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DRAFT TECHNICAL MEMORANDUM

DATE: June 4, 2021 **PROJECT #:** 9090.11

TO: Ad Hoc Sustainable Groundwater Planning Advisory Committee (GSU22 Committee)

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PROJECT: Basin Management Plan: Groundwater Sustainability Update 2022 (GSU22)

SUBJECT: Findings and Proposed Recommendation for Subsidence

SUMMARY OF PROPOSED RECOMMENDATION FOR SUBSIDENCE

Based on the preliminary results of the United States Geological Survey (USGS) evaluation on subsidence presented to the GSU22 Committee meeting on December 15, 2020, that confirm the lack of observed permanent subsidence in the Pajaro Valley Subbasin (Basin), the GSU22 Committee recommends the Pajaro Valley Water Board (the Board) affirm that sustainable management criteria for subsidence are not needed for the Basin.

INTRODUCTION

The Pajaro Valley Water Management Agency (PV Water or Agency) Groundwater Sustainability Plan (GSP) Alternative was submitted on December 31, 2016, and approved by the California Department of Water Resources (DWR). The Alternative explains that sustainable management criteria (SMC) for subsidence are not warranted because subsidence is unlikely due to groundwater levels historically being above the pre-consolidation stress threshold for the aquifer system of the Basin. The Alternative also states that significant and unreasonable reduction of storage and seawater intrusion would occur before subsidence and PV Water would act to address those conditions in advance of subsidence occurring.

In its 2019 assessment of the Alternative, DWR considered the Alternative's explanation that subsidence is unlikely but has not been confirmed by monitoring data. Therefore, DWR recommended the following for PV Water to include in its first 5-year update to the Alternative:

> Recommended Action 9: Staff recommend that the Agency determine a means by which the Subbasin may be assessed to confirm that no significant land subsidence has occurred. This can be accomplished by incorporating subsidence monitoring information from statewide or local studies into the monitoring program for the Basin.

This technical memorandum summarizes the Basin-specific study that addresses this recommended action for inclusion in the Basin Management Plan: Groundwater Sustainability Update 2022 (GSU22). The GSU22 will be submitted as the 5-year update to DWR by January 1, 2022.

In 2018, prior to receiving DWR's approval and assessment of the Alternative, PV Water amended its ongoing contract with the USGS to evaluate subsidence. This evaluation addresses DWR's recommended action for subsidence. The USGS presented preliminary results for the evaluation at the GSU22 Committee meeting on December 15, 2020.

The USGS report for its evaluation is currently in a review and editing process with a goal of publication in 2021. PV Water's plan is to include the published report as an appendix to the GSU22 submitted to DWR. However, the report is unlikely to be available while the GSU22 Committee is scheduled to meet. Therefore, this technical memorandum summarizes the preliminary findings of the USGS evaluation to be incorporated into the body of the GSU22 submittal. The preliminary findings confirm the lack of observed permanent subsidence in the Basin. We propose that the GSU22 Committee recommend the Board affirm that SMC for subsidence are not needed in its Alternative.

TECHNICAL BACKGROUND

Land subsidence is the lowering of the land surface due to aquifer-system compaction and can occur as a result of declining groundwater levels. Land subsidence from declining groundwater levels occurs when aquitards of fine-grained silts or clays are subjected to stress greater than their maximum pre-consolidation stress.

The Aromas Red Sands, the principal aquifer in the Basin, is divided into an upper and lower unit by an aquitard. The primary confining clays are thickest in the middle of the Pajaro Valley and trend roughly parallel to the Pajaro River. The aquitards thin inland toward Watsonville and become discontinuous in the foothills area. Minor seasonal uplift and subsidence is common in basins with a wet and dry season, and no anecdotal evidence of land subsidence related to groundwater extraction has been documented in the Basin. The USGS report documenting development of a numerical hydrologic model for the Basin (Hanson *et al.*, 2014) indicates that subsidence in the Basin is unlikely because historical groundwater levels have been above the pre-consolidation stress threshold for the Basin's aquifer sediments.

USGS EVALUATION METHODOLOGY

The USGS conducted an evaluation of land subsidence for the Basin for a period between 2015 and 2018 (Brandt *et al.*, 2020). The goal of the study was to collect and analyze land subsidence data for the Basin with the purpose of detecting any clear correlation between groundwater levels and subsidence. The duration of the study was intended to include both wet and dry years in an attempt to capture the greatest variance in land subsidence. The study utilized Interferometric Synthetic Aperture Radar (InSAR), calibrated and validated by continuous GPS (CGPS) data collected from multiple GPS stations within or near the Basin. Validated InSAR maps called interferograms were then spatially compared to groundwater level measurements from the monitoring network managed by PV Water throughout the Basin.

Of the more than 300 interferograms processed for this study, qualitative and quantitative assessments resulted in the selection of 35 interferograms for further time series analysis. Of the 106 comparisons between InSAR and CGPS results, nearly 91 percent agreed within 0.5 in., with a root mean square error of about 0.3 in. The favorable comparisons between InSAR and CGPS results provide reasonable confidence in the measurements of land-surface deformation using InSAR methods.

USGS EVALUATION RESULTS

Four of five selected InSAR time series locations do not exhibit deformation outside of the expected resolution of InSAR measurements. The fifth selected InSAR time series location at Watsonville North showed subsidence of approximately 2 inches, but that amount of deformation is likely recoverable.

Analysis of groundwater level time series for the study period demonstrates no discernable difference in groundwater levels during wet (2017) and dry (2018) years. In general, groundwater levels are recovering after declining below sea level during the 1986-1992 drought. Approximately 10 feet of seasonal drawdown and recovery were observed during the study period.

The Basin was measured to be relatively stable during the study period; the difference in land surface elevation relative to groundwater at the same time series locations selected in the study demonstrate a marginal seasonal fluctuation of subsidence and uplift. The largest deformation (approximately 2 inches) was measured in an area of the basin known to have relatively thick clay layers. This subsidence is minor and expected to be recoverable. Therefore, the data indicate that permanent subsidence is not occurring in the Basin.

CONCLUSIONS

The USGS evaluation demonstrates that measurable permanent land subsidence is not taking place in the Basin. Based on these results, the GSU22 team concludes that the subsidence sustainability indicator is not applicable in the Basin. The Alternative's determination is appropriate: SMC for subsidence is unnecessary.

Even though the indicator is not currently considered applicable, permanent land subsidence caused by lowering of groundwater levels occurring in the Basin would be considered significant and unreasonable. The identification of active permanent land subsidence will trigger the need for dedicated subsidence monitoring, and an update to the Alternative would then need to include SMC for the land subsidence sustainability indicator.

REFERENCES

Brandt, J., Earll, M., Henson W., and Sneed M., 2021, Preliminary Results of Evaluation of Land Subsidence Pajaro Basin, CA, 2015-2018, presentation to Pajaro Valley Water Management Agency Ad Hoc Sustainable Groundwater Planning Advisory Committee, December 15. https://www.pvwater.org/images/board-and-committees/Sustainable-GW-Planning-Committee/Pajaro_Subsidence_prelim_results_USGS_12-15-2020.pdf

Hanson, R.T., Schmid, W., Flaunt, C.C., Lear, J., and Lockwood, B., 2014, Integrated Hydrologic Model of Pajaro Valley, Santa Cruz and Monterey Counties, California, USGS Scientific Investigations Report 2014–5111, Prepared in cooperation with Pajaro Valley Water Management Agency.