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Using GPS to Quantify Three Dimensional Storage and Aquifer Deformation in the Virgin River Valley, Nevada

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Quantifying aquifer storage is important in order to characterize aquifer response and optimize aquifer pumping in large well fields located in thick sedimentary basins like those in the arid southwestern United States. The majority of this water is released from storage because of aquifer-system compaction. Historically this compaction was assumed to occur only in the vertical direction. However, aquifer mechanics and related field investigations indicate that strain is three-dimensional and the amount of water released from storage by horizontal strain can be significant. The development of empirically-based analytical techniques that allow for accurate quantification of storage and an assessment of the strain components at various radii from the pumping well are needed. From May through August, 2003, field scale aquifer testing and land subsidence monitoring were performed in the Virgin River Valley at Mesquite, NV. The goals were to determine the usefulness of storage quantification methods at the field scale and developing an effective inexpensive method to monitor three-dimensional deformation patterns due to removal of water from storage. The ground movement was monitored using choke ring antennas and GPS receivers at 10 different locations at various distances from the pumping well for 100 days. The well was pumped for approximately 12 hours each day at a rate of about 18000 m3/d. Compared to pumping at a steady rate, pulsating pumping (i.e. on and off cycles) has been shown to concentrate vertical deformation closer to the pumping well. The effect of pulsed pumping on horizontal deformation is previously not well documented but can now be investigated. The GPS data and pumping data collected from the aquifer test will be used to quantify aquifer strain in three dimensions at various distances from the well and stages during pumping. These strain patterns will provide information about possible faults in the area that affect groundwater flow, provide information on subsidence prone areas, and yield information on the general behavior of groundwater flow in the region. Two modeling programs, the BIOT4 code and the Interbed Storage 1 package of MODFLOW will be used to evaluate whether these models can effectively simulate the horizontal and vertical deformation of a semi-confined aquifer from GPS measurements recorded at the land surface. In addition, the BIOT4 Code can be used to compare deformation in both the horizontal and vertical directions for the pulsed pumping scheme used in the field and at a steady pump rate.