

Technical Memorandum 1

Base of the Unconfined Aquifer

The six Groundwater Sustainability Agencies (GSAs) in the Kings Groundwater Sub-basin (Kings Basin) are in the process of developing data and analyses to evaluate historical changes in groundwater storage. The attached memorandum from Kenneth D. Schmidt and Associates (KDSA) provides a description of the base of the unconfined aquifer within the Kings Sub-basin and describes the extent of the existing significant clay layers within the Sub-basin.

TECHNICAL MEMORENDUM ON DETERMINATION
OF BASE OF UNCONFINED GROUNDWATER
IN THE KINGS SUB-BASIN

INTRODUCTION

In order to estimate changes in groundwater in storage, it is important to distinguish between shallow unconfined conditions and deeper confined conditions. For unconfined aquifers, water-level changes can be multiplied by specific yields to estimate the changes in groundwater storage. Storage changes in confined aquifers are usually insignificant, as they stay full of water, despite water-level declines, as long as the water level stays above the top of the aquifer. Another purpose of separating the shallow unconfined and deep confined groundwater is for groundwater flow determinations. In general, the direction of groundwater flow may not be the same for the shallow and deep groundwater at specific locations. This is particularly true near the southwest edge of the Kings Basin. Thus water-level slopes and transmissivities need to be known for both the unconfined and confined groundwater, in order to estimate groundwater flows.

HISTORICAL CONTEXT

As of the 1950's and 1960's, when many of the earlier U.S. Geological Survey groundwater reports were done for the westside

of Fresno County and for the Fresno and Hanford Visalia areas, the concept was that there were two aquifers beneath the westerly areas, where the Corcoran Clay was present. Groundwater above this clay was generally considered to be unconfined, whereas the underlying groundwater was considered to be confined. In contrast, one unconfined aquifer was assumed at that time for the eastside lands, east of the Corcoran Clay. As of the mid-1960's, there were few deep water wells that had been drilled in the east part of the Fresno and Hanford-Visalia areas. The cable-tool method was widely used in this area through the mid-1960's. Most water wells were no deeper than about 300 to 400 feet, and electric logs were not available, as they could not be run in cased wells. Many of the eastside water supply wells prior to the mid-1960's tapped the upper coarse-grained deposits, termed the "Quaternary older alluvium" by the U.S. Geological Survey. For the most part, this groundwater was unconfined, and information on the deeper deposits was lacking in many areas along the eastside.

With the advent of reverse rotary drilled wells in the mid-1960's, deeper wells were drilled and eventually many electric logs became available. Along with geologic logs for many City and school wells drilled after the late 1970's, a much better understanding of the deposits below a depth of 300 to 400 feet

was obtained along the eastside. These Tertiary-Quaternary continental deposits are generally much finer grained than the overlying deposits, and clay layers are often present. After the 1960's, test holes and wells were commonly drilled to depths ranging from about 700 to 900 feet, or deeper. While no laterally continuous single confining bed like the Corcoran Clay (a geological marker bed) was indicated, a number of important, less continuous, local confining beds were identified.

In the Fresno urban area alone, there are more than 150 sites where nested monitor wells were installed during the past several decades. Electric logs and geologic logs are available, as well as water levels and groundwater quality for the shallow (about 200 feet deep), intermediate (about 400 feet deep), and deep (about 700 feet deep) groundwater. Major confining beds were identified. These were normally below 200 feet in depth and above 400 feet in depth. Monitoring of these wells allowed water-level differences and vertical hydraulic gradients to be determined. Differences in groundwater quality are consistent with the separation of shallow (above the confining bed) and deep (below the confining bed) groundwater. Information on vertical differences in water levels and groundwater quality, and the depths of confining beds has also been developed at hundreds of sites for wells in other cities, small water systems,

schools, and industries in the Kings Sub-Basin. These were obtained from test well and pilot hole programs associated with the development of new water supply wells. Subsurface geologic cross sections showing the deeper subsurface geologic conditions have been prepared in many parts of the Kings Sub-Basin. Together, these sources of information provide a good indication of the base of the unconfined groundwater in most of the Kings Sub-Basin east of the Corcoran Clay.

ENHANCED CONCEPT OF AQUIFER CONFINEMENT

The enhanced concept of aquifer confinement in the San Joaquin Valley is that the shallow groundwater throughout most of the valley is unconfined. In contrast, groundwater at depth in most of the valley is confined in most of the valley. Generally, confining beds east of the Corcoran Clay in the Kings Sub-Basin are below a depth of several hundred feet, and appear to often be near the base of the Quaternary older alluvium or in the upper part of the underlying continental deposits. As one drills deeper into the underlying continental deposits, local clay layers are more common than in the overlying deposits, and even though they are not continuous over distances of tens or hundreds of miles, like the Corcoran Clay, they are important locally. Some of these localized clays are much thicker than

the Corcoran Clay, and they tend to be found at specific depths in specific parts of the sub-basin.

As part of the City of Fresno Nitrate Study in 2006, KDSA defined confining beds at an average depth of about 250 feet in south and southeast Fresno. In general, high nitrate and DBCP concentrations were found in groundwater above the beds in those areas, whereas concentrations were much lower in the groundwater below these beds. Throughout much of the Kings Sub-Basin, unconfined groundwater beneath irrigated areas has usually been affected by irrigation practices. Based on its chemical composition and some age dating, this groundwater is generally indicated to be younger than about 70 years old. This groundwater has higher concentrations of total dissolved solids (TDS) and nitrate than does the underlying deeper groundwater. In much of the Kings Sub-Basin, groundwater beneath the confining beds is indicated to either not have been affected by irrigation practices, or to have been minimally affected by such practices.

Vertical hydraulic gradients are determined by dividing the difference in water levels (above and below the confining bed(s)), by the thickness of the confining bed(s). Vertical hydraulic gradients have been determined at many sites, and commonly range from about 10 to 20 feet per 100 feet, much greater than for lateral hydraulic gradients (commonly about 5 to 10 feet per mile).

UNCONFINED GROUNDWATER IN
THE KINGS SUB-BASIN

Figure 1 shows contours of depth to the base of the unconfined groundwater in most of the Kings Sub-Basin. The extent of the Corcoran Clay is shown on this figure. To the southwest, where the Corcoran Clay is present, the base of the unconfined groundwater is considered to be the top of this clay. The depth to the top of this clay was determined by reviewing a number of subsurface geologic cross sections, where the clay was identified, and several maps where the top of the Corcoran Clay was contoured. This information was supplemented by evaluating electric logs, where the clay was clearly identifiable. The depth to the top of the Corcoran Clay ranges from about 200 feet deep south of Traver to more than 550 feet to the southwest, near the southwest boundary of the Kings Sub-Basin.

The base of the unconfined groundwater generally becomes shallower to the northeast, and in some places it is less than 150 feet deep. In some parts of the sub-basin, such as in the Orange Cove I.D., no confined groundwater is indicated to be present. This is supported by the vertical distribution of nitrate, which doesn't indicate any influence of a confining bed. In the Fresno urban area, the base of the unconfined aquifer deepens rather quickly to the southwest, from less than 250 feet

to more than 400 feet. Between most of the area between northwest Fresno and Kerman, the base of the unconfined groundwater is more than 400 feet deep. This area includes the locations of the Fresno Irrigation District water banking projects. In contrast, the base of the unconfined groundwater is less than 200 feet deep in the area east of the Fresno Air Terminal, in an interfan area, where fine-grained deposits are predominant.

CALCULATING STORAGE CHANGES

Once the base of the unconfined groundwater has been established, then water-level measurements are selected for wells that only tap these deposits (not deeper ones). Also, specific yield estimates are made only for the unconfined groundwater (between the water level and the base of the unconfined groundwater). Storage changes for the groundwater are then calculated by multiplying the change in water levels during a base period by the specific yields.

