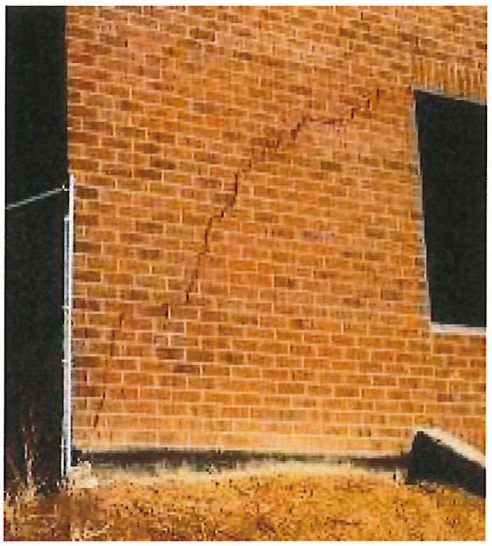
4.9 Expansive Soils

4.9.1 Hazard Profile

Soils and soft rock that swell and shrink from changes in moisture content are commonly known as expansive soils. Expansive soils, also called shrink/swell soils, are sometimes referred to as swelling clays because clay materials attract and absorb water. Dry clays will increase in volume as water is absorbed and, conversely, decrease as they dry. These movements lead to cracking and buckling of the infrastructure built on or in expansive soils and have resulted in billions of dollars of damage annually.



Location

Based on surveys of underlying soils, Figure 4–25 shows a generalized map of the areas of Canadian County where soils have from low to very high expansive qualities.

Comparatively, Canadian County has a low percentage of soils that have a high and very high shrink/swell potential—a little over 8.2%. Approximately 90% of the soils in Canadian County rank in the low to moderate range (see Table 4-27).

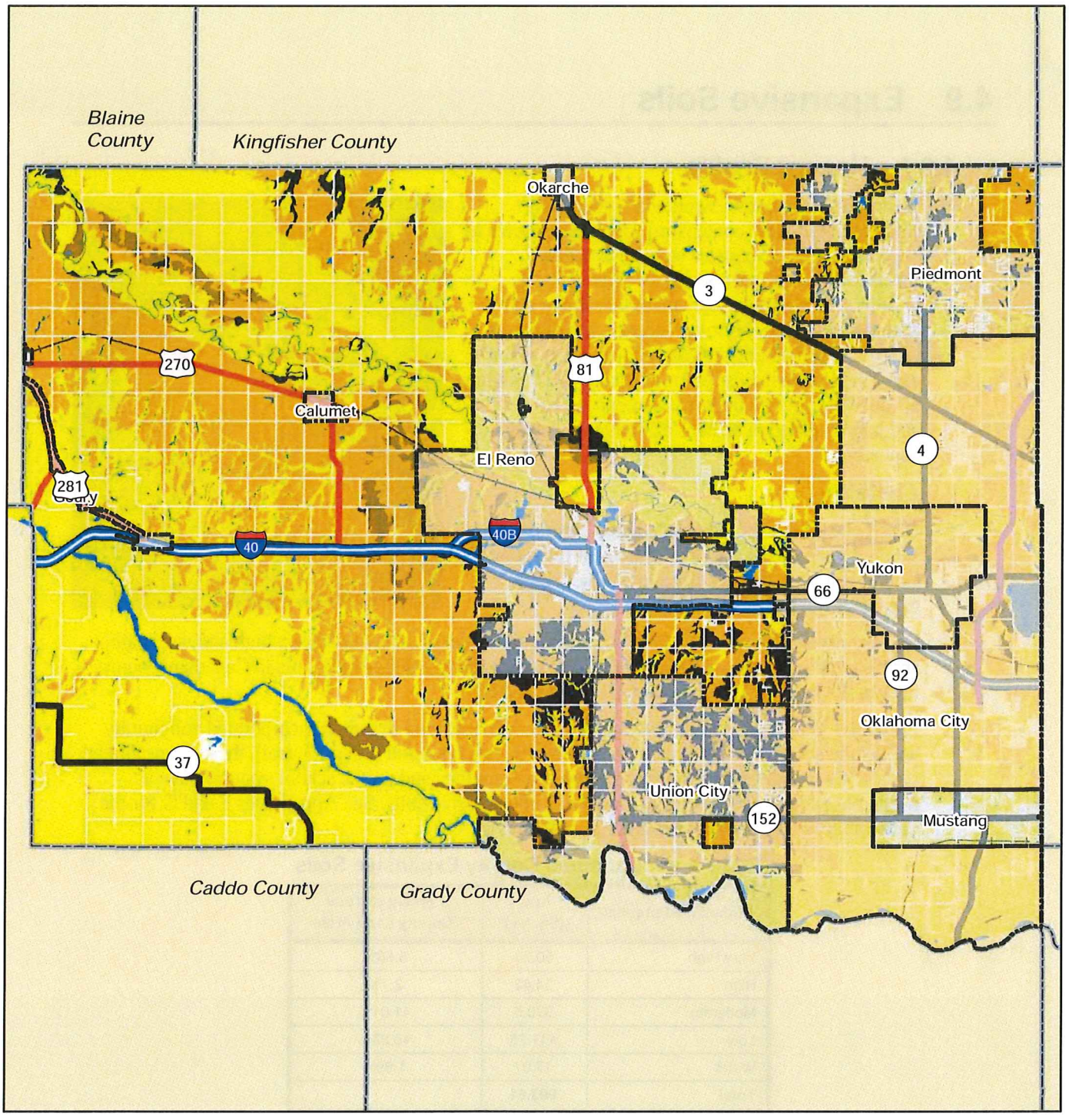
Expansive Soils is one of the site-specific hazards, meaning that each incorporated community and public school will have its own vulnerability analysis and rating. Overall, the unincorporated parts of Canadian County, its incorporated communities and public school systems have a Moderate exposure to the damaging effects of expansive soils. See Appendices F and G for the vulnerabilities of specific communities and schools.

Table 4–27: Canadian County Expansive Soils

Expansive Potential	Area (Sq. Mi.)	Percent of Total County Land Area
Very High	50.26	5.56%
High	24.42	2.7%
Moderate	370.6	41.01%
Low	441.26	48.83%
Water	17.07	1.89%
Total	**903.61**	

Measurement

The risk associated with expansive soil is related to shrink/swell potential in a qualitative manner: very high, high, moderate and low, as shown in Table 4-28.



LEGEND

Linear Extensibility

- Low
- Moderate
- High
- Very High
- Water

- Interstate
- US Highway
- State Highway
- Turnpike
- Railroads
- City Limits
- Not in Plan

N W E S

0 2.5 5 Miles

CANADIAN COUNTY 1890 OK

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Figure 4-25

Canadian County

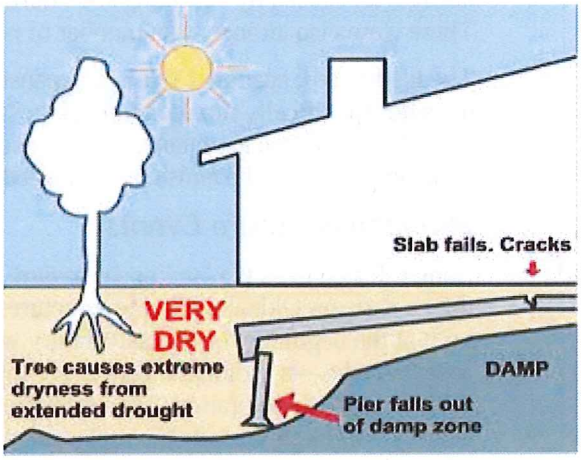
Expansive Soils

Table 4–28: Expansive Soils Linear Extensibility Percent

Expansion Potential	Linear Extensibility Percent
Very High	> 9%
High	6% - 9%
Moderate	3% - 6%
Low	< 3%
Water	0%

The Natural Resource Conservation Service (NRCS), in its Soil Survey Geographic Database (SSURGO), identified expansive soils for Canadian County shown in Figure 4–25. SSURGO map units were classified from low to very high as shown in Table 4-28 based on the linear extensibility percent (LEP) for the soils within the identified map units to depths up to 60 inches—the depth at which damage to improvements from expansive soils is most likely to occur. Soil samples are dehydrated through air- or oven-drying for a predetermined length of time under a constant temperature. Linear extensibility percent is the linear expression of the volume difference of natural soil fabric at 1/3 bar or 1/10 bar water content and oven dryness. The volume change is reported as percent change for the whole soil. In addition, the Oklahoma Department of Transportation has a program to evaluate the expansive tendencies of soils and shale formations in the state.

Figure 4–26: Effects of Expansive Soils



Extent/Severity

With about 8% of Canadian County having "high" to "very high" shrink/swell potential, the jurisdiction could suffer damage from expansive soils. This being said, the extent of expansive soils property damage can vary greatly, based on the long-term weather conditions, the type and quality of construction, materials used in construction, and, most importantly, the soils the structures are built upon. For example, aging gas and water pipelines, especially when originally constructed in wet soil, can rupture during periods of extended drought.

Damage from expansive soils can be reduced by mapping the soils in the jurisdiction and by informing property owners and prospective buyers and builders of potential soil hazards and the techniques that can be used to limit their impacts. The area extent of the expansive soils in Canadian County is shown on the map in Figure 4-25. (For information on individual communities and public schools, see Appendices F and G.)

Canadian County considers a shrink-swell level of moderate and below to be a minor severity and a shrink-swell level of high and above to be a major severity.

Frequency

With nearly 75 sq. miles of Canadian County having soils with "high" to "very high" shrink/swell potential, the jurisdiction could suffer damage from expansive soils. Due to lack of data, there is no way to predict the likely frequency of expansive soils impacts. The distribution of expansive

soils is shown in Figure 4-25. (For information on individual communities and public schools, see Appendices F and G.)

Impact

The impact of this hazard occurs over time and affects structures and infrastructure. Moderate to very high shrinking and swelling can damage buildings, roads, and other structures. The high degree of shrinkage associated with high and very high shrink-swell potentials can damage the roots of crops.

4.9.2 History/Previous Occurrences

In Oklahoma, numerous foundation failures and pipeline breaks resulted from soil shrinkage during the unusually hot and dry summers of 1998, 2005-2006 and 2011. During the drought of 2005-2006, soil shrinkage led to water main and sewer pipe breaks and leaks in many Oklahoma cities, including Ada, Holdenville, Okmulgee and Muskogee. From July through September 2011 Oklahoma City's water system had four times the number of daily water main breaks than normal, all caused by shrinking soils during the drought. El Reno experienced similar problems. There were also an increased number of roads that buckled due to the heat.

The history of Canadian County's expansive soil hazard is difficult to track, since the County does not specifically monitor damage to structures from expansive soils. The County treats all such damage as a maintenance issue. Based on this limited data, there is no record of exactly how many expansive soil events have occurred in the past.

Probability/Future Events

Long referred to as the "unknown hazard," expansive soils may be a hazard with more of a future than a past. As Oklahoma's infrastructures continues to age—particularly water and sewer lines built at the beginning of the last century with materials and techniques that would not meet today's codes—a prolonged period of drought could significantly speed and intensify infrastructure deterioration. The rehabilitation of roads and aging central business districts in the County will likely include the replacement of much of the underground infrastructure, especially where these are located in areas with highly expansive soils. The use of the more flexible PVC piping could reduce the impact of expansive soils.

Based on the nearly 49% of land area in the County underlain by Moderate to Very High shrink/swell soils, the number of extreme heat and drought events that continue to occur in Canadian County on an annual basis, Canadian County, the Cities of El Reno, Mustang, and Piedmont; the Towns of Calumet, Okarche, and Union City; and the participating School Districts: Banner Public Schools, Calumet Public Schools, Darlington Public Schools, El Reno Public Schools, Maple Public Schools, Mustang School District, Okarche School District, Piedmont Public Schools, Union City Public schools, Redlands Community College, and Canadian Valley Technology Center can expect to be impacted by the Expansive Soils hazard every summer. Canadian County has a High probability of future expansive soils effects.

4.9.3 Vulnerability

This section summarizes information about Canadian County's vulnerability to expansive soils, including the impact on people, structures and buildings, critical facilities, and infrastructure. This information, as well as information provided by the County, incorporated communities and public schools, was used to determine the Vulnerability Criteria identified in Tables 4-2 and 4-3. Canadian County was determined to be at High risk to the expansive soil hazard, primarily because of aging water and sewer infrastructure. (See Table 4-2 Hazard Risk Analysis, and Table

4-3, Summary of Hazard risk Analysis Ranking Criteria for an explanation of how the rankings were derived.)

The effects of expansive soils are most prevalent in regions of moderate to high precipitation, especially where prolonged periods of drought are followed by long periods of ground-saturating rainfall. The most problematic soil type for expansive soils is found in the semiarid west-central United States.

Site-specific vulnerabilities for incorporated communities and public school are analyzed in Appendices F and G, respectively. Although Canadian County has only about 10% of its soils in the high and very high range, its aging infrastructure is particularly vulnerable to damage during periods of extended drought. Overall, the County has a High vulnerability to the damaging effects of expansive soils. Communities and schools will, of course, have different ratings, as this is considered a site-specific hazard.

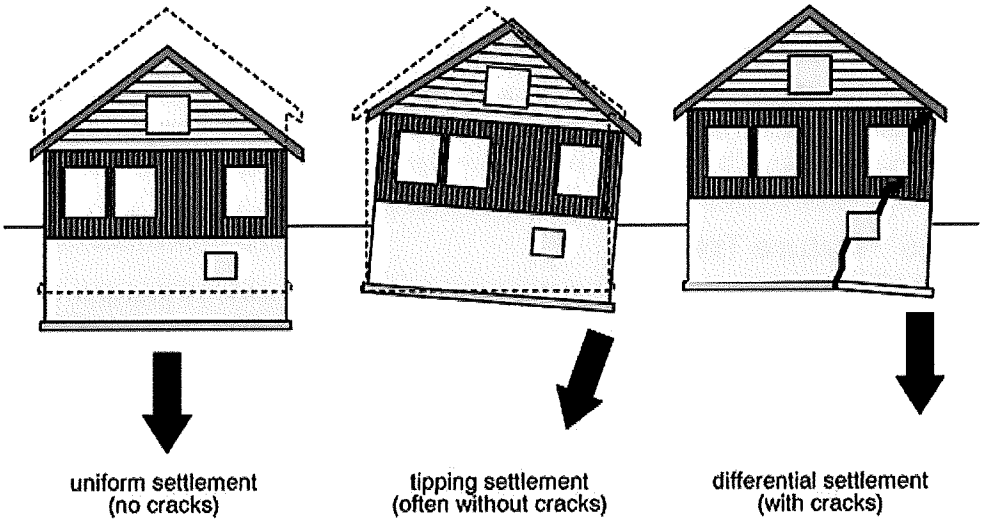
Population

Direct threats to life or personal injury have not generally been documented for expansive soils, due to the nature of the hazard. Populations of Canadian County, its communities and schools would be most vulnerable to the economic impacts of expansive soils.

Structures/Buildings

Houses and small buildings are impacted more by expansive soils than larger buildings, such as schools and large commercial structures. The greatest damage occurs when small buildings are constructed when clays are dry, such as during a drought, and then subsequent soaking rains swell the clay. Other cases of damage involve increases of moisture volume from broken or leaking water and sewer lines, over-watering of lawns and landscape, and surface modifications that produce ponding. Damages to houses caused by expansive soils are shown in Figure 4-27.

Figure 4–27: Types of Expansive Soil Damage



The increase in soil volume as soils expand can cause damage to foundations. The most obvious manifestations of damage to buildings are sticking doors, uneven floors, and cracked foundations, floors, walls, ceilings, and windows. If damage is severe, the cost of repair may exceed the value of the building.

It does not take much movement to damage buildings. As little as a differential movement of 0.25 inches between adjacent columns can cause cracking in load-bearing walls of a 2-foot wide bay.

Houses and one-story commercial buildings are more apt to be damaged by the expansion of swelling clays than are multi-story buildings, which usually are heavy enough to counter swelling pressures. However, if constructed on wet clay, multi-story buildings may be damaged by shrinkage of the clay if moisture levels are substantially reduced, such as by evapotranspiration or by evaporation from beneath heated buildings.

Critical Facilities

There is only one critical facility belonging to Canadian County that is situated on high or very high expansive soils. This is the County Shop District No. 2, summarized in the following table and located in Figure 4-25. The normal operation of this facility is not at risk from the hazard. However, over time, foundations and walls could develop cracks, and water and wastewater pipes could break.

Table 4–29: Critical Facilities Vulnerability to Expansive Soils

ID	Name	Address	Type	Threat
1	County Shop District No 2	2305 S Evans Rd	County	High

Infrastructure

Canadian County does not operate water or sewer systems, and therefore has no pipelines exposed to damage from expansive soils. However, communities and people living in unincorporated Canadian County who are served by water lines from the rural water districts and neighboring jurisdictions remain at risk to such damage. Broken water mains serving areas with already marginal service could be impacted by breaks due to a combination of deteriorating infrastructure and expansive soils.

4.9.4 Expansive Soils Scenario

Since specific cost data is not available for the average damages per property incurred from expansive soils, it is not possible to include a realistic Expansive Soils Scenario. In future versions of this plan, research data may become available that will allow such a scenario to be constructed.

4.9.5 Future Trends

Soils in Canadian County's identified future-development areas are primarily classed as "low" and "moderate", but soils with a "high" and "very high" are also present to a lesser extent. The irony of "future development" in unincorporated Canadian County is that as areas develop along the fringes of existing cities, they are sooner or later incorporated into those communities and are no longer under County jurisdiction. Nevertheless, Canadian County will continue to have a High vulnerability to the damaging effects of expansive soils in five general areas that contain high and very high shrink/swell soils: (1) the northwestern corner, from Blaine County and Kingfisher county lines east to "the Mound" area around Calumet Rd.; (2) between the Kingfisher County line and NW 220th, and east from Cimarron Rd. to Frisco Rd.; (3) on both sides of US Hwy 81 north of Darlington Rd.; (4) south of El Reno and west of Union City, northeast of the intersection of 15th St. and Airport Rd.; and (5) south of I-40, in the undeveloped land between El Reno, Union City and Oklahoma City. These areas should be developed with caution, particularly regarding buried utilities.

Population

Direct threats to life or personal injury have not generally been documented or projected for expansive soils because of the nature of the hazard. The primary threat is economic over the long term.

Structures / Buildings

Damage to structures in Canadian County can be expected during and following any period of extended drought. This is especially true of structures that were built during a period of a drought followed by soaking rains that cause swelling of clays.

Critical Facilities

While expansive soils will not impact the ability of Canadian County's facilities built on "high" and "very high" shrink/swell soils to function or respond to emergencies, they could shorten the effective lifespan of the buildings, or require more than normal maintenance. Over time, long-term structural damage could place the building at risk if, for example, already weakened wall and foundation cracks are then exposed to the stress of a tornado or major earthquake.

Infrastructure

As Canadian County's infrastructure ages, particularly those parts that were built at the beginning of the last century, a prolonged period of drought could significantly speed their deterioration—as was seen in the high number of pipeline breaks in Oklahoma City and El Reno during the drought of 2011. Aging water mains, especially when originally constructed in wet soil, are especially vulnerable. The rehabilitation of roads and aging central business districts will likely include the replacement of much of the infrastructure that lies underground, especially if located in expansive soils. The use of the more flexible PVC or HDPE piping could reduce some of the impact of expansive soils, or at least lessen the costs of maintenance and repair.

4.9.6 Conclusion

Although the hazard is not sudden and catastrophic, like a tornado or flooding, expansive soils is a growing problem for Canadian County, particularly for the roads and aging underground infrastructure, including major water, gas and oil pipelines. This vulnerability was highlighted during the drought of 2011 when El Reno and Oklahoma City were plagued with water main breaks that required four times the normal rate of maintenance and the imposition of water rationing. If predictions of hotter summers and longer periods of drought become a reality, Canadian County's infrastructure could be increasingly vulnerable to damage by expansive soils. For this reason, Canadian County's overall vulnerability to the Expansive Soils hazard is considered to be High.

Update Changes

Identified significant changes made from previous Multi-Hazard Mitigation Plans from Canadian County, Calumet, El Reno, Mustang, Piedmont, and Union City are outlined in Appendix E. Changes are based on criteria outlined for Plan Updates in the Local Multi-Hazard Mitigation Planning Guidance document of July 1, 2008.

4.9.7 Sources

Landslides and Expansive Soils in Oklahoma, at Web address: www.ou.edu/special/ogs-pttc/earthsci/landsl.htm. Oklahoma Geological Survey, Earth Sciences, October, 1998. (Source no longer available)

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Luza, Kenneth V. and Kenneth S. Johnson, Geologic Hazards in Oklahoma, Oklahoma Geological Survey, 2005. http://www.ogs.ou.edu/pubsscanned/InfSeries/IS11.pdf

Understanding Soil Risks and Hazards: Using Soil Surveys to Identify Areas with Risks and Hazards to Human Life and Property. US Department of Agriculture, Gary Muckle, editor. ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Risks/risk_low_res.pdf

There are many items on water main breaks during the summer of 2011 in El Reno and Oklahoma City. See, for example, http://www.news9.com/story/15246943/okc-water-main-break-sends-geyser-into-the-air; http://www.koco.com/r/28593394/detail.html;