The Endee pipeline leak-implications for treating ground-water contamination beneath the Great Plains, eastern New Mexico

William J. Stone, 2001, pp. 317-319

in:

Geology of Llano Estacado, Lucas, Spencer G.;Ulmer-Scholle, Dana; [eds.], New Mexico Geological Society 52nd Annual Fall Field Conference Guidebook, 340 p.

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THE ENDEE PIPELINE LEAK — IMPLICATIONS FOR TREATING GROUND-WATER CONTAMINATION BENEATH THE GREAT PLAINS, EASTERN NEW MEXICO

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Abstract.—In November 1992, a major petroleum pipeline between Amarillo, TX and Albuquerque, NM ruptured, spraying thousands of gallons of jet fuel onto the ground at a site 27 mi east of Tucumcari, NM. The so-called "Endee site" is characterized by Triassic redbeds (Chinle Formation) overlain by Quaternary eolian sand. Monitoring wells installed at the site revealed up to 8 ft of free product floating on a body of perched ground water within the eolian cover sand, approximately 16 to 36 ft below the site. Although yields are low and quality is poor, the redbeds are the major source of water for area ranches. However, this ground water is vulnerable to contamination due to its shallow depth. The overlying eolian sand is porous and readily takes up spills. Such contamination may first show up in local perched water bodies in the sand, where it is easier to clean up than if it reaches the redbeds, which are fairly tight. Where perched saturation is present, it serves as a buffer for the deeper groundwater, but clean-up should be prompt before contamination reaches the regional system.

INTRODUCTION

A major high-pressure petroleum pipeline passes through the Tucumcari area. It was built in 1958 and extends from Amarillo, Texas to Albuquerque, New Mexico. In the east-central portion of Quay County it parallels State Route 392 on the south side. Different products flow through the line at different times.

At 5:00 AM on the morning of 15 November 1992 (a Sunday) the pipeline company in Amarillo detected a pressure drop in the line. The leak was located by 7:20 AM and block valves straddling the portion of the pipeline where the rupture occurred (spaced every10 mi) were closed by 7:35 AM, halting flow through the pipeline. It is estimated that 2,088 barrels (87,695 gal) were released. By 9:40 PM the leak was repaired and flow was resumed.

The 34-yr-old, 6-in. pipeline had ruptured approximately 27 mi east of Tucumcari, spraying jet fuel high into the air. More specifically, the leak was located at a point 7 mi north and 5.4 mi east of San Jon, New Mexico. Although it is 4.4 mi east of the village of Porter, the pipeline operator assigned the name "Endee" to the leak, after a village farther to the southeast. The leak was also detected on-site, as the resulting fountain of fuel was spectacular. It was said to be clearly visible and audible from both the road and a nearby ranch house.

Because the spill occurred on a Sunday, it was reported to the New Mexico Environment Department (NMED) emergency hotline. First thing Monday morning, the incident was reported to the Chief of the Ground Water Protection and Remediation Bureau, in keeping with state regulations. Both the state and the pipeline operator's consultant initiated investigations. I was with NMED's Ground-Water Protection and Remediation Bureau (Albuquerque) and overseeing this case at the time.

SITE CHARACTERIZATION

Steps were taken to characterize the leak site. This included defining the local geology, the area hydrology, as well as the nature and extent of the contamination. Of particular concern was the threat of contamination posed by the leak to ground water supplying two adjacent ranch houses, one located ¼ mi east of the leak and the other 1 mi to the northeast.

Geology

The Endee site lies in the Great Plains physiographic province. The area is characterized by a gently rolling surface that is drained toward the northeast. The site lies on the northern slope of a branch of Rana Canyon, a small, ephemeral tributary of the Canadian River.

The surface geology of this portion of Quay County is characterized by Triassic redbeds (Chinle Formation) overlain by Quaternary eolian sand (Berkstresser and Mourant, 1966; Anonymous, 1982). The Chinle consists mainly of red shale and red siltstone, but also includes sandstone, clay and limestone. The thickness of the redbeds is on the order of 250 ft at the site. The eolian sand is very fine to medium grained and uncemented. Thickness of the dune sand is <50 ft throughout the area. Hand augering for samples of the sand at the site revealed the presence of caliche nodules at depths of approximately 4 ft and an interbedded layer of light green clay (at least 19 in. thick) at a depth of 5 ft.

Hydrology

The regional water table occurs at a shallow depth in the Chinle redbeds (Berkstresser and Mourant, 1966). Regional ground water flows northeasterly toward the Canadian River, where it discharges. Perched ground water has been reported in the San Jon and Porter areas (Berkstresser and Mourant, 1966). The hydraulic conductivity of the redbeds is low in contrast to that of the sand. As more suitable aquifers are not available, the Chinle Formation is an important source of stock and domestic water for area ranches. However, the water is of poor quality: total-dissolved-solids often exceed 1000 ppm. In most of the area the water is not used for drinking or cooking. In some places, it is not even usable for stock. The well at the closest ranch house is reportedly 80 ft deep and yields poor quality water from the redbeds at a rate of 8-9 gpm.

To define the nature and extent of the contamination, six monitoring wells were installed in and around the impacted area (Fig. 1). More specifically, five wells were located within the area of the surface plume (area of discolored soil) and one was located outside of that to the west. These wells revealed that there is a shallow body of saturation (16 – 36 ft below ground surface). This water appears to be perched on a well-cemented pebbly zone near the top of the redbeds (Stone, 1999). Water-level measurements suggest flow is southeasterly toward local drainage (Fig. 1).

CONTAMINANT PLUMES

The initial site visit revealed that the southeasterly wind at the time of the leak had spread the fuel over an elongate area, 600 ft long and 15 –150 ft wide. The maximum width occurred next to the source of the leak and the minimum occurred at the toe of the surface plume.

The location of the leak on a valley margin facilitates the movement of contaminated sand and water downslope during runoff events. Such movement is enhanced by the fact that much of the porosity of the sand is taken up by the fuel. Before the leak, most precipitation would have soaked into the sand; after the leak, most runs off. During one heavy rainstorm, fuel-contaminated sand and water flowed as far as the yard of the closest ranch house (Stone, 1999).

Characterization of the subsurface plume was made possible by the six monitoring wells. Three of the wells located within the surface plume encountered up to 8 ft of free product floating on the perched water. The other two wells detected major fuel components (benzene, toluene, ethylbenzene and xylene or BTEX) at 11–311 ug/L in the perched ground water, but no free product. The extent of the ground-water plume was found to generally mirror that of the surface plume.

REMEDIATION

Three remediation targets were recognized by the state: the free product, the potential spread of contaminated soil and water by runoff and the in-place contaminated soil. Thus, a three-phase remediation plan was implemented.

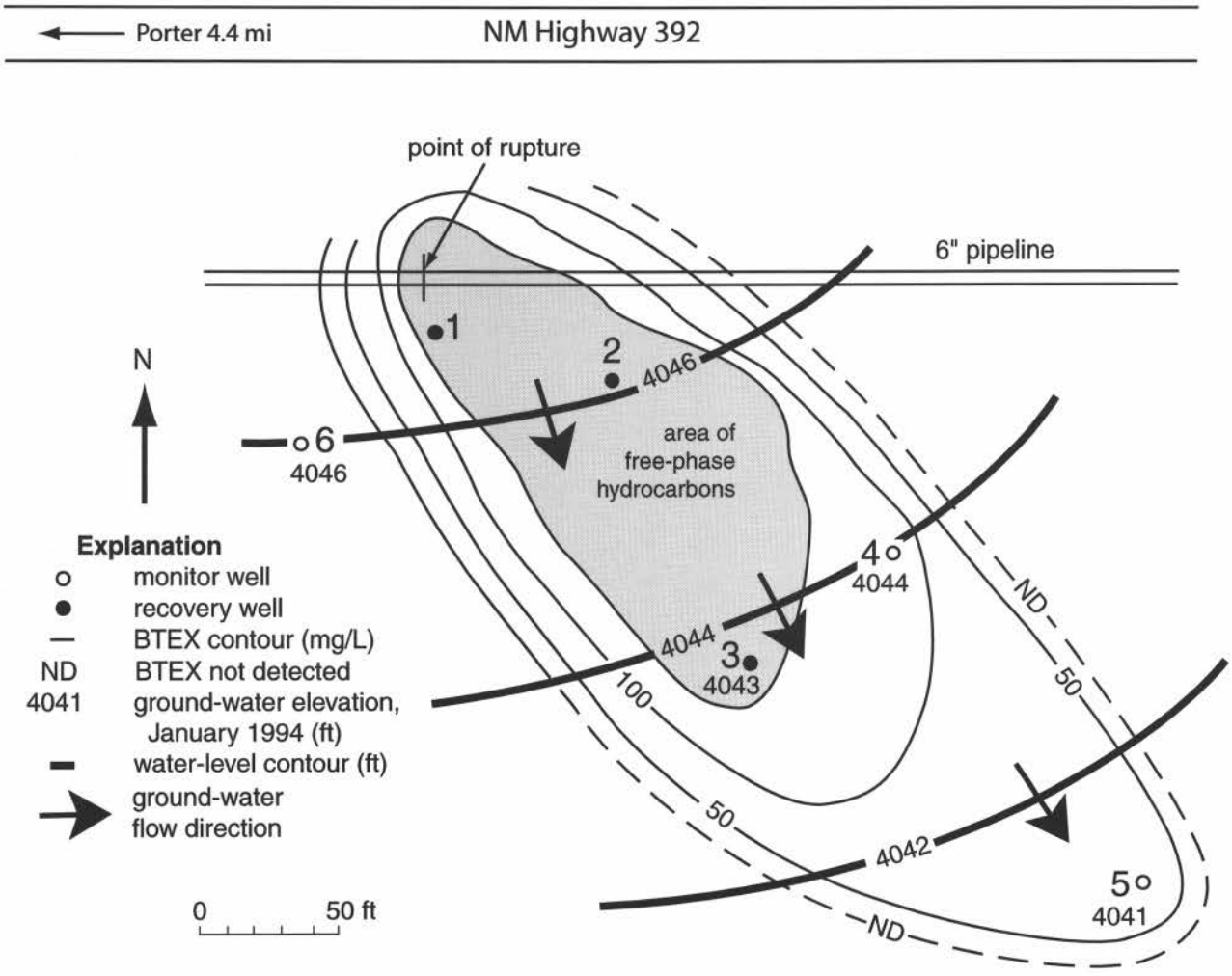

FIGURE 1. The Endee pipeline leak site, Quay County, New Mexico (constructed from figures in NMED files). BTEX contours are from October, 1996 measurements.

TABLE 1. Early product-recovery results at the Endee pipeline leak site, Quay County, New Mexico (compiled from data in NMED files).

Date	Removed From Tank (gal) Product	Water	Cumulative Product Recovered (gal)
1993			
05/25	400	0	400
08/04	300	0	700
10/26	300	0	1000
12/22	650[1]	0	1650
12/24	200	0	1850
12/29	300	0	2150
1994			
01/17	500	0	2650
02/07	250[2]	0	2900
03/02	200	200	3100
03/15	80	170	3180
03/29	120	100	3300
04/18	225	0	3525
05/02	160	0	3685
06/07	200	300	3885
06/29	250	250	4135
09/22	300	100	4435
10/03	350	25	4485
12/20	250	100	5035
1995			
01/12	380	0	5415

[1] pumps replaced in wells 1 and 2 on 12/13/93 (see Figure 1)
[2] pump installed in well 3 on 02/07/94

Product remediation was undertaken by means of a solar-powered recovery system. This involved outfitting initially two and eventually all three of the wells that penetrated free-phase hydrocarbons with pumps (Fig. 1). The pumps are connected to a storage tank that is emptied periodically. Recovered product is taken to a plant in Tucumcari for oil/water separation and appropriate reclamation. Until March 1994, only free product was collected by the recovery system (Table 1). Thereafter, quantities of water, sometimes exceeding those of product, were also produced. By 1995, more than 5,000 gal of fuel had been removed from the ground. Product-recovery efforts continue today.

The spread of contamination by runoff was minimized by installing impediments to flow and sediment transport along the slope below the leak. These included earthen diversion berms and fabric silt dikes.

The leak contaminated some 17,000 yds^3 of cropland. Natural attenuation was proposed by the pipeline operator as an approach to cleaning up such a large volume of in-place contaminated soil. This has been rejected by NMED. The final plan for soil remediation has not yet been determined.

Organic contaminants were never found in periodic analyses of water from the two ranch house wells. However, the rancher on whose land the leak occurred suffered a loss of production from the soil that was directly impacted and sued the pipeline operator for damages. He was awarded a yearly payment until the site is cleaned up. Furthermore, it was agreed that a new well would be provided if water in the current one is ever found to be contaminated.

IMPLICATIONS FOR OTHER SITES

Aging pipelines are not the only potential source of groundwater contamination on the Great Plains of eastern New Mexico. Accidental spills from tanker trucks and railroad tank cars, as well as seepage from feedlots, dairies, landfills and septic tanks all pose threats.

Findings at the Endee site have several implications for dealing with ground-water contamination in similar settings on the Great Plains of eastern New Mexico:

1. The regional ground water system in the redbeds of the Chinle Formation is vulnerable to contamination due to its shallow depth.
2. Although the redbeds yield small amounts of poor quality water, that water is all that is available in some areas and must be protected for local users.
3. The overlying eolian sand is very porous and permeable. Liquid spilled or leaked in areas where it lies at the surface is quickly taken up.
4. The first ground water such contamination encounters may be that perched in the eolian sand.
5. Unless remediated, contamination in the perched water may move down to the regional system.
6. It is easier to recover contaminated water from the sand than from the underlying redbeds, which are fairly tight.

In other words, where present, the perched water serves as a buffer for the regional system. However, protecting ground-water supplies requires prompt and effective action to clean up spills before contamination leaves the soil and perched saturation.

ACKNOWLEDGMENTS

Michael Space (now with Terradigm, Inc.) took the state's initial soil samples at the site. Charles Ferguson, (NMED/Tucumcari and Clovis Field Offices) was a valuable on-site resource as I was based in Albuquerque. William McDonald (now with NMED's Hazardous Materials Bureau) assisted me on various site visits. The cooperation of Jack Johnson (landowner), in allowing us to sample his well and that of his son Jimmy, as well as keeping me informed of activities at the site during my involvement with the case, is gratefully acknowledged. Mike Space and Patrick Longmire (Los Alamos National Laboratory) provided useful peer reviews of the paper. Annie Loweree and Randi Moore (Los Alamos National Laboratory) prepared the figure.

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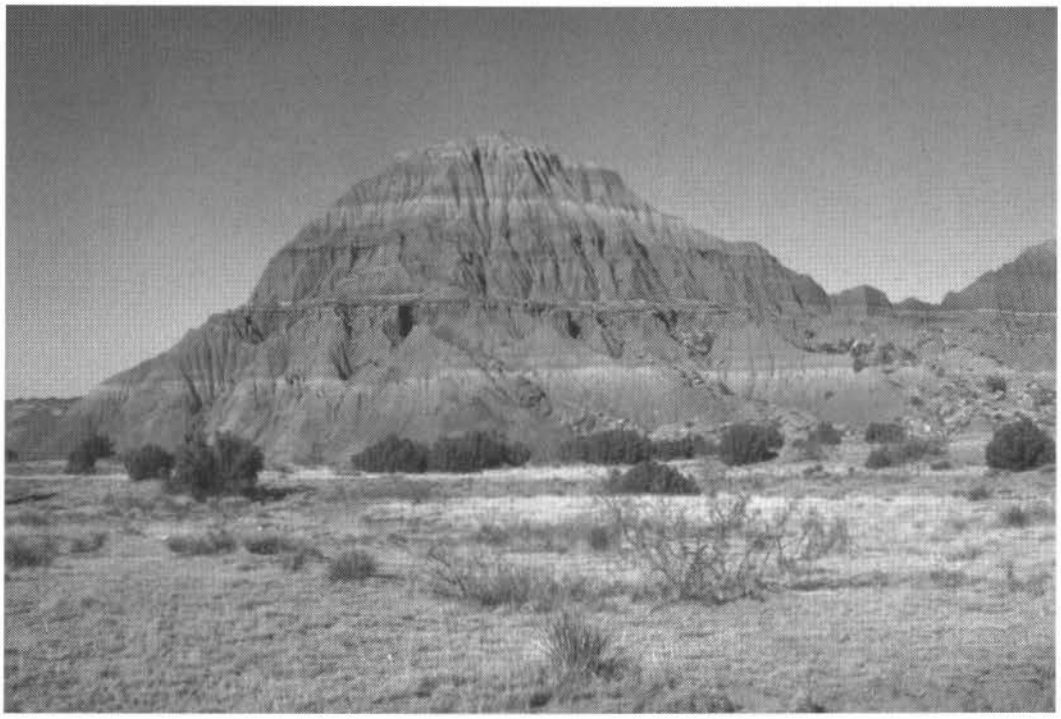

Red Peak southeast of Tucumcari is an erosional outlier developed in the Upper Triassic Bull Canyon and Redonda formations of the Chinle Group. Fossil vertebrates have been collected here, and copper was also mined here. (The fossil collecting was much better, by all accounts, than the copper mining.)