Tuscan Aquifer INVESTIGATION

Final Report Excerpt:
Hydrostratigraphy

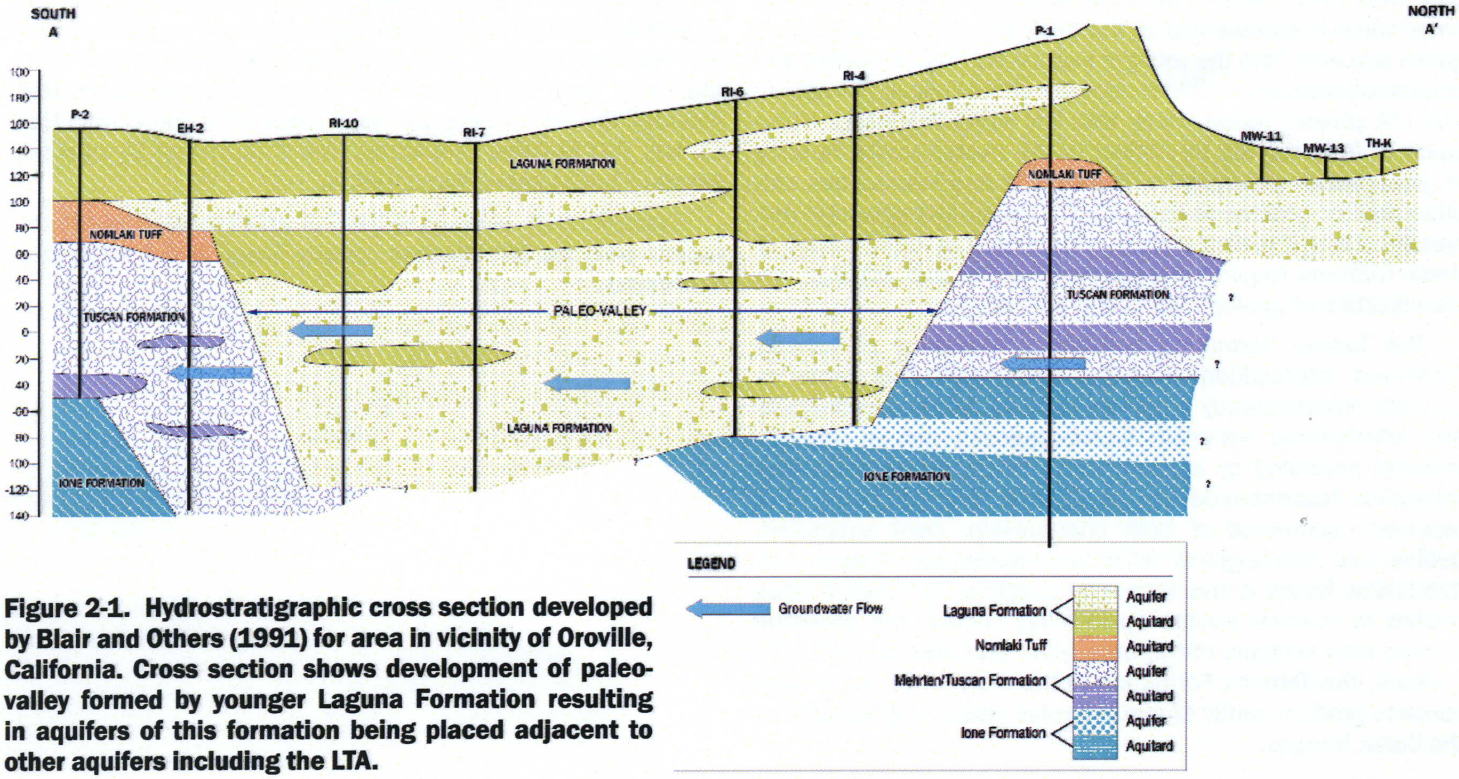

Figure 2-1. Hydrostratigraphic cross section developed by Blair and Others (1991) for area in vicinity of Oroville, California. Cross section shows development of paleo-valley formed by younger Laguna Formation resulting in aquifers of this formation being placed adjacent to other aquifers including the LTA.

As part of the Lower Tuscan Aquifer (LTA) project, the identification of both geologic and hydrogeologic units is critical to the overall understanding of how groundwater flows through the environment. Identification of **geologic formations,** such as the Tuscan Formation, should be based on explicit practices for classifying and naming all formally defined geologic units as presented in the North American Stratigraphic Code (North American Commission on Stratigraphic Nomenclature (NACSM, 2005).

The formation (always capitalized when used for geologic unit, i.e. Tuscan Formation) is the fundamental unit in lithostratigraphic (layers of rock in the ground) classification. As defined by the NACSM (2005), "a formation is a body of rock identified by lithic (rock or stone) characteristics and stratigraphic position; it is prevailingly but not necessarily tabular and is mappable at the Earth's surface or traceable in the subsurface." The key portion of this definition for the LTA project is mappable, or easily identified, at the Earth's surface or traceable in the subsurface. For the LTA, characteristics easily identifiable in **drill cuttings** (material from the ground when drilling a well) were critical to the identification of geologic formation boundaries. For example, the Tuscan Formation was identified in drill cuttings collected from soil borings completed as part of the LTA project following the criteria of Blair and others (1991) that distinguished this unit of material from overlying units by the significant presence (greater than 50 percent) of volcanic rock types referred to as andesite, andesitic basalt, and/or dacite. In contrast, the numerous Quaternary formations used by others in the area are based on geomorphic or buried-soil information rather than on criteria by which formal formations are distinguished. More importantly, the criteria used by others cannot be easily distinguished in drill cuttings. For the LTA Project, these units were defined to include all post-Tuscan sediments in the area and were designated as Quaternary Deposits.

Both the Quaternary Deposits and distal portion of the Tuscan Formation primarily consist of **fluvial** deposits, or deposits formed from the processes of rivers and streams. The term **distal** refers to areas farthest away from the source of rock material making up the sediments as opposed to **proximal**

that indicates portions of the geologic formation nearest the source of rock material. Characteristic of former river systems is the deposition of interbedded sands, gravels, silts and clays whereby the sand and gravel units represent material deposited within the high velocity flows of the main river channels and the silts and clays represent material deposited within areas of low velocity flows such as the floodplains. This type of depositional environment forms subsurface features referred to as **"paleo-valleys"** that represent areas of former canyons that have been filled in with coarse grained sediments. The paleo-valley is represented by the thick sequence of sands and gravel deposits from the younger Laguna Formation **juxtaposed** (deposited adjacent to) older deposits of the Tuscan Formation. The LTA project report notes that the identification of these types of features will be critical to the overall understanding of groundwater movement within the LTA and interactions with other aquifer systems as discussed below for hydrogeologic unit classification. It is also important to note, that identification of these features requires detailed analysis of drill cuttings and identification of geologic formation boundaries.

The Tuscan Formation includes a sequence of variably cemented, interbedded clay, sand, and gravel. This formation consists predominantly of purple volcanic debris flow deposits and interbedded waterlain fluvial deposits rich in volcanic material produced by erosion, but in many areas containing crystalline basement-derived clasts and rare tuff beds. The reported occurrence of both channel-lain, clast supported, pebble- and cobble-gravel facies and interbedded volcanic-rich debris-flow facies in this formation suggests that debris flows related to volcanic events episodically choked the ancestral stream/river systems of the area (Blair and others, 1991). In contrast, the Tehama Formation to the west of the study area consists predominantly of metamorphic clasts originating from the Coast Ranges.

Helley and Hardwood (1985) divided the Tuscan Formation into four hydrostratigraphic units, labeled from deepest to shallowest, A through D. Units A and B together define the LTA, the subject of this study, and units C and D define the Upper Tuscan Aquifer. It should be noted that although an attempt was made to distinguish these units from drill cuttings during the drilling of monitoring wells for the LTA project, the Helley and Harwood definitions of A through D are generalizations derived from the outcrop that have not been established in the subsurface. The approximate extent of the LTA within the project boundaries is shown on Figure 3-10 of the report. Helley and Hardwood (1985) also identified several tuffaceous units that were used to separate the hydrostratigraphic units that included the Tuff of Hogback Road (separates Unit D from Unit C), Ishi Tuff Member (separates Unit C from Unit B), and the Nomlaki Tuff Member (top of Unit A).

Geologic units underlying the Tuscan Formation within the project area are the Miocene Lovejoy Basalt and Eocene Ione Formation.

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Final Report Excerpt:
Future Data Needs and Road Map to Additional Studies

The LTA Project provides a wide-ranging scientific investigation to develop data and analytical tools to improve the understanding of the aquifer. The field investigation was designed to improve the scientific understanding of the properties of the LTA system.

Although the LTA project was not intended to assess recharge from the Sacramento River, comparison of the hydrograph from one of the newly installed groundwater monitoring well nests with flow data from the river and stable isotope signatures provided some important insight into potential interactions. This evaluation was not part of the original scope of work but was added to the project as a result of realized efficiencies and the recognition that additional available data could substantially enhance the findings of the investigation.

Based on the findings of the Final report, future data needs and additional studies have been identified to further the overall understanding of the LTA.

Recommendation 1: Expand Isotopic Analysis to Further Assess Spatial and Seasonal Relationships

As an add-on to this project, stable isotope data were obtained at several locations. Based on the insights gained from the initial data with respect to the identification and elimination of potential major recharge areas, it is recommended that future studies include much greater emphasis on the collection and interpretation of stable isotope data.

Recommendation 2: Assess Interaction between Sacramento and Other River Stage Response to Changes in Groundwater Levels

A comparison of the river stage data for the Sacramento River with the water levels in the monitoring well at the M&T Ranch indicate a possible correlation, which is supported by the stable isotope data from the river and the same monitoring well. Given the understanding of the hydrogeology of the study area, it is very likely that the Feather River also acts in a similar fashion. It is recommended that additional studies be conducted to better assess the interaction between the river stage on the Sacramento River, Feather River, and other major tributaries with changes in groundwater levels in the LTA and other aquifers that may also provide water to the LTA.

Recommendation 3: Assess Recharge Potential of Shallow Alluvial Aquifer to LTA

The results of the LTA Project indicate that the individual stream channels, flowing across the Tuscan Formation outcrop to the east of the valley floor, are not major sources of recharge to the LTA. Yet, the limited stable isotope data currently available suggests that appreciable recharge does occur near the eastern perimeter of the basin. One possible explanation for these observations is that the shallow alluvial aquifers overlying the Tuscan Formation near the foothills acts as a recharge source, or "sponge", that absorb water from local precipitation and from the creeks as they enter the valley. This water subsequently percolates downward into the LTA over a broad area due to the areal extent and vertical hydraulic head within the shallow alluvium. To test this hypothesis, and further evaluate the actual sources and mechanisms of recharge along the eastern perimeter of the valley, it is recommended that a localized study of recharge potential be conducted.

Recommendation 4: Conduct Focused Recharge and Aquifer Interaction Assessments Towards Development of Management Tools Such as Groundwater Model

Although the LTA Project identified a number of hydrologic complexities, there are approaches to build upon the information gained from the study. One opportunity would be to conduct focused recharge and aquifer interaction assessments that will improve management tools such as the groundwater model. It is recommended that the guiding objective be to obtain sufficient data to develop a subregional groundwater model with sufficient detail to be able to be used as a tool for planning and management of individual projects.

Recommendation 5: Definition of stratigraphic zones.

It is recommended that a uniform set of criteria for logging of cuttings from the LTA be developed. Such an effort would need the participation and cooperation of various agencies and, researchers in the region. The criteria adopted should be such that the contacts between geologic formations are easily identifiable from the drill cuttings, such as developed by Blair and others (1991) for the Oroville area.

Recommendation 6: Development of subregional groundwater models.

The current extent of the Butte Basin Groundwater Model (BBGM) and the existing data density limit the ability of the BBGM to be used for evaluation of the potential impacts or benefits of localized projects. Development of subregional models in areas of sufficient data density, for example as discussed in the Recharge and Aquifer Assessment Recommendation, is recommended where feasible. In addition, the knowledge gained from the development and use of such models can also help identify the data needs for

projects being considered outside of an area covered by a subregional model.

In closing, the results of the LTA project have provided important insights towards understanding the recharge mechanisms and interactions with other aquifers that will assist BCDWRC's and other stakeholder's management and protection of this important regional resource. The LTA project has:

Provided a framework for following a consistent characterization of the hydrostratigraphy

Shown that LTA characteristics change from north to south indicating that management of these resources should not be conducted under broad assumed aquifer characteristics.

Provided methods for assessing aquifer properties through use of existing pumping practices

Established a baseline for using isotopic and water quality analysis to evaluate recharge

Identified potential recharge mechanisms related to stages of the Sacramento River and other regional streams within the area

Demonstrated that surface infiltration does not follow a straight vertical pathway to the underlying aquifers

Demonstrated significant storage and recharge to the LTA occurs within the overlying and underlying aquitards and aquifers.

In addition, the project has provided the framework for continuing the overall understanding of the LTA that can be used to develop future studies such as those recommended above.