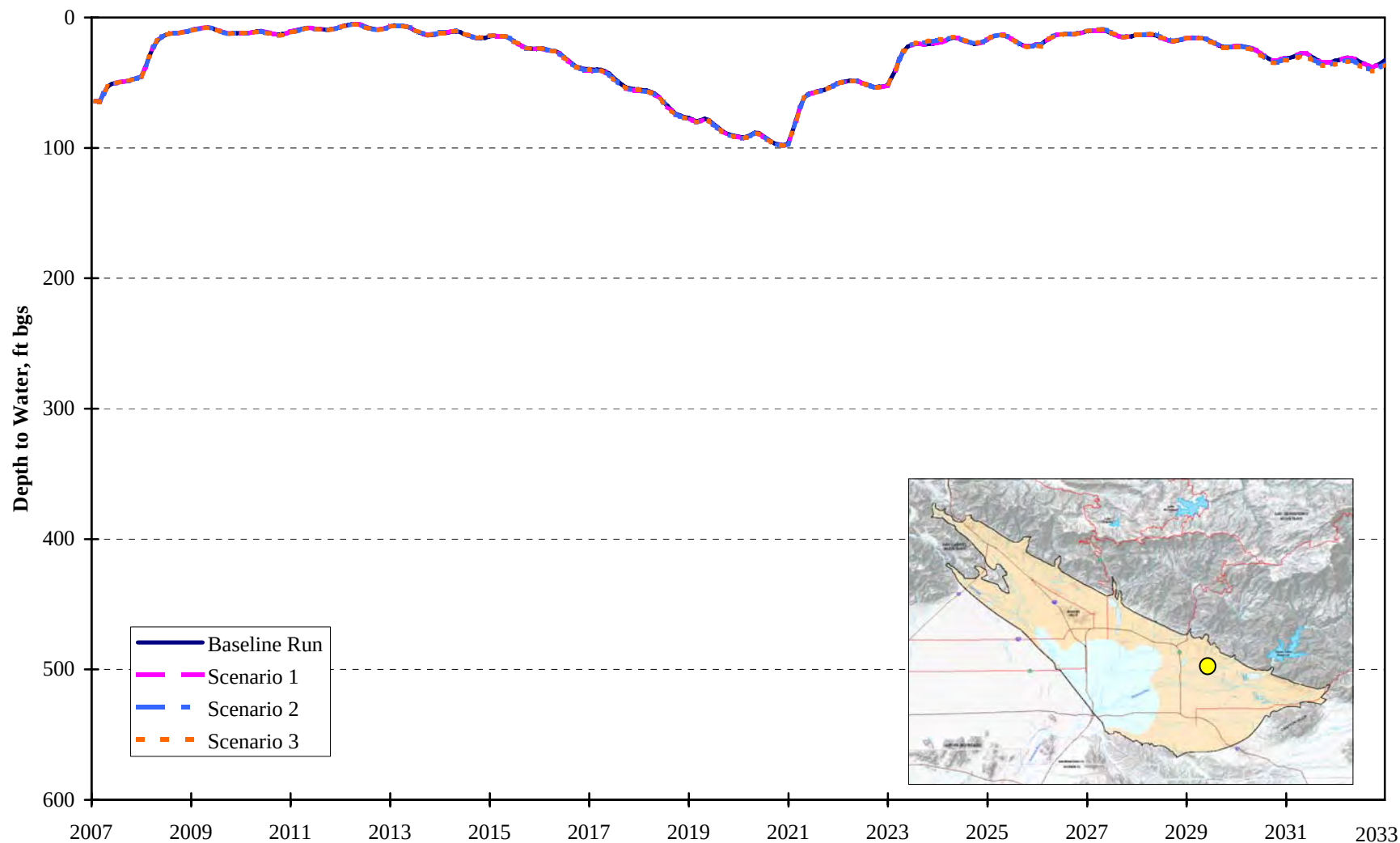
Appendix B

Depth to Water for City of Redlands Airport Well No. 2 Model Runs 2007-2032



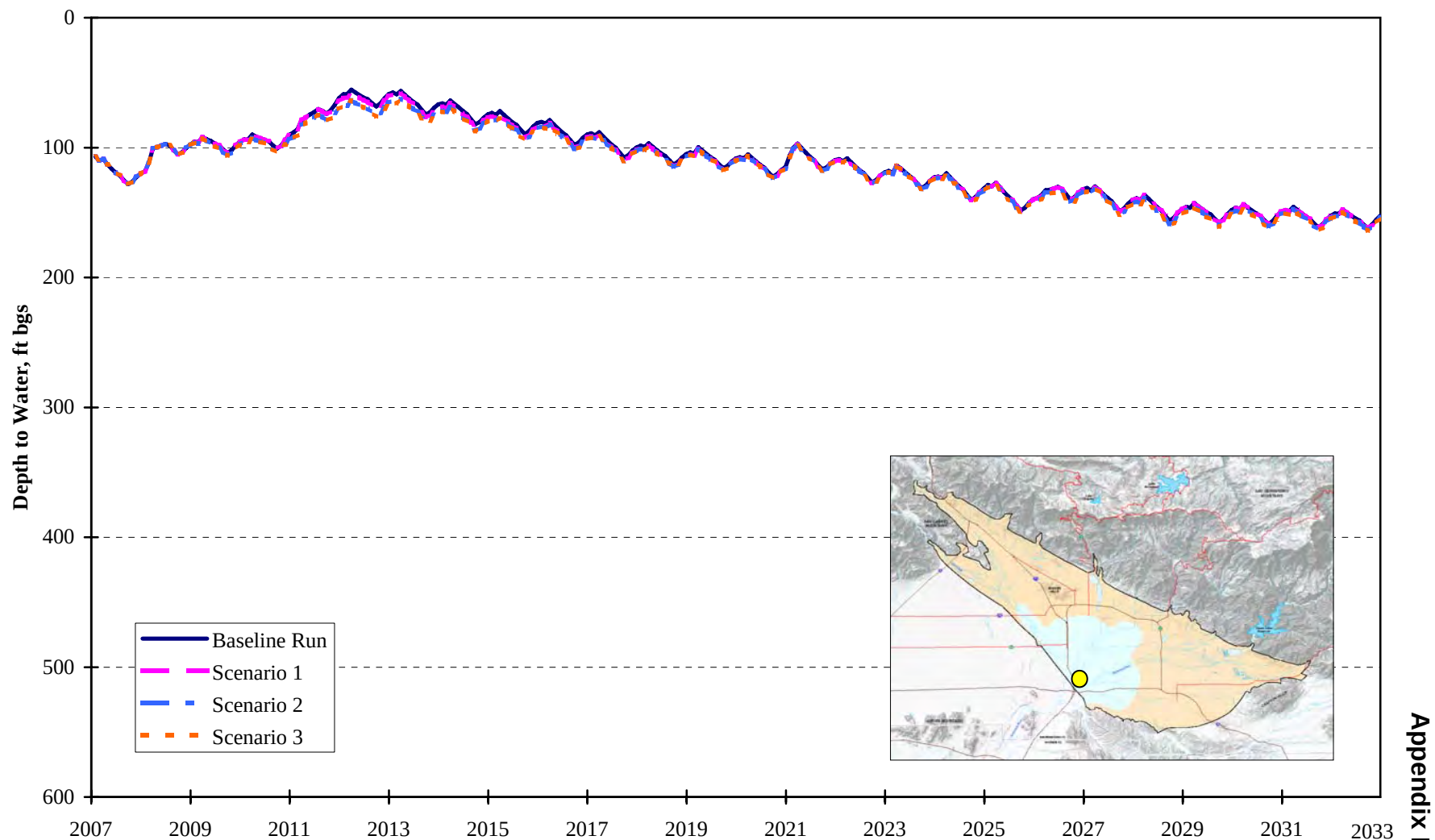
Appendix B

Depth to Water for East Valley Water District Well 146A Model Runs 2007-2032



Appendix B

Depth to Water for SBVMWD Backyard Well Model Runs 2007-2032



Appendix B

Technical Memorandum



GEOSCIENCE Support Services, Inc.
P.O. Box 220, Claremont, CA 91711
Tel: (909) 451-6650 Fax: (909) 451-6638
www.gssiwater.com

To:	Mr. Fakhri Mangi, P.E. Western Municipal Water District Water Resources Department 14205 Meridan Parkway Riverside, California 92518
From:	Dennis E. Williams, Ph.D. President GEOSCIENCE Support Services, Inc.
Date:	August 15, 2011
Subject:	Response to Selected Comments on Draft Supplemental Environmental Impact Report and Environmental Impact Statement for the Riverside-Corona Feeder Project

1.0 PURPOSE AND SCOPE OF WORK

As per your request, GEOSCIENCE Support Services, Inc. (GEOSCIENCE) has prepared this Technical Memorandum to provide responses to selected comments by a review panel¹ on the Draft Supplemental Environmental Impact Report/Environmental Impact Statement (SEIR/EIS) for the Riverside-Corona Feeder (RCF) Project. Comments that were provided by the review panel to the Western Municipal Water District (WMWD) were subsequently provided to GEOSCIENCE in early April 2011.

The following tasks were performed:

¹ Review panel consists of the City of San Bernardino Municipal Water Department (SBMWD), City of Redlands, City of Riverside - Community Development Department, and the U.S. EPA, Region IX.

- 1.1 Collected and compiled water quality data from GeoTracker database and evaluated potential impacts to water resources in the Redlands area due to operation of the RCF Project.
- 2.1 Compared existing TDS concentrations in the eastern portion of the San Bernardino Basin to average concentrations in SWP water to evaluate potential impacts to sewage treatment plant effluent due to operation of the RCF Project.
- 2.2 Described horizontal and vertical locations of contaminate plumes and their relative relationship to the proposed RCF Project well field.
- 2.3 Described past and present effects of recharge and extraction of SWP water in the San Bernardino Basin.
- 2.4 Described the hydrologic parameters used for the current San Bernardino Basin Area (SBBA) model to forecast specific geohydrologic conditions within the SBBA.

Each of these tasks is described in detail in the following sections.

2.0 EVALUATE POTENTIAL IMPACT ON WATER RESOURCES IN THE REDLANDS AREA DUE TO THE RCF PROJECT

In their comments on the Draft SEIR/EIS, the City of Redlands expressed concern that operation of the RCF Project would cause existing groundwater contaminants such as 1,2-dibromo-3-chloropropane (DBCP) and 1,2,3-Trichloropropane (TCP) to migrate downgradient and eventually be captured by City-owned Wells 38 and 39.

In order to evaluate this concern, GEOSCIENCE downloaded and compiled historic water quality data collected from water supply wells in the Redlands area. Source of data included the State Water Resources Control Board's GeoTracker web-based database² and the California Department of Public Health Drinking Water Program database³. The data was then compiled and analyzed for reported detectable concentrations of DBCP and TCP, which included wells owned by the City of Redlands. Time history concentration plots were generated for all wells with detectable concentration(s) of either contaminant.

² GeoTracker (<http://geotracker.swrcb.ca.gov/>)

³ EDT Library and Water Quality Analyses Data and Download Page
(<http://www.cdph.ca.gov/certlic/drinkingwater/Pages/EDTlibrary.aspx>)

Based on our evaluation of the available water quality data, it was determined that DBCP has been detected above the maximum contaminant level (MCL) of 0.2 micrograms per liter ($\mu\text{g/L}$) in City-owned wells since at least 2000, and has continued through 2010. Figure 1 shows the location of the wells with detected DBCP relative to the Crafton-Redlands perchlorate ($6 \mu\text{g/L}$)⁴ plume footprint reported by Tetra Tech (2009) and the five proposed RCF Project extraction wells. As shown, the highest reported DBCP concentrations occur in Agate 1 and Well 41. Additionally, TCP has been reportedly detected (since 2009) in Well 10 ($0.010 \mu\text{g/L}$) and Well 13 ($0.008 \mu\text{g/L}$). At this time, there is not an MCL for TCP; however, the California Department of Health Services (CDPH) has established a notification level (NL) of $0.005 \mu\text{g/L}$ for TCP. Plots showing historic TCP concentration in Wells 10, 13 and 38 are provided on Figure 1.

Both DBCP and TCP are associated with former agricultural activities that occurred in the basin and are not associated with the Crafton-Redlands Plume. However, it is reasonable to assume that both DBCP and TCP will dissipate in a similar manner as the primary compounds (i.e., Trichloroethene [TCE] and Perchlorate) associated with the Crafton-Redlands Plume. Therefore, results from the groundwater modeling performed for the Draft SEIR/EIS were used to determine if the RCF Project would impact Well 38 and/or Well 39 with DBCP and/or TCP.

Modeling results (see Appendix F of the Draft SEIR/EIS or GEOSCIENCE, 2009a) indicated that the Crafton-Redlands Plume footprint would dissipate slightly faster under the RCF Project as compared to the Baseline Run⁵ (i.e., No Project). This slight decrease in plume footprint is a result of RCF Project-related groundwater recharge and extraction that would slightly increase the rate of groundwater movement from the recharge areas (i.e., forebay) towards the Redlands area. The recharge of high quality SWP water will essentially dilute the existing (i.e., ambient) groundwater, improving the water quality in the SBBA over time. Therefore, based on current reported concentrations in the eastern and central areas of Redlands, movement of either DBCP or TCP westward towards Redlands Well 38 and/or Well 39 is not considered to be a significant impact.

⁴ Current MCL for Perchlorate.

⁵ Previously referred to as the "Updated Baseline Run," this was proposed by the Basin Technical Advisory Committee (BTAC) in 2009. The model assumptions used to update the Baseline Run are provided in the report for the Refined Basin Flow and Solute Transport Model (GEOSCIENCE, 2009b).

3.0 EVALUATE POTENTIAL IMPACT ON TDS CONCENTRATION OF TREATED WASTEWATER EFFLUENT DUE TO THE RCF PROJECT

Comments on the Draft SEIR/EIS from the cities of Redlands and Riverside included concerns that RCF Project recharge of SWP water would eventually increase the total dissolved solids (TDS) concentration of SBBA ambient groundwater, possibly leading to either city exceeding its Regional Board TDS discharge limit for treated wastewater effluent.

The potential impact from the RCF Project on TDS concentrations in the SBBA was evaluated using the Refined Basin Solute Transport Model (RBSTM) and results were reported under Appendix F of the Draft SEIR/EIS. The evaluation included four predicative model runs to evaluate water quality changes for a Baseline Run (No Project) and three RCF Project conjunctive use scenarios (Scenarios 1 through 3). The sources for TDS concentrations that were input into the model included:

- Direct infiltration from precipitation,
- Recharge from local runoff generated by precipitation,
- Artificial recharge,
- Return flow from groundwater pumping,
- Recharge from mountain front runoff,
- Underflow recharge, and
- Streamflow.

Description of the assumptions used are provided in Section 3.2 of the “Draft Groundwater Modeling of TDS and Nitrate-Nitrogen Concentrations – Riverside-Corona Feeder Project Conjunctive Use Scenarios” of Appendix F for the Draft SEIR/EIS. State Water Project water is one of three components (Santa Ana River water and recycled water being the other two) used to artificially recharge the SBBA. The TDS concentration for SWP water was assumed to be equal to or exceed 255 milligrams per liter (mg/L) 50 percent of the time during the simulation period (see Figure 4 in the referenced report). Initial concentrations for TDS in the SBBA were based on the 1987–2006 ambient concentrations calculated by Wildermuth Environmental, Inc. (2008). Artificial recharge of SWP water was predicted to range from 42,000 acre-ft to 198,000 acre-ft over a period of 26 years.

As shown on Figures 11 through 14 from the Draft Groundwater Modeling of TDS and Nitrate-Nitrogen Concentrations – Riverside-Corona Feeder Project Conjunctive Use Scenarios report,



model predicted TDS concentrations within the SBBA for Scenarios 1 through 3 would be similar to those for the Baseline Run (No Project).

In order to evaluate impacts on TDS concentrations from the RCF Project in the Redlands area, model-generated TDS concentration over time was plotted for City of Redlands Well 32, Orange Street Well, Agate 2 Well and Airport Well 2 (see Figure 2 of this technical memorandum). These concentration plots show the temporal variations in TDS concentrations due to hydrologic conditions, artificial recharge and groundwater pumping assumed under No Project and RCF Scenarios 1 through 3. More importantly, these plots, along with Table 3 of the Draft Groundwater Modeling of TDS and Nitrate-Nitrogen Concentrations – Riverside-Corona Feeder Project Conjunctive Use Scenarios report, indicate that the RCF Project will not impact the City's wells with higher TDS concentrations. In general, any future increases in TDS concentration in the Redlands area are more directly related to changes that are predicted to occur under "No Project" conditions.

The City of Riverside currently relies upon approximately 38 wells located within the SBBA to extract groundwater supplies. A summary of model predicted TDS concentrations for these wells under No Project and Scenarios 1 through 3 are provided in Table 1 of this technical memorandum. The average change in TDS concentration between the No Project and Scenarios 1 through 3 after a period of 26 years (i.e., the overall impact of RCF Project) ranges from 0.47 mg/L to 2.77 mg/L. Based on these results, the proposed recharge of SWP water under the RCF Project scenarios is predicted to have negligible impact on the TDS concentration of groundwater extracted by the City's wells located within the SBBA.

4.0 DESCRIBE HORIZONTAL / VERTICAL LOCATIONS OF CONTAMINANT PLUMES WITHIN AQUIFERS AND RELATIVE SPATIAL RELATIONSHIP TO THE CONE OF DEPRESSION FOR THE PROPOSED RCF PROJECT WELLFIELD

In the section entitled "Groundwater Quality and Management" of the USEPA's comments on the Draft EIS, it is recommended that the Final EIS include a description of the horizontal and vertical location of the contaminated plumes in the aquifers and their relative spatial relationship to the cones of depression of the proposed RCF Project extraction wells.

There are five major groundwater contaminant plumes that are known to affect the SBBA, which include: (1 and 2) Newmark/Muscoy plumes; (3) Crafton-Redlands plume; (4) Norton Air Force Base (AFB) plume; and, (5) Sante Fe plume⁶. These plumes have been extensively

⁶ Former Burlington Northern Santa Fe (BNSF) Railway Company Railyard Intermodel Facility.



investigated and documented by Federal and private entities. The current level of monitoring and remediation varies for each plume. A description of the horizontal and vertical location of each contaminant plume is provided below. Additionally, a discussion of the relative spatial relationship of each plume to the cones of depression associated with the proposed RCF Project wells is provided.

Crafton-Redlands Plume

The horizontal distribution of the Crafton-Redlands Plume is approximately 10 miles long (east to west) and 0.75 to 3.25 miles wide (north to south) (Tetra Tech, 2008). The vertical extent of the plume in the area of the proposed RCF wellfield was determined from water quality samples collected from City of Redlands Well 31-A. Well 31-A is perforated from 480 ft below ground surface (bgs) to 700 ft bgs, and is located approximately 3,000 ft east of the proposed RCF wellfield. In August 2008, the perchlorate concentration in Well 31-A was reported to range from 32 to 33 µg/L. Likewise, depth to groundwater in Well 31-A is approximately 190 ft bgs. Since the aquifer is unconfined in this portion of the SBBA, it is assumed that the vertical extent of the plume is from approximately 190 ft bgs to as much as 700 ft bgs.

Norton AFB Plume

The Norton AFB plume is located downgradient from the former Norton Air Force Base in the central part of the SBBA. The horizontal distribution of the plume was reported to be approximately three miles long (northeast to southwest) and approximately a half mile wide (U.S. Air Force, 1993). In July 1992, the known vertical extent of the plume was from approximately 100 ft bgs to approximately 280 ft bgs, which is within HSU-2 (U.S. Air Force, 1993).

Newmark-Muscoy Plumes

The Newmark Plume and Muscoy Plume have been designated by the U.S. EPA as the Newmark Groundwater Contamination Superfund Site, which borders Shandon Hills in the northwestern and west-central portions of the SBBA. This site consists of three Operable Units⁷ (OUs), including the Source OU, the Newmark OU, and the Muscoy OU. The Newmark OU covers approximately seven square miles on the north and east sides of Shandon Hills. The Muscoy OU covers approximately eight square miles west of Shandon Hills (USEPA, 2007). The groundwater contaminant plume is dispersed approximately five miles downgradient on the Newmark side and three miles downgradient on the Muscoy side (USEPA, 2007). The hydrostratigraphy of the Newmark OU consists of an unconfined alluvial aquifer that overlies igneous and metamorphic

⁷ A term for an area where separate activities are undertaken as part of an overall Superfund site cleanup.

bedrock units in the northern portion of the OU, and a two-aquifer system in the eastern and southern portions of the OU. The unconfined aquifer consists of 350 to 400 ft of unconsolidated sands and gravels with discontinuous layers of silt and clay (URS, 1995). The hydrostratigraphic units of the two-aquifer system have been termed the Upper Water Bearing Member (UWBM), the Middle Confining Member (MCM), and the Lower Water Bearing Member (LWBM). The LWBM generally occurs between 450 and 500 ft bgs, but may also extend to as much as 1,200 ft bgs (SECOR, 2005). The hydrostratigraphy of the Muscoy OU is similar to that of the Newmark OU, existing as a single unconfined aquifer in the northern portion that gradually separates into a multiple aquifer system in a southerly direction (SECOR, 2005). Contaminated groundwater associated with both OUs was found to be present in the unconfined aquifers, the UWBM, and the LWBM (possibly to the bedrock surface) (USEPA, 2007).

Santa Fe Plume

Although potential impacts to the Santa Fe plume were not evaluated in the same manner as the Newmark-Muscoy and Norton AFB plumes, the California Regional Water Quality Control Board recently declared that the Santa Fe plume has been remediated to the point where it no longer poses a threat to human health (RWQCB, 2011). Therefore, since the operation of the RCF Project is not predicted to impact this plume, a description of its horizontal and vertical locations and relative spatial relationship to the proposed RCF wellfield is not needed.

As indicated in section 3.7 of the Draft SEIR/EIS, there are currently four operational alternatives for the RCF Project. The fourth alternative, referred to as the Realignment Alternative with Additional Connections (Preferred Alternative) is the proposed “project” and would include the use of 20 project extraction wells. Five of these 20 wells are proposed to be drilled and constructed in the Redlands area. The locations of the remaining 15 project wells have not been determined. The five new wells would have an estimated capacity of 3,000 acre-ft/yr each (total of 15,000 acre-ft/yr), based on local geohydrologic conditions. The proposed area for the new wells (i.e., “RCF Project extraction wellfield”) is located immediately west of the 210 Freeway inbetween Lagonia Avenue and the Santa Ana River (refer to Figure 2 of Item 1, Appendix F of the Draft SEIR/EIS). The Redlands Plume Project Feasibility Study Remedial Action Plan (Strategic Engineering and Science *et. al.*, 2010) indicates that this area of the SBBA is composed of undifferentiated sand and gravel that overlie crystalline basement rocks (i.e., non-water bearing). Groundwater in this area of the basin is unconfined, having no significant layers of silt and clay throughout the formation. This unconfined condition of the aquifer continues approximately one mile west of the proposed RCF wellfield. From this area westward, silt and clay layers confine and divide the aquifer system into “upper,” “middle” and “lower” aquifers



that have been designated by Tetra Tech as HSU-2, HSU-4, and HSU-6, respectively. Results of model predicted groundwater levels show the cone of depression created from the RCF wellfield would be minimal (see Figures 18-29 of Item 1, Appendix F in the Draft SEIR/EIS).

Results from the model runs reported in Appendix F of the Draft SEIR/EIS were used to determine the relative spatial relationship of the major contaminant plumes to the cones of depression associated with the proposed RCF Project extraction wells. However, since the relative locations are only known for the proposed five new wells, an evaluation of the spatial relationship of the contaminant plumes and the remaining 15 project wells was not performed.

The Crafton-Redlands Plume is the only known contaminant plume to exist within the proposed RCF Project wellfield. Model results show that the difference between average groundwater levels in City of Redlands Well 32 (located next to Well 31-A, approximately 3,000 ft east of the RCF wellfield) for the Baseline Run (No Project) and Scenarios 1, 2 and 3 (i.e., Baseline water level minus Scenario water level) would be -1 ft, -4 ft and -6 ft, respectively (see Table 1 of Item 1, Appendix F of the Draft SEIR/EIS). Therefore, change to the horizontal or vertical extent of the Crafton-Redlands Plume due to the operation of the RCF wellfield would be minimal compared to the change predicted to occur under Baseline Run (No Project) conditions. The remaining four contaminant plumes in the SBBA (i.e., Newmark, Muscoy, Norton AFB, and Santa Fe) do not occur within the predicted cones of depression of the proposed RCF Project wellfield. Results for the TCE transport model show no change to the Norton AFB, Newmark-Musoy, or Santa Fe plumes for RCF Scenarios 1 through 3 as compared to the plume area under Baseline Run (No Project) conditions (see Appendix F of the Draft SEIR/EIS).

5.0 DESCRIBE PAST OR PRESENT EFFECTS OF RECHARGE AND EXTRACTION OF STATE WATER PROJECT WATER IN THE SAN BERNARDINO BASIN

In their comments on the Draft EIS, the USEPA recommended that the Final EIS provide a description of past or present effects of recharge and extraction of SWP water in the SBBA.

There are many benefits of using imported SWP water to recharge the aquifers in the SBBA. The use of SWP water allows for maximum reuse of local water supplies, and improves long-term and dry-year period water supply reliability. Additionally, the relatively rapid migration of high quality SWP from the forebay areas toward the central portion of the SBBA has expedited groundwater remediation operations. Artificial recharge of SWP water has been ongoing in the SBBA since 1972. Total annual recharge of SWP in the SBBA has ranged from zero to 32,200 acre-ft with an average of approximately 6,400 acre-ft/yr during the period 1972 to 2006 (see Figure 3 of this technical memorandum).

In a previous study performed by GEOSCIENCE (2009c) for Valley District, the relationship between the amount of SWP water recharged and predicted TDS concentrations was established for the SBBA. In general, model results indicated that the more SWP water was used for recharge, the lower the TDS concentration in the groundwater. For example, when the amount of SWP water recharge is zero, the predicted TDS concentrations in the SBBA would range from 329 to 451 mg/L. When the amount of SWP water recharge is 40,000 acre-ft/yr, the predicted TDS concentrations in the SBBA would range from 325 to 432 mg/L. This is a reduction of as much as 19 mg/L. The same relationship was observed for model-calculated nitrate-nitrogen concentrations in the SBBA. The primary reason for this relationship is because SWP water used to recharge the SBBA is generally of an equal or better quality than that of the receiving groundwater in the SBBA. For example, it was determined from historic water quality data that 50% of the time the TDS concentration of SWP water available for recharge was equal to or exceeded 255 mg/L (GEOSCIENCE, 2009c). This concentration is relatively lower than the ambient TDS concentration of 280 mg/L for the SBBA (Wildermuth, 1999). As a result through dilution, groundwater within the SBBA is of equal or higher quality than if SWP water would not have been used for recharge.

6.0 ADDRESS COMMENTS BY REVIEW PANEL REGARDING PARAMETERS USED IN CURRENT MODEL

The City of Riverside's comments on the Draft SEIR/EIS expressed their concern that model results do not accurately represent predicted conditions in the Basin as a result of the RCF Project. This concern is from errors in model parameters identified in a recently completed independent peer review.

The RCF conjunctive use scenarios proposed in the Draft SEIR/EIS were evaluated by GEOSCIENCE using the Refined Basin Flow Model/Newmark Groundwater Flow Model (RBFM/NGFM) and the Refined Basin Solute Transport Model (RBSTM). The current versions of these models represent highly refined versions of the initial modeling efforts that have evolved over the past four decades. Various groundwater flow models and refinements form part of the evolution of the current RBFM/NGFM and RBSTM, which include:

1. The first numerical model of the area (1966-67) by Tyson, Weber, and Frankel of the California Department of Water Resources.
2. A simplified well-response model by Durbin (1974), and Durbin and Morgan (1978) of the USGS.
3. A more complex groundwater flow model by Hardt and Hutchinson of the USGS.
4. The USGS Basin Flow Model developed by Danskin of the USGS. This model formed the basis for the current model refinement.



5. Updated the USGS model code (MODFLOW-2000) and added a solute transport component.
6. Refined USGS model cell size from 820 ft by 820 ft to 102.5 ft by 102.5 ft.
7. Modified the USGS model from two layers to five layers.
8. Extended the end of the model period from 2000 to 2006.
9. Refined the annual stress periods from 1983 to 2006 to monthly stress periods.
10. Developed TCE and PCE solute transport models.

The most recent refinement processes were conducted through a cooperative technical effort involving representatives of SBMWD and Valley District, their respective consultants at Stantec Consulting (Stantec) and GEOSCIENCE, and Mr. Wes Danskin of the USGS. This working technical group is the makeup of the current RBFM/NGFM modeling team (Modeling Team). One primary benefit of these refinement efforts is that the RBFM/NGFM and RBSTM, which are an approximation of a complex field situation, continue to improve and gain value as a water resource management tool for the SBBA.

GEOSCIENCE has played a vital role in the development and refinement processes of these models since the USGS Basin Flow Model was updated (see Item 5 above). GEOSCIENCE has extensive experience using these models to evaluate key groundwater characteristics of the SBBA, which includes:

- Interaction between surface streams and groundwater,
- Groundwater flow,
- Groundwater quality,
- Groundwater pathlines,
- Travel distances of groundwater contaminant plumes,
- Groundwater budgets,
- Artificial recharge and associated growth and decay of groundwater mounds,
- Potential liquefaction, and
- Aquifer system compaction (i.e., subsidence).

The table below summarizes the major projects in the SBBA that GEOSCIENCE has performed modeling work.



Year	Project	Purpose of Model	Client
2004	Santa Ana River Water Rights Applications for Supplemental Water Supply Draft EIR	Groundwater Flow, Particle Tracking, Groundwater Quality, Groundwater Recharge, Subsidence	WMWD/Valley District
2005	Riverside-Corona Feeder Project – Phase I Groundwater Modeling Results	Groundwater Flow, Particle Tracking, and Groundwater Quality	WMWD
2007	Upper Santa Ana River Watershed Integrated Regional Water Management Plan	Groundwater Flow and Groundwater Quality	Upper Santa Ana Water Resources Association
2009	San Bernardino Basin Area – Refined Basin Flow Model and Solute Transport Model Report	Groundwater Flow, Groundwater Quality, Potential Liquefaction, Groundwater Budgets	Valley District

Per the request of the Institutional Controls Groundwater Management Program (ICGMP)⁸, the RBFM/NGFM and RBSTM underwent an independent peer review following the completion of the most recent model refinements. Balleau Groundwater Inc. (Balleau Groundwater) was contracted to perform the peer review. Peer review comments were provided by Balleau Groundwater in the form of a report, dated December 15, 2010.

A BTAC meeting was held in January 2011 to address the concerns identified in the model review report. The major concerns that were identified from Balleau's review of the current RBFM/NGFM include: (1) model-calculated shallow groundwater in the Pressure Zone is not consistent with observed field data; and (2) model layers that "pinch out" (i.e., merge together vertically) in the mountain front areas of the SBBA is not comparable with the USGS Basin Flow Model, and could result in water levels to fall below model layer 1 which do not account for storage changes responding to fluctuations in water levels over 200 ft in the mountain front area.

⁸ The ICGMP group was established in response to concerns voiced by municipalities with interests within the SBBA during the Draft Consent Decree and Statement of Work administered by the EPA and California Department of Toxic Substances Control (DTSC) for the Newmark Groundwater Contamination Superfund Site cleanup projects in the SBBA.

Upon consideration of Balleau's identified issue regarding shallow groundwater in the Pressure Zone, the Modeling Team determined that the current RBFM/NGFM was calibrated adequately for the intended purpose of evaluating the potential liquefaction areas (i.e., areas with depth to water shallower than 50 ft.) in the SBBA. For example, the areas calculated by the RBFM/NGFM as having a depth to water less than 50 ft in 1983 were determined to be similar to the area previously mapped by Matti and Carson (1991) and based on observed field data by Martin and Lew (1999).

To address Balleau's concern regarding the model structure, the Modeling Team determined that the depth to bedrock in the mountain front area used for the 2009 version RBFM/NGFM is consistent with the following published documents:

- DWR Bulletin 104-5 (1970)
- CDMG Special Report 113 (1976)
- USGS Open-File Report 80-576 (1980)
- GEOSCIENCE (1993)
- Wildermuth Environmental (2000)
- USGS Open-File Report 00-193 (2000)

The geologic cross-section provided in the report for the USGS Basin Flow Model was used only to illustrate the conceptual model of the valley-fill aquifer. Therefore, the peer reviewer's comment on the current RBFM/NGFM is not a concern for the modeling results of the RCF Project.

In response to Balleau's comments, a work plan has been developed and proposes to provide additional enhancements to the RBFM/NGFM and RBSTM to improve its accuracy, functionality and make it accessible to the public via the internet. The proposed scope of work is estimated to take one and a half years to complete. As with past modeling refinement efforts, the Modeling Team will work closely together to prepare the proposed modeling enhancement scope of work outlined in the proposed work plan. The scope of work is intended to address GEOSCIENCE's and Stantec's recommendations as provided in previous modeling reports and to address Balleau Groundwater's peer review comments.

It is important to note that the purpose of using the RBFM/NGFM and RBSTM for the RCF Project was to assess the potential impacts of the RCF on groundwater levels and groundwater quality in the SBBA. In general, this assessment was made by comparing water levels and water quality predicted by the RBFM/NGFM and RBSTM (i.e., RCF Project Scenarios 1 through 3) to a



Baseline Run (No Project). Upon approval of the proposed work plan and completion of the scope of work, the RBFM/NGFM and RBSTM can be used to evaluate the proposed RCF Project without the concerns identified in the City of Riverside's comments.

7.0 FINDINGS

Based on comments by the review panel for the Draft SEIR/EIS the following findings are made:

- Modeling results indicated that RCF Project-related groundwater recharge and extraction will slightly increase the rate of groundwater movement from the recharge areas towards the Redlands area. Recharge of high quality SWP water will dilute the ambient groundwater, improving the water quality in the SBBA over time. Therefore, based on current reported concentrations in the eastern and central areas of Redlands, movement of either DBCP or TCP westward towards Redlands Well 38 and/or Well 39 is not considered to be a significant impact.
- Model results for RCF Project Scenarios 1 through 3 reported in the Draft SEIR/EIS indicated that predicted TDS concentrations in wells owned by the City of Redlands would be similar to those under the Baseline Run (No Project). In general, any future increases in TDS concentration in the Redlands area are more directly related to changes that are predicted to occur under "No Project" conditions. Likewise, the recharge of SWP water under the RCF Project scenarios is predicted to have a negligible impact on the overall TDS concentration of groundwater extracted by City of Riverside wells located within the SBBA.
- Of the five major groundwater contaminant plumes in the SBBA, the only known plume to exist within the proposed RCF wellfield under the "Preferred Alternative" is the Crafton-Redlands Plume. Change to the horizontal or vertical extent of the Crafton-Redlands Plume due to operation of the RCF wellfield (i.e., RCF Project extractions) would be minimal compared to the change predicted to occur under Baseline (No Project) conditions. Due to either distance from the proposed RCF wellfield or the current status of plume after remediation, the RCF Project is not predicted to impact the Newmark-Muscoy, Norton AFB, or the Santa Fe contaminant plumes.
- There are many benefits of using imported SWP water to recharge the aquifers in the SBBA. The use of SWP water allows for maximum reuse of local water supplies, and improves long-term and dry-year period water supply reliability. Additionally, the relatively rapid migration of high quality SWP from the forebay areas toward the central

portion of the SBBA has expedited groundwater remediation operations. A previous study by GEOSCIENCE showed that as recharge of SWP water increased, the TDS concentration in the SBBA will decrease.

- The current versions of the RBFM/NGFM and RBSTM were used to evaluate the RCF Project for the Draft SEIR/EIS. Improvements through on-going cooperative refinement efforts form the evolution of these models. In response to an independent peer review of the RBFM/NGFM, a work plan has been developed that proposes to provide additional enhancements to improve the accuracy, functionality, and accessibility of these models. It is important to note that the purpose of using the RBFM/NGFM and RBSTM for the RCF Project was to assess the potential impacts of the RCF Project on groundwater levels and groundwater quality in the SBBA. In general, this assessment was made by comparing groundwater levels and groundwater quality predicted by the models for RCF Project Scenarios 1 through 3 to the Baseline Run (No Project). Upon approval of the proposed work plan and completion of the scope of work, the refined models can be used to evaluate the RCF Project without the concerns identified by the City of Riverside.

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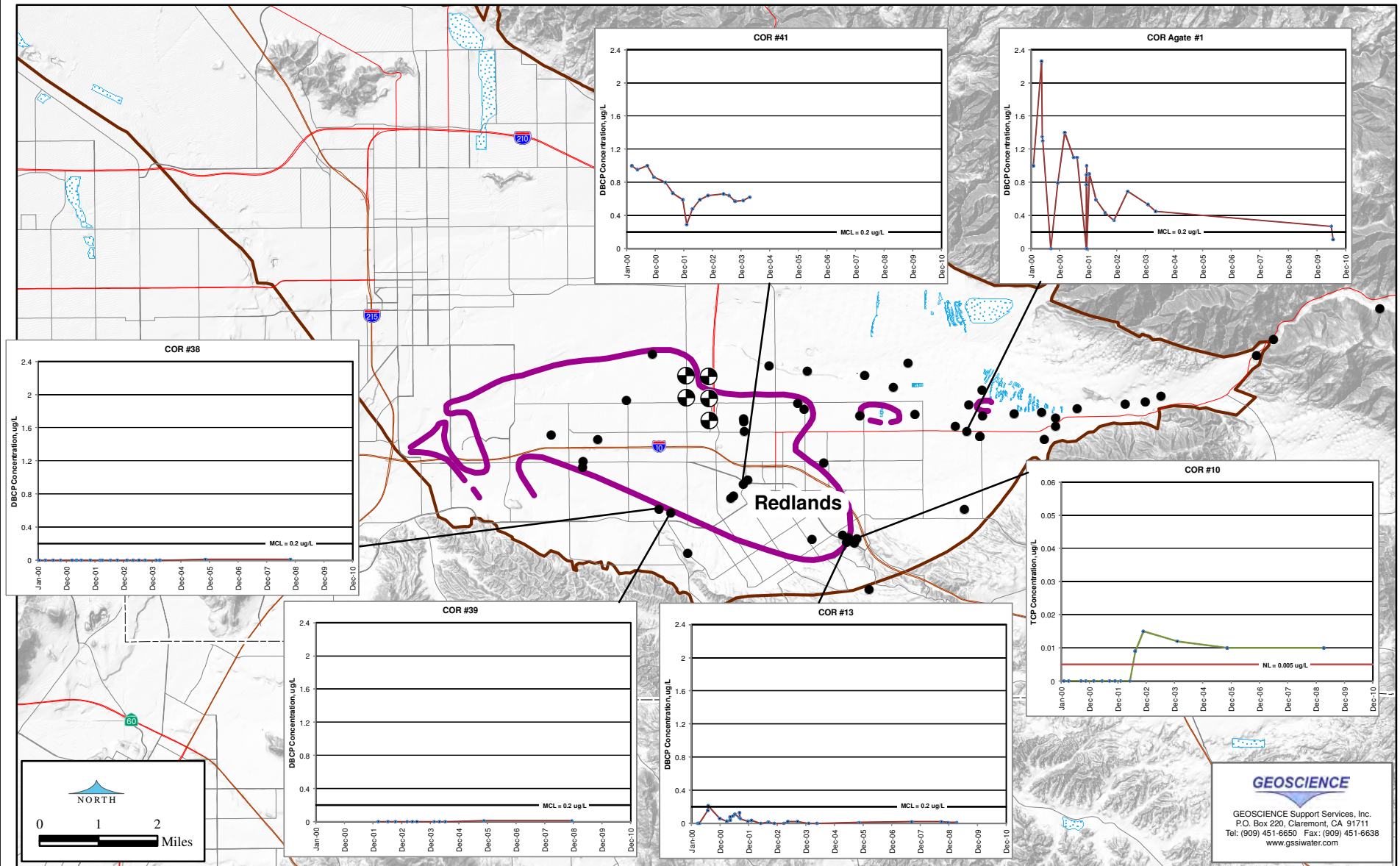
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WESTERN MUNICIPAL WATER DISTRICT

RESPONSE TO COMMENTS - GROUNDWATER MODELING OF RIVERSIDE-CORONA FEEDER PROJECT CONJUNCTIVE USE SCENARIOS



15-Aug-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone V.

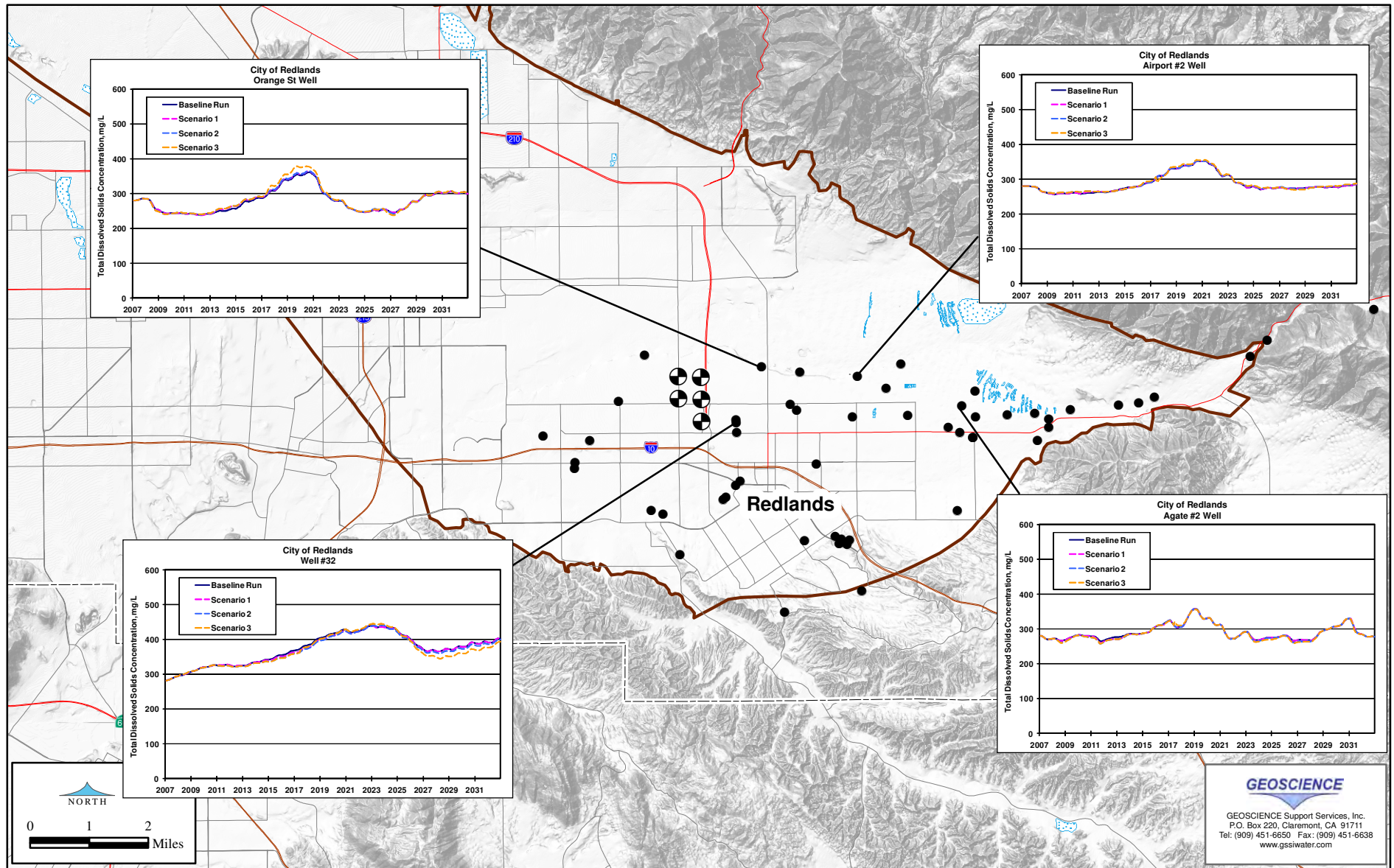
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- Proposed RCF Project Well
- City of Redlands Well
- Spreading Grounds or Basins
- Perchlorate Plume (Source: Tetra Tech, 2011)
- Bunker Hill Basin Boundary

**DBCP AND TCP
IN THE
REDLANDS AREA**

Figure 1



15-Aug-11

Prepared by: DWB. Map Projection: State Plane 1983, Zone V.

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**MODEL PREDICTED
TDS CONCENTRATIONS
IN THE REDLANDS AREA**

Figure 2

Total Annual Recharge of SWP in the SBBA 1972 - 2006

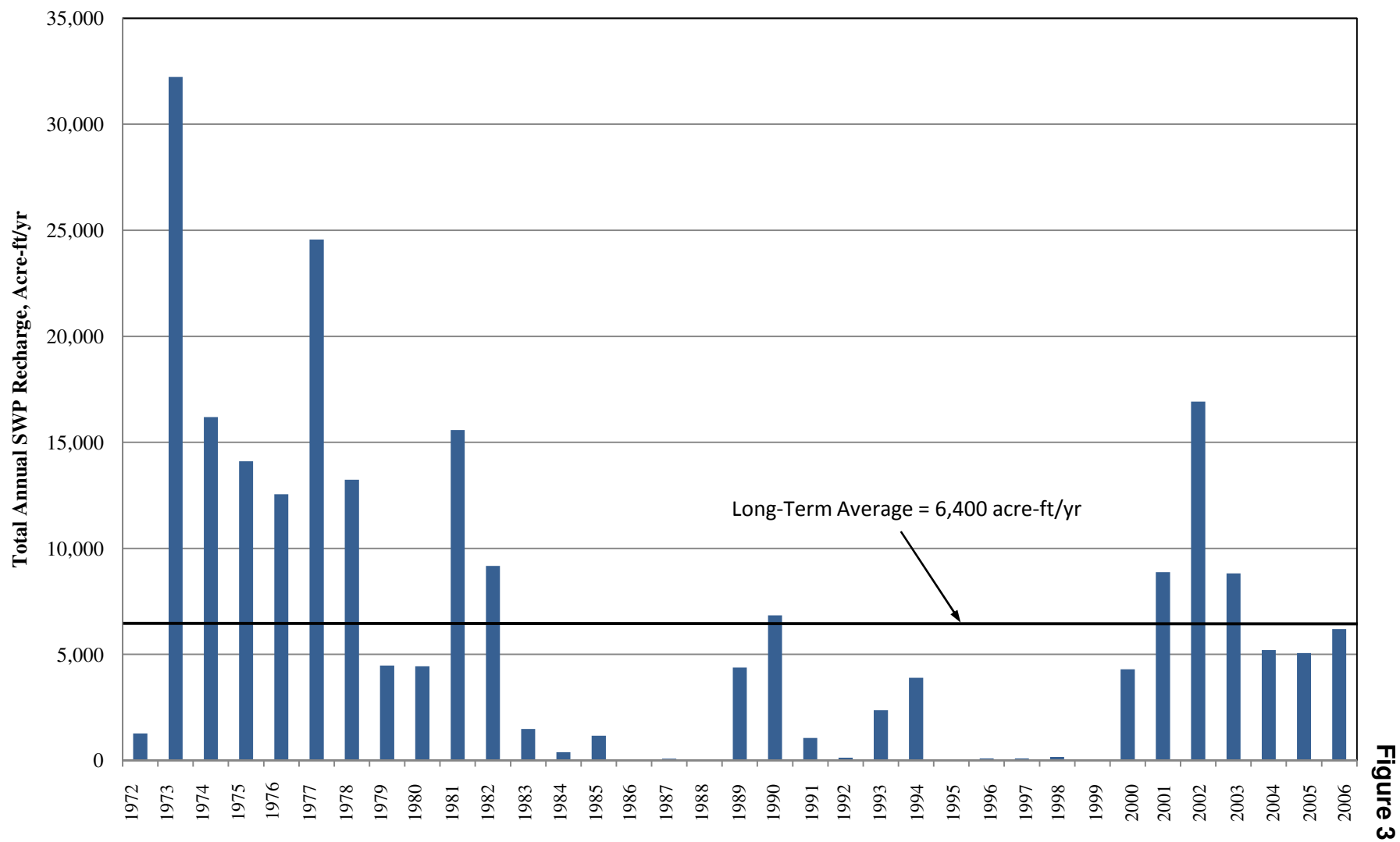


Figure 3

Source of Data: San Bernardino Valley Municipal Water District

Table 1

Model Predicted TDS Concentrations for City of Riverside Wells within the SBBA

Count	Well	Model-Predicted TDS Concentration [mg/L]				Change from Baseline [mg/L]		
		Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
1	COOLEY H	288.53	288.63	288.94	289.20	0.09	0.40	0.67
2	COOLEY I	326.98	326.67	326.68	327.44	-0.31	-0.30	0.46
3	COOLEY J	330.33	330.90	331.85	333.08	0.57	1.52	2.75
4	GAGE 26-1	376.93	377.10	377.08	378.04	0.17	0.15	1.11
5	GAGE 27-1	410.16	410.39	410.55	411.93	0.23	0.39	1.77
6	GAGE 27-2	423.93	424.04	424.26	425.83	0.11	0.33	1.90
7	GAGE 29-1	421.82	421.92	422.20	423.76	0.09	0.38	1.94
8	GAGE 29-2	347.81	347.98	347.54	348.05	0.16	-0.28	0.23
9	GAGE 29-3	327.24	327.18	325.64	325.68	-0.06	-1.60	-1.56
10	GAGE 30-1	304.99	305.52	306.42	307.57	0.52	1.43	2.58
11	GAGE 31-1	350.42	351.87	354.87	356.58	1.44	4.44	6.15
12	GAGE 46-1	307.05	308.15	310.11	312.02	1.11	3.06	4.97
13	GAGE 51-1	316.80	317.06	316.90	317.76	0.26	0.10	0.96
14	GAGE 56-1	276.64	276.64	277.28	278.68	-0.01	0.64	2.03
15	GAGE 66-1	333.03	333.05	333.26	334.43	0.02	0.22	1.40
16	GAGE 92-1	331.42	331.41	330.71	331.17	-0.02	-0.71	-0.25
17	GAGE 92-2	277.85	277.32	277.00	277.20	-0.53	-0.84	-0.64
18	GAGE 92-3	268.58	266.87	266.03	266.09	-1.70	-2.55	-2.49
19	GAGE 98-1	302.48	302.56	302.47	303.16	0.08	-0.01	0.68
20	GARNER 1	349.30	350.06	351.54	354.39	0.76	2.24	5.09
21	GARNER 2	345.87	347.04	348.62	350.02	1.17	2.75	4.15
22	GARNER 4	330.06	330.07	330.34	332.42	0.02	0.29	2.37
23	GARNER 5	433.07	433.96	435.52	437.82	0.89	2.45	4.75
24	GARNER 6	414.49	415.75	417.90	421.43	1.26	3.41	6.94
25	GARNER 7	343.65	344.19	345.32	348.05	0.54	1.67	4.40
26	HUNT 10	414.42	414.37	414.46	416.30	-0.05	0.04	1.88
27	HUNT 11	406.69	406.61	406.71	408.45	-0.07	0.02	1.77
28	RAUB 4	353.31	354.95	356.93	358.52	1.64	3.62	5.21
29	RAUB 5	370.67	372.89	376.71	378.93	2.23	6.05	8.26
30	RAUB 6	407.89	409.12	411.28	413.53	1.23	3.38	5.64
31	RAUB 7	383.98	384.63	385.14	386.47	0.66	1.16	2.49
32	RAUB 8	429.03	429.50	430.46	432.91	0.47	1.44	3.89
33	SCHEUER	514.57	514.59	514.80	517.10	0.01	0.23	2.53
34	STILES	426.11	426.71	427.57	430.44	0.60	1.46	4.33
35	THORNE 12	475.75	478.48	481.57	485.99	2.73	5.82	10.24
36	TIPPECANOE	341.32	341.43	341.19	341.96	0.10	-0.13	0.63
37	WARREN 1	405.38	405.65	405.78	407.96	0.27	0.40	2.58
38	WARREN 4	432.13	433.32	433.74	435.46	1.19	1.61	3.33
Average Change						0.47	1.18	2.77
Maximum Change						2.73	6.05	10.24
Minimum Change						-1.70	-2.55	-2.49