Work Plan

Develop a Subsidence-Management Plan for the Pomona Area

D R A F T

March 17, 2015

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Acronyms, Abbreviations, and Initialisms

acre-ft/yr	acre-feet per year
CCX	Chino Creek Extensometer Facility
DHX	Daniels Horizontal Extensometer
EDM	electronic distance measurement
ft-bgs	feet below ground surface
ft-btoc	feet below top of casing
IMP	Interim Monitoring Program
InSAR	Interferometric Synthetic Aperture Radar
MZ-1	Management Zone 1
OBMP	Optimum Basin Management Plan
PX	Pomona Extensometer
WEI	Wildermuth Environmental Inc.

The MZ-1 Subsidence Management Plan[1] (MZ-1 Plan) states that if data from existing monitoring efforts in the so-called "Areas of Subsidence Concern" indicate the potential for adverse impacts due to subsidence, then Watermaster will revise the MZ-1 Plan in an attempt to avoid the adverse impacts.

Land subsidence in the Pomona Area was first identified as a concern in 2006 in the MZ-1 Summary Report[2] in and again in 2007 in the MZ-1 Plan. Since then, the Watermaster has been monitoring subsidence in this area via InSAR and groundwater-levels with transducers at selected wells.

Figure 1-1 shows vertical ground motion across the Chino Basin as measured by Interferometric Synthetic Aperture Radar (InSAR) from 2005 to 2010. Historically, the MZ1 Managed Area in the City of Chino experienced the most land subsidence (*i.e.* over two feet of subsidence from 1987 to 1999). From 2005 to 2010, the InSAR data showed less than 0.1 ft of land subsidence in the MZ1 Managed Area, which indicates that subsidence is successfully being managed. Subsidence was greatest in the Pomona Area during 2005-2010, where up to 0.4 feet of subsidence was measured by InSAR. Figure 1-2 displays the most recent InSAR measurements of subsidence in the Pomona Area, which indicates that up to 0.16 ft of subsidence occurred during the period of spring 2011 to early 2014.

Figure 1-3 is a time-series chart that shows the long-term history of land subsidence as measured by InSAR within the Pomona Area. These data indicate that about 1.4 feet of inelastic subsidence has occurred in this area from 1993 through 2014—an average rate of about 0.06 feet per year. The chart also shows groundwater levels at wells in the area from 1930-2014. From about 1945 to 1978, groundwater levels in the Pomona Area declined by about 175 feet. Since then, groundwater levels have fluctuated, but have remained below the 1935 levels. The observed, continuous land subsidence that occurred during 1993-2014 cannot be explained entirely by the concurrent changes in groundwater levels. A plausible explanation for the subsidence is that thick, slowly-draining aquitards are compacting in response to the historical drawdowns that occurred from 1935 to 1978. It is logical to assume that subsidence began when the rate of groundwater-level drawdown increased around 1943. If subsidence has been occurring at a constant rate of 0.06 feet per year since 1943, then the Pomona Area has experienced about 4.2 feet of permanent subsidence since the onset of increased drawdown.

Of particular concern is that the subsidence in the Pomona Area has occurred differentially across the San Jose Fault—the same pattern of differential subsidence that occurred in the MZ1 Managed Area during the time of ground fissuring. Figures 1-1 and 1-2 show a steep gradient of subsidence across the San Jose Fault in the Pomona Area,

[1] Chino Basin Watermaster. 2007. *MZ-1 Subsidence Management Plan*. October, 2007.

[2] Chino Basin Watermaster. 2006. *MZ-1 Summary Report*. February, 2006.

indicating the potential for the accumulation of horizontal strain in the shallow sediments and the possibility of ground fissuring. Ground fissuring is the main subsidence-related threat to infrastructure.

Over the past few years, the Watermaster has increased monitoring efforts in the Pomona Area to include elevation surveys and electronic distance measurements (EDMs) because of the potential for ground fissuring near the San Jose Fault (see Figure 1-2). The data from these efforts are currently being analyzed by Watermaster.

The issue of differential subsidence and the potential for ground fissuring in the Pomona Area has been discussed at prior Land Subsidence Committee (LSC) meetings, and the subsidence has been documented and described as a concern in past State of the Basin Reports (see WEI, 2013 for example[3]) and annual reports of the LSC. Watermaster, consistent with the recommendation of the LSC, has determined that the MZ-1 Plan needs to be updated to include a *Subsidence Management Plan for the Pomona Area* with the long-term objective to minimize or abate the occurrence of the differential land subsidence[4].

To develop the *Subsidence Management Plan for the Pomona Area*, a number of questions need to be answered:

1. What are the mechanisms driving the observed subsidence?

   The available evidence indicates that the most likely mechanism behind the observed subsidence in the Pomona Area is compaction of fine-grained sediment layers within the aquifer-system. If so, the following questions need to be answered:

   a. What are the depth intervals within the aquifer system that are compacting?

   b. How does pumping from wells in the vicinity of the Pomona Area influence piezometric levels within the aquifer system?

   c. How does wet-water recharge via spreading and/or injection influence piezometric levels?

   d. What is the pre-consolidation stress[5] within the compacting intervals of the aquifer system?

   A hydrogeologic investigation of the Pomona Area is necessary to definitively answer these questions. The investigation will include installation of piezometers and extensometers, and the design and implementation of controlled aquifer-stress tests. To identify pre-consolidation stress, the

[3] Chino Basin Watermaster. 2013. *2012 State of the Basin Atlas*. June 2013.

[4] Chino Basin Watermaster. 2014. *2013 Annual Report of the Land Subsidence Committee*. July, 2014.

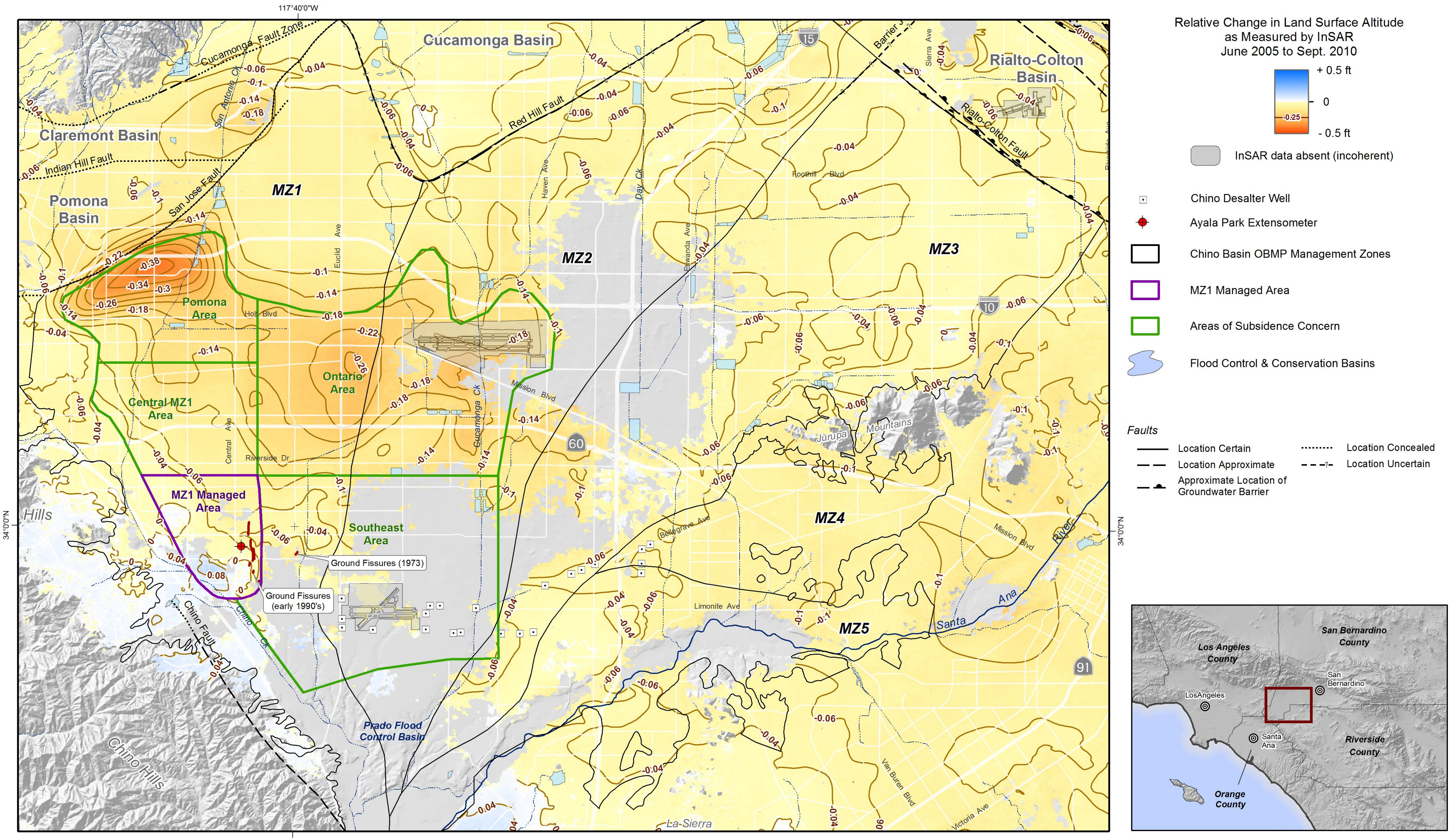
[5] A technical definition of pre-consolidation stress is included in the Glossary of Terms. In lay terms, the pre-consolidation stress is a groundwater-level “threshold.” When groundwater levels are above the threshold, subsidence is abated. When groundwater levels are below the threshold, subsidence is caused.

aquifer-stress testing will require an increase of groundwater levels in the Pomona Area.

2. What is the appropriate method to manage the land subsidence in the Pomona Area?

   Depending on the answers to Question 1, there may be multiple methods to manage the land subsidence, such as modification of pumping patterns, in-lieu recharge, wet-water recharge via spreading, injection, or a combination of methods. These methods might necessitate the modification of water-supply plans for purveyors in the Chino Basin and/or the implementation of regional-scale storage programs or conjunctive-use programs. Alternative methods are to accept the occurrence of subsidence and its consequences and liabilities, or insure against potential future damages. The methods need to be described as management alternatives, and evaluated in enough detail to choose a preferred alternative.

As proposed herein, the development of the Subsidence Management Plan for the Pomona Area is a multi-year effort. This report is a work plan that describes this effort as tasks with cost estimates and a schedule. Upon recommendation by the LSC and approval by the Watermaster, this work plan will be incorporated into the MZ-1 Plan as an appendix and characterized as an ongoing effort of the Watermaster.



Prepared by:

WEI
Wildermuth Environmental, Inc.

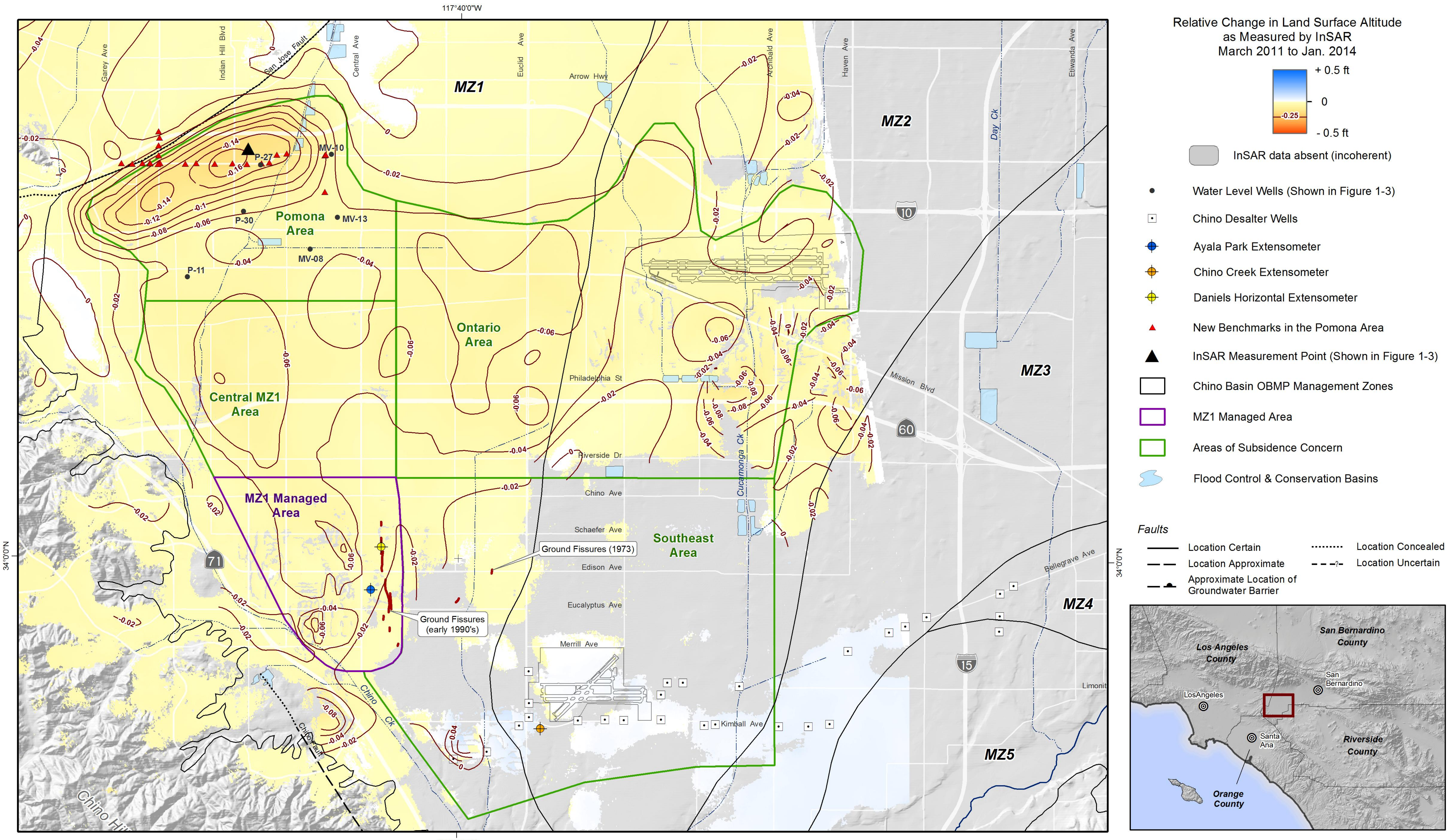
Author: NWS
Date: 3/3/2015
File: Figure_1-1_InSAR_05_10

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

Work Plan
Subsidence Management Plan for the Pomona Area

Vertical Ground Motion as Measured by InSAR
2005 to 2010

Figure 1-1



Prepared by:

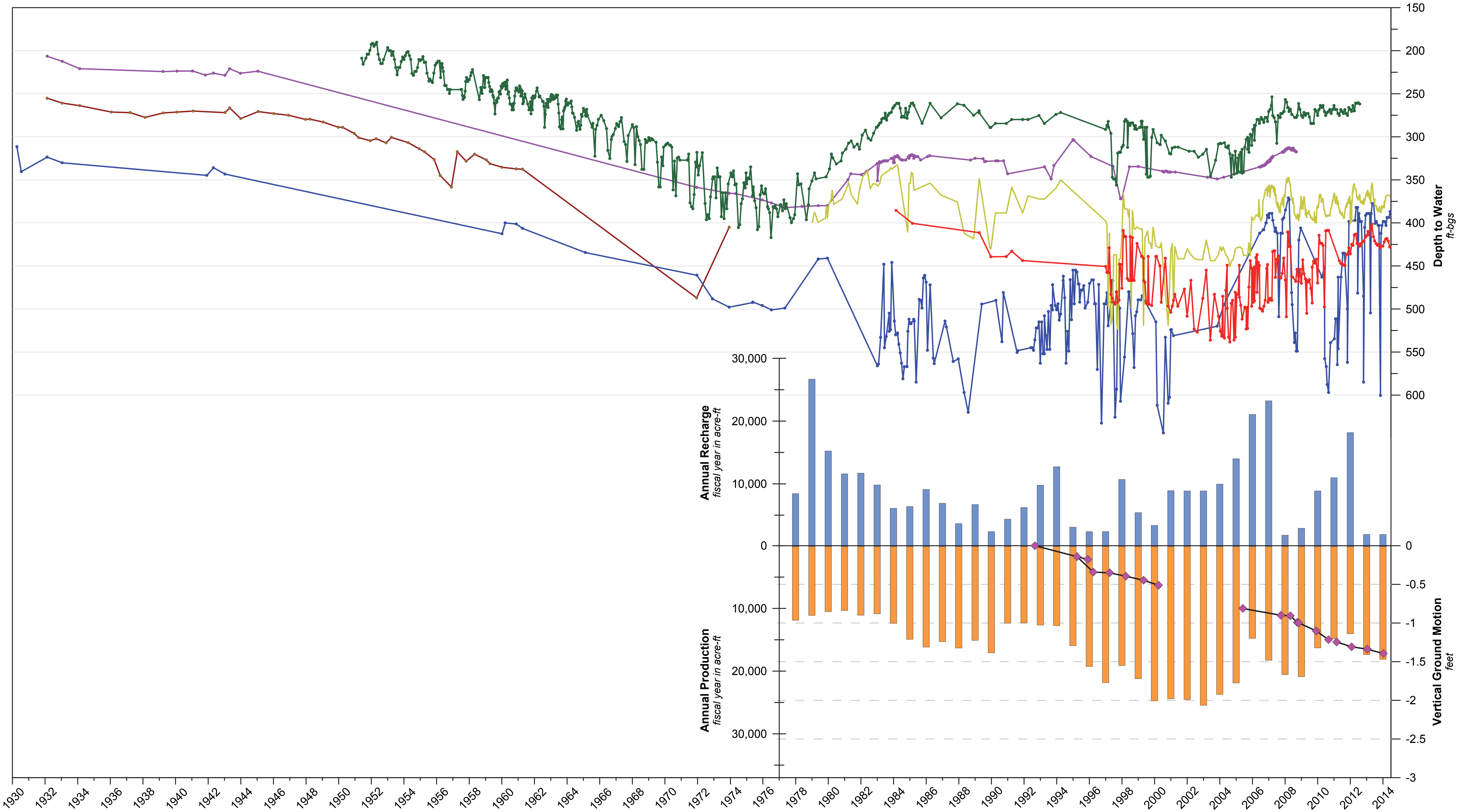
WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: NWS
Date: 3/3/2015
File: Figure_1-2_InSAR_11_14

Work Plan
Subsidence Management Plan for the Pomona Area

Vertical Ground Motion as Measured by InSAR
2011 to 2014

Figure 1-2



Prepared by:

WEI
Wildermuth Environmental, Inc.

Author: NWS
Date: 3/3/15
File: Figure_3_Pomona.grf

Groundwater Levels at Wells (Perforated Interval Depth)

- P-11 (168-550 ft-bgs)
- MV-08 (225-447 ft-bgs)
- MV-10 (520-1084 ft-bgs)
- MV-13 (203-475 ft-bgs)
- P-27 (472-849 ft-bgs)
- P-30 (565-875 ft-bgs)

Vertical Ground Motion

- Pomona Area InSAR Cumulative Displacement

Recharge and Production

- Recharge of Recycled Water, Storm Water*, and Imported Water at the College Heights, Upland, Montclair, and Brooks Basins; and at MVWD ASR Wells
  *Storm Water is an estimated amount prior to Fiscal Year 04/05
- Groundwater Production from Wells in the Pomona Area

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Subsidence Management Plan for the Pomona Area

The History of Land Subsidence in the Pomona Area

Figure 1-3

Section 2 – Work Plan

This section describes the work plan to develop the *Subsidence Management Plan for the Pomona Area*. The work plan is a series of tasks that will: (i) provide the technical information necessary to develop the management plan, (ii) develop and evaluate various alternatives for a management plan, and (iii) identify a preferred alternative.

Task 1 – Describe Initial Hydrogeologic Conceptual Model & the Monitoring and Testing Program

The objectives of this task are to:

1. Describe the technical information that is required to develop a subsidence-management plan for the Pomona Area.
2. Describe the current state of knowledge of the hydrogeology of the Pomona Area—particularly with respect to the occurrence and mechanisms of aquifer-system deformation and the pre-consolidation stress. Herein, the current state of knowledge is termed: the *Initial Hydrogeologic Conceptual Model of the Pomona Area*.
3. Identify the data gaps that need to be filled in order to fully describe the occurrence and mechanisms of aquifer-system deformation and the pre-consolidation stress.
4. Design a strategy to fill the data gaps.

   The data gaps will likely include:

   - Geologic data—particularly the spatial and depth distribution of the fine-grained, compressible sedimentary units
   - Depth-specific piezometric data
   - Depth-specific aquifer-system deformation data
   - Cause-and-effect information—particularly how pumping and recharge stresses effect piezometric levels and aquifer-system deformation
   - Pre-consolidation stress(s)

   The strategy to fill the data gaps will likely include:

   - Implement an initial monitoring program of pumping, recharge, piezometric levels, and ground motion. This program will expand upon current monitoring efforts in the Pomona Area.
   - Perform short-term controlled pumping tests.
   - Locate, design and install a monitoring facility of piezometers and cable extensometers to collect depth-specific geologic data, piezometric data,

and aquifer-system deformation data. This facility will be called the Pomona Extensometer (PX).

- Design and perform long-term, aquifer-system stress tests to reveal cause-and-effect information and the pre-consolidation stress(s).

Sub-Tasks:

Task 1.1 – Describe the information and knowledge needed to manage subsidence

Task 1.2 – Describe the current state of knowledge with tables and figures

Task 1.3 – Describe the gaps in data and knowledge

Task 1.4 – Describe the potential locations and general design of the Pomona Extensometer facility (PX)

Task 1.5 – Describe the proposed monitoring and testing program

Task 1.6 – Prepare Task 1 memorandum – *Initial Hydrogeologic Conceptual Model and the Monitoring and Testing Program for the Pomona Area*

Deliverables: A Task 1 memorandum, titled *Initial Hydrogeologic Conceptual Model and the Monitoring and Testing Program for the Pomona Area*, will be prepared to document the initial hydrogeologic conceptual model of the Pomona Area, proposed locations and descriptions for the PX, and the proposed initial monitoring and testing program.

Schedule: The draft technical memorandum will be prepared by October 31, 2015. The LSC will meet in November 2015 to review the draft memorandum. The final memorandum will be published in December 2015.

Task 2 – Implement the Initial Monitoring and Testing Program

In this task, the initial monitoring program described in the Task 1 memorandum is implemented. The immediate objective of this task is to improve the understanding of the aquifer system in the Pomona Area, which will assist in the siting of the PX and in the development of the plans and specifications of the PX.

The initial monitoring program will include:

- Recording on/off times and pumping rates for all production wells in the Pomona Area. The exact dates/times will be recorded for every well. Pumping rates will be recorded at the highest practicable frequency.
- Collecting artificial recharge data at basins and injection wells.
- Measuring and recording piezometric levels at all wells in the Pomona Area. To the extent possible, the existing transducers and SCADA systems of the producers in the Pomona Area will be used. If necessary, Watermaster will install pressure-transducers in all other wells in the Pomona Area. Water levels will be recorded once every 15 minutes.

- Performing one survey of elevation at currently-established benchmark monuments across the Pomona Area (consistent with current practices of the LSC).
- Performing one survey of EDMs between currently-established benchmark monuments that cross the San Jose Fault (consistent with current practices of the LSC).
- Collecting and analyzing InSAR data consistent with the current land-subsidence monitoring program.

Sub-Tasks:

Task 2.1 – Canvass all wells in the Pomona Area

Task 2.2 – Establish monitoring and reporting strategies with producers

Task 2.3 – Install transducers in all wells not currently equipped with transducers

Task 2.4 – Perform one quarter of passive monitoring

Task 2.5 – Conduct short-term controlled pumping tests; analyze data

Task 2.6 – Prepare Task 2 memorandum – *Results of Initial Monitoring and Testing Program*

Deliverables: A Task 2 memorandum, titled *Results of Initial Monitoring and Testing Program*, will be prepared to document the improved understanding of the hydraulic stresses and responses of the aquifer system in the Pomona Area. The improved understanding will assist in the siting of the PX and in the preparation of its plans and specifications.

Schedule: The initial monitoring program will be implemented beginning in August 2015. The draft Task 2 memorandum will be published in May 2016. The final memorandum will be published in June 2016 as an appendix to the Annual Report of the LSC.

Task 3 -- Develop and Evaluate the Baseline Management Alternative

One management alternative for the subsidence issue in the Pomona Area is to accept the occurrence of subsidence (no subsidence management) and its potential consequences. This alternative is called the Baseline Management Alternative (BMA).

The objective of this task is to characterize the basin response to the BMA and its potential consequences. The assumptions of the BMA, including the groundwater production and replenishment plans of the Chino Basin parties, will be described and agreed upon by the LSC. The Chino Basin groundwater model will be used to simulate the basin response to the BMA. Estimates of future subsidence in the Pomona Area will be made based on rates of historical subsidence. The overlying property and infrastructure that can be potentially damaged by subsidence and fissuring in the Pomona area will be described in maps and tables. The property values and the costs for replacement or repair to infrastructure will be estimated. Research will be performed to determine if damages due to subsidence are insurable and to estimate the cost for such an insurance policy.

Sub-Tasks:

Task 3.1 – Obtain concurrence on the Baseline-Management Alternative (BMA)

Task 3.2 – Characterize and evaluate the basin response to the BMA

Task 3.3 – Estimate future subsidence in the Pomona Area

Task 3.4 – Catalog property and infrastructure potentially impacted by subsidence and fissuring

Task 3.5 – Determine if damages due to subsidence are insurable and estimate cost for insurance policy

Task 3.6 – Prepare Task 3 memorandum – *Evaluation of the Baseline Management Alternative*

Deliverables: A Task 3 memorandum, titled *Evaluation of the Baseline Management Alternative*, will be prepared to document the development and evaluation of the BMA.

Schedule: This task will be completed during FY 2015/16. The draft Task 3 memorandum will be published in February 2016. The final memorandum will be published in March 2016.

Task 4 -- Develop and Evaluate the Initial Subsidence-Management Alternative

The objective of this task is to develop a management alternative that will minimize or abate the ongoing subsidence in the Pomona Area. To minimize or abate the ongoing subsidence, groundwater levels will need to increase. The specific groundwater level that will cease the ongoing subsidence is called the "pre-consolidation stress." A preliminary estimate of pre-consolidation stress in the Pomona Area will be made based on the time-series of historical groundwater levels.

There are several methods to increase groundwater levels, such as modification of pumping patterns, in-lieu recharge, wet-water recharge via spreading, injection, or a combination of methods. These methods will necessitate the modification of water-supply plans for purveyors in the Chino Basin. An initial method to increase and hold groundwater levels at the estimated pre-consolidation stress will be described and called the Initial Subsidence-Management Alternative (ISMA).

The assumptions of the ISMA, including the groundwater production and replenishment plans of the Chino Basin parties, will be described and agreed upon by the LSC. The Chino Basin groundwater model will be used to characterize the basin response to the ISMA and its ability to raise and hold groundwater levels above the assumed pre-consolidation stress. It is likely that an iterative process of modeling and adjustments to the ISMA will be necessary.

Sub-Tasks:

Task 4.1 – Estimate pre-consolidation stress in the Pomona Area

Task 4.2 – Describe the ISMA

Task 4.3 – Characterize and evaluate the basin response to the ISMA

Task 4.4 – Prepare Task 4 memorandum – *Evaluation of the Initial Subsidence-Management Alternative*

Deliverables: A Task 4 memorandum, titled *Evaluation of the Initial Subsidence-Management Alternative*, will be prepared to document the development and evaluation of the ISMA.

Schedule: This task will be completed during FY 2015/16 and 2016/17.

Task 5 – Design and Install the Pomona Extensometer Facility

The objective of this task is to install a monitoring facility that is capable of identifying the depth-specific occurrence of aquifer-system compaction, the mechanisms behind the compaction, and the pre-consolidation stress—the data and understanding that are necessary to develop a subsidence management plan.

This monitoring facility will be called the Pomona Extensometer (PX). The potential locations for the PX will be identified in Task 1. The results of the initial monitoring program in Task 2 will be used to finalize the location and the plans and specifications for the PX. The PX will likely include a shallow borehole drilled to a total depth of about 750 ft-bgs, and a deep borehole drilled to a total depth of about 1,500 ft-bgs. Two piezometers will be installed in each borehole at progressively deeper depths to measure piezometric levels and water quality at various depths within the aquifer system. Each piezometer will be equipped with a cable extensometer to measure aquifer-system deformation occurring within the depth interval of the piezometer. The wellhead completions and data-loggers will be installed in two vaults that will be flush with the ground surface.

Sub-Tasks:

Task 5.1 – Identify alternative sites for the Pomona Extensometer facility (PX)

Task 5.2 – Acquire construction and permanent easements

Task 5.3 – Prepare plans and technical specifications for bid package

Task 5.4 – Provide support for bidding process

Task 5.5 – Provide construction oversight to install the PX

Task 5.6 – Install transducers, data loggers, and telemetry; perform testing

Task 5.7 – Prepare Task 5 memorandum – *Completion Report for the Pomona Extensometer Facility*

Deliverables: A Task 5 memorandum, titled *Completion Report for the Pomona Extensometer Facility*, will be prepared to document the drilling and construction of the PX.

Schedule: Drilling and construction of the PX will occur in FY 2016/17.

Task 6 – Design and Conduct Aquifer-System Stress Tests

The objective of this task is to perform controlled aquifer-system stress tests to identify the subsidence mechanism(s) and the pre-consolidation stress(es) in the Pomona Area. The testing program will essentially be a one-year test of the ISMA developed in Task 4.

Sub-Tasks:

Task 6.1 – Describe the implementation plan for a one-year test of the ISMA

Task 6.2 – Collect and analyze data (monthly)

Task 6.3 – Prepare quarterly summaries of the data collection and analytical results

Deliverables: Memoranda that summarize the data collection and analytical results of the testing program will be prepared and distributed to the LSC quarterly.

Schedule: The testing program will follow the completion of the PX in FY 2017/18.

Task 7 – Update Hydrogeologic Conceptual Model and Prepare Summary Report

The objective of this task is to update the hydrogeologic conceptual model of the Pomona Area based on improved understanding from testing and modeling, and prepare a technical memorandum that describes and documents the subsidence mechanism(s) and the pre-consolidation stress(es) in the Pomona Area.

A one-dimensional compaction model will be constructed and calibrated to represent the aquifer system at the PX. The model will be used to estimate the hydraulic and mechanical properties of the aquifer system and the pre-consolidation stress. The information contained in the technical memorandum will form the basis for updating Watermaster's groundwater model and developing subsequent subsidence-management alternatives.

If the testing program is unsuccessful in determining the subsidence mechanisms and/or pre-consolidation stress, then this work plan will need to be re-evaluated by the LSC.

Sub-Tasks:

Task 7.1 – Construct and calibrate one-dimensional compaction model at the PX

Task 7.2 – Update hydrogeologic conceptual model based on testing and modeling results

Task 7.3 – Prepare Task 7 memorandum – *Updated Hydrogeologic Conceptual Model of the Pomona Area*

Deliverables: A Task 7 memorandum, titled *Updated Hydrogeologic Conceptual Model of the Pomona Area*, will be prepared to document the updated hydrogeologic conceptual model, including the subsidence mechanisms and the pre-consolidation stress.

Schedule: This task will be completed in FY 2018/19.

Task 8 -- Update Chino Basin Groundwater Model

The objective of this task is to update Watermaster groundwater modeling tools to support the development and evaluation of subsequent subsidence-management alternatives. The layering and aquifer properties of Watermaster's existing groundwater model will be updated, and a subsidence package (SUB) will be added to the model. The model will be re-calibrated, so it can be used to reliably predict groundwater levels and subsidence under future management alternatives.

Sub-Tasks:

Task 8.1 – Update groundwater model based on the Task 7 Memorandum

Task 8.2 – Add SUB package to Groundwater Model

Task 8.3 – Prepare Task 8 memorandum – *Updated Chino Basin Groundwater Model with SUB Package*

Deliverables: A Task 8 memorandum, titled *Updated Chino Basin Groundwater Model with SUB Package*, will be prepared to document update and calibration of the Chino Basin Groundwater Model.

Schedule: This task will be completed in FY 2018/19.

Task 9 -- Refine and Evaluate Subsidence-Management Alternatives

The objective of this task is to develop up to three additional subsidence-management alternatives that will minimize or abate the ongoing subsidence in the Pomona Area.

Using the new information on the subsidence mechanisms and the pre-consolidation stress and the results of the ISMA, a new method to increase and hold groundwater levels at the estimated pre-consolidation stress will be described and called Subsidence-Management Alternative 2 (SMA-2).

The assumptions of the SMA-2, including the groundwater production and replenishment plans of the Chino Basin parties, will be described and agreed upon by the LSC. The updated Chino Basin groundwater model will be used to characterize the basin response to the SMA-2, its ability to raise and hold groundwater levels above the pre-consolidation stress, and its ability to minimize or abate the ongoing subsidence in the Pomona Area.

Up to two additional subsidence-management alternatives (SMA-3 and SMA-4) will be developed and evaluated in the same fashion as with SMA-2.

Each alternative will be evaluated on its ability to mitigate the subsidence, the institutional changes that will need to occur, and the associated costs of the water-supply plans. Based on this information, the LSC can select and recommend a preferred subsidence-management alternative.

Sub-Tasks:

Task 9.1 – Re-evaluate the BMA and ISMA

Task 9.2 – Develop a new subsidence-management alternative (SMA-2)

Task 9.3 – Characterize and evaluate the basin response to the SMA-2

Task 9.4 – Characterize and evaluate the basin response to the SMA-3 and SMA-4

Task 9.5 – Select preferred subsidence-management alternative for the Pomona Area

Task 9.6 – Prepare Task 9 memorandum – *Subsidence Management Plan for the Pomona Area*

Deliverables: A Task 9 memorandum, titled *Subsidence Management Plan for the Pomona Area*, will be prepared to document the development and evaluations of the subsidence-management alternatives, and the recommendation of the preferred subsidence-management alternative.

Schedule: This task will be completed in FY 2019/20.

Task 10 -- Update the MZ-1 Subsidence Management Plan

The objective of this task is to incorporate the preferred subsidence-management alternative for the Pomona Area into the Subsidence Management Plan for the Chino Basin. An implementation plan will be prepared. The implementation plan will require review and approval by the Land Subsidence Committee and the Watermaster Pools, Advisory Committee, and Board. Watermaster will apprise the Court of revisions to the plan as part of its OBMP implementation status reporting.

Sub-Tasks:

Task 10.1 – Describe implementation plan for the Subsidence-Management Plan (SMP) for the Pomona Area

Task 10.2 – Prepare Task 10 memorandum – *Updated MZ-1 Subsidence Management Plan*

Task 10.3 – LSC recommends the updated MZ-1 Plan

Task 10.4 – Review the updated MZ-1 Plan with Watermaster in the monthly process meetings

Deliverables: A Task 10 memorandum, the *Updated MZ-1 Subsidence Management Plan*, will be prepared to incorporate the Subsidence-Management Plan for the Pomona Area.

Schedule: This task will be completed in FY 2019/20.

Section 3 – Cost Estimates

Table 3-1 describes the multi-year cost estimates to implement the work plan described in Section 2. The cost estimates will be used to inform the Watermaster's budgeting process for FY 2015/16 and thereafter.

Table 3-1

Work Breakdown Structure and Cost Estimates[a]

Work Plan to Develop a Subsidence-Management Plan for the Pomona Area

Task Descriptions	Notes	Labor: Person Days	Labor: Labor Costs	Other Direct Costs: Travel	Rental	Equip-ment	Subs	Repro	Misc.	Total ODC	Totals by: Sub-Task	Task	Totals by Fiscal Year: 2015-16	2016-17	2017-18	2018-19	2019-20
Task 1 -- Describe Initial Hydrogeologic Conceptual Model & the Monitoring and Testing Program												$52,927					
1.1 Describe the information and knowledge needed to manage subsidence		0.5	$860							$0	$860		$860				
1.2 Describe current state of knowledge with tables and figures											$13,585		$13,585				
Finalize cross-sections		6.0	$7,360							$0							
Finalize InSAR maps		0.8	$880							$0							
Finalize percent-fine maps		0.3	$290							$0							
Update and finalize production and recharge maps		0.6	$665							$0							
Update and finalize other maps (2)		1.3	$1,380							$0							
Finalize short-term time-series charts for Study Area		2.5	$2,760							$0							
Update and finalize long-term time-series chart		0.3	$250							$0							
1.3 Describe the gaps in data and knowledge		0.5	$860							$0	$860		$860				
1.4 Describe the potential locations and general design of the Pomona Extensometer facility (PX)											$4,360		$4,360				
Prepare map of potential locations for facility		1.5	$2,180							$0							
Prepare profile of the general design of the facility		1.5	$2,180							$0							
1.5 Describe the proposed monitoring and testing program											$7,110		$7,110				
Prepare map and table of monitoring locations (production, recharge, water levels, ground levels)		2.3	$2,750							$0							
Prepare text to describe initial monitoring and testing program (pre-PX installation)		1.5	$2,180							$0							
Prepare text to describe long-term monitoring and testing program (post-PX installation)		1.5	$2,180							$0							
1.6 Prepare Task 1 memorandum -- *Initial Hydrogeologic Conceptual Model and …*											$26,152		$26,152				
Prepare draft task memorandum and submit to the LSC		13.8	$19,820							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		2.5	$3,180							$0							
Task 2 -- Implement the Initial Monitoring Program												$191,908					
2.1 Canvass all wells in the Pomona Area											$13,960		$13,960				
Prepare maps and tables to support well canvass (well info, access, monitoring strategy, etc.)		2.5	$2,660					$50		$50							
Conduct field visits w/ producers (Pomona, MVWD, and GSWC); discuss monitoring strategies		9.0	$9,600	$320						$320							
Compile data collected from field visits; update HydroDaVE database		1.3	$1,330							$0							
2.2 Establish monitoring and reporting strategies with producers											$25,634		$25,634				
Prepare memorandums for monitoring and reporting protocols for agency staff		4.5	$6,740					$50		$50							
Review memorandums with agency staff		2.5	$3,700	$124						$124							
Provide as needed assistance to agencies on SCADA upgrades		3.5	$5,020				$10,000			$10,000							
2.3 Install transducers in all wells not currently equipped with transducers											$41,910		$41,910				
Purchase transducers and materials for installation		1.5	$1,660			$32,760				$32,760							
Install and test transducers; start data collection		10.0	$6,500	$800	$190					$990							
2.4 Perform one quarter of passive monitoring											$41,302		$41,302				
Collect production, recharge, and water-level data (monthly); update database		16.5	$13,830							$0							
Analyze, prepare, and distribute time-series charts of production, recharge, and levels (HDX files)		12.0	$18,240							$0							
Prepare preliminary plan for short-term controlled pumping tests		4.0	$6,080							$0							
Meet with LSC to review current data and the plan for short-term controlled pumping tests		2.0	$3,040	$62				$50		$112							
2.5 Conduct short-term controlled pumping tests; analyze data											$26,910		$26,910				
Coordinate with producers (Pomona, MVWD, GSWC)		3.0	$3,960							$0							
Collect production, recharge, and level data (monthly); update database		16.5	$13,830							$0							
Analyze, prepare, and distribute time-series charts of production, recharge, and levels (HDX files)		6.0	$9,120							$0							
2.6 Prepare Task 2 memorandum – *Results of Initial Monitoring and Testing Program*											$42,192		$42,192				
Prepare draft task memorandum and submit to the LSC		25.5	$32,240							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		5.5	$6,800							$0							
Task 3 -- Develop and Evaluate the Baseline Management Alternative												$68,032					
3.1 Obtain concurrence on the Baseline Management Alternative (BMA)	b	0.0									$0		$0				
Describe the assumptions required to develop the BMA; prepare presentation		0.0	$0							$0							
Present straw-man BMA to LSC		0.0	$0							$0							
Revise BMA based on LSC comments; circulate to LSC for comments		0.0	$0							$0							
Finalize BMA		0.0	$0							$0							
3.2 Characterize and evaluate the basin response to the BMA (no subsidence management)	b										$0		$0				
Update groundwater production and replenishment plans per BMA		0.0	$0							$0							
Run groundwater model to evaluate the basin response to the BMA		0.0	$0							$0							
Prepare maps, charts and tables to characterize the basin response to BMA		0.0	$0							$0							
3.3 Estimate future subsidence in the Pomona Area		2.5	$3,180							$0	$3,180		$3,180				
3.4 Catalog property and infrastructure potentially impacted by subsidence and fissuring											$30,280		$30,280				

Task Descriptions	Notes	Labor		Other Direct Costs							Totals by		Totals by Fiscal Year				
		Person Days	Labor Costs	Travel	Rental	Equip-ment	Subs	Repro	Misc.	Total ODC	Sub-Task	Task	2015-16	2016-17	2017-18	2018-19	2019-20
Prepare maps of property values and sensitive infrastructure (wells, utility pipelines, transportation)		10.5	$12,460							$0							
Prepare cost tables of property values and replacement/repair costs for damaged infrastructure		6.5	$7,820				$10,000			$10,000							
3.5 Determine if damages due to subsidence are insurable and estimate cost for insurance policy											$11,140		$11,140				
Research and determine the ability to insure against damages		2.5	$3,500							$0							
Obtain cost estimate for insurance policy		2.0	$2,640				$5,000			$5,000							
3.6 Prepare Task 3 memorandum -- *Evaluation of the Baseline Management Alternative*											$23,432		$23,432				
Prepare draft task memorandum and submit to the LSC		11.8	$17,100							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		2.5	$3,180							$0							
Task 4 -- Develop and Evaluate the Initial Subsidence-Management Alternative												$124,386					
4.1 Estimate pre-consolidation stress in the Pomona Area		0.0	$0							$0	$3,690		$3,690				
Review groundwater-elevation time series charts for all wells in the Pomona Area		0.5	$500							$0							
Prepare map of pre-development groundwater elevation in the Chino Basin (1933)		1.0	$1,000							$0							
Prepare elevation contour map and GIS raster of the estimated pre-consolidation stress		1.8	$2,190							$0							
4.2 Describe the Initial Subsidence-Management Alternative (ISMA)											$19,632		$19,632				
Describe the assumptions required to develop the ISMA; prepare presentation		4.0	$7,120							$0							
Present straw-man ISMA to LSC		1.0	$1,780	$62				$50		$112							
Review with other agencies that will be required to implement the ISMA		1.0	$1,780							$0							
Revise ISMA based on comments; circulate to LSC and other agencies for comments		3.0	$5,280							$0							
Finalize ISMA		2.0	$3,560							$0							
4.3 Characterize and evaluate the basin response to the ISMA											$57,352		$57,352				
Update groundwater production and replenishment plans per ISMA		4.0	$7,000							$0							
Run groundwater model to evaluate the basin response to the ISMA		2.0	$3,440							$0							
Prepare maps, charts and tables to characterize the basin response to the ISMA		10.0	$14,560							$0							
Present results of ISMA evaluation to LSC with recommendations for revision		2.5	$4,360	$62				$50		$112							
Revise ISMA based on LSC and other agency comments		0.5	$860							$0							
Update groundwater production and replenishment plans per revised ISMA		1.5	$2,640							$0							
Run groundwater model to evaluate the basin response to the revised ISMA		2.0	$3,440							$0							
Prepare maps, charts and tables to characterize the basin response to the revised ISMA		10.0	$17,440							$0							
Finalize ISMA		2.0	$3,500							$0							
4.4 Prepare Task 4 memorandum -- *Evaluation of the Initial Subsidence-Management Alternative*											$43,712		$43,712				
Prepare draft task memorandum and submit to the LSC		25.5	$37,520							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		2.0	$3,040							$0							
Task 5 -- Design and Install the Pomona Extensometer Facility												$1,289,826					
5.1 Identify alternative sites for the Pomona Extensometer facility (PX)											$27,502		$27,502				
Conduct siting study to identify five potential sites on publically-owned property		8.3	$9,820	$62						$62							
Review sites with LSC and receive comments		2.0	$3,040							$0							
Review sites with property owners and receive comments		2.0	$3,040							$0							
Finalize list of potential sites		2.0	$3,040							$0							
Prepare CEQA documentation		2.5	$3,500				$5,000			$5,000							
5.2 Acquire construction and permanent easements											$24,760			$24,760			
Select final site(s)		1.0	$1,520							$0							
Prepare legal descriptions of site(s)		3.0	$3,640				$10,000			$10,000							
Support negotiations for easements and approvals		5.0	$6,600						$3,000	$3,000					$3,000	$3,000	$3,000
5.3 Prepare plans and technical specifications for bid package											$18,032			$18,032			
Prepare draft technical specifications and submit to LSC		9.8	$11,480							$0							
Meet with LSC to review draft technical specifications and receive comments		2.0	$3,040	$62				$50		$112							
Prepare final technical specifications		2.8	$3,400							$0							
5.4 Provide support for bidding process		3.5	$3,980							$0	$3,980			$3,980			
5.5 Provide construction oversight to install the PX		155.8	$180,830	$12,300			$900,000			$912,300	$1,093,130			$1,093,130			
5.6 Install transducers, data loggers, and telemetry; perform testing		50.0	$52,900	$1,920	$190	$16,000	$22,000			$40,110	$93,010			$93,010			
5.7 Prepare Task 5 memorandum -- *Completion Report for the Pomona Extensometer Facility*											$29,412			$29,412			
Prepare draft task memorandum and submit to the LSC		18.0	$21,640							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		4.0	$4,620							$0							
Task 6 --Design and Conduct One-Year Aquifer-System Stress Tests												$199,484					
6.1 Describe the implementation plan for a one-year test of the ISMA											$19,724			$19,724			
Prepare draft memorandum -- *Schedule and Responsibilities of the One-Year Test of the ISMA*		7.0	$10,480							$0							
Meet with responsible agencies to review draft memorandum		2.0	$3,040	$62						$62							
Meet with LSC to review draft memorandum		2.0	$3,040	$62						$62							
Finalize memorandum and distribute to responsible agencies		2.0	$3,040							$0							
6.2 Collect and analyze data (monthly)											$138,240				$138,240		
Coordinate with agencies to conduct the one-year test		18.0	$26,160							$0							
Collect production, recharge, and water-level data		54.0	$43,320	$2,880						$2,880							

Task Descriptions	Notes	Labor		Other Direct Costs							Totals by		Totals by Fiscal Year				
		Person Days	Labor Costs	Travel	Rental	Equip-ment	Subs	Repro	Misc.	Total ODC	Sub-Task	Task	2015-16	2016-17	2017-18	2018-19	2019-20
Download and check piezometer/extensometer data from PX		18.0	$14,760	$960						$960							
Upload all data to HydroDaVE		24.0	$25,920							$0							
Prepare, analyze, and distribute time-series charts of production, recharge, levels, extensometer (HDX files)		18.0	$24,240							$0							
6.3 Prepare quarterly summaries of the data collection and analytical results											$41,520				$41,520		
Prepare and analyze stress-strain diagrams		2.3	$3,030							$0							
Prepare draft quarterly memoranda and distribute to LSC		19.5	$25,560							$0							
Meet with LSC to review task memoranda		6.0	$9,120	$180				$150		$330							
Finalize memoranda		3.0	$3,480							$0							
Task 7 -- Update Hydrogeologic Conceptual Model												$110,832					
7.1 Construct and calibrate one-dimensional compaction model at the PX											$36,640					$36,640	
Construct 1D model		9.0	$14,040							$0							
Calibrate 1D model		8.0	$13,880							$0							
Determine hydraulic and mechanical properties of aquitards		2.0	$3,440							$0							
Estimate pre-consolidation stress		3.0	$5,280							$0							
7.2 Update hydrogeologic conceptual model based on testing and modeling results											$33,600					$33,600	
Revise hydrogeologic cross-sections		6.0	$8,080							$0							
Update descriptions of aquifer and aquitard properties		7.0	$12,160							$0							
Analyze and describe stress-strain relationships and pre-consolidation stress		9.0	$13,360							$0							
7.3 Prepare Task 7 memorandum -- *Updated Hydrogeologic Conceptual Model of the Pomona Area*											$40,592					$40,592	
Prepare draft task memorandum and submit to the LSC		24.0	$35,120							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		2.0	$2,320							$0							
Task 8 -- Update Chino Basin Groundwater Model												$135,712					
8.1 Update groundwater model based on the Task 7 Memorandum											$23,400					$23,400	
Revise layering		3.5	$6,080							$0							
Revise aquifer properties		3.5	$6,080							$0							
Revise well pumping assignments		3.5	$6,080							$0							
Recalibrate model		3.0	$5,160							$0							
8.2 Add SUB package to groundwater model											$58,280					$58,280	
Implement SUB package		21.0	$36,240							$0							
Calibrate SUB Package		14.0	$22,040							$0							
8.3 Prepare Task 8 memorandum -- *Updated Chino Basin Groundwater Model with SUB Package*											$54,032					$54,032	
Prepare draft task memorandum and submit to the LSC		33.0	$48,560							$0							
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112							
Finalize task memorandum		2.0	$2,320							$0							
Task 9 -- Refine and Evaluate Subsidence-Management Alternatives												$253,766					
9.1 Re-evaluate the BMA and ISMA		12.0	$17,480							$0	$17,480					$17,480	
9.2 Develop a new subsidence-management alternative (SMA-2)										$0	$19,694					$19,694	
Describe the assumptions required to develop the SMA-2; prepare presentation		4.0	$7,120							$0							
Present straw-man SMA-2 to LSC		1.0	$1,780	$62				$50		$112							
Review with other agencies that will be required to implement the SMA-2		1.0	$1,780	$62						$62							
Revise SMA-2 based on comments; circulate to LSC and other agencies for comments		3.0	$5,280							$0							
Finalize SMA-2		2.0	$3,560							$0							
9.3 Characterize and evaluate the basin response to the SMA-2											$54,494						$54,494
Update groundwater production and replenishment plans per SMA-2		5.0	$8,720							$0							
Run groundwater model to evaluate the basin response to SMA-2		4.0	$6,880							$0							
Prepare maps, charts and tables to characterize the basin response to SMA-2		12.0	$17,280							$0							
Prepare presentation to summarize evaluation of SMA-2		2.0	$3,040							$0							
Describe up to two additional subsidence-management alternatives (SMA-3 and SMA-4)		4.0	$7,120							$0							
Review evaluation of SMA-2 and describe SMA-3 and SMA-4 with the LSC		2.0	$3,300	$62				$50		$112							
Review with other agencies that will be required to implement the SMA-3 and SMA-4		1.0	$1,780	$62						$62							
Finalize SMA-3 and SMA-4		3.5	$6,200							$0							
9.4 Characterize and evaluate the basin response to the SMA-3 and SMA-4											$89,474						$89,474
Update groundwater production and replenishment plans per SMA-3 and SMA-4		7.0	$12,160							$0							
Run groundwater model to evaluate the basin response to SMA-3 and SMA-4		6.0	$10,320							$0							
Prepare maps, charts and tables to characterize the basin response		14.0	$20,000							$0							
Prepare presentation of evaluation of SMA-3 and SMA-4		2.0	$3,040							$0							
Review evaluation with the LSC		2.5	$3,960	$62				$50		$112							
Revise SMA-3 and SMA-4 based on LSC comments		1.0	$1,720							$0							
Update groundwater production and replenishment plans		3.5	$6,080							$0							
Run groundwater model to evaluate the basin response		6.0	$10,320							$0							
Prepare maps, charts and tables to characterize the basin response		10.0	$15,160							$0							
Review evaluation with the LSC		2.0	$3,040	$62						$62							
Finalize SMA-3 and SMA-4		2.0	$3,500							$0							
9.5 Select preferred subsidence-management alternative for the Pomona Area											$18,872						$18,872

Task Descriptions	Notes	Labor		Other Direct Costs							Totals by		Totals by Fiscal Year					
		Person Days	Labor Costs	Travel	Rental	Equip-ment	Subs	Repro	Misc.	Total ODC	Sub-Task	Task	2015-16	2016-17	2017-18	2018-19	2019-20	
Describe additional costs associated with each alternative		6.0	$8,720							$0								
Describe institutional arrangements associated with each alternative		4.0	$7,000							$0								
Meet with LSC to review costs and institutional agreements		2.0	$3,040	$62				$50		$112								
Select the preferred subsidence-management alternative		0.0	$0							$0								
9.6 Prepare Task 9 memorandum -- *Subsidence Management Plan for the Pomona Area*											$53,752						$53,752	
Prepare draft task memorandum and submit to the LSC		32.5	$47,560							$0								
Meet with LSC to review task memorandum		2.0	$3,040	$62				$50		$112								
Finalize task memorandum		2.0	$3,040							$0								
Task 10 -- Update the MZ-1 Subsidence Management Plan												$61,472						
10.1 Describe implementation plan for the Subsidence-Management Plan (SMP) for the Pomona Area											$15,320						$15,320	
Describe activities, schedule and cost required to implement the SMP for the Pomona Area		5.0	$7,920							$0								
Describe monitoring plan and cost for the SMP for the Pomona Area		5.0	$7,400							$0								
10.2 Prepare task memorandum -- *Updated MZ-1 Subsidence Management Plan*											$46,152						$46,152	
Prepare draft task memorandum and distribute to LSC		25.5	$37,520							$0								
Prepare presentation for LSC		1.0	$1,520							$0								
Meet with LSC to review draft task memorandum		1.0	$1,520	$62				$50		$112								
Finalize task memorandum		2.5	$3,960							$0								
Revise presentation to conform to final task memorandum		1.0	$1,520							$0								
10.3 LSC recommends the updated MZ-1 Plan		0.0	$0							$0	$0						$0	
10.4 Review the updated MZ-1 Plan with Watermaster in the monthly process meetings	b	0.0	$0							$0	$0						$0	
Task 11 -- Meetings and Administration (Annual)	c											$16,642						
11.1 Ad Hoc Meetings		2.0	$3,040	$62						$62	$3,102		$3,102	$3,102	$3,102	$3,102	$3,102	
11.2 Project Administration and Financial Reporting		4.5	$6,540							$0	$6,540		$6,540	$6,540	$6,540	$6,540	$6,540	
11.3 Scope and Budget for Subsequent Fiscal Year		4.5	$7,000							$0	$7,000		$7,000	$7,000	$7,000	$7,000	$7,000	**5-Year Total**
Totals													**$481,397**	**$1,298,690**	**$199,402**	**$303,360**	**$297,706**	**$2,580,555**

Notes and Footnotes:

a All cost estimates are computed at 2015/16 rates.
b Sub-task to be completed under a separate Watermaster effort.
c Task 11 occurs annually.

Section 4 – Schedule

Figure 4-1 [in progress] describes the multi-year schedule to implement the work plan described in Section 2.

The following glossary of terms and definitions are utilized within this report and generally in the discussions at meetings of the LSC[6].

Aquifer – A saturated, permeable, geologic unit that can transmit significant quantities of groundwater under ordinary hydraulic gradients and is permeable enough to yield economic quantities of water to wells.

Aquifer System – A heterogeneous body of interbedded permeable and poorly permeable geologic units that function as a water-yielding hydraulic unit at a regional scale. The aquifer system may comprise one or more aquifers within which aquitards are interspersed. Confining units may separate the aquifers and impede the vertical exchange of groundwater between aquifers within the aquifer system.

Aquitard – A saturated, but poorly permeable, geologic unit that impedes groundwater movement and does not yield water freely to wells, but which may transmit appreciable water to and from adjacent aquifers and, where sufficiently thick, may constitute an important groundwater storage unit. Areally extensive aquitards may function regionally as confining units within aquifer systems.

Artesian – An adjective referring to confined aquifers. Sometimes the term artesian is used to denote a portion of a confined aquifer where the altitudes of the potentiometric surface are above land surface (flowing wells and artesian wells are synonymous in this usage). But more generally the term indicates that the altitudes of the potentiometric surface are above the altitude of the base of the confining unit (artesian wells and flowing wells are not synonymous in this case).

Compaction – Compaction in the geologic sense refers to the inelastic compression of the aquifer system. Compaction of the aquifer system reflects the rearrangement of the mineral grain pore structure and largely nonrecoverable reduction of the porosity under stresses greater than the preconsolidation stress. Compaction, as used here, is synonymous with the term “virgin consolidation” used by soils engineers. The term refers to both the process and the measured change in thickness. As a practical matter, a very small amount (1 to 5 percent) of the compaction is recoverable as a slight elastic rebound of the compacted material if stresses are reduced.

Compression – A reversible compression of sediments under increasing effective stress; it is recovered by an equal expansion when aquifer-system heads recover to their initial higher values.

Consolidation – In soil mechanics, consolidation is the adjustment of a saturated soil in response to increased load, involving the squeezing of water from the pores and a

[6] United States Geological Survey (USGS). 1999. Land subsidence in the United States / edited by Devin Galloway, David R. Jones, S.E. Ingebritsen. USGS Circular 1182. 175 p.

decrease in void ratio or porosity of the soil. The term “compaction” is sometimes used in preference to consolidation.

Confined Aquifer System – A system capped by a regional aquitard that strongly inhibits the vertical propagation of head changes to or from an overlying aquifer. The heads in a confined aquifer system may be intermittently or consistently different than in the overlying aquifer.

Deformation, Elastic – A fully reversible deformation of a material. In this report, the term “elastic” typically refers the deformation of the aquifer-system sediments or the land surface.

Deformation, Inelastic – A non-reversible deformation of a material. In this report, the term “inelastic” typically refers the permanent deformation of the aquifer-system sediments or the land surface.

Differential Land Subsidence – Markedly different magnitudes of subsidence over a short horizontal distance, which can be the cause ground fissuring.

Drawdown – Decline in aquifer-system head typically due to pumping by a well.

Expansion – In this report, expansion refers to expansion of sediments. A reversible expansion of sediments under decreasing effective stress.

Extensometer – A monitoring well housing a free-standing pipe or cable that can measure vertical deformation of the aquifer-system sediments between the bottom of the pipe and the land surface datum.

Ground Fissures – Elongated vertical cracks in the ground surface that can extend several tens of feet in depth.

Head – A measure of the potential for fluid flow. The height of the free surface of a body of water above a given subsurface point.

Hydraulic Conductivity – A measure of the medium’s capacity to transmit a particular fluid. The volume of water at the existing kinematic viscosity that will move in a porous medium in unit time under a unit hydraulic gradient through a unit area. In contrast to permeability, it is a function of the properties of the liquid as well as the porous medium.

Hydraulic Gradient – Change in head over a distance along a flow line within an aquifer system.

InSAR (Synthetic Aperture Radar Interferometry) – A remote-sensing method (radar data collected from satellites) that measures ground-surface displacement over time.

Linear Potentiometer – A highly sensitive electronic device that can generate continuous measurements of displacement between two objects. Used to measure movement of the land-surface datum with respect to the top of the extensometer measuring point.

Nested Piezometer – A single borehole containing more than one piezometer.

Overburden – The weight of overlying sediments including their contained water.

Piezometer – A monitoring well that measures groundwater levels at a point, or in a very limited depth interval, within an aquifer-system.

Piezometric (Potentiometric) Surface – An imaginary surface representing the total head of groundwater within a confined aquifer system, and is defined by the level to which the water will rise in wells or piezometers that are perforated within the confined aquifer system.

Pore pressure – Water pressure within the pore space of a saturated sediment.

Rebound – Elastic rising of the land surface.

Stress, Effective –The difference between the geostatic stress and fluid pressure at a given depth in a saturated deposit, and represents that portion of the applied stress which becomes effective as intergranular stress.

Stress, Preconsolidation – The maximum antecedent effective stress to which a deposit has been subjected and which it can withstand without undergoing additional permanent deformation. Stress changes in the range less than the preconsolidation stress produce elastic deformations of small magnitude. In fine-grained materials, stress increases beyond the preconsolidation stress produce much larger deformations that are principally inelastic (nonrecoverable). Synonymous with "virgin stress."

Stress – Stress (pressure) that is borne by and transmitted through the grain-to-grain contacts of a deposit, and thus affects its porosity and other physical properties. In one-dimensional compression, effective stress is the average grain-to-grain load per unit area in a plane normal to the applied stress. At any given depth, the effective stress is the weight (per unit area) of sediments and moisture above the water table, plus the submerged weight (per unit area) of sediments between the water table and the specified depth, plus or minus the seepage stress (hydrodynamic drag) produced by downward or upward components, respectively, of water movement through the saturated sediments above the specified depth. Effective stress may also be defined as the difference between the geostatic stress and fluid pressure at a given depth in a saturated deposit, and represents that portion of the applied stress which becomes effective as intergranular stress.

Subsidence – Sinking or settlement of the land surface, due to any of several processes.

Transducer, Pressure – An electronic device that can measure groundwater levels by converting water pressure to a recordable electrical signal. Typically, the transducer is connected to a data logger, which records the measurements.

Water Table – The surface of a body of unconfined groundwater at which the pressure is equal to atmospheric pressure, and is defined by the level to which the water will rise in wells or piezometers that are perforated within the unconfined aquifer system.