

**KANSAS GEOLOGICAL SURVEY
Open File Report 2009-02**

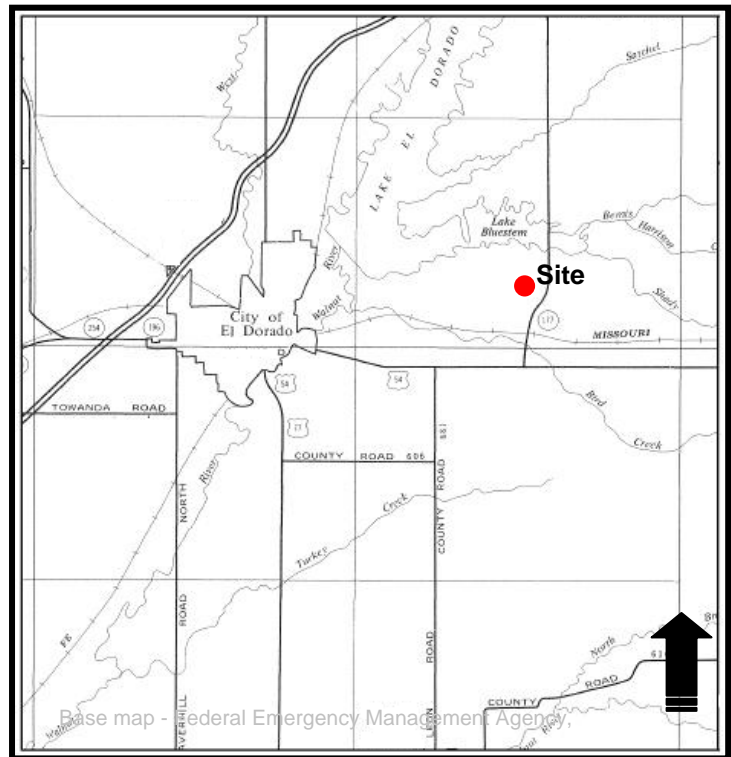
RECONNAISSANCE OF A SUBSIDENCE FEATURE IN BUTLER COUNTY, KANSAS

Prepared by
Michael T. Dealy, L.G.
February 1, 2009

SITE LOCATION

The site was approximately five miles east of the City of El Dorado, Kansas, and a mile south of El Dorado Reservoir, Figure 1. The site's global coordinates were 37° 49' 44.78" Latitude and -96° 45' 41.15" Longitude¹, Appendix - Exhibit 'A'.

Based on the global coordinates, the public land survey system description was computed to be the Southwest quarter of the Northeast quarter of the Southwest quarter of Section 34, Township 25 South, Range 06 East, Butler County, Kansas, and was located approximately 1,575 feet north and 3,581 feet west of the southeast corner of the section², Figure 2, Appendix - Exhibit 'B'.



BACKGROUND INFORMATION

The land owner first observed the feature July 2007 in a native grass hayland. Figure 1.—Site Location

The feature's shape was circular and was six feet in diameter and 30 feet deep. The land owner backfilled the feature October 2007 and submitted a plugging report to the Kansas Department of Health and Environment (KDHE), Appendix - Exhibit 'C'.

After a cutting of native grass in the summer 2008, the land owner observed the backfill had settled about three feet. Additionally, the land owner noted that the backfill material appeared to be churned up³. The land owner contacted Sandy Koontz, Butler County Conservation District (BCCD), about the feature and a field inspection was conducted by BCCD staff July 23, 2008, Appendix - Images 1 and 2.

¹ Fieser, Carey W., Natural Resources and Conservation Service, El Dorado Service Center, September 30, 2008

² LEO 7.0 – Geographic Conversion Program, Kansas Geological Survey, April 6, 2008

³ Koontz, Sandy, email, Butler County Conservation District, September 18, 2008

The Kansas Geological Survey (KGS) was contacted by the BCCD, advising KGS of the feature and requesting assistance with determining its cause.

On October 1, 2008, a field inspection was conducted by KGS, in cooperation with Sandy Koontz, BCCD, Appendix – Image 3.

SURFACE TOPOGRAPHY, SOIL, AND LAND USE

Surface elevation at the site ranged from 1,390 feet to 1,395 feet above mean sea level, Figure 2. The site was located in the Flint Hills Uplands Physiographic Province⁴, Figure 3.

Surface slope ranged from one percent to three percent and surface drainage was predominantly to the south.

Site soil was Labette-Dwight complex, one to three percent slopes, Appendix - Exhibit 'D'.

The Labette component makes up 50 percent of the map unit. Slopes are one to three percent. This component is on hill slopes on uplands. The parent material consists of silty and clayey residuum weathered from limestone and shale. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is well drained. Water movement ranged from very low to moderately high capacity to transmit water and is moderately low in the most restrictive soil layer. Shrink-swell potential is very high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about two percent. This soil does not meet hydric criteria⁵.

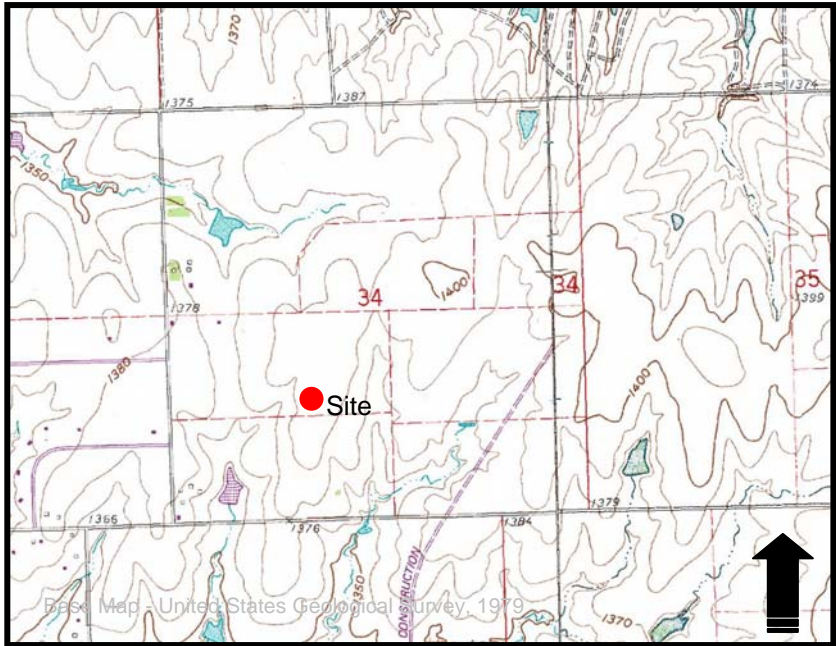


Figure 2.—Surface Topography

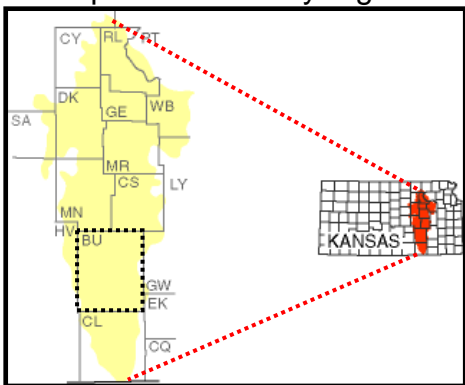


Figure 3. – Flint Hills Uplands Region

The Dwight component makes up 40 percent of the map unit. Slopes are one to three percent. This component is on hill slopes on uplands. The parent material consists of silty and clayey residuum weathered from cherty limestone. Depth to a root restrictive layer, bedrock, lithic, is 20 to 40 inches. The natural drainage class is moderately well drained. Water movement ranged from very low to moderately low capacity to transmit water

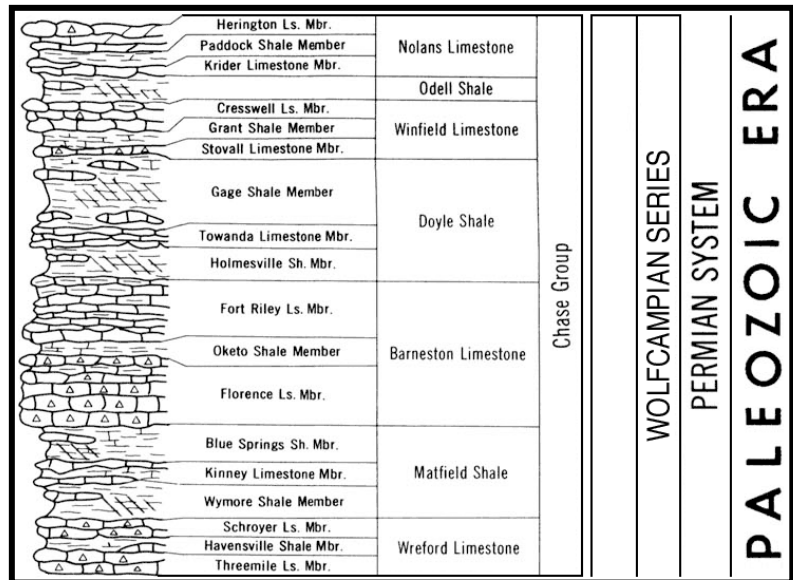
⁴ Physiographic Map, Kansas Geological Survey, <http://www.kgs.ku.edu/Physio/flinthil.html>, January 15, 2009

⁵ Web Soil Survey 2.1, National Cooperative Soil Survey, Natural Resources Conservation Service, January 9, 2009

and is low in the most restrictive soil layer. Available water to a depth of 60 inches is low. Shrink-swell potential is very high. This soil is not flooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about four percent. This soil does not meet hydric criteria. The soil has a very slightly saline horizon within 30 inches of the soil surface. The soil has a moderately sodic horizon within 30 inches of the soil surface⁵.

The soil's saturated hydraulic conductivity (Ksat) was moderately high, 1.53 micrometers per second, and was calculated using the Aggregation Method and a Dominant Component. Ksat refers to the ease with which pores in a saturated soil transmit water. The estimates are expressed in micrometers per second and are based on soil characteristics observed in the field, particularly structure, porosity, and texture. For each soil layer, this attribute is recorded as three separate values. A low value and a high value indicate the range of this attribute for the soil component. A "representative" value indicates the expected value of this attribute for the component. For this soil property, only the representative value is used⁵.

The numeric Ksat values have been grouped according to standard Ksat class limits and were 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 705⁵.



Land use was native hayland.

Figure 4.—Stratigraphic Relationships of the Chase Group

HYDROGEOLOGY

Site surficial geology is composed entirely of Doyle Shale, Permian System, Lower Permian Series, Chase Group⁶, Appendix - Exhibit 'E'.

Underlying the Doyle Shale are the Barneston Limestone, Matfield Shale, and the Wreford Limestone (Chase Group). Figure 4 illustrates the stratigraphic relationships of the Chase Group geologic units⁷. The Chase Group is made up of approximately 335 feet of escarpment-making limestones alternating with shales. The shale formations are

⁶ Aber, J.S., Geologic map, Butler County: Kansas Geological Survey, Map M-30, 1994

⁷ Sawin, R.S., Franseen, E.K., West, R.R., Ludvigson, G.A., and Watney, W.L., Clarification and Changes in Permian Stratigraphic Nomenclature in Kansas; *in*, Current Research in Earth Sciences: Kansas Geological Survey, Bulletin 254, part 2., 2008,

characterized by shades of red and green. The thick chert-bearing limestones are a prominent topographic feature in the Flint Hills⁸.

Site subsurface data was sparse. Query results of KGS WWC5 and the master list of oil and gas well databases found no wells or test holes located at the site.

Additionally, BCCD contacted the U.S. Army Corps of Engineers (USACE) to determine if any test holes had been drilled at the site during the construction of El Dorado Reservoir. USACE advised no test holes were drilled at the site⁹.

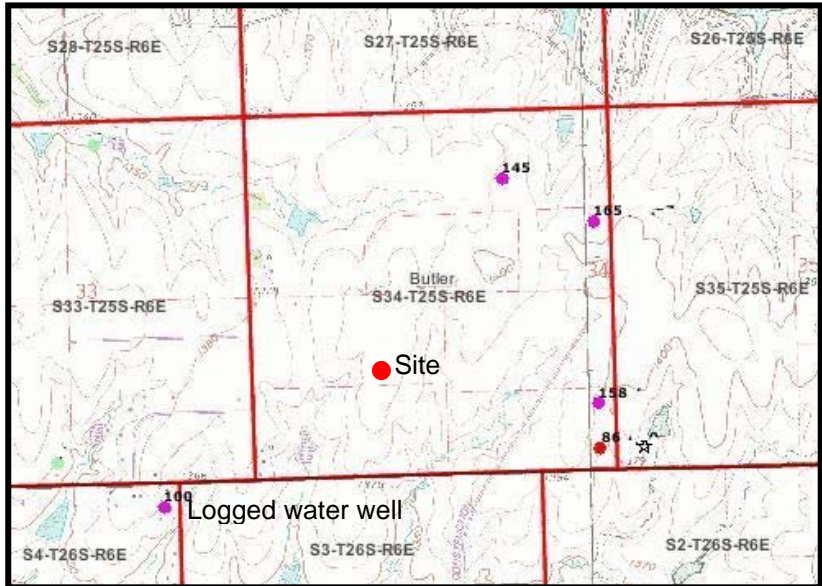


Figure 5. – Location of water well with well depth

Several water wells, Figure 5, and oil and gas wells, Figure 7, were located less than a mile from the site.

A water well was drilled and logged in the Northeast quarter of the Northeast quarter of the Northeast quarter Section 4, Township 25 South, Range 6 East, Figure 5. The well was drilled in 1981 and was located less than a mile southwest of the site. The drilling log, Figure 6, illustrates the alternating beds of limestone (tan) and shale (green) encountered to a depth of 100 feet below land surface (bls).

From (feet)	To (feet)	Description
0	2	Clay, brown
2	5	Limestone, weathered
5	19	Limestone, w/chert
19	21	Shale, olive
21	31	Limestone, buff medium
31	52	Limestone, cream, w/chert
52	66	Limestone, brown, w/chert
66	79	Shale, calc, grey
79	84	Shale, green
84	88	Shale, red
88	94	Limestone, light grey
94	100	Shale, dark grey

Figure 6.—Driller’s log

Figure 6, illustrates the alternating beds of limestone (tan) and shale (green) encountered to a depth of 100 feet below land surface (bls). Static water level in the well was 46 feet bls in April 1981. The estimated yield of the well was 0.5 gpm¹⁰.

Water-saturated rock in the Chase Group, consisting mostly of limestone and shale, yields small quantities of water to water wells and comprise the site aquifer. Groundwater availability is marginal with well yields less than 50 gallons per minute (gpm). Figure 5 shows the location of site water wells and the reported well depth. The nearest water well is over a

⁸ Zeller, D.E., The Stratigraphic Succession in Kansas, Kansas Geological Survey, Bulletin 189, 1968

⁹ Koontz, Sandy, email, Butler County Conservation District, October 2, 2008

¹⁰ J.C. McNee Drilling, Water Well Completion Record (WWC5), Kansas Department of Health and Environment, 1981

half-mile from the site.¹¹ Based on data from water well completion records for a 36 mi² area around the site, there were 16 water wells with pumping yields ranging from less than one gpm to 40 gpm and averaging 13 gpm. Well depths range from 54 feet to 165 feet and average 124 feet. Depth to water ranged from 15 feet bls to 60 feet bls and averaged 37 feet bls. Sixty-eight percent of the water wells were completed for domestic use, 13 percent livestock and lawn irrigation and six percent irrigation.

The land owner submitted a water well plugging record to KDHE October 2007 certifying the feature was plugged, Appendix - Exhibit 'C'. The record indicated the 30 foot deep feature did not have a static water level.

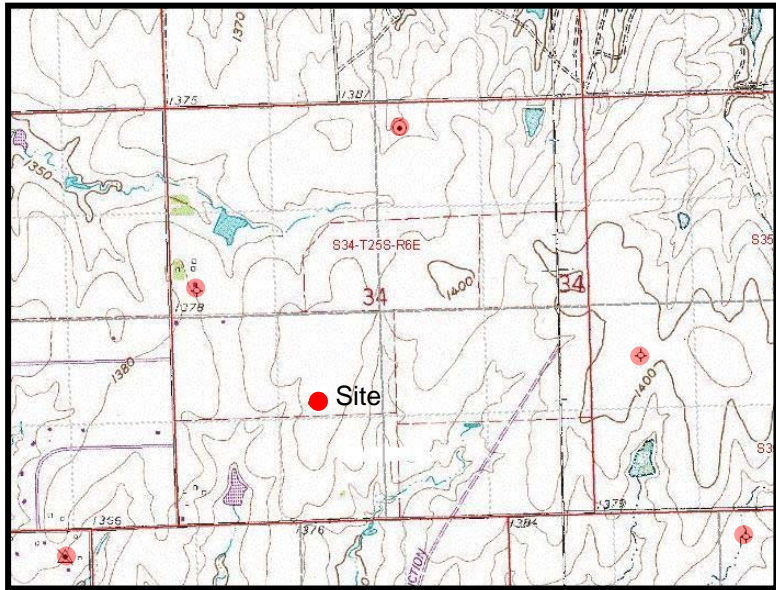


Figure 7. – Location of oil and gas wells

KARST FEATURES

Karst terrain or topography is characterized by sinkholes, depressions, caves, and underground drainage. The terrain is generally underlain by soluble rocks, such as limestone, gypsum, and dolomite, in which topography is influenced by dissolving rock. Karst features have been found in five limestone beds in the Flint Hills region. Four of these units, the Cresswell Limestone Member, the Fort Riley Limestone, the Florence Limestone Member and the Threemile Limestone Member, are in the Chase Group¹², Figure 4. Except for the Cresswell Limestone Member, all other limestone members underlie the site.

Known sinkholes in Butler County and the site location of the feature are shown in Figure 8¹³. Zones of dense sinkhole development are associated with several structural and topographic conditions:

1. structural crests of anticlines,
2. portions of active oil fields,
3. upland drainage divides,
4. nearly level to gently sloping land surface,
5. entrenched river valleys nearby, and
6. lack of thick surficial cover (chert gravel or loess).

¹¹ Water Well Completion Records (WWC5) Database, Kansas Geological Survey, January 9, 2009

¹² Young, J. and Beard, J., Caves in Kansas, Kansas Geological Survey, Educational Series 9, 1993

¹³ Modified from Aber, J.S., Emporia State University, Surficial Geology of Butler County, Kansas, Final Report, Kansas Geological Survey Open-file Report 1991-48, 1991

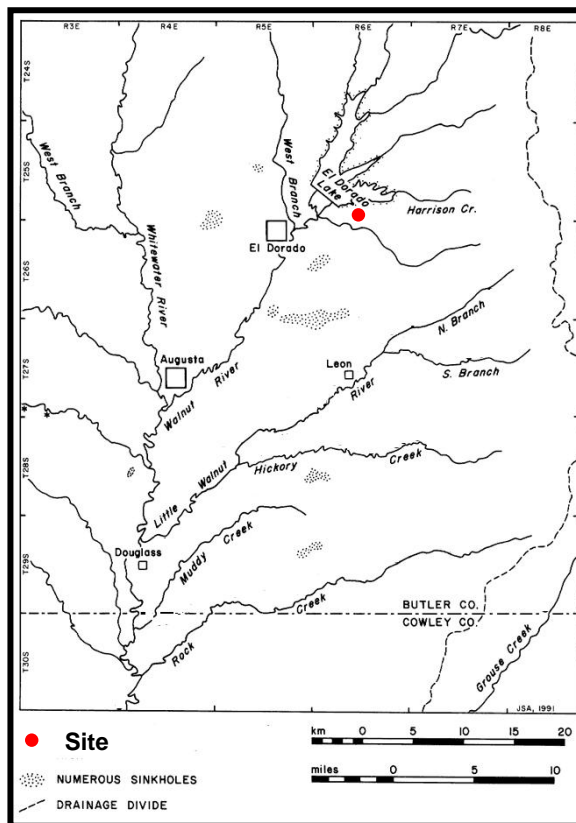
These factors in combination are thought to enhance the possibility for vertical drainage of water into highly fractured, soluble bedrock with resulting sinkhole solution. Many springs and caves are in the vicinity of sinkhole zones, especially in the region between El Dorado and Leon¹⁴.

The site has two karst conditions described by Aber: an anticline and level to gently sloping surface topography. To the north of the site, sinkholes are found around El Dorado Reservoir and to the south numerous sinkholes have been located, Figure 8.

FINDINGS AND CONCLUSION

Based on information provided by the Butler County Conservation District, published and unpublished reports, and the field inspection, the following site findings were made:

- 1) the site was located in SW NE SW 34-25-6E, Butler County, Kansas;
- 2) the site was located in the Flint Hills Figure 8.— Sinkholes in Butler County Uplands Physiographic Province;
- 3) site soils are well drained and have a very low to moderately high capacity to transmit water;
- 4) surficial geology is composed entirely of Doyle Shale, a formation in the Permian System, Lower Permian Series, Chase Group;
- 5) underlying the Doyle Shale are the Barneston Limestone, Matfield Shale, and the Wreford Limestone of the Chase Group;
- 6) the land owner initially observed the subsidence feature July 2007 in a native hay field;
- 7) the feature's shape was largely circular, six feet in diameter, 30 feet deep, and was dry throughout;
- 8) the land owner completely backfilled the feature October 2007;
- 9) query results of KGS WWC5 and the master list of oil and gas well databases indicated wells or test holes were not located at the site;
- 10) U.S. Army Corps of Engineers advised test holes were not drilled at the site during the construction of El Dorado Reservoir;



¹⁴ Aber, J.S., Emporia State University, Surficial Geology of Butler County, Kansas, Final Report, Kansas Geological Survey Open-file Report 1991-48, 1991

- 11) karst terrain or topography is characterized by sinkholes, depressions, caves, and underground drainage;
- 12) karst terrain is generally underlain by soluble rocks, such as limestone, gypsum, and dolomite, in which topography is chiefly formed by dissolving rock;
- 13) karst features have been found in five limestone beds in the Flint Hills Uplands;
- 14) four of these units, the Cresswell Limestone Member, the Fort Riley Limestone, the Florence Limestone Member, and the Threemile Limestone Member, are in the Chase Group;
- 15) all except the Cresswell Limestone Member underlay the site;
- 16) structural and topographic conditions associated with sinkhole development exist at the site, including an anticline and level to gently sloping surface topography;
- 17) north and south of the site, sinkholes have been observed and described in various reports; and
- 18) between El Dorado and Leon numerous sinkholes and karst features have been reported.

Based on the report findings, the subsidence feature appears to be a natural sinkhole caused by vertical drainage of water into fractured, soluble limestone with resulting sinkhole solution.

Because of site surface conditions and the regional hydrology and geology that are favorable to karst, the sinkhole may continue to develop and may not be an isolated karst feature. For safety purposes it is recommended that the feature's protective fencing is maintained and caution used as other karst features may develop in the vicinity.

Appendix, Exhibit 'A'

Global Position Coordinates and Site Image



Appendix, Exhibit 'B'

LEO 7.0 Geographic Coordinate Conversion of Feature

Kansas TRS = 25S06E34
Kansas STR = 34 T25S R06E

Township 25 Range 6E Section 34

Approximately 637 acres

length of north line = 5267 Ft

length of south line = 5250 Ft

length of east line = 5273 Ft

length of west line = 5279 Ft

Spot Footage 1575' N of South line & 3581' W of East line

Spot Northwest corner of SE SW NE SW subdivision of Section

NAD83 Datum

Latitude = 37.8291660 Longitude = -96.7613880

DMS Lat 37° 49' 44.99" Lon -96° 45' 40.99"

Deg MM.mm Lat 37° 49.7499' Lon -96° 45.6832'

UTM Northing = 4189222.06 Easting = 697011.86 Zone = 14

NW 37.8393120	NE 37.8393730
-96.7672570	-96.7490210

SW 37.8248170	SE 37.8248930
-96.7671500	-96.7489760

UTM coordinates:

NW 4190335.59 N	NE 4190380.9 N
696468.36 E	698073.07 E

SW 4188727.3 N	SE 4188774.14 N
696516.24 E	698115.77 E

Appendix - Exhibit 'C'

Plugging Record for Subsidence Feature

WATER WELL PLUGGING RECORD Form WWC-5P KSA 82a-1212

1 LOCATION OF WATER WELL:	Fraction	Section Number	Township Number	Range Number																											
County: <u>Butler</u>	<u>SW 1/4 NE 1/4 SW 1/4</u>	<u>34</u>	<u>25</u>	<u>6E</u>																											
Distance and direction from nearest town or city street address of well if located within city?																															
2 WATER WELL OWNER: <u>Richard Griffin</u>																															
RR#, St. Address, Box #: <u>250 NE Cole Creek Rd.</u>			Board of Agriculture, Division of Water Resources																												
City, State, ZIP Code: <u>Eldorado, KS 67042</u>			Application Number:																												
3 MARK WELL'S LOCATION WITH AN "X" IN SECTION BOX: N	4 DEPTH OF WELL..... <u>25.30</u>ft.																														
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr><td style="width: 25%; text-align: center;">N</td><td style="width: 25%; text-align: center;">W</td><td style="width: 25%; text-align: center;">E</td></tr> <tr><td style="width: 25%; text-align: center;">W</td><td style="width: 25%; text-align: center;">X</td><td style="width: 25%; text-align: center;">E</td></tr> <tr><td style="width: 25%; text-align: center;">S</td><td style="width: 25%; text-align: center;">W</td><td style="width: 25%; text-align: center;">E</td></tr> </table>	N	W	E	W	X	E	S	W	E	WELL'S STATIC WATER LEVEL..... <u>0</u>ft.																					
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4 Industrial	8 Air Conditioning	12 Other..... <u>Well casing</u>																													
Was a chemical/bacteriological sample submitted to Department? Yes.....No.. <u>X</u> .																															
If yes, mo/day/yr sample was submitted.....																															
Water Well Disinfected: Yes..... No.. <u>X</u>																															
5 TYPE OF BLANK CASING USED:																															
<table style="width: 100%; border: none;"> <tr> <td style="width: 25%;">1 Steel</td> <td style="width: 25%;">3 RMP (SR)</td> <td style="width: 25%;">5 Wrought</td> <td style="width: 25%;">7 Fiberglass</td> </tr> <tr> <td>2 PVC</td> <td>4 ABS</td> <td>6 Asbestos-Cement</td> <td>8 Concrete Tile</td> </tr> </table>					1 Steel	3 RMP (SR)	5 Wrought	7 Fiberglass	2 PVC	4 ABS	6 Asbestos-Cement	8 Concrete Tile																			
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6 GROUT PLUG MATERIAL: 1 Neat cement 2 Cement grout 3 <u>Bentonite</u> 4 Other.....																															
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What is the nearest source of possible contamination:																															
<table style="width: 100%; border: none;"> <tr> <td style="width: 25%;">1 Septic tank</td> <td style="width: 25%;">6 Seepage pit</td> <td style="width: 25%;">11 Fuel storage</td> <td style="width: 25%;">16 Other (specify below)</td> </tr> <tr> <td>2 Sewer lines</td> <td>7 Pit privy</td> <td>12 Fertilizer storage</td> <td rowspan="4"><u>Hay land</u></td> </tr> <tr> <td>3 Watertight sewer lines</td> <td>8 Sewage lagoon</td> <td>13 Insecticide storage</td> </tr> <tr> <td>4 Lateral lines</td> <td>9 Feedyard</td> <td>14 Abandoned water well</td> </tr> <tr> <td>5 Cess Pool</td> <td>10 Livestock pens</td> <td>15 Oil well/Gas well</td> </tr> </table>					1 Septic tank	6 Seepage pit	11 Fuel storage	16 Other (specify below)	2 Sewer lines	7 Pit privy	12 Fertilizer storage	<u>Hay land</u>	3 Watertight sewer lines	8 Sewage lagoon	13 Insecticide storage	4 Lateral lines	9 Feedyard	14 Abandoned water well	5 Cess Pool	10 Livestock pens	15 Oil well/Gas well										
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Direction from well? How many feet?																															
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;">FROM</th> <th style="width: 15%;">TO</th> <th style="width: 70%;">PLUGGING MATERIALS</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">30'</td> <td style="text-align: center;">27'</td> <td style="text-align: center;">Gravel & Sand</td> </tr> <tr> <td style="text-align: center;">27'</td> <td style="text-align: center;">8'</td> <td style="text-align: center;">Fill</td> </tr> <tr> <td style="text-align: center;">8'</td> <td style="text-align: center;">4'</td> <td style="text-align: center;">Plug - Bentonite</td> </tr> <tr> <td style="text-align: center;">4'</td> <td style="text-align: center;">0'</td> <td style="text-align: center;">Fill - top soil</td> </tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>					FROM	TO	PLUGGING MATERIALS	30'	27'	Gravel & Sand	27'	8'	Fill	8'	4'	Plug - Bentonite	4'	0'	Fill - top soil												
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7 CONTRACTOR'S OR LANDOWNER'S CERTIFICATION: This water well was plugged under my jurisdiction and was completed on (mo/day/year)..... and this record is true to the best of my knowledge and belief. Kansas Water Well Contractor's License No. This Water Well Record was completed on (mo/day/year)..... under the business name of by (signature)																															

Kansas Dept. of Health & Environment
 Bureau of Water - Geology Section
 1000 SW Jackson Street, Suite 420

3 Copies to KDHE
 1 Copy to Well Owner
 1 Copy to Contractor

Appendix - Exhibit 'D' Site Soil Description

Map Unit Description: Labette-Dwight complex, 0 to 3 percent slopes–Butler County, Kansas

Table 1.--Site Soil

Butler County, Kansas

4744—Labette-Dwight complex, 0 to 3 percent slopes

Map Unit Setting

Elevation: 800 to 2,600 feet
Mean annual precipitation: 31 to 47 inches
Mean annual air temperature: 54 to 61 degrees F
Frost-free period: 190 to 225 days

Map Unit Composition

Labette and similar soils: 50 percent
Dwight and similar soils: 40 percent

Description of Labette

Setting

Landform: Hillslopes
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Silty and clayey residuum weathered from limestone-shale

Properties and qualities

Slope: 1 to 3 percent
Depth to restrictive feature: 20 to 40 inches to lithic bedrock
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately high (0.00 to 0.20 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 5 percent
Available water capacity: Low (about 5.1 inches)

Interpretive groups

Land capability (nonirrigated): 3e
Ecological site: Loamy Upland (Draft) (PE 30-36) (R076XY015KS)

Typical profile

0 to 13 inches: Silty clay
13 to 18 inches: Silty clay
18 to 30 inches: Silty clay
30 to 38 inches: Silty clay
38 to 42 inches: Unweathered bedrock

Description of Dwight

Setting

Landform: Hillslopes
Landform position (three-dimensional): Crest
Down-slope shape: Convex
Across-slope shape: Convex

Appendix - Exhibit 'D', continued Site Soil Description

Map Unit Description: Labelle-Dwight complex, 0 to 3 percent slopes--Butler
County, Kansas

Table 1.--Site Soil

Parent material: Silty and clayey residuum weathered from
limestone, cherty

Properties and qualities

Slope: 1 to 3 percent

Depth to restrictive feature: 20 to 40 inches to lithic bedrock

Drainage class: Moderately well drained

Capacity of the most limiting layer to transmit water (Ksat): Very low
to moderately low (0.00 to 0.06 in/hr)

Depth to water table: More than 80 inches

Frequency of flooding: None

Frequency of ponding: None

Maximum salinity: Nonsaline to slightly saline (0.0 to 8.0 mmhos/cm)

Sodium adsorption ratio, maximum: 18.0

Available water capacity: Low (about 4.7 inches)

Interpretive groups

Land capability (nonirrigated): 4e

Ecological site: Claypan (Draft) (Peer Review) (PE 30-36)
(R076XY005KS)

Typical profile

0 to 5 inches: Silt loam

5 to 26 inches: Silty clay

26 to 33 inches: Silty clay loam

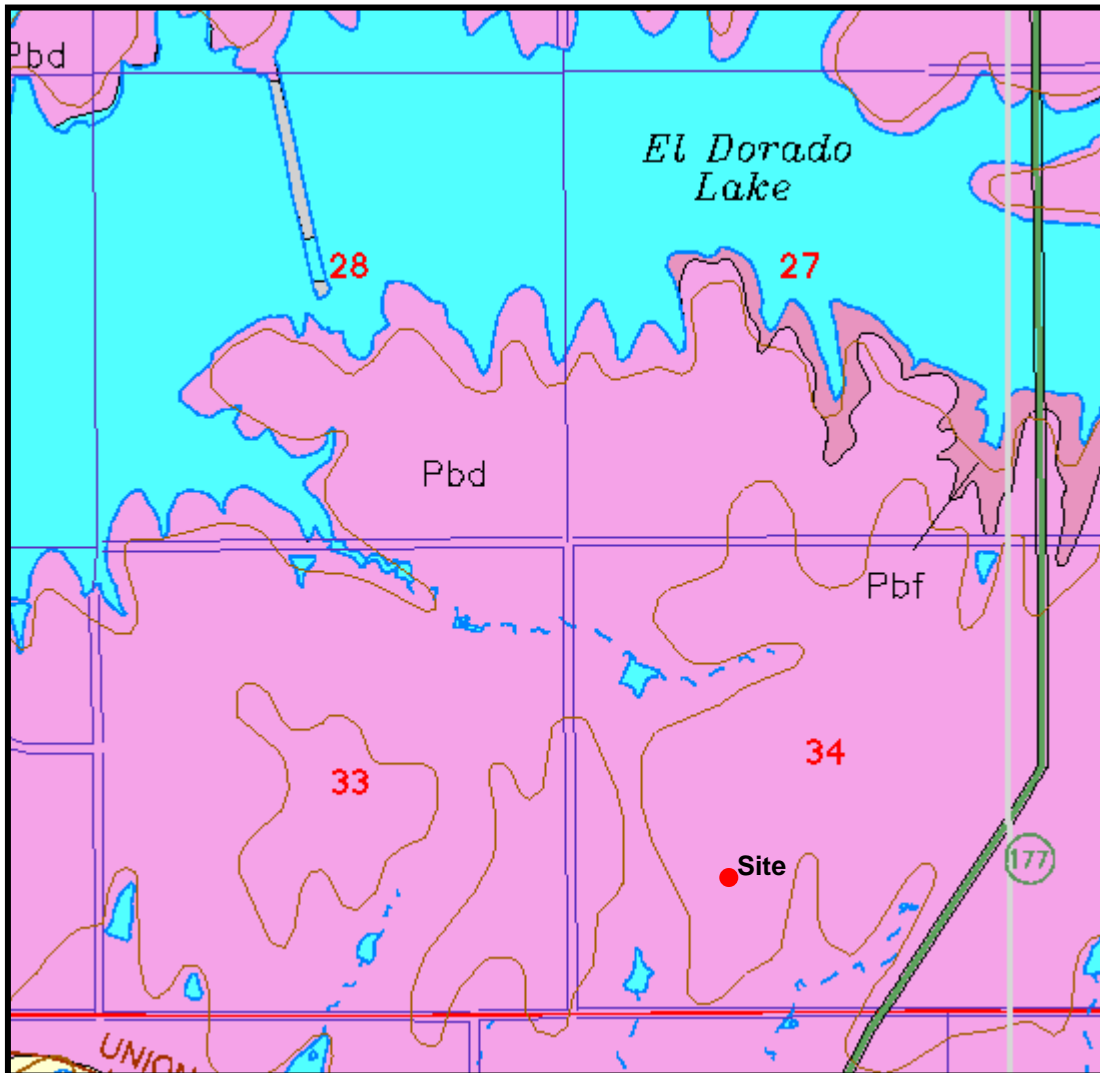
33 to 37 inches: Unweathered bedrock

Data Source Information

Soil Survey Area: Butler County, Kansas
Survey Area Data: Version 7, Nov 17, 2008

Appendix - Exhibit 'E'

Surficial Geology



Quaternary		Permian		Pennsylvanian	
Ql	Loess	Sumner Group	Council Grove Group	Admire Group	
Qt	Terrace	Pwe Wellington Fm	Pf Speiser Sh	Grenola Ls	
Qal	Alluvium	Hollenberg Ls	Funston Ls	Roca Sh	
		Chase Group	Pc Blue Rapids Sh	Red Eagle Ls	
		Pn Nolans Ls	Crouse Ls		
Tertiary		Pwi Winfield Ls	Pbe Easley Creek Sh		
Tg	Chert Gravels	Pbd Doyle Sh	Bader Ls		
		Pbf Barneston Ls	Stearns Sh		
		Pm Matfield Sh	Beattie Sh		
		Pwr Wreford Ls	Pe Eskridge Sh		
			Neva Ls		



Image 1.—Backfilled sinkhole SW 34-25-06E, north view direction, by S Koontz, BCCD, July 2008



Image 2.— Backfilled sinkhole SW 34-25-06E, south view direction, by S Koontz, BCCD, July 2008



Image 3.—Backfilled sinkhole SW 34-25-06E, south view direction, by MT Dealy, KGS, October 2008