2.6 Ground Subsidence

Ground subsidence, the loss of surface elevation due to removal of subsurface support, occurs in nearly every state in the United States. It is typically a gradual settling or sinking of the ground surface with little or no horizontal movement, although fissures (cracks and separations) are common. Subsidence is one of the most diverse forms of ground failure, ranging from small or local collapses to broad regional lowering of the earth's surface. While subsidence typically occurs throughout a susceptible valley, additional displacement and fissures occur at or near the valley margin. Susceptible valleys are predominantly filled with unconsolidated sand, and silty sand that includes thin layers of silt and clayey silt. Fine-grained alluvium and organic matter often underlie the fissure areas (Kupferman, 1995). Two types of fissures are reported in the literature: the first are generally straight and correspond to the traces of faults, while the second are more curvilinear on the surface and appear to correspond to the alluvium-bedrock contact at valley margins.

The causes of subsidence are as diverse as the forms of failure, and include dewatering of peat or organic soils, dissolution in limestone aquifers, first-time wetting of moisture-deficient low-density soils (hydrocompaction), natural compaction, liquefaction, crustal deformation, subterranean mining, and withdrawal of fluids (ground water, petroleum, geothermal). Most of the damaging levels of subsidence are induced by human activities. In the areas of southern California where ground subsidence has been reported, the phenomenon is usually associated with the extraction of oil, gas or ground water from below the ground surface, or the organic decomposition of peat deposits, with a resultant loss in volume. Ground subsidence can also occur as a response to natural forces such as earthquake movements, and the evolution of a sedimentary basin as it folds and subsides. Earthquakes can cause abrupt elevation changes of several feet.

Damage caused by subsidence is a world-wide phenomenon that annually costs governments and individuals hundreds of millions of dollars to investigate and to mitigate. According to the National Research Council (1991), the estimated yearly cost of subsidence in the U.S. is about $125 million. Ground subsidence can disrupt surface drainage, reduce aquifer system storage, form earth fissures (cracks and separations), and damage wells, buildings, roads and utility infrastructure. Regional subsidence generally damages structures that are sensitive to slight changes in elevations, such as canals, sewers, and drainages. In the County of Riverside, risk due to regional subsidence is greatest at valley margins.

Subsidence and fissuring have been well-documented in Riverside County (Proctor, 1962; Morton, 1977; Kupferman, 1995) since the early 1960s. Most of the early cases affected only agricultural land or open space. Since the late 1980s, increased urbanization has seen impact on structures designed for human occupancy. In Riverside County, subsidence and fissuring have been caused by falling groundwater tables and by hydrocollapse when groundwater tables rise (Shlemon and Hakakian, 1992). In addition, many fissures have

occurred along active faults that bound the San Jacinto Valley and Elsinore Trough. Some controversy surrounded the initial recognition of these features in the late 1980s and early 1990s. However, there is agreement on the geotechnical conditions that can lead to subsidence and earth fissure formation.

Plate 2-4 shows regions of documented subsidence and regions that may be susceptible to subsidence. The latter include all alluvial valley regions. Subsidence has only been documented in three areas (Figure 2-6):

- the Elsinore Trough, including Temecula and Murrieta.
- the San Jacinto Valley from Hemet to Moreno Valley.
- the southern Coachella Valley.

These areas are all potentially sensitive to the withdrawal of ground water. Depending on the depth and mechanical properties of the aquifer and the overlying sediments, they can subside if groundwater resources are not managed properly. Mitigation of ground subsidence usually requires a regional approach to groundwater conservation and recharge. Such mitigation measures are difficult to implement if the geology of the aquifer and overlying sediment are not well understood. Furthermore, conservation efforts can be quickly offset by rapid growth and attendant heavy water requirements (golf courses, for example, consume about 8 acre-feet of water per acre per year). Further, it is not uncommon for several jurisdictions to utilize a continuous groundwater aquifer, and then mitigation requires regional cooperation among all agencies.

2.6.1 Elsinore Trough

Two separate areas of active subsidence are known in the Elsinore Trough (Shlemon and others, 1995), a broad structural depression called a graben, which has been formed by active faulting in the Elsinore fault system (Figure 2-7). Subsidence in the two areas, near the communities of Temecula and Murrieta, was caused by different mechanisms.