ENGINEERING INVESTIGATION
Bunker Hill Basin
2008-2009

ADDENDUM

Groundwater Conditions in the San Bernardino Valley Water Conservation District

1630 W. Redlands Blvd.
Suite A
Redlands, CA 92373
(909) 793-2503
Fax (909) 793-0188

BOARD OF DIRECTORS

Melody A. McDonald, President

Manuel Aranda, Jr., Vice President

Richard Corneille

Clare Henry Day

Arnold L. Wright

Cheryl A. Tubbs

John Longville

R. Robert Neufeld, General Manager

SBV WATER CONSERVATION DISTRICT

OUR NAME IS OUR MISSION

Acknowledgments

The staff of San Bernardino Valley Water Conservation District would like to recognize the efforts of those agencies that contributed data for this Engineering Investigation. The cooperation received from the following agencies is gratefully acknowledged.

- **City of Colton**
- **City of San Bernardino**
- **East Valley Water District**
- **Gage Canal Company**
- **City of Riverside**
- **City of Redlands**
- **West Valley Water District**
- **Riverside Highland Water Company**
- **United States Geological Survey, Santee, CA Office**
- **Western Municipal Water District**
- **San Bernardino Valley Municipal Water District**
- **Watermaster Support Services**
- **San Bernardino County Department of Flood Control**
- **Elsinore Valley Municipal Water District/Meeks and Daley Water Company**
- **Big Bear Grizzly**
- **Redlands Daily Facts**

Figures

Tables

Appendices

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** for locations.

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (Fall 2007 to Fall 2008);

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (June 30, 2008);

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2007 - June 30, 2008);

Task 4. Estimate of the annual change in the Bunker Hill Basin storage for the current water year (July 1, 2008 - June 30, 2009);

Task 5. Estimate of the annual change in the Bunker Hill Basin storage for the ensuing water year (July 1, 2009 - June 30, 2010);

Task 6. Average annual change in Bunker Hill Basin storage for the immediate past ten water years (1998 - 2008);

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, 2009 - June 30, 2010);

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, 2009 - June 30, 2010); 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, 2009 - June 30, 2010).

To make the findings and determinations listed above, District staff researched available hydrogeologic 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 was developed. This relationship, based on empirical data, 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 historic water level changes throughout the Bunker Hill Basin.

Based on 20 measuring stations, precipitation throughout the contributing watershed was 88 percent of normal for the period October 1, 2007 to September 31, 2008. The amount of groundwater storage in the Bunker Hill Basin decreased by 2,600 acre-feet.

The required findings for the 2009 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.

This report was modified from the original Engineering Investigation Report of March 11, 2009, due to well production values and water level data that were received after the initial completion date that substantially changed the predicted usage values for the ensuing water year (2009-10). Tasks affected were number 3, and 7. Due to the magnitude of the modifications, staff felt an updated report was warranted.

Summary of Findings for the 2009 Engineering Investigation

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (Fall 2008 groundwater levels)

- Change in storage between Fall 2007 and Fall 2008 (See Table 3)

-2,600 acre-feet (decrease)

The amount of water stored in the Basin decreased by 2,600 acre-feet between 2007 and 2008.

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (June 30, 2008)

- Accumulated change in storage between Fall 1993 and Fall 2008[1] (See Table 4)

-362,200 acre-feet (decrease)

The amount in storage in the Fall of 2008 is 362,200 acre-feet less than in the Fall of 1993.

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2007 - June 30, 2008) (See Table 5)

133,840 acre-feet

[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, 2008 - June 30, 2009)

-8,628 acre-feet (decrease)

The amount of water in the Basin is estimated to decrease by also 8,628 acre-feet 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, 2009 - June 30, 2010)

-8,628 acre-feet (decrease)

The amount of water in the Basin is estimated to decrease by 8,628 acre-feet during the ensuing water year.

Task 6. Average annual change in Bunker Hill Basin storage for the immediate past 10 water years (1998 - 2008) (See Table 7)

-32,400 acre-feet (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, 2009 - June 30, 2010) (See Page 21)

- Estimated amount of agricultural water withdrawn from the groundwater supplies within the District boundary for the ensuing water year (July 1, 2009 - June 30, 2010)

8,831 acre-feet

- Estimated amount of other than agricultural water withdrawn from the groundwater supplies of the District for the ensuing water year (July 1, 2009 - June 30, 2010)

79,520 acre-feet

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, 2009 - June 30, 2010)

- Estimated amount of water necessary for surface distribution for the ensuing water year (July 1, 2009 - June 30, 2010) for the Bunker Hill Basin (Used Table 8, 2007 Average)

42,223 acre-feet

- Estimated amount of water necessary for surface distribution for the ensuing water year (July 1, 2009 - June 30, 2010) within the District boundary

33,340 acre-feet

Task 9. The amount of water necessary from all sources, including natural recharge, to maintain constant groundwater supplies in the Bunker Hill Basin for the ensuing water year (July 1, 2009 to June 30, 2010)

- The amount of water necessary from all sources, including natural recharge, to maintain constant groundwater supplies in the Bunker Hill Basin for the ensuing water year (July 1, 2009 to June 30, 2010)

205,650 acre-feet

- The amount of water necessary from all sources, including natural recharge, to maintain constant groundwater supplies within the District boundary for the ensuing water year (July 1, 2009 to June 30, 2010)

223,122 acre-feet

- The amount of water necessary from all sources, including natural recharge, to bring the basin back to "full" in the ensuing water year (July 1, 2009 to June 30, 2010)

576,278 acre-feet

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 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 2008-09 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.

Based on the results of the 2009 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 362,000 acre-feet below that which is considered full for purposes of this Investigation.

- During the ensuing water year (July 1, 2009 to June 30, 2010), the Bunker Hill Basin can be recharged, from all sources, with 576,278 acre-feet of water. This recharge quantity is needed to maintain the 1993 storage level considered full.

- The District should continue to take the necessary steps to enhance its capability to conduct recharge operations, which includes consideration 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.

2.0 Introduction

2.1 Purpose and Scope

The San Bernardino Valley Water Conservation District (District) was created by popular vote 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 percent of the Bunker Hill Basin. **Figure 1** displays the project area map for the Engineering Investigation. It includes the District boundary along with its location relative to the Interstate and State highways.

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.

Task 1. Annual change in storage for the Bunker Hill Basin for the preceding water year (Fall 2007 to Fall 2008);

Task 2. Accumulated change in storage of the Bunker Hill Basin as of the last day of the preceding water year (June 30, 2008);

Task 3. Total groundwater production from the Bunker Hill Basin for the preceding water year (July 1, 2007 - June 30, 2008);

Task 4. Estimate of the annual change in the Bunker Hill Basin storage for the current water year (July 1, 2008 - June 30, 2009);

Task 5. Estimate of the annual change in the Bunker Hill Basin storage for the ensuing water year (July 1, 2009 - June 30, 2010);

Task 6. Average annual change in Bunker Hill Basin storage for the immediate past ten water years (1998 - 2008);

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, 2009 - June 30, 2010);

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, 2009 - June 30, 2010); 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, 2009 - June 30, 2010).

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, based on empirical data, enables the prediction of change in storage, given certain annual production and precipitation levels. 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. 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 presented on **Figure 2**.

The major streams providing inflows and outflows for the Bunker Hill Basin are also provided on **Figure 2**. 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 percent 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 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. Precipitation in the region is highly variable depending on location and elevation. Historical annual averages range from 10.8 inches near Loma Linda Fire Department located at the southwest end of the basin to over 40.6 inches at Lake Arrowhead located at the upper end of the mountain watershed contributing flow to the basin. Precipitation data provided by the Water Resources Division of the San Bernardino County Department of Transportation for 20 stations are summarized in **Table 1** and displayed on **Figure 3**.

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 the Bunker Hill Basin is separate from the Lytle Groundwater Basin, but receives groundwater underflow from the Lytle Basin.

For the purposes of this report, the definition of the Bunker Hill Basin is extended to include the Lytle Basin.

- 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, 2007 through June 30, 2008.

- Current Water Year - As per the California Water Code, the current water year is the period July 1, 2008 through June 30, 2009.

- Ensuing Water Year - As per the California Water Code, the ensuing water year is the period July 1, 2009 through June 30, 2010.

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 2008 groundwater elevations and preceding water year (July 2007 to June 2008) production were obtained from the primary water purveyors in the Bunker Hill Basin including:

- City of Colton
- City of Loma Linda
- 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
- Geologic Associates
- Loma Linda University
- Patton State Hospital
- Redlands Farming, Inc.
- Riverside – Highland Water Company
- San Bernardino County Department of Transportation and Flood Control
- San Bernardino Valley Municipal Water District
- West Valley Water District
- Western Municipal 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
- Watermaster Support Services

Historic precipitation data were obtained from the following sources:

- San Bernardino County Department of Transportation and Flood Control
- Redlands Daily Facts
- Big Bear Grizzly
- WeatherSource.com

3.0 Fall 2008 Groundwater Elevation Contours

The District, the Western Municipal Water District, and the primary water purveyors in the Bunker Hill Basin provided Fall 2008 water level data. Static groundwater elevations for Fall 2008 for wells throughout the Bunker Hill Basin are compiled in **Appendix A**. These elevations were plotted on **Figure 4** for 132 wells using a Geographic Information System (GIS) and groundwater elevation contours for the Bunker Hill Basin were interpreted. For purposes of comparison, Fall 2007 static groundwater elevation contours are provided on **Figure 5**. **Figure 6** shows the delineation of the Bunker Hill Basin into the sub-areas used in this report.

3.1 Hydrographs for Key Wells in the Bunker Hill Basin

To provide an historical perspective of groundwater levels for the Bunker Hill Basin, hydrographs for 21 wells located throughout the basin are shown in **Appendix B**. The locations of these wells are shown on **Figure 7** and the annual changes in water level from Fall 2007 to Fall 2008 are shown in **Table 2**.

4.0 ***Task 1*** **- Annual Change in Storage (Fall 2007 to Fall 2008)**

4.1 Hydrologic Sub-areas

Using a Geographic Information System, the average groundwater elevation changes were determined for each of the eight hydrologic sub-areas shown on **Figure 6** 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 on **Figure 6**.

4.2 Area and Storativity

Each sub-area and storage unit was digitized to estimate its area. 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 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 2008 groundwater level elevation data were compared with the same from Fall 2007. Measurements for 231 wells were available for both periods and the differences are provided in **Appendix A**. These differences are plotted on **Figure 8** using a graduated symbol color. Those wells with the largest decline in groundwater elevation are shown in red, while those with the largest increase are displayed in blue.

Average changes in groundwater levels 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 2007 to Fall 2008 for the Bunker Hill Basin were calculated using the following formula:

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

where:

$Q_{\Delta\ storage}$ = 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 2007 and Fall 2008 was a decrease of 2,600 acre-feet.

5.0 ***Task 2*** - Accumulated Change in Storage (Fall 1993 to Fall 2008)

For purposes of this report, the accumulated change in storage as of the last day of the preceding water year (June 30, 2008) 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 2008.[2] The accumulated change in storage as of June 30, 2008 was determined by adding the change in storage for the preceding water year (July 1, 2007 to June 30, 2008) of (-2,600 acre-feet), determined in Section 4.4, to the accumulated change in storage as of June 30, 2007 (-359,400). The result of this calculation is an accumulated decrease in storage for the Bunker Hill Basin of 362,000 acre-feet.

[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.

Table 4 summarizes the accumulated change in storage of the Bunker Hill Basin for the period 1988 to 2008 based on 1993 as the "zero accumulated storage year". The accumulated storage values are also displayed on **Figure 9** with the percent of normal precipitation for the San Bernardino County Hospital station. As would be expected, storage generally increases with above average rainfall and decreases with normal and below average rainfall.

6.0 *Task 3* - Total Groundwater Production for the Preceding Water Year (July 1, 2007 to June 30, 2008)

Production data for the preceding water year (July 1, 2007 to June 30, 2008) 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 not available and were estimated using previous year and calendar year 2007 data published by the Western - San Bernardino Watermaster and Western Municipal Water District, respectively.

Appendix C shows the production for each groundwater well in the Bunker Hill Basin for the period July 2007 through June 2008. As summarized on the last page of Appendix C, groundwater production from the Bunker Hill Basin for the preceding water year was approximately 133,840 acre-feet. **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 2007 through June 2008 is shown on **Figure 10**. Each well is displayed with a graduated size symbol based on its annual production. 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, 2008 to June 30, 2009)

To estimate annual change in storage for the current water year, a multiple regression analysis was performed for the period between 1991-92 and 2004-05 for three parameters.

- Annual Change in Storage
- Precipitation
- Production

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 were based on a calendar year period instead of the June to July period required in the EI. Since 1991-92 more accurate and more complete production data for the July to June period have 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 though 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.

$$Q_{\text{Annual } \Delta \text{ storage}} = -221{,}564 + 8{,}171\, Q_{prec} + 0.125\, Q_{prod}$$

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 11**. 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 average annual precipitation for the representative stations is approximately 22.4 inches (**Table 6),** while the average or the preceding water year was 19.3 inches (86 percent of normal). Historic annual precipitation values are plotted in **Appendix D** for these eight stations and twelve other local stations.

Table 6 shows that for the period between July 2008 and December 2008, precipitation was 100 percent of normal for the eight stations. For purposes of this report, it was assumed that precipitation for the rest of the current water year (January 2009 to June 2009) would be average. Therefore, precipitation for the current water year (July 2008 to June 2009) was estimated to be 100 percent of normal or 22.4 inches of rainfall (1 x 22.4).

Based on these assumptions, the estimated production for the current water year will be approximately 239,245 acre-feet as shown on **Figure 12**. Using this result on **Figure 11**, an estimated change in storage for the current water year (July 2008 to June 2009) of -8,628 acre-feet was determined.

8.0 *Task 5* - Estimate of the Annual Change in Storage for the Ensuing Water Year (July 1, 2009 to June 30, 2010)

The annual change in storage for the ensuing water year (July 1, 2009 to June 30, 2010) 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 percent of normal or 22.4 inches. Based on this assumption, the estimated production for the ensuing water year will be approximately 239,245 acre-feet as shown on Figure 13. Again, using this result in the nomograph shown on Figure 11, the estimated annual change in storage for the ensuing water year (July 1, 2009 to June 30, 2010) is -8,628 acre-feet.9.0

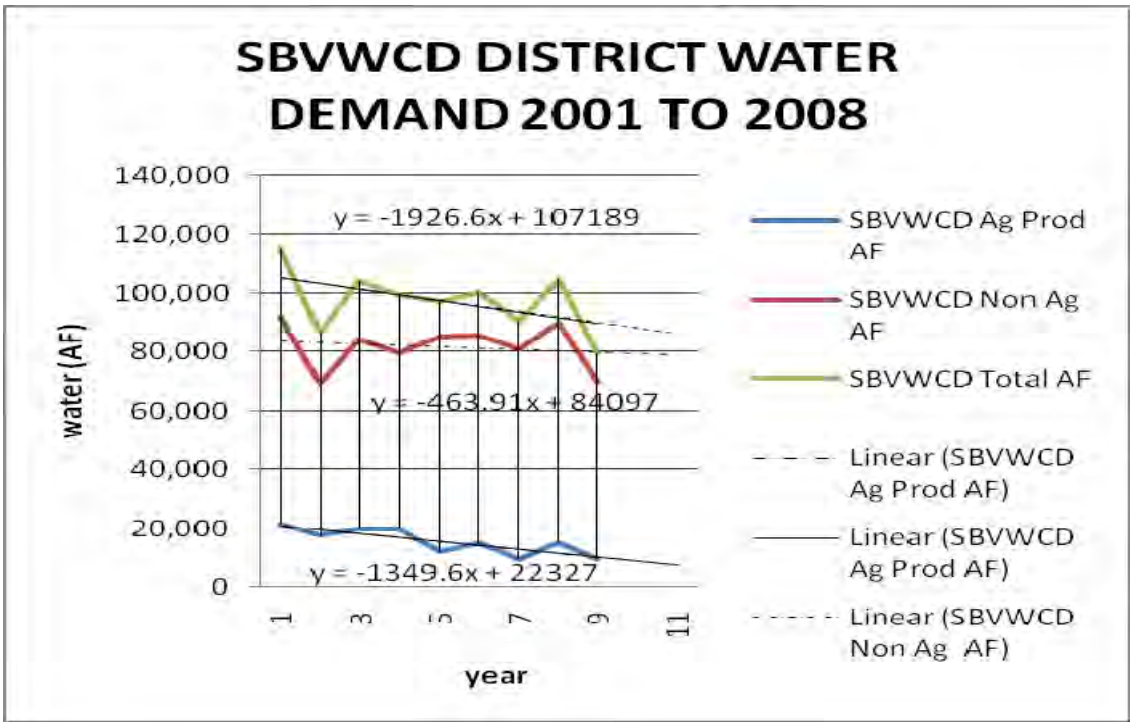
Task 6 - Average Annual Change in Storage for the Immediate Past Ten Water Years

Table 7 shows the average annual change in storage for the immediate past ten water years (Fall 1998 to Fall 2008) 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 -32,400 acre-feet.

10.0 *Task 7* - Estimated Amount of Agricultural Water and Other Than Agricultural Water to be Withdrawn for the Ensuing Water Year (July 1, 2009 to June 30, 2010)

The District received additional information regarding groundwater production in the preceding water year. Application of these new data using the methodology for predicting the amount of agricultural water and other than agricultural water withdrawn for the ensuing water year yielded results of 15,207 acre-feet of agricultural water and 113,596 acre-feet for non-agricultural water (See Appendix “A”).

District staff believes these values result likely overstate the actual amount of the agricultural and other than agricultural water to be produced within the District, for the ensuing water year. As such, staff has modified the methodology for predicting these values, by use of a regression analysis, based on actual production history from 2001 through 2008 as follows:



Graph 1-Table 1's SBVWCD Data and Projections

	Report Year	X (Year)	Y (AF)
Non Ag	2010	10	79,528
	2011	11	79,071
Agg	2010	10	8,831
	2011	11	7,481
Total	2009-10		88,359
	2010-11		86,552

Projections of Graph 1

Consequently, the revised conclusions for the ensuing water year estimated production are as follows:

Agricultural Water	8,831 acre-feet
Other Than Agricultural Water	79,520 acre-feet

Task 7 Calculations under Original Methodology -Appendix "A

$$Q_{agr(09\text{-}10)} = Q_{agr(07\text{-}08)} \times [(Q_{total(09\text{-}10)} - Q_{surf(09\text{-}10)}) / (Q_{total(07\text{-}08)} - Q_{surf(07\text{-}08)})]$$

and

$$Q_{non\text{-}agr(09\text{-}10)} = Q_{non\text{-}agr(07\text{-}08)} \times [(Q_{total(09\text{-}10)} - Q_{surf(09\text{-}10)}) / (Q_{total(07\text{-}08)} - Q_{surf(07\text{-}08)})]$$

where:

$Q_{agr(09\text{-}10)}$ = Agricultural use within the District for the ensuing water year, acre-ft

$Q_{agr(07\text{-}08)}$ = Agricultural use within the District for the preceding water year, acre-ft (10,330 from Appendix C)

$Q_{total(09\text{-}10)}$ = Production (including surface diversion) from the Bunker Hill Basin for the ensuing water year, acre-ft (= 239,245 from Figure 13)

$Q_{total(07\text{-}08)}$ = Production (including surface diversion) from the Bunker Hill Basin for the preceding water year, acre-ft (= 188,530 from Appendix C)

$Q_{non\text{-}agr(09\text{-}10)}$ = All other uses within the District for the ensuing water year, acre-ft

$Q_{non\text{-}agr(07\text{-}08)}$ = All other uses within the District for the preceding water year, acre-ft (= 77,171 from Appendix C)

$Q_{surf(09\text{-}10)}$ = Surface diversions from the Bunker Hill Basin for the ensuing water year, acre-ft (= 42,223 from Table 8)

$Q_{surf(07\text{-}08)}$ = Surface diversions from the Bunker Hill Basin for the preceding water year, acre-ft (= 54,691 from Appendix C)

Data on agricultural use and all other uses within the District for the preceding water year (July 1, 2007 to June 30, 2008) are provided in **Appendix C**. For the period July 1, 2007 through June 30, 2008 approximately 9654 acre-feet of groundwater was produced for agricultural applications within the San Bernardino Valley Water Conservation District boundary. For the same period, approximately 77,171 acre-feet of groundwater was produced for all other uses within the District boundary. Using the equations presented above with the following values inserted:

$Q_{agr(07-08)}$ = 10,330 acre-feet

$Q_{total(09-10)}$ = 239,245 acre-feet

$Q_{total(07-08)}$ = 188,530 acre-feet

$Q_{non-agr(07-08)}$ = 77,171 acre-feet

$Q_{surf(09-10)}$ = 42,223 acre-feet

$Q_{surf(07-08)}$ = 54,691 acre-feet

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

$Q_{agr(09-10)}$ = 10,330 x [(239,245 – 42,223) / (188,530 – 54,691)]

= 15,207acre-feet

$Q_{non-agr(09-10)}$ = 77,171 x [(239,245 – 42,223) / (188,530 – 54,691)]

= 113,596 acre-feet

$Q_{total\ (09-10)}$ = 15,207 + 113,596 = 128,803 acre-feet

By summing these two results, it is estimated that a total of 128,803 acre-feet of groundwater will be withdrawn within the District for the ensuing water year (July 1, 2009 to June 30, 2010).

11.0 *Task 8* - Estimated Amount of Water for Surface Distribution for the Ensuing Water Year (July 1, 2009 to June 30, 2010)

The amount of water for surface distribution for the ensuing water year (July 1, 2009 to June 30, 2010) was estimated based on the average surface diversions for the Santa Ana River, Mill Creek, and Lytle Creek for the period 1983 to 2007.

As shown in **Table 8**, average surface diversions for the Santa Ana River, Mill Creek, and Lytle Creek between 1983 and 2007 were 22,251, 11,089 and 8,612 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, 2009 to June 30, 2010) is found by summing the diversions as follows:

Bunker Hill Surface Distribution = 22,251 + 11.089 + 8,612= 42,223 acre-feet

As Lytle Creek is not within the District, the estimated amount of surface distribution from the District for the ensuing water year (July 1, 2009 to June 30, 2010) is the sum of the Santa Ana River and Mill Creek distributions.

District Surface Distribution = 22,251 + 11,089 = 33,340 acre-feet

12.0 *Task 9* - Estimated Amount of Water for Replenishment of the Groundwater Supplies for the Ensuing Water Year (July 1, 2009 to June 30, 2010)

The amount of water necessary from all sources, including natural recharge, to maintain constant groundwater supplies in the Bunker Hill Basin for the ensuing water year (July 1, 2009 to June 30, 2010) is estimated as follows:

Replenishment = Total Production - Surface Diversions - Change in Storage

or,

$$Q_{Replenishment\ (09\text{-}10)} = Q_{prod\ (09\text{-}10)} - Q_{surf\ (09\text{-}10)} + Q_{Annual\ \Delta\ storage\ (09\text{-}10)}$$

The estimated production and surface diversions from the Bunker Hill Basin for the ensuing water year (July 1, 2009 to June 30, 2010) were estimated as approximately 239,245 acre-feet (from **Figure 13**) and 42,223 acre-feet (from **Table 8**), respectively. The estimated change in storage determined in Section 8.0 and shown on **Figure 11** is a decrease of 8,628 acre-feet. Therefore, the amount of water necessary for replenishment of the groundwater supplies of the Bunker Hill Basin is estimated as follows:

$$Q_{Replenishment\ (09\text{-}10)} = 239{,}245 - 42{,}223 + 8{,}628 = 205{,}650 \text{ acre-feet}$$

The amount of water necessary to maintain constant groundwater supplies within the District for the ensuing water year (July 1, 2009 to June 30, 2010) is estimated using the same equation as shown above, but substituting values for the District area. The estimated production within the District for the ensuing water year is estimated as approximately 228,801 acre-feet (from Section 10.0) and 33,340 acre-feet (from Section 11.0), respectively. The change in storage for the ensuing water year for the District is estimated as a decrease of 4,314 acre-feet (assumed to be half of the Bunker Hill Basin). Therefore, the amount of water necessary for replenishment of the District's groundwater supplies for the ensuing water year (July 1, 2009 to June 30, 2010) is:

$$Q_{Dist\ Replenishment\ (09\text{-}10)} = (228{,}801 + 33{,}340) - (33{,}340 + 4{,}314) = 223{,}122 \text{ acre-feet}$$

The amount of groundwater recharge that must occur from all sources, including natural recharge, in order to bring the basin back to "full" in the ensuing water year is determined as follows:

$$Q_{Replenishment} = Q_{Accumulated\ \Delta\ storage\ (93\text{-}08)} + Q_{Annual\ \Delta\ storage\ (08\text{-}09)} + Q_{Replenishment\ (09\text{-}10)}$$

$$Q_{Replenishment} = 362{,}000 + 8{,}628 + 205{,}650 = 576{,}278 \text{ acre-feet}$$

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 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 2009-10 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 2009 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 362,000 acre-feet below that which is considered full for purposes of this Investigation.

- During the ensuing water year (July 1, 2009 to June 30, 2010), the Bunker Hill Basin can be recharged, from all sources, with 576,278 acre-feet of water. This recharge quantity is derived by 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 District should continue to take the necessary steps 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.

- The Task 7 traditional mathematical methodology uses the previous year's actual Conservation District production values multiplied by a factor based on the total projected Bunker Hill production for the ensuing water year. The rate of increased production and the Conservation District portion of the Bunker Hill Basin are not necessarily related 1:1 to the total Bunker Hill projected ensuing year production.

- Although the revised projected total production from the District decreased from 228,801 acre feet to 128,803 acre-feet, the District felt 128,803 acre-feet of production was excessive based on the actual District production for years 2001 to 2008. A linear progression analysis indicates the actual production for agricultural and non-agricultural water has been declining over that period (See pg. 26). District's projection of 88,359 acre-feet is more conservative and is recommended for use to calculate revised pump rates.