CHAPTER 2 – GEOLOGY

GENERAL

The Paso Robles Groundwater Basin was first formally defined by the California Department of Water Resources (DWR, 1958). In 1979, the DWR published a detailed investigation of the San Luis Obispo County portion of the basin (DWR, 1979).

The basin boundaries are re-defined in this study (Figures 5 and 6). The basin borders were defined using information obtained from oil well and geothermal well logs, water well logs, geologic mapping, and fault investigations. Six geologic cross sections were prepared correlating the main geologic units using deep well information and geologic mapping. A map of the base of permeable sediments was prepared using these cross sections, along with additional deep well data interspersed within the grid of the cross sections. A geologic map of the basin showing the extent of the basin and the underlying geology is presented on Figure 5. The basin boundary and the locations of the geologic cross sections are presented on Figure 6. A contour map of the base of the permeable sediments is presented as Figure 7, and the geologic cross sections are presented as Figures 8 through 19.

A single subbasin, the Atascadero subbasin, is defined as that portion of the Paso Robles Groundwater Basin west of the Rinconada fault. Between Atascadero and Creston, the Rinconada fault juxtaposes less permeable Monterey Formation rocks with the Paso Robles Formation basin sediments. South of the City of Paso Robles, the Paso Robles Formation is found on both sides of the Rinconada fault, however the fault zone is believed to form a leaky barrier that restricts flow from the Atascadero subbasin to the main part of the Paso Robles basin.

As shown on Figure 6, the western boundary of the Paso Robles Groundwater Basin roughly follows Highway 101 from Santa Margarita northward to Hames Valley. The eastern boundary follows a rough line from Highway 58 in the San Juan Creek area northward to Shandon and Cholame. The basin is downstream of and hydraulically connected by alluvial deposits to the Pozo Groundwater Basin south of the basin, and to the Cholame Groundwater Basin north of the basin. The Paso Robles basin outlet is northwest of and downstream of Bradley, where the Paso Robles basin is hydraulically connected with the Salinas Valley Groundwater Basin (Figure 6).

The stratigraphy in the watershed of the Paso Robles Groundwater Basin includes the water-bearing geologic units that form the basin aquifer, and the non-water bearing geologic units that underlie and are adjacent to the basin sediments. Figure 5 shows the extent of the geologic formations described in the following paragraphs. Descriptions of the water bearing and non-water bearing geologic formations are provided below, including hydrogeologic characterizations of each formation. In addition, the critical structural features within and bounding the groundwater basin are identified.

The main criteria for defining the water-bearing geologic formations in the basin are that they exhibit both sufficient permeability and storage potential for the movement and storage of groundwater such that wells can reliably produce more than 50 gallons per minute (gpm) on a long-term basis. Another criterion is that the groundwater produced from the geologic formation must have generally acceptable quality. DWR (1979) used groundwater conductivity of 3,000 micromhos/centimeter as the maximum limit for basin groundwater quality. Application of these two criteria limits definition of the basin sediments to Quaternary-age alluvial deposits and the Tertiary-age Paso Robles Formation.

The basin boundary generally follows the outcrop contact of these water-bearing geologic units but also follows fault lines, particularly on the eastern edge of the basin (Figures 5 and 6). The bottom of the basin, defined generally as the base of the Paso Robles Formation, is a reflection of the folding, faulting, and erosion that formed the highly variable surface upon which the nonmarine Paso Robles Formation sediments were deposited. The basin boundary and bottom should not be considered as absolute barriers to flow because in most cases the geologic units underlying and adjacent to the basin have limited porosity and permeability.

WATER-BEARING GEOLOGIC FORMATIONS

Alluvium

Alluvial deposits occur beneath the flood plains of the rivers and streams within the basin. These deposits reach a depth of about 100 feet below ground surface (bgs) or less and are typically comprised of coarse sand and gravel. The alluvium is generally coarser than the Paso Robles Formation sediments, with higher permeability that results in well production capability that often exceeds 1,000 gpm. The principal areas of groundwater recharge to the basin occur where the shallow alluvial sand and gravel beds are in direct contact with the Paso Robles Formation.

Paso Robles Formation

The Paso Robles Groundwater Basin is comprised predominantly of Paso Robles Formation sedimentary layers that extend from the ground surface to more than 2,000 feet below sea level in some areas (resulting in basin sediments with a thickness of more than 2,500 feet; best illustrated on Figure 14). Throughout most of the basin, however, the water-bearing sediments have a thickness of 700 to 1,200 feet (with the base of the sediments more or less at sea level; Figure 10).

The Paso Robles Formation is a Plio-Pleistocene, predominantly nonmarine geologic unit comprised of relatively thin, often discontinuous sand and gravel layers interbedded with thicker layers of silt and clay. It was deposited in alluvial fan, flood plain, and lake depositional environments. The formation is typically unconsolidated and generally poorly sorted. It is not usually intensely deformed, except locally near fault zones. The sand and gravel beds within the unit have a high percentage of Monterey shale gravel and generally have moderately lower permeability compared to the shallow, unconsolidated alluvial sand and gravel beds. The formation is typically sufficiently thick such that water wells generally produce several hundred gpm. In the area near Atascadero, the Paso Robles Formation has been folded, exposing the basal gravel beds. With the basal gravel exposed and in direct contact with the shallow alluvium, the Paso Robles Formation is recharged directly from the river alluvium.

NON-WATER BEARING GEOLOGIC FORMATIONS

Underlying the basin sedimentary beds are older geologic formations that typically have lower permeability and/or porosity. In some cases, these older beds yield in excess of 50 gpm flow to wells but they often have poor quality water or are of limited extent, such as are found along a fault fracture zone. The older geologic units that crop out along the basin border are identified on the base of the permeable sediments map (Figure 7) and on the cross sections (Figures 8-19). In general, the geologic units underlying the basin include Tertiary-age consolidated sedimentary beds, Cretaceous-age metamorphic rocks, and granitic rock.

Tertiary-Age Consolidated Sedimentary Formations

The Tertiary-age older consolidated sedimentary formations include the Pancho Rico Formation, an unnamed clastic unit, the Santa Margarita Formation, the Monterey Formation, the Obispo Formation, and the Vaqueros Formation. These units crop out around most of the basin edge and underlie the basin sediments.

The Pancho Rico Formation (Tp) is a Pliocene-age marine deposit found mostly in the northern portion of the study area. In places, it appears to be time-correlative to the Paso Robles Formation, and may be in lateral contact as a facies change. The presence of the Pancho Rico beneath the northern part of the basin is best illustrated in Figures 12 and 13. The increasing thickness of the formation northward is shown on Figures 14 and 15. The unit is predominantly comprised of fine-grained sediments up to 1,400 feet thick that yield low quantities of water in the Gabilan Mesa area north of the Paso Robles basin.

The upper Miocene-age unnamed clastic unit (Tuc) is time-equivalent to the Pancho Rico Formation and is comprised of up to 200 feet of sandy conglomerate beds in the Shandon area (Figures 10 and 11). This unit is cemented and produces limited flow to wells.

The Santa Margarita Formation (Tsm) is an upper Miocene-age marine deposit, consisting of a white, fine-grained sandstone and siltstone with a thickness of up to 1,400 feet (Figures 10, 16, 18, and 19). The unit is found beneath most of the basin. The Santa Margarita Formation crops out in the Santa Margarita area where more than 300 domestic water wells depend on its very limited flow capabilities. It is also a host to a number of springs. South of Templeton, water produced from the Santa Margarita Formation is often of acceptable water quality. However, north of Templeton in the area beneath the City of Paso Robles, the unit becomes progressively more permeable and is the main reservoir for the historical presence of geothermal water. Groundwater in the geothermal areas is often under pressure and artesian flow is a common occurrence, with flow rates at times exceeding 400 gpm. The Santa Margarita Formation aquifer in this area is not considered part of the Paso Robles basin because the produced water quality is usually very poor. The geothermal waters contained in the Santa Margarita Formation in this area are often highly mineralized and characterized by elevated boron concentrations that restrict agricultural uses. North of the study area, the Santa Margarita Formation crops out in the upper portions of the Gabilan Mesa. South of the basin, it is exposed along Highway 58 where springs occasionally issue from the unit.

The Miocene-age Monterey Formation (Tm) consists of interbedded argillaceous and siliceous shale, sandstone, siltstone, and diatomite. The unit is as great as 2,000 feet thick in the study area (Figures 14, 15, 16, 17), and is often highly deformed. It is exposed south and west of the groundwater basin (Figures 8, 10, 14, 18). Water wells completed in the Monterey Formation may be quite productive if a sufficient thickness of highly deformed and brittle siliceous shale is encountered. Springs issue from the Monterey Formation in the Atascadero area and on Cuesta Ridge south of the study area. The Monterey Formation can also be a source for oil as well as water in the area near Hames Valley, downstream of Lake San Antonio, and in upper Indian Valley. Groundwater produced from the Monterey Formation often has high concentrations of hydrogen sulfide, total organic carbon, and manganese. In the Paso Robles area, the Monterey Formation may be a host to geothermal water that has high sulfide concentrations in addition to high boron, iron, manganese, and total dissolved solids.

The lower Miocene-age Obispo Formation (To) is not found adjacent to or underlying the Paso Robles Groundwater Basin sediments but is described here briefly because it is found in the watershed south of the study area. It is a consolidated volcanic tuff bed underlying the Monterey Formation south of Santa Margarita. Wells in the Tassajara Creek area produce more than 100 gpm from the formation, and it is the host of several springs along Cuesta Ridge. Water produced from this unit is generally moderately saline (total dissolved solids concentrations around 1,000 mg/l).

The marine Oligocene-age Vaqueros Formation (Tv) is a highly cemented fossiliferous sandstone that reaches a thickness up to 200 feet. Springs with flows up to 25 gpm are common in canyons on the western and southern sides of the study area (Figure 18). Most water wells tapping this formation produce less than 20 gpm. Generally, the quality of water in this unit is good, though hard due to the calcareous cement within the rock.

Metamorphic and Granitic Rock

The southern and western edges of the basin are bordered by Cretaceous-age metamorphic and granitic rock (Figures 10, 14, 16). The metamorphic rock units include the Franciscan, Toro, and Atascadero formations. The Franciscan Formation consists of discontinuous outcrops of shale, chert, metavolcanics, graywacke, and blue schist, with or without serpentinite. The Franciscan Formation has an undetermined thickness and has low permeability and porosity. Limited volumes of groundwater can be produced from this geologic unit, generally only where the metavolcanics rock has been highly fractured.

The Toro Formation (Kt) is a highly consolidated claystone and shale that does not typically yield significant water to wells. The Atascadero Formation (Ka) is highly consolidated but does have some sandstone beds that yield limited amounts of water to wells. Both the Toro and Atascadero formations are exposed in the hills west of Santa Margarita, Atascadero, and Templeton.

The granitic rock (Kgr) lies east of the Rinconada fault zone, south of Creston, east of Atascadero, and in the area northwest of Paso Robles. The Park Hill area south of Creston and east of Atascadero is well known for the difficulty of finding sufficient groundwater to serve single residences. Where water is found, it is typically low in salinity. The granitic rocks often have a decomposed regolith up to 80 feet in thickness in the valley floor areas that may contain limited amounts of groundwater despite low sediment permeability due to the breakdown of feldspar and iron and magnesium silicates into clays and fine grained sediment. Springs are occasionally found where the rock is fractured, including one spring near Creston known as Iron Spring.

GROUNDWATER BASIN DEFINITION

Structural Boundaries

The lateral extent of the Paso Robles Groundwater Basin is generally defined by the contact of water-bearing unconsolidated aquifer sediments with older geologic units. In some areas, however, the basin boundary is a structural boundary defined by faults (Figures 5 and 6). The Rinconada fault defines the eastern boundary of the Atascadero subbasin and forms the hydraulic barrier between the main part of the basin and the Atascadero subbasin. The entire eastern boundary of the basin is defined by the Red Hill, San Juan, and White Canyon faults (Figures 6, 9, 11, 13, 19).

In the southern part of the Atascadero subbasin, the Rinconada fault juxtaposes the Paso Robles Formation sediments with the Monterey Formation (Figures 6 and 8). The presence of the shale east of the fault forms an effective barrier to groundwater flow between Atascadero and Creston.

Further north, the Rinconada fault zone was exposed in trenches on the Santa Ysabel Ranch (GeoSolutions, 2000). The fault was found to be a barrier to groundwater flow in the Paso Robles Formation as evidenced by differences in water levels at the Santa Ysabel warm water spring and wells drilled at the edge of the terrace above the Salinas River flood plain. Figure 14 illustrates the displacement on the fault in the Santa Ysabel Ranch area, bringing Santa Margarita Formation nearly to the ground surface east of the fault. Dibblee (1976) suggests that vertical displacement along the Rinconada fault exists, but the data conflicts depending on location. In the fault reach along the boundary of the Atascadero subbasin, evidence exists to suggest relative uplift of the northeast block. Dibblee (1976) suggests that the earliest displacement since Miocene time was up on the northeast, then up on the southwest in late Pleistocene time. All evidence indicates that horizontal displacement on the fault is right lateral (Dibblee, 1976; Campion, et al, 1983).

Groundwater flow from the Atascadero subbasin west of the Rinconada fault into the main Paso Robles basin is limited to shallow flow in the alluvial Salinas River deposits because the fault acts as a barrier to flow in the Paso Robles Formation. The Rinconada fault is not considered active because it does not displace Holocene-age deposits, but it is considered potentially active because it displaces the Quaternary-age Paso Robles Formation. North of the study area, however, the Rinconada fault zone and the San Marcos fault zone are considered active and are classified as Alquist-Priolo special studies zones.

East of Shandon, the Red Hill fault displaces the Paso Robles Formation, where exposures can be found in the banks of Cholame Creek along Highway 46 (Figure 11). East of White Canyon, near-vertical bedding of sand and gravel layers of the Paso Robles Formation is uplifted along the White Canyon fault (Figures 13 and 19). Although the fault juxtaposes Paso Robles Formation sediments on both sides of the fault, the uplifting and folding of the sediments on the east side of the fault form a hydraulic boundary that defines the eastern edge of the basin in this area.

Northeast of Cholame and across the White Canyon fault, the Cholame Valley is a separate and hydrologically distinct groundwater basin that overflows into the Paso Robles basin through the Cholame Creek alluvial deposits, much as the Paso Robles basin overflows into the Salinas Valley Groundwater Basin through the Salinas River alluvium. Previous investigations differentiated the Cholame Valley as a groundwater basin distinct from the Paso Robles Groundwater Basin, and bounded by the San Andreas fault zone (DWR, 1958).

Internal Basin Structure

Internally, the Paso Robles Groundwater Basin consists of two deep structural northwest-trending troughs separated by bedrock highs extending from the area east of the Salinas River at Camp Roberts, through the San Miguel Dome, to the Creston anticlinorium in the southern part of the basin (Figure 7). The subsurface expression of the bedrock high is illustrated on Figures 12 and 15, where the underlying consolidated rocks are either very shallow or are exposed at the surface. To the north, this bedrock high is associated with the King City fault, which may trend beneath the Paso Robles basin although there is no surface evidence or expression (Figure 10).

West of the San Miguel dome there is a deep trough that shallows progressively to the south (Figures 12 and 14). South of Paso Robles, the Rinconada fault divides the basin into the Atascadero subbasin and the main part of the Paso Robles Groundwater Basin. As shown on Figures 8 and 16, the basin sediments are generally relatively thin in the Creston area. The Creston area is separated from that part of the groundwater basin underlying Shedd, Shell, Camatta, and San Juan creeks by an anticlinal fold that brings a peninsula of older consolidated rocks to the surface (Figure 8). However, the peninsula of older consolidated rocks does not extend northward far enough to create an effective barrier to flow (Figures 7, 10, and 16). The thickness of basin sediments along the structural high between the San Miguel dome and the Creston anticlinorium reach a thickness as great as 1,200 feet.