TABLE OF CONTENTS

REFERENCES

1. Cimarron Corporation Materials License, SNM-928, Docket No. 070-00925, Amendment No. 9, dated December 28, 1992.

2. Cimarron Corporation Materials License, SNM-1174, Docket No. 070-1193, terminated February 5, 1993.

3. NRC letter February 5, 1993 from Mr. Richard E. Cunningham, Director to Mr. J. C. Stauter, Cimarron Corporation.

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7. Site Investigation Report for the Cimarron Corporation Facility. James L. Grant and Associates, Inc., September 12, 1989.

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9. Branch Technical Position for Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations. 46 Federal Register 52061, October 23, 1981.

10. Decontamination and Final Survey Report for Cimarron Facility Contaminated Waste Burial Ground, Cimarron Corporation, License No. SNM-928, Dated November 25, 1991.

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12. NRC letter from Mr. William L. Fisher, Acting Chief, to Mr. W. J. Shelley, Kerr-McGee Corporation, dated February 3, 1978.

13. NRC letter from Mr. Richard W. Starostecki, Chief to Mr. W. J. Shelley, Kerr-McGee Corporaton, dated July 10, 1978.

14. Cimarron Corporation Report from Mr. J. C. Stauter to Mr. A. Bert Davis, USNRC, Dated October 9, 1989. Reference: Amendment Request: Onsite Disposition of Uranium Containing Soils Meeting NRC Branch Technical Position Option 2 Criteria.

15. Kerr-McGee Corporation letter from Dr. J. C. Stauter to Mr. Glen L. Sjoblom, Deputy Director, Division of Fuel Cycle, Medical, Academic and Commercial Use Safety U.S. NRC, dated February 1, 1990.

16. NRC letter from Mr. Leland C. Rouse, Chief Fuel Cycle Safety Branch, to Dr. J. C. Stauter, Cimarron Corporation, dated December 7, 1988.

17. ORISE "Confirmatory Radiological Survey of the Wet Ceramic Area, Cimarron Corporation Facility, Crescent, Oklahoma-Final Report" dated July, 1993.

18. NRC letter from Mr. David N. Fauver, Project Manager, to Dr. Edwin T. Still, Kerr-McGee Corporation Dated January 10, 1994.

19. Guidelines of Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Materials, (NRC, 1987), Office of Nuclear Material Safety and Safeguards (NMSS).

20. Confirmatory Survey of the Cimarron Corporation Mixed Oxide Fuel Fabrication Plant, Crescent, Oklahoma. Prepared by J. D. Berger and L. F. Friedman, Oak Ridge Associated Universities, January, 1991.

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1.0 Introduction

The Cimarron Corporation (Cimarron) Facility, located near Crescent, Oklahoma, was operated by Kerr-McGee Corporation (Kerr-McGee) from 1966 to 1975 to manufacture enriched uranium and mixed oxide reactor fuels. Kerr-McGee, whose principal address is Kerr-McGee Center, Oklahoma City, Oklahoma, through its subsidiary, Cimarron, possessed the Special Nuclear Materials License required to operate the two plants.

The 1,100-acre Cimarron facility was originally licensed under two Special Nuclear Material Licenses. License SNM-928[1] was issued for the Uranium Plant and License SNM-1174[2] was issued for the Mixed Oxide Fuel Fabrication (MOFF) Plant. Therefore, two major plants, licensed as two separate and distinct facilities by the NRC, are located at the Cimarron site.

The task involving characterization, decontamination and decommissioning work, for both the MOFF Plant and the Uranium Plant was initiated in 1976 upon the termination of production operations. The goal of the decommissioning task is to release both facilities for unrestricted use.

Decommissioning efforts for the MOFF Plant were completed in 1990 and Cimarron applied to the NRC to terminate License SNM-1174 on August 20, 1990. The NRC terminated License SNM-1174 for the Mixed Oxide Plant on February 5, 1993[3]. Since the MOFF Plant is located within the licensed 1,100-acre Uranium Plant site, the termination of License SNM-1174 did not release the MOFF Plant building (exterior and grounds) from License SNM-928 (Uranium Plant license).

Decommissioning of the Uranium Plant is still ongoing. One step in completing this decommissioning process is the compilation of a site characterization report. This Radiological Characterization Report has been prepared for the Cimarron facility in accordance with the requirements of license condition #20 of Cimarron Corporation Materials License SNM-928 (Amendment #9). License SNM-928 covers the entire 1,100 acre site and thus the Radiological Characterization Report addresses the entire site. Amendment #9, issued December 30, 1992, is the most recent amendment to SNM-928.

A significant portion of the characterization, decontamination and decommissioning work for the Cimarron facility was performed prior to the existence of NUREG/CR-5849[4], NUREG-1444[5], and other guidance documents containing descriptions of recommended methodologies for characterization and decommissioning. Many of the areas within the

1,100-acre site were therefore at various stages of characterization and decommissioning when these guidance documents were first issued.

The historical information contained in this Radiological Characterization Report has been summarized and subdivided into separate areas within the 1,100 acre site. In most cases, drawings are provided as attachments to specific sections. All of these areas are then categorized as either affected areas or unaffected areas. To include all of the characterization data generated over the last 18 years in this Characterization Report would be impractical due to the voluminous quantity of data generated over that time period. All characterization data is located in the Cimarron facility site files.

If viewed strictly under the current guidance documents, this Radiological Characterization Report would be considered a combination of scoping surveys, characterization surveys, remediation control surveys, pre-remediation surveys, post-remediation surveys, final surveys, and confirmatory surveys (ORISE and NRC confirmatory survey results are included for some areas, and in some cases, survey results are included for areas which have already been released by the NRC). In fact, portions of this Radiological Characterization Report are appropriate for the *Decommissioning Plan* and the *Final Status Survey Report*.

The NRC has stated at numerous public meetings that the data generated by facilities that have performed extensive characterization and decommissioning activities prior to the issuance of the recent regulatory guidance will be acceptable even though the data does not fit exactly the format of the newly established regulatory criteria.

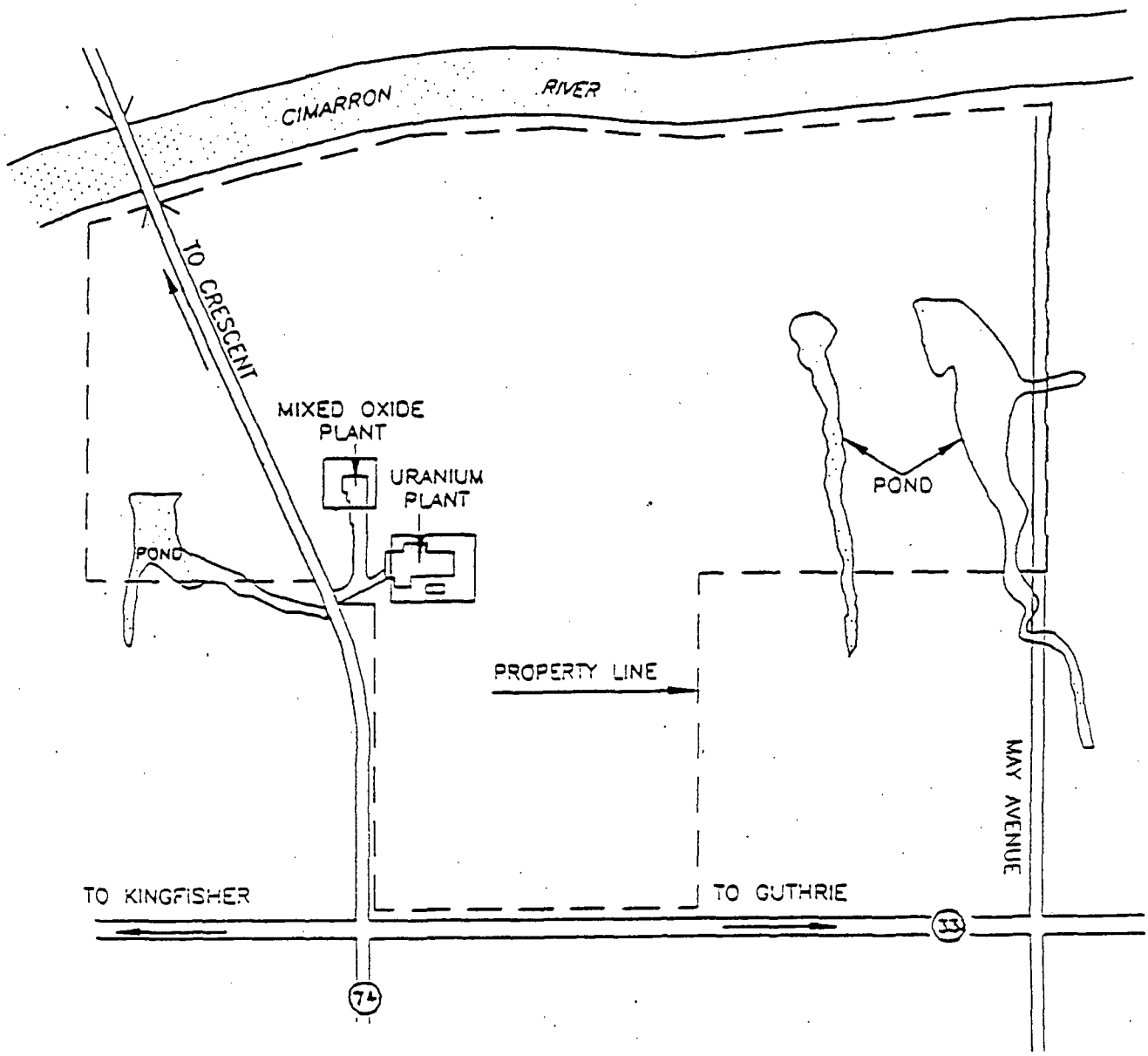
This Radiological Characterization Report follows the current regulatory guidance as closely as possible. As discussed above, much of the information on final surveys and decommissioning goes well beyond the scope of an initial radiological characterization.

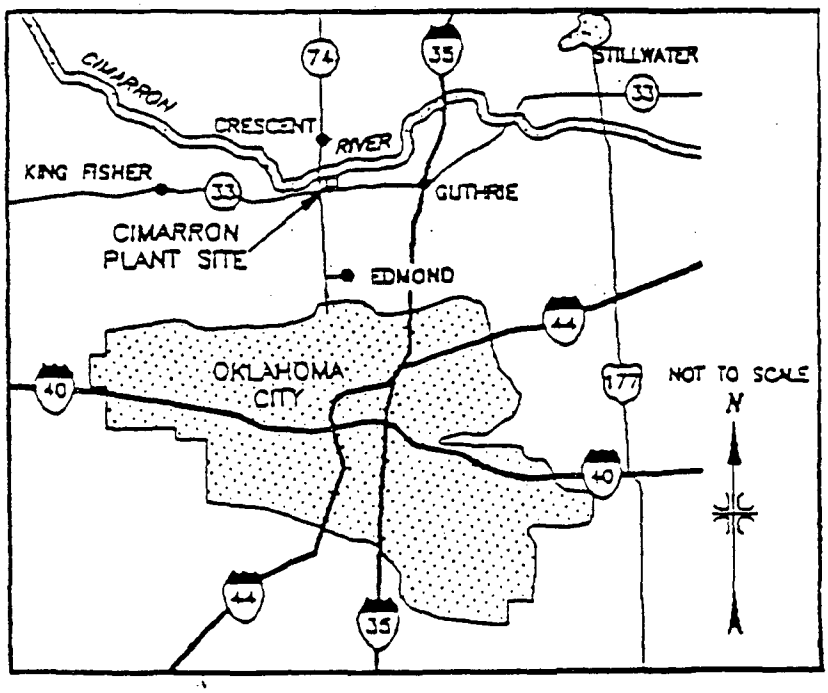
2.0 Site Description

Cimarron Corporation, a wholly-owned subsidiary of Kerr-McGee Corporation, continues to manage all characterization and decommissioning activities at the Cimarron site located in Logan County, Oklahoma. The Cimarron facility is located on the south side of the Cimarron River approximately 0.5 miles north of the intersection of Oklahoma State Highways No. 33 and 74. Figure 2.1 shows the location of the facility. This facility was formerly known as the Sequoyah Fuels Cimarron Plant operated by Sequoyah Fuels Corporation, a subsidiary of Kerr-McGee Corporation. When in production, the facility was operated by Kerr-McGee Nuclear Corporation, a wholly owned subsidiary of Kerr-McGee Corporation. The facility was operational from 1966 to 1975. The principal operations at the facility involved the fabrication of pellets of enriched uranium; and the manufacturer of mixed oxides (plutonium) reactor fuel. Mixed oxide reactor fuel was manufactured from 1970 through 1975. Production at the facility ceased in 1975 and characterization/ decommissioning efforts which commenced in 1976 are still ongoing.

The site included two primary plants, a uranium processing plant (Uranium Plant) and a plutonium processing plant (MOFF Plant). The Uranium Plant processed material from 1966 through 1975 when operations ceased. The MOFF Plant operated from 1970 until 1975. The license for the MOFF Plant (SNM-1174) included the plutonium fabrication facility, the drain line to the evaporation ponds, the fenced area surrounding the facility, the plutonium evaporation and emergency ponds, the east and west sanitary lagoons, some underground tanks, and the septic tank. The MOFF Plant has been decommissioned, and the plutonium license was terminated by the NRC in 1993. However, the MOFF Plant areas remain under the uranium license. The license for the Uranium Plant (SNM-928) encompasses the entire 1,100-acre site, including the MOFF plant areas. The general layout for the 1,100-acre facility is shown on Drawing No. 94MOST-RF7.

Enriched uranium fuel was produced at the Uranium Plant from 1966 through 1975. The process facilities included a main production building; several one-story ancillary buildings, five process related collection ponds, two original sanitary lagoons, one new sanitary lagoon, a waste incinerator, several uncovered storage areas, and three burial grounds. The main production building was divided into six major areas: ceramic UO_2, pellet, scrap recycle and recovery, waste treatment, fabrication and the high enriched area. In addition, space was provided for auxiliary services such as office, laboratory, maintenance, and warehousing. The low enriched fuel fabrication process is described by the following steps:





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Cimarron Corporation
Crescent Oklahoma Facility
Location Map
Figure 2.1

- Uranium hexafluoride gas (UF_6) was received and stored on site for processing.

- The UF_6 was heated; the gaseous UF_6 was then passed through an ammonia solution, producing solid ammonium diuranate (ADU).

- Ammonium diuranate was calcined to produce uranium oxide powder (UO_2).
- Uranium oxide powder was ground to break up agglomerates, and then blended and pressed into pellets.

- The pellets were converted into ceramic-grade uranium dioxide (UO_2) in reduction furnaces.

- After sintering, the pellets were ground to a straight-sided right circular cylinder. The UO_2 removed was sent to the scrap purification system.

Highly enriched uranium processing was performed also at Cimarron within the main process building. This fuel fabrication process is described by the following steps:

- UF_6 is vaporized by heating cylinders with steam, reached with a chemical to form a solid UF_4.

- The UF_4 is dried, placed in small muffle furnaces for conversion to UO_2 or U_3O_8 metal oxides.

- Subsequent grinding and blending completes the oxide process.

- Uranium metal is made by blending UF_4 powder calcium metal granules and heating.

- The Uranium separates and is placed in an acid solution to remove calcium and oxide slag.

- The metal and oxides are then packaged for shipment to fuel fabricators.

Additional operations at the facility included a solvent extraction process to recover uranium from the processing of scrap and from material that did not meet contract specifications. Mixed-oxide fuel also was produced from 1970 to 1975 in the MOFF plant.

In general, the plant was designed to be slightly pressurized at all times with the general plant air primarily discharging through roof vents. The exhaust systems for process equipment and operating areas was designed for effective control of airborne contaminants generated in processing. Special blowers, absolute filters and exhaust ducts were utilized in areas of high airborne contamination potential. The main plant for uranium processing had 22 individual exhaust stacks which were routinely monitored for releases of radioactivity. The solvent extraction operation had a single exhaust stack which likewise was continuously sampled and periodically analyzed for radioactivity in the gaseous effluent. The contaminated waste incinerator had efficient stack gas cleaning equipment for controlling air emissions.

In addition to the process buildings, there were other site areas which were affected either directly or indirectly by Cimarron operations. These areas included the sanitary lagoons, the waste settling ponds, the on-site disposal areas, selected drain lines, and the incinerator.

In converting the UF_6 gas to a solid fuel, contaminated liquids were generated that required processing. The liquid wastes produced via uranium processing were passed through an ion-exchange system for recovery of the uranium. The treated effluent was monitored prior to being discharged to the Cimarron River under the facility license from 1966 to 1971. From 1971 to 1975, the treated effluent was pumped to wastewater evaporation ponds. Contaminated sludges that accumulated in the ponds were removed in 1976 and 1977, solidified with concrete, and shipped to a licensed commercial low-level radioactive waste (LLRW) disposal facility. The ponds were subsequently reclaimed, sampled, inspected by regulatory agencies, and subsequently released by regulatory agencies for backfilling and unrestricted use.

Sanitary water and laundry water from the Uranium and MOFF Plant operations were discharged to the East and West Sanitary Lagoons. Contaminated sediments that accumulated were removed from these two sanitary lagoons. The sediments were solidified with concrete and then shipped off site to a commercial LLRW disposal facility. These East and West Sanitary Lagoons have been closed and backfilled.

Radioactively contaminated solid wastes generated from the uranium plant activities were buried at a designated on-site radioactive waste disposal area from 1966 to 1970. The solid wastes from this radioactive waste disposal area (Burial Area No. 1) have since been excavated, packaged, and shipped off site to a commercial LLRW disposal facility[6]. This burial area has been released by the NRC.

Beginning in 1970, all radioactively contaminated solid wastes generated on site were shipped off site to a commercial LLRW disposal facility.

Thorium was also present at this former burial site due to drummed waste materials being shipped to Cimarron from the decommissioning of the Kerr-McGee Corporation Cushing facility. Equipment contaminated with thorium from the Cushing facility also was stored in the Uranium Plant yard. This contaminated equipment and excavated drummed waste (from Burial Area No. 1) were shipped to a commercial LLRW disposal facility. Thorium have been detected in soils above background levels at limited locations on the Cimarron facility. This indicates that there has been minimal impact from these materials upon the Cimarron site. No plutonium-contaminated waste was disposed of on site.

Only uranium and plutonium in chemically separated form were used in the production processes at the Cimarron site. The concentration of daughter products was negligible. Radium and thorium detected in groundwater and soil samples are at natural background levels and thus are not due to the effects of facility operations.

URANIUM WASTE POND #1 (BACKFILLED 1978)
EAST SANITARY LAGOON
WEST SANITARY LAGOON
BURIAL AREA #2 (NORTH FIELD)
WAREHOUSE BUILDING #4
PLUTONIUM BUILDING
WEST LAKE
EMERGENCY BUILDING
URANIUM WASTE POND #2 (BACKFILLED 1978)
NORTH INCINERATOR BURIAL AREA #3
NEW LINED SANITARY LAGOON (ABOVE)
PLUTONIUM WASTE POND (BELOW) (BACKFILLED 1978)
URANIUM EMERGENCY POND (BACKFILLED 1978)
PLUTONIUM EMERGENCY POND (BACKFILLED 1978)
URANIUM BUILDING #1
ORIGIN FOR METRIC GRID (N9730.41072, E10064.44825)
BURIAL AREA #1
RESERVOIR #2
RESERVOIR #3
BURIAL AREA #4

9412080115 -01

CIMARRON CORPORATION

CIMARRON FACILITY
OVERALL SITE MAP

CLIENT DRAWING NO.

JOB NO.	DRAWING NO.	REV.
	94MOST-RF7	0

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:
JE	9/30/94	JA	10/1/94	KM	AS SHOWN

NORTH

100 0 100 200
SCALE IN METERS

M:\CIMARRON\REMEDI\94MOST07

3.0 Environmental Monitoring Program

This section presents a brief overview of the environmental monitoring program for sample locations presently being monitored. The Cimarron facility environmental monitoring program is performed in accordance with Health Physics Procedure KM-CI-RP-43, "Environmental Monitoring". Per this procedure, air, surface water, groundwater, soil, and vegetation samples are collected and analyzed for radionuclides and other indicators. In addition, ambient gamma exposure monitoring is performed using thermoluminescent dosimeters (TLD). Table 3.1 summarizes the locations, media, and frequency of sampling for the environmental sampling program.

Off-site air samples are collected using high-volume samplers at three locations as shown in Figure 3.1. Samples are collected on an eight-inch by ten-inch filter paper four hours each day for each seven-day period. Filter papers are changed each week, weather permitting. Samples are then divided for counting by Oklahoma State Department of Health and Cimarron health physics personnel. Gross alpha counts are performed on all samples. Uranium analyses may be performed on samples significantly above background levels.

Water samples are collected weekly from the New Sanitary Lagoon and analyzed for gross alpha activity. In addition, water samples are collected once each year from the Cimarron River (upstream and downstream), three on-site reservoirs, one stream, one slough, the sanitary lagoon, and 25 groundwater wells. Figures 3.2 and 3.3, show surface water and groundwater sampling locations respectively at the Cimarron facility. Sample analysis includes uranium, nitrate, fluoride, gross alpha, and gross beta. Uranium isotopic analysis is performed whenever gross alpha concentrations exceed 15 pCi/L or gross beta concentrations exceed 20 pCi/L.

Site soil samples are collected annually at 11 locations as shown in Figure 3.4. At each location, ten soil corings are collected and composited. Two samples, each three inches in diameter, are collected from each coring for compositing. The first sample is a composit from the soil collected at the surface to a depth of two inches. The second sample is a composit from soils collected from depths of two to ten inches. Sample analysis includes total uranium and fluoride.

Soil samples are collected one-half-mile north, south, east and west of the facility (locations 1401, 1404, 1405, and 1406, respectively), and one mile north, south, east, and west of the facility (locations 1407, 1408, 1409,

Table 3.1
Cimarron Facility
Environmental Sampling Schedule
Page 1 of 2

Location	Description	Frequency	Sample Analysis
	AIR		
1101	North-0.5 mile	Weekly	Gross Alpha
1102	East-0.5 mile		Gross Beta
1103	South-0.5 mil		Action level is 2E-12 uCi/cc
	SURFACE WATER		
1201	Cimarron River-Upstream	Annually	F,NO3, Gross Alpha,
1202	Cimarron River-Downstream		Gross Beta,
1204	Pond-West of Plant		Total Uranium (if
1205	Kerr-McGee Lake-East		Gross Alpha >15pCi/l,
1206	Slough-NW of Incinerator		or Gross Beta
1208	Stream North of Uranium Pond #2		>20 pCi/l,
1209	Kerr-McGee Lake-West		analyze for isotopic
1214	Sanitary Lagoon (sampled weekly)		uranium)
	WELL WATER		
1311	Monitor Well-South of Landfill	Annually	F,NO3, Gross Alpha,
1312	Monitor Well-West of Landfill		Gross Beta,
1313	Monitor Well-North of Landfill		Total Uranium (if
1314	Monitor Well-South of Burial Pit		Gross Alpha >15pCi/l,
1315	Monitor Well-North of Burial Pit		or Gross Beta
1316	Monitor Well-Northwest of Burial Pit		>20 pCi/l,
1317	Monitor Well-North of Burial Pit		analyze for isotopic
1319	Monitor Well-U Plant Yard East of Building		uranium)
1320	Monitor Well-North of Designated Area		
1321	Monitor Well-North of Designated Area (deep)		
1322	Monitor Well-West of Tractor Shed		
1323	Monitor Well-West of Tractor Shed (deep)		
1324	Monitor Well-East of Designated Area		
1325	Monitor Well-South of Designated Area		
1326	Monitor Well-West of U-Plant Yard		
1327B	Monitor Well-West of U-Plant Yard		
1328	Monitor Well-South of U-Plant Yard (deep)		
1329	Monitor Well-South of U-Plant yard		
1330	Monitor Well-Southwest of U-Plant Yard		
1331	Monitor Well-Northeast of Pu-Plant Yard		
1332	Monitor Well-West of Sanitary Lagoons (deep)		
1333	Monitor Well-West of Sanitary Lagoons		
1334	Monitor Well-North of Sanitary Lagoons		
1335	Monitor Well-West of Designated Area		
1336A	Monitor Well-North of U-Pond #2		

Table 3.1
Cimarron Facility
Environmental Sampling Schedule
Page 2of 2

Location	Description	Frequency	Sample Analysis
	SOIL		
1401	North-0.5 mile	Annually	Total Uranium
1402	North of Uranium Fence Line		Action level of
1403	South of Uranium Fence Line		10 pCi/g
1404	South-0.5 mile		
1405	East-0.5 mile		
1406	West-0.5 mile		
1407	North-1.0 mile		
1408	South-1.0 mile		
1409	East-1.0 mile		
1410	West-2.0 mile		
1418	North of Plutonium Fence Line		
	VEGETATION		
1508	Covered Pond #1	Annually	Total Uranium
1509	Covered Pond #2		Action level of
1510	Old Burial Pit		2X background
	AMBIENT GAMMA		
TLD01	N. E. U Yard Fence	Quarterly	Action level of
TLD02	South U Yard Fence		20 mR/quarter
TLD-3	U-Plant Vaporizer Rm		above ground
TLD04	East Pu Fence		
TLD05	North Pu Fence		
TLD06	West Pu Fence		
TLD07	E. Lagoon Fence		
TLD08	N. Designated Area Burial Cell Fence		
TLD09	E. DA Burial Cell Fence		
TLD10	S. DA Burial Cell Fence		
TLD11	W. DA Burial Cell Fence		
TLD12	Highway Marker #1		
TLD13	U-Plant Count Room		
TLD14	Intersection Route 33/74		

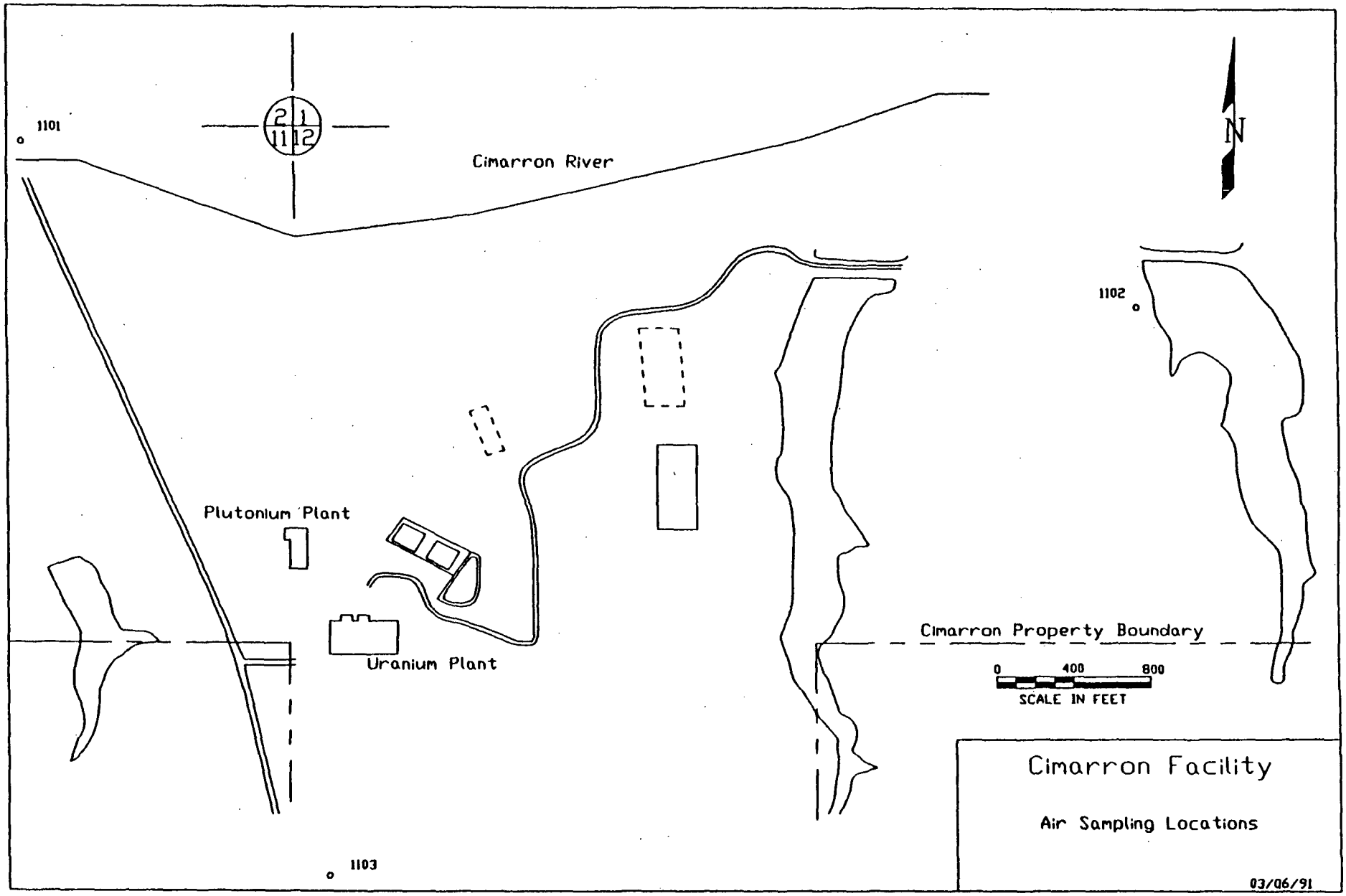

1101
Cimarron River
N
1102
Plutonium Plant
Uranium Plant
Cimarron Property Boundary
0 400 800
SCALE IN FEET
Cimarron Facility
Air Sampling Locations
03/06/91
1103

Figure 3.1

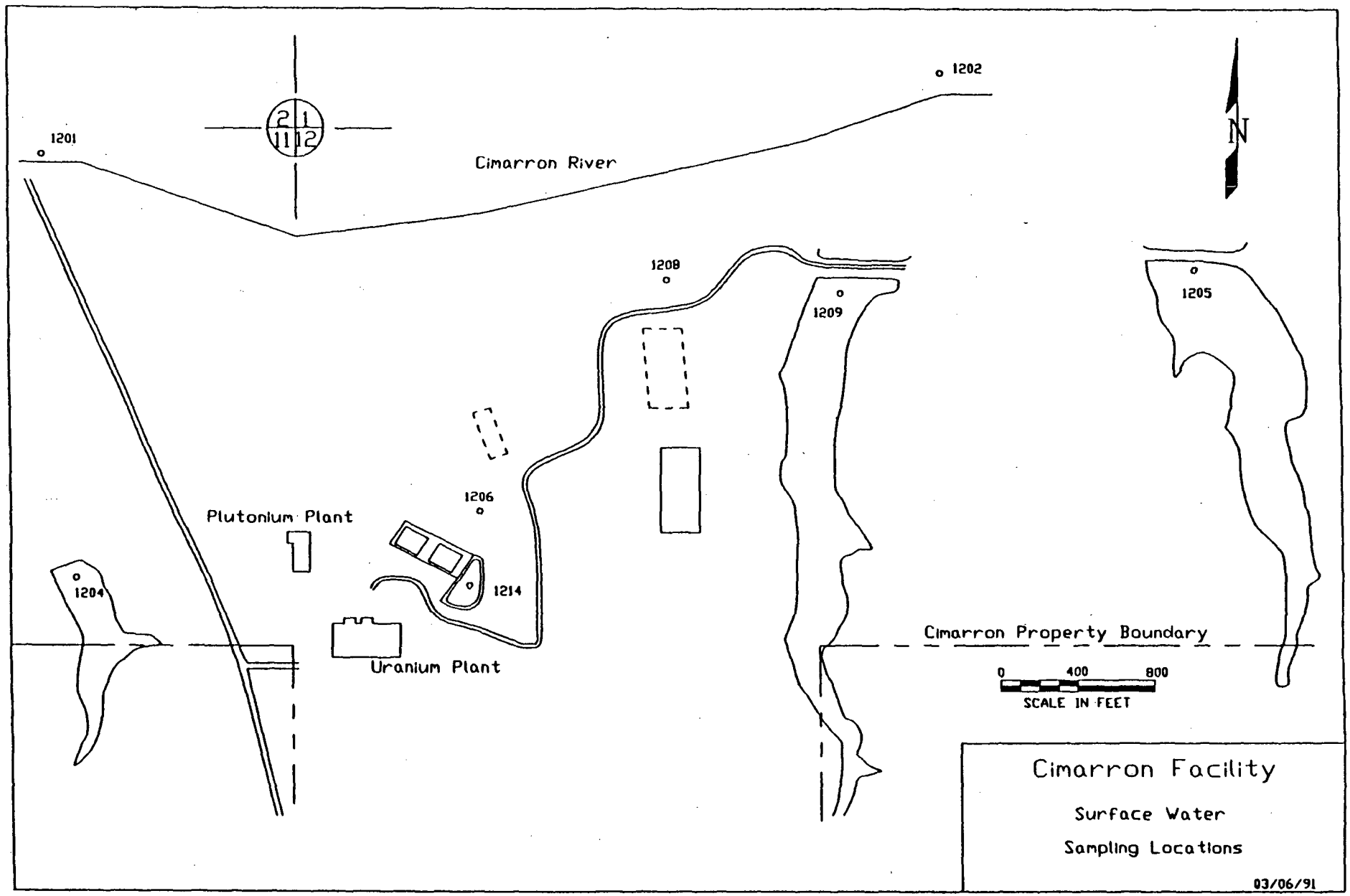

1202
1201
Cimarron River
N
1208
1209
1205
1206
Plutonium Plant
1214
1204
Uranium Plant
Cimarron Property Boundary
0 400 800
SCALE IN FEET
Cimarron Facility
Surface Water
Sampling Locations
03/06/91

Figure 3.2

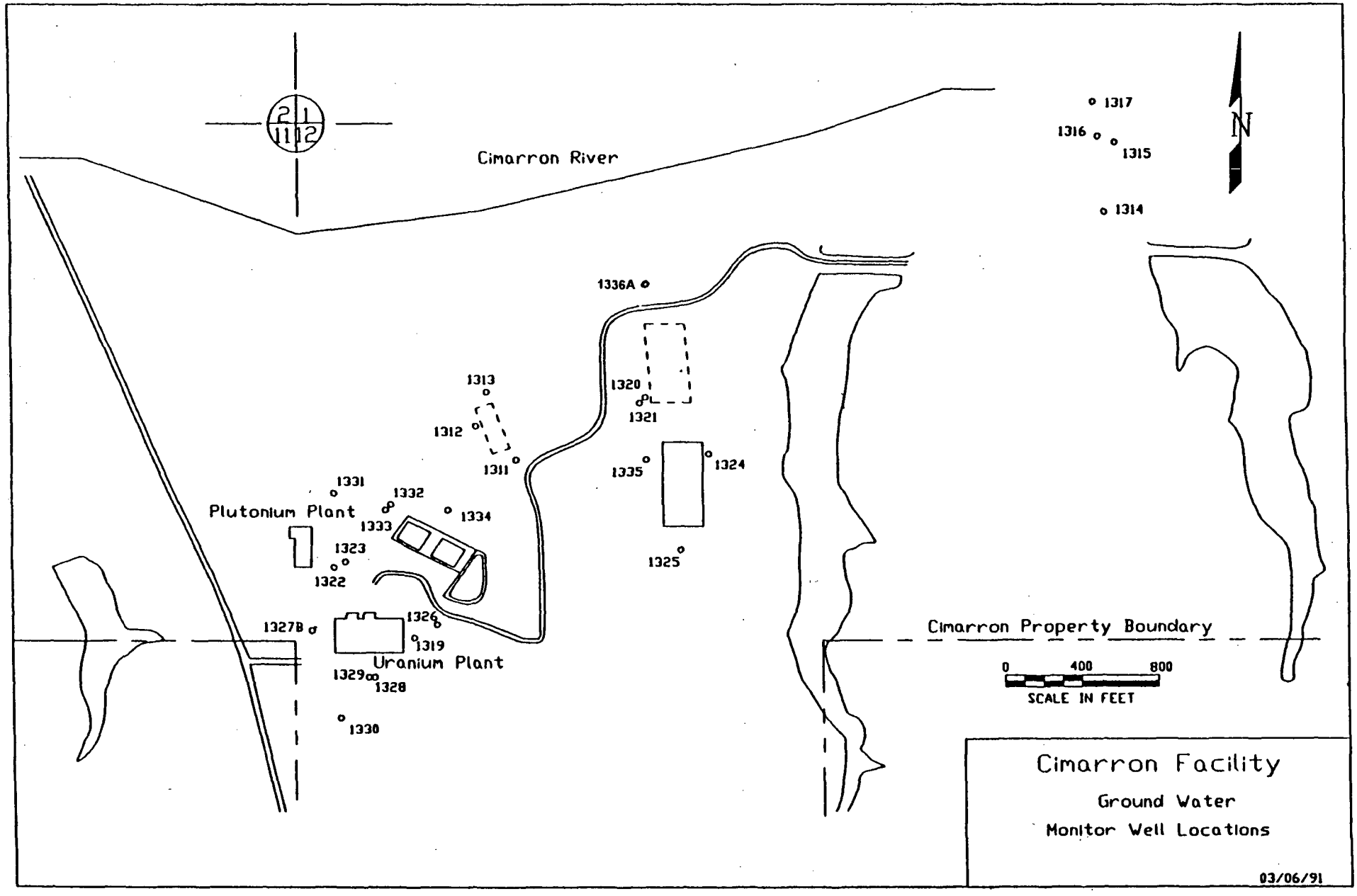

Cimarron River
1317
1316
1315
1314
N
1336A
1313
1312
1311
1320
1321
1335
1324
1325
1331
1332
1333
1334
Plutonium Plant
1323
1322
1327B
1326
1319
Uranium Plant
1329
1328
1330
Cimarron Property Boundary
0
400
800
SCALE IN FEET
Cimarron Facility
Ground Water
Monitor Well Locations
03/06/91

Figure 3.3

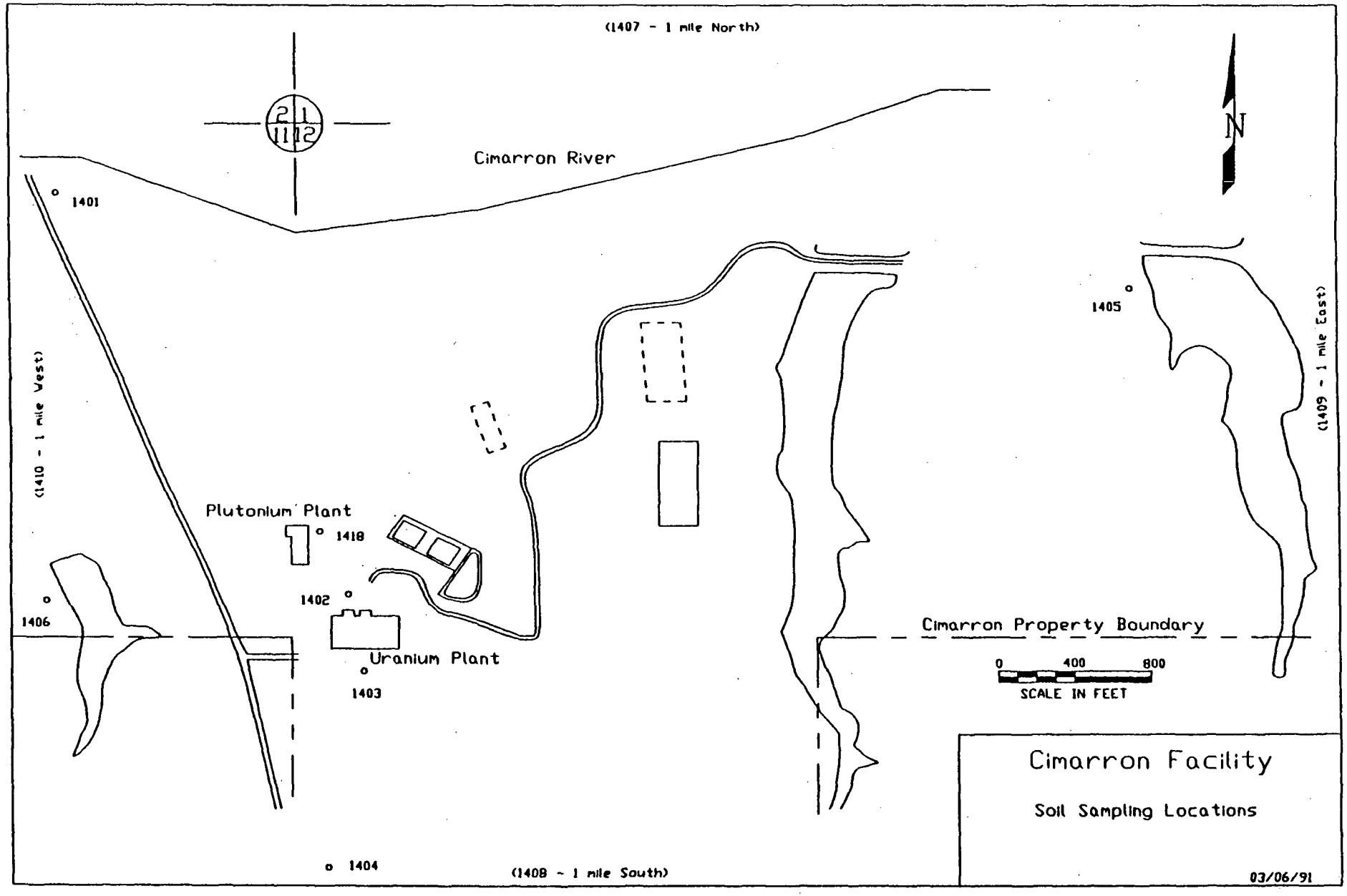

(1407 - 1 mile North)
Cimarron River
1401
(1410 - 1 mile West)
Plutonium Plant
1418
1402
1406
Uranium Plant
1403
1404
(1408 - 1 mile South)
1405
(1409 - 1 mile East)
Cimarron Property Boundary
0 400 800
SCALE IN FEET
N
Cimarron Facility
Soil Sampling Locations
03/06/91

Figure 3.4

and 1410, respectively) as shown in Figure 3.4. All sample results were less than detection limits for the monitoring periods 1990 through 1993.

Vegetation samples are collected annually at three on-site locations as shown in Figure 3.5. Samples are analyzed for total uranium.

In addition to routine samples, additional samples are collected whenever gross alpha, gross beta, or uranium concentrations are elevated. Action levels are set at 15 pCi/L gross alpha and 20 pCi/L gross beta for water samples.

Gross alpha, gross beta, total uranium, fluoride, and nitrate analyses are performed at the Kerr McGee Technical Center in Oklahoma City, Oklahoma. Isotopic analyses are also performed at an off-site contract laboratory. Laboratories utilize matrix blanks, spike samples, duplicates, and NIST traceable standards to ensure precision in reporting of analytical results. EPA standard methods are used for analysis when available. Samples are controlled through chain-of-custody forms which accompany the samples during transit from the Cimarron facility to the laboratory.

For specific areas of the site where monitoring wells are installed, sample results are compared to sample results from wells in unaffected areas to determine the impact of past and present activities on the Cimarron site. In addition, surface water sampling data will be discussed to support the conclusions of each section of this report regarding site cleanup status. These discussions are included in the report section that deals with the specific area discussed.

Throughout this report, surface water and groundwater data are compared with Table 2, Column 2 values in Appendix B to 10 CFR 20, "Annual Limits on Intake (ALIs) and Derived Air Concentrations (DACs) of Radionuclides for Occupational Exposure; Effluent Concentrations; Concentrations for Release to Sewerage." The values given in Table 2, Column 2 are equivalent to the concentrations which, if ingested continuously over the course of a year, would produce a total effective dose equivalent of approximately 0.05 rem (50 millirem) to a standard man. The comparisons are not meant to imply that dose limits will be exceeded, as the groundwater at the Cimarron facility is not considered suitable for drinking water purposes.

Total uranium data are presented in units of milligrams per liter (mg/L). For comparison purposes, an enrichment of 2.7 weight percent has been used to obtain a conversion factor. The specific activity is calculated as 1.5 E-06 Ci/g, using the equation from footnote 3 to Appendix B,

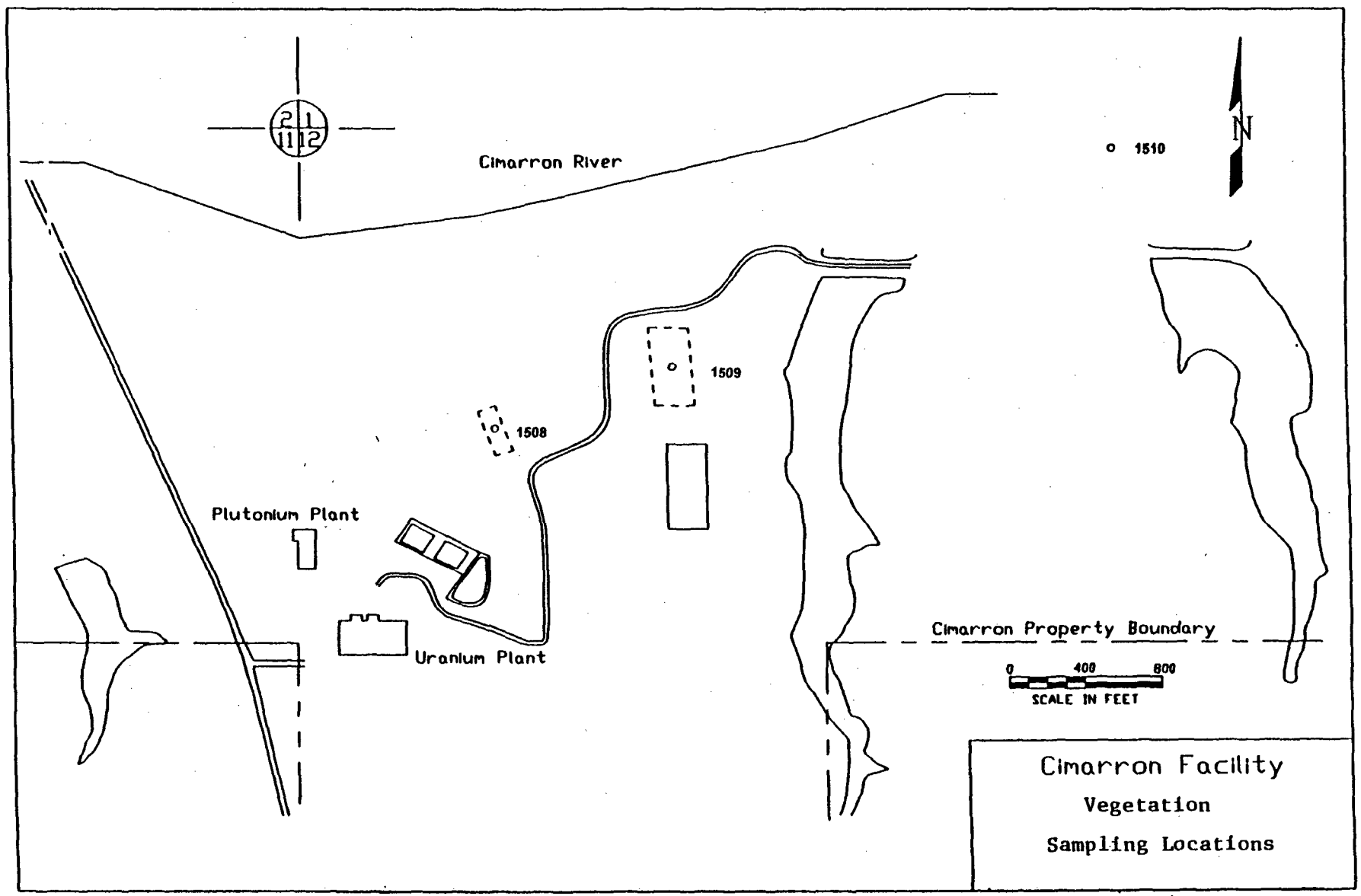

Cimarron River
1510
1509
1508
Plutonium Plant
Uranium Plant
Cimarron Property Boundary
0
400
800
SCALE IN FEET
Cimarron Facility
Vegetation
Sampling Locations

Figure 3.5

10 CFR 20. Data using this conversion factor are specifically noted in the text or are enclosed in parentheses immediately following the reported value.

Soil sample data are presented in later sections of this report and are compared with either background data or the NRC Branch Technical Position Option #1 limit of 30 pCi/g. Individual samples over this limit do not necessarily imply that the Option #1 criteria are exceeded, since background soil radioactivity can be subtracted and surface area averaging is allowed.

As discussed in Section 4.0, the groundwater flow is generally to the north-northwest across the facility toward the Cimarron River. Groundwater in the immediate vicinity of the facility is brackish and is not used for drinking purposes. Therefore, groundwater is not considered a direct pathway to humans. However, groundwater in the area could be used for irrigation and livestock.

This report does not address data from the air, vegetation, or ambient gamma exposure monitoring programs unless such data are significant with respect to site characterization.

3.1 Off-site Areas

Soil samples are collected one half-mile north, south, east and west of the facility (locations1401, 1404, 1405, and 1406, respectively), and one mile north, south, east, and west of the facility (locations 1407, 1408, 1409, and 1410, respectively) as shown in Figure 3.4. Samples are analyzed for total uranium concentration. One surface soil and one sub-surface soil sample in 1993 (both at location 1403)) contained detectable concentrations of total uranium (12 μg/g and 10 μg/g, respectively).

Weekly environmental air samples are collected at locations one half-mile northwest (location 1101), at the East Lake (location 1102), and at the junction of highways 33 and 74 (location 1103). Samples are collected on 8 x 10 inch media and counted for gross alpha activity using the on-site LB5100 Tennelec gas flow proportional counter. During 1992 and 1993, sample concentrations ranged form 1E-15 μCi/mL at location 1101 during the 24th week of 1993 to 2.9E-14 μCi/mL at location 1102 during the third week of 1993. All air sampling results appear to be due to normal background variations.

Surface water samples are collected in the Cimarron River at one upstream site (#1201) and one downstream site (#1201). Gross alpha and gross beta concentrations during 1992 and 1993 were all less than detectable (10 pCi/L and 20 pCi/L for gross alpha and gross beta respectively). Total uranium concentrations during 1992 and 1993 ranged from 0.006 mg/L to 0.008 mg/L. There were no observed differences between upstream and downstream river water concentrations.

Potential off site ambient radiation dose is measured via thermoluminescent dosimeters (TLD) located at the northeast uranium fence (location TLD01), south uranium fence (TLD02), east plutonium fence (TLD04), north plutonium fence (TLD05), west plutonium fence (TLD06), and East Lagoon (TLD07). In addition, an off-site TLD was placed during the first quarter of 1994 at the intersection of State Roads 74 and 33 to measure background. The locations are shown in Figure 3.5. Based upon first quarter 1994 results, background is approximately 46 mrem per year, or 5.2 μrem/h. Potential doses to members of the public during calendar years 1990-1993 were less than 55 mrem per year at all monitoring locations after subtraction of background.

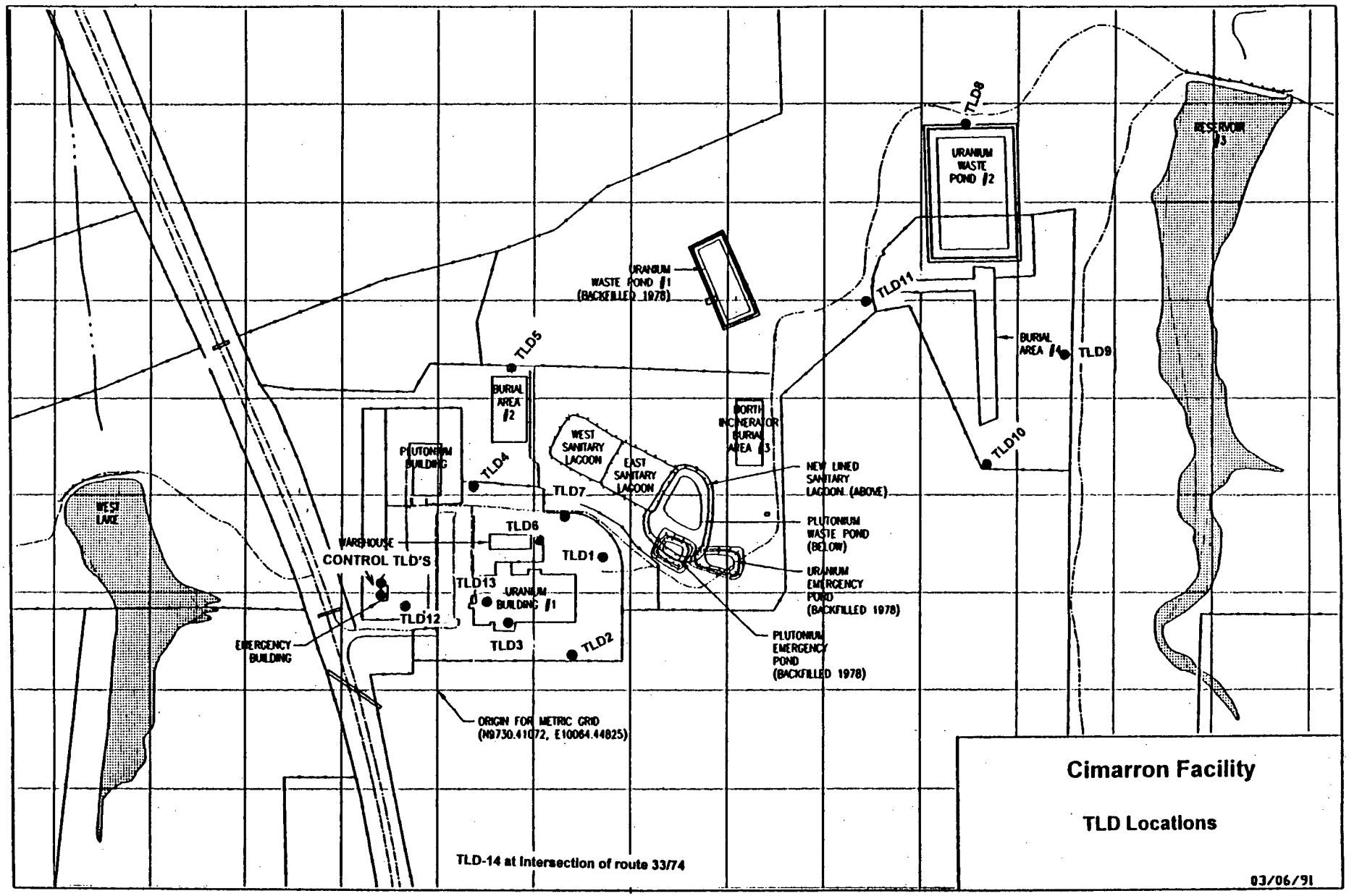

TLD8
URANIUM WASTE POND #2
RESERVOIR #3
URANIUM WASTE POND #1 (BACKFILLED 1978)
TLD11
BURIAL AREA #4
TLD9
TLD5
BURIAL AREA #2
NORTH INCINERATOR BURIAL AREA #3
TLD10
PLUTONIUM BUILDING
TLD4
WEST SANITARY LAGOON
EAST SANITARY LAGOON
NEW LINED SANITARY LAGOON (ABOVE)
TLD7
WEST LAKE
TLD6
WAREHOUSE
CONTROL TLD'S
TLD1
PLUTONIUM WASTE POND (BELOW)
TLD13
URANIUM BUILDING #1
URANIUM EMERGENCY POND (BACKFILLED 1978)
TLD12
TLD3
TLD2
EMERGENCY BUILDING
PLUTONIUM EMERGENCY POND (BACKFILLED 1978)
ORIGIN FOR METRIC GRID (N9730.41072, E10064.44825)
TLD-14 at Intersection of route 33/74
Cimarron Facility
TLD Locations
03/06/91

Figure 3.5

4.0 Geotechnical Site Investigation

A site investigation was conducted in 1989 by James L. Grant and Associates[7] to determine the possible impacts from facility production and decommissioning operations on the underlying site hydrogeologic system. This report was submitted to the NRC in 1989, and responses to NRC questions concerning the 1989 Report were submitted in May, 1990[8].

This report discussed the local groundwater system and assessed the impacts that facility operations may have had on this system. The anticipated behavior of radionuclides in the shallow subsurface of the site also is addressed, as are the engineering properties of materials to be used in the permanent soil repository (proposed new on-site disposal area for Option #2 material) planned at the site. The following information was presented in the Grant report:

- Characterization of stratigraphy and lithology of the soils and bedrock strata at the site;
- Characterization of aquifer properties including hydraulic conductivity, groundwater flow direction, and gradient;
- Characterization of groundwater quality and determination of the effects that facility operations may have had on groundwater quality;
- Determination of the mobility of radionuclides, particularly uranium, in the subsurface and the ability of subsurface materials to retard migration;
- The suitability of selected site soil and rock for cover materials of the planned landfill.

The facility is located south of the Cimarron River in an area of low, rolling hills and incised drainages. Local elevations range between about 940 feet along the river to 1,010 feet at the plant. Subsurface materials at the site include one to eight feet of soil covering the Garber Sandstone. The rock strata in the upper 140 feet of the Garber include alternating sandstones and mudstones. The sandstone layers, which are between 30 and 55 feet thick, have been designated Sandstones A, B, and C. The three sandstones are separated by mudstone layers. The mudstones are designated Mudstones A and B and are between 6 and 20 feet thick.

Shallow groundwater occurs in Sandstone A under water table conditions. Most of the site monitoring wells are completed in this zone. The depth to water is between 10 and 30 feet below ground surface. Groundwater flow

is to the north-northwest where discharge to the surface or to Cimarron River alluvium is likely. The hydraulic conductivity of Sandstone A is 1.03×10^{-3} cm/sec.

Groundwater also occurs in Sandstones B and C. Four of the site wells are completed in Sandstone C. The hydraulic conductivity in the deeper unit is about 1.27×10^{-4} cm/sec. Flow in the stratum is toward the northwest where discharge to the Cimarron River alluvium is likely.

Soil and rock samples from the unsaturated and saturated zones were chemically analyzed for the 1989 investigation. Radionuclides were not detected in significant concentrations and facility operations do not appear to have affected soil and rock in the subsurface.

However, current groundwater sample analysis results in Sandstone A indicate that past operations have affected the water quality in the immediate vicinity of certain facility units. As discussed in this Characterization Report, the units where down-gradient groundwater impacts may have occurred include: Uranium Waste Ponds #1 and #2, Burial Area #1, and the area between the plutonium and uranium buildings. No definite effects are apparent in the deeper Sandstone C stratum.

4.1 Groundwater Monitoring Wells

Twenty-five (25) groundwater monitoring wells are installed in the three sandstone layers discussed above and are sampled and analyzed as part of the site environmental monitoring program. The depth, screened interval, and completion zones are shown in Table 4.1.

4.2 Deep well for On-site Disposal of Waste Liquids

This well was installed in 1968 for the purpose of on-site disposal of liquid production waste, but was never used for disposal of industrial, radioactive, or any other type of waste liquids. The well was closed in October, 1989 . A closure report was submitted to the State of Oklahoma. This area is considered an unaffected area.

Table 4.1

CIMARRON FACILITY
Depths of Groundwater Monitoring Wells

WELL	SCREENED INTERVAL m (ft)	SCREENED IN
1311	7.6 - 12.2 (25.0 - 40.0)	Sandstone A
1312	6.4 - 10.7 (21.0 - 35.0)	Sandstone A
1313	7.0 - 11.6 (23.0 - 38.0)	Sandstone A
1314	9.1 - 13.7 (30.0 - 45.0)	Sandstone B
1315	3.7 - 8.2 (12.0 - 27.0)	Sandstone A *
1316	5.2 - 9.8 (17.0 - 32.0)	Sandstone A *
1317	0.9 - 5.5 (3.0 - 18.0)	Alluvium *
1319	Unknown Total Depth = 61 (200)	Sandstone C *
1320	8.7 - 11.7 (28.5 - 38.5)	Sandstone A
1321	34.0 - 37.1 (111.6 - 121.6)	Sandstone C
1322	7.6 - 10.7 (25.0 - 35.0)	Sandstone A
1323	35.6 - 38.6 (116.8 - 126.8)	Sandstone C
1324	7.6 - 10.7 (25.0 - 35.0)	Sandstone A
1325	10.7 - 13.9 (35.0 - 45.5)	Sandstone A
1326	9.8 - 12.9 (32.3 - 42.3)	Sandstone A
1327-A	8.8 - 11.9 (29.0 - 39.0)	Dry
1327-B	11.9 - 14.9 (39.0 - 49.0)	Sandstone A
1328	38.1 - 41.1 (125.0 - 135.0)	Sandstone C
1329	10.7 - 13.7 (35.0 - 45.0)	Sandstone A
1330	8.7 - 11.8 (28.7 - 38.7)	Sandstone A
1331	3.7 - 6.8 (12.1 - 22.2)	Sandstone A
1332	32.3 - 35.4 (106.0 - 116.0)	Sandstone C
1333	6.7 - 9.8 (22.0 - 32.0)	Sandstone A
1334	3.0 - 6.1 (10.0 - 20.0)	Sandstone A
1335	9.1 - 12.2 (30.0 - 40.0)	Sandstone A
1336A	5.5 - 8.5 (18.0 - 28.0)(Estimated)	Sandstone A

grwater.doc

*The formation shown for well screening was assumed based upon site geology and depth of well and not an as-built well log diagram.

5.0 Instrumentation, Analysis, and Quality Control

Characterization and decommissioning of the Cimarron Facility began during 1976. The characterization performed by Cimarron personnel to date has involved the use of surface gamma scans, bore hole loggings, soil sampling, on-site sample analysis, and off-site sample analysis. An extensive amount of analytical data has been generated during this characterization effort.

The on-site soil analyses are performed with a computer-linked multi-channel analyzer utilizing an EG & G Ortec Abcam Computer Analysis Program. The detector is a 4 inch x 4 inch x 16 inch sodium iodide crystal. The lead lined cabinet measures 25 inches wide by 44 inches tall by 25 inches deep. A 500 ml sample bottle of soil is placed on a turntable inside the lead-lined cabinet and rotated at approximately one RPM during counting. The rotating sample is placed approximately 2.5 inches from the center of the detector. The count data obtained from the emitted radiation of the soil sample is printed out for documentation.

Quality assurance measures to ensure proper equipment function and precise results include Cs-137 source centroid checks, Chi-square tests, background count trending and efficiency determinations.

Peak centroid checks are performed prior to sample counting using an NIST traceable Cs-137 pencil source. This check ensures that the energy calibration remains constant with respect to the Cs-137 peak and indicates when adjustment of the detector high-voltage supply may be necessary.

Chi-square tests are performed upon initial equipment set-up, after repairs and/or maintenance are performed, and after relocation or movement of the detector and/or electronics. In addition, Chi-square tests are performed on a monthly basis. The Chi-square test is an indication of deviation from the Gaussian distribution and can uncover problems due to faulty instrumentation.

Background counts are obtained daily when the soil counting system is in use. Trending of background provides indications of interferences due to sources of radioactivity located near the counting system and possible problems with the instrumentation.

Quality assurance measures also include the counting of three soil standards. These standards are derived from actual soil matrices at the Cimarron facility. Concentrations for the standards are based upon results from the off-site laboratories. The soil standards were chosen to

ensure counting reproducibility over the range of concentrations requiring decisions at the facility. Concentrations of total uranium in the three samples are approximately 28 pCi/g, 135 pCi/g, and 290 pCi/g. The standards are counted daily when the soil counter is in use.

Control charts are maintained to ensure that quality assurance parameters remain within normal limits. Parameters outside 2 sigma are investigated to ensure that they are due to normal statistical deviation. Values outside 3 sigma require additional investigation as they are not likely based upon normal statistical fluctuations.

Numerous split-sample analyses have been performed with Kerr-McGee's Technical Center or with an independent off-site laboratory for the purpose of comparison analysis. The off-site laboratories utilize industry standards such as EPA SW-846 protocols. The contractor laboratory used for alpha isotopic (uranium, thorium, and radium) analyses operates under a corporate quality assurance plan and participates successfully in EPA Intercomparison Performance and Department of Energy cross-check evaluations for alpha emitting radionuclides. The Kerr-McGee Technical Center participates in the Water Pollution Laboratory Performance Evaluation Study on a semi-annual basis.

Confirmatory radiological surveys have been performed by an NRC contractor in several specific areas on the facility that have been remediated by Cimarron personnel. These independent surveys indicate general agreement with respect to the Cimarron characterization survey activities at the facility.

In 1991, thirty-three soil samples were split and submitted to the Kerr-McGee Technical Center and to the Kerr-McGee Chemical Corporation for comparison analysis. Sample results as measured by the Cimarron facility laboratory are compared with results from both the Kerr-McGee Technical Center Laboratory in Oklahoma City, Oklahoma and the Kerr-McGee West Chemical Corporation's Chicago Laboratory. Comparisons are presented in Table 5.1.

The Cimarron facility laboratory-reported results for total uranium are generally higher than those reported by the Kerr-McGee Technical Center, especially at lower concentrations (See Table 5.1). The Cimarron facility laboratory does not subtract background activity (i.e. detector matrix background) from reported results. This will account for some of the differences, especially those observed at low concentrations, since background, as measured on the Cimarron soil counter, can equate to several pCi/g total uranium. If background subtraction was accounted for (i.e., performed), the uranium concentrations, reported by the Cimarron

Table 5.1

BURIAL GROUND COMPARISON SOIL SAMPLE ANALYSES

	SAMPLE LOCATION/ DEPTH	CIMARRON pCi/g U	KERR-McGEE TECH CENTER pCi/g U	CIMARRON/ TECH CENTER RATIO	CIMARRON pCi/g Th	W. CHICAGO pCi/g Th	CIMARRON/ W. CHICAGO RATIO
1	170N-30E 6"	28.58	13.79	2.07	3.67	3.0	1.22
2	120N-30E 2'	16.45	6.94	2.37	2.93	2.6	1.13
3	120N-30E 3'	17.20	4.03	4.27	1.77	2.2	0.80
4	120N-30E 1'	21.26	17.35	1.23	3.85	4.0	0.96
5	120N-30E 6"	15.53	8.17	1.90	2.49	1.4	1.78
6	150N-0E 6"	16.78	11.83	1.42	3.11	2.4	1.30
7	80N-60E 1'	22.24	12.80	1.74	0.92	.2	4.6
8	80N-40E 4'	15.29	4.08	3.75	6.92	9.8	0.71
9	70N-30E 6"	20.33	16.59	1.23	1.68	1.8	0.93
10	80N-40E 3'	10.27	.91	11.29	4.74	5.8	0.82
11	70N-30E 3'	24.60	22.91	1.07	2.31	2.6	0.89
12	70N-30E 4'	43.17	29.84	1.45	1.97	3.2	0.62
13	70N-30E 2'	33.88	24.30	1.39	1.30	2.4	0.54
14	70N-30E 1'	23.52	14.55	1.62	1.66	1.6	1.04
15	60N-50E 3'	17.60	6.77	2.60	1.59	2.8	0.57
16	60N-50E 3'	19.61	11.60	1.69	1.74	2.4	0.73
17	50N-70E 6"	10.24	4.02	2.55	4.43	4.8	0.92
18	40N-50E 6"	11.51	4.55	2.53	4.90	4.4	1.11
19	30N-70E 6"	21.98	18.09	1.22	2.21	3.0	0.74

Table 5.1

BURIAL GROUND COMPARISON SOIL SAMPLE ANALYSES
continued

	SAMPLE LOCATION/ DEPTH	CIMARRON pCi/g U	KERR-McGEE TECH CENTER pCi/g U	CIMARRON/ TECH CENTER RATIO	CIMARRON pCi/g Th	W. CHICAGO pCi/g Th	CIMARRON/ W. CHICAGO RATIO
20	90N-50E 6"	17.45	8.69	2.01	2.06	2.2	0.94
21	90N-50E 1'	24.25	14.87	1.63	1.44	1.2	1.2
22	90N-50E 2'	171.50	176.20	0.97	1.27	.2	6.35
23	90N-50E 3'	45.54	38.74	1.18	1.20	1.4	0.86
24	88N-50E 2'	33.59	32.98	1.02	1.18	.8	1.48
25	88N-50E 3'	68.16	48.03	1.42	0.93	1.4	0.66
26	90N-50E bottom	157.48	159.96	0.98	1.21	.4	3.03
27	92N-50E 2'	25.43	25.53	1.00	1.98	1.4	1.41
28	100N-50E 6"	19.15	9.28	2.06	1.64	2.0	0.82
29	100N-50E 3'	19.29	13.46	1.43	2.56	2.2	1.16
30	100N-50E 4'	24.61	27.38	0.90	.99	1.8	0.55
31	100N-60E 6"	17.79	8.67	2.05	2.21	1.8	1.23
32	110N-40E 6"	20.32	10.10	2.01	2.17	1.2	1.81
33	110N-50E 6"	20.93	24.39	0.86	2.38	3.2	0.74

facility, would generally fall within a factor of two of the Technical Center results.

The Cimarron soil counter algorithm for uranium and thorium determination is based upon reference spectra for uranium and thorium. Counts throughout the spectrum can be influenced by fluctuations in background and naturally-occurring sample matrix constituents. The minimum detectable concentration for the detector is approximately 3.2 pCi/g for total uranium and 0.7 pCi/g for total thorium.

Ratios of total uranium in soil samples with concentrations between 25 and 35 pCi/g (as measured by Kerr-McGee Technical Center) ranged from 0.90 to 1.45 and averaged 1.09. This range of sample concentrations is important since it represents the upper end of soils falling within Option #1 criteria of the Branch Technical Position on "Disposal or Onsite Storage of Thorium and Uranium Wastes from Past Operations." Total uranium concentrations are compared graphically in Figure 5.1.

Cimarron facility laboratory sample results for total thorium along with those from the Kerr-McGee West Chicago laboratory are presented in Figure 5.2. Results are generally reported within a factor of two and appear to be in good agreement over the range of concentrations measured. Sample ratios between the Cimarron facility and the Kerr-McGee Technical center ranged from 0.54 to 6.35. All ratios exceeding two are related to samples with measured concentrations (as reported by the Kerr-McGee Technical Center) below 0.5 pCi/g.

Oak Ridge Associated Universities (ORAU) performed an evaluation of the Kerr-McGee technique for measuring total uranium concentrations in soil samples (Letter Report from James D. Berger, ORAU, dated August 31, 1989). This evaluation involved comparison of results obtained by ORAU using alpha spectroscopy and gamma spectroscopy and the application of a uranium-234:uranium-235 ratio for purposes of calculating total uranium concentrations. Some of the results from this report are presented in Tables 5.2 and 5.3. ORAU reported an average U-235 enrichment of 2.5 to 3.0 percent and a U-234:U-235 ratio of 21.7. The report concluded that total uranium levels for the samples were in good agreement, with the exception of the background level samples. Kerr-McGee analysis indicated almost three times as much total uranium at background levels. It should be noted that the reported bias resulted in conservative estimates of uranium concentrations in soils. Results of the ORAU comparison are presented in Figures 5.3 and 5.4.

Figure 5.1

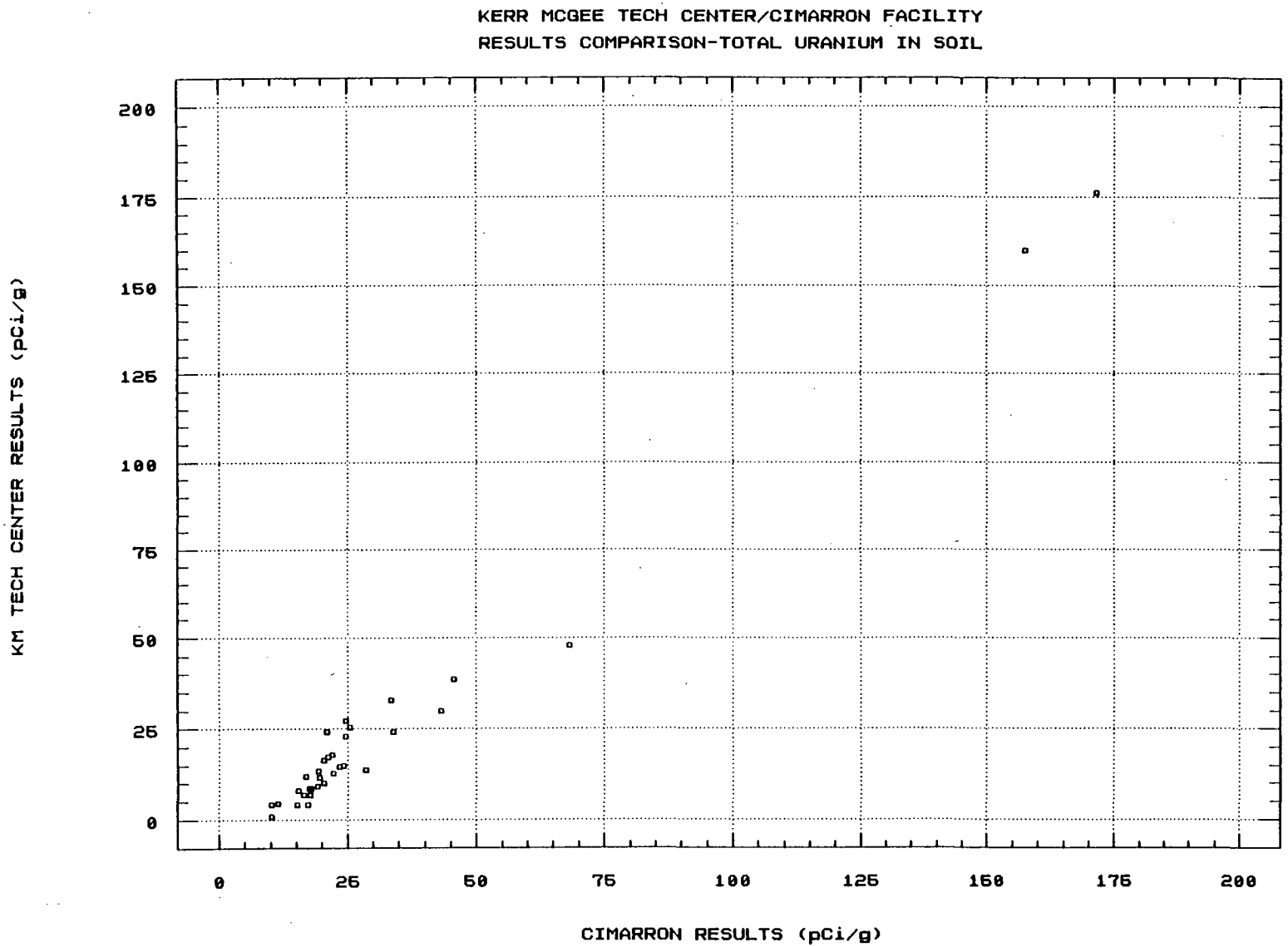

KERR MCGEE TECH CENTER/CIMARRON FACILITY
RESULTS COMPARISON-TOTAL URANIUM IN SOIL
KM TECH CENTER RESULTS (pCi/g)
0
25
50
75
100
125
150
175
200
CIMARRON RESULTS (pCi/g)
0
25
50
75
100
125
150
175
200

Figure 5.2

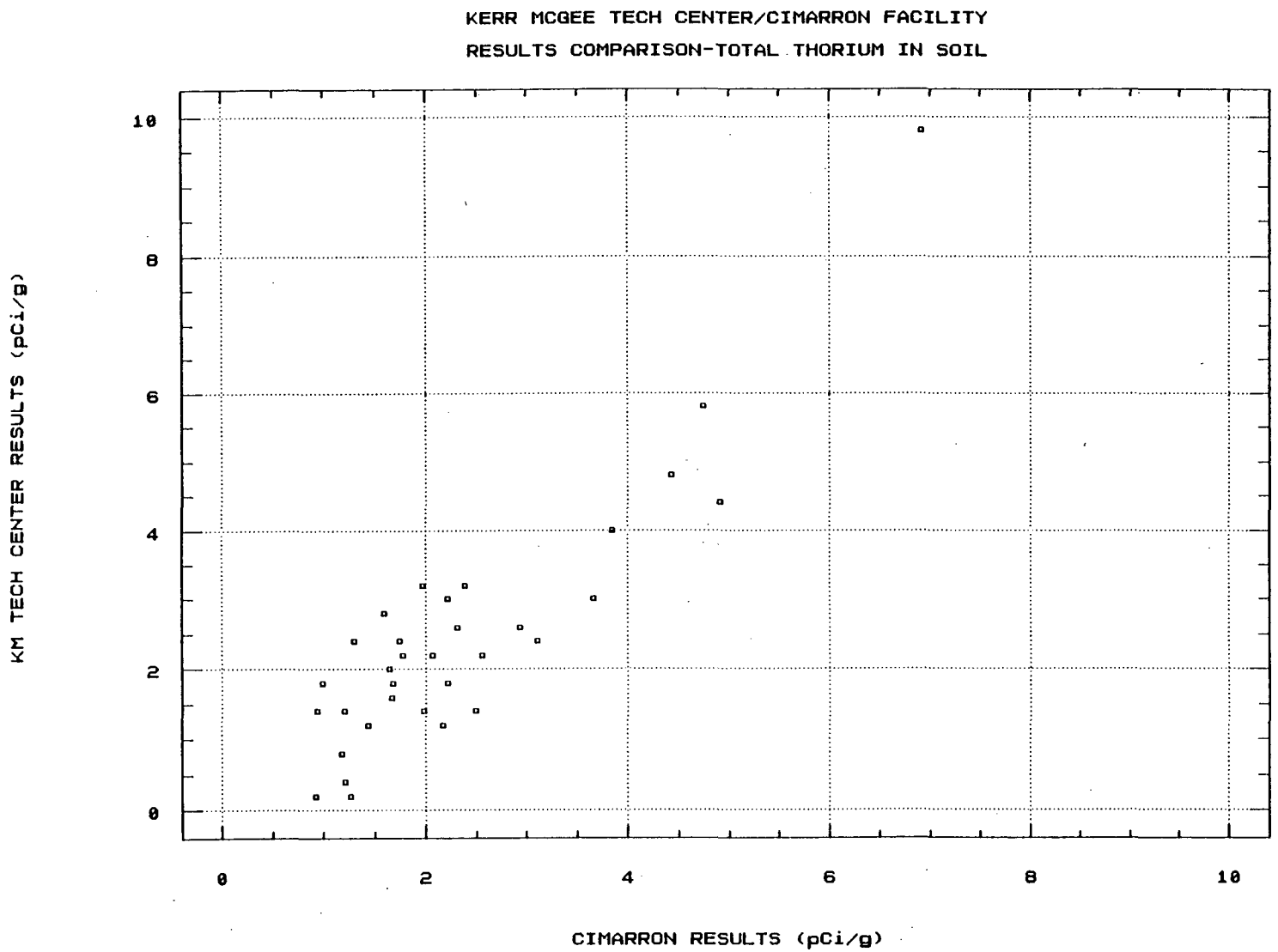

KERR MCGEE TECH CENTER/CIMARRON FACILITY
RESULTS COMPARISON-TOTAL THORIUM IN SOIL
KM TECH CENTER RESULTS (pCi/g)
CIMARRON RESULTS (pCi/g)
0
2
4
6
8
10

Table 5.2

Comparison Results of ORAU Alpha Spectrometry and Cimarron Soil Counter Analyses on Selected Soil Samples

Sample[a]	ORAU Analysis (pCi/g)				Kerr-McGee Total U (pCi/g)	Ratio ORAU/Kerr-McGee
	U-234[b]	U-235	U-238	Total U[b]		
COR - 2	260 ± 8[c]	12.4 ± 2.1	28.0 ± 2.7	300.4 ± 8.7	185 ± 7.0	1.61
COR - 8	27.9 ± 1.6	2.2 ± 0.6	8.3 ± 0.9	38.4 ± 1.9	29.9 ± 4.0	1.28
COR - 13	871 ± 34	55 ± 12	237 ± 18	1163 ± 40	1107.8 ± 45.4	1.05
COR - 17	215 ± 7	11.4 ± 1.9	50.8 ± 3.3	277.6 ± 7.7	264.2 ± 9.1	1.05
COR - 19	22.7 ± 1.3	0.8 ± 0.4	5.0 ± 0.7	26.1 ± 1.8	28.2 ± 3.3	0.93
COR - 20	2.3 ± 0.3	0.2 ± 0.1	1.4 ± 0.3	3.9 ± 0.4	10.4 ±3 .3	0.38

CIMTBL52

a. Kerr-McGee Identification
b. Average U-234/U-235 activity ratio = 21.7 ± 3.0
c. Uncertainties represent the 95% confidence interval based on counting statistics

Table 5.3

Results of Gamma Spectrometry Analyses
on Selected Soil Samples
Kerr-McGee
Crescent, Oklahoma

Sample[a]	ORAU Analysis (pCi/g)			Kerr-McGee Value (pCi/g)	Ratio
	U-235[b]	U-238	Total	Total U	ORAU/Kerr-McGee
COR - 1	4.8 ± 0.6[c]	17.3 ± 0.8	109 ± 20	74.4 ± 5.0	1.47
COR - 3	5.0 ± 0.5	15.8 ± 0.8	114 ± 19	98.8 ± 7.2	1.15
COR - 4	5.4 ± 0.3	26.9 ± 1.2	123 ± 25	145.9 ± 7.3	0.84
COR - 5	2.5 ± 0.3	10.0 ± 0.6	57 ± 15	54.1 ± 4.0	1.05
COR 6	0.2 ± 0.1	2.1 ± 0.3	4.5 ± 6.9	7.2 ± 3.6	0.63
COR - 7	2.0 ± 0.3	7.6 ± 0.8	45 ± 13	49.4 ± 4.4	0.91
COR - 9	4.5 ± 0.2	18.7 ± 0.6	102 ± 21	74.2 ± 3.8	1.37
COR - 10	2.2 ± 0.3	8.8 ± 0.7	50 ± 14	64.8 ± 4.0	0.77
COR - 11	9.4 ± 0.1	60.4 ± 0.6	213 ± 37	180.0 ± 6.3	1.18
COR - 12	3.1 ± 0.3	11.9 ± 0.6	70 ± 16	76.9 ± 4.4	0.91
COR - 16	2.4 ± 0.2	9.9 ± 0.4	55 ± 15	27.3 ± 3.7	2.01
COR - 18	2.0 ± 0.2	8.1 ± 0.5	45 ± 14	29.6 ± 4.0	1.52

CIMTBL53

a. Kerr-McGee Identification
b. Based on average ration of U-234/U-235 of 21.7 ± 3.0
c. Uncertainties represent the 95% confidence interval based on counting statistics

Figure 5.3

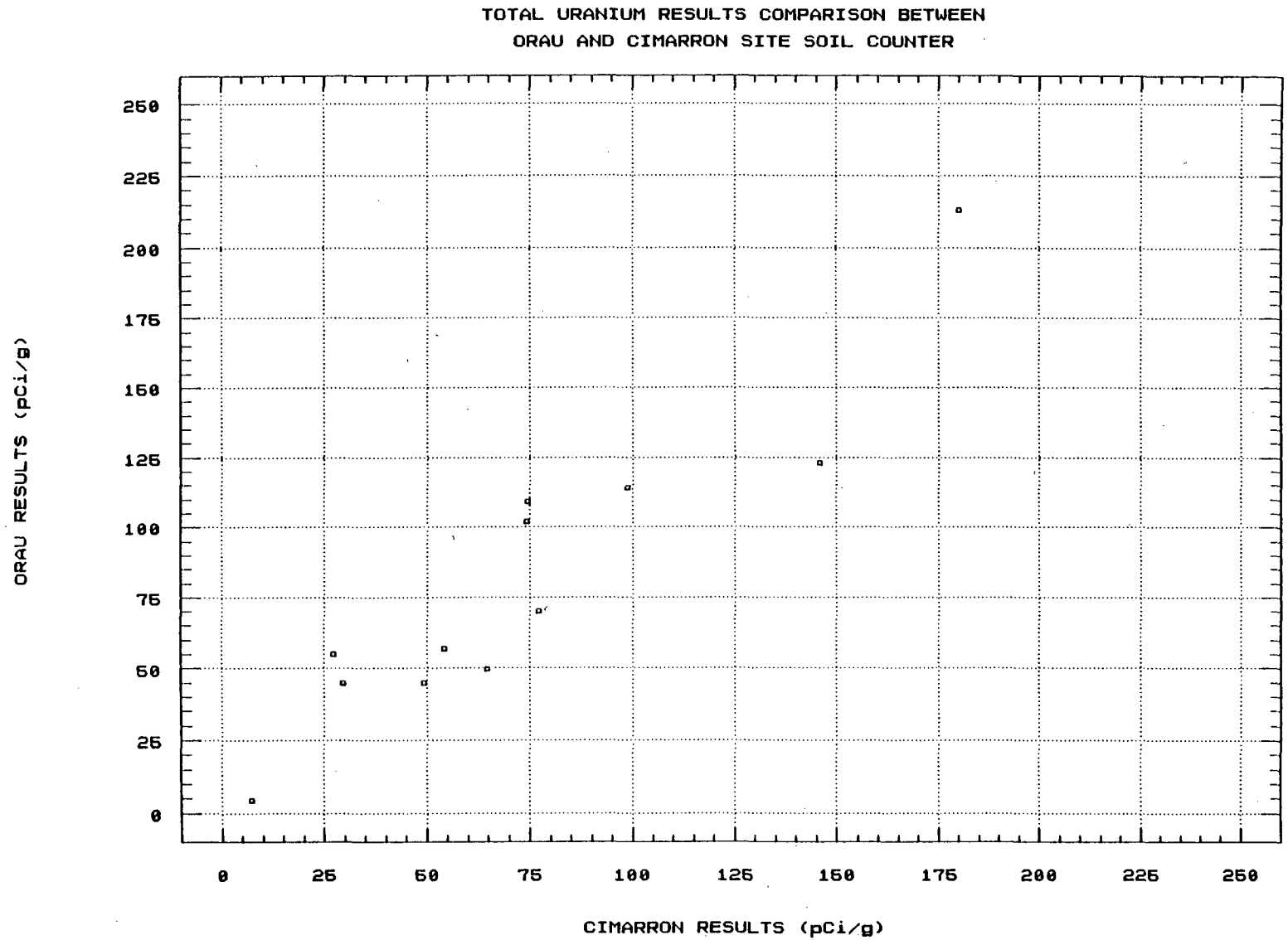
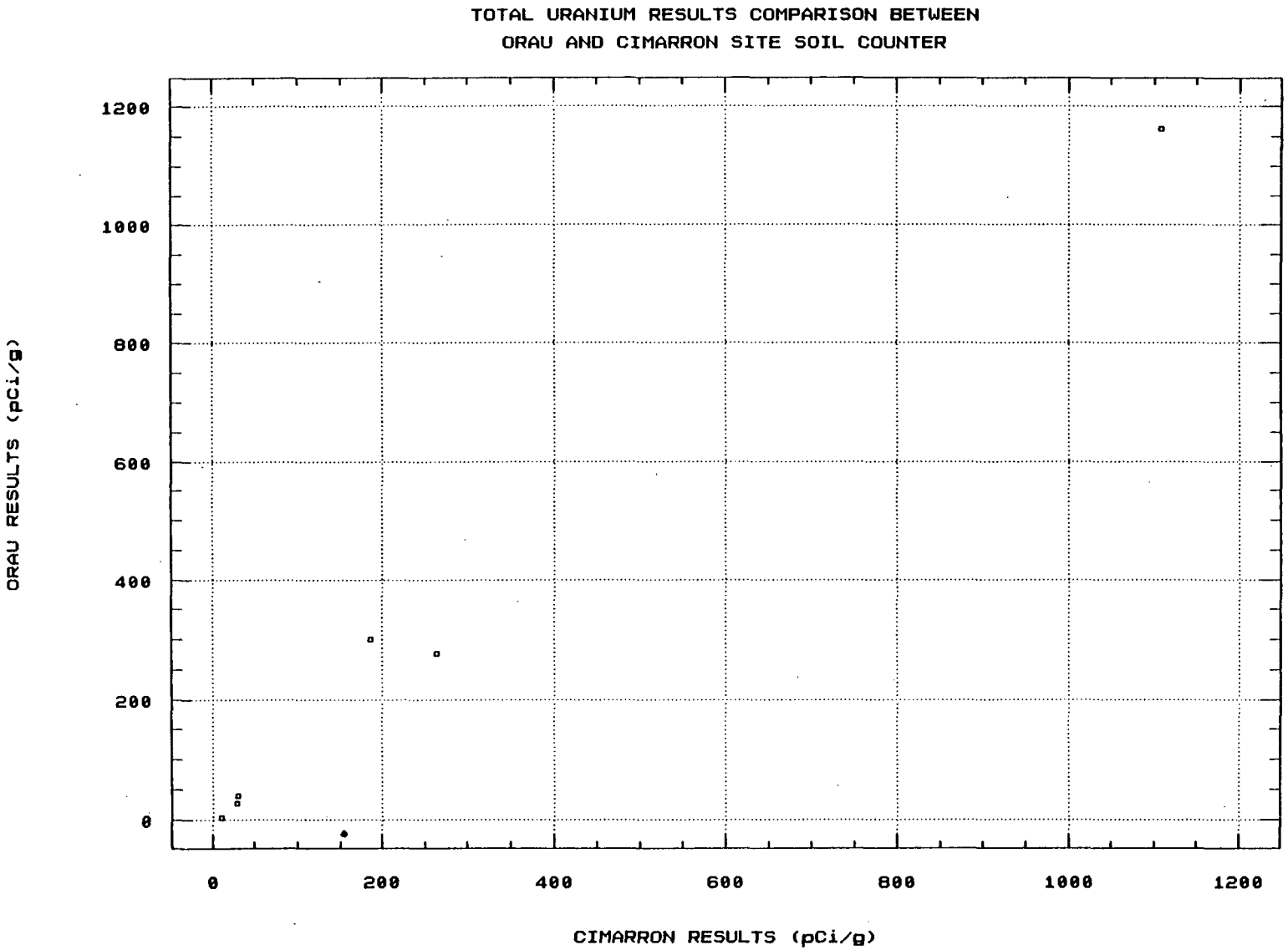

TOTAL URANIUM RESULTS COMPARISON BETWEEN
ORAU AND CIMARRON SITE SOIL COUNTER
ORAU RESULTS (pCi/g)
0
25
50
75
100
125
150
175
200
225
250
CIMARRON RESULTS (pCi/g)

Figure 5.4


TOTAL URANIUM RESULTS COMPARISON BETWEEN
ORAU AND CIMARRON SITE SOIL COUNTER
ORAU RESULTS (pCi/g)
1200
1000
800
600
400
200
0
0
200
400
600
800
1000
1200
CIMARRON RESULTS (pCi/g)

Oak Ridge Institute for Science and Education ((ORISE), previously designated as URAU) performed another comparison of analytical results during the confirmatory survey on May 4-5, 1994. Samples were split and analyzed on the Cimarron soil counter and at ORISE. Results of the draft report are presented in Table 5.4 and in Figure 5.5 Based upon the draft data, the NRC noted a statistically significant bias between the results at uranium concentrations exceeding 100 pCi/g. ORISE results were approximately 33 percent higher than the Cimarron results for total uranium. The apparent bias had previously been identified by Cimarron personnel and the soil counting equipment has been recalibrated to ensure precise results at all concentrations of interest.

A follow-up comparison of results was performed after recalibration, using the Teledyne-Brown laboratory in Westwood, NJ. Results are presented in Table 5.5 and Figure 5.6. Results were in general agreement with a small conservative bias in reporting by Cimarron at concentrations below 40 pCi/g. Additional confirmatory comparisons will be performed at concentrations exceeding 100 pCi/g to ensure correct reporting of results at higher concentrations. At this time the Cimarron soil counter is functioning within all quality assurance parameters. Trending of quality assurance parameters will serve to notify laboratory personnel of any potential problems with reported values.

Kerr-McGee uses many different instruments for characterization activities and to support personnel performing work. Table 5.6 provides a summary of the radiation monitoring instrumentation used in characterization activities, giving the number of each instrument available, the radiation detected, scale range, typical background, and typical detection limit for each instrument. Table 5.7 summarizes the radiological support instrumentation and monitoring equipment used for personnel protection during characterization activities.

Hand-held instruments used for surveys were calibrated on a quarterly basis in accordance with Kerr-McGee's calibration program. Daily source checks were also performed. Data quality for portable instrumentation is further substantiated by confirmatory surveys performed by the NRC and NRC contractors. These surveys indicate excellent agreement with Kerr-McGee results.

Table 5.4

COMPARISON OF SOIL SAMPLE RESULTS BETWEEN ORISE AND KERR-McGEE SOIL COUNTER

LOCATION	DEPTH	Radionuclide Concentrations (pCi/g)					
				Total Uranium		Total Thorium	
		U-235	U-238	ESSAP*	CIMARRON	ESSAP	CIMARRON
82.5N, 167.5E	35-50 cm	14.5 ± 0.3	85.4 ± 3.6	420	293	2.5	2
95N, 180E	85-100 cm	1.4 ± 0.2	8.1 ± 0.3	40	51	26	21
105N, 170E	185-200cm	21.1 ± 0.5	110.7 ± 5.9	590	442	1.8	3
110N, 175E	135-150 cm	5.8 ± 0.2	37.1± 2.4	170	137	2.0	1
110N, 175E	185-200 cm	6.1 ± 0.2	29.9 ± 3.0	170	128	1.8	1
140N, 122E	35-50 cm	0.4 ± 0.1	5.9 ± 1.4	15	14	1.8	2
140N, 122E	135-150 cm	4.2 ± 0.2	21.9 ± 1.9	120	90	2.2	<1
145N, 139E	185-200 cm	1.0 ± 0.1	8.7 ± 1.9	31	29	2.9	2
167.5N, 137.5E	35-50 cm	4.4 ± 0.2	12.7 ± 2.4	56	79	2.7	1
170N, 124E	85-100 cm	1.8 ± 0.1	9.4 ± 1.8	50	42	2.1	1

cimtabl54

*Environmental Survey and Site Assessment Program
Energy/Environment Systems Division of ORISE

Figure 5.5

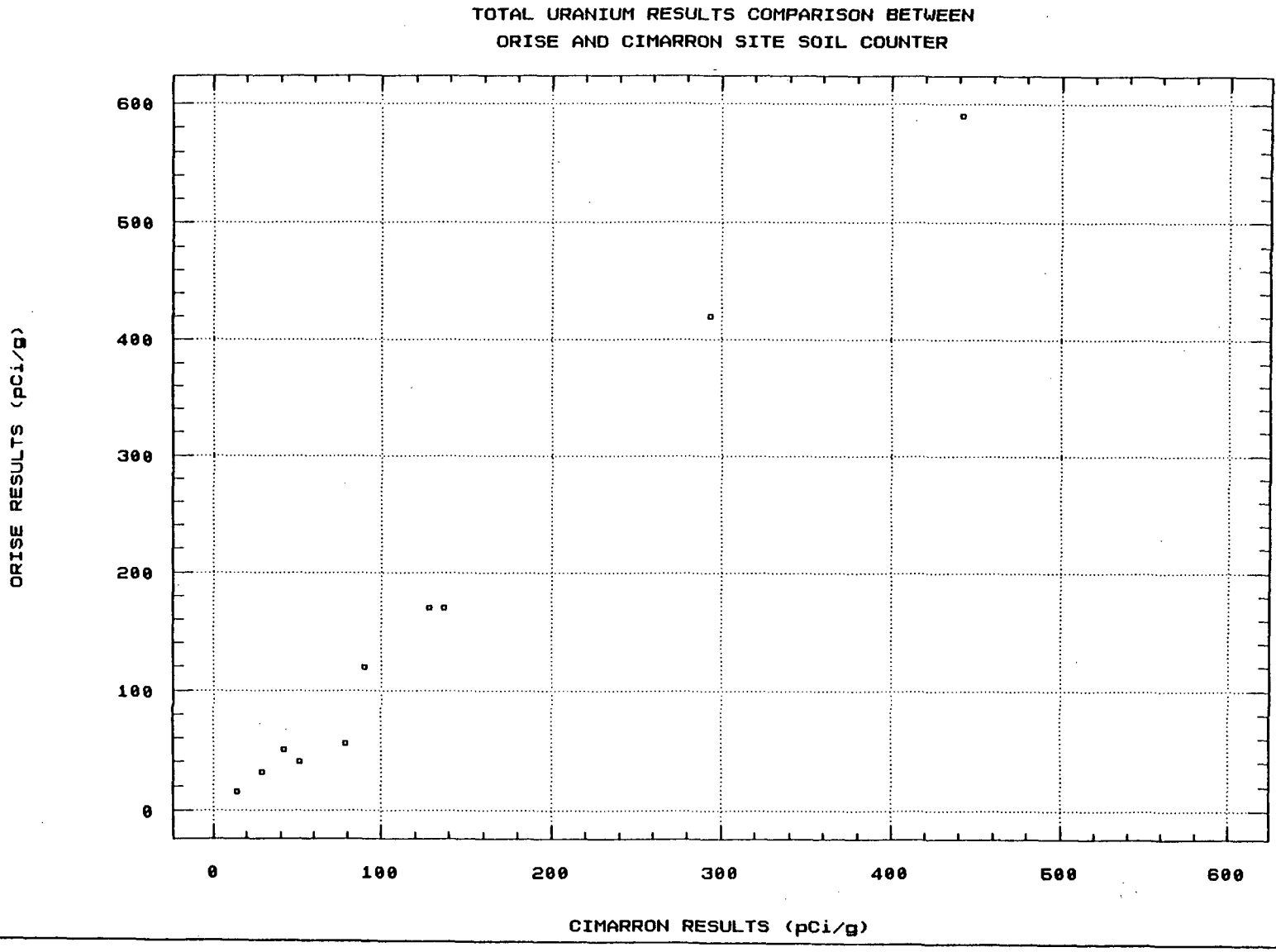

TOTAL URANIUM RESULTS COMPARISON BETWEEN
ORISE AND CIMARRON SITE SOIL COUNTER
ORISE RESULTS (pCi/g)
0
100
200
300
400
500
600
CIMARRON RESULTS (pCi/g)

Table 5.5

CIMARRON CORPORATION

CIMARRON FACILAITY

OPTION 2 SOIL STOCKPILES
RANDOM SAMPLES SENT FOR OUTSIDE ANALYSIS

LABORATORY: Teledyne
Brown Engineering
Westwood, New Jersey 97675-1235

DATE: 8/10/94

NORTH PILE LOCATION	SAMPLE DEPTH IN "M"	CIM. SOIL COUNTER		TELEDYNE-BROWN				
		pCi/g U	pCi/gTh	pCi/gU	pCi/g Th	pCi/g Ra	Pu-238 pCi/g	Pu-239/240 pCi/g
129E - 150N	0 - 0.5	23	3	10.41	0.89	5.1	<.02	<.02
129E - 150N	1 - 1.15	31	3	23.55	1.46	4.5	<.02	<.02
139E - 155N	0 - 0.5	52	1	46	0.58	3	<.03	<.03
144E - 135N	1 - 1.5	36	1	23.99	0.63	2.8	<.02	<.02

EAST PILE LOCATION	SAMPLE DEPTH IN "M"	CIM. SOIL COUNTER		TELEDYNE				
		pCi/g U	pCi/g Th	pCi/g U	pCi/g Th	pCi/g Ra	Pu-238 pCi/g	Pu-239/240 pCi/g
160E - 65N	0.5 - 1	45	1	50.9	0.58	2.8	<.02	<.02
165E - 55N	0.5 - 1	40	1	45.2	0.73	2.5	<.02	<.02
165E - 70N	0 - 0.5	36	1	35.27	0.78	2.9	<.03	<.04
165E - 95N	0.5 - 1	35	2	30.06	0.59	2.9	<.02	<.02
170E - 35N	1 - 1.5	29	1	31.26	0.66	2.1	<.01	<.02
170E - 60N	0.5 - 1	38	1	35.94	0.75	2.8	<.02	<.02
170E - 105N	1 - 1.5	48	1	43.9	0.75	2.8	<.02	<.04
190E - 45N	1.5 - 2	56	2	62.7	0.91	2.9	<.02	<.02

cimtbl55

Figure 5.6

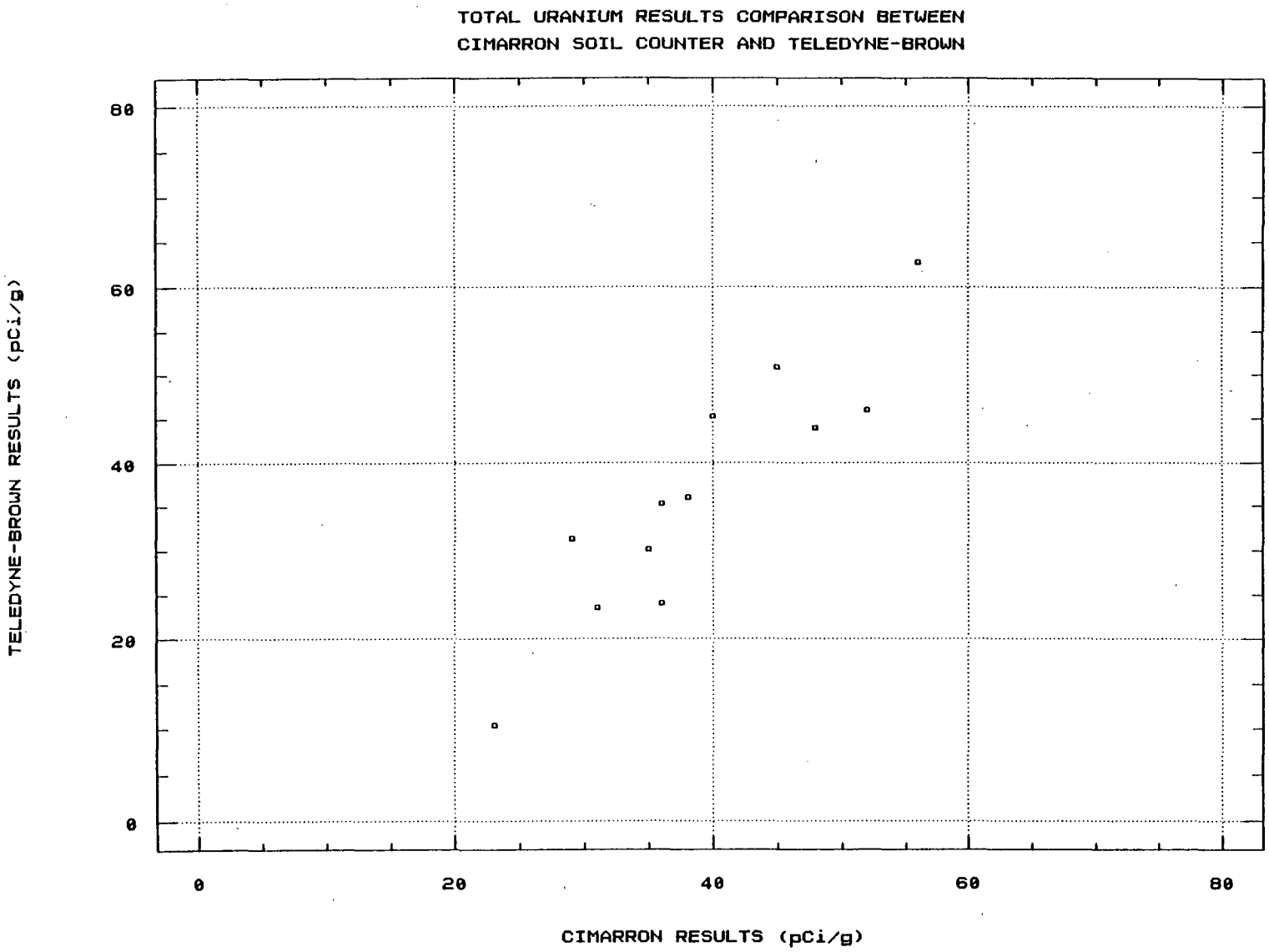

TOTAL URANIUM RESULTS COMPARISON BETWEEN
CIMARRON SOIL COUNTER AND TELEDYNE-BROWN
TELEDYNE-BROWN RESULTS (pCi/g)
0
20
40
60
80
0
20
40
60
80
CIMARRON RESULTS (pCi/g)

TABLE 5.6

RADIATION MONITORING INSTRUMENTS

INSTRUMENT TYPE	NUMBER AVAILABLE	RADIATION DETECTED	SCALE RANGE	BKG	TYPICAL MDA 95% CONFIDENCE LEVEL
Micro-R Meter (Ludlum) 1" x 1" Nal Detector	1	Gamma	0 - 3,000 μR/h	7 μR/h	7 uR/h
Ion Chamber (Victoreen)	2	Gamma	0.1 - 300 mR/h	<.01 mR/h	<0.2 mR/h
3" x 1/2" Nal Scintillation Detector Digital Scaler	3	Gamma	0 - 500,000 cpm	---	N/A
435 cm gas flow (43-27) Digital Scaler	1	Alpha	0 - 500,000 cpm	<10 cpm	20 dpm/100 cm^2
100 cm gas flow (43-68) Digital Scaler	1	Alpha	0 - 500,000 cpm	<10 cpm	100 dpm/100 cm^2
60 cm gas flow (43-4) Digital Scaler	1	Alpha	0 - 500,000 cpm	<10 cpm	200 dpm/100 cm^2
60 cm^2 Count Rate Meter (PRM-6)	6	Alpha	0 - 500,000 cpm	<100 cpm	350 dpm/100 cm^2
60 cm^2 Personnel Room Monitor (RM-3C)	5	Alpha	0 - 50,000 cpm	<100 cpm	350 dpm/100 cm^2
5" Slide-Drawer Counter	1	Alpha	0 - 500,000 cpm	<0.3 cpm	2 dpm
Eberline 2" GM Tube (Pancake)	1	Beta, Gamma	0 - 500,000 cpm 720 cpm = 0.2 mR/h	<200 cpm	200 cpm
Ludlum 2 GM Tube (Pancake)	2	Beta, Gamma	0 - 500,000 cpm 720 cpm - 0.2 mR/h	<200 cpm	200 cpm
Tennelec LB5100 Computer Based Auto Sample Counter	1	Alpha Beta	0 - 99,999,999 cpm	<0.3 cpm 1.5 cpm	0.41 dpm 1.54 dpm
Ludlum Dirt Probe 1 1/2" x 4" Nal (T1) Detector	2	Gamma	0 - 500,000 cpm	20,000 cpm	N/A
Soil Counter - Computer Linked 4" x 4" x16" Nal (T1) Detector	1	Gamma	---	6 pCi/g U 1.5 pCi/g Th	3.32 pCi/g U 0.66 pCi/g Th
100 cm Gas Flow Digital Scaler	2	Beta, Gamma	0 - 10,000 cpm	<300 cpm	570 dpm/100 cm^2
Ludlum 2" GM Tube (Pancake)	1	Alpha-Beta .Gamma	0-500,000 cpm	<200 cpm	N/A

CIMARRON CORPORATION
CIMARRON FACILITY

Table 5.7

PERSONAL, ENVIRONMENTAL AND AREA MONITORING EQUIPMENT

EQUIPMENT	MEDIA SAMPLED OR MONITORED	NUMBER AVAILABLE	CAPACITY OR RANGE
PERSONAL LAPEL PUMPS W/2" FILTER HEADS	AIR	5	0-4.5 LPM
PERSONAL LAPEL PUMPS W/2" FILTER HEADS	AIR	6	0-3 LPM
POWERED AREA MONITORS-ENVIRONMENTAL	AIR	4	0-45 CFM
PERSONAL FILM BADGES	BETA GAMMA RADIATION	AS REQUIRED	MDA = 10mRem
THERMOLUMINESCENT DOSIMETERS	BETA GAMMA RADIATION	AS REQUIRED	MDA = 0.8 mRem/WEEK
ELECTRIC POWERED AIR MONITORS	AIR	2	3.5 CFM
BATTERY POWERED AREA MONITORS	AIR	1	3.5 CFM

TABL57

6.0 Affected versus Unaffected Areas

Only a small portion of the licensed 1,100-acre Cimarron site was utilized for processing of fuel, product storage, liquid waste evaporation, waste storage and on-site waste disposal. The majority of the site can be considered an unaffected area.

A Micro-R Survey, using a Ludlum 12-S Micro-R meter, was performed in 1979 to provide an initial characterization (scoping survey) of the entire 1,100-acre site. The results of this survey are plotted on Drawings No. 79PRSAUR-0 and 79PRSBUR-0. All survey readings were at background levels(7 to 10 μR/hr) as shown on Drawing No. 79PRSAUR-0. (The 1992 ORISE Report[6], 92/G-57, reported a background average exposure rate at 1m above the surfaces of 10 μR/hr.) Survey readings shown on Drawing No. 79PRSBUR-0, which included the restricted area, show several areas within the restricted area above background. This area is being addressed as an affected area of the site.

In 1990, Cimarron personnel completed an extensive pre-remediation soil sampling program for the area surrounding the Uranium Building restricted area. The soil sampling program was conducted on a 10m x 10m grid with samples collected from 0 to 4 feet in depth. The analytical results are shown on Drawings No. 90PRUYSS-0 through 90PRUYSS-4.

Per NUREG/CR 5849, unaffected areas are areas of the site "not expected to contain residual radioactivity, based upon knowledge of site history and previous survey information". Additionally, to be considered an area acceptable for unrestricted release, the average radionuclide concentrations within the area are to be within the acceptable levels specified in Table 2, Option 1 Radioactivity Concentration Levels. This Table is contained in the USNRC Branch Technical Position (BTP) Paper, "Disposal Onsite of Thorium or Uranium Waste from Past Operations"[9]. Concentrations may be averaged over a 100 m^2 area. At any discrete location, the maximum radionuclide concentration above background may not exceed 3 times the Option #1 limit. The enriched uranium (Option #1) limit in Table 2 is 30 pCi/g above background levels. The BTP Option #2 limit for enriched uranium is 100 pCi/g (soluble) and 250 pCi/g (insoluble).

Based upon scoping surveys, site history, and the extensive amount of characterization data generated by Cimarron personnel to date (including the 1990 soil sampling program addressed above), the site can be divided into areas that are considered affected and unaffected. Some of the areas in this report that are classified as affected areas have already met the

NRC's unrestricted use criteria due to the remediation work that has been performed in the past. The NRC has released several of these areas based upon confirmatory surveys performed by both NRC and ORISE personnel.

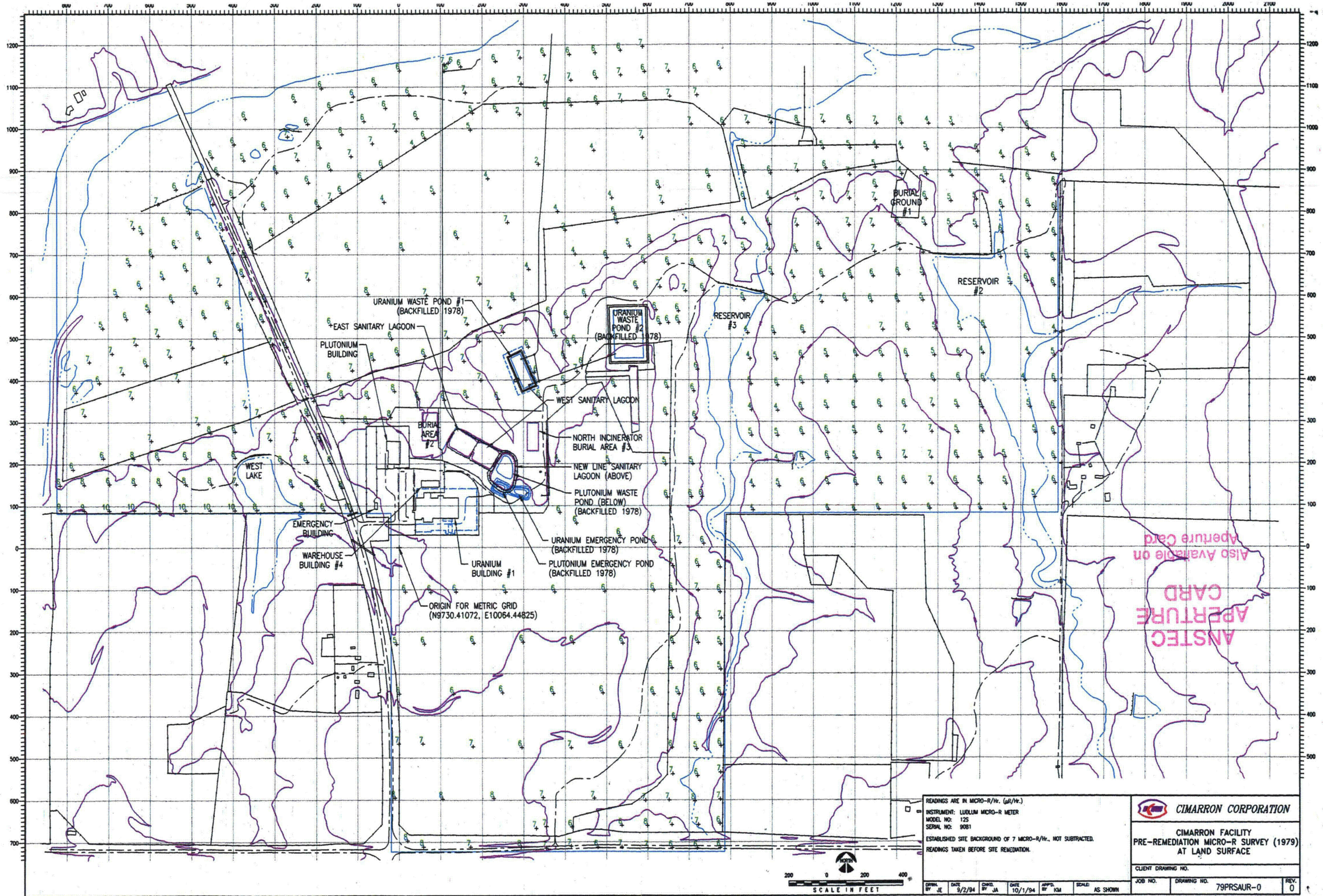
The affected and unaffected areas of the site are shown on Drawing No. 94MOST RF2. Of the 1,100-acre site, approximately 60 acres are considered to be affected areas, with the remaining 1,040 acres being considered unaffected areas. In this report the remediated and released areas have also been included as affected areas. In general, the areas that are considered to be affected areas are:

- Burial Area No. 1
- Uranium Waste Ponds #1 and #2
- The controlled area around and including the Uranium Buildings, the East, West, and New Sanitary Lagoons, Burial Areas #2 and #3, the Plutonium Building exterior surfaces and yard area, the Uranium Emergency Ponds, the Plutonium Evaporation and Emergency Ponds, the Warehouse/Coal Building, drain lines from Process Buildings to ponds, and the Emergency Building
- Drainage areas from Reservoir #2 and #3
- Drainage area from the Uranium Buildings to Reservoir #1, and Reservoir #1
- Drain areas and lines from Sanitary Lagoons and ponds to river and between ponds
- Site road.

The characterization and decommissioning status of the areas addressed above will be discussed in greater detail throughout the following sections of this report.

Natural background concentrations for uranium and thorium have not been subtracted from the sampling results discussed throughout this report. Natural background, as measured on the Cimarron counter, for these isotopes has been established numerous times by Cimarron. One example is the data presented from the 1991 Cimarron annual environmental soil samples[10]. Eleven sites on Cimarron property and surrounding areas were sampled (sample locations 1401 thru 1418). From each of the eleven locations, a composite was made up from soils collected at the surface and at a depth of ten inches. A total of twenty-two samples were analyzed at the Cimarron Laboratory. The sixteen samples from the eight locations, 0.5 and 1.0 miles from the plant, were utilized for determining background. The sample analytical results indicated average background concentrations of 6.5 pCi/g uranium and 1.7 pCi/g thorium. The analytical results for total uranium varied from 3.03 to 10.96 pCi/g and

for thorium from 0.83 to 2.45 pCi/g. Additional sampling by Cimarron has confirmed that background is approximately 6.0 pCi/g uranium and 1.5 pCi/g thorium.



READINGS ARE IN MICRO-R/Hr. (μR/Hr.)

INSTRUMENT: LUDLUM MICRO-R METER
MODEL NO: 125
SERIAL NO: 9081

ESTABLISHED SITE BACKGROUND OF 7 MICRO-R/Hr., NOT SUBTRACTED.

READINGS TAKEN BEFORE SITE REMEDIATION.

CIMARRON CORPORATION

CIMARRON FACILITY
PRE-REMEDIATION MICRO-R SURVEY (1979)
AT LAND SURFACE

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:
JE	9/2/94	JA	10/1/94	KM	AS SHOWN

JOB NO. | DRAWING NO. 79PRSAUR-0 | REV. 0

W:\CIMARRON\ACAD\79PRSAUR

9412080115 -02

URANIUM
WASTE POND #1
(BACKFILLED 1978)

BURIAL
AREA #2

PLUTONIUM
BUILDING

WEST
SANITARY
LAGOON

EAST
SANITARY
LAGOON

NEW LINED
SANITARY
LAGOON
(ABOVE)

NEW LINED
SANITARY
LAGOON (ABOVE)

PLUTONIUM
WASTE POND (BELOW)
(BACKFILLED 1978)

SE CORNER
INCINERATOR

WAREHOUSE
BUILDING #4

URANIUM
EMERGENCY POND
(BACKFILLED 1978)

EMERGENCY
BUILDING

URANIUM
BUILDING #1

PLUTONIUM
EMERGENCY POND
(BACKFILLED 1978)

ORIGIN FOR METRIC GRID
(N9730.41072, E10064.44825)

NORTH

SCALE IN METERS

READINGS ARE IN MICRO-R/Hr. (μR/Hr.)

INSTRUMENT: LUDLUM MICRO-R METER
MODEL NO: 12S
SERIAL NO: 9081

LEGEND
1 – 29 μR/hr.
30 – 89 μR/hr.
> 90 μR/hr.

ESTABLISHED SITE BACKGROUND OF 7 MICRO-R/Hr., NOT SUBTRACTED.

READINGS TAKEN BEFORE SITE REMEDIATION, EXCEPT FOR Pu POND, Pu EMERGENCY POND, AND URANIUM EMERGENCY POND WHICH WERE REMEDIATED & BACKFILLED IN 1978.

DRWN. BY	DATE	CHKD. BY	DATE	APPD. BY	DATE	SCALE:
JE	9/13/94	JA	KM		10/1/94	AS SHOWN

CIMARRON CORPORATION

CIMARRON FACILITY
PRE-REMEDIATION MICRO-R SURVEY (1979)
AT LAND SURFACE

CLIENT DRAWING NO.

JOB NO.	DRAWING NO.	REV.
	79PRSBUR-0	0

URANIUM WASTE POND #1 (BACKFILLED 1978)

NORTH INCINERATOR BURIAL AREA #3

BURIAL AREA #2

NEW LINED SANITARY LAGOON (ABOVE)

WEST SANITARY LAGOON

EAST SANITARY LAGOON

PLUTONIUM BUILDING

PLUTONIUM WASTE POND (BELOW) (BACKFILLED 1978)

SE COR INCINERATOR

PLUTONIUM EMERGENCY POND (BACKFILLED 1978)

URANIUM EMERGENCY POND (BACKFILLED 1978)

WAREHOUSE BUILDING #4

URANIUM BUILDING #1

EMERGENCY BUILDING

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U).
CIMARRON GAMMA SPEC SOIL COUNTER.
SITE SOIL BACKGROUND OF APPROXIMATELY 6 pCi/g U, NOT SUBTRACTED.
SAMPLES TAKEN ON 10 METER X 10 METER GRID.
SAMPLES TAKEN BEFORE REMEDIATION.

LEGEND
1 - 29 pCi/g U
30 - 89 pCi/g U
> 90 pCi/g U

NORTH
20 0 20
SCALE IN METERS

CIMARRON CORPORATION

CIMARRON FACILITY
URANIUM PLANT AREAS
PRE-REMEDIATION SOIL SAMPLE RESULTS (1990)
SOIL SAMPLE ALIQUOT: 0"-6" DEEP

CLIENT DRAWING NO.

DRAWN BY	DATE	CHKD. BY	DATE	APPD. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/14/94	JA	10/1/94	KM	AS SHOWN		90PRUYSS-0	0

URANIUM WASTE POND #1 (BACKFILLED 1978)

NORTH INCINERATOR BURIAL AREA #3

BURIAL AREA #2

NEW LINED SANITARY LAGOON (ABOVE)

WEST SANITARY LAGOON

EAST SANITARY LAGOON

PLUTONIUM BUILDING

PLUTONIUM WASTE POND (BELOW) (BACKFILLED 1978)

SE COR INCINERATOR

PLUTONIUM EMERGENCY POND (BACKFILLED 1978)

URANIUM EMERGENCY POND (BACKFILLED 1978)

WAREHOUSE BUILDING #4

URANIUM BUILDING #1

EMERGENCY BUILDING

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U).
CIMARRON GAMMA SPEC SOIL COUNTER.
SITE SOIL BACKGROUND OF APPROXIMATELY 6 pCi/g U, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.
SAMPLES TAKEN BEFORE REMEDIATION.

LEGEND
- 1 - 29 pCi/g U
- 30 - 89 pCi/g U
- > 90 pCi/g U

NORTH
20 0 20
SCALE IN METERS

CIMARRON CORPORATION

CIMARRON FACILITY
URANIUM PLANT AREAS
PRE-REMEDIATION SOIL SAMPLE RESULTS (1990)
SOIL SAMPLE ALIQUOT: 6"-1' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/14/94	JA	10/1/94	KM	AS SHOWN		90PRUYSS-1	0

M:\CIMARRON_KERR\PLOTS\90PRUYSS-1.DWG

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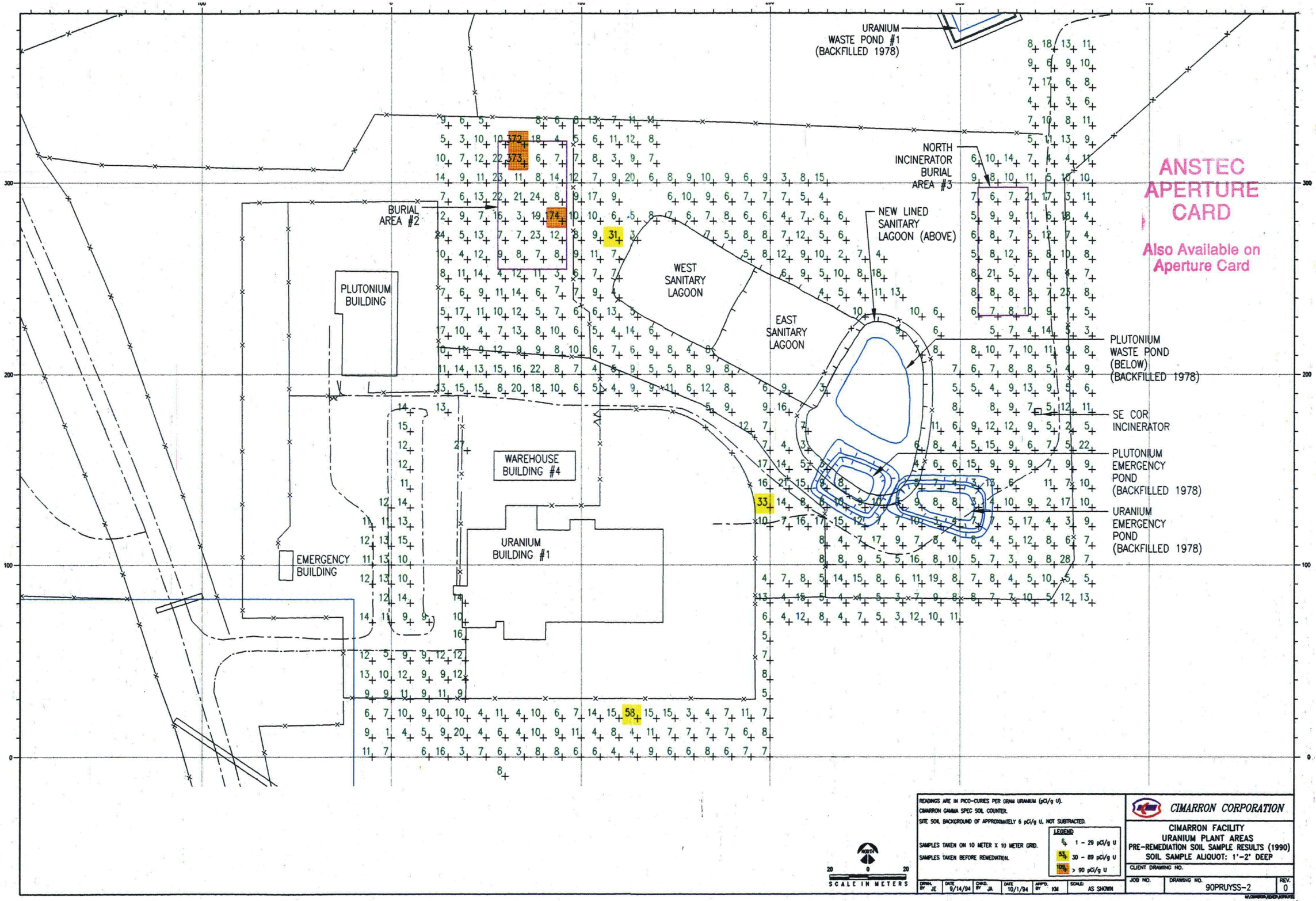

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U).
CIMARRON GAMMA SPEC SOIL COUNTER.
SITE SOIL BACKGROUND OF APPROXIMATELY 6 pCi/g U, NOT SUBTRACTED.
SAMPLES TAKEN ON 10 METER X 10 METER GRID.
SAMPLES TAKEN BEFORE REMEDIATION.

LEGEND
1 - 29 pCi/g U
30 - 89 pCi/g U
> 90 pCi/g U

CIMARRON CORPORATION

CIMARRON FACILITY
URANIUM PLANT AREAS
PRE-REMEDIATION SOIL SAMPLE RESULTS (1990)
SOIL SAMPLE ALIQUOT: 1'-2' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
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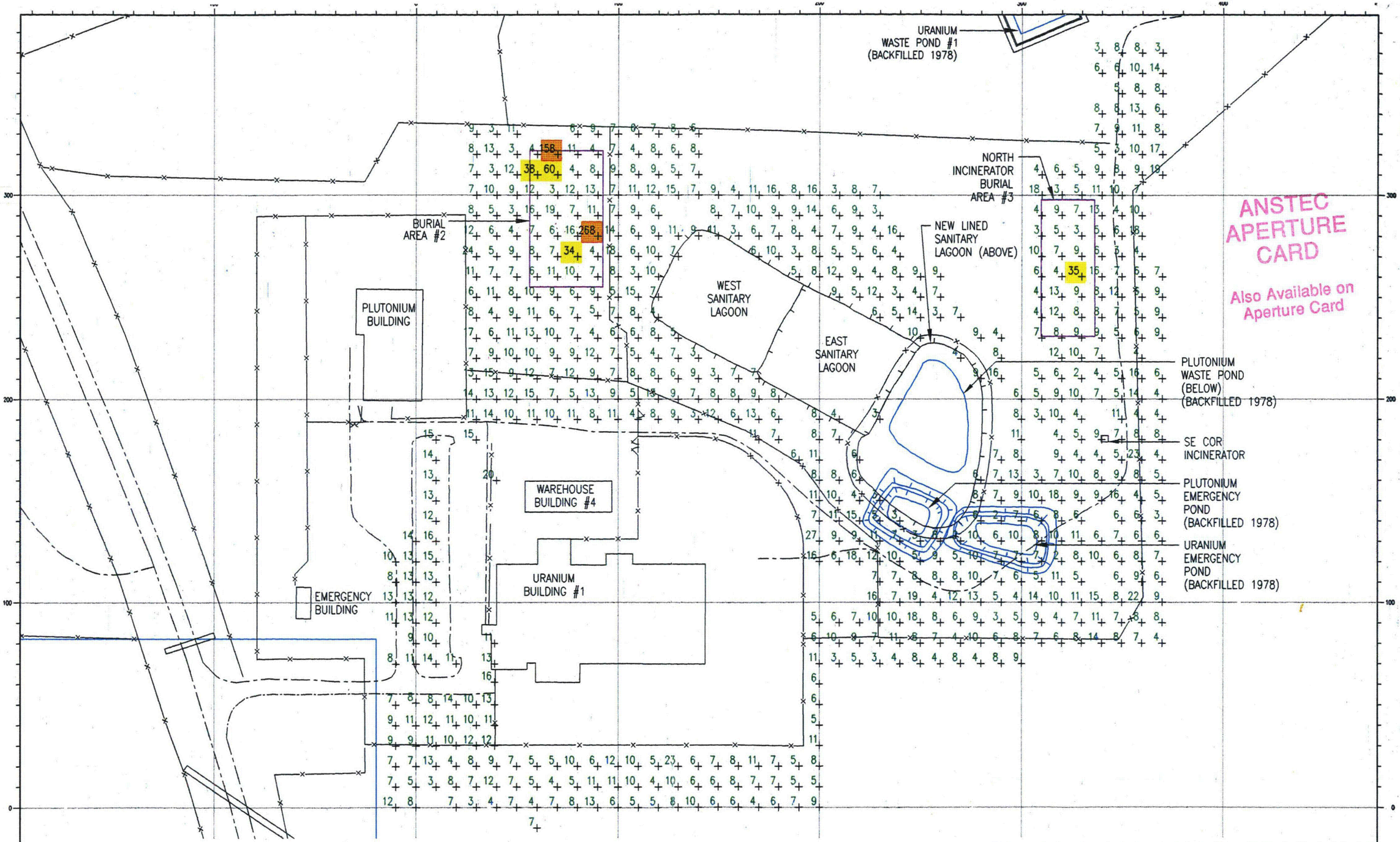


READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U).
CIMARRON GAMMA SPEC SOIL COUNTER.
SITE SOIL BACKGROUND OF APPROXIMATELY 6 pCi/g U, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.
SAMPLES TAKEN BEFORE REMEDIATION.

LEGEND
- 1 - 29 pCi/g U
- 30 - 89 pCi/g U
- > 90 pCi/g U

NORTH
20 0 20
SCALE IN METERS

CIMARRON CORPORATION

CIMARRON FACILITY
URANIUM PLANT AREAS
PRE-REMEDIATION SOIL SAMPLE RESULTS (1990)
SOIL SAMPLE ALIQUOT: 2'-3' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/14/94	JA	10/1/94	KM	AS SHOWN		90PRUYSS-3	0

URANIUM WASTE POND #1 (BACKFILLED 1978)

NORTH INCINERATOR BURIAL AREA #3

BURIAL AREA #2

NEW LINED SANITARY LAGOON (ABOVE)

PLUTONIUM BUILDING

WEST SANITARY LAGOON

EAST SANITARY LAGOON

PLUTONIUM WASTE POND (BELOW) (BACKFILLED 1978)

SE COR INCINERATOR

WAREHOUSE BUILDING #4

PLUTONIUM EMERGENCY POND (BACKFILLED 1978)

URANIUM BUILDING #1

URANIUM EMERGENCY POND (BACKFILLED 1978)

EMERGENCY BUILDING

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U).
CIMARRON GAMMA SPEC SOIL COUNTER.
SITE SOIL BACKGROUND OF APPROXIMATELY 6 pCi/g U, NOT SUBTRACTED.
SAMPLES TAKEN ON 10 METER X 10 METER GRID.
SAMPLES TAKEN BEFORE REMEDIATION.

LEGEND
1 - 29 pCi/g U
30 - 89 pCi/g U
> 90 pCi/g U

NORTH
20 0 20
SCALE IN METERS

CIMARRON CORPORATION

CIMARRON FACILITY
URANIUM PLANT AREAS
PRE-REMEDIATION SOIL SAMPLE RESULTS (1990)
SOIL SAMPLE ALIQUOT: 3'-4' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/14/94	JA	10/1/94	KM	AS SHOWN		90PRUYSS-4	0

URANIUM WASTE POND #1 (BACKFILLED 1978)
EAST SANITARY LAGOON
WEST SANITARY LAGOON
BURIAL AREA #2 (NORTH FIELD)
WAREHOUSE BUILDING #4
PLUTONIUM BUILDING
WEST LAKE
EMERGENCY BUILDING
URANIUM WASTE POND #2 (BACKFILLED 1978)
BURIAL AREA #1
RESERVOIR #2
RESERVOIR #3
BURIAL AREA #4
NORTH INCINERATOR BURIAL AREA #3
URANIUM EMERGENCY POND (BACKFILLED 1978)
PLUTONIUM EMERGENCY POND (BACKFILLED 1978)
URANIUM BUILDING #1
ORIGIN FOR METRIC GRID (N9730.41072, E10064.44825)

NORTH

100 0 100 200
SCALE IN METERS

CIMARRON CORPORATION

CIMARRON FACILITY
AFFECTED AREAS MAP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	10/10/94	JA	10/10/94	KM	AS SHOWN		94MOST_RF2	0

7.0 Burial Area #1

This burial area was constructed in 1965 and was opened for disposal in 1966 for radioactive material, including thorium contaminated waste from the Kerr McGee Cushing Facility. Burial Area #1 was closed and capped in 1970. The available burial records show that 1,303 kg of depleted uranium, 148 kg of enriched uranium, and 5,555 kg of natural thorium were buried within this area. Because of significant settlement over Burial Area #1 trenches, an investigation was initiated in 1984 to establish an appropriate remedial action. In February, 1985, several monitoring wells were installed at the burial ground; one up gradient and three down gradient of this burial area. In May, 1985, twelve soil samples from nine bore holes around the perimeter of this area were obtained to a maximum depth of twelve feet. A bore hole gamma scan was completed in 1986 on the four trenches and in the area surrounding the trenches. Based upon the significant slumping over the burial area and the borehole sampling data, the decision was made to excavate the disposal area. From 1986 through 1988, trenches were excavated to a depth of 7 to 8 feet and the waste generated was shipped off site for disposal at a licensed LLRW disposal facility. Waste shipment records indicate that approximately 65,000 ft^3 of waste was shipped off site for disposal. Approximately 16,000 ft^3 of contaminated soil has been removed and stockpiled east of the Uranium Building awaiting on-site disposal as Option #2 material.

In August, 1988, ORAU performed a confirmatory survey for Burial Area #1 and found eight (8) locations requiring further remediation. After additional excavation of Burial Area #1, soil samples were taken at elevations from 0 to 4 feet below excavated depth on a 10m x 10m grid. This initial grid sampling/surveying indicated several areas requiring further remediation. An additional 14,000 ft^3 of material was removed and stockpiled in the Uranium Building yard area. Additional soil samples at depths from 0 to 4 feet were taken in those excavated areas to confirm that the area had been decontaminated to limits at or below Option #1 levels.

Confirmatory soil sampling and surveys by ORAU were completed in December, 1991, with a final report issued in July, 1992[6]. Based upon this report, the NRC released Burial Area #1 for backfilling with clean soil through the issuance of Amendment #9 of License SNM-928.

A. Characterization Data:

The radiological characterization performed for this area was conducted in two phases. The first phase consisted of surveys and soil sampling performed prior to excavation. The second phase

included the soil sampling and surveys performed to verify that the area could be released per NRC guidelines.

B. Characterization Data - Phase 1:

In May, 1985, soil samples were collected to a depth of twelve feet, from nine bore holes around the perimeter of four trenches. This sampling effort constituted the initial characterization of this area. In April, 1986, a second bore hole logging and sampling program was initiated to more accurately characterize the soils in and around this area. A total of 44 bore holes to a maximum depth of 28 feet were sampled. Soil samples were taken at selected locations and depths from these bore holes.

The data gathered from this phase of the characterization were used to plan the excavation and remediation of this former burial area. The initial excavation and removal of the buried waste and contaminated soil was started in August, 1986 and completed in August, 1988. ORAU performed a confirmatory survey for this burial area during the period of August 24-31, 1988 and found eight (8) locations still needing further remediation. This remediation and the relocation of the contaminated soil stockpile (Option #2) initially stored south of the burial ground was completed by March, 1991. The stockpiled material was moved to the yard beside the Uranium Plant Building.

C. Characterization Data - Phase 2:

With the removal of what was believed to be the remaining areas of contaminated soil, a bore hole logging and sampling program was conducted on a 10m x 10m grid. The area contained 162 grids as shown on Drawing No. 91POB1SS-0 and encompassed the excavated area. A composite soil sample was taken from each grid intersect at depths of 0 to 0.5 ft., 0.5 to 1.0 ft., 1 to 2 ft., 2 to 3 ft. and 3 to 4 ft. The composite soil samples were analyzed at the Cimarron facility laboratory for total uranium and thorium. The soil counter is discussed in Section 3.0. The results of these analyses are shown on Drawings No. 91POB1SS-0 through 91POB1SS-4.

During this sampling effort 791 samples were taken. Areas were resampled on the same 10m x 10m grid in locations where additional remediation was performed and these sample results were used in the final survey report. In areas where bedrock was encountered during coring, soil samples could not be taken. The maximum soil concentrations found during this sampling effort were

23 pCi/g total uranium and 5 pCi/g total thorium (7.56 pCi/g total uranium average and 1.75 pCi/g total thorium average). Background values were not subtracted from the sample results.

Confirmatory soil sampling and surveys were performed by ORAU December 9 through 12, 1991. A draft report was issued by ORAU in April, 1992 and the final report was issued in July, 1992. Based upon this confirmatory report, the NRC issued Amendment #9 to Cimarron's SNM-928 Uranium License which authorized the backfilling of Burial Area #1. This amendment was signed December 28, 1992.

Between March and July, 1993, clean soil was transported to Burial Ground #1 and placed into the excavated area. The final grading of this area also was completed in July, 1993. Random surface soil sampling of the cap material was completed in August, 1993 and analyzed by the Cimarron laboratory for total uranium and thorium. These data are included on Drawing No. 93FIB1SS-0 which represents a 0- to 6-inch soil sampling depth with results listed in pCi/g. Total uranium results ranged from 2 to 13 pCi/g, while total Thorium ranged from 0 to 2 pCi/g. These results are within Option #1 criteria.

A final walkover gamma survey with a Ludlum 19 Micro-R meter was completed in September, 1993 on a 10m x 10m grid. These data were placed on Drawings No. 93FIB1UR-0 and 93FIB1UR-1. In addition, Cimarron personnel completed a gamma survey utilizing an unshielded NaI detector after the area was backfilled. This data is shown on Drawing 93FIB13D-0.

D. Environmental Data:

Monitoring wells #1314 through #1317 serve to monitor the area surrounding Burial Area #1. Well #1314 is southeast of the burial area and was installed as an up gradient well for this area. Wells #1315, #1316, and #1317 are north of the area and appear to be influenced by the disposal area, based upon the results of the environmental monitoring program. Figures 7.1 through 7.3 show trends occurring in these wells. "Less than" data are presented on graphs at the uppermost bound.

Figure 7.1

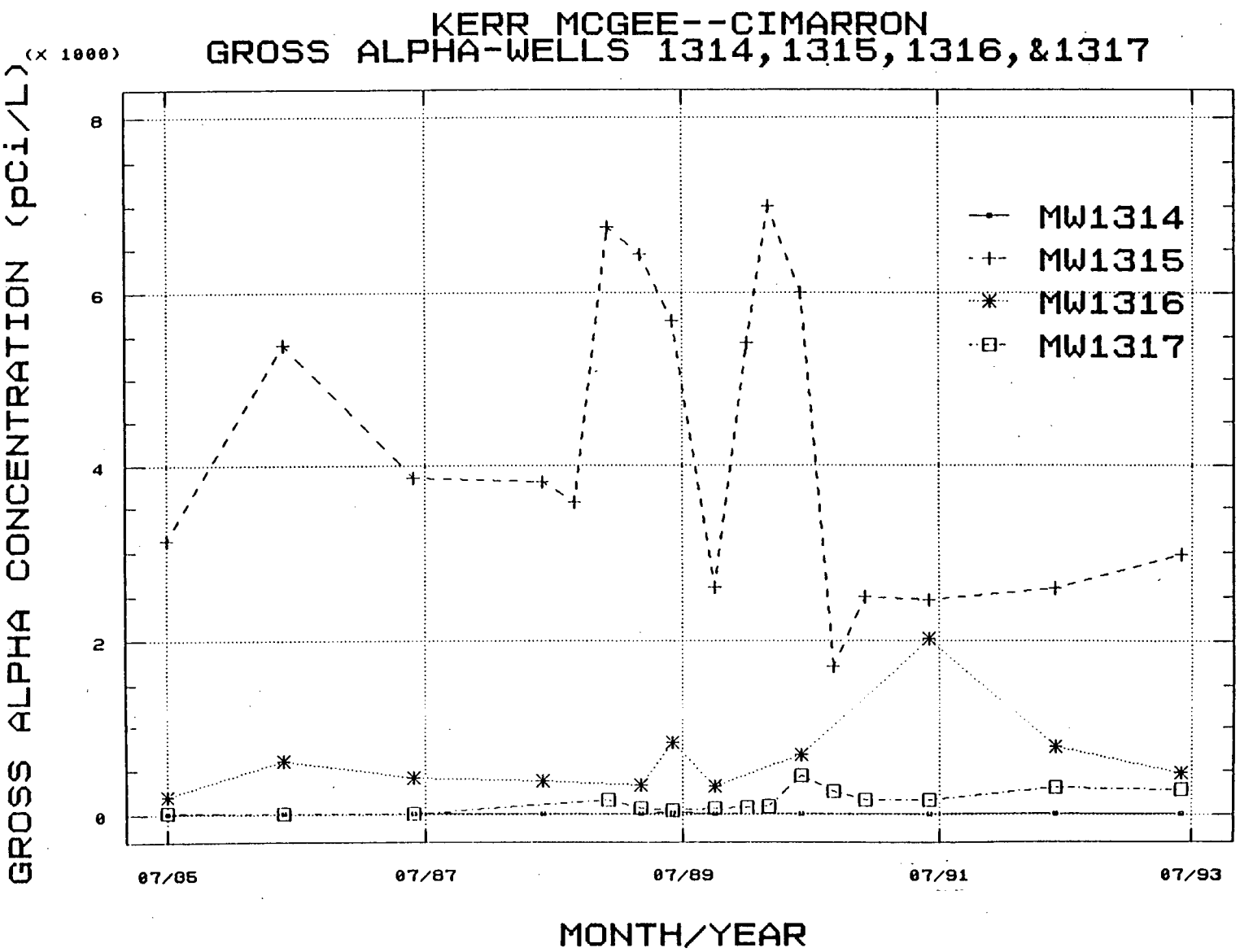

KERR MCGEE--CIMARRON
GROSS ALPHA-WELLS 1314,1315,1316,&1317
GROSS ALPHA CONCENTRATION (pCi/L)
(x 1000)
8
6
4
2
0
07/85
07/87
07/89
07/91
07/93
MONTH/YEAR
MW1314
MW1315
MW1316
MW1317

Figure 7.2

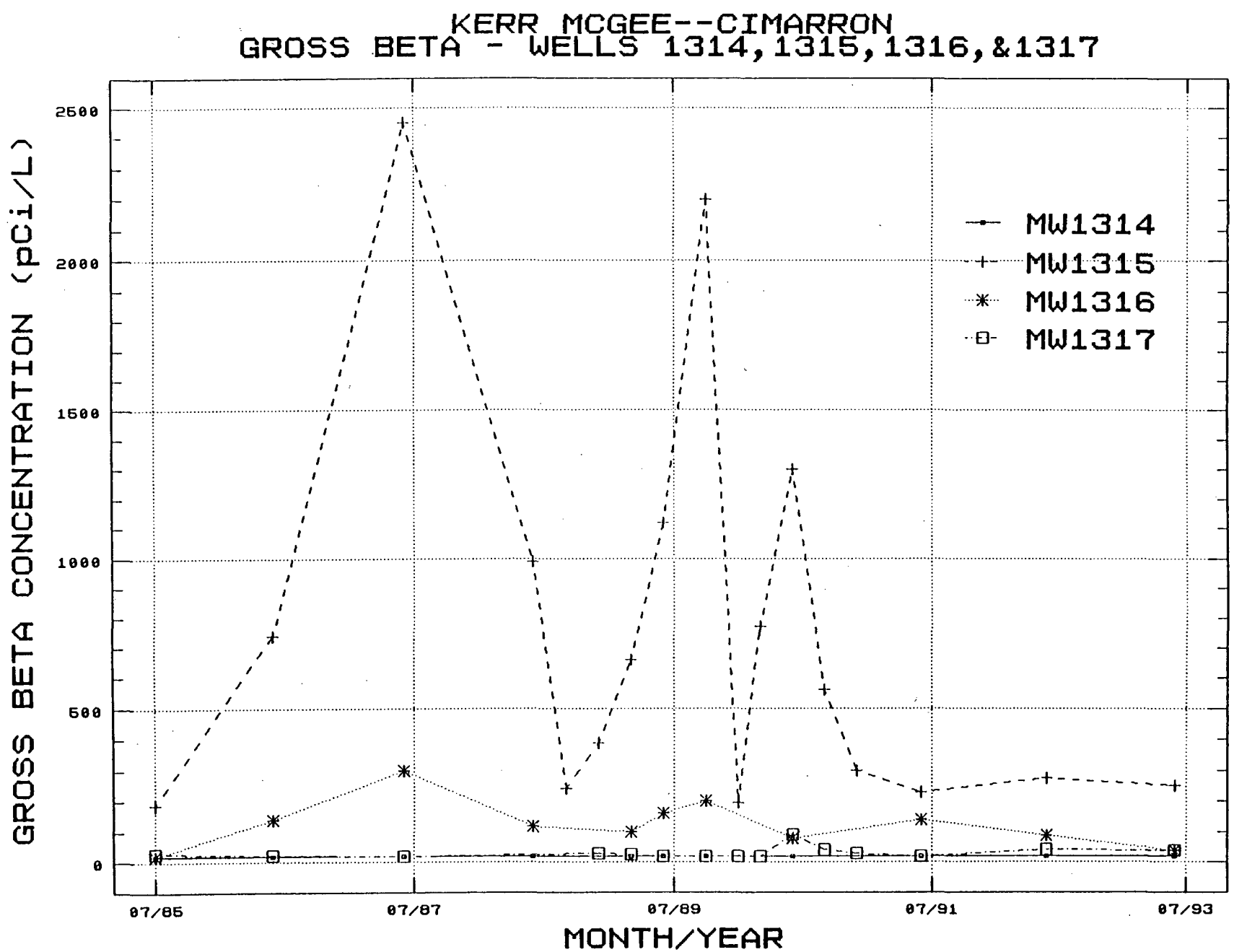
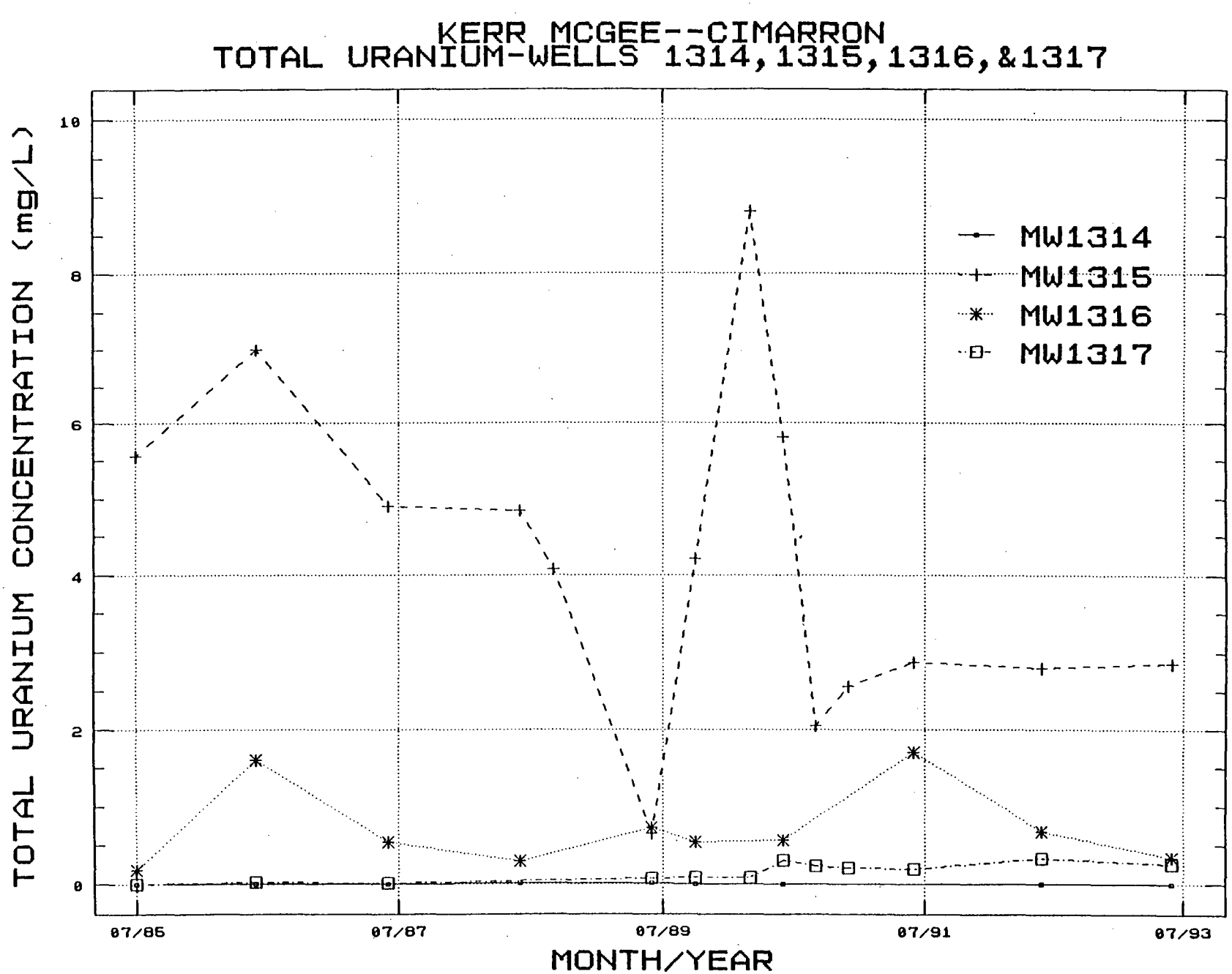

KERR MCGEE--CIMARRON
GROSS BETA - WELLS 1314,1315,1316,&1317
GROSS BETA CONCENTRATION (pCi/L)
2500
2000
1500
1000
500
0
07/85
07/87
07/89
07/91
07/93
MONTH/YEAR
MW1314
MW1315
MW1316
MW1317

Figure 7.3


KERR MCGEE--CIMARRON
TOTAL URANIUM-WELLS 1314,1315,1316,&1317
TOTAL URANIUM CONCENTRATION (mg/L)
10
8
6
4
2
0
07/85
07/87
07/89
07/91
07/93
MONTH/YEAR
MW1314
MW1315
MW1316
MW1317

Gross alpha concentrations in well #1314 were less than 10 pCi/L for all samples for the period 1985 through 1993 except for a sample collected in June, 1989 which contained 21 pCi/L. No indication of contamination from facility operations is indicated by this well.

Gross alpha concentrations in well #1315 remained elevated throughout the 1985 through 1993 monitoring period, ranging from 1,710 pCi/L in September, 1990, to 7,000 pCi/L in March, 1990. Results decreased prior to 1990 and have remained relatively constant since that time. The June, 1993, sample result was 2,970 pCi/L.

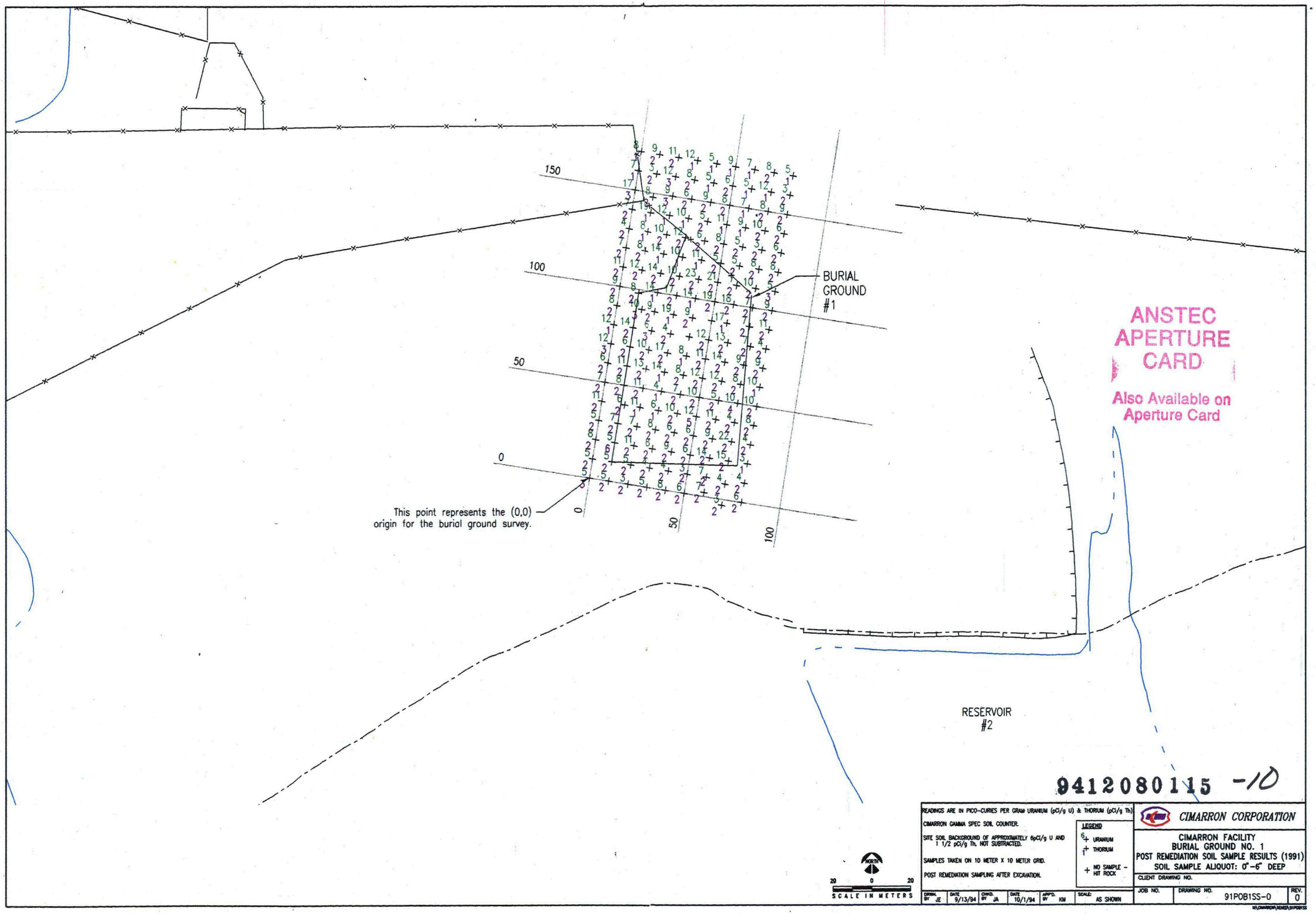
Gross alpha concentrations in well #1316 ranged from 200 pCi/L in 1985 to 2,030 pCi/L in 1991. Subsequent to 1991, gross alpha concentrations have decreased steadily to 473 pCi/L in 1993. The elevated activity can be attributed to uranium based upon laboratory results.

Gross alpha concentrations in well #1317 ranged from less than 10 pCi/L in 1986 to 440 pCi/L in 1990. Gross alpha activity is due to the presence of uranium, as discussed below. Figure 7.1 shows sample results for gross alpha concentrations in wells #1314 through #1317.

Gross beta concentrations in wells #1314 through #1317 are shown, by sample date, in Figure 7.2. Concentrations in well #1314 were less than 20 pCi/L during the 1985 through 1993 monitoring period. Gross beta concentrations in well #1315 ranged from 189 pCi/L in 1985 to 2,450 pCi/L in 1987. Sample results have remained below 300 pCi/L since September, 1990. Well #1316 ranged from less than 20 pCi/L in 1985 to 300 pCi/L in 1987. Sample results in well #1316 have decreased since 1991 to 37 pCi/L in 1993. Concentrations in well #1317 ranged from less than 20 pCi/L to 91 pCi/L in June, 1990. Well #1317 sample results for 1993 indicated a gross beta concentration of 37 pCi/L.

Total uranium concentrations in wells #1314 through #1317 ranged from less than 0.002 mg/L to 8.8 mg/L (well #1315, March, 1990). Total uranium concentrations in well #1314 have remained below detection limits (0.005 mg/L) since June, 1989. Concentrations in wells #1315, #1316, and #1317 remained elevated in 1993 at 2.86 mg/L (4,100 pCi/L), 0.35 mg/L (500 pCi/L), and 0.26 mg/L (380 pCi/g) respectively. Numbers in parentheses represent the total uranium concentrations in pCi/L after application of a conversion

factor based on a 2.7 weight percent enrichment (as discussed in Section 3.0). Total uranium concentrations are substantiated by isotopic uranium analyses. Well monitoring will continue to be performed in order to further define the impact of remedial activities upon groundwater quality.



READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) & THORIUM (pCi/g Th)

CIMARRON GAMMA SPEC SOIL COUNTER.

SITE SOIL BACKGROUND OF APPROXIMATELY 6pCi/g U AND 1 1/2 pCi/g Th, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.

POST REMEDIATION SAMPLING AFTER EXCAVATION.

LEGEND
6+ URANIUM
1+ THORIUM
+ NO SAMPLE - HIT ROCK

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
POST REMEDIATION SOIL SAMPLE RESULTS (1991)
SOIL SAMPLE ALIQUOT: 0"-6" DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/13/94	JA	10/1/94	KM	AS SHOWN		91POB1SS-0	0

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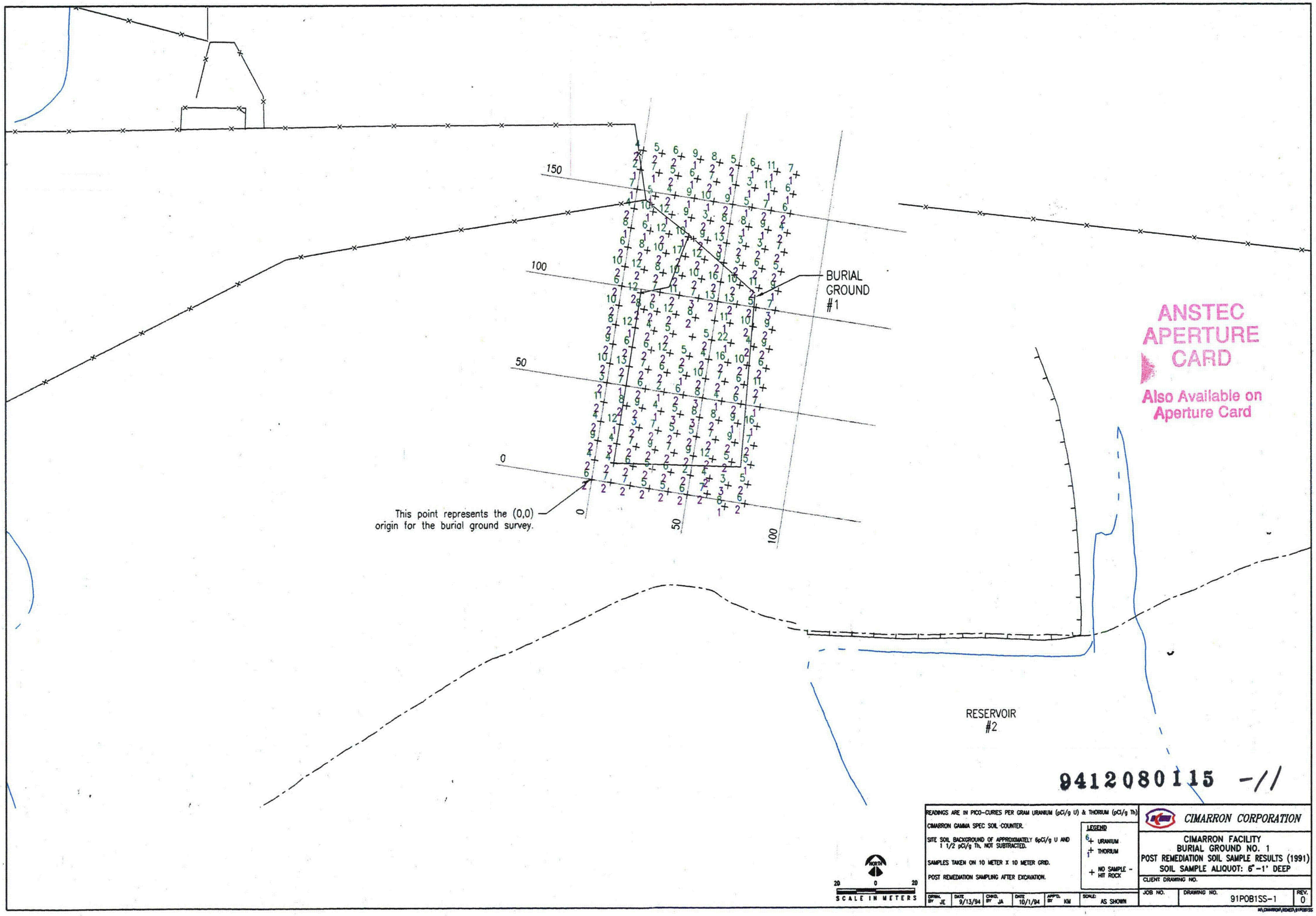

9412080115 -//

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) & THORIUM (pCi/g Th)

CIMARRON GAMMA SPEC SOIL COUNTER.

SITE SOIL BACKGROUND OF APPROXIMATELY 6pCi/g U AND 1 1/2 pCi/g Th, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.

POST REMEDIATION SAMPLING AFTER EXCAVATION.

LEGEND
6+ URANIUM
1+ THORIUM
+ NO SAMPLE - HIT ROCK

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
POST REMEDIATION SOIL SAMPLE RESULTS (1991)
SOIL SAMPLE ALIQUOT: 6"-1' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
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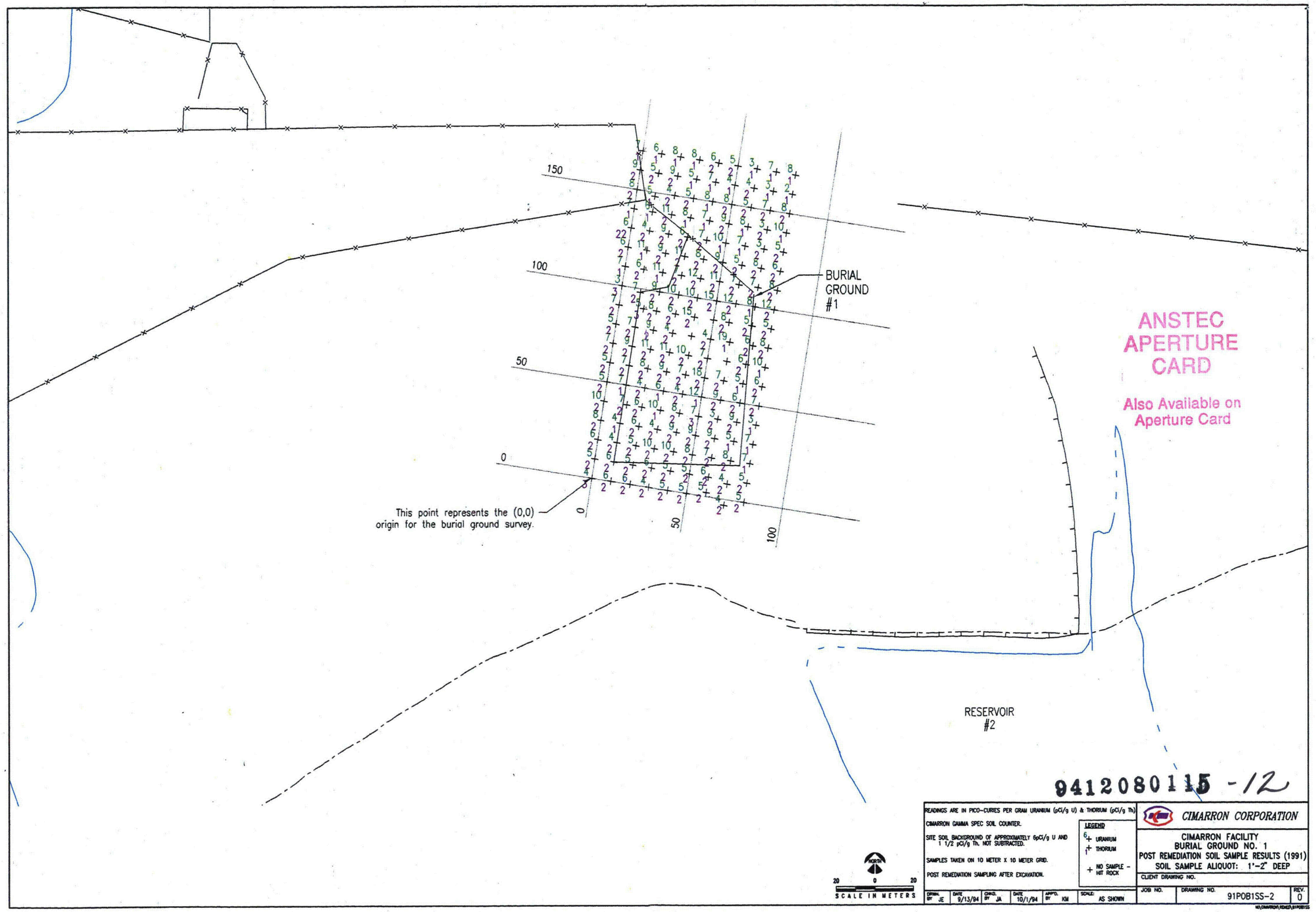

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) & THORIUM (pCi/g Th)

CIMARRON GAMMA SPEC SOIL COUNTER.

SITE SOIL BACKGROUND OF APPROXIMATELY 6pCi/g U AND 1 1/2 pCi/g Th. NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.

POST REMEDIATION SAMPLING AFTER EXCAVATION.

LEGEND
6+ URANIUM
7+ THORIUM
+ NO SAMPLE - HIT ROCK

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
POST REMEDIATION SOIL SAMPLE RESULTS (1991)
SOIL SAMPLE ALIQUOT: 1'-2" DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APPD. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/13/94	JA	10/1/94	KM	AS SHOWN		91P0B1SS-2	0

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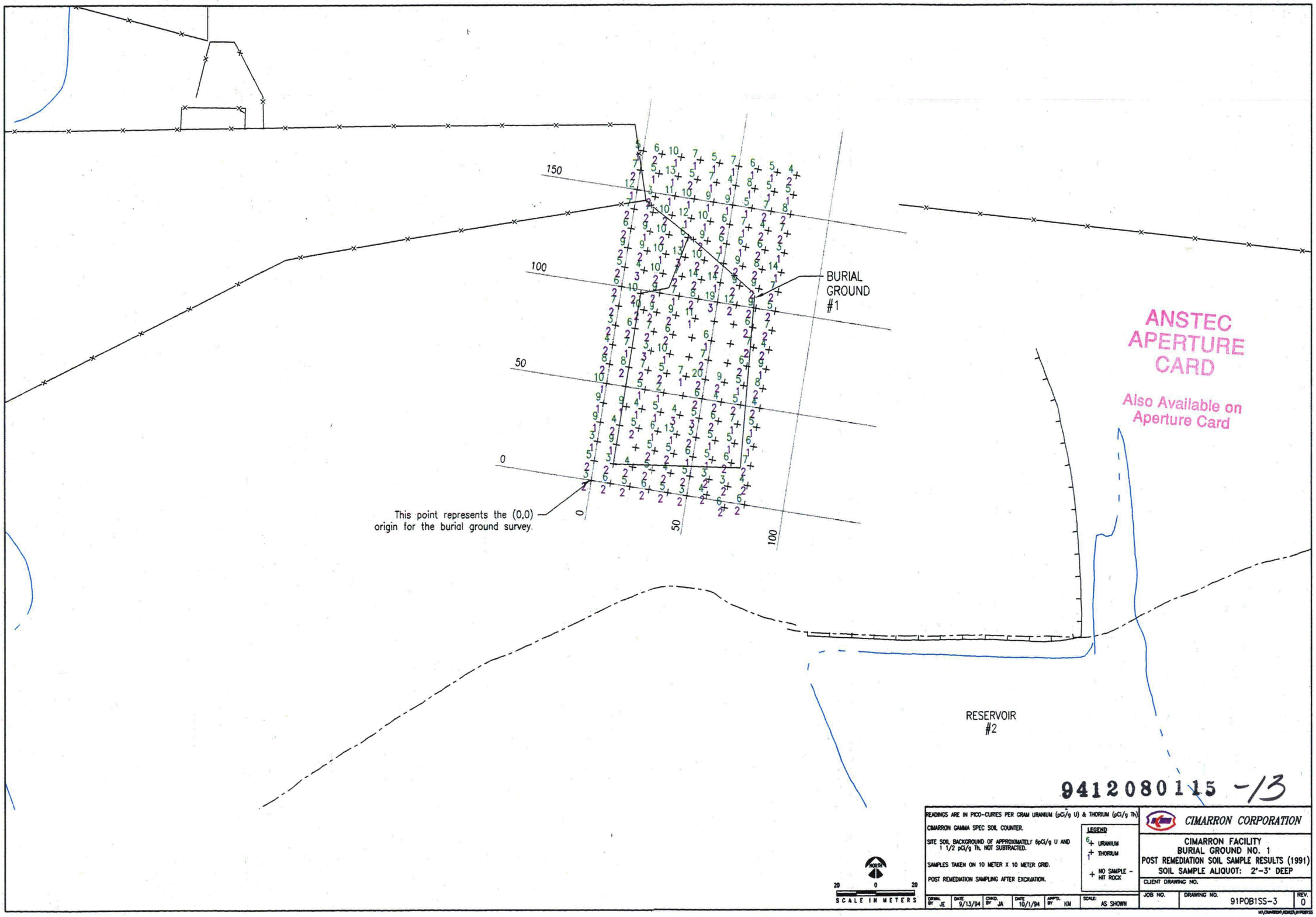

9412080115 -13

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) & THORIUM (pCi/g Th).

CIMARRON GAMMA SPEC SOIL COUNTER.

SITE SOIL BACKGROUND OF APPROXIMATELY 6pCi/g U AND 1 1/2 pCi/g Th, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.

POST REMEDIATION SAMPLING AFTER EXCAVATION.

LEGEND
6+ URANIUM
1+ THORIUM
+ NO SAMPLE - HIT ROCK

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
POST REMEDIATION SOIL SAMPLE RESULTS (1991)
SOIL SAMPLE ALIQUOT: 2"-3" DEEP

CLIENT DRAWING NO.

DRAWN BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
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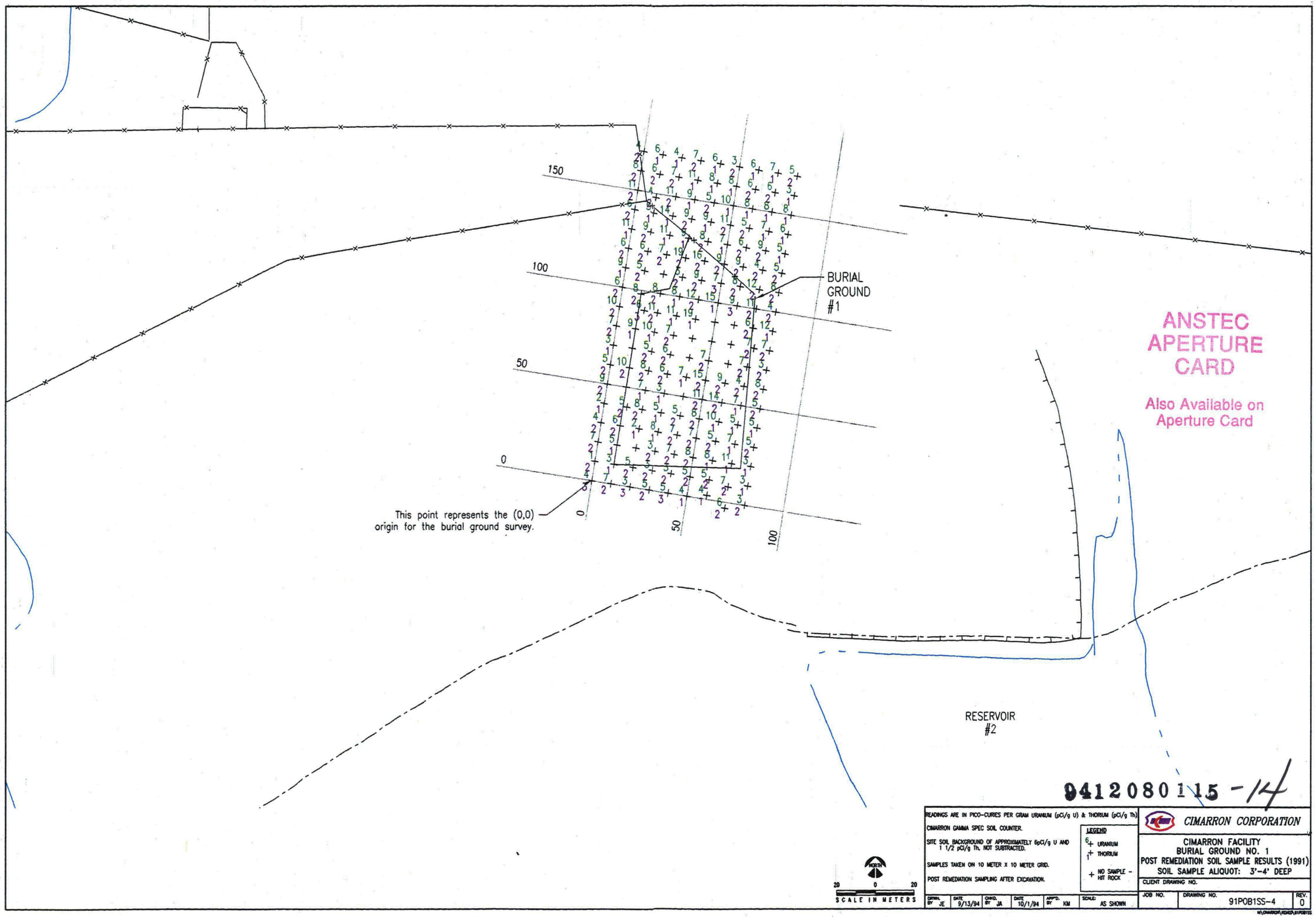

9412080115 -14

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) & THORIUM (pCi/g Th)

CIMARRON GAMMA SPEC SOIL COUNTER.

SITE SOIL BACKGROUND OF APPROXIMATELY 6pCi/g U AND 1 1/2 pCi/g Th, NOT SUBTRACTED.

SAMPLES TAKEN ON 10 METER X 10 METER GRID.

POST REMEDIATION SAMPLING AFTER EXCAVATION.

LEGEND

6+ URANIUM

1+ THORIUM

+ NO SAMPLE - HIT ROCK

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
POST REMEDIATION SOIL SAMPLE RESULTS (1991)
SOIL SAMPLE ALIQUOT: 3'-4' DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/13/94	JA	10/1/94	KM	AS SHOWN		91POB1SS-4	0

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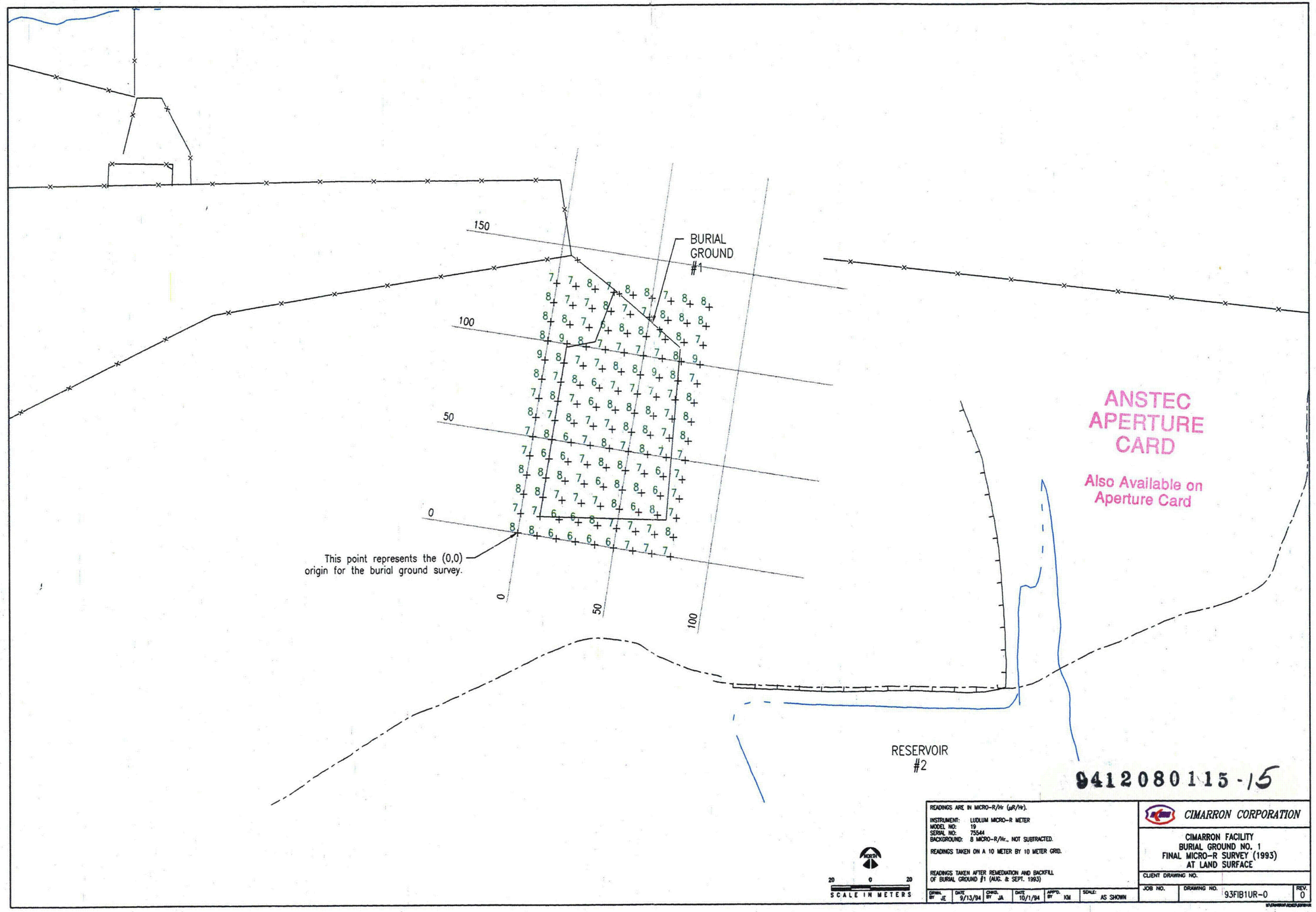


READINGS ARE IN MICRO-R/Hr (μR/Hr).

INSTRUMENT: LUDLUM MICRO-R METER
MODEL NO: 19
SERIAL NO: 75544
BACKGROUND: 8 MICRO-R/Hr., NOT SUBTRACTED.

READINGS TAKEN ON A 10 METER BY 10 METER GRID.

READINGS TAKEN AFTER REMEDIATION AND BACKFILL OF BURIAL GROUND #1 (AUG. & SEPT. 1993)

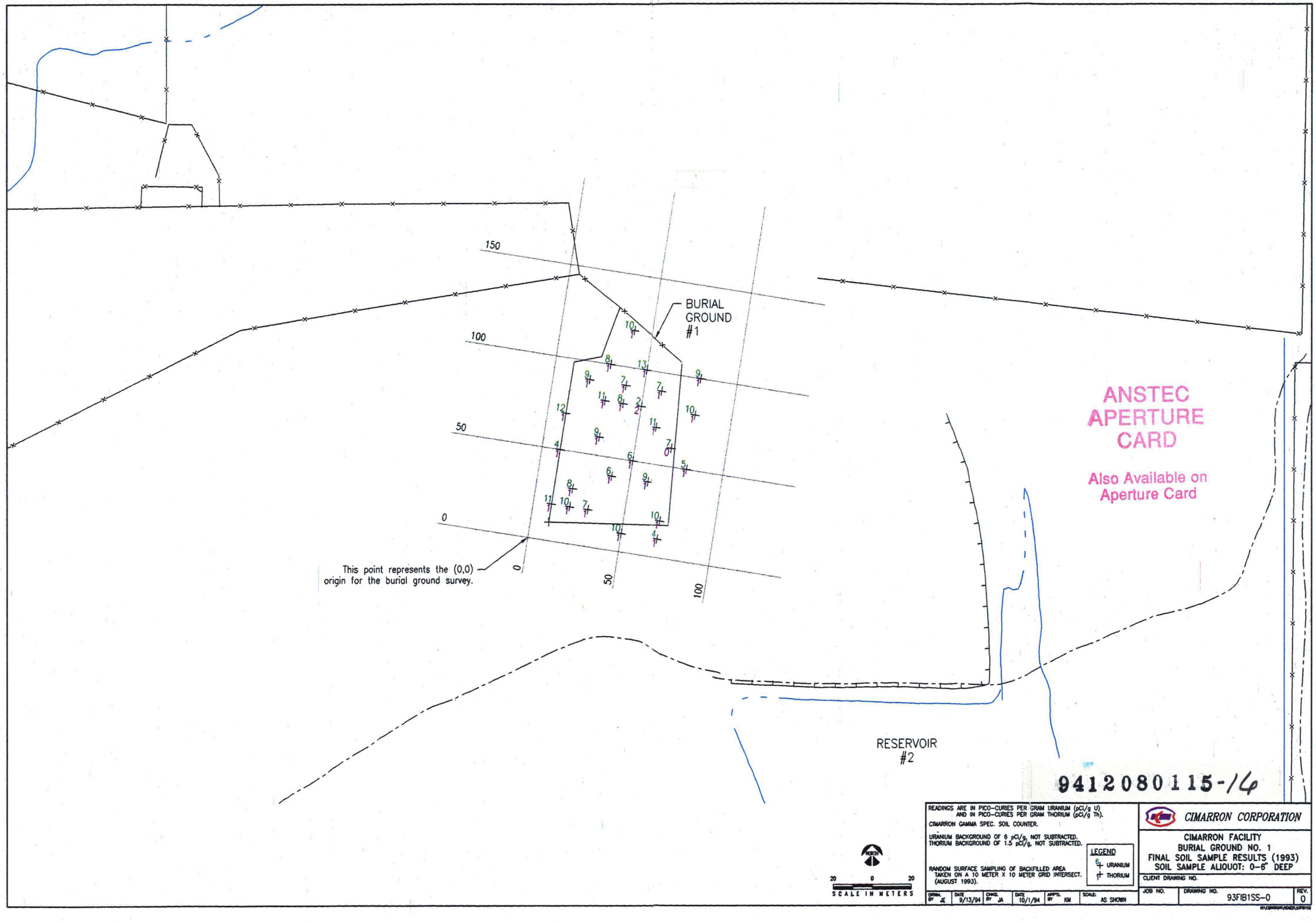
DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:
JE	9/13/94	JA	10/1/94	KM	AS SHOWN

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
FINAL MICRO-R SURVEY (1993)
AT LAND SURFACE

CLIENT DRAWING NO.

JOB NO.	DRAWING NO.	REV.
	93FIB1UR-0	0



9412080115-14

READINGS ARE IN PICO-CURIES PER GRAM URANIUM (pCi/g U) AND IN PICO-CURIES PER GRAM THORIUM (pCi/g Th).

CIMARRON GAMMA SPEC. SOIL COUNTER.

URANIUM BACKGROUND OF 6 pCi/g, NOT SUBTRACTED.
THORIUM BACKGROUND OF 1.5 pCi/g, NOT SUBTRACTED.

RANDOM SURFACE SAMPLING OF BACKFILLED AREA TAKEN ON A 10 METER X 10 METER GRID INTERSECT. (AUGUST 1993).

LEGEND
6 URANIUM
7 THORIUM

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
FINAL SOIL SAMPLE RESULTS (1993)
SOIL SAMPLE ALIQUOT: 0-6" DEEP

CLIENT DRAWING NO.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:	JOB NO.	DRAWING NO.	REV.
JE	9/13/94	JA	10/1/94	KM	AS SHOWN		93FIB1SS-0	0

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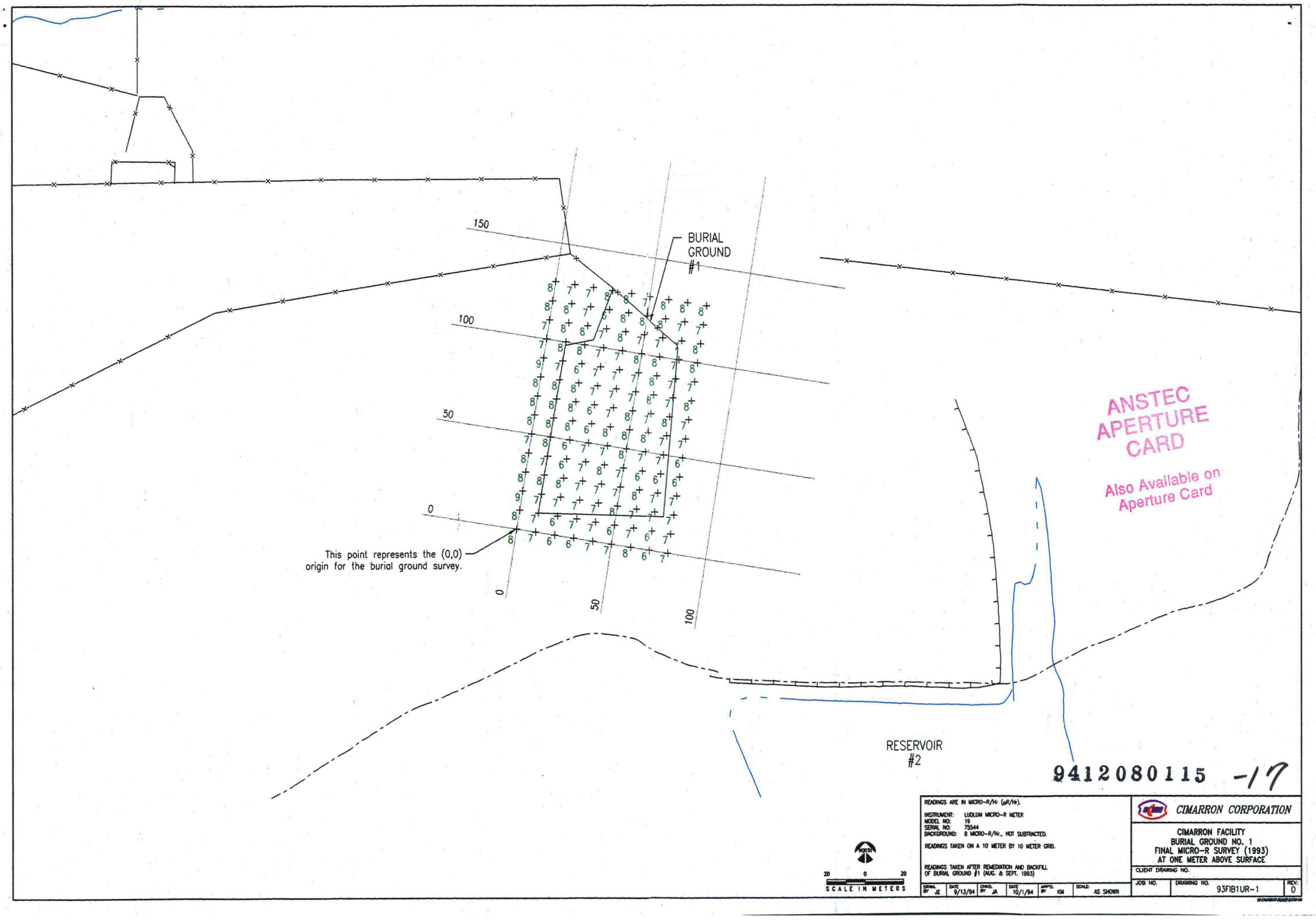


9412080115 -17

READINGS ARE IN MICRO-R/Hr (μR/Hr).

INSTRUMENT: LUDLUM MICRO-R METER
MODEL NO: 19
SERIAL NO: 75544
BACKGROUND: 8 MICRO-R/Hr., NOT SUBTRACTED.

READINGS TAKEN ON A 10 METER BY 10 METER GRID.

READINGS TAKEN AFTER REMEDIATION AND BACKFILL OF BURIAL GROUND #1 (AUG. & SEPT. 1993)

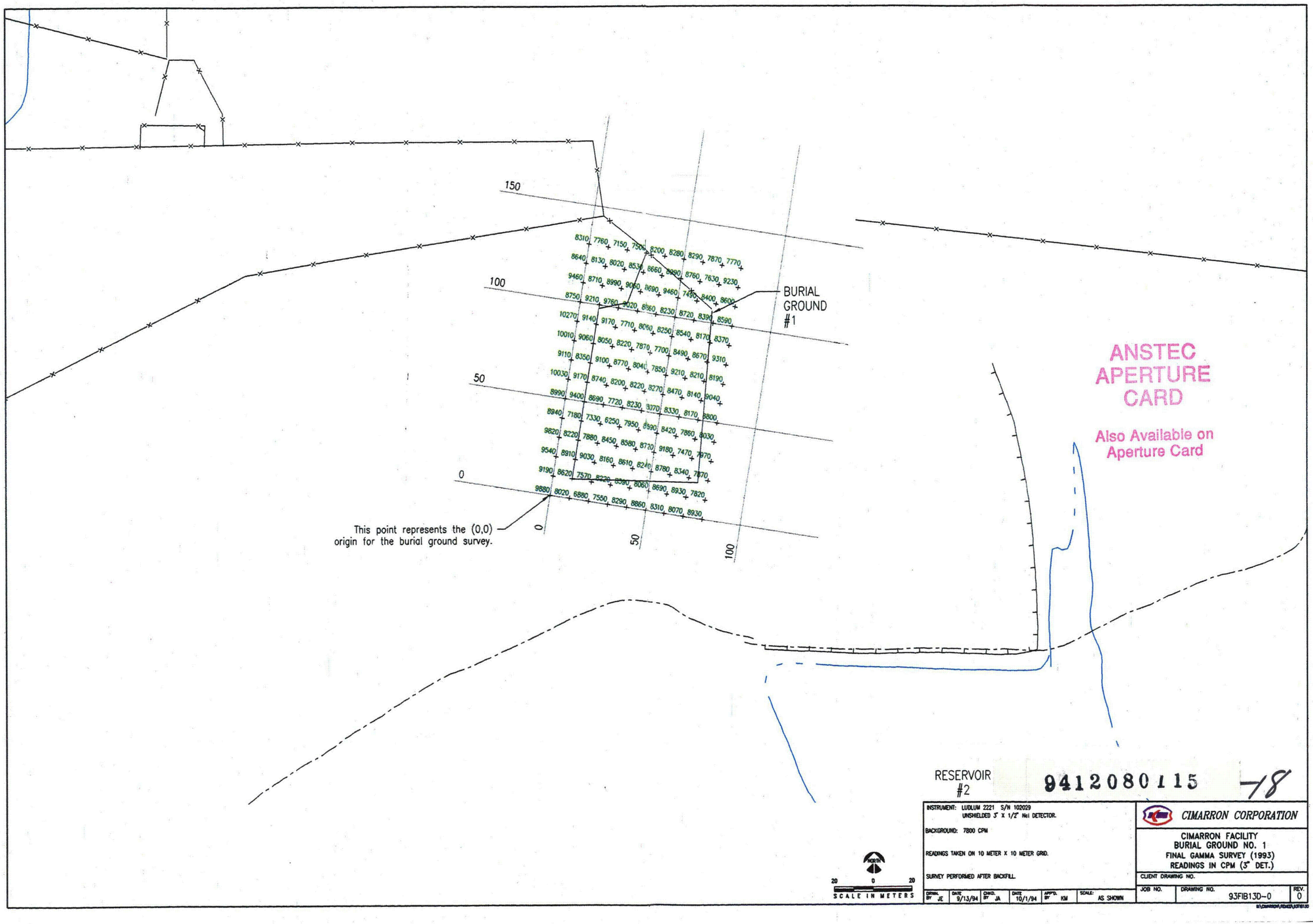
DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:
JE	9/13/94	JA	10/1/94	KM	AS SHOWN

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
FINAL MICRO-R SURVEY (1993)
AT ONE METER ABOVE SURFACE

CLIENT DRAWING NO.

JOB NO.	DRAWING NO.	REV.
	93FIB1UR-1	0



9412080115 -18

INSTRUMENT: LUDLUM 2221 S/N 102029
UNSHIELDED 3" X 1/2" NaI DETECTOR.

BACKGROUND: 7800 CPM

READINGS TAKEN ON 10 METER X 10 METER GRID.

SURVEY PERFORMED AFTER BACKFILL.

DRWN. BY	DATE	CHKD. BY	DATE	APP'D. BY	SCALE:
JE	9/13/94	JA	10/1/94	KM	AS SHOWN

CIMARRON CORPORATION

CIMARRON FACILITY
BURIAL GROUND NO. 1
FINAL GAMMA SURVEY (1993)
READINGS IN CPM (3" DET.)

CLIENT DRAWING NO.

JOB NO.	DRAWING NO.	REV.
	93FIB13D-0	0