Modeling Artificial Recharge in Coachella Valley, California: Historical Data, Model Approach, and Simulation Results

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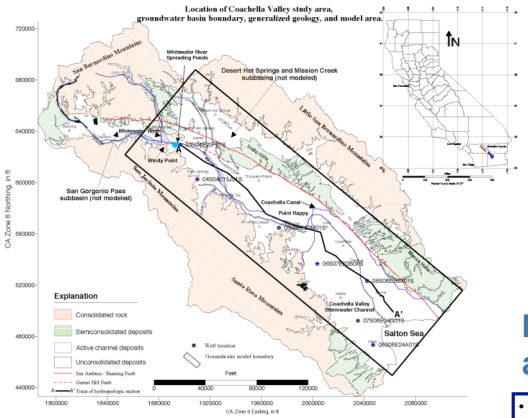
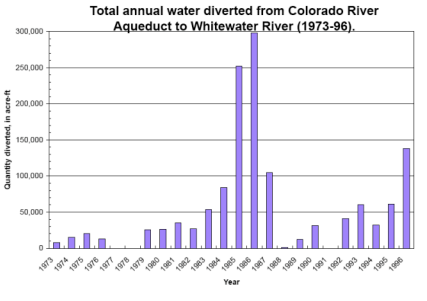
Introduction

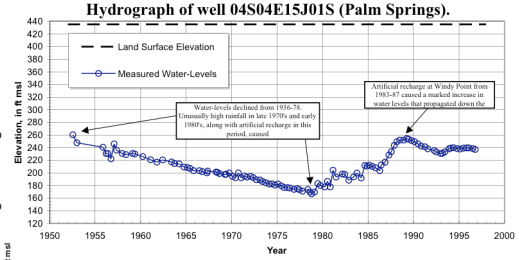
- Coachella Valley is located in central Riverside County in the hot, arid Colorado Desert of California. The upper valley (above Point Happy) consists of desert resort communities; the lower valley has a year-round, agricultural economy.
- Precipitous and rugged mountains bound Coachella Valley, except to the southeast, where the valley drains into the Salton Sea.
- Average annual rainfall on the valley floor is less than 5 inches.
- Average annual precipitation on the San Bernardino and San Jacinto Mountains ranges from 30 to 40 inches, and natural recharge to the groundwater basin occurs from infiltration of mountain runoff.
- Coachella Valley Water District (CVWD) was formed in 1918 to conserve Coachella Valley's water supply. CVWD acquired land in the area of Windy Point to be used as a groundwater recharge area.
- CVWD obtains water for artificial recharge from the Colorado River Aqueduct which crosses the Whitewater River north of Palm Springs.

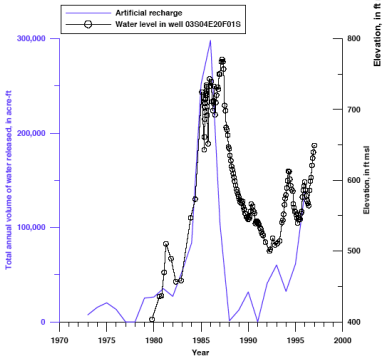


Historical Data

- From 1936-73, groundwater levels declined over 100 ft in the Palm Springs area.
- In 1972 CVWD built nine percolation ponds along the Whitewater River channel near Windy Point; deliveries of water for artificial recharge began in 1973.
- From 1984-87, an advance delivery of over 700,000 acre-ft was released to the Whitewater River; groundwater levels in the artificial recharge area increased over 300 ft. The number of percolation ponds was expanded to 19.
- While groundwater pumpage has continued to increase in the upper valley, above average precipitation in the late 1970's, early 1980's and mid-1990's, combined with the artificial recharge, reversed the trend of water-level declines in 1979, and by 1996, water levels in the Palm Springs area had increased over 80 ft to their early 1950's levels

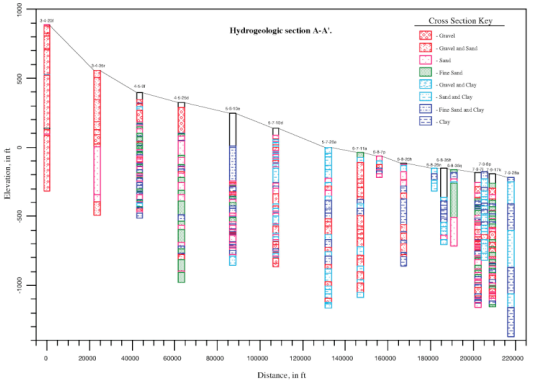


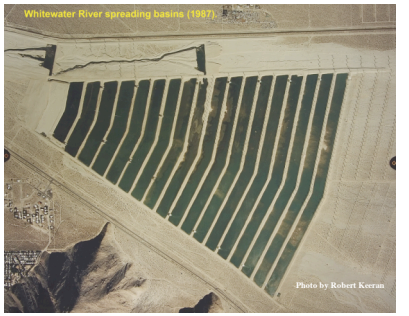




Aquifer system

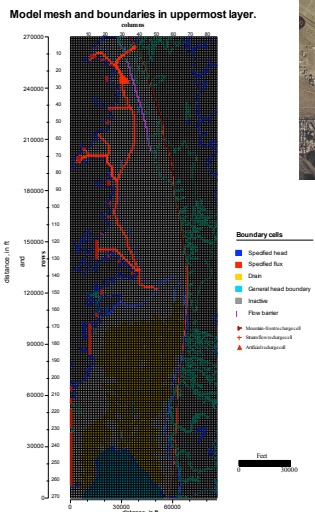
- Unconsolidated Recent and late Pleistocene alluvial deposits are the principal aquifers (CDWR, 1964).
- Channels of the Whitewater River and its tributaries contain the most permeable deposits (coarse sand, gravel and boulders) where infiltration is highest.
- Heterogeneous alluvial fan and stream wash deposits with relatively small amounts of fine-grained materials exist along the periphery of the entire valley, and from the San Gorgonio Pass to Cathedral City.
- Alluvial plain and lake deposits (interbedded sand, silts and clays) underlie the center of the valley from as far north as Cathedral City to the Salton Sea.
- In the lower valley, 100 to 200 ft of lake-deposited materials of low permeability form a confining unit (or aquitard) above the lower aquifer, separating it from an upper aquifer. Available electric and drillers log data show that the aquifers and aquitard are complexly interbedded intervals of sand, gravel, silt and clay rather than distinct, coherent zones.
- Southeast of Indio, Recent silts and clays up to 100 ft thick caps the upper aquifer. The low permeability of these materials retards deep percolation of irrigation water, causing drainage problems. CVWD has installed a vast network of drains underlying the irrigated lands to alleviate these problems.

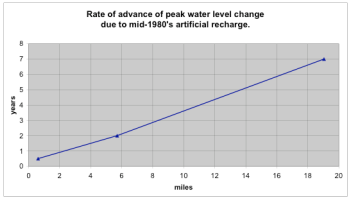


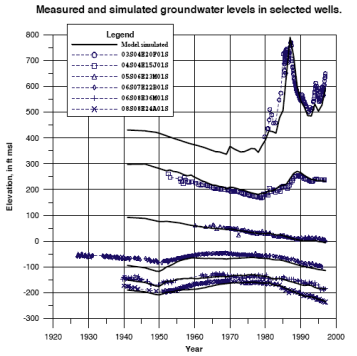


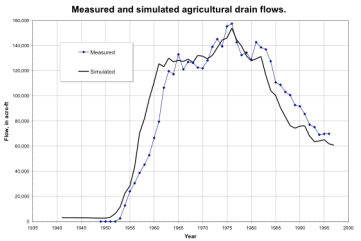
Modeling Approach and Simulation Results

- Three-dimensional, numerical groundwater flow model of entire valley from San Gorgonio Pass to the Salton Sea built on previous work by USGS in the upper valley.
- Conceptual model based on regional hydrostratigraphy and hydrologic boundaries
- Calibration focused on (1) compilation and analysis of the vast amounts of available hydrologic and well data, and (2) estimating the temporal and spatial distribution of the major water budget terms: pumpage, natural recharge from mountain runoff, and return flows.
- The historical period was divided into fifty-one, mostly one-year, stress periods.
- Parameter calibration was moderate and geologically based.
- Calibrated under transient conditions in the basin from 1936-96: measured data on groundwater levels, artificial recharge amounts, drain flows, and Salton Sea elevations were available in this period. The data show significant changes in groundwater levels, both up and down, owing to major historical shifts in both pumpage and recharge.
- A major goal was to simulate these important historical changes, thereby providing a rigorous test of the ability of the model to adequately simulate effects of future fluctuations in pumpage and recharge.
- Results are generally excellent, with groundwater levels computed by the model throughout the basin closely tracking the measured historical trends and elevations. Additionally, the model closely simulated historic trends and flows in measured agricultural drain discharges.









Conclusions

- Artificial recharge played a key role in calibration: simulating the marked head changes due to the large quantities of water recharged was an important calibration objective.
- Excellent agreement between measured and simulated groundwater levels and drain flows for the period 1936-96 was obtained largely through (1) careful, methodical development of progressively more accurate databases on groundwater pumpage and recharge estimates, and (2) hydrogeologically prudent, moderate adjustments in aquifer parameters.
- The full 60 years of hydrologic record, including effects of major precipitation events and drought, pumping, agricultural drainage, and artificial recharge, was reproduced with great accuracy by the model.
- Results indicate the model is valid for analysis of regional management issues where imposed stresses on the system are similar to those experienced in the past.

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