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TECHNICAL MEMORANDUM

DATE: August 4, 2023 Project No.: 941-80-22-26 B.2

TO: Ground-Level Monitoring Committee

CC: Peter Kavounas, *General Manager of the Chino Basin Watermaster*

FROM: West Yost Associates, *Watermaster Engineer*

REVIEWED BY: Andy Malone, PG

SUBJECT: *Description of Subsidence Management Alternative #1 for 1D Model Simulation of Subsidence in Northwest MZ-1 (FINAL)*

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BACKGROUND AND OBJECTIVES

The Chino Basin Watermaster's Subsidence Management Plan (SMP)[1] identified several "Areas of Subsidence Concern" across the western portion of Chino Basin where the future occurrence of land subsidence and ground fissuring is a concern. The SMP states that if data from existing monitoring efforts in the "Areas of Subsidence Concern" indicate the potential for adverse impacts due to subsidence, Watermaster will revise the SMP to avoid those adverse impacts.

Figure 1 is a map of the so-called Northwest MZ-1 Area of Subsidence Concern (Northwest MZ-1). Watermaster has monitored vertical ground motion in Northwest MZ-1 via InSAR[2] dating back to 1992. Land subsidence in Northwest MZ-1 was first identified as a concern in 2006 in the MZ-1 Summary Report[3] (WEI, 2006). Of particular concern is that the subsidence across the San Jose Fault in Northwest MZ-1 has occurred in a pattern of concentrated differential subsidence—the same pattern of differential subsidence that occurred in the Managed Area during the time of ground fissuring. Ground fissuring is the main subsidence-related threat to infrastructure.

The issue of differential subsidence and the potential for ground fissuring in Northwest MZ-1 has been discussed at prior meetings of the Ground Level Monitoring Committee (GLMC), and the subsidence has been documented and described as a concern in Watermaster's State of the Basin Reports, the annual reports of the GLMC, and in the Initial Hydrologic Conceptual Model for Northwest MZ-1.[4] Watermaster increased monitoring efforts in Northwest MZ-1 beginning in 2012 to include ground-elevation surveys and electronic distance measurements (EDM) to monitor ground motion and the potential for fissuring.

In 2015, the Watermaster's Engineer developed the *Work Plan to Develop a Subsidence Management Plan for the Northwest MZ-1 Area* (Work Plan).[5] The Work Plan is characterized as an ongoing Watermaster effort and includes a description of a multi-year scope of work, a cost estimate, and an implementation schedule. The Work Plan was included in the SMP as Appendix B. Implementation of the Work Plan began in July 2015. On an annual basis, the GLMC analyzes the data and information generated by the implementation of the Work Plan. The results and interpretations generated from the analysis are documented in the annual report of the GLMC and used to prepare recommendations for future activities.

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[1] Wildermuth Environmental, Inc. 2015. Chino Basin Subsidence Management Plan. Prepared for the Chino Basin Watermaster. July 23, 2015.

[2] Interferometric Synthetic Aperture Radar (InSAR) is a remote sensing technique that is used to monitor vertical ground motion over time.

[3] Wildermuth Environmental, Inc. 2006. MZ-1 Summary Report. Prepared for the MZ-1 Technical Committee. February 2006.

[4] Wildermuth Environmental, Inc. 2017. Initial Hydrologic Conceptual Model and Monitoring and Testing Program for the Northwest MZ-1 Area. Prepared for the Chino Basin Watermaster. December 2017.

[5] Wildermuth Environmental, Inc. 2015. Work Plan to Develop a Subsidence-Management Plan for Northwest MZ-1. Prepared for the Chino Basin Watermaster. July 23, 2015.

The objective of the *Subsidence Management Plan for Northwest MZ-1* is to provide guidance for the Watermaster and the Parties for how to manage hydraulic heads in Northwest MZ-1 (potentially through the management of pumping, recharge, the use of managed storage, and/or the design and implementation of Storage and Recovery Programs) so that the future occurrence of subsidence is minimized or abated in this area. The development of the *Subsidence Management Plan for Northwest MZ-1* will also include the evaluation of the minimum recharge quantity of supplemental water in MZ-1 as called for in Section 8.4 of the Peace II Agreement.[6]

The Work Plan included tasks to construct, calibrate, and use one-dimensional aquifer-system compaction models in Northwest MZ-1 (1D Models) to:

- Assist in understanding the mechanisms behind the ongoing subsidence in Northwest MZ-1
- Assist in the development of the *Subsidence Management Plan for Northwest MZ-1*.

The Work Plan envisioned the use of the 1D Models to update the Watermaster's three-dimensional groundwater-flow model so it could simulate aquifer-system compaction and then be used to develop the Subsidence Management Plan for Northwest MZ-1. However, the GLMC has recommended to use the 1D Models directly to develop the Subsidence Management Plan for Northwest MZ-1.

In 2021 and 2022, the Watermaster Engineer constructed and calibrated the 1D Models and published a technical memorandum to document the results.[7] The GLMC has advised the Watermaster that the 1D Models are sufficiently calibrated to be used to estimate the future occurrence of land subsidence in Northwest MZ-1, and therefore, can be used to help develop the *Subsidence Management Plan for Northwest MZ-1*.

The next step is to use the 1D Models to project the future magnitude of land subsidence in Northwest MZ-1 under various "Subsidence Management Alternatives." The first Subsidence Management Alternative (SMA-1) represents the recent plans of the Chino Basin Parties for groundwater management over a defined planning horizon (e.g., pumping, recharge, use of managed storage, etc.). The need to develop additional Subsidence Management Alternatives for 1D Model simulations will be based on the 1D Model results of prior alternatives. Each new Subsidence Management Alternative must be reviewed by the GLMC before model simulations are conducted.

The objective of this memorandum is to describe the assumptions of SMA-1.

TECHNICAL APPROACH AND METHODS

This section describes the technical approach and methods that will be employed to achieve the objectives of this investigation.

[6] See Section 8.4 of the *Final_Peace_II_Documents.pdf (cbwm.org)*

[7] West Yost Associates. 2022. *Construction and Calibration of One-Dimensional Compaction Models in the Northwest MZ-1 Area of the Chino Basin*. Prepared for the Chino Basin Watermaster. December 2022.

The primary question that needs to be answered to develop a *Subsidence Management Plan for Northwest MZ-1* is: What groundwater levels and groundwater management activities need to occur to minimize or abate the future occurrence of land subsidence in Northwest MZ-1 to avoid material physical injury (MPI)? To help answer this question, the following steps are proposed:

1. **Develop SMA-1 with review and input from the GLMC**. SMA-1 will represent the recent plans of the Chino Basin parties for pumping, recharge, and the use of managed storage over a defined planning horizon. The GLMC reviews and provides input on SMA-1 before it is used in this effort.
2. **Simulate the hydrologic response of the Chino Basin to SMA-1 by aquifer layer**. The existing numerical groundwater-flow model of the Chino Basin (referred to as the Chino Valley Model [CVM]) is used to simulate the hydrologic response of the Chino Basin to SMA-1. The CVM is a five-layer model, so it can predict the hydraulic heads in each model layer under the projected pumping and recharge stresses over the planning horizon.
3. **Simulate the vertical ground motion that is predicted to occur in Northwest MZ-1 under SMA-1**. The hydraulic heads of SMA-1, as simulated by the CVM in each model layer, are used as input data for the 1D Models. The output of the 1D Models represents the vertical aquifer-system compaction (and hence, the vertical ground motion) that is predicted to occur in Northwest MZ-1 under SMA-1. The output will be described in terms of the rates, duration, and magnitude of vertical deformation of the aquifer sediments that is predicted to occur at the 1D Model locations over the planning horizon.
4. **Evaluate model results and develop recommendations**. The GLMC will evaluate the projected hydraulic heads versus the projected compaction as simulated by the 1D Models, and then make the following recommendations:
    a. Based on the model simulation results, recommend "acceptable thresholds" for projected land subsidence to avoid or mitigate MPI.
    b. Recommend "subsidence management strategies" for Northwest MZ-1. These recommended strategies may come in the form of:
        i. Recommended operating ranges for hydraulic heads by aquifer layer.
        ii. Recommended groundwater management practices, such as pumping, recharge, the use of local storage, and/or the design of Storage and Recovery Programs.
    c. Recommend the minimum recharge quantity of supplemental water in MZ-1.
    d. Consider recommending additional work, such as: filling data gaps and/or collecting additional hydrogeologic information; developing additional SMAs; performing CVM and 1D Model simulations of the additional SMAs; and making revised recommendations based on the model results (*i.e.,* 4.a. through 4.c. above). Any additional SMAs will be reviewed by the GLMC before taking the next step to simulate the SMA with the CVM and the 1D Models.
5. **Repeat methods to develop the Subsidence Management Plan for Northwest MZ-1**. The methods above are repeated until enough information has been generated to develop the *Subsidence Management Plan for Northwest MZ-1*.

SUBSIDENCE MANAGEMENT ALTERNATIVE #1

SMA-1 is equivalent to the planning scenario that was simulated to support the 2020 Safe Yield Recalculation (2020 SYR)[8] using the 2020 CVM. The 2020 SYR was intended to represent and simulate the Parties' projected pumping, recharge, and use of storage through 2050. This scenario spanned from fiscal year (FY) 2018 through 2050 and included the cultural conditions (e.g., land use, water supply plans) that were assumed based on the best-available planning data at the time of the 2020 SYR.[9] An advantage of using 2020 SYR as the planning scenario for SMA-1 is that the CVM modeling is complete and the simulated hydraulic heads by model layer are readily available for use as input data for the 1D Models.

The remainder of this section describes the pumping and recharge assumptions of 2020 SYR (*i.e.,* SMA-1) and the CVM output, which is the simulated hydrologic response of the aquifer system to SMA-1.

Pumping Projections

The Parties' projected pumping and use of managed storage is based on planning data collected from the Parties. The Parties provided projections of monthly groundwater pumping and other water supplies, the use of current and projected wells including a prioritization of use, and the future use of their local storage accounts. These projections were used to develop monthly pumping projections by well in the Chino Basin for 2018-2050.

Table 1 shows the projected pumping by well for the three Appropriative Pool parties with wells near Northwest MZ-1 for 2018-2050: Monte Vista Water District (MVWD), City of Pomona (Pomona), and Golden State Water Company (GSWC). Projected pumping of the three parties reaches 18,650 afy in FY 2040 and stays constant through FY 2050.

Managed Recharge Projections

Recharge components in the Chino Basin primarily include (i) subsurface inflow from adjacent groundwater basins and bedrock, (ii) deep infiltration of precipitation and applied water, (iii) streambed infiltration, and (iv) managed aquifer recharge. Managed aquifer recharge includes the recharge of stormwater, recycled water, and imported water in the Chino Basin via spreading basins or Aquifer Storage and Recovery (ASR) wells.

Table 2 shows the projected managed aquifer recharge at the recharge basins located within or directly upgradient of Northwest MZ-1. Projected stormwater recharge was based on the CVM's surface-water model simulations, which included planned improvements developed during and after the 2013 Recharge Master Plan Update that were assumed to be operational in FY 2023. Projected recycled water recharge at spreading basins were estimates provided by the Inland Empire Utilities Agency (IEUA). Projected imported water recharge were estimates based on the requirement to satisfy a portion of the Parties' replenishment obligations when aggregate production exceeds aggregate production rights. Projected managed aquifer recharge in Northwest MZ-1 reaches about 7,000 afy in FY 2040 and stays constant through FY 2050.

[8] West Yost Associates. 2020. *2020 Safe Yield Recalculation*. Prepared for the Chino Basin Watermaster. May 2020.

[9] Refer to Section 7.3 of the 2020 SYR report for more detail on the pumping and recharge projections.

Hydrologic Response of the Aquifer System to SMA-1

SMA-1 was simulated for the 2020 SYR from FY 2018 through 2050. Figures 2, 3, and 4 are maps of the Chino Basin that illustrate the changes in hydraulic heads from FY 2018 to FY 2050 in CVM Layers 1, 3, and 5, respectively:

- Figure 2 shows that heads in Layer 1 are projected to decline by up to 25 feet across Northwest MZ-1. At the 1D Model locations, heads are projected to decline in Layer 1 by about 13 to 15 feet.
- Figure 3 shows that heads in Layer 3 are projected to increase by up to 5 feet in the western portion of Northwest MZ-1 and decrease by up to 30 feet in the eastern portion of Northwest MZ-1. At the 1D Model locations, heads are projected to decline by about 5 feet near PX and decline by about 10 feet near MVWD 28.
- Figure 4 shows that heads in Layer 5 are projected to increase across most of Northwest MZ-1. At the 1D Model locations, heads are projected to increase by about 25 feet near PX and increase by about 40 feet near MVWD 28.

Figures 5 and 6 are time-series charts of hydraulic heads in CVM model layers 1, 3, and 5 at the PX and MVWD 28 locations, respectively. These charts indicate the following changes in hydraulic heads from 2018 to 2050:

- In Layers 1 and 3, heads at the PX and MVWD-28 locations are projected to decline at a gradual rate starting in 2019 with total declines of up to 17 ft by 2050. These projected declines in heads are generally due to a projected increase in pumping from 2018 through 2050 across the Chino Basin. The projected declining heads in Layers 1 and 3 may increase the differential between the aquifer heads and pre-consolidation stresses within the thicker aquitard layers within Layers 1 and 3, which could increase the rates of projected aquitard compaction in Layers 1 and 3.
- In layer 5, heads at the PX and MVWD-28 locations increase immediately and significantly at the start of the projection. This immediate increase in heads is due to less projected pumping at several wells in Northwest MZ-1 that are screened across Layer 5. However, by 2030 heads begin to gradually decline through 2050, but remain above their initial 2019 heads. The projected increasing heads in Layer 5 may decrease the differential between the aquifer heads and pre-consolidation stresses within the thicker aquitard layers within Layer 5, which could reduce the rates of projected aquitard compaction in Layer 5.

RECOMMENDATIONS AND NEXT STEPS

The GLMC has reviewed a draft of this memorandum and discuss it at the GLMC meeting on March 2, 2023. The GLMC members submitted written comments and suggested revisions to the memorandum and SMA-1 and the Watermaster Engineer has responded to those comments in Appendix A.

The Watermaster Engineer will perform the 1D Model simulation of SMA-1 and document the 1D Model results in a technical memorandum for GLMC review. In its review, the GLMC will evaluate the projected hydraulic heads versus the projected compaction as simulated by the 1D Models, and then make the following recommendations:

a. Based on the model simulation results, recommend "acceptable thresholds" for projected land subsidence to avoid or mitigate MPI.

b. Recommend "subsidence management strategies" for Northwest MZ-1. These recommended strategies can be considered a preliminary or draft *Subsidence Management Plan for Northwest MZ-1*, and may come in the form of:

   i. Recommended operating ranges for hydraulic heads by aquifer layer.

   ii. Recommended groundwater management practices, such as pumping, recharge, the use of local storage, and/or the design of Storage and Recovery Programs.

c. Recommend the minimum recharge quantity of supplemental water in MZ-1.

d. Consider recommending additional work, such as: filling data gaps and/or collecting additional hydrogeologic information; developing additional SMAs; performing CVM and 1D Model simulations of the additional SMAs; and making revised recommendations based on the model results (i.e., a. through c. above). Any additional SMAs will be reviewed by the GLMC before taking the next step to simulate the SMAs with the CVM and 1D Models.

Other Related Recommendations

1. **Construct and Calibrate Additional 1D Models Across Western Chino Basin**. Quantifying the risk of future land subsidence resulting from future pumping and recharge behavior is one of the criteria upon which the potential for MPI is evaluated in the Chino Basin. 1D Models of aquifer-system compaction are likely the most appropriate tools to evaluate for MPI due to land subsidence. Therefore, the GLMC should consider recommending to the Watermaster the use of 1D Models to evaluate subsidence-related MPI in future groundwater modeling studies, such as the forthcoming reevaluation of the Safe Yield of the Chino Basin (2025 SYR). Such a recommendation may include:

   - Verifying and/or recalibrating the 1D Model that was prepared by the GLMC in the Managed Area at the Ayala Park Extensometer.

   - Constructing and calibrating additional 1D Models in other Areas of Subsidence Concern, such as the Southeast Area around the Chino Desalter well fields and in the Northeast Area (City of Ontario). The locations for additional 1D Models should be screened for evidence of historical land subsidence and the potential for groundwater levels to decline below pre-consolidation stress levels, and should be reviewed by the GLMC. Any new 1D Models that are constructed should be calibrated over a historical period using local, depth-specific heads and measured vertical ground motion.

   - Determining "subsidence thresholds" that, if exceeded, would represent MPI.

2. **Provide Advice in the Development of the 2025 SYR Scenarios**. The forthcoming 2025 SYR will involve the development of multiple projection scenarios of future hydrology, pumping, managed recharge, and use of managed storage in the Chino Basin. These projection scenarios will be simulated with an updated CVM. The CVM results will be evaluated for MPI and then

used to evaluate the current Safe Yield of the Chino Basin. The GLMC should advise the development of the 2025 SYR scenarios, and then oversee the use 1D Models to simulate the land subsidence. These CVM and 1D Model results could be used by the GLMC and Watermaster to:

a. Evaluate for the potential for subsidence-related MPI associated with the Safe Yield estimates.

b. Evaluate for the minimum recharge quantity of supplemental water in MZ-1 as required by the Peace II Agreement.

Providing GLMC advice on the 2025 SYR projection scenarios and the methods to evaluate for subsidence-related MPI should be conducted in conjunction with the 2025 SYR and can be discussed at regularly scheduled GLMC meetings during FY 2023/24. The evaluations for MPI and for the minimum recharge quantity of supplemental water in MZ-1 would likely be conducted in FY 2024/25.

Table 1. Projected Pumping at Wells in Northwest MZ-1 for Subsidence Management Alternative #1

Well Name	Well Owner	Well Layers	Historical Pumping FY 2010-18 (afy)	Annual Projected Pumping by Fiscal Year[1] (af)																				
				2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
2	Pomona	1	1,362	0	1,190	1,190	1,190	1,200	1,200	1,200	1,200	1,200	1,210	1,210	1,210	1,210	1,220	1,210	1,220	1,220	1,220	1,220	1,220	1,220	1,220
5B	Pomona	1,3	725	500	850	850	850	850	850	850	850	850	860	860	860	860	860	860	860	860	870	860	860	860	870
6	Pomona	1,3	101	640	900	890	900	900	900	900	900	900	910	910	910	910	910	910	910	910	920	910	910	910	920
10	Pomona	1,3	1,258	1,130	1,000	990	1,000	1,000	1,000	1,000	1,000	1,000	1,010	1,010	1,010	1,010	1,010	1,010	1,010	1,020	1,020	1,020	1,020	1,020	1,020
15	Pomona	1	355	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Pomona	1	353	550	850	850	850	850	850	850	850	850	860	860	860	860	860	860	860	860	870	860	860	860	870
17	Pomona	1,3	235	420	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	Pomona	1	649	340	800	800	800	800	800	800	800	800	810	810	810	810	810	810	810	810	810	810	810	810	810
23	Pomona	1,3	864	410	900	890	900	900	900	900	900	900	910	910	910	910	910	910	910	910	920	910	910	910	920
25	Pomona	1,3	1,541	1,540	1,090	1,090	1,100	1,100	1,100	1,100	1,100	1,100	1,110	1,110	1,110	1,110	1,110	1,110	1,120	1,120	1,120	1,120	1,120	1,120	1,120
26	Pomona	1,3	569	270	500	500	500	500	500	500	500	500	500	500	500	500	510	510	510	510	510	510	510	510	510
27	Pomona	1,3	525	1,250	800	800	800	800	800	800	800	800	810	810	810	810	810	810	810	810	810	810	810	810	810
29	Pomona	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	Pomona	1,3	1,296	1,490	1,190	1,190	1,190	1,200	1,200	1,200	1,200	1,200	1,210	1,210	1,210	1,210	1,220	1,210	1,220	1,220	1,220	1,220	1,220	1,220	1,220
35	Pomona	1,3	7	0	500	500	500	500	500	500	500	500	500	500	500	500	510	510	510	510	510	510	510	510	510
36	Pomona	1,3	1,007	730	800	800	800	800	800	800	800	800	810	810	810	810	810	810	810	810	810	810	810	810	810
Margarita #1	GSWC	1	447	530	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370
4	MVWD	1	247	290	190	190	180	180	180	180	180	180	180	180	180	190	190	190	190	190	190	190	190	190	190
5	MVWD	1,3	1,084	1,020	660	650	650	640	640	640	640	640	640	650	650	650	650	650	650	660	660	660	660	660	670
10	MVWD	1,3	165	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	MVWD	1,3,5	1,997	2,480	800	790	790	780	780	770	780	780	780	780	790	790	790	790	800	800	800	800	800	810	810
26	MVWD	1,3,5	1,789	1,330	890	880	880	870	870	860	870	870	870	880	880	880	890	890	890	890	900	900	900	900	910
27	MVWD	1,3,5	384	370	100	100	90	90	80	80	80	80	90	90	90	100	100	100	110	110	110	110	120	120	120
28	MVWD	1,3,5	2,129	1,540	870	860	860	850	850	840	840	850	850	850	860	860	860	860	870	870	870	870	880	880	880
30	MVWD	1,3,5	182	330	100	100	90	90	80	80	80	80	90	90	90	100	100	100	110	110	110	110	120	120	120
31	MVWD	1,3,5	967	370	940	930	920	920	920	910	910	920	920	920	920	930	930	930	940	940	940	940	950	950	950
32	MVWD	1,3,5	495	310	100	100	90	90	80	80	80	80	90	90	90	100	100	100	110	110	110	110	120	120	120
33	MVWD	1,3,5	659	0	940	930	920	920	920	910	910	920	920	920	920	930	930	930	940	940	940	940	950	950	950
34	MVWD	1,3,5	244	0	940	930	920	920	920	910	910	920	920	920	920	930	930	930	940	940	940	940	950	950	950
Subtotal from Layers 1 and 3			*12,790*	*11,110*	*12,590*	*12,550*	*12,580*	*12,590*	*12,590*	*12,590*	*12,590*	*12,590*	*12,700*	*12,710*	*12,710*	*12,720*	*12,760*	*12,740*	*12,770*	*12,790*	*12,830*	*12,790*	*12,790*	*12,790*	*12,840*
Subtotal from Layers 1, 3, and 5			*8,845*	*6,730*	*5,680*	*5,620*	*5,560*	*5,530*	*5,500*	*5,440*	*5,460*	*5,500*	*5,530*	*5,540*	*5,560*	*5,620*	*5,630*	*5,630*	*5,710*	*5,710*	*5,720*	*5,720*	*5,790*	*5,800*	*5,810*
Total			**21,635**	**17,840**	**18,270**	**18,170**	**18,140**	**18,120**	**18,090**	**18,030**	**18,050**	**18,090**	**18,230**	**18,250**	**18,270**	**18,340**	**18,390**	**18,370**	**18,480**	**18,500**	**18,550**	**18,510**	**18,580**	**18,590**	**18,650**

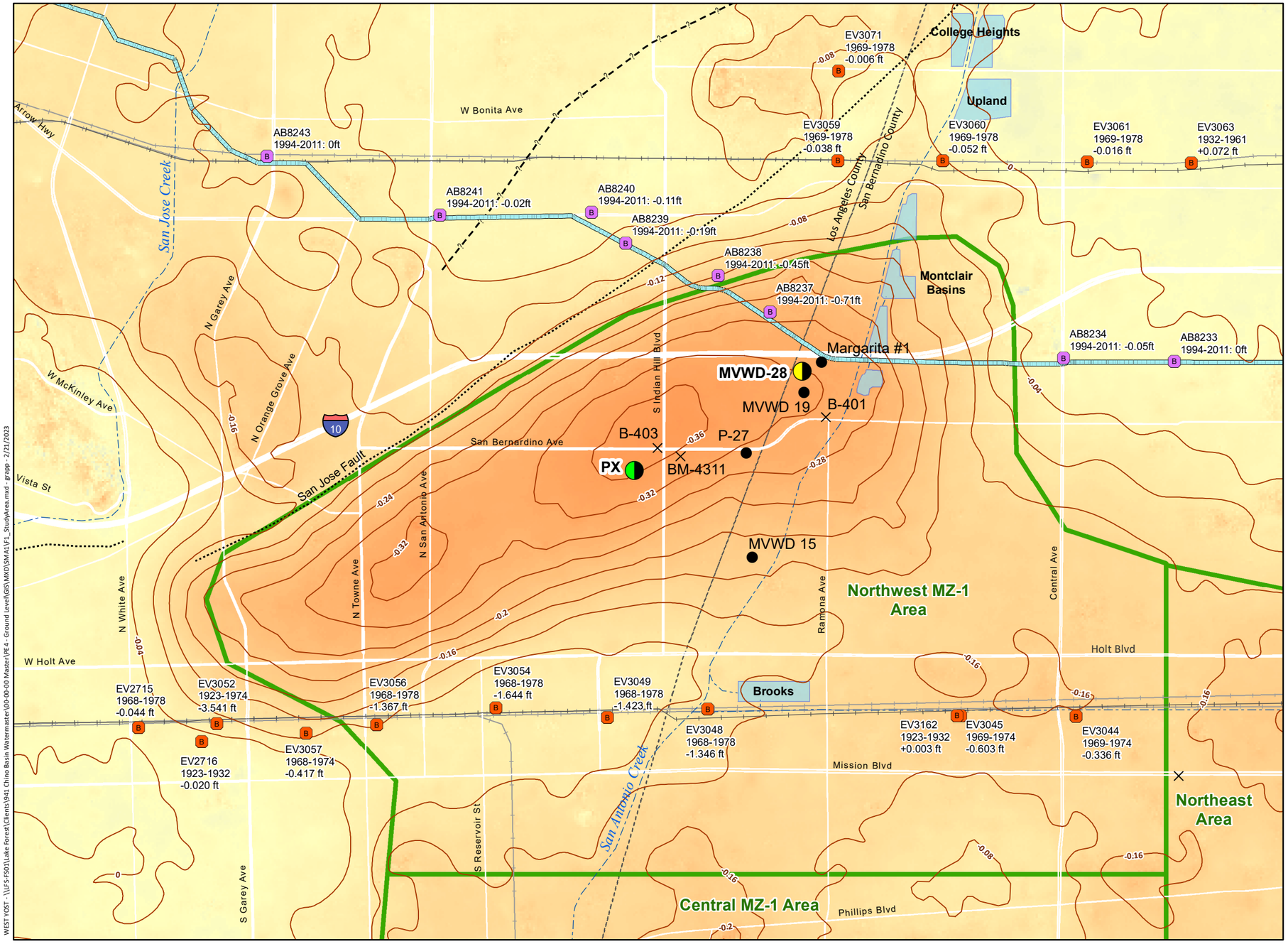
[1] Annual pumping is constant after FY 2040.

Table 2. Projected Managed Recharge Near Northwest MZ-1 for the Baseline Management Alternative

Managed Recharge Type	Historical Recharge FY 2010-18 (afy)	Annual Projected Recharge Volume Near Northwest MZ-1 by Fiscal Year[1,2] (af)																						
		2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Stormwater	1,528	2,520	2,500	2,520	2,620	2,610	2,590	2,610	2,610	2,610	2,590	2,610	2,610	2,610	2,590	2,610	2,610	2,610	2,590	2,610	2,610	2,610	2,580	2,600
Recycled Water	1,177	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650	1,650
Imported Water	6,748	0	0	0	0	0	0	0	0	10	150	350	510	320	760	1,200	1,630	2,060	2,380	2,690	3,010	3,330	3,550	2,810
Total	**9,453**	**4,170**	**4,150**	**4,170**	**4,270**	**4,260**	**4,240**	**4,260**	**4,260**	**4,270**	**4,390**	**4,610**	**4,770**	**4,580**	**5,000**	**5,460**	**5,890**	**6,320**	**6,620**	**6,950**	**7,270**	**7,590**	**7,780**	**7,060**

[1] Tabulated recharge includes recharge in College Heights Basins, Upland Basin, Montclair Basins, Brooks Basin, and MVWD ASR wells. No imported water recharge is projected to occur via ASR wells.

[2] Annual managed recharge is constant from FY 2041 through FY 2050.



1D Model Locations

- MVWD-28
- PX

Land Subsidence Features

+0.55 ft
0 ft
-0.55 ft

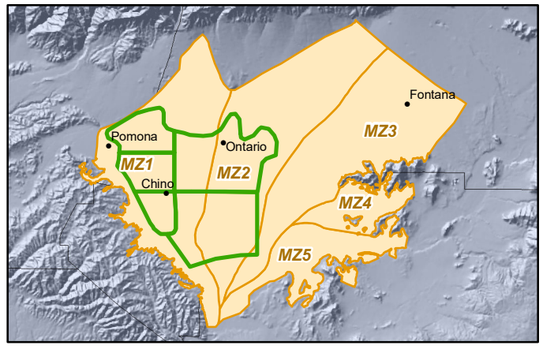
Relative Change in Land Surface Elevation as Estimated by InSAR *(March 2011 to March 2022)*

-1:0- Contours of Relative Change in Land Surface Elevation as Estimated by InSAR *(March 2011 to March 2022)*

- Benchmark used for 1D Model Calibration
- NGS Benchmarks
- MWD Benchmarks

Other Features

- Well with Historical Measured Heads
- Recharge Basin
- Areas of Subsidence Concern
- Fault (dotted where concealed; queried where uncertain)
- MWD Upper Feeder
- Railroads



Prepared by:

WEST YOST
Water. Engineered.

0 1 2 Miles

0 2 4 Km

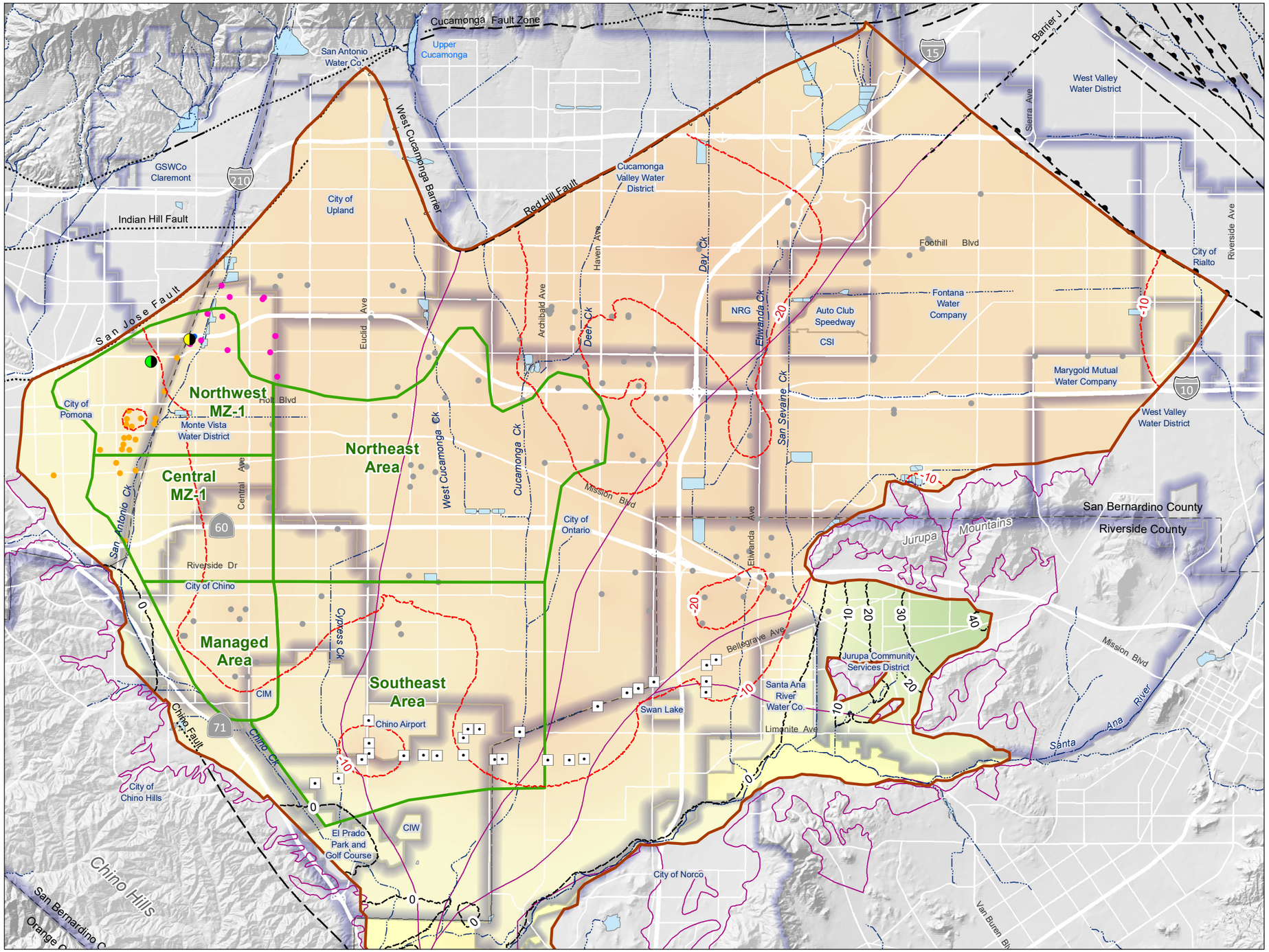
N

Figure 1

Locations of PX and MVWD-28 1D Models and Historical Elevation Surveys at Benchmarks

Chino Basin Watermaster
Ground-Level Monitoring Committee
Subsidence Management Plan for Northwest MZ-1

WEST YOST - \\LF5-FS01\Lake Forest\Clients\941 Chino Basin Watermaster\00-00-00 Master\PE 4 - Ground Level\GIS\MXD\SMA1\F1_StudyArea.mxd - grapp - 2/21/2023



Contour of Difference in Hydraulic Head (ft)
Positive Change *July 2018 through June 2050 - SMA-1*

Contour of Difference in Hydraulic Head (ft)
Negative Change *July 2018 through June 2050 - SMA-1*

Difference in Hydraulic Head (ft)
July 2018 through June 2050 - SMA-1

100 — *Increasing*
0
-100 — *Decreasing*

1D Model Locations

- MVWD-28
- PX

Wells

- Monte Vista Water District
- City of Pomona
- Golden State Water Co.
- Other Appropriative Pool
- Chino Desalter Wells

Other Features

- Streams & Flood Control Channels
- Flood Control & Conservation Basins
- Areas of Subsidence Concern
- Water Service Area
- Chino Basin Part of the Active CVM MODFLOW Domain
- OBMP Management Zones

Prepared by:

WEST YOST

Author: GR
Date: 2/21/2023
File: Figure 2 SYR_2050-2018_L1.mxd

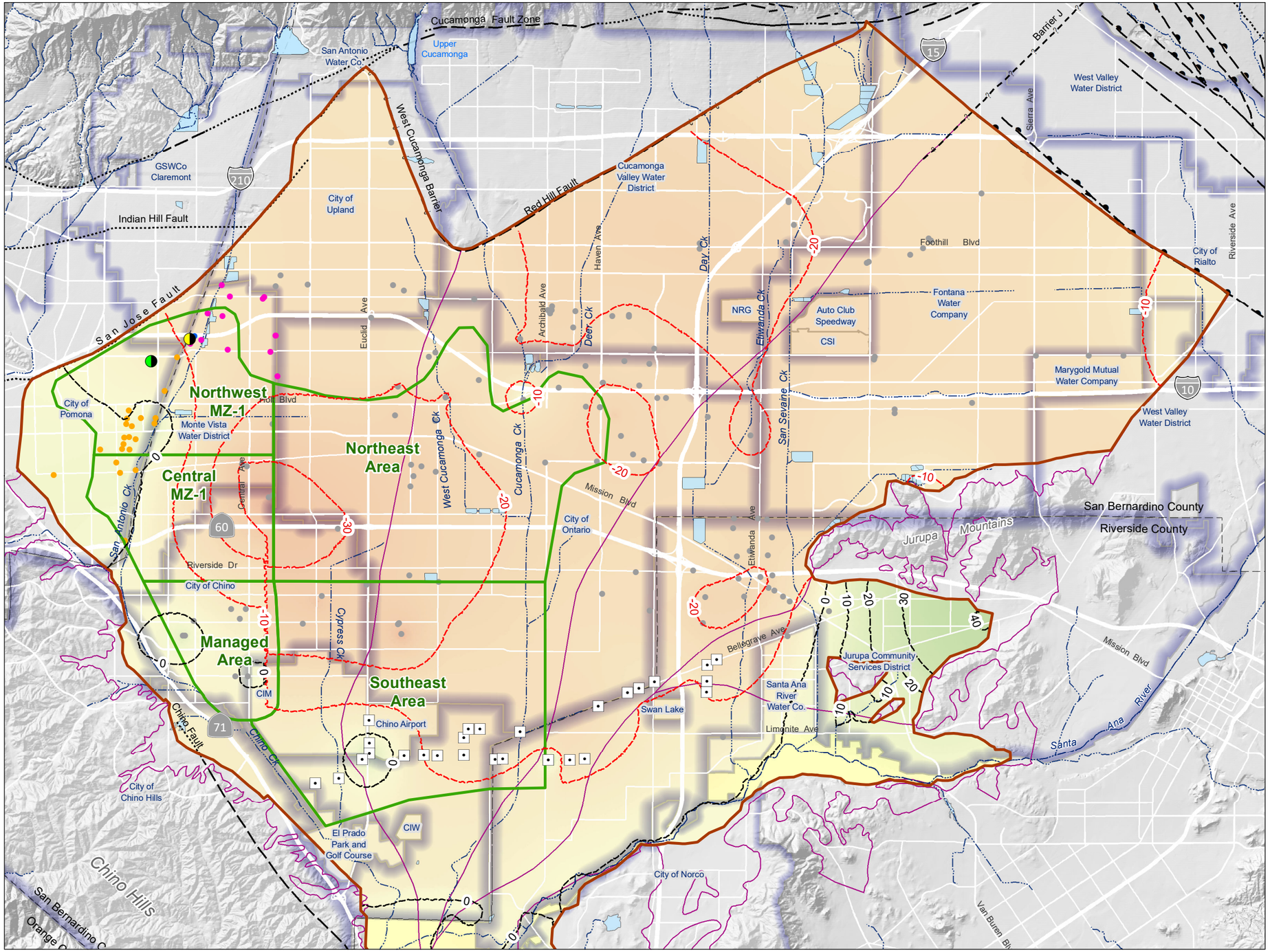
0 1 2 3 4 5 Miles
0 2 4 6 8 Km

Prepared for:

Evaluation of Land Subsidence in Northwest MZ-1 under SMA-1

Projected Difference in Hydraulic Head for Layer 1
Subsidence Management Alternative #1
July 2018 through June 2050

Figure 2



Contour of Difference in Hydraulic Head (ft)
Positive Change *July 2018 through June 2050 - SMA-1*

Contour of Difference in Hydraulic Head (ft)
Negative Change *July 2018 through June 2050 - SMA-1*

Difference in Hydraulic Head (ft)
July 2018 through June 2050 - SMA-1

100 — *Increasing*
0
-100 — *Decreasing*

1D Model Locations

- MVWD-28
- PX

Wells

- Monte Vista Water District
- City of Pomona
- Golden State Water Co.
- Other Appropriative Pool
- Chino Desalter Wells

Other Features

- Streams & Flood Control Channels
- Flood Control & Conservation Basins
- Areas of Subsidence Concern
- Water Service Area
- Chino Basin Part of the Active CVM MODFLOW Domain
- OBMP Management Zones

Prepared by:

WEST YOST

Author: GR
Date: 2/21/2023
File: Figure 3 SYR_2050-2018_L3.mxd

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

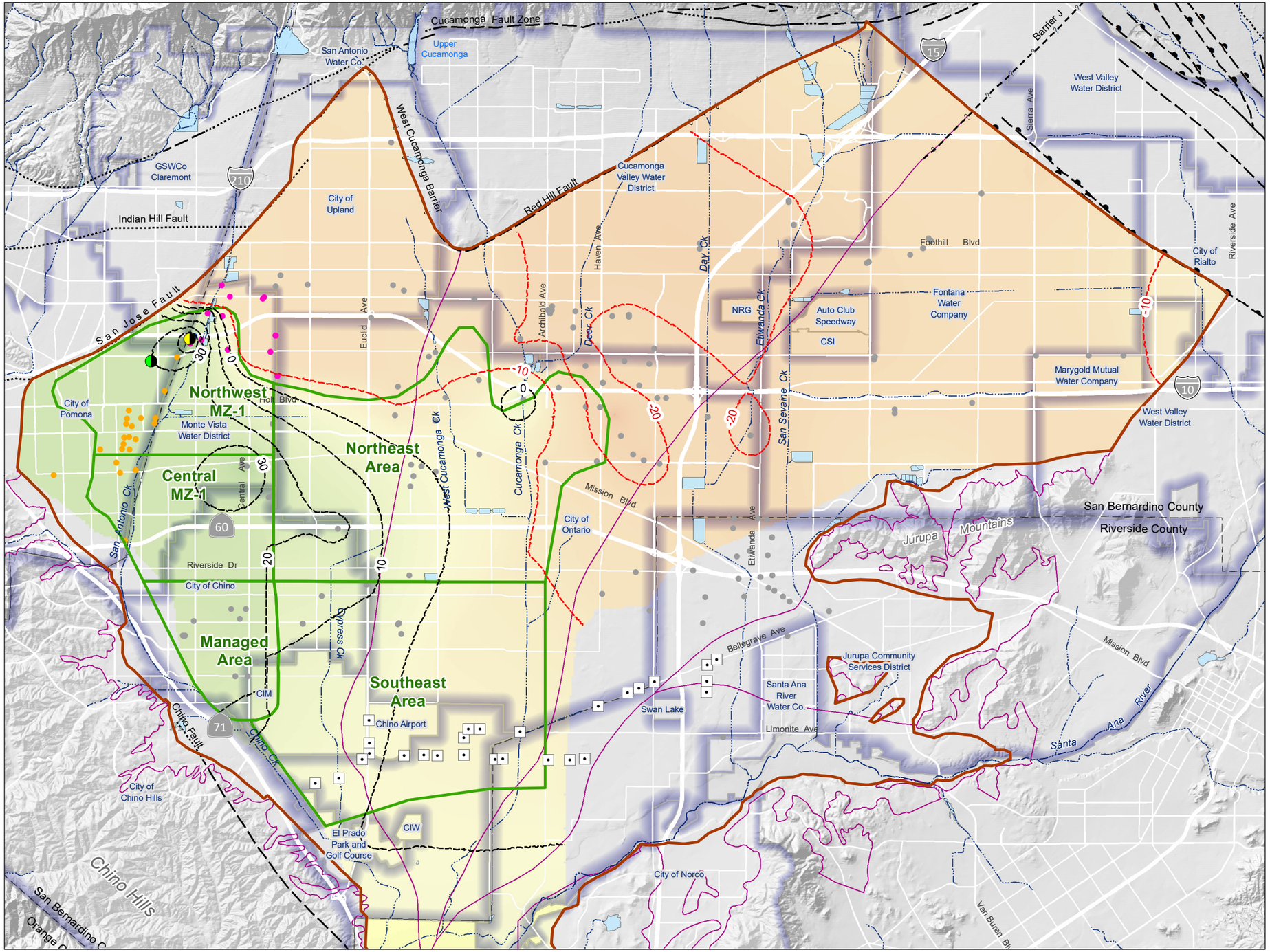
Prepared for:

Evaluation of Land Subsidence in Northwest MZ-1 under the SMA-1

CHINO BASIN WATERMASTER — Partners in Basin Management

Projected Difference in Hydraulic Head for Layer 3
Subsidence Management Alternative #1
July 2018 through June 2050

Figure 3



Contour of Difference in Hydraulic Head (ft)
Positive Change *July 2018 through June 2050 - SMA-1*

Contour of Difference in Hydraulic Head (ft)
Negative Change *July 2018 through June 2050 - SMA-1*

Difference in Hydraulic Head (ft)
July 2018 through June 2050 - SMA-1

100 — *Increasing*
0
-100 — *Decreasing*

1D Model Locations

- MVWD-28
- PX

Wells

- Monte Vista Water District
- City of Pomona
- Golden State Water Co.
- Other Appropriative Pool
- Chino Desalter Wells

Other Features

- Streams & Flood Control Channels
- Flood Control & Conservation Basins
- Areas of Subsidence Concern
- Water Service Area
- Chino Basin Part of the Active CVM MODFLOW Domain
- OBMP Management Zones

Prepared by:

WEST YOST

Author: GR
Date: 2/21/2023
File: Figure 4 SYR_2050-2018_L5.mxd

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

Prepared for:

Evaluation of Land Subsidence in Northwest MZ-1 under SMA-1

Projected Difference in Hydraulic Head for Layer 5
Subsidence Management Alternative #1
July 2018 through June 2050

Figure 4

Figure 5. Simulated Heads at the PX Site under SMA-1

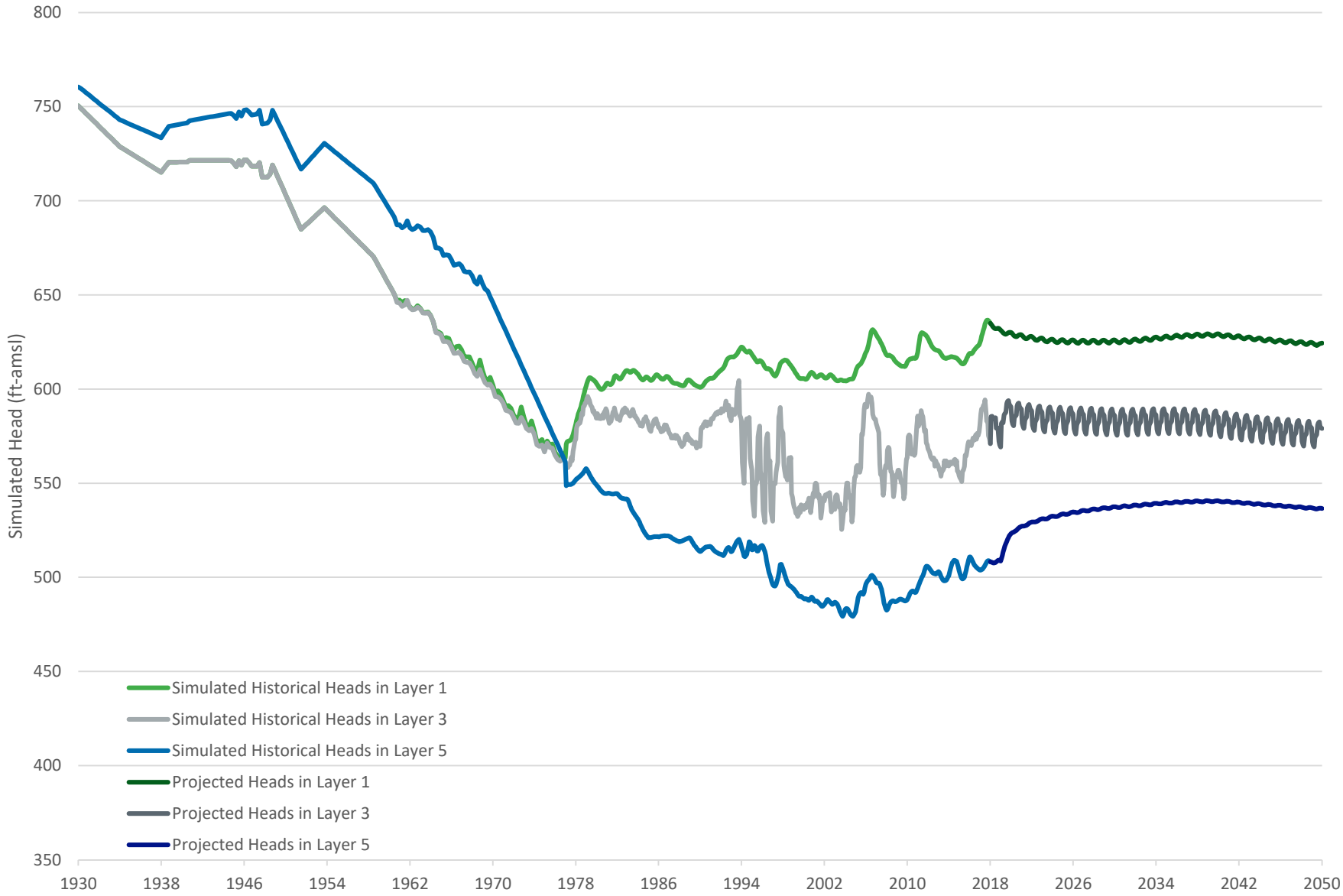
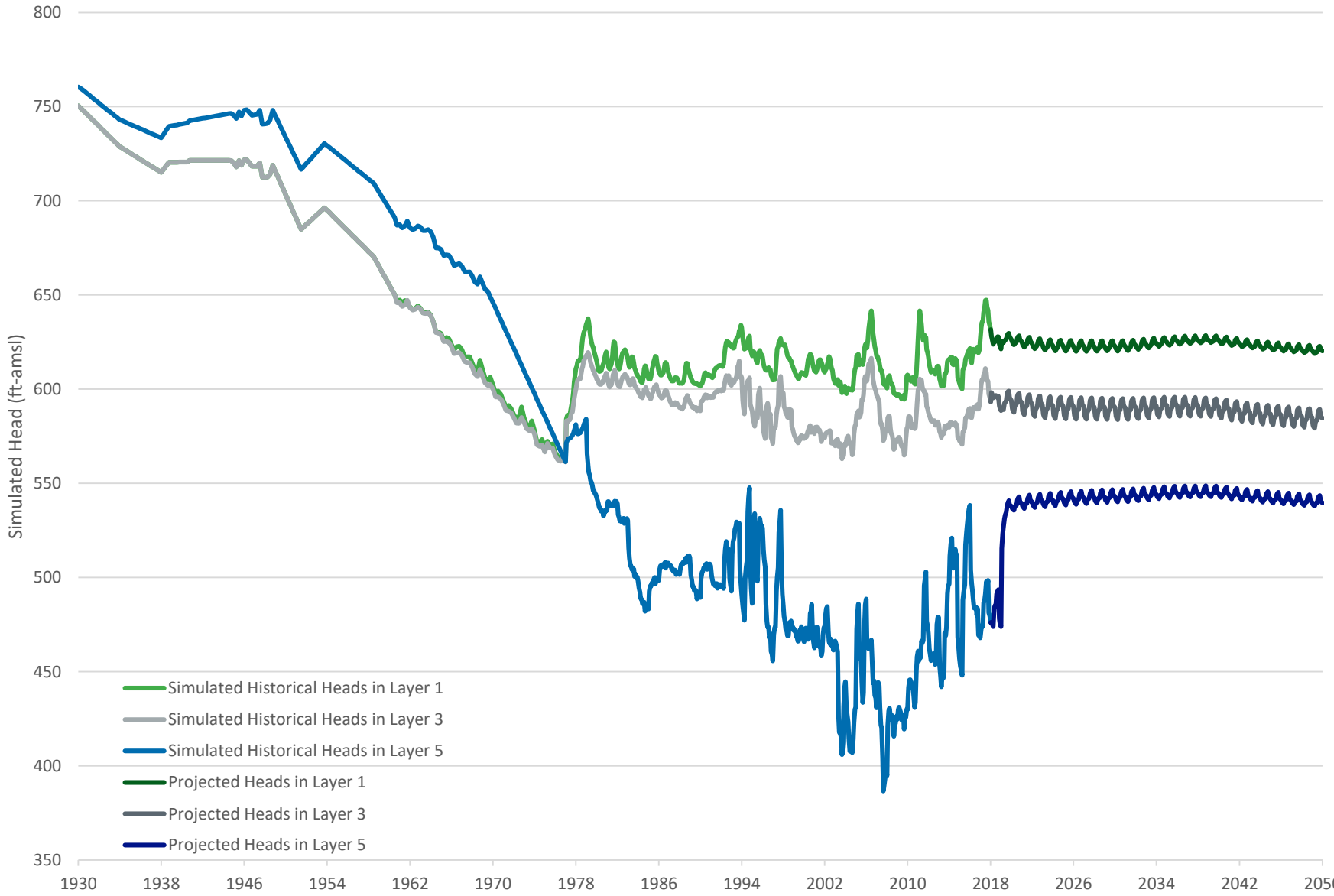


Figure 6. Simulated Heads at MVWD 28 under SMA-1



Appendix A

APPENDIX A – COMMENTS AND RESPONSES TO COMMENTS

The comments received from the GLMC as of March 31, 2023 on the "Description of Subsidence Management Alternative #1 for 1D Model Simulation of Subsidence in NWMZ-1 (Draft)" and the Watermaster Engineer's response to comments are documented below.

Comments from City of Chino (Eric Fordham)

Comment 1 – Technical Approach and Methods, page 4, bullet 3, Title.

The title of this paragraph should be changed to "Simulate the ground level response that is predicted to occur…" to avoid the bias that suggesting "land subsidence" will be the predicted outcome for future operations.

Response:

The phrase "land subsidence" has been replaced by "vertical ground motion."

Comment 2 – Technical Approach and Methods, page 4, bullet 3, last sentence.

This sentence should be restated to acknowledge that any future operations that result in land subsidence needs to be considered within the concept of avoidance or mitigation of undesirable results or material physical injury (MPI).

Response:

We agree that avoidance of MPI due to land subsidence is the objective of the Subsidence Management Plan.

The introductory sentence to the technical approach (top of Page 4) has been modified to read: "The primary question that needs to be answered to develop a *Subsidence Management Plan for Northwest MZ-1* is: What groundwater levels and groundwater management activities need to occur to minimize or abate the future occurrence of land subsidence in Northwest MZ-1 to avoid material physical injury (MPI)?"

The sentence referenced in this comment (in bullet 3) has been deleted because it is no longer necessary because the topic of evaluation for MPI is discussed in bullet 4.

Comment 3 – Technical Approach and Methods, page 4, bullet 4.a.

"Acceptable thresholds" must be considered within the concept of avoidance or mitigation of MPI.

Response:

Bullet 4.a has been revised to read: "Based on the model simulation results, recommend "acceptable thresholds" for projected land subsidence to avoid or mitigate MPI."

Comment 4 – Technical Approach and Methods, page 4, bullet 4 d.

Recommendation for additional work should also include identification of potential data gaps or need for additional hydrogeologic information.

Response:

To address this comment, bullet 4.d has been revised to read: "Consider recommending additional work, such as: filling data gaps and/or collecting additional hydrogeologic information; developing additional SMAs; performing CVM and 1D Model simulations of the additional SMAs; and making revised recommendations based on the model results (*i.e.,* 4.a. through 4.c. above). Any additional SMAs must be reviewed by the GLMC before taking the next step to simulate the SMA with the CVM and the 1D Models."

Comment 5 – Hydrologic Response of the Aquifer System to SMA-1, page 6, bullets 4 and 5 referencing Figures 5 and 6.

Historic and projected groundwater levels within the 5 layers described in these paragraphs and referenced on Figures 5 and 6 should also be discussed with reference to the estimated pre-consolidation head levels.

Response:

To address this comment, bullets 4 and 5 have been revised as follows:

- In Layers 1 and 3, heads at the PX and MVWD-28 locations are projected to decline at a gradual rate starting in 2019 with total declines of up to 17 ft by 2050. These projected declines in heads are generally due to a projected increase in pumping from 2018 through 2050 across the Chino Basin. The projected declining heads in Layers 1 and 3 may increase the differential between the aquifer heads and pre-consolidation stresses within the thicker aquitard layers within Layers 1 and 3, which could increase the rates of projected aquitard compaction in Layers 1 and 3.
- In layer 5, heads at the PX and MVWD-28 locations increase immediately and significantly at the start of the projection. This immediate increase in heads is due to less projected pumping at several wells in Northwest MZ-1 that are screened across Layer 5. However, by 2030 heads begin to gradually decline through 2050, but remain above their initial 2019 heads. The projected increasing heads in Layer 5 may decrease the differential between the aquifer heads and pre-consolidation stresses within the thicker aquitard layers within Layer 5, which could reduce the rates of projected aquitard compaction in Layer 5.

While these revisions to the bullets provide a preview of the expected 1D Model results for aquitard compaction, the 1D Models results themselves will provide the quantitative projection of aquitard compaction by CVM Layer under SMA-1.

Comment 6 – Recommendations and Next Steps, page 6, bullet a

Determination of acceptable thresholds should be considered within the concept of avoidance or mitigation of MPI.

Response:

Bullet a has been revised to read: “Based on the model simulation results, recommend “acceptable thresholds” for projected land subsidence to avoid or mitigate MPI.”

Comment 7 – Other Related Recommendations, page 7, Item 1, second bullet.

The need to construct additional 1D models should be screened for areas showing evidence of land subsidence and where there is a potential for groundwater levels to decline below pre-consolidation stress levels.

Response:

To address this comment, the second bullet has been revised to read:

- Constructing and calibrating additional 1D Models in other Areas of Subsidence Concern, such as the Southeast Area around the Chino Desalter well fields and in the Northeast Area (City of Ontario). The locations for additional 1D Models should be screened for evidence of historical land subsidence and the potential for groundwater levels to decline below pre-consolidation stress levels, and should be reviewed by the GLMC.

Comments from State of California (Rick Rees)

Comment 1

One subsidence management alternative (SMA-1) is proposed as a basis for estimating the future magnitude of land subsidence in Northwest MZ-1. The SMA-1 alterative is based on production, recharge, and use of storage through 2050 as estimated from planning data collected from the parties for the 2020 Safe Yield Reset. We understand that Watermaster has more recent estimates of production and use of groundwater in storage (updated in late 2022) as described in the Data Collection and Evaluation Effort Workshop held on March 21, 2023. Is there a reason that this data set is not used? Even if the more recent data are used to modify the SMA-1, actual future conditions are still uncertain, and the scenario would represent just one possible scenario. It might be useful for the Committee to consider a range of production from the deeper zone wells. For example, a scenario where production from the deeper zone approaches average production in the deeper zone from 2010 through 2018 and a scenario where the deeper production is less than currently projected. This would help bracket the impact of potential operational scenarios for future consideration by the Committee. The TM notes that additional scenarios may be considered but indicates this would occur only after review of the results for SMA-1 and approval by the GLMC.

Response:

SMA-1 is being proposed as the initial planning alternative for two main reasons:

- SMA-1 represents a reasonable future planning scenario for pumping and recharge in the Chino Basin that was developed and approved for the 2020 Safe Yield Reset.
- The CVM results for SMA-1—hydraulic heads by Layer at the 1D Model locations—are readily available and do not require a new CVM run to generate the required heads as 1D Model input data (which avoids additional labor and costs).

We agree with the comment, in that: the results of SMA-1—projected aquifer-system compaction at the 1D Model locations—will guide the preparation of additional model scenarios that could be used in this subsidence management effort, as well as in the upcoming 2025 Safe Yield Reevaluation. The GLMC can provide valuable input for "scenario building" for both modeling efforts.

Comment 2

The TM indicates the GLMC will "Determine acceptable thresholds for projected land subsidence based on the simulation results." The GLMC is a technical body, but a definition of "acceptable" may involve technical as well as a variety of socioeconomic factors that are beyond the purview of the GLMC. Consider whether it might be more appropriate for the GLMC to conduct a literature review to identify acceptable thresholds for land subsidence established in other basins and to summarize the efforts to establish a threshold for permanent land subsidence in the MZ-1 Managed Area. We recall discussions regarding a threshold for subsidence in this area but are not aware that a threshold was established.

Response:

We agree that the GLMC is a technical body that provides advice and recommendations to the Parties and the Watermaster. We have revised the language in this TM to describe that the main objective of

this task is to "recommend 'acceptable thresholds' for projected land subsidence to avoid or mitigate MPI." The GLMC has not yet recommended a subsidence threshold for Northwest MZ-1.

We agree that a literature review would be useful in this effort; however, we caution that each groundwater basin is unique with respect to land subsidence (rates of land subsidence, history of land subsidence, the differential nature of the subsidence, the overlying sensitive infrastructure, etc.), such that comparisons of "acceptable thresholds" will be nuanced and subjective.

Comment 3 – Other Related Recommendations, page 7, Item 1.

Under the header "Other Related Recommendations," enumerated bullet item 1, "Construct and Calibrate Additional 1D Models Across Western Chino Basin," the TM suggests recommending construction of other 1D models of the aquifer system because these are "likely the most appropriate tools to evaluate for MPI due to land subscience." We agree, and suggest adding the clarification that new 1D models will need to be sufficiently calibrated to local groundwater level fluctuations and observed inelastic subsidence. There are sufficient data available at the Ayala Park Extensometer and we agree that the existing 1D model for this area should be verified/and or recalibrated. Doing so may provide useful insights for applying the 1D models in the Northwest MZ-1 areas based on the long history of direct measurements of depth-discrete aquifer compaction and corresponding depth-discrete aquifer water level declines at Ayala Park.

Response:

We agree with this entire comment. The following language has been added to the bullet:

> "Any new 1D Models that are constructed should be calibrated over a historical period using local, depth-specific heads and measured vertical ground motion."

Comment 4 – Other Related Recommendations, page 7, Item 2.

As part of Other Related Recommendations, enumerated bullet item 2 on page 7, "Provide Advice in Development of the 2025 SYR Scenarios," we suggest the Committee reevaluate the potential use of the Chino Valley Model to simulate aquifer-system compaction for the basin in addition to using the 1D Models. This would not need to be a detailed or costly re-evaluation, but might involve discussion and documentation of whether anything learned during development of SMA-1 (or other SMAs) or in the 2025 SYR process points to use of the 3-dimensional CVM for this purpose.

Response:

The GLMC recommended the use of 1D Models to simulate aquifer-system compaction based on importance of delayed drainage of the multitude and various thicknesses of aquitard layers in the Chino Basin that control the occurrence of land subsidence. The majority of the GLMC did not recommend the construction, calibration, and use of the SUB package in the CVM to simulate subsidence because it simulates aquitard compaction at a much lower depth resolution (by model layer) compared to the 1D Models (by aquitard layer). That said, the final paragraph of this bullet has been modified to address this comment:

> "Providing GLMC advice on the 2025 SYR projection scenarios and the methods to evaluate for subsidence-related MPI should be conducted in conjunction with the 2025 SYR and can be

discussed at regularly scheduled GLMC meetings during FY 2023/24. The evaluations for MPI and for the minimum recharge quantity of supplemental water in MZ-1 would likely be conducted in FY 2024/25."

Comments from Monte Vista Water District (Justin M. Scott-Coe)

Watermaster received a comment letter from the District dated April 7, 2023. The responses to the comment letter below relate only to those sections of the letter that are technical in nature and address the construction and calibration of the 1D Models.

Comment V.a

Watermaster requests Table 1 be updated to reflect projected pumping requirements. There are many variables that affect groundwater pumping demands including future State Water Project deliveries and environmental factors, especially during peak water demand periods. The District can only provide projections based on its current water supply plan which projects groundwater production of approximately 8,600 AF/year. This includes 6,500 AF for the District and 2,100 AF for the City of Chino Hills consistent with our wholesale water supply agreement. Using these figures, the District estimates the following well production numbers for Production Year 2024.

Well #	Annual Production *AF/Yr*	Notes
4	390	Future treatment may be required.
5	810	
19	1,600	Must run 24/7 due to sanding. Future treatment may be required.
26	1,070	
27	950	Future treatment may be required.
28	820	
30	620	Treatment installed for two contaminants
31	1,100	
32	620	Treatment installed for two contaminants
34	620	Treatment installed for two contaminants

The District's operational philosophy is to run wells that require less treatment first and then bring other systems online to meet the water demand. This minimizes water production costs for the District's water customers. Shifting production to wells with treatment will increase operational costs and affect water rates.

Response:

Thank you for the information, which will likely become useful in the development of Subsidence Management Alternatives that follow SMA-1.

Comment V.b

The District continues to express concern over the groundwater model calibration. Comments to the 2020 Safe Yield Reset identified local calibration issues in the western portion of Chino Basin and at its boundary with the Six Basins Groundwater Basin. While calibration over the full Chino Valley Model is within industry standards, residuals in these areas are high. Water levels from the PX-1 monitoring wells

showed significant difference from the predicted water levels used as inputs for the initial calibration of the 1D model, and the 1D model was sensitive to these differences. As the layer specific heads are inputs for the 1D model, problems with local calibration of the groundwater model may result in errors in predicted subsidence.

The lack of layer specific water levels, especially in layers 3 and 5, during the period when the 1D model predicts the greatest subsidence occurred, raises further concerns over the 1D modeling approach. Further, the 1D model is calibrated against an interpolated subsidence measurement. The InSAR data record contains several significant gaps. The methodology to interpolate land level trends in this period is not clear and has not been tested for sensitivity. The District requests that West Yost provide full statistical analysis on calibration of all wells in MZ-1. Of most importance is the calibration of the wells pumping from the deeper layers.

Response:

At the request of the GLMC, a sensitivity analysis was performed to evaluate the sensitivity of the 1D Model calibrations to the estimates of historical heads. This sensitivity analysis was prudent given the lack of historical data, and hence, uncertainty in knowledge of depth-specific historical heads (i.e., the time series of historical heads in each model layer).

The results of the sensitivity analysis were published in draft and final technical memoranda on the construction and calibration of the 1D Models and was shared with the GLMC. The adjustment in historical heads in the sensitivity analysis did not significantly affect the simulated compaction in the 1D Models. This observation indicated that the 1D Models are ***not*** sensitive to minor differences in the assumptions for historical heads. More likely, the 1D Models are most sensitive to the number and thicknesses of the Clay layers and the long-term declining trends in historical heads that drive the delayed drainage and compaction of the Clay layers.

It will always be the case that historical data (i.e., head data or vertical ground motion data) will be limited, and these limited data will create some degree of uncertainty in the model simulations. That said, based on the results of the 1D Model calibration and the sensitivity analysis, the majority of the GLMC stated that the 1D Models are sufficiently calibrated to provide a useful tool for evaluating potential future subsidence under future planning scenarios. A similar verbal statement was made by the GLMC consultant for MVWD at the GLMC meeting on December 13, 2022, but the Watermaster never received this statement in writing.

Comment V.c

West Yost requests a definition for “accepted thresholds for projected land subsidence based on simulation results.” The subsidence model indicates a drop between seven and nine feet near the center of depression over the last 40 years or so. Review of historical aerial photos of the City of Pomona does not show or indicate this level of decline. The area has been well developed for much of the period and does not show structural damage or any indication of surface decline.

The District contacted Chris Diggs (City of Pomona Water Resources Director) to determine if the City is seeing subsidence-induced issues in their sewer lines at the “center of subsidence.” He indicated that the City is not aware of any vertical alignment changes. It appears that the physical evidence does not

support the model subsidence conclusions. The District's recommendation is that unacceptable levels of subsidence be defined by actual or imminent physical damage to any infrastructure or land fissuring.

Response:

We are not aware of any published review of historical air photos that were used to estimate the magnitude of historical land subsidence in Northwest MZ-1. We also agree that there have been no published reports of subsidence-related damage to surface infrastructure.

However, there are published historical leveling surveys that support the historical simulations of subsidence at these magnitudes (see Figure 1 in this TM and the Initial Hydrologic Conceptual Model and Monitoring and Testing Program for the Northwest MZ-1 Area [WEI, 2017]). In addition, the historical subsidence occurred over multiple decades since the early 1900s. It is possible that damage occurred (e.g., fissuring, broken pipes, etc.) but was repaired and never attributed to the gradual process of land subsidence across Northwest MZ-1. As an example, the City of Pomona had to rehabilitate its only two wells that are located within the main area of subsidence in Northwest MZ-1 (Well 27 and Well 30). Video logs of those wells showed that the well casings were compressed, damaged, and required repair. The damage to the well casings could have been caused by the compaction of the aquifer system but was never directly attributed.

We agree with the District's recommendation that unacceptable levels of subsidence be defined by the magnitude or rate of future subsidence that could cause physical damage to any infrastructure or land fissuring. However, that magnitude or rate cannot be known precisely. This is because land subsidence can cause strain to accumulate in the shallow soils or the overlying infrastructure over many years before triggering damage, such as opening of a ground fissure, cracking of pipe, or failure of a well casing.

We believe the GLMC should consider both the historical data and the 1D Model simulation results, and then recommend a subsidence threshold that will hopefully stop short of causing physical damage to any infrastructure or land fissuring in Northwest MZ-1. Through the GLMC process, the District will have opportunities to contribute its ideas for what constitutes unacceptable levels of subsidence in Northwest MZ-1, and what thresholds should be recommended to avoid causing physical damage to any infrastructure or land fissuring.

Comment V.d

West Yost discusses two subsidence management strategies. The first is specifying operating ranges for hydraulic head ranges by aquifer. This is not a practical strategy for the District to use for operation of its groundwater production system. The second is groundwater management practices which includes pumping, recharge, storage, etc. This strategy can practically be implemented but potentially could restrict the District from producing its groundwater rights due to limits of existing wells and the current distribution system. The District could consider modification of their facilities but would likely result in significant capital investments and an application to Watermaster for reimbursement or assessment credits (see Section IV above).

Response:

The TM discusses general concepts for subsidence management strategies. Through the GLMC meetings and review process, the District will have opportunities to contribute its ideas for subsidence management strategies and any perceived limitations in specific strategies that are being considered by the GLMC.

Comment V.e

West Yost discusses development of additional subsidence management alternatives for this effort. This effort would use the existing Chino Valley Model (CVM) and their 1-D model. The limitation of the 1-D model is that it could show "X" feet of subsidence, and then it could be re-run at a location 100 feet away and show "10X" feet of subsidence. (The 1-D model does not consider the effects of differing groundwater model inputs across locations.) The District's consultant, Geoscience, continues to recommend using the Subsidence and Aquifer System Compaction (SUB) Package. The increase of vertical resolution in the 1D model is still constrained by the layer-specific heads for inputs and the lithology recorded during the well drilling. The 1D models are point-specific and cannot account for the differential subsidence that is most likely to cause physical damage. If the SUB package cannot be calibrated with the 2020 CVM, the 2025 update to the CVM should include additional consideration of the conceptual model in MZ1 and additional effort to achieve better local calibrations in the Northwest MZ1 area.

Response:

During the process to develop the GLMC scope of work and budget for FY 2021/22, the Watermaster Engineer and the majority of the GLMC recommended that the 1D Models be used (instead of the SUB package in MODFLOW) to simulate subsidence and develop the Subsidence Management Plan for Northwest MZ-1. This change in scope was recommended because: (i) the higher depth-specific resolution that 1D Models provide were expected to result in higher confidence in the model calibration and simulation results and (ii) it would eliminate the effort and costs associated with constructing and calibrating the SUB package in MODFLOW. Ever since, the GLMC has been implementing the effort to develop a subsidence management plan for Northwest MZ-1 using the 1D Models at the PX and MVWD-28 locations.

We disagree with the comment that the 1D Models have a significant limitation as a predictive tool for subsidence in Northwest MZ1, including the comment that "The 1D models are point-specific and cannot account for the differential subsidence that is most likely to cause physical damage." The historical InSAR data has shown that spatial and temporal patterns of vertical ground motion behave similarly across Northwest MZ1 over time (i.e., the historical InSAR datasets show how the rest of Northwest MZ1 behaves relative to the vertical ground motion that occurs at the 1D Model locations). Hence, predictions of vertical ground motion at the 1D Model locations can be used to estimate the directions and rates of vertical ground motion across all of Northwest MZ1.

Regarding the layer-specific heads as a constraint, this will be true for both the SUB package and the 1D Models; hence, the constraints of layer-specific heads are not a reason to choose the SUB package over the 1D Models.

Lastly, the 2025 update to the CVM will indeed include additional consideration for revisions to the conceptual model in MZ1 and additional effort to achieve better local calibrations of head in this area.

The geologic and depth-specific head data that has been collected at the Pomona Extensometer facility will be particularly useful in these efforts.