Chino Basin

Optimum Basin Management Program

2008 State of the Basin Report

Final Report

Prepared for

Chino Basin Watermaster

Prepared by

WILDERMUTH™ ENVIRONMENTAL INC.

NOVEMBER 2009

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Acronyms, Abbreviations, and Initialisms

μg/L	micrograms per liter
1,1,1-TCA	1,1,1-trichloroethane
1,1-DCE	1,1-dichloroethene
1,2,3-TCP	1,2,3-trichloropropane
1,2-DCA	1,2-dichloroethane
AF	acre-feet
AFY	acre-feet per year
B&V	Black & Veatch, Inc.
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
CAO	Cleanup and Abatement Order
CBWM ID	Chino Basin Watermaster Well Identification
CDA	Chino Desalter Authority
CDFM	cumulative departure from mean precipitation
CDPH	California Department of Public Health (formerly the Department of Health Services)
CIM	California Institution for Men
cis-1,2-DCE	cis-1,2-dichloroethene
COPC	Constituents of Potential Concern
CVWD	Cucamonga Valley Water District
DLR	detection limit for reporting
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
EMP	Evaluation Monitoring Program
EPA	US Environmental Protection Agency
ft	feet
ft-bgs	feet below ground surface
ft-brp	feet below reference point (*e.g.* static surveyed measurement point)
GE	General Electric
GIS	Geographic Information System
GRCC	Groundwater Recharge Coordination Committee
HCMP	Hydraulic Control Monitoring Program
IEUA	Inland Empire Utilities Agency

Acronyms, Abbreviations, and Initialisms

InSAR	Synthetic Aperture Radar Interferometry
ISOB	Initial State of the Basin
JCSD	Jurupa Community Services District
M&RP	Monitoring and Reporting Program
MCL	maximum contaminant level
mg/L	milligrams per liter
MSL	Milliken Sanitary Landfill
MVSL	Mid-Valley Sanitary Landfill
MVWD	Monte Vista Water District
MWDSC	Metropolitan Water District of Southern California
MZ	Management Zone
NDMA	N-nitrosodimethylamine
NO_3 - N	Nitrate expressed as nitrogen
NPL	National Priorities List
OBMP	Optimum Basin Management Program
OIA	Ontario International Airport
PBMZ	Prado Basin Management Zone
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
ROD	Records of Decision
RP	Regional Plant
RWQCB	Regional Water Quality Control Board
SARWC	Santa Ana River Water Company
SOB	State of the Basin
SWP	State Water Project
SWQIS	State Water Quality Information System
TCE	trichloroethene
TDS	total dissolved solids
TOC	total organic carbon
US EPA	US Environmental Protection Agency
USGS	US Geological Survey
USL	Upland Sanitary Landfill

Acronyms, Abbreviations, and Initialisms

VOC	volatile organic chemical
Watermaster	Chino Basin Watermaster
WEI	Wildermuth Environmental, Inc.
WQS	water quality standard

ES-1 Summary and Background

The baseline for the ISOB was on or about July 1, 2000—the point in time that represents the start of Optimum Basin Management Program (OBMP) implementation. The State of the Basin (SOB) reports serve as a metric for measuring OBMP implementation progress. This current SOB report contains water level, water quality, ground-level, and other data through 2007/08 and describes Watermaster activity through fall 2008.

The intent of this report is twofold:

- During Watermaster fiscal year 2000/01, several OBMP-spawned investigations and initiatives commenced, encompassing groundwater level and quality, ground level, annual recharge assessment, recharge master planning, hydraulic control, desalter planning and engineering, and meter installation. This report describes the progress made in these activities through the fall of 2008.
- This report also describes the general state of the basin with respect to groundwater levels, groundwater quality, subsidence, recharge, and hydraulic control.

ES-2 Section 2 – General Hydrologic Condition

The Chino Basin covers about 220 square miles. Figure 2-1 shows the location of the Chino Basin within the context of the Santa Ana River watershed. The watershed of the Chino Basin is almost identical to the Santa Ana River at Prado, the exception being the addition of the Temescal Creek watershed that enters the Prado Dam reservoir just upstream of the dam and for practical purposes contributes negligible inflow to the Chino Basin. In total, the watershed area for streams crossing the Chino Basin is about 1490 square miles.

The Chino Basin has a semi-arid Mediterranean climate. Precipitation is a major source of local groundwater recharge for the Basin and thus, the availability of this recharge can be understood by analyzing long-term precipitation records.

The hydrologic regime in the Chino Basin has important implications for water supply and groundwater management. The occurrence of long dry periods, characteristic of the region's climate, limit the recharge of precipitation and storm water recharge for years at a time and requires management strategies that conserve precipitation and storm water recharge whenever available. The amount of stormwater produced per unit of precipitation has increased over time due to urbanization and will continue to increase in the future as the remaining undeveloped and agricultural land uses are converted to developed uses.

ES-3 Section 3 – Basin Operations and Groundwater Monitoring

Future re-determinations of safe yield for the Chino Basin will be based largely on accurate estimations of groundwater production, artificial recharge, and basin storage changes over time. Watermaster is actively improving its programs to track production, recharge, and groundwater levels (storage). A meter installation program has improved production estimates in the agricultural areas. Watermaster continues to implement comprehensive, high-frequency, groundwater-level monitoring programs across the basin to support various OBMP-related activities. Since 2003, Watermaster has been installing pressure transducers/data loggers in many of the wells it monitors for water levels to improve data quality. In addition, nine (9) nested sets of monitoring wells have been installed in the southern Chino Basin for the HCMP and provide highly detailed, depth-specific piezometric (and water quality) data. It is likely that additional monitoring wells will need to be constructed in southern Chino Basin as private wells (that are currently being used for monitoring by Watermaster) are destroyed as agricultural land uses convert to urban.

The following are the general trends in groundwater production:

- There was a basin-wide increase in the number of wells producing over 1,000 AFY between 1978 and 2008. This is consistent with (1) the land use transition from agricultural to urban, (2) the trend of increasing imported water costs, and (3) the use of desalters.
- Since the implementation of the OBMP in 2000, the number of active production wells just north of the Santa Ana River has decreased. This is consistent with the conversion of land use from agricultural to urban that has been occurring in the area.
- Since the implementation of the OBMP in 2000, desalter pumping has commenced and has progressively increased; in 2007/08, desalter pumping reached a historical high of 26,972 AF.
- Since the implementation of the OBMP in 2000, the number of wells that produce over 1,000 AFY on the west side of Chino Basin (west of Euclid Avenue) has decreased. This is consistent with (1) the implementation of the MZ1 Interim Management Plan, which reduced pumping by up to 3,000 AFY in the Chino area, and (2) the reduced pumping by the City of Pomona, the Monte Vista Water District, and the City of Chino Hills from 2003 to 2008 as these agencies have been participating in in-lieu recharge for the Dry Year Yield program.
- Agricultural Pool pumping continues to decline. In 2007/08, total production for the Agricultural Pool fell to 30,910 AF, the lowest production on record for the pool. In accordance with the hypothesis that urbanization is the cause of decreased agricultural production, Appropriative Pool production tends to increase at approximately the same rate that Agricultural Pool production decreases.

As required by the Peace Agreement and summarized in the OBMP Recharge Master Plan, Watermaster initiated the Chino Basin Groundwater Recharge Program. This is a comprehensive program to enhance water supply reliability and improve the groundwater quality of local drinking water wells throughout the Chino Basin by increasing the recharge of storm water, imported water, and recycled water.

There are 21 Chino Basin recharge facilities described in the OBMP Recharge Master Plan, Phase II Report (WEI, 2001).

The following are the general trends in groundwater recharge:

- Since 2000, total storm water recharge has averaged approximately 4,600 AFY. During 2006/07 and 2007/08, total storm water recharge in the Chino Basin was approximately 4,600 and 9,900 AF, respectively.

- Since 2000, the total supplemental water recharge—consisting of imported and recycled waters—has averaged approximately 11,500 AFY. During 2006/07 and 2007/08, total supplemental water recharge in the Chino Basin was approximately 6,350 and 2,400 AF, respectively.

The Chino Basin groundwater level analysis for fall 2008 revealed notable pumping depressions in the groundwater level surface that interrupt the general flow pattern surrounding the Chino I & Chino II Desalter well fields. There are also discernible groundwater level depressions in the northern portion of MZ1 (Montclair and Pomona areas) and directly southwest of the Jurupa Hills due to local groundwater production.

Watermaster has developed a Geographic Information System model to estimate groundwater storage changes from groundwater level contour maps. This model was utilized to estimate storage changes during the period following OBMP implementation. During the 2006 to 08 period, storage changed by about -54,000 AF. The total change in storage since implementation of the OBMP (2000-08) is approximately -62,000 AF.

With regard to hydraulic control, since 2000, pumping at the Chino I Desalter well field has generally flattened the regional hydraulic gradient within the shallow aquifer system around the western half of the Chino I Desalter well field and has created a capture zone surrounding the eastern half of the well field. Piezometric data suggest a significant reduction in the southward component of the hydraulic gradient around the western half of the Chino I Desalter well field but do not indicate a gradient reversal (northward component) and, hence, do not yet provide compelling evidence for complete hydraulic control at the Chino I Desalter well field. The ultimate fate of groundwater that flows past the Chino I Desalter well field is continued flow southward toward Prado Basin where groundwater rises to become surface water in the tributaries of Prado Basin.

ES-4 Section 4 – Groundwater Quality

Watermaster continues to monitor water quality in the basin and stores these data in a relational database, which also includes all of the historical data that Watermaster has been able to acquire for wells in the region. Watermaster has instituted a cooperative process whereby water quality data are acquired on a routine basis from the appropriators. This alleviates some of the data quality control issues with downloading data from the state water quality database.

Groundwater quality in Chino Basin is generally very good with better groundwater quality found in the northern portion of Chino Basin where recharge occurs. Salinity (TDS) and nitrate-nitrogen concentrations increase in the southern portion of Chino Basin. Between July 2003 and June 2008, 32 percent of the wells south of Highway 60 had TDS concentrations below the secondary MCL, an improvement from the 20 percent reported in the 2006 State of the Basin Report (period of July 2001 through June 2006). In some places, wells with low TDS concentrations are proximate to wells with higher TDS concentrations, suggesting a vertical stratification of water quality. Between July 2003 and June 2008, about 69 percent of the wells sampled south of Highway 60 had nitrate-nitrogen concentrations greater than the MCL, an improvement from the 80 percent reported in the 2006 State of the Basin Report (period of July 2001 through June 2006). However, please note that these statistical improvements may be an artifact of sampling occurrence and frequency.

Other constituents that impact groundwater quality from a regulatory or Basin Plan standpoint include certain VOCs, arsenic, and perchlorate. As discussed in Section 4.3.4, there are a number of point source releases of VOCs in the Chino Basin that are in various stages of investigation or cleanup. There are also known point source releases of perchlorate (Milliken Valley Sanitary Landfill, Stringfellow, etc.), and non-point source related perchlorate contamination appears to have resulted from natural and anthropogenic sources. Arsenic at levels above the WQS appears to be limited to the deeper aquifer zone near the City of Chino Hills. Hexavalent chromium, while not currently a groundwater quality issue in the Chino Basin, may become so, depending on the promulgation of future standards.

The Initial State of the Basin and subsequent State of the Basin Reports discussed the need for future long-term monitoring. Due to commercial and residential development in the Chino Basin area; many of the private agricultural wells south of State Route 60 that have been used for monitoring activities are being destroyed as land is developed. In response to the loss of historically utilized wells, Watermaster developed a water quality key well program. This program designates a series of wells across a wide areal distribution for long-term monitoring activities. This key well monitoring program provides a good representation of the areal groundwater quality in this portion of the basin. Watermaster's program relies on municipal producers, government agencies, and private consultants to supply their groundwater quality data on a cooperative basis. Watermaster supplements these data with data obtained through its own sampling and analysis program of private wells in the area generally south of State Route 60. As with past water quality monitoring, the results will be added to the Watermaster database.

Point sources of concern are critical to the overall quality of Chino Basin groundwater. To ensure that Chino Basin groundwater remains a sustainable resource, it is of the utmost importance that Watermaster closely monitor point sources and emerging contaminates. It is recommended that Watermaster continue to work closely with the RWQCB and potentially responsible parties within the Chino Basin. This will allow for up-to-date understanding of groundwater quality, investigations, remediation activities, and potential mutually beneficial remedial options through Chino Basin desalting facilities.

ES-5 Section 5 – Ground-Level Monitoring

Implementation of the MZ1 Plan began in 2008. The MZ1 Plan calls for (1) the continued scope and frequency of monitoring implemented during the IMP within the MZ1 Managed Area and (2) expanded monitoring of the aquifer system and land subsidence in other areas of the Chino Basin where the Interim Management Plan (IMP) indicated concern for future subsidence and ground fissuring. The expanded monitoring efforts outside of the MZ1 Managed Area are consistent with the requirements of PE1.

Watermaster's current ground-level monitoring program includes:

- *Piezometric Levels.* Piezometric levels are an important part of the ground-level monitoring program because piezometric changes are the mechanism for aquifer-system deformation and land subsidence.
- *Aquifer-System Deformation.* Watermaster records aquifer-system deformation at the Ayala Park Extensometer facility where two extensometers record the vertical component of aquifer-system compression and/or expansion once every 15 minutes.
- *Vertical Ground-Surface Deformation.* Watermaster monitors vertical ground-surface deformation via the ground-level surveying and remote sensing (InSAR) techniques established during the IMP.
- *Horizontal Ground-Surface Deformation.* Watermaster monitors horizontal ground-surface displacement across the eastern side of the subsidence trough and the adjacent area east of the barrier/fissure zone. These data, obtained by electronic distance measurements (EDMs), are used to characterize the horizontal component of land surface displacement caused by groundwater production on either side of the fissure zone.

The conclusions and recommendations for Watermaster's basin-wide ground-level monitoring program are provided below:

- Land subsidence does not appear to be a concern in the eastern and northernmost portions of Chino Basin. In these areas, the underlying aquifer system is composed primarily of coarse-grained sediments that are not prone to compaction.

- Land subsidence and the potential for ground fissuring are major concerns in the western and southern portions of the Chino Basin. In these areas, the underlying aquifer system consists of interbedded, fine-grained sediment layers (aquitards) that can drain and compact when groundwater levels decline in the adjacent coarse-grained aquifers. Ground fissuring has occurred in the past where land subsidence was differential (i.e. steep gradient of subsidence). Ground fissuring is the main subsidence-related threat to infrastructure.

- Land subsidence has been persistent across most of the western and southern portions of the Chino Basin since, at least, 1987 when land subsidence monitoring began. In many of these areas, land subsidence continues even during periods of groundwater level recovery, indicating that thick, slowly-draining aquitards are compacting in response to the large historical drawdowns of 1935 to 1978.

- Pumping-induced drawdown has caused accelerated occurrences of land subsidence in the recent past, including subsidence in the City of Chino during the early 1990s and, currently, in the vicinity of the Chino I Desalter well field. Watermaster should anticipate similar occurrences of land subsidence in areas (1) that are prone to subsidence and (2) where drawdown will occur in the future.

- Watermaster will continue its basin-wide ground-level monitoring program, using InSAR and ground-level surveys. Watermaster will consider expanding the ground-level surveys to cover the area of the proposed Chino Creek Desalter Well Field. This is an area that is prone to subsidence, where drawdown is planned near where ground fissuring has occurred in the past, and where InSAR data is not currently available. Watermaster will also consider expanding the ground-level surveys to cover the Pomona and Ontario Areas. In general, InSAR data coverage is continuous and of high quality throughout both areas, so ground-level surveys would primarily provide supporting and confirmation data for the InSAR and would occur at a frequency of once every three to five years.

- Watermaster will consider installing low-cost piezometer/extensometer facilities at appropriate locations in all Areas of Subsidence Concern. This type of facility has been successfully constructed and tested at Ayala Park in Chino. Such facilities record the requisite data (1) to monitor land subsidence and groundwater levels at high resolution and accuracy, (2) to provide the information necessary to characterize the elastic and/or inelastic nature of any land subsidence occurring in an area, and (3) to provide the information necessary to characterize aquifer and aquitard properties that could be used in a predictive computer-simulation model of subsidence.

- Watermaster will consider building and calibrating predictive computer-simulation models of subsidence across all Areas of Subsidence Concern in the Chino Basin. These models would provide information on the rates and ultimate magnitude of land subsidence that could be associated with various basin management planning scenarios (i.e. pumping and recharge patterns). This information would be valuable to affected Watermaster parties.

- Because ground fissuring caused by differential land subsidence is the main threat to infrastructure, Watermaster will periodically inspect for signs of ground fissuring in areas that are experiencing differential land subsidence. In addition, Watermaster will consider monitoring the horizontal strain across these zones of potential ground fissuring in an effort to better understand and manage ground fissuring.

1.1 Background

The Chino Basin Watermaster (Watermaster) completed the *Initial State of the Basin* (ISOB) Report in October 2002. The baseline for the ISOB was on or about July 1, 2000—the point in time that represents the start of Optimum Basin Management Program (OBMP) implementation. The ISOB and subsequent State of the Basin (SOB) reports serve as a metric for measuring OBMP implementation progress. This current SOB report contains water level, water quality, ground-level, and other data through 2007/08 and describes Watermaster activity through fall 2008.

The OBMP was developed for the Chino Basin (see Figure 1-1 for the location of Chino Basin and its management zones) pursuant to the Judgment (Chino Basin Municipal Water District v. City of Chino, et al.) and the February 19, 1998 ruling (WEI, 1999). Pursuant to the OBMP Phase 1 Report, the Peace Agreement and associated Implementation Plan, and the November 15, 2001 Court Order, Watermaster staff has prepared this State of the Basin (SOB) Report. The intent of this report is twofold:

- During Watermaster fiscal year 2000/01, several OBMP-spawned investigations and initiatives commenced, encompassing groundwater level and quality, ground level, annual recharge assessment, recharge master planning, hydraulic control, desalter planning and engineering, and meter installation. This report describes the progress made in these activities through the fall of 2008.
- This report also describes the general state of the basin with respect to groundwater levels, groundwater quality, ground surface levels (subsidence), recharge, and hydraulic control.

1.2 Report Organization

Executive Summary: The Executive Summary provides a brief overview of the OBMP and its results.

Section 1 – Introduction: This section describes the project background, summarizes the project objectives, and provides an outline.

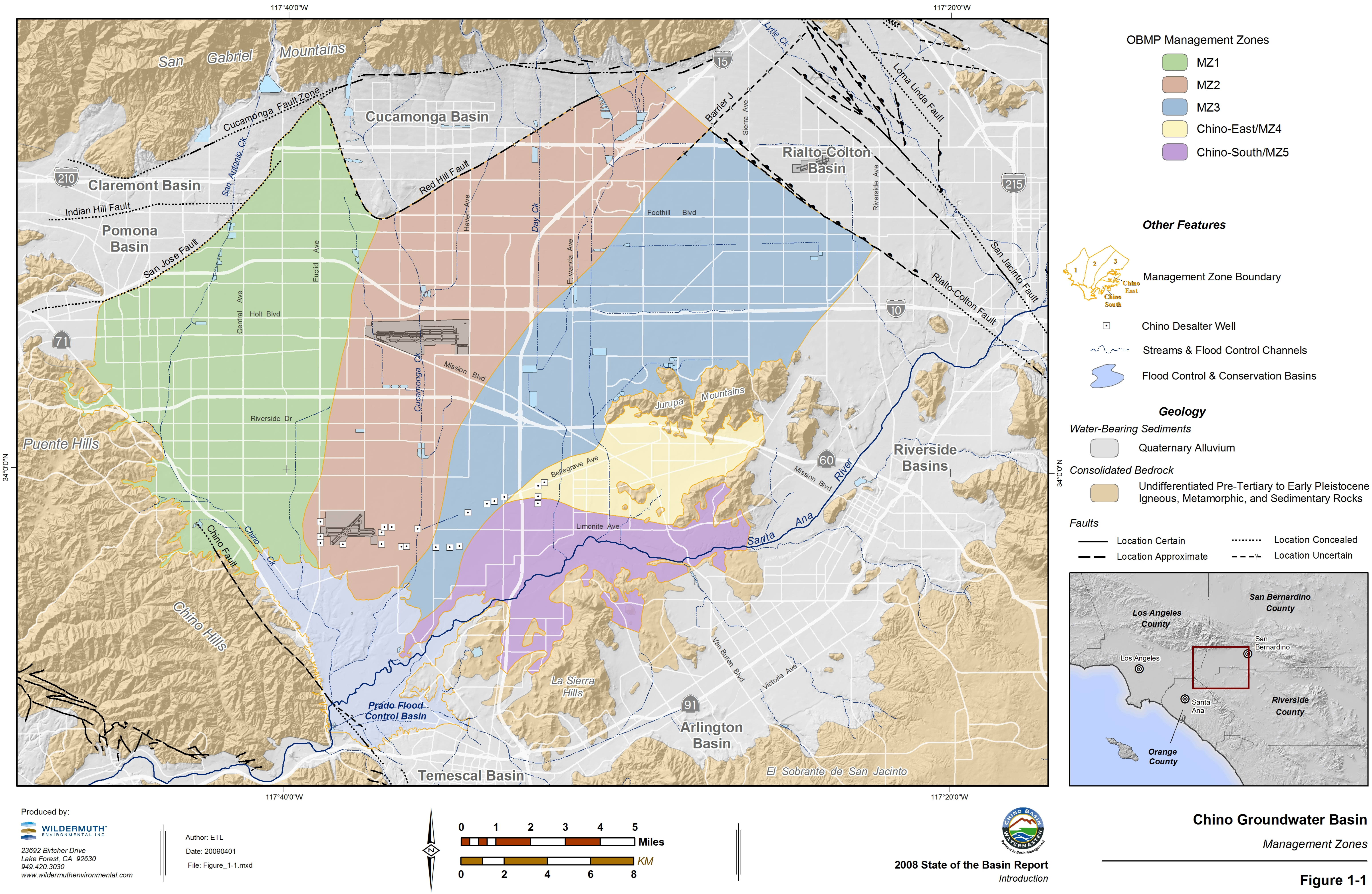
Section 2 – General Hydrologic Condition: Section 2 describes the general hydrologic condition of the Chino Basin.

Section 3 – Basin Operations and Groundwater Level Monitoring: Section 3 describes Basin operations, including groundwater level, groundwater quality, groundwater production, recharge, and ground surface monitoring efforts.

Section 4 – Groundwater Quality: Section 4 describes historical and current groundwater quality and lists and describes point sources of concern.

Section 5 – Ground Level Monitoring: Section 5 describes ground surface monitoring in the Basin using InSAR and traditional leveling surveys, describes areas of subsidence concern, and presents the results of the subsidence analyses.

Section 6 – References: Section 6 contains the references consulted in this investigation.



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2008 State of the Basin Report
Introduction

Chino Groundwater Basin
Management Zones

Figure 1-1

Section 2 – General Hydrologic Condition

The Chino Basin covers about 220 square miles. Figure 2-1 shows the location of the Chino Basin within the context of the Santa Ana River watershed. The watershed of the Chino Basin is almost identical to the Santa Ana River at Prado, the exception being the addition of the Temescal Creek watershed that enters the Prado Dam reservoir just upstream of the dam and for practical purposes contributes negligible inflow to the Chino Basin. The Santa Ana River watershed area tributary to the Chino Basin at the MWD Crossing is about 852 square miles. The area tributary to the Chino Basin down stream of the MWD Crossing is about 414 square miles and includes the watershed areas of San Antonio and Chino Creeks, Cucamonga Creek, Day Creek, the East Etiwanda and San Sevaine Creeks, and small drainages from the Riverside and Arlington areas south of the Santa Ana River. In total, the watershed area for streams crossing the Chino Basin is about 1490 square miles. The time of concentration[1] for the Santa Ana River at the MWD Crossing is estimated to be between one to two days. By contrast the time of concentrations for streams discharging from north to south over the Chino Basin is a few hours.

2.1 Precipitation

The Chino Basin has a semi-arid Mediterranean climate. Precipitation is a major source of local groundwater recharge for the Basin and thus, the availability of this recharge can be understood by analyzing long-term precipitation records. Four precipitation stations in the Basin were used to characterize the long-term precipitation patterns in the Basin. The location of the precipitation station used herein to construct the Claremont/Montclair hybrid (combined records of 1034 and 1137)[2] station and the Ontario hybrid (combined records of 1017 and 1075) station records are shown in Figure 2-1. A third station of historical prominence in the Santa Ana watershed, the San Bernardino Hospital station, was used to characterize the historical precipitation upstream of the Chino Basin. The location of the San Bernardino Hospital station (2146) is shown in Figure 2-1. Table 2-1 lists annual statistics for the stations utilized in this characterization.

Figure 2-2 illustrates the annual precipitation time series and the cumulative departure from the mean (CDFM) precipitation for the 1900 to 2008 period at the Claremont/Montclair hybrid precipitation station. During this period, four series of dry-wet cycles are apparent: prior to 1904 through 1922; 1922 through 1946; 1946 through 1983, and 1983 through 1998. A fifth cycle appears to have started in 1998 and continues through present. The records of the Ontario hybrid and San Bernardino Hospital stations also show the same patterns of dry-wet cycles as the Claremont/Montclair hybrid station during the historic period (see Figures 2-3 and 2-4).

The long-term average annual precipitation for these stations are 17.8 inches at the Claremont/Montclair hybrid station (1900 through 2008), 15.4 inches at the Ontario hybrid

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[1] The time of concentration is the time it takes for runoff from the most distant upstream part of the watershed to reach a specified point of interest.

[2] These two precipitation stations are close to each other, their overlapping records are highly correlated, and their records have been combined to produce a hybrid record of over 100 years duration.

station (1914 through 2008) and 16.4 inches at the and San Bernardino Hospital station (1900 through 2008). The ratio of dry years to wet years is about three to two. That is, for every ten years about six years will have below average precipitation and four years will have greater than average precipitation.

The safe yield of the Chino Basin is based on the hydrology during 1965 through 1974, a period of ten years (base period). This base period contains two wet years in 1965 and 1969 with annual precipitation depths of 24 and 26 inches, respectively, at the Claremont/Montclair hybrid station, and 19.8 and 25.6 inches, respectively at the Ontario hybrid station. This base period falls within the longest dry period on record (1946 to 1976). The average annual precipitation for the base period at the Claremont/Montclair hybrid station was 16.3 inches, or 1.5 inches less than the long-term annual average. The average annual precipitation for the base period at the Ontario hybrid station was 14.7 inches, or 0.6 inches less than the long-term annual average. The base period was preceded by a 20-year dry period that was punctuated with a few wet years (1952, 1954, 1957 and 1958).

The Peace Agreement period runs from 2000 to the present, an eight-year period. The Peace Agreement period contains three wet years in 2001, 2004, and 2005 with 19.7, 22.1, and 29.2 inches, respectively, as measured at the Claremont/Montclair hybrid station. The Peace Agreement period lies within a dry period that appears to have started in 1998 and continues to the present. The average annual precipitation for the Peace Agreement period at the Claremont/Montclair hybrid station was 16.6 inches, or 1.2 inches less than the long-term annual average.

2.2 Surface Water Discharge

The principal surface water features of the Chino Basin include the Santa Ana River and its tributaries in the reach between the MWD Crossing and Prado Dam. The main tributaries in this reach of the river include the San Antonio/Chino Creeks, Cucamonga Creek, Day Creek, and East Etiwanda/San Sevaine Creeks. Figure 2 1 shows the locations of these surface water features for the Chino Basin. Figure 2-1 shows the locations of two USGS discharge monitoring stations, one located at the MWD Upper Feeder Crossing of the Santa Ana River (11066460) that measures the discharge into the Chino Basin, and one located just downstream of Prado Dam (11074000) that measures the discharge exiting the watershed at the downstream end of the from the Chino and Temescal Basins.

Figure 2-5 shows the annual time history of storm flow for the Santa Ana River at below Prado Dam from water year 1919/20 to 2007/08 (October to September). Figure 2-5 also has a plot of the CDFM for precipitation at the Ontario hybrid station. Figure 2-5 demonstrates that that the relationship of precipitation to stormwater runoff changed significantly around water year 1977/78, such that more runoff per unit of precipitation was produced after 1977/78. To see this, note the positive slope of the CDFM (indicative of a wet period) during the 1936/37 to 1944/45 period. During this period, about 49 inches of precipitation occurred above the mean precipitation of 15.4 inches per year. From 1977/78 to 1982/83, another wet period, there was about 51 inches of precipitation above the mean but there was much more storm water discharge than occurred between 1937 and 1945. A similar observation can be made about the 1991/92 to 1997/98 period.

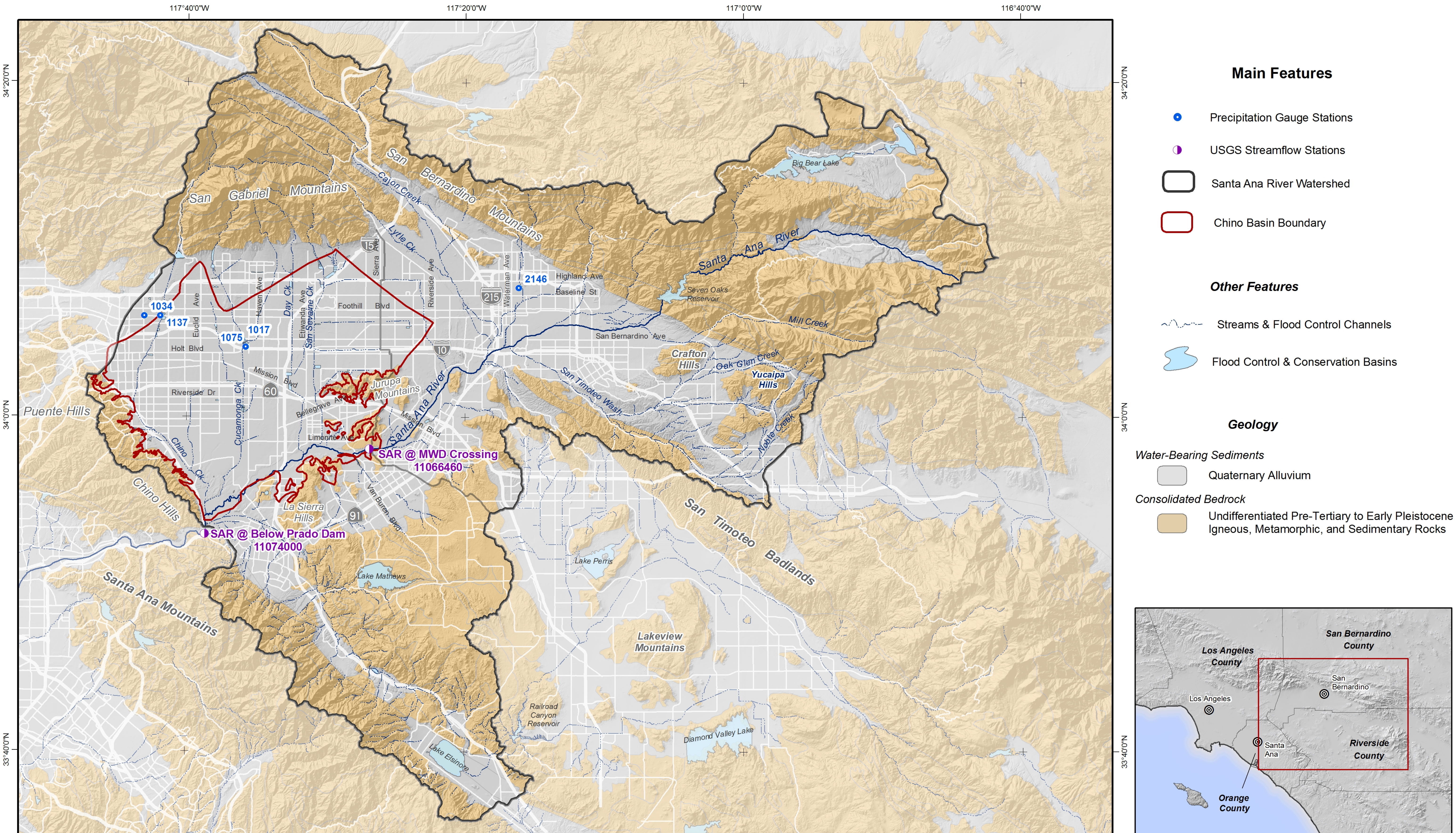
To further illustrate the change in rainfall-runoff relationship, a double mass analysis can be used. A double mass analysis is an arithmetic plot of the accumulated values of observations for two related variables that are paired in time and thought to be related. As long as the relationship between the two variables remains constant, the double mass curve will appear as a straight line (constant slope). A change in slope indicates that the relationship has changed where the break in slope denotes the timing of that change. Figure 2-6 is a double mass curve plot of precipitation at the Claremont/Montclair hybrid, Ontario, and San Bernardino Hospital precipitation stations versus storm water discharge at below Prado Dam for the 1919/20 through 2007/08 period. Note that the slope of the double mass curve after water year 1976/77 is much steeper than prior to 1976/77. The change in curvature denotes that a significant change occurred in the rainfall–runoff relationship. Figure 2-7 is a double mass curve plot of precipitation at the Claremont/Montclair hybrid station and Ontario precipitation stations versus storm water discharge generated in the watershed between the MWD Crossing and Prado Dam. The relationship of storm water discharge and precipitation in Figure 2-7 is similar to that shown in Figure 2-6 with Chino Basin producing about 75 percent of the storm water between the MWD Crossing and Prado Dam. Two observations can be regarding the time history of surface water discharge of the Santa Ana River: 1) there is a steady increase in the baseflow of the river starting around the 1970s and 2) there is an increase in the magnitude of storm water discharge starting in the late 1970s. These changes in discharge have occurred due to urbanization of the watershed. The increase in non-stormwater discharge is due to primarily to increases in recycled water discharges to the Santa Ana River. The increase in stormwater discharge is due to the modification of the land surface caused by the conversion from agricultural to urban uses, lining of stream channels, and other associated improvements in drainage systems.

2.3 Summary/Characterization of Current Hydrologic Regime

The hydrologic regime in the Chino Basin has important implications for water supply and groundwater management. The occurrence of long dry periods, characteristic of the region's climate, limit the recharge of precipitation and storm water recharge for years at a time and requires management strategies that conserve precipitation and storm water recharge whenever available. The amount of stormwater produced per unit of precipitation has increased over time due to urbanization and will continue to increase in the future as the remaining undeveloped and agricultural land uses are converted to developed uses.

Table 2-1
Annual Statistics of Long-Term Records at Precipitation Stations in the Chino Basin
(inches)

Area	Montclair/Claremont	S B Hospital	Ontario
Period of Record	1900 to 2008	1900 to 2008	1914 to 2008
Annual Average	17.78	16.36	15.38
Maximum	37.58	35.65	37.41
Minimum	5.39	5.95	3.84
Standard Deviation	7.66	6.83	7.05
Mean + 1 Standard Deviation	25.44	23.19	22.43
Coefficient of variation	43%	42%	46%



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File: Figure_2-1.mxd

0 2 4 6 8 Miles
0 3 6 9 12 KM

2008 State of the Basin Report
General Hydrologic Condition

Santa Ana River Watershed Tributary to the Chino Basin

Figure 2-1

Figure 2-2
Annual Precipitation in the Claremont/Montclair Area

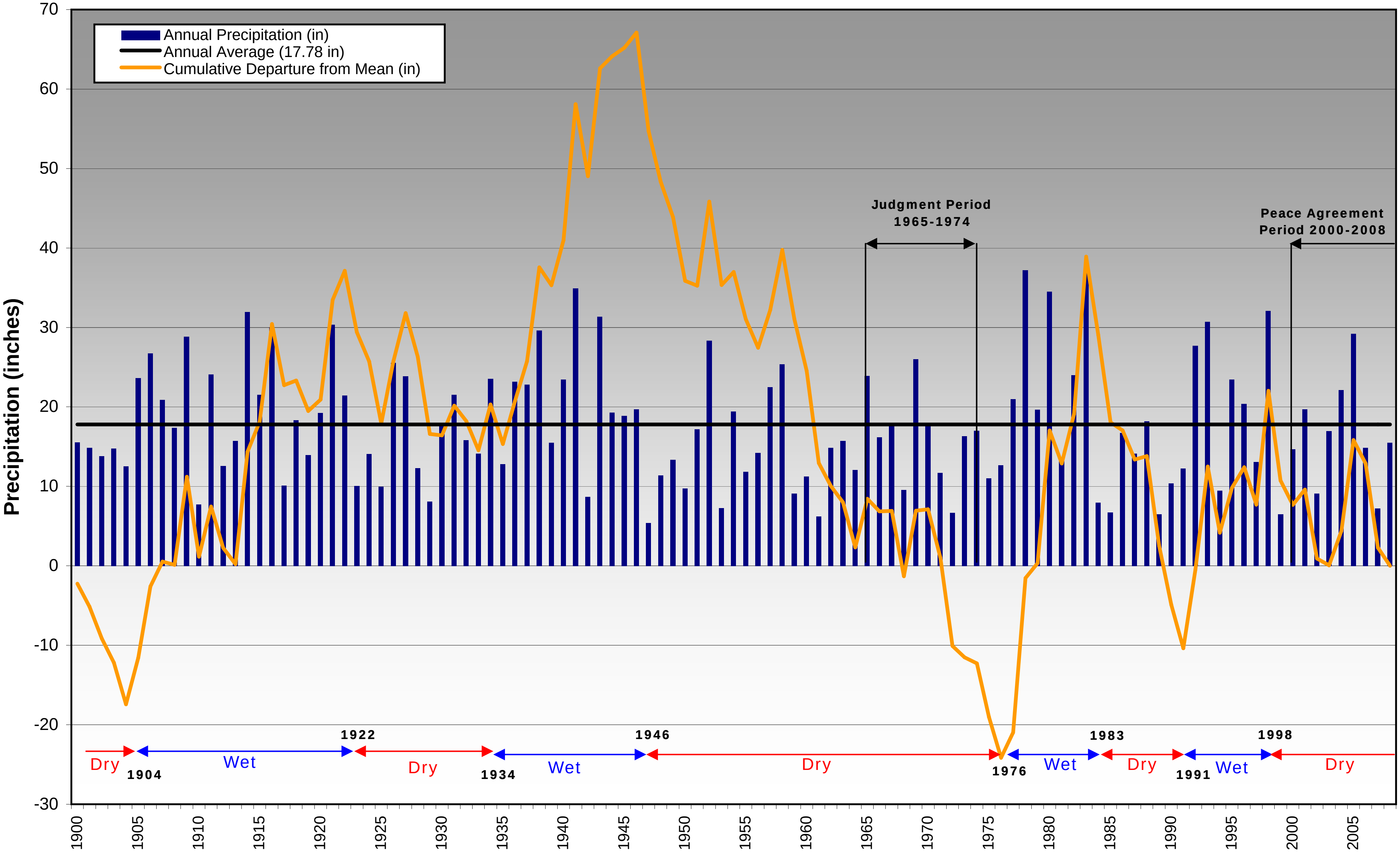

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Figure 2-3
Annual Precipitation in the Ontario Area

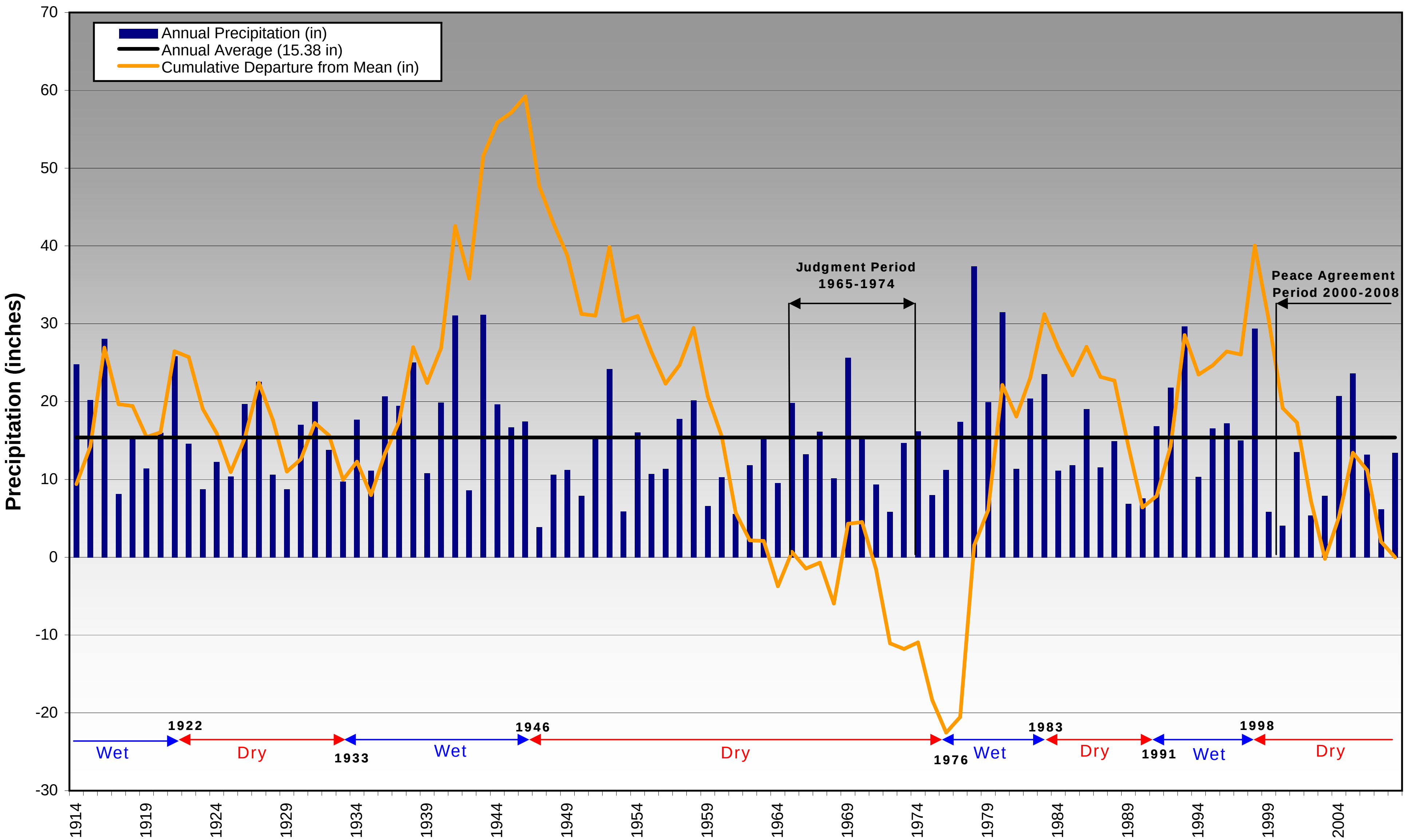

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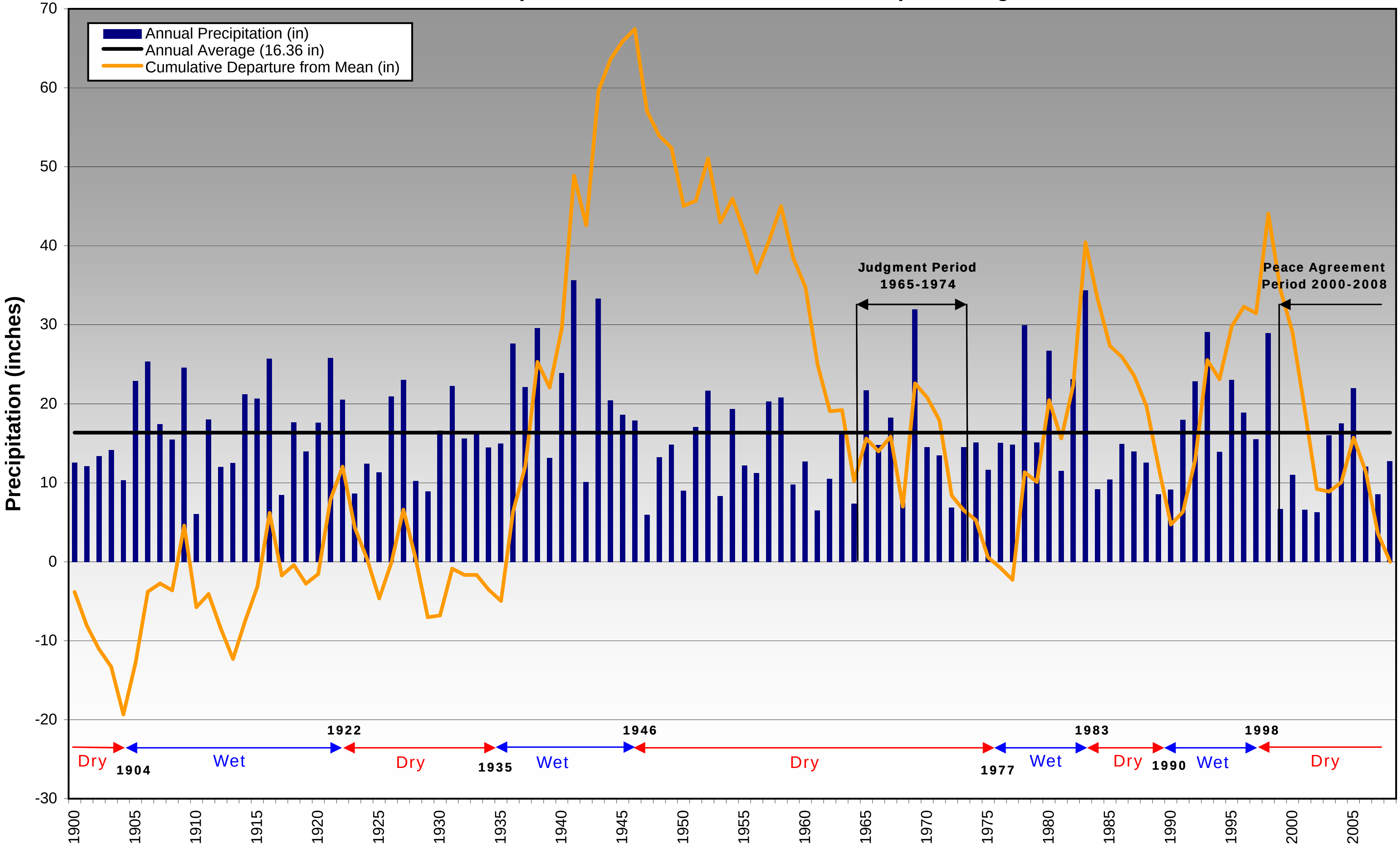
Figure 2-4
Annual Precipitation at the San Bernardino Hospital Gauge



SOB_08hydrology.xls -- SB_Hospital_Chart-fig2-4

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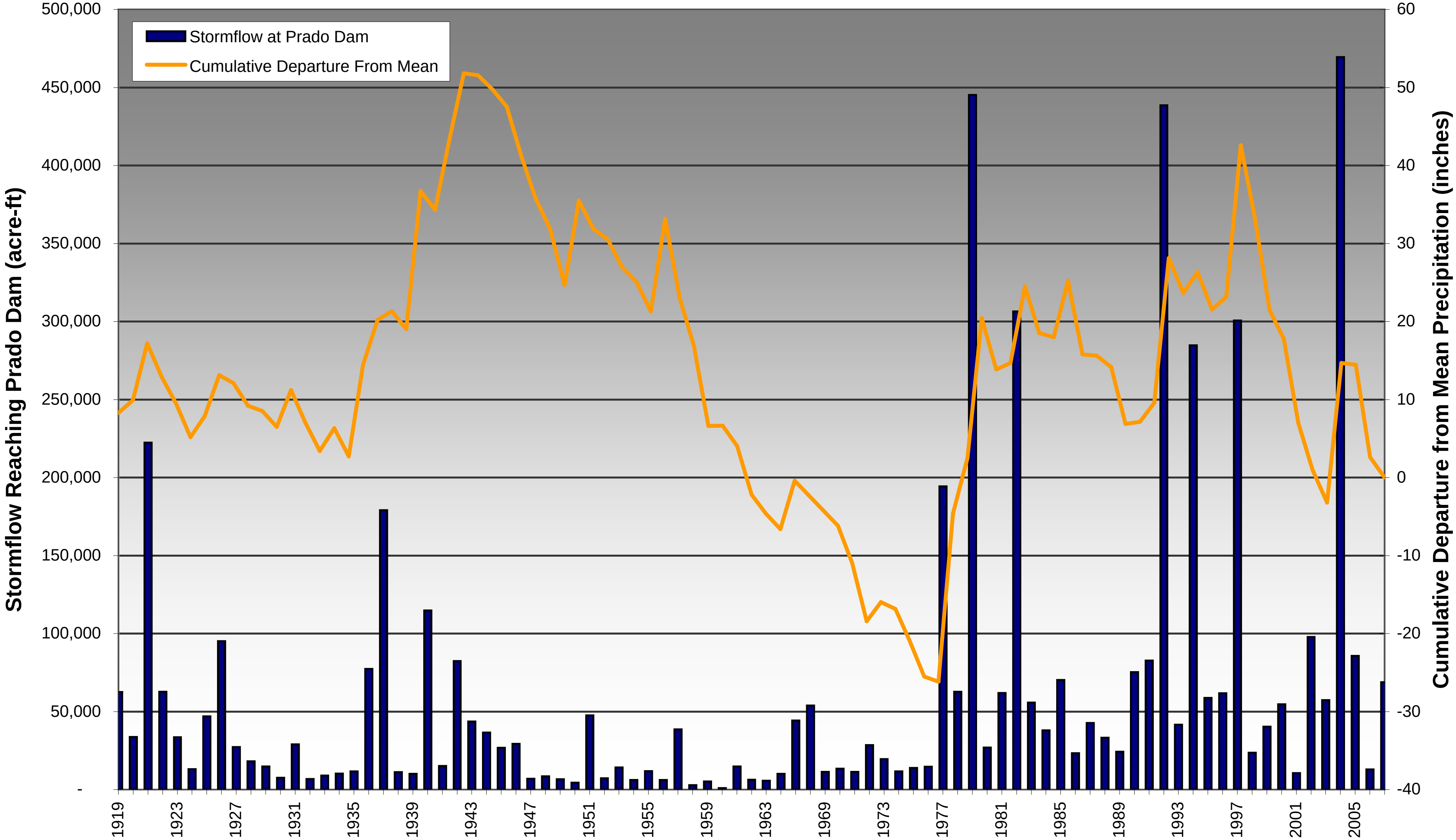
Figure 2-5
Annual Stormflow Measured at below Prado Dam
Water Year 1919/20 - 2007/08



Figs_2-5_to_2-7.xls -- Fig 2-5 Stormflow and CDFM

Figure 2-6
Double Mass Curve of Precipitation
vs Storm Flow Measured at below Prado Dam
Water Years 1919/20 through 2007/08

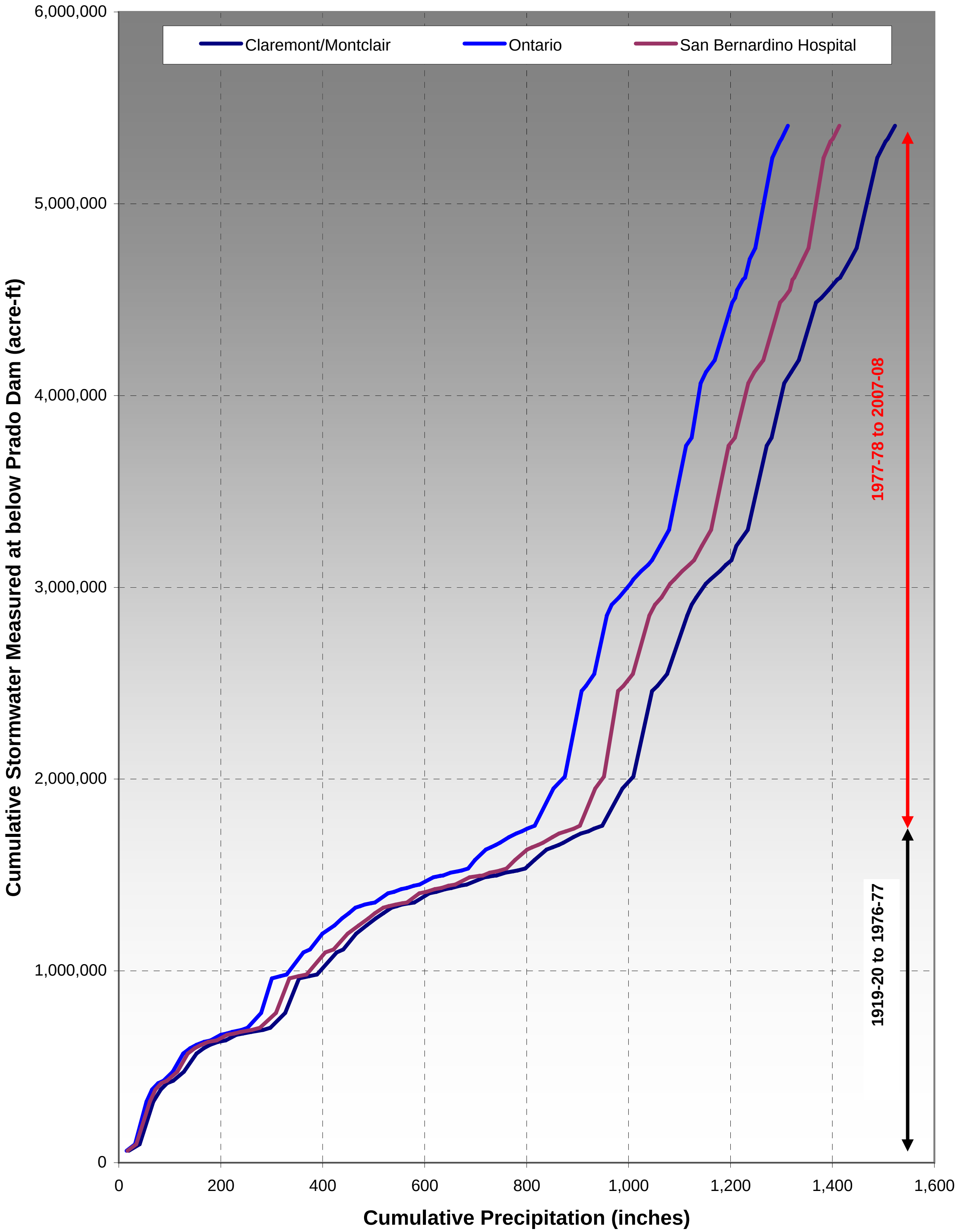
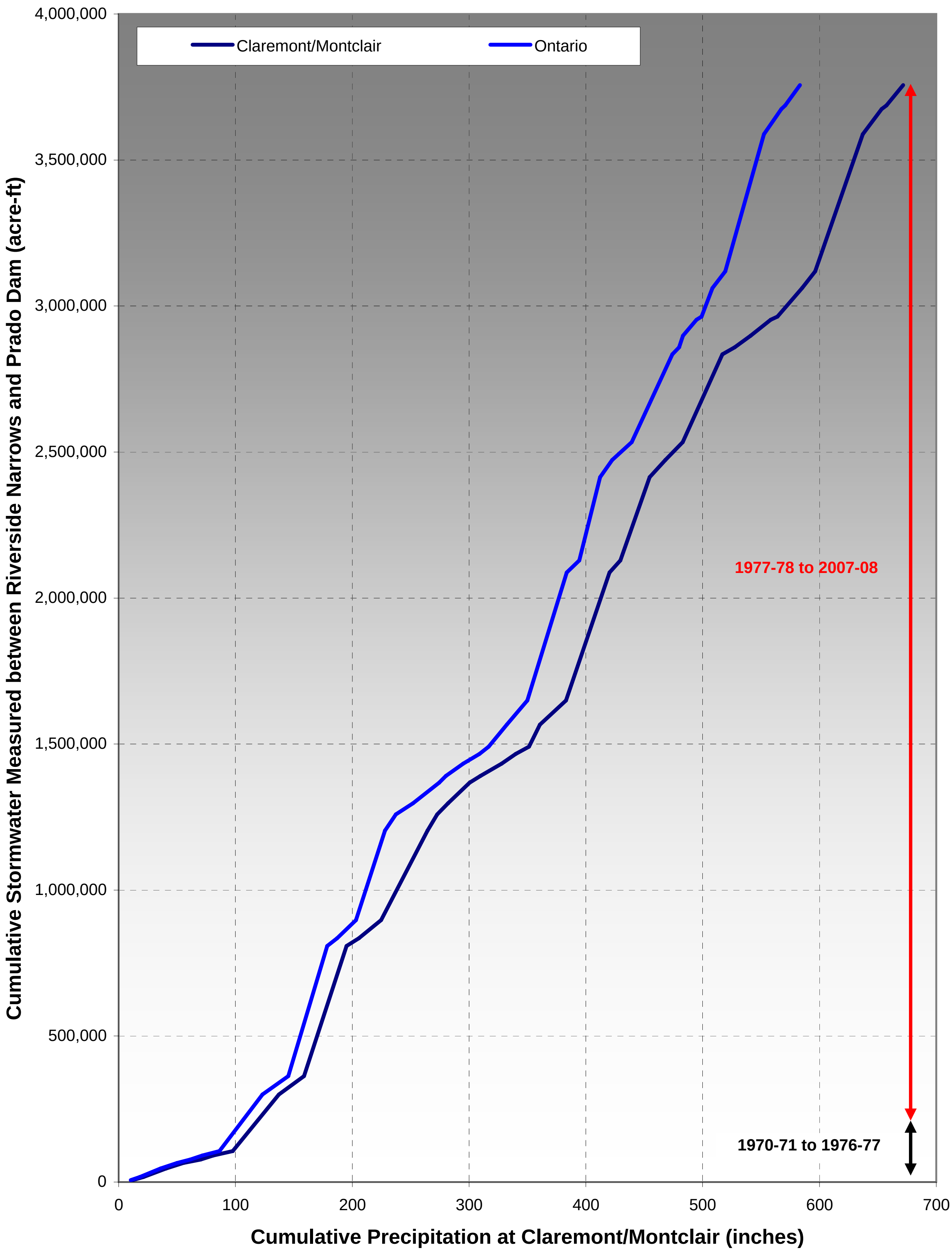


Figure 2-7
Double Mass Curve of Precipitation in Chino Basin vs Storm Flow Generated between Riverside Narrows and Prado Dam
Water Years 1970/71 through 2007/08



Figs_2-5_to_2-7.xls -- Fig 2-7 DM StormRNtoPD vPrecip

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Section 3 – Basin Operations and Groundwater Monitoring

3.1 Background

The OBMP states that the re-determination of safe yield and the estimation of losses from groundwater storage programs require comprehensive groundwater-level mapping across the basin, analyses of groundwater level time histories at wells, and accurate estimations of groundwater production and artificial recharge activities. Pursuant to the Peace Agreement, Watermaster will re-determine safe yield and establish loss rates from storage in 2010.

The monitoring of basin activities—such as groundwater production and artificial recharge—and potential responses to those activities—such as changes in groundwater levels and storage—is a major component of *OBMP Program Element 1 – Develop and Implement a Comprehensive Monitoring Program*. Program Element 1 was developed, in part, to address the first impediment to *OBMP Goal 1 – Enhance Basin Water Supplies*: "Unless certain actions are taken, safe yield of the Basin will be reduced […] due to groundwater outflow from the southern part of the Basin." (WEI, 1999) This impediment speaks to the possibility of increased groundwater outflow to the Santa Ana River as a result of (1) reduced groundwater production in the southern part of the basin as agricultural land is converted to urban uses and (2) increased groundwater storage due to other management activities, such as artificial recharge and storage and recovery programs. That is, increased groundwater levels in the southern Chino Basin (via reduced groundwater production and/or increased groundwater storage) may result in increased groundwater discharge to the Santa Ana River (i.e. loss of basin yield). This potential loss of safe yield needs to be computed periodically and used in the administration of the Judgment; otherwise, the Chino Basin could be overdrafted.

This section describes the physical state of the Chino Basin with respect to groundwater pumping, artificial recharge, groundwater levels, and groundwater storage. Special attention is given to changes that have occurred since the implementation of the OBMP (2000) and since the last State of the Basin Report (2006).

3.2 Groundwater Flow System

The physical nature of groundwater occurrence and movement with regard to basin boundaries, recharge, groundwater flow, and discharge is described below.

3.2.1 Groundwater Recharge, Flow, and Discharge

While considered one basin from geologic and legal perspectives, the Chino Basin can be hydrologically subdivided into at least five flow systems that act as separate and distinct hydrologic units. Each flow system can be considered a management zone, and the management zones delineated in the OBMP were determined based on these hydrologic units (WEI, 1999), as shown in Figure 1-1. Each management zone has a unique hydrology, and water resource management activities that occur in one management zone have limited impacts on the other management zones.

The predominant sources of recharge to Chino Basin groundwater reservoirs are percolation of direct precipitation and returns from applied water. The following is a list of other potential sources of recharge:

- Infiltration of flow within unlined stream channels overlying the basin
- Underflow from fractures within the bounding mountains and hills
- Artificial recharge of urban runoff, storm water, imported water, and recycled water at recharge basins
- Underflow from seepage across the bounding faults, including the Red Hill Fault (from Cucamonga basin), the San Jose Fault (from the Claremont Heights and Pomona basins), and the Rialto-Colton Fault (from the Rialto-Colton Basin)
- Deep percolation of precipitation and returns from use
- Intermittent underflow from the Temescal Basin

In general, groundwater flow mimics surface drainage patterns: groundwater flows from the forebay areas of high elevation (areas in the north and east flanking the San Gabriel and Jurupa Mountains) towards areas of discharge near the Santa Ana River within the Prado Flood Control Basin.

In detail, groundwater discharge throughout Chino Basin primarily occurs via:

- Groundwater production
- Rising water within Prado Basin (and potentially other locations along the Santa Ana River, depending on climate and season)
- Evapotranspiration within Prado Basin (and potentially other locations along the Santa Ana River, depending on climate and season) where groundwater is near or at the ground surface
- Intermittent underflow to the Temescal Basin

3.3 Monitoring Programs

3.3.1 Groundwater Pumping Monitoring

Since its establishment in 1978, Watermaster has collected information to develop groundwater production estimates. Appropriative Pool and Overlying Non-Agricultural Pool estimates are based on flow meter data that are provided by producers on a quarterly basis. Agricultural Pool estimates are based on water duty methods and meter data. The Watermaster Rules and Regulations require groundwater producers that produce in excess of 10 acre-feet per year (AFY) to install and maintain meters on their well(s). In 2000, Watermaster initiated a meter installation program for Agricultural Pool wells and a meter-reading program that required at least one reading per year.

In the OBMP Phase I Report (WEI, 1999), it was estimated that up to 600 private wells would need to be equipped with meters. Watermaster staff completed meter installation on the majority of these wells and began reading meters in 2003. Some agricultural wells were not metered due to the anticipated conversion of land from agricultural to urban uses. As of

December 2008, Watermaster had installed or repaired meters at 326 active agricultural wells. Watermaster records production data from these meters on a quarterly basis. These data are then entered into Watermaster's database. Figure 3-1 shows the locations of all active wells in fiscal 2007/08 by pool.

3.3.2 Artificial Recharge Monitoring

Figure 3-2 shows the locations of the basins used for artificial recharge in the Chino Basin. There are four types of water recharged within Chino Basin: imported water from the State Water Project (SWP), storm water, urban runoff, and recycled water. Deliveries of SWP water are monitored using water delivery records supplied by the Metropolitan Water District of Southern California (MWDSC) and the IEUA. Historically, the recharge of storm water and urban runoff was incidental to flood control operations, and many opportunities to measure and record this recharge were missed. Since the implementation of the OBMP, water level data sensors have been installed in each recharge basin. Recorded changes in recharge basin water levels during storm events coupled with elevation-area-volume curves and elevation-outflow relationships allow for the calculation of storm water and urban runoff recharge. Recycled water is recharged at seventeen of the recharge sites, most of which have multiple basins. The IEUA monitors and reports recycled water quality and recharge volumes. Groundwater quality within the vicinity of the recycled water recharge basins is measured and reported quarterly by the IEUA.

3.3.3 Groundwater Level Monitoring

Groundwater level monitoring was inadequate prior to OBMP implementation. Problems with historical groundwater level monitoring included an inadequate areal distribution of wells in monitoring programs, short time histories, questionable data quality, and insufficient resources to develop and conduct a comprehensive program.

The OBMP defined a new, comprehensive groundwater level monitoring program. The program start-up occurred in two steps: an initial survey from 1998 to 2001, followed by long-term monitoring at a set of key wells.

Watermaster has three active groundwater level monitoring programs operating in the Chino Basin: (1) a semiannual basin-wide well monitoring program, (2) a key well monitoring program that is associated with the Chino I/II Desalter well fields and the HCMP, and (3) a piezometric monitoring program that is associated with land subsidence and ground fissuring in Management Zone 1 (MZ1). Monitoring frequency varies with each program. Figure 3-3 shows the locations and measurement frequencies of all the wells that are currently used in Watermaster's groundwater level monitoring programs. In addition to its field programs, Watermaster collects groundwater level data from municipal producers, government agencies, and private entities. All collected water level measurements are entered into Watermaster's relational database.

3.3.3.1 Basin-wide Groundwater Level Monitoring Program

The objective of the basin-wide groundwater level monitoring program is to collect groundwater level data from all wells in the Chino Basin that can be reliably monitored. These wells are shown in Figure 3-2, symbolized by their measurement frequencies. Wells in the other groundwater level monitoring programs (see Sections 3.3.3.2 and 3.3.3.3 below) are, by definition, also part of the basin-wide monitoring program. In total, the basin-wide program consists of about 900 wells. Watermaster staff measures water levels at about 450 private wells at least twice per year (spring and fall). At the remaining wells, water levels are measured by other agencies, including:

- California Department of Toxic Substances and Control (Stringfellow Superfund Site)
- Orange County Water District (Prado Basin)
- Santa Ana Regional Water Quality Control Board (various remediation sites)
- USGS (special investigations)
- County of San Bernardino (landfill monitoring)
- Private Consultants (various remediation sites)

Watermaster collects data for these wells twice per year; though, for some of these wells, data are collected more frequently as part of other monitoring programs (see below).

3.3.3.2 Key Well Water Level Program

Watermaster developed and implemented a key well monitoring program in the southern portion of the Chino Basin. The objective of this program is to increase measurement frequency and data quality at a reduced but representative network of wells. This network of wells and the monitoring program must satisfy the requirements for monitoring desalter impacts to local producers and for determining hydraulic control (see Section 3.6.4 for a description of the HCMP).

In the Chino Basin, development has led to the conversion of land from agricultural to urban uses and has resulted in the destruction of wells that were previously included in Watermaster's key well water level monitoring program. As key wells are lost to development, nearby wells are evaluated for suitability as key well replacements. Currently, there are 159 wells in the key well water level monitoring program. Manual water levels measurements are done monthly at 95 of these wells. The remaining 64 wells contain pressure transducers/data loggers that automatically record water levels once every 15 minutes.

3.3.3.3 MZ1 Monitoring Program

The MZ1 monitoring program is an intensive aquifer-system monitoring program that was implemented beginning in Watermaster fiscal year 2001/02 to provide information that could be used by Watermaster to determine the causes of subsidence in MZ1 and develop a long-term subsidence management plan for MZ1. In fiscal 2002/03, an aquifer system monitoring facility was constructed at Ayala Park in the City of Chino. This facility includes multi-depth piezometers that record depth-specific head once every 15 minutes. In addition, about 30 production and monitoring wells that surround this facility are equipped with pressure transducers that record water levels once every 15 minutes. All of these data are uploaded to Watermaster's water level database. Several of these wells are also included in the key well water level monitoring program.

3.4 Groundwater Pumping

3.4.1 Historical Groundwater Pumping

Table 3-1 lists Watermaster's records of Chino Basin production by pool for the period fiscal 1977/78 through fiscal 2007/08. Figure 3-4 depicts the distribution of production by pool. Over this period, annual groundwater production has ranged from a high of about 198,000 AF (fiscal 2006/07) to a low of about 123,000 AF (fiscal 1982/83) and has averaged about 154,000 AFY since fiscal 1977/78. The distribution of production by pool has shifted since 1977. Agricultural Pool production, which is mainly concentrated in the southern portion of the basin, dropped from about 54 percent of total production in 1977-78 to about 19 percent in 2007/08. During the same period, Appropriative Pool production, which is mainly concentrated in the northern half of the basin, increased from about 40 percent of total production in 1977-78 to about 79 percent in 2007/08 (sum of production for the appropriative pool and the Chino Desalter Authority [CDA]). Increases in Appropriative Pool production have approximately kept pace with declines in agricultural production. Production in the Overlying Non-Agricultural Pool declined from about 5 percent of total production in fiscal 1977/78 to about 2 percent in the mid-1980s, rose to about 4 percent through the 1990s, and recently decreased to about 2 percent in 2003-04 where it remained through fiscal 2007/08.

Figures 3-5 through 3-9 illustrate the location and magnitude of groundwater production at wells in the Chino Basin for fiscal years 1977/78, 1999/2000, 2005/06, 2006/07, and 2007/08, respectively. A close review of these figures indicates:

- There was a basin-wide increase in the number of wells producing over 1,000 AFY between 1978 and 2008. This is consistent with (1) the land use transition from agricultural to urban, (2) the trend of increasing imported water costs, and (3) the use of desalters.
- Since the implementation of the OBMP in 2000, the number of active production wells just north of the Santa Ana River has decreased. This is consistent with the land use transition from agricultural to urban that has been occurring in the area.
- Since the implementation of the OBMP in 2000, desalter pumping has commenced and progressively increased; in fiscal 2007/08, desalter pumping reached a historical high of 26,972 AFY.
- Since the implementation of the OBMP in 2000, the number of wells that produce over 1,000 AFY on the west side of Chino Basin (west of Euclid Avenue) has decreased. This is consistent with (1) the implementation of the MZ1 Interim Management Plan, which reduced pumping by up to 3,000 AFY in the Chino area, and (2) reduced pumping by the City of Pomona, the Monte Vista Water District, and the City of Chino Hills from 2003 to 2008, as these agencies have been participating in in-lieu recharge for the Dry-Year Yield Program.

3.4.2 Agricultural Pool Pumping

Agricultural Pool pumping has declined steadily since 1978 (see Figure 3-1). In fiscal 2007/08, total production for the Agricultural Pool fell to 30,910 AF—the Agricultural Pool's lowest production on record. Since OBMP implementation in 2000, Agricultural Pool production has decreased from about 40,000 AF in fiscal 2000/01 (24 percent of total basin production) to about 31,000 AF in fiscal 2007/08 (19 percent of total basin production).

3.4.3 Overlying Non-Agricultural Pool Pumping

Since OBMP implementation in 2000, Overlying Non-Agricultural Pool production has accounted for less than 5 percent of total basin production, ranging from about 2,300 AF (1 percent of total production in fiscal 2004/05) to 8,000 AF (5 percent of total production in fiscal 2000/01). In fiscal 2007/08, Overlying Non-Agricultural production of about 3,400 AF accounted for 2 percent of total basin production.

3.4.4 Appropriative Pool Pumping

Since OBMP implementation in 2000, average production by the Appropriative Pool, excluding desalter production, has been about 122,000 AFY, which accounts for about 70 percent of total basin production.

The CDA operates two desalter facilities (Chino I and Chino II) that are supplied with raw groundwater from 22 wells. The desalter facilities belong to the Appropriative Pool. In fiscal 2007/08, the CDA desalters produced more water than in any previous year (26,972 AF). Since the CDA began pumping in 2000, its production has accounted for about 16 percent of total Appropriative Pool production and about 8 percent of total basin production. During 2005/06, the Chino II Desalter facility became operational, and as a result, CDA groundwater production increased by about 60 percent from the previous year. Average annual production by the CDA since 2000 has been about 14,800 AFY.

Since OBMP implementation in 2000, average annual production by the Appropriative Pool, including desalter production, has been about 137,000 AFY. Approximately 130,000 AF were produced in fiscal 2007/08. As a percent of total basin production, Appropriative Pool production increased from about 72 percent in fiscal 2000/01 to about 79 percent in fiscal 2007/08.

3.5 Artificial Recharge

Watermaster initiated the Chino Basin Groundwater Recharge Program as required by the Peace Agreement. This program is an integral part of Watermaster's OBMP and is summarized in the OBMP Recharge Master Plan. This comprehensive program aims to enhance water supply reliability and improve the groundwater quality of local drinking water wells throughout the Chino Basin by increasing the recharge of storm water, imported water, and recycled water.

Below, the physical volumes of water percolated at recharge basins in the Chino Basin are discussed. Specific source waters include storm water and supplemental water, which consists of State Water Project (SWP) water and recycled water.

3.5.1 Recharge Facilities

There are 21 recharge facilities described in the OBMP Recharge Master Plan, Phase II Report (B&V & WEI, 2001). Table 3-2 lists the operable recharge facilities in the Chino Basin and summarizes annual wet water recharge (by type) for the period of July 1, 2000 through June 30, 2008. Figure 3-2 shows the locations of the groundwater recharge facilities. Detailed descriptions of these facilities and their operating characteristics can be found in *Chino Basin Recharge Facilities Operating Procedures* (GRCC, 2006).

3.5.2 Regulatory Requirements for Recharge in the Chino Basin

The general recharge requirements for the Chino Basin are outlined in Section 5.1 of the Chino Basin Peace Agreement – Recharge and Replenishment. The requirements of the Peace Agreement are further discussed and expanded on in the OBMP Recharge Master Plan (WEI, 2001).

The Recycled Water Groundwater Recharge Program, which is being implemented by the IEUA and Watermaster, is subject to the following requirements:

- California Regional Water Quality Control Board, Santa Ana Region. Monitoring and Reporting Program (M&RP) No. R8-2005-0033 for IEUA and Chino Basin Watermaster. Phase 1 Chino Basin Recycled Water Groundwater Recharge Project, San Bernardino County. April 15, 2005.
- California Regional Water Quality Control Board, Santa Ana Region. Order No. R8-2007-0039. Water Recycling Requirements for Inland Empire Utilities Agency and Chino Basin Watermaster, Chino Basin Recycled Groundwater Recharge Program, Phase I and Phase II Projects, San Bernardino County. June 29, 2007.

3.5.3 Historical Recharge

3.5.3.1 Storm Water Recharge

Storm Water recharge is monitored by the IEUA pursuant to the Chino Basin Recharge Facilities Operating Procedures (GRCC, 2006). Transducers have been installed in each recharge basin that receives storm water. The percolation rate in each basin is measured directly and used in conjunction with established elevation-storage-area tables to calculate recharge.

Since 2000, total storm water recharge has averaged approximately 4,600 AFY. During fiscal years 2006/07 and 2007/08, total storm water recharge in Chino Basin was approximately 4,600 and 9,900 AF, respectively (see Table 3-2).

3.5.3.2 Supplemental Water Recharge

SWP water for artificial recharge is currently available to the region from the MWDSC. The MWDSC delivers SWP water into the Chino Basin from the Foothill Feeder, which flows from east to west across the northern half of the Chino Basin. During fiscal 2006/07, total SWP water recharge in Chino Basin was approximately 6,500 AF. During fiscal 2007/08, there was no SWP water recharge in the Chino Basin. The aggregate average SWP water recharge that has occurred since the OBMP was implemented is about 10,100 AFY.

During fiscal 2007/08, the Banana, Hickory, 7th and 8th Street, and Ely Basins were used to recharge recycled water. During fiscal years 2006/07 and 2007/08, total recycled water recharge in Chino Basin was approximately 3,000 and 2,400 AF, respectively. The aggregate average recycled water recharge that has occurred since the OBMP was implemented is about 1,000 AFY.

During fiscal years 2006/07 and 2007/08, supplemental water recharge—consisting of imported and recycled waters—was approximately 6,350 and 2,400 AF, respectively. The aggregate average supplemental water recharge that has occurred since the OBMP was implemented is about 11,500 AFY.

3.6 Groundwater Levels

This subsection analyzes groundwater levels at wells in the various management zones (MZs) throughout the Chino Basin and discusses changes in groundwater storage since the implementation of the OBMP in 2000 and since the 2006 State of the Basin report.

3.6.1 Historical Groundwater Level Trends

Figure 3-10 shows the locations of wells with groundwater level time histories discussed herein and the Chino Basin management zone boundaries. Wells were selected based on length of record, density of data points, quality of data, geographical distribution, and aquifer system. Wells are identified by their local name (usually owner abbreviation and well number) or their Watermaster ID (CBWM ID) if privately owned.

Figures 3-11 through 3-15 are groundwater level time history charts for the wells shown in Figure 3-10. Some of the short-term groundwater level fluctuations shown in these figures result from the inclusion of static and dynamic observations. Below, by management zone, the behavior of groundwater levels at specific wells is compared to climate, groundwater production, wet water recharge activities, and other factors as appropriate.

To compare groundwater levels to climate, a cumulative departure from mean precipitation (CDFM) curve has been plotted on the groundwater level time history charts. Positive sloping lines on the CDFM curve show wet years or wet periods. Negatively sloping lines show dry years or dry periods. For example, the period from 1978 to 1983 was an extremely wet period, and it is represented by a positively sloping line. To compare groundwater levels to pumping and recharge activities, bar charts that show groundwater production and wet water recharge by management zone have been superimposed on the groundwater level time history charts.

3.6.1.1 Management Zone 1

MZ1 is an elongate region, running generally north-south, and comprises the westernmost area of the Chino Basin. It is bounded by MZ2 to the east, various basin-boundary faults to the north, and sedimentary bedrock outcrops to the west and south.

Figure 3-11 shows groundwater level time histories for the following wells: Monte Vista Water District Well 10 (MVWD-10), City of Pomona Well 11 (P-11), City of Chino Well 10 (C-10), and Chino Hills Wells 15A and 16 (CH-15A and CH-16). The Montclair, College Heights, Upland, and Brooks Street Basins are located in the northern portion of MZ1 and are the primary sites for artificial recharge.

Wells MVWD-10 and P-11 exhibit representative groundwater levels for the northern portion of MZ1. An analysis of static groundwater levels at these wells shows a decline from 1995 to 2001, a period of increased groundwater production in MZ1. Since 2001, water levels have risen by about 100 feet at MVWD-10 and by about 45 feet at P-11. This increase is most likely attributed to a decrease in local production and an increase in wet water recharge in MZ1 since 2001.

Well C-10 is located in central MZ1. Water levels at C-10 peak in the mid-1990s but decline by about 20 feet from 1995 to 2000, which is likely due to increased groundwater production in MZ1. Unlike other wells in MZ1 that experienced significant water level recovery from 2000 to 2006, C-10's water levels remained essentially unchanged. Since 2006, water levels have risen by approximately 20 feet. This increase is due to a decrease in local production and an increase in wet water recharge.

Water levels measured at CH-15A are representative of the shallow aquifer system in the southern portion of MZ1. The recent land subsidence investigation (Section 5) has shown that in southern MZ1, the aquifer system is hydrologically stratified. The shallow aquifer system is unconfined to semi-confined while the deep aquifer system is confined. Water levels in CH-15A have historically been stable at around 80-90 ft-bgs and have experienced small variations in response to nearby pumping. Though, since 2000, water levels have risen by about 10 feet. This is primarily due to the decrease in local production associated with the MZ1 Interim Management Plan.

CH-16 is perforated in the confined deep aquifer system, which is characterized by large changes in piezometric pressure due to nearby pumping. In 2003 and 2004, during a series of pumping tests conducted by Watermaster in southern MZ1, water levels in CH-16 dropped by approximately 100 feet, and the period of recovery lasted several months. These tests demonstrated that piezometric levels in CH-16 (and the deep aquifer system in general) are heavily influenced by changes in pumping from local wells screened within the deep aquifer system. The static water levels at CH-16 declined by about 100 feet from 1995 to 2000 and subsequently recovered by about 140 feet from 2000 to 2006. At the end of 2008, static water levels had declined by about 30 feet from the 2006 highs with a maximum drawdown of about 60 feet observed in the summer of 2008.

3.6.1.2 Management Zone 2

Management Zone 2 (MZ2) is a large, central, elongate area of the Chino Basin (see Figure 3-10). Figure 3-12 shows groundwater level time histories for Cucamonga Valley Water District (CVWD) Wells CB-3 and CB-5 (CVWD CB-3 and CVWD CB-5), City of Ontario Well 16 (O-16), CBWM ID 600394, and Hydraulic Control Monitoring Program Wells 2/1 and 2/2 (HCMP-2/1, and HCMP-2/2). These wells are aligned north to south, approximately along a groundwater flow line. The San Sevaine, Etiwanda, Lower Day, Victoria, Turner, and Ely Basins are located in the northern and central regions of MZ2 and are the primary sites for artificial recharge.

The groundwater level time histories for the northernmost wells—CVWD CB-3 and CB-5 and O-16—show a general water level increase following 1978, which is likely due to a combination of the 1978 to 1983 wet period, the reduction in overdraft following the implementation of the Chino Basin Judgment, and the start of artificial replenishment with imported water in the San Sevaine and Etiwanda Basins. Following the early 1990s, water levels at these wells began to decrease and have continued to decrease to present. The static water levels at CB-3 and CB-5 decreased by approximately 30 feet between 2003 and 2006. Long-term water level decreases in this area of MZ2 are likely due to decreased wet water recharge from 1996 to 2003 and increased groundwater production from 1995 to present.

Well CBWM ID 600394 is located in the central portion of MZ2, north of the Chino I Desalter well field. Water levels at this well have decreased by about 15 feet since 2000.

Wells HCMP 2/1 and HCMP 2/2 are located at the southern end of MZ2 near the Chino I Desalter well field. These wells were completed and the first measurements were recorded in early 2005. HCMP 2/1 is perforated in the shallow aquifer system, and HCMP 2/2 is perforated in the deep aquifer system. Contrary to that of of MZ1, the deeper aquifer in this MZ behaves much more like the shallow, unconfined aquifer, which is indicative of a greater degree of hydraulic communication between the two aquifer systems. Both wells exhibited similar groundwater level increases (15-20 feet) from 2005 to 2006. It is likely that this was due to changes in local production—especially at some of the nearby Chino I Desalter wells, which experienced a production decrease in 2005 and 2006. Since 2006, water levels have decreased by 5-10 feet in both wells.

3.6.1.3 Management Zone 3

Management Zone 3 (MZ3) consists of the area along the eastern boundary of the Chino Basin. It is bounded by MZ2 to the west, Chino-East (MZ4) and Chino-South (MZ5) to the south, and the Rialto-Colton Fault to the east (see Figure 3-10). Figure 3-13 shows water level time histories for Fontana Water Company Wells F30A and F35A (F30A and F35A), Milliken Landfill Well M-3 (M-3), County of San Bernardino MIL M-06B, CBWM ID 3602468, and HCMP Well 7/1 (HCMP 7/1). These wells are aligned northeast to southwest, approximately along a groundwater flow line. The RP-3 and Declez Basins are located in the central region of MZ3 and are the primary sites for artificial recharge.

Wells F30A and F35A are located in the northeastern portion of MZ3. The groundwater level time histories of these two wells show relatively stable water levels from 1978 until the late

1990s. From 2000 to 2006, the wells experienced a progressive decline in water levels of about 25 feet. This decline is likely due to increased production in MZ3. Their lack of responsiveness to climate is likely due to the absence of significant sources of recharge. Since 2006, water levels at F35A have remained relatively unchanged, and water levels at F30A have fluctuated ±5 to 10 feet.

Wells M-3/M-06B and CBWM ID 3602468 are located in the central portion of MZ3. From 2000 to 2006, a groundwater decline of about 30 feet was observed at these wells.

The southernmost well, HCMP-7/1, experienced a groundwater level decline of about 20 feet from 2005 to the end of 2008. Similar water level declines can be observed in most wells throughout MZ3. This regional drawdown in MZ3 is likely due to the steady increase in production within MZ3 over the past 30 years and a lack of artificial recharge.

3.6.1.4 Management Zone 4

MZ4 – also known as Chino-East – is bounded by the Jurupa Hills to the north, the Pedley Hills to the east, MZ5 to the south, and MZ3 to the west (see Figure 3-10). Figure 3-14 shows groundwater level time histories for HCMP Well 9/1 (HCMP-9/1), Jurupa Community Services District Well 10 (JCSD-10), and CBWM ID 3300718. There are no major recharge basins in MZ4, and very little groundwater production occurs in this area.

Groundwater levels at these wells decreased by about 30 feet between 2000 and 2008. These declines are likely due to groundwater production at nearby wells, including the Chino II desalter well field, which is located near the western boundary of the MZ.

3.6.1.5 Management Zone 5

MZ5 – also known as Chino-South – is bounded by MZ4 to the north, MZ3 to the west, the Riverside Narrows to the east, and various unnamed hills to the south (see Figure 3-10). Figure 3-15 shows groundwater level time histories for USGS Well Archibald-1, HCMP Well 8/1 (HCMP 8/1), and Santa Ana River Water Company Well 07 (SARWC-07). There are no groundwater recharge basins in MZ5, but the Santa Ana River is a major source of groundwater recharge.

These wells exhibit very little groundwater level variation due to the stabilizing effects of the Santa Ana River. Production in MZ5 decreased steadily from 1978 to 2008 due to the destruction of many private agricultural wells. Current production is approximately 3,000 AFY (see Figure 3-15). Groundwater levels in HCMP-8/1 and SARWC-07 have declined about 10-15 feet since 2006. This decline is likely due to the onset of pumping at nearby Chino II Desalter wells.

3.6.2 Current Groundwater Levels

The groundwater level data collected from the various monitoring programs described in Section 3.3 were used to create groundwater level elevation contour maps of the Chino Basin for fall 2000 (Figure 3-16), fall 2003 (Figure 3-17), fall 2006 (Figure 3-18), and fall 2008 (Figure 3-19). Appendix A is an E-sized water level map that includes the point data used to contour the fall 2008 groundwater levels. The following procedures were used in the creation of these maps:

- Extract the entire time history of groundwater level data from Watermaster's groundwater level database for all wells in the Chino Basin.
- Plot and explore groundwater elevation time histories for all wells.
- Choose one "static" groundwater level elevation data point per well that is representative of the fall 2008 period.
- Plot groundwater level elevation data on maps with background geologic/hydrologic features.
- Contour and digitize groundwater elevation data.

The groundwater elevation contours for fall 2008 (Figure 3-19) are generally consistent with past groundwater elevation contour maps (see, for example, Figures 3-16, 3-17, and 3-18). These maps show that groundwater generally flows in a south-southwest direction from the primary areas of recharge in the northern parts of the basin toward the Prado Flood Control Basin in the south. There are notable pumping depressions in the groundwater level surface that interrupt the general flow patterns in the northern portion of MZ1 (Montclair and Pomona areas) and directly southwest of the Jurupa Hills. There is a discernible depression in groundwater levels surrounding the Chino I & Chino II Desalter well fields.

Close inspection of the groundwater level data used to construct these maps suggests the existence of hydraulically distinct aquifer systems—primarily in MZ1 and the western parts of MZ2. Previous investigations have concluded that two distinct aquifer systems exist in these areas: a shallow unconfined to semi-confined aquifer and deeper confined aquifer. The groundwater levels shown in these maps correspond to the shallow aquifer system and do not reflect the piezometric levels of the deeper aquifers.

3.6.3 Changes in Groundwater Storage

Watermaster developed a GIS model to estimate groundwater storage changes from the groundwater level contour maps discussed above. In preparing this model, Watermaster compiled a comprehensive library of well driller's logs for wells in the Chino Basin. Lithologic descriptions of borehole cuttings and associated depth intervals were digitized and added to Watermaster's database. All lithologic descriptions were then assigned a value of specific yield based on USGS investigations (Johnson, 1967). These data were then used to estimate the average specific yield across each hydrostratigraphic layer in the Chino Basin (see Section 2 of this report for additional details).

The storage change model and the procedures for estimating storage change include:

- Create groundwater elevation contour maps of the Chino Basin for the beginning and ending of the period for which a storage change will be estimated (e.g. fall 2000, fall 2003, and fall 2006).
- Create three-dimensional raster surfaces (ESRI grids) of the groundwater elevation contour maps.

- Create a 400-meter by 400-meter grid (polygon shapefile) of the Chino Basin.
- Assign attributes to each grid cell for (1) surface area, (2) overlying management zone, (3) beginning groundwater elevation surface (e.g. fall 2003), (4) ending groundwater elevation surface (e.g. fall 2006), (5) top and bottom elevations for the model layers, and (6) the specific yield of sediments for each model layer.
- Export the attribute table of the 400-meter grid to spreadsheet format to calculate the volumetric storage change.

Figure 3-20 shows the 400x400-meter grid, symbolized by the storage change between fall 2000 and fall 2003. Basin-wide, the groundwater storage model estimates a change in storage of about -93,400 AF over this three-year period. Based on this figure, the following sub-areas experienced a decrease in storage:

- In the northwest near Pomona and Montclair
- In the northeast near Fontana and eastern Ontario and Rancho Cucamonga
- Near the Chino I Desalter well field, which began producing groundwater in 2000

And, the following sub-areas experienced an increase in storage:

- In the southwest within the City of Chino where pumping decreased in association with the land subsidence investigation and the Forbearance Agreement
- In the south, just north of the Santa Ana River, where many agricultural wells are being destroyed as land use transitions from agricultural to urban

Figure 3-21 shows the 400x400-meter grid, symbolized by the storage change between fall 2003 and fall 2006. Basin-wide, the groundwater storage model estimates a change in storage of about +46,500 AF over this three-year period. Based on this figure, the following sub-areas experienced a decrease in storage:

- In the northeast near Fontana as well as in eastern Ontario and Rancho Cucamonga in MZ2 and MZ3
- In the area directly west of the Jurupa Mountains in MZ3
- In the area immediately surrounding the eastern portions of the Chino I Desalter well field (During this period, increased production in this area was mainly due to the onset of pumping at the Chino I Desalter expansion wells.)

And, the following sub-areas experienced an increase in storage:

- In the northwest near Pomona and Montclair in MZ1 where pumping decreased in association with in-lieu recharge for the Dry-Year Yield program
- In the southwest within the City of Chino where pumping decreased in association with the land subsidence investigation and the Forbearance Agreement
- In the southern region of MZ2 on the west side of the Chino I Desalter well field
- In the south, just north of the Santa Ana River, where many agricultural wells are being destroyed as land use transitions from agricultural to urban

Figure 3-22 shows the 400x400-meter grid, symbolized by the storage change between fall 2006 and fall 2008. Basin-wide, the groundwater storage model estimates a change in storage of about -53,600 AF over this two-year period. Based on this figure, the following sub-areas experienced a decrease in storage:

- In the area directly west and southwest of the Jurupa Mountains in MZ3 (This area is influenced by groundwater production at wells owned by the Jurupa Community Services District.)
- In the area immediately surrounding the eastern portion of the Chino I Desalter well field (During this period, increased production in this area was mainly due to the continued pumping at the Chino I Desalter expansion wells.)
- In the area immediately surrounding the Chino II Desalter well field (During this period, increased production in this area was due to increased pumping at the Chino II Desalter wells.)

And, the following sub-areas experienced an increase in storage:

- In the northwest near Pomona and Montclair in MZ1 where pumping decreased in association with in-lieu recharge for the Dry-Year Yield program
- In the southwest where pumping decreased in association with the land subsidence investigation and the Forbearance Agreement
- In the south, just north of the Santa Ana River, where many agricultural wells are being destroyed as land use transitions from agricultural to urban

The total change in storage since implementation of the OBMP (2000-08) is approximately -62,000 AF.

3.6.4 Assessment of Hydraulic Control

The hydrologic conceptual model of Chino Basin describes an aquifer system where groundwater flows from areas of recharge in the Chino-North MZ (a grouping of the northern portions of MZs 1, 2, and 3) toward areas of historical surface discharge in the south near the Prado Basin and the Santa Ana River (WEI, 2006a). One of the intended purposes of the Chino Desalter well fields is to intercept (capture) groundwater originating in the Chino-North MZ before discharges to the Prado Basin or the Santa Ana River as surface water.

Piezometric data collected from monitoring and production wells in the southern portion of the Chino Basin during the period of 1997 through 2008 were analyzed to determine the state of hydraulic control. For a full discussion of hydraulic control, see the *Chino Basin Maximum Benefit Monitoring Program 2008 Annual Report* (WEI, 2009). Figure 3-23 shows groundwater elevation contours and data for the shallow aquifer system in spring 2000—prior to any significant pumping by the Chino I Desalter wells. The contours depict regional groundwater flow from the northeast to the southwest. Figure 3-24 shows groundwater elevation contours and data for the shallow aquifer system in spring 2006—after six years of pumping from the Chino I Desalter wells but prior to any significant pumping from the Chino II Desalter wells. Note that desalter pumping in 2006 interrupts the regional flow pattern of 2000. Specifically, the contours to the north and southeast of the desalter well field swing in towards the eastern half of the well field where the desalter wells are perforated primarily within the shallow aquifer system. Figure 3-26 shows groundwater elevation contours and data for the shallow aquifer system in spring 2008, approximately eight years after the commencement of Chino I Desalter pumping and two years after the commencement of Chino II Desalter pumping. The Chino II Desalter well field began producing groundwater in mid-2006, causing the contours to swing in toward the well field from the north and the southeast. The data continue to suggest a reduction in the southward component of the hydraulic gradient around the western half of the Chino I Desalter well field; however, the contours do not indicate a gradient reversal and, hence, do not provide compelling evidence for hydraulic control in this region.

Since 2000, pumping at the Chino I Desalter well field has generally flattened the regional hydraulic gradient within the shallow aquifer system around the western half of the Chino I Desalter well field and has created a capture zone surrounding the eastern half of the well field. Around the western half of the Chino I Desalter well field, piezometric data suggest a significant reduction in the southward component of the hydraulic gradient but do not indicate a gradient reversal (northward component) and, hence, do not yet provide compelling evidence for complete hydraulic control at the Chino I Desalter well field. Pumping at the Chino II Desalter well field, where all wells are perforated within the shallow and deep aquifer systems, began in mid-2006. A depression continues to develop in the piezometric surface. The ultimate fate of groundwater that flows past the western portion of the Chino I Desalter well field is continued flow southward toward the Prado Basin where groundwater rises to become surface water in the tributaries of the Prado Basin.

Table 3-1
Summary of Recharge and Discharge
(acre-ft)

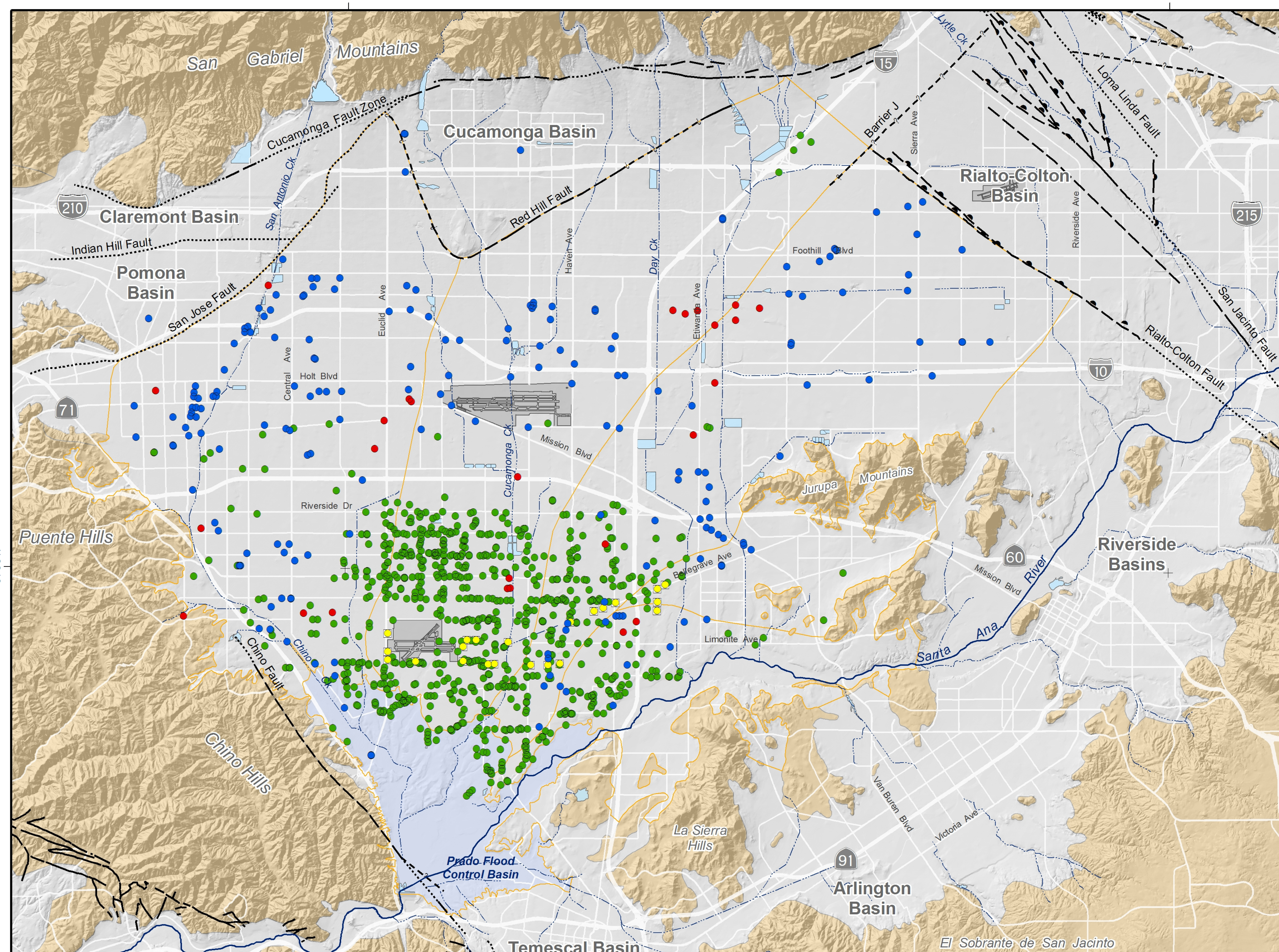
Fiscal Year		Wet Water Recharge to the Chino Basin								Discharge[7]										
	Safe Yield	Wet Water Recharge[1]							Total Inflow	Pumping						Pumping Distribution (% of Total)				
		Replenish	Cyclic or Conj Use	MZ1 Program	Recycled	New Storm Water[5]	Desalter Induced SAR Inflow[6]	Total		Appropriative Pool less CDA Desalters[2, 3, 4]	Chino Desalter Authority	Total Appropriative Pool	Agricultural Pool	Overlying Non-Ag Pool	Total	Appropriative Pool less CDA Desalters[2, 3, 4]	Chino Desalter Authority	Total Appropriative Pool	Agricultural Pool	Overlying Non-Ag Pool
1977 - 1978	140,000	10,680	0	0	0	0	0	10,680	150,680	60,659	0	60,659	83,934	10,082	154,675	39%	0%	39%	54%	7%
1978 - 1979	140,000	12,638	15,757	0	0	0	0	28,395	168,395	60,597	0	60,597	73,688	7,127	141,412	43%	0%	43%	52%	5%
1979 - 1980	140,000	2,507	14,243	0	0	0	0	16,751	156,751	63,834	0	63,834	69,369	7,363	140,566	45%	0%	45%	49%	5%
1980 - 1981	140,000	12,228	8,662	0	0	0	0	20,890	160,890	70,726	0	70,726	68,040	5,650	144,416	49%	0%	49%	47%	4%
1981 - 1982	140,000	16,609	5,047	0	0	0	0	21,656	161,656	66,731	0	66,731	65,117	5,684	137,532	49%	0%	49%	47%	4%
1982 - 1983	140,000	13,188	15,501	0	0	0	0	28,689	168,689	63,481	0	63,481	56,759	2,395	122,635	52%	0%	52%	46%	2%
1983 - 1984	140,000	13,777	7,960	0	0	0	0	21,737	161,737	70,558	0	70,558	59,033	3,208	132,799	53%	0%	53%	44%	2%
1984 - 1985	140,000	12,188	8,709	0	0	0	0	20,897	160,897	76,912	0	76,912	55,543	2,415	134,870	57%	0%	57%	41%	2%
1985 - 1986	140,000	16,332	2,095	0	0	0	0	18,427	158,427	80,859	0	80,859	52,061	3,193	136,113	59%	0%	59%	38%	2%
1986 - 1987	140,000	10,086	9,921	0	0	0	0	20,007	160,007	84,662	0	84,662	59,847	2,559	147,068	58%	0%	58%	41%	2%
1987 - 1988	140,000	2,494	0	0	0	0	0	2,494	142,494	91,579	0	91,579	57,865	2,958	152,402	60%	0%	60%	38%	2%
1988 - 1989	140,000	7,407	0	0	0	0	0	7,407	147,407	93,617	0	93,617	46,762	3,619	143,998	65%	0%	65%	32%	3%
1989 - 1990	140,000	0	0	0	0	0	0	0	140,000	101,344	0	101,344	48,420	4,856	154,620	66%	0%	66%	31%	3%
1990 - 1991	140,000	3,291	503	0	0	0	0	3,793	143,793	86,658	0	86,658	48,085	5,407	140,150	62%	0%	62%	34%	4%
1991 - 1992	140,000	3,790	1,761	0	0	0	0	5,551	145,551	91,982	0	91,982	44,682	5,240	141,904	65%	0%	65%	31%	4%
1992 - 1993	140,000	12,535	1,677	0	0	9,041	0	23,253	163,253	86,367	0	86,367	44,092	5,464	135,923	64%	0%	64%	32%	4%
1993 - 1994	140,000	8,859	7,634	0	0	0	0	16,493	156,493	80,798	0	80,798	44,298	4,586	129,682	62%	0%	62%	34%	4%
1994 - 1995	140,000	0	10,300	0	0	0	0	10,300	150,300	93,419	0	93,419	55,022	4,327	152,768	61%	0%	61%	36%	3%
1995 - 1996	140,000	82	0	0	0	0	0	82	140,082	101,606	0	101,606	43,639	5,424	150,669	67%	0%	67%	29%	4%
1996 - 1997	140,000	0	17	0	0	0	0	17	140,017	110,163	0	110,163	44,809	6,309	161,281	68%	0%	68%	28%	4%
1997 - 1998	140,000	8,323	0	0	0	0	0	8,323	148,323	97,435	0	97,435	43,344	4,955	145,734	67%	0%	67%	30%	3%
1998 - 1999	140,000	5,697	0	0	0	0	0	5,697	145,697	107,723	0	107,723	47,538	7,006	162,267	66%	0%	66%	29%	4%
1999 - 2000	140,000	1,001	0	0	507	0	0	1,508	141,508	126,645	0	126,645	44,401	7,774	178,820	71%	0%	71%	25%	4%
2000 - 2001	140,000	30	0	6,500	500	0	3,995	7,030	147,030	113,437	7,989	121,426	39,954	8,084	169,464	67%	5%	72%	24%	5%
2001 - 2002	140,000	0	0	6,500	505	0	4,729	7,005	147,005	121,489	9,458	130,947	39,494	5,548	175,989	69%	5%	74%	22%	3%
2002 - 2003	140,000	0	0	6,499	185	0	5,220	6,684	146,684	120,557	10,439	130,996	38,487	4,853	174,336	69%	6%	75%	22%	3%
2003 - 2004	140,000	4,020	2,463	3,558	48	0	5,303	10,089	150,089	136,834	10,605	147,439	41,978	2,915	192,332	71%	6%	77%	22%	2%
2004 - 2005	140,000	4,380	0	7,877	158	12,500	4,927	24,915	164,915	127,811	9,854	137,665	34,450	2,327	174,441	73%	6%	79%	20%	1%
2005 - 2006	140,000	33,756	0	1,554	1,304	12,999	4,944	49,613	189,613	124,315	16,479	140,794	33,900	3,026	177,720	70%	9%	79%	19%	2%
2006 - 2007	140,000	32,991	0	0	2,989	4,770	7,907	40,750	180,750	130,826	26,356	157,182	37,295	3,369	197,846	66%	13%	79%	19%	2%
2007 - 2008	140,000	0	0	0	2,340	10,243	8,092	12,583	152,583	103,078	26,972	130,050	30,910	3,440	164,400	63%	16%	79%	19%	2%
Totals	4,340,000	248,888	112,249	32,489	8,536	49,553	45,114	451,715	4,791,715	2,946,702	118,152	3,064,853	1,552,816	151,162	4,768,832					
Average	140,000	8,029	3,621	1,048	275	1,598	1,455	14,571	154,571	95,055	14,769	98,866	50,091	4,876	153,833	59%	8%	63%	35%	3%
Max	140,000	33,756	15,757	7,877	2,989	12,999	8,092	49,613	189,613	136,834	26,972	157,182	83,934	10,082	197,846	73%	16%	79%	55%	7%
Min	140,000	0	0	0	0	0	0	0	140,000	60,597	0	60,597	33,900	2,327	122,635	39%	0%	39%	19%	1%

1 Includes only water actually spread
2 Includes only actual water produced and does not include MWD exchanges
3 Includes adjustment for Ontario production of 633 AF in FY 2001-02
4 Includes adjustment for Jurupa, Niagara, and Chino production correction of 1,030 AF in FY 2002-03
5 Includes 9,041 acre-ft of surface water recharge in the Chino Basin that would otherwise have recharged the Claremont Heights Basin in FY 1992-93; and CBFIP stormwater capture of 12,500 acre-ft/yr beginning in FY 2004-05.
6 Watermaster has assumed that half of the desalter pumping has been replenished by induced recharge in the Santa Ana River through FY 2004-05 and that 30 percent of the desalter pumping has been replenished by induced recharge in the Santa Ana River in FY 2005-06
7 The only discharge considered herein is pumping, the other discharges are assumed netted out in the safe yield

Table 3-2
Summary of Annual Wet Water Recharge in the Chino Basin

Basin Name	2000/2001				2001/2002				2002/2003				2003/2004			
	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge
Banana Basin	390	0	0	390	184	0	0	184	366	0	0	366	188	0	0	188
Declez Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Etiwanda Conservation Ponds	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Hickory Basin	37	0	0	37	105	0	0	105	551	0	0	551	224	0	0	224
Jurupa Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
RP-3 Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Turner Basin	167	0	0	167	100	0	0	100	192	0	0	192	0	0	0	0
7th and 8th Street Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Brooks Street Basin	0	0	0	0	104	0	0	104	676	0	0	676	--	0	0	0
College Heights Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Ely Basins	--	0	500	500	--	0	505	505	--	0	185	185	--	0	48	48
Etiwanda Spreading Basins	--	0	0	0	--	0	0	0	--	0	0	0	--	2,812	0	2,812
Lower Day Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Montclair Basins	2,890	6,530	0	9,420	773	6,500	0	7,273	1,328	6,499	0	7,827	--	3,558	0	3,558
San Sevaine	--	0	0	0	--	0	0	0	--	0	0	0	--	1,211	0	1,211
Upland Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Victoria Basin	--	0	0	0	--	0	0	0	--	0	0	0	--	0	0	0
Totals:	3,484	6,530	500	10,514	1,266	6,500	505	8,271	3,113	6,499	185	9,797	412	7,582	48	8,042

Basin Name	2004/2005				2005/2006				2006/2007				2007/2008			
	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge	Storm Water	Imported Water	Recycled Water	Total Recharge
Banana Basin	459	0	0	459	221	206	529	956	226	783	643	1,652	278	0	157	435
Declez Basin	--	0	0	0	737	0	0	737	0	0	0	0	730	0	0	730
Etiwanda Conservation Ponds	--	197	0	197	--	0	0	0	0	0	0	0	0	0	0	0
Hickory Basin	653	0	0	653	517	623	586	1,726	536	212	646	1,394	949	0	625	1,574
Jurupa Basin	--	0	0	0	--	0	0	0	0	0	0	0	0	0	0	0
RP-3 Basins	--	0	0	0	767	0	0	767	802	0	0	802	511	0	0	511
Turner Basin	297	310	0	607	2,575	346	0	2,921	406	313	1237	1,956	1542	0	0	1,542
7th and 8th Street Basins	--	0	0	0	1,271	0	0	1,271	640	0	0	640	959	0	1,054	2,013
Brooks Street Basin	--	0	0	0	524	2033	0	2,557	205	1604	0	1,809	475	0	0	475
College Heights Basins	--	0	0	0	108	5,432	0	5,540	1	3,125	0	3,126	172	0	0	172
Ely Basins	--	0	158	158	1,531	0	188	1,719	631	0	466	1,097	1,603	0	562	2,165
Etiwanda Spreading Basins	--	2,137	0	2,137	20	2,488	0	2,508	0	1,160	0	1,160	10	0	0	10
Lower Day Basin	--	107	0	107	624	2,810	0	3,434	78	2,266	0	2,344	303	0	0	303
Montclair Basins	--	7,887	0	7,887	1,296	5,536	0	6,832	355	10,681	0	11,036	859	0	0	859
San Sevaine	--	1,621	0	1,621	2,072	9,172	0	11,244	244	5,749	0	5,993	749	0	0	749
Upland Basin	--	0	0	0	214	5,922	0	6,136	195	7068	0	7,263	312	0	0	312
Victoria Basin	--	0	0	0	330	0	0	330	260	0	0	260	427	0	0	427
Totals:	1,409	12,258	158	13,825	12,807	34,568	1,303	48,678	4,579	32,961	2,992	40,532	9,879	0	2,398	12,277



Groundwater Production Wells by Pool

- Pool 1
- Pool 2
- Pool 3
- Desalter Wells

Other Features

- Chino Basin Management Zones
- Chino Desalter Well
- Streams & Flood Control Channels
- Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

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Author: ETL
Date: 20090401
File: Figure_3-1.mxd

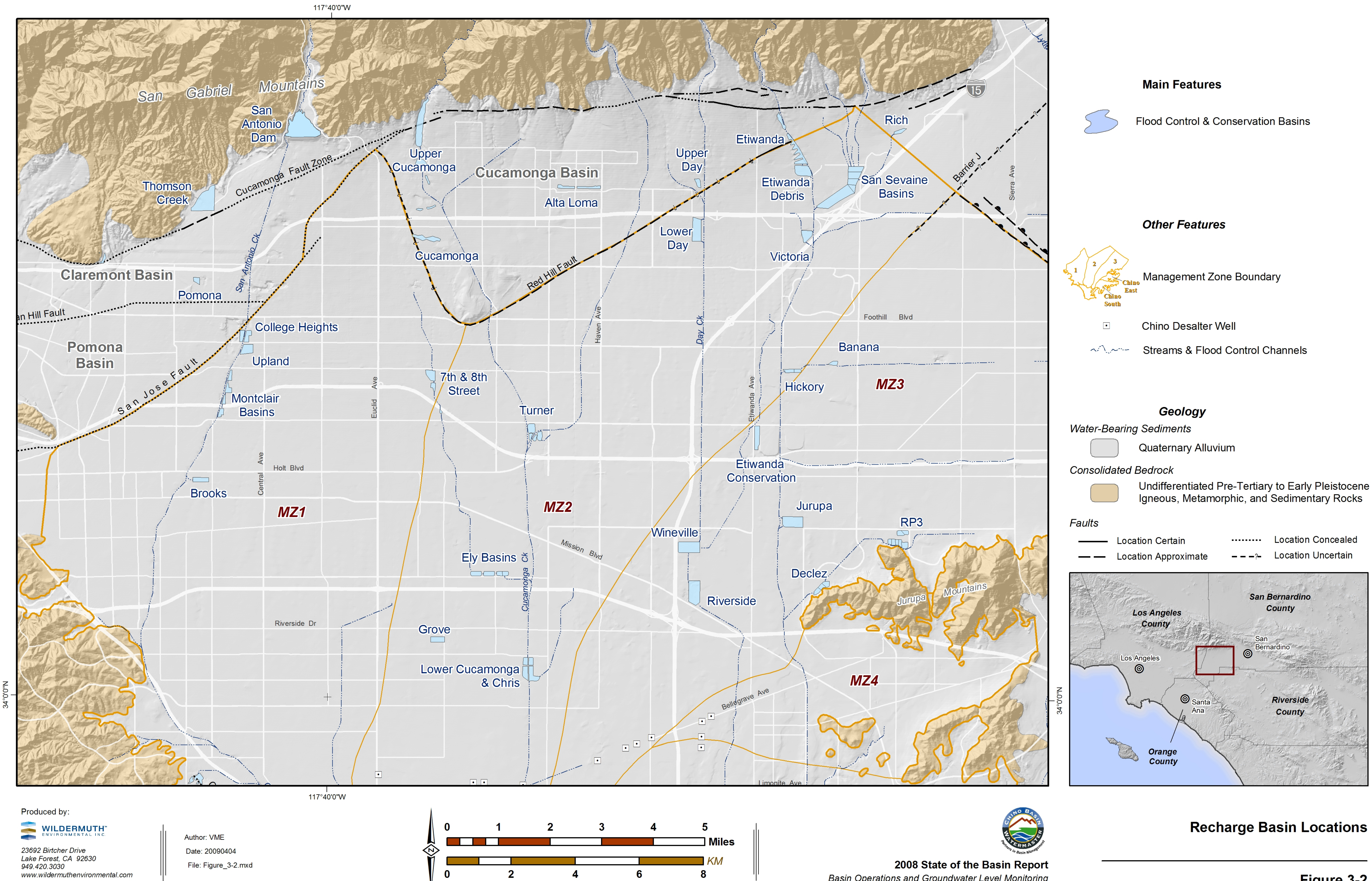
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

2008 State of the Basin Report
Basin Operations and Groundwater Level Monitoring

Active Production Wells by Pool

Production Wells as of Fiscal Year 2007-08

Figure 3-1



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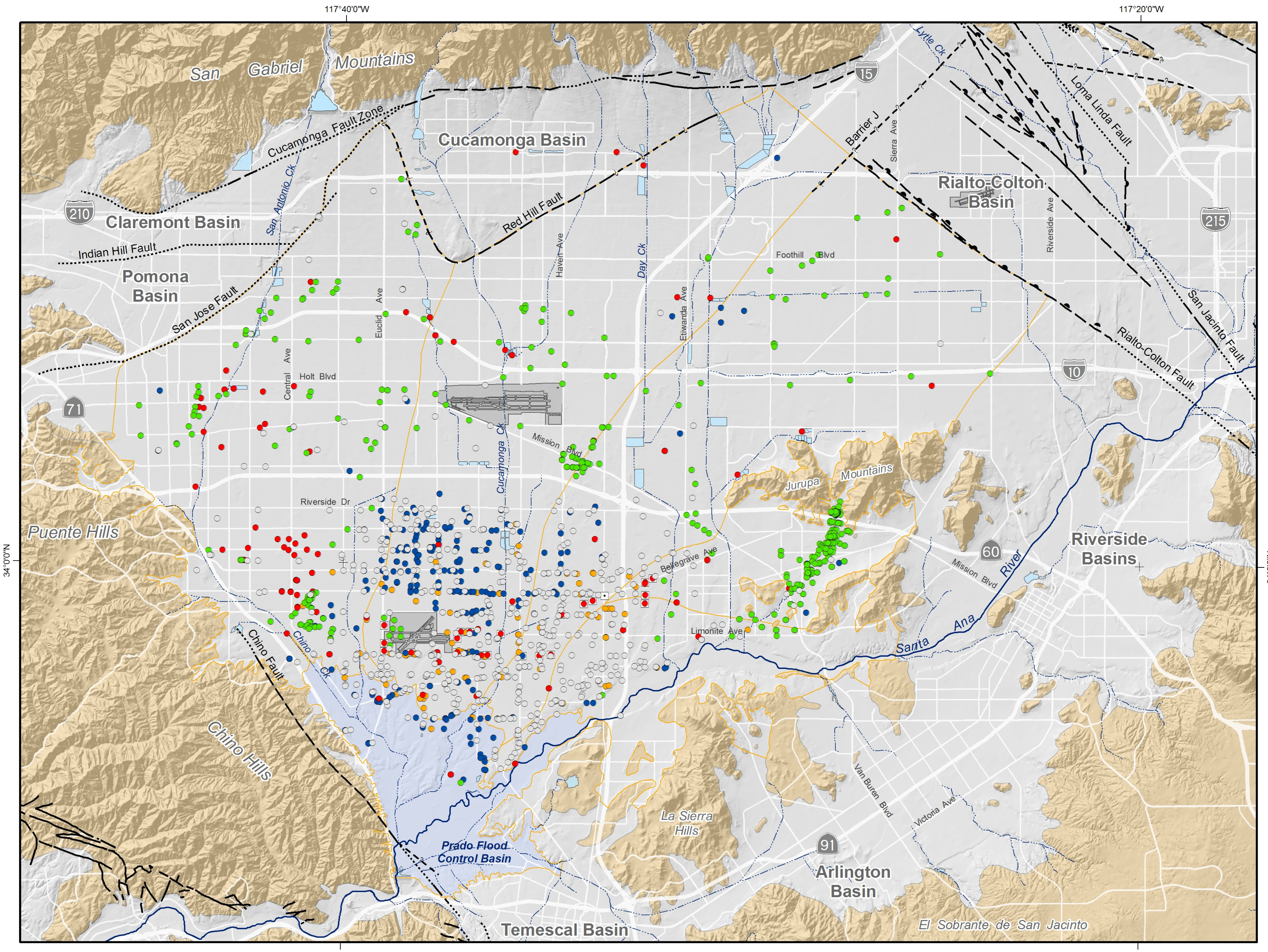
Date: 20090404
File: Figure_3-2.mxd

2008 State of the Basin Report
Basin Operations and Groundwater Level Monitoring

Recharge Basin Locations

Figure 3-2



Basin-Wide Monitoring Program by Measurement Frequency

- Monthly Measurement (84 wells)
- Semi-Annual Measurement (212 wells)
- Measurement by Transducer (134 wells)
- Owner Measures Water Level (476 wells)
- Unable to Obtain Water Level (510 wells)

Other Features

- Management Zone Boundary
- Chino Desalter Well
- Streams & Flood Control Channels
- Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

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Author: VME

Date: 20090427

File: Figure_3.3.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

2008 State of the Basin Report

Basic Operations and Groundwater Level Monitoring

Groundwater Level Monitoring Network

Well Locations and Measurement Frequency

Figure 3-3

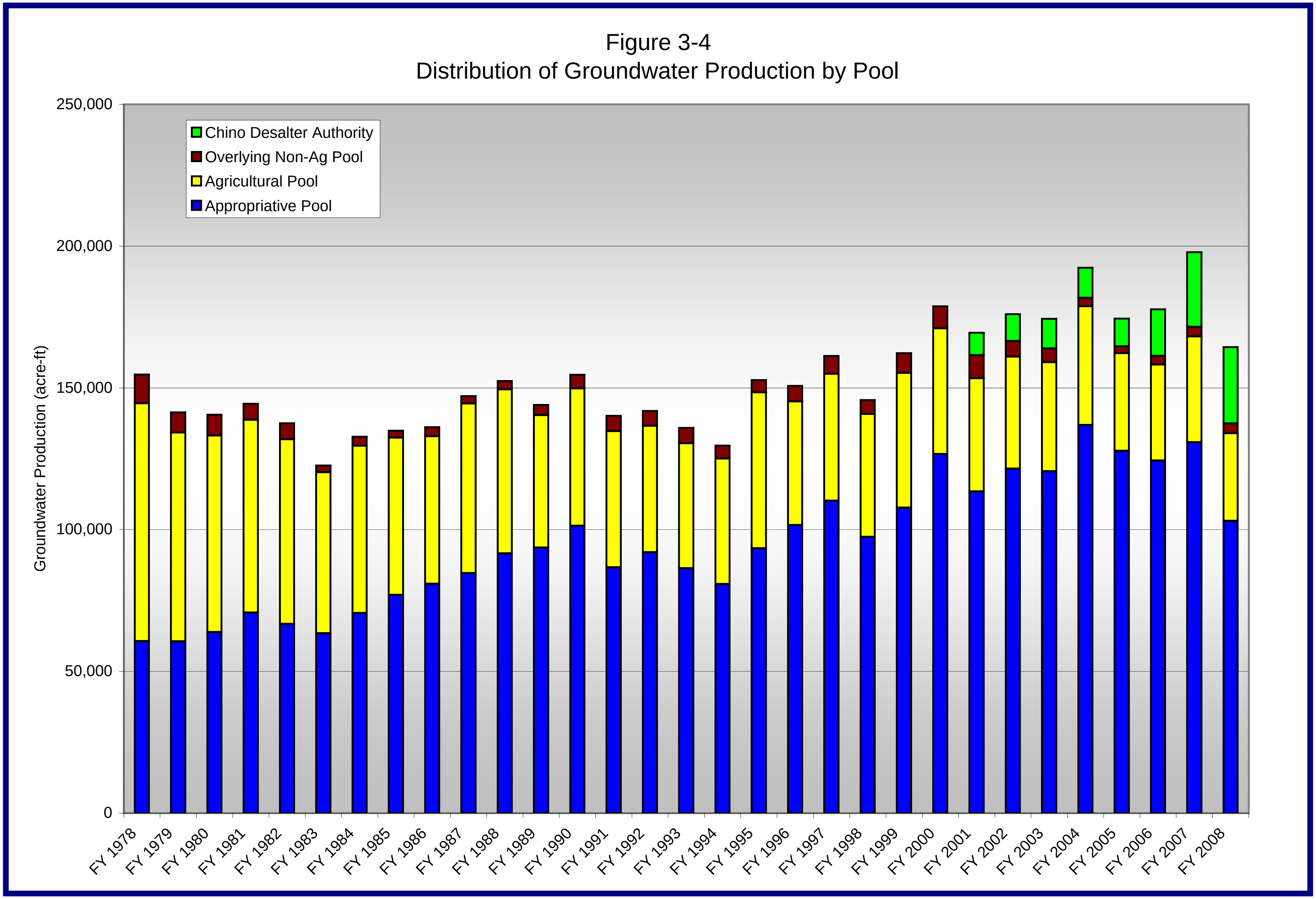
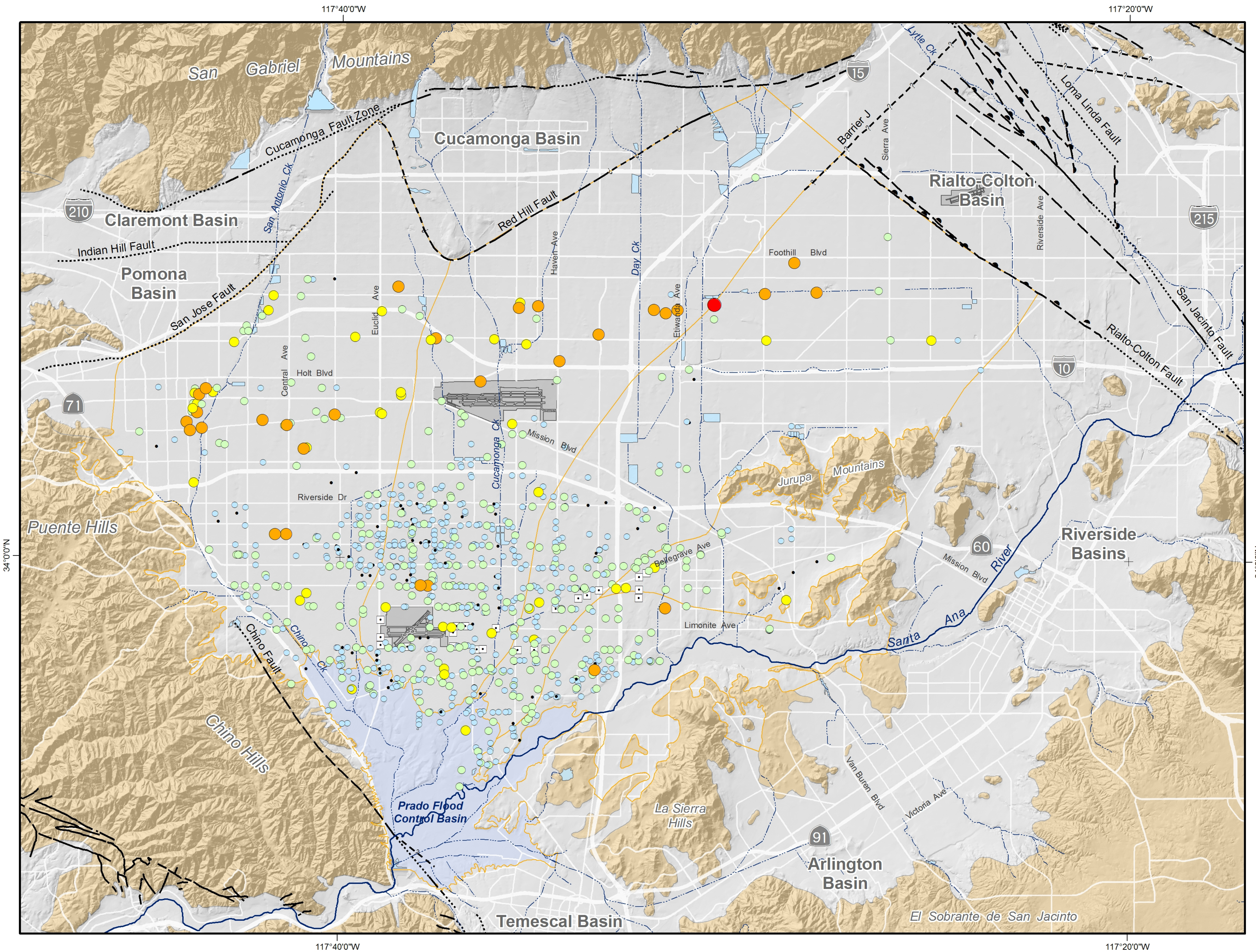


Figure_3-4.xlsFigure 3-4

WILDERMUTH ENVIRONMENTAL INC.



Groundwater Production (July-77 to June-78)

acre-ft

- < 10
- 10 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000
- > 5,000

Other Features

- Management Zone Boundary
- Chino Desalter Well
- Streams & Flood Control Channels
- Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain

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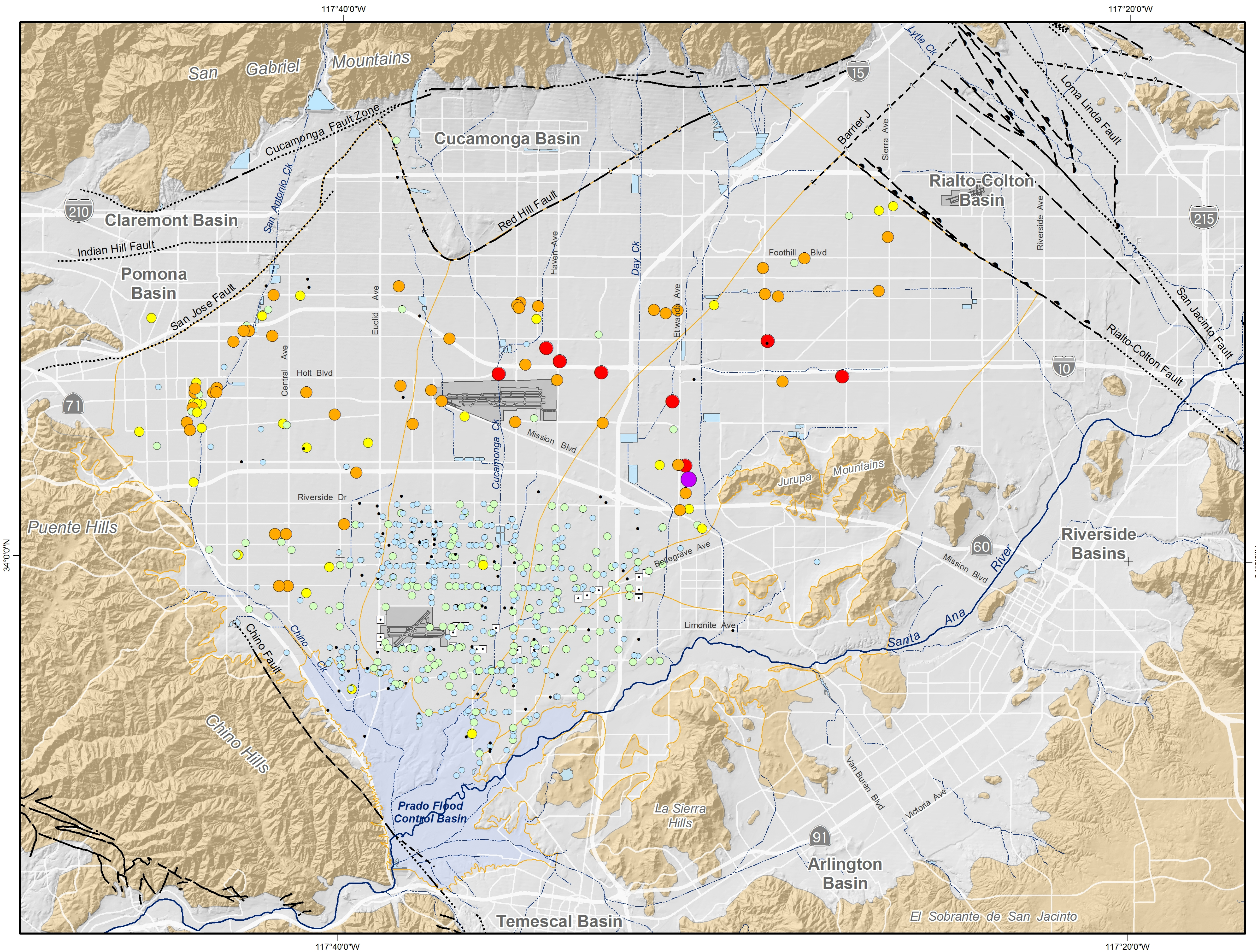
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

2008 State of the Basin Report
Groundwater Pumping

Groundwater Production by Well
Fiscal Year 1977-1978

Figure 3-5



Groundwater Production (July-99 to June-00)

acre-ft

- < 10
- 10 - 100
- 100 - 500
- 500 - 1,000
- 1,000 - 2,500
- 2,500 - 5,000
- > 5,000

Other Features

- Management Zone Boundary (1, 2, 3, Chino East, Chino South)
- Chino Desalter Well
- Streams & Flood Control Channels
- Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

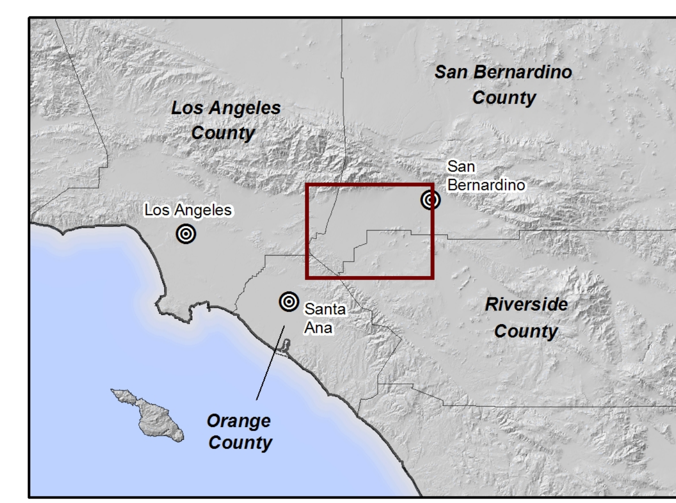
- Quaternary Alluvium

Consolidated Bedrock

- Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

- Location Certain
- Location Approximate
- Location Concealed
- Location Uncertain



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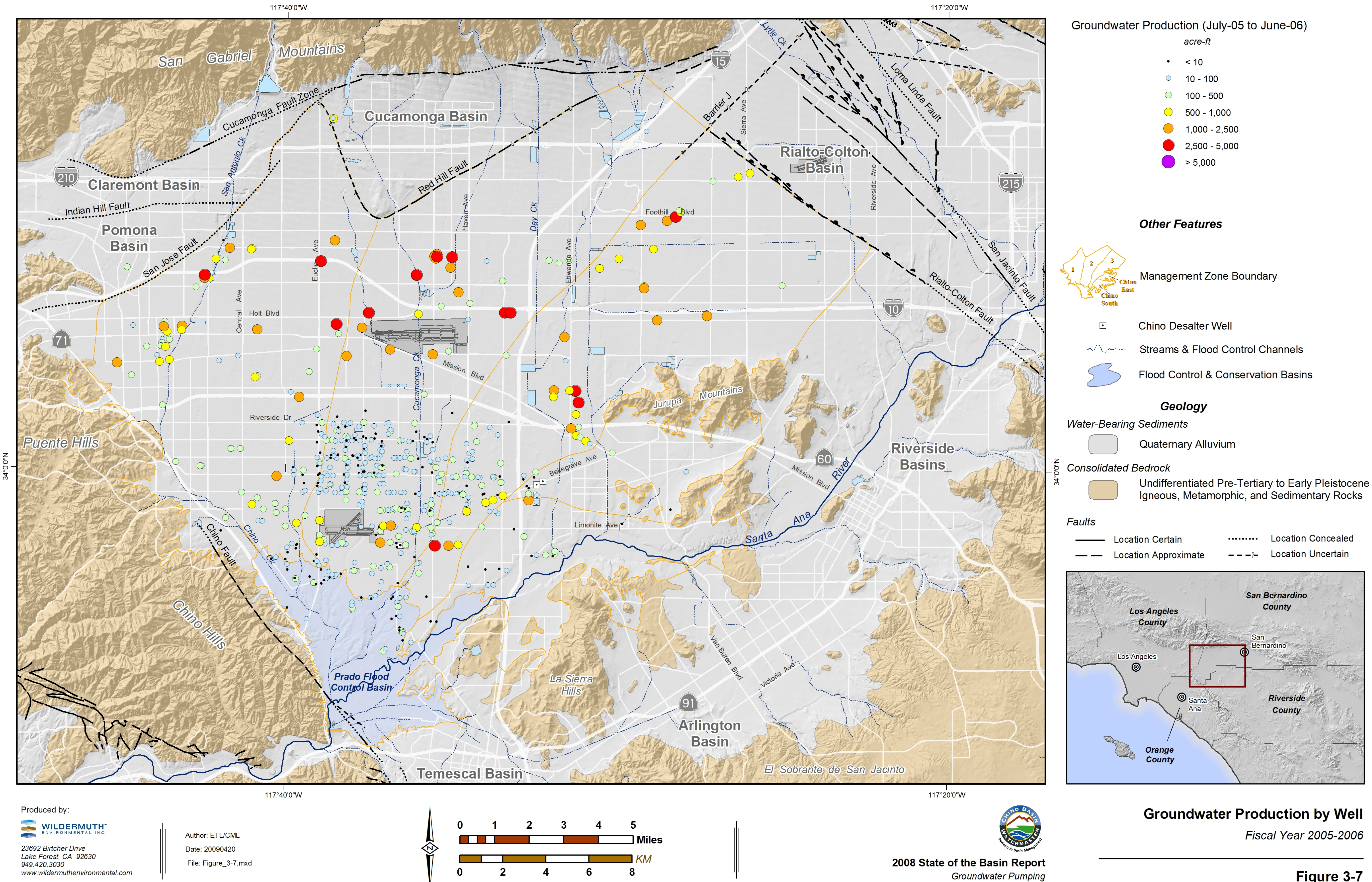
0 1 2 3 4 5 Miles
0 2 4 6 8 KM

2008 State of the Basin Report
Groundwater Pumping

Groundwater Production by Well

Fiscal Year 1999-2000

Figure 3-6



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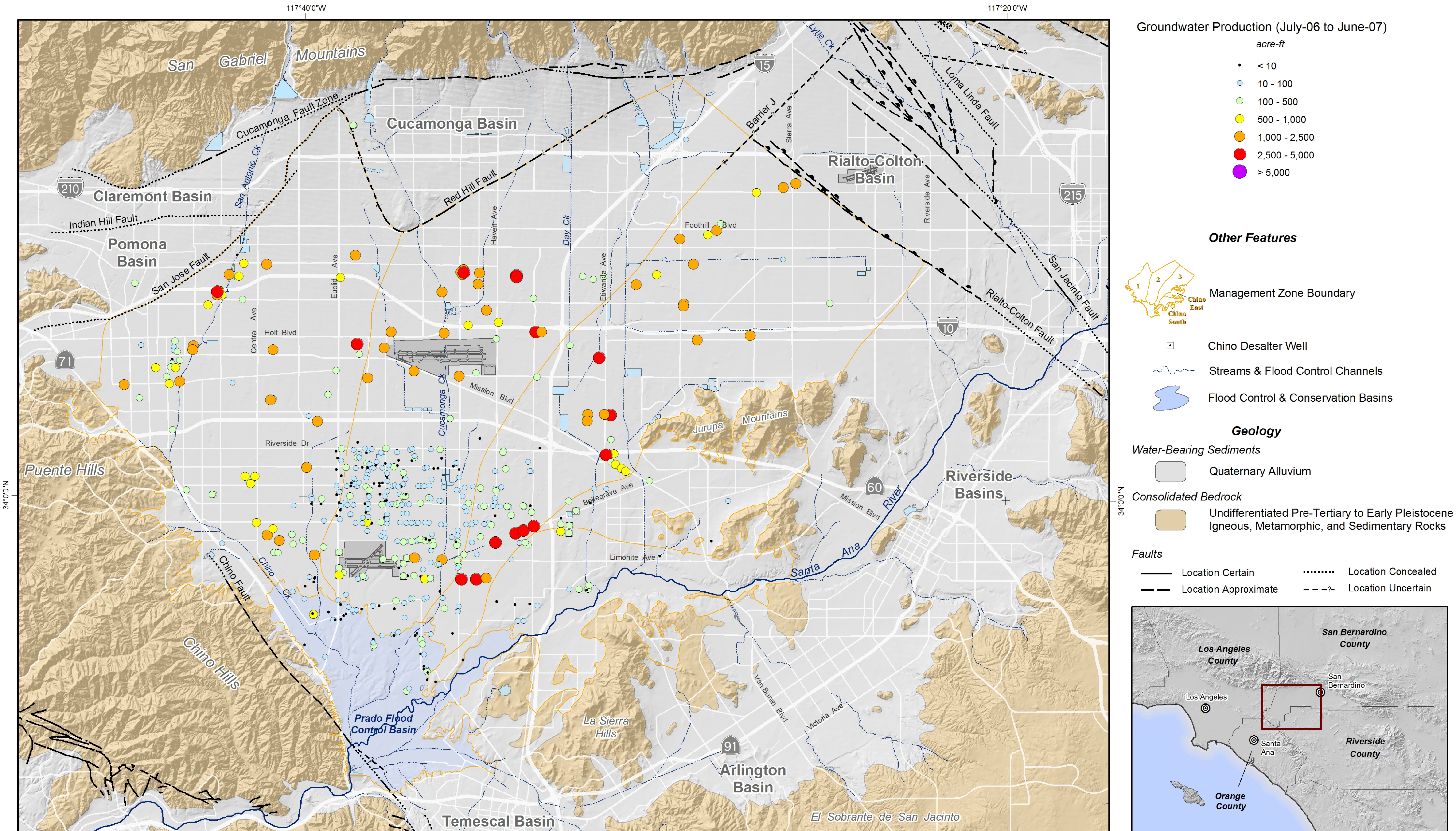
2008 State of the Basin Report
Groundwater Pumping

Groundwater Production by Well
Fiscal Year 2005-2006

Figure 3-7



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0 1 2 3 4 5 Miles

0 2 4 6 8 KM

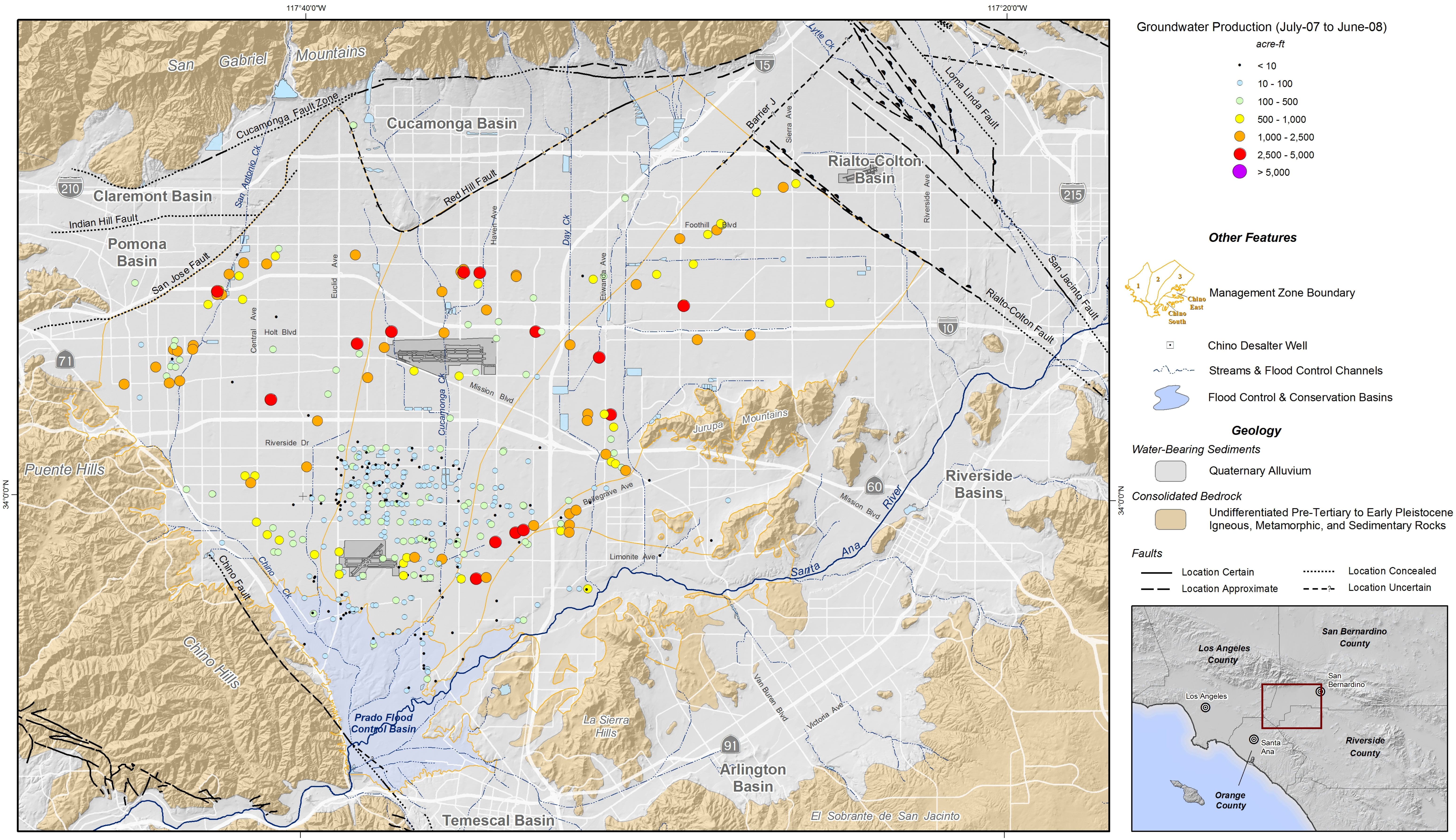
2008 State of the Basin Report

Groundwater Pumping

Groundwater Production by Well

Fiscal Year 2006-2007

Figure 3-8



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CHINO BASIN WATERMASTER

2008 State of the Basin Report
Groundwater Pumping

Groundwater Production by Well
Fiscal Year 2007-2008

Figure 3-9

Wells Used in Historical Groundwater Analyses

Management Zone

- MZ-1
- MZ-2
- MZ-3
- MZ-4
- MZ-5

Other Features

Management Zone Boundary (1, 2, 3, Chino East, Chino South)

Chino Desalter Well

Streams & Flood Control Channels

Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

Location Certain
Location Approximate
Location Concealed
Location Uncertain

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0 1 2 3 4 5 Miles
0 2 4 6 8 KM

2008 State of the Basin Report
Groundwater Levels

Historical Groundwater Level Trends
Well Location Map
Wells Used in Historical Groundwater Level Analyses

Figure 3-10

Figure 3-11 - Time History of Production, Recharge, and Groundwater Levels in MZ1

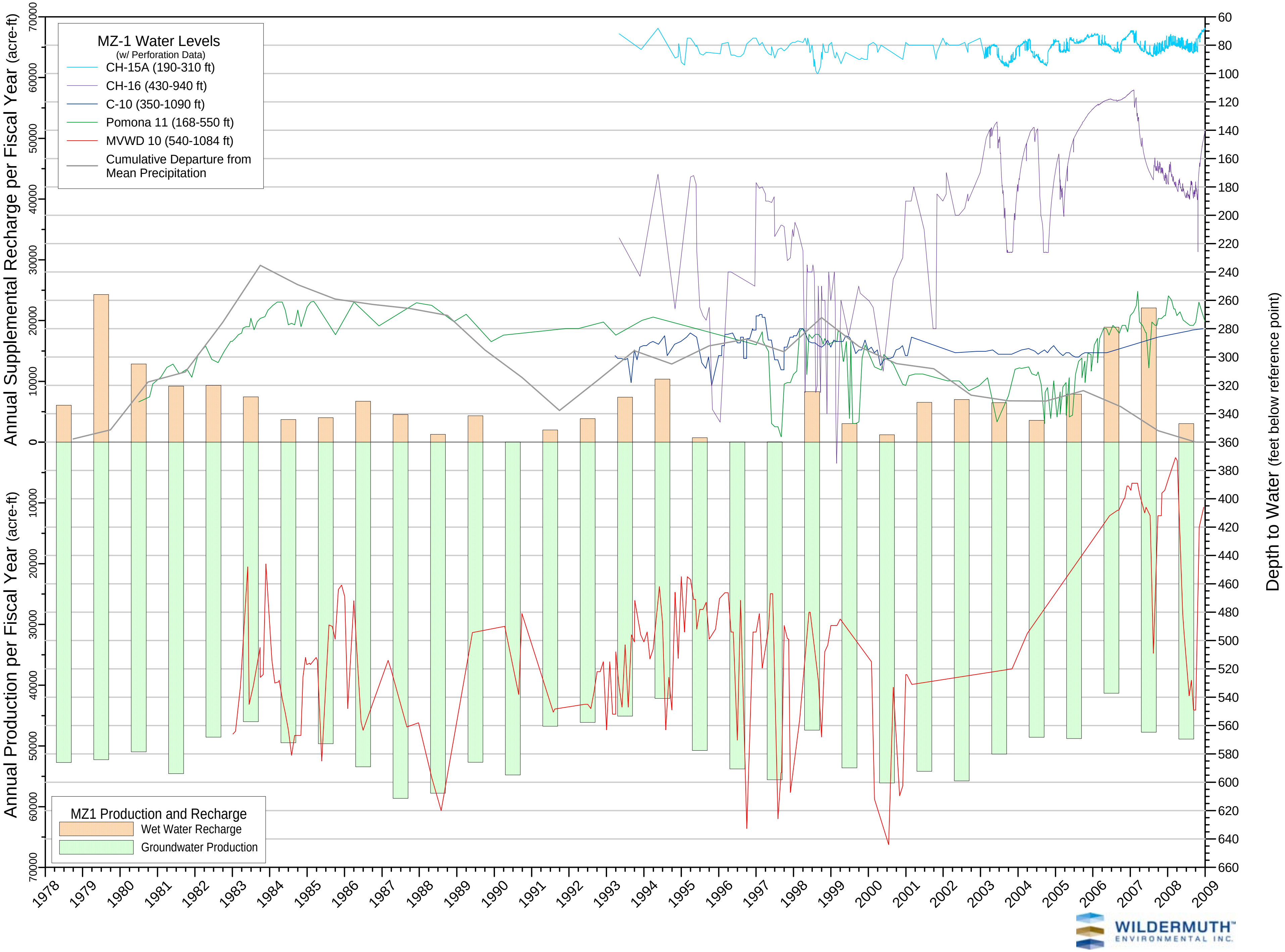

Figure 3-12 - Time History of Production, Recharge, and Groundwater Levels in MZ2

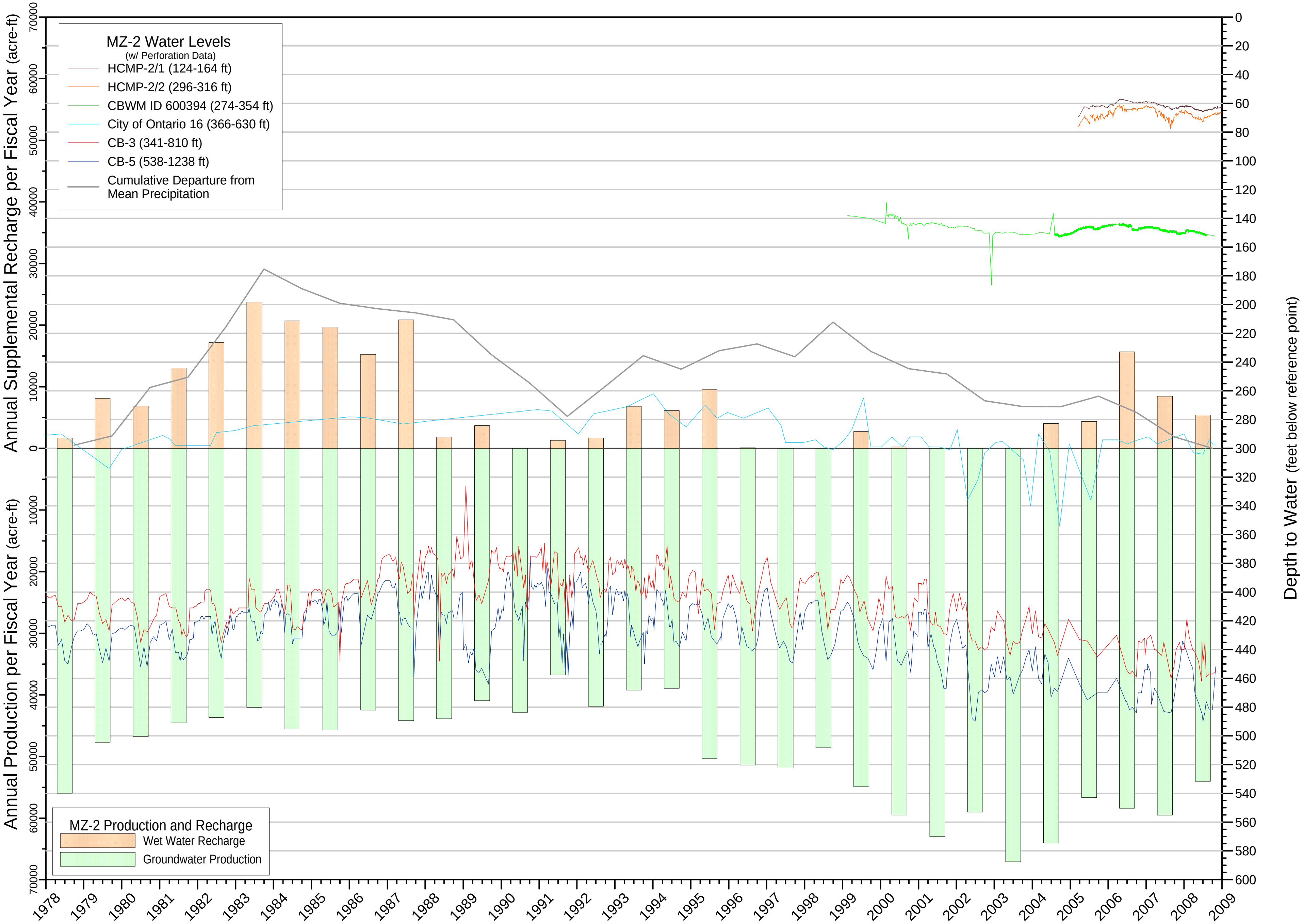

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Figure 3-13 - Time History of Production, Recharge, and Groundwater Levels in MZ3

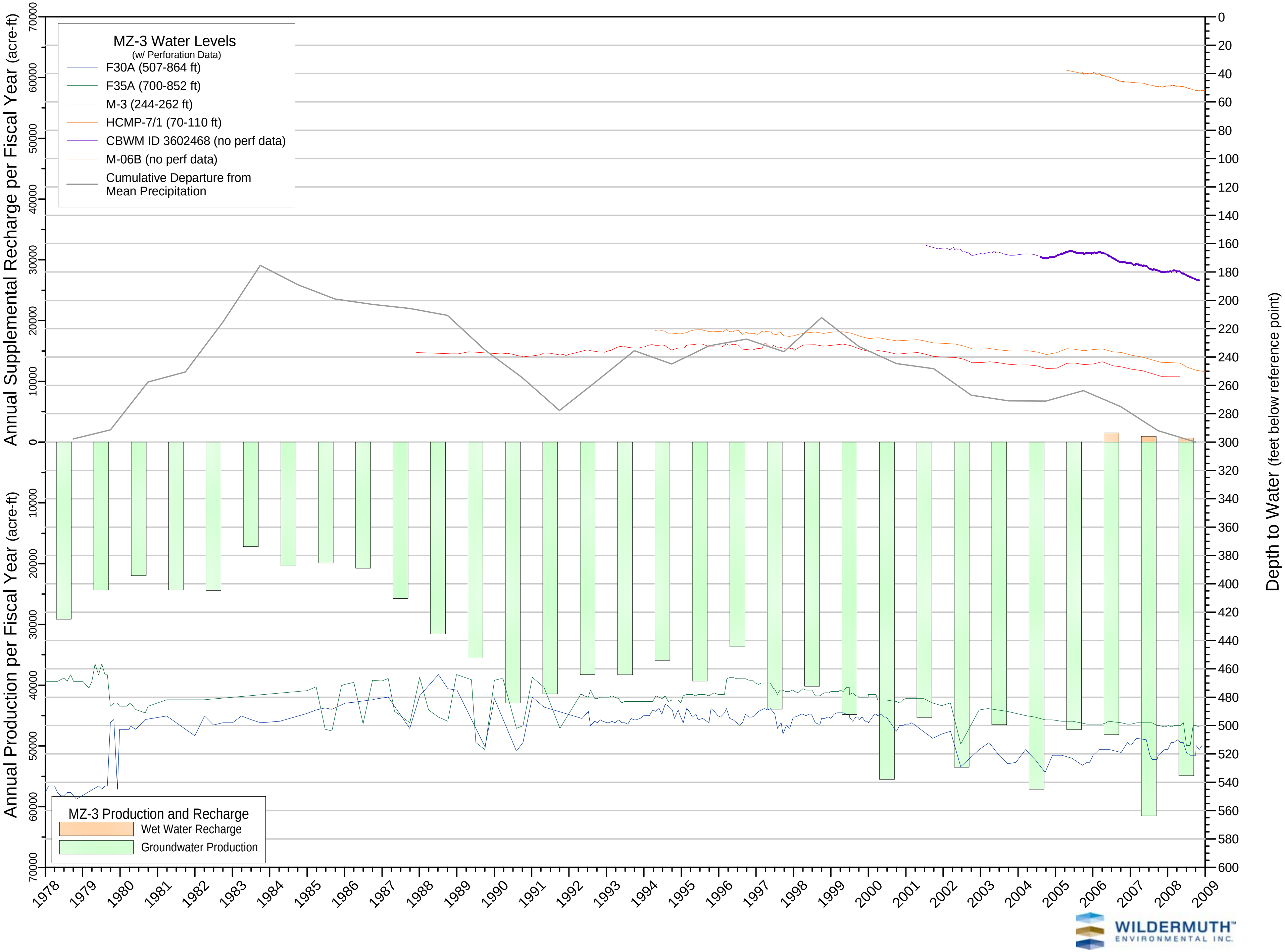

Figure 3-14 - Time History of Production, Recharge, and Groundwater Levels in Chino-East MZ

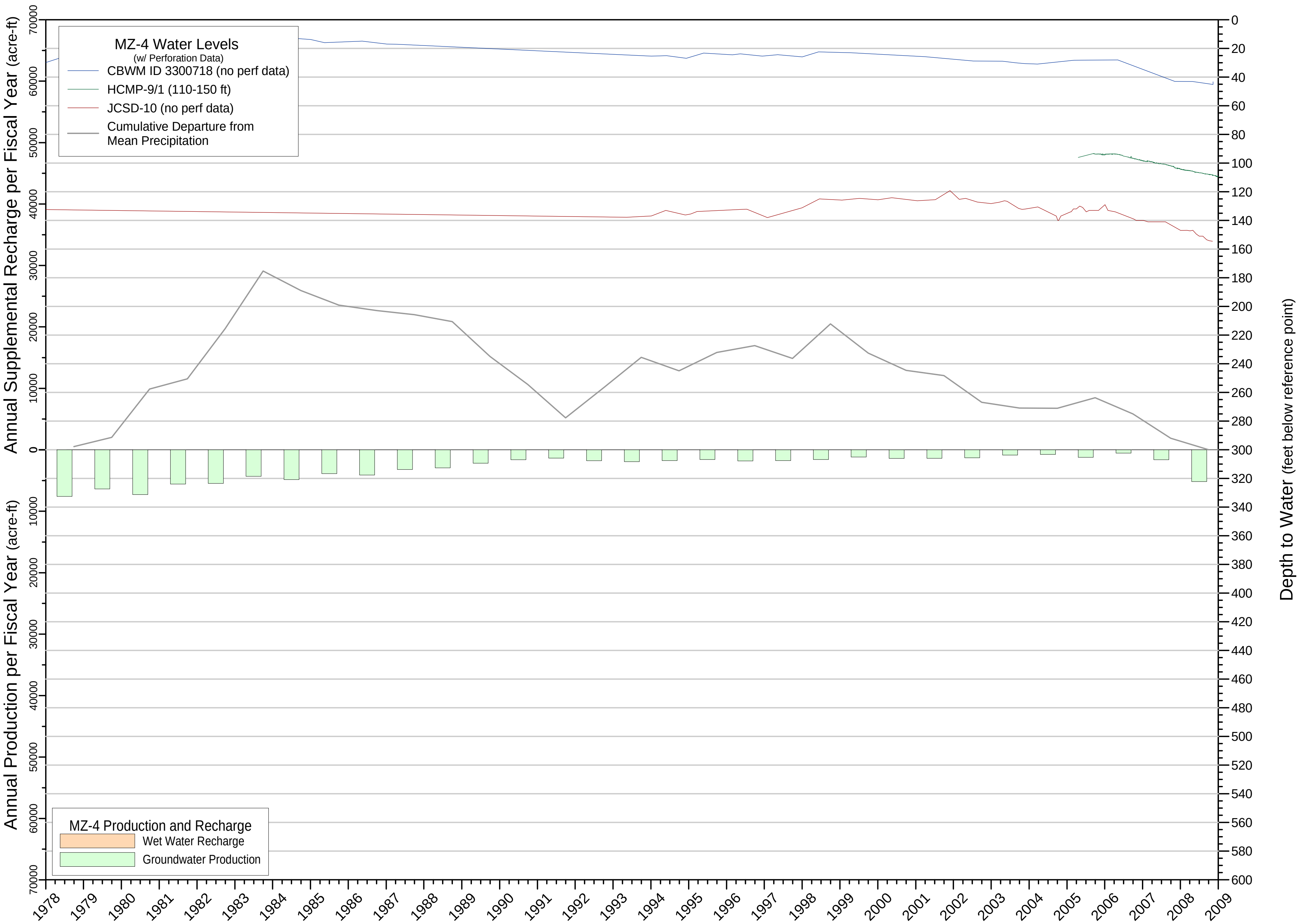

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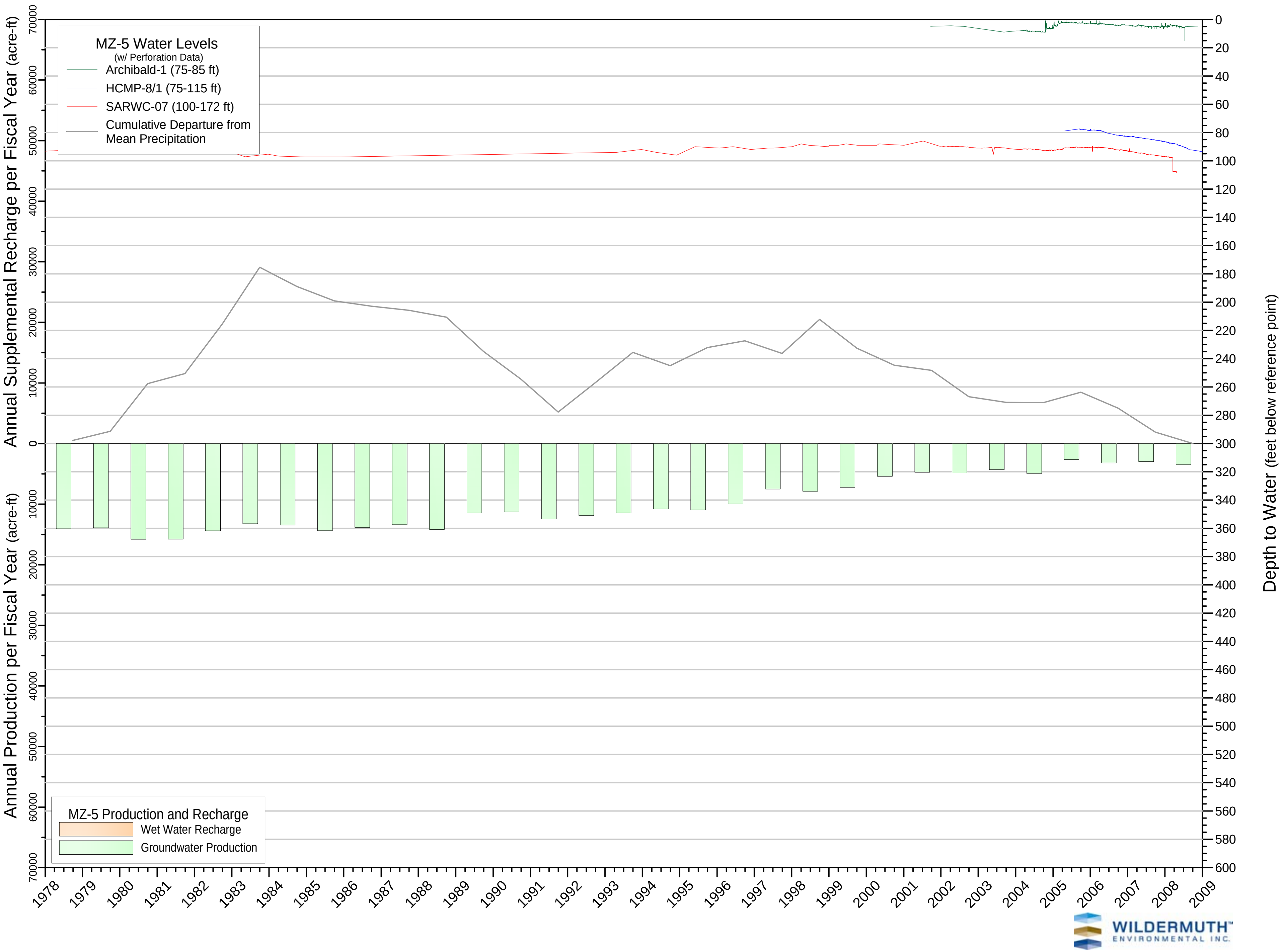
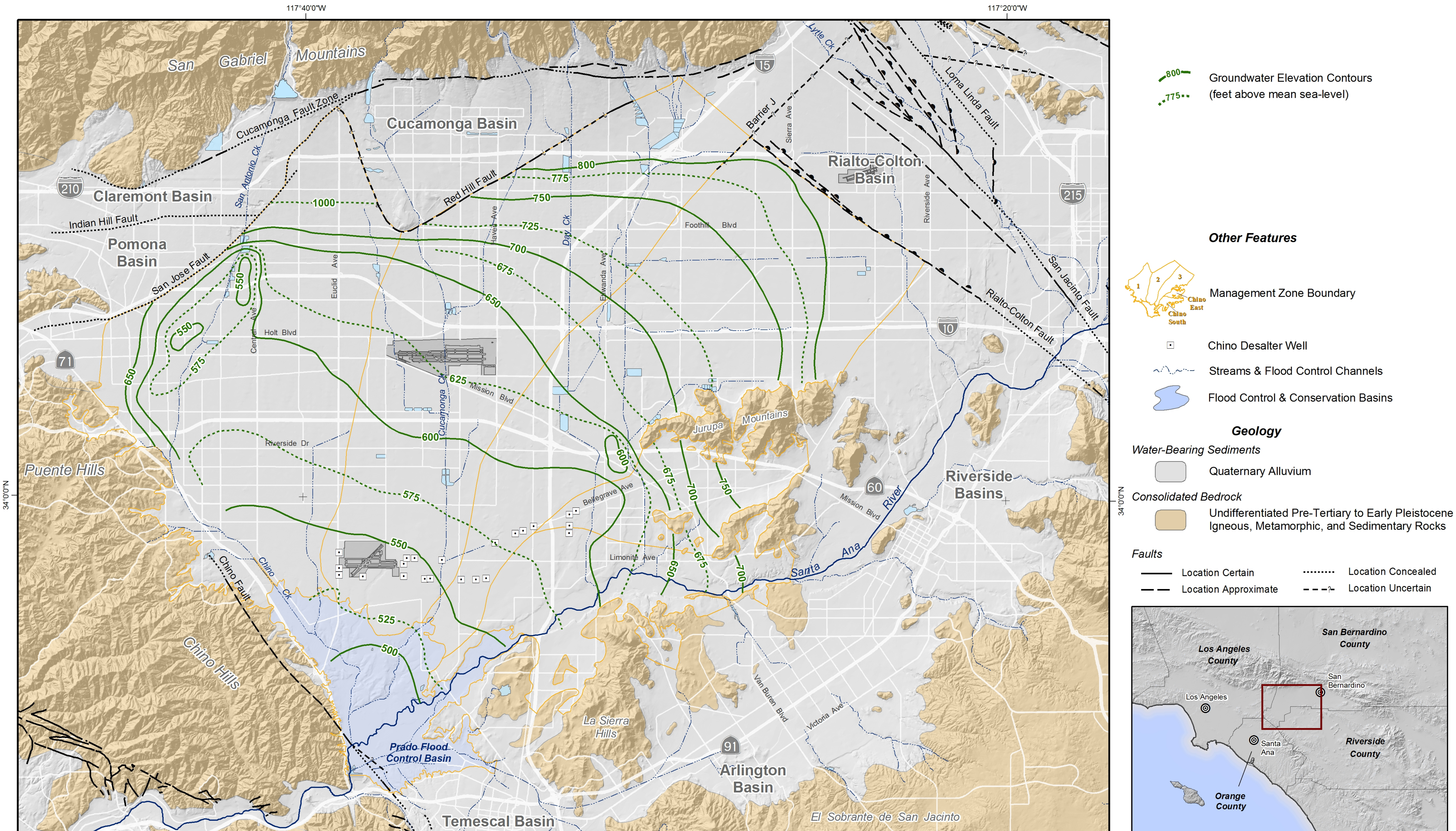
Figure 3-15 - Time History of Production, Recharge, and Groundwater Levels in Chino-South MZ





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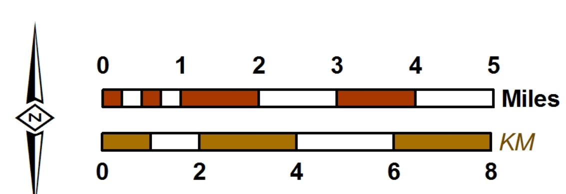
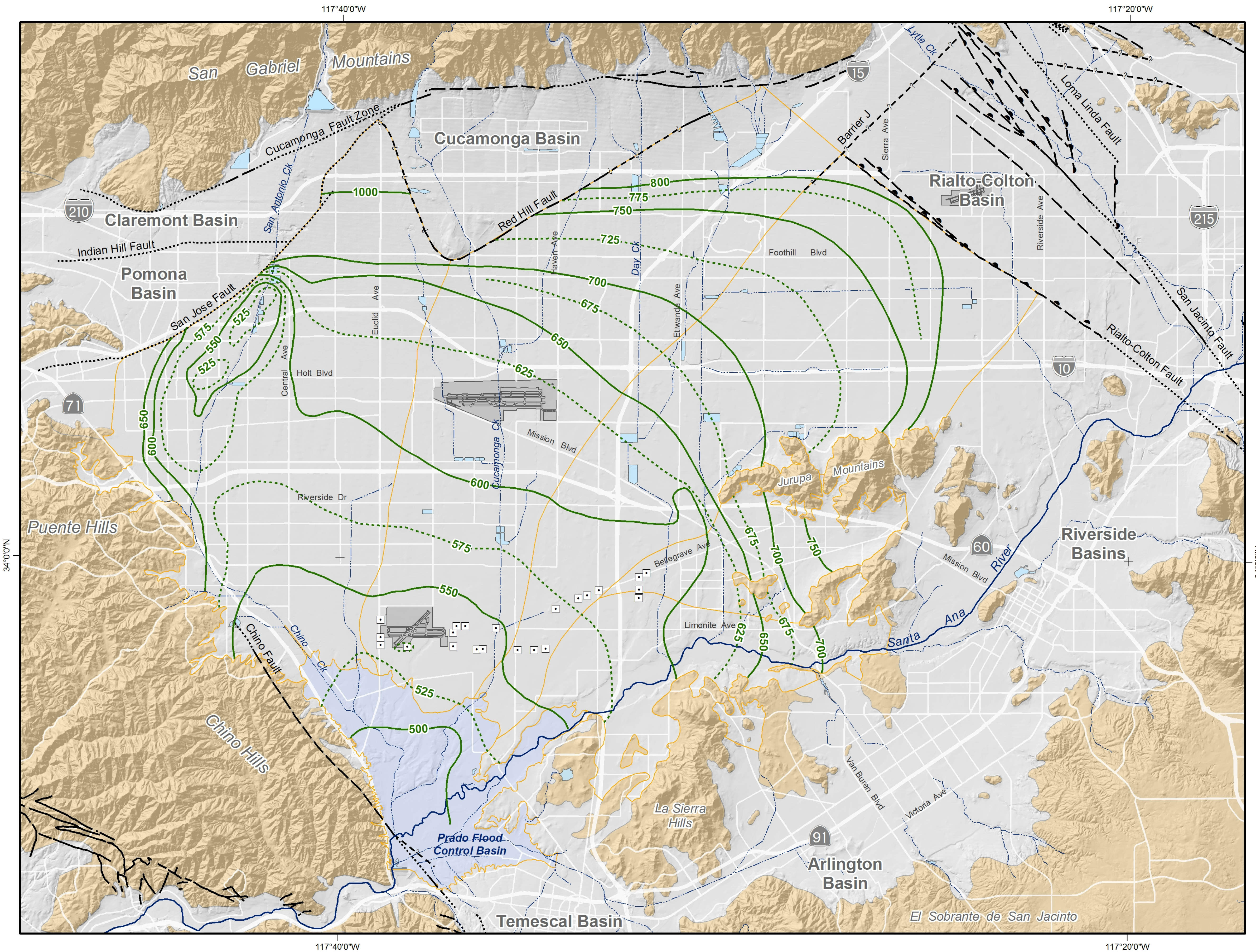


2008 State of the Basin Report
Groundwater Levels

Groundwater Elevation Contours
Fall 2000 -- Chino Basin

Figure 3-16



Groundwater Elevation Contours (feet above mean sea-level)

800

775

Other Features

Management Zone Boundary

1 2 3 Chino East Chino South

Chino Desalter Well

Streams & Flood Control Channels

Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

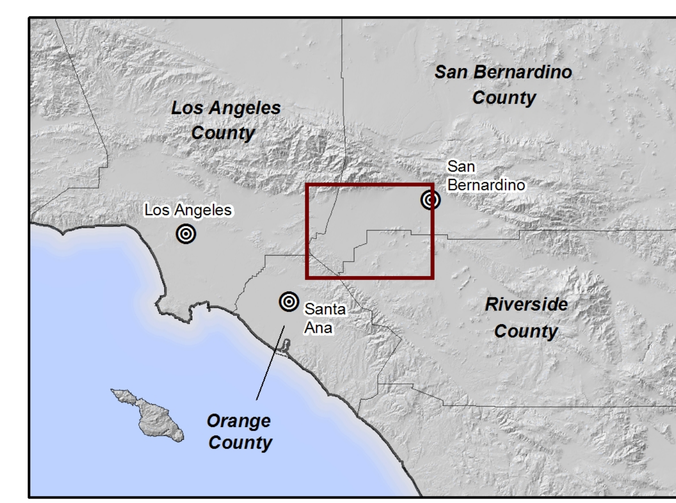
Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain



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0 1 2 3 4 5 Miles

0 2 4 6 8 KM

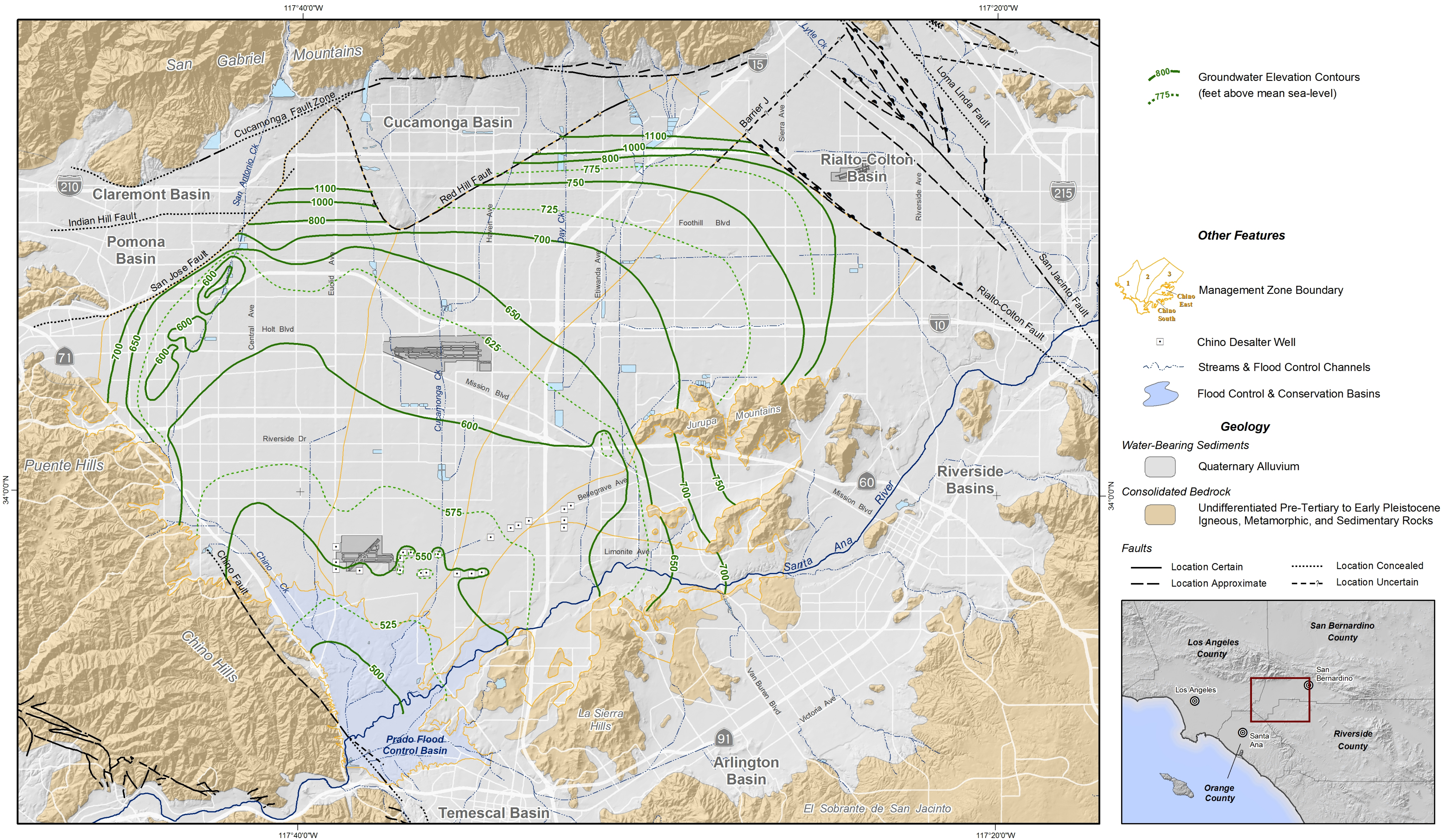
2008 State of the Basin Report

Groundwater Levels

Groundwater Elevation Contours

Fall 2003 -- Chino Basin

Figure 3-17



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0 1 2 3 4 5 Miles

0 2 4 6 8 KM

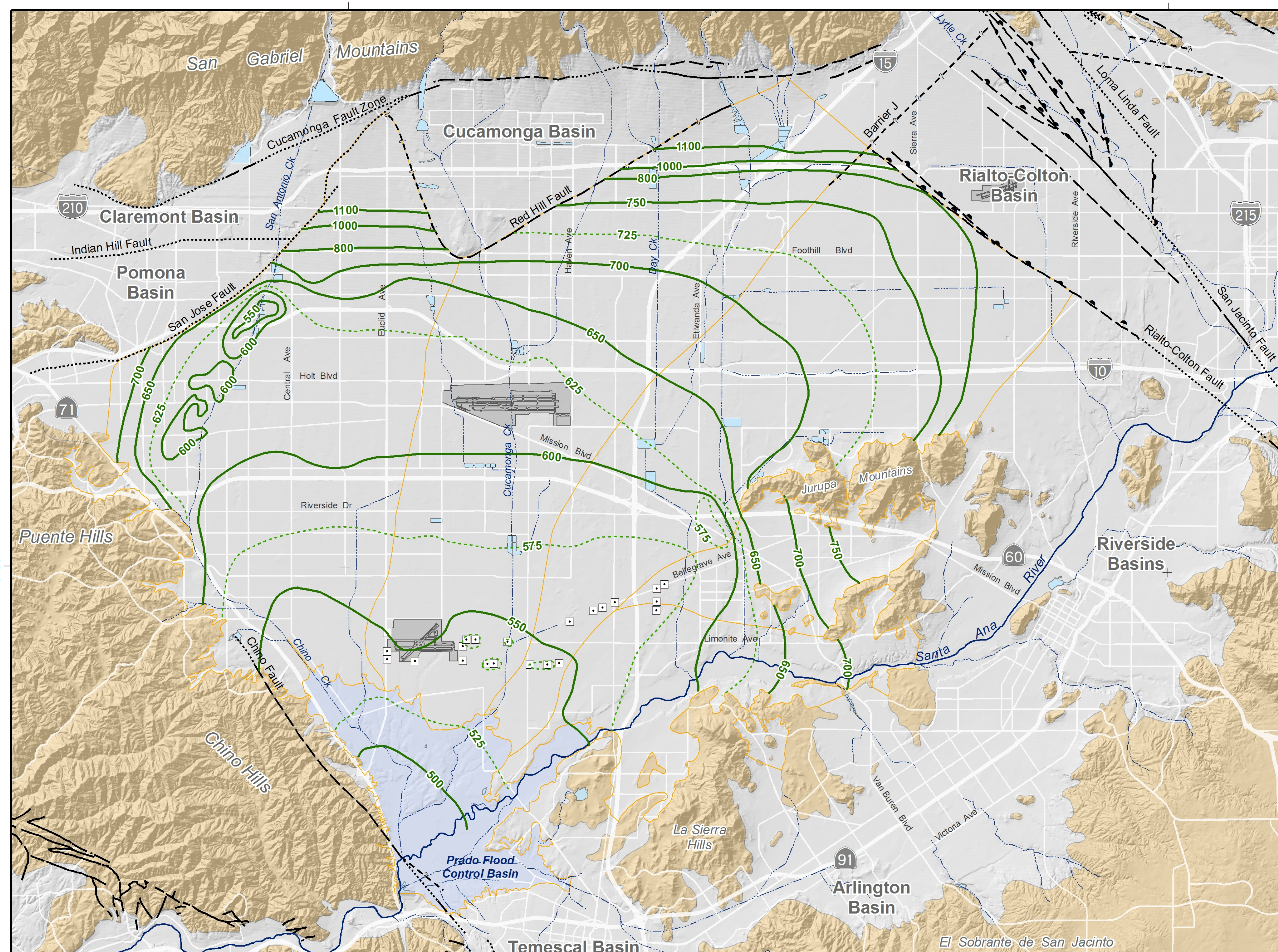
2008 State of the Basin Report

Groundwater Levels

Groundwater Elevation Contours

Fall 2006 -- Chino Basin

Figure 3-18



Groundwater Elevation Contours (feet above mean sea-level)

800
775

Other Features

Management Zone Boundary

Chino Desalter Well

Streams & Flood Control Channels

Flood Control & Conservation Basins

Geology

Water-Bearing Sediments

Quaternary Alluvium

Consolidated Bedrock

Undifferentiated Pre-Tertiary to Early Pleistocene Igneous, Metamorphic, and Sedimentary Rocks

Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

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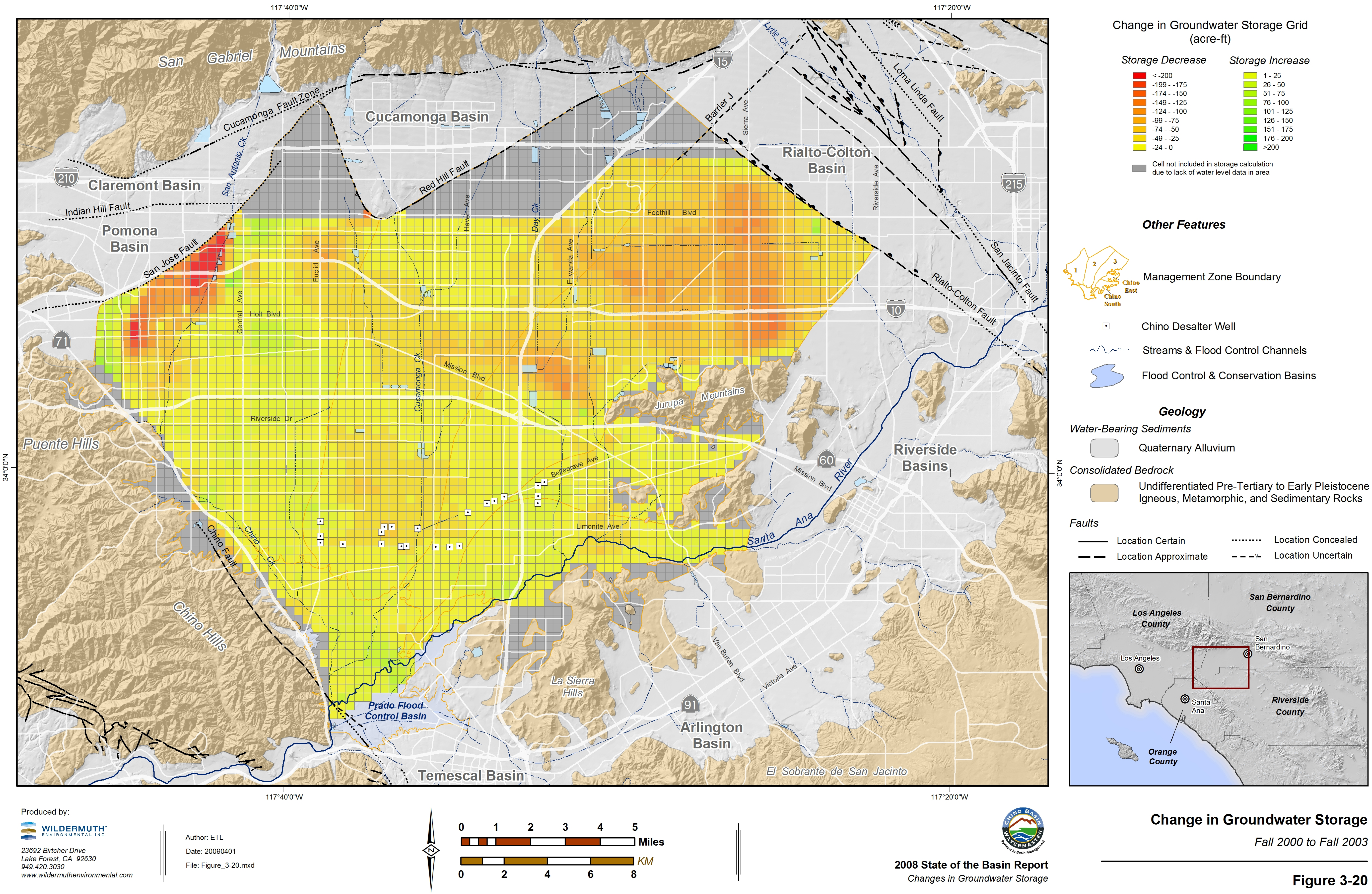
2008 State of the Basin Report
Groundwater Levels

Groundwater Elevation Contours

Fall 2008 -- Chino Basin

Figure 3-19



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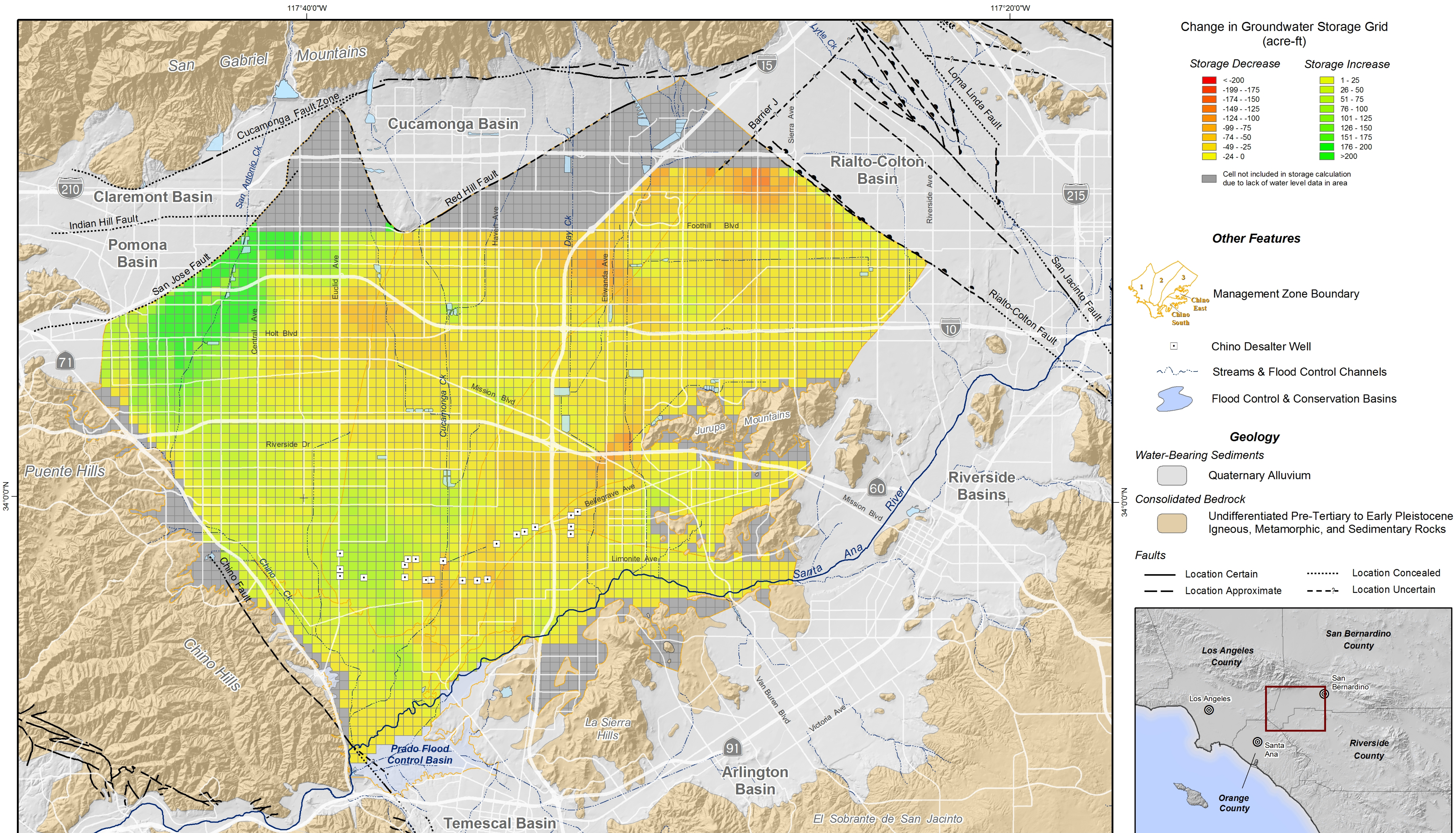
2008 State of the Basin Report
Changes in Groundwater Storage

Change in Groundwater Storage
Fall 2000 to Fall 2003

Figure 3-20



Change in Groundwater Storage

Fall 2003 to Fall 2006

Figure 3-21

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Changes in Groundwater Storage

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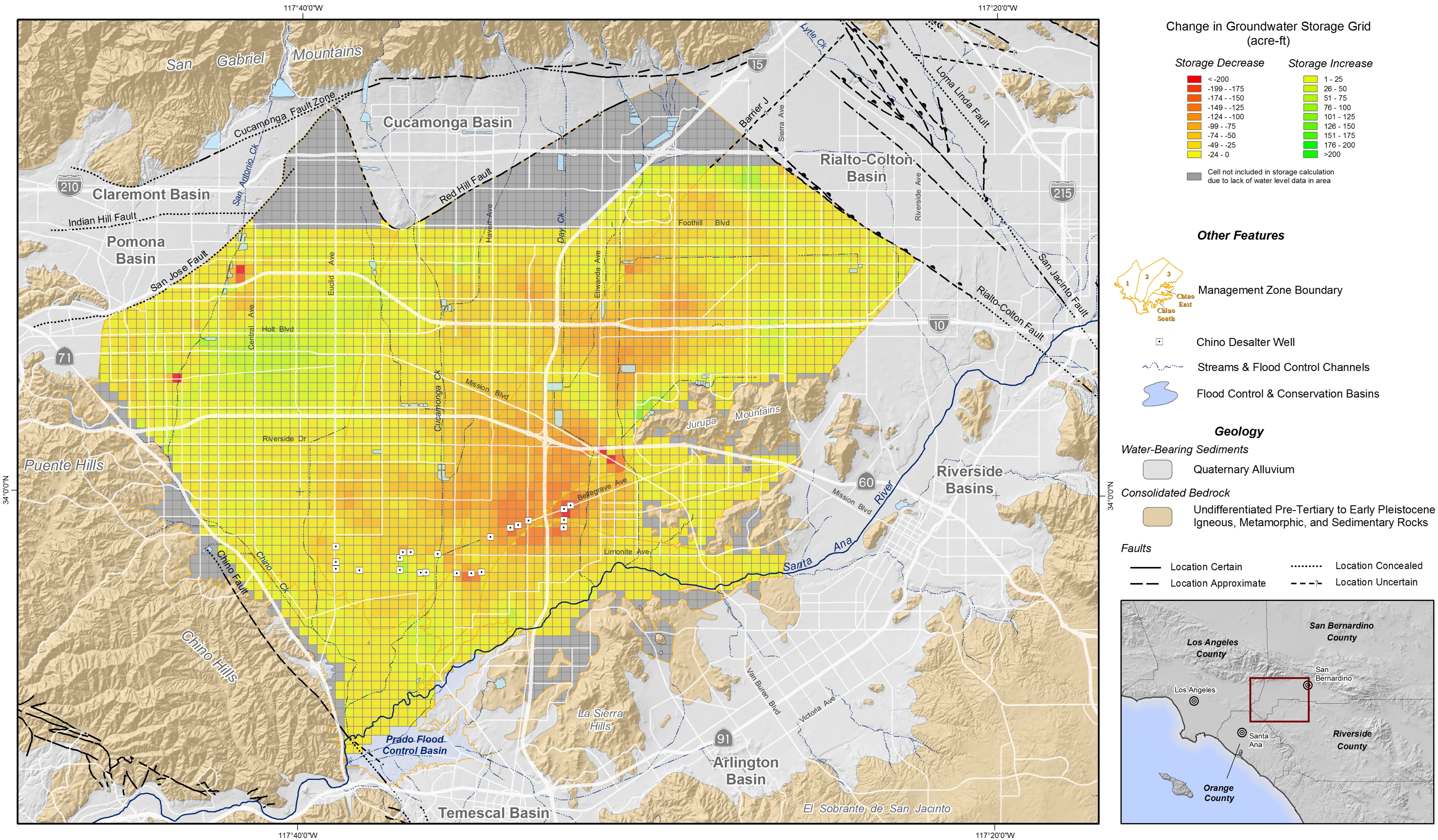

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File: Figure_3-22.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 KM

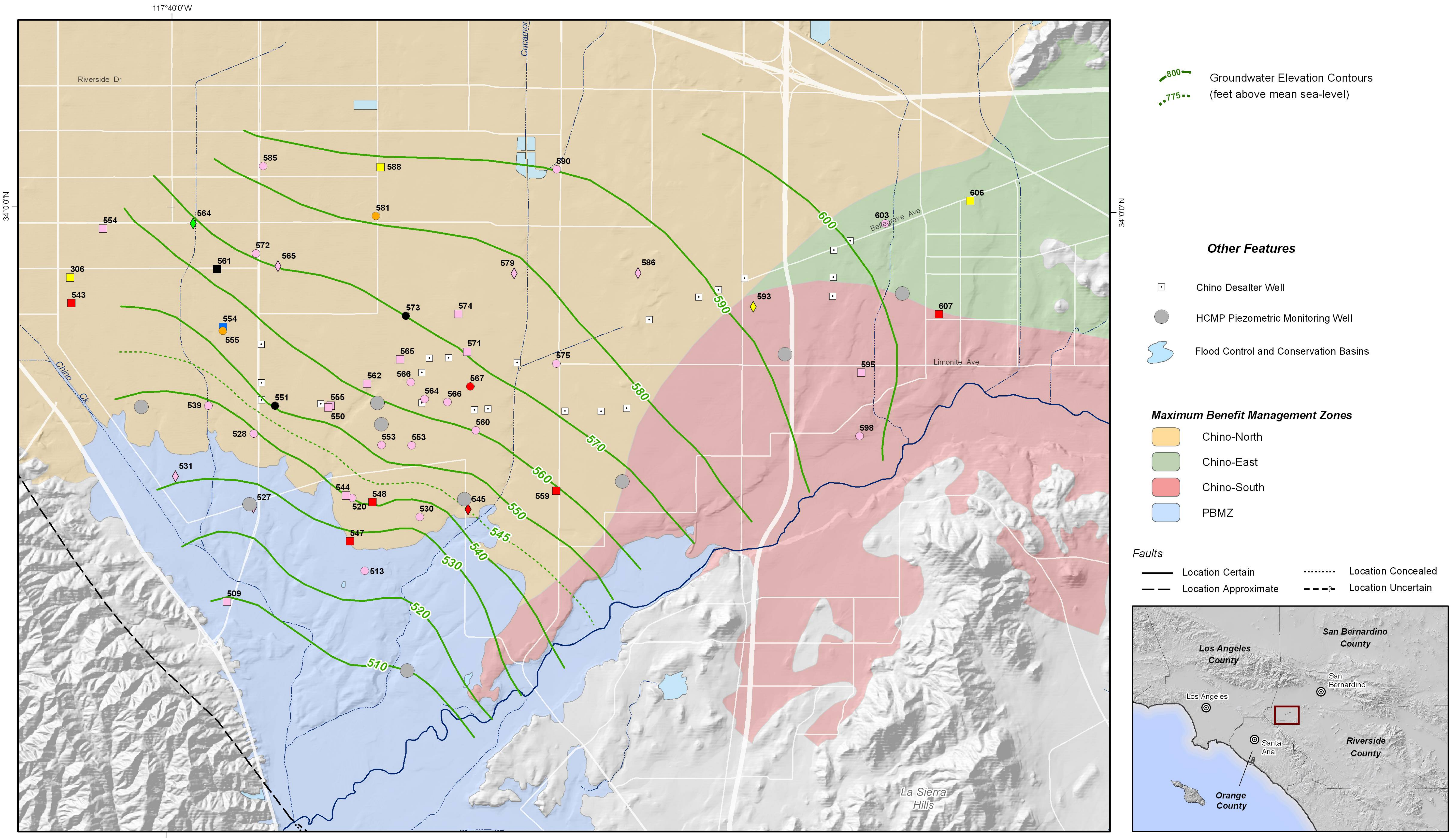
2008 State of the Basin Report

Changes in Groundwater Storage

Change in Groundwater Storage

Fall 2006 to Fall 2008

Figure 3-22



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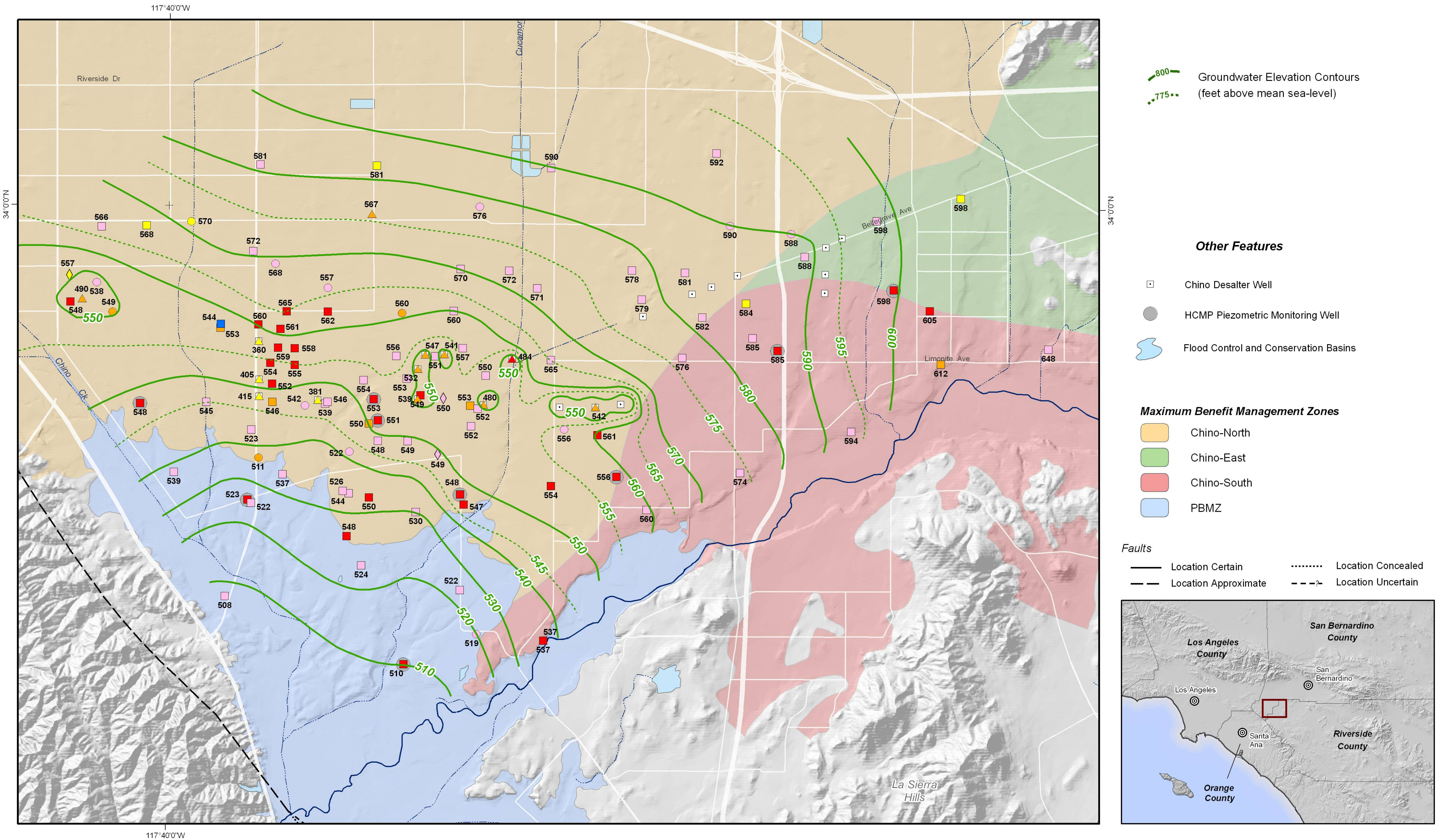
0 1 2 Miles
0 1 2 3 KM

2008 State of the Basin Report
Assessment of Hydraulic Control

State of Hydraulic Control -- Spring 2000
Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-23



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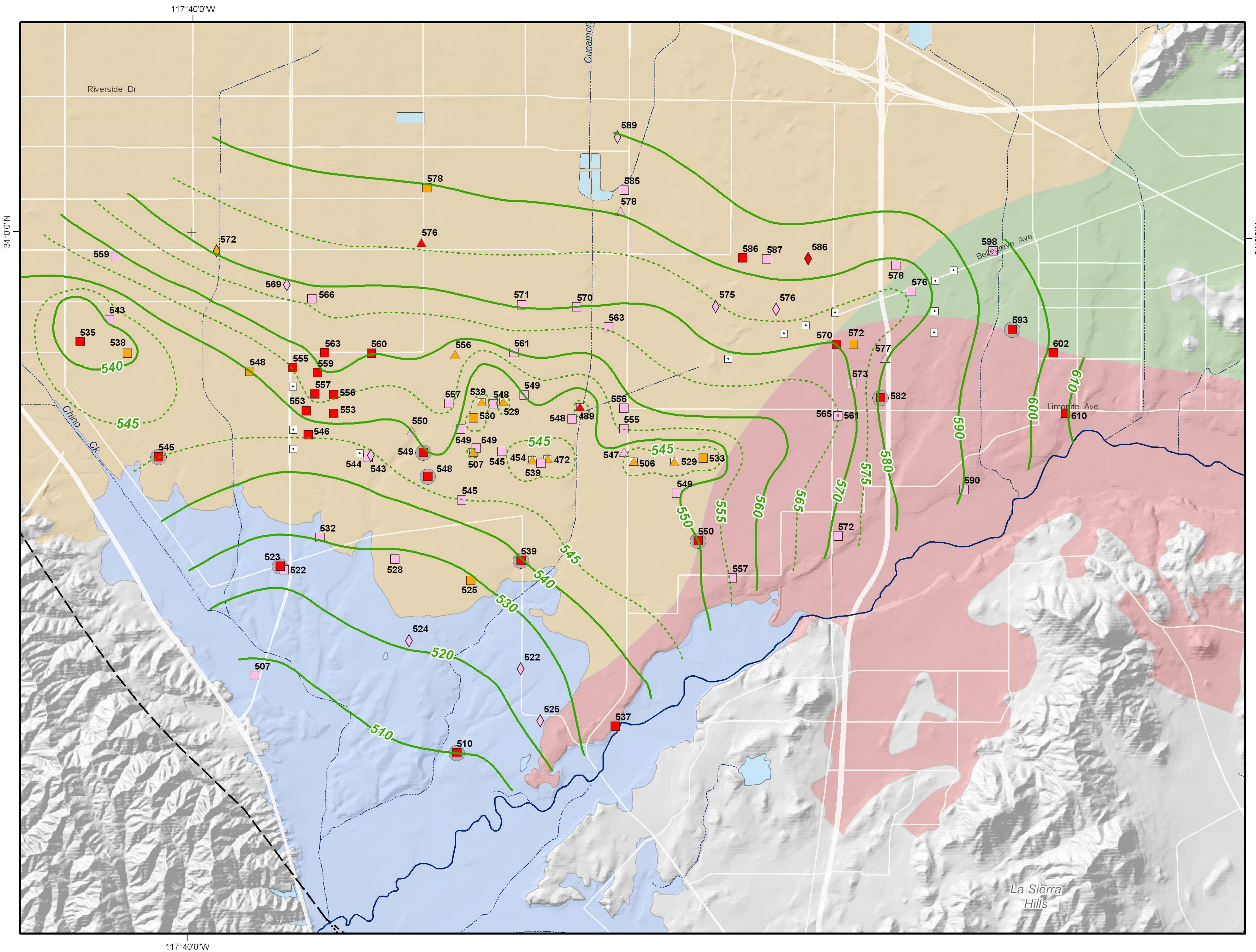
CHINO BASIN WATERMASTER

2008 State of the Basin Report
Assessment of Hydraulic Control

State of Hydraulic Control -- Spring 2006
Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-24



Groundwater Elevation Contours (feet above mean sea-level)

800

775

Other Features

Chino Desalter Well

HCMP Piezometric Monitoring Well

Flood Control and Conservation Basins

Maximum Benefit Management Zones

Chino-North

Chino-East

Chino-South

PBMZ

Faults

Location Certain

Location Approximate

Location Concealed

Location Uncertain

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0 1 2 Miles

0 1 2 3 KM

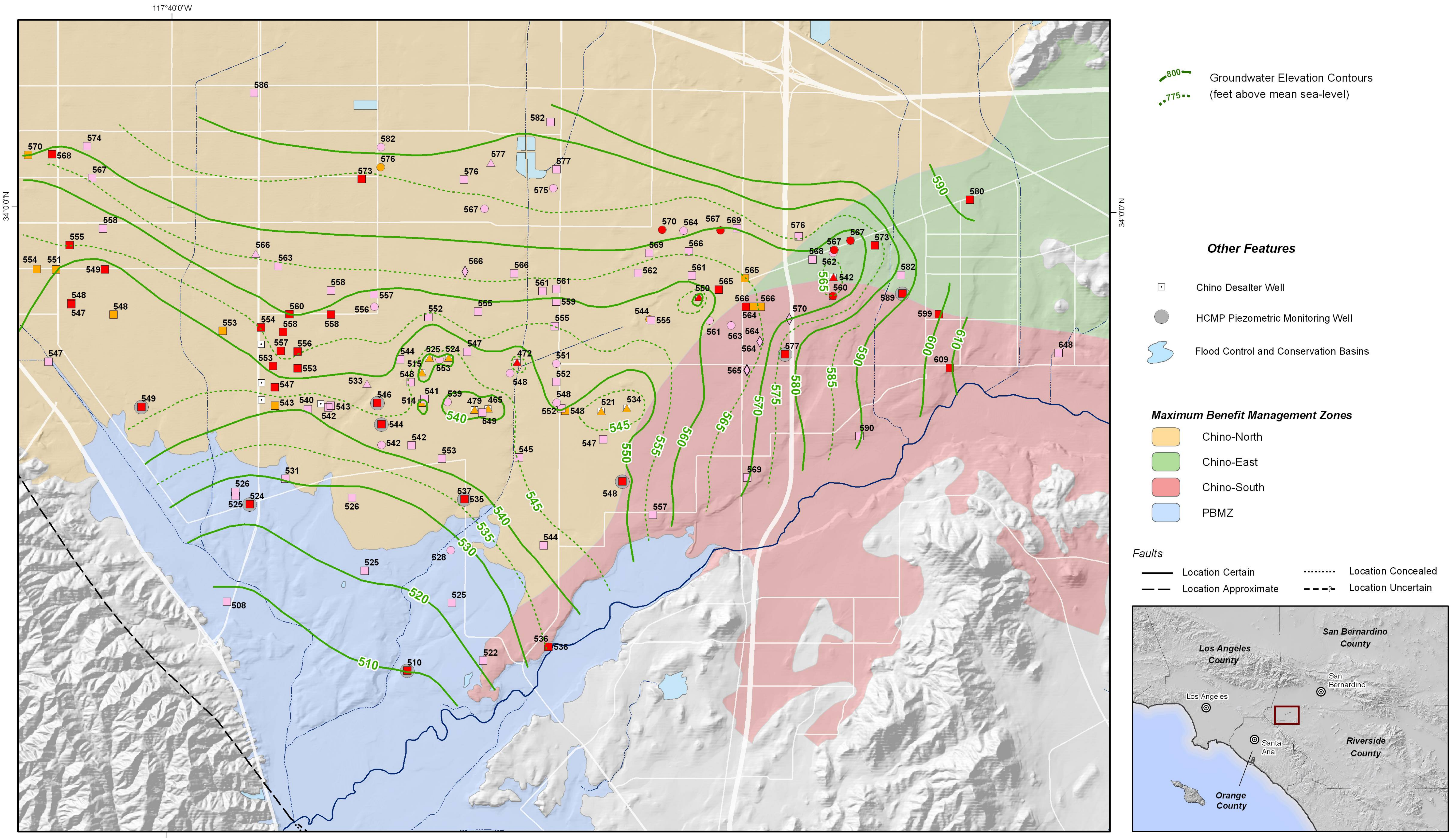
2008 State of the Basin Report

Assessment of Hydraulic Control

State of Hydraulic Control -- Spring 2007

Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-25



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0 1 2 Miles

0 1 2 3 KM

CHINO BASIN WATERMASTER — Partners in Basin Management

2008 State of the Basin Report
Assessment of Hydraulic Control

State of Hydraulic Control -- Spring 2008

Groundwater Contours -- South Chino Basin Shallow Aquifer System

Figure 3-26