SUBSURFACE MIGRATION OF OIL AND GAS DRILLING WASTES FROM AN ABANDONED STRIP PIT, GOWEN, LATIMER COUNTY, OKLAHOMA

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J. Fred Heitman
Environmental Specialist

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INTRODUCTION

From the 1920's through the 1950's, coal was actively mined throughout Pittsburg and Latimer Counties in eastern Oklahoma. The coal was mined in both surface (strip) and underground mines in the area around the western Latimer County community of Gowen. In the 1920's surface entrances to the underground mines originated in the valley floor and followed the down-dip of the coal toward a syncline. Later the coal was mined up dip. The mine sub-mains and laterals trend east to west along the strike of the coal. Surface mining occurred horizontally (east to west) along the strike of an outcrop of the upper Hartshorne coal and resulted in a number of abandoned strip pits. There are several hundred acres. Retired miners have reported that these mines were directly connected by illegal removal of the separating walls in some of the chambers and that the surface mines also broke into the upper chambers of the underground mines. Depth of the underground mines varied depending on distance from the crop line and degree of dip, but never exceeded 650 feet below the valley floor.

The community of Gowen lies in a valley bounded on the north, east, and south by a horseshoe shaped ridge where the coal outcrops. This ridge contains numerous strip mines and entrances and air portals to the underground mines. Along the north ridge to the west of Gowen lies a series of strip mines (Figure 1). Individual strip pits in this series lie adjacent to and/or on entrances to some of the underground mines.

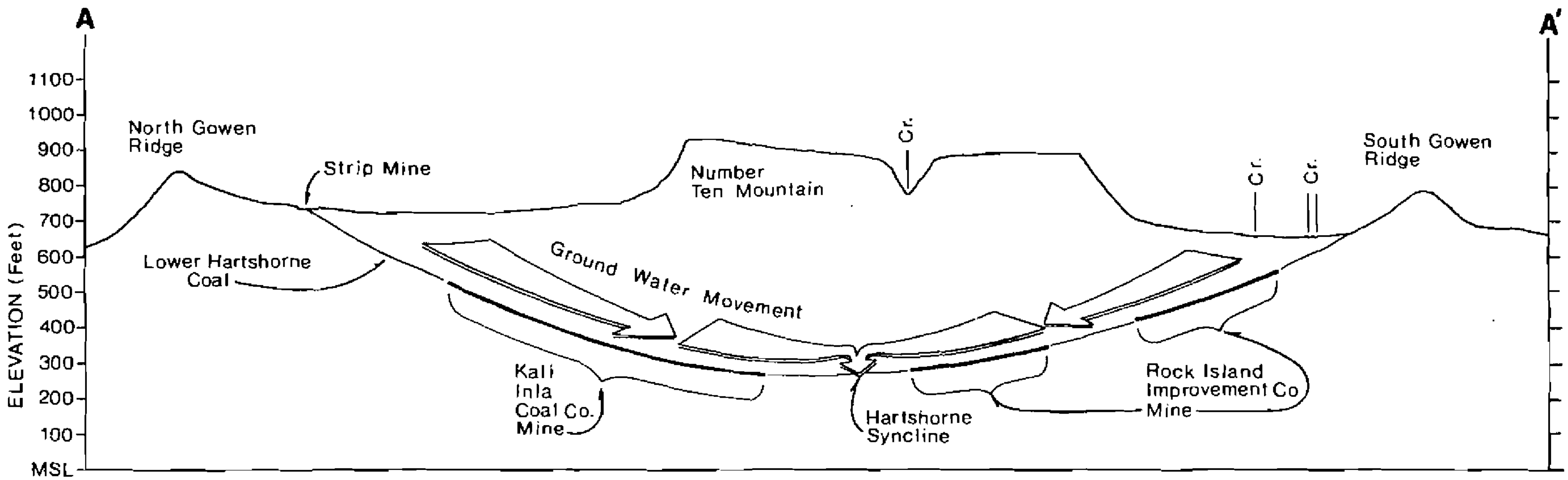

Figure 1. Cross-sectional view of the Gowen area showing the location of underground mines and direction of groundwater movement.

The westernmost pit in the series of pits was permitted by the Oklahoma Corporation Commission (OCC) to be used as a disposal site for oil and gas field wastes (Emergency Order 191496, June 2, 1981) for Fluid Haulers, Inc. of McAlester. The decision was later reversed (Order No. 210795, March 12, 1982) and the area around the Fluid Haulers pit was to be fenced and the pit emptied of all fluids and leveled. Fluid Haulers objected to the portion of the order that required the pit to be emptied and leveled.

On October 22, 1982, a hearing was held before an OCC Trail Examiner to determine if the pit was to be emptied and leveled. The Trail Examiner decided that the case would be continued before the Corporation Commission en banc. During the original hearing there was no discussion of Fluid Haulers being required to empty the pit of all fluids. As a result, on November 1, 1982, the Corporation Commission determined (Order No. 227860) that the words "shall be emptied of all fluids" in the second paragraph of OCC Order No. 210795 be stricken.

Throughout this investigation local residents have been very concerned about direct hydrologic connections between the Fluid Haulers pit and the underground mines and surface and groundwater supplies. To determine if such a connection exists a basic knowledge of strip pit construction and physiographic knowledge of the area is useful. The strip mines along the north Gowen ridge were developed along the coal outcrop and mined laterally along the strike of the coal. The depth of these mines, therefore, was relatively shallow and probably never significantly exceeded the depth of the coal at that point. Therefore, in a simplistic sense a long hole was dug in the ground and the coal removed from the hole. Therefore, along the high wall of the strip pit a cross-section of the geological sructure down to and including the coal seam became exposed to the elements. Through groundwater infiltration, precipitation, and surface runoff the pits fill with water. Water is then in direct contact with the exposed geology including the coal seam at the bottom of the strip pit. The Hartshorne coal is highly fractured and very permeable (COE 1977). The depth of the water in the strip pit, therefore, creates a head pressure to push water into the coal seam and other geological strata. Because of the head pressure, water that enters the coal seam would generally be expected to follow the down-dip of bed, which in this case is to the south toward the syncline.

The coal in the area of Gowen has been removed along the seam in the underground mines. Therefore, instead of water following the coal seam across the valley it will flow into and fill the underground mines. As these mines filled so would their haulageways, air shafts and entrance shafts. Also, some of the underground mines in the area originated along the south Gowen ridge and progressed north. The underground mines honeycomb the valley in the Gowen area. Many of these mines were in close proximity to each other and often were separated by only a few feet of rock and coal. In some cases, retired miners have reported that the separating walls between these mines were removed. This would, in effect, create direct hydrologic connections between the mines. If the mine walls were not removed, then the mines would be connected hydrologically by the coal vein. In any event, water can enter the underground mines in the Gowen area from either the north or south ridge, therefore, creating a hydrostatic pressure from both ridges. This would prevent water from entering on one side of the valley and being discharged on the other side (Figures 1 and 2), therefore, allowing water to be discharged in the valley floor.

As the underground mines filled, the water level rose in the old shafts and subsequently saturated the coal seam. Eventually, with water in underground shafts and coal seams, the water level rose in the shafts to a level higher than the valley floor. This continued until the shafts and coal seams were saturated to their outcrops on the surrounding ridges. As a result, a head pressure was created. As a relief from the head pressure, water came to the surface in the valley floor at points of the least resistance, such as old air shafts or any fissure in the surface extending down the depth of the old mines. This water would then flow into the normal surface drainage of the valley. The best information available indicates that the south seep sample site is the approximate location of an old air shaft and water quality sample analysis indicates that this seep water is from the deep mines.

In many cases strip mines were started after the underground mines had been abandoned. When the strip mine encountered an old mine or air shaft, mining occurred horizontally through the shaft. As a result, in the bottom of some pits there are direct connections to the underground mines.

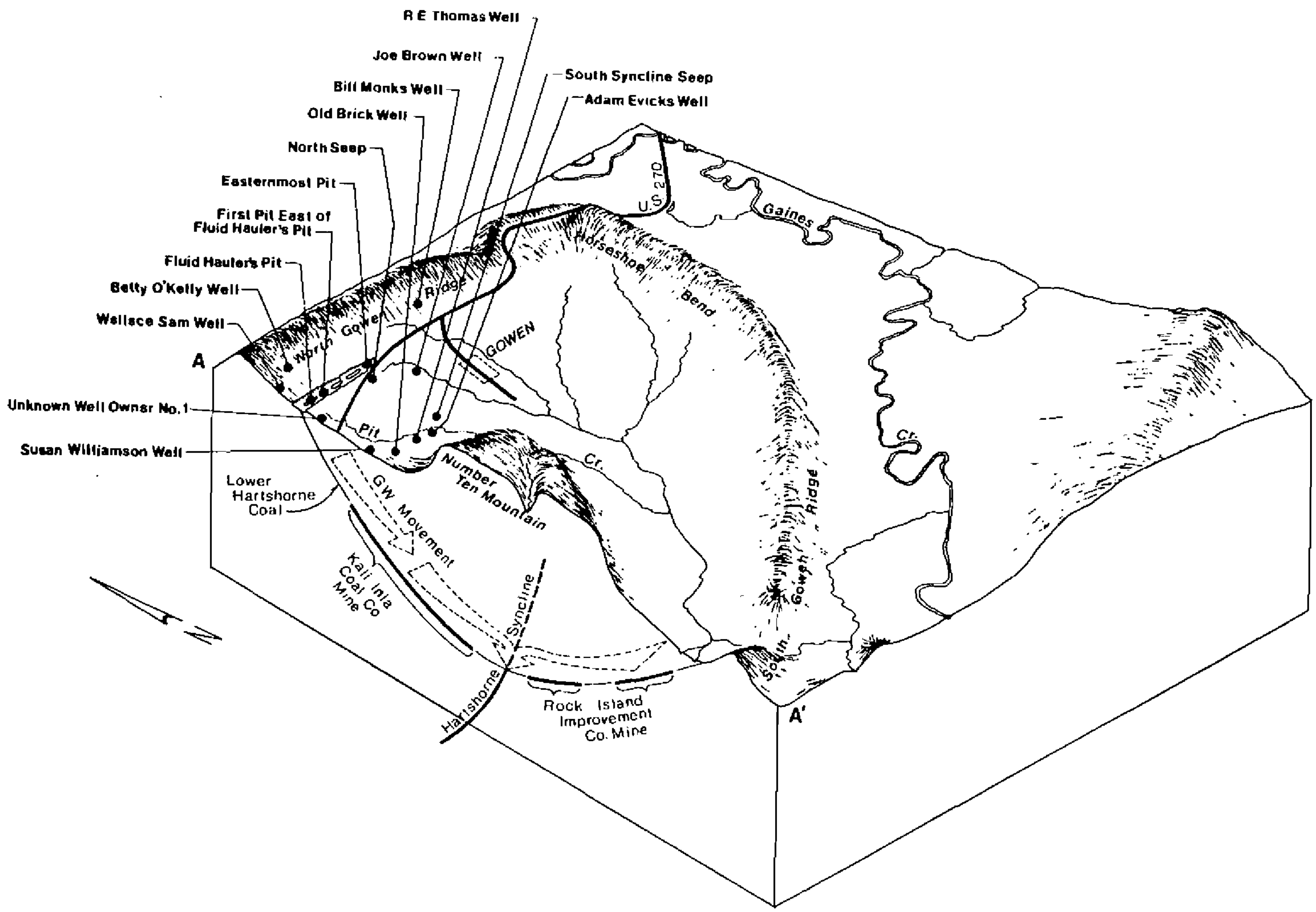

Figure 2. Three demensional view of the Gowen area showing sample sites, strip pits, underground mines and groundwater movement.

It should be noted that, contrary to the popularly held belief of many residents in the Gowen area, there is no evidence of any shafts in the bottom of the Fluid Haulers' pit. However, retired miners report that the high wall between Fluid Hauler's pit and the adjacent underground mine was partially removed. From these reports it appears there could be direct hydrologic connections between the strip pits on the north Gowen ridge and the underground mines. Also, there is almost certainly an indirect connection through the coal seam between the pits and underground mines. Although the coal is highly permeable, an indirect connection would allow a lesser amount of water flow from the pits to the deep mines than would occur with the flow from a direct connection.

A previous Oklahoma Water Resources Board (OWRB) complaint investigation (WR-82-707) concluded there was a high probability of a hydrologic connection between the Fluid Haulers pit and the underground mines and local aquifers. Since there appeared to be a potential for pollution from the Fluid Haulers pit, the OCC and OWRB decided to conduct a joint investigation to determine if any contaminants were leaving the Fluid Haulers pit.

The purpose of this investigation was to determine the extent, if any, of pollution caused by the substances in the Fluid Haulers pit.

METHODS AND MATERIALS

Sample sites (Table 1) are north of a syncline that crosses the valley from southwest to northeast (Figure 3). Water and sediment samples were

Table 1. List of sample sites near Gowen, Latimer County, Oklahoma, November and December 1982.

SAMPLE SITE	LEGAL DESCRIPTION
Fluid Haulers' pit	NW¼, SW¼, SE¼, Section 22, Township 5N, Range 17EIM
First pit east of Fluid Haulers' pit	NE¼, SW¼, NE¼, Section 22, Township 5N, Range 17EIM
East pit	NW¼, SW¼, SW¼, Section 23, Township 5N, Range 17EIM
North seep	SW¼, SW¼, SW¼, Section 23, Township 5N, Range 17EIM
South seep	SW¼, SW¼, NW¼, Section 26, Township 5N, Range 17EIM
Wallace Sam water well	NE¼, SW¼, Section 26, Township 5N, Range 17EIM
Betty O'Kelley water well	NE¼, SW¼, Section 22, Township 5N, Range 17EIM
Bill Monks water well	SE¼, SE¼, Section 23, Township 5N, Range 17EIM
Joe Brown water well	NE¼, NE¼, NW¼, Section 26, Township 5N, Range 17EIM
Adam Evicks water well	SE¼, SE¼, NE¼, Section 26, Township 5N, Range 17EIM
R. E. Thomas water well	SW¼, SE¼, NE¼, Section 27, Township 5N, Range 17EIM
Old brick water well	SW¼, SW¼, NE¼, Section 27, Township 5N, Range 17EIM
Susan Williamson water well	NW¼, SE¼, NW¼, Section 27, Township 5N, Range 17EIM
Unknown water well owner #1	SE¼, SE¼, SW¼, Section 22, Township 5N, Range 17EIM
Soils near east pit	SW¼, Section 23, Township 5N, Range 17EIM
Soils near Fluid Haulers' pit	SE¼, Section 23, Township 5N, Range 17EIM

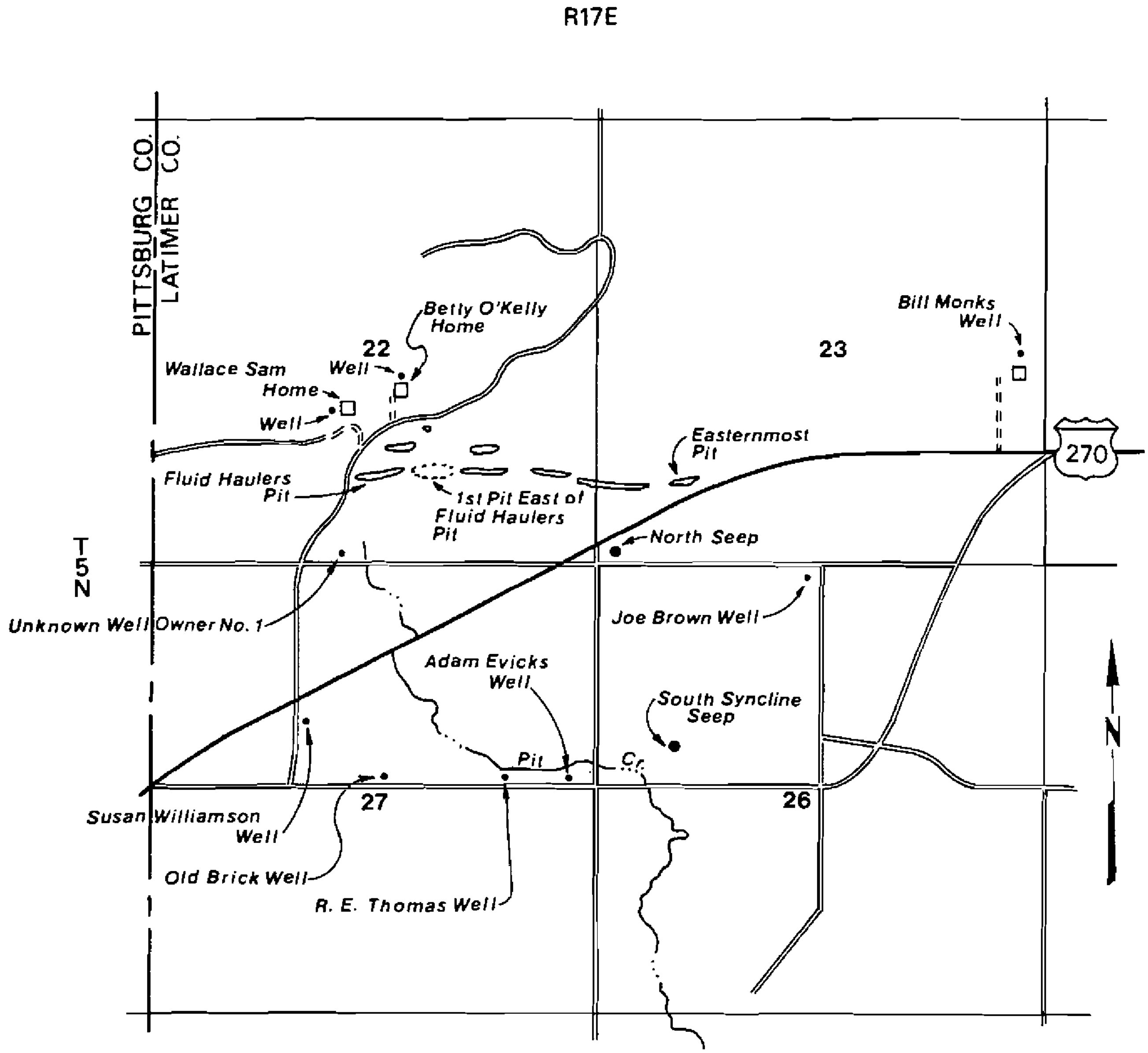

Figure 3. Map of the Gowen area showing sample sites utilized in November-December, 1982.

taken from water wells, stream water, Fluid Haulers pit, a deep mine surface seep, and nearby strip pits. At each site, three one liter bottles of water were collected: one for metals analysis (preserved with nitric acid to a pH of less than 2), one for chemical oxygen demand and total organic carbon (COD and TOC, preserved with sulphuric acid to a pH of less than 2), and one for chemical quality analyses (no preservative). Each water sample was placed on ice to cool to 4°C.

On November 18, 1982, samples were collected for preliminary data from surface and groundwater sources in the vicinity of the Fluid Haulers pit. The collection of water and sediment samples at the Fluid Haulers pit and the east pit was done with the aid of a canoe. The Fluid Haulers pit was sampled on both the east and west ends. All subsequent samples from the Fluid Haulers pit were collected from the west bank of the pit.

A second set of water samples was collected on December 6, 1982. Between the first and second samples the Gowen area received approximately eight inches of precipitation (climatological data from the Oklahoma Climatological Survey per telephone conversation, January 25, 1983).

The December 6, 1982, samples were collected to determine rainfall influence on the Fluid Haulers pit and the ground and surface waters.

A third set of water samples was collected on December 21, 1982, to corroborate static conditions. Several additional water wells were sampled because some water wells originally sampled were no longer accesible and the additional wells were believed to be in the direction that groundwater would flow from the Fluid Haulers pit.

All sample analyses were performed by the State Environmental Laboratory, Oklahoma State Department of Health (OWRB Lab-Certification No. 7503).

ANALYTICAL RESULTS

On the first sampling trip the Fluid Haulers pit was sampled in the east end and west end, with surface water, bottom water, and sediment samples collected at each site. Oil and grease samples were not collected since oil was evident on the surface of the pit. The depth from surface to sediments was three and six feet on the east and west ends, respectively. Fluids in the pit were black and oily. Sediments might be best described as having the consistency of jello. Throughout the sampling period extremely high levels of total chromium (Cr, Total), chlorides (Cl), sodium (Cr), total organic carbon (TOC), total dissolved solids (TDS), and barium (Ba) were found in the water and/or sediments of the Fluid Haulers pit.

Sample analyses confirmed the presence of oil and gas field wastes in the Fluid Haulers pit (Table 2) and the first pit east of the Fluid Haulers pit. These two pits are separated by an earthern dike which appeared to have been constructed from the overburden during mining. An inspection of the dike revealed no apparent leaks from the Fluid Haulers pit into the next pit east, which was nearly void of water. This indicates that oil field wastes have been introduced into the pit adjacent to the Fluid Haulers pit by unidentified sources.

Table 2. Analytical results from water and sediment samples collected near Gowen, Latimer County, Oklahomas; November and December 1982.

SURFACE WATER

SITES	pH (su)	COD mg/L	SO_4 mg/L	TDS mg/L	TOC mg/L	Cl mg/L	As µg/L
Fluid Haulers pit							
East End (S)							
11/16/82	7.3	865.4	200*	3344	119.2	1289	50*
East End (B)							
11/18/82	7.3	480.8	200*	3384	112.3	1297	50*
West End (S)							
11/16/82	7.4	673.1	200*	3281	114.1	1296	50*
12/6/82	6.5	421.5	75	2310	237.6	997	50*
12/21/82	8.0	558.6	100*	2764	147.0	1134	50*
West End (B)							
11/18/82	7.4	576.9	200*	3363	120.5	1300	50*
East Pit (S)							
11/18/82	7.1	21.2	20*	124	21.9	10*	10*
12/6/82	6.4	11.5	20*	78	8.4	10*	10*
12/21/82	6.5	23.3	20*	103	5.6	10*	10*
East Pit (B)							
11/18/82	6.1	21.2	20*	124	21.9	10*	10*
North Seep							
11/18/82	2.9	42.2	363	567	5.0*	35	10*
12/6/82	5.4	15.3	255	578	5.0*	94	10*
12/21/82	3.2	5.0	307	505	5.0*	60	10*
South Seep							
11/18/82	3.7	147.8	6133	8470	5.0*	31	10*
12/2/82	6.0	183.9	4759	8415	57.0	31	10*
12/21/82	3.7	151.2	5547	8155	83.0	30	10*

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

Table 2. Continued.

SURFACE WATER

SITES	Ba µg/L	Cr-T µg/L	Mn µg/L	Na µg/L	Zn µg/L	Fe µg/L	Hg µg/L
Fluid Haulers pit							
East End (S)							
11/16/82	8350	2350	1000	959	200*		0.5*
East End (B)							
11/18/82	19,350	3150	1350	363	1150		
West End (S)							
11/16/82	9000	2450	1100	1103	200*		
12/6/82	8900	2000	800	852			
12/21/82	8400	2300	900	1031	200*	1850	
West End (B)							
11/18/82	9000	2600	1100	115	200*		
East Pit (S)							
11/18/82	450	21	680	14			
12/6/82	290	10*	350	11			
12/21/82	470	10*	320	10*	40	1410	
East Pit (B)							
11/18/82	450	21	680	14	4*		
North Seep							
11/18/82	370	17	3800	38	49		
12/6/82	230	10*	3700	68			
12/21/82	490	10*	3320	45	29	22,200	
South Seep							
11/18/82	510	14	35,500	1015	52		
12/2/82	180	10*	31,600	941			
12/21/82	530	10	28,100	768	31	81,000	

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

Table 2. Continued.

SEDIMENT

SITES	pH (su)	COD mg/kg	SO_4 mg/kg	Cl mg/kg	As mg/kg	Ba mg/kg
Fluid Haulers pit						
East End						
11/18/82	8.0	26,920	2000*	1489	35.0	834
West End						
11/18/82	7.5	41,350	2000*	1527	26.0	601
Pit East of Fluid Haulers pit						
West End						
11/18/82	7.0	77,890	2000*	1696	25.0	804
East End						
11/18/82	7.0	27,890	2000*	1872	12.5	491
North of Fluid Haulers pit						
12/21/82	4.6	112,200	2000*	1000*	11.0	75
East Pit						
11/18/82	7.0	25,000	2000*	1278	13.8	187
Near East pit 12/21/82	7.3	45,670	2000*	1000*	5.0*	39
North Seep Sediment						
11/18/82	7.0	49,040	2000*	1000*	18.4	121
South Seep Sediment						
11/18/82	6.0	1931	2000*	1000*	12.5*	43

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

Table 2. Continued.

SEDIMENT

SITES	Cr-T mg/Kg	Mn mg/kg	Na mg/kg	Zn mg/kg	Fe mg/kg	Hg mg/kg
Fluid Haulers pit East End 11/18/82	332	495	10,890	195.0		0.05*
West End 11/18/82	440	410	21,950	320.0		
Pit East of Fluid Haulers pit West End 11/18/82	165	515	3925	305.0		
East End 11/18/82	133	335	2430	139.0		
North of Fluid Haulers pit 12/21/82	49	60	500*	45.0	32,500	
East Pit 11/18/82	33	495	500*	119.0		
Near East pit 12/21/82	20	159	500*	74.0	16,500	
North Seep Sediment 11/18/82	20	115	500*	24.0		
South Seep Sediment 11/18/82	13	116	1085	7.5		

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

Table 2. Continued.

WATER WELLS

SITES	pH (su)	COD mg/L	SO_4 mg/L	TDS mg/L	TOC mg/L	Cl mg/L	As µg/L
Sam Well							
11/18/82	6.0	5.0*	20*	201	5.0*	12	10*
O'Kelley Well							
11/18/82	6.1	5.0*	20*	157	5.0*	13	10*
12/6/82	6.9	5.0*	20*	29	5.0*	19	10*
Monks Well							
11/18/82	6.1	6.4	68	985	5.0*	111	10*
12/6/82	7.4	11.5	58	912	5.0*	113	10*
12/21/82	7.6	5.4	20*	1085	5.6	142	10*
Brown Well							
12/21/82	7.4	15.4	234	611	5.0*	60	10*
Evicks Well							
12/21/82	6.7	18.3	52	325	5.1	81	10*
Old Brick Well							
12/21/82	6.8	5.0*	20*	79	5.0*	10*	10*
Thomas Well							
12/21/82	6.9	5.0*	20*	113	5.0*	10*	10*
Unknown Well #1							
12/21/82	7.0	27.1	20*	127	11.0	10*	10*
Williamson Well							
12/21/82	7.4	5.0	20*	83	5.0*	10*	10*

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

Table 2. Continued.

WATER WELLS

SITES	Ba µg/L	Cr-T µg/L	Mn µg/L	Na µg/L	Zn µg/L	Fe µg/L	Hg µg/L
Sam Well							
11/18/82	430	10*	440	21	6		
O'Kelley Well							
11/18/82	330	10*	100	24			
12/6/82	290	10*	540	25	34		
Monks Well							
11/18/82	600	10*	60	387	4		
12/6/82	420	10*	50	421			
12/21/82	540	10*	30	470	11		
Brown Well							
12/21/82	350	10*	600	127	19		
Evicks Well							
12/21/82	430	10*	50	89	262	290	
Old Brick Well							
12/21/82	420	10*	20*	10	40	530	
Thomas Well							
12/21/82	400	10*	20*	10*	15	100*	
Unknown Well #1							
12/21/82	410	10*	90	10*	279	340	
Williamson Well							
12/21/82	430	10*	20*	10*	58		

* = less than detection limit
(S) = surfact sample
(B) = bottom sample

It appears as if the sediments in the Fluid Haulers pit are absorbing sodium from the water. At two different sites in the Fluid Haulers pit surface waters contained from 2.6 to 9.6 times as much sodium as the bottom water at the same site (Table 2). Sodium values in the sediments ranged from 10,890 to 21,950 mg/kg with the highest value at the same site (west end) as the lowest bottom water value for sodium. The easternmost pit in the series was used as a control, and sodium levels in surface waters, bottom waters and sediments were found to be 14 mg/L, 13 mg/L and less than 500 mg/kg, respectively.

Water from the south seep (sample site locations, Figure 1) showed higher sodium values than other sample sites. However, it should be noted that the sodium level in the south seep water was not excessive, only higher than background data found at other sites.

The area around the south seep is denuded of vegetation (photos attached), as is the flow path leading toward Pit Creek (a tributary of Gaines Creek). Analytical results of the sediment at this site also show sodium values higher than at all sites other than those contaminated by drilling wastes. These data suggest the possibility of a hydrologic connection existing between the Fluid Haulers pit and the south seep.

Other potential contaminants from the pit were not in high enough concentrations to be detected at this sample site. This will be discussed later.

The north seep is located down slope from the easternmost pit (east pit) in the series of strip pits previously described (Figure 1). This sample site is a small unnamed stream that originates around the strip pits. Water was consistently present at this site even during sustained periods of dry weather, indicating a groundwater infiltration from upslope around the strip pits and old mine shafts. Sulfates and manganese results also suggest that water at this site may receive some acid mine water, which is diluted in times of surface runoff. Although the water at this site was clear, there was an orange precipitate on the substrate (photos attached).

The east pit site was selected as a control site to determine background data for strip pits in the immediate area. Along the southern edge of the pit the coal outcrop is readily distinguishable and is in direct contact with the water in the pit when the water level in the pit is high. Analytical results show slightly acidic water and no evidence of oil field contamination.

DISCUSSION

This study was to determine if the contents of the Fluid Haulers pit were migrating to local groundwater supplies. Residents in the area now utilize a rural water system for domestic supplies. In the past, each residence had a private water well for domestic use, however, these wells are now abandoned or used only to water lawns or gardens. During the first sampling only water wells at the residences of Mr. Wallace Sam, Ms. Betty O'Kelly and Mr. Bill Monks were sampled (Figure 1 shows location,

Table 1 shows results). At the time of the second sampling the Sam well was not in use and could not be sampled. Neither the O'Kelly well nor the Sam well were accessible at the time of the third sampling.

The expected flow of groundwater is south toward the syncline then west following the dip of the local geology. To better understand the water quality in the wells in the expected direction of groundwater flow from the Fluid Haulers pit, several additional wells south and west of the pit were sampled on December 21, 1982.

When the results of the third set of sampling data were received an interesting trend developed. The Monks well, in the northeast part of the sampling area, showed higher TDS, chloride, barium, and sodium values than other water wells. The values of these parameters decreased in a southwesterly direction from the Monks well to the Brown, Evicks, and old Brick wells (Figure 1 shows locations). Groundwater from the area of the Monks well would be expected to flow towards these other wells. Any contamination detected at the Monks well might decline in concentration through mixing and dilution by other groundwater in the area. However, for water or contaminants to leave the Fluid Haulers pit and be detected in the Monks well, they would have to flow to the east along the coal seam, then move in the expected direction (southwest) of groundwater flow towards the other wells.

A study of acid mine drainage (COE, 1977) suggested groundwater might flow in an easterly direction along the Adamson Anticline (Figure 4). The anticline lies north and parallel to the ridge where the Fluid

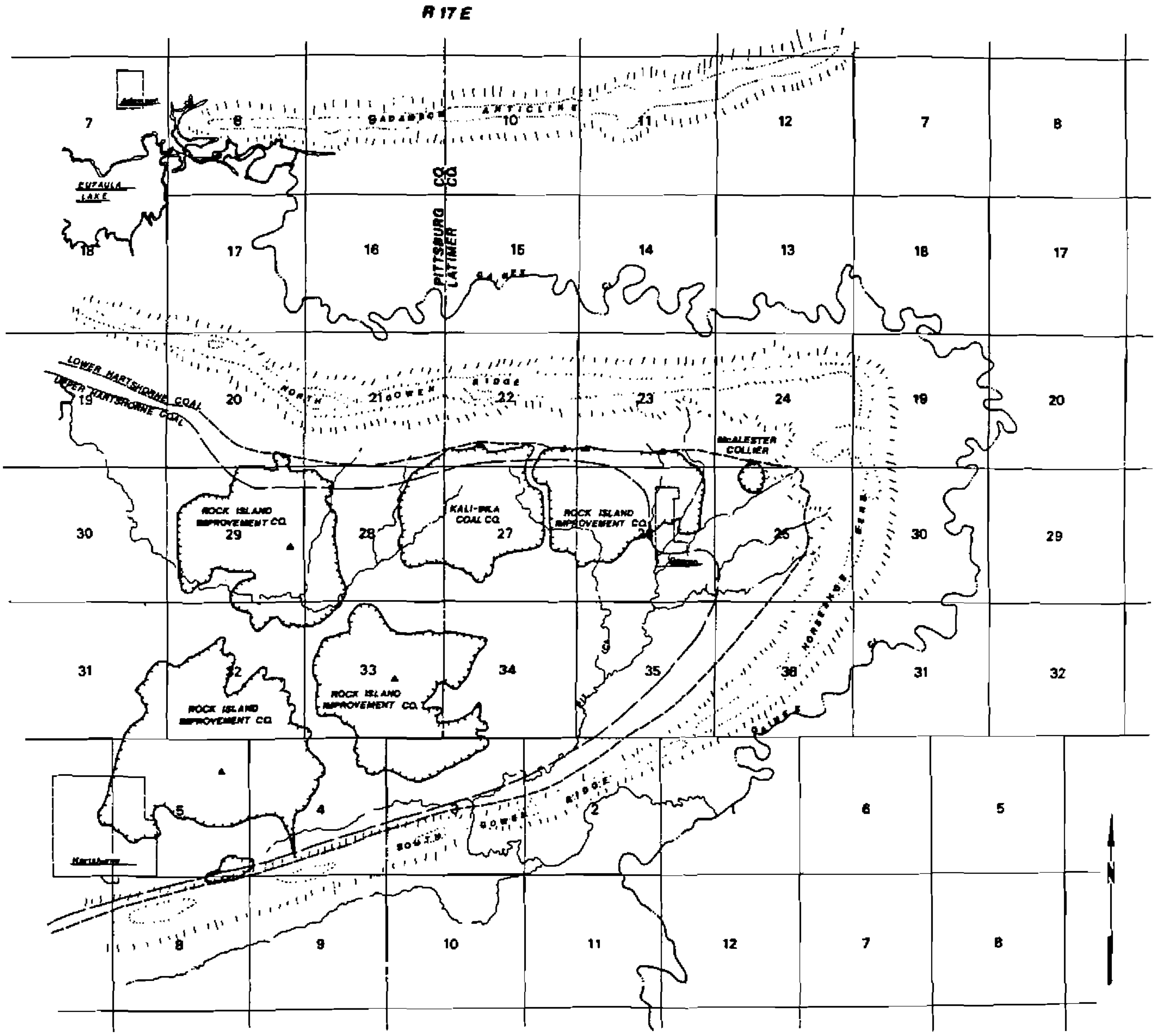

Figure 4. Map of the local region around Gowen, Oklahoma, showing the location of underground mines and the Adamson Anticline.

Haulers pit is located (north Gowen). The two ridges are connected to the west by a horseshoe bending of the formation similar to the horseshoe bend of the ridge east of Gowen that connects the north Gowen ridge with the ridge to the south (south Gowen). There would initially appear to be a geological similarity between the Adamson ridge and the north Gowen ridge. If this were true then water might flow easterly along the north Gowen ridge and as it approaches the horseshoe bend flow southwesterly (from the Monks well to the old Brick well).

Underground mines in the area contain substantial amounts of water. The volume of water estimated to be in three of the mines in the Gowen area is about 3,474 acre-feet (Bigda and Associates, 1976). These include the Kali-Inla Mine, Rock Island No. 10 Mine, and Rock Island Mine adjacent to Kali-Inla. Other local mines were not included in the Bigda survey.

These large quantities of water could have a substantial effect on any contaminants that might leave the Fluid Haulers pit by serving as a diluting agent. From testimony at the first hearing, the Fluid Haulers general manager stated that the pit was 400 feet by 125 feet by 20 feet, and had a capacity of 312,000 barrels (from these measurements, however, the volume would only be 178,107 barrels).

The depth of fluids in the Fluid Haulers pit at the November 18 sampling was six feet on the west end and three feet on the east end. Therefore, the estimated volume of fluids in the pit on November 18 was approximately 1.7 million gallons (40,074 barrels). This volume represents about 22.5% of the total pit volume based on calculations from the pit measurements given by Fluid Haulers personnel.

However, if the entire volume of the fluids in the Fluid Haulers pit (November 18 estimate) were to be mixed with the estimated water volume in the underground mines, the contaminants would be diluted by a factor of 672 (conservative estimate). Presumably, all the fluids in the pit have not been injected as a slug into the mine waters. Because of the proposed hydrologic connection, it would be more logical to assume that the contaminated fluids would seep out more slowly, diluting the contaminants to an even greater extent, thus making them very difficult to detect.

The presence of several feet of drilling muds in the bottom of the Fluid Haulers pit would tend to retard the migration of contaminants from the pit. However, to assume that these muds have completely sealed the pit may not be valid. From visual observations during field sampling and conversations with local residents, the fluid level in the pit fluctuates vertically several feet, particularly after periods of heavy rainfall. The fluid level in the pit would not be expected to decline due to evaporation since precipitation and evaporation are nearly equal, on an annual basis, in this part of the state (OWRB, 1980). In fact, a slightly rising water level would be expected due to the presence of substantial amounts of oil floating on the pit which would greatly reduce the air-water interface, thus decreasing the rate of evaporation. In this case, the pit would be expected to overflow at some point in time.

CONCLUSIONS

(1) As was originally known and confirmed in this study, there have been large amounts of oil and gas drilling wastes deposited in the Fluid Haulers pit. Also, the pit adjacent to Fluid Haulers pit has been contaminated by similar type wastes; but the origin is not known.

(2) After reviewing the analytical data available, there is a high probability that a hydrologic connection exists between the Fluid Haulers pit and the underground mines. Since this connection passes twice through the aquifer zone of the area, once going down to the mines and also coming back up in seep areas, any contamination of the pit or water in the underground mines poses a threat to local groundwater supplies.

(3) Any contaminants migrating from the pit into the underground mines would be very difficult to detect because the quantity of water contained in the underground mines would serve as a dilutent. However, levels of sodium in the south seep water are higher than other background data, thereby suggesting that this metal, which is concentrated in the sediments of the Fluid Haulers pit, may be migrating from the pit to the surface through area formations or the underground mines.

(4) There is not any empirial evidence to prove that a hydrologic connection exists between the Fluid Haulers pit and the north seep sample site.

(5) Currently, surface waters (i.e., Pit Creek) are being contaminated by acid mine drainage from the deep mines via the various seeps in the area. Therefore, any contamination of the water in the deep mines poses a threat to surface waters.

(6) There is also some evidence that contaminants are leaving the pit and migrating east along the coal seam, then southwesterly in the direction that groundwater would normally be expected to flow. While there was some indication from the water well samples that this is occurring, it could not be proven.

(7) There has been some speculation that drilling mud disposed in the pit may have sealed the pit, thereby preventing the contaminants from migrating through the bottom of the pit. Because of fluid level flucutations, this does not appear to be the case.

In summary, it would appear that contaminants are probably leaving the Fluid Haulers pit, but there is little likelihood that any contamination can be detected utilizing sampling schemes similar to those available for use in this study due to dilution of the fluids by the deep mine waters and the slow rate at which these contaminants are leaving the pit.

RECOMMENDATIONS

In light of the most recent data gathered in this investigation, there is a high probability that contaminants are migrating from the Fluid Haulers pit. The possibility of adverse affects to the environment and/or humans will undoubtedly increase if increased quantities leave the pit. Therefore, to monitor this situation for further understanding and to alert the appropriate agencies if significant contamination of either the surface or groundwaters of the state occurs the following recommendations are made:

(1) A series of four monitoring wells should be installed around the pit. Two of these wells should be located south of the pit and one each on the east end on west side of the pit. These wells should be drilled to a sufficient depth so that water in the coal seam is adequately sampled. Care should be taken in drilling these wells to insure that the coal seam sampled is directly connected to the vein exposed in the pit and that a portion of the coal vein has not been previously removed.

(2) The cost of developing and monitoring these wells should be the responsibility of Fluid Haulers, Inc. of McAlester. This monitoring will insure that Fluid Haulers is making every resonable effort to insure the state agencies involved that no violations of rules or state law are occurring.

(3) The expertise and staff of the OWRB should be made available to Fluid Haulers for technical assistance and advise.

(4) Should the monitoring program further illustrate that contaminants are migrating from the pit, then the pit should be emptied of all fluids and solids. The contents must then be disposed of in an approved manner.

(5) In lieu of monitoring the situation as described above, Fluid Haulers should be required to empty the pit of all contents and dispose of the materials in an acceptable manner.

J. Fred Heitman, Investigator

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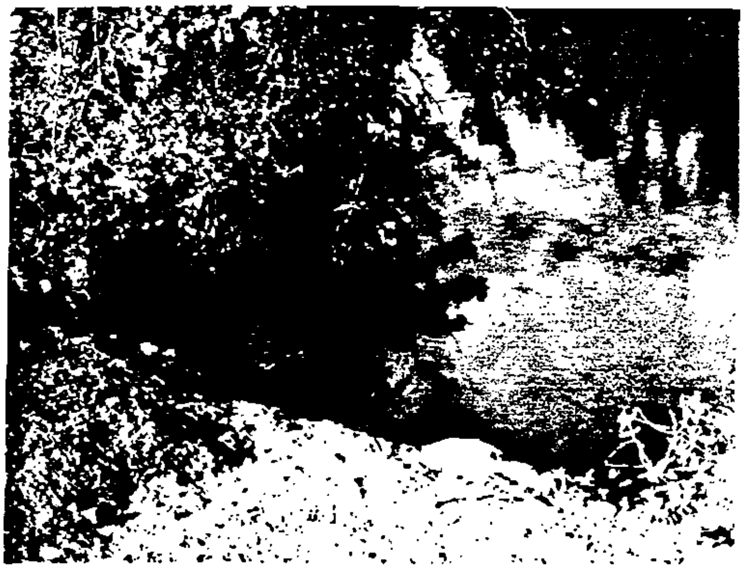
Corps of Engineers. 1977. Study of Acid Water Drainage, Gaines Creek Arm Lake Eufaula, Canadian River, Oklahoma. U.S. Army Corps of Engineers Contract DACW 56-77-C-0070, 26p and Appendix.

Oklahoma Water Resources Board. 1980. Oklahoma Comprehensive Water Plan. OWRB Publication No. 94, 248p.

West end of Fluid Haulers pit. Note trash and oil on water.

West end of Fluid Haulers pit. Note black water and oil on water.

Fluid Haulers pit, east end looking west. Note color of water and drilling mud delta. This is the area where drilling wastes were dumped into the pit.



Sample site at the east pit.

Sampling at the east pit.

Flow path of water at the north seep sample site. Note orange precipitate on denuded area.

South seep area showing flow path to the south. Note the extent of the denuded area.

North seep sample site. Note orange color of the water.

South seep sample site. Note orange and red color in the water and on substrate. Also, iron sheen on water in front of rock.