ABSTRACT

HYDROSTRATIGRAPHIC FRAMEWORK OF THE BUTTE BASIN,
NORTHERN SACRAMENTO VALLEY, CHICO AREA,
CALIFORNIA

by

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Accurate aquifer characterization is critical for understanding the true potential of an aquifer system, but many alluvial aquifers, including the Butte Basin aquifer of the northern Sacramento Valley, California, are not well understood due to the complexity of the deposits. Characterization of the Butte Basin aquifer in the Chico area was accomplished by interpreting stratigraphic data within the context of a volcanic fan apron and overlying fluvial deposits and then developing a three-dimensional stochastic realization derived from a geostatistical analysis. Stratigraphic data were obtained by measuring sections, analyzing drilling core and interpreting electric resistivity logs. Nine lithofacies were established from the stratigraphic data. The lithofacies were interpreted into hydro
facies, which included volcaniclastic breccia, volcaniclastic conglomerate, volcaniclastic sandstone and volcaniclastic siltstone for the Pliocene-age Tuscan Formation and conglomerate, sandstone and mudstone for the Pleistocene-age Modesto Formation. The hydrostratigraphic framework of the study area was defined by adapting the volcanic fan apron model to the Tuscan Formation and incorporating the overlying Modesto Formation. The lower Tuscan Formation represents the distal facies of the volcanic fan apron. The upper member of the Tuscan Formation represents the medial facies of the volcanic fan apron, which occurs as two units. The subsurface extent of the upper member of the Tuscan Formation lies in the western portion of the study area. The surface exposure of the upper member of the Tuscan Formation lies in the eastern portion of the study area. The Modesto Formation represents fluvial deposits that overlie the western portion of the upper member of the Tuscan Formation.

A geostatistical approach provided transition probabilities between hydrofacies and allowed creation of a three-dimensional model of the study area. Transition probabilities were calculated using a three-dimensional embedded Markov chain analysis conducted in the Groundwater Modeling System (GMS) software. A duplicate embedded Markov chain analysis, in the vertical direction, was conducted in Statistical Analysis System (SAS). Transition probabilities calculated in SAS corresponded with those acquired through the GMS analysis. In addition, a chi-squared analysis proved dependence between transitions, which validates the utility of a Markov chain analysis in this study. Separate analyses and stochastic realizations were produced for each formational unit.
The individual stochastic realizations were filtered for overlapping data and combined into a three-dimensional stochastic realization of the study area.

The results indicate that flowpaths occur in the channelized deposits, the connectivity increases where flowpaths intersect, and the degree of confinement is highest where the volcaniclastic breccias are thick and preserved. Preferential flowpaths occur as thick sequences of channel deposits. In the Modesto and lower Tuscan formations these deposits extend both laterally and vertically whereas in the upper Tuscan Formation the vertical extent is limited. Connectivity is greatest where the flowpaths intersect, particularly in the amalgamated braided stream deposits of the Tuscan Formation, and where the Modesto Formation has incised through the upper Tuscan Formation. The volcaniclastic breccia deposits of the upper Tuscan Formation and the thick volcaniclastic siltstone deposits of the lower Tuscan Formation primarily control the degree of confinement. The degree of confinement is greatest in the eastern portion of the study area due to the continuous thick volcaniclastic breccia deposits. The degree of confinement is lowest where the Modesto Formation has incised through the upper member of the Tuscan Formation in the west and where the siltstones of the lower member of the Tuscan Formation are discontinuous. The combined realization suggests a direct contact between aquifer-bearing rock of the lower member of the Tuscan Formation and the Modesto Formation in the west and thick continuous aquitards throughout the eastern portion of upper member of the Tuscan Formation. The model provides a geologically reasonable
hydrostratigraphic characterization of the Butte Basin aquifer which may be refined as more data become available.