

**KANSAS GEOLOGICAL SURVEY
Open File Report 2007-22**

LAND SUBSIDENCE KIOWA COUNTY, KANSAS

May 2, 2007

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SITE LOCATION

The site was approximately four miles west and 13 miles south of the City of Greensburg, Kansas. The site was located in the Southwest quarter of the Northeast quarter of the Southeast quarter of Section 23, Township 30 south, Range 19 west, Kiowa, County, and was approximately 745 feet west and 2,230 feet north of the southeast corner of the section. Figure 1.—Site Location.

BACKGROUND INFORMATION

The Kansas Geological Survey (KGS) was contacted by State Representative Dennis McKinney, advising KGS of the subsidence and for assistance. On May 2, 2007, a field inspection was conducted by KGS, in cooperation with the property owner, Harold McKinney, and, District Office Supervisor: Steve Durrant, Kansas Corporation Commission (KCC).

KCC staff member Lindley Reimer, provided coordinates for subsidence features, Table 1.—GPS Point Coordinates Site Features.

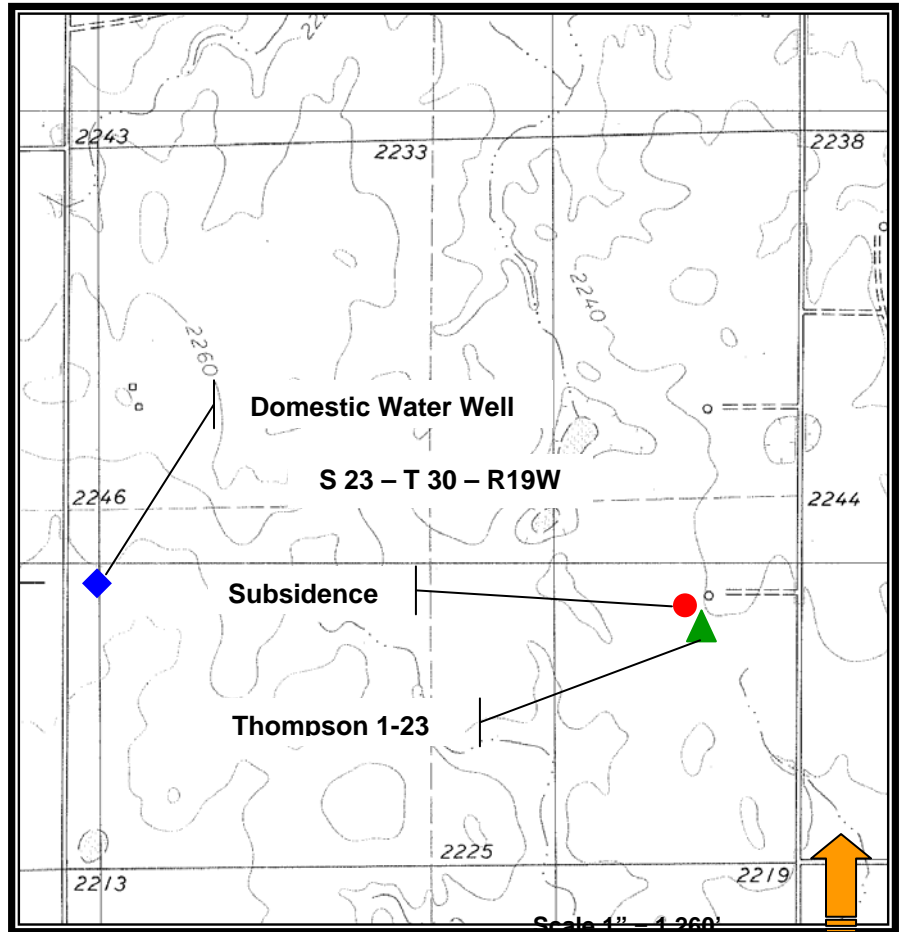


Figure 1.—Site Location Map

References included:
a) KGS Oil and Gas Well database, b) KGS Bulletin 65, c) KGS Water Well Completion Records database, d) KGS

Water Level database, e) Natural Resources Conservation Service Web Soil Survey and f) KGS Bulletin 162.

Property owner, Harold McKinney, was present during the field inspection and provided historical site information.

SURFACE TOPOGRAPHY, SOIL, AND LAND USE

Surface elevation at the proposed site ranged from 2,244 feet to 2,219 feet above mean sea level. The land surface slope ranged from one percent to 20 percent and surface drainage was predominantly to the southeast.

Site soil was Harney Silt Loam 1 to 3 percent slopes. The soil was described as deep, gently sloping, well drained, soils on uplands. The soil unit has a silt loam surface layer, a very firm silty clay loam and silty clay subsoil. The soil unit was not highly erodible. The soil's hydraulic conductivity (Ksat) was 6.7 micrometers per second and was based on soil characteristics observed in the field, particularly structure, porosity, and texture.

The numeric Ksat values have been grouped according to standard Ksat class limits. The classes are: Very low: 0.00 to 0.01; Low: 0.01 to 0.1; moderately low: 0.1 to 1.0; moderately high: 1 to 10; High: 10 to 100; Very high: 100 to 705

Land use was agricultural, predominately dryland grain production. For water conservation purposes, level terraces were constructed at the site.

HYDROGEOLOGY

The proposed site overlies a portion of the unconsolidated freshwater aquifer known as the High Plains aquifer. The aquifer is the principal source of freshwater for the site and region. Underlying the High Plains aquifer were consolidated rocks of the Cretaceous(?) and Permian systems which may yield small quantities of mineralized water to wells. Refer to Table 2 for a generalized geologic section for Kiowa County from alluvium, Quaternary System, to the Flowerpot Shale, Permian System.

Rocks in the Cretaceous system were predominantly shale, siltstone, and sandstone. Unconformities were present between younger rocks, Tertiary system, and older rocks, Permian system.

Rocks in the Permian system were predominantly sandstone, siltstone, gypsum, and salt. Thickness of evaporitic rocks in the Permian system ranged from 500 feet to 1,000 feet. Data from the Wheeler #1, API # 15-097-30205, located in the Northwest quarter of the Southeast quarter of the Southeast quarter Section 28, Township 30 south, Range 19 west, show top of the Hutchinson Salt member at 1,877 feet above mean sea level and base at 2,334 feet above mean sea level.

Site data for the Nippewalla group was sparse. Steve Durrant advised that a shallow lost circulation zone, less than 500 feet below land surface, was encountered while drilling several oil and gas wells in the area.

Data from the KGS High Plains Aquifer Section-Level Database for Township 30, Range 19 West, show average annual precipitation was 24.42 inches, USGS potential average annual recharge 1.60 inches, average hydraulic conductivity 75.69 ft/day, specific yield ranges from 10 to 18 and averages 13.5 and the average bedrock elevation was 2,087.90 feet above mean sea level.

Water well record (WWC5) data for a domestic water well drilled in January 1987 located less than a mile west of the site, Fig. 1, in the Northwest quarter of the Northwest quarter of the Southwest quarter of Section 23, Township 30 south, Range 19 west, described subsurface lithology as clay from land surface to 83 feet, gravel from 83 feet to 94 feet, clay from 94 feet to 120 feet, sandy clay from 120 feet to 158 feet, and shale from 158 feet to 190 feet.

Static water level in the completed domestic well was measured at 127 feet below land surface and the estimated yield of the well was five gallons per minute. Based on water well completion data the aquifer's saturated thickness was computed at 31 feet. The nearest WIZARD water level monitoring well was over six miles north of the site.

Fig. 2 shows oil and gas activity in Section 23, Township 30 south, Range 19 west. Located near the site was an abandoned and plugged oil well listed as the Thompson 1-23, as shown in Fig. 1. The well was drilled August 11, 1974 to a total depth of 5,154 feet below land surface. The well was plugged October 1, 1986. A gamma – neutron log was completed on the well from 3,000 feet bls to 5,148 feet bls.

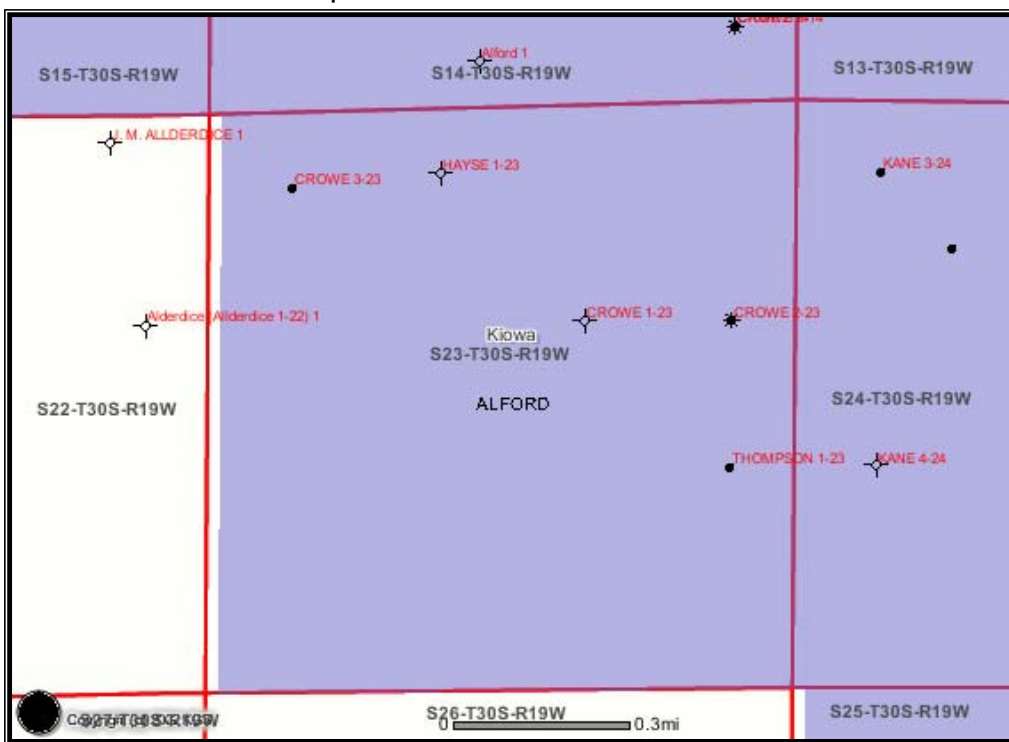


Figure 2.—Oil and Gas Activity

Images 1 through 6 show the site and radial cracks located to the north and south of the site. According to the landowner, the site appeared in the early 1990's. In the past five years, the rate of subsidence appeared to be increasing. Additionally, the radial cracks appeared about one to two years ago. No site data was measured or collected for the event period.

RECOMMENDATIONS

The following recommendations were made based on the findings of the field inspection and were not intended to limit or preclude other investigative actions. Funding and implementation of the recommendations were not within the scope of the report.

1. Establish at least one elevation bench mark(s) in the area of subsidence to monitor elevation changes.
2. For elevation control, establish or use an existing elevation bench mark away from the area of subsidence.
3. Measure both elevation bench marks a minimum of once a year.
4. Review the completion and plugging records for the Thompson 1-23 and other surrounding oil or gas wells to determine if fluid is migrating to the evaporitic rocks via the well borehole or casing.
5. Review the elevation data each year to determine elevation change.
6. Perform a literature review for similar subsidence phenomena in Kiowa County and the surrounding region.
7. Based on the findings and results of Recommendations 1 through 6, determine if a shallow seismic survey should be conducted at the site.

Table 1.—Kansas Corporation Commission, Conservation Division, GPS Point Coordinates Site Features survey.

Latitude	Longitude	Projection	Waypoint ID	Comments
37.4167	-99.358	NAD83;	WPT004	1st GPS Reading of South Crevice
37.4166	-99.359	NAD83;	WPT005	
37.4166	-99.359	NAD83;	WPT006	
37.4166	-99.359	NAD83;	WPT007	
37.4166	-99.359	NAD83;	WPT008	
37.4167	-99.359	NAD83;	WPT009	
37.4168	-99.359	NAD83;	WPT010	1st GPS Reading of Sink Pond Water's Edge
37.4172	-99.359	NAD83;	WPT011	
37.4174	-99.359	NAD83;	WPT012	
37.4175	-99.359	NAD83;	WPT013	
37.4177	-99.359	NAD83;	WPT014	
37.4178	-99.359	NAD83;	WPT015	
37.4176	-99.359	NAD83;	WPT016	
37.4174	-99.358	NAD83;	WPT017	
37.4172	-99.359	NAD83;	WPT018	
37.4183	-99.358	NAD83;	WPT019	1st Reading of NE Crevice
37.4184	-99.358	NAD83;	WPT020	

Table 2. shows a geologic section for the County from alluvium (Quaternary System) to the Flowerpot Shale (Permian System).

Table 2. – Generalized section of the geologic formations of Kiowa County,

SYSTEM	Series	Subdivision	Thickness (feet)	Physical character	Water supply	
Quaternary	Recent and Pleistocene	Alluvium	0-40 ±	Very coarse gravel, sand, and silt comprising stream deposits in Medicine Lodge Valley and the valleys of smaller streams.	Yields moderate amounts of water to wells in the larger stream valleys. (Well 73 in Soldier Creek Valley is reported to yield 180 gallons a minute.) Waters are very hard—three samples had from 316 to 1,782 parts per million of hardness.	
		unconformable on older formations				
		Terrace deposits	0-20 (?)	Sandy silt containing small amounts of sand and gravel occur as terrace deposits along Medicine Lodge Valley. These deposits together with certain slope-wash deposits probably are equivalent to the Gerlane formation. Coarse terrace gravels are believed to occur beneath dune sand in the northern part of the county.	Are believed to occur everywhere above the water table; therefore they probably would not yield water to wells.	
		unconformable on older formations				
		Dune sand	0-60 +	Fine- to medium-grained wind-blown sand. Covers approximately the northern third of Kiowa County.	Occurs above the water table; therefore it yields no water to wells. Serves as an important catchment area for recharge from local precipitation, however.	
			Kingsdown silt	0-100 +	Light-tan to brown silt and sandy silt containing some clay and stringers, nodules, and thin beds of lime carbonate; contains lenses of Pleistocene and Recent age in upper part, and minor amounts of sand and gravel in lower part. Underlies the surface in the upland area and in the Mule Creek drainage area.	Is above the water table everywhere in this area; hence does not supply water to wells.
	Pleistocene	Meade formation	300 +	Interbedded lenses of clay, silt, sand, and gravel that are lithologically similar to materials of the Ogallala formation, and are both consolidated and unconsolidated. Contains nodules, stringers, and irregular beds of caliche and locally volcanic ash.	Sand and gravel beds of the Meade and Ogallala formations are the most important sources of water in Kiowa County, and yield large supplies. Most of the domestic, stock, and industrial wells and all of the irrigation and public supply wells derive water from these deposits, and they also supply water to numerous springs in the southern part of the county. The water, although hard, is satisfactory for most purposes.	
Tertiary	Pliocene	Ogallala formation	65 +	Consolidated and unconsolidated, calcareous silt, sand, and gravel. Caliche occurs as cementing material, pipy concretions, nodules, or beds.		
		unconformable on older formations				
Cretaceous	Gulfian*	Dakota formation	90 +	Light-gray, blue-gray, yellow, yellow-tan, red, and mottled red and gray shale, sandy shale, and clay and tan to white and dark-brown, fine- to coarse-grained sandstone that is in part cemented with iron. Contains nodules, concretions, and thin beds of ironstone.	No wells are known to obtain water from the Dakota formation in this area, as adequate supplies of water of good quality are obtained from deposits above the Dakota.	
		unconformable on older formations				
	Comanchean*	Kiowa shale	300	Dark gray to black thinly laminated shale in lower part and gray, tan, brown, and red clay and clay shale in upper part. Contains thin beds of shell limestone and light- to dark-gray and white fine-grained sandstone. Large lense of yellow-tan to buff cross-bedded fine-grained sandstone occurs locally at top of formation. Also contains crystals of gypsum. Is exposed over a wide area in the southeastern part of the county.	Most of the materials of the Kiowa shale are relatively impermeable and will not yield water to wells. The large sandstone lense at the top of the formation supplies moderate amounts of water to one well (91) and several springs. The water is similar in quality to that from the Meade and Ogallala formations.	
		local disconformity (?)				
		Cheyenne sandstone	20-94	Light-colored fine- to coarse-grained friable cross-bedded sandstone and lenses of gray to black sandy carbonaceous shale. Contains lenses of pebble conglomerate at or near base, and also contains crystals of selenite, pyrite, nodules of iron, and remains of plants. Exposed in the southeastern part of the county.	Supplies water to a few stock and domestic wells in the south-central and southeastern parts of the county. Water in the Cheyenne sandstone is highly mineralized and locally is unfit for ordinary purposes.	
		unconformity				
	Guadalupian*	Whitehorse sandstone	60 +	Red poorly bedded fine-grained friable sandstone and siltstone containing minor amounts of shale. Crops out in the southeastern part of Kiowa County and in two small areas in the southwestern part.	Supplies small quantities of very hard water to a few wells (74, 81, and 82) in southeastern Kiowa County.	
Permian	Leonardian*	Nippewalla group	Dog Creek shale	50 ±	Red shale containing thin beds of light-gray and mottled red and light-gray fine-grained sandstone. Contains thin bed of light-gray shaly dolomite in lower part. Exposed in narrow bands along the sides of Medicine Lodge Valley in the southeastern part of Kiowa County.	Relatively impermeable; not known to yield water to wells in Kiowa County.
			Blaine formation (Medicine Lodge gypsum member)	22 ±	White massive gypsum; weathers to light gray. Other members of the Blaine formation are missing in this area.	Not known to yield water to wells.
			Flowerpot shale	200 -	Dark red-brown to reddish-purple shale containing many thin and a few thick beds of sandstone. Contains gypsum in veins and as cementing material. Not exposed in Kiowa Co.	Supplies highly mineralized water to one well (55) in this area, but is not an important water-bearer.

* The classification here shown, which is used by the State Geological Survey of Kansas, differs somewhat from that employed by the Federal Geological



Image 1.—Kiowa County subsidence SE 23-30-19W, northwest view, by MT Dealy, KGS



Image 2.—Kiowa County subsidence SE 23-30-19W, southwest view, by MT Dealy, KGS



Image 3.-- Kiowa County Subsidence, SE 23-30-19W, radial crack south of subsidence, northeast view, by MT Dealy, KGS



Image 4. -- Kiowa County Subsidence, SE 23-30-19W, radial crack south of subsidence, east view, Lindley Reimer, KCC, by MT Dealy, KGS



Image 5 - Kiowa County Subsidence, SE 23-30-19W, radial crack north of subsidence, southeast view, by MT Dealy, KGS



Image 6 - Kiowa County Subsidence, SE 23-30-19W, radial crack north of subsidence, northwest view, by MT Dealy, KGS -