

HYDROGEOLOGIC CONCEPTUAL MODEL AND GROUNDWATER
CONDITIONS FOR THE EAST KINGS SUB-BASIN GSP

Draft Report- For Review Purposes Only

prepared for
East Kings Sub-basin GSA
c/o Alta Irrigation District
Dinuba, California

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Heim
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HYDROGEOLOGIC CONCEPTUAL MODEL AND GROUNDWATER CONDITIONS FOR THE EAST KINGS SUB-BASIN GSP

INTRODUCTION

This report is intended to satisfy Sections 354.14 (Hydrologic Conceptual Model) and Section 354.16 (Groundwater Conditions) of a Groundwater Sustainability Plan (GSP) for the East Kings Sub-basin GSA. The GSA is located east of the Kings River in Fresno and Tulare Counties. The GSA includes the Alta, Hills Valley, and Orange Cove Irrigation Districts, the Kings River, and Tri Valley Water Districts, the Cities of Reedley, Orange Cove, and Dinuba, and several public utility and community services districts.

SURFICIAL CHARACTERISTICS OF BASIN

Topography

Figure 1 shows topographic conditions in the basin. The land surface generally slopes to the southwest. Land surface elevations range from about 270 feet above mean sea level near the southwest corner of the GSA to about 500 feet above mean sea level near parts of the northeast edge of the GSA. The Kings River is the west boundary of the part of the GSA northeast of Highway 99. Cottonwood Creek passes through the south part of the GSA. Other streams include Wahtoke Canal, Travers Creek,

**FIGURE 1- TOPOGRAPHIC MAP OF GSA AND LOCATIONS OF SUBSURFACE
GEOLOGIC CROSS SECTIONS**

Wooten Creek, and Sand Creek. Significant topographic high areas to the east inside Jesse Morrow Mountain, Campbell Mountain, and Smith Mountain.

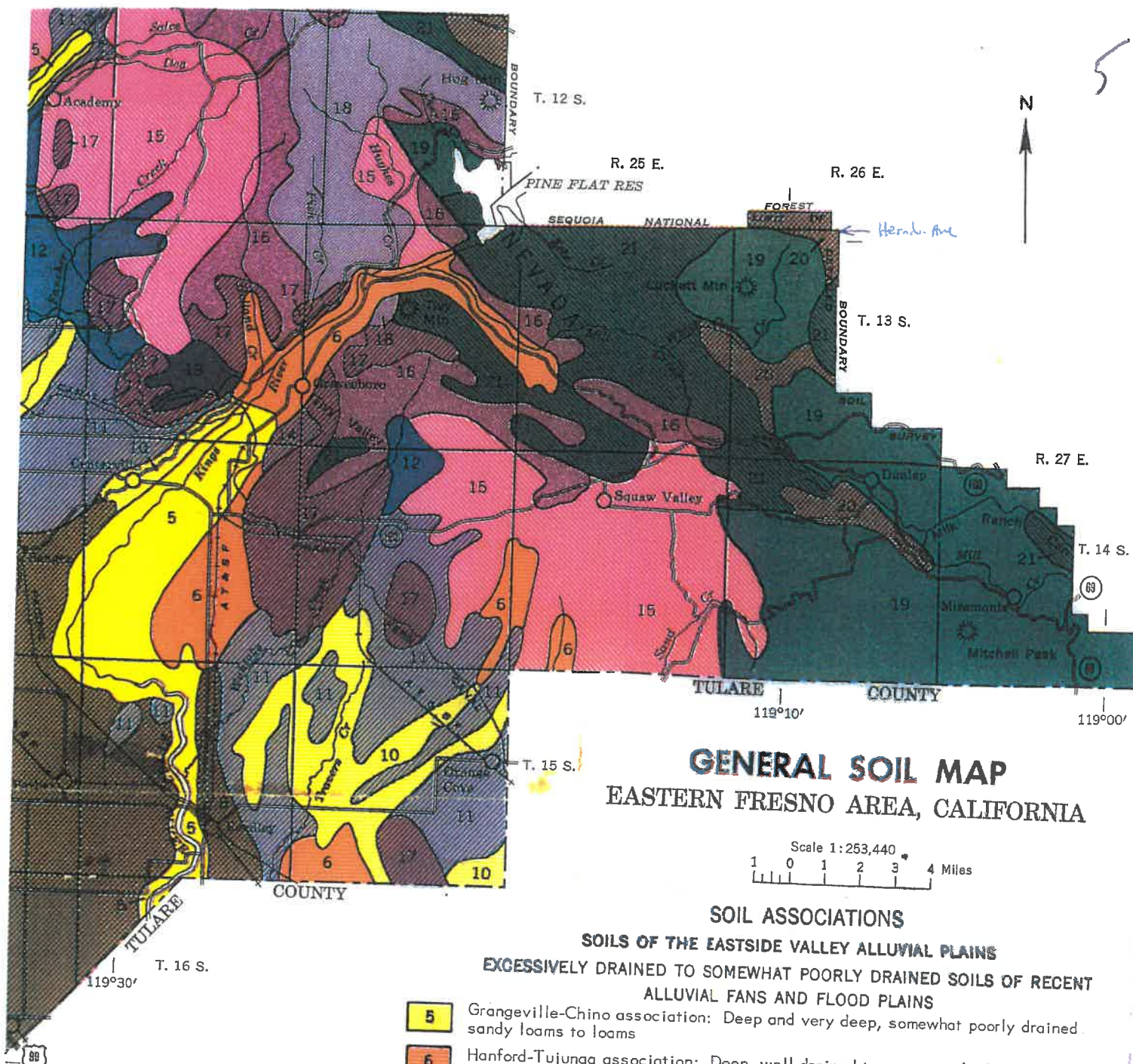
Surficial Geology

Page and LeBlanc (1969) mapped the surficial geology of the Fresno Area, which includes most of the GSA. Croft and Gordon (1969) mapped the surficial geology in the Hanford-Visalia Area, which includes the south part of the GSA. Figure 2 shows these features in the GSA. Surficial deposits along and near the Kings River, Wahtoke Creek, and Cottonwood Creek were termed the Quaternary Younger Alluvium. The predominant deposits in the rest of the valley part of the GSA were mapped as Quaternary Older Alluvium, which is also the predominant aquifer material in most of the GSA. Terrace deposits are present neat the edge of the valley. Rocks of the basement complex of the hardrock generally occur where hills are present and in the foothills.

Topsoils

Figure 3 shows the main soil groups in the Fresno County part of the GSA. Huntington (1971) provided a soil survey for the Eastern Fresno Area, which includes the part of the GSA in Fresno County. The main soils associations in this part of the GSA are:

FIGURE 2- SURFICIAL GEOLOGIC MAP



SOIL ASSOCIATIONS

SOILS OF THE EASTSIDE VALLEY ALLUVIAL PLAINS

EXCESSIVELY DRAINED TO SOMEWHAT POORLY DRAINED SOILS OF RECENT ALLUVIAL FANS AND FLOOD PLAINS

- 5** Grangeville-Chino association: Deep and very deep, somewhat poorly drained sandy loams to loams
- 6** Hanford-Tujunga association: Deep, well-drained to excessively drained, dominantly loamy sands to fine sandy loams

SOMEWHAT EXCESSIVELY DRAINED TO MODERATELY WELL DRAINED SOILS OF YOUNG ALLUVIAL FANS

- 7** Hanford-Hesperia association: Well-drained sandy loams and fine sandy loams that are moderately deep or deep to compact silt
- 8** Hanford-Delhi-Hesperia association: Deep, somewhat excessively drained and well-drained sands to fine sandy loams; partly wind modified
- 9** Pachappa-Hesperia association: Well drained and moderately well drained fine sandy loams or loams that are moderately deep or deep to compact silt
- 10** Greenfield-Atwater association: Well-drained loamy sands and sandy loams that are moderately deep or deep to compact sandy material; partly wind modified

WELL-DRAINED SOILS OF LOW ALLUVIAL TERRACES

- 11** San Joaquin-Exeter-Ramona association: Sandy loams to loams that are shallow or moderately deep to a hardpan and deep sandy loams and loams
- 12** Academy-Yokohl association: Loams that are moderately deep to a compact layer and soils of similar texture that are shallow to a cemented hardpan

WELL-DRAINED SOILS OF HIGH ALLUVIAL TERRACES

- 13** Centerville-Keyes association: Clays that are moderately deep to compact sandy material and cobbly clay loams that are shallow to a cemented hardpan
- 14** Positas-Redding association: Gravelly loams that are moderately deep to -

Figure 3

Grangeville-Chino	San Joaquin-Exeter-Ramona
Hanford-Tujunga	Cibo-Porterville
Greenfield-Atwater	Vista-Fallbrook.

Grangeville-Chino Association

These are deep to very deep, somewhat poorly drained sandy loams and fine sandy loams to loams. These are present primarily along a band within several miles of the Kings River.

Hanford-Tujunga Association

These are deep well drained to excessively drained dominantly loamy sands to fine sandy loams. There are primarily present along the upper part of the Kings River and along Mill Creek in T13S, east of the Grangeville-Chino association soils in T14S, and southeast of Reedley.

Greenfield-Atwater Association

These are well drained loamy sands and sandy loams that are moderately deep or deep to compact material; partly wind modified. The deposits are predominant along Travers Creek in T15S and part of T16S.

San Joaquin-Exeter-Ramona Association

These are sandy loams to loams that are well drained and shallow or moderately deep with a hardpan and deep sandy loams and loams. These soils are predominant in T14S/R24E, the east half of T15S/R23E, and in T15S/R24E.

Cibo-Porterville Association

These are well drained and somewhat excessively drained clays that are moderately deep to deep, overlying granitic rock and permeable sediment in the foothills. These soils are common in the east half of T14S/R23E and the southwest part of T14S/R24E.

Vista Fallbrook Association

These are well drained sandy loams that are shallow to moderately deep over granitic rock in the foothills. These are common in the southeast part of T13S/R24E and on T14S/R25E.

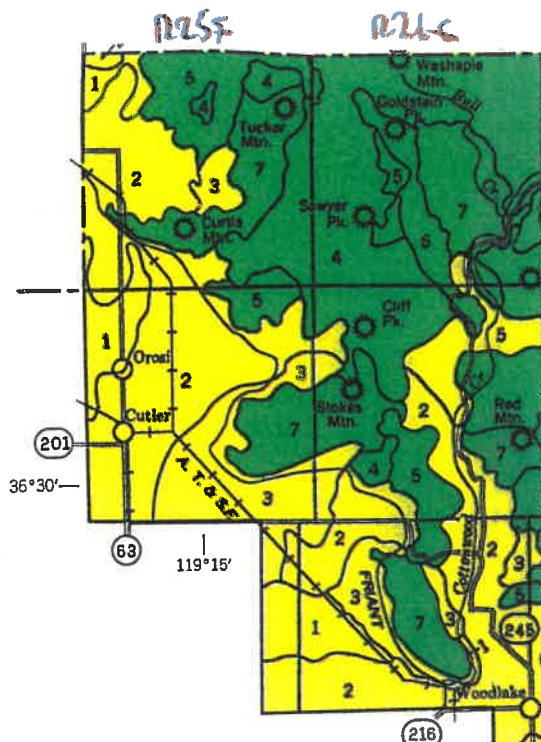
Stephens (1987) presented a soil survey of the central part of Tulare County (Figure 4). The parts of the survey that are in the GSA are in T15S/R25E, T16S/R25E, and T17S/R26E, and in the east part of T17S/R25E. In the valley part of this area, three map units were shown:

8

T
155

T
16
S

T
17
S



MAP UNITS*

SOILS OF THE SAN JOAQUIN VALLEY

- 1** San Emigdio-Yetter-Honcut: Very deep, nearly level to gently sloping, well drained loams and sandy loams; on alluvial fans
- 2** San Joaquin-Exeter: Moderately deep, nearly level to gently rolling, well drained loams that have a hardpan; on terraces
- 3** Centerville-Porterville: Moderately deep and very deep, nearly level to hilly, well drained clays; on dissected terraces and alluvial fans

SOILS ON THE LOWER SIERRA NEVADA FOOTHILLS

- 4** Blasingame-Auberry: Moderately deep and deep, gently rolling to steep, well drained sandy loams
- 5** Cieneba-Vista: Shallow and moderately deep, rolling to very steep, somewhat excessively drained and well drained coarse sandy loams
- 6** Friant-Coarsegold: Shallow and moderately deep, hilly to very steep, well drained fine sandy loams and loams
- 7** Cibo-Las Posas: Moderately deep, rolling to steep, well drained clays and loams

GENERAL SOIL MAP

TULARE COUNTY, CALIFORNIA, CENTRAL PART

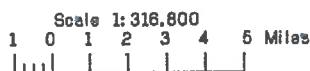


Fig 4

1. San Emigdio-Yetter-Honcut
2. San Joaquin-Exeter
3. Centerville-Porterville.

San Emigdio-Yetter Honcut Unit

These topsoils are present in the west part of T15S/R25E, the northwest part of T16S/E25E, the east part of T17S/R25E, and in T17S/R26E. They are very deep, well drained loams and sandy loams developed on alluvial fans.

San Joaquin-Exeter Unit

These topsoils are predominant in the west half of T15S/R25E, and in the northwest part of T16S/R25E, and are common in T17S/R26E. They are moderately deep, well drained loams that have a hardpan.

Centerville-Porterville Unit

These topsoils are common in the southeast part of T16S/R25E and in T17S/R26E. They are moderately deep and very deep well drained clays.

Subsurface Water Bodies

Figure 1 shows the location of surface water bodies in and near the District. The Kings River is the major stream in the area and comprises the west boundary of much of the GSA. Pine Flat Dam and Reservoir are just upstream of the GSA. Other streams in the area include Wahtoke Creek, Travers Creek, Wooten Creek, Sand Creek, and Cottonwood Creek. The Alta I.D. has several major canals that pass through the District and the Friant-Kern Canal is in the GSA or near part of the eastern edge of the GSA.

SUBSURFACE GEOLOGIC CONDITIONS

Page and LeBlanc (1969) described the geology, hydrology, and water quality of the Fresno Area, which includes the GSA. Site specific hydrogeologic evaluations have been done by KDSA for a number of cities and water systems in the area, including Reedley, Dinuba, Orange Cove, Sultana, Orosi, Cutler, and Monson. These reports provide significant information on subsurface geologic conditions that was used in this report.

Regional Geologic and Structural Setting

The area evaluated is within the San Joaquin Valley, which is a topographic and structural trough, bounded on the east by the Sierra Nevada fault block and on the west by the folded and faulted Coast Ranges. Alluvial deposits in and near the GSA have been derived from the Sierra Nevada, and comprise the aquifer in the area. These interlayered deposits dip slightly to the south-southwest in the area.

Lateral Basin Boundaries

Figure 1 shows the boundaries of the Sub-basin. The west boundary of most of the sub-basin is the Kings River. Most of the southern boundary is the south edge of the Alta I.D. Most of the east boundary is the edge of the groundwater basin, near or adjacent to hardrock outcrops. The sub-basin extends upstream along the Kings River to just below Pine Flat Dam.

Definable Bottom of the Basin

Figure 5 shows the definable bottom of the sub-basin. The bottom base of the sub-basin is the base of the unconsolidated deposits or top of the hardrock. Several generalized maps are available that shown the depth to the top of the hardrock. A more specific map of depth to the top of the hardrock was pre-

FIGURE 5-DEFINABLE BOTTOM OF THE SUB-BASIN

pared for this report by evaluating logs for deep holes or wells in the area. As part of this evaluation, electric logs for a number of deep holes were also obtained from the California Division of Oil, Gas, and Geothermal Resources. A review of these logs indicated depths to the top of the hardrock ranging from about 1,200 to more than 3,500 feet deep in the southwest part of the GSA. Southwest of the Central Valley Railroad, the top of the hardrock is much deeper than existing water wells.

Formation Names

Page and LeBlanc (1969) divided the unconsolidated deposits in the Fresno area into the younger alluvium (normally less than about 50 feet thick), the Quaternary older alluvium (less than 1,000 feet thick), and the Tertiary Quaternary Continental deposits (1,000 to 2,200 feet thick). The Corcoran Clay is a regional confining bed located in the west and central parts of the valley. The northeast edge of the clay is located near the southwest corner of the GSA. There are no other regional clay layers that have been delineated in or near the GSA. The U.S. Geological Survey has divided the alluvial deposits in the east part of the Fresno Area into several formations, including the Turlock Lake, Riverbank, and Modesto Formations (progressively younger).

Confining Beds

Although no regional confining beds have been delineated in most of the sub-basin, there are local clay layers that function as confining beds, to separate groundwater with different hydraulic heads and of differing chemical quality. A substantial amount of data has been developed on vertical variations in water levels and groundwater quality in and near the GSA. These local confining beds are usually in the range of about 200 to 300 feet deep. They commonly separate shallow groundwater with higher concentrations of nitrate, DBCP, and 1,2,3-TCP from the deeper groundwater. Schmidt (1986) discussed a number of these in the Fresno-Dinuba area. Historically, most irrigation wells in large parts of the sub-basin tapped strata above these confining beds. However most new public supply and school wells are designed to seal off poor quality groundwater above these confining beds. In recent years, some irrigation wells have also been constructed to tap only the deep confined groundwater. This has primarily been done to avoid adverse impacts to shallow existing wells in the area.

Principal Aquifers

Based on subsurface geologic cross sections (presented in the next section) and water well drillers logs and completion reports,

the principal aquifer in the GSA is the older alluvium. The deeper wells that have been constructed for public supply tap what can be considered a deeper aquifer in the underlying continental deposits. Hydraulic heads are generally much lower in those deposits than in the overlying older alluvium.

Subsurface Geologic Cross Sections

As part of this evaluation, four subsurface geologic cross sections were developed in the sub-basin. Two cross sections (A-A' and B-B') were developed to extend from the northwest to the southeast, generally perpendicular to the inferred dip of the alluvial deposits. Two other cross sections (C-C' and D-D') were developed to extend from the southwest to the northeast, generally along the inferred dip of the deposits. Each of the cross sections shows major water producing strata and localized confining beds. The top of the hard-rock, or bottom of the sub-basin, is also shown on some of the section.

Cross Section A-A'

Cross Section A-A' (Figure 6) extends from the Vulcan Materials Co. Sanger Aggregate Mine to the southeast, through the Great Western School near the Reedley Airport, through Reedley and Dinuba, then to the southeast to near Avenue 368 and the Central Valley Railroad tracks, northeast of Sequoia Field. The

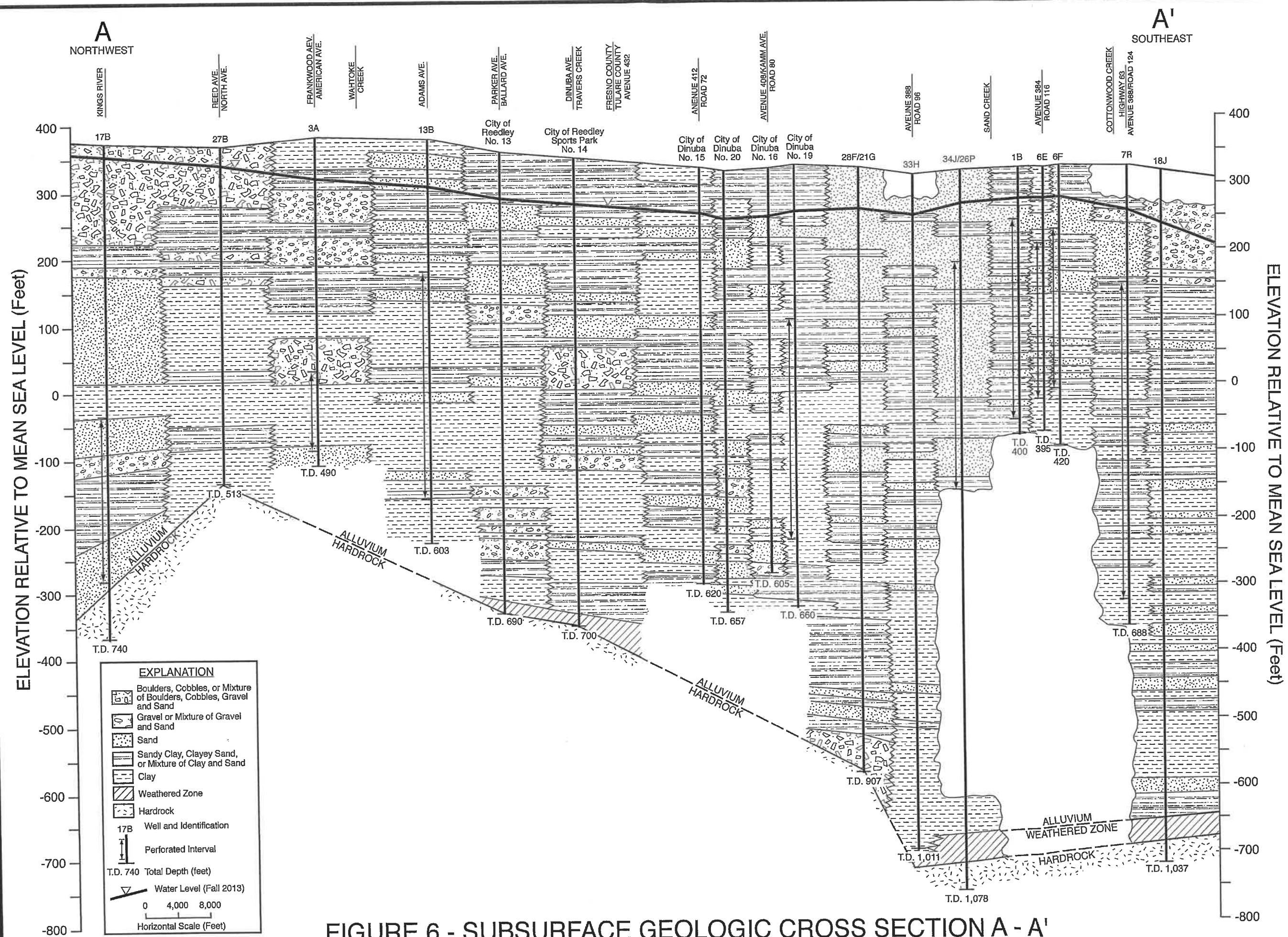


FIGURE 6 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'

top of the hardrock was encountered at depths ranging from about 500 to 1,025 feet along this section. The deepest top of the hardrock was near the southeast edge of the section.

Deposits coarser than gravel are termed stream channel deposits. Those deposits are common near the Kings River, including beneath Reedley. They are most predominant above a depth of about 200 feet along the northwest part of the cross section, and become progressively deeper toward Reedley, where they are often between 200 and 350 feet in depth. These deposits are generally missing farther southeast along the section, until near the edge of the section, where deposits of the ancestral Cottonwood Creek are encountered with the uppermost 150 feet.

Along the east side of the valley, the areas between the major stream such as the Kings and St. Johns Rivers are termed the "interfan areas". Fine-grained deposits are usually predominant in the interfan areas, particularly below a depth of about 300 feet. Deposits below a depth averaging about 600 feet along this section are normally blue or green and the groundwater contained in them is reduced or anaerobic. In contrast, the overlying deposits are primarily brown, yellow, or red, and groundwater in them is oxidized. The oxidation status of the groundwater is important in terms of specific chemical constituents, which are discussed later in the report. Coarse-grained deposits above a

depth of about 200 feet were historically termed the Quaternary Older Alluvium, whereas the underlying fine-grained deposits were termed the Tertiary-Quaternary continental deposits (Page and LeBlanc, 1969).

Cross Section B-B'

Section B-B' (Figure 7) extends from near Avenue 332 and Road 68 on the southwest to the northeast through Sequoia Field and the Town of Seville. Depth to the top of the hardrock ranges from about 30 feet to more than 2,084 feet along this section. The Corcoran Clay was found at the two most southwesterly wells (12H and 31J) along the section. The clay ranged in depth from about 200 to 280 feet. The east edge of the Corcoran Clay is indicated to not be too far east of Well 31J. Materials coarser than gravel weren't indicated along this section, as it is largely in the interfan area. Fine-grained strata are predominant, except in the uppermost 200 feet. However, some sands are present in some areas to depths of at least 1,200 feet. Blue or green deposits are present below a depth of about 550 feet along the southwest edge of the section and below a depth of about 650 feet near Sequoia Field.

Cross Section C-C.

This Cross Section (Figure 8) extends from the north edge of

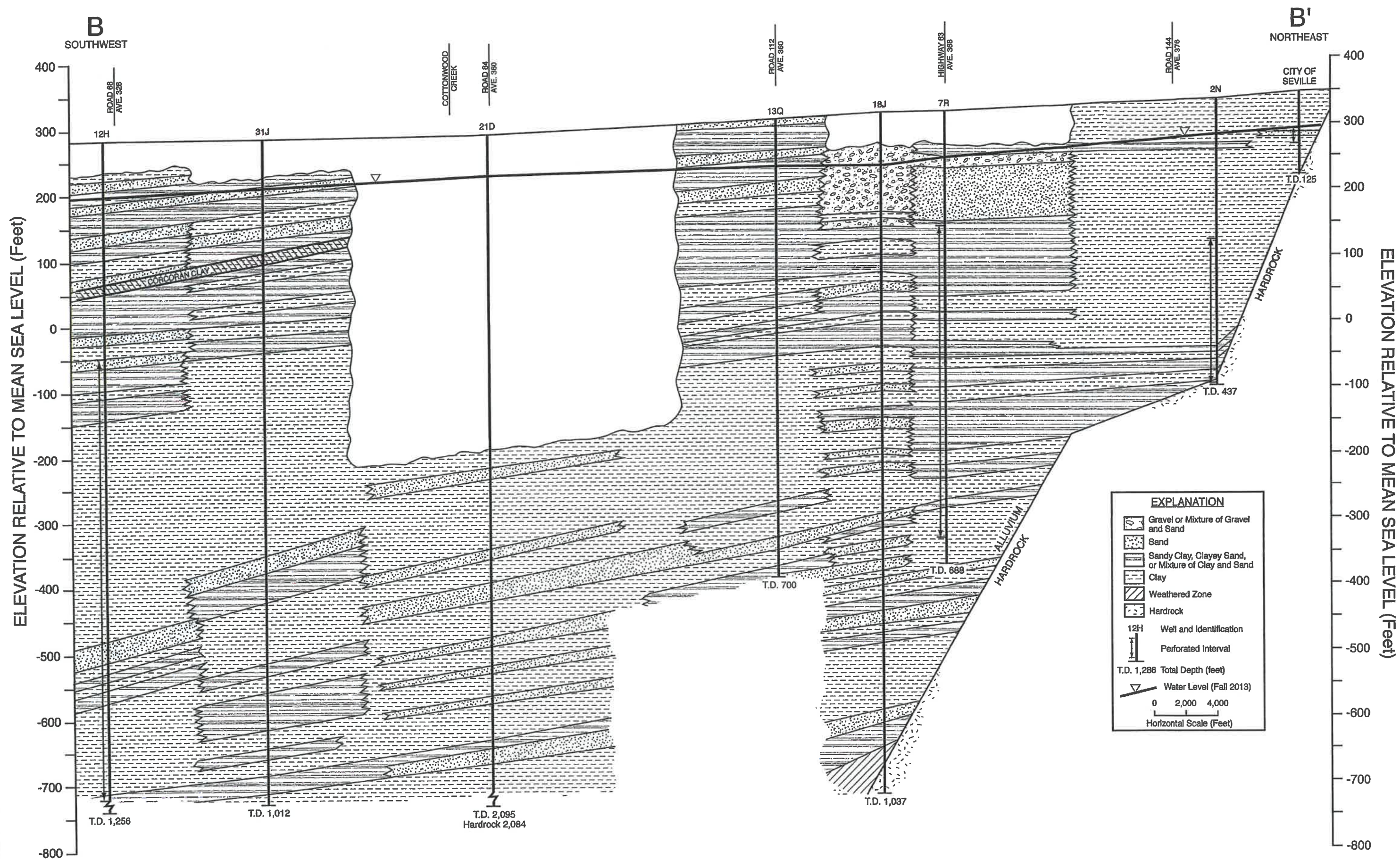


FIGURE 7 - SUBSURFACE GEOLOGIC CROSS SECTION B - B'

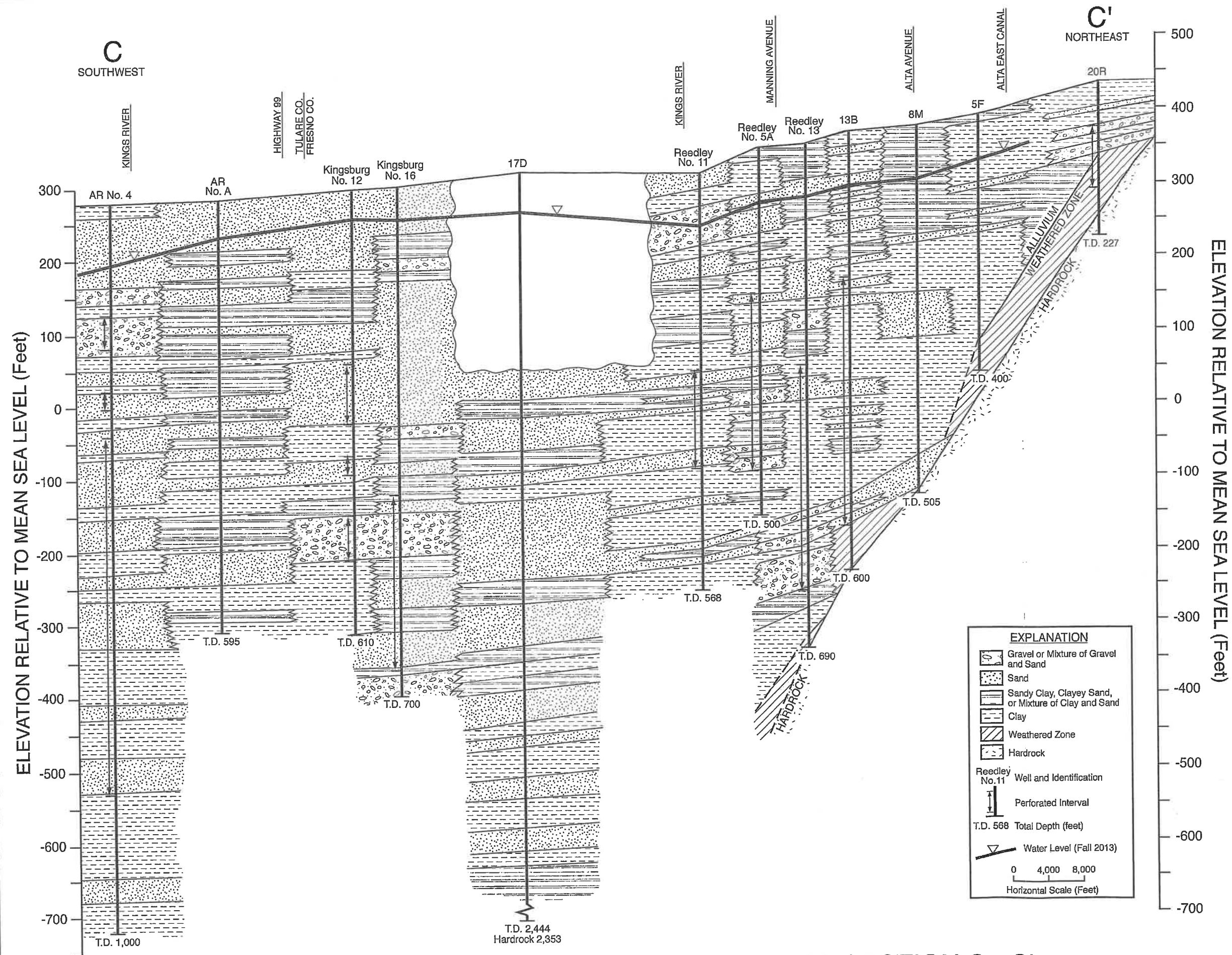


FIGURE 8 - SUBSURFACE GEOLOGIC CROSS SECTION C - C'

the Apex Ranch project, west of the Kings County-Tulare County line near Avenue 384 to the north and northeast, through the Cities of Kingsburg and Reedley, to the northeast near Navelencia. Depth to the top of the hardrock ranged from about 200 feet to the northeast to 690 feet at Well No. 13 in northeast Reedley. Depth to the top of the hardrock increased much more steeply along the section southwest of Reedley, to about 2,350 feet at Exploratory Hole 17D, between Reedley and Kingsburg. Stream channel deposits were indicated beneath Apex Ranch (southwest edge of section), Kingsburg, Reedley, and near the northeast edge of the section. At Apex Ranch Well No. 4, these deposits were above a depth of about 200 feet, whereas beneath Kingsburg, some stream channel deposits were between 300 and 700 feet in depth. At Reedley, some stream channel deposits were more than 650 feet deep. Stream channel deposits were also encountered near Wahtoke Creek in the Navalencia area (Well 20R). Clay strata are predominant below a depth of about 600 feet at Apex Ranch. At deep Hole 17D, between Kingsburg and Reedley, a substantial amount of sands were indicated below a depth of 450 feet and above a depth of 900 feet. Northeast of Reedley, clay is predominant, typical of the interfan area. At depths below about 600 feet in Reedley and Kingsburg, blue or green deposits are present, indicative of reduced conditions in the groundwater.

GROUNDWATER USE AND WELL DATA

Primary Uses of Each Aquifer

Groundwater in the older alluvium and underlying continental deposits is used for irrigation, private domestic use, and dairies in the GSA. Groundwater exclusively in the continental deposits is used primarily for public supply and some schools, and also for some irrigation.

Depths of Water Supply Wells

Depths of most irrigation wells in the GSA range from several hundred feet to more than 500 feet in much of the sub-basin northeast of the Central Valley Railroad tracks. Depths of most City wells in Reedley, Dinuba, and Kingsburg (near the GSA) range from about 500 to 700 feet. Some of the deepest irrigation wells in the sub-basin range from about 700 to more than 1,000 feet deep. These wells are southwest of Highway 99 and south of Avenue 368.

WATER LEVELS

Depth to Water

Depth to water in the GSA generally increases to the southwest. Recent depth to water maps prepared by Alta I.D. such as for Fall 2013 (Figure 9) indicate depth to water of less than 20

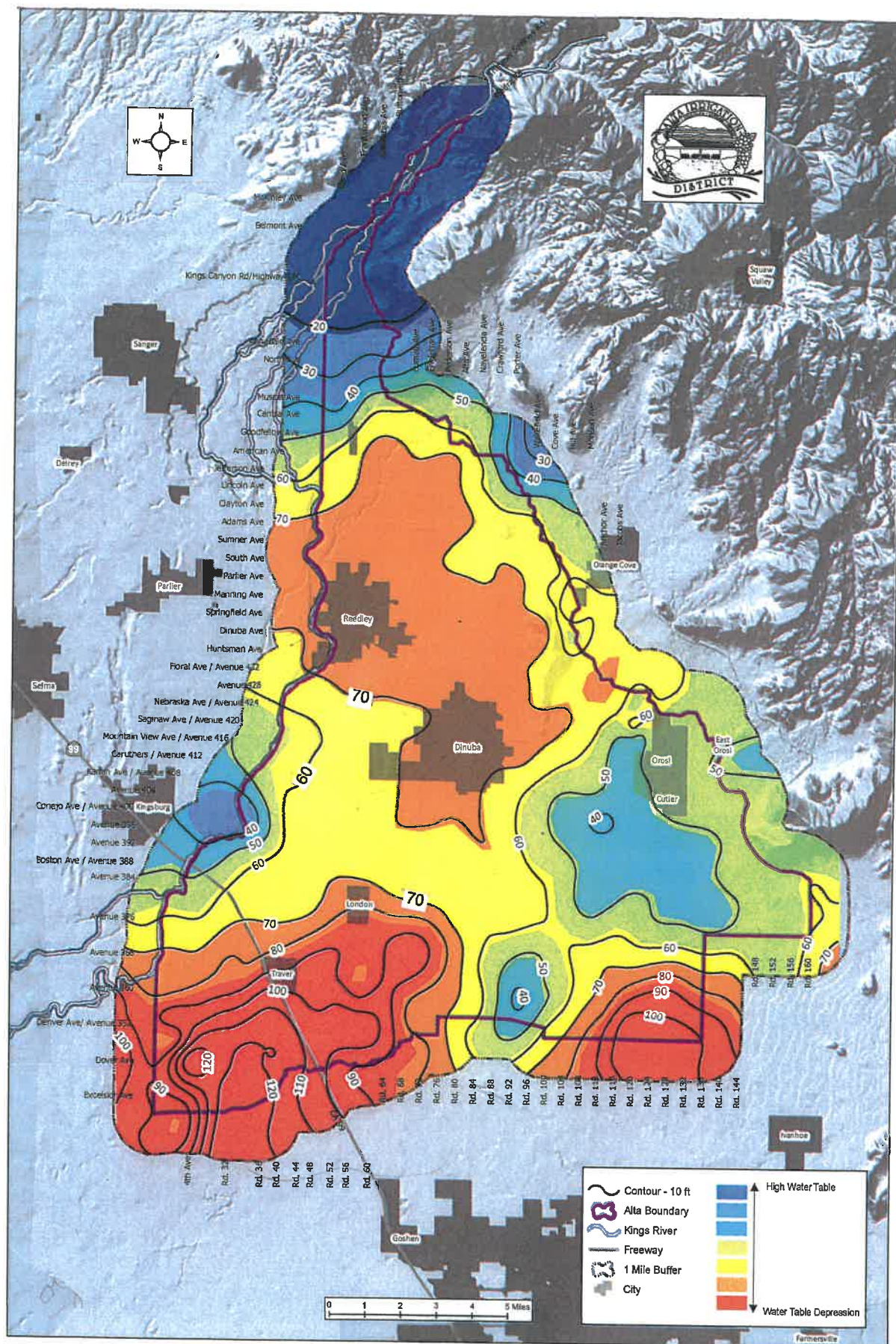


FIGURE 9-DEPTH TO GROUNDWATER FALL 2013

feet in the area north of Annadale Avenue. Depth to water in the Orange Cove I.D. has generally been less than 60 feet deep. In the Reedley-Dinuba area, the depth to water was greater than 70 feet deep. Further to the east, depth to water has ranged from about 40 to 60 feet deep in the Orosi-Cutler and Yettem areas.

South of Reedley, depth to water increases to the southeast and south, away from the Kings River. South of Avenue 284, depth to water increases to the south, from about 80 feet near London to more than 120 feet in the area southwest of Traver and west of Highway 99.

Water-Level Elevations and Direction Of Groundwater Flow

Water-level elevation maps prepared by the California Department of Water Resources (DWR) have generally indicated a southwesterly direction of groundwater flow in most of the sub-basin (Figure 10). However, a groundwater depression has been present in the area west of Goshen, and the direction of groundwater flow north of this depression has been to the south. Water-level elevation contours along the Kings River south of Reedley indicate a recharge ridge, and that the river is a losing stream in this reach. The water-level maps prepared by the DWR are generally based on supply well measurements, which tend to be more affected by pumping. They may not be indicative of the shallowest groundwater in a par-

**FIGURE 10-GROUNDWATER LEVEL ELEVATIONS AND DIRECTION OF
GROUNDWATER FLOW**

ticular area, which is more influenced by recharge.

There are a number of monitor wells along the Kings River reach along the Kings River between Highway 180 and Reedley. They are used for monitoring shallow groundwater at several existing or proposed gravel processing facilities, and for waste-water facilities for Sanger and Reedley. Most of these monitor wells tap the shallowest groundwater at the sites, and water levels in these wells are more affected by recharge. The results of monitoring indicate that shallow groundwater normally flows toward the river in this reach. Thus the river is a gaining stream along this reach and functions as a groundwater drain, except during temporary high river stages. Along the reach of the Kings River upstream of the Reedley Narrows, the groundwater is indicated to be in direct hydraulic communication with streamflow in the Kings River.

Water-level Fluctuations

Water-level measurements and hydrographs for wells in the area were obtained from the California Department of Water Resources (DWR). Over the long-term, water levels on the Orange Cove I.D. have been relatively stable. Water levels in the King River Water District have slightly declined, at an average rate of about 0.2 foot per year. Average water-level declines for the past several decades in the Alta I.D. have ranged from about 0.2

foot to 1.4 feet per year. The smallest rates of decline (less than 0.5 foot per year) have been in the north and northeast part of District, including near Cutler, Dinuba and Monson. There have been water-level declines averaging about 0.8 foot per year near Highway 99. The largest water-level declines (1.0 foot per year or greater) have been southwest of Highway 99. Several representative water-level hydrographs for wells in the GSA are provided in Figure 11. Other hydrographs are provided in Appendix A.

SOURCES OF RECHARGE

The sources of recharge to groundwater in the GSA are:

1. Seepage from the Kings River in the reach upstream of Reedley
2. Seepage of flows from other streams
3. Seepage from canals and other conveyance facilities
4. Deep percolation from excess applied irrigation water
5. Intentional recharge basins
6. Groundwater inflow from the mountain fronts
7. Deep percolation of rainfall in areas of sandy soils

On a volume basins, the last two sources are indicated to be small compared to the other sources. Figure 12 shows the locations of these potential groundwater recharge area. Water-level elevation contour maps indicate the presence of recharge ridges

FIGURE 11-REPRESENTATIVE WATER-LEVEL HYDROGRAPHS

FIGURE 12-POTENTIAL GROUNDWATER RECHARGE AREAS

beneath the Kings River (south of Reedley) and beneath part of Cottonwood Creek in the GSA.

SOURCES OF DISCHARGE

Sources of groundwater discharge are primarily 1) to pumping wells, and 2) groundwater outflow. The primary groundwater outflow from the GSA is to the south, along the south boundary of the Alta I.D. Groundwater in this area is moving into an undistricted area south of the District, where well pumpage is essentially the sole source of water for irrigation. There are a lot of dairies in this area and the water demand is relatively high. There is outflow of shallow groundwater to the Kings River in the area upstream of the Reedley Narrows and to evaporation losses in some excavations. Figure 13 shows the locations of the potential groundwater discharge areas in the GSA.

AQUIFER CHARACTERISTICS

Pumping rates in the GSA vary widely, from less than 300 to more than 2,000 gpm. Higher pumping rates in the area are generally possible from moderately deep wells (about 400 to 800 feet deep). Pumping rates exceeding about 1,500 gpm can be obtained from properly constructed and developed moderately deep wells in most of the part of the GSA southwest of the Central

FIGURE 13-POTENTIAL GROUNDWATER DISCHARGE AREAS

Valley Railroad tracks. The lowest well yields are generally in the area of shallowest hardrock (in the Orange Cove I. D., the Hills Valley and Tri-Valley Water Districts, and between Dinuba and Cutler), where obtainable yields in some places may be less than about 200 gpm.

Aquifer test results are available for a number of public supply wells, schools wells, and deeper irrigation wells. In general, specific capacities have a wide range in the GSA. Relatively low values (less than about 10 gpm per foot) are common in areas away from major streams, where the alluvial deposits are predominantly fine-grained. On the other hand, for moderately deep wells in favorable areas, such as near the Kings River, specific capacities often range from about 50 to 80 gpm per foot. For deep City wells, the most productive shallower strata have often been sealed off, due to chemical quality issues. These wells thus tap the fine-grained continental deposits, and also have low relatively specific capacities (usually less than about 20 gpm per foot), except near the Kings River, where specific capacities may range from about 40 to 70 gpm per foot.

CHANGES IN GROUNDWATER IN STORAGE

LAND SUBSIDENCE

Most studies of land subsidence in the San Joaquin Valley have been done where the Corcoran Clay is present (generally beneath the west and central parts of the valley). Pumping from

confined strata beneath the Corcoran Clay has caused almost all of the historical irreversible land subsidence associated with groundwater pumping in the valley. The only part of the GSA that is indicated to overlay the Corcoran Clay is the southwest corner, southwest of Traver. The influence of pumping from confined strata below the Corcoran Clay extends miles beyond the eastern extent of the clay. Thus lands near Traver are likely in an area of some past land subsidence. Land subsidence due to pumping below the Corcoran Clay is considered to be irreversible. The only way to address it is through less pumping or by recharging strata below the clay. Land subsidence has essentially not been measured in the GSA, but is to be monitored as part of future groundwater management activities.

Figure 14 shows recent land subsidence, projected from measuring stations adjoining parts of the GSA.

FIGURE 14-RECENT LAND SUBSIDENCE

GROUNDWATER QUALITY

The chemical quality of groundwater in most of the GSA is indicated to be suitable for irrigation of most crops. However, some local groundwater degradation has been observed, such as near some dairies. Total dissolved solids (TDS) concentrations in shallow groundwater affected by irrigation in most of the area range from about 300 to 600 mg/l. The quality of the groundwater below a depth of about 300 feet has usually not been affected by irrigation practices, and TDS concentrations are often below 200 mg/l. High nitrate and DBCP concentrations are common in shallow groundwater in the area north of Avenue 384. Schmidt (1985) discussed vertical trends in chemical constituents, such as DBCP, in groundwater of the Fresno-Dinuba area. Groundwater of suitable quality for public supply in the GSA has normally been found between about 300 and 600 feet in depth. Such wells have been constructed in Reedley, Dinuba, Sultana, Cutler, Orosi, Delft Colony, Kingsburg, at Sequoia Field, and at a number of schools in the area.

California State University, Fresno Foundation (1994), and Lassotovitch (1996) discussed the presence of DBCP in shallow groundwater in the Kings Basin. The study area for these reports was west of and adjacent to the GSA. High DBCP concentra-

tions in the groundwater were generally found only above a depth of about 250 feet. DBCP concentrations were generally not detectable in groundwater below a depth of about 300 to 350 feet. The half life of DBCP in the groundwater (the time for the concentration to reduce by 50 percent) was found to be about six years. Both DBCP concentrations in the shallow groundwater and the geographic extent of high DBCP concentrations have decreased over time.

The most important areas in the GSA where DBCP has been a problem in the shallow groundwater is in and east of Reedley, in Dinuba and to the east to Sultana, at Delft Colony, and at Grandview School, southwest of Dinuba. These are generally areas when vineyards were common and topsoils were fairly permeable.

Another more recent concern is the presence of 1,2,3-trichloropropane (TCP) in the shallow groundwater, generally in the same geographic areas as where DBCP is present.

INTERCONNECTED SURFACE AND GROUNDWATER SYSTEMS

As previously discussed, shallow groundwater is in hydraulic communication with streamflow in the Kings River upstream of

Reedley, north of about Adams Avenue. Thus groundwater flows along this reach into the river, except during high river stages, associated with flood releases. The evidence for this is from monitoring at a number of sites pursuant to Fresno County conditional use permits or to Regional water quality Control Board waste discharge requirements.