WEI
Wildermuth Environmental, Inc.

Chino Basin Optimum Basin Management Program
2018 State of the Basin Report

June 2019

Chino Basin Watermaster

2018 State of the Basin Report

June 2019

Prepared for:

Prepared by:

Front cover image – San Sevaine Basin in Winter 2019.

Back cover image – Victoria Basin in Winter 2009.

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Acronyms, Abbreviations, and Initialisms

μgl	micrograms per liter
1,1-DCE	1,1-dichloroethene
1,2,3-TCP	1,2,3-trichloropropane
1,2-DCA	1,2-dichloroethane
2013 RMPU	2013 Amendment to the 2010 Recharge Master Plan Update
af	acre-feet
afy	acre-feet per year
ASR	Aquifer Storage Recovery
AWQ	ambient water quality
Basin Plan	Water Quality Control Plan for the Santa Ana River Basin
BM	bench mark
CAO	Cleanup and Abatement Order
CBDC	Chino Basin Data Collection
CCWF	Chino Creek Well Field
CCWRF	Carbon Canyon Water Reclamation Facility
CCX	Chino Creek Extensometer
CDA	Chino Basin Desalter Authority
CDFM	cumulative departure from mean
CIM	California Institution for Men
COPC	constituent of potential concern
DDW	California State Board Division of Drinking Water
DLR	detection limit for reporting
DTSC	California Department of Toxic Substances Control
DWR	California Department of Water Resources
DYYP	Dry Year Yield Program
EDM	electronic distance measurement
EPA	US Environmental Protection Agency
ET	Evapotranspiration
ET_o	Potential Evapotranspiration
ft	feet
ft-bgs	feet below ground surface
ft-brp	feet below reference point
FY	fiscal year
GE	General Electric
GIS	Geographic Information System
GLMC	Ground-Level Monitoring Committee
GMZ	Groundwater Management Zone
HCMP	Hydraulic Control Monitoring Program
IEUA	Inland Empire Utilities Agency
IMP	Interim Monitoring Program
InSAR	Synthetic Aperture Radar Interferometry
JCSD	Jurupa Community Services District
KM	kilometer
MCL	maximum contaminant level
mgl	milligrams per liter
MSL	Milliken Sanitary Landfill
MVWD	Monte Vista Water District
MWDSC	Metropolitan Water District of Southern California
MZ	Management Zone
NAWQA	National Water Quality Assessment Program
ND	non-detect
NDMA	N-nitrosodimethylamine
NL	Notification Level
Nitrate - N	nitrate expressed as nitrogen
NPL	National Priorities List
OBMP	Optimum Basin Management Program
OIA	Ontario International Airport
PBHSP	Prado Basin Habitat Sustainability Program
PBMZ	Prado Basin Management Zone
PCE	tetrachloroethene
PE	Program Element
PRISM	Parameter-Elevation Regressions on Independent Slope Model
PRP	potentially responsible party
ROD	Record of Decision
RP	Regional Plant
RWQCB	Santa Ana Regional Water Quality Control Board
SARWC	Santa Ana River Water Company
SWRCB	State Water Resources Control Board
TCE	trichloroethene
TDS	total dissolved solids
TOC	Total Organic Carbon
UCMR	Unregulated Contaminant Monitoring Rule
USGS	United States Geological Survey
VOC	volatile organic compound
Watermaster	Chino Basin Watermaster
WEI	Wildermuth Environmental, Inc.
WQS	Water Quality Standard
XRef	anonymous well reference ID

The Chino Basin Optimum Basin Management Program (OBMP) was developed pursuant to the Judgment (*Chino Basin Municipal Water District v. City of Chino, et al.*) and a ruling by the Court on February 19, 1998 (WEI, 1999). The OBMP maps a strategy that provides for the enhanced yield of the Chino Basin and seeks to provide reliable, high-quality, water supplies for the development that is expected to occur within the Basin. The OBMP Implementation Plan is the court approved governing document for achieving the goals defined in the OBMP. The OBMP Implementation Plan includes the following Program Elements (PE):

PE 1 – Develop and Implement a Comprehensive Monitoring Program

PE 2 – Develop and Implement a Comprehensive Recharge Program

PE 3 – Develop and Implement a Water Supply Plan for the Impaired Areas of the Basin

PE 4 – Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1

PE 5 – Develop and Implement a Regional Supplemental Water Program

PE 6 – Develop and Implement Cooperative Programs with the Regional Board and Other Agencies to Improve Basin Management

PE 7 – Develop and Implement a Salt Management Program

PE 8 – Develop and Implement a Groundwater Storage Management Program

PE 9 – Develop and Implement Conjunctive Use Programs

A fundamental component in the implementation of each of the OBMP PEs is the monitoring performed in accordance with *PE 1*, which includes the monitoring of basin hydrology, pumping, recharge, groundwater levels, groundwater quality, and ground-level movement. Monitoring is performed by basin pumpers, Chino Basin Watermaster (Watermaster) staff, and other cooperating entities. Watermaster staff collects and compiles the monitoring data into relational databases to support data analysis and reporting.

As a reporting mechanism and pursuant to the OBMP Phase 1 Report, the Peace Agreement and the associated OBMP Implementation Plan, and the November 15, 2001 Court Order, Watermaster staff prepares a *State of the Basin Report* every two years. In October 2002, Watermaster completed the *Initial State of the Basin Report* (WEI, 2002). The baseline for this report was on or about July 1, 2000—the point in time that represents the adoption of the Peace Agreement and the start of OBMP implementation. Subsequent *State of the Basin Reports* (WEI, 2005a; 2007a; 2009a; 2011c; 2013a; 2015b; 2017a) were used to:

- describe the then-current state of the Basin with respect to hydrology, production, recharge, groundwater levels, groundwater quality, and ground-level movement; and
- demonstrate the progress made since July 1, 2000 related to activities, such as: production meter installation, desalter planning and engineering, recharge assessments, recharge master planning, hydraulic control, expansion of monitoring programs for groundwater levels and quality, and the monitoring and management of land subsidence.

This 2018 *State of the Basin Report* is an atlas-style document. It consists of detailed exhibits that characterize current Basin conditions related to hydrology, groundwater production and recharge, groundwater levels, groundwater quality, and ground-level monitoring at of the end of fiscal year (FY) 2017/2018. In many of these exhibits, data are characterized as they relate to the Management Zones (MZs) defined in the OBMP. Exhibit 1-1 is a location map of the Chino Basin the OBMP MZs. Exhibit 1-2 shows the water service area boundaries for the major municipal producers in the Chino Basin related to the OBMP MZs.

The exhibits in this report are grouped into the following sections:

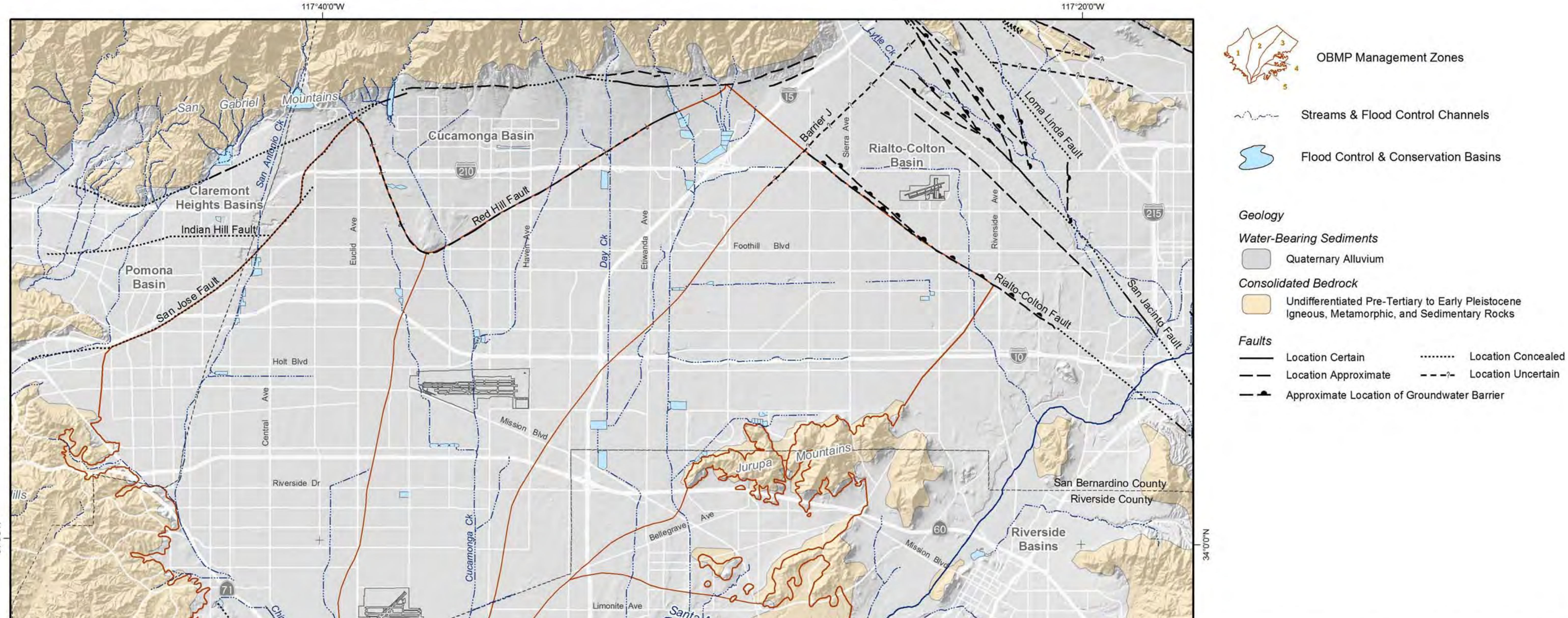
Hydrologic Conditions: This section contains exhibits that characterize the state of the Chino Basin as it relates to land use, hydrology, and climate (e.g. precipitation, temperature, and evaporation). This information provides a context for understanding the other changes in the Basin that are managed through the OBMP.

Basin Production and Recharge: This section contains exhibits that characterize groundwater production and recharge over time and space, including progress towards the expansion of the Chino Basin Desalters and the Chino Basin Groundwater Recharge Program. This information is useful in understanding historical changes in groundwater levels and quality.

Groundwater Levels: This section contains exhibits that characterize groundwater flow patterns and the change in groundwater elevations since 2000. It includes groundwater-elevation maps for spring 2000, spring 2014, and spring 2016, and groundwater-elevation change maps for 2000 to 2016 and 2014 to 2016. This section also includes characterizations of the time history of groundwater levels throughout the Chino Basin and correlates the change in groundwater levels to observed precipitation, recharge, and pumping patterns.

Groundwater Quality: This section contains exhibits that characterize the groundwater quality across the Chino Basin. The constituents characterized include total dissolved solids (TDS), nitrate, and other constituents of concern. This characterization includes maps of the spatial distribution of constituent concentrations, updated delineations of known point-source contaminant plumes across the Basin, and time-series charts that characterize TDS and nitrate concentration trends in the OBMP MZs since 1972.

Ground-Level Monitoring: This section contains exhibits that characterize the history of land subsidence and ground fissuring and the current state of ground-level movement in the Chino Basin as understood through the Watermaster's ground-level monitoring program. This characterization includes an assessment of ground-level movement in each of the five Areas of Subsidence Concern.



While the Chino Basin is considered one basin from geologic and legal perspectives, the OBMP delineated five management zones (MZs) based on groundwater flow systems that function as distinct hydrologic units. Each MZ has a unique hydrology and unique water resource management activities that have limited impacts on the other MZs. Management, monitoring, and reporting activities for these management zones are discussed throughout this State of the Basin Report.

This exhibit is a reference for key map features of the other exhibits within this report.

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File: Exhibit_1-1_LocationMap_V2.mxd

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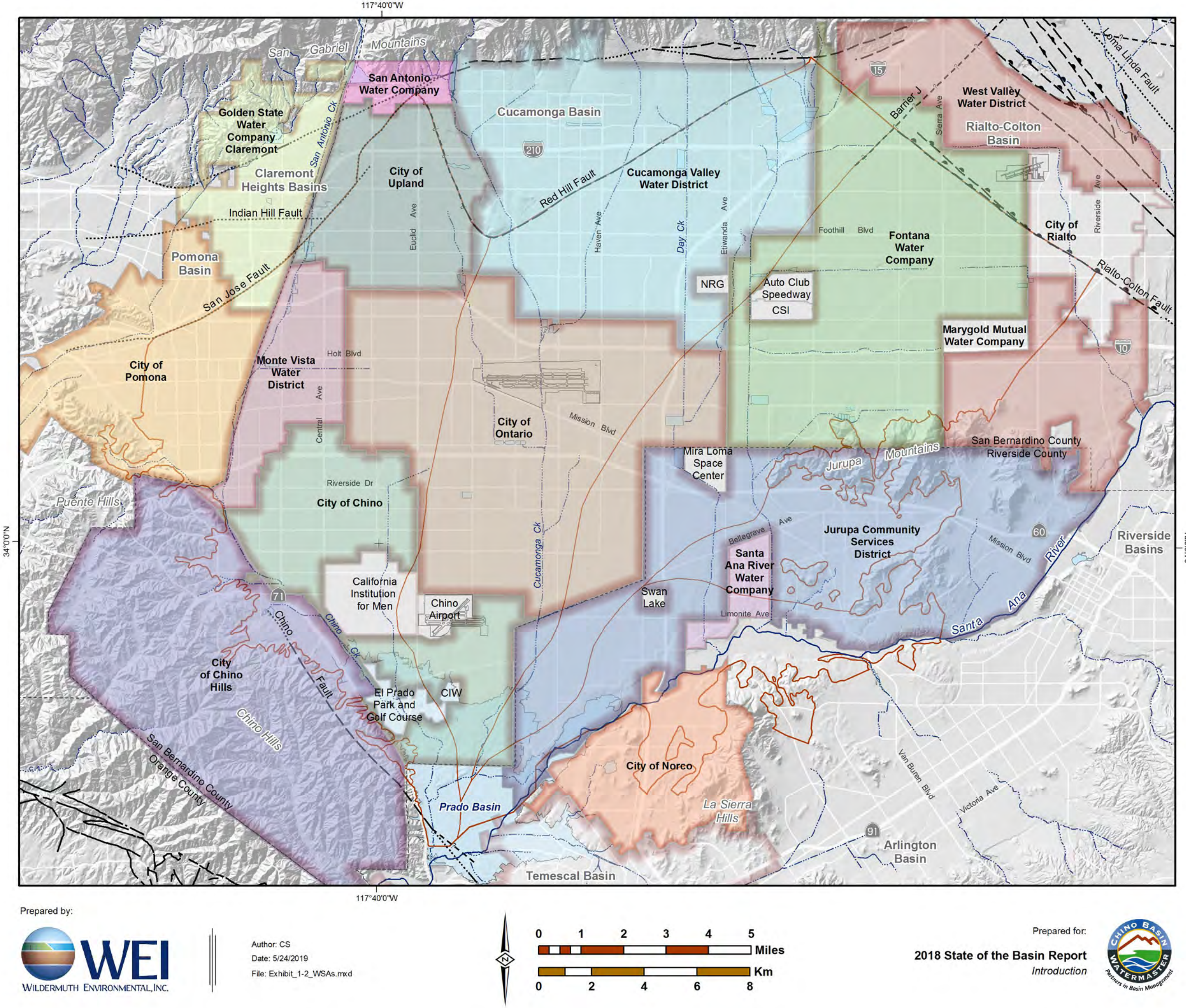
2018 State of the Basin Report
Introduction

Chino Basin Watermaster
Partners in Basin Management

Chino Basin Groundwater Basin
Key Map Features

Exhibit 1-1



Other key map features are described in the legend of Exhibit 1-1.

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File: Exhibit_1-2_WSAs.mxd

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2018 State of the Basin Report
Introduction

Water Service Areas

Exhibit 1-2

This section contains seven exhibits that illustrate important hydrologic concepts to aid in understanding contemporary water management issues in the Chino Basin.

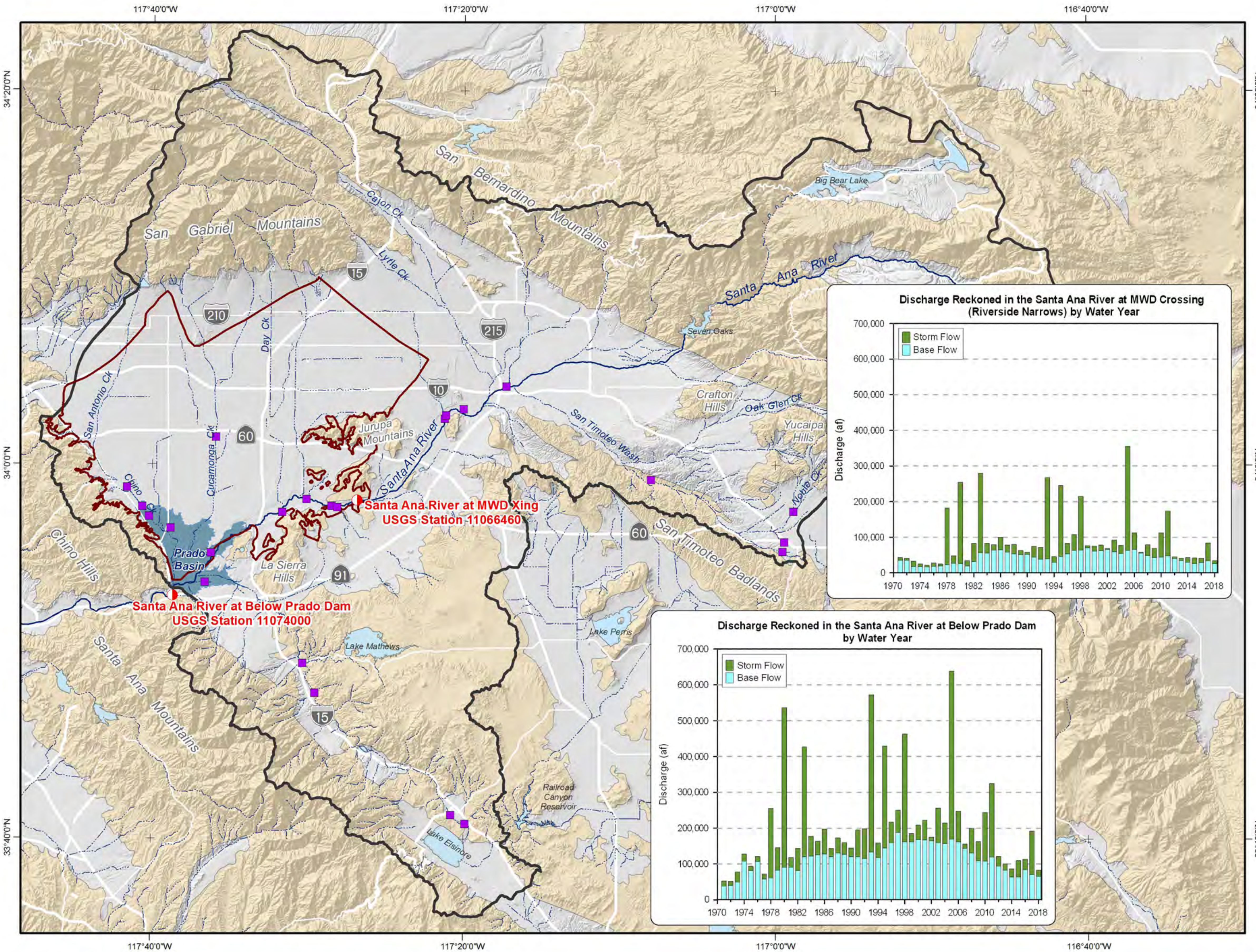
Significant hydrologic investigations have been completed in the Chino Basin that have: led to the construction of new recharge facilities, increasing the amount of storm water recharge and the supplemental water recharge capacity (WEI, 2013); produced estimates of annual net recharge and Safe Yield (WEI, 2015); developed the relationship of desalter production and reoperation and Santa Ana River recharge (WEI, 2015); and the relationship of managed storage to annual net recharge and Safe Yield (WEI, 2018). The information presented herein was mostly drawn from these investigations and some information is being published here for the first time. Apart from Exhibit 2-1, each exhibit contains text that describes and interprets the charts on them.

Exhibit 2-1 shows the location of the Chino Basin within the Upper Santa Ana River Watershed and the locations of two key stream-gaging stations in the Chino Basin. Daily discharge data measured at the USGS gaging stations on the Santa Ana River at MWD Xing (USGS Station 11066460) and at the Santa Ana River at Below Prado Dam (USGS Station 11074000) can be used to characterize the discharge of the Santa Ana River as it enters and exits the Chino Basin. The relationship of groundwater management activities in the Chino Basin and the streambed infiltration of Santa Ana River discharge was incorporated into the Chino Basin OBMP. Santa Ana River discharge is composed of storm flow and base flow. Storm flow is discharge that is the direct result of runoff from precipitation. Base flow is the difference between the total measured discharge and storm flow, and it consists of discharge from wastewater treatment plants and rising groundwater. Exhibit 2-1 shows the locations of the USGS gaging stations and the wastewater treatment plant discharge. Base flow is a significant source of recharge to the Chino Basin.

Exhibit 2-1 also shows the annual discharge hydrographs for the Santa Ana River at MWD Xing and at Below Prado Dam. The annual discharge values have been divided into storm and base flows. The base flow time series tends to increase over time, following the conversion of land uses to urban and industrial, until the onset of the great recession in 2008. These land use conversions increased base flow because the improved land uses were sewered and the resulting wastewater was discharged to the River. After 2008, the base flow decline was caused by decreased water use due to recession and drought and the Inland Empire Utilities Agency's (IEUA) increased use of recycled water for direct and indirect uses, thereby reducing its wastewater discharges to the River.

Total Santa Ana River discharge entering the Chino Basin at the MWD Xing (Riverside Narrows) has exceeded 50,000 acre-feet per year (afy) since 1983 except from 1991 to 1995 and from 2009 to 2018. Part of the decrease in base flow at the Riverside Narrows after 2009 is due to a decrease in wastewater discharge to the River upstream and falling groundwater levels in the groundwater basins underlying the Santa Ana River upstream, the combined effect of which is a decrease in rising groundwater just upstream of the MWD Xing.

Total Santa Ana River discharge exiting the Chino Basin at Below Prado Dam has exceeded 100,000 afy since 1983 except from 2012 to 2018. The base flow leaving the Chino Basin is about twice the base flow entering the Basin due to the combined wastewater treatment plant discharges of the Cities of Corona and Riverside, the IEUA, and the West Riverside County Wastewater Reclamation Authority. The decrease in base flow exiting the Basin after 2005 is due to the decrease in baseflow entering the Basin at the Riverside Narrows, decreases in wastewater discharges due to water conservation and recycled water reuse, and increased streambed infiltration caused by increased groundwater production in the southern Chino Basin.



USGS Stream-gaging Station

Wastewater Treatment Plant Discharge Locations

Santa Ana River Watershed Tributary to Prado Dam (Upper Watershed)

Chino Basin Hydrologic Boundary

Lakes and Reservoirs

Prado Basin

Other key map features are described in the legend of Exhibit 1-1.

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Document Name: Exhibit_2-1_SARWtrsd

0 5 10 15 Miles
0 10 20 Km

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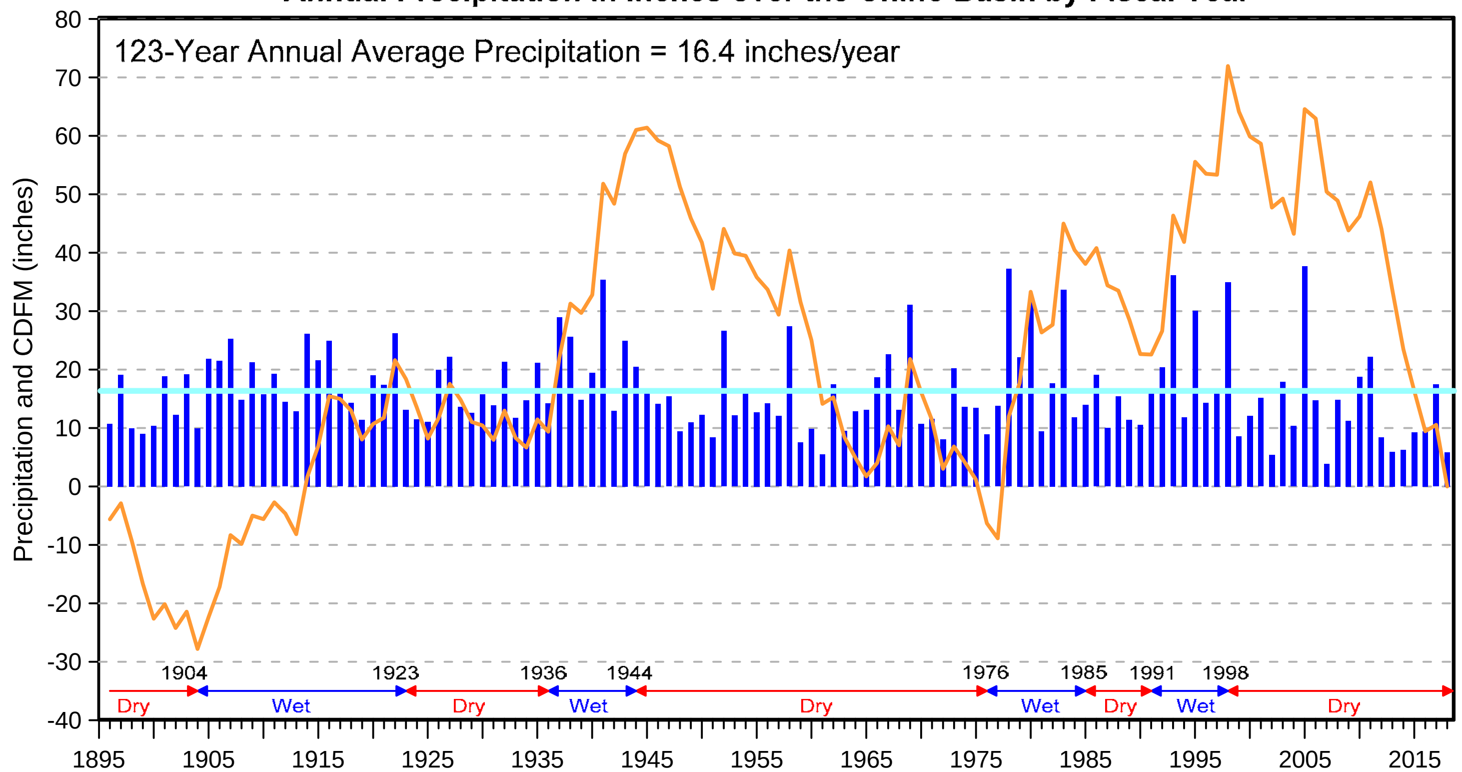
Hydrologic Conditions

Santa Ana River Watershed Tributary to Prado Dam

Exhibit 2-1

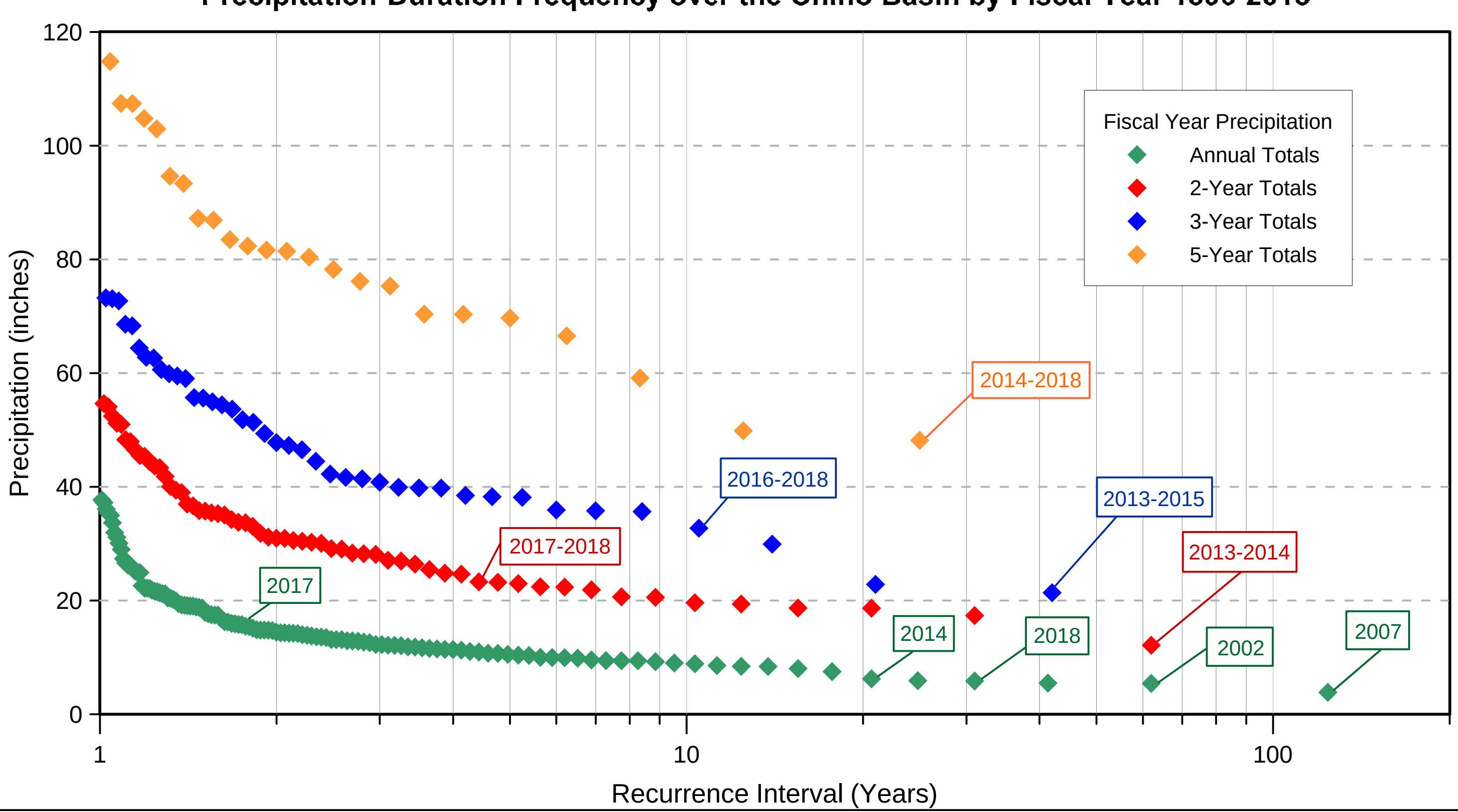
Annual Precipitation in Inches over the Chino Basin by Fiscal Year



Precipitation is a major source of groundwater recharge for the Chino Basin through the deep infiltration of precipitation and applied water and stormwater recharge in streams and recharge facilities. The chart on the upper left shows the long-term annual precipitation time series. These annual precipitation estimates are based on an areal average over the Chino Basin, created from gridded monthly precipitation estimates prepared by the PRISM Climate Group and covers the period 1895 through 2017. The annual precipitation estimates cover the fiscal year (FY) (July through June). The chart contains a horizontal line indicating the 123-year average annual precipitation of 16.4 inches, and it contains the cumulative departure from mean (CDFM) precipitation. The CDFM plot is a useful way to characterize the occurrence and magnitude of wet and dry periods: positive sloping segments (trending upward from left to right) indicate wet periods, and negative sloping segments (trending downward from left to right) indicate dry periods. The wet and dry periods are labeled at the bottom of the chart. On average, the ratio of dry years to wet years is about three to two. That is, for every ten years, about six years will experience below average precipitation and four years will experience greater than average precipitation. That said, 1945 through 1976 was a 32-year dry period, punctuated by five years of above average precipitation: a dry-to-wet year ratio of about six to one. The period 1999 through 2018 was a 20-year dry period punctuated with three wet years: a dry-to-wet year ratio of also about six to one. Dry periods tend to be long and very dry and wet periods tend to relatively shorter and very wet (see for example 1936 through 1944, 1977 through 1985 and 1993 through 1998).

The chart on the lower left contains annual precipitation frequency estimates for durations of one-, two-, three-, and five-year periods. A recurrence interval is the average number of periods between recurrence of a period equal to or less than the total given precipitation value. For example, 2013-2014, the driest two-year span on record, has a recurrence interval of 62 years, meaning that based on the historical data, a two-year period with less than or equal to 12 inches will only occur once every 62 years. The chart shows that four of the five driest years on record occurred in the 1999 through 2018 dry period; and that the driest consecutive two, three and five-year periods have all occurred since 1999. The OBMP implementation period corresponds with this dry period.

Precipitation-Duration Frequency over the Chino Basin by Fiscal Year 1896-2018



Annual Precipitation (inches)

Long-Term Average Annual Precipitation (inches)

Cumulative Departure from Mean Precipitation (CDFM)

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File: Exhibit_2-2_Precip.grf

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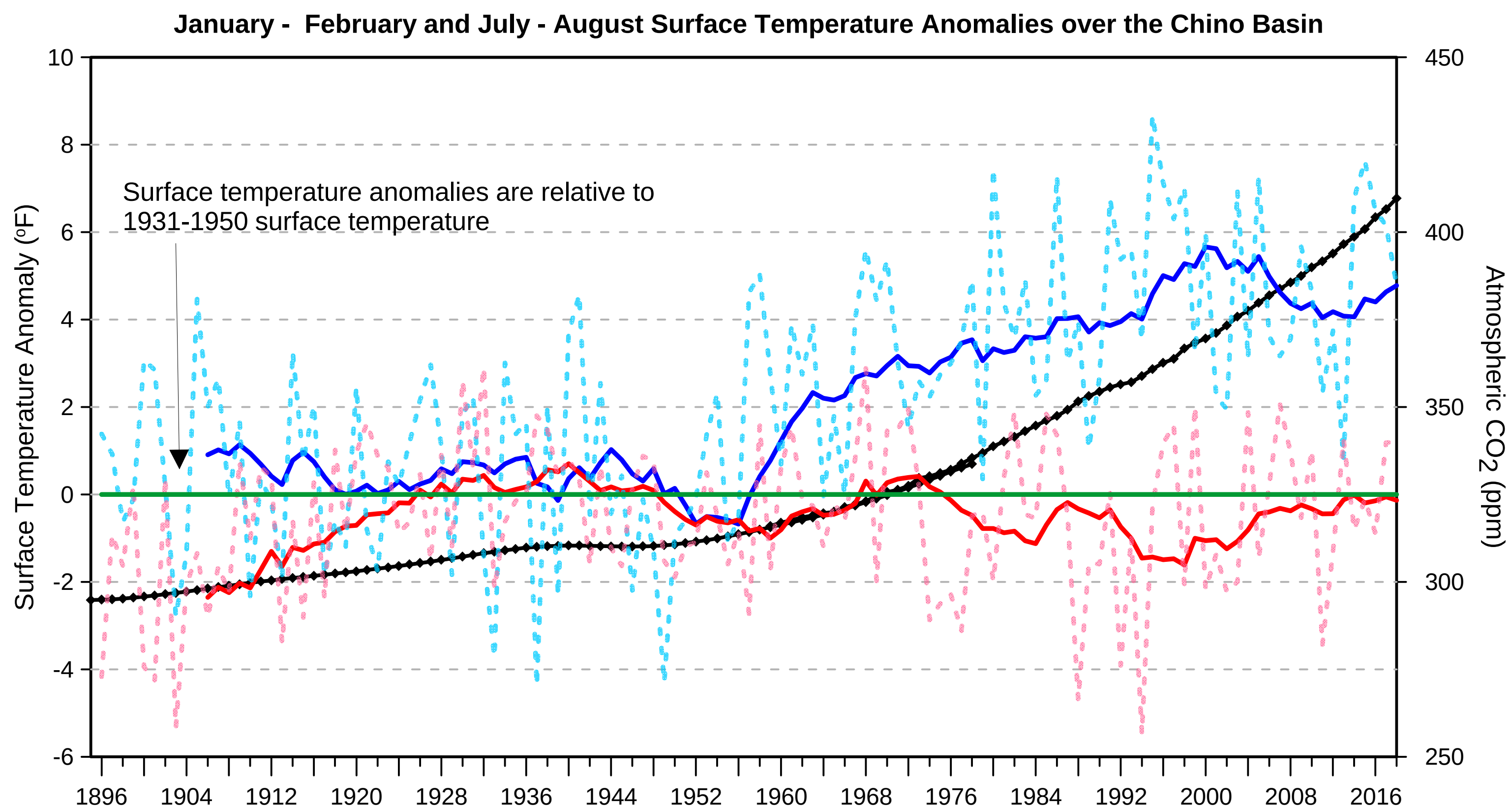
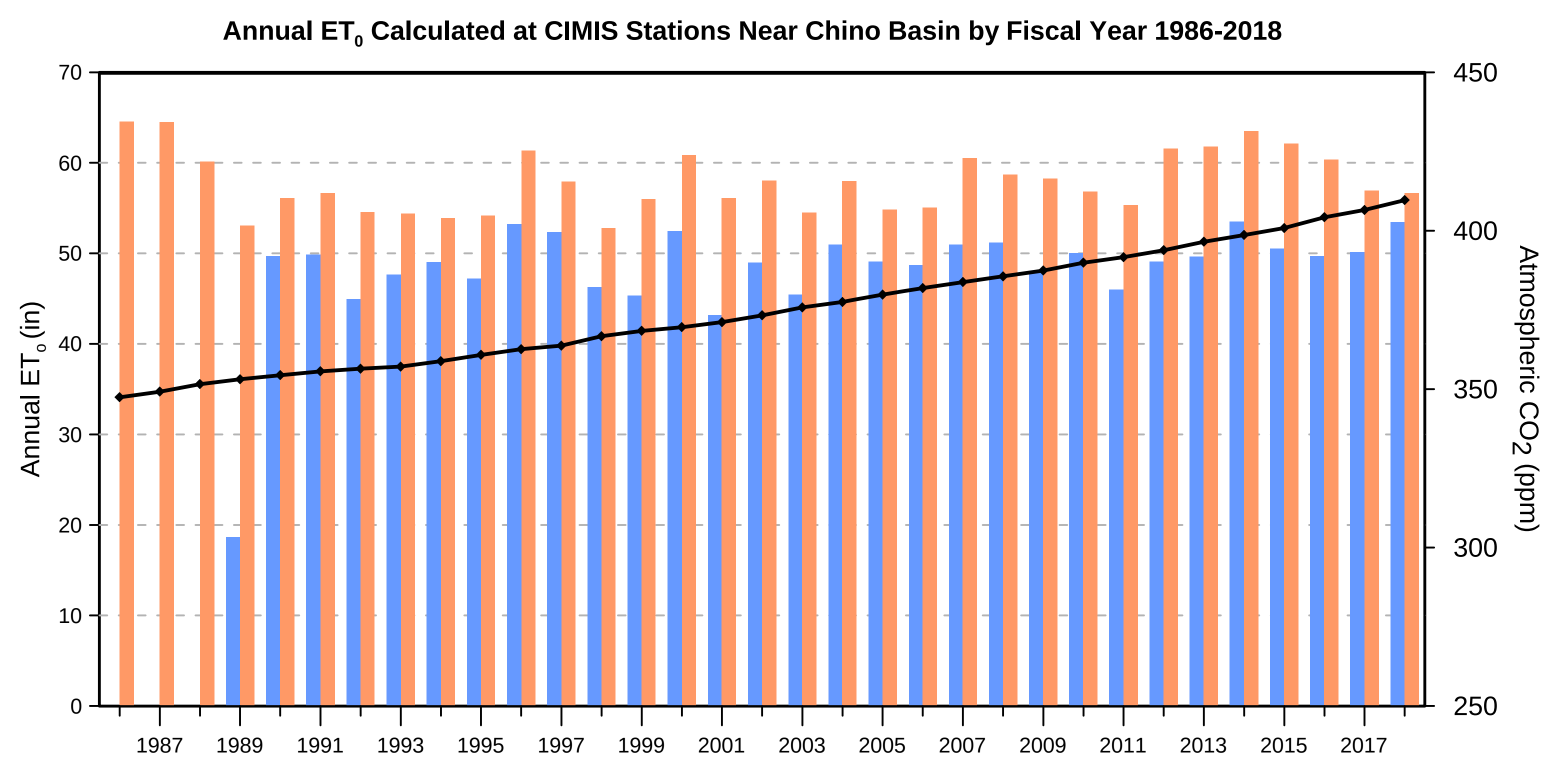
2018 State of the Basin Report
Hydrologic Conditions

Characterization of Long-Term Annual Precipitation over the Chino Basin

Exhibit 2-2





The chart on the upper left shows the time history of annual surface temperatures and ten-year average surface temperature anomalies for January-February and July-August. The January-February period represents winter and the coldest time of the year, and the July-August period represents summer and the hottest time of the year. The average ten-year surface temperature anomaly is computed as the difference between the running ten-year average surface temperature and the 20-year average surface temperature for the 1931 through 1950 (baseline) period. This chart also shows the estimated atmospheric carbon dioxide concentration. The 1931 to 1950 baseline period corresponds to a period of relatively stable atmospheric carbon dioxide concentration of about 320 parts per million (ppm). After 1950, the atmospheric carbon dioxide concentration increases at an increasing rate through 2018. The surface temperature anomaly is a useful way to characterize surface temperature trends. The data used to generate this chart is based on observed daily maximum and minimum temperatures converted to monthly statistics and interpolated by the PRISM Climate Group to produce gridded monthly maximum and minimum temperature estimates. The complete record of atmospheric carbon dioxide concentrations is assembled from multiple sources: prior to 1959, the annual values shown were estimated from an analysis of the Law Dome DE08 and DE08-2 ice cores in Antarctica (D.M. Etheridge, et al., 1998); values after 1959 were directly measured at the Mauna Loa Observatory in Hawaii (NOAA, 2019). The 10-year moving average of the surface temperature anomaly for the July-August period varies between -2.0 and +0.5 degrees Fahrenheit. In contrast, the 10-year moving average of the surface temperature anomaly for the January-February period has been increasing from 1954 to 2018 at a rate of 0.08 degrees Fahrenheit per year and resulted in a winter temperature departure of about +5 degree Fahrenheit in 2018 compared to the 1931 to 1950 baseline period. The increase in the winter temperatures during this period appears to correlate with the increase in atmospheric carbon dioxide concentration. The significance of the increasing winter temperature to Chino Basin groundwater management is two-fold: a decrease in the occurrence of snowfall and increase in precipitation and a slight increase in winter-time evapotranspiration (ET). The reduction in snowfall coupled with an increase in precipitation will increase the surface water discharge associated with individual precipitation events, cause more frequent exceedances of the recharge capacity of existing recharge facilities, and subsequently reduce the amount of stormwater recharged in the Basin.

The chart on the lower left shows the annual potential ET (ET0) as computed at the California Irrigation Management Information System for stations in Pomona and Riverside. The reported ET0 values are computed from measurements of solar radiation, temperature, humidity, and wind speed. It is unclear from these time series data that ET0 is changing in response to increases in atmospheric carbon dioxide concentration. The trends in ET0, when they become more apparent, will need to be included in future hydrologic evaluations of the Chino Basin.

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File: Exhibit_2-3_Climate.grf

10-Year Moving Average Surface Temperature Anomaly (July - August)
10-Year Moving Average Surface Temperature Anomaly (January - February)
Surface Temperature Anomaly (July - August)
Surface Temperature Anomaly (January - February)
Annual Average Atmospheric CO_2 Concentration - Various Sources
Annual ET_o at Pomona Station
Annual ET_o at UCR Station

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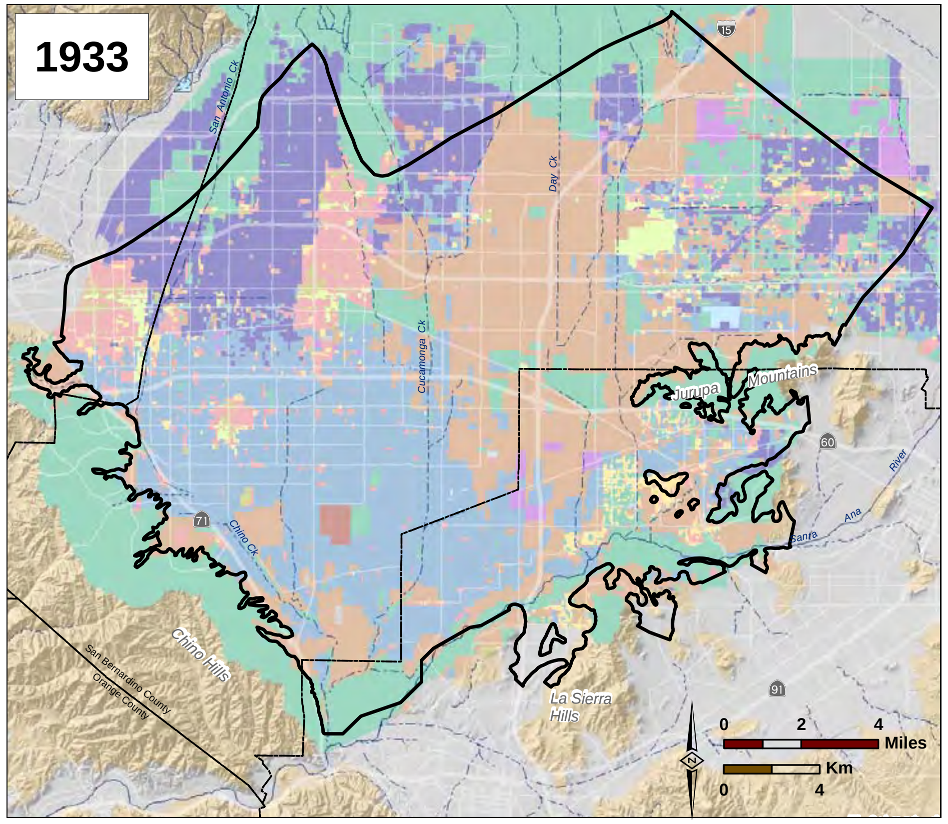
Hydrologic Conditions

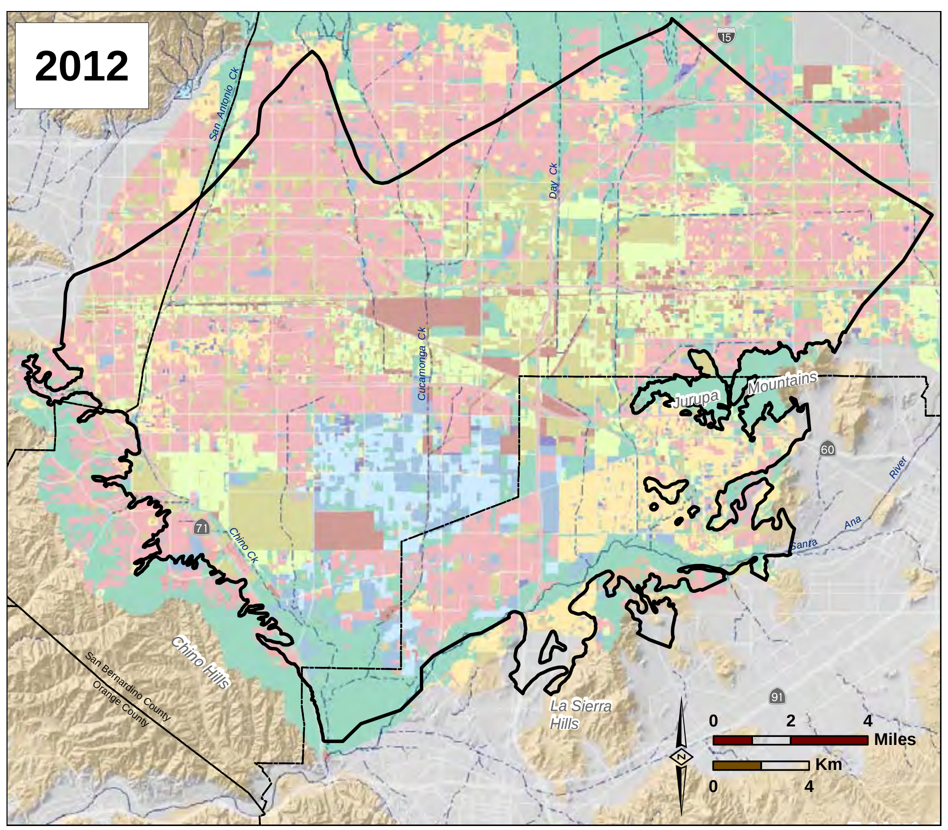
Annual Departure from Baseline Temperature and ET_0 in the Chino Basin

Exhibit 2-3

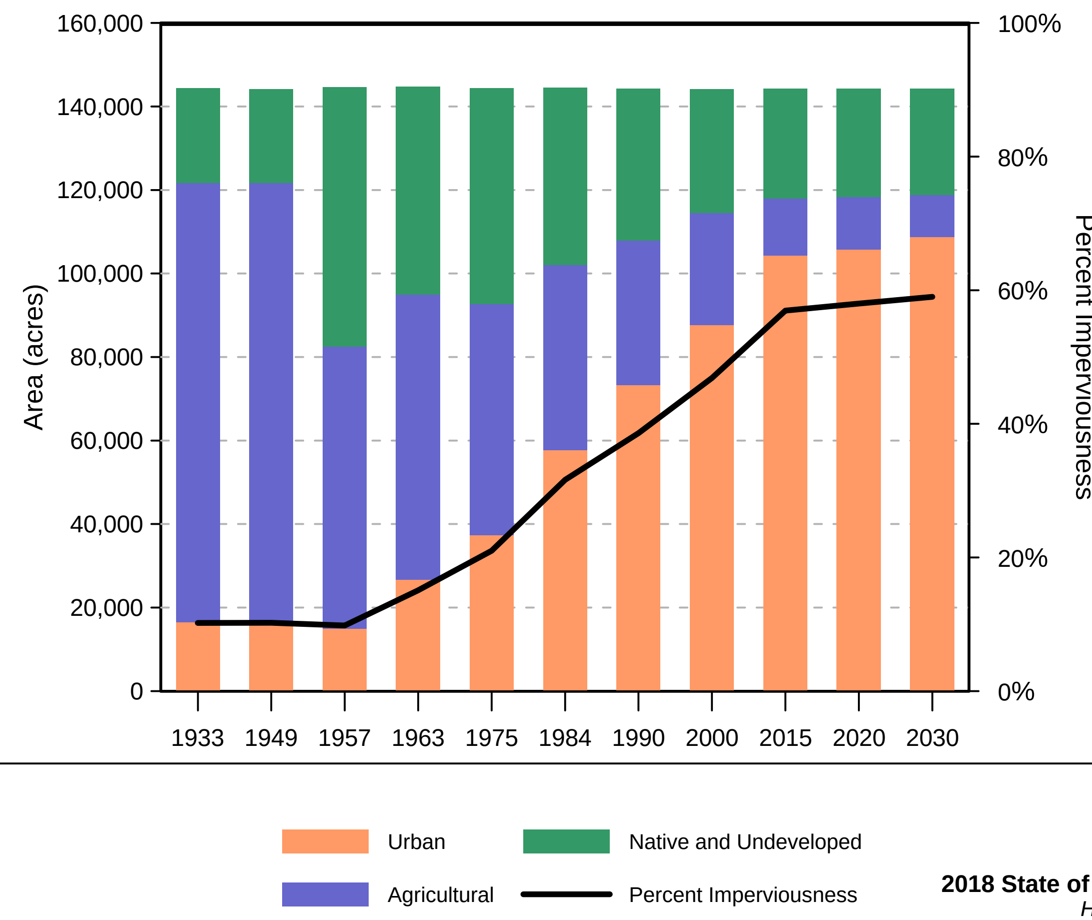


Land Use Categories

- Non-Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated Field Crops, Pasture, Fruit and Nuts
- Irrigated and Non-Irrigated Citrus
- Irrigated Vineyard
- Non-Irrigated Vineyard
- Dairies and Feedlots
- Urban Residential
- Special Impervious
- Native Vegetation
- Low Density Urban Residential
- Commercial
- Industrial

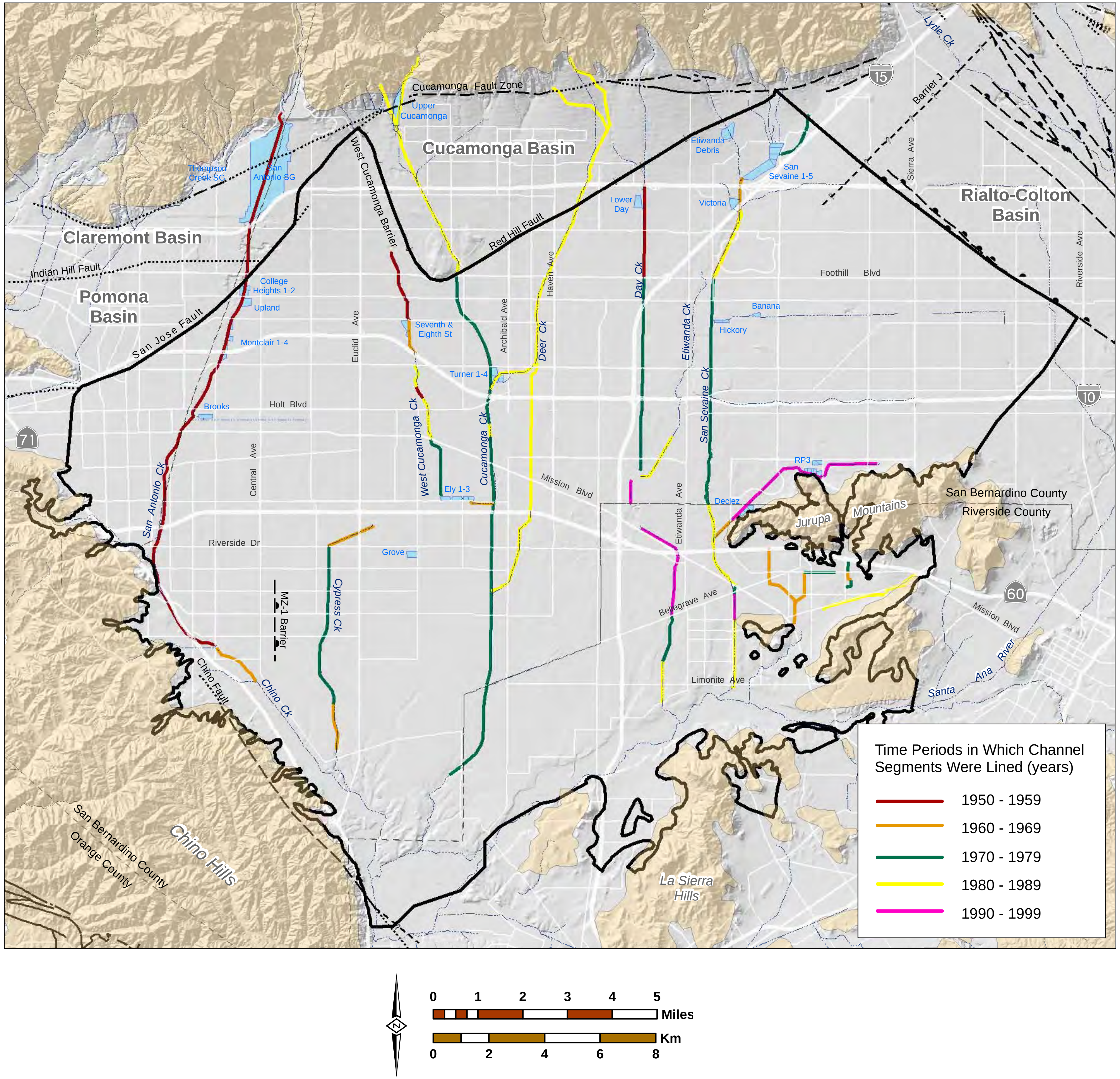


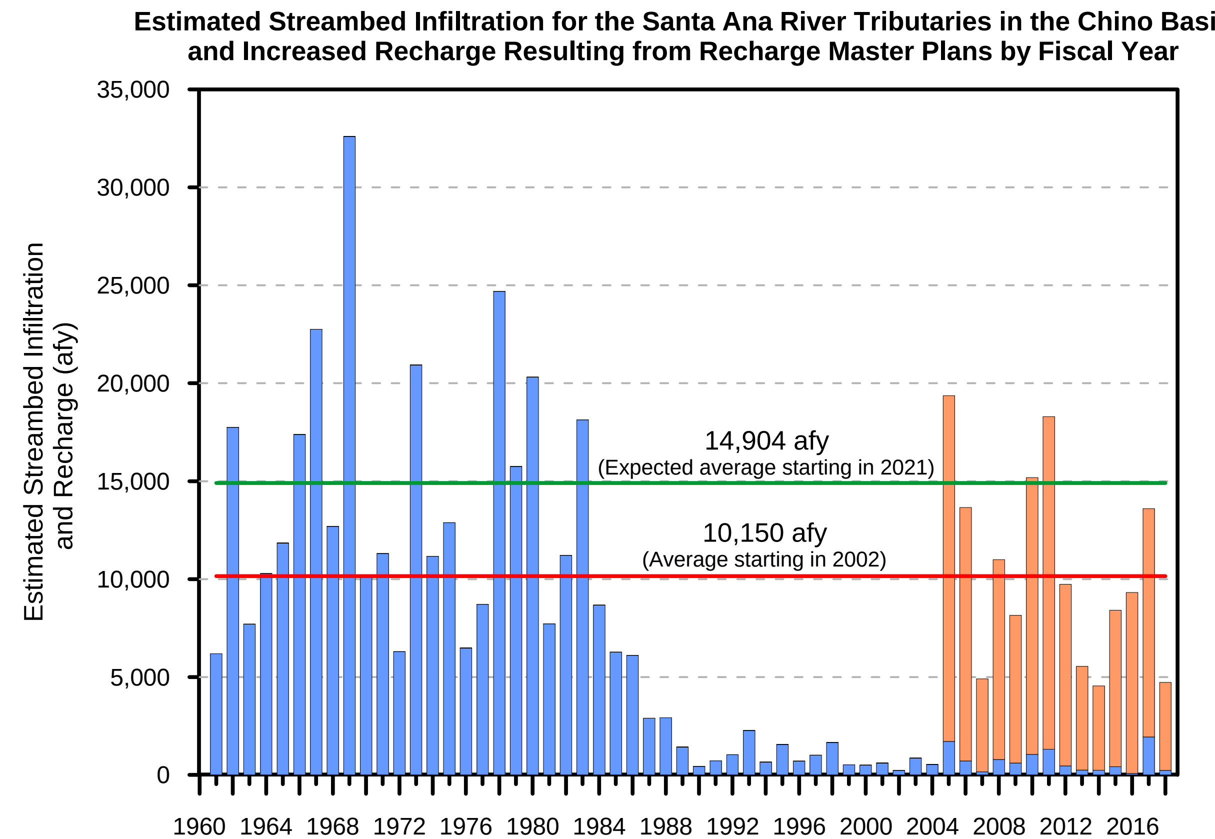
Historical and Projected Distribution of Land Use in the Chino Basin



The watershed surface that is tributary to and overlies the Chino Basin and the water management practices over this surface have changed dramatically over the last 80 years. The land use, water management, and drainage conditions that are tributary to and overlie the Basin at a specific time are referred to collectively as the cultural condition of the basin. The types of land uses that overlie a groundwater basin have a profound impact on recharge. The land use transition from natural to agricultural uses and subsequently to developed urban uses radically changes the amount of recharge to the basin. Furthermore, irrigation practices change over time in response to agricultural economics (e.g. demand for various agricultural products, commodity prices, production costs, etc.), regulatory requirements, technology, and the availability and cost of water. Urbanization increases the amount of imperviousness and decreases the irrigable and permeable areas that allow irrigation return flows and precipitation to infiltrate through the soil. And, urbanization increases the amount of stormwater produced on the land surface. Drainage improvements associated with the transition from natural and agricultural uses to urban uses reduce the recharge of stormwater: channels and streams in the Chino Basin were concrete-lined to move stormwater efficiently through the watershed to the Santa Ana River.

With few exceptions, as land is converted from natural, undeveloped conditions to human uses, it becomes more impervious and produces more stormwater runoff. Historically, when land use has converted from natural and agricultural uses to urban uses, imperviousness has increased from near 0 to between 60 and almost 100 percent, depending on the specific land use. Land use maps for 1933 and 2012 are shown on the left of this exhibit. Also shown is a chart that summarizes land use into three broad categories (urban, agricultural, and native/undeveloped) and the estimated total imperviousness associated with the land uses. This latter chart is based on land use mapping for the years shown on the x-axis and projected land use from the land use control agencies. The land use was predominantly in an agricultural and undeveloped state until 1984: urban uses accounted for about 10 percent from 1933 through 1957, grew steadily thereafter to about 26 percent in 1975, and reached about 60 percent in 2000. At 2040, the fraction of the Chino Basin that is projected to be impervious is about 78 percent. Based on an investigation to recalculate the Chino Basin Safe Yield, the impact of these land use changes reduced the deep infiltration of precipitation and applied water from about 140,000 afy in the period of 1930 through 1940 to less than 100,000 afy by and after 2000 (WEI, 2015).





Drainage improvements were incorporated into the urban landscape in the Chino Basin to convey stormwater rapidly, safely, and efficiently from the land surface through urban developments, and to discharge stormwater away from urbanized areas. Until the late 1990s, there was little or no thought as to the value of the stormwater that discharged out of the Chino Basin. The map to the left shows the stream systems that start in the San Gabriel Mountains and flow from the north to the south, crossing the Cucamonga, Chino, and Six Basins. From about 1957 to the present, the drainage areas overlying the valley floor have been almost completely converted to urban uses, and almost all of the streams have been converted from unlined to concrete-lined channels. The above chart illustrates the estimated stormwater recharge in the Chino Basin (blue bars) for the Santa Ana River tributaries that flow south over the Chino Basin for the period 1961 through 2018. The lining of these channels has almost eliminated stormwater recharge in the Chino and Cucamonga Basins after 1984. The orange bars indicate the estimated increase in stormwater recharge due to the construction of stormwater recharge improvements from the 2002 Recharge Master Plan that was implemented in OBMP. The red line indicates the long-term average stormwater recharge (10,150 afy) after completion of the 2002 Recharge Master Plan (RMP) projects: the 2002 RMP projects have replaced some of the recharge lost with channel lining. The green line indicates the expected average stormwater recharge (14,904 afy) after the completion of the projects identified in the 2013 Amendment to the 2010 Recharge Master Plan Update (2013 RMPU), which is expected to be in 2021.

Estimated Streambed Infiltration
Stormwater Recharge Resulting from Implementation of the 2002 RMP
Average Annual Total Stormwater Recharge with the 2002 RMP
Average Annual Total Stormwater Recharge After Completion of the 2013 RMPU Projects

History of Channel Lining and Streambed Infiltration in the Chino Basin

Exhibit 2-5

Earth's water is moved, stored, and exchanged between the atmosphere, land surface, and subsurface according to the hydrologic cycle. The hydrologic cycle begins with evaporation from the ocean. As the evaporated water rises, the water vapor cools, condenses, and ultimately returns to the Earth's surface as precipitation (rain or snow). As the precipitation falls on the land surface, some water may infiltrate into the ground to become groundwater, some water may run off and contribute to streamflow, some may evaporate, and some may be used by plants and transpired back into the atmosphere to continue the hydrologic cycle (Healy, R.W. et al., 2007).

A water budget takes into account the storage and movement of water between the four physical systems of the hydrologic cycle: the atmospheric system, the land surface system, the river and stream system, and the groundwater system. A water budget is a foundational tool used to compile water inflows (supplies) and outflows (demands). It is an accounting of the total groundwater and surface water entering and leaving a basin or a user-defined area. The difference between inflows and outflows is the change in the amount of water stored (DWR, 2016).

Exhibit 2-6 is a tabular presentation of the Chino Basin water budget for the OBMP implementation period of fiscal years 2000 through 2018, based on the research and modeling investigations conducted to recalculate the Chino Basin Safe Yield (WEI, 2015) and annual model updates conducted by Watermaster to support ongoing investigations (e.g. Storage Framework Investigation [WEI, 2018]) and annual compliance reporting pursuant to the Sustainable Groundwater Management Act (SGMA). The water budget shown in Exhibit 2-6 shows the recharge and discharge components and estimated change in storage on an annual time step. The recharge components include subsurface inflows from adjacent mountain blocks and groundwater basins, streambed infiltration, managed aquifer recharge, and the deep infiltration of precipitation and applied water. The discharge components include groundwater pumping, ET from riparian vegetation, groundwater discharge to streams, and subsurface outflow to adjacent groundwater basins. The change in storage is equal to the total recharge minus total discharge. The net recharge is equal to: R_{net} = Pumping + Δ Storage – R_{sw}, where: R_{net} is net recharge, Δ Storage is the change in storage, and R_{sw} is supplemental water recharge

The net recharge is used with other information to estimate the Chino Basin Safe Yield. The estimated recharge and discharge components, change in storage, and net recharge shown in Exhibit 2-6 are slightly different than reported in the Safe Yield recalculation (WEI, 2015), and are based on updated information. The average net recharge for the period of 2000 through 2010 was about 138,000 afy and the net recharge for the period of 2011 through 2018 was about 136,000 afy.

Fiscal Year	Recharge										Discharge							Change in Storage = Recharge minus Discharge	Net Recharge
	Subsurface Boundary Inflow from:			Streambed Infiltration from:		Water Recharged in Basins from:					Pumping:								
	*Chino/Puente Hills, Six Basins, Cucamonga Basin and Rialto Basin	Bloomington Divide	Temescal Basin	*Santa Ana River Tributaries	Santa Ana River	Storm Water	Recycled Water	Imported Water	*Deep Infiltration of Precipitation and Applied Water	Subtotal Recharge	Chino Basin Desalter Authority	Overlying Non-Agricultural** and Appropriative Pools	Overlying Agricultural Pool	Evapo-transpiration of Riparian Vegetation	Groundwater Discharge to Streams	Subsurface Discharge to Temescal Basin	Subtotal Discharge		
FY 1999/2000	22,348	13,078	6,588	506	24,600	3,505	772	1,009	108,442	180,849	523	133,086	43,465	18,272	22,834	2,704	220,885	-40,037	135,257
FY 2000/2001	21,201	12,983	7,453	635	24,011	4,552	367	6,522	106,375	184,100	9,470	120,396	35,518	18,457	24,981	3,298	212,120	-28,020	130,475
FY 2001/2002	23,199	13,661	7,991	197	25,204	1,806	298	8,253	103,593	184,203	10,173	129,760	40,402	18,440	24,447	3,329	226,551	-42,348	129,436
FY 2002/2003	22,152	13,959	8,086	865	25,440	8,441	186	4,747	107,061	190,937	10,322	123,471	34,246	18,609	24,579	3,716	214,943	-24,006	139,100
FY 2003/2004	26,375	14,036	8,290	537	25,260	5,197	185	11,146	106,132	197,157	10,480	128,548	38,068	18,581	25,148	3,823	224,648	-27,491	138,273
FY 2004/2005	22,252	11,918	6,198	5,981	26,685	20,051	569	15,349	104,917	213,920	10,595	112,943	31,694	18,754	24,841	4,886	203,715	10,205	149,519
FY 2005/2006	19,499	12,672	5,984	1,816	29,647	13,327	2,472	40,087	95,367	220,872	19,819	113,553	27,005	18,534	18,810	3,185	200,906	19,966	137,784
FY 2006/2007	20,727	13,126	5,743	83	28,621	4,990	1,682	20,786	92,418	188,175	28,529	123,695	28,817	18,108	17,105	2,121	218,375	-30,200	128,373
FY 2007/2008	22,102	13,127	5,507	1,530	32,255	10,787	2,623	0	94,255	182,188	30,116	127,696	24,601	18,050	16,653	2,851	219,968	-37,780	142,010
FY 2008/2009	23,318	13,189	6,240	845	31,405	8,015	2,672	0	94,931	180,615	28,456	137,345	23,940	18,127	17,484	2,809	228,161	-47,546	139,523
FY 2009/2010	24,431	13,297	6,808	1,959	31,725	15,356	8,729	5,001	94,240	201,546	28,964	108,983	21,142	18,277	18,041	2,987	198,394	3,152	148,512
FY 2010/2011	22,885	13,444	7,482	3,380	32,513	18,155	7,615	31,943	91,792	229,209	28,941	94,413	19,983	18,356	18,361	2,737	182,790	46,419	150,197
FY 2011/2012	22,047	12,652	6,203	455	36,428	9,974	8,226	661	89,705	186,352	28,230	108,501	22,655	17,989	16,003	3,235	196,612	-10,260	140,238
FY 2012/2013	21,149	12,008	5,000	245	36,497	5,388	12,495	0	89,075	181,856	27,380	111,748	23,916	17,634	14,422	3,057	198,157	-16,300	134,247
FY 2013/2014	19,768	11,665	4,567	248	36,824	4,713	13,016	778	89,048	180,626	29,626	118,849	20,566	17,608	14,897	3,428	204,974	-24,347	130,900
FY 2014/2015	18,750	11,536	4,705	514	38,259	9,435	10,876	0	88,221	182,295	30,022	104,317	17,502	17,763	16,098	3,651	189,353	-7,058	133,908
FY 2015/2016	18,533	11,728	4,650	80	33,193	9,236	13,222	0	90,536	181,177	28,191	101,301	16,883	17,946	16,976	3,515	184,812	-3,635	129,518
FY 2016/2017	18,165	11,635	5,024	1,940	33,418	11,575	13,924	13,152	98,180	207,012	28,284	98,960	16,161	17,931	18,398	2,991	182,726	24,287	140,616
FY 2017/2018	17,215	11,107	5,059	2,186	31,826	4,494	13,212	35,875	93,848	214,821	30,088	93,904	16,776	17,813	17,439	2,389	178,409	36,412	128,093
Statistics for the Peace Agreement Period, 2000 through 2018																			
Total	406,116	240,820	117,577	24,003	583,810	168,997	113,143	195,308	1,838,137	3,687,911	418,208	2,191,469	503,340	345,250	367,518	60,713	3,886,498	-198,587	2,605,980
Total (%)	11%	7%	3%	1%	16%	10%	3%	5%	50%	100%	11%	56%	13%	9%	9%	2%	100%	NA	NA
Average	21,375	12,675	6,188	1,263	30,727	8,895	5,955	10,279	96,744	194,101	22,011	115,340	26,492	18,171	19,343	3,195	204,553	-10,452	137,157
Maximum	26,375	14,036	8,290	5,981	38,259	20,051	13,924	40,087	108,442	229,209	30,116	137,345	43,465	18,754	25,148	4,886	228,161	46,419	150,197
Minimum	17,215	11,107	4,567	80	24,011	1,806	185	0	88,221	180,615	523	93,904	16,161	17,608	14,422	2,121	178,409	-47,546	128,093

*Recharge terms that are the results of calibrated surface water models or estimated via other analytical methods.

**Not Agicultural

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

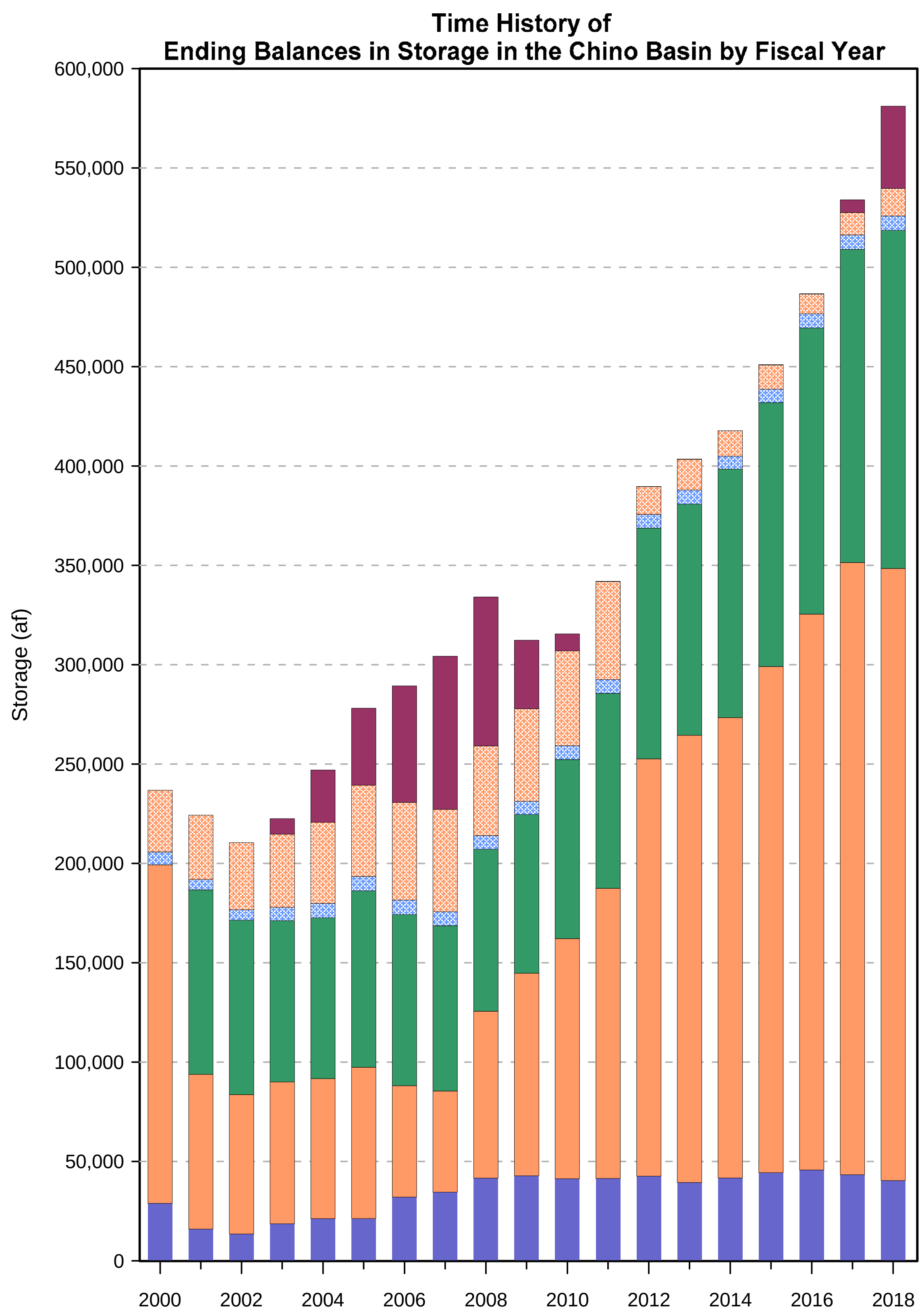
Author: SO
Date: 5/24/2019

Prepared for:
2018 State of the Basin Report
Hydrologic Conditions

CHINO BASIN WATERMASTER
Partners in Basin Management

Water Budget for Chino Basin for the Period July 1, 1999 through June 30, 2018

Exhibit 2-6



The Overlying Non-Agriculture Pool and Appropriative Pool Parties individually engage in conjunctive-use activities by storing unpumped groundwater pumping rights, and subsequently recovering their stored water as their individual needs arise. The water stored by the Overlying Non-Agricultural Parties is classified as Carryover Water (unpumped rights to the Safe Yield) and local storage (stored water other than carryover water). The water stored by the Appropriative Pool Parties includes carryover water, excess Carryover Water, and local supplemental water. Excess carryover water is unpumped carryover water. Local supplemental water is imported water and recycled water stored by a Party. Managed storage collectively refers to all water stored by the Parties. The conjunctive-use activities of the Parties have caused managed storage to increase since 2000. The chart to the left and the table below show the time history of water held in managed storage at the end of each fiscal year from July 1999 through June 2018. The Parties, in aggregate, have continued to under-pump their pumping rights, causing managed storage to increase from about 237,000 af in July 2000 to about 540,000 af in July of 2018.

Metropolitan Water District's Dry-Year Yield Program (DYYP) is the only active Storage and Recovery program in the Basin. In the DYYP, Metropolitan can store up to 100,000 af of imported water for subsequent recovery when called upon by Metropolitan. By the end of fiscal 2018, Metropolitan had about 41,000 af in its DYYP account.

Fiscal Year	Appropriative Pool				Overlying Non-Agricultural Pool			Total Managed Storage by Parties	Dry Year Yield Program Storage[6]	Total Managed Storage
	Carryover[2]	Excess Carryover (ECO)[3]	Local Supplemental Storage[4]	Subtotal	Carryover[2]	Local Storage[5]	Subtotal			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) = (7) + (4)	(9)	(10) = (9) + (8)
FY 1999/2000	28,911	170,342		199,253	6,541	31,031	37,572	236,825	0	236,825
FY 2000/2001	15,940	77,907	92,813	186,660	5,301	32,330	37,631	224,291	0	224,291
FY 2001/2002	13,521	70,103	87,801	171,425	5,285	33,727	39,012	210,437	0	210,437
FY 2002/2003	18,656	71,329	81,180	171,165	6,743	36,850	43,593	214,758	7,738	222,496
FY 2003/2004	21,204	70,503	80,963	172,670	7,177	40,881	48,058	220,728	26,300	247,028
FY 2004/2005	21,289	76,080	88,849	186,218	7,227	45,888	53,115	239,333	38,754	278,087
FY 2005/2006	32,062	56,062	86,170	174,294	7,227	49,178	56,405	230,699	58,653	289,352
FY 2006/2007	34,552	50,895	83,184	168,631	7,084	51,476	58,560	227,191	77,116	304,307
FY 2007/2008	41,626	83,962	81,520	207,108	6,819	45,248	52,067	259,175	74,877	334,052
FY 2008/2009	42,795	101,908	79,890	224,593	6,672	46,600	53,272	277,865	34,494	312,359
FY 2009/2010	41,263	120,897	90,133	252,293	6,934	47,732	54,666	306,959	8,543	315,502
FY 2010/2011	41,412	146,074	98,080	285,566	6,959	49,343	56,302	341,868	0	341,868
FY 2011/2012	42,614	209,981	116,138	368,733	6,914	13,993	20,907	389,640	0	389,640
FY 2012/2013	39,413	225,068	116,378	380,859	7,073	15,473	22,546	403,405	0	403,405
FY 2013/2014	41,708	231,679	125,052	398,439	6,478	12,812	19,290	417,729	0	417,729
FY 2014/2015	44,437	254,643	132,791	431,871	6,823	12,225	19,048	450,919	0	450,919
FY 2015/2016	45,683	279,757	144,012	469,452	7,195	9,949	17,144	486,596	0	486,596
FY 2016/2017	43,314	308,100	157,628	509,043	7,226	11,343	18,569	527,612	6,315	533,927
FY 2017/2018	40,390	308,056	170,168	518,614	7,198	13,894	21,092	539,706	41,380	581,086

1. Account balances are from Watermaster Assessment Packages and do not account for the desalter replenishment obligation or the change in Safe Yield.
2. The un-produced water in any year that may accrue to a member of the Non-Agricultural Pool or the Appropriative Pool and that is produced first each subsequent Fiscal Year or stored as Excess Carryover
3. Carryover Water which in aggregate quantities exceeds a party's share of Safe Yield in the case of the Non-Agricultural Pool, or the assigned share of Operating Safe Yield in the case of the Appropriative Pool, in any year.
4. Water imported to Chino Basin from outside the Chino Basin Watershed and recycled water.
5. Water held in a storage account pursuant to a Local Storage Agreement between a party to the Judgement and Watermaster. "Local Storage Agreement" means a Groundwater Storage Agreement for Local Storage.
6. Ending balance in the Dry Year Yield Program storage account.

Prepared by:

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Date: 05/24/2019
File: Exhibit_2-7_Managed Storage.grf

Overlying Non-Agriculture Pool
- Carryover
- Local Storage

Appropriative Pool
- Carryover
- Excess Carryover
- Local Supplemental Storage

- Dry Year Yield Storage

Prepared for:

2018 State of the Basin Report
Hydrologic Conditions

Time History of Managed Storage in the Chino Basin

Exhibit 2-7

The accurate accounting of groundwater production and artificial recharge is vital to the management of the Chino Basin. Several of the Program Elements of the OBMP have been developed to address these needs, primarily *OBMP PE 1 – Develop and Implement a Comprehensive Monitoring Program* and *PE 2 – Develop and Implement Comprehensive Recharge Program*. Estimates of production and recharge are essential inputs to inform re-determinations of the Safe Yield of the Chino Basin, which are scheduled to occur every ten years. The exhibits in this section characterize the physical state of the Chino Basin with respect to groundwater production and artificial recharge.

Groundwater Production. Since its establishment in 1978, Watermaster has collected information to estimate total groundwater production from the Chino Basin. The Watermaster Rules and Regulations require groundwater producers that produce in excess of 10 afy to install and maintain meters on their well(s). Well owners that pump less than 10 afy are considered "minimal producers" and are not required to meter or report to the Watermaster. When the OBMP was adopted, many of the Agricultural Pool wells did not have properly functioning meters installed, so Watermaster initiated a meter installation program for these wells as part of *PE 1*. Meters were installed at most agricultural wells by 2003. Watermaster staff visit and record production data from the meters at these wells on a quarterly basis. For the remaining unmetered Agricultural Pool wells, including minimal producer wells, Watermaster applies a "water duty" method to estimate their production on an annual basis. Members of the Appropriative Pool and Overlying Non-Agricultural Pool, and the Chino Desalter Authority (CDA) record their own meter data and submit them to Watermaster staff on a quarterly basis. All Chino Basin production data are checked for accuracy and stored in Watermaster's relational database. Watermaster summarizes and reports the groundwater production data based on FY (July 1 to June 30). Watermaster uses reported production to quantify and levy assessments pursuant to the Judgment. Exhibit 3-1 shows the locations of all active production wells, symbolized by Pool, in the Chino Basin during FY 2017/2018.

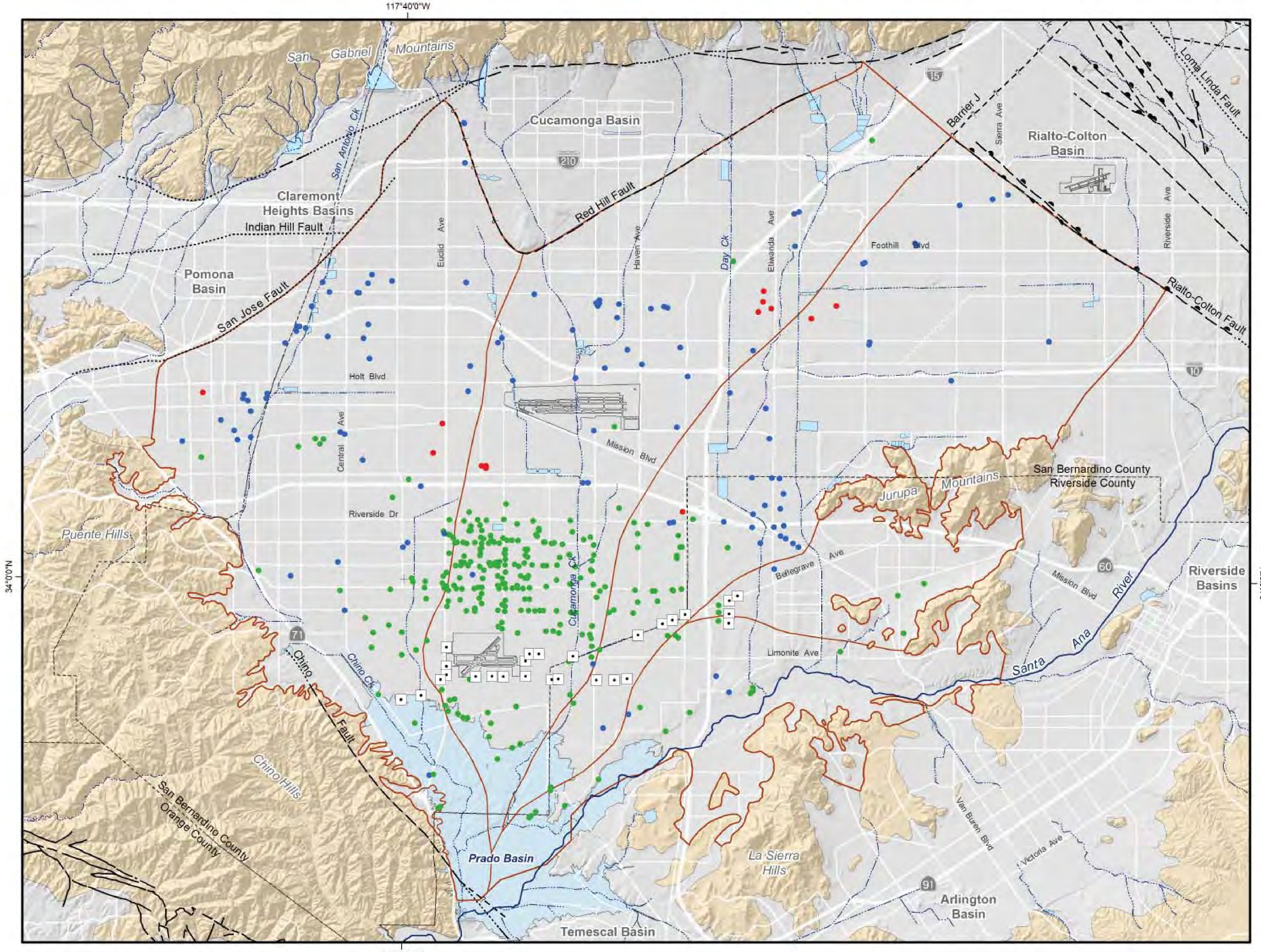
Prior to the widespread metering of Agricultural Pool production wells, Agricultural Pool production estimates in Watermaster's database are believed to have been consistently underreported. For the development of the 2013 Chino Basin Groundwater Model (WEI, 2015), agricultural production prior to FY 2001/2002 was estimated based on historical land use data and the applied water requirements for those land uses. Exhibit 3-2 shows two bar charts depicting the annual groundwater production by Pool for FY 1977/1978 through 2017/2018: Exhibit 3-2a shows the estimated production by Pool as recorded in Watermaster's database, and Exhibit 3-2b shows the same production values as 3-2a except Agricultural Pool production totals prior to FY 2001/2002 were replaced with the volumes estimated for the Safe Yield recalculation effort (WEI, 2015). Based on the dataset that includes model estimations (Exhibit 3-2b), total annual groundwater production in the Chino Basin has ranged from a maximum of about 191,000 af during FY 1980/1981 to a minimum of about 141,000 af during FY 2017/2018 and has averaged about 170,000 afy.

The remaining characterizations of production data in this report are based on Watermaster's records (Exhibit 3-2a). Total annual groundwater production has ranged from a maximum of about 189,000 af during FY 2008/2009 to a minimum of about 123,000 af during FY 1982/1983 and has averaged about 153,000 afy. Since FY 1977/1978, Agricultural Pool production has decreased nearly 70,000 af—declining in proportion to the decline in total production—from 55 percent of total production in FY 1977/1978 to 13 percent in FY 2017/2018. During the same period, Appropriative Pool production increased by about 56,000 af—from 39 percent of total production in FY 1977/1978 to 85 percent as of FY 2017/2018—inclusive of production at the CDA wells. Production in the Overlying Non-Agricultural Pool declined from about six percent of total production in FY 1977/1978 to two percent as of FY 2017/2018.

The spatial distribution of production has also shifted since 1978. Exhibit 3-3 is a series of maps that illustrate the location and magnitude of groundwater production at wells in the Chino Basin for FYs 1977/1978 (Establishment of Watermaster), 1999/2000 (commencement of the OBMP), and 2017/2018 (current conditions).

The decline in agricultural production in the southern half of the Chino Basin has gradually been replaced by production at the CDA wells since FY 2000/2001. The CDA wells and treatment facilities were developed as part of *OBMP PE 3 – Develop and Implement Water Supply Plan for the Impaired Areas of the Basin* and *PE 5 – Develop and Implement Regional Supplemental Water Program*. The desalters are meant to enhance water supply reliability and improve groundwater quality in the Chino Basin. Exhibit 3-4 is a map that displays the locations of current and future desalter wells and treatment facilities. This exhibit also summarizes the history of desalter production in the southern portion of the Chino Basin and its nexus to the OBMP goals.

Artificial Recharge. Watermaster also improves water supply reliability and water quality in the Chino Basin through the execution of *OBMP PE 2*. The comprehensive recharge program has been developed through a recharge master planning process that began in 1998 to increase the recharge of local and supplemental waters in the Chino Basin. Since the *Recharge Master Plan Phase II* report was developed in 2001 (WEI, 2001), Watermaster has partnered with the Inland Empire Utilities Agency, San Bernardino County Flood Control District, and Chino Basin Water Conservation District to construct and/or improve recharge facilities in the Chino Basin, in accordance with the Recharge Master Plan and the Four-Party Agreement (2003). The Peace Agreement required the preparation of a recharge master plan update (RMPU) no more than every five years; the most recent approved recharge master plan update is the *2013 Amendment to the 2010 Recharge Master Plan Update* (WEI, 2013). The 2018 RMPU is scheduled to be approved in October 2018. A primary goal of the recharge master plan is to increase the capacity for and recharge of stormwater, imported water, and recycled water in the Chino Basin. Exhibit 3-5 shows the network of recharge facilities in the Chino Basin, a time history of the magnitude and types of groundwater recharge since FY 2004/2005 (when the Chino Basin Recycled Water Groundwater Recharge Program was initiated), and a summary of the groundwater recharge programs and recharge master planning. Exhibit 3-6 summarizes the existing recharge capacity and the recharge capacity expected when the planned 2013 RMPU projects are online in 2020. Exhibit 3-7 is a tabulation of annual recharge by water type and recharge facility for FY 2000/2001 through FY 2017/2018.



Groundwater Production Wells by Pool

- Agricultural Pool (Pool 1 - 276 Wells)
- Overlying Non-Agricultural Pool (Pool 2 - 13 Wells)
- Appropriative Pool (Pool 3 - 143 Wells)
- Chino Basin Desalter Authority (25 Wells)

Other key map features are described in the legend of Exhibit 1-1.

During FY 2017/2018, 432 production wells were active in the Chino Basin. Total production was about 140,600 af and was divided as follows:

Agricultural Pool:
18,900 af, 13 percent of total production

Overlying Non-Agricultural Pool:
2,900 af, two percent of total production

Appropriative Pool:
88,700 af, 63 percent of total production

Chino Basin Desalters:
30,100 af, 22 percent of total production

Exhibits 3-2 and 3-3 characterize how production has changed over time, by producer type and spatially, across the Chino Basin.

Prepared by:

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Wildermuth Environmental, Inc.

Author: CS
Date: 5/23/2019
File: Exhibit_3-1_ActiveProd_Wells_.mxd

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

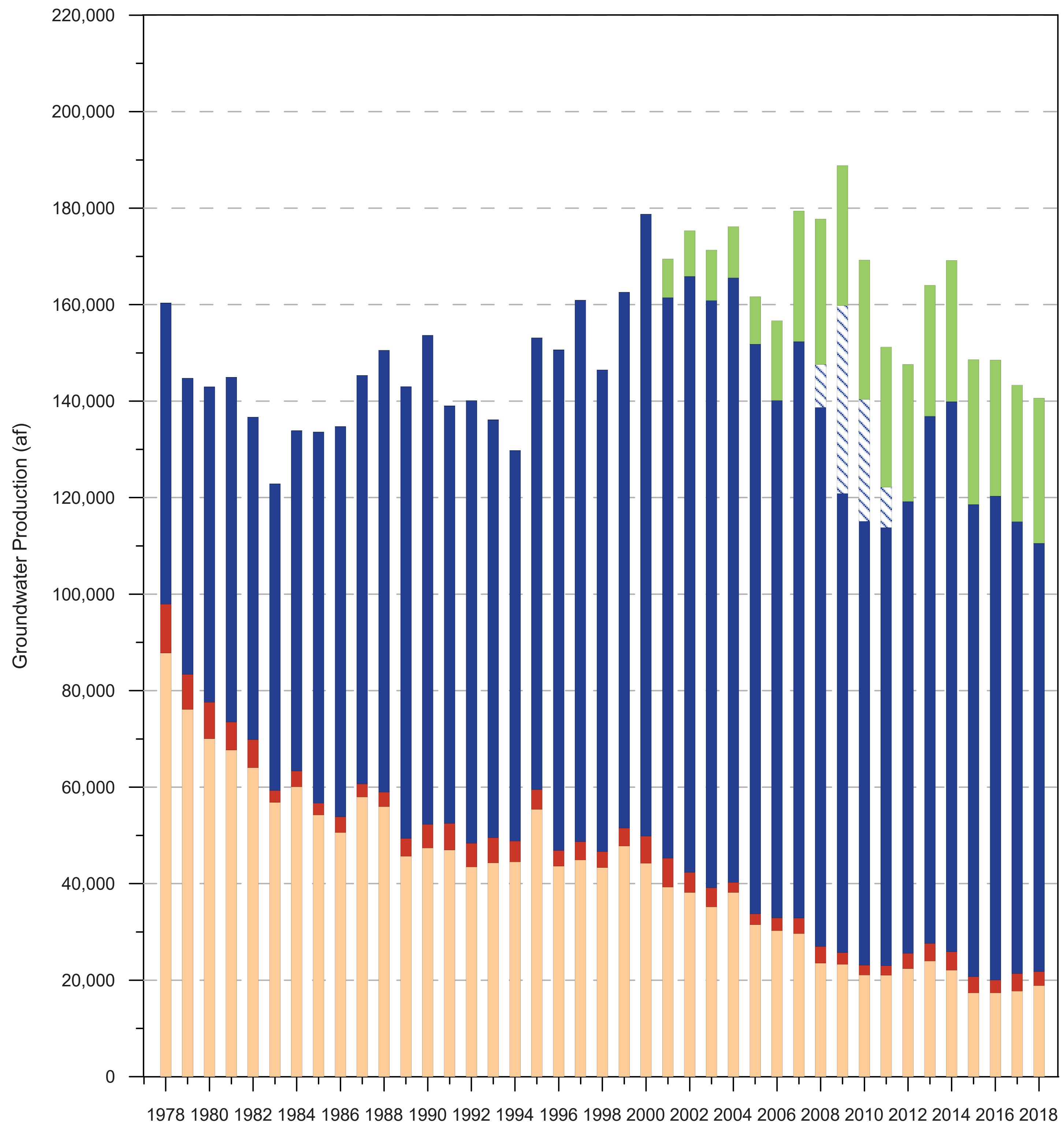
Prepared for:

2018 State of the Basin Report
Basin Production and Recharge

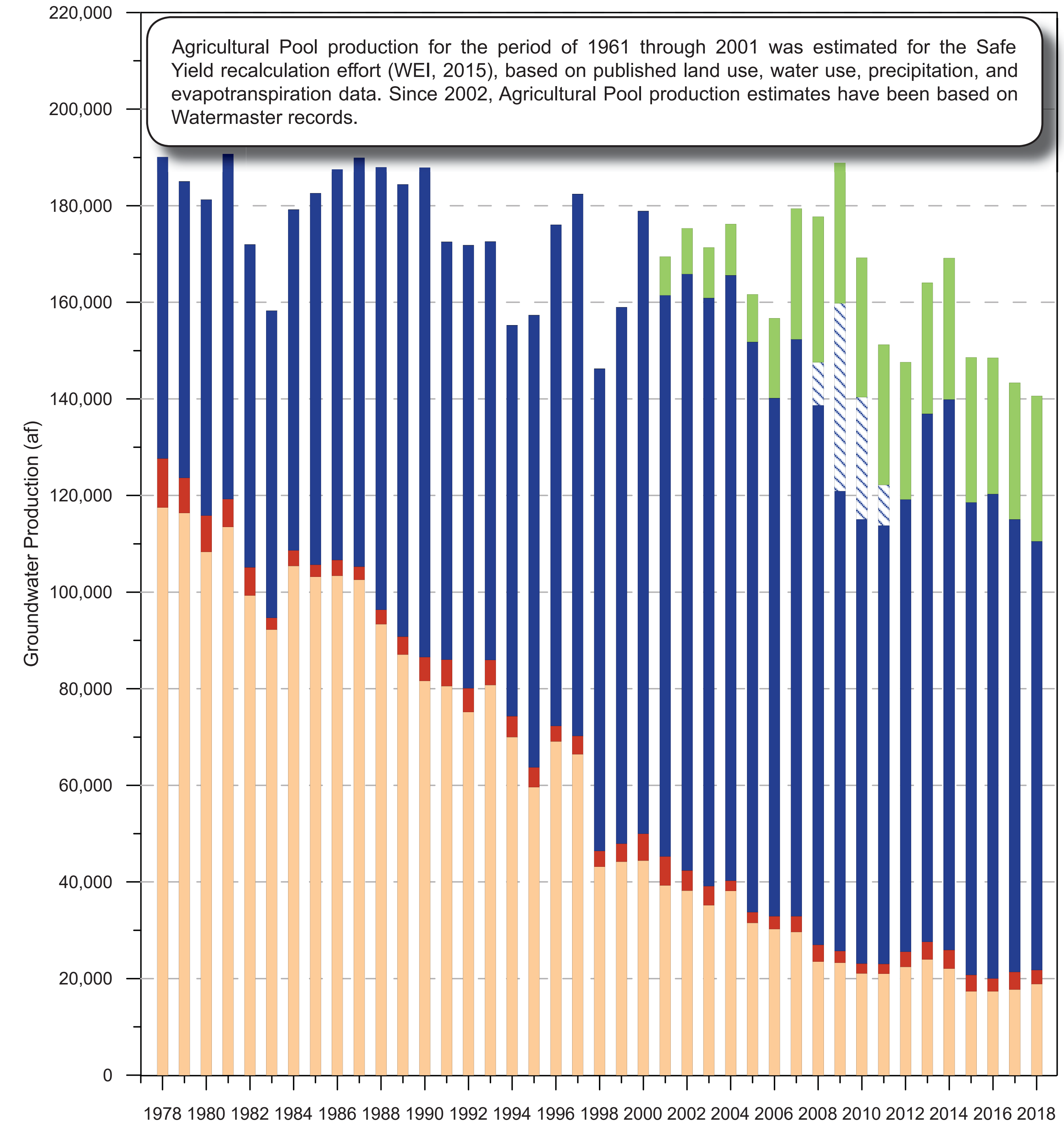
Active Groundwater Production Wells in the Chino Basin
Fiscal Year 2017/2018

Exhibit 3-1

3-2a
Groundwater Production by Pool in the Chino Basin with Agricultural Pool Production Amounts from Watermaster Database by Fiscal Year



3-2b
Groundwater Production by Pool in the Chino Basin with Agricultural Pool Production Amounts from the Chino Basin Model Prior to 2002 by Fiscal Year



Agricultural Pool
Overlying Non-Agricultural Pool
Appropriative Pool
Appropriative Pool - MWDSC Dry Year Yield Program
Chino Basin Desalter Authority

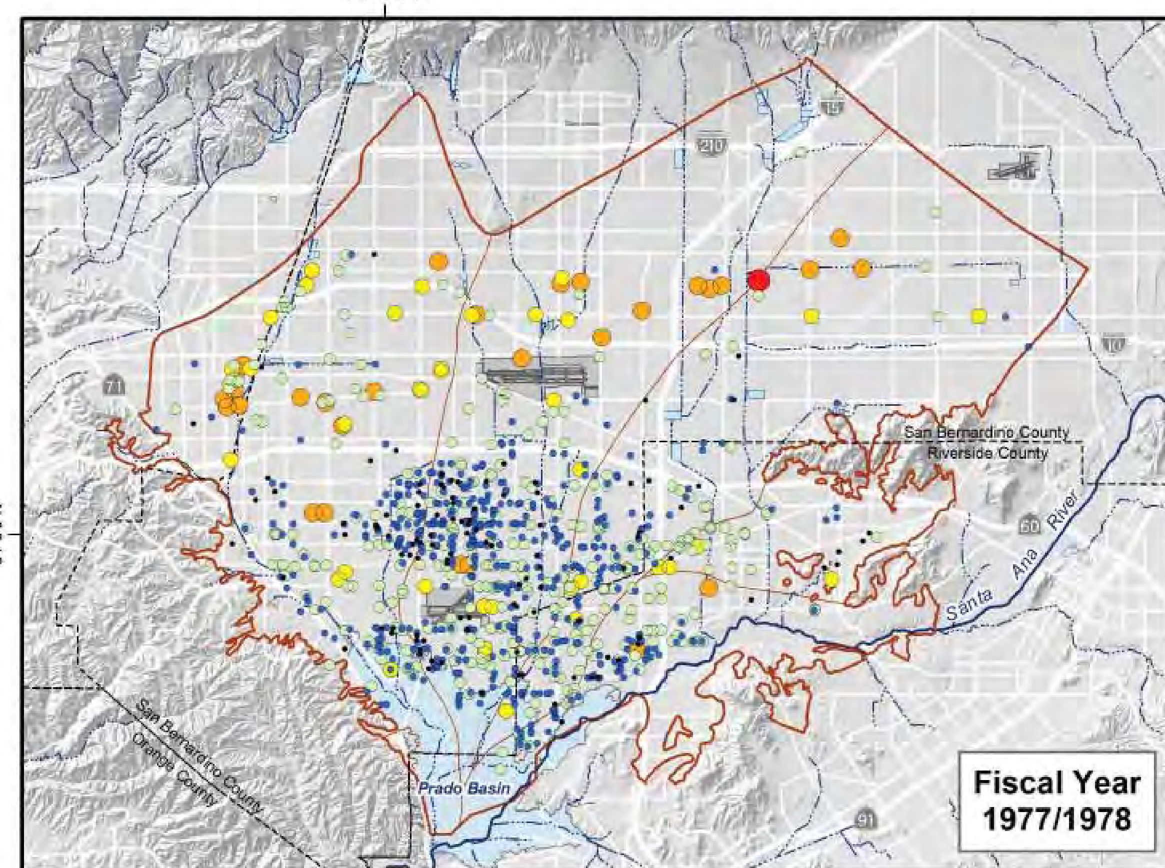
Prepared by:
WEI
Wildermuth Environmental, Inc

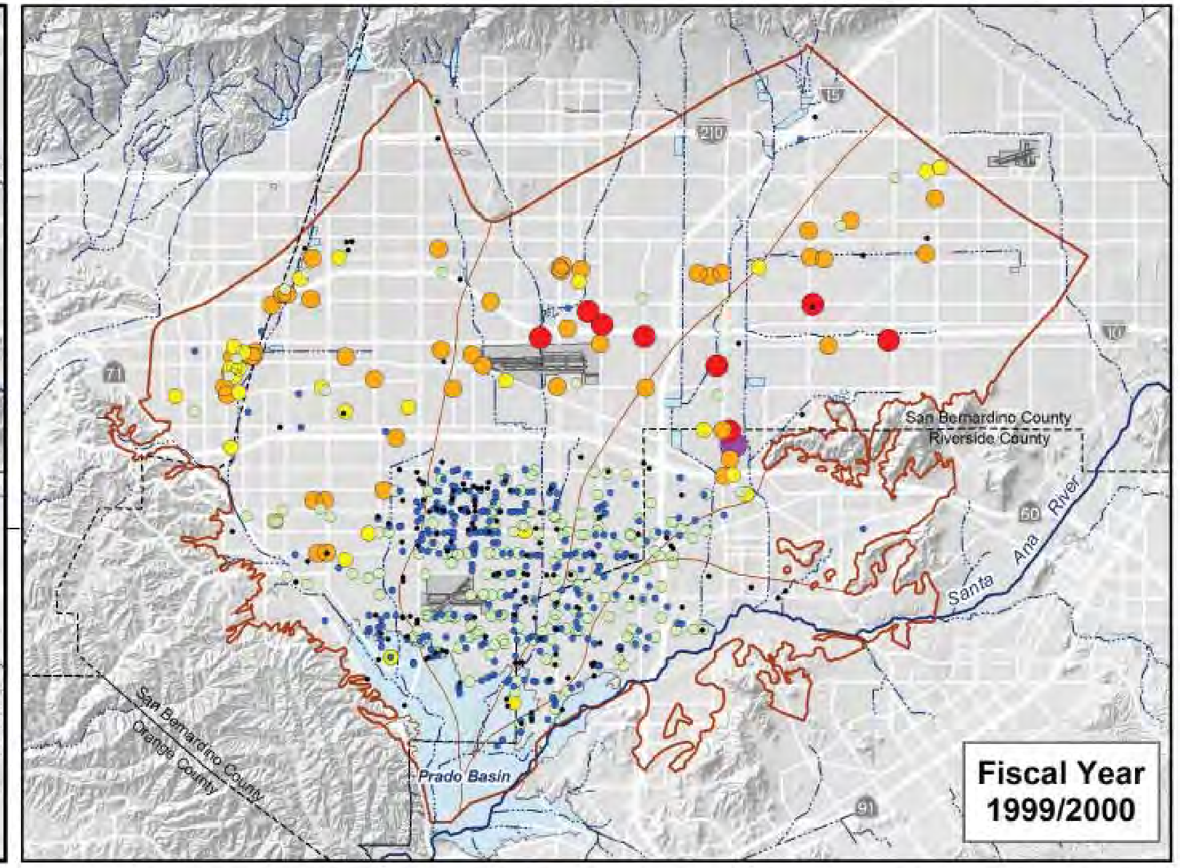
Author: CS
Date: 05/23/2019
File: Exhibit_3-2

Prepared for:
2018 State of the Basin
Basin Production and Recharge

Distribution of Groundwater Production
Fiscal Year 1978 to 2018

Exhibit 3-2

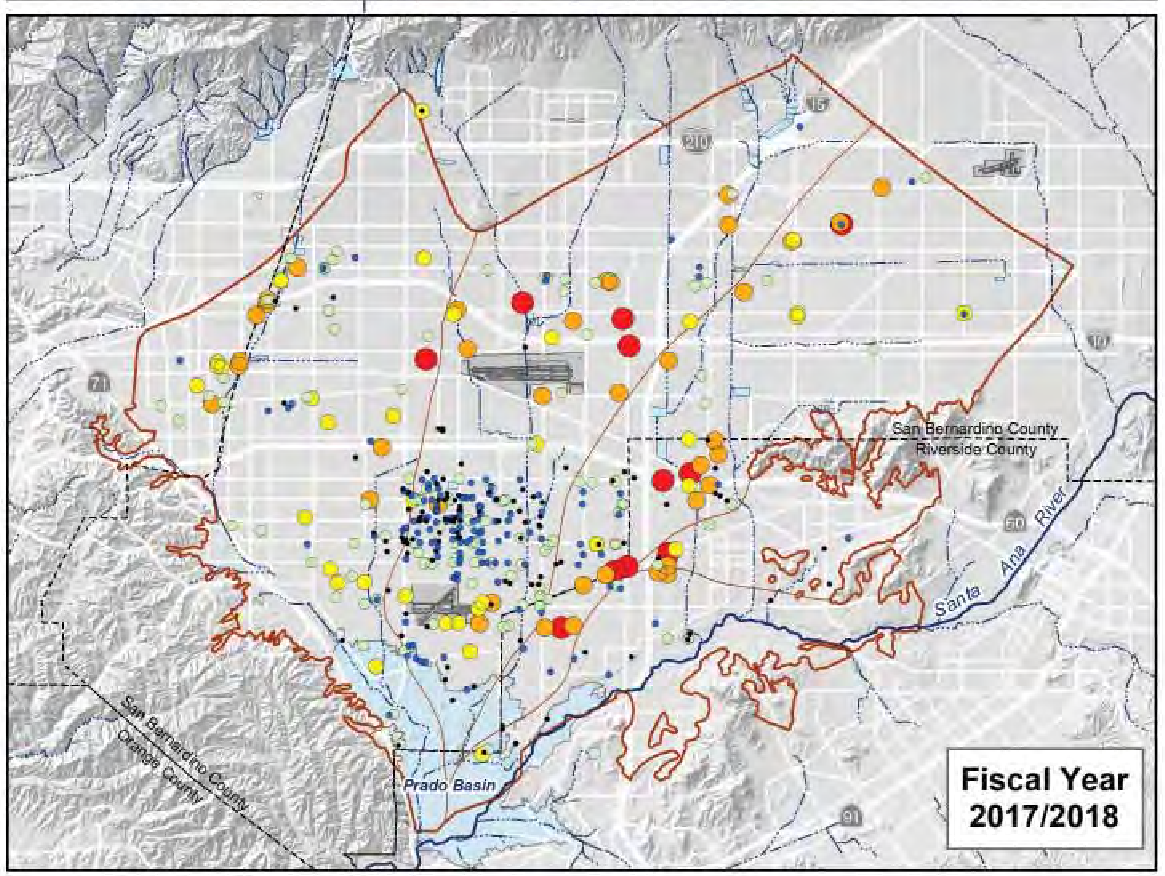




Groundwater Production (af)

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

Other key map features are described in the legend of Exhibit 1-1.



In FY 1977/1978, south of Highway 60, production was about 93,500 af, accounting for about 59 percent of total production. North of Highway 60, production was about 65,300 af, accounting for about 41 percent of total production. Agricultural groundwater production estimates were made for the Chino Basin Safe Yield recalculation (WEI, 2015), and these production estimates were significantly greater than reported by the Agricultural Pool Parties in the early post Judgment years. Exhibit 3-2b is similar to Exhibit 3-2a; however, the agricultural production estimates were revised, consistent with those used in the Safe Yield recalculation. For FY 1977/1978, the revised agricultural production was estimated to be about 30,000 af greater than reported and was estimated to have occurred primarily south of Highway 60. Reported and model-estimated agricultural production estimates became aligned in the early 2000s.

Between FY 1977/1978 and FY 1999/2000, groundwater production shifted north, with groundwater production south of Highway 60 declining from 59 to 31 percent of total production. North of Highway 60, production increased from 41 to 69 percent of total production. This shift in production was a result of land use transitions: south of Highway 60, irrigated agricultural land had been largely replaced by dairies, which have lower water use requirements; north of Highway 60, Appropriative Pool production increased concurrent with urbanization. In FY 1999/2000, after the CDA wells were constructed and came online south of Highway 60 (see Exhibit 3-4), the spatial distribution of pumping began to shift south of Highway 60 again.

The number of wells producing greater than 1,000 afy began to increase in FY 1977/1978. This was due to the increase in urbanization, which tends to concentrate production over fewer wells, compared to agricultural production. The construction and operation of the Chino Desalter wells, most of which produce more than 1,000 afy, also contributed to this increase. Since 2007, groundwater production has declined due to the economic downturn that occurred in 2008, drought conditions, state-mandated water conservation measures, and a trend towards greater water conservation.

Pool	FY 1977/1978 Production		FY 1999/2000 Production		FY 2017/2018 Production	
	af	percentage	af	percentage	af	percentage
Agricultural	87,800	55	44,200	25	18,900	13
Overlying Non-Agricultural	10,100	6	5,600	3	2,900	2
Appropriative	62,400	39	128,900	72	88,700	23
CDA	0	0	0	0	30,100	21
Total	**160,300**	**100**	**178,700**	**100**	**140,600**	**100**

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 5/23/2019
Document Name: Exhibit_3-3_Prod_FY78_00_18

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

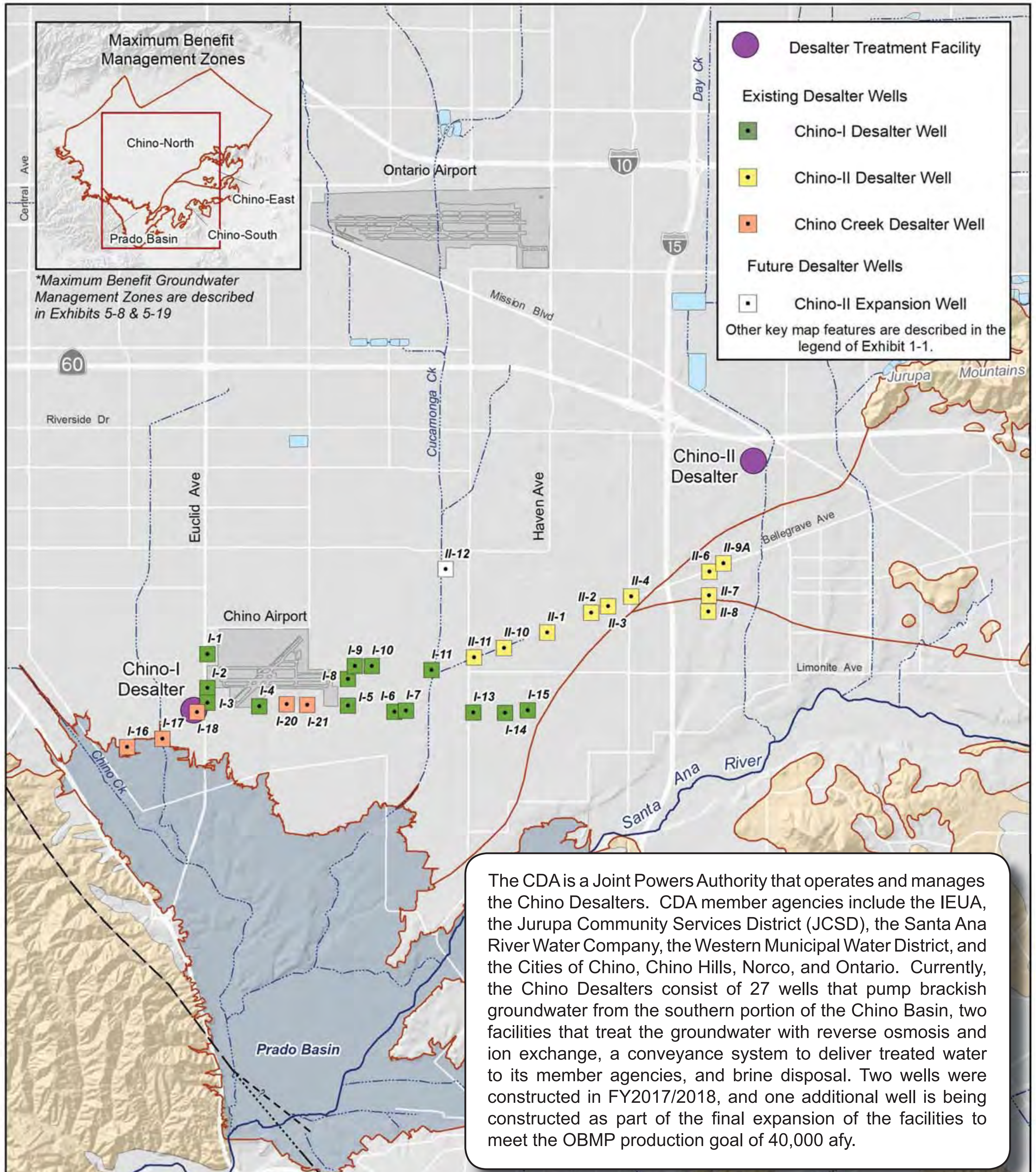
Prepared for:

2018 State of the Basin Report
Basin Production and Recharge

Chino Basin Watermaster

Groundwater Production by Well
Fiscal Year 1977/1978, 1999/2000, and 2017/2018

Exhibit 3-3



The CDA is a Joint Powers Authority that operates and manages the Chino Desalters. CDA member agencies include the IEUA, the Jurupa Community Services District (JCSD), the Santa Ana River Water Company, the Western Municipal Water District, and the Cities of Chino, Chino Hills, Norco, and Ontario. Currently, the Chino Desalters consist of 27 wells that pump brackish groundwater from the southern portion of the Chino Basin, two facilities that treat the groundwater with reverse osmosis and ion exchange, a conveyance system to deliver treated water to its member agencies, and brine disposal. Two wells were constructed in FY2017/2018, and one additional well is being constructed as part of the final expansion of the facilities to meet the OBMP production goal of 40,000 afy.

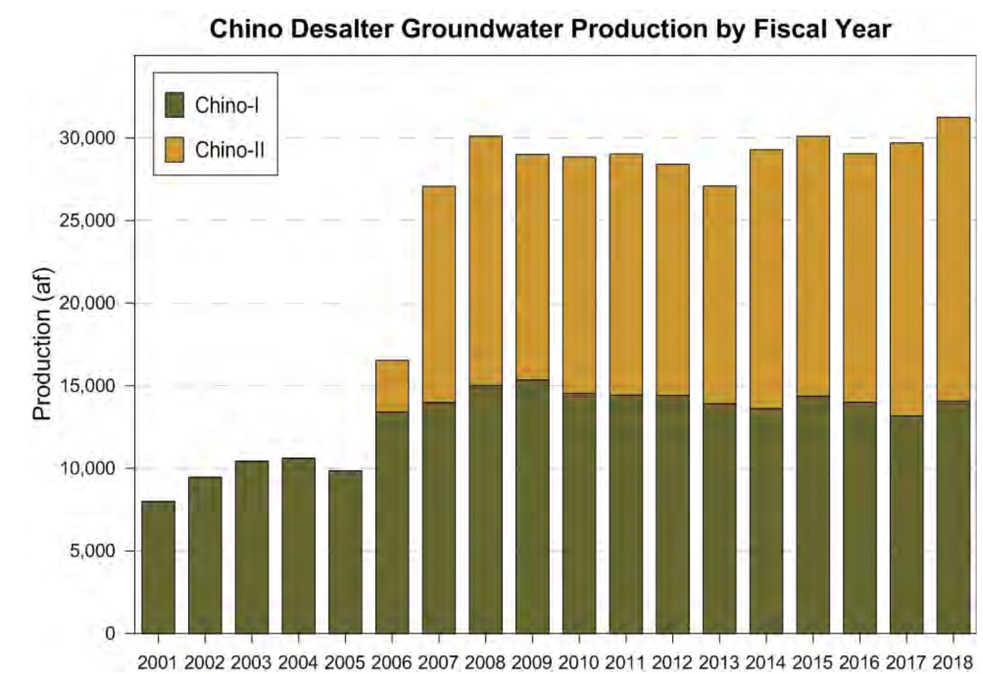
The need for the Chino Desalters was described in the OBMP Phase 1 Report. Throughout the 20th century, land uses in the southern portion of the Chino Basin were primarily agricultural. Over time, groundwater quality degraded in this area, and it is not suitable for municipal use unless it is treated to reduce TDS, nitrate, and other contaminant concentrations. The OBMP recognized that urban land uses would ultimately replace agriculture and that if municipal pumping did not replace agricultural pumping, groundwater levels would rise and discharge to the Santa Ana River. The potential consequences would be the loss of Safe Yield in the Chino Basin and the degradation of the quality of the Santa Ana River—the latter of which could impair downstream beneficial uses in Orange County. Mitigating the lost yield and the subsequent degradation of water quality would come with high costs to the Chino Basin parties.

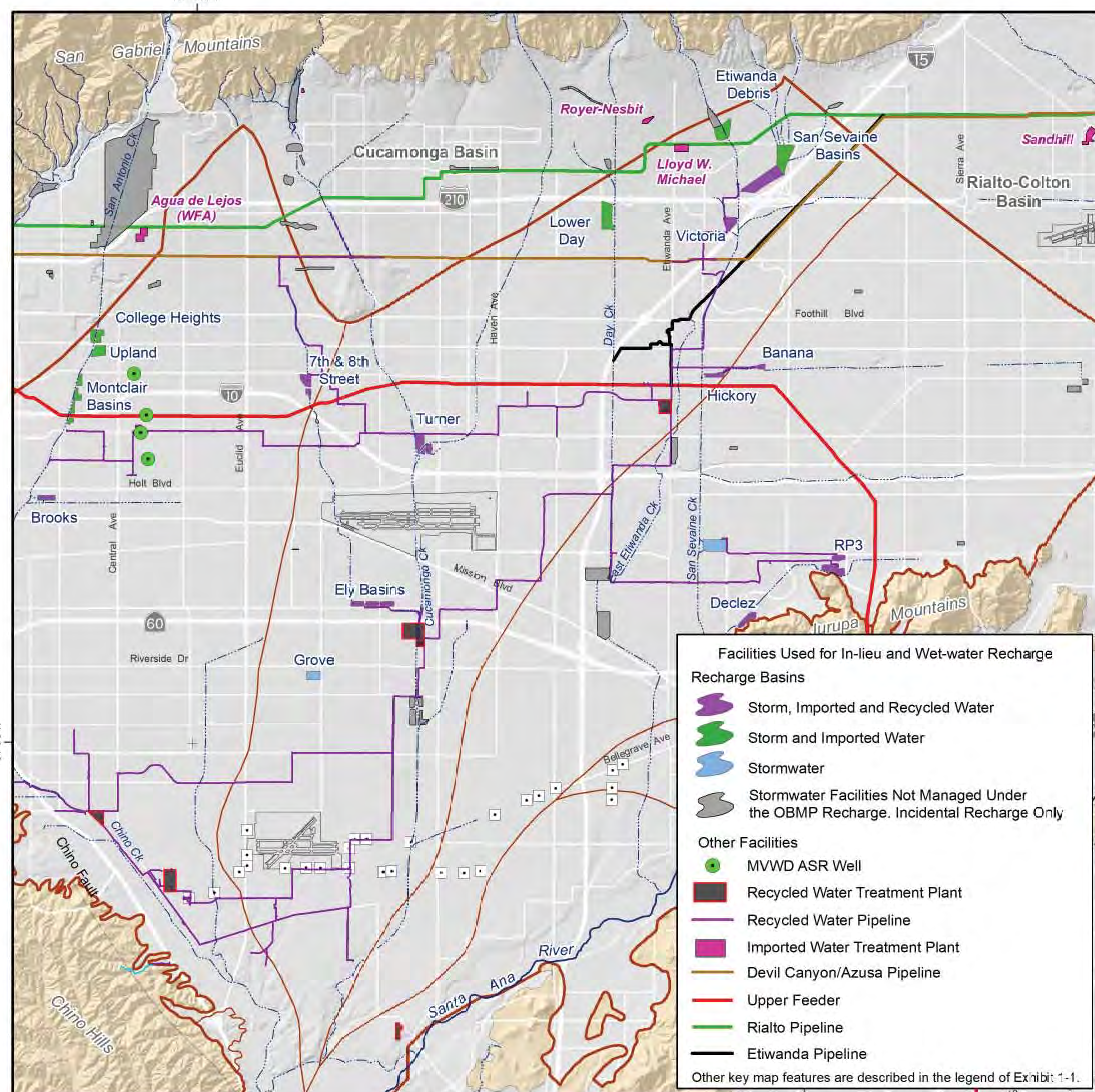
The Chino Desalters were designed to replace the expected decrease in agricultural production and accomplish the following objectives: meet emerging municipal demands in the Chino Basin, maintain or enhance Safe Yield, remove groundwater contaminants, and protect the beneficial uses of the Santa Ana River. Pursuant to the OBMP and Peace Agreement, Watermaster's goal for desalter production was set at 40,000 afy.

The Chino Desalters also became a fundamental component of the salt and nutrient management plan for the Chino Basin, which was written into the Water Quality Control Plan for the Santa Ana River Basin (Basin Plan). In 2004, the Regional Board adopted maximum-benefit based water quality objectives in the Chino Basin, enabling the implementation of large-scale recycled-water reuse projects in the Chino Basin for direct reuse an indirect potable reuse. Watermaster and the IEUA made nine "maximum-benefit commitments," ensuring that beneficial uses in the Chino Basin will not be impaired by TDS and nitrate and groundwater management in the Chino Basin will not contribute to the impairment of beneficial uses of the Santa Ana River. The operation of the Chino Desalters is necessary to attain "Hydraulic Control" in the southern portion of Chino Basin. Hydraulic Control is achieved when groundwater discharge from the Chino-North Management Zone to the Santa Ana River is eliminated or reduced to de minimis levels by pumping at the Chino Desalter wells. Hydraulic Control is necessary to maximize the Safe Yield and to prevent degraded groundwater from discharging from the Chino Basin to the Santa Ana River. Four of the nine maximum-benefit commitments are related to the Chino Desalters and Hydraulic Control.

The Chino-I Desalter began operating in 2000 with a design capacity of 8 mgd (about 9,000 afy). In 2005, the Chino-I Desalter was expanded to 14 mgd (about 16,000 afy). The Chino-II Desalter began operating in June 2006 at a capacity of 15 mgd (about 17,000 afy). In 2012, the CDA completed construction of the Chino Creek Well Field (CCWF). Production at some of the CCWF wells began in late FY 2013/2014, and production at the other CCWF wells began in early 2016, reaching the level of production required to achieve Hydraulic Control. Currently, the Chino-I and Chino-II Desalters produce about 30,000 afy of groundwater. The chart below shows annual groundwater production for the Chino Desalters. The final expansion of the Chino Desalters to achieve the OBMP production goal of 40,000 afy includes the construction of one well and the startup of two newly constructed wells in the south-central portion of the Chino Basin that will feed into the Chino-II Desalter. Two of these wells are anticipated to begin production at the end of FY 2018/2019, and the third well is anticipated to begin production in early FY 2019/2020.

Pursuant to the Peace II Agreement, Watermaster initiated additional controlled overdraft, referred to as "Re-operation." Re-operation is the controlled overdraft of 400,000 af through 2030, allocated specifically to meet the replenishment obligation of the Chino Desalters (WEI, 2009b). An investigation conducted to evaluate the Peace II Agreement and desalter expansion concluded that Re-operation was required to ensure the attainment of Hydraulic Control (WEI, 2007).





Increasing groundwater recharge is an integral part of the OBMP's goals to enhance water supplies and improve water quality, and it is essential for compliance with the maximum-commitments in the Basin Plan. The IEUA, Watermaster, the Chino Basin Water Conservation District, and the San Bernardino County Flood Control District are partners in the planning and implementation of groundwater recharge projects in the Chino Basin. Existing and planned recharge facilities are shown in the map to the left and include recharge basins and Aquifer Storage and Recovery (ASR) wells, not shown on the map are the municipal separate storm sewer system (MS4) facilities.

Recharge basins. Imported water, stormwater, dry-weather flow, and recycled water are recharged at 17 recharge basins. Watermaster has permits from the State Water Resources Control Board (SWRCB) to divert stormwater and dry-weather flow to the recharge basins for recharge, store it in the Chino Basin, and subsequently recover it for beneficial use. Since about 2004, water-level sensors have been installed at most of the recharge basins. These sensors are used to estimate recharge and measure infiltration rates. The estimated recharge is then used in SGMA reporting, in determining compliance with maximum benefit commitments and recharge permits, in Safe Yield calculations, and for scheduling maintenance.

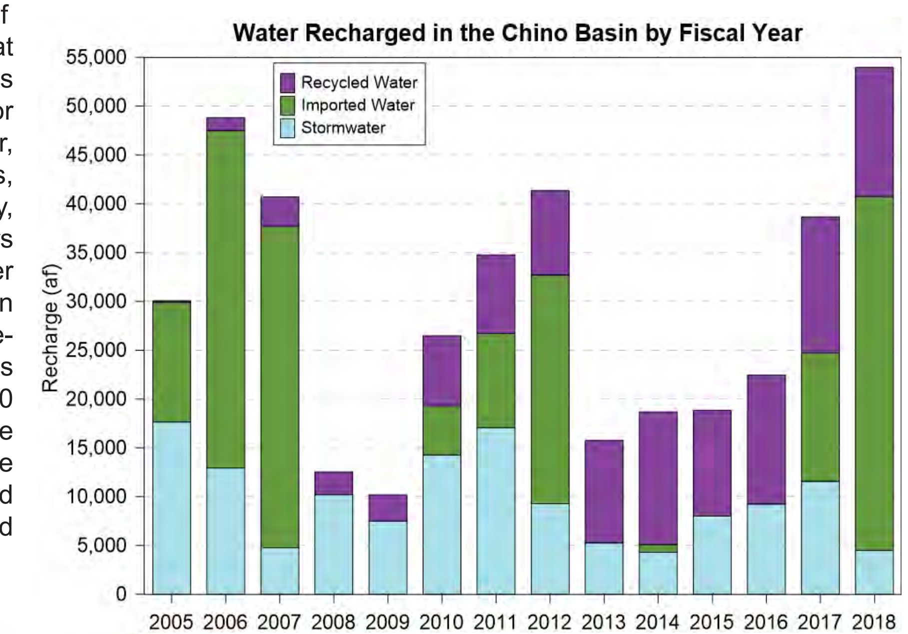
ASR wells. ASR wells are used to inject treated imported water into the Basin and to pump groundwater. The Monte Vista Water District (MVWD) owns and operates four ASR wells in the Chino Basin.

In-lieu recharge. In-lieu recharge can occur when a Chino Basin Party with pumping rights in the Chino Basin elects to use supplemental water directly in lieu of pumping some or all its rights in the Chino Basin for the specific purpose of recharging supplemental water.

MS4 facilities. The 2013 RMPU implementation included a process to create and update a database of all known runoff management projects implemented through the MS4 permits in the Chino Basin. This was done to create the data necessary to evaluate the significance of new stormwater recharge created by MS4 projects. As of FY 2016/2017, a total of 114 MS4 projects were identified as complying with the MS4 permit through infiltration features. These 114 projects have an aggregate drainage area of 1,733 acres.

Watermaster maintains a database of monthly recharge volumes by water type and recharge location. The chart below shows annual wet-water recharge at recharge basins and ASR wells by water type since the initiation of the recharge program in FY 2004/2005 (dry-weather flow is included with stormwater). Exhibit 3-6 lists the annual recharge by wet-water recharge facility and water type for FY 2000/2001 through FY 2017/2018. With OBMP implementation, recycled water has become a significant portion of annual recharge, totaling 13,200 af in FY 2017/2018 and averaging about 11,400 afy over the past five years. Recycled water recharge reduces the need for and dependence on imported water for replenishment.

The annual magnitude of imported water recharge at recharge basins fluctuates based on the need for replenishment water, conjunctive-use operations, imported water availability, and other factors. In years where imported water has been recharged in basins for conjunctive-use operations, it has ranged from about 12,000 to 35,000 afy. And in the other non-conjunctive-use influenced years, imported water recharge has varied from 0 to about 9,700 afy.



Groundwater Recharge in the Chino Basin

Exhibit 3-5

Basin Name	FY 2000/2001				FY 2001/2002				FY 2002/2003				FY 2003/2004				FY 2004/2005				FY 2005/2006				FY 2006/2007				FY 2007/2008				FY 2008/2009			
	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total
MVWD ASR Well	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
College Heights Basins	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	0	0	0	0	108	5,326	0	5,434	1	3,125	0	3,126	172	0	0	172	0	0	0	0
Upland Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	989	0	0	989	214	5,985	0	6,199	195	7,068	0	7,263	312	0	0	312	274	0	0	274
Montclair Basins	NM	6,530	0	6,530	NM	6,500	0	6,500	NM	6,499	0	6,499	NM	3,558	0	3,558	3,350	7,887	0	11,237	1,296	5,579	0	6,875	355	10,681	0	11,036	859	0	0	859	611	0	0	611
Brooks Street Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	1,776	0	0	1,776	524	2,032	0	2,556	205	1,604	0	1,809	475	0	0	475	434	0	1,605	2,039
7th and 8th Street Basins	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	620	0	0	620	1,271	0	0	1,271	640	0	0	640	959	0	1,054	2,013	1,139	0	352	1,491
Ely Basins	NM	0	500	500	NM	0	505	505	NM	0	185	185	NM	0	49	49	2,010	0	158	2,168	1,531	0	188	1,719	631	0	466	1,097	1,603	0	562	2,165	927	0	364	1,291
Grove Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	0	0	0	0	133	0	0	133	166	0	0	166	326	0	0	326	405	0	0	405
Turner Basins	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	1,428	310	0	1,738	2,575	346	0	2,921	406	313	1,237	1,956	1,542	0	0	1,542	1,200	0	171	1,371
Lower Day Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	2,798	107	0	2,905	624	2,810	0	3,434	78	2,266	0	2,344	303	0	0	303	168	0	0	168
Etiwanda Debris Basins	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	2,812	0	2,812	0	2,137	0	2,137	20	2,488	0	2,508	0	1,160	0	1,160	10	0	0	10	28	0	0	28
Victoria Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	0	0	0	0	330	0	0	330	260	0	0	260	427	0	0	427	250	0	0	250
San Sevaine	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	1,211	0	1,211	2,830	1,621	0	4,451	2,072	9,172	0	11,244	244	5,749	0	5,993	749	0	0	749	225	0	0	225
Jurupa	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0
Hickory Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	298	197	0	495	438	636	586	1,660	536	212	647	1,395	949	0	567	1,516	199	0	46	245
Banana Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	425	0	0	425	300	193	529	1,022	226	783	643	1,653	278	0	157	435	383	0	40	423
RP-3 Basins	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	1,105	0	0	1,105	767	0	0	767	802	0	0	802	511	0	0	511	613	0	106	719
Declez Basin	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	19	0	0	19	737	0	0	737	0	0	0	0	730	0	0	730	656	0	0	656
Totals:	NM	6,530	500	7,030	NM	6,500	505	7,005	NM	6,499	185	6,684	NM	***7,582***	49	7,631	17,648	***12,258***	158	30,065	12,940	***34,567***	1,303	48,810	4,745	***32,960***	2,993	40,698	10,205	0	2,340	12,545	7,512	0	2,684	10,196

Basin Name	FY 2009/2010				FY 2010/2011				FY 2011/2012				FY 2012/2013				FY 2013/2014				FY 2014/2015				FY 2015/2016				FY 2016/2017				FY 2017/2018			
	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total	SW	IW	RW	Total
MVWD ASR Well	0	0	0	0	0	186	0	186	0	889	0	889	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2,495	0	2,495
College Heights Basins	65	382	0	447	593	559	0	1,152	4	578	0	582	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	70	2,179	0	2,249	24	7,819	0	7,842
Upland Basin	532	0	0	532	1,308	899	0	2,207	222	2,118	0	2,340	119	0	0	119	95	0	0	95	325	0	0	325	425	0	0	425	583	2,575	0	3,158	155	1,547	0	1,702
Montclair Basins	937	4,592	0	5,529	1,762	3,672	0	5,434	703	11,893	0	12,596	204	0	0	204	416	0	0	416	411	0	0	411	441	0	0	441	1,046	6,149	0	7,195	292	11,253	0	11,545
Brooks Street Basin	666	0	1,695	2,361	628	0	1,373	2,001	363	561	836	1,760	115	0	1,505	1,620	112	0	1,308	1,420	198	0	1,011	1,209	182	0	1,215	1,397	673	188	385	1,246	81	197	1,268	1,546
7th and 8th Street Basins	1,744	6	1,067	2,817	1,583	543	1,871	3,997	1,047	572	641	2,260	751	0	2,261	3,012	441	5	1,423	1,869	1,751	0	48	1,799	921	0	1,470	2,391	955	18	2,271	3,244	353	1,130	1,037	2,520
Ely Basins	1,164	0	246	1,410	1,415	83	757	2,255	1,096	885	393	2,374	568	0	1,378	1,946	548	0	3,298	3,846	183	0	1,751	1,934	1,506	0	1,012	2,518	1,378	0	1,491	2,869	715	9	1,511	2,234
Grove Basin	351	0	0	351	431	0	0	431	400	0	0	400	177	0	0	177	258	0	0	258	481	0	0	481	471	0	0	471	363	0	0	363	204	0	0	204
Turner Basins	2,220	0	397	2,617	2,308	0	53	2,361	1,879	199	1,034	3,112	1,120	0	176	1,296	596	0	1,565	2,161	1,289	0	948	2,237	1,616	0	1,958	3,574	1,667	290	1,236	3,193	695	299	1,526	2,520
Lower Day Basin	540	3	0	543	703	894	0	1,597	158	1,439	0	1,597	106	0	0	106	114	28	0	142	341	0	0	341	281	0	0	281	449	292	0	741	138	3,033	0	3,172
Etiwanda Debris Basins	775	7	0	782	1,213	147	0	1,360	100	567	0	667	33	0	0	33	45	0	0	45	27	0	0	27	83	0	0	83	426	281	0	707	59	1,249	0	1,308
Victoria Basin	494	2	0	496	461	69	773	1,303	221	281	665	1,167	94	0	842	936	192	0	1,379	1,571	306	0	931	1,237	343	0	635	978	642	128	1,621	2,391	112	575	793	1,480
San Sevaine	993	0	0	993	1,049	1,707	396	3,152	436	1,228	513	2,177	147	0	575	722	162	0	274	436	330	0	1	331	585	0	0	585	785	540	0	1,325	305	3,388	0	3,693
Jurupa	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	NM	0	0	0	186	25	0	211	77	23	0	100
Hickory Basin	700	7	856	1,563	371	10	776	1,157	258	515	783	1,556	199	0	874	1,073	171	13	1,920	2,104	243	0	2,034	2,277	184	0	575	759	142	0	136	278	216	1,472	1,399	3,087
Banana Basin	416	0	898	1,314	149	0	267	416	247	0	1,915	2,162	114	0	670	784	87	24	1,071	1,182	197	0	1,148	1,345	365	0	2,106	2,471	166	0	500	666	193	485	2,131	2,809
RP-3 Basins	1,902	1	2,051	3,954	2,201	882	1,799	4,882	1,339	1,724	1,789	4,852	1,021	0	2,198	3,219	717	350	1,355	2,422	1,030	0	2,968	3,998	1,226	0	3,282	4,508	1,437	386	5,339	7,162	300	1,153	2,960	4,413
Declez Basin	774	0	0	774	877	0	0	877	798	0	65	863	530	0	0	530	341	374	0	715	895	0	0	895	607	0	969	1,576	607	99	945	1,651	574	131	588	1,294
Totals:	14,273	5,000	7,210	26,483	17,052	9,650	8,065	34,767	9,271	23,449	8,634	41,354	5,298	0	10,479	15,777	4,299	795	13,593	18,687	8,007	0	10,840	18,847	9,236	0	13,222	22,458	11,575	***13,150***	13,924	38,649	4,494	***36,258***	13,212	53,963

NM - Not measured SW - Surface Water IW - Imported Water (values including Dry Year Yield deliveries are shown ***bold and italicized***) RW - Recycled Water

Prepared by:

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Prepared for:

2018 State of the Basin Report
Basin Production and Recharge

CHINO BASIN WATERMASTER
Partners in Basin Management

Summary of Annual Wet Water Recharge Records in the Chino Basin

Exhibit 3-6

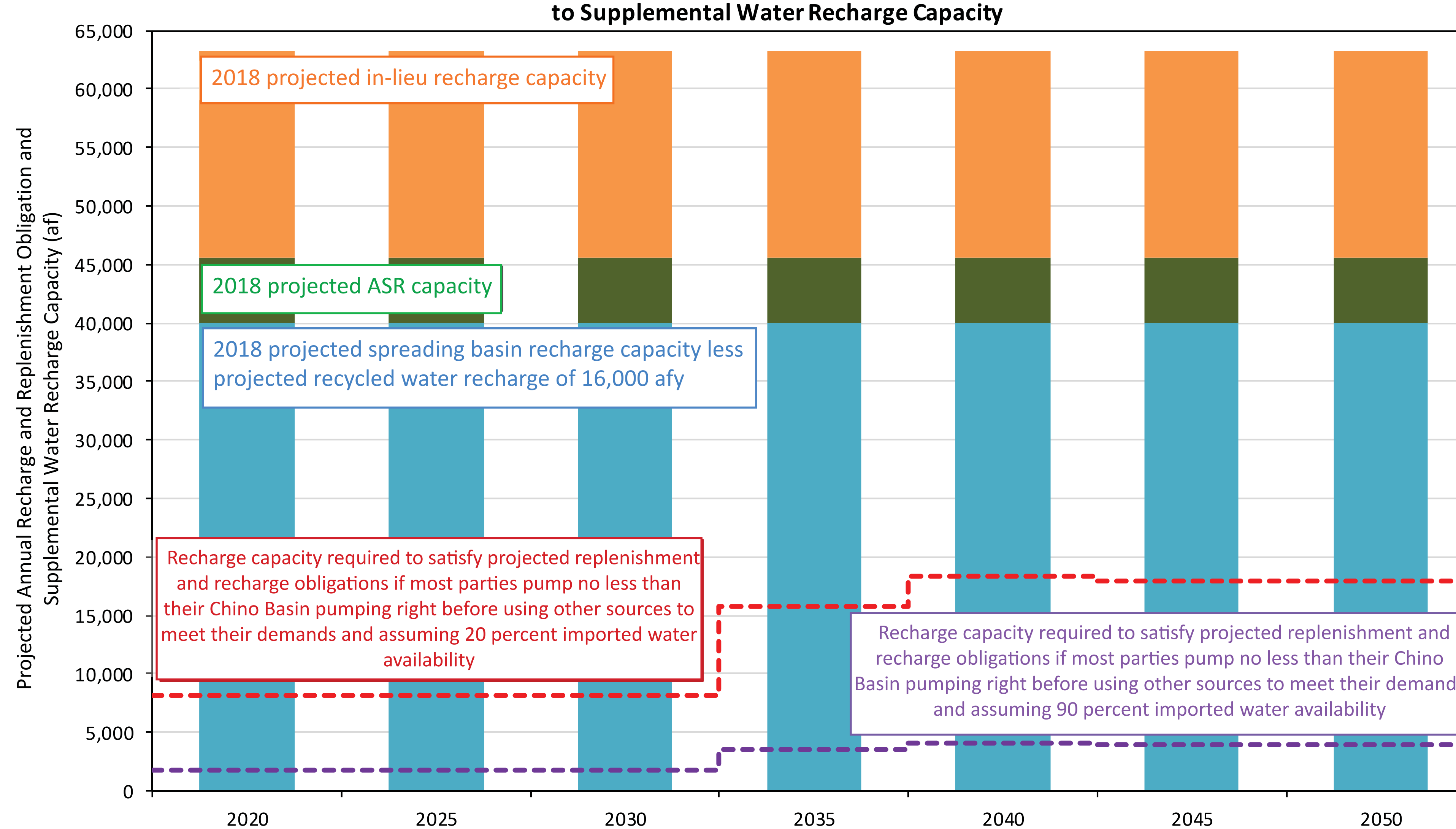
Estimated Recharge Capacities in the Chino Basin (afy)

Water Type	Recharge Type	2018 Conditions	2018 Conditions Plus Current Recommended 2013 RMPU Projects
Stormwater	Average Stormwater Recharge in Spreading Basins	10,150	14,950
	Average Expected Recharge of MS4 Projects	380	380
	Subtotal	10,530	15,330
Supplemental Water	Spreading Capacity for Supplemental Water	56,600	56,600
	ASR Injection Capacity	5,480	5,480
	In-Lieu Recharge Capacity	17,700	17,700
	Subtotal	79,780	79,780
	Total	90,310	95,110

The table above summarizes the existing recharge capacity and the recharge capacity expected when the planned 2013 RMPU projects are online in 2021. Stormwater recharge varies by year, based on hydrologic conditions, and averaged about 10,150 afy during the period FY 2004/2005 through FY 2017/2018 (period of available historical data). The net new stormwater recharge from MS4 projects constructed in the period FY2000/2001 through FY 2017/2018 is estimated to average about 380 afy. Supplemental water recharge in recharge basins occurs during non-storm periods. The recharge capacity available for supplemental water recharge varies from year to year based on the hydrologic conditions and is projected to average about 56,600 afy (WEI, 2018). The ASR and in-lieu recharge capacities are estimated to be about 5,480 afy and 17,700 afy, respectively (WEI, 2018).

The initial OBMP recharge master plan was developed in 2002; its current version is the 2013 Amendment to the 2010 Recharge Master Plan Update (2013 RMPU) (WEI, 2013). The projects selected for implementation in the 2013 RMPU involve improvements to existing recharge facilities and the construction of new facilities that, in aggregate, will increase the recharge of stormwater and dry-weather flow by 4,900 afy and increase recycled water recharge capacity by 7,100 afy. These projects are expected to be fully constructed and operational by 2021. Pursuant to the Peace II Agreement, Watermaster and the IEUA update their recharge master plan on a five-year frequency with the next plan scheduled to be completed in October 2018.

Comparison of Projected Annual Recharge and Replenishment Obligation to Supplemental Water Recharge Capacity

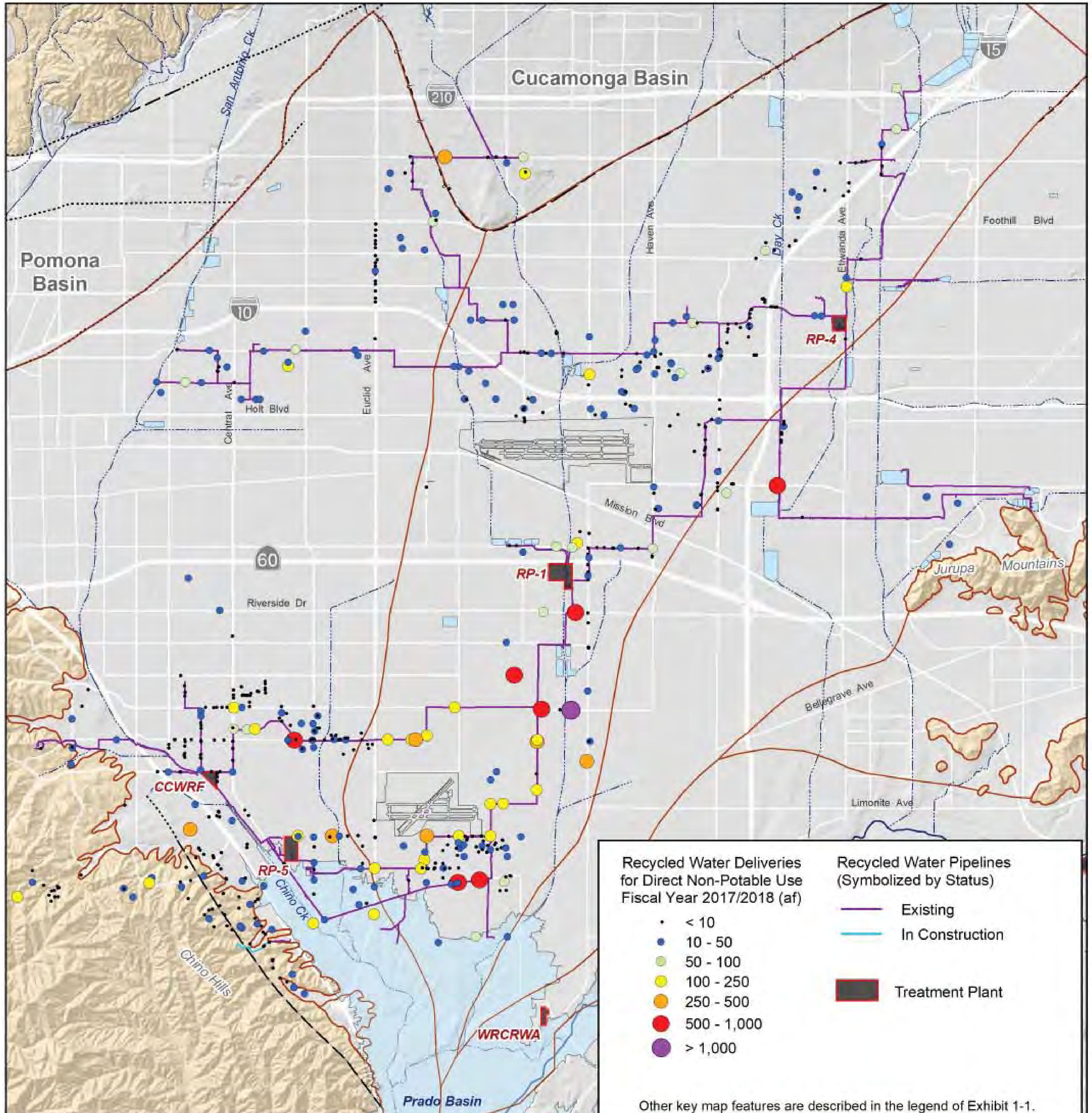


Future supplemental water recharge capacity requirements are estimated by assessing future supplemental water recharge projections in the context of the availability of supplemental water for recharge. Recycled water is assumed 100-percent reliable, and therefore the recharge capacity requirement to recharge recycled water is assumed equal to its projected supply. The imported water supply from MWDSC is assumed to be 20 percent reliable (available one out of five years) without full implementation of its 2015 Integrated Resources Plan (IRP) and 90 percent reliable (available nine out ten years) with it (WEI, 2018). Therefore, the recharge capacity required to meet recharge and replenishment obligations with imported water supplied by Metropolitan is five times the projected recharge and replenishment requirement without full implementation of the 2015 IRP and about 1.1 times the projected recharge and replenishment requirement with its full implementation. The chart above shows the recharge capacity available at recharge basins less that used for recycled water recharge, in-lieu recharge capacity, and ASR recharge capacity as a stacked bar chart—the total supplemental capacity being the sum of these recharge capacities. The chart also shows the time history of the supplemental water recharge capacity required to recharge imported water from Metropolitan without and with full implementation of Metropolitan's 2015 IRP.

As the chart above shows, whether or not Metropolitan fully implements its 2015 IRP, Watermaster and the IEUA are projected to have enough recharge capacity available to meet all of their recharge and replenishment obligations through 2050.

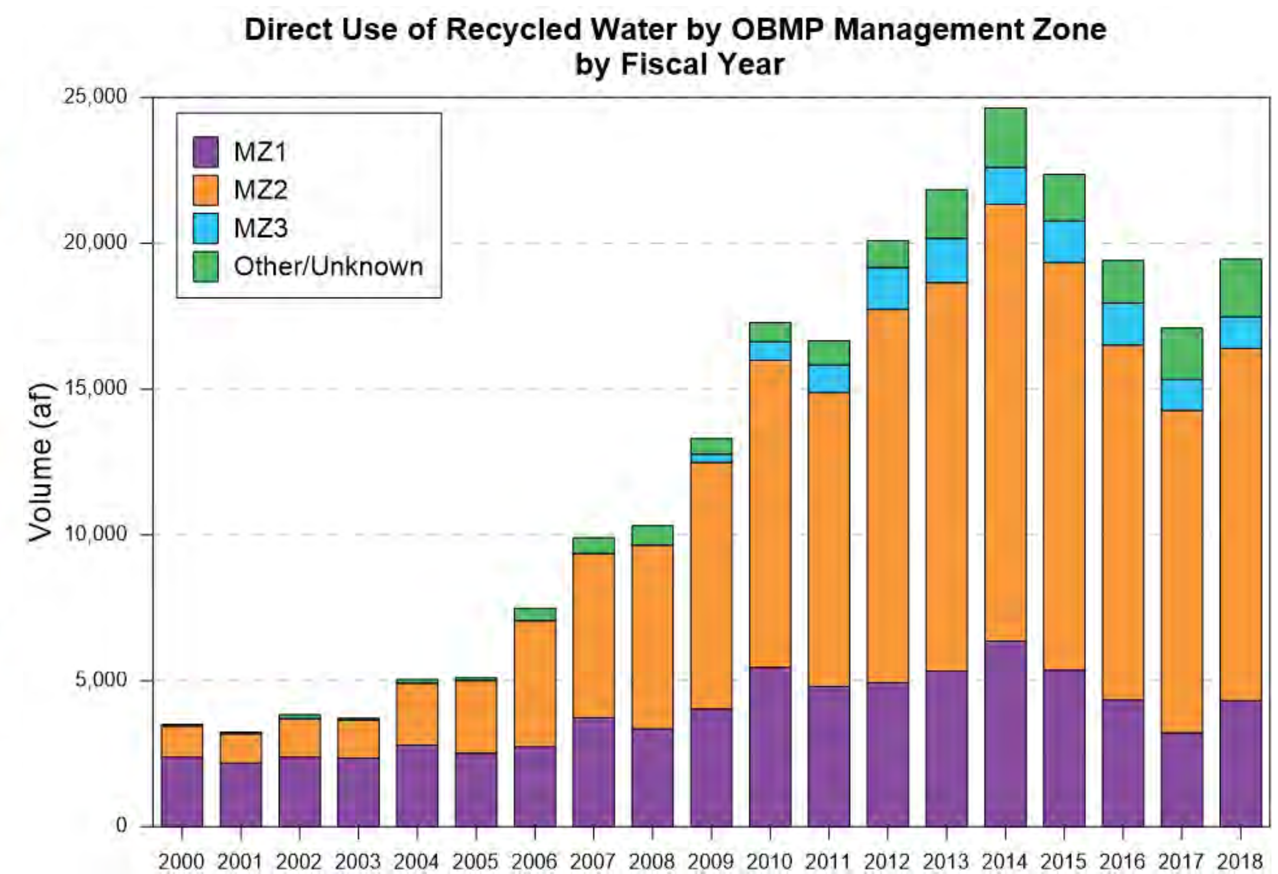
Recharge Capacity and Projected Recharge and Replenishment Obligation in the Chino Basin

Exhibit 3-7



Increasing recycled water reuse is an integral part of the OBMP's goal to enhance water supplies. The direct use of recycled water increases the availability of native and imported waters for higher-priority beneficial uses. The 2004 Basin Plan Amendment (Regional Board, 2004), which incorporated the maximum-benefit based salt and nutrient management program into the Basin Plan, is an innovative regulatory construct that enabled an aggressive expansion of recycled-water reuse in the Chino Basin. The IEUA owns and operates four treatment facilities: Regional Plant No. 1 (RP-1), Regional Plant No. 4 (RP-4), Regional Plant No. 5 (RP-5), and the Carbon Canyon Water Reclamation Facility (CCWRF). And, the IEUA has progressively built infrastructure to deliver recycled water to all of its member agencies throughout much of the Chino Basin.

This exhibit characterizes the direct use of recycled water in the Chino Basin from FY 1999/2000 to FY 2017/2018. Recycled water from the IEUA's facilities is reused directly for: irrigation of crops, animal pastures, freeway landscape, parks, schools, and golf courses; commercial laundry and car washes; outdoor cleaning and construction; toilet plumbing; and industrial processes. Prior to 1997, there was minimal reuse of recycled water. Recycled water reuse expanded starting in 1997 after the completion of the conveyance facilities from the CCWRF to the Cities of Chino and Chino Hills. The direct use of recycled water has increased significantly since OBMP implementation began from about 3,500 af in FY 1999/2000 to about 24,600 af in FY 2013/2014, declining to 19,400 af in FY 2017/2018. The decline in direct use of recycled water over the past four years results from reduced water use during the recent drought and state-mandated water conservation programs, both reducing the amount of recycled water available for reuse.



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: CS
Date: 20170215
File: Exhibit_14.mxd

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

Prepared for:

2018 State of the Basin Report
Basin Production and Recharge

Recycled Water Deliveries for Direct Use

Exhibit 3-8

The exhibits in this section show the physical state of the Chino Basin with respect to changes in groundwater levels since the Judgment and OBMP implementation. The groundwater-level data used to generate these exhibits were collected and compiled as part of Watermaster's groundwater-level monitoring program.

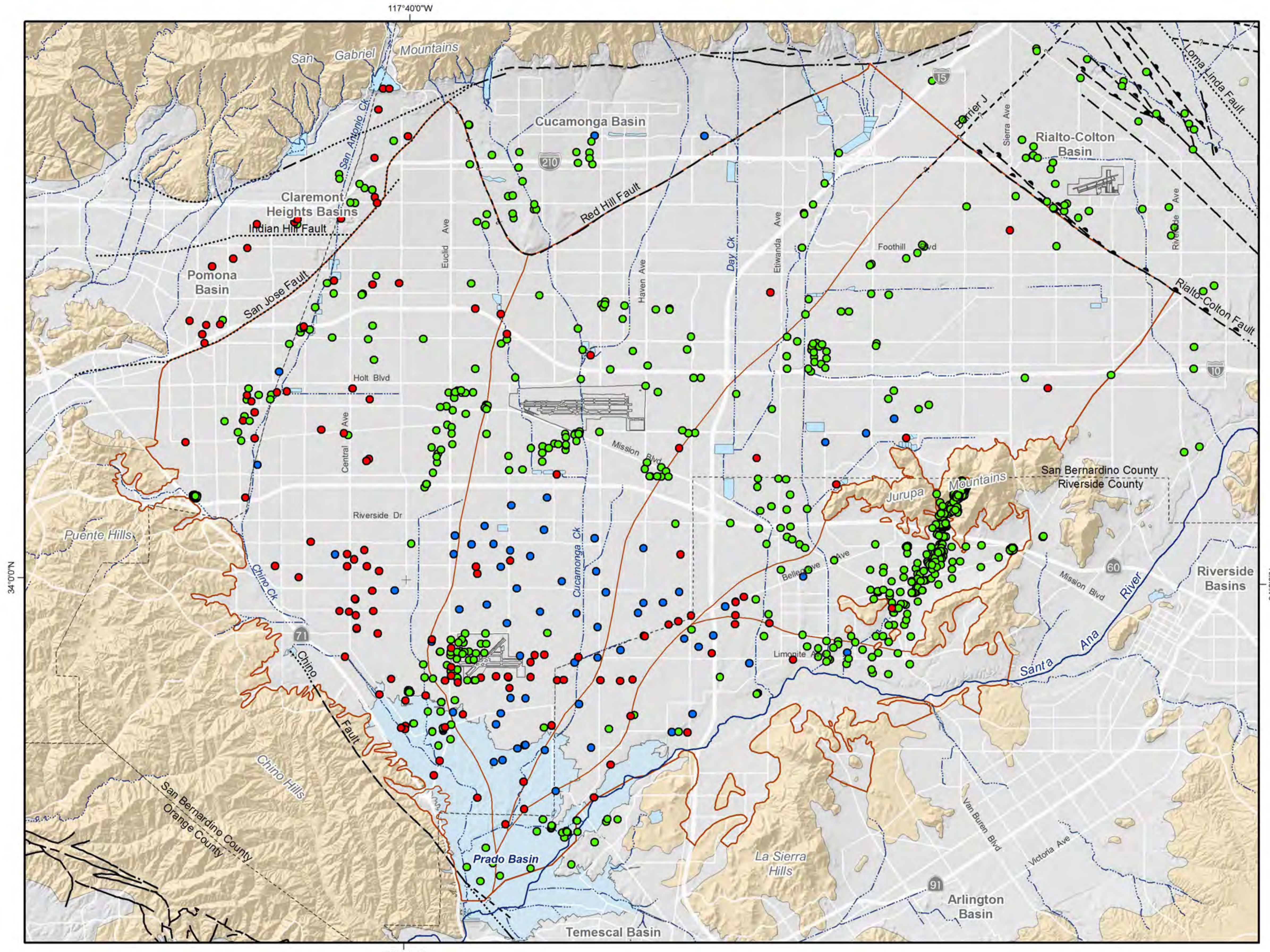
Prior to OBMP implementation, there was no formal groundwater-level monitoring program in the Chino Basin. Problems with historical groundwater-level monitoring included an inadequate areal distribution of wells that were monitored, short time histories, questionable data quality, and insufficient resources to develop and conduct a comprehensive program. The OBMP defined a new, comprehensive, basin-wide groundwater-level monitoring program, pursuant to *OBMP Program Element 1 – Develop and Implement a Comprehensive Monitoring Program*, to support the activities in other Program Elements, such as *PE 4 – Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1*. The monitoring program has been refined over time to increase efficiency and to satisfy the evolving needs of Watermaster and the IEUA, such as new regulatory requirements.

Currently, the groundwater-level monitoring program supports many Watermaster functions, including the periodic reassessment of Safe Yield, the monitoring and management of land subsidence, and the assessment of Hydraulic Control. The data are also used to update and recalibrate Watermaster's groundwater-flow model, to understand directions of groundwater flow, to estimate storage changes, to interpret groundwater-quality data, to identify areas of the basin where recharge and discharge are not in balance, and to monitor changes in groundwater levels in the Prado Basin where riparian vegetation is consumptively using shallow groundwater.

Exhibit 4-1 shows the locations and measurement frequencies of all wells currently in Watermaster's groundwater-level monitoring program. The groundwater-level data collected at these wells were used to create groundwater-elevation contour maps for the shallow aquifer system in the Chino Basin for spring 2000 (Exhibit 4-2), spring 2016 (Exhibit 4-3), and spring 2018 (Exhibit 4-4). These contour maps indicate the direction of groundwater flow, which is perpendicular to the contours from high to low elevations. The contour maps were subtracted from each other to show how groundwater levels have changed during OBMP implementation: Exhibit 4-5 shows the change from spring 2000 to spring 2018—the total 18-year period of OBMP implementation—and Exhibit 4-6 shows the change from spring 2016 to spring 2018—the two-year period since the last State of the Basin analysis. The groundwater-level changes are illustrative of changes in groundwater storage.

Exhibits 4-7 and 4-8 address the state of Hydraulic Control in the southern portion of Chino Basin in 2000 and 2018, respectively. Achieving "Hydraulic Control" is an important objective of Watermaster, the IEUA, and the Regional Water Quality Control Board (RWQCB). Hydraulic Control is achieved when groundwater discharge from the Chino-North groundwater management zone (GMZ) to Prado Basin is eliminated or reduced to *de minimis* levels. *De minimis* discharge is defined as less than 1,000 afy. The RWQCB made achieving Hydraulic Control a commitment for Watermaster and the IEUA in the Basin Plan (RWQCB, 2004) in exchange for relaxed groundwater-quality objectives in Chino-North GMZ. These objectives, called "maximum benefit" objectives, allow for the implementation of recycled-water reuse in the Chino Basin for both direct use and recharge while simultaneously assuring the protection of the beneficial uses of the Chino Basin and the Santa Ana River. Achieving Hydraulic Control also enhances the yield of the Chino Basin by controlling groundwater levels in its southern portion, which has the effect of reducing outflow as rising groundwater and increasing streambed recharge in the Santa Ana River. These exhibits include a brief interpretation of the state of Hydraulic Control. For an in-depth discussion of Hydraulic Control, see *Chino Basin Maximum Benefit Monitoring Program 2018 Annual Report* (WEI, 2019).

Exhibit 4-9 shows the location of selected wells across the Chino Basin that have long time-histories of water levels. The time-histories describe long-term trends in groundwater levels in the OBMP MZs. The wells were selected based on geographic location within the MZ, well-screen interval, and the length, density, and quality of the water-level records. Exhibits 4-10 through 4-14 are water-level time-series charts for these wells grouped by MZ for the period of 1978 to 2018. These exhibits compare the behavior of water levels to trends in precipitation, groundwater production, and recharge, which reveal cause-and-effect relationships.



Basin-Wide Groundwater-Level Monitoring Program
Wells symbolized by Measurement Frequency

- Monthly Measurement by CBWM Staff (69 wells)
- Measurement by Transducer - Every 15 Minutes (177 wells)
- Measurement by Owner at Various Frequencies (1,077 wells)

Other key map features are described in the legend of Exhibit 1-1.

To support OBMP implementation, Watermaster conducts a comprehensive groundwater-level monitoring program. In FY 2017/2018, about 1,300 wells comprised Watermaster's groundwater-level monitoring program. At about 1,050 of these wells, well owners measure water levels and provide data to Watermaster. These well owners include municipal water agencies, private water companies, the California Department of Toxic Substance Control (DTSC), the County of San Bernardino, and various private consulting firms. The remaining 250 wells are private or dedicated monitoring wells that are mostly located in the southern portion of the Basin. Watermaster staff measures water levels at these wells once a month or with pressure transducers that record water levels once every 15 minutes. These wells were preferentially selected to support Watermaster's monitoring programs for Hydraulic Control, Prado Basin habitat sustainability, land subsidence, and others. All groundwater-level data are collected, compiled, and checked by Watermaster staff, and uploaded to a centralized relational database that can be accessed online through HydroDaVE[SM].

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: SO
Date: 5/24/2019
File: Exhibit_4-1_WL with wells.mxd

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

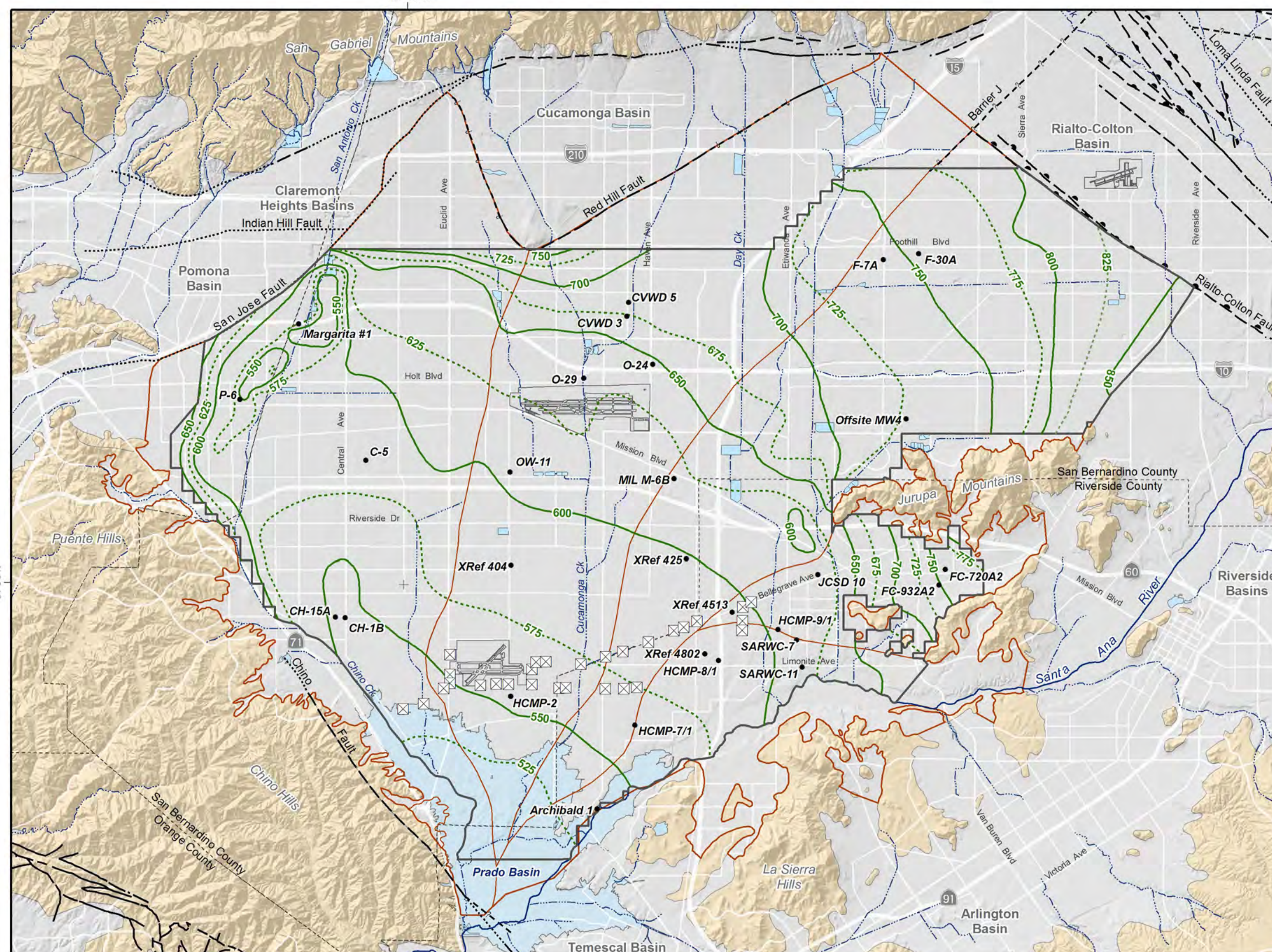
Prepared for:

2018 State of the Basin Report
Groundwater Levels

Groundwater-Level Monitoring Network

Well Location and Measurement Frequency During Fiscal Year 2017/2018

Exhibit 4-1



800 775 Groundwater-Elevation Contours (feet above mean sea-level)

Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)

Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

Future Location of Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2000—just prior to OBMP implementation. Two distinct aquifer systems exist in Chino Basin: a shallow unconfined to semi-confined aquifer system and a deeper confined aquifer system. The groundwater elevations shown on this map (and Exhibits 4-3, 4-4, 4-7, and 4-8) were drawn based on measured groundwater levels and represent the shallow aquifer system.

Groundwater flows from higher to lower elevations, with flow direction perpendicular to the contours. The groundwater-elevation contours on this map indicate that in 2000 groundwater was flowing in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There were notable pumping depressions in the groundwater-level surface that interrupted the general flow patterns in the northern portion of MZ1 (Montclair and Pomona areas) and directly west of the Jurupa Mountains (near the Jurupa Community Services District's [JCSD] main well field). Pumping at the desalter wells had not yet begun in the spring of 2000.

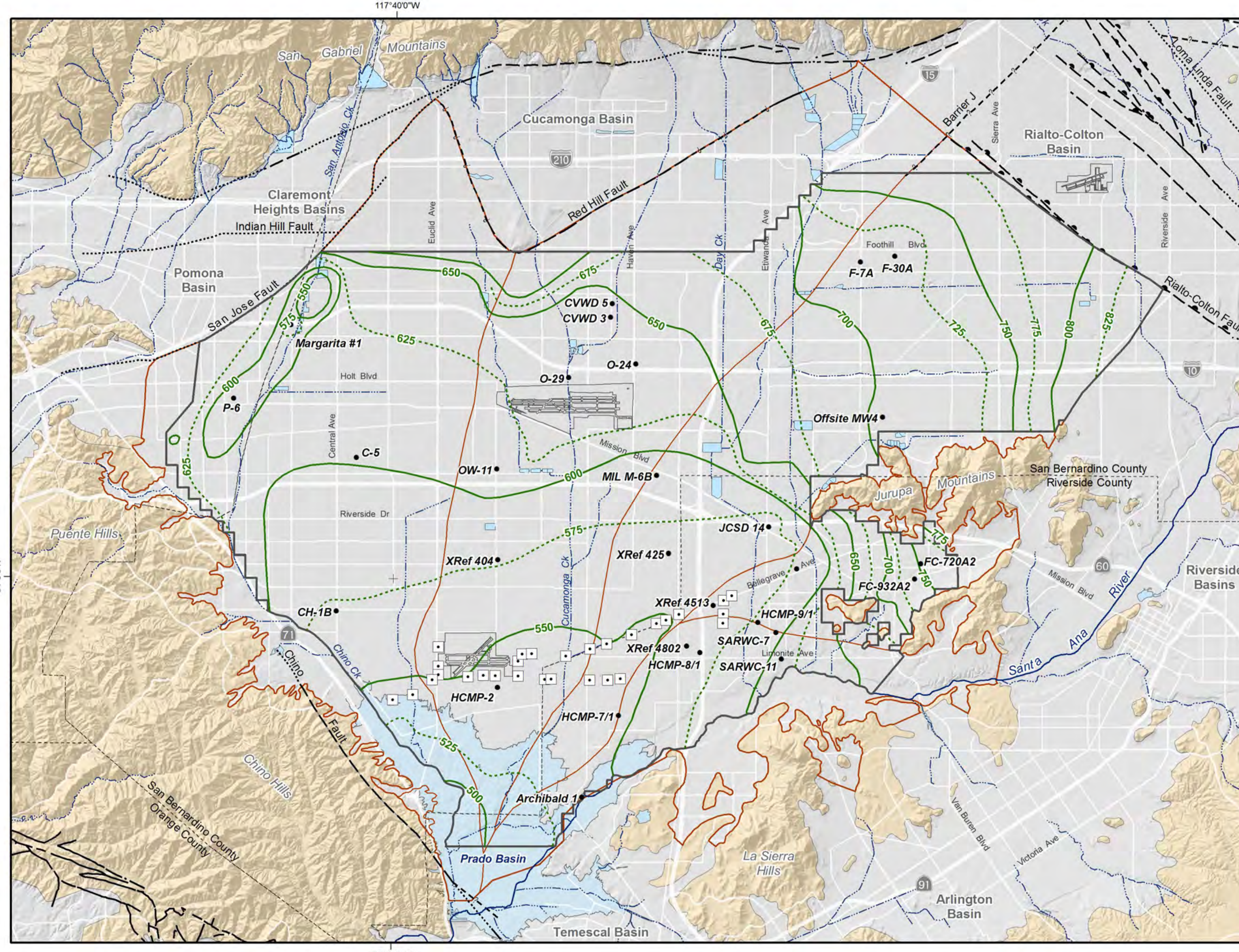
Prepared by:
WEI
Wildermuth Environmental, Inc.
Author: NWS
Date: 5/24/2019
File: Exhibit_4-2_sp2000.mxd

Prepared for:
2018 State of the Basin Report
Groundwater Levels

Groundwater-Elevation Contours for Spring 2000

Shallow Aquifer System

Exhibit 4-2



800 775 Groundwater-Elevation Contours (feet above mean sea-level)

Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)

Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2016, showing the effects of about 16 years of OBMP implementation. There was a large increase in the data available for this contouring effort—nearly twice as many wells were monitored in 2016 as were monitored in 2000. As with Exhibit 4-2, the groundwater elevation contours indicate that groundwater was flowing in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There is a discernible depression in groundwater levels around the eastern portion of the Chino Basin Desalter well field, which demonstrates the achieved Hydraulic Control in this area. This depression had merged with the pumping depression around the JCSD well field to the east and had increased the hydraulic gradient from the Santa Ana River toward the desalter well field. As was the case in 2000, there continued to be a notable pumping depression in the groundwater-level surface in the northern portion of MZ1 (Montclair and Pomona areas).

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-3_sp2016.mxd

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

Prepared for:

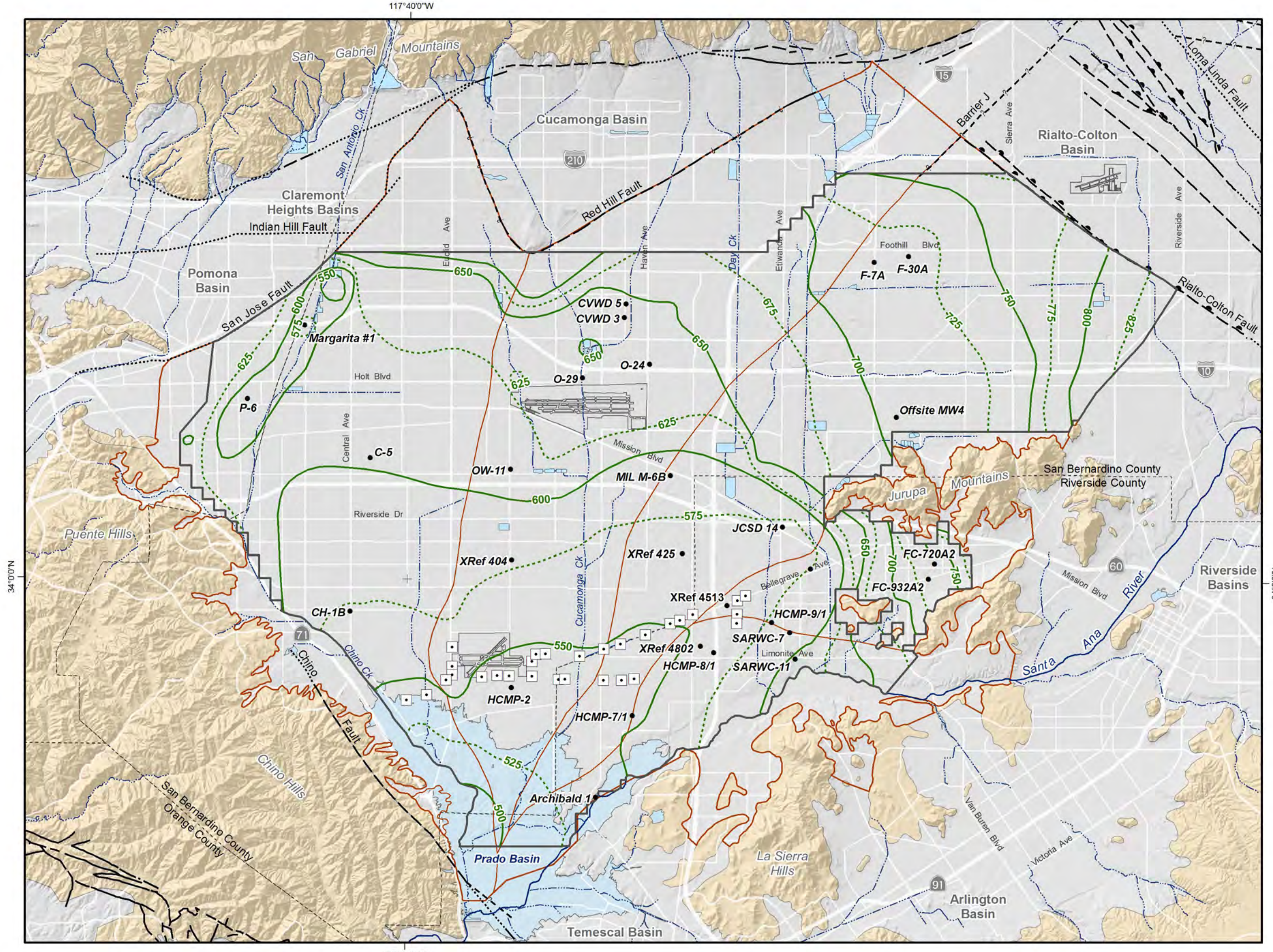
2018 State of the Basin Report
Groundwater Levels

Chino Basin Watermaster — Partners in Basin Management

Groundwater-Elevation Contours for Spring 2016

Shallow Aquifer System

Exhibit 4-3



Groundwater-Elevation Contours (feet above mean sea-level)

Boundary of Contoured Area (contours are not shown outside of this boundary due to lack of groundwater-level data)

Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

Chino Basin Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map displays contours of equal groundwater elevation across the Chino Basin during the spring of 2018, showing the effects of about 18 years of OBMP implementation. The contours are generally consistent with the groundwater-elevation contours for spring 2016, indicating regional groundwater flow in a south-southwest direction from the primary areas of recharge in the northern parts of the Basin toward the Prado Basin in the south. There continued to be a discernible depression in groundwater levels around the eastern portion of the Chino Basin Desalter well field, which demonstrates the achievement of Hydraulic Control in this area. This depression merged with the pumping depression around the JCSD well field to the east and increased the hydraulic gradient from the Santa Ana River toward the desalter well field. As was the case in 2000 and 2016, there continues to be a notable pumping depression in the groundwater-level surface in the northern portion of MZ1 (Montclair and Pomona areas).

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-4_sp2018.mxd

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

Prepared for:

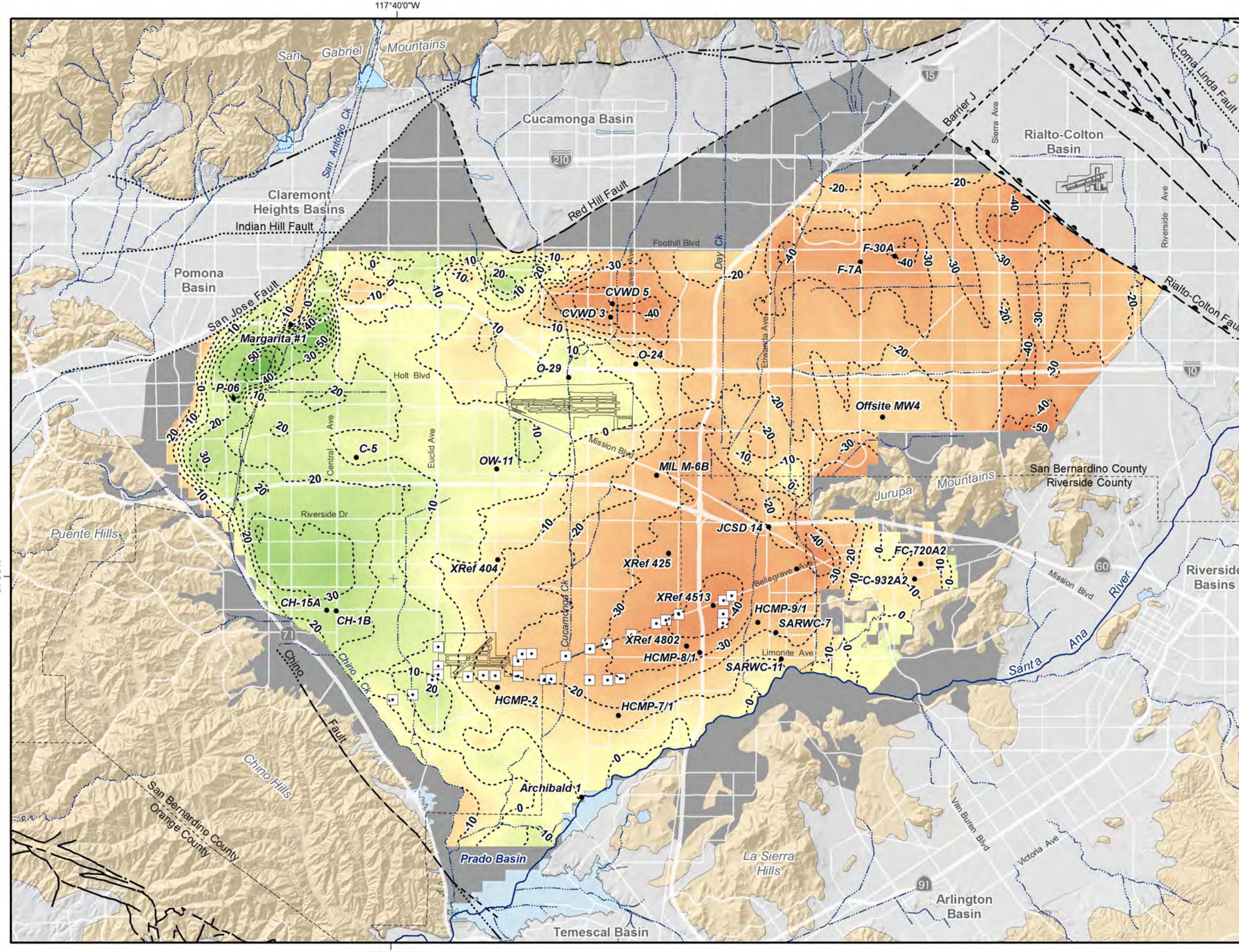
2018 State of the Basin Report
Groundwater Levels

Chino Basin Watermaster

Groundwater-Elevation Contours for Spring 2018

Shallow Aquifer System

Exhibit 4-4



Contour of Groundwater-Level Change (foot) Spring 2000 to Spring 2018

Groundwater-Level Change (foot) Spring 2000 to Spring 2018

+100 Increase

-100 Decrease

Area Not Included in the Change Calculation Due to Lack a of Groundwater-level Data

Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map shows the change in groundwater elevation during the 18-year period of OBMP implementation: spring 2000 to spring 2018. This map was created by subtracting a rasterized grid created from the groundwater elevations for spring 2000 (Exhibit 4-2) from a rasterized grid created from the groundwater elevations for spring 2018 (Exhibit 4-4).

Groundwater levels have increased in the western portion of the basin. Groundwater levels have decreased in the central and eastern portions of the basin, and around the eastern portion of the Chino Desalter well field in the south. The changes in groundwater elevation shown here are consistent with projections from Watermaster's groundwater modeling efforts (WEI, 2003a; 2007c; 2014a; 2015) that simulated changes in the groundwater levels and flow patterns from the production and recharge strategies described in the Judgment, OBMP, Peace Agreement, and Peace II Agreement. These strategies include: desalter production in the southern portion of the Basin; controlled overdraft through Basin Re-operation to achieve Hydraulic Control; subsidence management in MZ1; mandatory recharge of Supplemental Water in MZ1 to improve the balance of recharge and discharge; and facilities improvements to enhance the recharge of storm, recycled, and imported waters.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-5_change00-18.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 Km

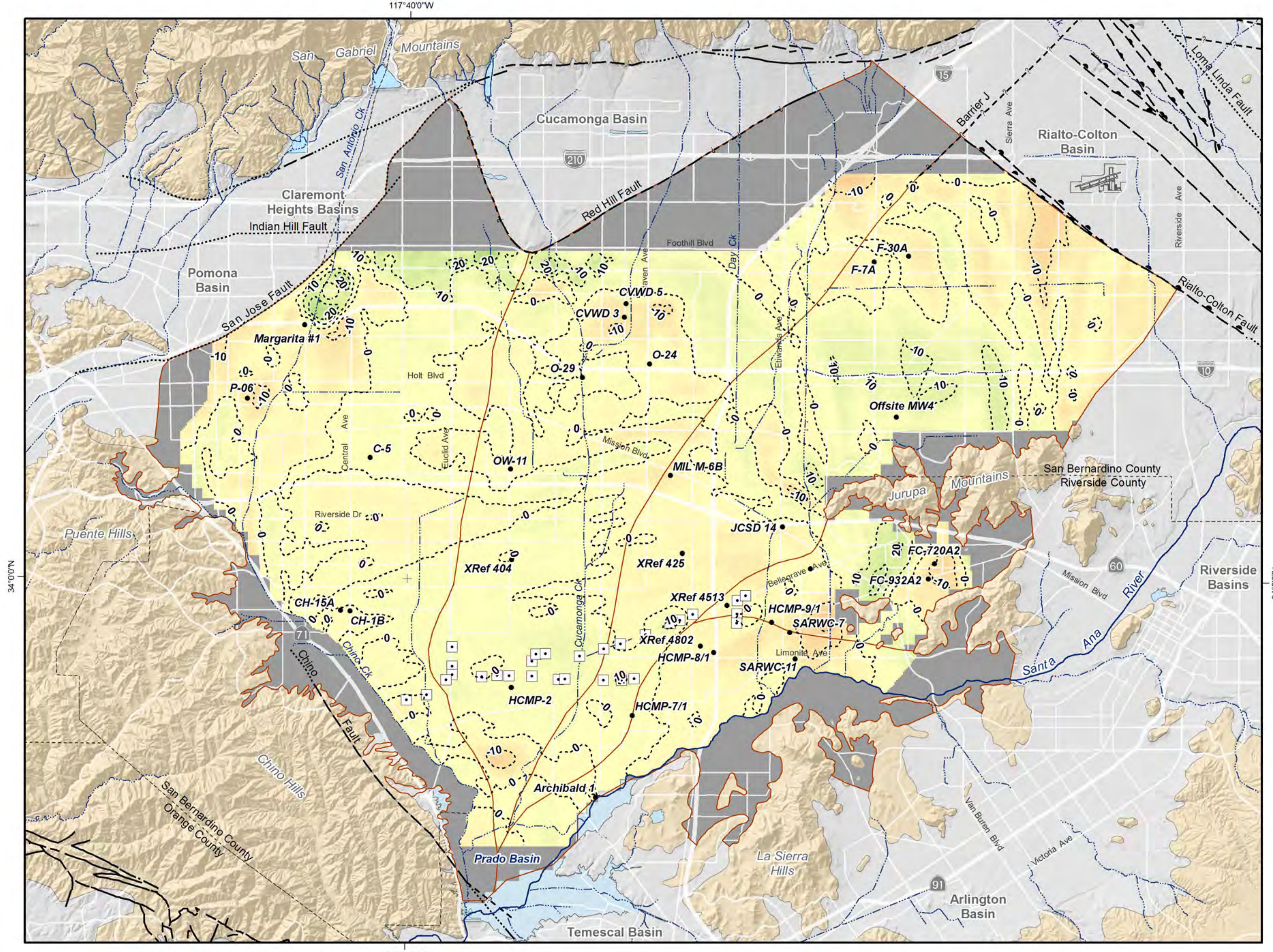
Prepared for:

2018 State of the Basin Report
Groundwater Levels

Groundwater-Level Change from Spring 2000 to Spring 2018

Shallow Aquifer System

Exhibit 4-5



Contour of Groundwater-Level Change (feet) Spring 2000 to Spring 2018

Groundwater-Level Change (feet) Spring 2016 to Spring 2018

+100 Increase

-100 Decrease

Area Not Included in the Change Calculation Due to Lack a of Groundwater-level Data

Well With a Groundwater-Level Time History Plotted on Exhibits 4-10 through 4-14

Chino Desalter Well

Other key map features are described in the legend of Exhibit 1-1.

This map shows the change in groundwater elevation for the two-year period since the last State of the Basin Report: spring 2016 to spring 2018. It was created by subtracting a rasterized grid created from the groundwater elevations for spring 2016 (Exhibit 4-3) from a rasterized grid created from the groundwater elevations for spring 2018 (Exhibit 4-4). Groundwater levels have changed by less than 10 feet across most of the basin during this two-year period. Groundwater levels have increased in western portion of the basin and decreased in parts of the eastern portion of the basin—consistent with changing patterns of local pumping from 2016 to 2018.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-6_change16-18_x.mxd

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

Prepared for:

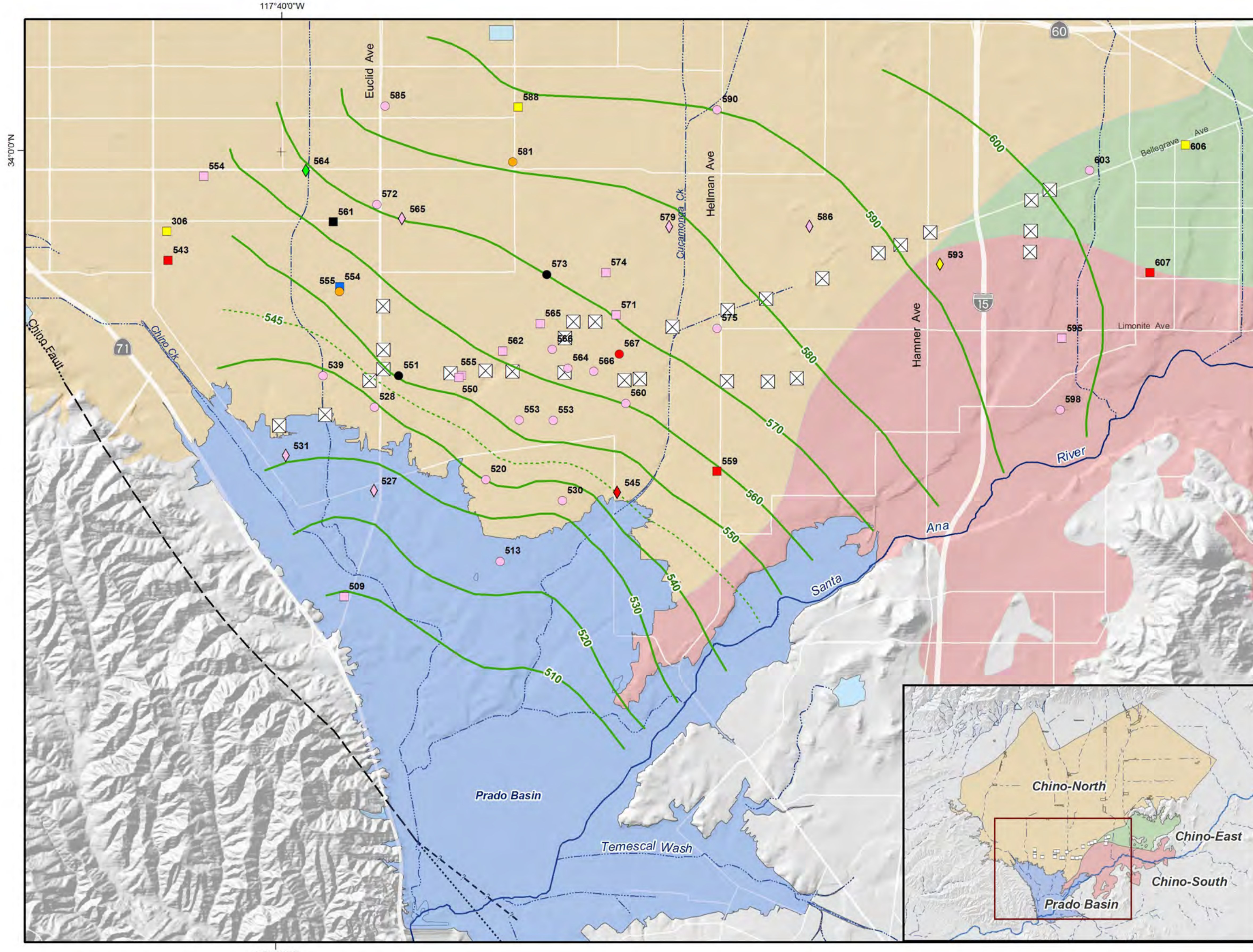
2018 State of the Basin Report
Groundwater Levels

Chino Basin Watermaster

Groundwater-Level Change from Spring 2016 to Spring 2018

Shallow Aquifer System

Exhibit 4-6



Groundwater-Elevation Contours (feet above mean sea-level)

Water-Level Qualification Symbol Code (Showing Groundwater Elevation)

- Static
- Recovering
- Estimated Static
- Dynamic

Aquifer Layer Where Well Casing is Perforated

- Layer 1
- Layers 1 & 2
- Layer 2
- Layers 2 & 3
- Layer 3
- Layers 1 & 2 & 3
- Unknown Well Construction

Future Location of Chino Desalter Well

Numbers next to well indicate groundwater-levels

Other key map features are described in the legend of Exhibit 1-1.

Hydraulic Control is a commitment of the Watermaster and IEUA to the Regional Board that allows for the reuse and recharge of recycled water in the Chino Basin. Hydraulic Control is defined as eliminating groundwater discharge from the Chino-North GMZ to the Prado Basin MZ, or controlling the discharge to *de minimis* levels of less than 1,000 afy. Hydraulic Control is to be achieved and maintained via drawdown of groundwater levels caused by pumping at the Chino Basin Desalter wells.

This map illustrates groundwater elevation and flow directions in the southern Chino Basin prior to the commencement of pumping at the Chino Basin Desalter wells (Spring 2000). The groundwater-elevation contours depict regional groundwater flow from the northeast to the southwest under a hydraulic gradient that steepens slightly south of the current location of the Chino-I Desalter well field. This map is consistent with the conceptual model of the Chino Basin, wherein groundwater flows from areas of recharge in the north/northeast toward areas of discharge in the south near the Prado Basin and the Santa Ana River. Pumping at the Chino-I Desalter well field began in late spring to early summer 2000, so its effects on groundwater levels are not apparent on this map.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: NWS
Date: 5/24/2019
File: Exhibit_4-7_HCMP_00.mxd

0 1 2 Miles
0 1 2 3 Km

Prepared for:

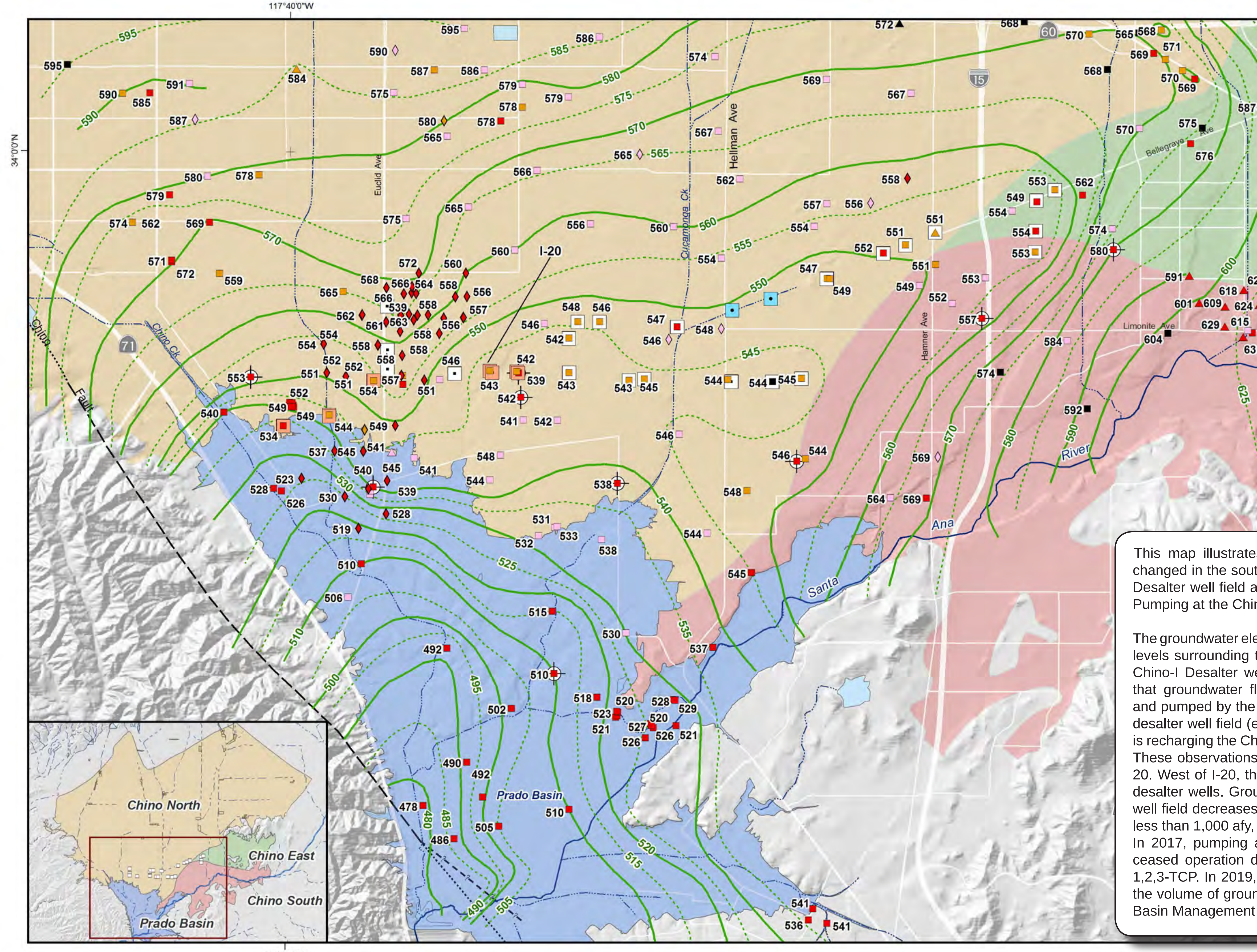
2018 State of the Basin Report
Groundwater Levels

Chino Basin Watermaster
Partners in Basin Management

State of Hydraulic Control in Spring 2000

Shallow Aquifer System

Exhibit 4-7



800 / 775 Groundwater-Elevation Contours (feet above mean sea-level)

Water-Level Qualification Symbol Code (Showing Groundwater Elevation)

- Static
- Recovering
- Estimated Static
- Dynamic

Aquifer Layer Where Well Casing is Perforated

- Layer 1
- Layers 1 & 2
- Layers 1 & 2 & 3
- Unknown Well Construction

- Chino-I Desalter Well
- Chino-II Desalter Well
- Chino Creek Desalter Well
- HCMP Monitoring Well

Numbers next to well indicate groundwater-levels

Other key map features are described in the legend of Exhibit 1-1.

This map illustrates how groundwater elevations and flow directions have changed in the southern Chino Basin after 18 years of pumping at the Chino-I Desalter well field and 12 years of pumping at the Chino-II Desalter well field. Pumping at the Chino Creek Desalter well field (CCWF) began in 2014.

The groundwater elevation contours depict a regional depression in groundwater levels surrounding the Chino-II Desalter well field and the eastern half of the Chino-I Desalter well field (east of I-20). This regional depression suggests that groundwater flowing south in the Chino-North GMZ is being captured and pumped by the desalter wells. Furthermore, the contours southeast of the desalter well field (east of Archibald Avenue) indicate that the Santa Ana River is recharging the Chino Basin and flowing northwest towards the desalter wells. These observations indicate that Hydraulic Control is achieved east of well I-20. West of I-20, the contours suggest that some groundwater flows past the desalter wells. Groundwater modeling has shown that pumping at the CCWF well field decreases the volume of groundwater flow past the desalter wells to less than 1,000 afy, which the Regional Board defines as *de minimis* discharge. In 2017, pumping at the CCWF well field declined as well I-17 temporarily ceased operation due to a decrease in the maximum contaminant level for 1,2,3-TCP. In 2019, Watermaster will use its groundwater model to determine the volume of groundwater discharge from the Chino-North GMZ to the Prado Basin Management Zone (PBMZ) under 2018 pumping conditions in the area.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-8_HCMP_18.mxd

0 1 2 Miles
0 1 2 3 Km

Prepared for:

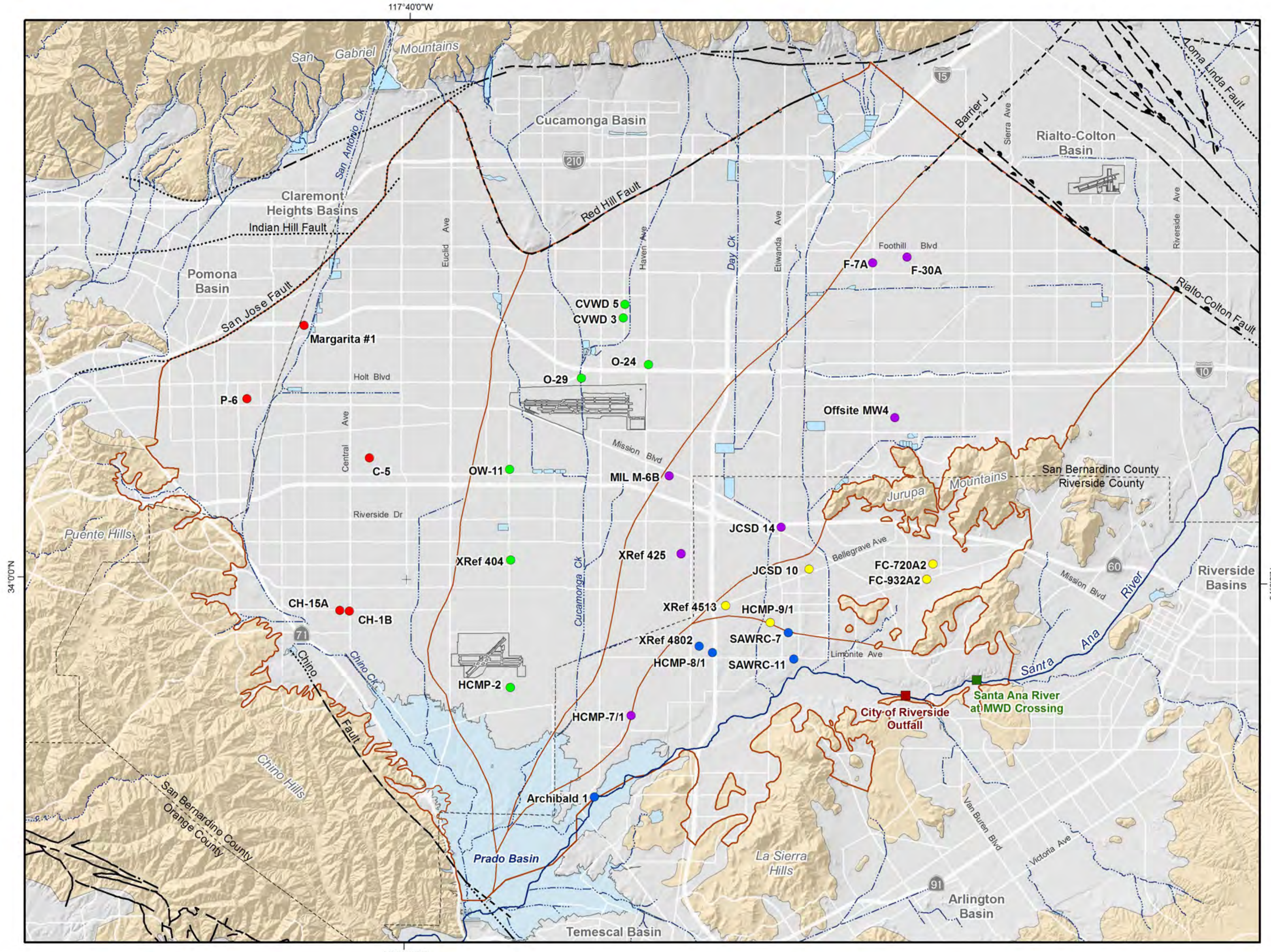
2018 State of the Basin Report
Groundwater Levels

Chino Basin Watermaster — Partners in Basin Management

State of Hydraulic Control in Spring 2018

Shallow Aquifer System

Exhibit 4-8



Wells With a Groundwater-Level Time History Plotted on Exhibit 4-10 through Exhibit 4-14

- Wells in MZ1
- Wells in MZ2
- Wells in MZ3
- Wells in MZ4
- Wells in MZ5

Surface Water Sites With Discharge Time History Plotted on Exhibit 4-14

- Wastewater Discharge Location
- USGS Gaging Station

Other key map features are described in the legend of Exhibit 1-1.

The wells shown on this map have long groundwater-level time histories that are representative of the groundwater-level trends in their respective management zones. Subsequent exhibits display time-series charts of groundwater-level data from these wells by OBMP MZ with respect to precipitation, production, and artificial recharge, which are stresses that cause changes in groundwater levels. Precipitation trends on the charts are displayed as a CDFM precipitation curve using PRISM data from 1896 to 2018. An upward slope on the CDFM curve indicates wet years or periods. A downward slope indicates dry years or periods. See Section 2 of this report for more information on precipitation trends.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: EM
Date: 5/24/2019
File: Exhibit_4-9_WLTime_His.mxd

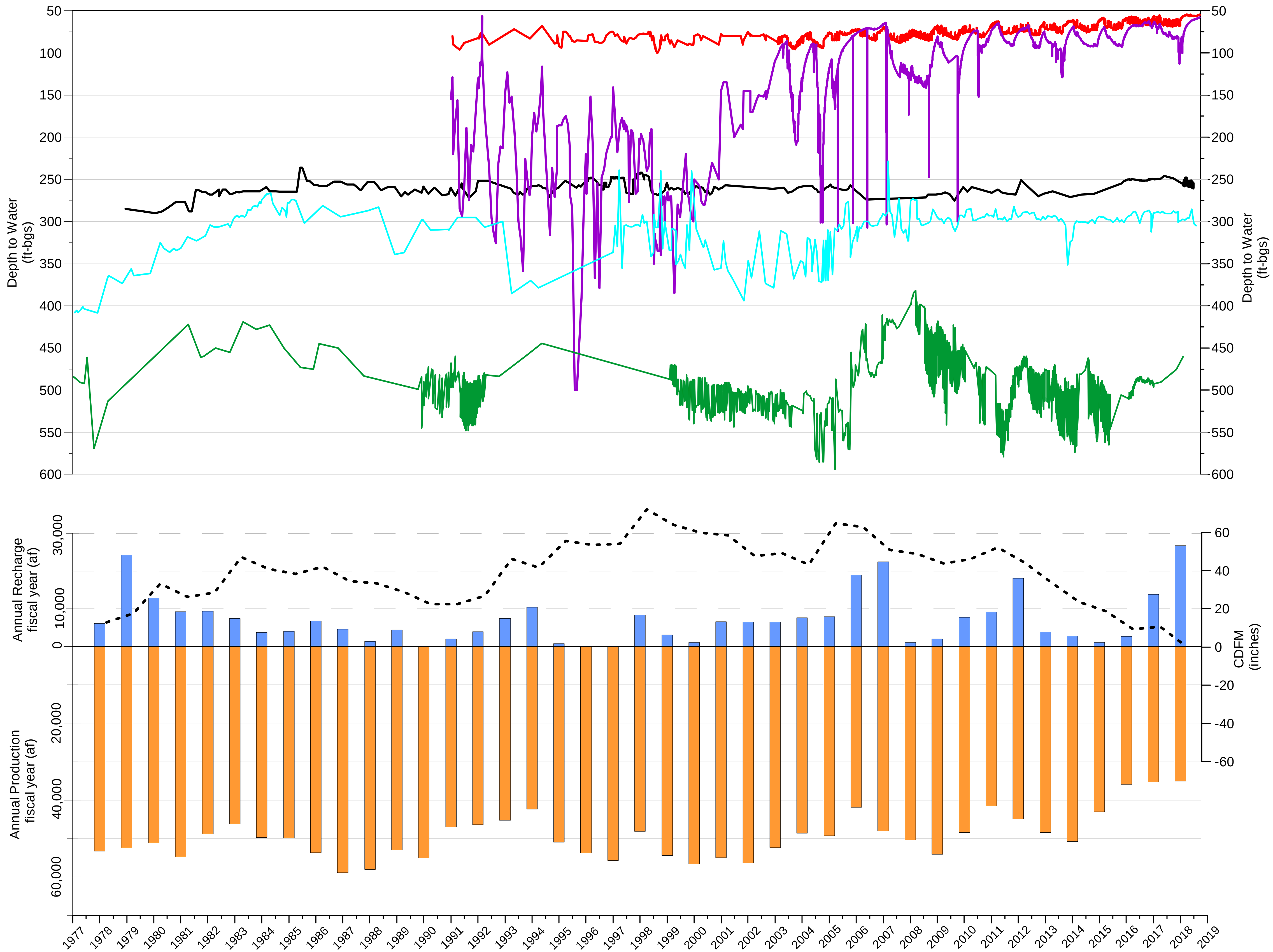
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Levels

Wells Used to Characterize Long-Term Trends in Groundwater Levels Versus Precipitation, Production, and Recharge

Exhibit 4-9



Water levels at Margarita #1 are representative of groundwater-level trends in the northern portion of MZ1. In this area, water levels appear to be controlled by local pumping and recharge stresses. Water levels at wells P-6 and C-5 are representative of groundwater-level trends in the central portion of MZ1. During the implementation of the OBMP from 2000 to 2016, groundwater levels at P-06 increased by 35 feet even though this was a relatively dry period. The changes in groundwater levels in this area are due to a general decline in groundwater production, the “put and take” cycles associated with Metropolitan’s Dry-Year Yield storage program in Chino Basin, the mandatory recharge of Supplemental Water in MZ1 to improve the balance of recharge and discharge, and facilities improvements to enhance the recharge of storm, recycled, and imported waters. From 2016 to 2018, groundwater levels at P-06 remained relatively stable. At well C-5, groundwater levels remained relatively stable from 2000 to 2018, fluctuating by about +/- 10 feet.

Water levels at well CH-1B are representative of groundwater-level trends in the deep, confined aquifer system in the southern portion of MZ1. Water levels at this well are influenced by pumping from nearby wells that are also screened within the deep aquifer system. During the 1990s, water levels at this well declined by up to 200 feet due to increased pumping from the deep aquifer system in this area. From 2000 to 2007, water levels at this well increased primarily due to decreased pumping from the deep aquifer system associated with poor groundwater quality and the management of land subsidence (WEI, 2007b). Since 2007, water levels at this well have remained relatively stable, fluctuating annually by about +/- 30 feet due to seasonal production patterns from the deep aquifer system.

Water levels at well CH-15A are representative of groundwater-level trends in the shallow, unconfined aquifer system in the southern portion of MZ1. Historically, water levels in CH-15A were stable, fluctuating between 80 to 90 ft-bgs in response to nearby pumping. Since 2000, water levels have risen by about 25 feet, which is partly due to the increasing availability of recycled water for direct uses, resulting in decreased local pumping.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 05/24/2019
File: Exhibit_4-10_MZ1.grf

Groundwater Levels at Wells (Perforated Interval Depth)

- Margarita #1 (182-448 ft-bgs)
- P-6 (536-1,050 ft-bgs)
- C-5 (430-1,078 ft-bgs)
- CH-1B (440-1,180 ft-bgs)
- CH-15A (190-310 ft-bgs)

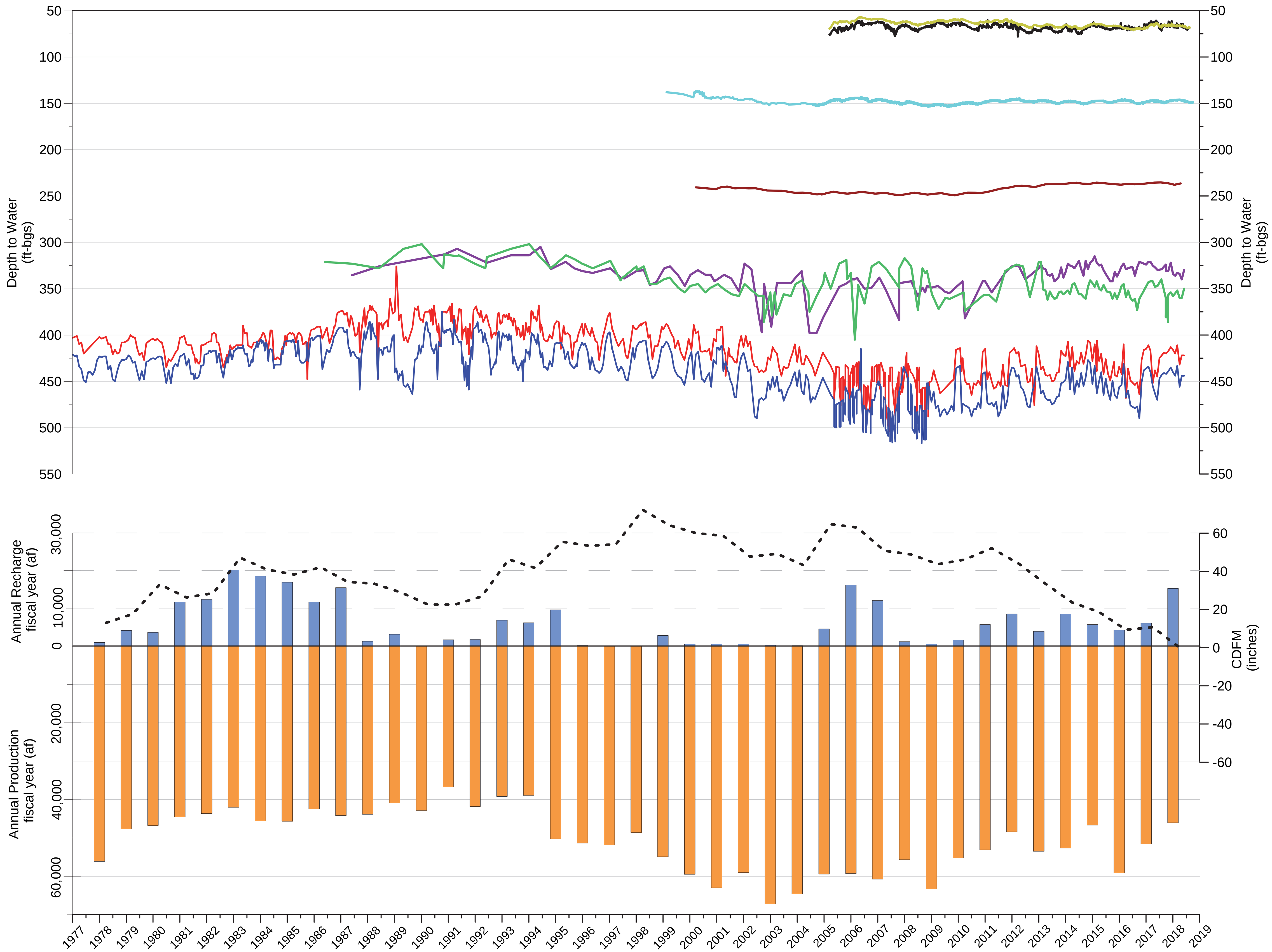
Production, Recharge, and Precipitation

- Recharge of Imported Water and Recycled Water at Basins in MZ1
- Groundwater Production from Wells in MZ1
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2018 (Spatial Average for the Chino Basin)

2018 State of the Basin
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ1 - 1978 to 2018

Exhibit 4-10



Water levels at wells CVWD-3, CVWD-5, O-29 and O-24 are representative of groundwater-level trends in the north-central portion of MZ2. Water levels increased from 1978 to about 1990, likely due to a combination of the 1978 to 1983 wet period, decreased production following the execution of the Judgment, and the initiation of the artificial recharge of imported water in the San Sevaine and Etiwanda Basins. From 1990 to 2010, water levels progressively declined by about 75 feet due to increased production in the region. From 2010 to 2014, water levels increased by about 30 feet, likely due to decreased production and increased artificial recharge. From 2014 to 2018 water levels remained relatively stable, indicating a general balance of recharge and discharge during this period.

Water level data at wells OW-11 and XRef 404 are representative of trends in the central portion of MZ2. Well OW-11 is located adjacent to the Ely Basins, and well XRef 404 is located in the region south of all recharge basins in MZ2 and north of the Chino Basin Desalter wells. From 2000 to 2004, water levels at both wells decreased by about 10 feet, likely due to a combination of a dry period, increases in production in MZ2, and very little artificial recharge. From 2005 to 2018, water levels increased by up to 15 feet, likely due to decreased production and increased artificial recharge.

Water levels at wells HCMP-2/1 (shallow aquifer) and HCMP-2/2 (deep aquifer) are representative of groundwater-level trends in the southern portion of MZ2, just south of the Chino-I Desalter wells. One of the objectives of the desalter well field is to cause the lowering of groundwater levels to achieve Hydraulic Control of the Chino Basin (see Exhibits 4-7 and 4-8 for further explanation of Hydraulic Control). The Chino-I Desalter well field began pumping in late 2000. Since 2005, when these wells were constructed, groundwater levels in this area have declined by about five feet.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 05/24/2019
File: Exhibit_4-11.grf

Groundwater Levels at Wells (Perforated Interval Depth)

- CVWD-5 (538-1,238 ft-bgs)
- CVWD-3 (341-810 ft-bgs)
- O-29 (400-1,095 ft-bgs)
- O-24 (484-952 ft-bgs)
- OW-11 (323-333 ft-bgs)
- XRef 404 (274-354 ft-bgs)
- HCMP-2/2 (296-316 ft-bgs)
- HCMP-2/1 (124-164 ft-bgs)

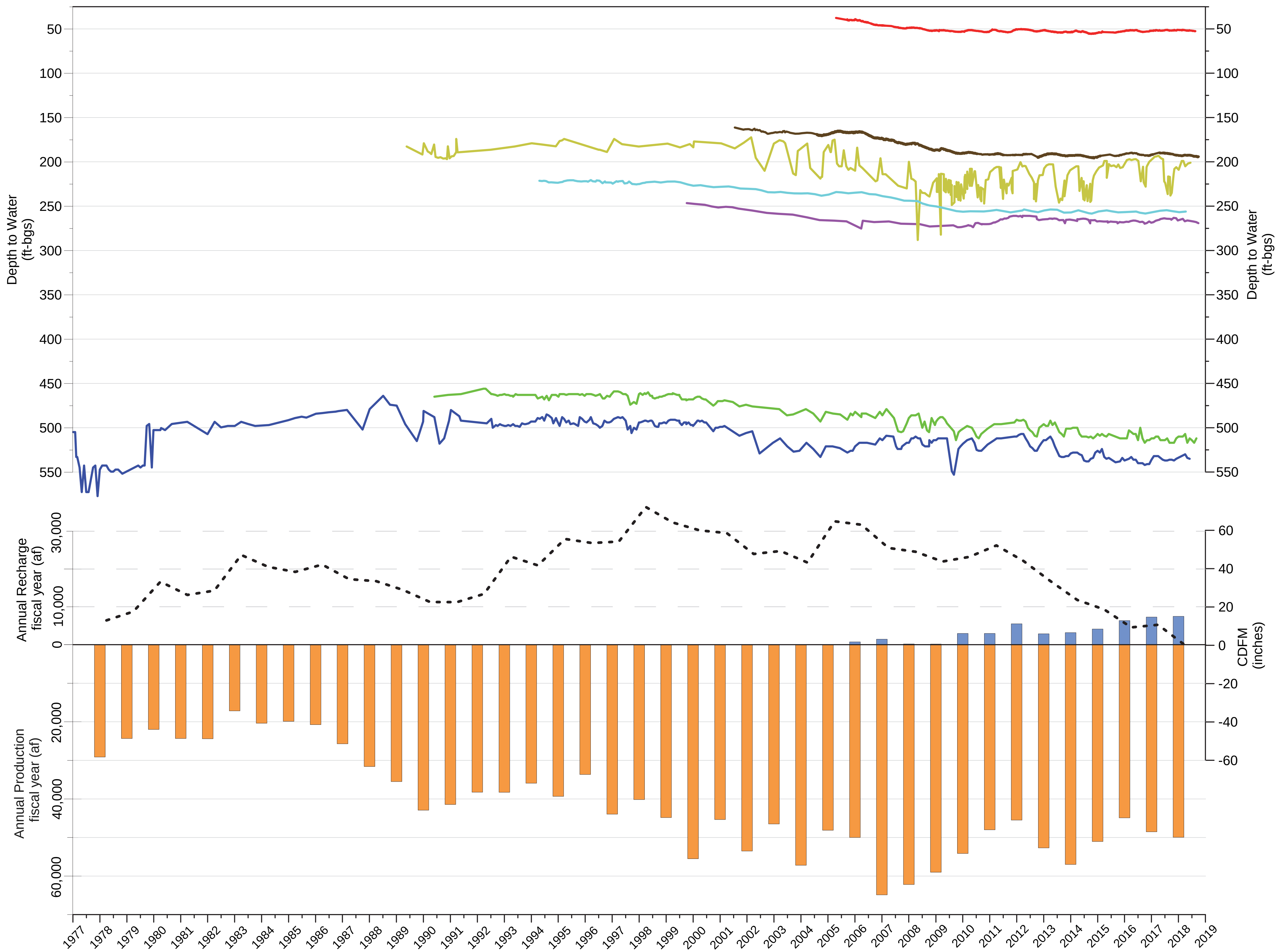
Production, Recharge, and Precipitation

- Recharge of Imported Water and Recycled Water at Basins in MZ2
- Groundwater Production from Wells in MZ2
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2018 (Spatial Average for the Chino Basin)

2018 State of the Basin
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ2 - 1978 to 2018

Exhibit 4-11



Water levels at wells F-30A and F-7A are representative of groundwater-level trends in the northeastern portions of MZ3. From 2000 to 2018, water levels declined in this area by approximately 35-50 feet due to a dry climatic period and increased pumping in MZ3.

Water levels at wells Offsite MW4, Mill M-6B, JCSD-14, and XRef 425 are representative of groundwater-level trends in the central portion of MZ3. From 2000 to 2010, groundwater levels in this area progressively declined by about 30 feet due to a dry period and increased pumping in MZ3. From 2010 to 2018, groundwater levels stabilized or increased by up to 15 feet, likely due to reduced production and increases in artificial recharge.

Water levels at well HCMP-7/1 are representative of groundwater-level trends in the southernmost portion of MZ3—just south of the Chino-II Desalter well field and just north of the Santa Ana River. From 2005 to 2010, water levels at this well declined by about 15 feet, mainly due to the onset of pumping at the Chino-II Desalter well field. From 2011 to 2018, water levels remained relatively stable in this area.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 05/24/2019
File: Exhibit_4-12.grf

Groundwater Levels at Wells (Perforated Interval Depth)

- F-30A (507-864 ft-bgs)
- F-7A (590-1000 ft-bgs)
- Offsite MW4 (222-282 ft-bgs)
- Mill M-06B (255-275 ft-bgs)
- JCSD-14 (210-370 ft-bgs)
- XRef 425 (no perf data)
- HCMP-7/1 (70-110 ft-bgs)

Production, Recharge, and Precipitation

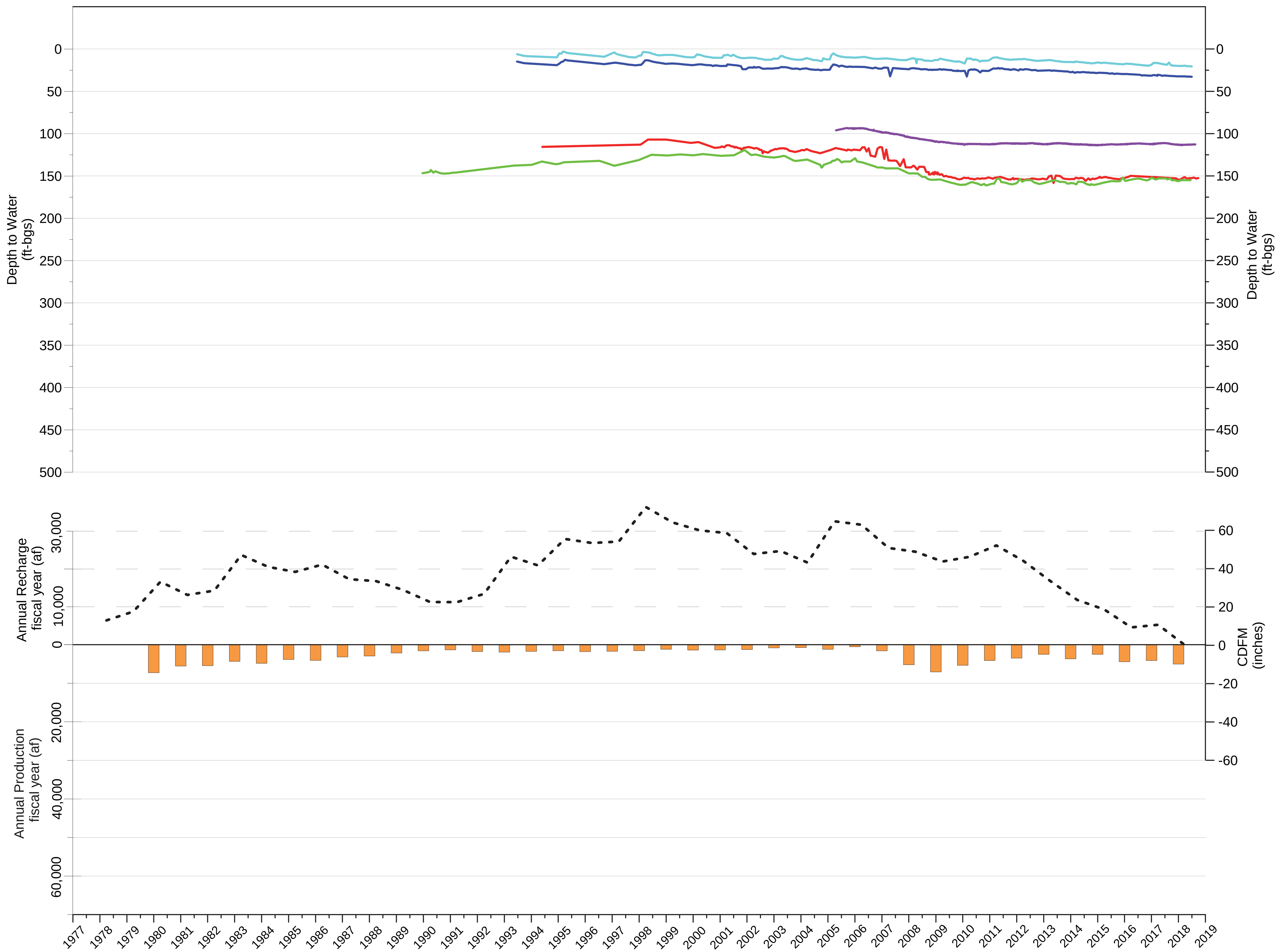
- Recharge of Imported Water and Recycled Water at Basins in MZ3
- Groundwater Production from Wells in MZ3
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2018 (Spatial Average for the Chino Basin)

Chino Basin Watermaster — Partners in Basin Management

2018 State of the Basin
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ3 - 1978 to 2018

Exhibit 4-12



Water levels at wells JCSD-10, XRef 4513, and HCMP-9/1 are representative of groundwater-level trends in the western portion of MZ4 in the vicinity of the JCSD and Chino-II Desalter well fields. Water levels at JCSD-10 and XRef 4513 began to decrease around 2000 and notably accelerated in decline around 2006 when pumping at Chino-II Desalter wells commenced in MZ3 and MZ4. From 2000 to 2010 water levels declined by about 35 feet at these wells. Water levels at HCMP 9/1 show a similar decrease during this time, declining by about 20 feet from the well's construction in 2005 to 2010. The decline of groundwater levels in this portion of the basin was necessary to achieve Hydraulic Control of the Chino Basin (see Exhibits 4-7 and 4-8 for further explanation of Hydraulic Control); however groundwater level decline in this area is a concern of the JCSD with regard to production sustainability at its wells. Hydraulic control was achieved in this area by 2010, and from 2010 to 2018, groundwater levels stabilized.

Water levels at wells FC-720A2 and FC-932A2 are representative of groundwater-level trends in the eastern portion of MZ4. From 2000 to 2018, the water levels at these wells declined by about 10 feet, likely in response to the dry period.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Groundwater Levels at Wells (Perforated Interval Depth)

- JCSD-10 (no perf data)
- XRef 4513 (no perf data)
- HCMP-9/1 (110-150 ft-bgs)
- FC-752A2 (no perf data)
- FC-932A2 (no perf data)

Production, Recharge, and Precipitation

- Recharge of Imported Water and Recycled Water at Basins in MZ4
- Groundwater Production from Wells in MZ4
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2018 (Spatial Average for the Chino Basin)

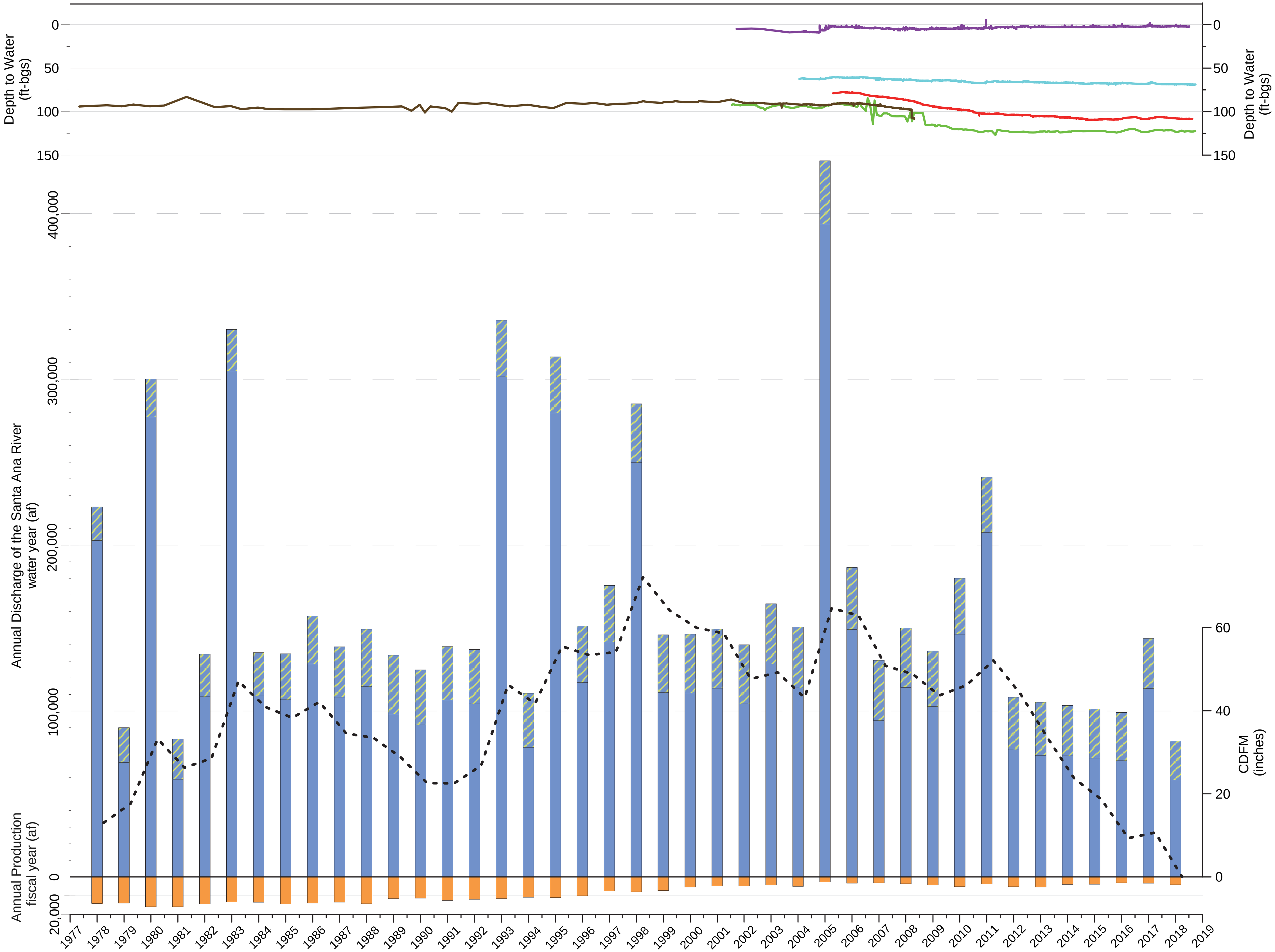
Author: LH
Date: 05/24/2019
File: Exhibit_4-13_MZ4.grf

Chino Basin Watermaster
Partners in Basin Management

2018 State of the Basin
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ4 - 1978 to 2018

Exhibit 4-13



MZ5 is a groundwater flow system that parallels the Santa Ana River. The discharge of the Santa Ana River shown on this chart is the total flow measured at USGS gage SAR at MWD Crossing and the total effluent discharged to the Santa Ana River from the City of Riverside's wastewater treatment plant. A portion of this Santa Ana River discharge can recharge the Chino Basin in MZ5.

Water levels at wells XRef 4802, SARWC-7, SARWC-11, and HCMP-8/1 are representative of groundwater levels in the eastern portion of MZ5, where the Santa Ana River is recharging the Chino Basin. From 2005 to 2018, water levels at these wells progressively declined by about 8 to 30 feet. This decline of groundwater-levels coincided with increased pumping at the Chino Basin Desalter well field nearby in MZ3 and MZ4, which has helped to achieve Hydraulic Control in this portion of the Chino Basin. This decline of groundwater-levels also suggests that Santa Ana River recharge to the Chino Basin in this area has increased.

Water levels at the Archibald-1 well are representative of groundwater levels in the southwestern portion of MZ5, where groundwater is very near the ground surface and could be rising to become flow in the Santa Ana River. Water levels at this near-river well have remained relatively stable since monitoring began in 2000.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 05/24/2019
File: Exhibit_4-14_MZ5.grf

Groundwater Levels at Wells (Perforated Interval Depth)

- XRef 4802 (no perf data)
- SARWC-07 (100-172 ft-bgs)
- HCMP-8/1 (75-115 ft-bgs)
- SARWC-11 (75-230 ft-bgs)
- Archibald 1 (75-85 ft-bgs)

Production, Recharge, and Precipitation

- Flow of the *Santa Ana River at MWD Xing*
- Discharge from the City of Riverside WWTP
- Groundwater Production from Wells in MZ5
- CDFM Precipitation Plot using PRISM 4-km grid for 1896-2018 (Spatial Average for the Chino Basin)

2018 State of the Basin
Groundwater Levels

Time-Series Chart of Groundwater Levels Versus Precipitation, Production, and Recharge
MZ5 - 1978 to 2018

Exhibit 4-14

The exhibits in this section show the physical state of the Chino Basin with respect to groundwater quality, using data from the Chino Basin groundwater-quality monitoring programs.

Prior to OBMP implementation, historical groundwater-quality data were obtained from the California Department of Water Resources (DWR) and supplemented with data from some producers in the Appropriative Pool and some data from the State of California Department of Public Health (now the California State Water Resources Control Board Division of Drinking Water [DDW]). As part of the implementation of OBMP *PE 1 – Develop and Implement a Comprehensive Monitoring Program*, Watermaster began conducting a more robust water-quality monitoring program to support the activities in other Program Elements, such as *PE 6 – Develop and Implement Cooperative Programs with the Regional Board and Other Agencies to Improve Basin Management* and *PE 7 – Develop and Implement Salt Management Program*.

In 1999, Watermaster initiated a comprehensive monitoring program to perform systematic sampling of private wells south of State Route 60 in the Chino Basin. By 2001, Watermaster had sampled all known wells at least once to develop a robust baseline dataset. Since that time, Watermaster has continued its sampling and data collection efforts and is constantly evaluating and revising the monitoring programs as wells are abandoned or destroyed due to urban development. The details of the groundwater monitoring programs as of FY 2017/2018 are described below.

Chino Basin Data Collection (CBDC). Watermaster routinely and proactively collects groundwater-quality data from well owners that perform sampling at their own wells, such as municipal producers and government agencies. Groundwater-quality data are also obtained from special studies and monitoring that takes place under the orders of the RWQCB, the Department of Toxic Substances Control (DTSC), the USGS, and others. These data are collected from well owners and monitoring entities twice per year. In 2018, data from over 630 wells were compiled as part of the CBDC program.

Watermaster Field Groundwater Quality Monitoring Programs. Watermaster continues to sample privately owned wells and its own monitoring wells on a routine basis.

Private Wells. Watermaster collects groundwater quality samples at about 85 private wells, located predominantly in the southern portion of the Basin. The wells are sampled at various frequencies based on their proximity to known point-source contamination plumes. 77 wells are sampled on a triennial basis, and eight wells near contaminant plumes are sampled on an annual basis.

Watermaster Monitoring Wells. Watermaster collects groundwater quality samples at 22 multi-nested monitoring sites located throughout the southern Chino Basin. There are a total of 53 well casings at these sites. These include nine HCMP monitoring sites constructed to support the demonstration of Hydraulic Control, nine sites constructed to support the Prado Basin Habitat Sustainability Program (PBHSP), and four sites that fill spatial data gaps near contamination plumes in MZ3. Each nested well site contains up to three wells in the borehole. The HCMP and MZ3 wells are sampled annually. The PBHSP wells are sampled quarterly to triennially.

Other wells. Watermaster collects samples from four near-river wells quarterly. The data are used to characterize the interaction of the Santa Ana River and groundwater in this area. These shallow monitoring wells along the Santa Ana River consist of two former US Geological Survey (USGS) National Water Quality Assessment Program (NAWQA) wells (Archibald 1 and Archibald 2) and two Santa Ana River Water Company (SARWC) wells (well 9 and well 11).

All groundwater-quality data are checked for quality assurance and quality control (QA/QC) by Watermaster staff and uploaded to a centralized database management system that can be accessed online through HydroDaVE℠. The data are used (1) to comply with two of Watermaster and IEUA's maximum benefit salinity management commitments: the triennial ambient water quality re-computation and the analysis of hydraulic control; (2) to prepare Watermaster's biennial SOB report (this report); (3) to support ground-water modeling; (4) to characterize non-point source contamination and plumes associated with point-source discharges; (5) to characterize long-term trends in water quality; and (6) to periodically perform special studies.

Groundwater-quality data representing the five-year period from July 2013 to June 2018 were analyzed synoptically and temporally to characterize current water quality conditions in the Basin. This analysis does not represent a programmatic investigation of potential sources of chemical constituents in the Basin. Exhibit 5-1 shows the wells with data over this five-year period.

Groundwater quality is characterized with respect to constituents where groundwater exceeds primary or secondary California Maximum Contaminant Levels (MCLs) or Notification Levels (NLs). Wells with constituent concentrations greater than a primary MCL represent areas of concern, and the spatial distribution of these wells indicates areas in the Basin where groundwater may be impaired from a beneficial use standpoint. Exhibit 5-2 characterizes the number of wells in the Basin that exceed primary or secondary MCLs, and Exhibits 5-3 through 5-14 show the areal distribution of concentrations for the constituents of potential concern (COPC) described in Exhibit 5-2.

Several of the constituents in Exhibits 5-3 through 5-14 are associated with known point-source contaminant discharges to groundwater. Understanding point-sources of concern is critical to the overall management of groundwater quality to ensure that Chino Basin groundwater remains a sustainable resource. Watermaster closely monitors information, decisions, cleanup activities, and monitoring data pertaining to point-source contamination within the Chino Basin. The following is a list of the regulatory and voluntary groundwater-quality contamination monitoring efforts in the Chino Basin that are tracked by Watermaster, the locations of which are shown in Exhibit 5-15.

• Alumax Aluminum Recycling Facility

Constituents of Concern: TDS, sulfate, nitrate, chloride

Order: RWQCB Cleanup and Abatement Order 99-38

• Alger Manufacturing Co.

Constituents of Concern: volatile organic chemicals (VOCs)

Order: Voluntary Cleanup and Monitoring

• Chino Airport

Constituents of Concern: VOCs

Order: RWQCB Cleanup and Abatement Orders 90-134, R8-2008-0064, and R8-2017-0011

• California Institution for Men (No Further Action status, as of 2/17/2009)

Constituents of Concern: VOCs

Order: Voluntary Cleanup and Monitoring

• General Electric Flatiron Facility

Constituents of Concern: VOCs and hexavalent chromium

Order: Voluntary Cleanup and Monitoring

• General Electric Test Cell Facility

Constituents of Concern: VOCs

Order: Voluntary Cleanup and Monitoring

• Former Kaiser Steel Mill

Constituents of Concern: TDS, total organic carbon (TOC), VOCs

Order: RWQCB Order No. 91-40 Closed. Kaiser granted capacity in the Chino II Desalter to remediate.

• Former Kaiser Steel Mill – CCG Property

Constituents of Concern: chromium, hexavalent chromium, other metals, VOCs

Order: DTSC Consent Order 00/01-001

• Milliken Sanitary Landfill

Constituents of Concern: VOCs

Order: RWQCB Order No. 81-003

• Upland Sanitary Landfill

Constituents of Concern: VOCs

Order RWQCB Order No 98-99-07

• South Archibald Plume

Constituents of Concern: VOCs

Order: Stipulated Settlement and Cleanup and Abatement Order No. R8-2016-0016 to a group of eight responsible parties

• Stringfellow NPL Site

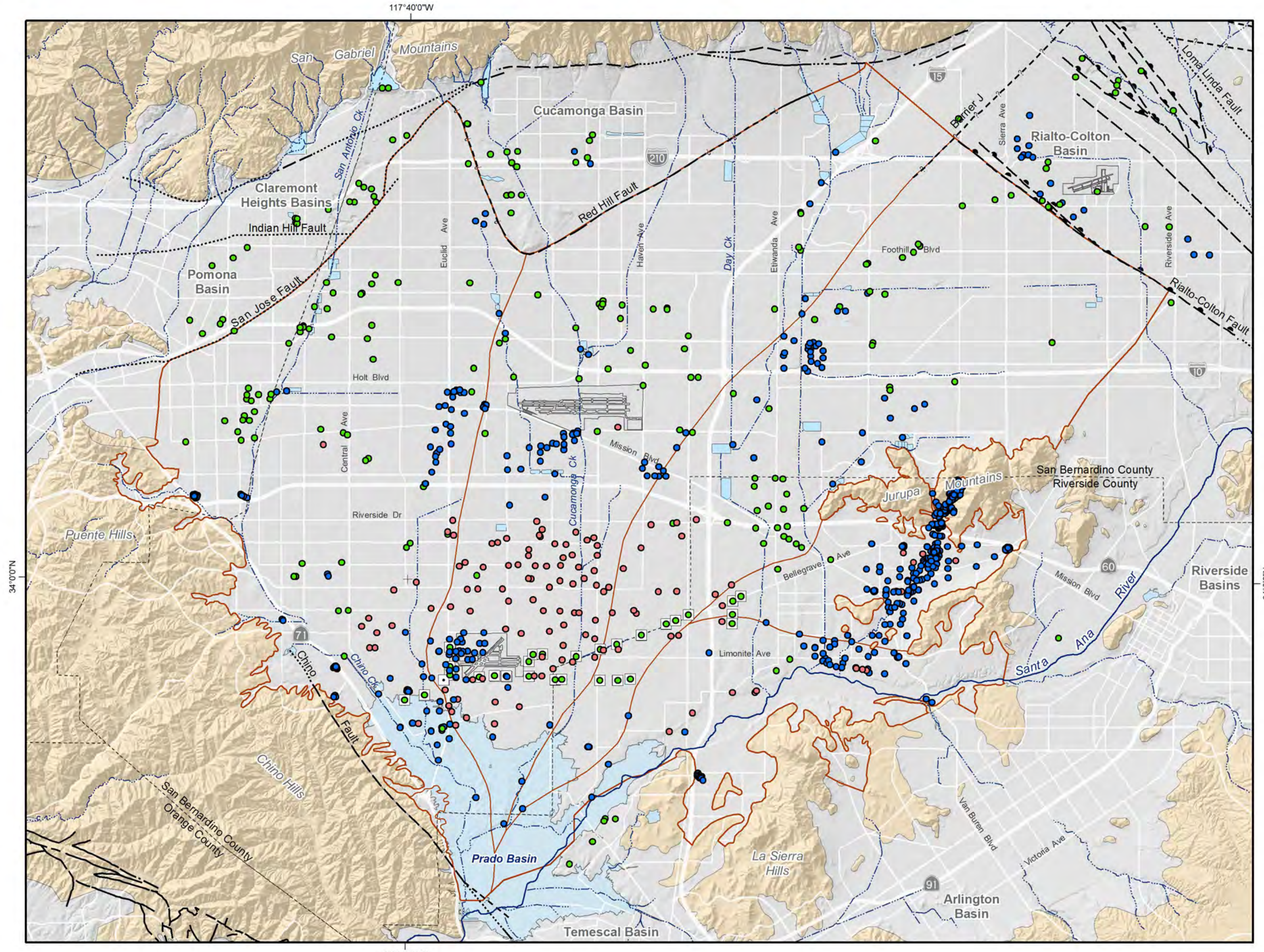
Constituents of Concern: VOCs, perchlorate, N-nitrosodimethylamine (NDMA), trace metals

Order: The Stringfellow Site is the subject of US Environmental Protection Agency (EPA) Records of Decision (RODs): EPA/ROD/R09-84/007, EPA/ROD/R09-83/005, EPA/ROD/R09-87/016, and EPA/ROD/R09-90/048.

Every two years, Watermaster uses the data collected as part of its monitoring programs and other information to delineate the extent of contaminant plumes comprised of VOCs. Exhibits 5-15 and 5-16 show the current delineation and chemical differentiation of the VOC plumes. Exhibits 5-17 through 5-20 show more detailed information about the Chino Airport, South Archibald, General Electric Flatiron, and General Electric Test Cell plumes, the monitoring and remediation activities for which are tracked and reported on by Watermaster on a semi-annual or annual basis.

Exhibit 5-21 shows all known point sources of potential contamination in the Chino Basin as of 2018, based on the SWRCB's GeoTracker and EnviroStor websites. GeoTracker is the State Board's online data-management system for the compliance data collected from point-source discharge sites with confirmed or potential impacts to groundwater. This includes locations where there have been unauthorized discharges of waste to land or unauthorized releases of hazardous substances from underground storage tanks. EnviroStor is the DTSC's online data-management system for permitted hazardous waste facilities. In 2014, Watermaster performed a comprehensive review of the GeoTracker and EnviroStor databases to identify sites in the Chino Basin that may have an impact on groundwater quality but have not been previously tracked by Watermaster. Watermaster reviews the GeoTracker and EnviroStor databases annually to track the status of previously identified sites, identify new sites with potential or confirmed impacts to groundwater, and add new data to Watermaster's database.

The remaining exhibits in this section characterize long-term trends in groundwater quality in the Basin with respect to TDS and nitrate concentrations. The management of TDS and nitrate concentrations is essential to Watermaster's maximum benefit salt and nutrient management plan. In 2002, Watermaster proposed that the Regional Board adopt alternative maximum benefit water quality objectives for the Chino-North GMZ that were higher than the antidegradation water quality objectives for MZ1, MZ2, and MZ3. The proposed objectives were approved by the Regional Board and incorporated into the Basin Plan in 2004 (RWQCB, 2004). The maximum benefit objectives enabled Watermaster and the IEUA to implement recycled water recharge and reuse throughout the Chino Basin. The application of the maximum benefit objectives is contingent upon the implementation of specific projects and programs known as the "Chino Basin maximum benefit commitments." The commitments include requirements for basin-wide monitoring of groundwater quality, and the triennial recomputation of ambient TDS and nitrate. They also require the development of plans and schedules for water quality improvement programs when current ambient TDS exceeds the maximum benefit objective or when recycled water used for recharge and irrigation exceeds the discharge limitations listed in the IEUA's recycled water discharge and reuse permits. Exhibits 5-22 and 5-23 show trends in the ambient water quality determinations for TDS and nitrate. Exhibits 5-24 through Exhibit 5-31 show TDS and nitrate concentration time histories from 1972 to 2018 for selected wells. These time histories illustrate groundwater-quality variations and trends within each management zone and the trends in groundwater quality compared to the MZ TDS and nitrate objectives.



Wells with Groundwater-Quality Monitoring Data Between June 2013 to June 2018

- Monitoring (986 wells)
- Municipal (248 wells)
- Private (123 wells)
- Chino Basin Desalter Wells

Other key map features are described in the legend of Exhibit 1-1.

Watermaster's current water quality monitoring program relies on municipal producers, government agencies, and others to supply groundwater-quality data on a cooperative basis. Watermaster supplements these data through its own sampling and analysis of private wells and monitoring wells in the area generally south of Highway 60. All groundwater-quality data are collected and checked for QA/QC by Watermaster staff and uploaded to a centralized data management system that can be accessed online through HydroDaVE. For the July 2013 to June 2018 period, water quality data were available for a total of 1,357 wells within and adjacent to the Chino Basin. Of those, 650 wells were sampled in FY 2017/2018.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: CS
Date: 5/29/2019
File: 2018_Exhibit_5-1_WQ_Wells_new_txt.mxd

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

Prepared for:

2018 State of the Basin Report
Groundwater Quality

CHINO BASIN WATERMASTER
Partners in Basin Management

Wells with Groundwater Quality Data

July 2013 to June 2018

Exhibit 5-1

Contaminant with a Primary MCL		
Contaminant	California MCL	Number of Wells with Exceedance
1,1-Dichloroethane	5 μgl	1
1,1-Dichloroethene (1,1-DCE)	5 μgl	13
1,2,3-Trichloropropane (1,2,3-TCP)	0.005 μgl	111
1,2,4-Trichlorobenzene	5 μgl	37
1,2-Dibromo-3-chloropropane	0.2 μgl	4
1,2-Dichlorobenzene	600 μgl	43
1,2-Dichloroethane	0.5 μgl	55
1,2-Dichloropropane	5 μgl	2
1,4-Dichlorobenzene	5 μgl	97
Aluminum	1 mgl	72
Antimony	6 μgl	2
Arsenic	0.01 mgl	74
Barium	1 mgl	11
Benzene	1 μgl	90
Beryllium	0.004 mgl	13
Bromate	0.01 mgl	9
Cadmium	0.005 mgl	47
Carbon Tetrachloride	0.5 μgl	13
Chlorobenzene	70 μgl	66
Chromium	50 μgl	184
cis-1,2-Dichloroethene (cis-1,2-DCE)	6 μgl	51
Copper	1.3 mgl	22
Cyanide	150 μgl	2
Di(2-ethylhexyl)phthalate	4 μgl	37
Dichloromethane (Freon 30)	5 μgl	91
Ethylbenzene	300 μgl	46
Fluoride	2 mgl	34
Gross Alpha	15 pCi/L	14
Heptachlor	0.01 μgl	1
Heptachlor Epoxide	0.01 μgl	2
Lead	0.015 mgl	28
Mercury	0.002 mgl	3
Methyl Tert-Butyl Ether (MTBE)	13 μgl	48
Nickel	0.1 mgl	56
Nitrate-Nitrogen	10 mgl	553
Nitrite-Nitrogen	1 mgl	17
Pentachlorophenol	1 μgl	3
Perchlorate	6 μgl	387
Selenium	0.05 mgl	4
Tetrachloroethene (PCE)	5 μgl	96
Thallium	2 μgl	5
Toluene	150 μgl	37
Total Xylene	1750 μgl	29
Trichloroethylene (TCE)	5 μgl	269
Trihalomethanes	80 μgl	2
Vinyl Chloride	0.5 μgl	5

Contaminant with a Secondary MCL		
Contaminant	California MCL	Number of Wells with Exceedance
Chloride	500 mgl	8
Color	15 color units	11
Copper	1.3 mgl	24
Iron	0.3 mgl	250
Manganese	0.05 mgl	212
Methyl Tert-Butyl Ether (MTBE)	5 μgl	64
Odor	3 TON	2
Specific Conductance	1600 μS/cm	104
Sulfate	250 mgl	90
TDS	1000 mgl	141
Turbidity	5 NTU	58
Zinc	5 mgl	29

Contaminant with a California NL		
Contaminant	California NL	Number of Wells with Exceedance
1,2,4-Trimethylbenzene	330 μgl	24
1,3,5-Trimethylbenzene	330 μgl	15
1,4-Dioxane	1 μgl	115
Chlorate	800 μgl	4
Ethylene glycol	14,000 μgl	1
Formaldehyde	100 μgl	2
Hexahydo-1,3,5-trinitro-1,3,5-triazine (RDX)	0.3 μgl	12
HMX	350 μgl	12
Manganese	500 μgl	105
Methyl Isobutyl Ketone	120 μgl	11
Naphthalene	17 μgl	50
n-Butylbenzene	260 μgl	1
N-Nitrosodiethylamine (NDEA)	0.01 μgl	3
N-Nitrosodimethylamine (NDMA)	0.01 μgl	50
n-Propylbenzene	260 μgl	7
Propachlor	90 μgl	0
Tert-Butyl Alcohol	120 μgl	52
Vanadium	50 μgl	56

All Chino Basin groundwater-quality data for the five-year period of July 2013 through June 2018 were analyzed for exceedances of primary or secondary California maximum contaminant levels (MCLs) and (NLs). Primary MCLs are enforceable drinking water standards set by the DDW to protect the public from potential negative health effects associated with constituents of concern. Secondary MCLs are drinking water standards set by the DDW on the basis of undesirable aesthetic, cosmetic, or technical effects caused by a respective constituent. NLs are set by the DDW as a health advisory level for unregulated contaminants with the potential for negative health impacts. Contaminants with an NL may eventually become regulated with an MCL, pending formal regulatory review. HydroDaVESM was used to create an exceedance report for wells in the Chino Basin. The tables shown here list the number of wells in the Chino Basin with sample results that exceeded California primary or secondary MCLs during the reporting period.

Exhibits 5-3 through 5-14 are maps of the Chino Basin depicting the spatial distribution of wells with exceedances for contaminants of potential concern. The contaminants of potential concern are defined as follows:

- Contaminants associated with salt and nutrient management (i.e. TDS and nitrate).
- Contaminants where a primary MCL was exceeded in fifty or more wells from July 2013 to June 2018 and where the majority of the fifty or more wells with exceedances are not primarily exclusive to a known single point-source contamination plume (i.e. the Stringfellow NPL Site, Milliken Landfill, etc.). These contaminants include nitrate, perchlorate, total chromium, arsenic, trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichloroethane, and 1,2,3- trichloropropane (1,2,3-TCP).
- Contaminants for which a NL was exceeded in 100 or more wells from July 2013 to June 2018 and where the majority of wells with exceedances are not primarily exclusive to a known single point source contamination plume, and/or the California DDW considers them a candidate for the development of an MCL. These contaminants include hexavalent chromium and 1,4-dioxane.

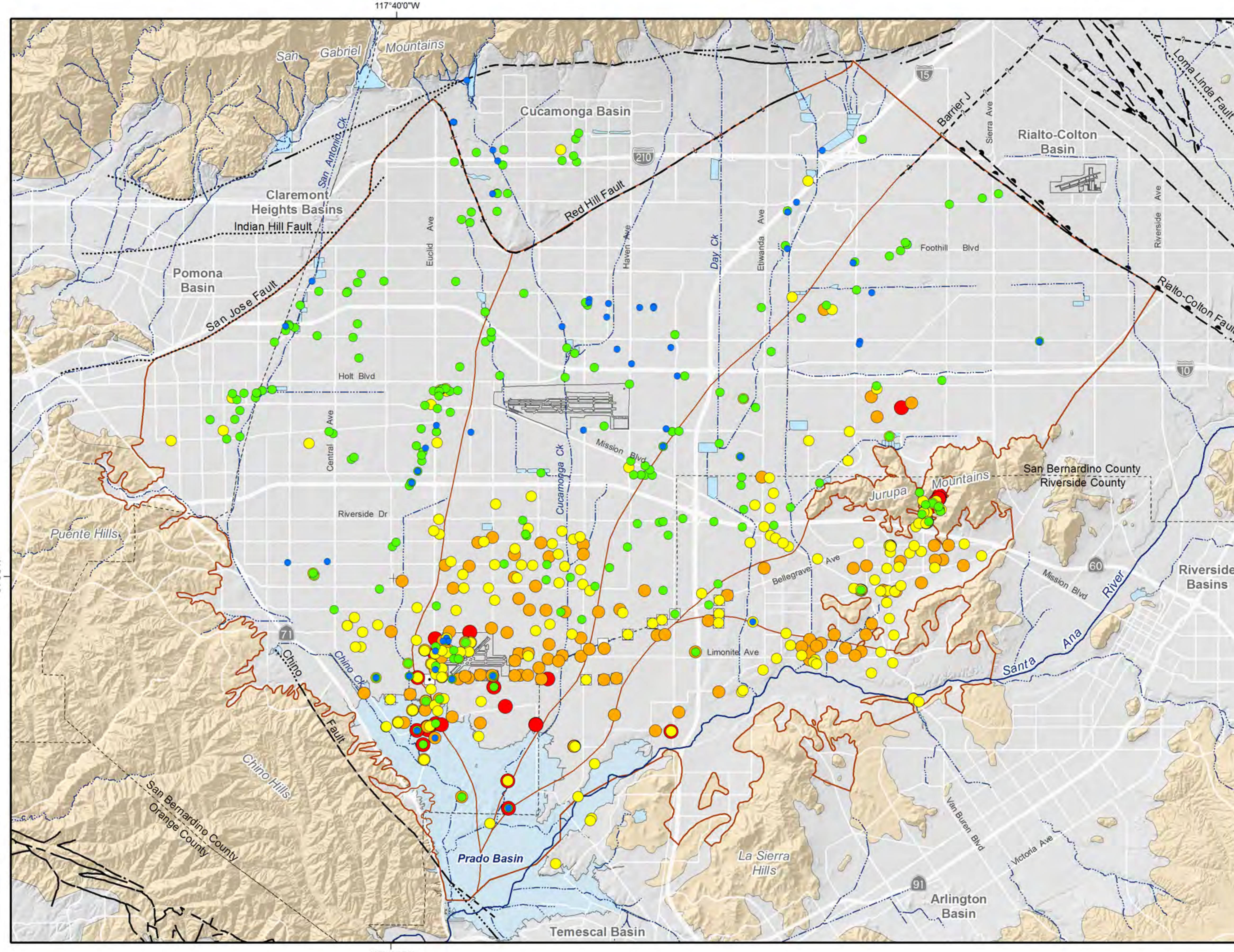
In each exhibit, the water-quality standard is defined in the legend, and each well is symbolized by the maximum concentration value measured during the reporting period. The following class interval convention is applied to each exhibit, based on the subject water quality standard (WQS).

Symbol	Class Interval
○ (small white)	Not Detected above reporting limits (ND)
● (small blue)	<0.5x WQS
● (green)	0.5x WQS to WQS
● (yellow)	WQS to 2x WQS
● (orange)	2x WQS to 4x WQS
● (red)	> 4x WQS

Note:

mgl = milligrams per liter

μgl = micrograms per liter



TDS (mgl)

- < 125
- 125 - 250
- 250 - 500
- 500 - 1,000
- 1,000 - 2,000
- > 2,000

California Secondary MCL = 500 mgl

Other key map features are described in the legend of Exhibit 1-1.

TDS is a measure of all dissolved substances in water (salinity), including organic matter and ions, such as chloride, sodium, nitrate, calcium, potassium, magnesium, bicarbonate, and sulfate. Common sources of salinity in groundwater include agriculture, municipal and industrial wastewaters, applied water for irrigation (urban and agricultural), or natural sources. TDS has a secondary California MCL of 500 mgl. From 2013 to 2018, TDS was measured at 604 wells in the Basin. Of these, 366 (61 percent) have five-year maximum values that exceed the MCL. The highest five-year maximum TDS concentrations are anomalous and located near the Jurupa Mountains, within the Stringfellow NPL site, and range from 5,300 to 23,000 mgl. Exclusive of these anomalous concentrations, the five-year maximum concentrations range from 130 to 4,600 mgl, with average and median values of 778 and 614 mgl, respectively. The wells with the highest TDS concentrations in this range are predominantly located south of Highway 60 in the area of historic and current agricultural land uses, which include irrigated agriculture and dairies. Agricultural land uses impact TDS concentrations through the disposal of dairy waste via land application and discharge to ponds, the use of fertilizer on crops, and the concentrating effects of the consumptive use of applied water for irrigation.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-3_TDS_txt2.mxd

0 1 2 3 4 5 Miles

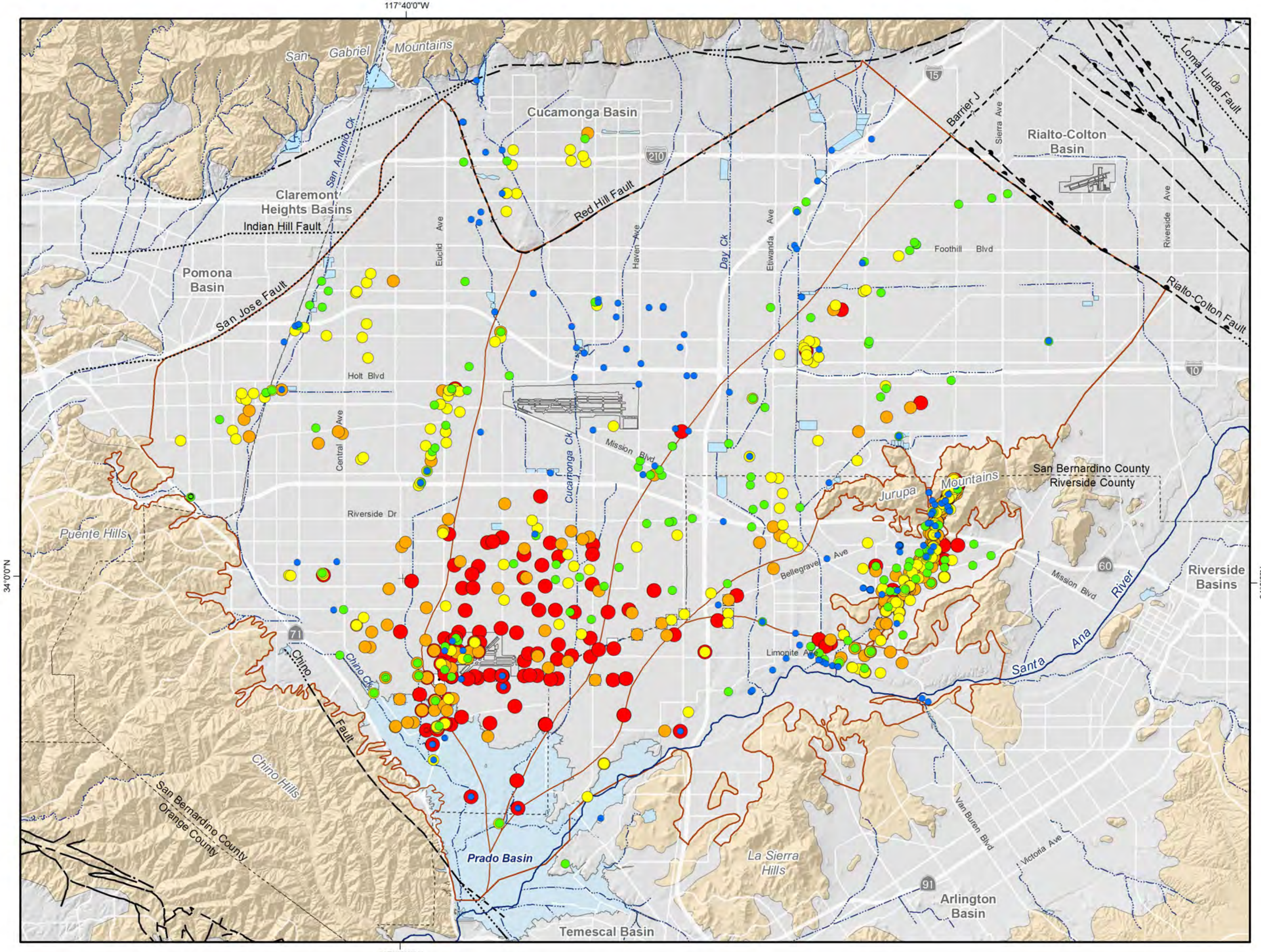
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Total Dissolved Solids (TDS) in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-3



Nitrate-N (mgl)

- ND
- < 5
- 5 - 10
- 10 - 20
- 20 - 40
- > 40

California Primary MCL = 10 mgl

Other key map features are described in the legend of Exhibit 1-1.

Nitrate is a common contaminant in groundwater and forms naturally through a process known as nitrification or is synthesized in the industrial manufacturing of fertilizers (USGS, 2017). The California primary MCL for nitrate (expressed as nitrogen) in drinking water is 10 mgl. From 2013 to 2018, nitrate was measured at 856 wells in the Basin with 839 (98 percent) of the wells having detectable concentrations. 568 wells (66 percent) have a five-year maximum concentration value that exceeds the MCL. The five-year maximum concentrations range from 0.02 to 650 mgl, with average and median concentrations of 26 and 17 mgl, respectively. The wells with the highest nitrate concentrations are predominantly located south of Highway 60 where historical agricultural land uses progressively converted from irrigated agricultural to dairies. In this area, sample results frequently exceed the MCL and often exceed 40 mgl (four times the MCL).

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-4_NO3_new_txt.mxd

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

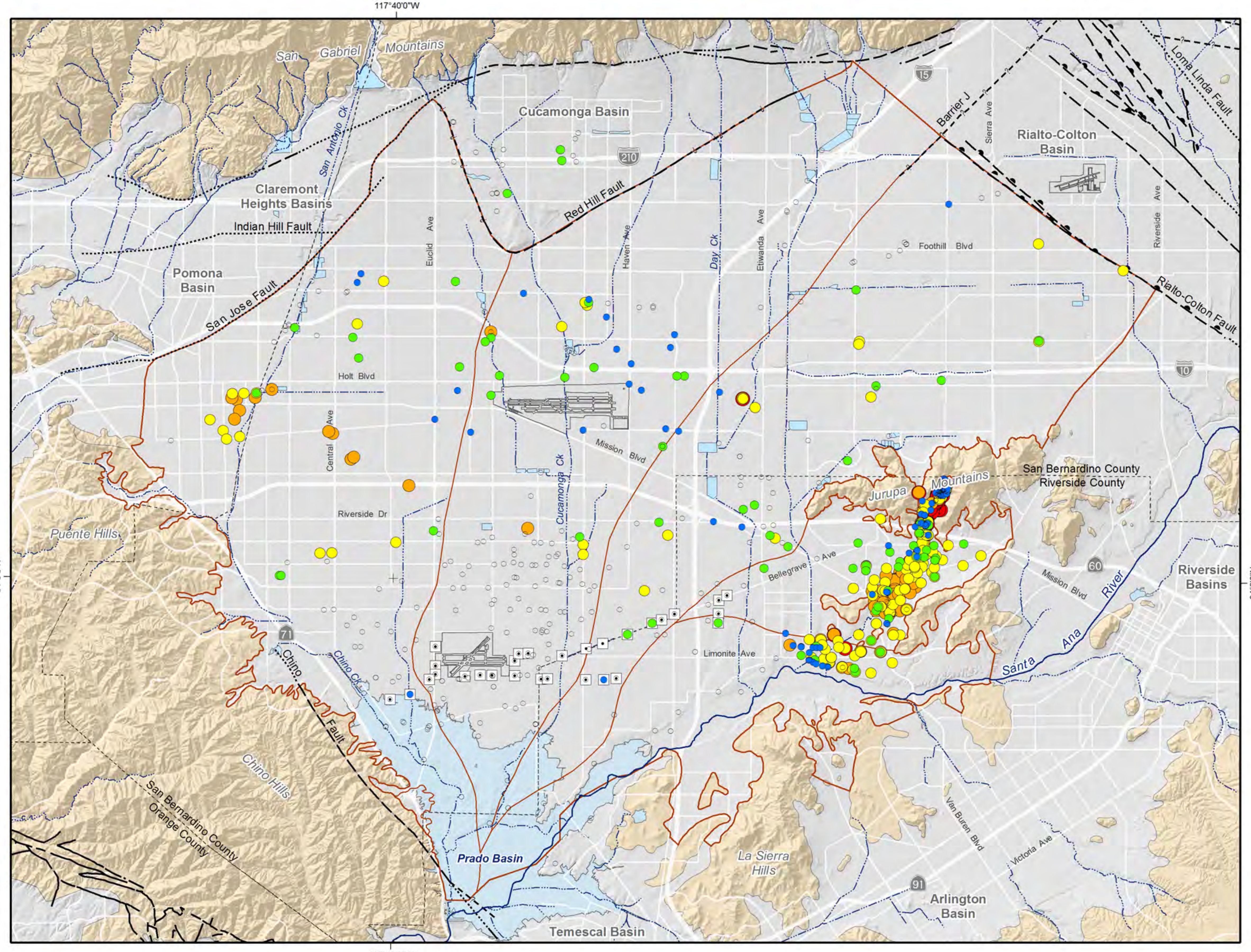
Prepared for:

2018 State of the Basin Report
Groundwater Quality

Chino Basin Watermaster
Partners in Basin Management

Nitrate (as Nitrogen) in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-4



Perchlorate (µgl)

- ND
- < 3
- 3 - 6
- 6 - 12
- 12 - 24
- > 24

California Primary MCL = 6 µgl

Other key map features are described in the legend of Exhibit 1-1.

Perchlorate is a regulated in California with a primary MCL of 6 µgl. From 2013 to 2018, perchlorate was measured at 834 wells in the Chino Basin, with 587 (70 percent) having detectable concentrations. 410 wells (49 percent) have a five-year maximum concentration that exceeds the MCL. The five-year maximum detectable concentrations range from 0.07 to 14,000 µgl, with average and median concentrations of 103 and 11 µgl, respectively. Perchlorate in groundwater can originate from synthetic and natural sources. Synthetic perchlorate, such as ammonium perchlorate, is used in the manufacturing of solid propellants for rockets, missiles, and fireworks. The majority of the wells with concentrations that are more than twice the MCL are monitoring wells associated with the Stringfellow NPL site, where a perchlorate plume of synthetic nature extends from the Jurupa Mountains downgradient to Limonite Avenue. Natural perchlorate, such as that derived from Chilean caliche used in Chilean nitrate fertilizer, was imported into the Chino Basin in the early 1900s by the citrus industry, which covered the north, west, and central portions of the Basin. A perchlorate isotope investigation performed by Watermaster in 2006 confirmed that most of the perchlorate in the west and central portions of the Basin was derived from Chilean nitrate fertilizer. In 2015, the California Office of Environmental Health Hazard Assessment (OEHHA) lowered the public health goal (PHG) for perchlorate from 6 to 1 µgl, which prompted the DDW to initiate a process to evaluate the current MCL. The State Water Resources Control Board (State Board) approved a July 2017 DDW recommendation that a lower detection limit for the purposes of reporting (DLR) be established to gather state-wide occurrence data and established that this data could be used to determine if a revision to the MCL is warranted.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-5_CLO4_new_txt.mxd

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

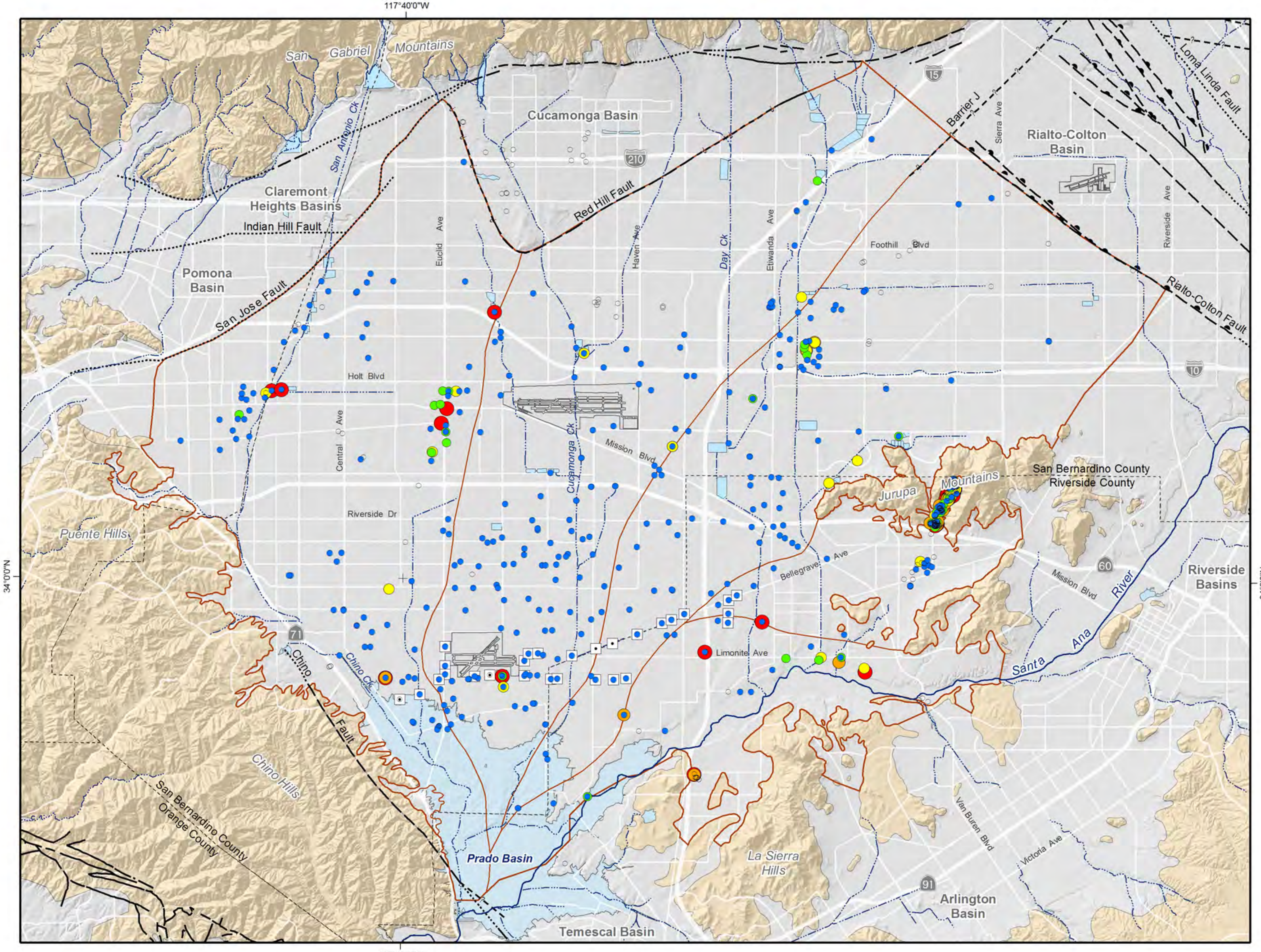
Prepared for:

2018 State of the Basin Report
Groundwater Quality

Perchlorate in Groundwater

Maximum Concentration (July 2013 to June 2018)

Exhibit 5-5



Total Chromium (µgl)

- ND
- < 25
- 25 - 50
- 50 - 100
- 100 - 200
- > 200

California Primary MCL = 50 µgl

Other key map features are described in the legend of Exhibit 1-1.

Total chromium is a regulated drinking water contaminant in California with a primary MCL of 50 µgl. Total chromium in groundwater consists of trivalent and hexavalent chromium, deriving from both natural and anthropogenic sources. Examples of anthropogenic sources include dye, paint pigments, and chrome plating liquid wastes. Most chromium in the environment exists as the trivalent ion; however, under oxidizing conditions, the hexavalent ion may form and dissolve in water (DDW, 2016). While trace amounts of trivalent chromium are required for maintaining human health, hexavalent chromium is a known carcinogen. From 2013 to 2018, 689 wells in the Chino Basin were sampled for total chromium with 583 (85 percent) having detectable concentrations. 126 wells (18 percent) have a five-year maximum concentration that exceeds the MCL. The five-year maximum concentrations range from 0.68 to 740,000 µgl, with average and median concentrations of 8,846 and 10 µgl respectively.

Prepared by:

WEI Wildermuth Environmental, Inc.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-6_Cr_new_txt.mxd

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

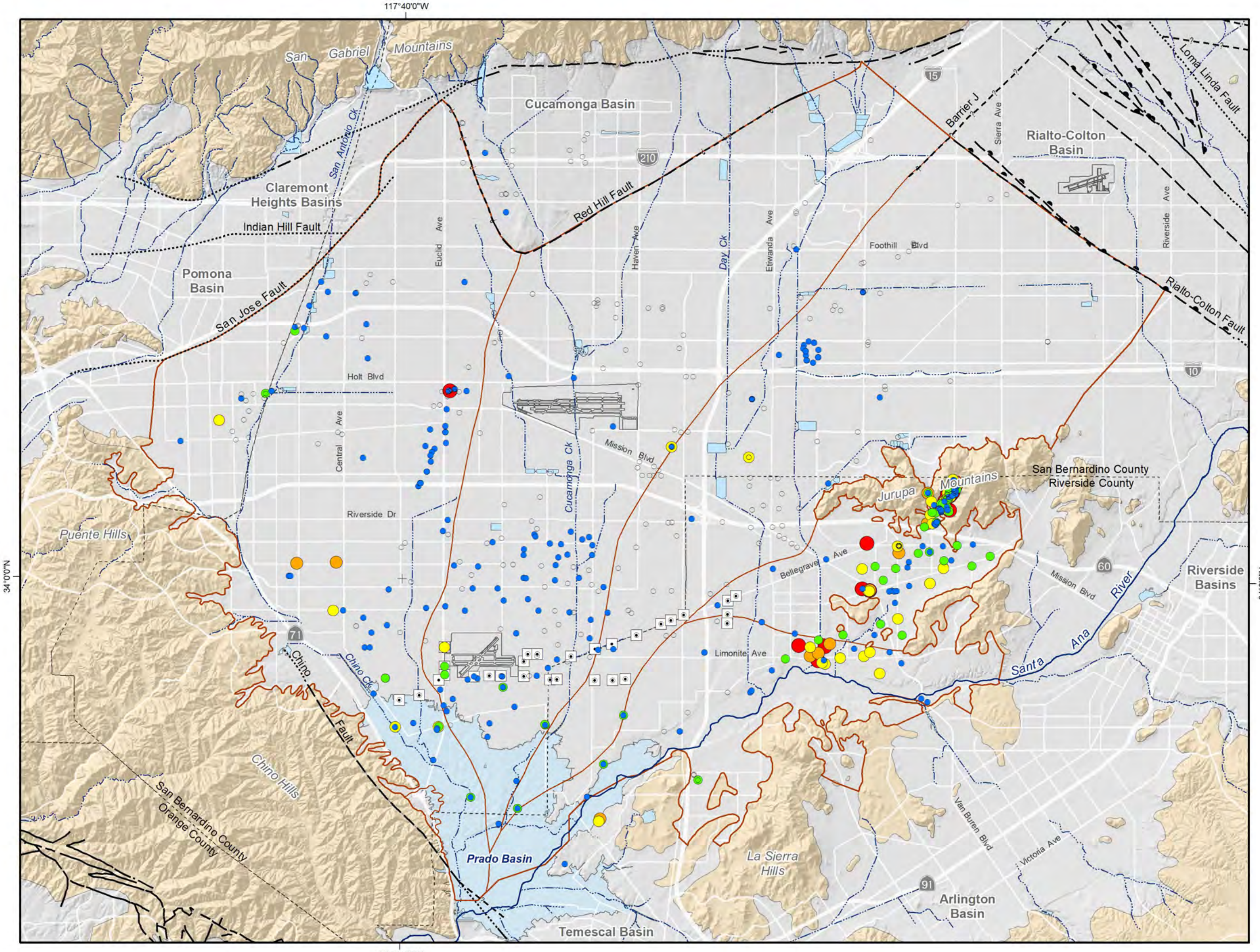
Prepared for:

2018 State of the Basin Report
Groundwater Quality

Total Chromium in Groundwater

Maximum Concentration (July 2013 to June 2018)

Exhibit 5-6



Arsenic (µgl)

- ND
- < 5
- 5 - 10
- 10 - 20
- 20 - 40
- > 40

California Primary MCL = 10 µgl

Other key map features are described in the legend of Exhibit 1-1.

Arsenic is a regulated drinking water contaminant in California with a primary MCL of 10 µgl. Arsenic in groundwater is made up of both natural and anthropogenic sources. Most anthropogenic arsenic contamination derives from manufacturing processes with significant sources from ore mining operations. Arsenic may naturally derive from bedrock weathering of arsenic-containing rock. From 2013 to 2018, 598 wells in Chino Basin were sampled for arsenic with 356, or 60%, having detectable concentrations. 84 wells (14 percent) have a five-year maximum concentration exceeding the MCL. The five-year maximum concentrations range from 0.5 to 4,200 µgl, with average and median concentrations of 40 and 3.3 µgl, respectively. Most of the exceedances occur within the general area of point source contamination sites. The higher arsenic concentrations shown in the City of Chino/Chino Hills area in the southwestern area of the Basin occur in the deeper aquifer at depths greater than about 350 ft-bgs; these higher arsenic concentrations are thought to be of natural, geologic origin.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-7_Ar_new_txt.mxd

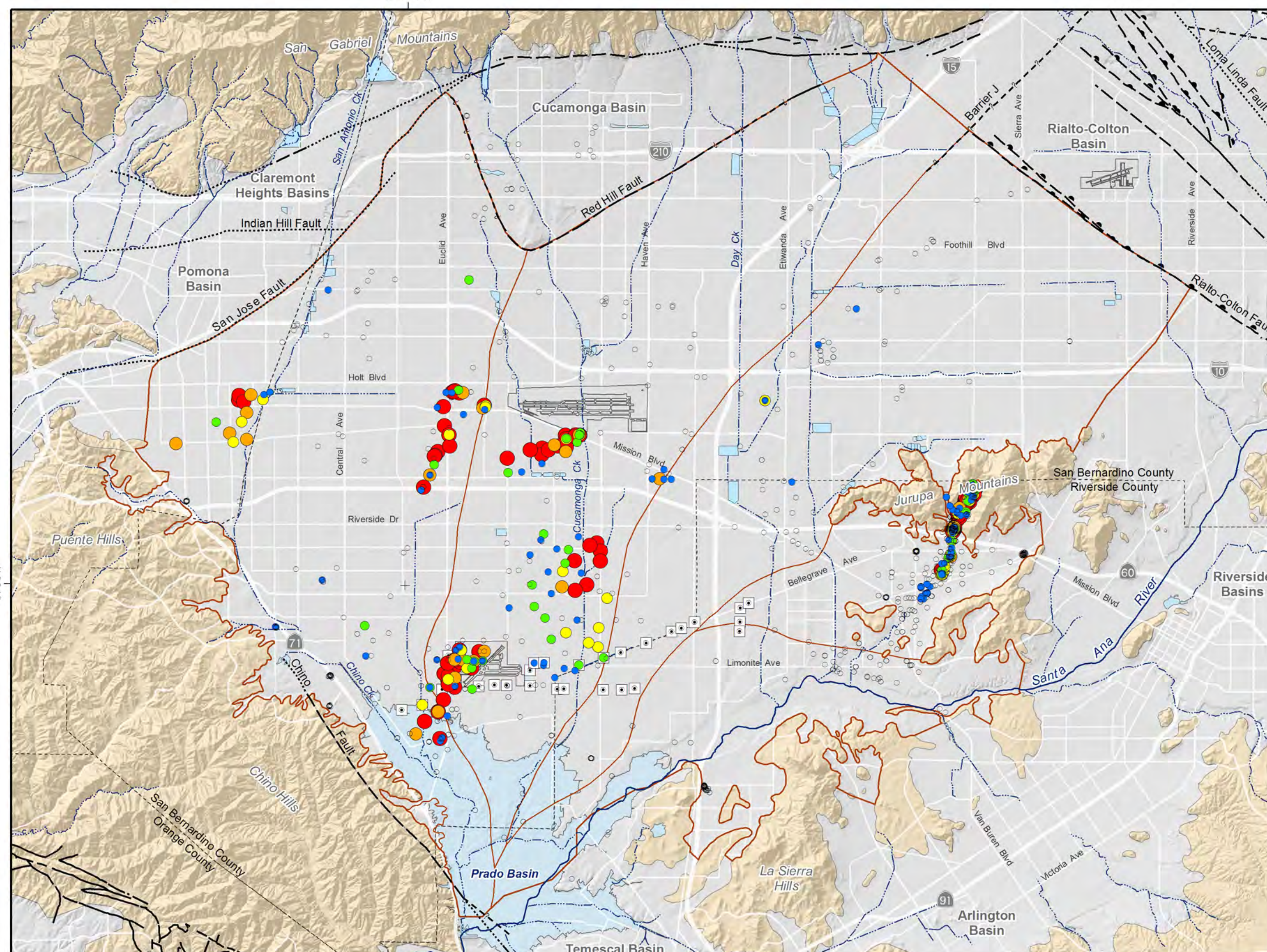
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Arsenic in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-7



TCE (µgl)

- ND
- < 2.5
- 2.5 - 5
- 5 - 10
- 10 - 20
- > 20

California Primary MCL = 5 µgl

Other key map features are described in the legend of Exhibit 1-1.

TCE is a regulated drinking water contaminant in California with a Primary MCL of 5 µgl. TCE, along with PCE, is an industrial solvent that has been widely used as a metal degreaser in the aviation, automotive, and other metal working industries. From 2013 to 2018, 1,097 wells in the Chino Basin were sampled for TCE, with 443 (40 percent) having detectable concentrations. 283 wells (26 percent) have a five-year maximum concentration exceeding the MCL. The five-year maximum concentrations range from 0.23 to 330,000 µgl, with average and median concentrations of 3,038 and 13 µgl respectively. Wells with detectable levels of TCE occur predominantly in monitoring well clusters associated with known VOC point-source contamination sites, such as the Milliken Landfill, General Electric Flatiron facility, General Electric Test Cell facility, South Archibald plume, Chino Airport, and Stringfellow NPL site.

117°40'0"W

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-8_TCE_new_txt.mxd

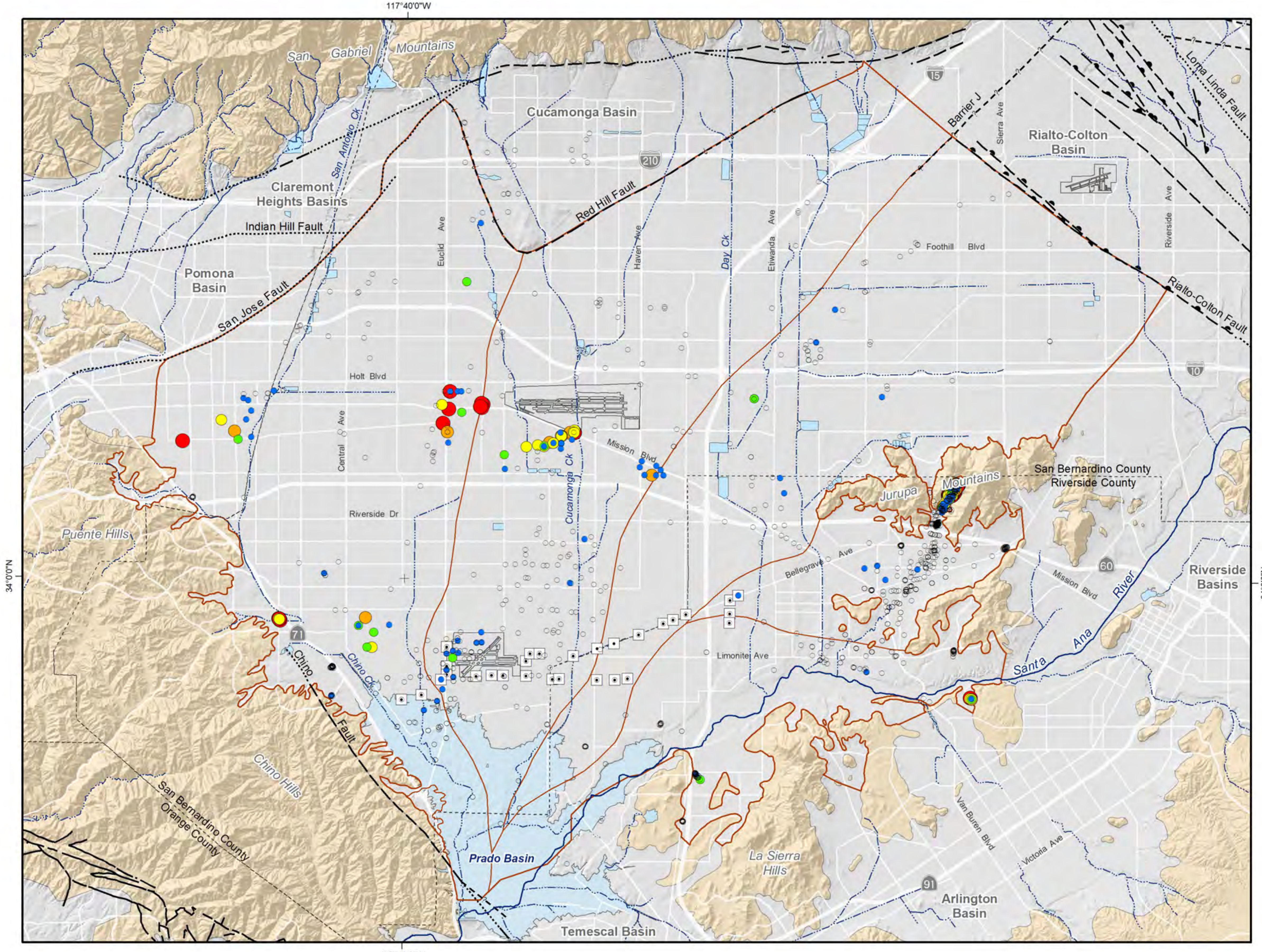
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Trichloroethene (TCE) in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-8



PCE (µgl)

- ND
- < 2.5
- 2.5 - 5
- 5 - 10
- 10 - 20
- > 20

California Primary MCL = 5 µgl

Other key map features are described in the legend of Exhibit 1-1.

PCE is a regulated drinking water contaminant in California with a Primary MCL of 5 µgl. PCE is an industrial solvent that has been widely used as a metal degreaser in the aviation, automotive, and other metal working industries. PCE is also commonly used in the dry-cleaning industry. From 2013 to 2018, 1,182 wells in Chino Basin were sampled for PCE with 231 (20 percent) having detectable concentrations. 117 wells (10 percent) have concentrations exceeding the MCL. The five-year maximum concentrations range from 0.13 to 17,000 µgl, with average and median concentrations of 228 and 5.1 µgl, respectively. Wells with detectable levels of PCE occur predominantly in well clusters associated with known VOC point-source contamination plumes, such as the Milliken Landfill, General Electric Flatiron Facility, General Electric Test Cell Facility, Alger Manufacturing Facility, Chino Airport, California Institute for Men (CIM), former Crown Coach Facility, and Stringfellow NPL site.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-9_PCE_new_txt.mxd

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

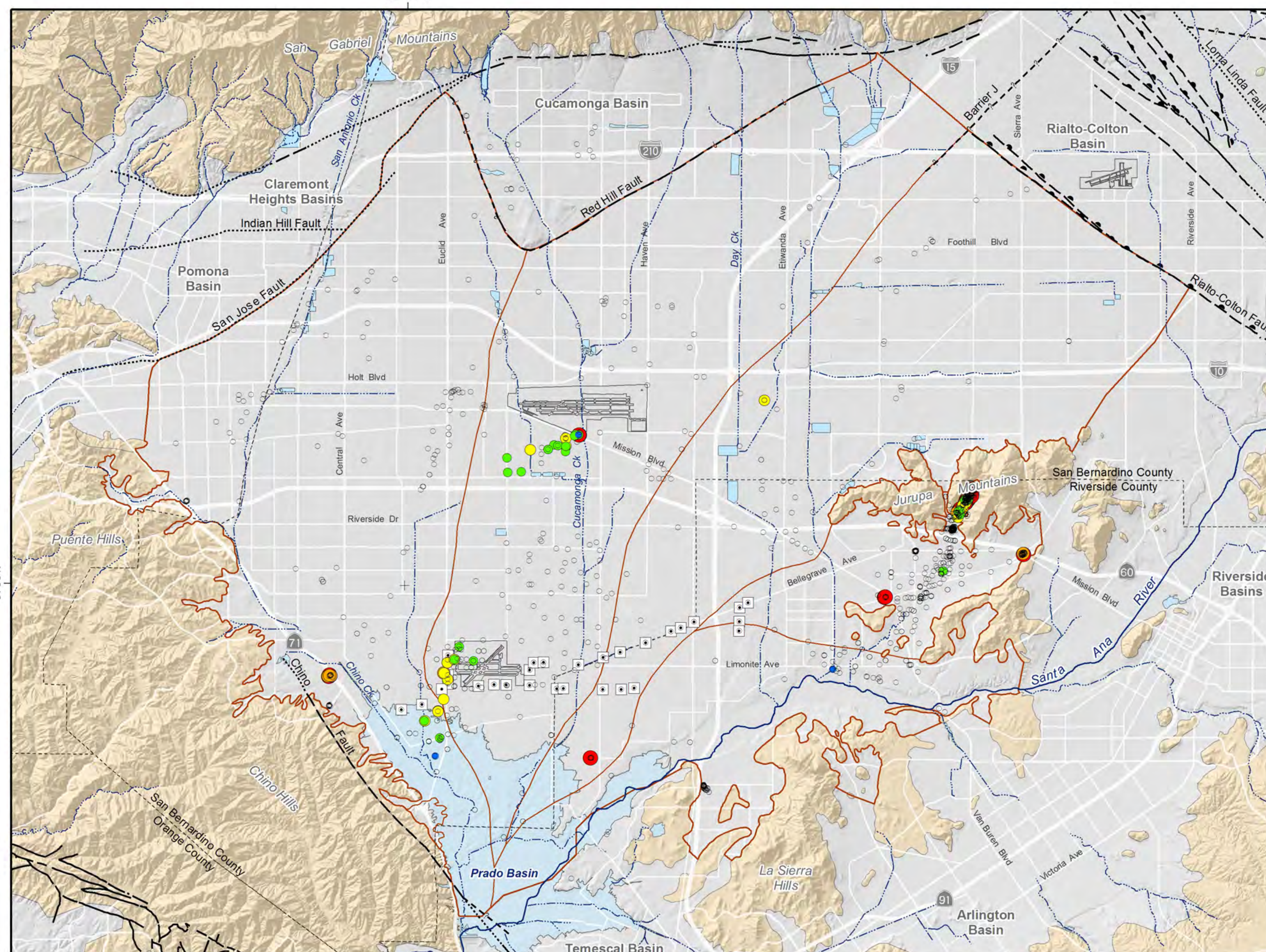
Prepared for:

2018 State of the Basin Report
Groundwater Quality

Tetrachloroethene (PCE) in Groundwater

Maximum Concentration (July 2013 to June 2018)

Exhibit 5-9



1,2-DCA (µgl)

- ND
- < 0.25
- 0.25 - 0.50
- 0.5 - 1
- 1 - 2
- > 2

California Primary MCL = 0.5 µg/L

Other key map features are described in the legend of Exhibit 1-1.

1,2-DCA is a regulated drinking water contaminant in California with a Primary MCL of 0.5 µgl. 1,2-DCA is used in the manufacturing of plastics and rubber (typically as an intermediate chemical for the production of vinyl chloride) and is a common component of certain soil fumigants used for agriculture. From 2013 to 2018, 1,080 wells in Chino Basin were sampled for 1,2-DCA with 89 (8 percent) having detectable concentrations. 62 wells (6 percent) have concentrations exceeding the MCL. The five-year maximum concentrations range from 0.24 to 52 µgl, with average and median concentrations of 4.2 and 0.8 µgl, respectively. Wells with detectable levels of 1,2-DCA occur predominantly in monitoring well clusters associated with known VOC point-source contamination sites, such as the General Electric Test Cell Facility, Chino Airport, and Stringfellow NPL site.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: VW
Date: 5/28/2019
File: 2018_Exhibit_5-10_1,2DCA_new txt.mxd

0 1 2 3 4 5 Miles

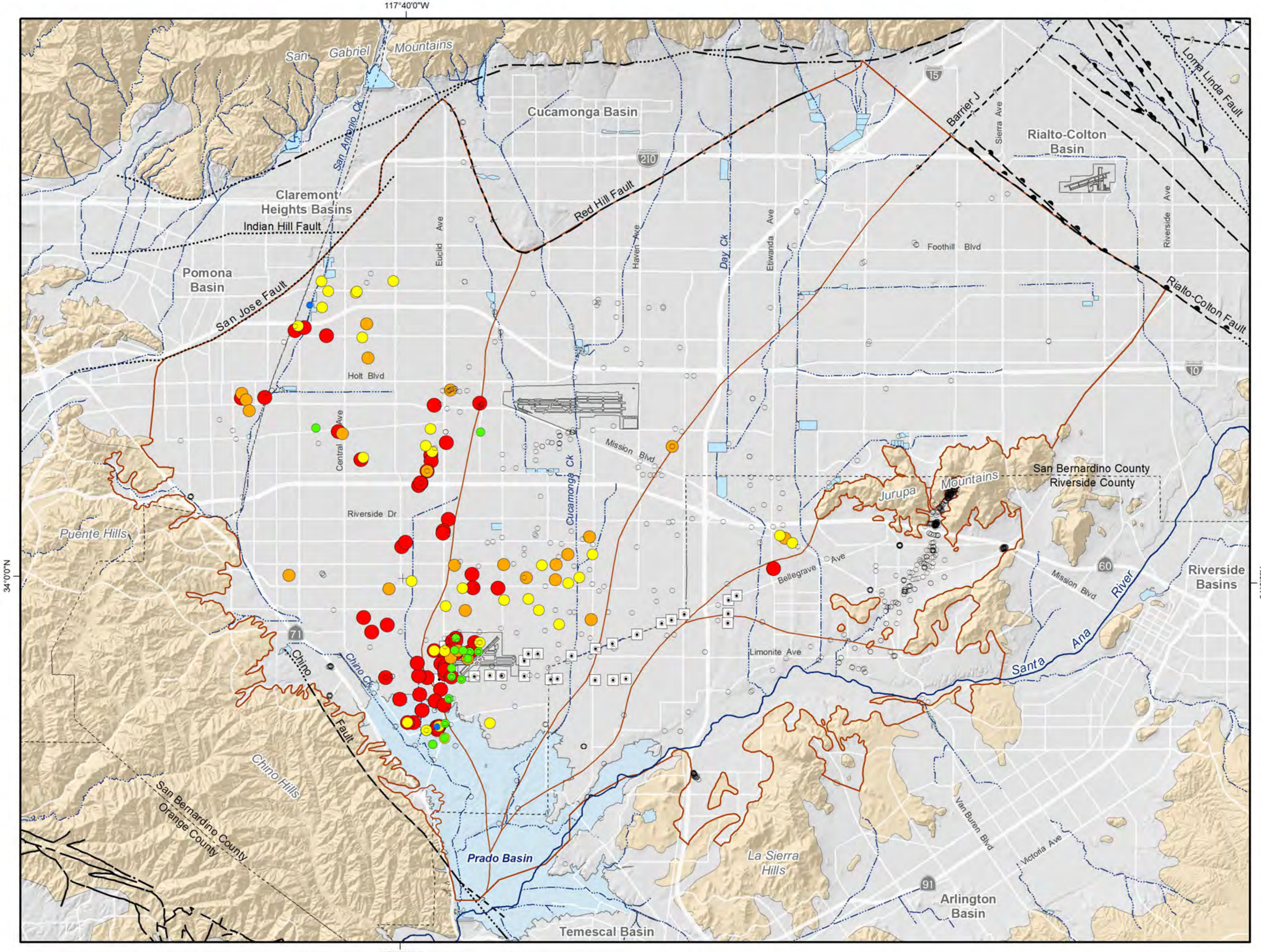
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

1,2-Dichloroethane (1,2-DCA) in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-10



1,2,3-TCP (µgl)

- ND
- < 0.0025
- 0.0025 - 0.005
- 0.005 - 0.01
- 0.01 - 0.02
- > 0.02

California Primary MCL = 0.005 µgl

Other key map features are described in the legend of Exhibit 1-1.

In December 2017, California adopted a Primary MCL for 1,2,3-TCP of 0.005 µgl, which was equivalent to the California NL established in 1999. 1,2,3-TCP was used historically as a solvent, an extractive agent, a paint remover, a cleaning and degreasing agent, and in the manufacturing of soil fumigants for agriculture. From 2013 to 2018, 953 wells in the Chino Basin were sampled for 1,2,3-TCP, with 128 (13 percent) having detectable concentrations. 112 wells (12 percent) have concentrations exceeding the MCL. The five-year maximum concentrations range from 0.0021 to 44 µgl, with average and median concentrations of 1.8 and 0.023 µgl, respectively. There is a 1,2,3-TCP plume that emanates from Chino Airport, and it has comingled with the Chino Airport TCE plume. The concentrations of 1,2,3-TCP measured in the Chino Airport plume are one to two orders of magnitude greater than the concentrations measured at wells north of the Chino Airport. The detections of 1,2,3-TCP north of the Chino Airport are likely the result of the application of soil fumigants to crops.

Although 953 wells were tested over the reporting period, this reporting period is not the most accurate representation of the occurrence of 1,2,3-TCP relative to the MCL due to the use of laboratory analytical methods with detection limits significantly greater than MCL. Exhibit 5-12 characterizes the history of the monitoring and understanding of the occurrence of 1,2,3-TCP in the Chino Basin from 2001 through 2018.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-11_TCP_new_txt.mxd

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

Prepared for:

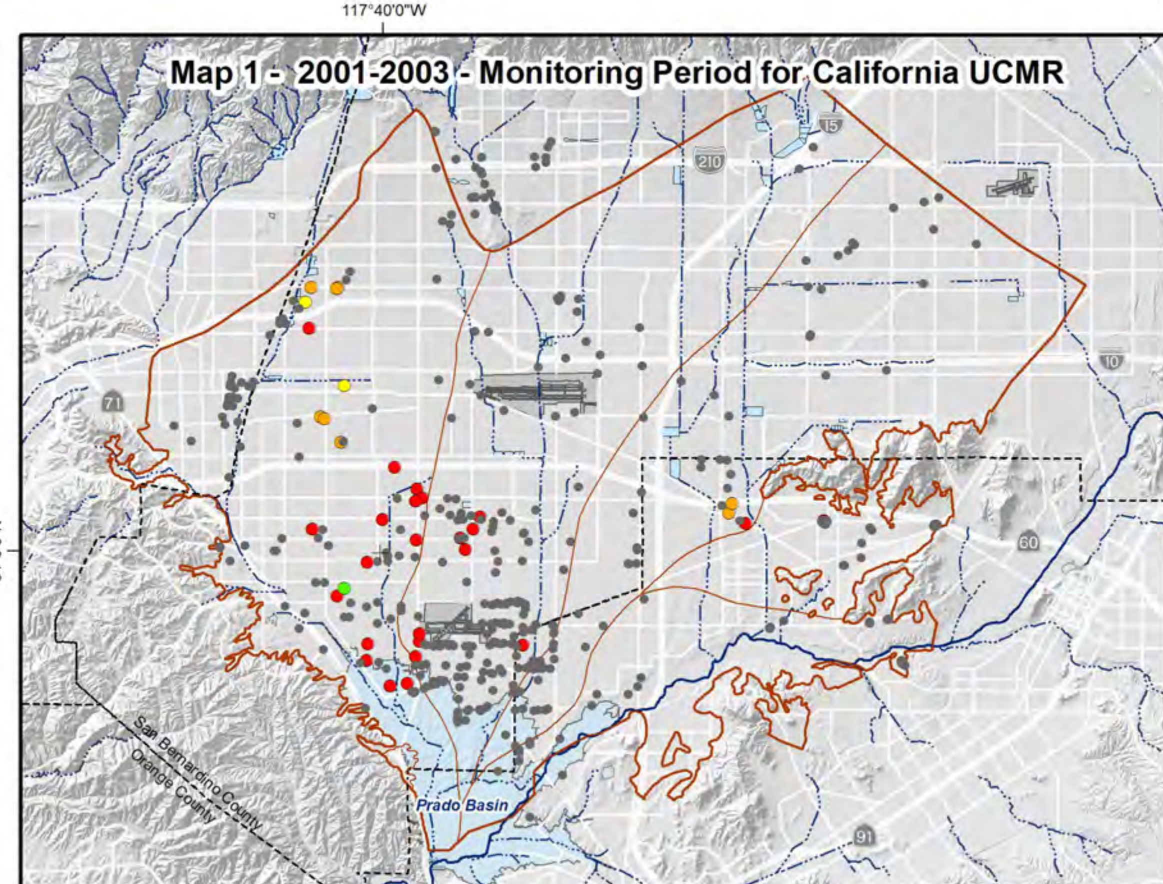
2018 State of the Basin Report
Groundwater Quality

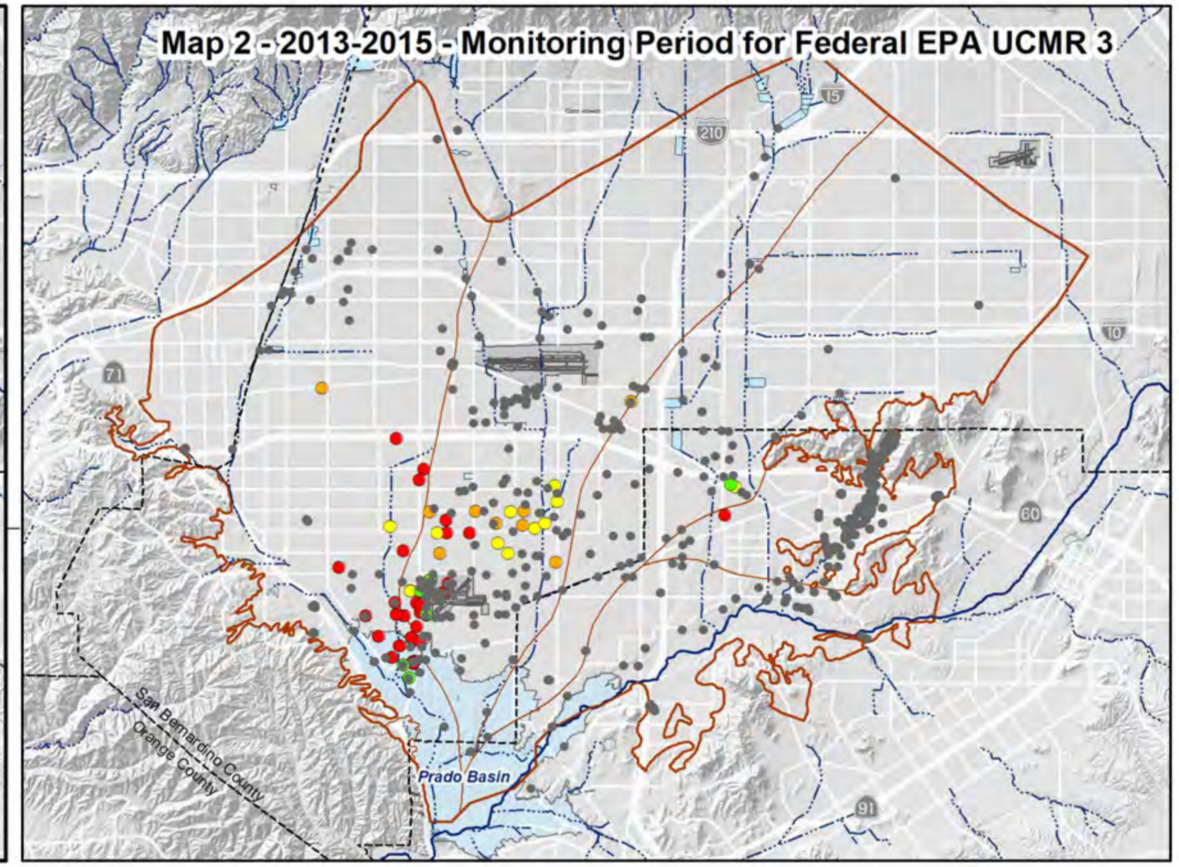
Chino Basin Watermaster — Partners in Basin Management

1,2,3-Trichloropropane (1,2,3-TCP) in Groundwater

Maximum Concentration (July 2013 to June 2018)

Exhibit 5-11



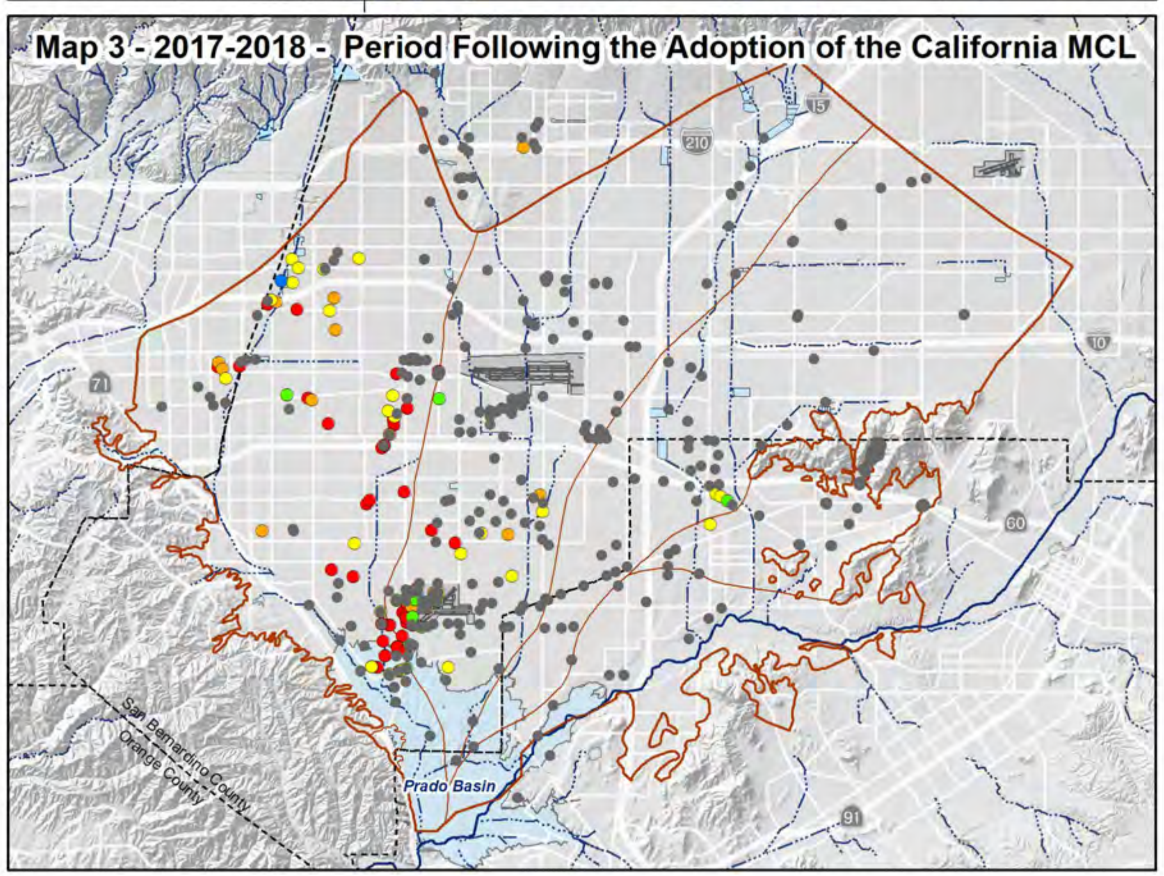


1,2,3-TCP (µgl)

- ND
- < 0.0025
- 0.0025 - 0.005
- 0.005 - 0.01
- 0.01 - 0.02
- > 0.02

California Primary MCL = 0.005 µgl

Other key map features are described in the legend of Exhibit 1-1.



This exhibit characterizes the history of the monitoring and known occurrence for 1,2,3-TCP in the Chino Basin for three required monitoring periods between the adoption of the NL in 1999 through the MCL compliance period in 2018.

Map 1 (2001-2003): CA established a NL of 0.005 µgl in 1999. Following the establishment the NL, 1,2,3-TCP was included on California's Unregulated Contaminant Monitoring Rule (UCMR) sampling list (Title 22 of the California Code of Regulations [CCR], §66450) to collect data from municipal wells from 2001 to 2003. The CA UCMR monitoring effort was initiated before the availability of a laboratory analytical method that could test 1,2,3-TCP concentrations at detection limits equivalent to the NL. An analytical method to test 1,2,3,-TCP to a DLR of 0.005 µgl became available near the end of the UCMR sampling period. In the Chino Basin, some water systems tested their wells using laboratory methods with a 0.5 µgl DLR (100 times greater than the NL) and some monitored using the new method with the 0.005 µgl DLR. Findings of non-detect based on the 0.5 µgl DLR did not provide adequate information on the occurrence of 1,2,3-TCP relative to the NL.

Map 2 (2013-2015): In May 2012, the Federal Environmental Protection Agency (EPA) released its UCMR 3 constituent list, which required nation-wide sampling of 1,2,3-TCP between 2013 and 2015. UCMR 3 did not require the use of the 0.005 µgl DLR analytical method and only required monitoring at a small subset of municipal drinking water wells. Some supply agencies performed additional sampling following the completion of UCMR 3 using laboratory methods with the 0.005 µgl DLR. Watermaster began using the 0.005 µgl DLR method for its monitoring programs in the southern Chino Basin in 2008. This map represents the understanding of the occurrence of 1,2,3-TCP just before the adoption of an MCL. Due to continued use of the higher DLR methods, there was still inadequate information on the occurrence of 1,2,3-TCP relative to the NL in the Chino Basin.

Map 3 (2017-2018): During 2017, some water systems sampled for 1,2,3-TCP at the 0.005 µgl DLR in anticipation of the adoption of the MCL. In December 2017, the MCL of 0.005 µgl went into immediate effect and pursuant to Title 22 of the CCR, §64445, water systems were required to initiate quarterly compliance monitoring for 1,2,3-TCP at active drinking water supply wells using laboratory methods with the 0.005 µgl beginning in January 2018. The 1,2,3-TCP sample results collected from 2017-2018 are the best characterization of the occurrence of 1,2,3-TCP in the Chino Basin relative to the MCL.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: VW
Date: 6/18/2019
Document Name: 2018_Exhibit_5-12_123TCP_Historical_new_txt

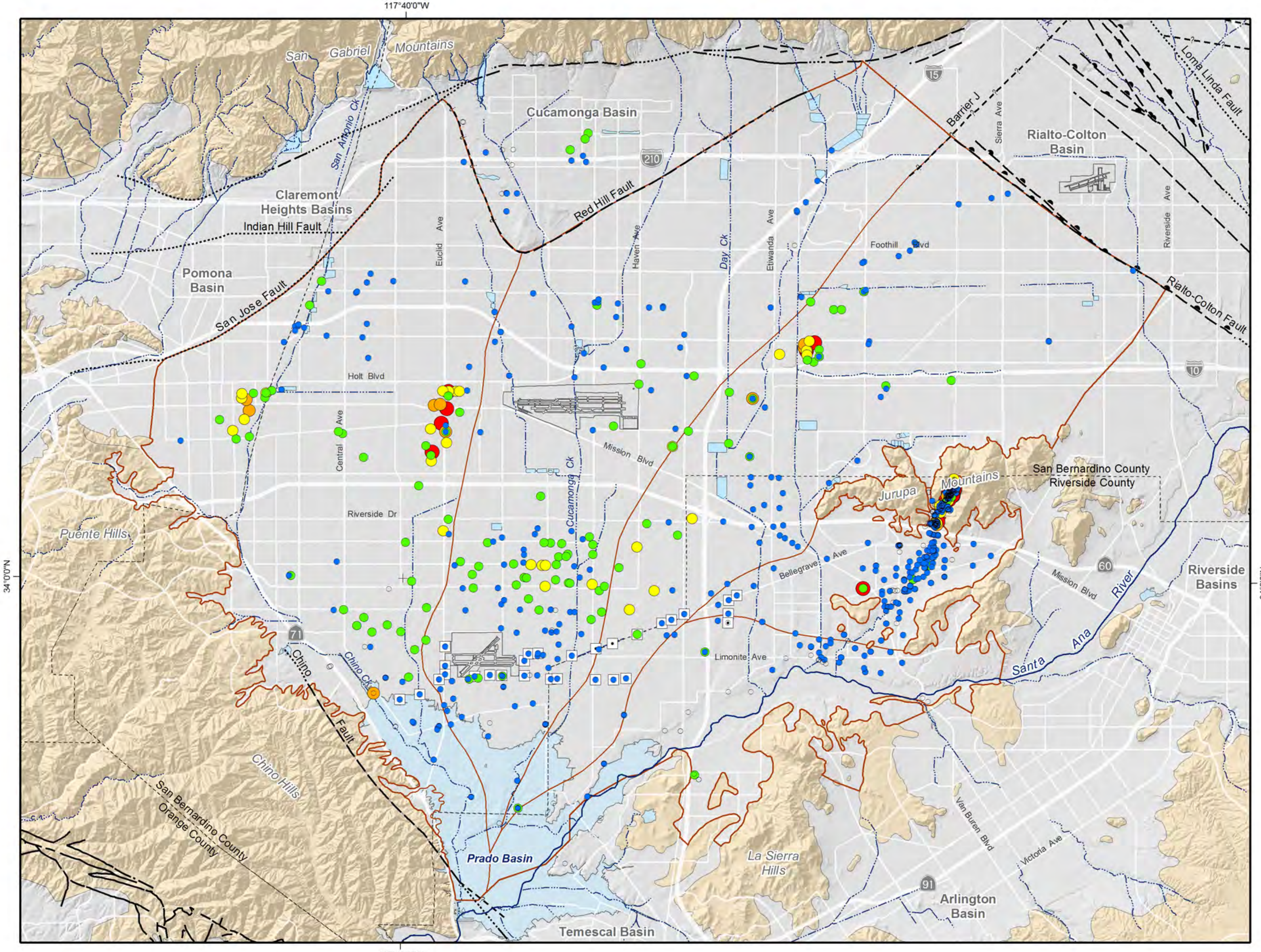
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:
2018 State of the Basin Report
Groundwater Quality

Historical Monitoring and Occurence of 1,2,3-TCP in Groundwater

2001 to 2018

Exhibit 5-12



In July 2014, the California DDW adopted a Primary MCL for hexavalent chromium of 10 µgl and required that all public drinking water supply wells be sampled for hexavalent chromium within six months. In 2016, the MCL was challenged in court by the California Manufacturers and Technology Association and the Solano County Taxpayers Association; they petitioned that the MCL concentration was too low to allow for economically feasible compliance (Superior Court of California, County of Sacramento; case #34-2015-80001850). In 2017, the Superior Court of Sacramento County issued a judgment invalidating the MCL for hexavalent chromium because the DDW failed to properly consider the economic feasibility of complying with the MCL. The court ordered the DDW to establish and adopt a new MCL, which could be the same or different from the invalidated MCL of 10 µgl. The DDW expects that the data obtained since 2014 from mandatory monitoring will enable them to adopt a new MCL more promptly.

From 2013 to 2018, 884 wells in the Chino Basin were sampled for hexavalent chromium with 777 (89 percent) having detectable concentrations. 92 wells (12 perecent), have a five-year maximum concentration exceeding 10 µgl. The five-year maximum hexavalent chromium concentrations range from 0.01 to 14,000 µgl, with average and median concentrations of 59 and 2.6 µgl, respectively. The highest observed concentrations of hexavalent chromium are at wells associated with the GE Flatiron

Prepared by:

WEI Wildermuth Environmental, Inc.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-13_HexCr_new_txt.mxd

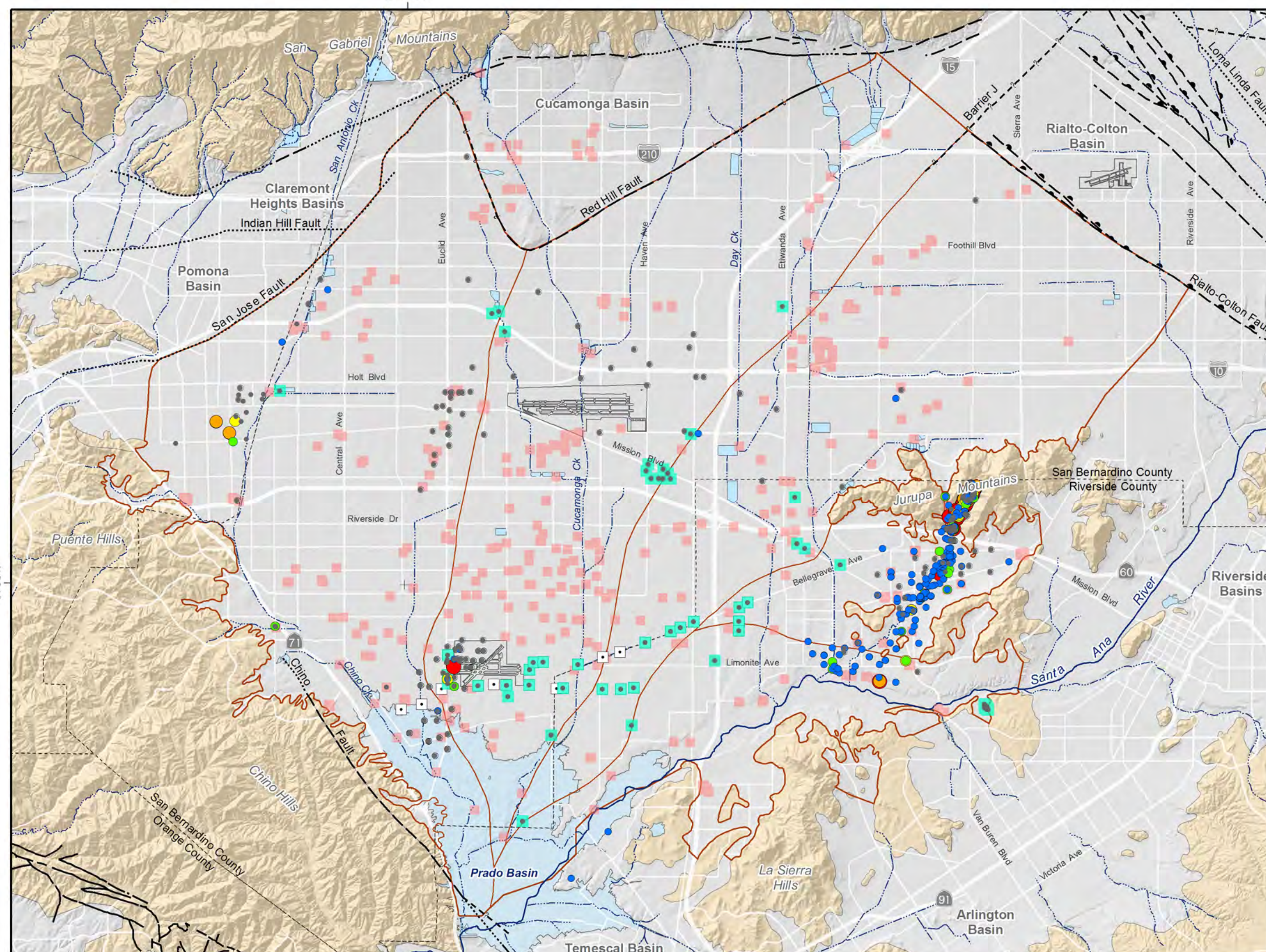
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Hexavalent Chromium in Groundwater
Maximum Concentration (July 2013 to June 2018)

Exhibit 5-13



1,4-Dioxane (μgl)

- ND
- < 0.50
- 0.50 - 1
- 1 - 2
- 2 - 5
- > 5

California NL = 1 μgl

- Well Sampled for 1,4-Dioxane but the Method Detection Limit was Greater than the NL of 1 μgl
- Well Has Not Been Sampled for 1,4-Dioxane

Other key map features are described in the legend of Exhibit 1-1.

1,4-dioxane is an industrial solvent commonly used as a stabilizer for other solvents, specifically 1,1,1-trichloroethane (1,1,1-TCA). In 2010, the California NL for 1,4-dioxane was lowered from 3 to 1 μgl. 1,4-dioxane is a contaminant of emerging concern that is not commonly monitored for in the Chino Basin, and when monitoring is performed, it is not always done using laboratory methods with a DLR that is lower than or equivalent to the NL. This exhibit characterizes the monitoring and occurrence of 1,4-dioxane in the Chino Basin that has occurred for the entire period of record of available data (July 1998 through June 2018) and identifies which wells have yet to be tested using a 1 μgl DLR. Over the period of record, 730 wells in the Chino Basin were tested for 1,4-dioxane with 429 (59 percent) having detectable concentrations. 163 wells (22 percent) have concentrations exceeding the NL. The maximum concentrations ranged from 0.1 to 820 μgl, with average and median concentrations of 18 and 0.5 μgl, respectively. Of the 301 wells with "non-detect" results, 95 (31 percent) were tested using laboratory methods with a DLR higher than 1 μgl. Most of the wells with sample results for 1,4-dioxane are associated with known point-source contamination plumes.

Currently there are about 1,150 water supply wells or monitoring wells in the Chino Basin that are sampled for water quality analyses. 614 wells (53 percent) have never been sampled for 1,4-dioxane, and 65 (6 percent) were tested using the laboratory methods with DLRs higher than the NL of 1 μgl. Thus, the occurrence of 1,4-dioxane in the Chino Basin relative to the NL of 1 μgl has not been fully characterized, and the impact of the potential future establishment of a primary MCL equivalent to the NL is unquantifiable.

Prepared by:

WEI Wildermuth Environmental, Inc.

Author: VMW
Date: 5/28/2019
File: 2018_Exhibit_5-14_1,4Dx.mxd

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

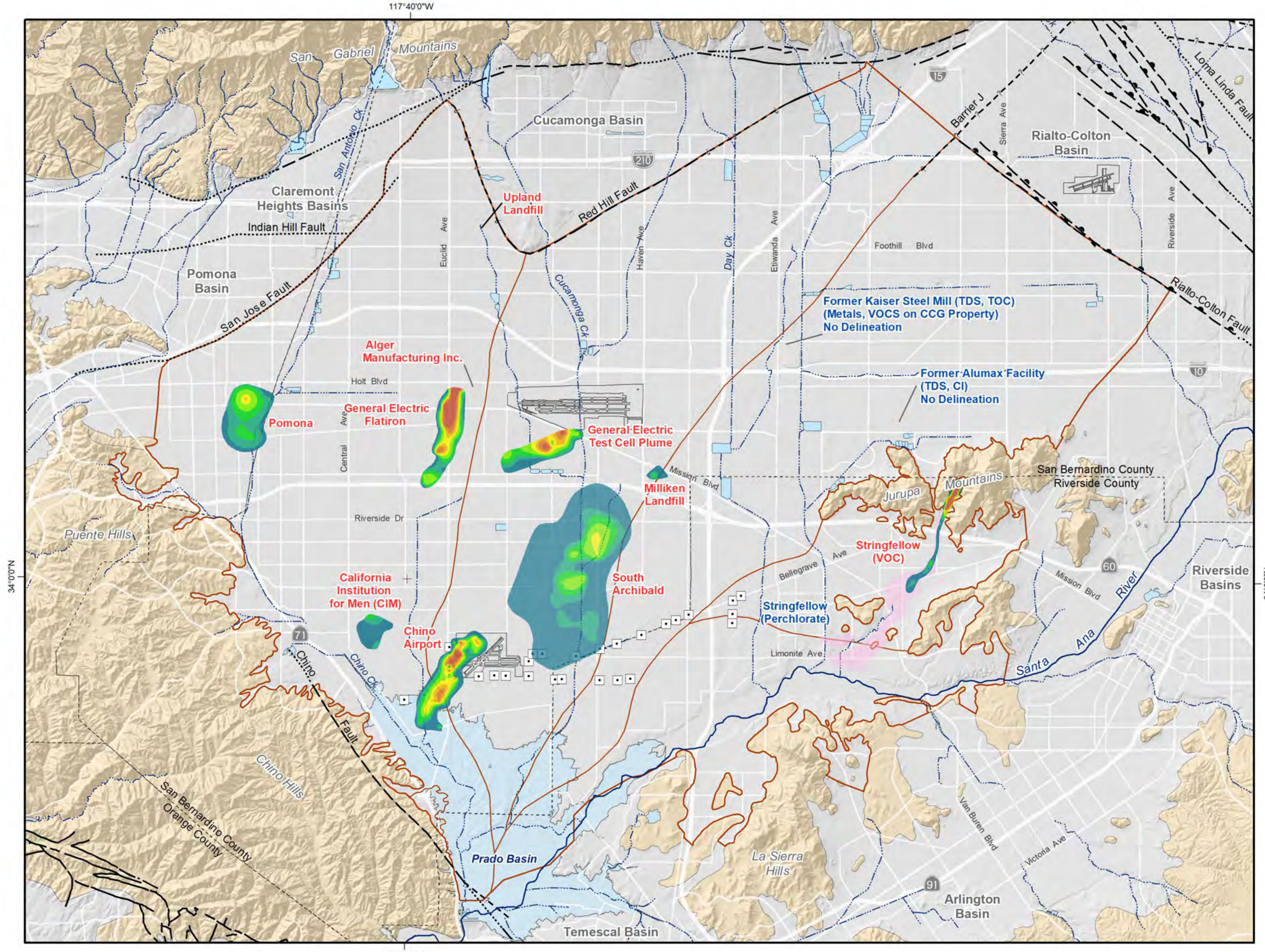
Prepared for:

2018 State of the Basin Report
Groundwater Quality

1,4-Dioxane in Groundwater

Maximum Concentration (July 1998 to June 2018)

Exhibit 5-14



VOC Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

The VOC plumes shown on this map are generalized illustrations of the estimated spatial extent of TCE or PCE, based on the maximum concentration measured at wells over the five-year period of July 2013 to June 2018. The VOC plume illustrations were created with the grid function in Golden Software's Surfer 16 using an ordinary kriging interpolation model with model input parameter estimation and optimization performed by semivariogram analysis in Golden Software's Surfer 16. Interpretations of the plume extent and boundary delineation were made based on measured concentrations and local groundwater flow patterns as predicted by the Chino Basin groundwater flow model.

VOC Plumes Labeled in Red by Name

Other Plumes - Labeled in Blue by Name and Dominant Contaminant

The plumes characterized by color ramp represent Watermaster's most recent characterization of the primary contaminant of concern. The spatial extent of the VOC contamination was delineated by Watermaster based on the five-year maximum concentrations of the primary contaminant of concern for the period of July 2013 to June 2018. The primary VOC contaminant of concern in all of the plumes is TCE with the exception of the CIM plume, which is PCE. The VOC plumes associated with the Upland Landfill and the Alger Manufacturing Facility are of limited geographical extent at the scale of this map, so only their general locations are identified.

Other point-source contamination plumes in the Chino Basin include the former Kaiser Steel Mill, the former Alumax Facility, and the Stringfellow NPL Site, which are labeled by name and the primary contaminants associated with the sites. The former Kaiser Steel Mill TDS and total organic carbon (TOC) plume has not been delineated since 2008 (WEI, 2008b), and there are no plume delineations for the contamination associated with the former Kaiser Steel Mill CCG Property for metals and VOCs or the former Alumax Facility for TDS and chloride (Cl). The Stringfellow perchlorate plume shown here was delineated in the most recent remediation evaluation report for the site (Kleinfelder, 2018).

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 6/18/2019
File: 2018_Exhibit_5-15_Plumes_new_txt.mxd

0 1 2 3 4 5 Miles

0 2 4 6 8 Km

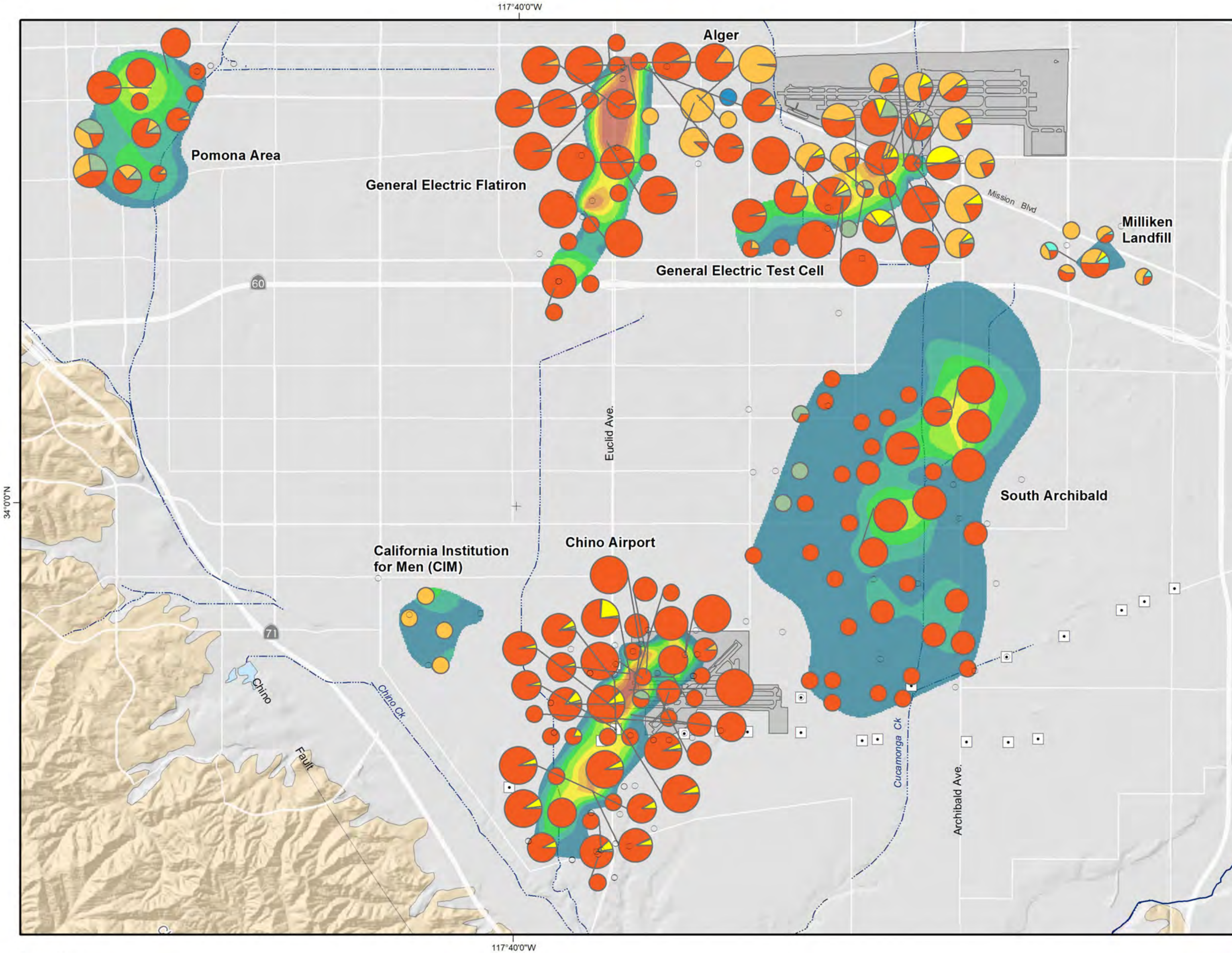
Prepared for:

2018 State of the Basin Report
Groundwater Quality

Chino Basin Watermaster — Partners in Basin Management

Delineation of Groundwater Contamination
Plumes and Point Sources of Concern

Exhibit 5-15



Percent of Detectable TCE, PCE, and their Degradation By-Products During the Last Sample

- 1,1,1-Trichloroethane
- 1,1-Dichloroethane
- 1,1-Dichloroethene
- 1,2-Dichloroethane
- cis-1,2-Dichloroethene
- Tetrachloroethene (PCE)
- trans-1,2-Dichloroethene
- Trichloroethene (TCE)
- Vinyl Chloride

Sample Size (Based on the Sum of TCE, PCE, and their Degradation By-Products (µgl)

- 0.01 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- > 50

Well with Non-Detect Results for VOCs During Last Sample Event

These composition pie charts show the relative percentages of VOCs measured at wells within each of the VOC plumes shown on Exhibit 5-15. The data used to create the charts are based on the results from the most recent sampling event over the five-year period of July 2013 to June 2018. The chemical differentiation of these plumes can be understood by comparing the proportions of TCE, PCE, and their breakdown by-products. For example, the Milliken Landfill plume and the General Electric Test Cell plume north of the Ontario Airport have significant concentrations of both TCE and PCE and the presence of breakdown products, whereas the South Archibald plume is predominantly comprised of TCE. This demonstrates that there is no intermingling of these plumes.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: AP
Date: 6/18/2019
File: 2018_Exhibit_5-16_PieChart_new_txt.mxd

0 0.25 0.5 0.75 1 2 Miles

0 0.5 1 1.5 2 4 Km

Prepared for:

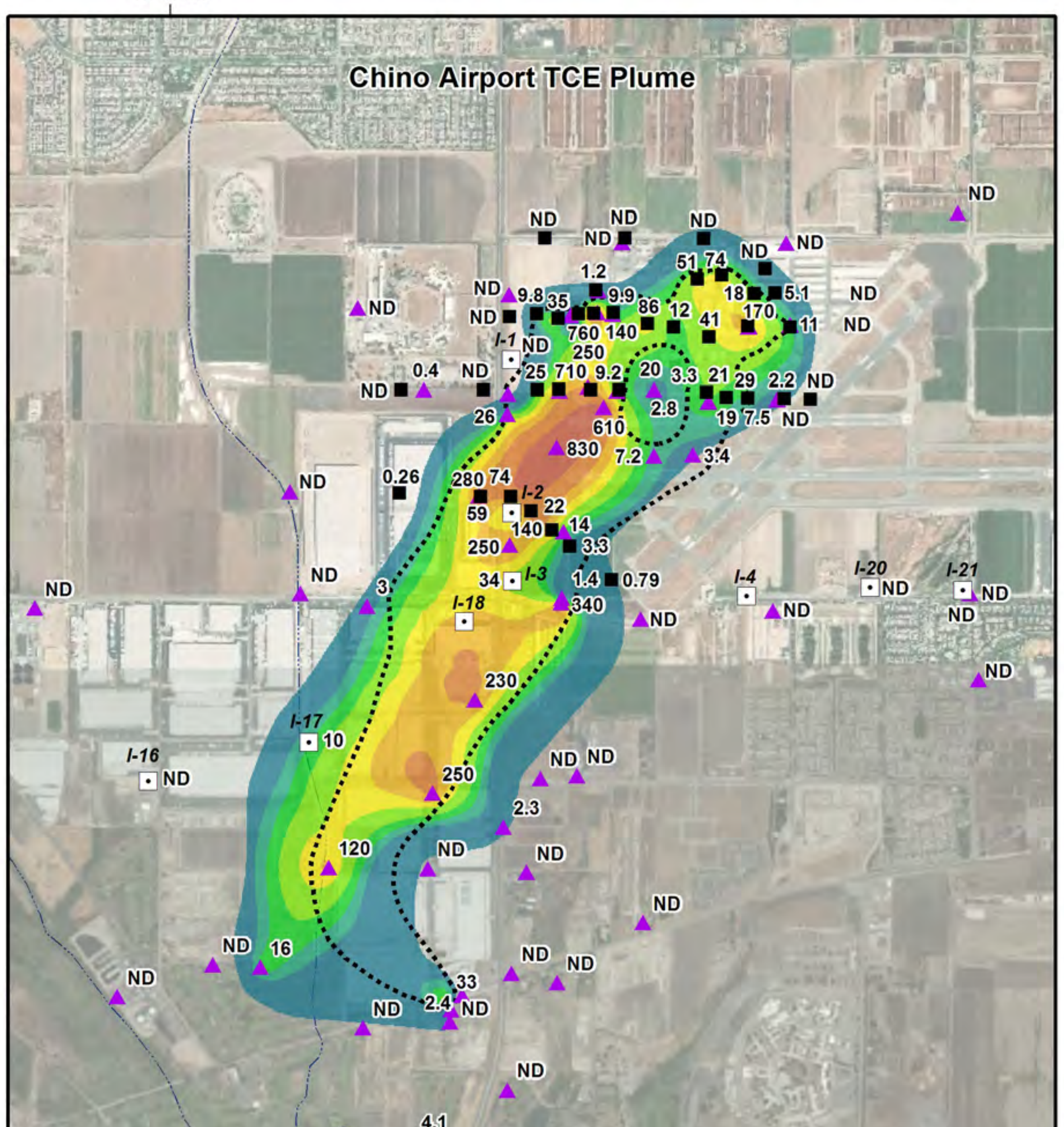
2018 State of the Basin Report
Groundwater Quality

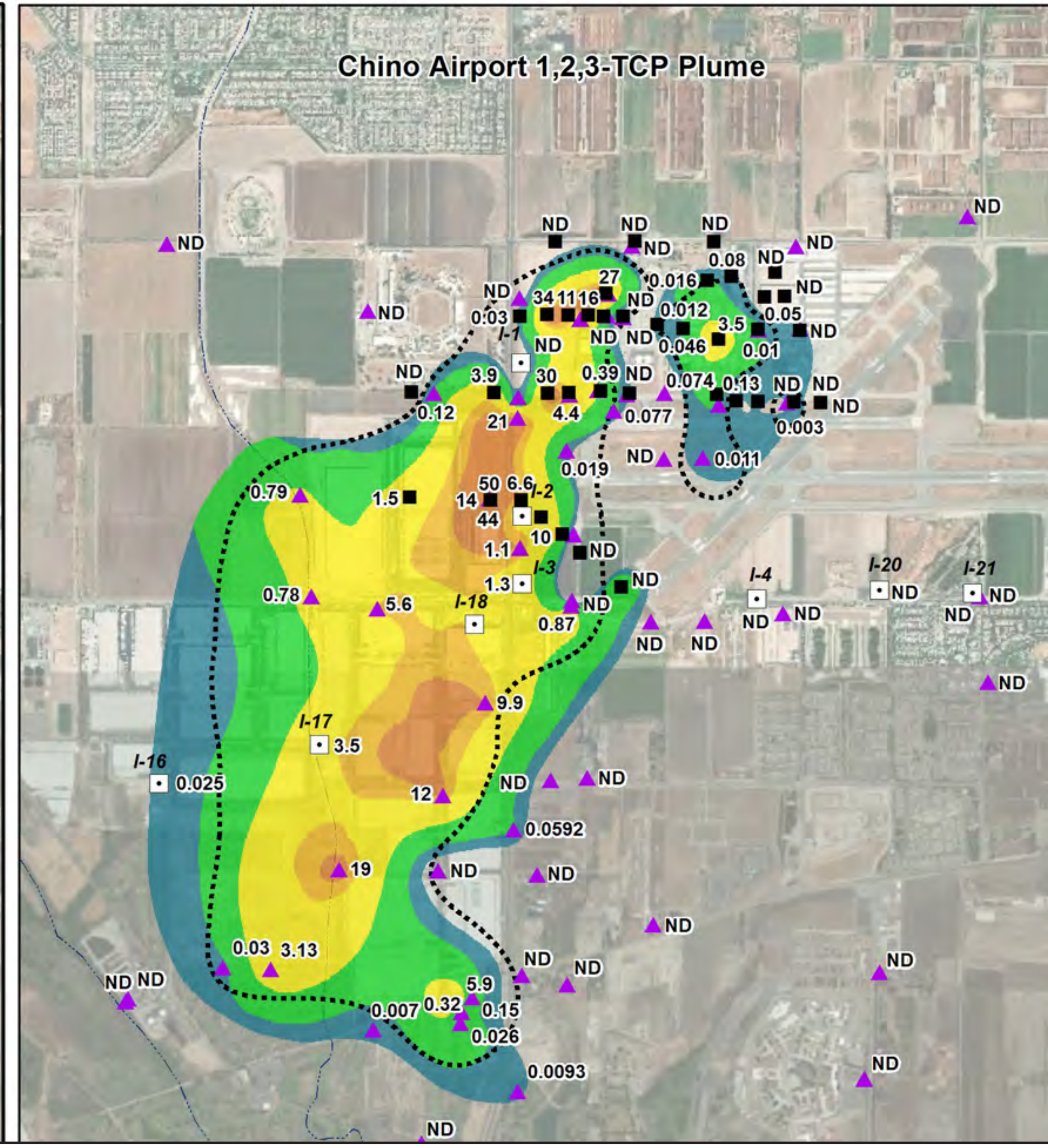
Chino Basin Watermaster
Partners in Basin Management

VOC Composition Charts

Wells Within and Adjacent to VOC Plumes

Exhibit 5-16





TCE Concentration (µgl)
> 0 to ≤ 5
> 5 to ≤ 10
> 10 to ≤ 20
> 20 to ≤ 50
> 50 to ≤ 100
> 100 to ≤ 200
> 200 to ≤ 500
> 500

1,2,3-TCP Concentration (µgl)
> 0.005 to ≤ 0.05
> .05 to ≤ .5
> .5 to ≤ 5
> 5 to ≤ 10
>10 to ≤100

TCE MCL = 5 µgl

1,2,3-TCP MCL = 0.005 µgl

The VOC plumes shown on this map are generalized illustrations of the estimated spatial extent of TCE and 1,2,3-TCP, based on the maximum concentration measured at wells over the five-year period of July 2013 to June 2018. The VOC plume illustrations were created with the grid function in Golden Software's Surfer 16 using an ordinary kriging interpolation model with model input parameter estimation and optimization performed by semivariogram analysis in Golden Software's Surfer 16. Interpretations of the plume extent and boundary delineation were made based on measured concentrations and local groundwater flow patterns as predicted by the Chino Basin groundwater flow model.

5 ▲ Wells & Maximum TCE or 1,2,3-TCP Concentration (µgl) for July 2013 to June 2018

5 ■ Location of Depth-Specific Vertical Aquifer Profile Samples & Maximum TCE or 1,2,3-TCP Concentration (µgl) at that Location During 2013 to 2014

Chino Basin Desalter Well

Approximate Extent of TCE or 1,2,3-TCP Plumes as Delineated by the County of San Bernardino Using Data Through 2018

The Chino Airport TCE and 1,2,3-TCP plumes are located in the southwestern portion of the Chino Basin within the City of Chino, southwest of the Chino Airport. The County of San Bernardino Department of Airports is identified as the responsible party for the Chino Airport Plume, and the RWQCB has issued cleanup and abatement order (CAO Nos. 90-134, R8-2008-0064, and R8-2017-0011), ordering the County to characterize the extent of the plume on and offsite and prepare a feasibility study and remedial action plan. From 1991 to 1992, ten inactive underground storage tanks and 310 containers of hazardous waste were removed. Since 2003, the County has constructed a total of 86 monitoring wells and conducted extensive investigations to characterize the soil and groundwater contamination. Investigative work included: piezocone-penetrometer tests, vertical-aquifer-profiling (VAP) borings with depth-discrete groundwater sampling, soil-gas probe sampling, high-resolution soil sampling and analysis, real-time data analysis, and three-dimensional contaminant distribution modeling. The County submitted a Final Feasibility Study for the Chino Airport in May 2017 and a draft interim remedial action plan in December 2017 (Tetra Tech, 2017a and 2017b). The remedial action identified is a groundwater pump-and-treat system to provide hydraulic containment of the contamination originating from the Chino Airport.

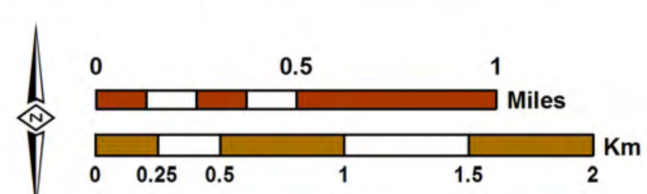
The County identifies TCE, 1,2,3-TCP, 1,2-DCA, and cis-1,2-dichloroethene as the primary contaminants associated with the Chino Airport plume. The County conducts quarterly, annual, or biennial water-quality monitoring and quarterly water-level monitoring at the 86 monitoring wells constructed to date. These data are used to characterize the extent of the plume vertically in multiple cross-sectional views and laterally in an areal view. The County prepared its most recent characterization of the TCE and 1,2,3-TCP plumes in 2018 (Tetra Tech, 2019), which is shown here compared to Watermaster's delineation of the plume.

Watermaster collects groundwater-quality data in and surrounding the plume at private wells, monitoring wells, and CDA production wells, and uses these data to independently characterize the spatial extent of the Chino Airport TCE plume every two years for the State of the Basin Report. In 2018, Watermaster developed independent delineations for both the TCE and 1,2,3-TCP plumes since the County recognizes these as two distinct plumes that coincide. Watermaster's 2018 plume characterizations are based on the maximum concentrations measured at wells from July 2013 to June 2018.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: LH
Date: 5/14/2019
File: 2018_Exhibit_5-17_CAirport_new_4.mxd



Prepared for:

2018 State of the Basin Report
Groundwater Quality

Chino Basin Watermaster
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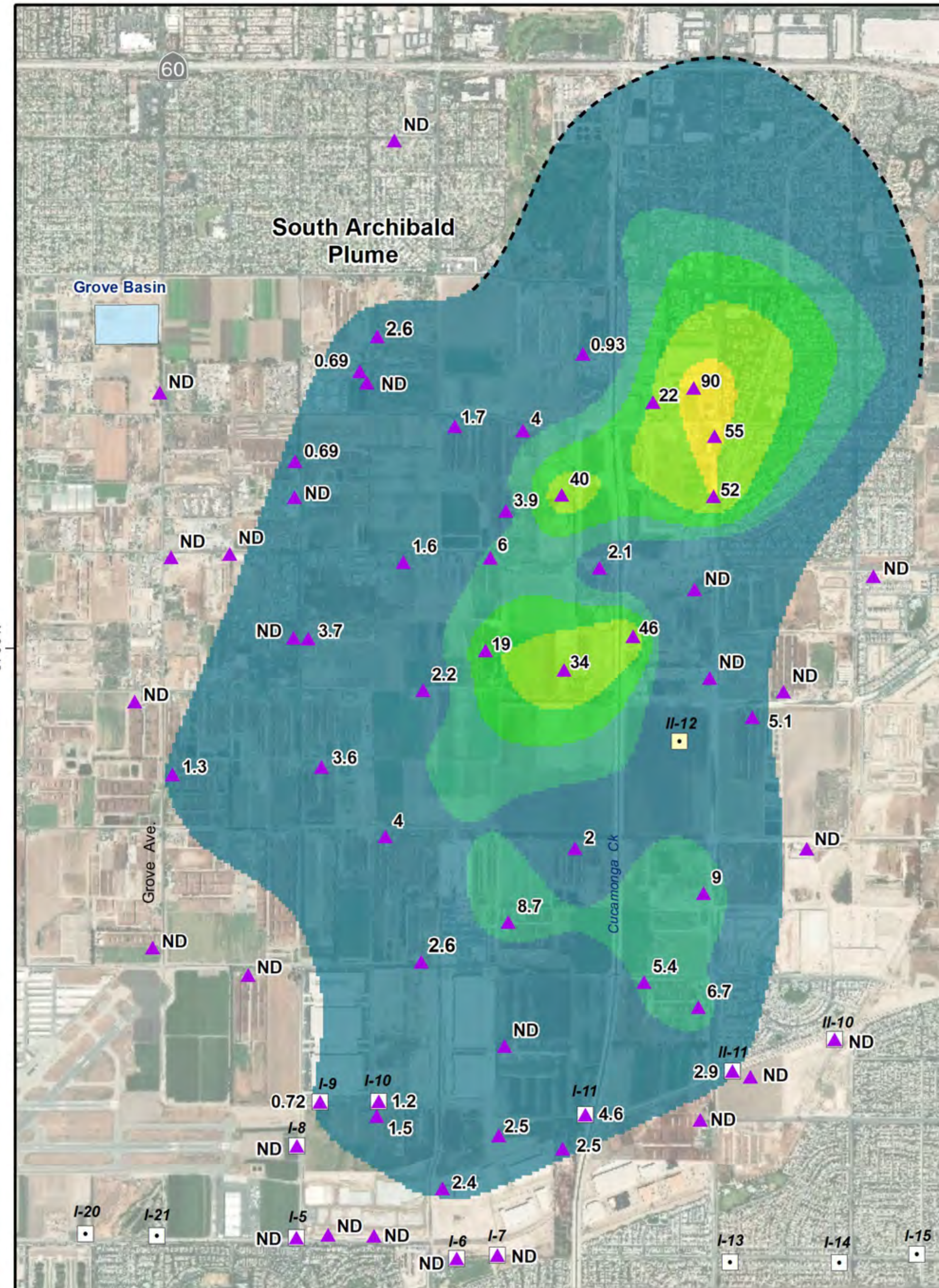
Chino Airport TCE and 1,2,3-TCP Plume

Exhibit 5-17



The South Archibald TCE plume is located in the southern Chino Basin within the City of Ontario. In the mid-1980s, the Metropolitan Water District of Southern California (MWDSC) determined that TCE was present in private wells in the area south of the Ontario International Airport (OIA), as part of the work associated with the Chino Basin Storage Program (MWDSC et al., 1987). The RWQCB confirmed this with subsequent rounds of sampling and identified activities at OIA as a likely source of TCE. In 2005, the RWQCB issued Draft CAOs to six different parties who were tenants on the OIA property. On a voluntary basis, four of the six parties—Aerojet, Boeing, General Electric, and Lockheed Martin, collectively the ABGL parties—worked together, along with the U.S. Department of Defense, to investigate the source of the contamination. Part of the investigations included collecting water-quality samples from private wells and taps at residences and the construction and sampling of four triple-nested monitoring wells. Alternative water systems were provided at private residences in the area where groundwater was contaminated with TCE. In 2012, the RWQCB issued an additional Draft CAO collectively to the City of Ontario, City of Upland, and IEUA (the RP-1 Parties) as the previous and current operators of the RP-1 treatment plant and disposal area where wastewater from the previously identified parties was treated and discharged and may have contained TCE. Under the Regional Board's oversight from 2007 to 2014, the ABGL parties and/or the RP-1 parties conducted sampling at private residential wells and taps approximately every two years in the region where groundwater was potentially contaminated with TCE.

In November 2015, the RP-1 Parties completed a draft feasibility study and remedial action plan. The preferred groundwater remediation alternative identified in the remedial action plan involves the use of existing and proposed CDA production wells and treatment facilities and includes the construction and operation of three new CDA production wells and a dedicated pipeline to convey groundwater produced from these wells to the Desalter II treatment facility. The preferred domestic water supply alternative identified in the remedial action plan is a hybrid between the installation of tank systems for some residences, where water is delivered from the City of Ontario potable supply, and the installation of a pipeline to connect some residences to the City of Ontario potable water system.

In September 2016, the RWQCB issued the Final Stipulated Settlement and CAO R8-2016-0016 (Stipulated CAO) collectively to the RP-1 parties and the ABGL parties (excluding Northrop Grumman). The Stipulated CAO was adopted by all parties in November 2016, thus approving the preferred plume remediation and domestic water supply alternatives identified in the remedial action plan. The parties also reached a settlement agreement that aligned with the Final CAO and authorized funding to initiate implementation of the plume remediation alternative. The remediation alternative is anticipated to be operational by 2020.

Watermaster routinely collects and analyzes samples from active private wells in and around the plume and uses the available data to delineate the TCE plume every two years. This 2018 plume characterization is based on the maximum TCE concentrations measured at wells from July 2013 to June 2018. Watermaster works closely with the RWQCB, the responsible parties, and other stakeholders in providing any available information to assist in the investigation, and provides semi-annual updates to the Watermaster Board on the status of the investigation and remediation.

TCE Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

TCE MCL = 5 µgl

The VOC plume shown on this map is a generalized illustration of the estimated spatial extent of TCE, based on the maximum concentration measured from July 2013 to June 2018. The VOC plume illustrations were created with the grid function in Golden Software's Surfer 16 using an ordinary kriging interpolation model with model input parameter estimation and optimization semivariogram analysis in Golden Software's Surfer 16. Interpretations of the plume extent and boundary delineation were made based on measured concentrations and local groundwater flow patterns as predicted by the Chino Basin groundwater flow model.

5 Wells & Maximum TCE Concentration (µgl) from July 2013 to June 2018

ND = TCE was Non-Detect in Samples from July 2013 to June 2018

Location of Future Chino Desalter Well

Chino Desalter Well

No data exist in the northern portion of the plume for the analysis period, and the approximate location of the spatial extent and TCE concentrations in the northern portion of the plume is unknown

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LH
Date: 5/29/2019
File: 2018_Exhibit_5-18_southarchibald_new_txt.mxd

0 0.5 1 1.5 Miles

0 0.25 0.5 1 1.5 2 Km

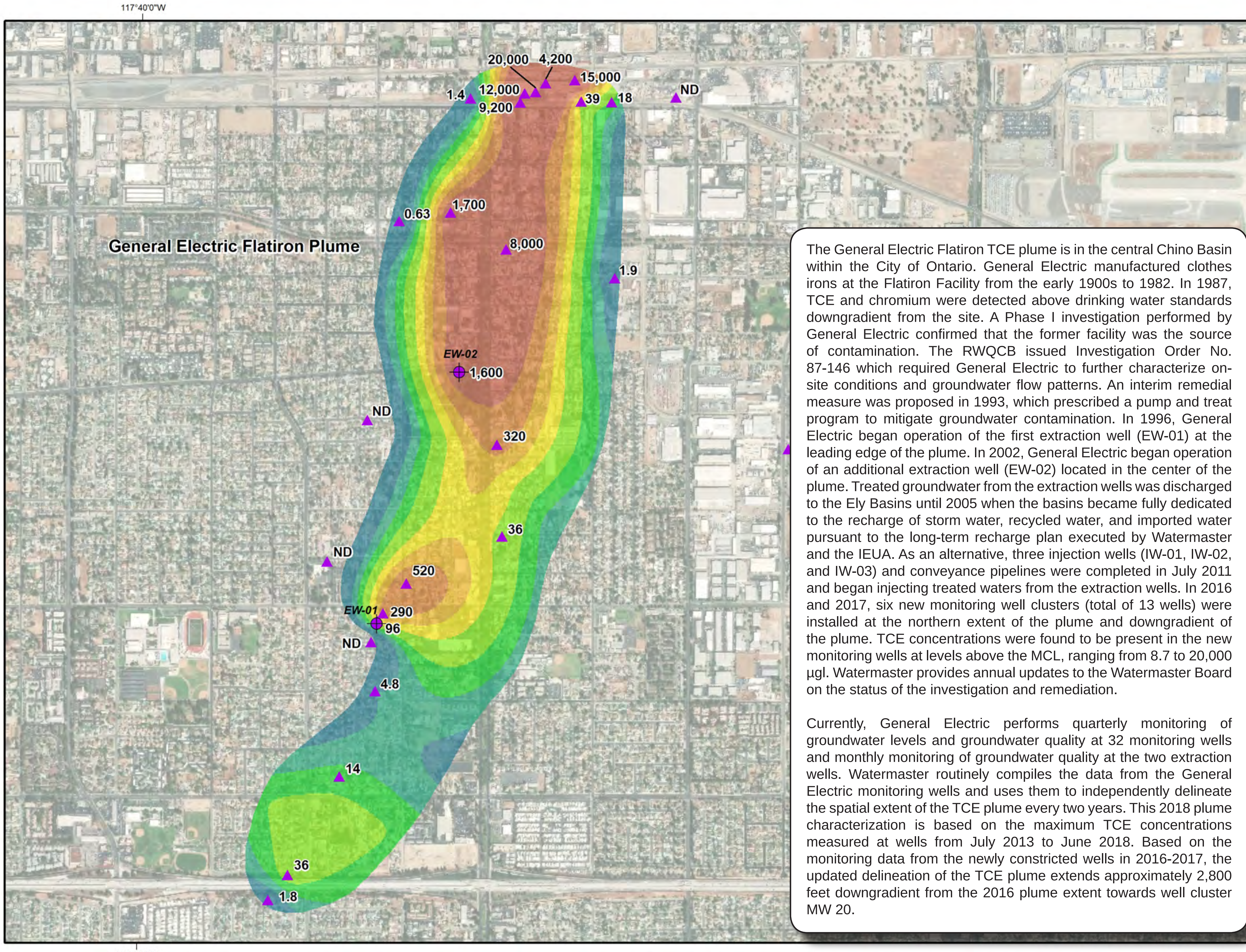
Prepared for:

2018 State of the Basin Report
Groundwater Quality

CHINO BASIN WATERMASTER

South Archibald TCE Plume

Exhibit 5-18



The General Electric Flatiron TCE plume is in the central Chino Basin within the City of Ontario. General Electric manufactured clothes irons at the Flatiron Facility from the early 1900s to 1982. In 1987, TCE and chromium were detected above drinking water standards downgradient from the site. A Phase I investigation performed by General Electric confirmed that the former facility was the source of contamination. The RWQCB issued Investigation Order No. 87-146 which required General Electric to further characterize on-site conditions and groundwater flow patterns. An interim remedial measure was proposed in 1993, which prescribed a pump and treat program to mitigate groundwater contamination. In 1996, General Electric began operation of the first extraction well (EW-01) at the leading edge of the plume. In 2002, General Electric began operation of an additional extraction well (EW-02) located in the center of the plume. Treated groundwater from the extraction wells was discharged to the Ely Basins until 2005 when the basins became fully dedicated to the recharge of storm water, recycled water, and imported water pursuant to the long-term recharge plan executed by Watermaster and the IEUA. As an alternative, three injection wells (IW-01, IW-02, and IW-03) and conveyance pipelines were completed in July 2011 and began injecting treated waters from the extraction wells. In 2016 and 2017, six new monitoring well clusters (total of 13 wells) were installed at the northern extent of the plume and downgradient of the plume. TCE concentrations were found to be present in the new monitoring wells at levels above the MCL, ranging from 8.7 to 20,000 µgl. Watermaster provides annual updates to the Watermaster Board on the status of the investigation and remediation.

Currently, General Electric performs quarterly monitoring of groundwater levels and groundwater quality at 32 monitoring wells and monthly monitoring of groundwater quality at the two extraction wells. Watermaster routinely compiles the data from the General Electric monitoring wells and uses them to independently delineate the spatial extent of the TCE plume every two years. This 2018 plume characterization is based on the maximum TCE concentrations measured at wells from July 2013 to June 2018. Based on the monitoring data from the newly constricted wells in 2016-2017, the updated delineation of the TCE plume extends approximately 2,800 feet downgradient from the 2016 plume extent towards well cluster MW 20.

TCE Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

TCE MCL = 5 µgl

The VOC plume shown on this map are generalized illustrations of the estimated spatial extent of TCE, based on maximum concentration measured from July 2013 to June 2018. The VOC plume illustrations were created with the grid function in Golden Software's Surfer 16 using an ordinary kriging interpolation model with model input parameter estimation and optimization performed by semivariogram analysis in Golden Software's Surfer 16. Interpretations of the plume extent and boundary delineation were made based on measured concentrations and local groundwater flow patterns as predicted by the Chino Basin groundwater flow model.

5 Wells & MaximumTCE Concentration (µgl) from July 2013 to June 2018

ND = TCE was Non Detect in Samples from July 2013 to June 2018

Extraction Well

Prepared by:

WEI Wildermuth Environmental, Inc.

Author: LH
Date: 5/28/2019
File: 2018_Exhibit_5-19_new_GE_Flatiron_2.mxd

0 0.1 0.2 0.3 0.4 0.5 Miles

0 0.25 0.5 0.75 1 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

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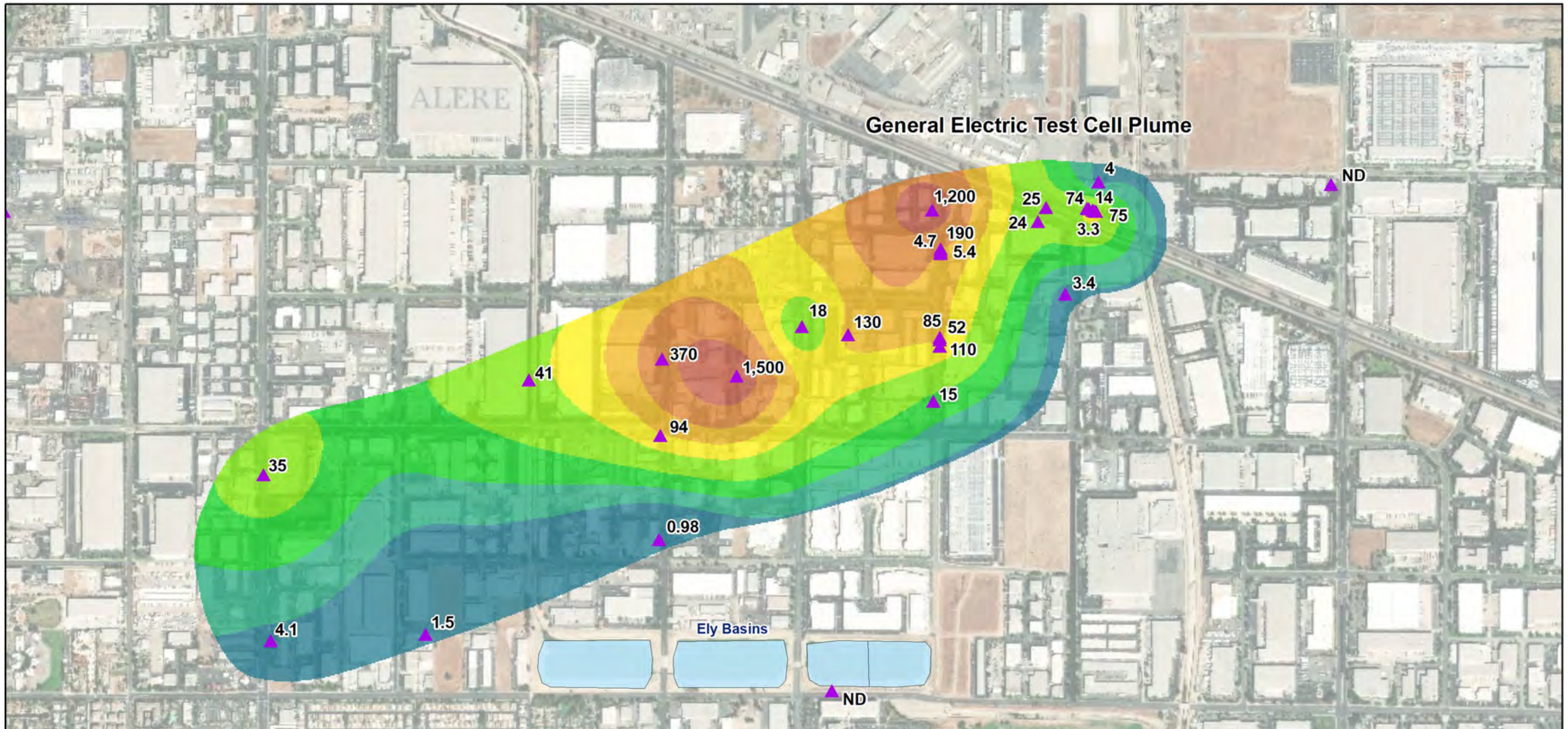
General Electric Flatiron TCE Plume

Exhibit 5-19



TCE Concentration (µgl)

- > 0 to ≤ 5
- > 5 to ≤ 10
- > 10 to ≤ 20
- > 20 to ≤ 50
- > 50 to ≤ 100
- > 100 to ≤ 200
- > 200 to ≤ 500
- > 500

TCE MCL = 5 µgl

The VOC plume shown on this map is a generalized illustration of the estimated spatial extent of TCE, based on maximum concentration measured from July 2013 to June 2018. The VOC plume illustration was created with the grid function in Golden Software's Surfer 16 using an ordinary kriging interpolation model with model input parameter estimation and optimization performed by semivariogram analysis in Golden Software's Surfer 16. Interpretations of the plume extent and boundary delineation were made based on measured concentrations and local groundwater flow patterns as predicted by the Chino Basin groundwater flow model.

5 Wells & Maximum TCE Concentration (µgl) from July 2013 to June 2018

ND = TCE was Non-Detect in Samples from July 2013 to June 2018

The General Electric Test Cell plume is located in the central Chino Basin within the City of Ontario, south of the OIA. From 1956 to 2011, the General Electric Test Cell Facility was predominately used to test and maintain commercial and military aircraft engines. Solvents used at the facility included TCE, PCE, 1,1,1-TCA, methyl ethyl ketone, and isopropyl alcohol, which were stored in drums and aboveground storage tanks. From 1974 to 2011, wastewater from manufacturing was disposed of by discharging to the onsite dry wells. The Test Cell Facility ceased operation in 2011, and the site is currently vacant.

In 1988, Consent Order 88/89-009 was signed between General Electric and the California Department of Health Services to initiate the investigation of soil, surface water, and groundwater contamination. From 1991 to 1998, 13 monitoring wells were constructed, which indicated that the VOC plume extended about 4,000 feet offsite. Two additional offsite multi-depth well clusters were installed between 2001 and 2002 to provide information on the vertical distribution of VOCs. Monitoring of these multi-depth wells indicated that TCE concentrations were highest in the intermediate and deep interval zones, prompting General Electric to submit a groundwater feasibility study and draft remedial action plan (RAP) to the RWQCB in 2003 and 2006, respectively. The RAP identified two groundwater remediation alternatives: (1) extraction and treatment of groundwater for areas that have VOC concentrations approximately ten times the MCL and (2) monitored natural attenuation of groundwater for areas that have VOC concentrations less than ten times the MCL. As of 2018, monitored natural attenuation is the only remedial action that has been implemented. Watermaster provides annual updates to the Watermaster Board on the status of the investigation and remediation.

Currently, General Electric performs quarterly monitoring of groundwater levels and groundwater quality at 13 single casing monitoring wells and 17 multi-nested monitoring wells. Watermaster routinely compiles the data from the General Electric monitoring wells and uses them to independently delineate the spatial extent of the TCE plume every two years. This 2018 plume characterization is based on the maximum TCE concentrations measured at wells from July 2013 to June 2018.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LH
Date: 5/29/2019
File: 2018_Exhibit_5-20_new_GE_Test_Cell_2_txt.mxd

N

0 0.1 0.2 0.3 0.4 0.5 Miles

0 0.25 0.5 0.75 1 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

CHINO BASIN WATERMASTER
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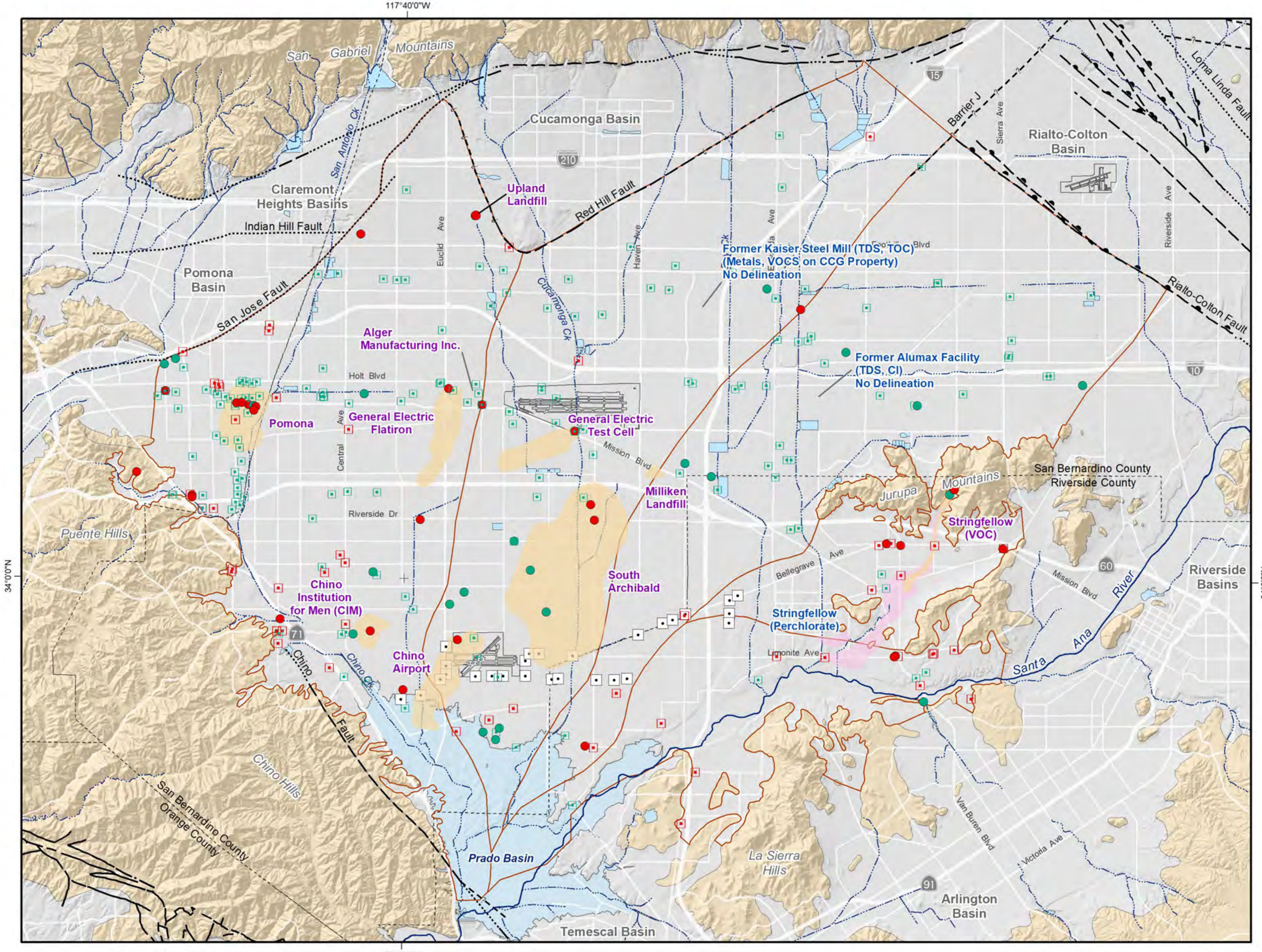
General Electric Test Cell TCE Plume

Exhibit 5-20



GeoTracker and EnviroStor Sites

Site Status (Symbol)

- Open Case
- Closed Case

Contaminated Media (Color)

- Groundwater (potential or confirmed)
- No Media Established, but Potentail Impacts to Groundwater Quality Identified

VOC Plumes Delineated in 2018
- Labeled in Purple by Name

Other Plumes
- Labeled in Blue by Name and Dominant Contaminants

* Plumes that are too small to be delineated at this map extent, or are not delineated, are labeled with a line indicating the general location of the point-source site

Other key map features are described in the legend of Exhibit 1-1.

In 2014, Watermaster began performing an extensive review of the GeoTracker and EnviroStor databases to identify all sites in the Chino Basin that have the potential to impact groundwater quality. As of 2018, a total of 875 sites with contaminated media were identified in the Chino Basin. The sites are categorized by site status (open or closed case) and the contaminated media (groundwater, soil, air, or not identified). Of the 875 sites, 278 were identified as having the potential to impact groundwater quality. Since 2016, seven new sites have been identified with the potential to impact groundwater quality. 54 of the 278 sites with the potential to impact groundwater quality are open cases and 224 are closed cases. Watermaster downloads all newly available monitoring data for the open sites about twice per year. For more information about GeoTracker, see:

www.geotracker.waterboards.ca.gov
www.envirostor.dtsc.ca.gov

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-21_Geotracker_Enviro_new_txt.mxd

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

Prepared for:

2018 State of the Basin Report
Groundwater Quality

CHINO BASIN WATERMASTER
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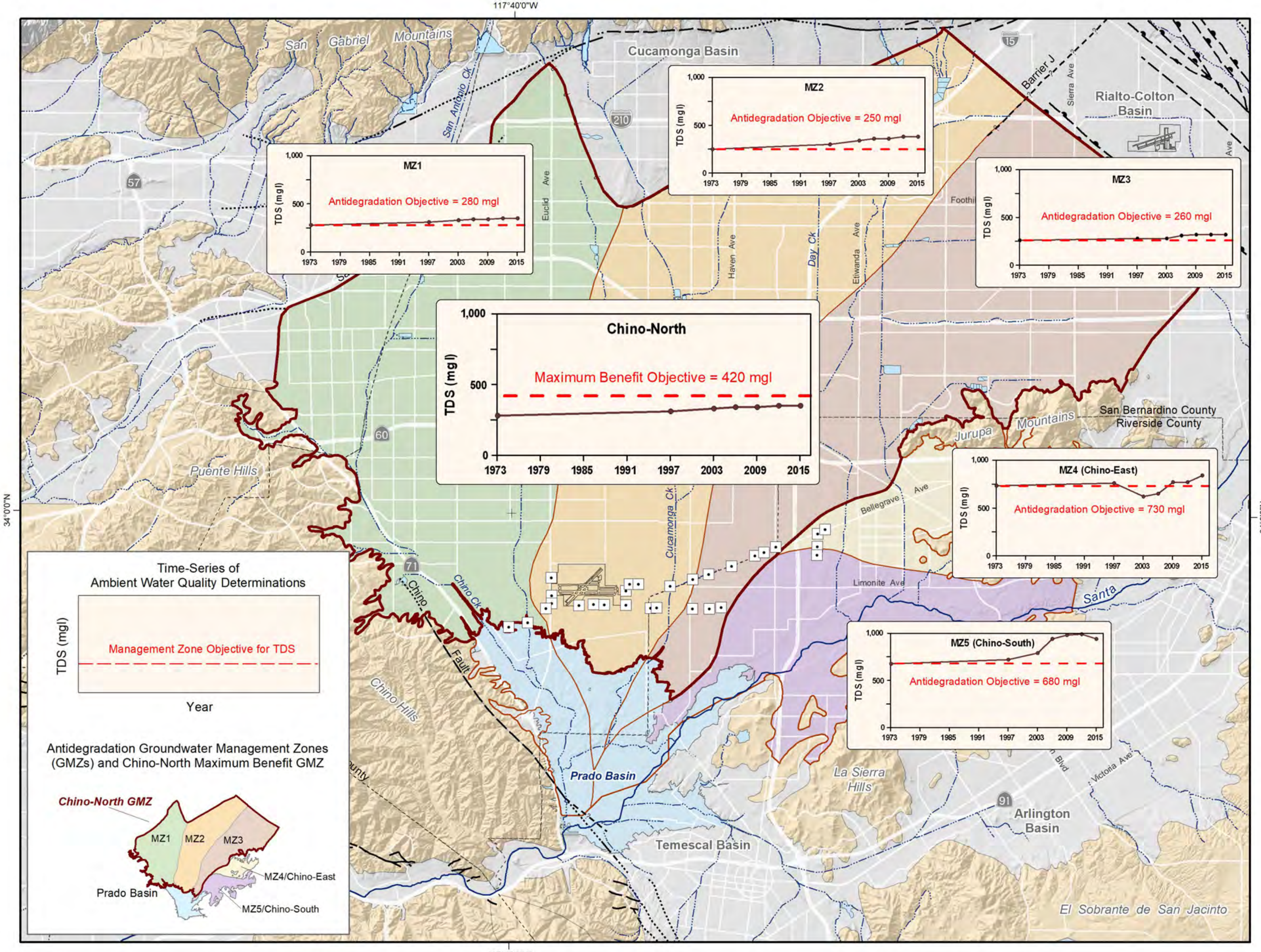
GeoTracker and EnviroStor Sites in the Chino Basin
With the Potential to Impact Groundwater Quality

Exhibit 5-21



The ambient water quality (AWQ) of GMZs in the Santa Ana Watershed are computed on a triennial basis and compared with the groundwater-quality objectives defined in the Basin Plan to determine assimilative capacity for TDS and nitrate and to assess if waste discharge requirements are protective of groundwater quality. AWQ represents the volume-weighted average constituent concentration for a GMZ and is derived from water quality statistics computed at wells based on a 20-year time-history of sample results.

In the Chino Basin, the Chino-North GMZ maximum benefit objective is used as the measure of compliance to permit recycled water discharge and reuse. The Chino-North GMZ is the combined extent of MZ1, MZ2, and MZ3 up-gradient of the Prado Basin. The Chino-North maximum benefit objective is numerically higher than the individual antidegradation objectives set for MZ1, MZ2, and MZ3. If Watermaster and the IEUA do not implement the specific projects and programs described in the Chino Basin maximum benefit commitments (Table 5-8 in the Basin Plan), the antidegradation objectives will apply, and Watermaster and the IEUA will be required to mitigate TDS and nitrate loading from recycled water discharge and reuse above the antidegradation objectives.

AWQ determinations have been made for seven 20-year periods: 1954-1973, 1978-1997, 1984-2003, 1987-2006, 1990-2009, 1993-2012 (WEI, 2000; 2005b; 2008a; 2011b; and 2014), and 1996-2015 (DBS&A, 2017). The AWQ determinations for 1999-2018 will be published in 2020. From 1973 to 2015, the ambient TDS increased from 260 to 360 mgl but remains below the maximum benefit objective of 420 mgl; 60 mgl of assimilative capacity remains. When the current ambient TDS exceeds the maximum benefit objective, there will be a mitigation requirement for the recharge and direct use of recycled water. Based on the current rate of increase in the ambient TDS concentration for the Chino North GMZ, assimilative capacity will likely exist until about 2033. In the Chino-East and Chino-South GMZs, the current ambient TDS concentrations are greater than the objectives. Because the TDS concentration of the recycled water reused by the Chino Basin parties in these GMZs is less than the antidegradation objectives of 730 and 680 mgl, there are no regulatory compliance challenges.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-22_AWQ_TDS_new_txt.mxd

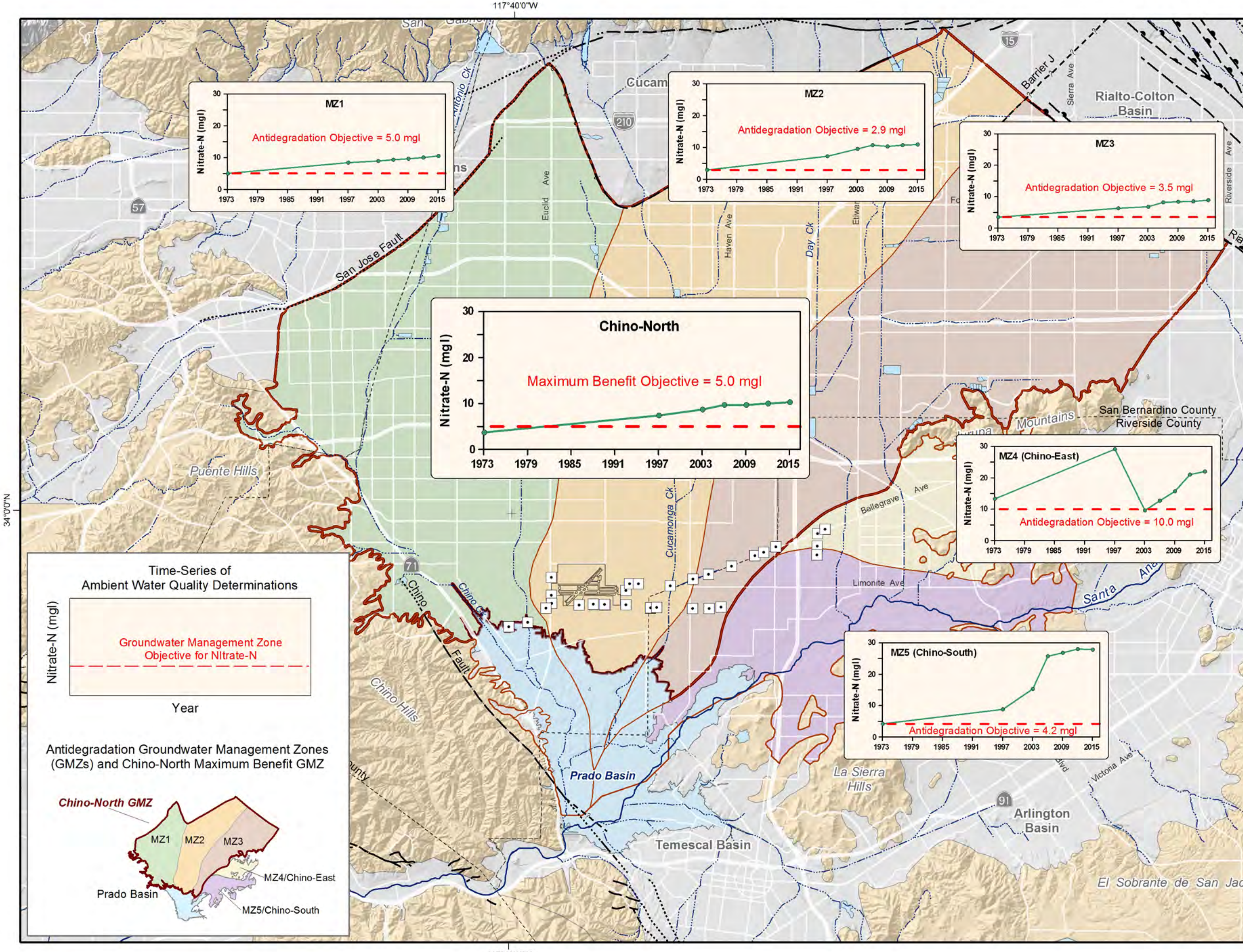
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Trends in Ambient Water Quality Determinations for Total Dissolved Solids By Groundwater Management Zone

Exhibit 5-22



From 1973 to 2015, the ambient nitrate in Chino-North GMZ increased from 3.7 to 10.3 mgl and is currently above the maximum benefit objective of 5 mgl. To ensure recycled water recharge in the Chino-North GMZ is in compliance with the maximum benefit objective, Watermaster and the IEUA must recharge low-nitrate imported and storm waters such that the 12-month, volume-weighted concentration of the all recharge sources (storm water, recycled water, and imported water) is less than or equal to the maximum-benefit objective.

In the Chino-East and Chino-South GMZs, the current ambient nitrate concentrations are two to three times greater than the antidegradation objectives of 10 mgl and have been increasing since 1973.

For all GMZs, the increase in ambient constituent concentrations is likely related to an increase in the data available to perform the calculations since the implementation of the OBMP monitoring programs, opposed to actual the degradation of water quality.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 5/28/2019
File: 2018_Exhibit_5-23_AWQ_NO3_new_txt.mxd

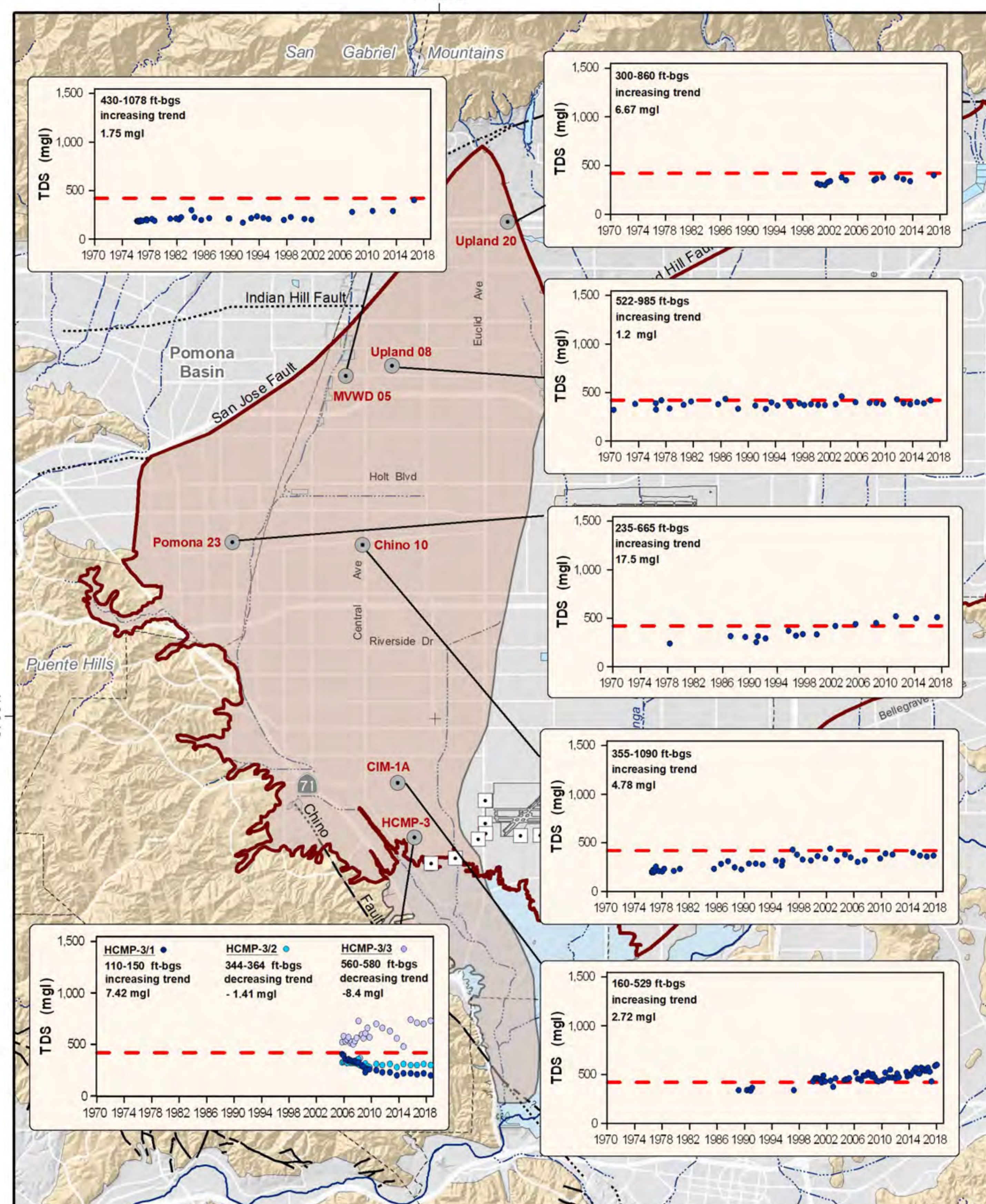
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

2018 State of the Basin Report
Introduction

Trends in Ambient Water Quality Determinations for Nitrate as Nitrogen By Groundwater Management Zone

Exhibit 5-23



It is expected that TDS concentrations in the Chino Basin will increase over time, increase in magnitude from north to south, and be greatest in the shallow layer of the aquifer in areas where the primary loading source occurs at the ground surface (e.g. areas with outdoor water use). The anticipated trends are based on the following:

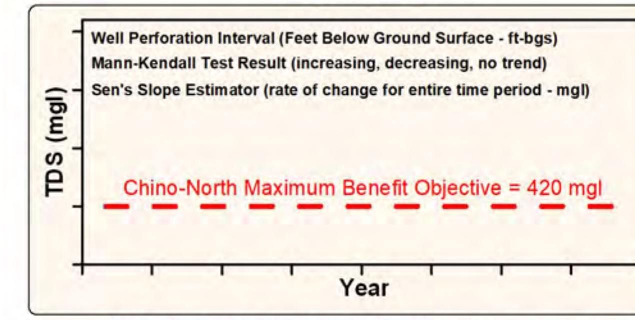
- The Chino Basin is operated as a closed basin, meaning that salts will accumulate in the Basin over time. The only export of salt is through the CDA's brine line and wastewater discharged to the Santa Ana River.
- Low-TDS source waters (e.g. mountain front recharge and storm and supplemental waters) are being recharged in the forebay areas to the north and at recharge basins that are primarily located north of Highway 60 (refer to Sections 2 and 3 of this report).
- The direction of groundwater-flow is generally from north to south (as shown in Section 4 of this report).
- The land use types with the greatest impact on TDS concentrations (irrigated agriculture and dairies) have been concentrated to the south of Highway 60.

Other factors that contribute to localized TDS concentrations and trends include: proximity to production wells, recharge sources, and point-source discharges; and underlying aquifer properties.

Exhibits 5-24 through 5-26 show time-history plots of TDS concentrations measured at selected wells in each of the OBMP management zones compared to the TDS objectives defined in the Basin Plan for the Chino-North, Chino-South, and Chino-East GMZs. Data are shown for the 47-year period of 1972 through 2018. The wells and time-histories included in these exhibits were selected based on location, geographical distribution, length of data record, depth of well perforations, and the representativeness of TDS concentrations in the area. Noted on each time-series chart are the results of two statistical trend analyses, indicating the trend in the data (increasing, decreasing, no statistical trend) and the rate of change. For the period of record, the data show that TDS concentration trends throughout the Chino Basin are consistent with expected trends. Specifically:

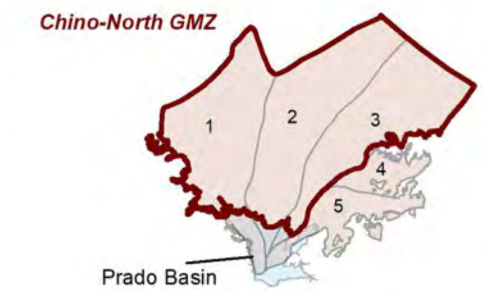
- TDS concentrations at wells located north of Highway 60 in MZ1, MZ2, and MZ3 have generally increased and are less than or about equal to the maximum-benefit objective for Chino-North of 420 mgl.
- TDS concentrations at wells located south of Highway 60 in MZ1, MZ2, and MZ3 have generally increased and are about equal to or greater than the maximum-benefit objective for Chino-North of 420 mgl.
- TDS concentrations at wells located in MZ4 and MZ5 are both below and above the anti-degradation objectives for Chino-East and Chino South of 730 and 680 mgl, respectively.
- TDS concentrations at wells with shallow well perforations (e.g. less than 200 ft-bgs) are higher than at wells with deep well perforations. Note that the wells with data to the north of Highway 60 are primarily deep municipal production wells.

TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-24_MZ1_TDS_new_final_txt.mxd

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

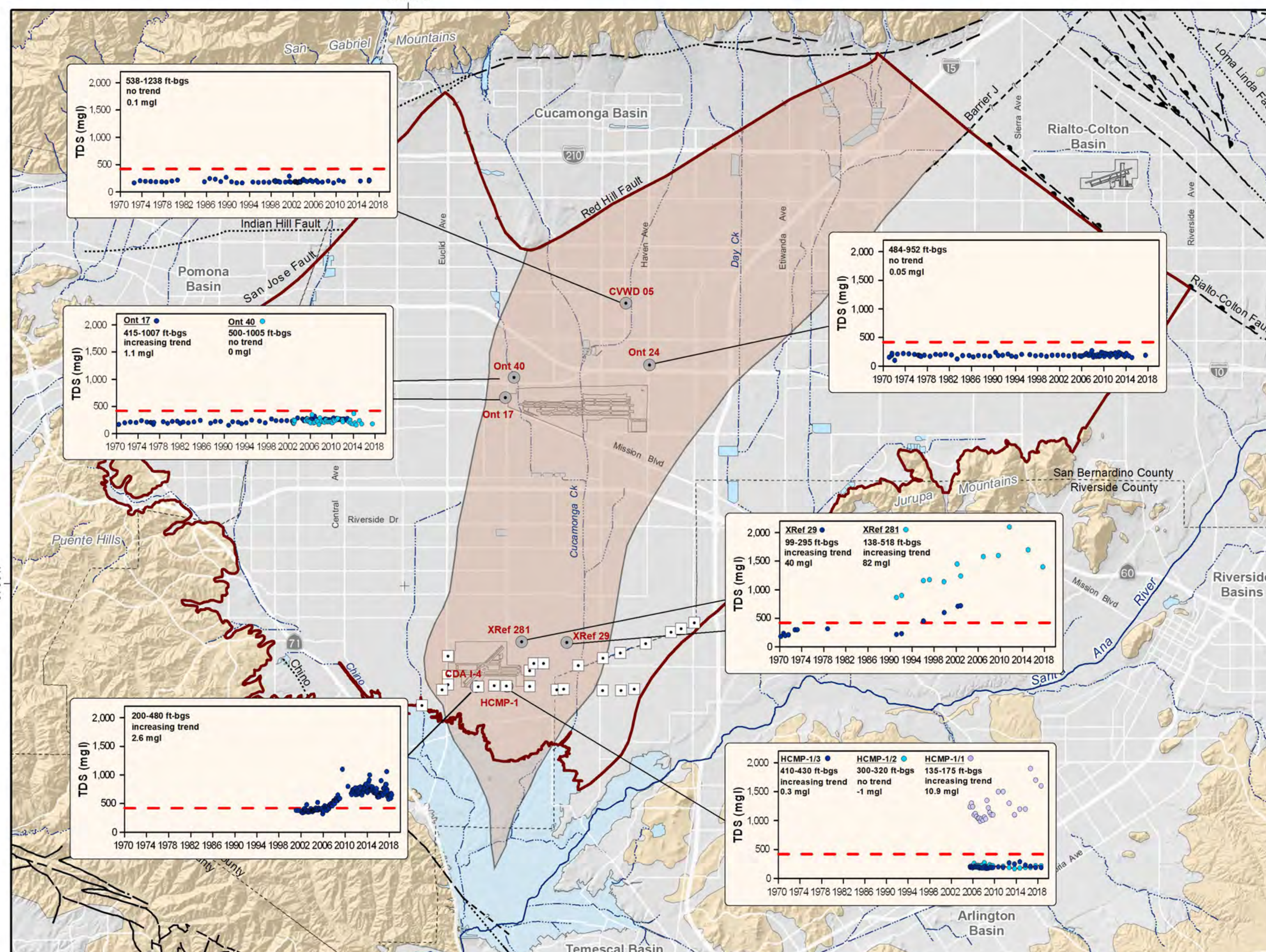
Prepared for:

2018 State of the Basin Report
Groundwater Quality

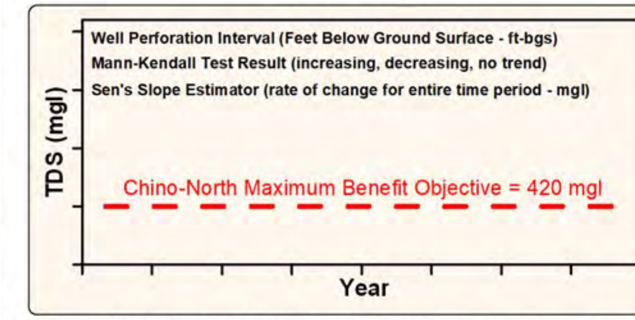
Chino Basin Watermaster — Partners in Basin Management

Chino Basin Management Zone 1
Trends in TDS Concentrations

Exhibit 5-24

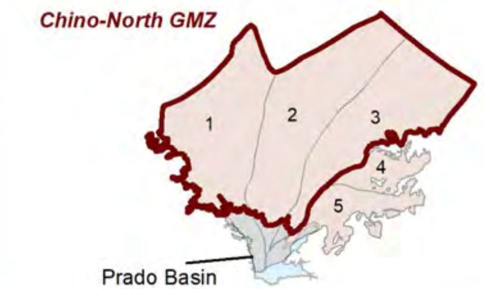


TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-25_MZ2_TDS_new_final_2.mxd

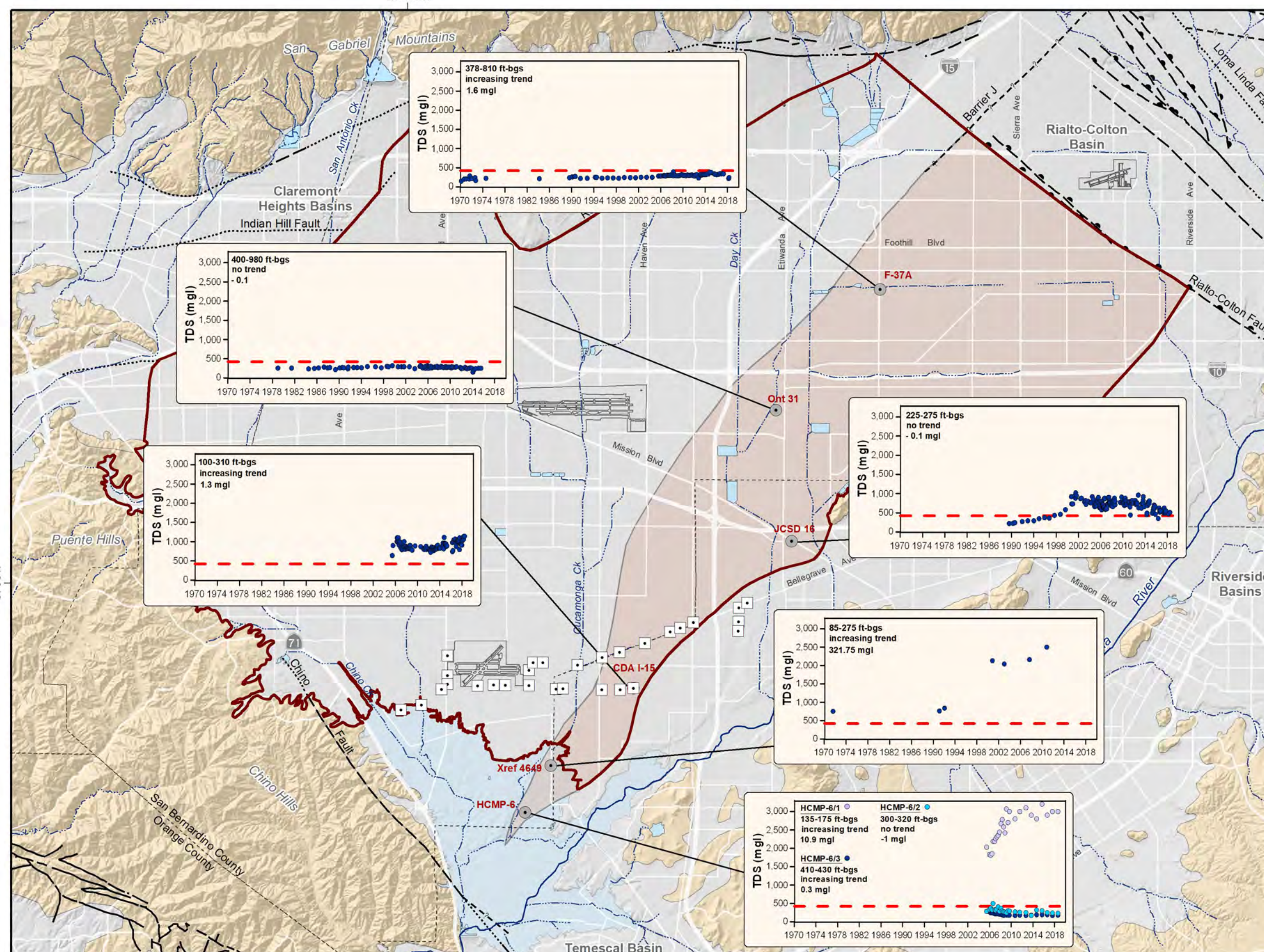
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

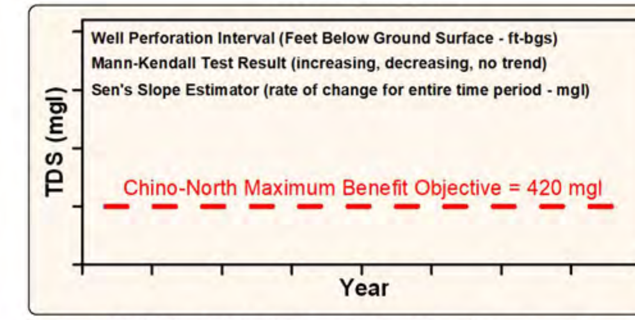
2018 State of the Basin Report
Groundwater Quality

Chino Basin Management Zone 2
Trends in TDS Concentrations

Exhibit 5-25

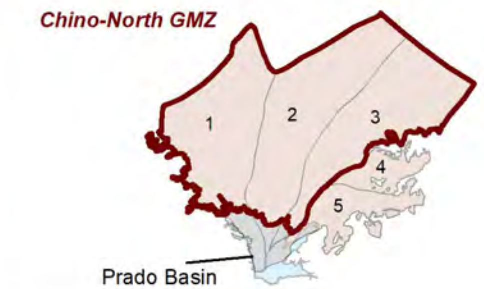


TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ



Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-26_MZ3_TDS_new_2.mxd

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

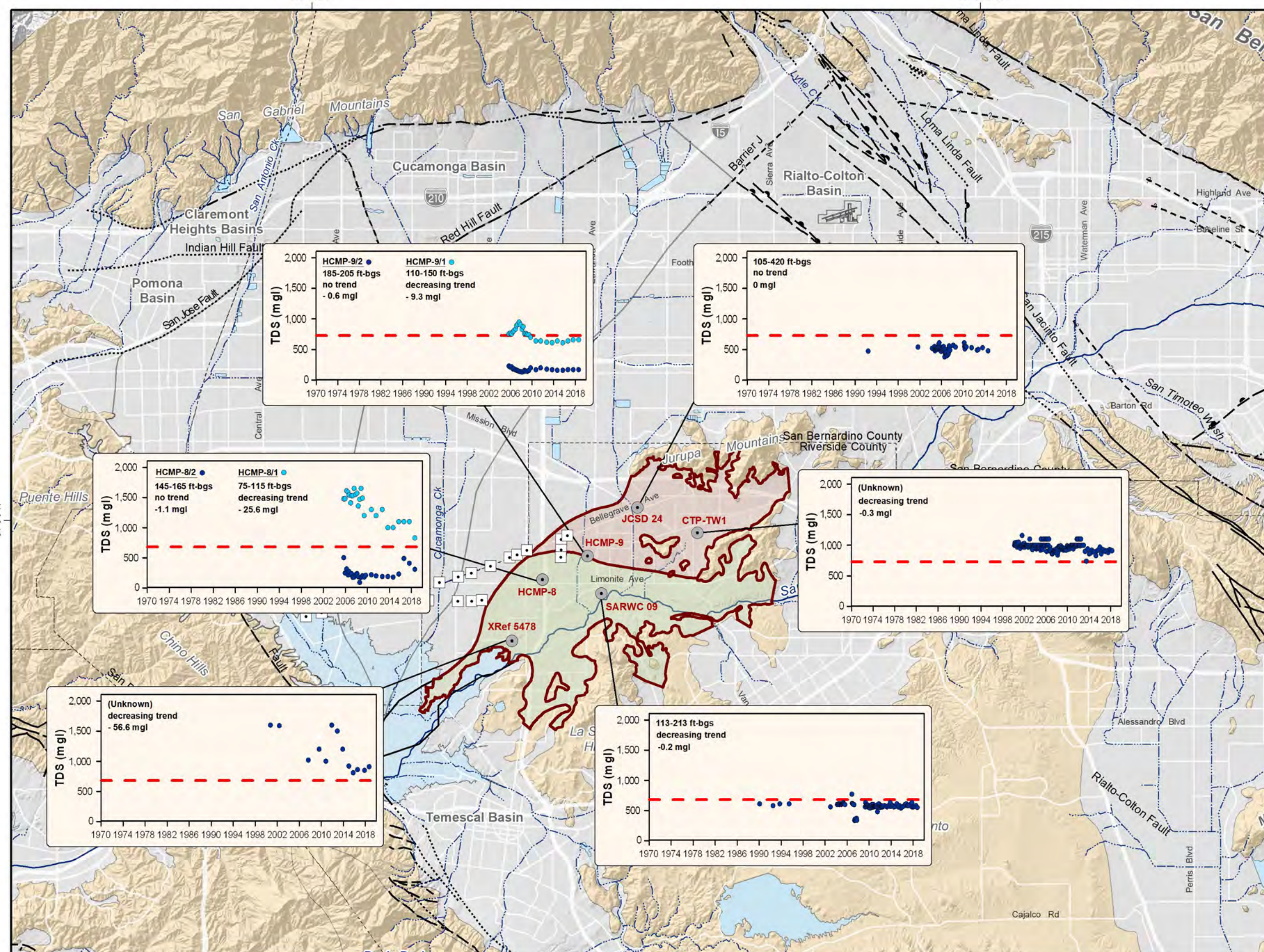
Prepared for:

2018 State of the Basin Report
Groundwater Quality

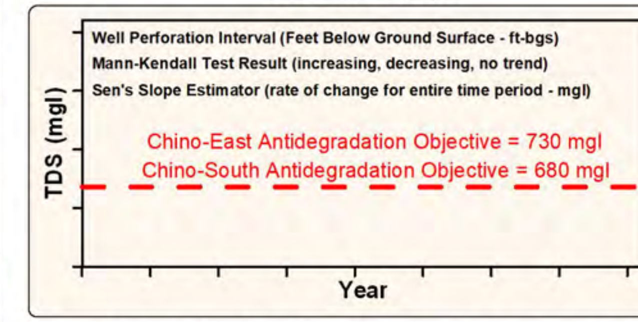
Chino Basin Management Zone 3

Trends in TDS Concentrations

Exhibit 5-26

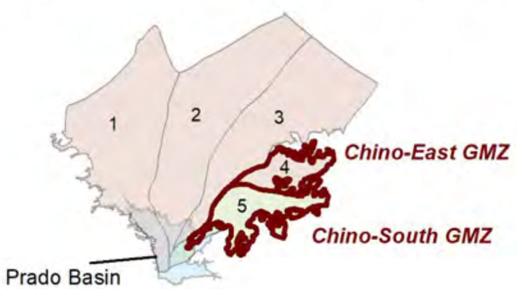


TDS Concentration



Two statistical trend tests were computed on the TDS concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-East and Chino-South GMZ's



Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-27_MZ4_5_TDS_new_2.mxd

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

Prepared for:

2018 State of the Basin Report
Groundwater Quality

CHINO BASIN WATERMASTER
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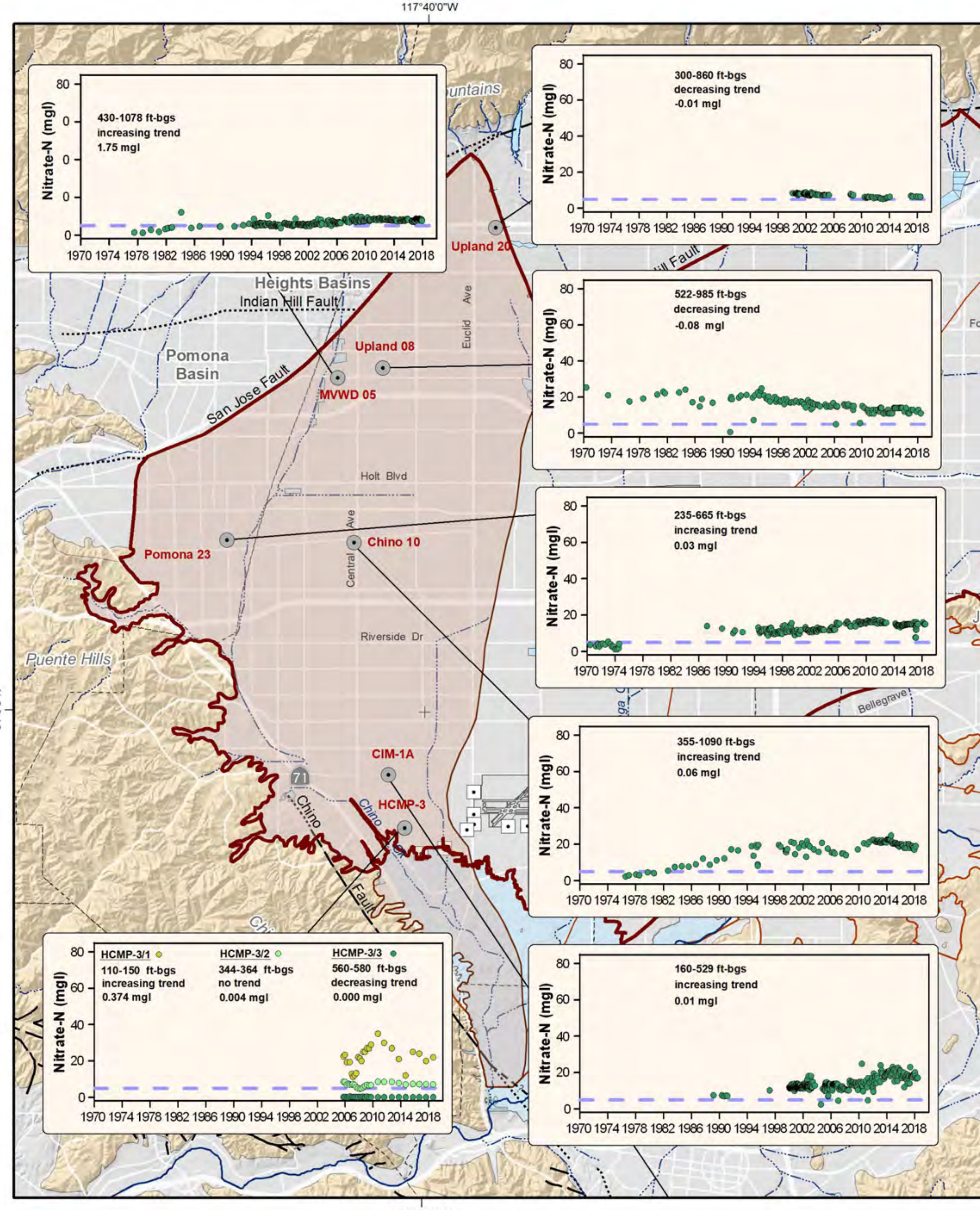
Chino Basin Management Zone 4 and Zone 5
Trends in TDS Concentrations

Exhibit 5-27



It is expected that nitrate concentrations in the Chino Basin will increase over time, increase in magnitude from north to south, and be greatest in the shallow layer of the aquifer in areas where the primary loading source occurs at the ground surface (e.g. areas with outdoor water use). One exception to the generally increasing trend occurs in the north-western area of the Chino Basin where decreasing trends in nitrate are observed in some areas that previously had high concentrations from historical loading from agricultural land uses. The anticipated trends are based on the following:

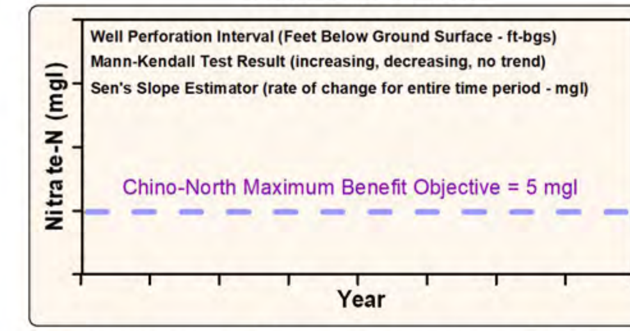
- The Chino Basin is operated as a closed basin, meaning that salts will accumulate in the basin over time. The only export of salt is through the CDA's brine line and wastewater discharged to the Santa Ana River.
- The low-nitrogen sources of recharge (e.g. mountain front recharge and storm water) are recharging the basin in the fore-bay areas to the north and at recharge basins that are primarily located north of HIghway 60 (refer to Sections 2 and 3 of this report).
- The direction of groundwater-flow is generally from north to south (as shown in Section 4 of this report).
- The current land use types with the greatest impact on nitrate concentrations (irrigated agriculture and dairies) are concentrated south of Highway 60.
- Historically, the northwest areas of the Chino Basin contained agricultural land use types, particularly irrigated citrus that relied heavily on fertilizers. As the agricultural land uses converted to urban uses, the high-nitrate loading at the ground surface has been replaced with lower-nitrate returns from outdoor water use, low-nitrate boundary inflows, and storm water recharge.

Other factors contribute to localized nitrate concentrations and trends, such as: proximity to production wells, recharge sources, and point-source discharges, and underlying aquifer properties.

Exhibits 5-28 through 5-31 show time-history plots of nitrate concentrations measured at selected wells in each of the OBMP management zones. Data are shown for the 47-year period of 1972 through 2018. The wells and time-histories included in these exhibits were selected based on location, geographical distribution, length of data record, depth of well perforations, and the representativeness of nitrate concentrations in the area. Noted on each time-series chart are the results of two statistical trend tests, indicating the trend in the data (increasing, decreasing, no statistical trend) and the rate of change. For the period of record, the data show that the nitrate concentration trends throughout the Chino Basin are consistent with expected trends. Specifically:

- Nitrate concentrations at wells located north of HIghway 60 in MZ1, MZ2, and MZ3 are both above and below maximum-benefit objective for Chino-North of 5 mgl and most of the wells are showing an increasing trend.
- Nitrate concentrations at wells located south of HIghway 60 in MZ1, MZ2, and MZ3 are above the than the maximum-benefit objective for Chino-North of 5 mgl.
- Nitrate concentrations at wells located in MZ4 and MZ5 are typically above the anti-degradation objectives for Chino-East and Chino-South of 10 and 5 mgl, respectively.
- Nitrate concentrations at wells with shallow well perforations (e.g. less than 200 ft-bgs) are higher than those at wells with deep well perforations.

Nitrate-N Concentration



Two statistical trend tests were computed on the Nitrate-N concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ

Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-28_MZ1_NO3_new3.mxd

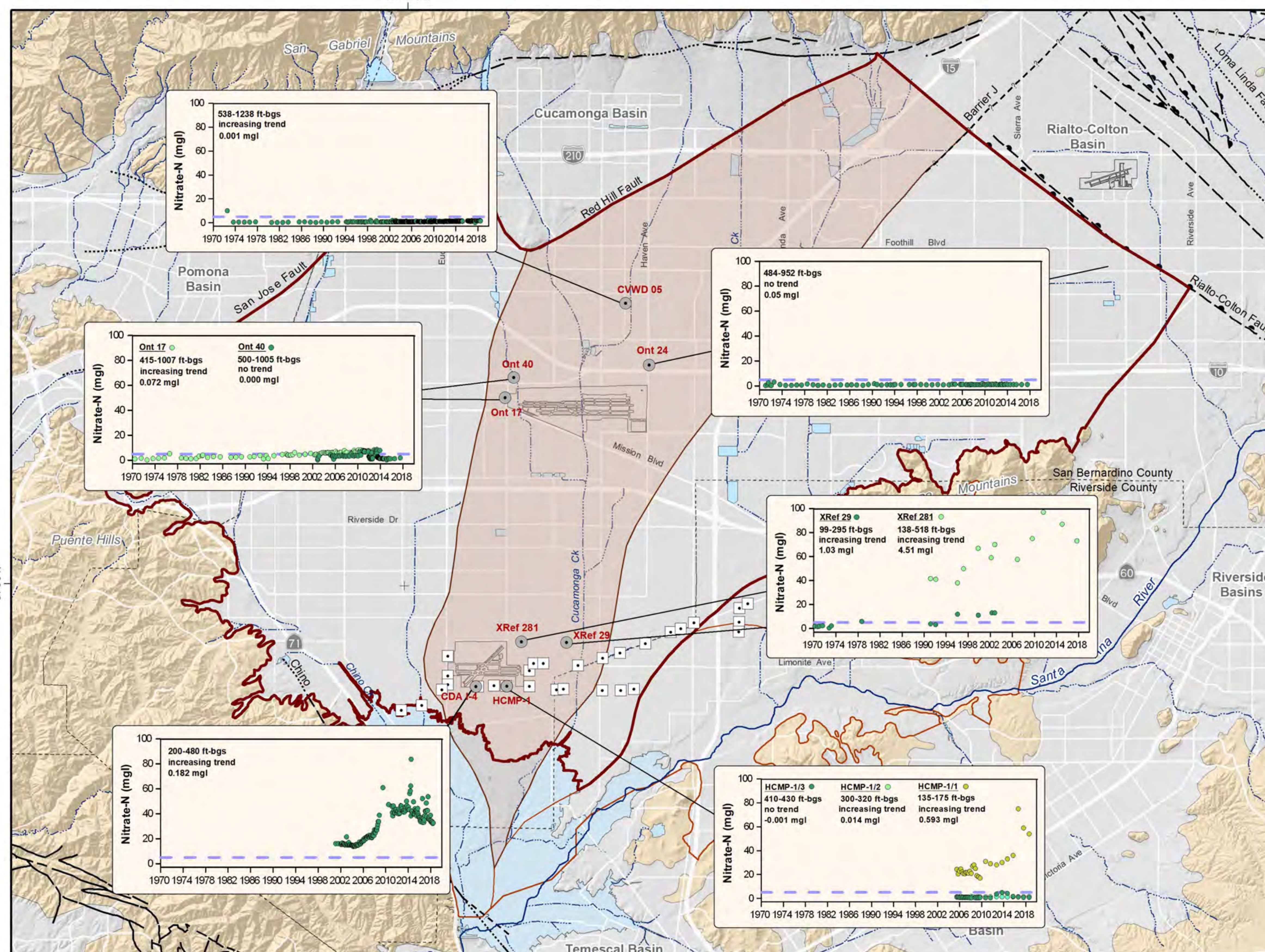
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

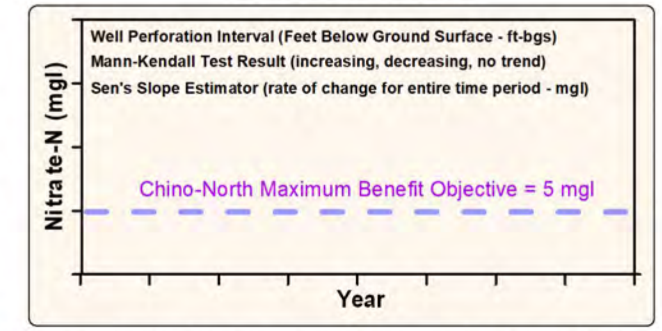
2018 State of the Basin Report
Groundwater Quality

Chino Basin Management Zone 1
Trends in Nitrate Concentrations

Exhibit 5-28



Nitrate-N Concentration



Two statistical trend tests were computed on the Nitrate-N concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ

Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-29_MZ2_NO3_new.mxd

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

Prepared for:

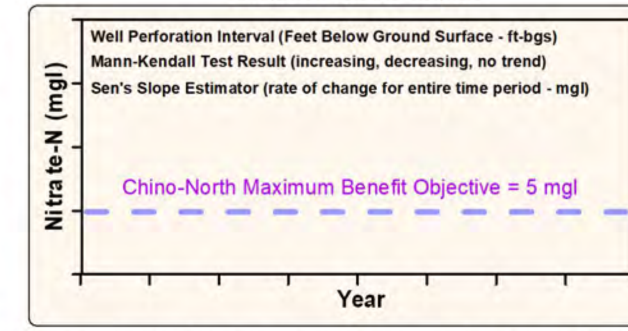
2018 State of the Basin Report
Groundwater Quality

Chino Basin Watermaster

Chino Basin Management Zone 2
Trends in Nitrate Concentrations

Exhibit 5-29

Nitrate-N Concentration

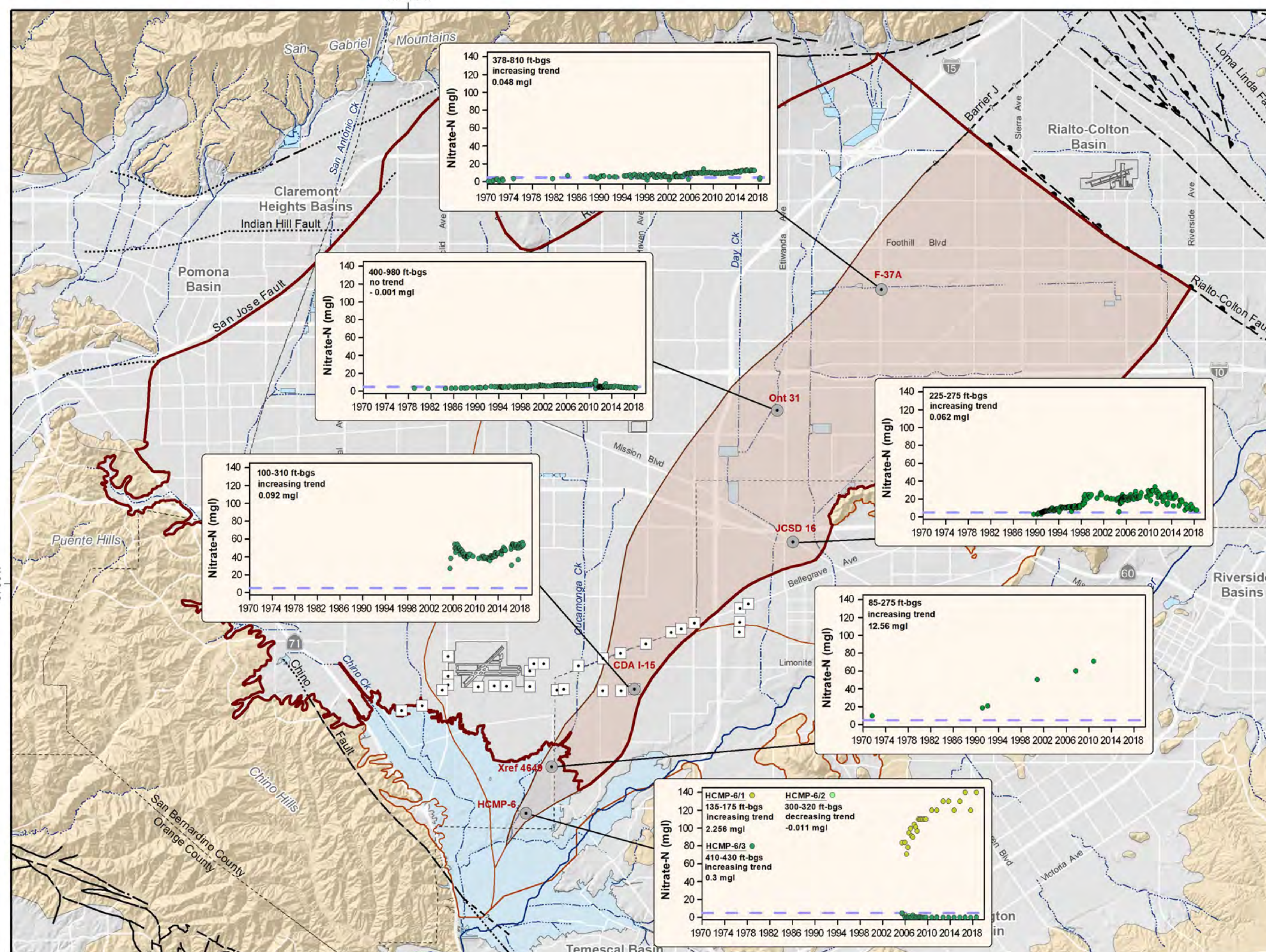


Two statistical trend tests were computed on the Nitrate-N concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-North Maximum Benefit GMZ

Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-30_MZ3_NO3_new_2.mxd

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

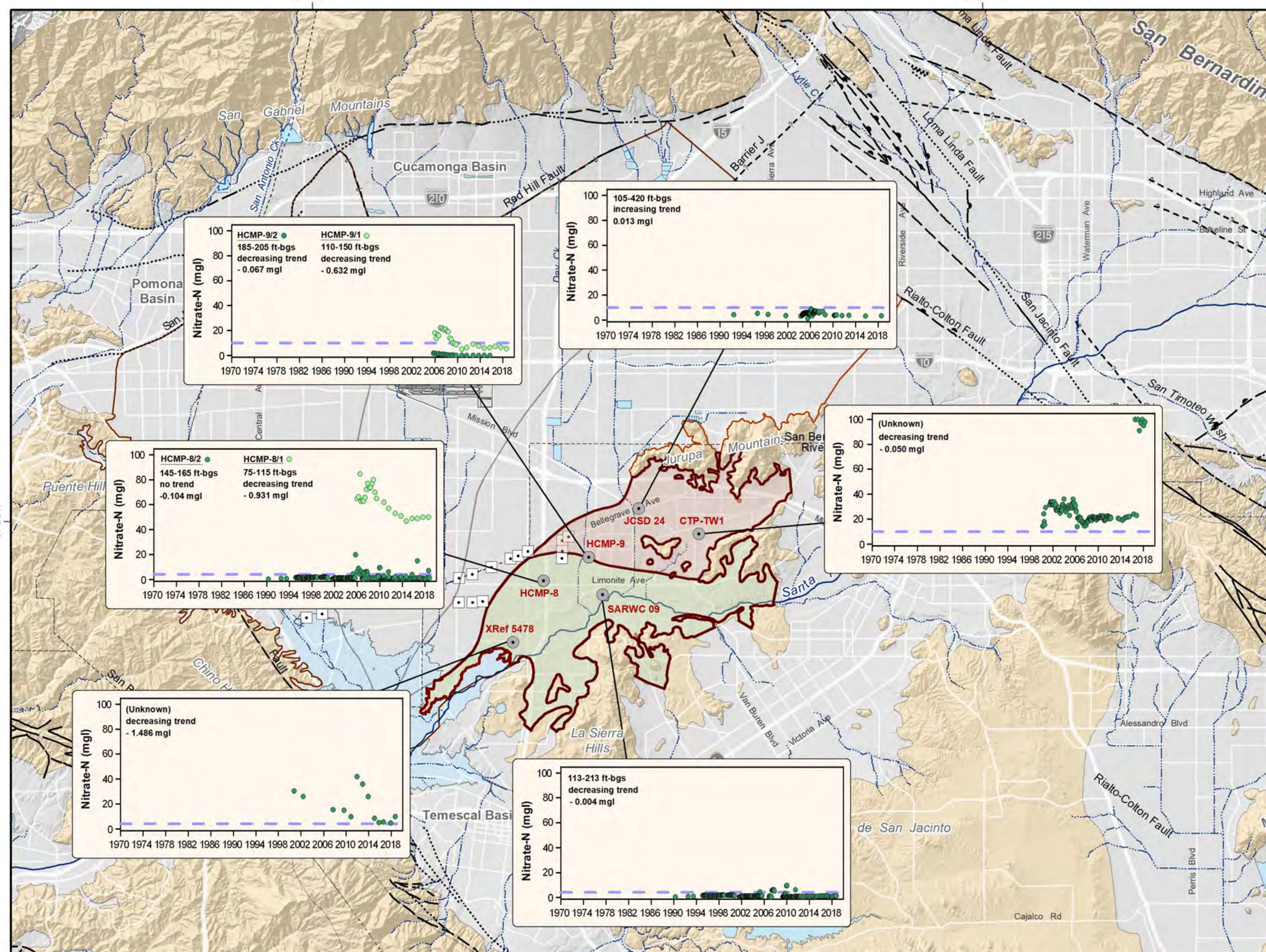
Prepared for:

2018 State of the Basin Report
Groundwater Quality

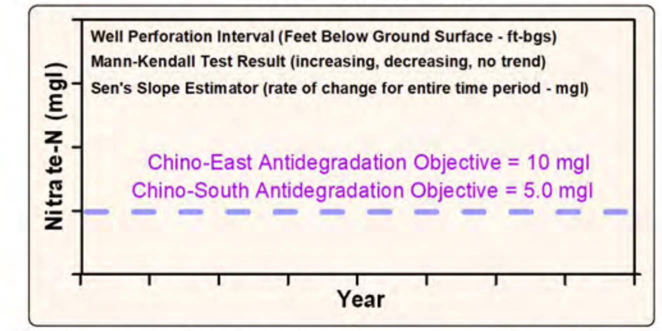
Chino Basin Watermaster — Partners in Basin Management

Chino Basin Management Zone 3
Trends in Nitrate Concentrations

Exhibit 5-30

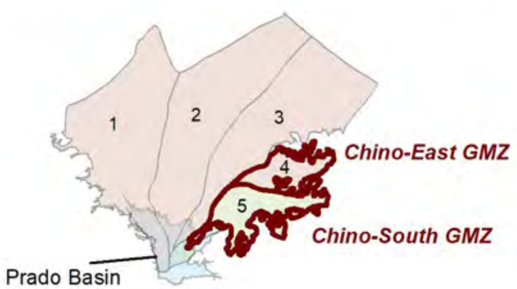


Nitrate-N Concentration



Two statistical trend tests were computed on the Nitrate-N concentration data. The Mann-Kendall test indicates whether data is increasing, decreasing, or does not have a statistically quantifiable trend (no trend). The Sen's Slope estimator is a non-parametric determination of the rate of change in concentration over time. All calculations were computed using Rstudio. Both statistics were interpreted using a confidence level of 95%.

OBMP MZ's and Chino-East and Chino-South GMZ's



Note: Prado Basin Management Zone has a surface water objective only.

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: RT
Date: 6/18/2019
File: 2018_Exhibit_5-31_MZ4_5_NO3_new_2.mxd

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

Prepared for:

2018 State of the Basin Report
Groundwater Quality

Chino Basin Watermaster — Partners in Basin Management

Chino Basin Management Zone 4 and Zone 5

Trends in Nitrate Concentrations

Exhibit 5-31

This section characterizes the history of land subsidence and ground fissuring and the current state of ground motion in the Chino Basin as understood through Watermaster's ground-level monitoring program.

One of the earliest indications of land subsidence in Chino Basin was the appearance of ground fissures in the City of Chino. These fissures appeared as early as 1973, but an accelerated occurrence of ground fissuring ensued after 1991 and resulted in damaged infrastructure.

In 1999, the OBMP Phase I Report (WEI, 1999) identified pumping-induced decline of piezometric levels and subsequent aquifer-system compaction as the most likely cause of land subsidence and ground fissuring observed in MZ1. PE 1 – *Develop and Implement a Comprehensive Monitoring Program* called for basin-wide analysis of ground-motion via ground-level surveys and remote sensing (InSAR) and ongoing monitoring based on the analysis of the ground-motion data. PE *4 – Develop and Implement a Comprehensive Groundwater Management Plan for Management Zone 1* called for the development and implementation of an interim management plan for MZ1 that would:

- Minimize subsidence and fissuring in the short-term.
- Collect the information necessary to understand the extent, rate, and mechanisms of subsidence and fissuring.
- Formulate a management plan to monitor and manage ground-level movement to abate future subsidence and fissuring or reduce it to tolerable levels.

In 2000, the Implementation Plan for the Peace Agreement called for an aquifer-system and land-subsidence investigation in the southwestern portion of MZ1 to support the development of a management plan (second and third bullets above). This investigation was titled the MZ1 Interim Monitoring Program (IMP). From 2001 to 2005, Watermaster developed, coordinated, and conducted the IMP under the guidance of the MZ1 Technical Committee, which was composed of representatives from all major producers in MZ1 and their technical consultants. The investigation methods, results, and conclusions are described in detail in the *MZ1 Summary Report* (WEI, 2006). The investigation provided enough information for Watermaster to develop Guidance Criteria for MZ1 that, if followed, would minimize the potential for subsidence and fissuring in the investigation area.

The Guidance Criteria also formed the basis for the *MZ1 Subsidence Management Plan* (MZ1 Plan; WEI, 2007b). The MZ1 Plan was developed by the MZ1 Technical Committee and approved by Watermaster in October 2007. In November 2007, the California Superior Court for the County of San Bernardino, which retains continuing jurisdiction over the Chino Basin adjudication, approved the MZ1 Plan and ordered its implementation. The MZ1 Plan called for the continued scope and frequency of monitoring implemented within the MZ1 Managed Area during the IMP and expanded monitoring of the aquifer-system and ground-motion in other areas of the Chino Basin where the IMP indicated concern for future subsidence and ground fissuring. The so-called Areas of Subsidence Concern include the Central MZ1, Northwest MZ1, and the Northeast and Southeast Areas.

Watermaster's 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. Watermaster conducts high-frequency, piezometric level monitoring at about 60 wells as part of its ground-level monitoring program. A pressure-transducer/data-logger is installed at each of these wells and records one water-level measurement every 15 minutes. Data loggers also record depth-specific piezometric levels at the piezometers located at Watermaster's Ayala Park Extensometer and Chino Creek Extensometer facilities once every 15 minutes.
- *Aquifer-System Deformation.* The vertical deformation of the aquifer-system is measured and recorded with borehole extensometers. In 2003, Watermaster installed the Ayala Park Extensometer in the Managed Area to support the IMP. At this facility, two extensometers are completed to depths of 550 ft-bgs and 1,400 ft-bgs. In 2012, Watermaster installed the Chino Creek Extensometer facility (CCX) in the Southeast Area to understand the effects of pumping at the newly constructed Chino Creek Well Field (CCWF). The CCX also consists of two extensometers: one completed to a depth of 140 ft-bgs and the other to 610 ft-bgs. Both extensometer facilities record the vertical component of aquifer-system compression and expansion once every 15 minutes, synchronized with the piezometric measurements to understand the relationships between piezometric changes and aquifer-system deformation.
- *Vertical Ground-Motion.* Watermaster monitors vertical ground-motion via traditional elevation surveys at benchmark monuments and via remote sensing (InSAR) techniques established during the IMP. Elevation surveys are typically conducted in the MZ1 Managed Area, Northwest MZ1 Area, Northeast Area, and Southeast Area once per year. Vertical ground-motion data, based on InSAR, are collected about every two months and analyzed once per year.
- *Horizontal Ground-Surface Deformation.* Watermaster monitors horizontal ground-surface deformation across areas that are experiencing differential land subsidence to understand the potential threats and locations of ground fissuring. These data are obtained by electronic distance measurements (EDMs) between benchmark monuments in two areas: across the historical zone of ground fissuring in the MZ1 Managed Area and across the San Jose Fault Zone in Northwest MZ1.

Exhibits 6-1 through 6-3 illustrate the historical occurrence of vertical ground motion in the Chino Basin as interpreted from InSAR and elevation surveys. These maps demonstrate that land subsidence concerns are primarily confined to the west side of the Chino Basin.

The land subsidence that has occurred in the Chino Basin was mainly controlled by changes in piezometric levels, which, in turn, were mainly controlled by pumping and recharge. Exhibits 6-4b through 6-8b show the relationships between groundwater pumping, recharge, recycled water reuse, piezometric levels, and vertical ground motion in the MZ1 Managed Area and the other Areas of Subsidence Concern. These graphics can reveal cause-and-effect relationships and the current state and nature of vertical ground motion. For reference, Exhibits 6-4a through 6-8a illustrate vertical ground motion for each area of subsidence concern as estimated by InSAR for the period March 2011 to March 2018 and display the locations of wells with long-term time series of depth to groundwater, key benchmark locations with time series of cumulative ground-surface-elevation displacement, and InSAR with time series of cumulative vertical ground motion.

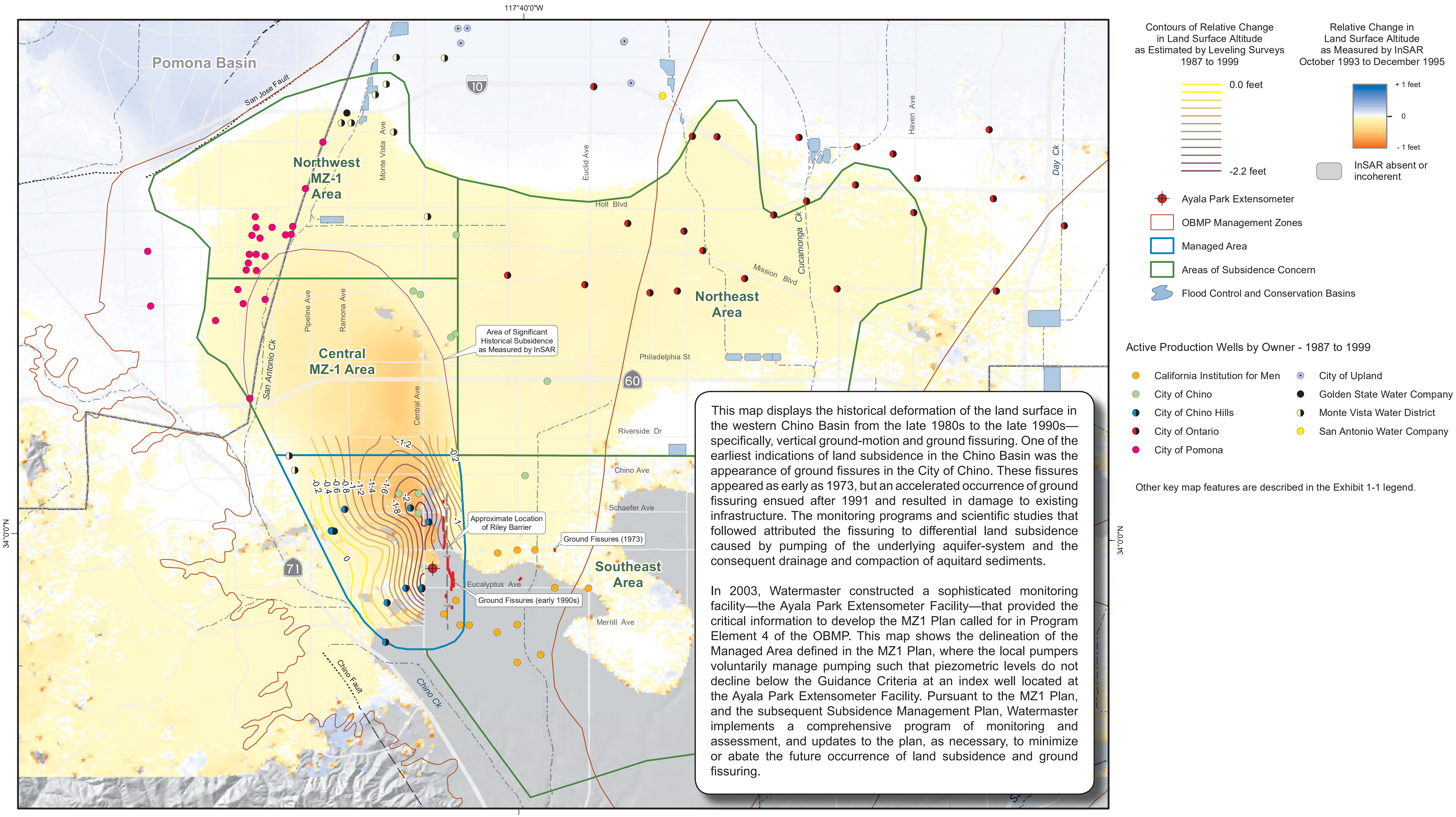
Watermaster convenes a Ground-Level Monitoring Committee (GLMC) annually to review and interpret data from the ground-level monitoring program. The GLMC prepares annual reports that include recommendations for changes to the monitoring program and/or the MZ1 Plan, if such changes are demonstrated to be necessary to achieve the objectives of the monitoring program.

Based on the data collected and analyzed for the ground-level monitoring program, the GLMC became increasingly concerned with the occurrence of persistent differential subsidence in Northwest MZ1. In 2014, the GLMC recommended that the MZ1 Plan be updated to include a subsidence management plan for Northwest MZ1 with the long-term objective of minimizing or abating the occurrence of the differential land subsidence. In 2015, Watermaster updated the MZ1 Plan to more accurately reflect Watermaster's current and future efforts to monitor and manage land subsidence, including the effort to develop a subsidence management plan for Northwest MZ1. The MZ1 Plan was renamed the *Chino Basin Subsidence Management Plan* (WEI, 2015c).

This new effort in Northwest MZ1 is an example of adaptive management of land subsidence, based on monitoring data, and includes the following activities:

- To better understand the extent, rate, and causes of the ongoing subsidence in Northwest MZ1, the GLMC and Watermaster have increased monitoring efforts to include the installation of benchmark monuments across Northwest MZ1, performing annual elevation surveys at the benchmarks, performing EDMs between benchmarks across the San Jose Fault, and expanding the high-frequency measurement of piezometric levels at wells.

- Aquifer-system compaction may be occurring (or may have occurred historically) at specific depths within Northwest MZ1, caused by depth-specific piezometric changes. Depth-specific data, obtained from piezometers and extensometers, are critical to understanding how groundwater production and recharge affect piezometric levels and the deformation of the aquifer-system. This understanding is needed to develop a subsidence management plan. Watermaster has identified a site for a new extensometer facility in Northwest MZ1 and is currently constructing two dual-nested piezometers in Montvue Park, Pomona, CA. This facility is expected to start collecting piezometric and aquifer-system deformation data by July 2019. The subsidence management plan for Northwest MZ1 is expected to be completed by the end of 2023.



This map displays the historical deformation of the land surface in the western Chino Basin from the late 1980s to the late 1990s—specifically, vertical ground-motion and ground fissuring. One of the earliest indications of land subsidence in the Chino Basin was the appearance of ground fissures in the City of Chino. These fissures appeared as early as 1973, but an accelerated occurrence of ground fissuring ensued after 1991 and resulted in damage to existing infrastructure. The monitoring programs and scientific studies that followed attributed the fissuring to differential land subsidence caused by pumping of the underlying aquifer-system and the consequent drainage and compaction of aquitard sediments.

In 2003, Watermaster constructed a sophisticated monitoring facility—the Ayala Park Extensometer Facility—that provided the critical information to develop the MZ1 Plan called for in Program Element 4 of the OBMP. This map shows the delineation of the Managed Area defined in the MZ1 Plan, where the local pumpers voluntarily manage pumping such that piezometric levels do not decline below the Guidance Criteria at an index well located at the Ayala Park Extensometer Facility. Pursuant to the MZ1 Plan, and the subsequent Subsidence Management Plan, Watermaster implements a comprehensive program of monitoring and assessment, and updates to the plan, as necessary, to minimize or abate the future occurrence of land subsidence and ground fissuring.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: NWS
Date: 5/28/2019
File: Exhibit_6-1_InSAR.mxd

N
0 1 2 3 Miles
0 2 4 Km

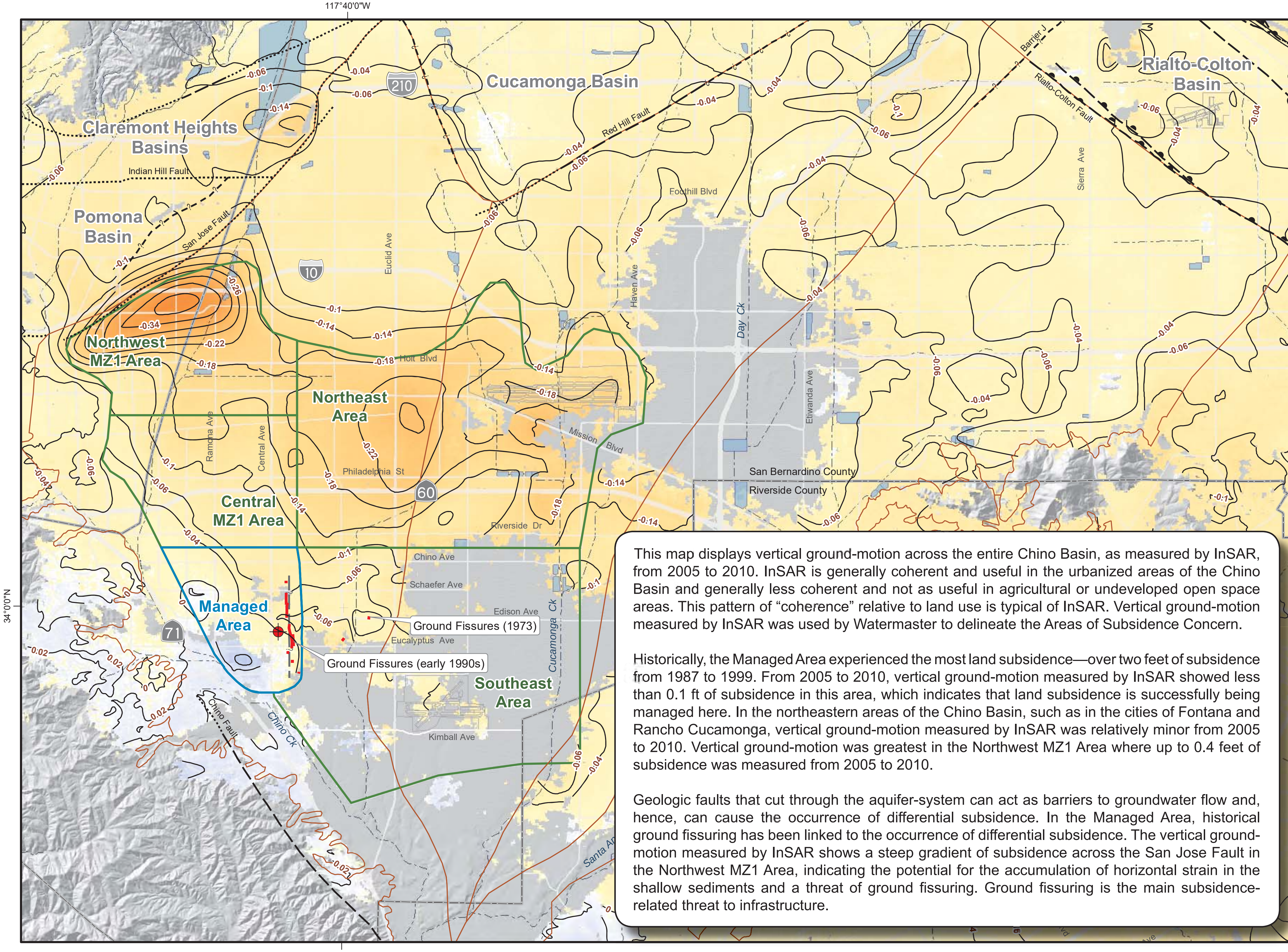
Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

Chino Basin Watermaster
Partners in Basin Management

Historical Land Surface Deformation in Management Zone 1
Leveling Surveys (1987 to 1999) and InSAR (1993 to 1995)

Exhibit 6-1



This map displays vertical ground-motion across the entire Chino Basin, as measured by InSAR, from 2005 to 2010. InSAR is generally coherent and useful in the urbanized areas of the Chino Basin and generally less coherent and not as useful in agricultural or undeveloped open space areas. This pattern of “coherence” relative to land use is typical of InSAR. Vertical ground-motion measured by InSAR was used by Watermaster to delineate the Areas of Subsidence Concern.

Historically, the Managed Area experienced the most land subsidence—over two feet of subsidence from 1987 to 1999. From 2005 to 2010, vertical ground-motion measured by InSAR showed less than 0.1 ft of subsidence in this area, which indicates that land subsidence is successfully being managed here. In the northeastern areas of the Chino Basin, such as in the cities of Fontana and Rancho Cucamonga, vertical ground-motion measured by InSAR was relatively minor from 2005 to 2010. Vertical ground-motion was greatest in the Northwest MZ1 Area where up to 0.4 feet of subsidence was measured from 2005 to 2010.

Geologic faults that cut through the aquifer-system can act as barriers to groundwater flow and, hence, can cause the occurrence of differential subsidence. In the Managed Area, historical ground fissuring has been linked to the occurrence of differential subsidence. The vertical ground-motion measured by InSAR shows a steep gradient of subsidence across the San Jose Fault in the Northwest MZ1 Area, indicating the potential for the accumulation of horizontal strain in the shallow sediments and a threat of ground fissuring. Ground fissuring is the main subsidence-related threat to infrastructure.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: NWS
Date: 5/28/2019
File: Exhibit_6-2_InSAR_v2.mxd

0 2 4 Miles
0 2 4 Km

Prepared for:

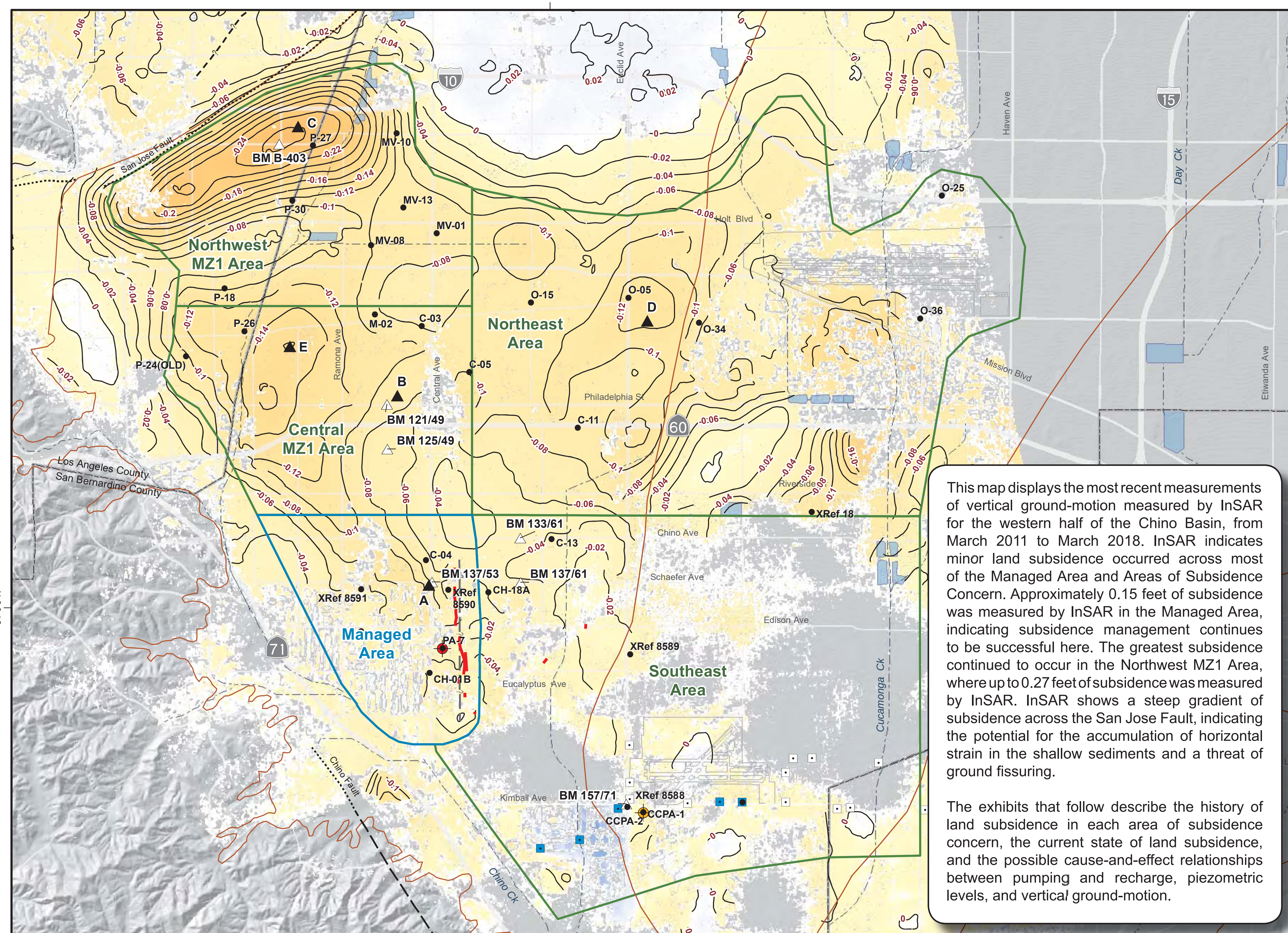
2018 State of the Basin Report
Ground-Level Monitoring

Chino Basin Watermaster
Partners in Basin Management

Vertical Ground-Motion as Measured by InSAR

2005 to 2010

Exhibit 6-2



This map displays the most recent measurements of vertical ground-motion measured by InSAR for the western half of the Chino Basin, from March 2011 to March 2018. InSAR indicates minor land subsidence occurred across most of the Managed Area and Areas of Subsidence Concern. Approximately 0.15 feet of subsidence was measured by InSAR in the Managed Area, indicating subsidence management continues to be successful here. The greatest subsidence continued to occur in the Northwest MZ1 Area, where up to 0.27 feet of subsidence was measured by InSAR. InSAR shows a steep gradient of subsidence across the San Jose Fault, indicating the potential for the accumulation of horizontal strain in the shallow sediments and a threat of ground fissuring.

The exhibits that follow describe the history of land subsidence in each area of subsidence concern, the current state of land subsidence, and the possible cause-and-effect relationships between pumping and recharge, piezometric levels, and vertical ground-motion.

Relative Change in Land Surface Altitude as Measured by InSAR March 2011 to March 2018

+ 0.5 feet
0
-0.25
- 0.5 feet

InSAR absent or incoherent

Wells with Piezometric Level Time Histories Plotted on Exhibits 6-4b to 6-8b

InSAR Time-History Point Plotted on Exhibits 6-4b to 6-8b

Ground-Level Survey Benchmark Time-History Point Plotted on Exhibits 6-4b to 6-8b

Ayala Park Extensometer

Chino-1/Chino-II Desalter Well

Chino Creek Extensometer

Chino Creek Desalter Well

OBMP Management Zones

Areas of Subsidence Concern

Managed Area

Ground Fissures

Approximate Location of the Riley Barrier

Other key map features are described in the legend of Exhibit 1-1.

Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: NWS
Date: 5/28/2019
File: Exhibit_6-3_InSAR.mxd

0 2 4 Miles

0 2 4 Km

Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

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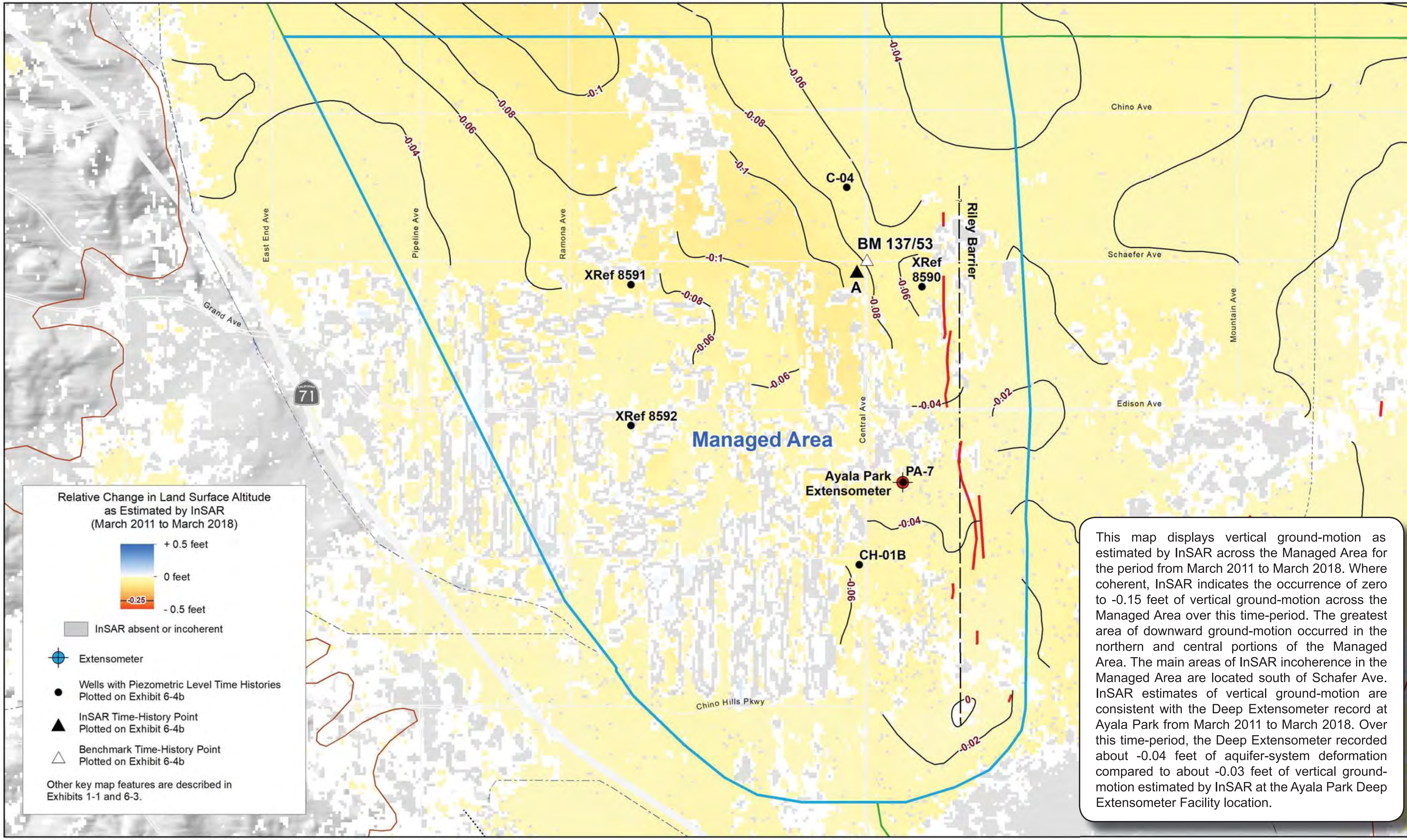
Vertical Ground-Motion as Measured by InSAR
2011 to 2018

Exhibit 6-3



This map displays vertical ground-motion as estimated by InSAR across the Managed Area for the period from March 2011 to March 2018. Where coherent, InSAR indicates the occurrence of zero to -0.15 feet of vertical ground-motion across the Managed Area over this time-period. The greatest area of downward ground-motion occurred in the northern and central portions of the Managed Area. The main areas of InSAR incoherence in the Managed Area are located south of Schafer Ave. InSAR estimates of vertical ground-motion are consistent with the Deep Extensometer record at Ayala Park from March 2011 to March 2018. Over this time-period, the Deep Extensometer recorded about -0.04 feet of aquifer-system deformation compared to about -0.03 feet of vertical ground-motion estimated by InSAR at the Ayala Park Deep Extensometer Facility location.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: NWS
Date: 6/21/2019
File: Exhibit_6-4a_ManagedLocationMap.mxd

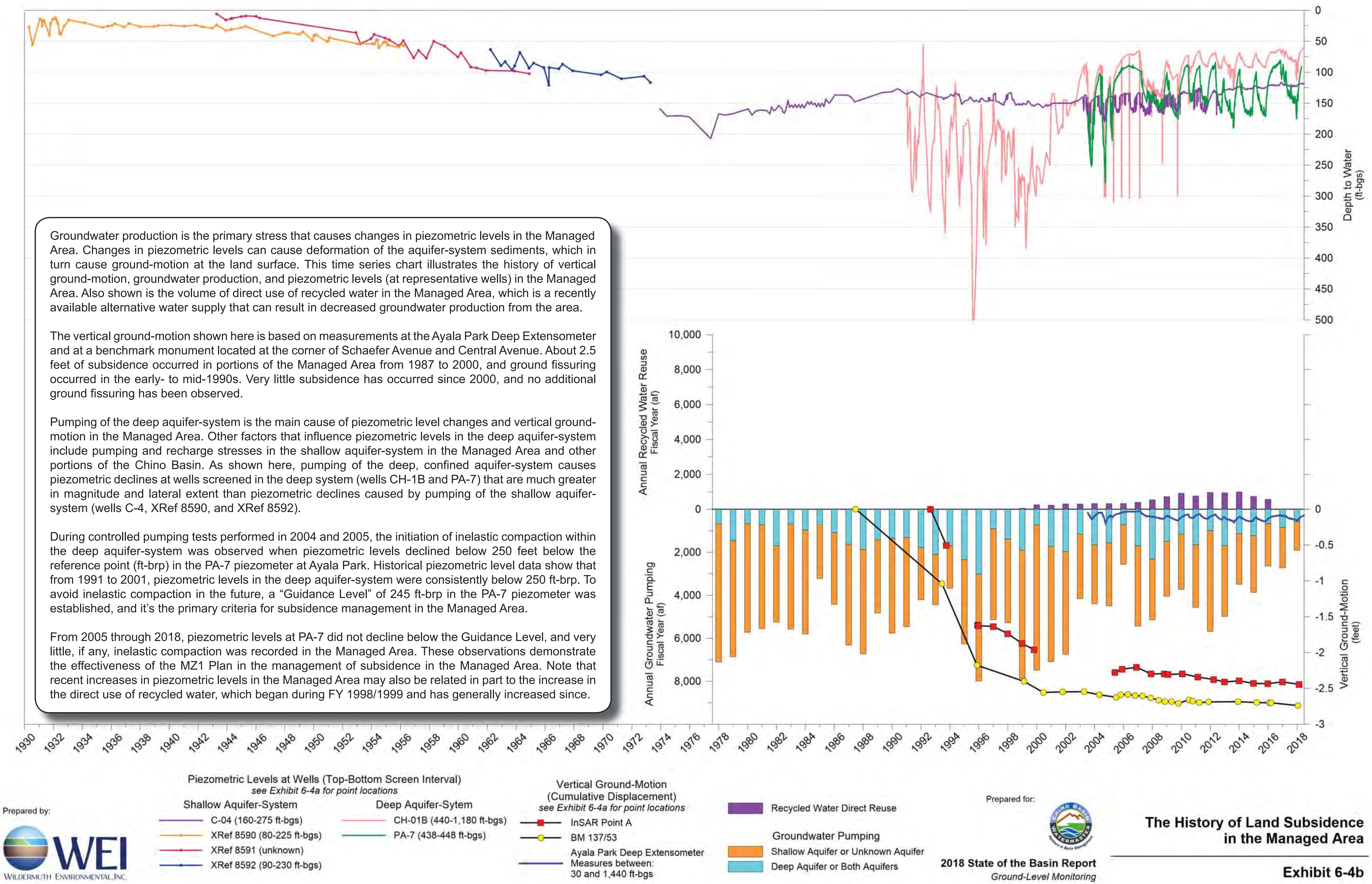
Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

CHINO BASIN WATERMASTER
Partners in Basin Management

Vertical Ground-Motion across the Managed Area
2011 - 2018

Exhibit 6-4a



Groundwater production is the primary stress that causes changes in piezometric levels in the Managed Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which in turn cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, and piezometric levels (at representative wells) in the Managed Area. Also shown is the volume of direct use of recycled water in the Managed Area, which is a recently available alternative water supply that can result in decreased groundwater production from the area.

The vertical ground-motion shown here is based on measurements at the Ayala Park Deep Extensometer and at a benchmark monument located at the corner of Schaefer Avenue and Central Avenue. About 2.5 feet of subsidence occurred in portions of the Managed Area from 1987 to 2000, and ground fissuring occurred in the early- to mid-1990s. Very little subsidence has occurred since 2000, and no additional ground fissuring has been observed.

Pumping of the deep aquifer-system is the main cause of piezometric level changes and vertical ground-motion in the Managed Area. Other factors that influence piezometric levels in the deep aquifer-system include pumping and recharge stresses in the shallow aquifer-system in the Managed Area and other portions of the Chino Basin. As shown here, pumping of the deep, confined aquifer-system causes piezometric declines at wells screened in the deep system (wells CH-1B and PA-7) that are much greater in magnitude and lateral extent than piezometric declines caused by pumping of the shallow aquifer-system (wells C-4, XRef 8590, and XRef 8592).

During controlled pumping tests performed in 2004 and 2005, the initiation of inelastic compaction within the deep aquifer-system was observed when piezometric levels declined below 250 feet below the reference point (ft-brp) in the PA-7 piezometer at Ayala Park. Historical piezometric level data show that from 1991 to 2001, piezometric levels in the deep aquifer-system were consistently below 250 ft-brp. To avoid inelastic compaction in the future, a “Guidance Level” of 245 ft-brp in the PA-7 piezometer was established, and it’s the primary criteria for subsidence management in the Managed Area.

From 2005 through 2018, piezometric levels at PA-7 did not decline below the Guidance Level, and very little, if any, inelastic compaction was recorded in the Managed Area. These observations demonstrate the effectiveness of the MZ1 Plan in the management of subsidence in the Managed Area. Note that recent increases in piezometric levels in the Managed Area may also be related in part to the increase in the direct use of recycled water, which began during FY 1998/1999 and has generally increased since.

Prepared by:

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Prepared for:

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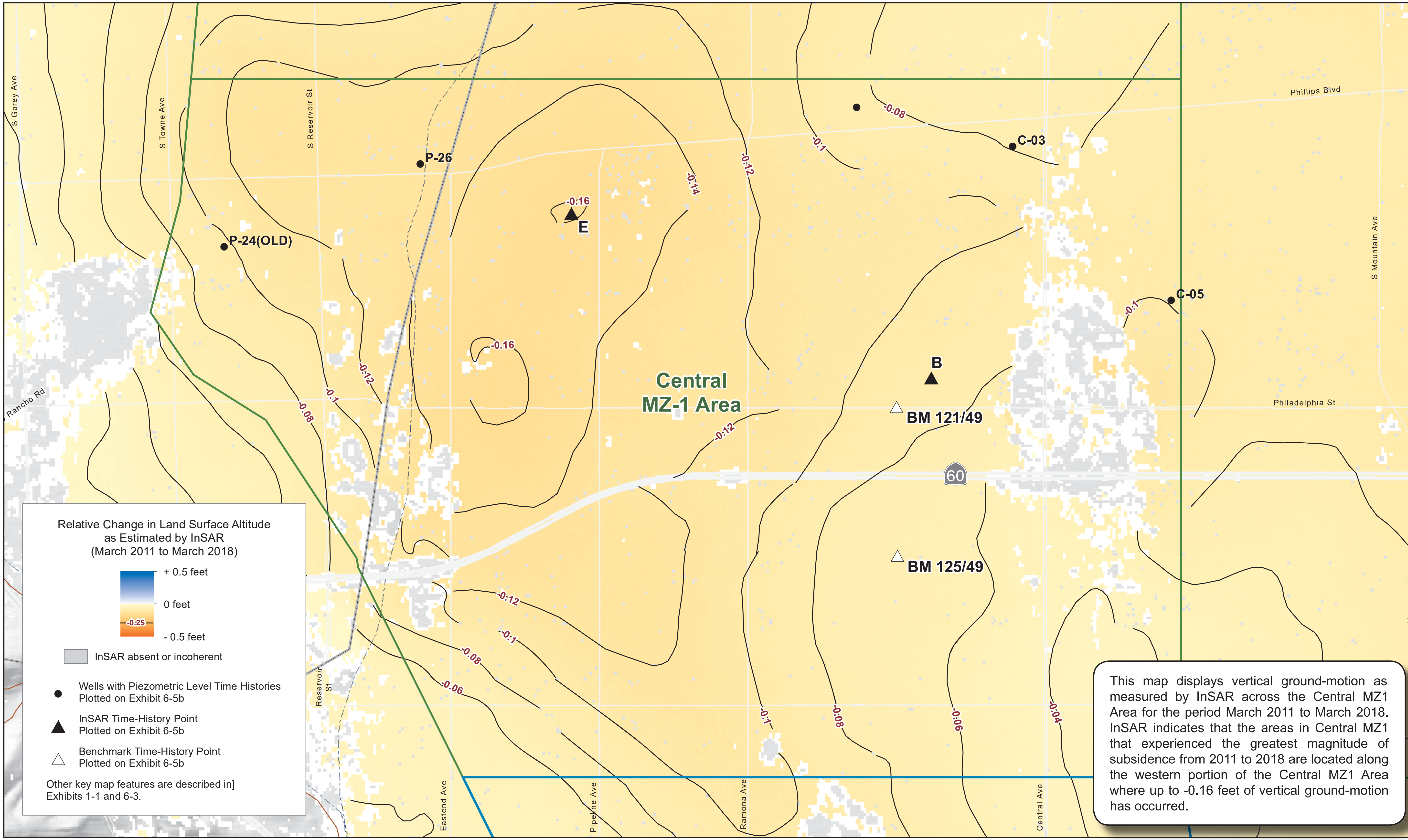
The History of Land Subsidence in the Managed Area

Exhibit 6-4b



This map displays vertical ground-motion as measured by InSAR across the Central MZ1 Area for the period March 2011 to March 2018. InSAR indicates that the areas in Central MZ1 that experienced the greatest magnitude of subsidence from 2011 to 2018 are located along the western portion of the Central MZ1 Area where up to -0.16 feet of vertical ground-motion has occurred.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: NWS
Date: 5/28/2019
File: Exhibit_6-5a_CentralLocationMap.mxd

0 1 Mile
0 1 Kilometer

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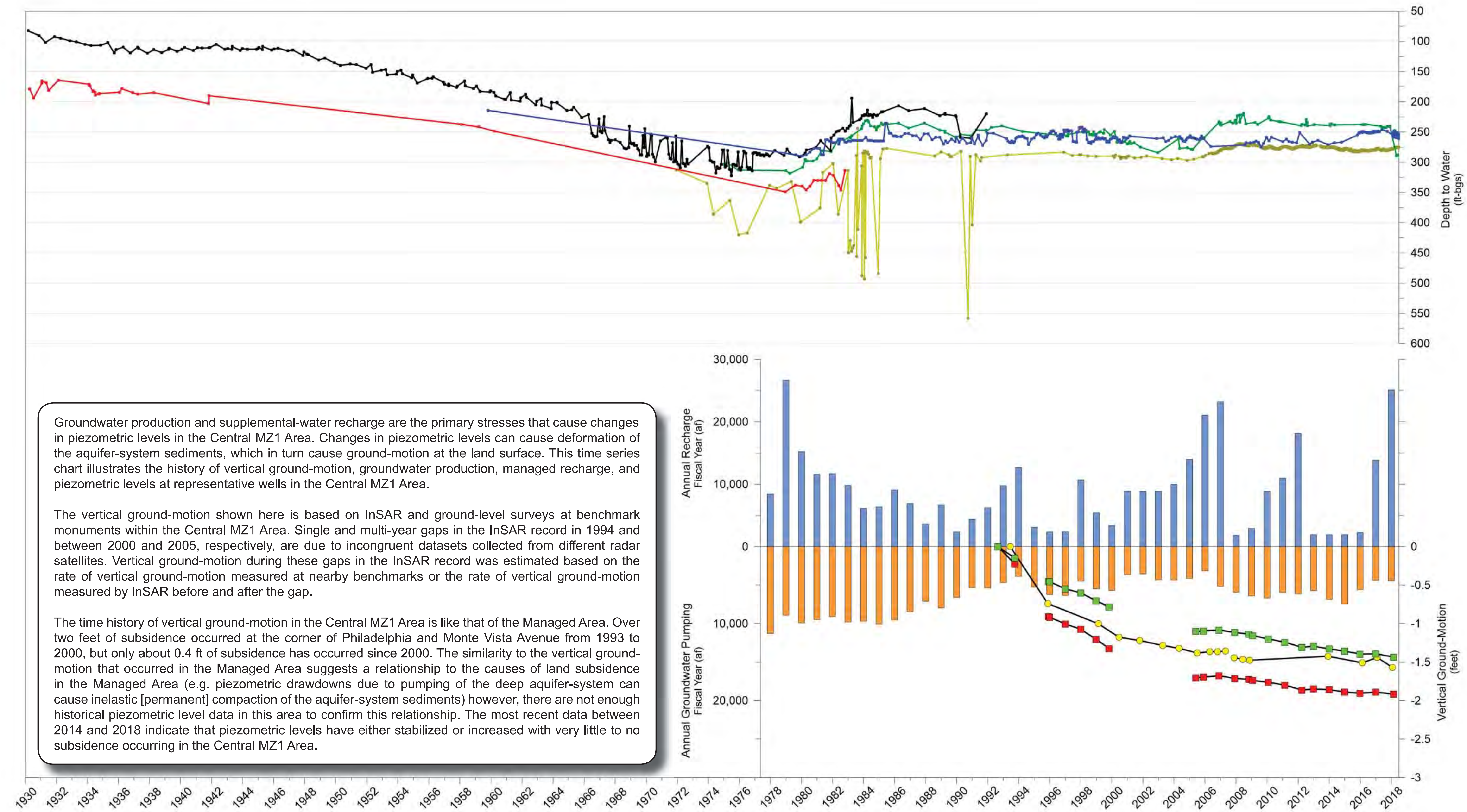
Ground-Level Monitoring

CHINO BASIN WATERMASTER
Partners in Basin Management

Vertical Ground-Motion across the Central MZ1 Area
2011 - 2018

Exhibit 6-5a



Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in the Central MZ1 Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which in turn cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in the Central MZ1 Area.

The vertical ground-motion shown here is based on InSAR and ground-level surveys at benchmark monuments within the Central MZ1 Area. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during these gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured at nearby benchmarks or the rate of vertical ground-motion measured by InSAR before and after the gap.

The time history of vertical ground-motion in the Central MZ1 Area is like that of the Managed Area. Over two feet of subsidence occurred at the corner of Philadelphia and Monte Vista Avenue from 1993 to 2000, but only about 0.4 ft of subsidence has occurred since 2000. The similarity to the vertical ground-motion that occurred in the Managed Area suggests a relationship to the causes of land subsidence in the Managed Area (e.g. piezometric drawdowns due to pumping of the deep aquifer-system can cause inelastic [permanent] compaction of the aquifer-system sediments) however, there are not enough historical piezometric level data in this area to confirm this relationship. The most recent data between 2014 and 2018 indicate that piezometric levels have either stabilized or increased with very little to no subsidence occurring in the Central MZ1 Area.

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Wildermuth Environmental, Inc.

Prepared for:

Chino Basin Watermaster

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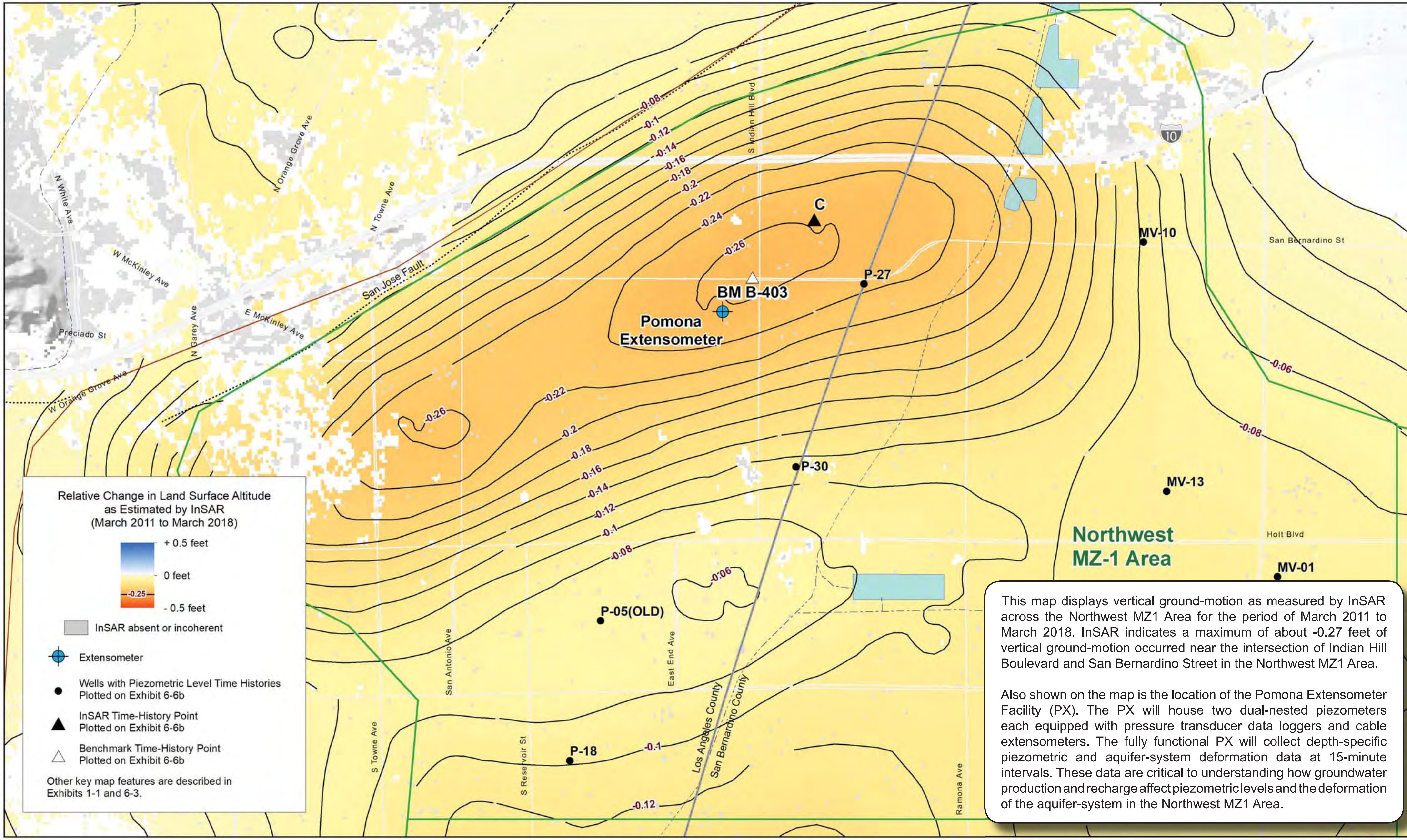
Ground-Level Monitoring

The History of Land Subsidence in the Central MZ1 Area

Exhibit 6-5b



This map displays vertical ground-motion as measured by InSAR across the Northwest MZ1 Area for the period of March 2011 to March 2018. InSAR indicates a maximum of about -0.27 feet of vertical ground-motion occurred near the intersection of Indian Hill Boulevard and San Bernardino Street in the Northwest MZ1 Area.

Also shown on the map is the location of the Pomona Extensometer Facility (PX). The PX will house two dual-nested piezometers each equipped with pressure transducer data loggers and cable extensometers. The fully functional PX will collect depth-specific piezometric and aquifer-system deformation data at 15-minute intervals. These data are critical to understanding how groundwater production and recharge affect piezometric levels and the deformation of the aquifer-system in the Northwest MZ1 Area.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: NWS
Date: 6/21/2019
File: Exhibit_6-6a_NorthwestAreaLocationMap.mxd

Prepared for:

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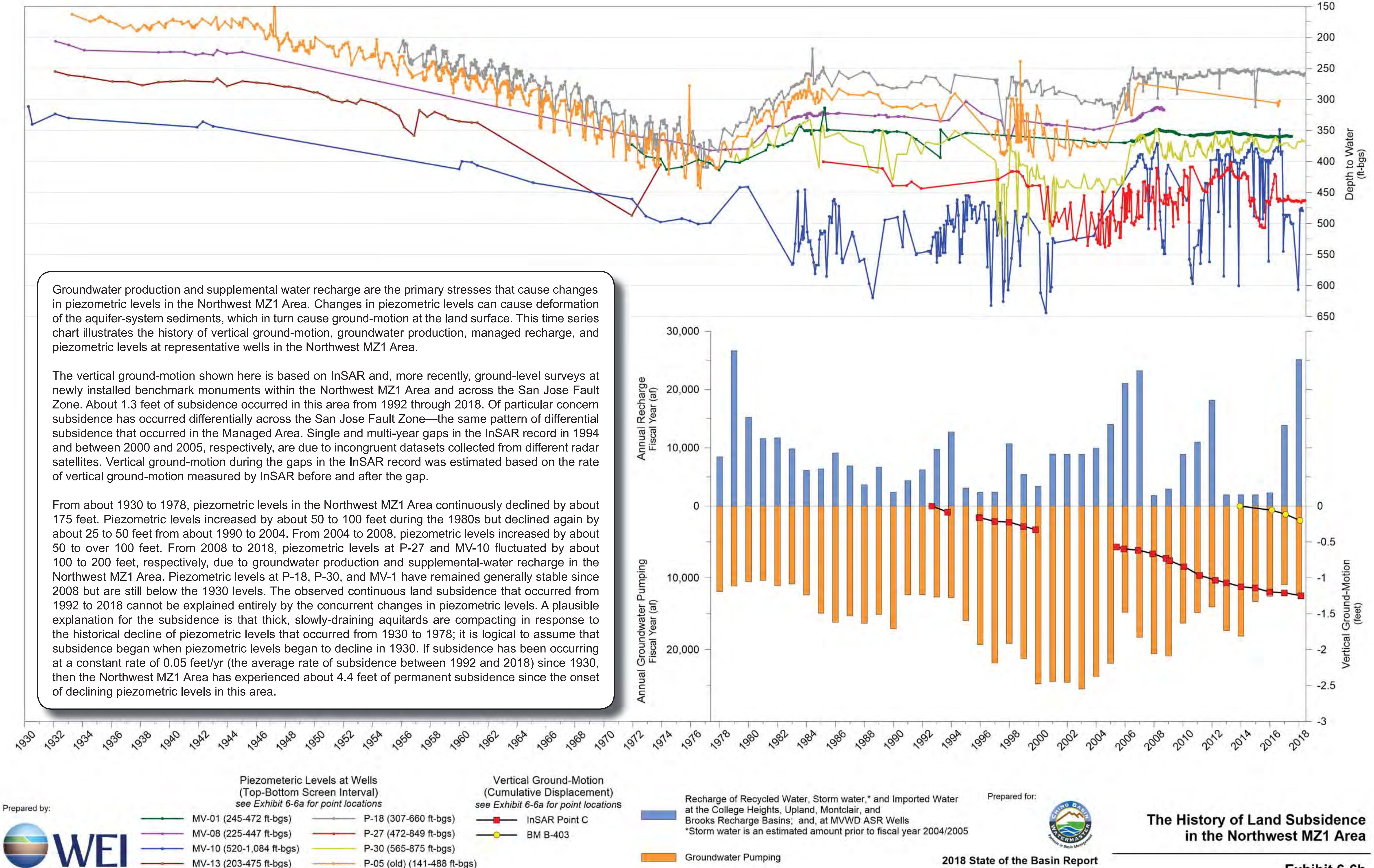
Ground-Level Monitoring

Vertical Ground-Motion across the Northwest MZ1 Area
2011 - 2018

Exhibit 6-6a



Groundwater production and supplemental water recharge are the primary stresses that cause changes in piezometric levels in the Northwest MZ1 Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which in turn cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in the Northwest MZ1 Area.

The vertical ground-motion shown here is based on InSAR and, more recently, ground-level surveys at newly installed benchmark monuments within the Northwest MZ1 Area and across the San Jose Fault Zone. About 1.3 feet of subsidence occurred in this area from 1992 through 2018. Of particular concern subsidence has occurred differentially across the San Jose Fault Zone—the same pattern of differential subsidence that occurred in the Managed Area. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during the gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured by InSAR before and after the gap.

From about 1930 to 1978, piezometric levels in the Northwest MZ1 Area continuously declined by about 175 feet. Piezometric levels increased by about 50 to 100 feet during the 1980s but declined again by about 25 to 50 feet from about 1990 to 2004. From 2004 to 2008, piezometric levels increased by about 50 to over 100 feet. From 2008 to 2018, piezometric levels at P-27 and MV-10 fluctuated by about 100 to 200 feet, respectively, due to groundwater production and supplemental-water recharge in the Northwest MZ1 Area. Piezometric levels at P-18, P-30, and MV-1 have remained generally stable since 2008 but are still below the 1930 levels. The observed continuous land subsidence that occurred from 1992 to 2018 cannot be explained entirely by the concurrent changes in piezometric levels. A plausible explanation for the subsidence is that thick, slowly-draining aquitards are compacting in response to the historical decline of piezometric levels that occurred from 1930 to 1978; it is logical to assume that subsidence began when piezometric levels began to decline in 1930. If subsidence has been occurring at a constant rate of 0.05 feet/yr (the average rate of subsidence between 1992 and 2018) since 1930, then the Northwest MZ1 Area has experienced about 4.4 feet of permanent subsidence since the onset of declining piezometric levels in this area.

Prepared by:

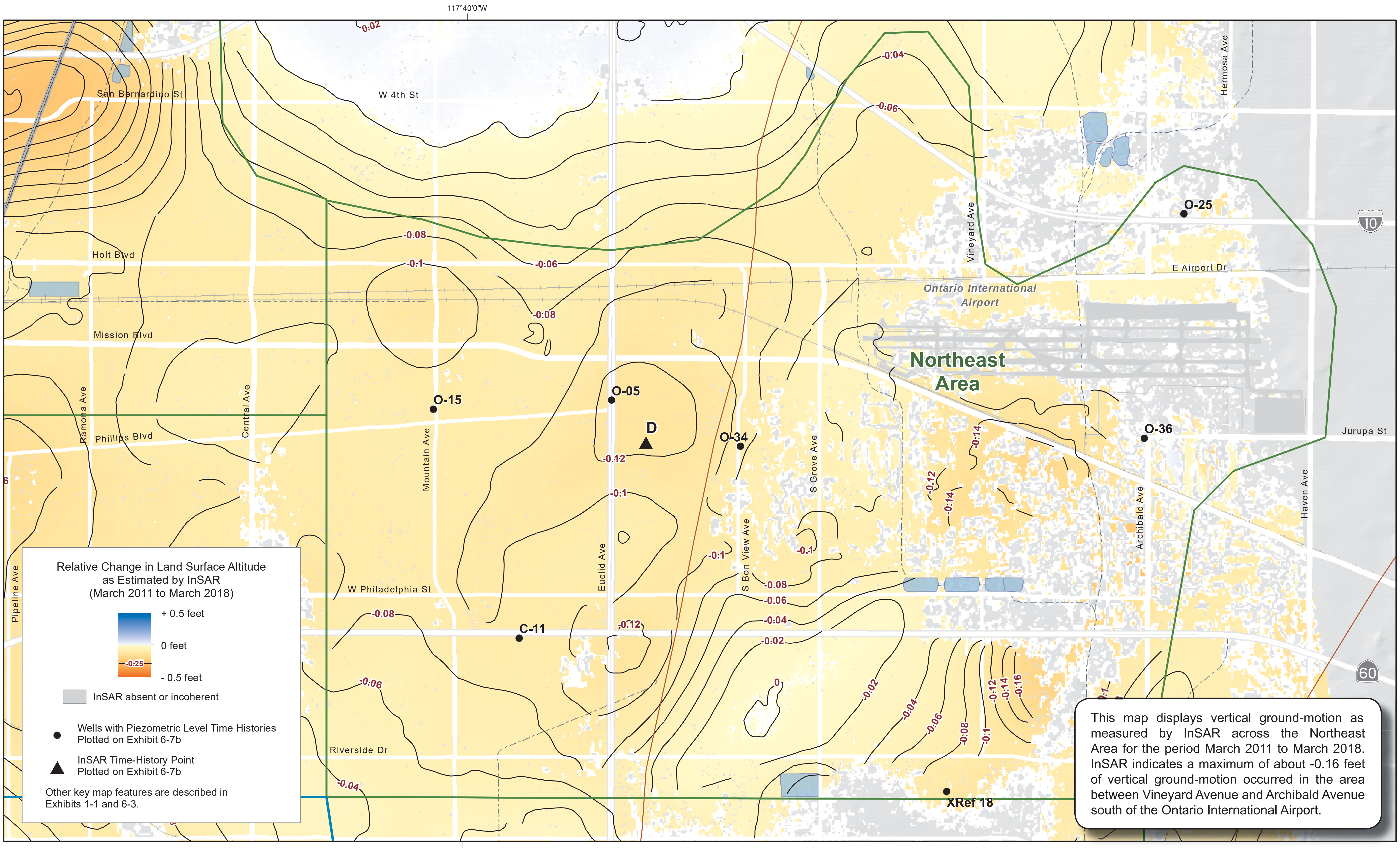
WEI
Wildermuth Environmental, Inc.

Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

The History of Land Subsidence in the Northwest MZ1 Area

Exhibit 6-6b



This map displays vertical ground-motion as measured by InSAR across the Northeast Area for the period March 2011 to March 2018. InSAR indicates a maximum of about -0.16 feet of vertical ground-motion occurred in the area between Vineyard Avenue and Archibald Avenue south of the Ontario International Airport.

Prepared by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: NWS
Date: 5/28/2019
File: Exhibit_6-7a_NortheastAreaLocationMap.mxd

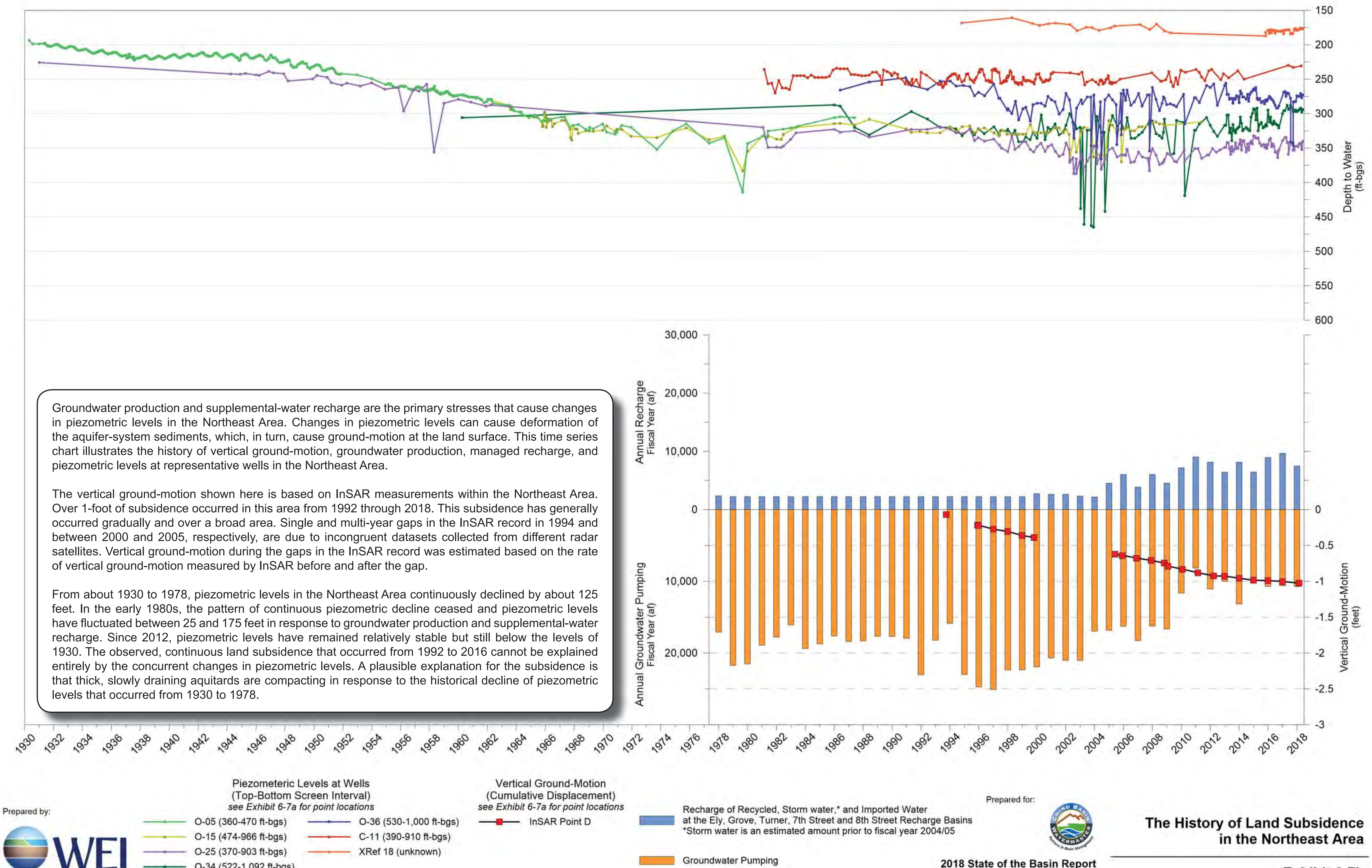
0 1 Mile
0 1 Kilometer

Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

Vertical Ground Motion across the Northeast Area
2011 - 2018

Exhibit 6-7a



Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in the Northeast Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which, in turn, cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in the Northeast Area.

The vertical ground-motion shown here is based on InSAR measurements within the Northeast Area. Over 1-foot of subsidence occurred in this area from 1992 through 2018. This subsidence has generally occurred gradually and over a broad area. Single and multi-year gaps in the InSAR record in 1994 and between 2000 and 2005, respectively, are due to incongruent datasets collected from different radar satellites. Vertical ground-motion during the gaps in the InSAR record was estimated based on the rate of vertical ground-motion measured by InSAR before and after the gap.

From about 1930 to 1978, piezometric levels in the Northeast Area continuously declined by about 125 feet. In the early 1980s, the pattern of continuous piezometric decline ceased and piezometric levels have fluctuated between 25 and 175 feet in response to groundwater production and supplemental-water recharge. Since 2012, piezometric levels have remained relatively stable but still below the levels of 1930. The observed, continuous land subsidence that occurred from 1992 to 2016 cannot be explained entirely by the concurrent changes in piezometric levels. A plausible explanation for the subsidence is that thick, slowly draining aquitards are compacting in response to the historical decline of piezometric levels that occurred from 1930 to 1978.

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Wildermuth Environmental, Inc.

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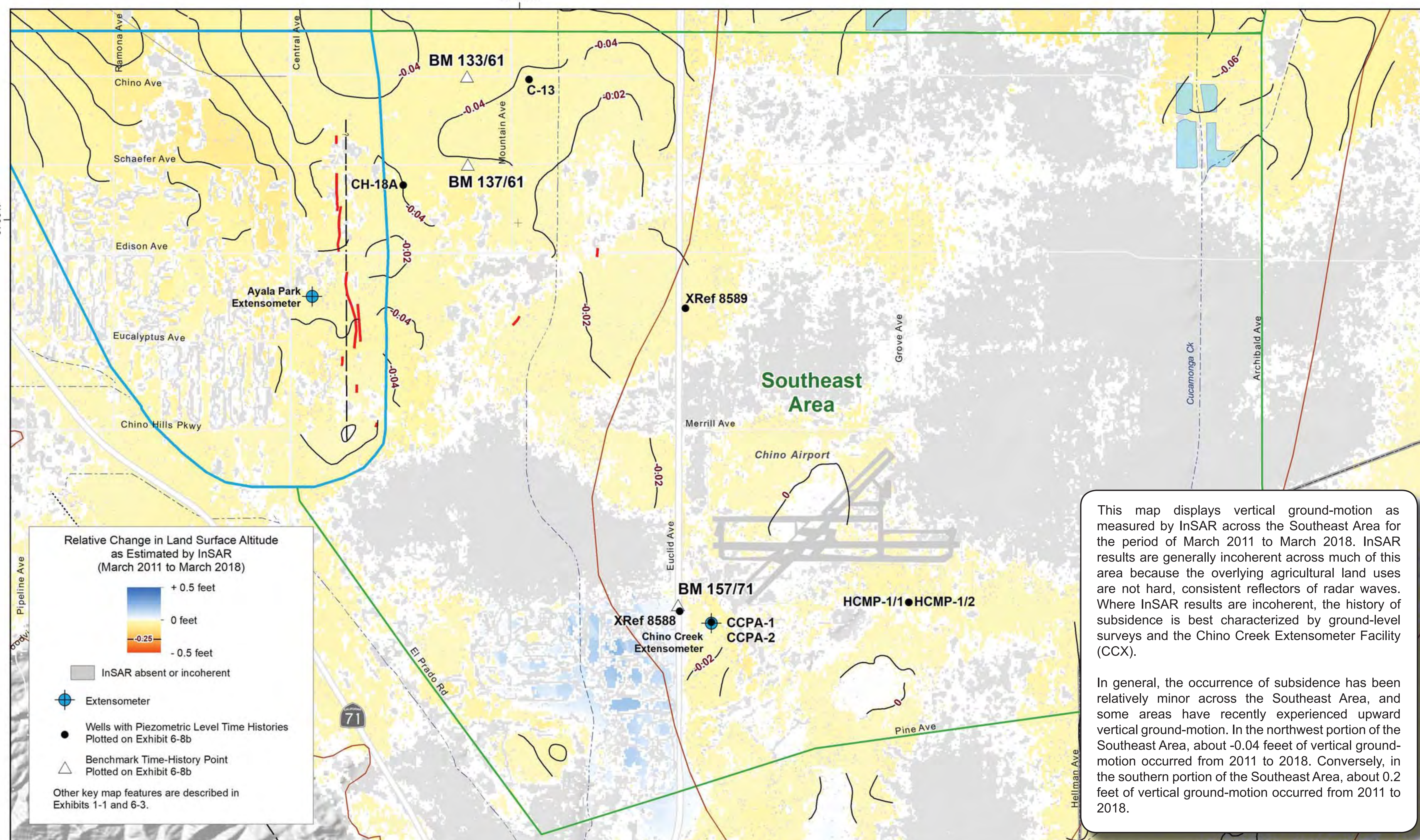
Chino Basin Watermaster

2018 State of the Basin Report
Ground-Level Monitoring

The History of Land Subsidence in the Northeast Area

Exhibit 6-7b



This map displays vertical ground-motion as measured by InSAR across the Southeast Area for the period of March 2011 to March 2018. InSAR results are generally incoherent across much of this area because the overlying agricultural land uses are not hard, consistent reflectors of radar waves. Where InSAR results are incoherent, the history of subsidence is best characterized by ground-level surveys and the Chino Creek Extensometer Facility (CCX).

In general, the occurrence of subsidence has been relatively minor across the Southeast Area, and some areas have recently experienced upward vertical ground-motion. In the northwest portion of the Southeast Area, about -0.04 feeet of vertical ground-motion occurred from 2011 to 2018. Conversely, in the southern portion of the Southeast Area, about 0.2 feet of vertical ground-motion occurred from 2011 to 2018.

Prepared by:

WEI
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Author: NWS
Date: 6/21/2019
File: Exhibit_6-8a_SoutheastAreaLocationMap.mxd

0 1 Mile
0 1 Kilometer

Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

Vertical Ground-Motion across the Southeast Area
2011 - 2018

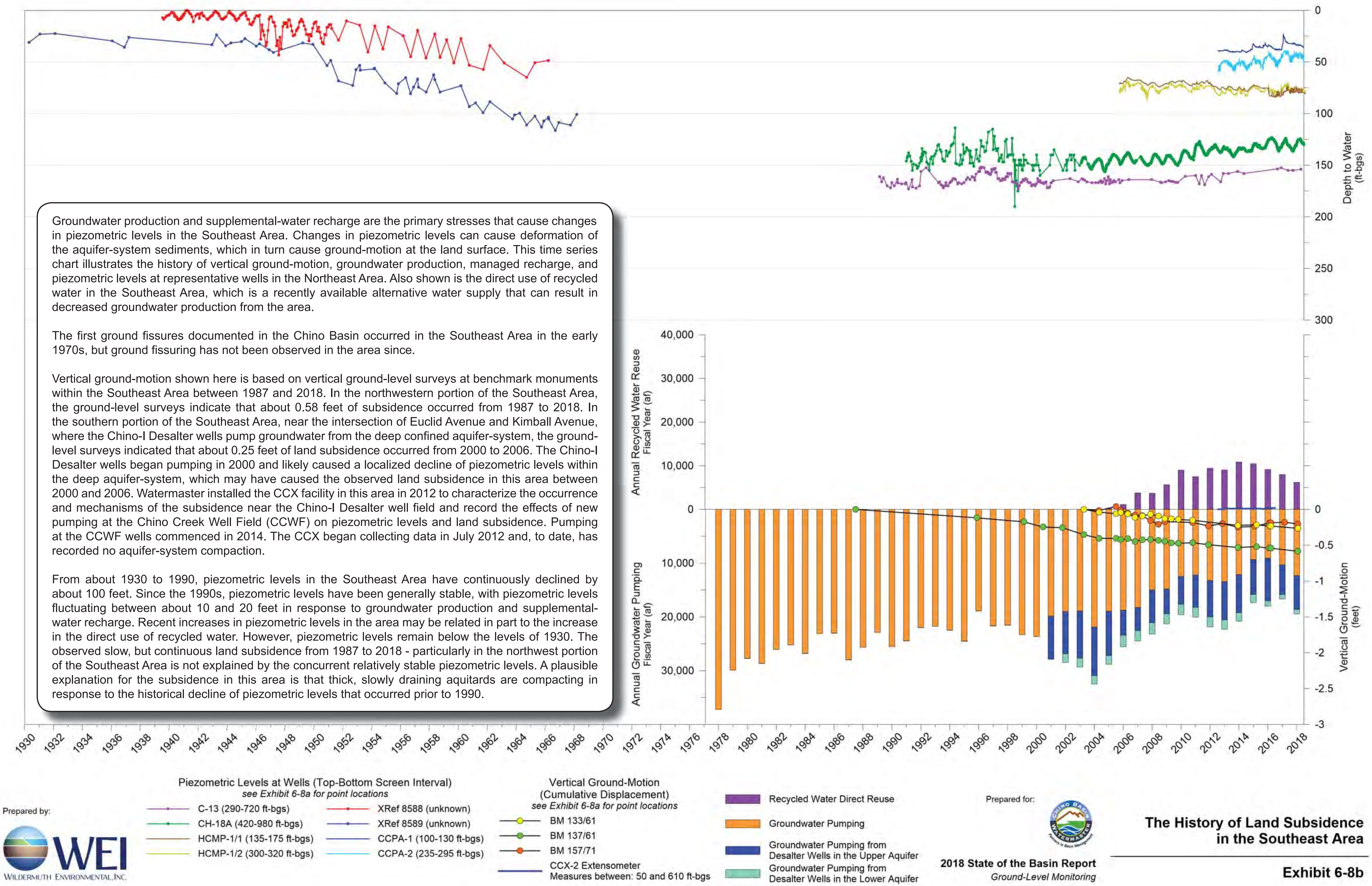
Exhibit 6-8a

Groundwater production and supplemental-water recharge are the primary stresses that cause changes in piezometric levels in the Southeast Area. Changes in piezometric levels can cause deformation of the aquifer-system sediments, which in turn cause ground-motion at the land surface. This time series chart illustrates the history of vertical ground-motion, groundwater production, managed recharge, and piezometric levels at representative wells in the Northeast Area. Also shown is the direct use of recycled water in the Southeast Area, which is a recently available alternative water supply that can result in decreased groundwater production from the area.

The first ground fissures documented in the Chino Basin occurred in the Southeast Area in the early 1970s, but ground fissuring has not been observed in the area since.

Vertical ground-motion shown here is based on vertical ground-level surveys at benchmark monuments within the Southeast Area between 1987 and 2018. In the northwestern portion of the Southeast Area, the ground-level surveys indicate that about 0.58 feet of subsidence occurred from 1987 to 2018. In the southern portion of the Southeast Area, near the intersection of Euclid Avenue and Kimball Avenue, where the Chino-I Desalter wells pump groundwater from the deep confined aquifer-system, the ground-level surveys indicated that about 0.25 feet of land subsidence occurred from 2000 to 2006. The Chino-I Desalter wells began pumping in 2000 and likely caused a localized decline of piezometric levels within the deep aquifer-system, which may have caused the observed land subsidence in this area between 2000 and 2006. Watermaster installed the CCX facility in this area in 2012 to characterize the occurrence and mechanisms of the subsidence near the Chino-I Desalter well field and record the effects of new pumping at the Chino Creek Well Field (CCWF) on piezometric levels and land subsidence. Pumping at the CCWF wells commenced in 2014. The CCX began collecting data in July 2012 and, to date, has recorded no aquifer-system compaction.

From about 1930 to 1990, piezometric levels in the Southeast Area have continuously declined by about 100 feet. Since the 1990s, piezometric levels have been generally stable, with piezometric levels fluctuating between about 10 and 20 feet in response to groundwater production and supplemental-water recharge. Recent increases in piezometric levels in the area may be related in part to the increase in the direct use of recycled water. However, piezometric levels remain below the levels of 1930. The observed slow, but continuous land subsidence from 1987 to 2018 - particularly in the northwest portion of the Southeast Area is not explained by the concurrent relatively stable piezometric levels. A plausible explanation for the subsidence in this area is that thick, slowly draining aquitards are compacting in response to the historical decline of piezometric levels that occurred prior to 1990.



Prepared by:

WEI
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Prepared for:

2018 State of the Basin Report
Ground-Level Monitoring

The History of Land Subsidence in the Southeast Area

Exhibit 6-8b

California Department of Water Resources. (2016). Best Management Practices for the Sustainable Management of Groundwater: Water Budget. December 2016.

California Regional Water Quality Control Board, Santa Ana Region. (2004). Resolution No. R8-2004-0001 Resolution Amending the Water Quality Control Plan for the Santa Ana River Basin to Incorporate an Updated Total Dissolved Solids (TDS) and Nitrogen Management Plan for the Santa Ana Region.

California State Water Resources Control Board - Division of Water Quality GAMA Program. (2016). Groundwater Information Sheet; Hexavalent Chromium. August 2016.

Chino Basin Municipal Water District v. City of Chino, et al., San Bernardino Superior Court, No. 164327. (1978).

D.M. Etheridge, L.P. Steele, R.L. Langenfields, R.J. Francey, J.-M. Barnola and V.I. Morgan. (1998). Historical CO_2 Records from the Law Dome DE08, DE08-2, and DDS Ice Cores. In Trends: A Compendium of Data on Global Change. Carbon Dioxide Information Analysis Center. June 26, 1998.

Daniel B. Stephens & Associates, Inc. (2017). *Recomputation of Ambient Water Quality in the Santa Ana River Watershed for the Period 1996 to 2015*. September 2017.

Healy, R.W. Winter, T.C., LaBough, J.W. and Franke, L.O. (2007). Water Budgets: Foundations for Effective Water-Resources and Environmental Management. U.S. Geological Survey, Circular 1308. 2007.

Kleinfelder West, Inc. (2018). *Final Zone 4 Monitored Natural Attenuation Technical Memorandum Stringfellow Superfund Site Jurupa Valley, California Kleinfelder Project No. 0180656.001A*. Prepared on behalf of the State of California Environmental Protection Agency, Department of Toxic Substances Control, Brownfields and Environmental Restoration Program Legacy Landfill Office. September 28, 2018.

Metropolitan Water District of Southern California. (1987). Results of Chino Basin Well Sampling and Testing. Letter Prepared for the Water Quality Control Board, Santa Ana Region. May 21, 1987.

NOAA. (2019) Acquired from the National Oceanic and Atmospheric Association's Earth Systems Research Laboratory (https://www.esrl.noaa.gov/gmd/ccgg/trends/full.html); Accessed on June 5, 2017.

Peace Agreement, Chino Basin. SB 240104 v 1:08350.0001. 29 June 2000.

Peace II Agreement: Party Support for Watermaster's OBMP Implementation Plan, - Settlement and Release of Claims Regarding Future Desalters. SB 447966 v 1:008250.0001. October, 25 2007.

Tetra Tech. (2017a). Final Feasibility Study Chino Airport San Bernardino County, California. Prepared for the County of San Bernardino, Department of Architecture and Engineering. May 2017.

Tetra Tech. (2017b). Draft Interim Remedial Action Plan. Chino Airport, San Bernardino County, California. Prepared for County San Bernardino Department of Airports. December 2017.

Tetra Tech. (2019). Semiannual Groundwater Monitoring Report Summer and Fall 2018. Chino Airport Groundwater Assessment, San Bernardino County, California. Prepared for County of San Bernardino Department of Architecture and Engineering. March 19, 2019.

U.S. Department of Health and Human Services; Agency for Toxic Substances and Disease Registry (ATSDR). (2012). Toxicological Profile for Chromium. September 2012.

Wildermuth Environmental, Inc. (1999). Optimum Basin Management Program. Phase I Report. Prepared for the Chino Basin Watermaster. August 19, 1999.

Wildermuth Environmental, Inc. (2000). TIN/TDS Phase 2A: Tasks 1 through 5. TIN/TDS Study of the Santa Ana Watershed. Technical Memorandum. July 2000.

Wildermuth Environmental, Inc. and Black & Veatch. (2001). Optimum Basin Management Program. Recharge Master Plan Phase II Report. Prepared for the Chino Basin Watermaster. August 2001.

Wildermuth Environmental, Inc. (2003a). Optimum Basin Management Program, Chino Basin Dry-Year Yield Program, Preliminary Modeling Report, Chino Basin Watermaster. July 2003.

Wildermuth Environmental, Inc. (2003b). Technical Memorandum. Analysis of Supplemental Water Recharge Pursuant to the Peace Agreement. Analysis of Operational Storage Requirement, Safe Storage, and Safe Storage Capacity Pursuant to the Peace Agreement. August 2003.

Wildermuth Environmental, Inc. (2002). Optimum Basin Management Program, Final Initial State of the Basin Report. Prepared for the Chino Basin Watermaster. October 2002.

Wildermuth Environmental, Inc. (2005a). Optimum Basin Management Program, State of the Basin Report – 2004. Prepared for the Chino Basin Watermaster. July 2005.

Wildermuth Environmental, Inc. (2005b). TIN/TDS Phase 4: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1984 to 2003. Technical Memorandum. November 2005.

Wildermuth Environmental, Inc. (2006). Management Zone 1 Interim Monitoring Program: MZ-1 Summary Report. Prepared for the MZ-1 Technical Committee. Feb 2006.

Wildermuth Environmental, Inc. (2007a). Optimum Basin Management Program, State of the Basin Report – 2006. Prepared for the Chino Basin Watermaster. July 2007.

Wildermuth Environmental, Inc. (2007b). Optimum Basin Management Program, Management Zone 1 Subsidence Management Plan. Prepared for the Chino Basin Watermaster. Final Report October 2007.

Wildermuth Environmental, Inc. (2007c). 2007 CBWM Groundwater Model Documentation and Evaluation of the Peace II Project Description. Prepared for the Chino Basin Watermaster. November 2007.

Wildermuth Environmental, Inc. (2008a). TIN/TDS Phase 6: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1987 to 2006. Technical Memorandum. August 2008.

Wildermuth Environmental, Inc. (2008b). Chino Basin Management Zone 3 Monitoring Program, DWR Agreement No. 4600004086, Final Report. Prepared for Chino Basin Watermaster and Inland Empire Utilities Agency. December 2008.

Wildermuth Environmental, Inc. (2009a). Optimum Basin Management Program, State of the Basin Report – 2008. Prepared for the Chino Basin Watermaster. November 2009.

Wildermuth Environmental, Inc. (2009b). 2009 Production Optimization Evaluation of the Peace II Project Description. Prepared for the Chino Basin Watermaster. November 25, 2009.

Wildermuth Environmental, Inc. (2010). 2010 Recharge Master Plan Update. Volume I – Final Report. Prepared for the Chino Basin Watermaster. June 2010.

Wildermuth Environmental, Inc. (2011a). Chino Basin Maximum Benefit Monitoring Program 2010 Annual Report. Prepared for the Chino Basin Watermaster and Inland Empire Utilities Agency. April 2011.

Wildermuth Environmental, Inc. (2011b). TIN/TDS: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1990 to 2009. Technical Memorandum. August 2011.

Wildermuth Environmental, Inc. (2011c). Optimum Basin Management Program 2010 State of the Basin Atlas. Prepared for the Chino Basin Watermaster. December 2011.

Wildermuth Environmental, Inc. (2012). Chino Basin Maximum Benefit Monitoring Program 2011 Annual Report. Prepared for the Chino Basin Watermaster and Inland Empire Utilities Agency. April 2012.

Wildermuth Environmental, Inc. (2013a). Optimum Basin Management Program 2012 State of the Basin Atlas. Prepared for the Chino Basin Watermaster. June 2013.

Wildermuth Environmental, Inc. (2013b). 2013 Amendment to the 2010 Recharge Master Plan Update. Prepared for Chino Basin Watermaster. September 2013

Wildermuth Environmental, Inc. (2014). TIN/TDS: Recomputation of Ambient Water Quality in the Santa Ana Watershed for the Period 1993 to 2012. Technical Memorandum. August 2014.

Wildermuth Environmental, Inc. (2015a). Optimum Basin Management Program Chino Basin Maximum Benefit Annual Report. Prepared for Chino Basin Watermaster April 2015.

Wildermuth Environmental, Inc. (2015b). Optimum Basin Management Program 2014 State of the Basin Atlas. Prepared for the Chino Basin Watermaster. June 2015.

Wildermuth Environmental, Inc. (2015c). 2015 Annual Report of the Ground-Level Monitoring Committee. Prepared for Chino Basin Watermaster. September 2016.

Wildermuth Environmental, Inc. (2015d). 2013 Chino Basin Groundwater Model Update and Recalculation of Safe Yield Pursuant to the Peace Agreement. Prepared for Chino Basin Watermaster. October 2015.

Wildermuth Environmental, Inc. (2017a). Optimum Basin Management Program 2016 State of the Basin Atlas. Prepared for the Chino Basin Watermaster. June 2017.

Wildermuth Environmental, Inc. (2017b). Optimum Basin Management Program Chino Basin Maximum Benefit Annual Report. Prepared for Chino Basin Watermaster April 2017.

Wildermuth Environmental, Inc. (2019). Optimum Basin Management Program Chino Basin Maximum Benefit Annual Report. Prepared for Chino Basin Watermaster April 2019.