SEQUOYAH FUELS CORPORATION
POST OFFICE BOX 25861 • OKLAHOMA CITY OKLAHOMA 73125

September 4, 1987

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Bruce S. Mallet, Chief
Materials Licensing Section
Region III
U.S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

RE: License SNM-1174, Docket 70-1193
Amendment Request: On-site stabilization of materials meeting NRC Branch Technical Position Option 2

Dear Mr. Mallet:

Attached for NRC's review and approval is an application for amendment to the above referenced license providing for leaving, in a designated on-site area, certain material resulting from the Cimarron Uranium Plant decommissioning activities. The materials remaining on site will be within concentrations established in the Nuclear Regulatory Commission's Branch Technical Position Option 2 for soils containing uranium and thorium. This action will allow termination of the license and release of the area for unrestricted use. A check for $150.00 is enclosed in payment of the required fee to begin administrative review.

We appreciate your timely review and approval of this amendment request.

Sincerely,

J. C. Stauter

J. C. Stauter, Director
Nuclear Licensing and
Regulation

JCS:ms

Enclosure as stated

REQUEST FOR AMENDMENT

ON-SITE SOIL DISPOSITION

CIMARRON URANIUM PLANT

LICENSE SNM - 928

DOCKET NUMBER 70-925

SEQUOYAH FUELS CORPORATION

OKLAHOMA CITY, OKLAHOMA

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picocuries per gram. When left under these conditions, no restrictions are placed on subsequent land use and there is no licensing requirement.

Justification

Detailed soil surveys around the immediate area of the Uranium Fuel Plant facilities, including the storage yard, sanitary lagoon and pipelines, indicate a possible 400,000 cubic feet of soil that meet Option 2 criteria. Leaving the material on-site in a designated area under a minimum four feet of cover is justified for these reasons:

- No risk is posed to public health or the environment. NRC's comprehensive assessment in the Branch Technical Position demonstrates that the concentrations permitted under Option 2 conditions are sufficiently low that no individual will receive a dose from the uranium or thorium that is of any concern, even in the event of intrusion beneath the four feet of cover. Because of the area characteristics, the material will be retained in place and be environmentally secure.

- The estimated volume makes relocation of the material to a licensed commercial waste disposal site infeasible. Commercial sites have limited capacity and have established annual quotas for volume of material received. Further, even if capacity were available, relocation would not be justified on the basis of cost. The unit cost for leaving the material at the facility is approximately $0.11 per cubic foot compared to an estimated $60.00 per cubic foot for relocation to a commercial site. (Commercial site cost estimate reflects actual cost experience of SFC.)

- No restrictions will be required to be placed on the area and normal use will be permitted.

Description of the Material

The material to be left has been characterized through isotopic analyses of multiple samples obtained by coring to depth the storage yard and other areas around the facility. The analyses show the composition of the material to be primarily insoluble enriched uranium (hereafter "uranium" -- assumed 3% based on the uranium handled at the Uranium Fuel Plant and samples analyzed during decontamination activities). The thorium is thorium-natural and is also insoluble. Table 1 summarizes the isotopic analyses of the various samples and includes a background location for data comparison.

The characterization activities have generally identified the areas with uranium and thorium in soil that fall within or exceed the Option 2 concentration criteria. The uranium and thorium generally are not uniform in concentration or in the distribution within a given location.

In collecting the soil for consolidation and relocation for cover, additional measurements will be made, including walkover surveys with a gamma-scintillation instrument and soil sample isotopic analyses. The areas of interest will be gridded on a 10 meter by 10 meter basis and evaluated for assignment into one of three categories:

- Soil not requiring consolidation and cover: the concentration of uranium is not greater than 30 pCi/g; the concentration of thorium is not greater than 10 pCi/g; and if both uranium and thorium are present, the combined fractions do not exceed unity.

- Soil requiring consolidation and cover: the concentration of uranium exceeds 30 pCi/g but not 100 pCi/g soluble or 250 pCi/g insoluble; the concentration of thorium exceeds 10 pCi/g but not 50 pCi/g; and if both are present, the combined fractions exceed unity for the lower limit but not the upper limit.

- Soil requiring relocation to a licensed commercial site: The concentration of uranium exceeds 100 pCi/g soluble or 250 pCi/g insoluble; the concentration of thorium exceeds 50 pCi/g; and if both are present, the combined fractions exceed unity.

Since the areas with uranium and thorium are not uniform in concentration, an averaging approach will be taken in categorizing the soil. Small, localized areas within an individual 10 meter by 10 meter plot that exceed the Option 2 threshold criteria by up to a factor of 2 may be left in place provided the average concentration within the plot does not exceed the threshold criteria. Where soil is removed, the removal will have the objective of reducing the residual concentration as low as is reasonably achievable; in no case will uranium concentrations greater than an average of 30 pCi/g or thorium concentrations greater than 10 pCi/g be left in place. Where a mixture of uranium and thorium is present, the unity principle will be applied.

Removal and relocation of the material for cover will be on a continuous basis until completion of the activity; the only interruption will be that caused by adverse weather conditions that prohibit the work to proceed. No absorbent or other amendments will be mixed with the removed material; however the excavation, loading, unloading and placement activities will distribute the

uranium and thorium generally throughout the material volume. The material is natural soil and earth and since the operational facilities at the Facility did not involve hazardous waste constituents as defined by the Environmental Protection Agency, no such defined hazardous materials are assumed present.

Handling of the Material

The material to be consolidated, relocated and placed under a minimum of four feet of cover will be excavated with mechanical equipment, such as a backhoe or front-end loader, and transported via dump truck in bulk to the relocation site. Packaging will not be required; the material is natural soil and rock containing uranium and thorium at concentrations sufficiently low that the radionuclides require no special handling.

Relocation and Cover Site

The site to which the material will be relocated for leaving permanently beneath a cover is approximately 1,500 feet northeast of the Uranium Fuel Facility and is well within the more than 1,100 acres of Sequoyah Fuels Corporation property that comprise the facility site. Figure 1 is a sketch of the facility property, with the relocation site depicted. The general features of the facility property and the surrounding environs are summarized below.

The Cimarron Facility site is in a sparsely populated rural area in Logan County, Oklahoma. The nearest town is Crescent, OK, some six miles to the north. The nearest resident is located approximately 2,500 feet to the southwest of the relocation site and is also shown on Figure 1.

The Facility site surrounding environs are typical of the plains section of Central Oklahoma, with gentle rolling relief in an otherwise flat setting. The plains section is interspersed with relatively shallow stream and river courses located in wide gentle valleys; native grasses are generally abundant but trees are relatively sparse except for profuse stands along water drainage ways and courses.

The predominant land utilization is for growing of wheat and other small grains and cattle grazing. The grasses are primarily wild pasture types of many varieties that in many instances have been supplemented with bermuda or other improved forage species. The grasses grow rapidly in the spring, are mainly dormant in the summer, with additional growth during the fall season. This growth pattern is consistent with the rainfall and temperature patterns; most of the annual average 31 inches of rain is received in the spring and fall months. Summers are typically hot (average July temperature of 82.9°F) and dry.

The features of the approximately 1,100 acre facility site are consistent with those described above. The site is located on a bluff overlooking and immediately south of the Cimarron River flood plain. The site topography ranges from an elevation of about 940 feet above mean sea level (MSL) at the Cimarron River to the north to about 1,010 feet above MSL on the top of the bluff and promotes rainfall runoff to the north toward the river. The site vegetation is mainly native grasses; several drainage ways are bordered by heavy stands of scrub trees and brush.

Relocation Site Features

The site to which the material will be relocated is shown on Figure 1. The topographical, geological, hydrological and meteorological characteristics are typical of those for the entire facility site and have been documented in previous submissions. For convenience, pertinent information is summarized herein.

Topography:

The relocation site is a bluff area that is relatively flat; the topographic relief across the area is less than 10 feet (Figure 2). The highest elevation (approximately 1,010 feet above MSL) is at the south end; the lowest elevation (approximately 1,000 feet above MSL) is near the north end. Surface drainage is to the east, north and west, away from the relocation site. There are no major drainages established in the area, which is approximately 50 feet above the 100-year flood elevation of the Cimarron River.

Geology:

The Cimarron site is located in the Central Lowlands of the Great Plains Physiographic Province, a relatively flat, featureless plain developed upon sedimentary formations of Paleozoic and Mesozoic age.[1] The portion of the Central Lowlands that includes the site is locally referred to as the Central Redbed Plains. Geologic units ranging in age from the Pre-Cambrian basement complex to Permian sandstones and shales underlie the site, but only the Permian deposits are relevant, as the other units occur at depths of several hundreds of feet below ground surface and have no geologic or hydrologic importance for the relocation site.

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[1] N.M. Fenneman, 1931, Physiography of the Western United States; McGraw-Hill Book Company, Inc., New York

The Central Redbed Plains in the vicinity are immediately underlain by the Permian Age Garber Sandstone and Hennessey group (shale) of non-marine origin.[2] Outcrops of the Garber Sandstone form sharp escarpments overlooking the Cimarron River; outcrops of the overlying Hennessey Shale underlie the more gentle slopes farther south from the river. These formations dip to the west at a gradient of 20 to 30 feet per mile.[3]

The general geologic structure of the vicinity can be characterized as a gentle, west-southwesterly dipping homocline. The major structure of the area is the Nemaha ridge,[4] which was formed prior to the Pennsylvanian age and has no significant effect upon the overlying Permian geologic units. There are no faults or surface lineations reported in the vicinity.[5]

The Garber Sandstone at this location consists primarily of red- to gray-colored sandstones interbedded with siltstones and shales. The sandstones are fine to very fine grained and are loosely cemented. The sandstone near the relocation site has been characterized by borings to a depth of 16 to 20 feet. The locations of the borings are shown in figure 3 and descriptions of the corings are in Appendix A. The shallow bedrock has also been characterized by three additional borings to depths of approximately 30 to 80 feet at an area near the relocation site. Locations of these borings are also shown on figure 3 and descriptions are contained in Appendix A. (These latter three borings were completed as groundwater monitor wells.)

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[2] R.H. Bingham and R. L. Moore, 1975: Reconnaissance of the Water Resources of the Oklahoma City Quadrangle, Central Oklahoma; The University of Oklahoma, Hydrologic Atlas 4.

[3] W. J. Ford, 1954: The Subsurface Geology of Southwest Logan County, Oklahoma; Shale, Shaker V. 5, No. 2, pp. 5-24.

[4] W. J. Ford, Note 3 supra

[5] R.H. Bingham and R.L. Moore, Note 2 supra

The characteristics of the soils underlying the relocation site have been mapped and are of the undifferentiated Renfrow and Zaneis series.[6] The Renfrow soil, which typically develops on gentle slopes underlain by shale, consists of a brown silt loam that grades into a dark reddish-brown clay subsoil. The Zaneis soil, which typically develops on silty shale interbedded with fine-grained sandstone, consists of loam and fine sandy loam.

Hydrology:

Water supplies in the vicinity of the Cimarron Facility are derived from local surface water and groundwater sources. The principal source of water for livestock is small ponds that impound surface runoff.[7] Water for domestic use is generally derived from groundwater sources at depths generally less than 200 feet.[8]

The primary surface water feature in the vicinity of the Cimarron Facility is the Cimarron River, an east-flowing tributary to the Arkansas River. The Cimarron River has poor water quality due to heavy mineralization derived from natural chloride sources. The river water is very hard with moderate to high turbidity and pH levels sometimes in excess of water quality standards. Dissolved oxygen remains at or near saturation levels. Iron, manganese, lead, silver, cadmium and arsenic are present in the river water concentrations elevated from typical background valves.

The Garber Sandstone is the principal source of groundwater south of the Cimarron River near the Cimarron Facility.[9] Permeability values for the

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[6] H. M. Galloway, et al, 1960: Soil Survey of Logan County, Oklahoma; U.S. Department of Agriculture, Soil Conservation Service.

[7] H. M. Galloway, Note 6 supra

[8] R. H. Bingham and R.L. Moore, Note 2 supra

[9] Engineering Enterprises, 1973: Hydrological Information in the Vicinity of the Kerr-McGee Facility, Logan County, Oklahoma; Kerr-McGee Corporation Document.

Garber Sandstone range from 2.7 to 4.8 feet per day and attendant storage coefficient values are reported to be in the 10^{-4} range based upon studies in Oklahoma and Cleveland Counties to the south.[10]

The Garber Sandstone becomes thinner and progressively more silty and clayey north of Oklahoma County.[11] A corresponding decrease in permeability is associated with this facies change to a finer-grained lithology. Because of the lenticular nature of the Garber Sandstone, water quantity and quality can vary greatly over relatively short distances.[12]

The effective thickness of the Garber Sandstone aquifer is limited by the presence of brackish and salty connate waters. The base of the fresh water in the Garber Sandstone in southwestern Logan County is reported to be at an elevation of approximately 700 to 800 feet above mean sea level.[13] At the Cimarron Facility brackish water was encountered at a depth of approximately 200 feet below ground level, confirming the reported freshwater base.[14] The depth to water in the vicinity of the relocation site is generally between 20 and 30 feet. The zone of fresh water saturation at the Cimarron Facility is thus approximately 170 to 180 feet in thickness.

Replenishment of the Garber Sandstone is believed to be restricted to lateral movement of groundwater recharging outcrops located to the east. Data derived from aquifer tests suggest that there is no significant hydraulic connection

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[10] P. R. Wood and L. C. Burton, 1968: Groundwater Resources in Cleveland and Oklahoma Counties, Oklahoma; The University of Oklahoma Circular 71.
[11] P. R. Wood and L. C. Burton, Note 10 supra
[12] Engineering Enterprises, Note 9 supra
[13] P. R. Wood and L. C. Burton, Note 10 supra
[14] Engineering Enterprises, Note 9 supra

between sandstone aquifers separated by intervening shale layers.[15] Most recharge to the upper part of the Garber Sandstone in the vicinity of the Cimarron Facility is believed to be derived from subcrops beneath intermittent streams.

Groundwater in the upper units of the Garber Sandstone discharges along entrenchments in the prairie surface caused by the Cimarron River and its tributaries. Groundwater in the deeper part of the Garber Sandstone, below the depth of surface entrenchments, is believed to move down dip to the west-southwest towards the Anadarko Basin.

Water from the Garber Sandstone is generally suitable for drinking. Locally, the water is hard and high in sulfates, chloride, fluoride, nitrates, or dissolved solids.[16][17] As described earlier, salt water was encountered beneath the Cimarron Facility at a depth of approximately 200 feet below ground surface.[18]

The site specific hydrologic characteristics of the Garber Sandstone have been established from the analysis of several groundwater monitor wells that have been completed at the Cimarron Facility. The locations and nomenclature of these wells are shown on Figure 4.

The three monitor wells designated 1306, 1309, and 1310 were constructed near the sites of borings 1E, 2E, and 3E at the north end of the relocation site

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[15] P. R. Wood and L. C. Burton, Note 10 supra
[16] P. R. Wood and L. C. Burton, Note 10 supra
[17] Oklahoma Water Resources Board, 1984: Oklahoma's Water Atlas; Publication No. 120.
[18] Engineering Enterprises, Note 9 supra

area. Each of these three wells, which are completed to depths of approximately 20 feet, were designed to monitor water in the unsaturated zone. Water appears in these wells only during extended wet periods.

The three wells designated 1311, 1312, and 1313 in figure 4 were constructed at the sites of borings LF-1, LF-2, and LF-3, respectively. These wells, which were completed to depths of approximately 40 feet, were designed to monitor groundwater within the saturated zone in the bedrock.

Aquifer Permeability - Instantaneous recharge tests were performed on each of the groundwater monitor wells 1311, 1312, and 1313 in 1985. These tests were conducted by placing a weighted length of PVC pipe into the well, instantaneously displacing the water level upward. Measurements were taken of the residual head and elapsed time during stabilization of the potentiometric surface as water moved into the formation around the well. Data from these tests and calculations of transmissivity and permeability are provided in Appendix B.

The data show a wide range of permeabilities for the Garber Sandstone, indicating anisotropic, nonhomogeneous conditions within the area tested. This anisotrophy is believed due to variations in unloading fracture density and differences in grain size and the degree of cementation within the Garber Sandstone.

The permeability of the Garber Sandstone at monitor well 1311 was determined to be 1.7 feet per day, and 0.35 foot per day at monitor well 1312. Due to the very slow recovery in monitor well 1313, a permeability was not calculated

from the test data. The test data for monitor wells 1312 and 1313 confirm the slow rate of recovery observed in these wells during the removal of water for sampling purposes.

Average permeabilities in the range of 2.7 to 4.8 feet per day have been reported for the Garber Sandstone in Oklahoma and Cleveland counties to the south.[19] Considering the increase in the silt and clay fraction in the Garber Sandstone northward from Oklahoma County[20] and the attendant decrease in yields in Logan County[21], the Garber Sandstone permeabilities determined from the tests of wells 1311 and 1312 are reasonable values. For the relocation site, permeabilities ranging from 0.35 to 1.7 feet per day are representative of the upper part of Garber Sandstone.

<u>Direction and Rate of Groundwater Movement</u> - Groundwater movement is to the north-northwest towards the Cimarron River. The difference in potentiometric surface elevation between monitor wells 3011 and 3012 along the direction of groundwater movement is 3.3 feet across a horizontal distance of 230 feet, which is equivalent to a hydraulic gradient of approximately 76 feet per mile. This relatively steep gradient is believed due to entrenchment of the prairie surface by the Cimarron River and its tributaries in the immediate vicinity. Calculations presented in Appendix C show the average velocity of groundwater movement through the upper part of the Garber Sandstone to be between 0.03 and 0.12 foot per day. Assuming the maximum velocity of 0.12 foot per day, groundwater would traverse the 230 feet along the hydraulic gradient between monitor wells 3011 and 3012 in approximately 1,917 days (5.3 years).

19/ P. R. Wood and L. C. Burton, Note 10 supra
20/ P. R. Wood and L. C. Burton, Note 10 supra
21/ Oklahoma Water Resources Board, Note 17 supra

Meteorology:

The area climate is characterized by hot summers and moderate winters. July, the hottest month, has an average temperature of 82.9°F and January, the coldest month, averages 38.3°F. The average annual rainfall is 31 inches, received predominantly in the early spring and late fall months. The annual net evaporation rate is approximately 30 inches.

Summary of Pertinent Relocation Site Features:

The relocation site topography is compatible with the topography of the general area and the surrounding environs. The site is a bluff area at the higher elevation within the facility property and will promote drainage of surface water away from the covered area and prevent accumulation or percolation of precipitation on or beneath the cover. The geological and soil characteristics are such that no fault structures are present, assuring stability of the area and no concern for erosion. Similarly, the hydrogeological characteristics assure there are no concerns regarding contact with groundwater.

<u>Material Relocation and Stabilization Procedure</u>

The relocation site will be prepared by excavating with mechanical equipment an area of sufficient size and depth to accommodate the estimated 400,000 cubic feet of material and a minimum of four feet of backfill cover. All the relocated material will be placed in the single excavation that will have dimensions approximating 200 feet by 500 feet by 8 feet deep. Thus, there will be a minimum of 10 feet between the lower dimension of the excavation and the occurrence of water bearing strata, which are some 20 to 30 feet beneath the surface.

The material to be placed in the excavation will be transported in dump trucks and will be covered when required to prevent dusting. The material will be placed in the excavation in lifts. The consistency of the material will not produce voids and consolidation will be enhanced with heavy equipment traversing the lifts. As required, dust suppression methods will be used to prevent dusting. Additional cover will be provided to compensate for any future subsidence.

The material placed in the excavation will be covered with a minimum of four feet of clean soil that will be placed in lifts and compacted. The cover will be contoured to blend with the area topography and to promote runoff of precipitation. The surface will be prepared and seeded with a pasture grass mixture.

Following the seeding, the area will be inspected and maintained to assure that viable and complete revegetation occurs and no erosion develops. Any required remediation measures will be done promptly.

Radiation Safety Procedures

The current facility radiation protection and monitoring program will apply for all activities involved in defining, excavating, relocating and covering the material. Additional procedures will be employed as dictated by good health physics practices and consistent with the ALARA principle. The essential elements of the radiation safety program are described briefly below.

Personnel Monitoring:

Radiation detection devices consist of film badges with activation foils for monitoring beta, gamma and neutron exposures. The badges are changed monthly and results are reviewed for compliance with permissible dose limits and

filed. All personnel working in radiation areas are required to wear a detection device.

Bioassay Program:

Bioassay specimens are obtained and analyzed in accordance with NRC's Regulatory Guide No. 8.11, "Applications of Bioassay for Uranium."

Radiation Surveys:

Radiation surveys are made of all areas where work is in progress and on a routine basis for determining surface levels and exposure rates.

Air Sampling:

Airborne radioactive material is monitored using commercial portable air samplers and analysis of the filter papers for alpha activity.

Contamination Control:

To guard against spread of contamination, protective clothing will be worn by all personnel when required. Change rooms with locker and shower facilities are available. Monitoring for hand, shoe and clothing contamination shall be done at the work areas, and spot checks made upon exiting the change rooms.

Equipment Survey:

Equipment used for excavating, relocating and covering the material will be surveyed. Any contaminated surfaces will be cleaned to meet unrestricted release criteria.

Records

A narrative report will be prepared that describes the procedures employed in removing, relocating and covering the material. The report will include a summation of the volume of material covered, the types and quantities of radionuclides contained in the relocated material, the time period over which relocation occurred, the physical characteristics of the relocated material and relocation area identification. The report will be maintained until termination of the license.

State and Local Considerations

Oklahoma is a non-agreement state and defers to NRC for regulation of licensed material. SFC is not aware of any state or local laws and requirements that would apply to the proposed action.

Figure 1

INSERT MAI PACKET w/ FIG. #1 HERE.

FIGURE 2: Map of Proposed Cimarr Facility Material Relocation Site and Vicinity Showing Topography and the 100-Year Flood Prone Area Elevation Limit

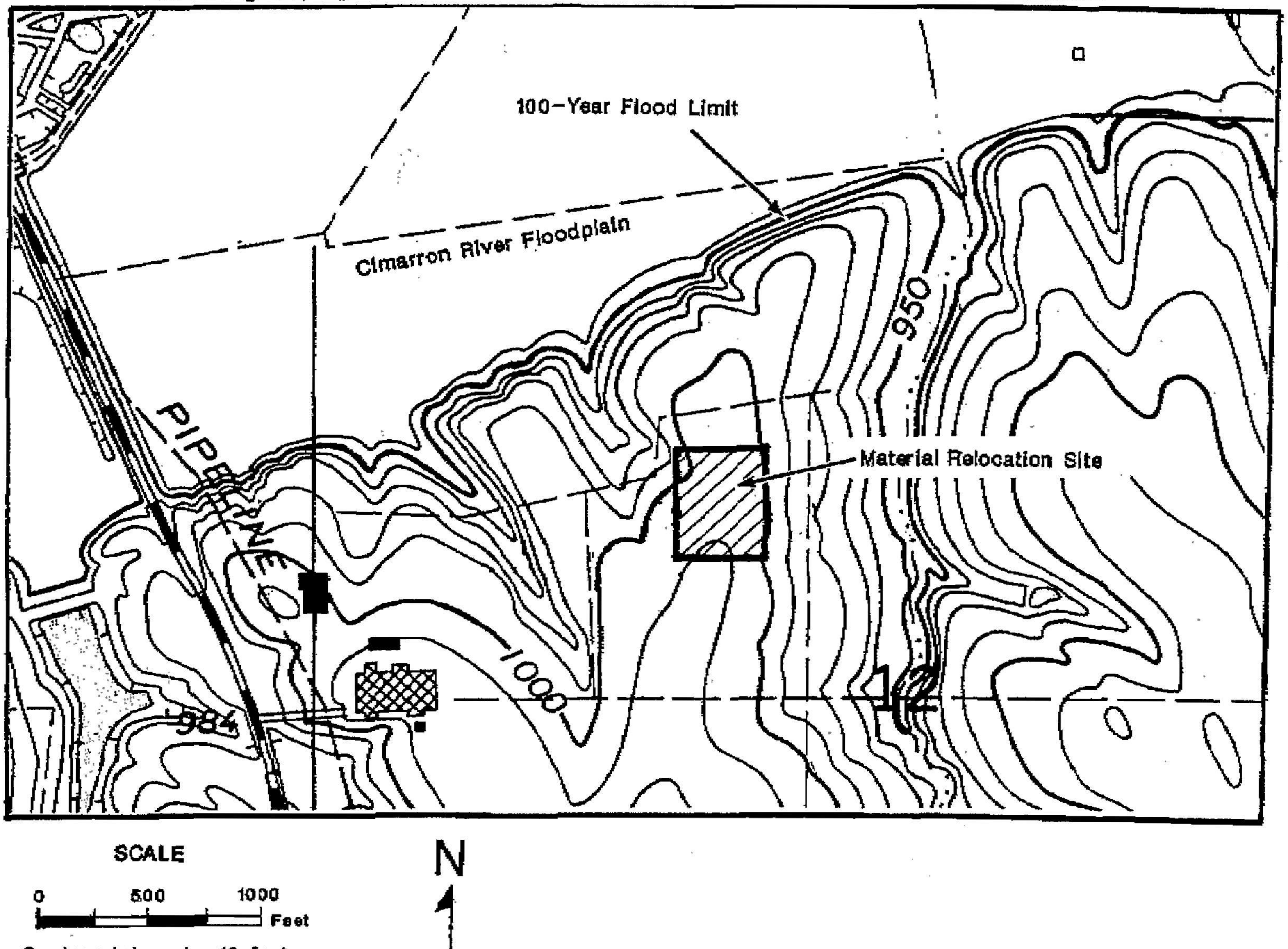

FIGURE 3: Map of Proposed Cim) Facility Material Relocation Site and Vicin
Showing Locations of Geotechnical Borings

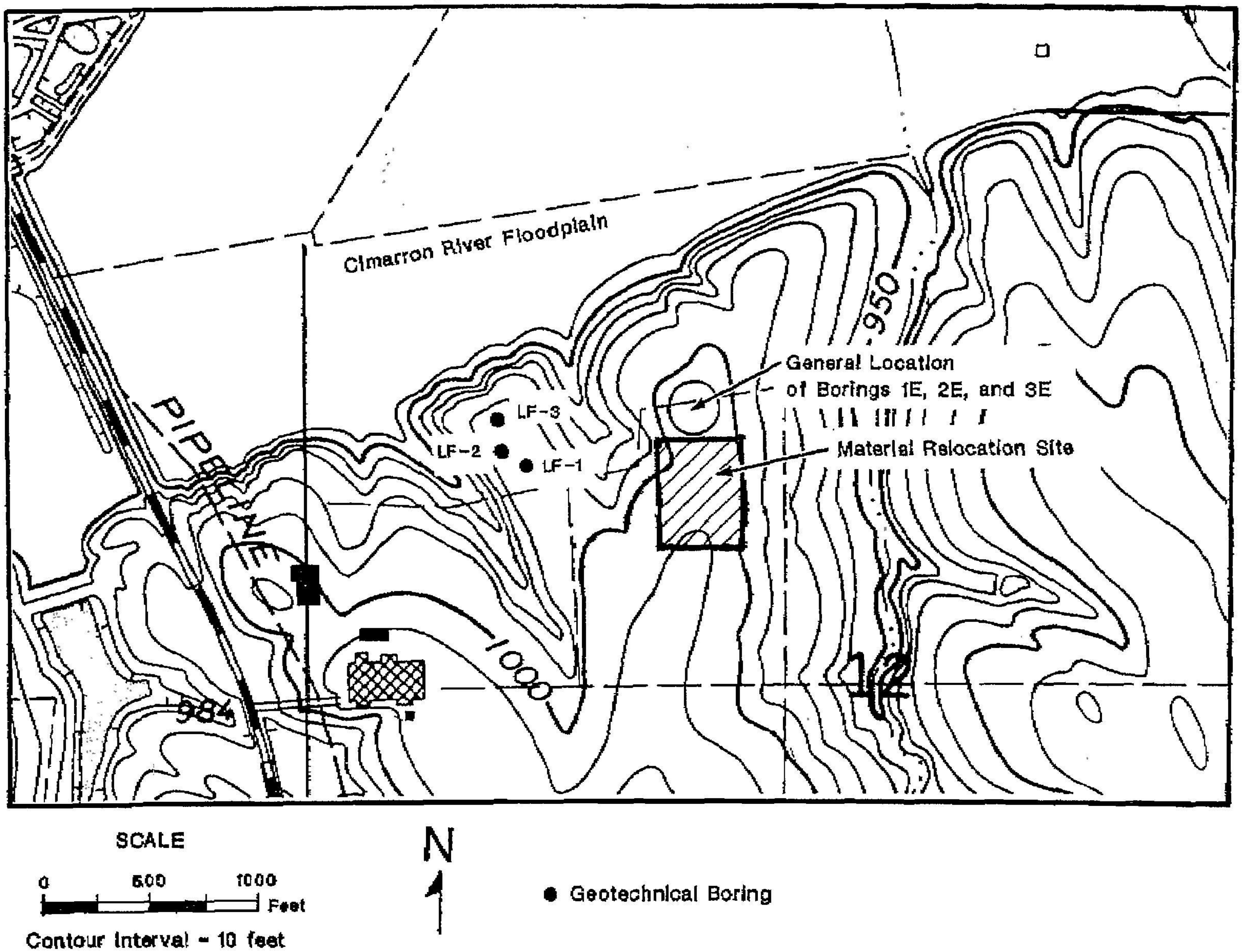

Figure 4: Map of Proposed Cim(ı Facility Material Relocation Site and Vicin(
Showing Locations of Monitor Wells

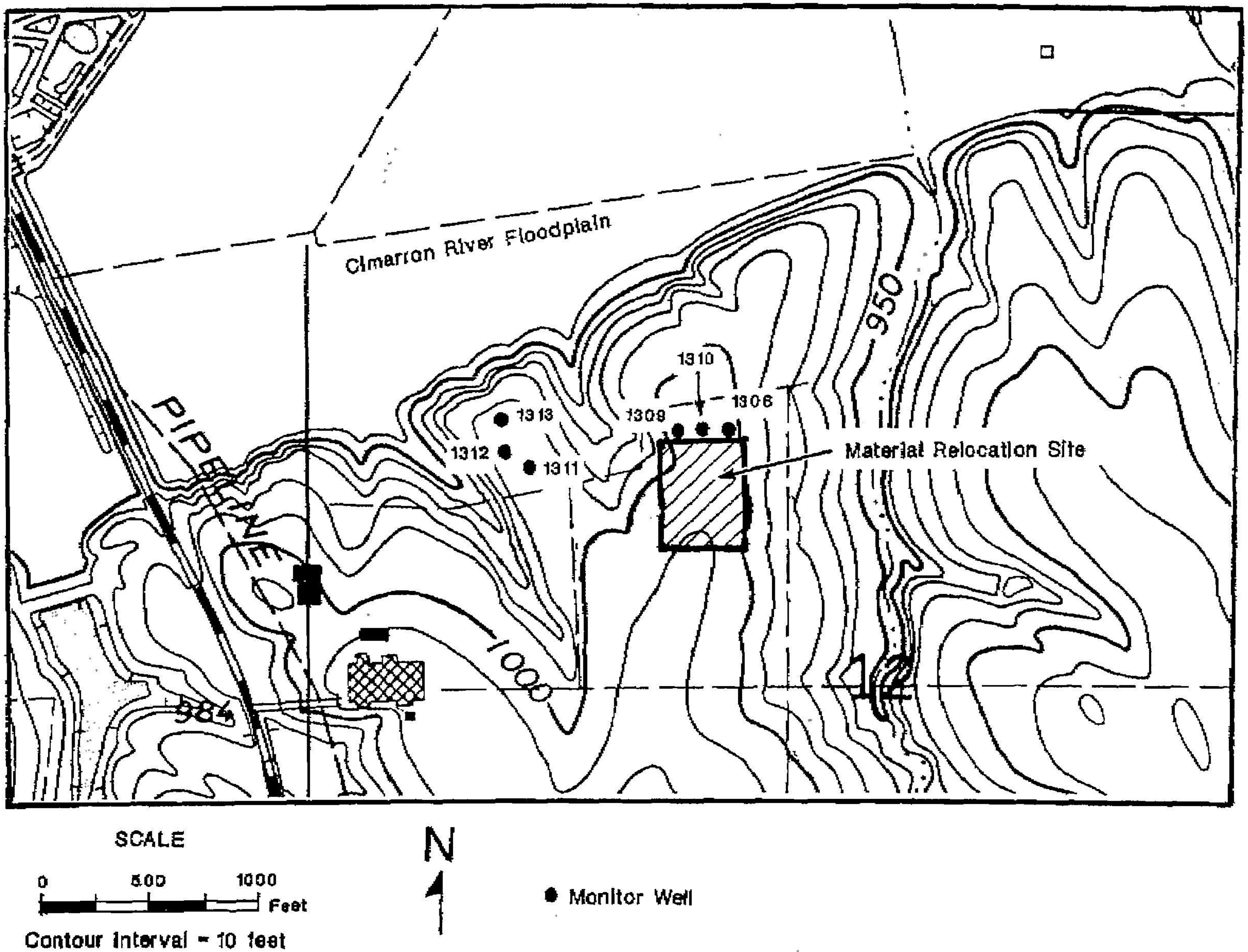

TABLE 1

Typical Soil Sample Analysis Results
Uranium Plant Areas

Location	Activity, pCi/g				
	U-238	U-235	U-234	Th-232	Th-228
Uranium Plant Yard #9	17.3	4.43	107.4	0.93	1.31
Uranium Plant Yard #28-C	1.59	0.34	3.63	1.18	1.33
Uranium Plant Yard #27-B	1.17	0.33	2.36	0.82	0.92
Lagoon #5	7.05	1.47	22.19	1.91	2.08
Pipe Line #3	0.36	0.20	0.96	1.26	1.32
1/2 Mile So. U-Plant (Background Location)	0.41	0.12	0.64	1.38	1.47

APPENDIX A

Logs for Geotechnical Boreholes

Proposed Disposal Area and Vicinity

Cimarron Facility

Logan County, Oklahoma

TABLE A-1
LOG OF GEOTECHNICAL BORING LF-1
Cimarron Facility
Crescent, Oklahoma

ithology

.ILTY SAND: red, very fine grained.
:LAYEY SILT: red, moist, weathered. Grades
o siltstone at 8.5 feet.
LAYEY SILTSTONE: red, slightly sandy.
ILTY SANDSTONE: red, very fine grained,
ery silty, cross-bedded.
ANDY SILTSTONE: red, some clay.
ANDSTONE: grades red to buff at base. Silty
t top, clean at base.
ILTY SANDSTONE: red with yellow-green
inerals. Very silty, very fine, very soft.
ross-bedded near base.
ANDSTONE: buff-pink, fine grained, clean,
assive. Groundwater encountered at 31
eet.
.ANDY SILTSTONE: red, very sandy, with
ccasional light gray-blue silt.
ILTY SANDSTONE: red, with frequent
ross-bedding. Very fined grained and silty.
ANDY SILTSTONE: red, damp.
ILTY SANDSTONE: red, very fine grained,
oist.
t.

TABLE A-2
LOG OF GEOTECHNICAL BORING LF-2
Cimarron Facility
Crescent, Oklahoma

Depth (ft)	Lithology
0 - 6.0	SILTY SAND/CLAY: red-brown, wet, roots.
6.0 - 12.5	CLAYEY SANDY SILTSTONE: red, weathered.
12.5 - 15.0	SILTY SANDSTONE: red, very fine to coarse grained, well cemented at base.
15.0 - 18.0	SILTY SANDSTONE: red with pink bands, cross-bedded.
18.0 - 22.0	SAND: red, fine grained, slightly silty, very soft, uncemented, wet.
22.0 - 25.4	SANDSTONE: pink-buff, fine grained with some cross-bedding.
25.4 - 26.4	SILTY SANDSTONE: red with yellow minerals, fine to very fine grained. Groundwater encountered at 26 feet.
26.4 - 36.0	SILTY SANDSTONE: red, very fine to fine grained, very silty, frequent cross-bedding.

Total Depth 36 feet.

TABLE A-3
LOG OF GEOTECHNICAL BORING LF-3
Cimarron Facility
Crescent, Oklahoma

Depth (ft)	Lithology
0 - 7.5	SILT and SAND: red-brown, very fine grained, wet. Grades into weathered silty sandstone at base.
7.5 - 17.6	SILTY SANDSTONE: red, very fine grained, very silty, some cross-bedding.
17.6 - 18.1	SAND: red, very fine to fine grained, uncemented.
18.1 - 20.2	SANDSTONE: red, some cross-bedding.
20.2 - 30.0	SANDSTONE: red, relatively clean, slightly silty, wet, no cross-bedding.

Total Depth 30 feet.

TABLE A-4
LOG OF GEOTECHNICAL BORING 1E
Cimarron Facility
Crescent, Oklahoma

Depth (ft)	Lithology
0 - 1.0	SILT: red, loose.
1.0 - 3.0	CLAY: red, silty, dry, firm.
3.0 - 7.5	SANDSTONE: red, with hard and firm zones.
7.5 - 8.8	SANDSTONE: red, brown, weathered.
8.8 - 9.3	SHALE: red, clayey, firm.
9.3 - 10.5	SHALE: red, with gray sandstone lenses.
10.5 - 13.0	CLAY: red, moist, firm.
13.0 - 14.4	SANDSTONE: gray, with red shales lenses.
14.4 - 17.5	SANDSTONE: red, hard.
17.5 - 18.0	SANDSTONE: red-brown, weathered, hard.
18.0 - 20.0	SANDSTONE: red-brown, with gray lenses, hard.

Total Depth 20 feet.

TABLE A-5
LOG OF GEOTECHNICAL BORING 2E
Cimarron Facility
Crescent, Oklahoma

Depth (ft)	Lithology
0 - 1.5	SILT: red-brown, sandy, loose.
1.5 - 2.8	CLAY: red, silty, sandy, firm.
2.8 - 8.0	SANDSTONE: red-brown, hard.
8.0 - 12.2	SANDSTONE: red, with soft lenses and layers.
12.2 - 15.3	SANDSTONE: brown.
15.3 - 16.0	SANDSTONE: gray, firm.

Total Depth 16 feet.

TABLE A-6
LOG OF GEOTECHNICAL BORING 3E
Cimarron Facility
Crescent, Oklahoma

Depth (ft)	Lithology
0 - 0.8	SILT: red, loose.
0.8 - 2.0	SANDSTONE: brown, firm.
2.0 - 16.5	SANDSTONE: light and dark brown, hard.
16.5 - 17.0	SANDSTONE: red, with clay lenses, hard.

Total Depth 16 feet.

Appendix B

Instantaneous Recharge Test Descriptions,

Data, and Calculations

Kerr-McGee Cimarron Facility

Logan County, Oklahoma

INTRODUCTION

The instantaneous recharge test data were analyzed by the methodology of Cooper, Bredehoeff, Papadopulos (1967) as modified by Papadopulos, Bredehoeff and Cooper (1973). To analyze these test data, values for the ratio of the observed change in water level (induced head) with time to the initial head change above static water level following instantaneous displacement (H/HO) were plotted against the log of elapsed time (t). The plotted data were matched with the appropriate Type Curve presented in Lohman (1972, Plate 2) and Papadopulos (1973, Plate 2a). Transmissivity (T) and permeability (P) were then calculated as shown below:

$$T = \frac{(Tt/r\ \ )(86400 \text{ sec/day})(r\ )}{t}$$

Where: T = Transmissivity, is square feet per day.
r_c = Casing radius, in feet.
t = Time value of match point on semi-log plot of H/HO versus time equivalent to the point where $Tt/r_c^2 = 1.0$, from Lohman (1972), Plate 2, or Papadopulous (1973), in seconds.

The permeability P of the formation is determined by dividing the transmissivity calculated from the test data by the comppleted saturated thickness of the formation being tested.

It should be noted that in all cases for the tests of monitor wells 1311, 1312, and 1313 the value r_c is equivalent to 0.17 foot, determined from the radius of the four-inch diameter (ID) PVC casing and screen. Also, the value of match point Tt/rc was always selected from the Type Curves at a position being equivalent to 1.0.

Test of Monitor Well 1311

Monitor well 1311 is completed to a depth of 41.1 below ground surface. Groundwater was encountered during drilling at a depth of 31 feet. The static water level at the time of the test was located 29.3 feet below grade for a potentiometric surface elevation of 964.7 feet above MSL. The bottom 15 feet of the well is screened; thus, the well is fully penetrating opposite the 11.8 feet of completed saturated formation.

Following the instantaneous induced rise in water level of 1.00 foot above the static water level, measurements of potentiometric surface recovery were made over a period of approximately 21 minutes (see Table B-1). During this period the well experienced 100% recovery. Calculations presented in Table B-2 show the transmissivity of the Garber Sandstone at this location to be 20.3 ft.2/day with a permeability of 1.7 feet per day.

[illegible]

Monitor well is completed to a depth of 36.2 below ground surface. Groundwater was encountered during drilling at a depth of 26 feet. The static water level at the time of the test was located 28.2 feet below grade for a potentiometric surface elevation of 961.4 feet above MSL. The bottom 14 feet of the well is screened; thus, the well is fully penetrating opposite the 8 feet of completed saturated formation.

Following the instantaneous induced rise in water level of 1.02 feet above the static water level, measurements of potentiometric surface recovery were made over a period of approximately 62 minutes (see Table B-3). During this period the well experienced 77.5% recovery. Calculations presented in Table B-4 show the transmissivity of the Garber Sandstone at this location to be 2.8 ft.2/day with a permeability of 0.35 feet per day.

Test of Monitor Well 1313

Monitor well 1313 is completed to a depth of 37.9 below ground surface. Groundwater was not noticed during drilling; however, groundwater seeped into the borehole during completion. The static water level at the time of the test was located 29.4 feet below grade for a potentiometric surface elevation of 962.8 feet above MSL. The bottom 15 feet of the well is screened; thus, the well is fully penetrating opposite the 8.5 feet of completed saturated formation.

Following the instantaneous induced rise in water level of 1.38 feet above the static water level, measurements of potentiometric surface recovery were made over a period of approximately 70 minutes (see Table B-5). During this period the well experienced 54% recovery. Due to the apparent poor water bearing characteristics of the Garber Sandstone at this location, no transmissivity and permeability values could be calculated.

TABLE B-1
Data for Instantaneous Recharge Test of Monitor Well 1311
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
-------	29.31	-----	-----	-----	Static WL
0.0	28.29	1.02	1.02	1.000	Start Test
0.2	28.33	.98		.961	
0.4	28.34	.97		.951	
2.0	28.36	.95		.931	
3.0	28.37	.94		.922	
4.0	28.38	.93		.912	
5.0	28.40	.91		.892	
8.0	28.44	.87		.853	
9.0	28.45	.86		.843	
10.0	28.47	.84		.824	
11.0	28.48	.83		.814	
12.0	28.49	.82		.804	
13.0	28.50	.81		.794	
14.0	28.52	.79		.775	
16.0	28.53	.78		.765	
17.0	28.54	.77		.755	
18.0	28.55	.76		.745	
19.0	28.57	.75		.735	
25.0	28.60	.71		.696	
30.0	28.63	.68		.667	
35.0	28.65	.66		.647	
40.0	28.68	.63		.618	
45.0	28.69	.62		.608	
50.0	28.72	.59		.578	
55.0	28.74	.57		.559	
60.0	28.76	.55		.539	
65.0	28.77	.54		.529	
70.0	28.79	.52		.510	
75.0	28.80	.51		.500	
80.0	28.82	.49		.480	
85.0	28.83	.48		.471	
90.0	28.85	.46		.451	
95.0	28.86	.45		.441	
100.0	28.87	.44		.431	
105.0	28.88	.43		.422	
110.0	28.89	.42		.412	
115.0	28.90	.41		.402	
120.0	28.92	.39		.382	
150.0	28.97	.34		.333	
180.0	29.02	.29		.284	
210.0	29.06	.25		.245	
240.0	29.09	.22		.216	
270.0	29.12	.19		.186	
300.0	29.14	.17		.167	

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Table B-1 (continued)
Data for Instantaneous Recharge Test of Monitor Well 1311
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
330.0	29.17	.14		.137	
360.0	29.19	.12		.118	
390.0	29.20	.11		.108	
420.0	29.22	.09		.088	
450.0	29.23	.08		.078	
480.0	29.24	.07		.069	
510.0	29.25	.06		.059	
540.0	29.27	.04		.039	
600.0	29.28	.03		.029	
720.0	29.31	0.00		0.000	End of Test

Notes: Water level is in feet below ground surface.
H is the head inside the well above the static water level at time t after the instantaneous recharge event.
HO is the head inside the well above the static water level at time t=0 of the instant of the instantaneous recharge event.

TABLE B-2
Calculation of Transmissivity and Permeability Values
Instantaneous Recharge Test of Monitor Well 1311
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

The semi-log plot of H/HO versus Time for the test of monitor well 1311 show a good match with Type Curve $a = 10^{-2}$ (see Figure B-1). The departure of the observed recovery data from the Type Curve during the first 15 seconds of the test is believed to be due to the instability of the water surface following placement of the displacement weight.

The transmissivity T and permeability P of the Garber Sandstone at this location can be calculated from:

$$Tt/r_c^2 = 1.0$$
$$r_c = 0.17 \text{ ft.}$$
$$t = 123 \text{ seconds}$$

$$T = \frac{(1.0)(86400 \text{ sec/day})(0.17 \text{ ft})^2}{123 \text{ seconds}} = 20.3 \text{ ft}^2\text{/day}$$

$$P = 20.3 \text{ ft}^2\text{/day} \ / \ 11.8 \text{ feet} = 1.7 \text{ ft/day}$$

Thus, the permeability of the Garber Sandstone at this location is 1.7 per day.

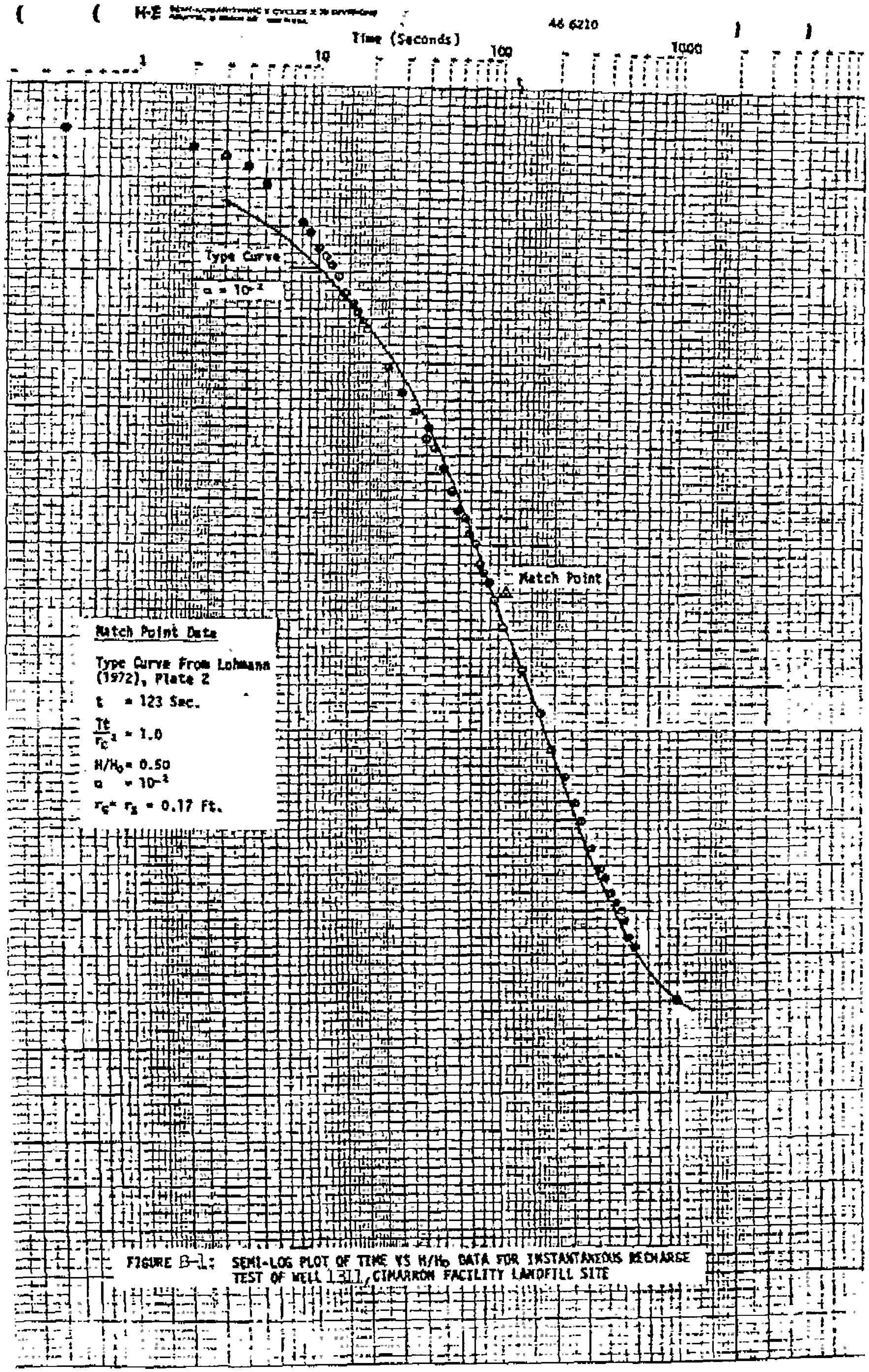

FIGURE B-1: SEMI-LOG PLOT OF TIME VS H/H_0 DATA FOR INSTANTANEOUS RECHARGE TEST OF WELL 1311, CIMARRON FACILITY LANDFILL SITE

TABLE B-3
Data for Instantaneous Recharge Test of Monitor Well 1312
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
-------	28.20	-----		-----	Static WL
0.0	27.03	1.17	1.17	1.000	Start Test
.6	27.07	1.13		.966	
1.6	27.08	1.12		.957	
5.0	27.09	1.11		.949	
6.0	27.10	1.10		.940	
10.0	27.11	1.09		.932	
16.0	27.12	1.08		.923	
25.0	27.13	1.07		.915	
35.0	27.14	1.06		.906	
45.0	27.15	1.05		.897	
50.0	27.16	1.04		.889	
65.0	27.17	1.03		.880	
80.0	27.18	1.02		.872	
85.0	27.19	1.01		.863	
100.0	27.20	1.00		.855	
115.0	27.21	.99		.846	
150.0	27.23	.97		.829	
180.0	27.25	.95		.812	
210.0	27.26	.94		.803	
240.0	27.28	.92		.786	
270.0	27.29	.91		.778	
300.0	27.30	.90		.769	
330.0	27.32	.88		.752	
360.0	27.33	.87		.744	
390.0	27.34	.86		.735	
420.0	27.35	.85		.726	
450.0	27.36	.84		.718	
480.0	27.37	.83		.709	
510.0	27.38	.82		.701	
540.0	27.39	.81		.692	
570.0	27.41	.79		.675	
720.0	27.45	.75		.641	
840.0	27.49	.71		.607	
960.0	27.53	.67		.573	
1080.0	27.55	.65		.556	
1200.0	27.57	.63		.538	
1320.0	27.60	.60		.513	
1440.0	27.62	.58		.496	
1560.0	27.65	.55		.470	
1680.0	27.67	.53		.453	
1800.0	27.69	.51		.436	
1920.0	27.71	.49		.419	
2040.0	27.74	.46		.393	
2160.0	27.75	.45		.385	

TABLE B-3 (continued)
Data for Instantaneous Recharge Test of Monitor Well 1312
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
2280.0	27.77	.43		.368	
2400.0	27.79	.41		.350	
2520.0	27.82	.38		.325	
2640.0	27.84	.36		.308	
2760.0	27.86	.34		.291	
2880.0	27.87	.33		.282	
3000.0	27.89	.31		.265	
3120.0	27.90	.30		.256	
3240.0	27.92	.28		.239	
3360.0	27.94	.26		.222	
3600.0	27.96	.24		.205	
3720.0	27.97	.23		.197	End of Test

Notes: Water level is in feet below ground surface.
H is the head inside the well above the static water level at time t after the instantaneous recharge event.
HO is the head inside the well above the static water level at time t=0 of the instant of the instantaneous recharge event.

TABLE B-4
Calculation of Transmissivity and Permeability Values
Instantaneous Recharge Test of Monitor Well 1312
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

The semi-log plot of H/HO versus Time for the test of monitor well 1312 shows a good match with Type Curve $a = 10^{-5}$ (see Figure C-2). The departure of the observed recovery data from the Type Curve during the first 3 minutes of the test is believed to be due to the instability of the water surface following placement of the displacement weight.

The transmissivity and permeability of the Garber Sandstone at this can be calculated from:

$$Tt/r_c^2 = 1.0$$
$$r_c = 0.17 \text{ ft}$$
$$t = 900 \text{ seconds}$$

$$T = \frac{(1.0)(86400 \text{ sec/day})(0.17)^2}{900 \text{ seconds}} = 2.8 \text{ ft}^2\text{/day}$$

$$P = 2.8\text{ft}^2\text{/day} \;/\; 8.0 \text{ feet} = 0.35 \text{ ft/day}$$

Thus, the permeability of the Garber Sandstone at this location is 0.35 per day.

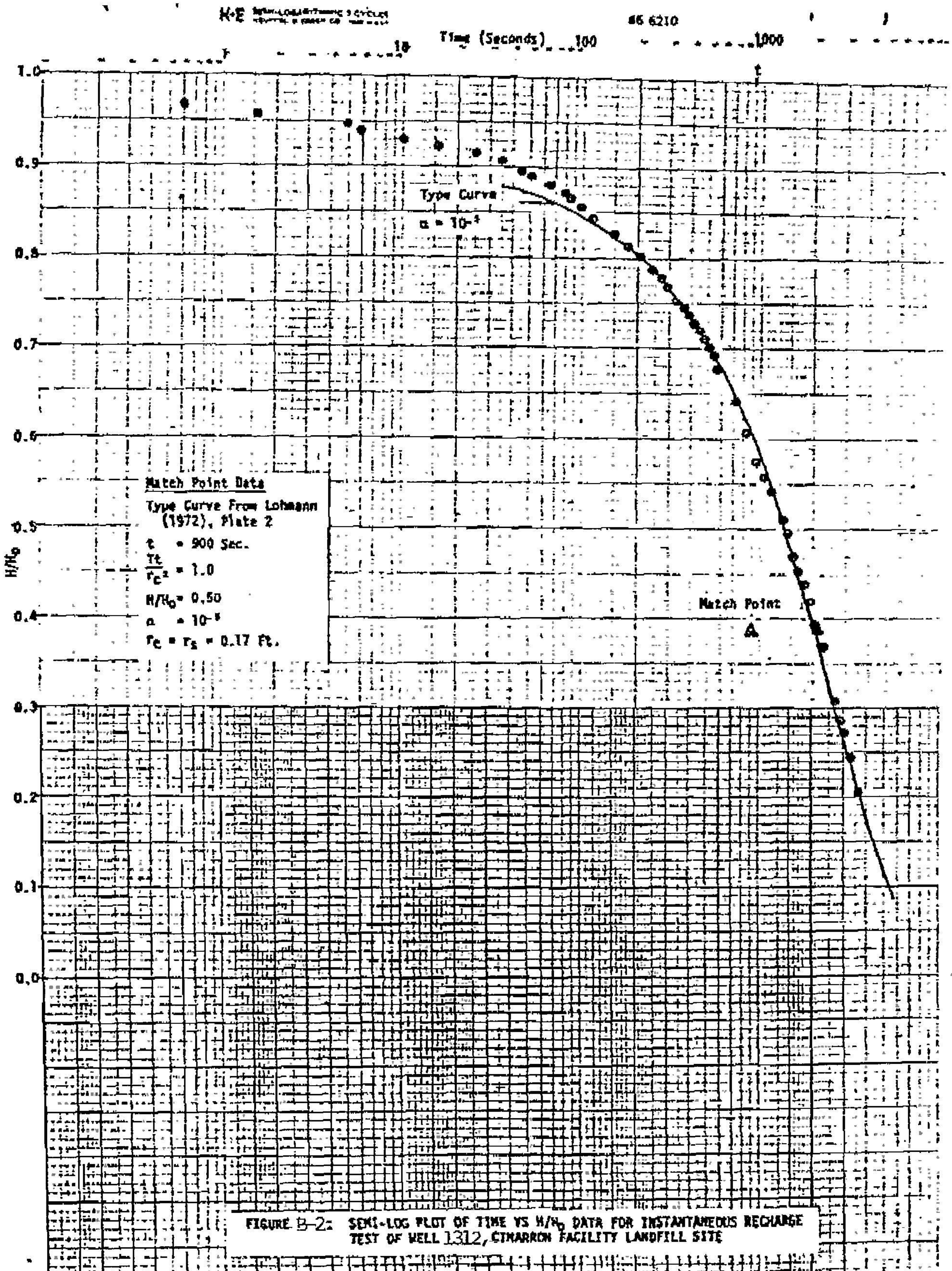

FIGURE B-2: SEMI-LOG PLOT OF TIME VS H/H_0 DATA FOR INSTANTANEOUS RECHARGE TEST OF WELL 1312, CIMARRON FACILITY LANDFILL SITE

TABLE B-5
Data for Instantaneous Recharge Test of Monitor Well 1313
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
------	29.38	-----		-----	Static WL
0.0	28.00	1.38	1.38	1.000	Start Test
.2	28.01	1.37		.993	
.4	28.09	1.29		.935	
.8	28.13	1.25		.906	
1.2	28.14	1.24		.899	
2.0	28.15	1.23		.891	
3.0	28.16	1.22		.884	
4.0	28.17	1.21		.877	
6.0	28.18	1.20		.870	
8.0	28.19	1.19		.862	
13.0	28.20	1.18		.855	
18.0	28.21	1.17		.848	
30.0	28.22	1.16		.841	
35.0	28.23	1.15		.833	
50.0	28.24	1.14		.826	
65.0	28.25	1.13		.819	
70.0	28.26	1.12		.812	
85.0	28.27	1.11		.804	
110.0	28.28	1.10		.797	
150.0	28.30	1.08		.783	
180.0	28.31	1.07		.775	
210.0	28.32	1.06		.768	
240.0	28.33	1.05		.761	
300.0	28.34	1.04		.754	
330.0	28.35	1.03		.746	
390.0	28.36	1.02		.739	
420.0	28.37	1.01		.732	
450.0	28.38	1.00		.725	
510.0	28.40	.98		.710	
540.0	28.41	.97		.703	
600.0	28.43	.95		.688	
720.0	28.45	.93		.674	
840.0	28.47	.91		.659	
960.0	28.49	.89		.645	
1080.0	28.52	.86		.623	
1200.0	28.54	.84		.609	
1320.0	28.55	.83		.601	
1440.0	28.56	.82		.594	
1560.0	28.57	.81		.587	
1680.0	28.59	.79		.572	
1800.0	28.60	.78		.565	
1920.0	28.61	.77		.558	
2040.0	28.62	.76		.551	
2280.0	28.65	.73		.529	
2640.0	28.66	.72		.522	

TABLE B-5 (continued)
Data for Instantaneous Recharge Test of Monitor Well 1313
Kerr-McGee Cimarron Facility
Logan County, Oklahoma

Time (seconds)	Water Level (feet)	H (feet)	Ho	H/Ho	Remarks
2880.0	28.67	.71		.514	
3000.0	28.68	.70		.507	
3120.0	28.69	.69		.500	
3360.0	28.70	.68		.493	
3480.0	28.71	.67		.486	
3720.0	28.72	.66		.478	
3840.0	28.73	.65		.471	
4080.0	28.75	.63		.457	End of Test

Notes: Water level is in feet below ground surface.
H is the head inside the well above the static water level at time t after the instantaneous recharge event.
HO is the head inside the well above the static water level at time t=0 of the instant of the instantaneous recharge event.

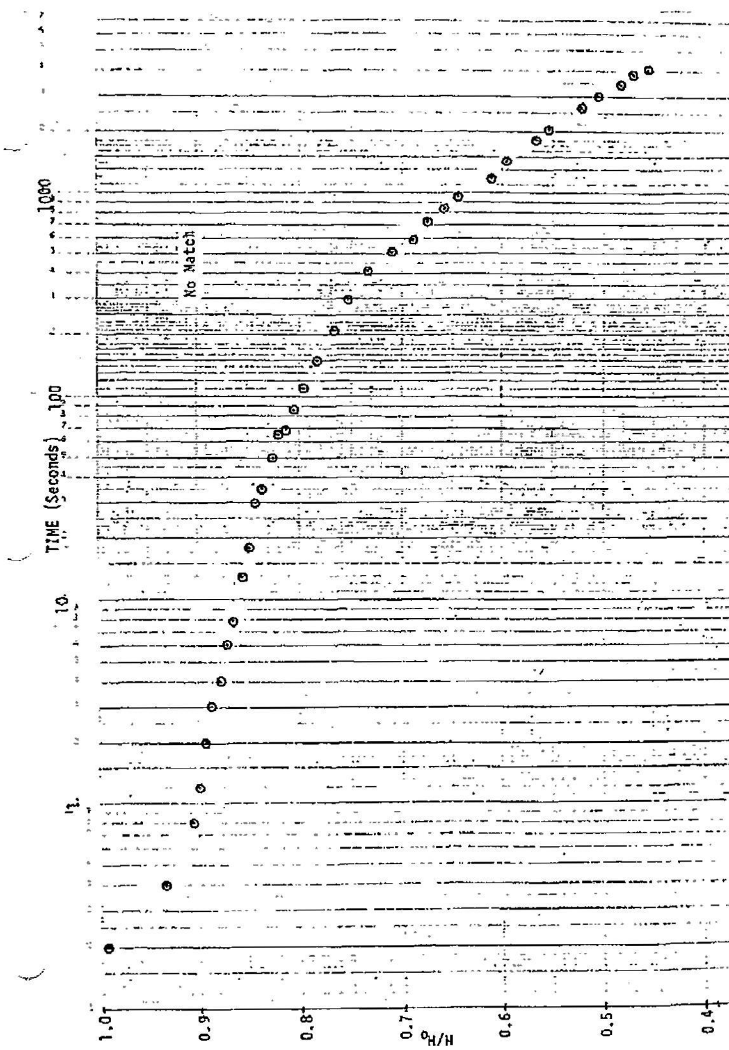

FIGURE B-3: SEMI-LOG PLOT OF TIME VS H/H_o DATA FOR INSTANTANEOUS RECHARGE TEST OF WELL 1313, CIMARRON FACILITY LANDFILL SITE

Appendix C

Calculations of Groundwater Velocity

Kerr-McGee Cimarron Facility

Logan County, Oklahoma

The average velocity of groundwater movement beneath the Cimarron Facility can be calculated from the relation (Lohman, 1972):

$$v = \frac{-Kdh/dh}{0}$$

where v = average velocity, in feet per day.
0 = porosity as a decimal fraction.
dh/dl = hydraulic gradient, in feet per mile.
= hydraulic conductivity, in feet per day.

Davis and Dewiest (1966) and Dunne and Leopold (1978) report a porosity range of 0.05 to 0.30 for sandstone, with the value dependent largely upon clay content, the degree of cementation, and the extent of jointing. Given the silt and clay content of the bedrock underlying the Cimarron Facility, the average porosity of the Garber Sandstone at this location is assumed to be a maximum of approximately 0.20.

The permeability of the upper part of the Garber Sandstone at this location was determined to be in the range of 0.35 foot per day to 1.7 feet per day. A hydraulic gradient (dh/dl) of 76 feet per mile was determined from monitor well potentiometric surface data. Given these parameters, the average velocity of groundwater beneath the Cimarron Facility, assuming a permeability of 0.35 foot per day, is calculated to be:

$$v = \frac{(0.35ft/day)(-76ft/5280ft)}{0.20} = 0.03 \text{ foot per day.}$$

For a permeability of 1.7 feet per day, the groundwater velocity is calculated to be:

$$v = \frac{(1.7ft/day)(-76ft/5280ft)}{0.20} = 0.12 \text{ foot per day.}$$

APPENDIX D

SOIL CONTAMINATION ASSESSMENT

BOREHOLE LOGGING

The extent of uranium or thorium contamination in subsurface soils at the Cimarron Facility was assessed by gamma probe logging of boreholes located on a sampling gird. The area around the uranium building, underground pipelines and lagoons was gridded using 50 foot centers from which boreholes were completed at grid intersections. The boreholes were logged by traversing a sodium iodide crystal scintillation probe, doped with thalium, down the hole and noting the count rate (cpm) at one foot intervals. The data were then compared to counting results from known concentration standards derived from identical geometries.

Count rate action levels corresponding to uranium and thorium activity concentrations were used to identify areas requiring excavation and/or further investigation. Action levels were based on Option 1 or 2 concentration values listed in the Branch Technical Position, as appropriate. Probe results were entered into a computer and analyzed to estimate the location and volume of material requiring removal.

The counting system used for gamma logging was calibrated with a series of specially prepared drums containing known uniform concentrations of uranium and thorium. A three inch diameter access pipe was installed in each drum to provide a portal for the NaI(Tl) scintillation probe prior to placement of

thorium or uranium containing materials into the drum. The probe was placed in the center of each drum and the count rate response recorded. Table D-1 shows the results of the probe calibration. Concentrations of uranium and thorium isotopes versus the probe reading in cpm are shown. This data and the analytical results of samples collected during the drilling operations at depth were used to determine count rate action levels.

Documentation of logging results will be maintained at the Cimarron Facility for review by NRC.

TABLE D-1

Calibration Drum Isotopic Content

vs.

Scintillation Probe Response

Drum No.	Activity, pCi/g U-238	U-235	U-234	Th-Nat	Probe Response, cpm
U-1	4.90	1.06	20.3	3.52	23,670
U-2	12.1	2.23	51.8	2.54	33,223
U-3	18.3	3.41	62.9	3.17	40,257
U-4	1060	176	3590	147.	740,717
Th-U	55	6.5	178	119.	387,712
Th-1	0.65	0.21	0.71	9.8	58,756
Th-2	1.89	0.39	1.90	60.5	244,310
Th-3	8.0	1.38	8.01	251.	752,656
Th-4	19.3	2.3	19.3	477	1,333,413
Depl. U	517	7.68	60.3	2.71	98,813
Bkgd Soil	1.55	0.24	0.73	2.3	19,009