Engineering Investigation of the Bunker Hill Basin 2011–2012

Prepared By:

SBV WATER CONSERVATION DISTRICT

OUR NAME IS OUR MISSION

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1.0 Executive Summary

Article 1, Section 75560 of the California Water Code requires that a Water Conservation District that proposes to levy a groundwater charge *"… shall annually cause to be made an engineering investigation and report upon groundwater conditions of the District*". In accordance with these requirements, the San Bernardino Valley Water Conservation District (District) must make the following findings and determinations as they relate to the ground and surface water conditions of the Bunker Hill Basin and those areas within the District boundary. Refer to **Figure 1 and 3** for locations.

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (Fall 2010 to Fall 2011);

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (June 30, 2011);

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2010 - June 30, 2011);

Task 4. Estimate of the annual change in the Bunker Hill Basin storage for the current water year (July 1, 2011 - June 30, 2012);

Task 5. Estimate of the annual change in the Bunker Hill Basin storage for the ensuing water year (July 1, 2012 - June 30, 2013);

Task 6. Average annual change in Bunker Hill Basin storage for the immediate past ten water years (2001 - 2011);

Task 7. Estimated amount of agricultural water and other than agricultural water to be withdrawn from the groundwater supplies of the District for the ensuing water year (July 1, 2012 - June 30, 2013);

Task 8. Estimated amount of water necessary for surface distribution for the ensuing water year for the Bunker Hill Basin and the District (July 1, 2012 - June 30, 2013); and

Task 9. The amount of water that is necessary for the replenishment of the groundwater supplies of the Bunker Hill Basin and the District for the ensuing water year (July 1, 2012 - June 30, 2013).

To make the findings and determinations listed above, District staff researched available hydro-geologic and engineering data for the Bunker Hill Basin. These data were compiled and analyzed and a predictive relationship between precipitation, production, and change in basin storage. This relationship was based on empirical data since 1993 and enables the prediction of change in storage, given certain annual production and precipitation levels. In addition, annual and accumulated change in storage values were calculated based on current and historic water level changes throughout the Bunker Hill Basin.

The report is Based on 20 measuring stations, precipitation throughout the contributing watershed was 93% of normal for the period October 1, 2009 to September 31, 2010. The report uses production and water level data from nearly 240 wells in the basin.

The required findings for the 2012 Engineering Investigation are provided below. Each of the tasks is further explained in the main body of the report. Throughout this document a positive sign (+) denotes an increase in groundwater storage or groundwater level elevation while a negative sign (-) denotes a decrease in groundwater storage or groundwater level elevation.

Section 75574 of the California Water Code requires that the District Board indicate the amount of water the District is obligated by contract to purchase. The San Bernardino Valley Water Conservation District is not required by contract to purchase any water.

Summary of Findings for the 2012 Engineering Investigation

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (July 1, 2010 to June 30, 2011 groundwater levels)

Change in storage between Fall 2010 and Fall 2011

116,020 acre-ft (increase)

The amount of water stored in the Basin increased by 116,020 acre-feet between 2010 and 2011.

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (2011)

Accumulated change in storage between July 1993 and June 2011.[1]

-224,603 acre-ft (decrease)

The amount in storage in the Summer of 2011 is 224,603 acre-ft less than in the Summer of 1993.

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2010 - June 30, 2011)

184,122 acre-ft

[1] In the District's Engineering Investigation (EI) prior to 1993-94, the accumulated change in storage was based on the basin storage in 1984 as considered full. A concern arose regarding the flooding of basements due to high groundwater levels in the Pressure Zone of the Bunker Hill Basin. Therefore, in response to the City of San Bernardino's comments on accumulated change in storage, all EI's since that time are based on 1993 basin storage levels considered as full.

Task 4. Estimate of the annual change in the Bunker Hill Basin storage for the current water year (July 1, 2011 - June 30, 2012)

7,700 acre-ft (increase)

The amount of water in the Basin is estimated to increase by 7,700 acre-ft during the current water year.

Task 5. Estimate of the annual change in the Bunker Hill Basin storage for the ensuing water year (July 1, 2012 - June 30, 2013)

7,700 acre-ft (increase)

The amount of water in the Basin is estimated to increase by 7,700 acre-ft during the ensuing water year.

Task 6. Average annual change in Bunker Hill Basin storage for the immediate past 10 water years (2001-2011) shows a decrease, although much less in magnitude than in previous years:

-362 acre-ft (decrease)

Task 7. Estimated amount of agricultural water and other than agricultural water to be withdrawn from the groundwater supplies of the District for the ensuing water year (July 1, 2012 - June 30, 2013)

Estimated amount of agricultural water withdrawn from the groundwater supplies within the District boundary for the ensuing water year (July 1, 2012 - June 30, 2013)

6,045 acre-ft

Estimated amount of other than agricultural water withdrawn from the groundwater supplies of the District for the ensuing water year (July 1, 2012 - June 30, 2013)

58,886 acre-ft

Task 8. Estimated amount of water necessary for surface distribution for the ensuing water year for the Bunker Hill Basin and the District (July 1, 2012 - June 30, 2013)

Estimated amount of water necessary for surface distribution for the ensuing water year (July 1, 2012 - June 30, 2013) for the Bunker Hill Basin

76,370 acre-ft

Estimated amount of water necessary for surface distribution for the ensuing water year (July 1, 2012 - June 30, 2013) within the District boundary

64,035 acre-ft

Task 9. The amount of water which is necessary for the replenishment of the groundwater supplies of the Bunker Hill Basin and the District for the ensuing water year (July 1, 2012 - June 30, 2013)

The amount of water which is necessary for the replenishment of the groundwater supplies of the Bunker Hill Basin for the ensuing water year (July 1, 2012 - June 30, 2013)

135,843 acre-ft

The amount of water which is necessary for the replenishment of the groundwater supplies within the District boundary for the ensuing water year (July 1, 2012 - June 30, 2013)

53,232 acre-ft

In addition to the above findings, Section 75505 of the California Water Code requires that a finding be made as to the amount of water necessary to be replaced in the intake areas of the groundwater basins within the District to prevent the landward movement of salt water into the fresh groundwater body, or to prevent subsidence of the land within the District. Because of its location and the elevations of its water table, the Bunker Hill Basin is not subject to salt-water intrusion and the current groundwater levels do not indicate any significant land subsidence.

Section 75540 of the California Water Code requires that the District Board establish a zone or zones where a groundwater charge is to be implemented. The Code specifically states that a single zone may include the entire District and in May 1993 the Board established the entire District as one zone. This determination may be amended in the future, but lacking any evidence to the contrary, in the 2011-11 year the entire District will remain as a single zone in regard to any groundwater charge.

Section 75561 of the California Water Code further requires the Engineering Investigation to include a finding related to the amount of water the District is obligated by contract to purchase. At this time the District has no contractual obligation to purchase water for the replenishment of the groundwater supplies. However, instead cooperates with local and regional agencies to recharge the aquifer. The District works with San Bernardino Valley Municipal Water District (Valley) to spread excess allocation State Project Water in the District's spreading basins. In the past the District has utilized reserves to offset the cost of water purchases which have spread in its basins. Due to the significant reduction in District reserves it has not purchased water this year.

Based on the results of the 2012 Engineering Investigation, the San Bernardino Valley Water Conservation District finds that:

- Due to the imbalance between groundwater recharge and production since 1993, the Bunker Hill Basin's storage is 224,603 acre-feet below that which is considered full for purposes of this investigation. This value is significantly less than 2011 report due to local rainfall rates and management of the basin.
- During the ensuing water year (July 1, 2012 - June 30, 2013), the Bunker Hill Basin could be recharged, with up to 352,746 acre-feet of water. This recharge quantity would be needed to attain the 1993 storage level that is considered full. The Basin Technical Advisory Committee (BTAC) recommends a maximum of 80,000 acre-ft safely manage and recharge the basin. This amount includes 48,000 acre-ft in Mill Creek and Santa Ana River Basins.
- The District must continue to take all necessary steps to maintain and enhance its capability to conduct recharge operations. These steps may include maintenance and repair of existing, diversion facilities, canals, dikes, basins, roads, and other water recharge facilities. These improvements are required to ensure that the groundwater demands on the Basin, especially during drought periods, can be met.
- The District should continue to work cooperatively in the collaborative planning for the Enhanced Recharge Program to plan, design, build and maintain facilities to expand the capabilities for recharge of waters that are developed as a result of water conservation due to the construction of Seven Oaks Dam (SOD).
- The District has begun collaborative construction efforts with Valley to improve the capacities and delivery capabilities of the District's Upper Santa Ana River diverted water conveyance canals and spreading basins. The District should review the single zone of influence/benefit in 2012-2013 and revise if needed.

2.0 Introduction

The 2011-2012 Engineering Investigation (EI) is very similar to the previous 2010-2011 EI Report. The report uses the same basis of calculation, however updates the document as proposed in the work plan prepared and approved in December 2011. This approach also includes close coordination with other groups particularly San Bernardino Valley Municipal Water District (SBVMWD) who do their own calculations for elements similar to the EI Report. We believe this approach makes the best use of the resources of all water entities within the basin. This year's report provides more research, source documentation, and summary displaying of surface and groundwater activities within the Bunker Hill Basin and specifically within the Water Conservation District's boundaries compared to prior years.

2.1 Purpose and Scope

The San Bernardino Valley Water Conservation District (District) was created by a vote of the people in 1931 for the purpose of managing the recharge activities that were previously conducted by the Water Conservation Association. The Water Conservation Association was incorporated in 1909 and had been diverting flows from the Santa Ana River for groundwater recharge since 1911. Currently the District has ownership, as well as easements and/or use of properties owned by the Bureau of Land Management (BLM), on a total of 3,735 acres within the Santa Ana River and Mill Creek Wash areas. The District boundary covers an area of approximately 50,000 acres, which represents about 60% of the Bunker Hill Basin. **Figure 1** displays the project area map for the Engineering Investigation. The figure shows the District boundary along with its location relative to the County and State boundaries. **Figure 2** shows the District Boundaries relative to the water agencies served by the District.

Article 1, Section 75560 of the California Water Code requires that a Water Conservation District that proposes to levy a groundwater charge "… shall annually cause to be made an engineering investigation and report upon groundwater conditions of the District". In accordance with these requirements, the San Bernardino Valley Water Conservation

District (District) must make the following findings and determinations as they relate to the ground and surface water conditions of the Bunker Hill Basin and those areas within the District boundary. Sub-Basins of the Bunker Hill Basin are shown in **Figure 3.**

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (Fall 2010 to Fall 2011);

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (June 30, 2011);

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2010 - June 30, 2011);

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Task 9. The amount of water that is necessary for the replenishment of the groundwater supplies of the Bunker Hill Basin and the District for the ensuing water year (July 1, 2012 - June 30, 2013).

To make the findings and determinations listed above, District staff researched available hydrogeologic, precipitation, and engineering data for the Bunker Hill Basin and surrounding areas. These data were compiled and analyzed and a predictive relationship between precipitation, production, and change in basin storage was adapted from similar relationships developed by Geoscience Support Services in the preparation

of previous Engineering Investigations. This relationship was based on empirical data enables the prediction of change in storage, given certain annual production and precipitation levels. Precipitation trends and stations are shown in Figure 4. In addition, annual and accumulated change in storage was calculated based on historic water level changes throughout the Bunker Hill Basin.

2.2 Location, Topography and Climate

The Bunker Hill Basin is located at the top of the Santa Ana River Watershed and receives all the surface water runoff from the headwaters of the Santa Ana River, Mill Creek, and a portion of that from the Lytle Creek area as well as smaller periodic flows from Plunge, City, Devil Canyon, Cajon and Elder Creeks. It is part of the inland valley called the San Bernardino Valley located in San Bernardino County, California and encompasses approximately 89,600 acres. Once past the Bunker Hill Basin, the Santa Ana River continues to flow southwesterly for approximately 60 miles until it reaches the Pacific Ocean.

The Bunker Hill Basin is bounded on the northwest by the San Gabriel Mountains, on the northeast by the San Bernardino Mountains, on the south by the Crafton Hills and the Badlands, and on the southwest by a low east-facing escarpment produced by the San Jacinto fault. These geologic features are easily identified on **Figure 5** and **Figure 6**.

The major streams providing inflows and outflows for the Bunker Hill Basin are provided on **Figure 1**. The United States Geological Survey (USGS) administers stream flow gauging stations on all of these waterways except Mill Creek. Mill Creek flow is assumed to be 56% of the Santa Ana River flow based on historic data. Total diversions for direct use and recharge on the Santa Ana River may exceed the stream flows due to measurements by different agencies.

The Bunker Hill Basin is also expressed by a large group of City and Water Agencies that are working to increasingly collaborate for improved transparency. **Figure 2**

presents an overview of the Water Agency Jurisdictions with an overlay of City boundaries.

The climate in the region is a semi-arid Mediterranean-type characterized by long dry summers and relatively short mild winters. The annual average temperature in the valley is 62° F, with extremes ranging from as low as 18° F to as high as 116° F (Burnham and Dutcher, 1960). Precipitation in the region is highly variable depending on location and elevation. Historical annual averages range from 11 inches near Loma Linda Fire Department located at the southwest end of the basin to over 41 inches at the Lake Arrowhead located at the upper end of the mountain watershed contributing flow to the basin. Precipitation data provided by the Water Resources Division for 20 stations are summarized in **Table 1** and displayed on **Figure 4**.

2.3 Definition of Terms

For the purposes of this report, the following terms are defined:

- Bunker Hill Basin - The Bunker Hill Basin is the groundwater basin that underlies the San Bernardino Valley. By strict definition according to (Dutcher and Garrett, 1963), the Bunker Hill Basin is separate from the Lytle Groundwater Basin, but receives groundwater underflow from the Lytle Basin. However, for completeness, the definition of the Bunker Hill Basin is extended to include the Lytle Basin for the purposes of this report.

- Production - The term production includes extraction of water by groundwater pumping from wells and surface diversions from the Santa Ana River, Mill Creek, City Creek, Devil Canyon Creek, Cajon Creek, Plunge Creek, and Lytle Creek.

- Preceding Water Year - As per the California Water Code, the preceding water year is the period July 1, 2010 through June 30, 2011.

- Current Water Year - As per the California Water Code, the current water year is the period July 1, 2011 through June 30, 2012.

- Ensuing Water Year - As per the California Water Code, the ensuing water year is the period July 1, 2012 through June 30, 2013.

2.4 Sources of Data

Data used in the development of this engineering investigation were obtained from a variety of sources including public and private agencies. The data analysis tasks involved tabulating and summarizing information from documented and undocumented reports, public and private files, and personal communication with local, State, and Federal agencies. Some of the more important data sources are listed below.

Data for Fall 2010 and Fall 2011 groundwater elevations and preceding water year (July 2010 to June 2011) production were obtained from the primary water purveyors in the Bunker Hill Basin including:

- City of Colton
- City of Loma Linda/Loma Linda University
- City of Redlands
- City of Rialto
- City of Riverside
- City of San Bernardino
- East Valley Water District
- Elsinore Valley Municipal Water District/Meeks and Daley Water Company
- Gage Canal Company
- Riverside – Highland Water Company
- San Bernardino County Department of Transportation and Flood Control
- Southern California Edison
- San Bernardino Valley Municipal Water District
- Watermaster Support Services, Steve E. Mains

- West Valley Water District
- United States Geological Survey, Santee, CA Office

Data regarding historic diversions from the Santa Ana River, Mill Creek, Plunge Creek, City Creek, Devil Canyon Creek, Cajon Creek, and Lytle Creek were obtained from the following sources:

- San Bernardino Valley Water Conservation District (acting as Project Manager for the Cooperative Water Project - Exchange Plan)
- Western Municipal Water District
- City of San Bernardino

Historic precipitation data were obtained from the following sources:

- San Bernardino County Department of Transportation and Flood Control

Current precipitation data is downloaded from USGS stations.

3.0 Fall 2010 and Fall 2011 Groundwater Elevation Contours

The District, the Western Municipal Water District, and the primary water purveyors in the Bunker Hill Basin provided Fall 2010 and 2011 water level data. Static groundwater elevations for wells throughout the Bunker Hill Basin are compiled in **Appendix A**. These elevations were plotted for 184 wells using a Geographic Information System (GIS) are plotted in **Figures 5 & 6** for Fall 2010 and Fall 2011. The water elevation values were used to derive an interpolated surface for the extent of the Bunker Hill Basin. For purposes of comparison, Fall 2010 and Fall 2011 static groundwater elevation surface contours are provided in **Figures 5** & **6** Fall 2010 and Fall 2011.

4.0 ***Task 1*** **- Annual Change in Storage (Fall 2010 to Fall 2011)**

4.1 Hydrologic Sub-areas

Using a Geographic Information System, the average groundwater elevation changes were determined for each of the nine hydrologic sub-areas shown in **Figure 3** and listed below.

- Bunker Hill I - Southwest of Interstate 215
- Bunker Hill I - Northeast of Interstate 215
- Bunker Hill II - West of Mentone Fault
- Bunker Hill II - East of Mentone Fault
- Lytle Basin - Southeast of Barrier J
- Lytle Basin - Northwest of Barrier J
- Pressure Zone - North of Santa Ana Wash
- Pressure Zone - Santa Ana Wash

Due to variations of changes in groundwater level elevation, the Bunker Hill II - East of Mentone Fault was further subdivided into Storage Units North of Redlands Fault and Southeast of Redlands Fault. These Storage Units are also shown in **Figure 3**.

4.2 Area and Storativity

Digitizing each polygon made estimates of the area extent of the sub-areas and storage. Average storativity for each sub-area was determined based on data from Hardt and Hutchinson, 1980. Both of these values are shown in **Table 3**. Storativity values ranged from 0.02 for the Pressure Zone - North of the Santa Ana Wash to 0.13 for the Lytle Basin - Northwest of Barrier J and Bunker Hill II - East of the Mentone Fault.

4.3 Groundwater Level Elevation Changes

In order to determine the annual change in storage for the Bunker Hill Basin, Fall 2011 groundwater level elevation data were compared with the same from Fall 2010. Measurements for 238 wells were available for both periods and the differences are provided in **Appendix A**. **Figure 7** shows key wells for the Bunker Hill basins. These wells have long hydrologic histories.

Average changes in groundwater were determined by averaging the changes for all wells in each of the eight sub-areas and storage units as shown in **Table 3.**

4.4 Change in Groundwater Storage

The total annual change in storage for the Bunker Hill Basin was determined by summing the changes from each sub-area. Changes in groundwater storage for the period Fall 2010 to Fall 2011 for the Bunker Hill Basin were calculated using the following formula:

$$Q_{\text{change in storage}} = \Sigma\ A_i \times S_i \times \Delta h_i$$

where:

$Q_{\text{change in storage}}$ = Annual change in storage for the Bunker Hill Basin, (acre-feet)

A_i = Area of sub-area and storage unit *i*, (acres)

S_i = Storativity of sub-area and storage unit *i*

Δh_i = Average water level change of sub-area and storage unit *i*, (feet)

As shown in **Table 3**, the change in groundwater storage for the Bunker Hill Basin between Fall 2010 and Fall 2011 was an increase of 116,020 acre-ft.

5.0 *Task 2* - Accumulated Change in Storage from Fall 1993 to Fall 2011

For purposes of this report, the accumulated change in storage as of the last day of the preceding water year (July 30, 2011) was based on the changes in water levels between Fall 1993, when the accumulated basin change in storage was considered "zero", and the Fall of 2011.[2] The accumulated change in storage as of June 30, 2011 was determined by adding the change in storage for the preceding water year (July 1, 2011 to June 30, 2012) of 116,020 determined in Section 4.4, to the accumulated change in storage as of June 30, 2010 (-340,623). The result of this calculation is an accumulated decrease in storage for the Bunker Hill Basin of -224,603 acre-ft.

Table 4 summarizes the accumulated change in storage of the Bunker Hill Basin for the period 1988 to 2011 based on 1993 as the "zero accumulated storage year". As would be expected, storage generally increases with above average rainfall and decreases with normal and below average rainfall.

[2] In the District's Engineering Investigation (EI) prior to 1993-94, the accumulated change in storage was based on the basin storage in 1984 as considered full. A concern arose regarding the flooding of basements due to high groundwater levels in the Pressure Zone of the Bunker Hill Basin. Therefore, in response to the City of San Bernardino's comments on accumulated change in storage, all EI's since that time are based on 1993 basin storage levels considered as full.

6.0 *Task 3* - Total Groundwater Production for the Preceding Water Year (July 1, 2010 to June 30, 2011)

Production data for the preceding water year (July 1, 2010 to June 30, 2011) for the Bunker Hill Basin were obtained from the primary water purveyors as listed in Section 2.4. Production data for wells owned by some smaller water agencies were included if data was available from the Western-San Bernardino Watermaster, Western Municipal Water District and semiannual billing statements issued by the District.

Appendix C shows the production for each groundwater well in the Bunker Hill Basin for the period July 2010 through June 2011. As summarized on the last page of the Appendix, groundwater production from the Bunker Hill Basin for the preceding water year was approximately 184,122 acre-ft. **Table 5** summarizes the Bunker Hill Basin groundwater production for each of the sub-areas defined in Section 4.1.

Groundwater production within the Bunker Hill Basin during the period July 2010 through June 2011 is shown on **Figure 8**. The Pressure Zone has the greatest density of higher producing facilities with pockets of substantial production scattered throughout the rest of the basin.

7.0 *Task 4* - Estimate of the Annual Change in Storage for the Current Water Year (July 1, 2011 to June 30, 2012)

To estimate annual change in storage for the current water year, a multiple regression analysis was performed for the period between 1991-2011 three parameters.

- Annual Change in Storage
- Precipitation
- Production

This analysis is shown in **Figure 9.**

In Engineering Investigations (EI) prior to 1998, data for the period 1982 calendar year through 1991 calendar year were also utilized in the regression analysis. The only production data available for this time frame was based on a calendar year period instead of the June to July period required in the EI. Since the 1991-92 period, more accurate and more complete production data for the July to June period has become available, as the District has compiled detailed information for its EI. Since 1998, the regression analysis has not included pre-1991 data to more accurately represent June through July production.

Annual change in storage for the current water year is estimated using the following relationship between change in storage, precipitation, production, and the calculated regression coefficients. The accumulated change in storage is shown in **Figure 10**.

$$Q_{\text{Annual } \Delta \text{ storage}} = -91450 + 7572 * Q_{prec} - 0.342 * Q_{prod}$$

where:

$Q_{\text{Annual } \Delta \text{ storage}}$ = Annual change in storage, (acre-feet)
Q_{prec} = Annual Precipitation, inches
Q_{prod} = Annual Production, acre-feet

A nomograph, constructed using the above equation, is shown on **Figure 9**. Through the use of this chart or the equation above, annual change in storage can be estimated for a given set of annual precipitation and production values. The precipitation used in the nomograph is based on the average of the representative Bunker Hill Basin drainage area stations listed in **Table 6**. The historic annual precipitation information is show in **Table 1**.

The historic annual average annual precipitation for nine of the ten stations with recent data is shown in **Table 6** approximately 23.1 inches (107 percent of normal). Historic annual precipitation values are plotted in **Appendix D** for these nine stations and twelve other local stations.

Table 6 shows that for the period between July 1, 2010 and December 31, 2010, precipitation was 236 percent of normal for the nine stations with data. Remainder of the water year, January 1 to June 30, 2011, the rainfall averaged 56 percent of the long term average. Annually, precipitation for the 2010-11 water year averaged 112 percent. For purposes of this report, it was assumed that precipitation for the current water year (July 1, 2011 to June 30, 2012) would be 23.1 inches, 100 percent of the Historical average (rather than the average for the 2010 to 2011 season). The reason for this is the preceding year's average is 112 percent, which would be a high estimate based on the low amount of rain received so far this year. The precipitation for the ensuing water year (July 1, 2012 to June 30, 2013) was estimated, like it has typically been done, as 100 percent of normal, or 23.1 inches of rainfall.

Based on these assumptions, the estimated production for the current water year will be approximately 219,913 acre-ft as shown in **Figure 10**. Using this result in **Figure 9** an estimated change in storage for the current water year (July 2011 to June 2012) of 7,700 acre-ft was determined.

8.0 *Task 5* - Estimate of the Annual Change in Storage for the Ensuing Water Year (July 1, 2012 to June 30, 2013)

The annual change in storage for the ensuing water year (July 1, 2012 to June 30, 2013) was estimated using the same method as described in Section 7.0. It was assumed that precipitation for the ensuing water year would be 100% of normal or 23.1 inches. Based on this assumption, the estimated production for the ensuing water year will be approximately 219,913 acre-ft as shown in **Figure 11**. Again, using this result in the nomograph shown in **Figure 9**, the estimated annual change in storage for the ensuing water year (July 1, 2012 to June 30, 2013) is 7,700 acre-ft.

9.0 *Task 6* - Average Annual Change in Storage for the Immediate Past 10 Water Years

Table 7 shows the average annual change in storage for the immediate past ten water years (July 2001 to June 2011) using the same method as described in Section 4.0. By summing the average annual change in storage for each sub-area, a total average annual change in storage for the Bunker Hill Basin for the immediate past ten water years was determined to be -362 acre-feet/year.

10.0 *Task 7* - Estimated Amount of Agricultural Water and Other Than Agricultural Water to be Withdrawn for the Ensuing Water Year (July 1, 2012 to June 30, 2013)

The estimated amount of agricultural water and other than agricultural water to be withdrawn within the District for the ensuing water year (July 1, 2012 to June 30, 2013) was based on the following equations:

$$Q_{agr(10\text{-}11)} = Q_{agr(10\text{-}11)} \times [(Q_{total(12\text{-}13)} - Q_{surf(12\text{-}13)}) / (Q_{total(10\text{-}11)} - Q_{surf(10\text{-}11)})]$$

and

$$Q_{non\text{-}agr(10\text{-}11)} = Q_{non\text{-}agr(10\text{-}11)} \times [(Q_{total(12\text{-}13)} - Q_{surf(12\text{-}13)}) / (Q_{total(10\text{-}11)} - Q_{surf(10\text{-}11)})]$$

where:

$Q_{agr(12\text{-}13)}$ = Agricultural use within the District for the ensuing water year, acre-ft

$Q_{agr(10\text{-}11)}$ = Agricultural use within the District for the preceding water year, acre-ft (Appendix C)

$Q_{total(12\text{-}13)}$ = Production (including surface diversion) from the Bunker Hill Basin for the ensuing water year, acre-ft (Figure 13)

$Q_{total(10\text{-}11)}$ = Production (including surface diversion) from the Bunker Hill Basin for the preceding water year, acre-ft (Appendix C)

$Q_{non\text{-}agr(12\text{-}13)}$ = All other uses within the District for the ensuing water year, acre-ft

$Q_{non\text{-}agr(10\text{-}11)}$ = All other uses within the District for the preceding water year, acre-ft (Appendix C)

$Q_{surf(12\text{-}13)}$ = Surface diversions from the Bunker Hill Basin for the ensuing water year, acre-ft (Table 8)

$Q_{surf(10\text{-}11)}$ = Surface diversions from the Bunker Hill Basin for the preceding water year, acre-ft (Appendix C)

Data on agricultural use and other uses within the District for the preceding water year (July 1, 2010 to June 30, 2011) are provided in **Appendix C**. For the period July 1, 2010 through June 30, 2011 approximately 14,119 acre-ft of groundwater was produced for agricultural applications within the District boundary. For the same period, approximately 46,064 acre-ft of groundwater was produced for all other uses within the District boundary. Using the equations presented above with the following values inserted:

$Q_{agr(10\text{-}11)}$ = 5,061 acre-ft (Appendix C)

$Q_{total(12\text{-}13)}$ = 296,283 acre-ft (Figure 13

$Q_{total(10\text{-}11)}$ = 255,638acre-ft (Appendix C)

$Q_{non\text{-}agr(10\text{-}11)}$ = 45,954 acre-ft (Appendix C)

$Q_{surf(12\text{-}13)}$ = 76,370 acre-ft (Task 8)

$Q_{surf(10\text{-}11)}$ = 71,516 acre-ft (Table 8)

The estimated production within the District for the ensuing water year for agricultural uses and other than agricultural uses is:

$Q_{total(12\text{-}13)}$ = 219,913 + 76,371 = 296,283 acre-ft

$Q_{agr(12\text{-}13)}$ = 5,061 x [(296,283 – 76,370) / (255,638– 71,516)]

= 6,045 acre-ft

$Q_{non\text{-}agr(12\text{-}13)}$ = 45,954 x [(296,283 – 76,370) / (255,638– 71,516)]

= 54,886 acre-ft

$Q_{agr(12\text{-}13)}$ = 6,045 acre-ft

$Q_{non\text{-}agr(12\text{-}13)}$ = 54,886 acre-ft

$Q_{Dist(12\text{-}13)}$ = 60,931 acre-ft

By summing these two results, it is estimated that 60,931 acre-feet of groundwater will be withdrawn within the District for the ensuing water year (July 1, 2011 to June 30, 2012). **Appendix C** shows the Agriculture and Non-Agriculture trends for the District by sub-basin using approximately 240 wells within the District Boundary reporting type of use.

11.0 *Task 8* - Estimated Amount of Water for Surface Distribution for the Ensuing Water Year (July 1, 2012 to June 30, 2013)

The amount of water for surface distribution for the ensuing water year (July 1, 2012 to June 30, 2013) was estimated based on the average surface diversions for the Santa Ana River, Mill Creek, and Lytle Creek for the period 1985 to 2011.

As shown in **Table 8**, average surface diversions for the Santa Ana River, Mill Creek, Lytle Creek and smaller tributary creeks collectively called "Bunker Hill Creeks," between 1985 and 2011 were 42,334, 21,701, 11,207, and 1,128 acre-feet, respectively. Therefore, the total estimated amount of water for surface distribution from the Bunker Hill Basin for the ensuing water year (July 1, 2012 to June 30, 2013) is found by summing the diversions as follows:

Bunker Hill Surface Distribution =11,207 + 21,704 + 1,128 + 42,334 = 76,370 acre-ft

As Lytle Creek and Bunker Hill Creeks are not within the District, the estimated amount of surface distribution from the District for the ensuing water year (July 1, 2012 to June 30, 2013) is the sum of the Santa Ana River and Mill Creek distributions.

District Surface Distribution = 42,334 + 21,701 = 64,035 acre-ft

12.0 *Task 9* - Estimated Amount of Water for Replenishment of the Groundwater Supplies for the Ensuing Water Year (July 1, 2012 to June 30, 2013)

The amount of water necessary for replenishment of the groundwater supplies of the Bunker Hill Basin for the ensuing water year (July 1, 2012 to June 30, 2013) was estimated based on:

Replenishment = Total Production - Surface Diversions - Change in Storage

The estimated production and surface diversions from the Bunker Hill Basin for the ensuing water year (July 1, 2012 to June 30, 2013) were estimated at approximately 219,913 acre-feet (from **Figure 13**) and 76,370 acre-feet (from **Table 8**), respectively. The estimated change in storage determined in Section 8.0 and shown on **Figure 9** is an increase of 7,700 acre-feet. Therefore, the amount of water necessary for replenishment of the groundwater supplies of the Bunker Hill Basin is estimated as follows:

Replenishment = 223,361 -76,370 -7,700 = 135,843 acre-ft

The amount of water necessary for replenishment of the District's groundwater supplies for the ensuing water year (July 1, 2012 to June 30, 2013) was estimated using the same equation as shown above and substituting values for the District area. The estimated production within the District for the ensuing water year was estimated at approximately 60,931 acre-ft (from Section 10.0) and 64,035 acre-ft (from Section 11.0), respectively. The change in storage for the ensuing water year for the District was estimated as a increase of 7,700 acre-ft. Therefore, the amount of water necessary for replenishment of the District's groundwater supplies for the ensuing water year (July 1, 2012 to June 30, 2013) is:

Replenishment = Total Production - Surface Diversions - Change in Storage
Replenishment = (60,931 + 64,035) -64,035 -7,700 = 53,232 acre-ft

13.0 General Findings

In addition to the above findings, Section 75505 of the California Water Code requires that a finding be made as to the amount of water necessary to be replaced in the intake areas of the groundwater basins within the District to prevent the landward movement of salt water into the fresh groundwater body, or to prevent subsidence of the land within the District. Because of its location and the elevations of its water table, the Bunker Hill Basin is not subject to salt-water intrusion and the current groundwater levels will not (lowest=593 msl) result in any significant land subsidence.

Section 75540 of the California Water Code requires that the District Board establish a zone or zones where a groundwater charge is to be implemented. The Code specifically states that a single zone may include the entire District and in May 1993 the Board established the entire District as one zone. This determination may be amended in the future, but lacking any evidence to the contrary, in the 2010-11 year the entire District will remain as a single zone in regard to any groundwater charge.

Section 75561 of the California Water Code further requires the Engineering Investigation to include a finding related to the amount of water the District is obligated by contract to purchase. At this time the District has no contractual obligation to purchase water for the replenishment of the groundwater supplies.

14.0 Conclusions

Based on the results of the 2012 Engineering Investigation, the San Bernardino Valley Water Conservation District finds that:

- Due to the imbalance between recharge and production since 1993, the Bunker Hill Basin's storage is 224,603 acre-feet below that which is considered full for purposes of this Investigation.

- During the ensuing water year (July 1, 2012 to June 30, 2013), the Bunker Hill Basin can be recharged, from all sources, with 352,746 acre-feet of water. This recharge quantity is derived by algebraically adding together the accumulated deficit as of the end of the preceding water year with the estimated quantity needed to maintain the 1993 storage level considered full. The BTAC recommends a maximum basin recharge of 80,000 acre-ft.

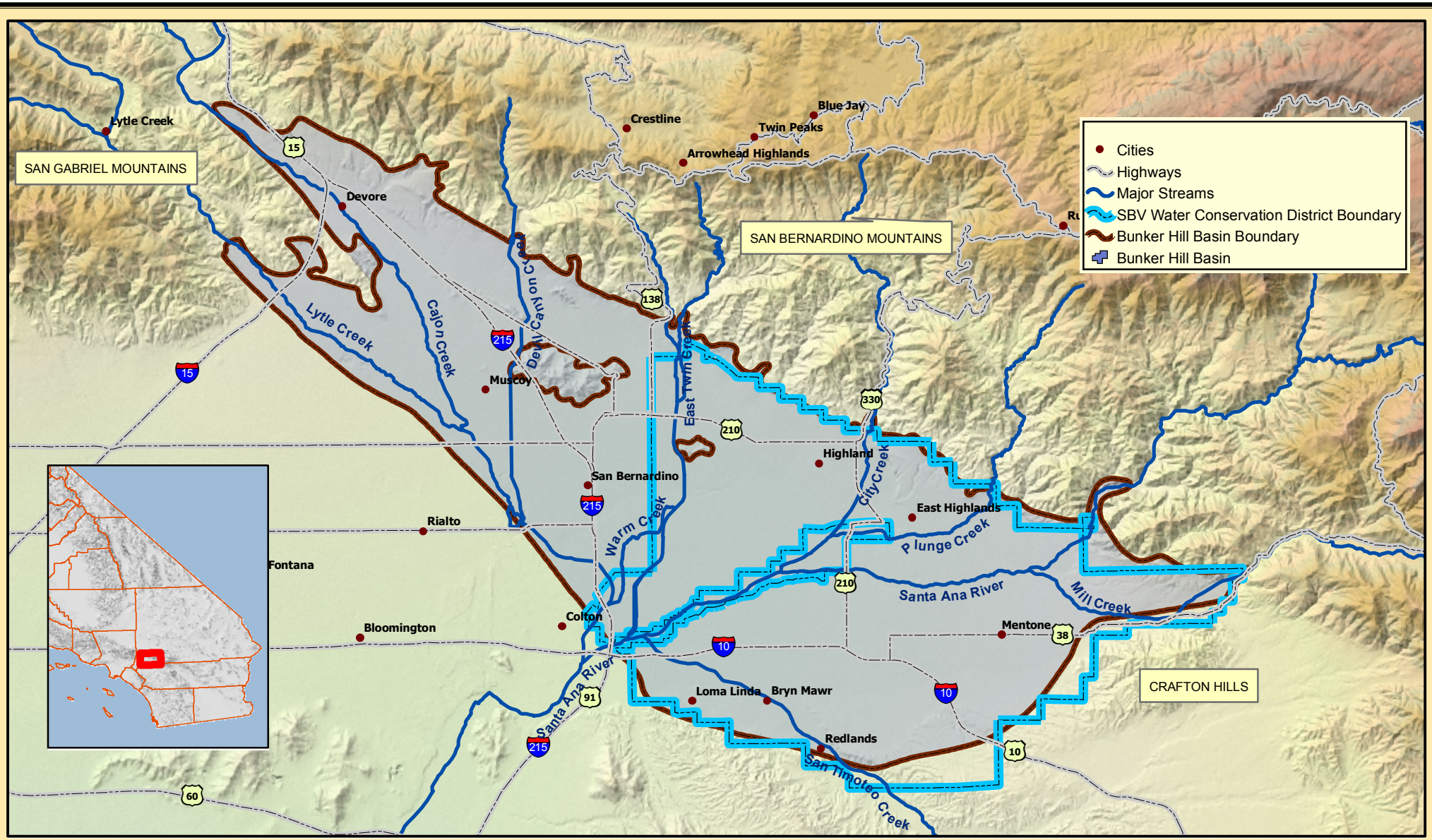
- The District should continue to take the necessary steps to work with its partners to enhance its capability to conduct recharge operations, which includes construction of new, or maintenance and repair of existing, diversion facilities, canals, dikes, basins, roads, and other water recharge facilities. These

improvements are required to ensure that the increasing demands on the Basin, especially during drought periods, can be met.

15.0 Financial Data

The San Bernardino Valley Water Conservation District, in response to questions previously provided information about the groundwater charge in this section. The District provides a complete budget and report of operations as a companion document to this report.

Any changes to the groundwater charge will not be reflected on the District's financial reports as income until the fiscal year 2012 – 2013, as the first increment of the new charge is not due until that time.



State Plane
NAD 83, Zone V, feet
10M DEM DWR
Data Sources:
SBVWCD, CASIL, SBVMWD

Miles
0 0.5 1 2

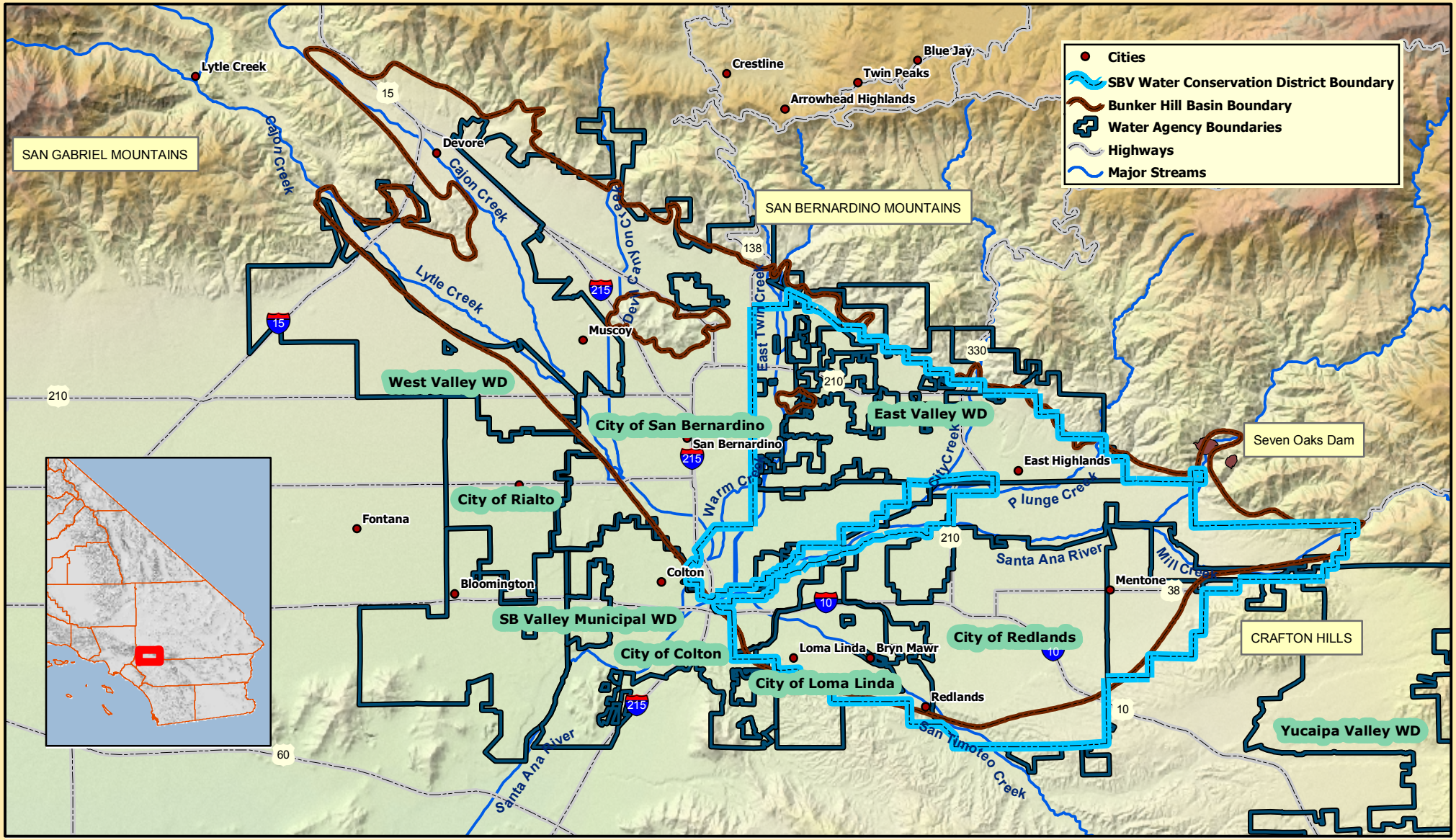
Project Area
2011- 2012
Engineering Investigation Report

Engineering Investigation
March 2012

Source: SBVWCD GIS
L. Pierce

Figure 1

M:\SBVWCD\2010EI\EI2010Maps\Fig01ProjectArea.mxd (03/11)



State Plane
NAD 83, Zone V, feet
10M DEM - DWR 2008
Data Sources: 2010 -11
SBVWCD, SBVMWD

0 0.5 1 2 3 Miles

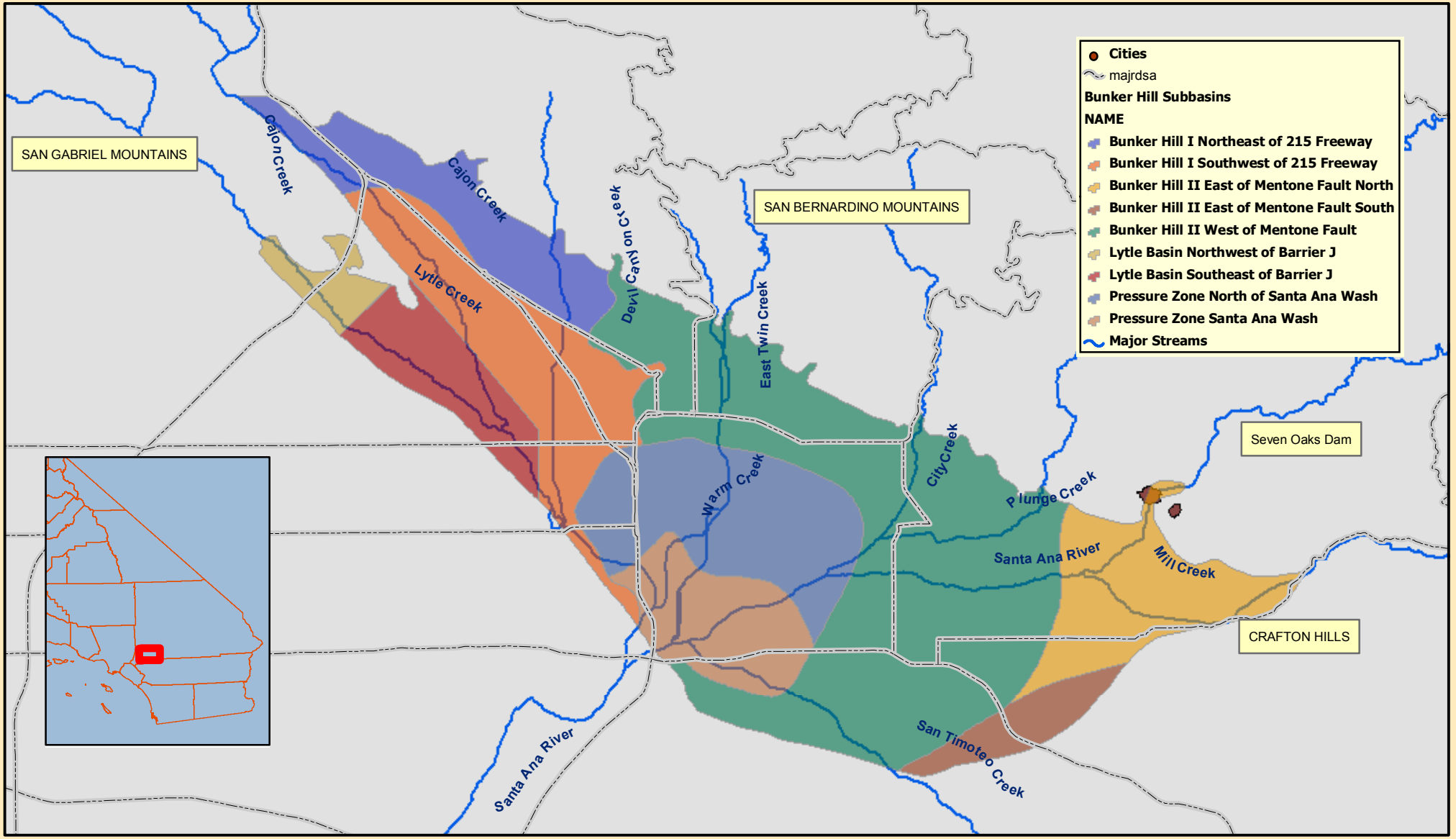
Conservation District and Water Agency Boundaries 2011 - 2012 Engineering Investigation Report

Engineering Investigation
March 2012

Map Creation: SBVWCD GIS
L. Pierce

Figure 2

X:\SBVWCD\2011EI\EI2011Maps\Fig02_Project_Area.mxd (03/11)



State Plane
NAD 83, Zone V, feet
10M DEM - DWR 2008
Data Sources: 2010 -11
SBVWCD, SBVMWD

0 0.5 1 2 3 Miles

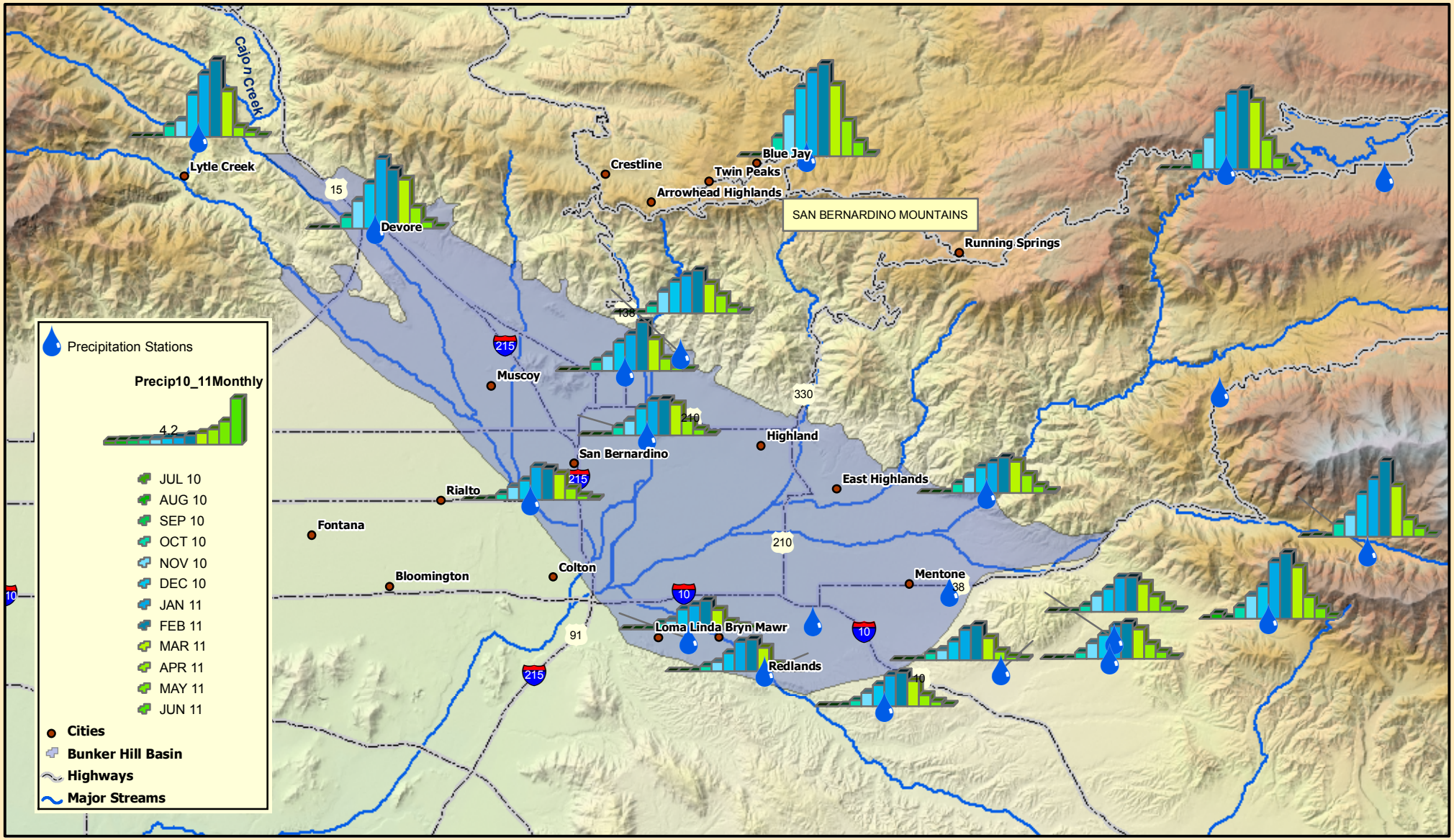
Bunker Hill SubBasins
2011 - 2012
Engineering Investigation Report

Engineering Investigation
March 2012

Map Creation: SBVWCD GIS
L. Pierce

Figure 3

M:\EIR\2011EI\EI2011Maps\Fig03_Subbasins.mxd (01/11)



State Plane
NAD 83, Zone V, feet
10M DEM - DWR 2008
Data Sources:
21 Active Gauging Stations
2011

0 0.5 1 2 3 Miles

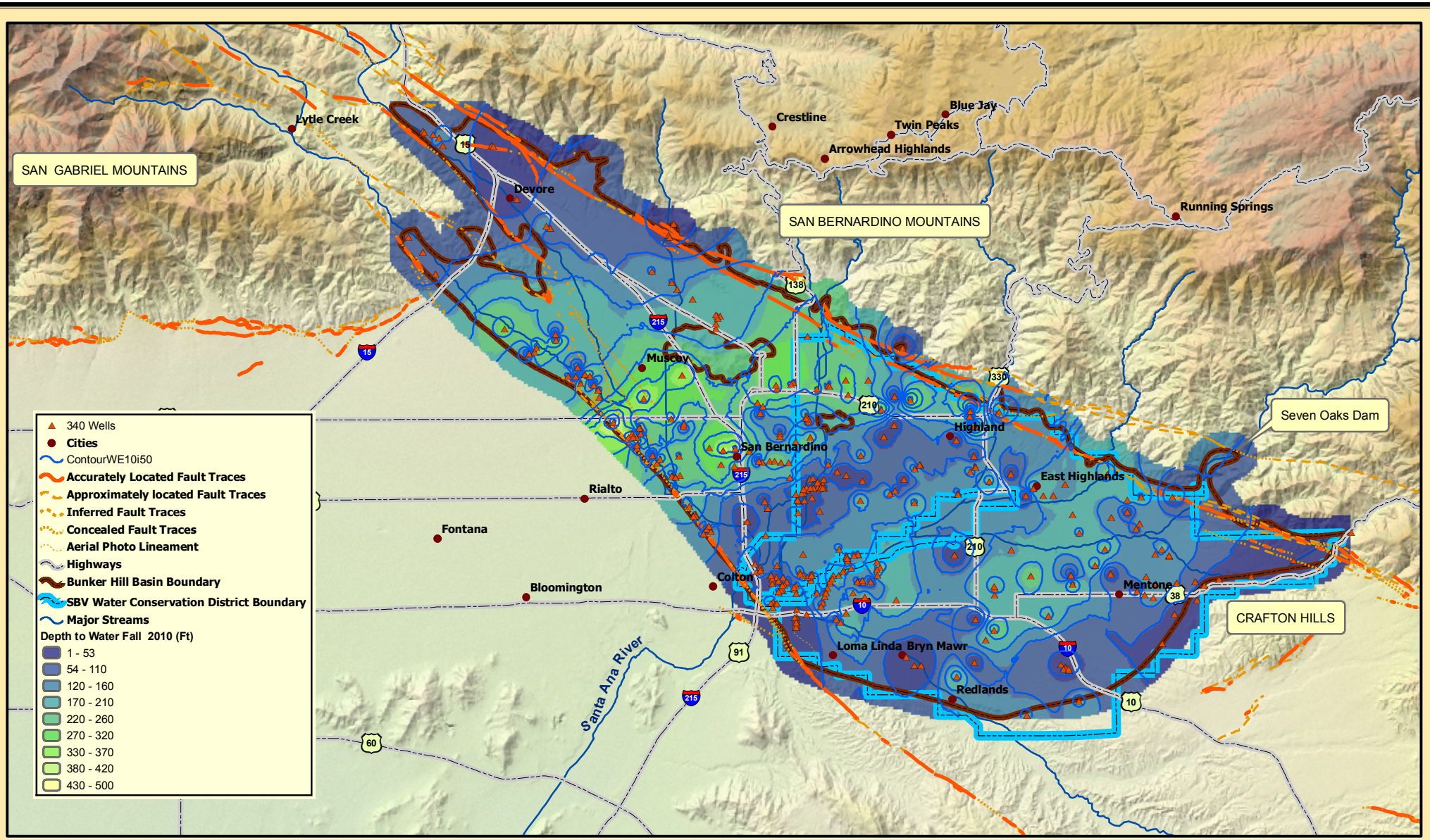
Precipitation Trends and Station Locations
July 2011 - June 2012
Engineering Investigation Report

Engineering Investigation
March 2012

Map Creation: SBVWCD GIS
C. Maxey

Figure 4

M:\EIR\2011EI\EI2011Maps\Fig03_Subbasins.mxd (01/11)



State Plane NAD 83, Zone V, feet
10M DEM DWR
SBVWCD Water Elevation
2009- 2010 - 340 Wells
IDW Interpolation Method
Watermaster Services,
All City Water Agencies
and SBVMWD

0 0.5 1 2 3 Miles

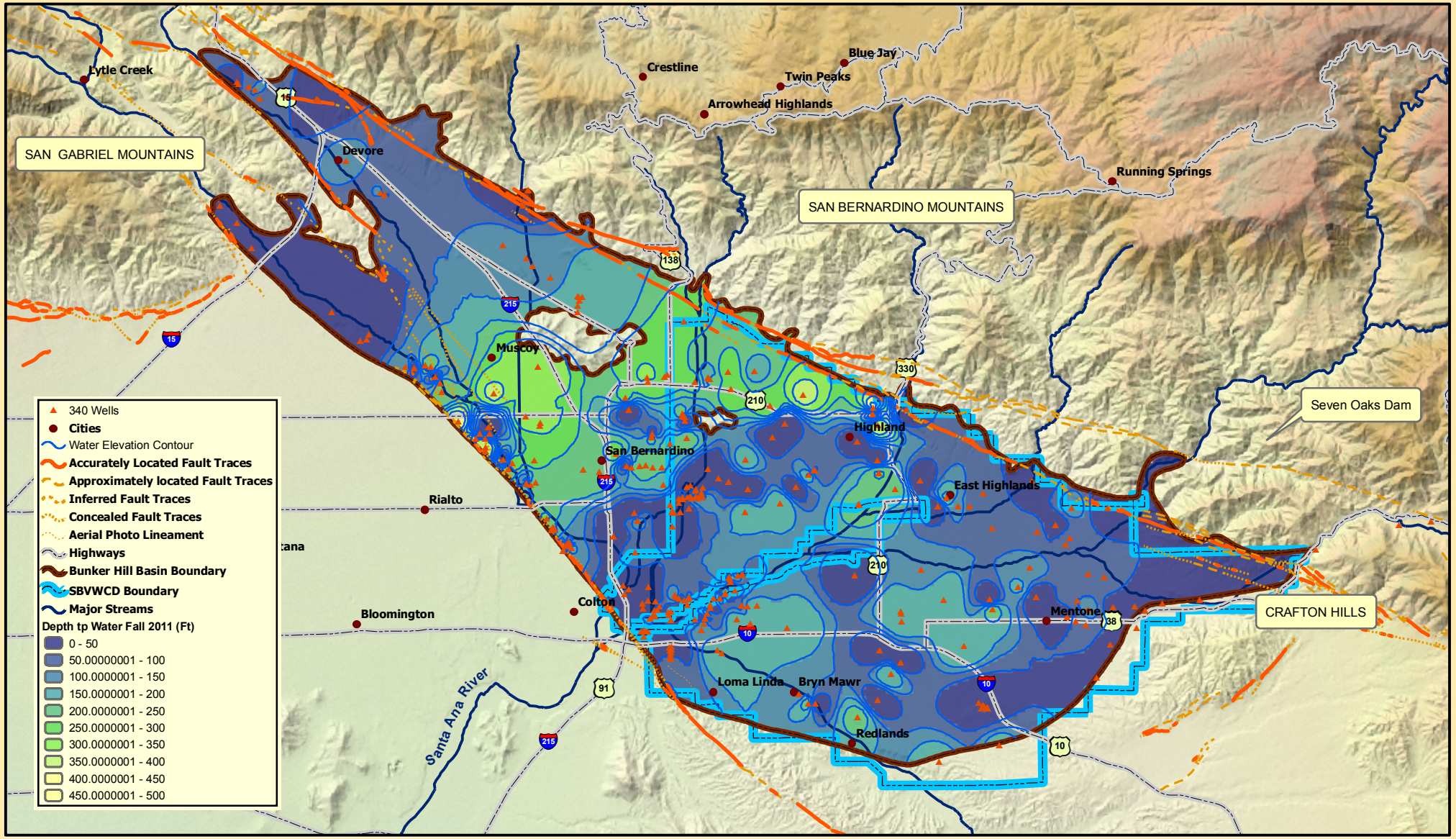
Water Elevation Contour Surface Fall 2010
2011 - 2012
Engineering Investigation Report

Engineering Investigation
March 2012

Source: SBVWCD GIS
L. Pierce

Figure 5

SBVWCD\2010EI\EI2010Maps\Fig06_WellElevContour2010.mxd (03/11)



State Plane NAD 83, Zone V, feet
10M DEM DWR
SBVWCD Water Elevation
2011 - 340 Wells
IDW Interpolation Method
Watermaster Services,
All City Water Agencies
and SBVMWD

0 0.5 1 2 3 Miles

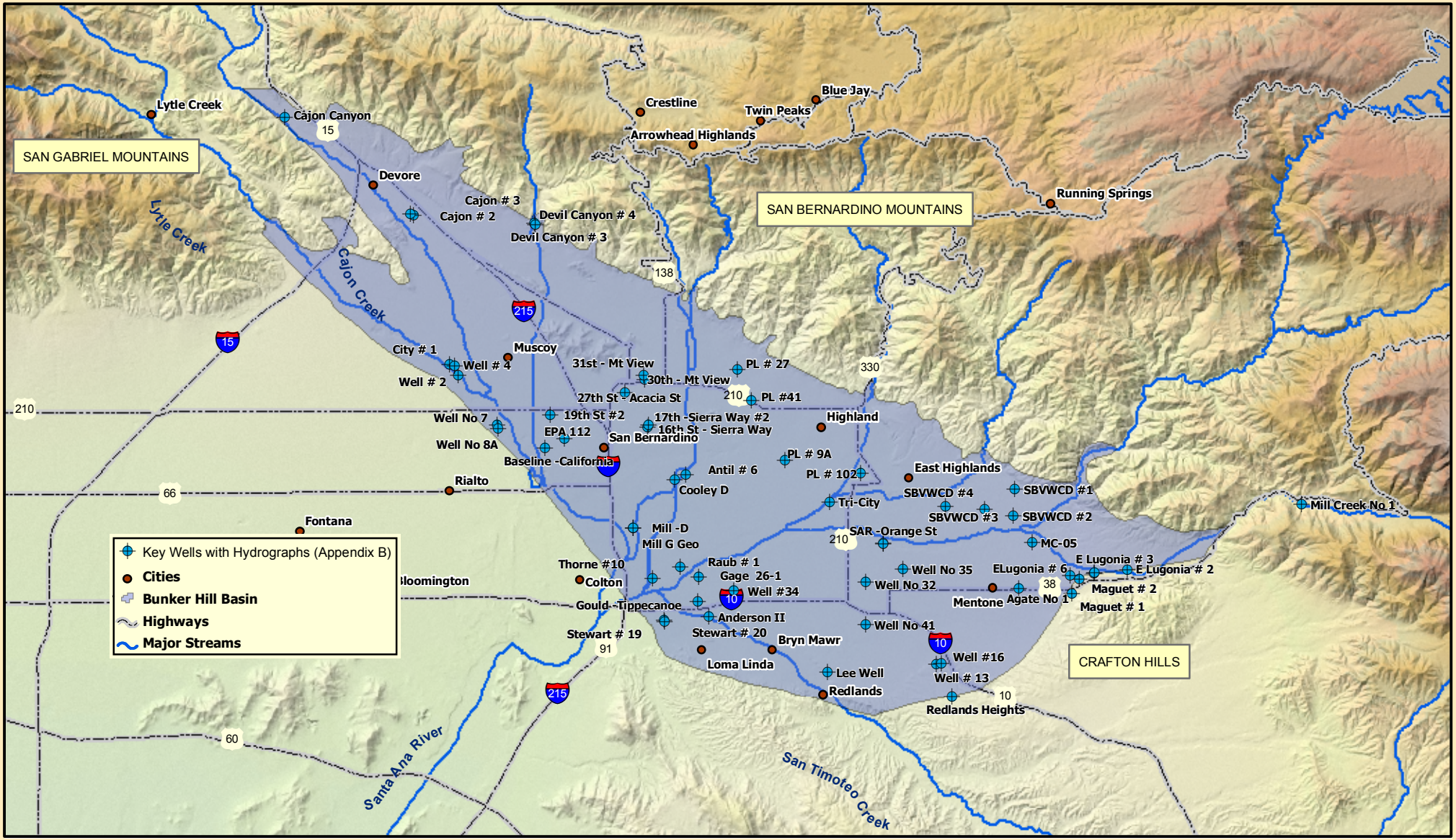
Water Elevation Contour Surface Fall 2011
2011 - 2012
Engineering Investigation Report

Engineering Investigation
March 2012

Source: SBVWCD GIS
C. Maxey

Figure 6

SBVWCD\2010EI\EI2010Maps\Fig06_WellElevContour2010.mxd (03/11)



State Plane
NAD 83, Zone V, feet
10M DEM - DWR 2008
Data Sources: 2010 -11
SBVWCD, SBVMWD, WVWD

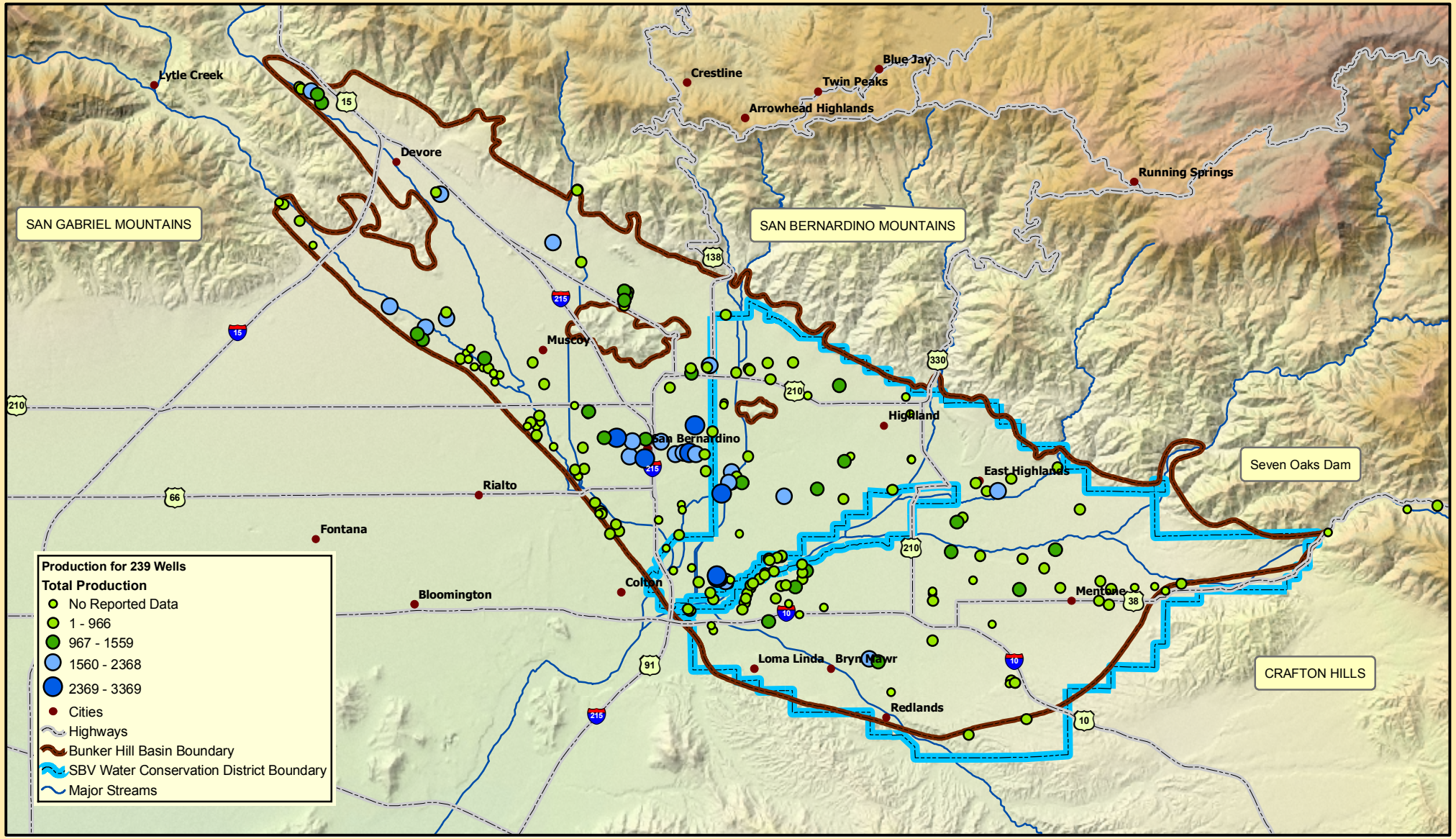
Key Wells (Appendix B Hydrographs)
2011 - 2012
Engineering Investigation Report

Engineering Investigation
March 2012
57 KEY Wells
Refer to Appendix B

Map Creation: SBVWCD GIS
L. Pierce

Figure 7

M:\EIR\2011EI\EI2011Maps\Fig07_KeyWellsHydrograph.mxd (03/7/11)



State Plane
NAD 83, Zone V, feet
10M DEM DWR
Data Sources:
SBVWCD EI Production
241 wells with 184 reporting
Watermaster Services,
All City Water Agencies
and SBVMWD

0 0.5 1 2 3 Miles

Groundwater Production -Bunker Hill Basin Subbasins
Total Well Production for July 2010 - June 2011(Water Year)
2011- 2012
Engineering Investigation Report

Engineering Investigation
March 2012

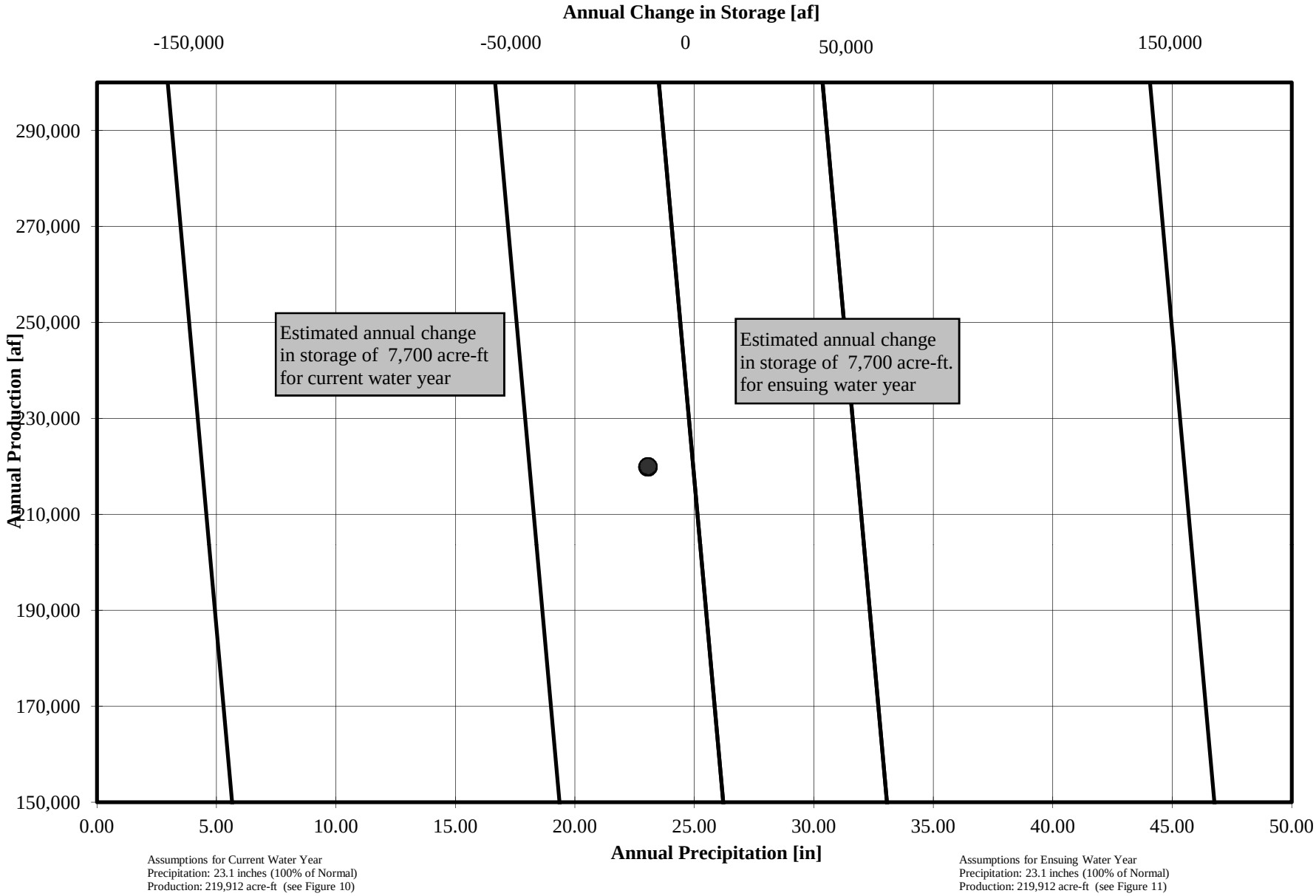
Source: SBVWCD GIS
C. Maxey

Figure 8

SBVWCD\2011EI\EI2011Maps\Fig08_Production.mxd (03/11)

Prediction Chart for Annual Change in Storage

Current and Ensuing Water Years



Assumptions for Current Water Year
Precipitation: 23.1 inches (100% of Normal)
Production: 219,912 acre-ft (see Figure 10)

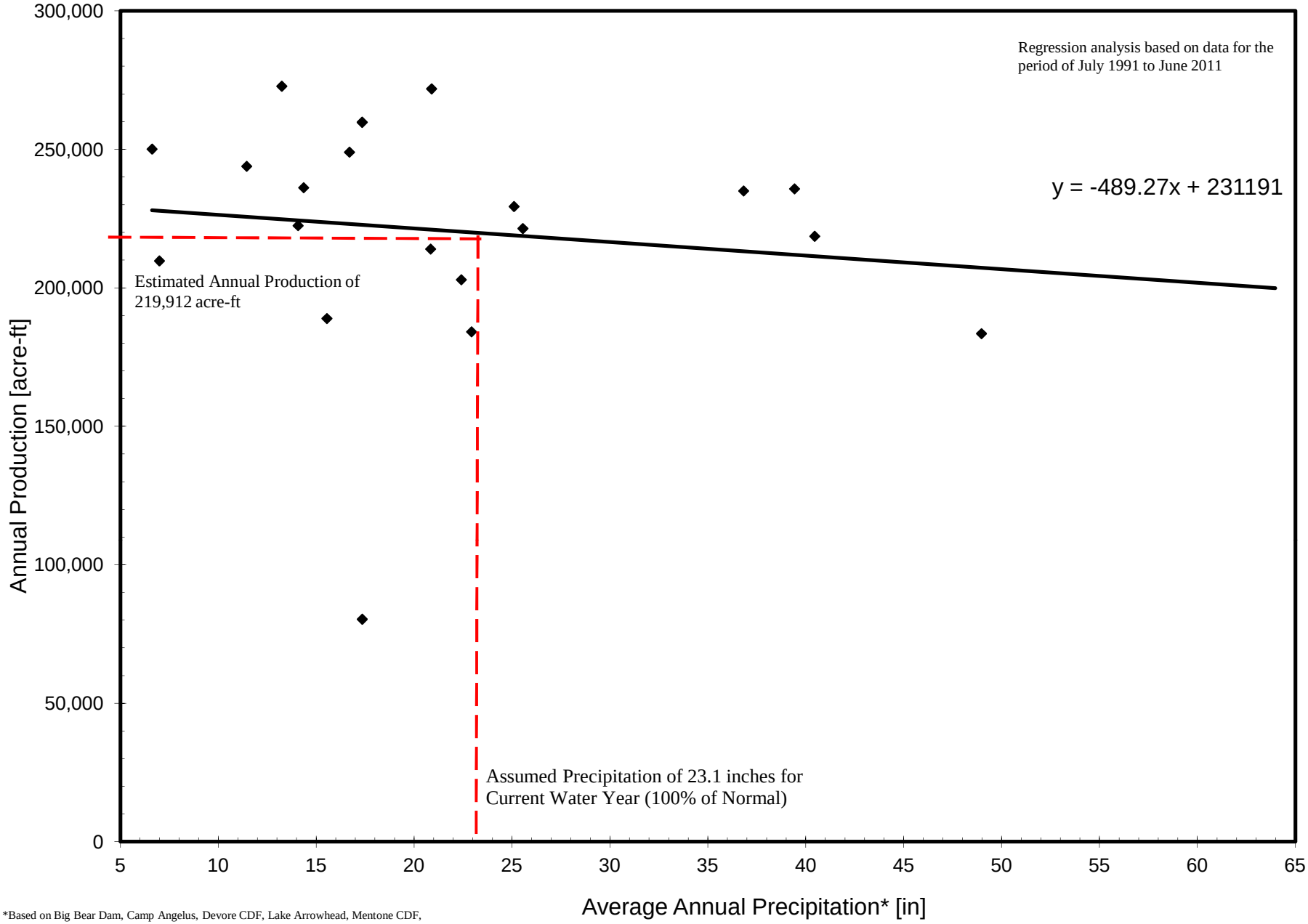
Assumptions for Ensuing Water Year
Precipitation: 23.1 inches (100% of Normal)
Production: 219,912 acre-ft (see Figure 11)

* Based on Big Bear Dam, Camp Angelus, Devore CDF, Lake Arrowhead, Mentone CDF, Redlands Country Club, San Bernardino County Hospital, Santa Ana Powerhouse #3, and Yucaipa CDF.

Change in Storage = -91450 + 7572 * Precipitation - 0.342 * Production (R^2 = 0.80)

Estimate of Production for Current Water Year

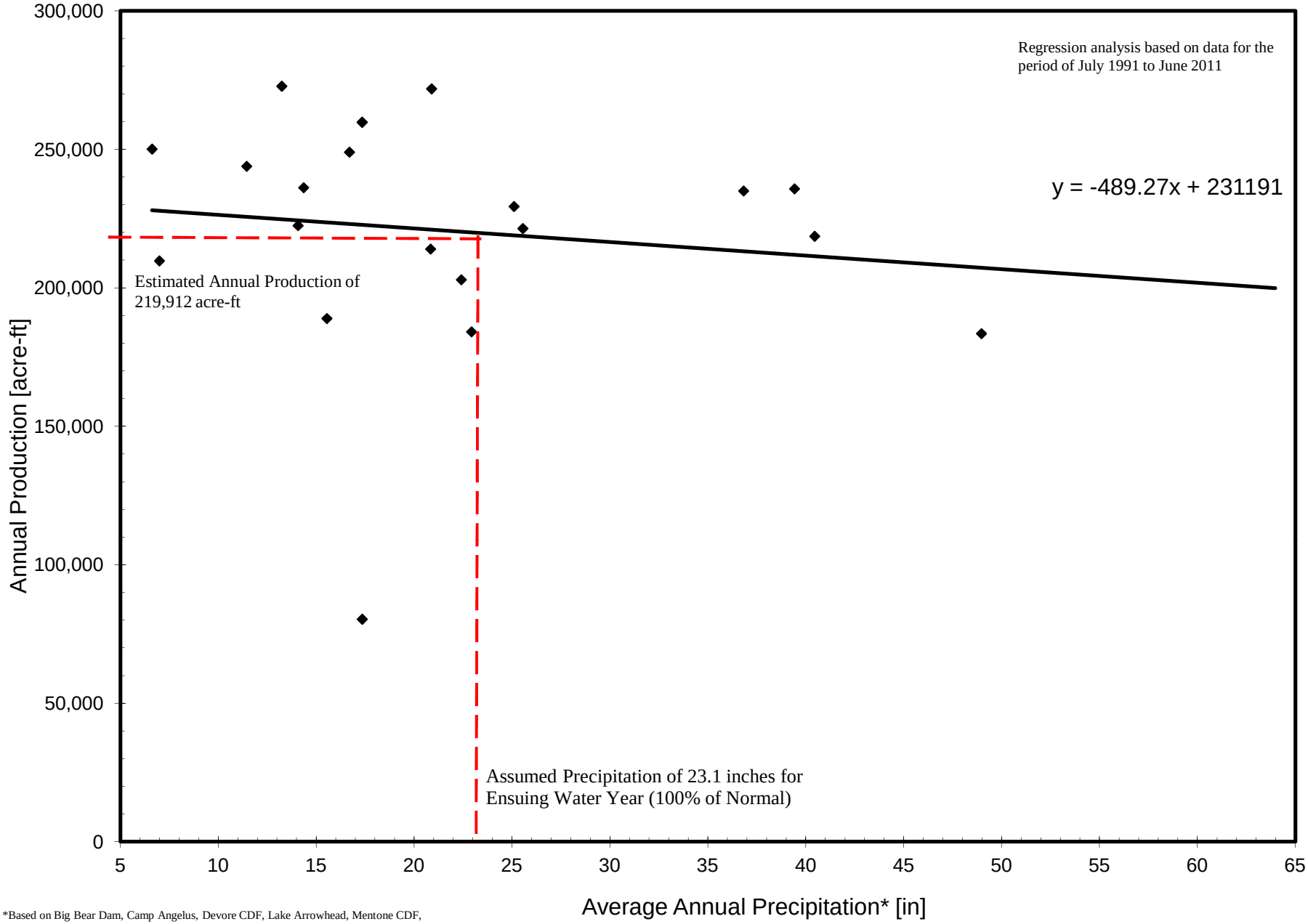
(July 2011 to June 2012)



*Based on Big Bear Dam, Camp Angelus, Devore CDF, Lake Arrowhead, Mentone CDF, Redlands Country Club, San Bernardino County Hospital, Santa Ana Powerhouse #3, and Yucaipa CDF.

Estimate of Production for Ensuing Water Year

(July 2012 to June 2013)



*Based on Big Bear Dam, Camp Angelus, Devore CDF, Lake Arrowhead, Mentone CDF, Redlands Country Club, San Bernardino County Hospital, Santa Ana Powerhouse #3, and Yucaipa CDF.

Summary of Percentage of Normal Precipitation

1984 to 2011 (Water Year - Oct. to Sept.)

Station	Historic Annual Avg. [in]	1984 -1985 [in]	1985 -1986 [in]	1986 -1987 [in]	1987 -1988 [in]	1988 -1989 [in]	1989 -1990 [in]	1990 -1991 [in]	1991 -1992 [in]	1992 -1993 [in]	1993 -1994 [in]	1994 -1995 [in]	1995 -1996 [in]	1996 -1997 [in]	1997 -1998 [in]	1998 -1999 [in]	1999 -2000 [in]	2000 -2001 [in]	2001 -2002 [in]	2002 -2003 [in]	2003 -2004 [in]	2004 -2005 [in]	2005 -2006 [in]	2006 -2007 [in]	2007 - 2008 [in]	2008 - 2009 [in]	2009 - 2010 [in]	2010 - 2011 [in]	Each Station 28 Yr. Avg. [in.]
Big Bear City	13.69654	13.23	19.12	10.18	10.59	9.37	10.23	17.81	13.96	22.92	11.53	18.59	11.17	12.06	16.83	6.53	4.75	20.14	3.33	12.62	7.55	23.25	14.36	3.67	8.53	3.51	16.24	24.55	12.84
Big Bear Dam	35.72	22.25	40.28	19.17	28.89	20.84	17.60	34.79	38.90	81.92	28.67	52.65	24.40	29.97	51.70	14.20	20.60	21.40	9.20	38.10	19.60	59.10	26.40	10.30	23.00	19.70	26.00	20.24	29.62
Camp Angelus	28.57	26.60	30.10	20.50	4.95	17.20	17.90	26.44	28.16	61.14	17.20	46.70	26.00	29.00	49.52	16.10	21.10	21.50	7.70	35.40	13.20	35.20	41.90	0.00	2.70	18.00	18.80	1.60	23.50
Crafton Hills	12.56	5.90	12.64	9.00	12.11	10.00	6.30	12.27	10.69	22.99	5.45	27.10	7.84	16.67	25.55	7.29	6.40	10.49	2.46	17.57	9.47	31.39	11.45	3.34	13.34	8.82	17.80	24.52	12.92
Del Rosa Ranger Station	18.31	15.40	20.13	9.48	18.92	13.16	12.85	8.79	24.24	41.39	12.30	27.69	14.21	17.31	37.26	8.30	12.73	16.60	6.09	19.69	13.02	38.55	17.40	8.77	17.77	13.57	22.01	30.84	18.46
Devore CDF	27.50	23.99	36.79	12.39	17.90	10.75	15.00	20.41	31.32	63.98	15.40	45.44	20.58	33.10	45.13	13.61	8.04	15.52	10.90	35.35	16.44	60.36	24.80	8.86	25.21	16.51	34.12	43.20	26.11
Fallsvale	31.88	16.90	50.00	23.00	20.30	3.50	51.00	22.50	36.00	71.90	52.00	54.90	22.10	33.80	53.00	16.30	21.20	15.30	6.50	37.50	25.20	61.40	26.90	11.10	29.30	24.70	2.85	29.52	30.32
Lake Arrowhead	40.27	30.76	50.56	23.74	40.39	28.51	26.62	23.68	45.24	85.00	28.20	74.51	30.84	36.50	72.80	18.10	25.80	28.60	10.70	36.50	22.70	69.70	46.20	18.50	41.91	30.28	26.00	37.76	37.41
Loma Linda FD	11.07	9.15	13.16	7.41	10.45	8.84	7.69	7.16	13.44	25.56	10.99	19.02	7.15	9.78	22.74	5.12	7.74	6.38	2.45	14.48	8.06	22.59	11.06	3.51	9.63	8.95	13.10	18.24	11.25
Lytle Creek at Foothill	13.17	10.19	16.04	7.00	12.96	3.90	8.50	15.51	14.91	31.61	9.16	25.51	12.23	13.83	25.84	6.25	9.81	12.12	4.00	13.60	7.16	27.23	11.22	3.84	11.89	9.03	13.03	0.23	12.47
Lytle Creek Fire Station	23.94	18.95	27.60	11.20	22.40	12.83	17.90	32.07	49.09	87.71	20.50	47.57	24.49	23.10	52.18	11.81	20.40	18.34	4.47	16.96	12.09	44.11	18.92	4.22	21.89	3.32	0.00	28.46	24.17
Mentone CDF	12.61	7.74	12.01	9.23	8.85	8.64	6.13	12.55	15.93	23.85	8.35	17.10	9.42	15.73	27.09	4.28	9.08	10.16	4.06	15.00	10.38	24.94	11.01	5.41	10.75	9.38	14.96	17.77	12.21
Oak Glen	27.08	22.02	26.00	19.29	21.46	17.82	17.71	26.92	30.78	57.96	18.76	57.92	20.04	30.39	49.46	11.32	17.12	12.28	6.72	14.28	18.39	34.14	22.58	9.71	27.60	19.92	29.72	36.82	25.08
Redlands - Roth	12.31	8.72	9.25	7.79	11.18	8.08	7.21	13.34	14.96	25.57	10.06	20.49	8.08	10.77	22.29	6.46	7.41	10.38	3.35	12.18	9.16	24.43	9.52	3.31	9.46	8.82	15.12	17.38	11.66
Redlands Country Club	13.83	10.74	13.38	8.80	14.18	10.68	8.58	14.48	16.11	29.44	12.55	19.76	8.52	9.03	17.22	6.30	5.68	9.96	3.97	16.45	11.58	29.37	10.30	4.13	11.93	11.35	17.25	22.33	13.11
San Bernardino CDF	17.55	16.06	20.12	9.27	18.26	12.85	10.55	15.49	21.89	37.35	4.46	20.29	15.77	16.17	34.32	9.30	13.62	16.61	5.29	13.14	11.52	37.28	16.39	6.33	18.91	9.85	20.45	27.94	17.02
San Bernardino Co. Hospital	15.93	12.86	17.86	8.08	13.53	12.63	8.12	15.48	16.54	30.78	11.65	24.10	11.92	17.80	32.67	8.02	11.09	2.33	3.60	17.06	10.49	29.89	13.20	4.68	12.81	10.05	17.03	21.76	14.67
Santa Ana Pumphouse #3	17.04	11.88	15.87	12.28	14.67	9.38	10.32	15.84	18.38	22.98	15.92	24.85	11.05	16.60	27.95	7.01	6.78	8.63	3.23	18.24	9.40	27.65	11.78	6.13	10.73	9.73	14.58	20.18	14.15
Yucaipa CDF	15.89	10.69	12.96	11.02	11.33	9.74	7.25	11.16	17.85	34.20	11.40	30.24	10.52	15.62	24.70	7.63	11.10	9.92	5.66	19.47	11.84	32.70	13.14	6.56	14.67	12.11	18.79	25.09	15.09
Yucaipa Valley Water District	15.93	12.31	15.20	10.55	14.36	10.55	10.84	16.98	18.68	18.08	12.51	25.20	10.88	16.93	28.60	9.87	9.63	9.65	5.27	19.50	11.10	32.73	12.52	5.53	14.79	12.11	17.68	22.74	14.99
Percent of Normal	**102%**	**76%**	**113%**	**62%**	**81%**	**59%**	**69%**	**90%**	**118%**	**216%**	**78%**	**168%**	**76%**	**100%**	**177%**	**48%**	**62%**	**68%**	**27%**	**105%**	**64%**	**184%**	**92%**	**32%**	**83%**	**64%**	**88%**		**93%**

Total Station Average	**20.24**

Source: San Bernardino County Department of Transportation/Flood Control

Change in Groundwater Levels in Key Wells

Fall 2010 to Fall 2011

WCDCode	State Well Number	Well Name	Owner Or Measuring Agency	2010 Depth To Water (ft)	2011 Depth To Water (ft)	Difference Fall 2010 to Fall 2011
1364	1S3W04J01S	102	East Valley Water District	230.0	216.2	13.8
1510	2N5W19K02S	Cajon Canyon Well	San Bernardino, City of	56.1	44.8	11.3
1520	1N4W27M02S	27th Street Well	San Bernardino, City of	287.5	261.4	26.1
1537	1S4W10N06S	Mill & D	San Bernardino, City of	93.5	92.2	1.3
1537	01S/04W-10N	#62, Mill & "D"	San Bernardino, City of / shallow wells	93.8		
1591	2S3W01E01S	Redlands Heights	Redlands, City of	170.0	172.0	-2.0
1612	1N5W36H04S	7/Lord 7	West Valley Water District	427.0		
1662	1S4W14P02S	Raub 1	Riverside, City of	134.0	133.8	0.1
1668	1S4W02P02S	Cooley D	Riverside, City of	140.0	146.4	-6.4
1677	1S4W27A19S	Stewart 19	Riverside, City of		121.0	
1702	1N5W23Q01S	City 1	Rialto, City of	284.0	212.0	72.0
1706	1S2W36F01S	Maguet #1	Redlands, City of	20.0	16.0	4.0
1707	1S1W08H01S	Mill Creek #1	Redlands, City of	0.0		
1708	1S2W22C02S	E. Lugonia #2	Redlands, City of			
1709	1S2W21E01S	Maguet #2	Redlands, City of	45.0	24.0	21.0
1712	1S2W21B02S	E. Lugonia #3	Redlands, City of	28.0	21.0	7.0
1714	1S2W21D01S	E. Lugonia #6	Redlands, City of	51.0	22.0	29.0
1718	1S3W35G09S	Well #13	Redlands, City of	64.0	58.0	6.0
1720	1S3W35H03S	Well #16	Redlands, City of	44.0	38.0	6.0
1722	1S3W21H01S	Well #32	Redlands, City of	205.0	182.0	23.0
1723	1S4W24K01S	Well #34	Redlands, City of	196.0	200.0	-4.0
1725	1S3W28H01S	Well #41	Redlands, City of	276.0		
1727	1S2W19K01S	Agate #1	Redlands, City of	140.0	71.0	69.0
1744	1S4W27H01S	Stewart 20	Riverside, City of		127.2	
1819	1S3W15F01S	Orange Street	Redlands, City of	154.0	118.0	36.0
1851	1S3W06H04S	9A	East Valley Water District	216.2	205.0	11.2
1865	1N4W25A01S	27	East Valley Water District	206.0	191.0	15.0
1910	1N5W03H02S	Cajon Well #2	San Bernardino, City of	153.0	117.5	35.5
1936	1N5W23Q01S	2/Lower 7	West Valley Water District	292.0	223.0	69.0
1964	1S3W22A02S	Well #35	Redlands, City of	232.0	200.0	32.0
1970	1S3W32J02S	Lee Well	Redlands, City of	219.0	212.0	7.0
1979	1N4W27B01S	31st & Mtn. View	San Bernardino, City of	324.2	306.0	18.2
1984	1N3W30N01S	41	East Valley Water District	306.0	297.0	9.0
2007	1N4W06H01S	Devil Canyon #4	San Bernardino, City of	41.2	42.5	-1.3
2008	1N4W06H02S	Devil Canyon #3	San Bernardino, City of	26.9	26.9	0.0
2062	1N4W32N01S	Baseline Well	San Bernardino, City of	257.0	270.2	-13.2
2066	1S4W02K08S	Antil Well #6	San Bernardino, City of	172.0	156.3	15.7
2115	1N5W03A02S	Cajon Well #3	San Bernardino, City of	147.5	114.1	33.4
2286	1S3W12J01S	SBVWCD #3	San Bernardino Valley Water Cons. Dist.	108.7	59.8	48.9
2288	1S3W11H01S	SBVWCD #4	San Bernardino Valley Water Cons. Dist.	170.4	89.5	80.9
2290	1S2W07K01S	SBVWCD #2	San Bernardino Valley Water Cons. Dist.	104.0	74.5	29.6
2291	1S2W07B01S	SBVWCD #1	San Bernardino Valley Water Cons. Dist.	160.7	112.2	48.4
1519	1N4W27G01S	30th & Mtn. View	San Bernardino, City of	318.9	295.8	23.1
1010	1S3W09E02S	Tri-City Concrete	East Valley Water District	217.2	203.0	14.2
1401	1S3W01H01S	142 Mt. Harrison	East Valley Water District	220.5	118.8	101.7
1419	1N5W25E01S	5A/Lower 5	West Valley Water District	271.0	237.0	34.0
1514	1N4W16E01S	Newmark #1	San Bernardino, City of	185.4	165.2	20.2
1516	1N4W16E03S	Newmark #3	San Bernardino, City of	190.8	170.7	20.1
1517	1N4W32D03S	19th Street No. 1	San Bernardino, City of		300.4	
1525	1N4W34G01S	17th & Sierra Way #2	San Bernardino, City of			
1554	1S4W23A02S	26-1	Riverside, City Of-Gage Canal	158.0		
1647	1N4W26P03S	Perris Hill #5	San Bernardino, City of	272.6	246.5	26.1
1660	1N3W33F01S	94 Corwin	East Valley Water District	393.6	391.1	2.5
1683	1S4W22H04S	Warren 1	Riverside, City of			
1767	1S4W22B03S	Thorn 10	Riverside, City of			
2271	1S4W25D07S	Anderson III	Western Municipal Water District			
2448	1S4W23H	#52 Brier/Gould/Tippecanoe	San Bernardino, City of / shallow wells	38.0		
3139	01N/04W-32P--S	EPA EXTRAC WELL 112	San Bernardino, City of	424.0	347.6	76.4
	01S/04W-22C	#21,Wastewater N MW #1	San Bernardino, City of / shallow wells			

Annual Change in Storage for Bunker Hill Basin

Fall 2010 to Fall 2011

Sub-area	[1] Annual Change in Water Level 2011 [ft]	[2] Area [acres]	[3] Storativity (*S*)	[4] Annual Change in Storage** [acre-ft]
Bunker Hill I - Northeast of 215 Freeway	12.5	7,795	0.11	**10,707**
Bunker Hill I - Southwest of 215 Freeway	-1.2	11,714	0.09	**-1,223**
Bunker Hill II - West of Mentone Fault	23.0	35,206	0.06	**48,529**
Bunker Hill II - East of Mentone Fault, North	32.8	8,584	0.13	**36,622**
Bunker Hill II - East of Mentone Fault, South	3.6	2,507	0.13	**1,182**
Lytle Basin - Northwest of Barrier J	0.0	1,924	0.13	**0**
Lytle Basin - Southeast of Barrier J	45.3	5,237	0.07	**16,597**
Pressure Zone - North of Santa Ana Wash	9.6	11,920	0.02	**2,294**
Pressure Zone - Santa Ana Wash	9.8	6,686	0.02	**1,313**
			Total =	**116,020**

[1] Based on average changes in water level within each Sub-area

[2] Estimated using GIS

[3] Based on data from Hardt and Hutchinson (1980).

S, storativity: The amount of water stored or released per unit area of aquifer given unit head change.

[4] = [1] x [2] x [3]

*A positive sign denotes an increase in water level and a negative sign represents a decline in water level.

Accumulated Change in Storage for Bunker Hill Basin

1989 to 2011 (Based on "Zero Year" of 1993)

Year	Accumulated Storage [acre-ft]
1989	-58,000
1990	-170,700
1991	-196,000
1992	-191,000
1993	0
1994	-50,000
1995	41,100
1996	-43,100
1997	-75,500
1998	40,400
1999	-85,700
2000	-131,100
2001	-212,200
2002	-301,500
2003	-338,800
2004	-406,900
2005	-183,100
2006	-245,500
2007	-359,400
2008	-362,000
2009	-397,600
2010	-340,623
2011	**-224,603**

Note: A negative sign indicates a decline in storage and a positive sign represents an increase in storage.

Production for Sub-basins of Bunker Hill Basin

Preceding Water Year (July 2010 to June 2011)

Sub-area	Production July 2010 to June 2011 [acre-ft][2]
Bunker Hill I - Northeast of Interstate 215	7,488
Bunker Hill I - Southwest of Interstate 215	19,512
Bunker Hill II - West of Mentone Fault	35,731
Bunker Hill II - East of Mentone Fault, North	4,479
Bunker Hill II - East of Mentone Fault, South	1,188
Lytle Basin - Northwest of Barrier J	1,603
Lytle Basin - Southeast of Barrier J	15,624
Pressure Zone - North of Santa Ana Wash	66,476
Pressure Zone - Santa Ana Wash	32,020
Total	**184,122**

Notes: 239 Wells Used in these Calculations

1 - Refer to Appendix C for Well Values Compiled for Estimate.

2 - Estimated for Water Year July 2010-June 2011 production.

Data Sources: 25 Primary Water Purveyors (excluding Fontana Union),
as well as San Bernardino Watermaster, and SBVMWD.

Estimates of Percentage of Normal Precipitation for Previous Water Year

July 2010 to June 2011

	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	July to June	**July. to June**	**Season - July to December**			**Season - January to June**			**Jul. 2010 to Jun. 2011**
Station	**Historic Average Annual**	**2010-2011**	**Historic Average**	**Sum Jul 2010 to Dec 2010**	**% of Normal**	**Historic Average**	**Sum Jan 2011 to Jun 2011**	**% of Normal**	**Water Year % of Normal**
	[inches]	**[inches]**	**[inches]**	**[inches]**	**[%]**	**[inches]**	**[inches]**	**[%]**	**[%]**
Big Bear Dam	35.3	20.2	11.7	18.8	161%	23.7	1.5	6%	57%
Devore CDF	27.7	42.6	8.5	28.5	335%	19.2	14.1	73%	154%
Camp Angelus	28.2	0.9	9.7	0.0	0%	18.6	0.9	5%	3%
Lake Arrowhead	40.4	36.6	13.1	19.0	145%	27.3	17.6	64%	90%
Mentone CDF	12.7	17.5	3.9	11.7	301%	8.8	5.9	67%	138%
Redlands Country Club	14.1	22.1	4.3	13.9	324%	9.8	8.2	84%	157%
San Bernardino County Hospital	16.0	21.5	5.0	14.4	292%	11.0	7.1	64%	135%
Santa Ana Pumphouse #3	17.0	20.1	5.5	13.8	251%	11.5	6.3	55%	118%
Yucaipa CDF	16.0	24.8	5.0	15.5	312%	11.1	9.4	85%	155%
Avg (in) =	**23.1**	**22.9**		**Average =**	**236%**		**Average =**	**56%**	
								2010-11 Average =	**112%**

[1], [4]: Based on data provided by San Bernardino County Department of Transportation/Flood Control

[3] = ([2] / [1]) x 100

[5] = [0] - [2]

[6] = ([5] / [4]) x 100

[7] =(([2] + [5]) / ([1] + [4])) x 100

Average Annual Change in Storage for Bunker Hill Basin

Fall 2001 to Fall 2011

(The Immediate Past 10 Water Years)

Sub-area	[1] Average Change in 10 Years in Water Level* [ft]	[2] Area [acres]	[3] Storativity (*S*)	[4] Average Annual Change in Storage** [acre-ft]
Bunker Hill I - Southwest of 215 Freeway	-2.34	11,714	0.09	-2,410
Bunker Hill I - Northeast of 215 Freeway	0.35	7,795	0.11	296
Bunker Hill II - West of Mentone Fault	-5.27	35,206	0.06	-10,944
Bunker Hill II - East of Mentone Fault	2.54	11,091	0.13	3,663
Lytle Basin - Southeast of Barrier J	18.56	5,237	0.07	6,804
Lytle Basin - Northwest of Barrier J	-0.97	1,924	0.13	-243
Pressure Zone - North of Santa Ana Wash	14.66	11,920	0.02	3,495
Pressure Zone - Santa Ana Wash	-7.65	6,686	0.02	-1,023
			Total =	**-362**

[1] Based on average annual changes in water level within each Sub-area over last 10 years.
(See Appendix E)

[2] Estimated using GIS.

[3] Based on data from Hardt and Hutchinson (1980).

S storativity: The amount of water stored or released per unit area of aquifer given unit head change.

[4] = [1] x [2] x [3]

*A positive sign denotes an increase in water level and a negative sign represents a decline in water level.

Summary of Surface Distribution Water for Bunker Hill Basin

1984 to 2010

Streamflow Diversions	1985 [acre-ft]	1986 [acre-ft]	1987 [acre-ft]	1988 [acre-ft]	1989 [acre-ft]	1990 [acre-ft]	1991 [acre-ft]	1992 [acre-ft]	1993 [acre-ft]	1994 [acre-ft]	1995 [acre-ft]	1996 [acre-ft]	1997 [acre-ft]	1998 [acre-ft]
Lytle Creek														
Fontana Union WC	2,743	1,798	2,725	2,991	2,245	204	1,633	12,980	7,860	12,270	10,000	10,100		
Mount Vernon WC	724	724	724	724	724	724	724	724	1,143	102	0	0	0	0
Rialto, City of	1,075	1,325	539	1,111	1,005	792	1,014	743	193	843	44	1,070	393	896
San Bernardino, City of	1,448	1,448	1,448	1,448	1,448	1,448	1,448	1,448	520		2,400	2,400	0	0
West Valley Water District	3,340	3,686	3,686	3,696	3,696	2,554	3,701	3,696	3,696	3,697	3,696	3,686	4,079	3,696
Subtotal	**9,330**	**8,981**	**9,122**	**9,970**	**9,118**	**5,722**	**8,520**	**19,591**	**13,412**	**16,912**	**16,140**	**17,256**	**4,472**	**4,592**
Mill Creek														
Redlands, City of	12,932	11,676	11,178	7,731	8,285	6,794	11,109	14,559	19,086	14,505	9,786	12,250	10,250	11,224
SBVWCD Mill Creek Spreading														
SBVWCD-MC-DWR														
Subtotal	**12,932**	**11,676**	**11,178**	**7,731**	**8,285**	**6,794**	**11,109**	**14,559**	**19,086**	**14,505**	**9,786**	**12,250**	**10,250**	**11,224**
Bunker Hill Creeks														
Arrowhead Water & Power West Twin Crk														
Arrowhead Water & Power East Twin Crk														
Devore Water Company Kimbark Lower Cajon														
Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Santa Ana River														
Bear Valley Mutual WC	19,837	23,160	16,373	14,170	14,785	11,244	20,651	26,014	42,079	23,812	30,794	38,252	31,479	36,632
Redlands Water Co		1,122	961	963	890	577							760	
SBVWCD SAR Spreading														
SBVWCD-DWR-SAR														
Subtotal	**19,837**	**24,282**	**17,334**	**15,133**	**15,675**	**11,821**	**20,651**	**26,014**	**42,079**	**23,812**	**30,794**	**38,252**	**32,239**	**36,632**

Streamflow Diversions	1999 [acre-ft]	2000 [acre-ft]	2001 [acre-ft]	2002 [acre-ft]	2003 [acre-ft]	2004 [acre-ft]	2005 [acre-ft]	2006 [acre-ft]	2007 [acre-ft]	2008 [acre-ft]	2009 [acre-ft]	2010 [acre-ft]	2011 [acre-ft]	Avg. [acre-ft]
Lytle Creek														
Fontana Union WC									8,209	7,336	5,050	*5,000*	5750*	5,821
Mount Vernon WC	0	0	0	0	0	0	0	0	0	0	0	0	0	**261**
Rialto, City of	1,461	NA	1,305	1,143	726	1,707	1,209	1,448	1,160	1165.00	1,135	*1,000*	1,148	987
San Bernardino, City of	0	0	0	0	0	580	5	254	483	498	*450*	*450*	520*	785
West Valley Water District	3,408	3,047	3,175	2,573	2,380	4,710	2,079	3,081	NA	3,369	*2,435*	*3,322*	3382	3,368
Subtotal	**4,869**	**3,047**	**4,480**	**3,716**	**3,106**	**6,997**	**3,293**	**4,783**	**9,852**	**12,368**	**9,070**	**9,772**	**4,530**	**11,222**
Mill Creek														
Redlands, City of	11,951	8,852	9,496	5,867	12,541	10,168	12,574	15,409	9,607	12,332	5,485	7,004	7187	10,735
SBVWCD MC							29,138	9,510	1,531	3,810	4,450	8,891	16,185	10,502
SBVWCD-MC-DWR							0	0	0	431	555	831	1,434	464
Subtotal	**11,951**	**8,852**	**9,496**	**5,867**	**12,541**	**10,168**	**41,712**	**24,919**	**11,138**	**16,573**	**10,490**	**16,726**	**24,806**	**21,701**
Bunker Hill Creeks														
Arrowhead Water & Power West Twin Crk						50	50	50	50	40	*40*	*40*	25	43
Arrowhead Water & Power East Twin Crk						2,500	1,750	1,700	1,725	3	*200*	*200*	127	1,026
Devore Water Company Kimbark						29	97	80	62	68	*68*	*68*	0	59
Subtotal	**0**	**0**	**0**	**0**	**0**	**2,579**	**1,897**	**1,830**	**1,837**	**111**	**308**	**308**	**152**	**1,128**
Santa Ana River														
Bear Valley Mutual WC	30,245	29,498	26,301	23,458	12,633	11,227	12,516	17,689	11,560	13,519	7,303	*7,000*	15,445	21,025
Redlands Water Co							981	1,044	884	1,044	1,474	*1,000*	1150*	975
SBVWCD SAR Spreading							27,841	14,476	4,002	17,550	8,456	21,662	36,801	18,684
SBVWCD-DWR-SAR							0	5,855	1,993	0	981	1,115	1,511	1,636
Subtotal	**30,245**	**29,498**	**26,301**	**23,458**	**12,633**	**11,227**	**41,338**	**39,064**	**18,439**	**32,113**	**18,214**	**30,777**	**29,488**	**42,321**

*** Assumed and are provisional data.**

Total =	**76,371**

2011 Total =	58,976

Source: Calendar year totals from Western Municipal Water District