Chapter 4
THE IMPACT OF GEOLOGY AND SOILS IN SALT MANAGEMENT

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I. Introduction

Special farm management is needed on the Westside of the San Joaquin Valley because of its unique soil, climate and geological conditions. The soils are of marine origin and contain naturally occurring salts and trace elements that can be mobilized through cultural practices, such as irrigation. Accumulation and concentration of salts and trace elements can harm wildlife and reduce crop yields.

Valley land must be irrigated for crop production because of the arid climate (annual rainfall is less than 10 inches). Irrigation water is either imported or pumped from the ground and contains dissolved salts. When water is applied to crops, evaporation and transpiration remove the water from the soil, leaving behind the salts previously dissolved in the water. The salts become concentrated in the soil over time.

The unique geology of the Westside of the San Joaquin Valley results in a shallow groundwater table. The addition of irrigation water to leach salts further exacerbates the groundwater problem. The shallow water table saturates the root zone resulting in plant death and soil degradation. To solve this problem, subsurface drainage systems are installed 6 to 8 feet below the ground surface to collect the deep percolation (water that has moved beyond the root zone).

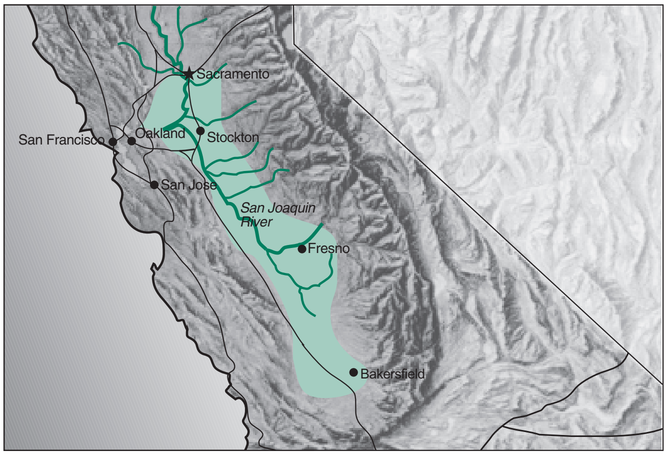

Figure 1. The San Joaquin Valley.

II. Soils of the Westside

A. Geography and Geology

The following information is taken from *Groundwater in the Central Valley of California - A Summary Report A2-A5*; Bertoldi, G.L., R.H. Johnson, et al. 1987. U.S. Geological Survey.

The Central Valley of California stands out as a notable topographic basin. It is about 400 miles long and averages about 50 miles in width. Surrounded on all sides by mountain ranges, the Valley has only one natural outlet through which surface water drains. That outlet, the Carquinez Strait, cuts through the central Coast Range on the Valley's west boundary. This work is focused around the San Joaquin and Tulare Basins, which make up most of the southern two-thirds of the Central Valley. The San Joaquin Basin is at the north end and drains into the San Joaquin River. At the southern end is a hydrologically closed basin (no drainage) called the Tulare Lake Hydrologic Basin.

Climate in the San Joaquin Basin and the Tulare Lake Hydrologic Basin is Mediterranean with an annual precipitation ranging between 5 and 16 inches. About 85 percent of the annual precipitation occurs from November to April. Summers are hot while winters are mild resulting in a long growing season. In contrast to the Valley's low precipitation, mean annual precipitation in the adjacent Sierra Nevada increases with altitude and ranges from 40 to more than 90 inches annually. Much of the precip–itation in the mountains is snow, especially in the higher southern Sierra Nevada. Peak runoff in the San Joaquin Valley generally lags peak precipitation by 5 to 6 months.

The southern San Joaquin Valley, made up of the San Joaquin and the Tulare Lake Hydrologic basins, contains 4 of the top 10 agricultural counties in the U.S., including Tulare, Fresno, Kern and Kings. To support this level of agricultural activity in an area that is deficient in precipitation requires a substantial amount of irrigation water. About half of the additional requirement comes from groundwater and half from surface water sources. The proportions of groundwater and surface water vary with annual precipitation.

B. Geologic Setting

From: *Groundwater in the Central Valley of California – A Summary Report*, A8-A9.

Learning about the formation of the Sierra Nevada and the Coast Range is important for understanding the deposition of aquifer material in the Central Valley and the distribution and movement of groundwater.

The Sierra Nevada is the largest single mountain range in the contiguous 48 states and is about 350 miles long and 55 to 80 miles wide. The Sierra Nevada is composed primarily of granite and related rocks. These rocks were tilted up toward the east by tectonic forces, and are evident by the much steeper slopes on the east side of the range. Wells drilled in the San Joaquin Valley penetrated granitic rocks at increasing depths toward the west, indicating that the granite exposed in the Sierra Nevada is only a small part of the whole mass.

The Coast Range is a result of overland thrusting of marine sediments that impact the San Joaquin and Tulare Lake Hydrologic basins in two ways. First, the emergence of the Coast Range thrust and its subsequent development established an orographic barrier for moisture-laden on-shore oceanic winds. As a result the San Joaquin Valley effectively was put into a rain shadow since the formation of its western boundary.

Secondly, the parent material of the Coast Range is marine sediment that remained inundated by the Pacific Ocean until fairly recently. The inundated areas were continuously changing in size and shape as the Coast Range emerged. Consequently both marine and continental shelf sediments were deposited.

Marine deposition was dominant in the initial developmental stages of the Coast Range and continental shelf deposits were prevalent during the latter stages of development. The marine deposits differ greatly in sediment type, sorting, and thickness because of the continually changing depositional environment. That is why the alluvial fans of the Westside of the San Joaquin and Tulare Lake Hydrologic basins differ considerably in their chemical constituents.

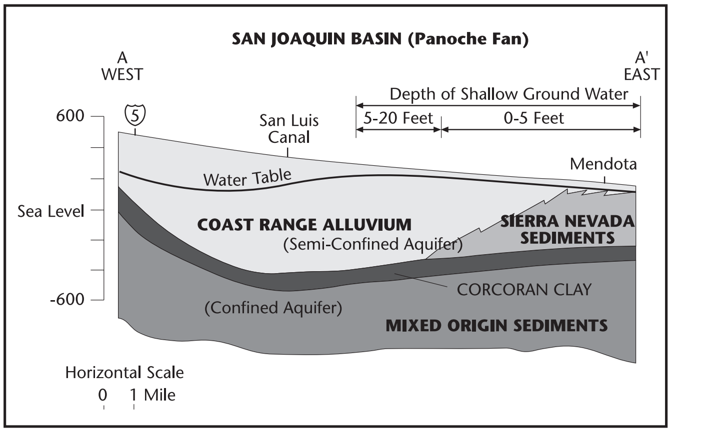

Figure 2: Cross-section diagram of the San Joaquin Valley showing Corcoran Clay layer in the San Joaquin Basin. Adapted from: *A Management Plan for Agricultural Subsurface Drainage and related Problems on the Westside San Joaquin Valley*: September 1990.

C. Cultural Practices

For years, farmers in the San Joaquin and Tulare Lake Hydrologic basins have been pre-irrigating to provide proper seed bed moisture and to leach salts below the crop root zone; providing enough seasonal irrigation water to satisfy crop water requirements using an irrigation schedule; fertilizing; and realizing an acceptable yield.

Many Valley farmers have modified their cultural practices to manage drainage problems and to maintain acceptable yields. Cropping patterns have shifted in favor of increasing salt tolerance. Modifications of cultural practices have taken two forms: source control and the use of the shallow groundwater to satisfy some crop water needs.

The Valley's Westside slopes from the base of the Coast Range down to the Valley's center. The source of some shallow groundwater that impacts land in the Valley's center is the irrigated, upslope land on the Westside. The leaching faction, along with any over irrigation of this upslope land contributes to the shallow groundwater table as the water travels down the hydrologic slope to the Valley's center. The groundwater dissolves marine salts and minerals as it passes through the soil strata, adding to the salinity at the Valley's center.

D. Salinity

All soil has some level of salinity, which is a result of the dissociation of soil salts. These soil salts produce negative and positive ions upon dissociation.

Salts are necessary for plant growth and to maintain soil physical properties. The application of irrigation water with very low or very high concentrations of salt may cause infiltration problems, depending on the soil structure, compaction, organic matter content, and chemical make-up of the soil.

To determine whether infiltration problems may be a factor, it is important to determine the EC, or electrical conductivity, of the soil, as well as the concentration of calcium, magnesium, sodium, and SAR (sodium absorbtion ration) or ESP (exchangeable sodium percentage) (Oster and Jayawardane, 1998; Oster et al., 1996; Shainberg and Letey, 1984; and Hanson et al., 1999). Infiltration rates, hydraulic conductivity and soil tilth are affected by the balance between salinity and exchangeable sodium, especially as salinity decreases and exchangeable sodium increases.

Soil salinity is expressed as “ECe,” the electrical conductivity of a saturated soil paste extract expressed in dS/m, but may be converted to TDS (ppm). The conversion factor varies with the degree of salinity. Soils that have ECs higher than 4 dS/m ECe (~2560 ppm TDS) are considered to be “saline;” however this designation certainly depends on the salt tolerance of the particular crop and management practices. Consequently, it is preferable to consult salinity tolerance tables and choose your crop accordingly. See Chapter 6 and Appendix for salinity tolerance tables.

E. Sodicity

Soils that have a SAR of 13 or an ESP of 15 are considered to be “sodic” and are likely to have low permeability to water. This tendency will be greater when irrigating with water that is very low in salinity.

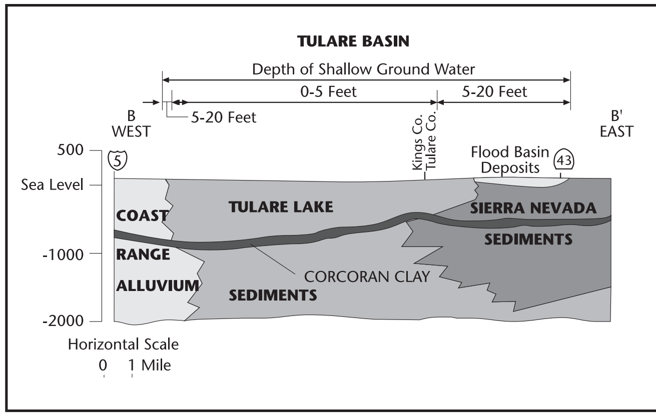

Figure 3: Cross-section diagram of the San Joaquin Valley showing the Corcoran Clay layer in the Tulare Basin. Adapted from: *A Management Plan for Agricultural Subsurface Drainage and related Problems on the Westside San Joaquin Valley*: September 1990.

F. Soil Reclamation

Reclamation of sodic soils is possible through chemical and physical management of the soils.

Reclamation techniques include the addition of soil or water amendments, fertilizer, organic residues, blending water supplies, cultivation and deep tillage, and irrigation management.

Amendments supply the calcium required to improve the chemical and physical properties (poor infiltration, compaction, high sodium levels) of the soil.

Addition of gypsum supplies calcium directly to the soil while adding acid to the soil or water can supply calcium indirectly. Acid liberates calcium from the lime that is commonly present in Westside soils and irrigation waters.

Gypsum or other amendments will not cause any significant improvement in soil physical properties if the soil problems result from restrictive layers or high water tables and no provision for subsurface drainage is made.

Notes: