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PAPER

Water availability and land subsidence in the Central Valley, California, USA

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Abstract The Central Valley in California (USA) covers about 52,000 km^2 and is one of the most productive agricultural regions in the world. This agriculture relies heavily on surface-water diversions and groundwater pumpage to meet irrigation water demand. Because the valley is semi-arid and surface-water availability varies substantially, agriculture relies heavily on local groundwater. In the southern two thirds of the valley, the San Joaquin Valley, historic and recent groundwater pumpage has caused significant and extensive drawdowns, aquifer-system compaction and subsidence. During recent drought periods (2007–2009 and 2012-present), groundwater pumping has increased owing to a combination of decreased surface-water availability and land-use changes. Declining groundwater levels, approaching or surpassing historical low levels, have caused accelerated and renewed compaction and subsidence that likely is mostly permanent. The subsidence has caused operational, maintenance, and construction-design problems for water-delivery and flood-control canals in the San Joaquin Valley. Planning for the effects of continued subsidence in the area is important for water agencies. As land use, managed aquifer recharge, and surface-water availability continue to vary, long-term groundwater-level and subsidence monitoring and modelling are critical to understanding the dynamics of historical and continued groundwater use resulting in additional water-level and groundwater storage declines, and associated subsidence. Modeling tools such as the Central Valley Hydrologic Model, can be used in the evaluation of management strategies to mitigate adverse impacts due to subsidence while also optimizing water availability. This knowledge will be critical for successful implementation of recent legislation aimed toward sustainable groundwater use.

Keywords Subsidence · Groundwater/surface-water relations · Compaction · USA · Geohazards

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Introduction and background

California's Central Valley covers about 52,000 km^2 and is one of the most productive agricultural regions in the world. More than 250 different crops are grown in the broad alluvial filled structural trough with an estimated value exceeding $20 billion per year (Faunt 2009; Fig. 1). Central Valley agriculture depends on state and federal water systems that divert surface water, predominantly sourced from Sierra Nevada snowmelt, to agricultural fields. Because the valley is semi-arid and the availability of surface water varies substantially from year to year, agriculture developed a reliance on groundwater. Long-term groundwater-level declines can result in a one-time release of "water of compaction" from compacting fine-grained deposits, which causes land subsidence (Galloway et al. 1999). More than half of the thickness of the aquifer system is composed of fine-grained sediments, including clays, silts, and sandy or silty clays (Williamson et al. 1989) that are susceptible to aquifer-system compaction if depressurized by groundwater pumping.

Prior to the early 1960s, groundwater pumpage exceeded surface-water deliveries in the southern two thirds of the

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