

codes. Special engineering designs include the use of reinforcing steel in foundations, drainage control devices, over-excavation and backfilling with non-expansive soils. Active enforcement, peer review and homeowner's involvement are required to maintain these standards. Although expansive soils are now routinely alleviated through the County Building Code, problems related to past inadequate codes constantly appear. Homeowners should be informed and educated about the importance of maintaining a constant level of moisture below their foundation. Excessive watering, or allowing expansive soils to become too dry, both have negative consequences. Excessive swelling and shrinkage cycles can result in distress to improvements and structures.

#### **2.8.4 Mitigation of Collapsible Soils**

Sampling and laboratory testing for collapsible soils is required under the County-enforced Uniform Building Code. Collapse potential may be mitigated by removal and recompaction under optimum moisture conditions, pre-saturation of foundation soils, and improvements to post-development site drainage. Special attention must be paid to avoid saturation of foundation soils after construction. For example, there should be positive drainage away from the foundation, and planters with open bottoms should be avoided in areas adjacent to foundations.

The raw data for mapping this hazard in the County of Riverside exists in the form of Bureau of Reclamation Soil Survey Maps. While the mapping of collapsible soils is beyond the scope of this project, a future study should be directed at preparing a collapsible soils distribution map.

#### **2.8.5 Ground Subsidence**

In regions of active or potential subsidence, four distinct regulations require proposed development to prepare geotechnical reports that address subsidence and outline mitigation where required. These regulations include:

- Safety Element of the General Plan;
- Uniform Building Code;
- California Environmental Quality Act; and
- County Subsidence Report Zones.

As a result of past experience, the County of Riverside has developed extensive methodology to mitigate ground subsidence hazard and reduce associated losses. During preliminary site investigations, geotechnical consultants are required to

evaluate the potential for subsidence and fissuring. In cases where subsidence and fissuring are discovered during development, the Riverside County Board of Supervisors adopt a local "Subsidence Report Zone" (Kupferman, 1995). The purpose of a report zone is to prevent construction of structures for human occupancy on known or potential earth fissures.

As a case history, the Riverside County Geologist (Kupferman, 1995) has outlined the County Board of Supervisors' adoption of a Subsidence Report Zone, following the discovery of earth fissures in the Temecula area:

1. In 1987, a northwest-trending, curvilinear system of earth fissuring about 3 km long was observed in recently graded residential tracts.
2. Ground cracks and water levels in nearby wells were monitored by consultants for the developers.
3. The developers and their geotechnical consultants notified Riverside County of the problem and the County ceased issuance of building permits for areas in the vicinity of the cracks.
4. About three months later, similar northwest-trending features were noticed in a commercial part of Temecula. Attorneys and expert consultants (ground water, geotechnical and geologic) were retained by the County for legal and technical assistance.
5. In early 1988, the Riverside County Board of Supervisors resolved to create a Subsidence Report Zone. The zone included areas of known and suspected fissuring, and spanned the alluvial areas of Temecula Valley between two mapped fault zones (Figure 2-7). The zone was approximately 1.6 km wide and 15 km long. Before issuing further building permits, the board required special geotechnical studies that addressed the fissuring, and a licensed structural engineer to certify that proposed structures within this zone were safe for their intended use. Reports submitted to satisfy these requirements ranged from one-page opinions to detailed trenching investigations. Initially, reports were submitted and accepted by the Building and Safety Department if these reports included the required certification. Subsequently, more detailed subsurface investigation reports were reviewed and approved by the County Geologist.
6. Initial site-specific studies indicated that fissuring coincided with active (Holocene) faulting. The County notified the State Division of Mines and Geology, which began a study in accordance with the Alquist-Priolo Special Studies Zone Act (APSSZ) (Hart, 1990). This resulted in establishment of a state Special Studies Zone (SSZ) where the fissures coincided with active (Holocene) faulting. Planned development within these zones was required to comply with the APSSZ Act. The new special studies zones were 0.2 - 0.3 km wide and 2.0 - 4.0 km long. The original, larger Subsidence Report Zone also remained in effect.

7. Two years after initial adoption, the Subsidence Report Zone and the Board of Supervisors' resolution was changed. The new resolution kept the original zone intact, removed the certification by a structural engineer, and retained the requirement that fissuring should be addressed by geotechnical engineers for projects within the Zone.
8. The SSZ and the larger Subsidence Report Zone are still in place; however, most of the area is now incorporated into cities. Indications are that the cities are still implementing these zones.
9. No new cracks have occurred within the Subsidence Report Zone since it was established. The original fissures within the narrow state Special Studies Zone continue to show periodic movement.
10. The original, wide Subsidence Report Zone was ruled an appropriate safeguard. It did not substantially slow development, and allowed building to proceed with controls that evaluated the potential for fissuring.

As reported by Kupferman (1995), two additional Subsidence Report Zones have since been created by the County Board of Supervisors:

**Murrieta Area-California Oaks:** In 1991, a Subsidence Report Zone was created in the Murrieta area, as a result of ground cracking at the California Oaks project (see section 2.6.1). This cracking was determined to be a result of a rising ground water table, rather than a falling ground water table. Shlemon and Hakakian (1992) attribute the cracking at California Oaks to be the result of saturation of collapsible alluvium that was left in-place during rough grading. The limits of the Subsidence Report Zone for the Murrieta area was based on natural hydrologic and political boundaries (Kupferman, 1995). Shortly after creation of this Zone, the area was adopted into the city of Murrieta and continues to be enforced by the city.

The cracking at California Oaks led to modifications in County policies. The County Department of Buildings and Safety adopted a set of technical guidelines for the review of geotechnical reports. The guidelines require that a project geotechnical consultant must document observations and inspections during grading; and that the County Geologist review and approve geotechnical reports for all grading projects (Kupferman, 1995).

**Silverhawk Development:** In 1994, a third Subsidence Report Zone was established. The establishment of this Zone was pre-emptive, as no ground fissuring had yet been observed. However, geotechnical data, and similarities in geology, topography, hydrology and grading with the previously established California Oaks zone, warranted its establishment. This third Subsidence Report Zone was removed following the preparation of geotechnical studies by the project developer.

#### **2.8.5.1 Recommended Minimum Requirements to Address Subsidence Potential:**

This Technical Background Report recognizes the hazard of subsidence and ground fissuring in Riverside County and supports the implementation of a Safety Element policy to require preliminary soils engineering and engineering geologic reports. Prior to issuance of grading permits, the potential for subsidence must be addressed in regions identified by this study as active or susceptible. This recommendation is supported by the Uniform Building Code.

At a minimum, geotechnical investigations and reports that address subsidence potential should: