PDR 40-2061

KERR-McGEE CHEMICAL CORPORATION

KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

May 1, 1980

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

W. T. Crow, Section Leader
Uranium Fuel Fabrication Section
Fuel Processing & Fabrication Branch
Division of Fuel Cycle & Material Safety
US Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Mr. Crow:

The NRC transmitted to Kerr-McGee on November 13, 1979, a series of comments prepared by NRC and other interested parties on the Plan for Decommissioning and Stabilizing the West Chicago facilities. We have reviewed these comments and have responded to some of them by alterating the text of the Plan.

The alternate pages of the Plan plus additional pages as necessary are attached for your use. They should be inserted into the Plan at the appropriate location. Each change in wording is indicated by a mark located on the right side of the page and each page is dated May 1, 1980.

If additional information is developed, further changes may be made and, if so, will be distributed in the same manner.

Very truly yours,

J. L. Rainey

J. L. Rainey, President

JLR/hmw

THIS DOCUMENT CONTAINS POOR QUALITY PAGES

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Preferred Plan (Section 4.0)

Kerr-McGee proposes to restore the entire property to beneficial use. Following implementation of the Plan, the Factory and Intermediate Sites would be decommissioned and released for unrestricted use. The Disposal Site would be stabilized; although it would remain under NRC license for an indefinite period thereafter, it would be available for beneficial uses other than housing and activities that might penetrate the clay cover or erode the topsoil. Specifically, the Plan involves disposition of the three key parcels of land in the following manner:

Factory Site

All buildings will be demolished and all rubble and radioactive soil removed. Following completion of this work, the Site will be backfilled with clean soil, landscaped and revegetated.

Intermediate Site

During execution of the Plan, the Site will be used for transport of material between the Factory and Disposal Sites. Following completion of this work, it will be graded, landscaped and revegetated.

Disposal Site

The Disposal Site will be stabilized by neutralizing with lime and encapsulating with clay those materials that might conceivably be leachable if exposed to rainwater and covering the balance of the material with clay, fill and topsoil.

Referring to Figure 4.1, Area 1 will be covered by a compacted clay liner with bottom and sides ten feet thick upon which will be placed lime treated sediments from the ponds and radioactive metal from the Factory Site. Then, the neutralized ore residue on the Disposal Site will be spread evenly over Area 2 and the radioactive building rubble from the Factory and Disposal Sites will be spread over Area 3. Finally, Areas 1, 2 and 3 will be covered with two feet of compacted clay and at least three feet of clean fill and topsoil. Following of this work, the Site will be landscaped and revegetated. (See also Figures 4.4 and 4.5.)

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1.0 INTRODUCTION

1.1 PROPOSAL

The Plan includes a description of the decontamination phase (Phase I-A) which will be commenced after approval by NRC, Region III, of a Radiological Health Safety Plan and before approval of the Plan described herein. The decontamination phase is limited to preparatory work required by any of the alternatives. It includes the dismantling of roofs and walls of the two buildings on the Disposal Site, but does not include either the demolition of any buildings on the Factory Site or movement of materials from the Factory Site to the Disposal Site. If Phase I-A is completed before this Plan is approved, Kerr-McGee will propose additional steps under Phase I-A.

After approval of this Plan, Kerr-McGee will undertake the following activities in a coordinated schedule. (See Figure 4.1).

Factory Site. All buildings will be demolished, and all rubble and low specific activity soil will be removed. The Site will be backfilled with clean soil and the entire Site landscaped and revegetated.

Intermediate Site. Kerr-McGee has acquired the two parcels of approximate 8 acres of land (Intermediate Site) between the Factory and Disposal Sites and applied to place this property under NRC license. This Site will be used as necessary for the transport of materials between the Factory and Disposal Sites. The Site will be graded, landscaped and revegetated.

Disposal Site. A drainage system will be constructed around the perimeter of the Disposal Site.

Area 1 of the Disposal Site will be prepared with a ten-foot clay liner on the bottom and sides to hold low specific activity metals and lime treated sediments. The ore residue on the Site will also be neutralized with lime and spreaded evenly over Area 2. The low

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Reed-Keppler Park and Other Locations. The NRC intended to contract for a radiological survey of the low specific activity material in Reed-Keppler Park. The Plan has been designed to accomodate that material in Area 3 of the Disposal Site if a timely request is made by City, State and Federal officials. Kerr-McGee is prepared, without accepting legal liability, to include the Reed-Keppler material if transported to the Disposal Site by others within a time frame consistent with Phase II of the Plan.

The Plan includes removal, at Kerr-McGee's expense, from one location on the east side of Factory Street of material with a significantly higher radioactive level than any of the other 74 locations in West Chicago. (See Section 2.9.2). None of the 75 locations are health or safety hazards.

Monitoring and Fencing. After completion of the Plan, a monitoring program will be implemented for radiation, groundwater and soil stability at the Disposal Site. The three Sites will remain fenced off during implementation of the Plan until termination of monitoring and/or release is made by the NRC.

Ultimate Disposition. After completion of all work on the Plan, which could be completed in the summer of 1983 if the Plan is approved during the spring of 1980, Kerr-McGee will seek release of the Factory and Intermediate Sites from NRC license. These Sites would then be available for unrestricted use.

The Disposal Site will remain under NRC license for an indefinite period and, under current federal law, title to that Site will have to be transferred to the United States or the State of Illinois before the Kerr-McGee license is terminated. Future use of this Site will preclude residential housing and activities that might penetrate the two-foot clay cover or erode the topsoil.

The Factory Site and Intermediate Sites are presently zoned estate residence. Kerr-McGee plans to retain a city planner to advise on alternative uses

2.1.2 WINDS

A wind rose composed from data taken at the O'Hare International Airport is given in Figure 2.1.2.

Meteorological data for 1978 recorded at O'Hare International Airport along with calculations of normal means and extremes are given on Table 2.1.2.

As can be seen from this data, average wind speeds are approximately 10 miles per hour and originate mainly in south and southwesterly directions.

2.1.3 PRECIPITATION

In addition to the data shown in Table 2.1.2 from O'Hare Airport which shows a total precipitation of 37 inches for 1978 and a total snowfall of 75 inches of which 35 inches occurred in the month of December, data recorded at Aurora College is included as Table 2.1.3 indicating a slight difference from Chicago. The Aurora station indicates that a mean of 34.7 inches of precipitation fall, of which the mean snowfall averages 23.2 inches. This average data covers the period of 1951 through 1973 and does not include the higher than average snowfalls in the recent past.

2.1.4 STORMS

West Chicago is in an area subject to severe summer thunderstorms and occasional tornadic activity. The reported tornado frequency, indicating high winds, is given in the paragraph below. In view of the lack of topographic interference, it is expected that these data can be taken as equivalent to West Chicago.

Reported Tornadoes

The National Weather Service Office in Chicago, Illinois records show 18 tornados in Du Page County during the 27 year period from 1950 through 1976 as reported and verified. The National Severe Storms's Laboratory in Norman, Oklahoma has reported that the average damage area resulting from a tornado is a path ¼ mile wide by four miles in length or an area of one square mile.

The average number of tornados per year in Du Page County (18/27) equals .67 tornados per year. Therefore, the average area effected by tornados into Du Page County each year is .67 square miles. Since the area of Du Page County, Illinois is 332 square miles, the probability of a tornado striking on a given square mile within the County is .67/332 or .002 per year. The reciprocal of this number, the recurrance factor, is on the average a tornado strike on any given square mile in Du Page County once each 498 years.

Since the factory disposal site is only 27 acres, the probability of a touchdown within that 27 acres can be determined by the equation 27/640 x 2.01×10^{-3} which equals a probability of 8.48×10^{-5} per year or recurrance factor of once each 12,000 years.

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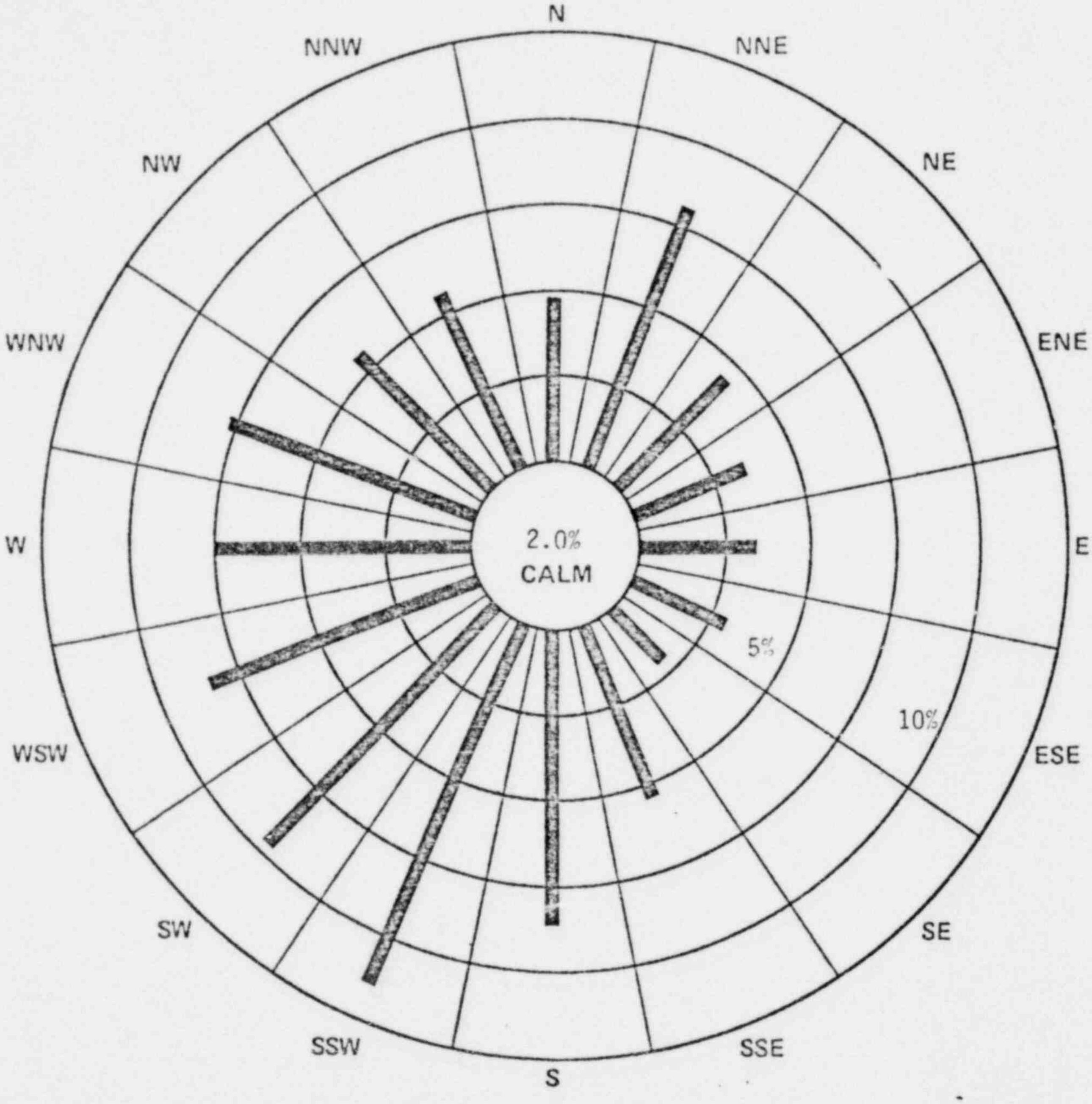

WIND FREQUENCY DISTRIBUTION: Chicago, IL/O'Hare

DATA PERIOD 1/60 - 12/64

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2.2 AIR QUALITY

The EPA (Federal Register, Friday, March 3, 1978, Part II) reports that the neighboring town of Winfield does not meet secondary air standards for Total Suspended Particulates (p. 8986). Du Page County is reported to be better than national standards with respect to SO_2 (p. 8987), but does not meet primary standards with respect to ozone (p. 8988) and is better than national standards with respect to CO (p. 8990), and is better than national standards with respect to NO_x (p. 8992).

2.3 TOPOGRAPHY OF SITE AND SITE AREA

The City of West Chicago, located in a moraine area as described under paragraph 2.7, is in an area with very little topographical relief except on approaches to the Du Page River on the south and east. Total land fall from north and south, a distance of approximately two miles from the center of the city, shows no pronounced topographical relief. The site itself slopes gradually from north to south from an elevation of approximately 760 to 735 feet resulting in a net slope of 1 to 126 feet or less than 1 percent. Topographic map is shown on Figure 2.3.

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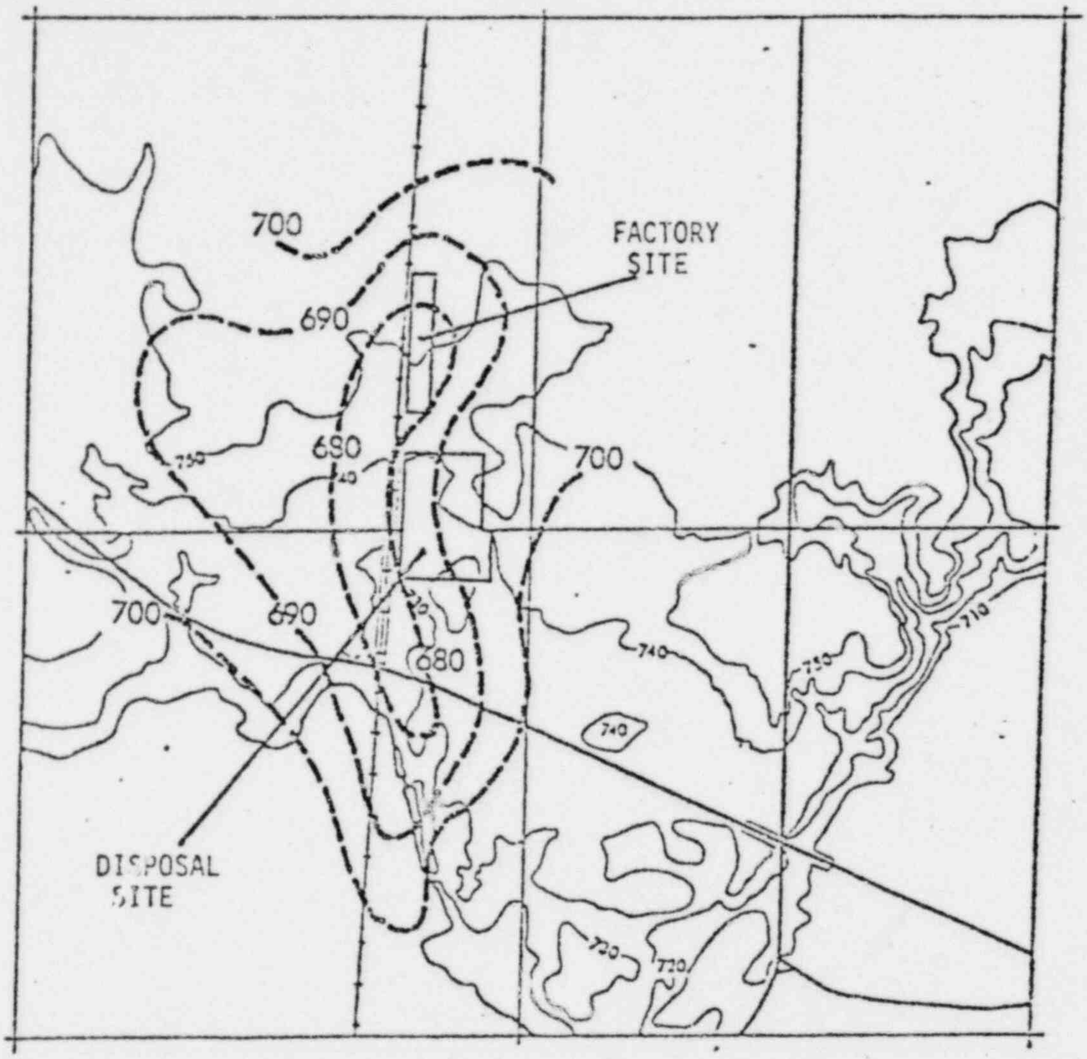

*Fig. 2.6.2 Static Water Level in the West Chicago Area, (After Illinois Environmental Protection Agency, July 1976.)

(Reproduced from ANL report, 1977)

*This figure (reproduced from ANL report, 1977) was derived from the Illinois EPA report (July, 1976) and represents an estimate of the static water level in the dolomite aquifer based on available well data dating from the 1930's to the early 1970's. Due to the inherent uncertainties in this approach, including large time spans between measurements, the ANL staff in co-operation with the Illinois EPA conducted a field program to measure the water levels in the dolomite aquifer in the site vicinity during the fall of 1977.

This recent data indicates a groundwater gradient to the west-northwest beneath the site. Aside from a few local perturbations and possible biases in interpretation, the plots of the two data sets are similar.

2.8 BIOTA

A limited field survey was conducted to characterize the terrestrial and aquatic environment at the nonoperational Kerr-McGee facility located in West Chicago, Illinois. A qualitative site evaluation was performed over three consecutive days to describe the vegetational aspects and to determine the wildlife species present during the winter season.

The project area consists of three adjacent parcels of land: a Factory Site, an Intermediate Site, and a Disposal Site. The 8-acre Factory Site is primarily occupied by buildings and related facilities as well as some manufacturing debris and other waste materials. A small portion of the Factory Site is covered with grass and weeds. The Intermediate Site, also about 8 acres in size, was used for manufacturing until the late 1960's. The Site still contains some manufacturing debris, several building foundations, and an access road. Most of the intermediate site is covered with grass, weeds, brush, and some trees. The Disposal Site, approximately 27 acres in size, contains the ore residue piles, some chemical storage facilities, waste ponds, and a large amount of manufacturing debris. Much of the Site is covered with grass, weeds, and brush. Few trees are present.

2.8.1 TERRESTRIAL

Terrestrail Flora

The Kerr-McGee West Chicago Facility, located in Du Page County, Illinois, lies just southwest of the Lake Michigan drainage basin. In pre-settlement days, the region supported four major vegetation types (Stearns and Kobriger 1975; Shelford 1963), including:

- Oak Savanna
- Southern Xeric (Oak or Oak Hickory) Forest
- Southern Mesic (Maple-Beech) Forest
- Grassland.

Presently, the area is heavily populated, industrialized, and for the most part, urban in makeup. The Kerr-McGee Facility is bounded to the north and east by residential development, to the south by commercial facilities and to the west by the Elgin Joliet and Eastern Railroad tracks, beyond which lies an open field. The existing vegetation at the project site is in an early state of succession due to disturbances created by human manipulation. The vegetation at the Kerr-McGee Facility represents a m' ture of elements from pre-settlement vegetation types and disturbanc. related species (e.g., vigorous, aggressive, pioneering species introduced from Europe primarily through agricultural practices). Vegetational cover on the project site varies greatly with the amount of disturbance due to human activities and includes:

- o denuded bare soil areas
- o mowed grassy fields
- o overgrown fencerows
- o areas of thick grass with brush
- o marshy areas along the waste ponds.

Few trees are present on the project site. Two clumps of maple (Acre sp.) predominate on the intermediate site, while the disposal site contains scattered willows (Salix sp.) and cottonwoods (Populus deltoides) and a small stand of pine (Pinus sp.). Shrubs were observed around the edges of ponds and depressions. Common forbs on the site area include thistle (Cirsium sp.), asters (Aster sp.), goldenrod (Solidago sp.), cocklebur (Xanthium sp.), Queen Anne's lace (Daucus carota), rosinweed (Silphum sp.), and compass plant (Silphum lactinatum). Grasses of the area include foxtail (Alopecurus sp.), bluegrass (Poa sp.), ryegrass (Lolium sp.), love grass (Eragrostis sp.), and needlegrass (Stipa sp.), among others.

Terrestrial Fauna

A variety of avian species occur or are expected to occur within and adjacent to the project site. The most common species observed during the field survey period was the dark-eyed junco (Junco hyemalis). This bird is classed as a common transient species in the northern counties of Illinois. Its preferred habitat consists of fields and borders and it feeds primarily on insects and seeds (Wallace 1977). Other avian species observed on the project site included mourning dove (Zenaida macroura), rock dove (domestic pigeon) (Columba livia), and the common crow (Corvus brachyrhynchos). The ring-necked pheasant (Phasianus colchicus), important because of its recreational value as a gamebird, also occurs on the project site. Additional bird species are expected to occur either as residents or as seasonal visitors within or adjacent to the project site. These would include such typical field and fencerow inhabitants as the bobolink (Dolichonyx orizivorus), eastern meadowlark (Sturnella magna), horned lark (Eremophila alpestris), American robin (Turdus megratorius), northern shrike (Lanius excubitor), starling (Sturnus vilo--is), savannah sparrow (Passerculus sandwichensis), and lark sparrow (Chondestes grammacus), among others (Robbins et al. 1966; Wallace 1977). Waterfowl, especially puddle ducks such as the mallard (Anas platyrhynchos), are likely, on occasion, to use the waste ponds for resting areas.

Several species of small and medium-sized mammals occur or are expected to occur on the project site. Small mammal live trapping was conducted for two consecutive nights during the December field survey. The total trapping effort consisted of 170 trap nights. Two species were captured: the white-footed mouse (Peromyscus leucopus) and the short-tailed shrew (Blarina brevicauda). The white-footed mouse is abundant throughout Illinois, occurring in forests, brushlands, river bottoms, forest edges, and in brush areas extending out into prairies (Hoffmeister and Mohr 1972). It is rarely found in fields away from brushy cover, although it may invade corn fields in the fall (Doutt et al. 1973). Its food consists of both animal and plant matter. The white-footed mouse is active year-round. The other species captured, the short-tailed shrew, is found principally in forests, forest edges, meadows near woods or swampy, brushy habitats. Its food consists primarily of invertebrates such as earthworms, snails, and insects, but it has also been known to consume voles and mice, as well as its own species (Hoffmeister and Mohr 1972; Doutt et al. 1973). Although only two species of small mammals were trapped, several additional species are expected to occur on the project site including the deer mouse (Peromyycus maniculatus), long-tailed weasel (Mustela frenata), prairie vole (Microtus orchrogaster), and house mouse (Mus musculus) (Burt and Grossenheider 1964; Hoffmeister and Mohr 1972; Long 1974).

The eastern cottontail (Sylvilagus floridans) was the common medium-sized mammal observed on the project site. The cottontail is a very popular game animal in Illinois and more hunters pursue them than any other game species in the state. The eastern cottontail prefers brushy or weedy fields, thickets along fencerows and margins of wood lots, forest edges, and dry bottomlands. It feeds predominately on grasses and broad-leaved weeds and within Illinois, reaches its highests population levels in the western half and southern third of the state (Lord 1963; Hoffmeister and Mohr 1972). Raccoon (Procyon lotor) are known to inhabit the project site and numerous tracks were observed during the field survey. Approximately 170 burrows of medium-sized mammals are located on the Kerr-McGee property. Although a burrow survey cannot be used directly to determine the number of individuals present, it can serve as an aid in determining species present. The majority of the burrows were probably constructed by woodchuck (Marmota monax) although many were small enough to have been dug by thirteen-lined ground squirrels (Citellus tridecemlineatus). Several enlarged burrows may represent the activities of red fox (Vulpes fulva) which have been observed on the site by local workers. Additional medium-sized mammals which may occur in the project area include the striped skunk (Mephitis mephitis), muskrat (Ondatra zibethicus), and Norway rat (Rattus norvegicus).

The project site lies within the grand Prairie Herpetofaunal Division of Illinois. Of the most abundant species of amphibians and reptiles found in the area, those likely to occur in the vicinity of the project site would include the American toad (Bufo americanus americanus), plains garter snake (Thamnophis radix), and the western fox snake (Elaphe vulpina) (Smith 1961).

Endangered and Threatened Species

Based upon known distributions, no endangered or threatened species are expected to occur on the project site.

2.8.2 AQUATIC BIOTA

Existing aquatic habitat on the Kerr-McGee property consists of four waste ponds and a pit which, in aggregate, comprise about 2.5 surface acres. These ponds were constructed to store liquid wastes generated by the chemical separation and purification processes used by the West Chicago facility. Aqueous waste was directed to the ponds and when insoluble sediments built up, they were dredged.

During the field survey, only two ponds contained enough water to totally cover the bottom of the ponds. The remaining ponds and pit were partially dry and grasses and marshy vegetation such as cattails (Typha sp.) and bulruch (Scirpus sp.) were well established. Additonal aquatic vegetation included duckweed (Lemna minor) and an unidentified filamentous green algae. Ice cover prevented the collection of samples from the ponds, however, it is likely that, given the chemical nature of the waters and sediments, the aquatic fauna would likely be limited to pollution tolerant forms such as midges (Chironomidae) and aquatic worms (Oligochaeta).

Kress Creek is located in west central Du Page County and drains approximately 18½ square miles of gently rolling water shed which is devoted primarily to agriculture except for the residential and industrial areas found in the western portion of West Chicago. The creek receives runoff from a portion of the Fermi National Accelerator Laboratory, storm water runoff from West Chicago, and effluent from an industrial park sewage disposal plant. The upper four miles of the Creek flow southerly as a drainage rapidly to empty into the west branch of the Du Page River two miles south of West Chicago. The Forest Preserve District owns the last tenth mile prior to its confluence with the west branch of the Du Page River.

A June, 1969 report, "Du Page County Surface Resources", describes several fish kills. The absence of a desirable fish population renders Kress Creek virtually unfished.

The Northeastern Illinois Planning Commission performed a "Biological Survey of the Du Page River; Staff Paper #13, January, 1977" and reported that Kress Creek in its upper reaches is semi-polluted, that it becomes unbalanced west and southwest of West Chicago, and downstream it becomes semi-polluted again.

The Illinois Environmental Protection Agency performed a Biological Survey in 1973 of the entire length of Kress Creek. This survey sampled the Creek at 13 stations starting at its origins at Du Page County Airport and continuing through its passage as an open ditch where it receives several industrial discharges northwest of West Chicago. The sampling consisted of handpicking organisms, classifying them as to species, counting and determining the organisms' tolerance for polluted water. Immediately upstream of the Kerr-McGee Facility discharge point, 38 organisms were collected and as a result, the Creek classified as a non-balanced stream. Three organisms were collected at the Kerr-McGee Facility discharge point, and the results caused the Creek to be classified as polluted. Seventy-four organisms were collected 200 yards downstream resulting in classification of semi-polluted. Three-quarters of a mile downstream, 112 organisms were collected and the Creek was still classified as semi-polluted. The quality was restored 1¼ miles downstream where 93 organisms were collected of a more balanced diversity.

The Fermi National Accelerator Laboratory supplied two water quality analyses taken in October 1978 and April 1979 of Kress Creek, presumably from points where it crosses the Laboratory area. The analysis shows the following as an average of the two samples:

pH	7.8
Dissolved oxygen	10 mg/ℓ
COD	3.1 mg/ℓ
Suspended solids	3.5 mg/ℓ
Fecal coliform	40 colonies/100 mℓ

Data on the west branch of the Du Page River is located in Staff Paper 31 of the Northeastern Planning Commission. This paper, dated August, 1978, summarizes water quality by saying that the "West branch of the Du Page River receives toxic ammonia nitrogen concentration at its extreme headwater. Water quality improves when Kress Creek joins with the west branch. Kress Creek also receives an initial toxic ammonia nitrogen concentration but rapidly recovers."

50,000 pounds of dissolved solids. The main source of the process water was obtained from wells located on the Factory Site. The liquid waste was piped to the Disposal Site and was discharged to ponds. The ponds acted as infiltration ponds which percolated to the perched groundwater. In order to make the percolation effective, it was necessary to acidify the waste by adding sulfuric acid to the process discharge stream. Insoluble sediments were carried by the liquid waste to the ponds and were deposited on the bottom.

Solid residues from the rare earth ore processing operations were piled in the Disposal Site. Fluorspar gangue (gypsum) produced during the 1940's was fill material for various West Chicago locations.

3.2.1.4 TAILINGS WASTE KRESS CREEK

The report prepared by Argonne National Laboratory entitled "Thorium Residuals in West Chicago, Illinois" describes the work done by that organization to define thorium contamination found along this creek. The material is described as a dense and granular with the material characteristics of the tailings pile. Identification of the material required microscopic and radio autographic examination. The report states that, "The material along Kress Creek ... was almost a classic example of placer deposition," and observes that "over some 47 years the great bulk of the material ... has moved less than one mile downstream."

There are two modes of potential radiological exposure from this material: the first is internal exposure to individuals who might consume water contaminated with soluble radionuclides; the second, direct external gamma exposure to individuals in contaminated areas. With respect to the first mode, contaminated water consumption, the Argonne National Laboratory report cited above states:

> "The material is so dense, and so insoluble, that it was transported purely as grains of sandlike material, and these grains were found and identified down along the watershed."

> "Deposits proved to be almost exclusively the dense, gray, insoluble particles of thorium-ore tailings from the process,..."
>
> "No excess soluble thorium was ever detected in the waters of either the creek or the river. ... Considering the high density and extremely insoluble nature of the material, this was precisely what might have been expected."

On this basis, the thorium residuals in Kress Creek would not appear to produce any measurable or significant soluble concentrations and, hence, no measurable or significant internal exposures from consumption of that water.

The basis for assessing the direct external gamma exposure potential is also presented in the ANL report in which the results of radiometric analyses one meter above the ground are graphically presented. Measured values of dose rate range from background to a maximum of 150 μrem/hour. Thus, a person would need to occupy the space immediately above the area of the maximum dose rate for a period of 167 hours in a year to receive the 25 mrem dose limit specified by the EPA in 40 CFR 190.

Along the approximately 6,000 feet of Kress Creek to its junction with the West Branch of the DuPage River, it passes through old farm fields, forest preserves and heavily wooded areas, as well as behind backyards of 10 private homes occupying 1200 feet of bank length. In these areas, the only recreational usage which might provide significant occupancy factors is at the private homes in near proximity to the deposited materials. At a 60 μrem/hour dose rate, the occupancy time would have to rise to more than 416 hours per year to reach the 25 mrem EPA limit.

On this basis, external gamma radiation exposures from the deposited materials would not be expected to exceed a few mrem/year to any individual. Nevertheless, decontamination procedures were evaluated which would involve the excavation and removal of deposited material. The mechanics of decontamination would require a significant alteration of the creek and its banks by heavy grading and excavating equipment (assuming owners' approval and consent for access to privately owned property). Areas with heavy brush and trees would need to be cleared with revegetation requiring an extensive time. Working in this matter would result in substantial contamination of the creek water by erosion of natural soils. It is expected that such eroded material would contribute measurable contamination in the form of naturally occurring uranium and radium in the soil. Re-establishment of the original grades with fresh soil material would result in continued erosion in the flow of water through the creek bed especially during periods of heavy runoff until revegetation occurred. Alteration may lead to serious scouring of the creek bed and with it generally deeper cutting than is currently evident.

As a result of this review, it is Kerr-McGee's opinion that evidence of thorium-containing sands in Kress Creek do not constitute a creditable public hazard. Therefore, no plans to reclaim Kress Creek have been included.

3.2.2 EXISTING MANUFACTURING WASTES

Aqueous waste was directed to Ponds No. 1 or No. 2 and overfill protection was provided by diverting the wastes to Pond No. 3. Clarified waste overflowed to Ponds No. 4 and No. 5. When insoluble sediments built up within Ponds 1, 2, and 3, they would be dredged and the contents stored directly west of Building No. 18.

The volume of process waste contained in the Disposal Site is summarized in Table 3.2.2(a).

Table 3.2.2(a) Process Waste in Disposal Site

Waste Location	Volume in Cubic Feet
Ore Residue Pile	636,000
Sediment Pile West of Bldg. 18	86,000
Pond No. 1	306,000*
Pond No. 2	66,000
Pond No. 3	177,000

*This does not include the 80,000 cubic feet of fill covering this pond.

Samples of the process waste were analyzed and the quantity of thorium and uranium, source material, is expressed as oxides as ThO_2 and U_3O_8. This is shown in Table 3.2.2(b).

*Table 3.2.2(b) Source Material Contained in Process Waste

Location	Estimated Quantity of Source Material in Pounds	
	ThO_2	U_3O_8
Ore Residue Pile	464,300	6,100
Sediment Pile West of Bldg. 18	1,035,300	13,000
Pond No. 1	938,000	14,300
Pond No. 2	202,300	3,100
Pond No. 3	542,500	8,300

Since 1973, about 110,000 cubic feet of contaminated process equipment has been removed from the Factory Site and stored on the Disposal Site. About 7,000 cubic feet consists of filled or partially filled steel and fiberboard drums and steel tote boxes whose contents vary from partially filled to empty, another 5,000 cubic feet of low level contaminated wood in the form of pallets; and about 98,000 cubic feet consisting mainly of various sized rubber lined process tanks which are now empty.

There are about 11,000 cubic feet of rare earth chemical compounds which do not contain accountable thorium and which are presently stored in Building No. 19. There is a possibility that these compounds may be sold to the chemical industry, but if the sales cannot be made, these compounds will be included in the disposal operations within the Disposal Site.

*Estimates are based on the analytical data found in Tables 3.2.3f and g. In each case, the volume from Table 3.2.2(a) was used in estimating the quantity of source material.

IEPA Leach Tests

In 1978, the Illinois EPA requested that a set of samples of the solid waste stored on the Disposal Site be subjected to leach tests using IEPA procedures. As a result, 26 samples were taken on waste piles at the location and depths noted in Table 3.2.3c.

A portion of each sample was leached in accordance with the IEPA method (Appendix A). This method requires the digestion of the solid in concentrated nitric acid and subsequently concentrated hydrochloric acid for a period of 30 minutes. This extremely severe test would be expected to dissolve all potentially soluble material. In fact, it is estimated that approximately 75% of all sample material was dissolved; the undissolved material was mainly silicates and silica. The results are reported in Table 3.2.3c.

A second portion of each sample was subjected to the requirements of another IEPA method (Appendix B). This method requires leaching at a pH of 4.9 to 5.2. maintained by dilute hydrochloric acid or sodium hydroxide. As the results in Table 3.2.3d indicate, these leaching conditions produce a leachate acceptable to the U.S. EPA under proposed regulations published December 18, 1978, Part 4, which implement the Resource Conservation and Recovery Act. These regulations provide that materials will not be considered hazardous if leachable constituents produce a leachate that does not exceed 10 times the drinking water standards. None of the metal constituents shown exceed 10 times the respective standard for drinking water.

U.S. EPA-RCRA Leach Tests

Kerr-McGee performed additional laboratory tests on the 26 sludge and residue samples using the leaching method described by U.S. EPA under RCRA.

The specific contaminants which are listed under the extraction procedure of RCRA and the acceptable extract concentration levels, as published in the Federal Register that are based on 10 times drinking water standards are as follows:

Contaminant	Extract Level, mg/ℓ
Arsenic	0.5
Barium	10.
Cadmium	0.1
Chromium	0.5
Lead	0.5
Mercury	0.02
Selenium	0.1
Silver	0.5

Results of the EPA-RCRA tests are found in Tables 3.2.3f and 3.2.3g. The overall average concentration for each contaminant showed that the average concentration of lead was the only contaminant exceeding 10 times the drinking water standard.

In other tests, leachate produced from a composite of samples from each pile (#28, 29) was chemically neutralized to a pH of 8. Analysis of this leachate for heavy metals showed concentrations well below the RCRA extraction level.

Also a composite of (#30) 36 sump residue samples (Table 3.2.3j) collected from pond #1 was treated by the U.S. EPA-RCRA method, with results of the soluble constituents showing acceptable levels for heavy metal contaminants. This composite sample was not neutralized, since results met RCRA standards.

In performing these additional tests and subsequently compositing the material for neutralization, the procedure was examined and a specific choice made in regard to the composites. The RCRA testing procedure specifies that it apply to as received material. As a consequence, each individual sample was selected from a significant amount of sample in 10 gram quantites and individually tested for leaching with a similar 10 gram quantity dried for solid analysis. In order to composite samples for our neutralization tests, another sample was taken from each container and blended wet prior to separating an aliquot for dry analysis and the balance for leaching with subsequent pH adjustment. As a result of these methods and the non-homogeniety of the individual samples, certain anomalies have resulted, i.e., the average uranium content versus the composite uranium. The data have been used in calculations with the most conservative value selected.

U.S. EPA-RCRA Leach Tests - Isotopic Data

Leachate and solids from each of the 26 samples subjected to the RCRA test were isotopically analyzed for uranium, thorium and radium isotopes. These results are also given in Tables 3.2.3f and 3.2.3g. Consistent with heavy metal data, as previously discussed, isotopic levels found (samples #28, 29 and 30) in the neutralized-leachate composite were much lower than isotopic levels found in the leachate of the non-neutralized samples.

The neutralization procedure consisted of mixing two milligrams of calcium hydroxide to ~1 gram of residue-sludge solids. By extrapolation a ratio of 20 pounds of calcium oxide to a ton of solids is equivalent to the mixture used in the laboratory test.

These tests indicate that the leaching of heavy metals and/or radiological constituents from sludge and residue piles is reduced below acceptable RCRA extraction levels when the systems are chemically neutralized. Consequently, the Stabilization Plan has been changed to reflect this additional step of neutralization.

Additional Tests

Samples 4 and 8 used in the IEPA leach test and samples of the soils and clay which are tentatively planned to be used for the final cover material were subjected to isotopic analysis for uranium and thorium. The results are given on Table 3.2.3e.

The radioactivity of the soils and clay is typical of that found in many places in the United States. There is nothing remarkedly different between the samples except that the clay contains slightly more natural uranium than the other material.

Additional tests were performed on the sludge and residue piles to further document the average activity concentrations. Dry and wet screen fractions of the composite samples were isotopically analyzed. Results of the isotopic concentrations are shown in Table 3.2.3h and 3.2.3i.

TABLE 3.2.3f
SLUDGE SAMPLES
PILE 1

Sample Location	Sample Number	Analysis of Solids: ThO_2 (percent)	U_3O_8 (ppm)	Ra_{226} (pCi/g)	Ra_{224} (pCi/g)	Analysis of Leachate from RCRA Test: Initial pH	Radioisotopes: Th_{232} (pCi/ℓ)	Th_{230} (pCi/ℓ)	Th_{228} (pCi/ℓ)	U (µg/ℓ)	*Ra_{226} (pCi/ℓ)	Ra_{224} (pCi/ℓ)
18" Depth												
NNE	#4	6.7	400	202	5444	7.0	1.2	11.	797	31	13.3	.92
W	#26	3.2	1700	204	6211	3.2	829	108	2750	67	23	N.D.
SE	#23	10.1	970	440	6494	6.5	1.5	8.7	3.4	24	1	1.8
S	#18	1.9	290	110	3878	6.8	1.8	6.8	3.2	54	.5	.36
36" Depth												
NNE	#13	8.6	910	380	6070	3.8	4.8	6.9	21	12	7.5	87.3
W	#25	8.4	1600	281	5756	2.7	3680	568	28,360	154	11	N.D
SE	#16	7.8	1200	399	5191	3.6	64	9.0	219	18	4.9	43.1
S	#24	5.1	370	101	3159	6.2	3.2	6.5	7.1	31	.9	2.7
At Depth												
NNE - 6'	#21	7.9	410	246	5366	3.1	530	104	3390	76	6.4	65.3
W - 7'	#14	8.8	1600	322	6080	7.0	0.9	8.7	5.3	32	9.6	247
SE - 7.5'	#22	8.9	940	456	6299	3.8	106	14	391	36	6.8	38.3
S - 6'	#17	7.3	350	186	5302	6.4	1.0	6.0	3.2	22	7.3	.48
Overall Average		7.1	895	277	5438		435	71	2996	46	7.3	40.60
Neutralized Composite	#28	7.3	390			8.0	.091	.060	.65	.014	1.0	1.74

* Radon by Emanation
N.D. Not Detected

TABLE 3.2.3f
SLUDGE SAMPLES
PILE 1

Analysis of Leachate From RCRA Test

Sample Location	Sample Number	pH	Heavy Metals - mg/ℓ											
			Ag	As	Ba	Cd	Cu	Cr	Fe	Hg	Ni	Pb	Se	Zn
18" Depth														
NNE	#4	7.0	<.001	<.001	.083	.010	<.001	<.001	.002	<.001	.024	< .001	<.001	.086
W	#26	3.2	.14	.004	.048	.032	.180	.012	7.0	<.001	1.0	4.2	.017	.110
SE	#23	6.5	<.001	.003	.088	.018	.018	<.001	.006	<.001	.051	< .001	.009	.280
S	#18	6.8	<.001	<.001	.027	.004	.054	<.001	<.001	<.001	.014	< .001	.006	1.5
36" Depth														
NNE	#13	3.8	<.001	<.001	.061	.015	.031	<.001	.006	<.001	.004	.25	<.001	.053
W	#25	2.7	.012	.008	0.100	.062	.730	.071	150	<.001	3.4	1.5	.015	.210
SE,	#16	3.6	.099	.004	.120	.040	.190	.002	.130	<.001	.014	.5	.003	.067
S	#24	6.2	<.001	.002	.014	.008	.006	<.001	<.001	<.001	.022	<.001	.004	.180
At Depth														
NNE -6'	#21	3.1	.160	.006	.065	.018	.210	.012	15	<.001	1.2	4.0	.016	.096
W -7'	#14	7.0	<.001	<.001	.130	.004	.003	<.001	<.001	<.001	.025	<.001	.002	.086
SE -7.5'	#22	3.8	<.001	.004	.095	.035	.079	<.001	.190	<.001	.015	1.1	.010	.120
S -6'	#17	6.4	<.001	<.001	.021	.004	.014	<.001	.022	<.001	.023	<.001	.005	.120
Overall Average			.035	.003	.071	.021	.126	.009	14.4	<.001	.483	0.96	.007	.242
Neutralized Composite	#28	8.0	<.001	.002	.016	.001	.016	.006	.006	<.001	.002	.002	.006	.025

TABLE 3.2.3f
SLUDGE SAMPLES
PILE 1

Sample Location	Sample Number	Analysis of Leachate from RCRA Test								
			Other Ions - mg/ℓ							
		Initial pH	Ca^{++}	K^{+}	Mg^{++}	Na^{+}	$SO_4^{=}$	Cl^{-}	F^{-}	NO_3^{-}
18" Depth										
NNE	#4	7.0	35	3.8	52	65	50	< 2	21.0	0.3
W	#26	3.2	440	20	5.2	130	2880	2	4.06	<0.1
SE	#23	6.5	110	4.5	130	200	310	31	17.0	0.3
S	#18	6.8	5.2	1.3	14	230	200	< 2	38.8	0.2
36" Depth										
NNE	#13	3.8	410	7.8	2.7	54	1780	< 2	0.68	0.1
W	#25	2.7	430	6.2	19	110	3900	< 2	15.5	0.1
SE	#16	3.6	430	23	0.4	140	2540	3	0.94	< .1
S	#24	6.2	36	4.5	59	140	340	12	19.7	0.3
At Depth										
NNE -6'	#21	3.1	450	23	2.2	160	3060	< 2	4.37	< .1
W -7'	#14	7.0	51	2.7	60	130	110	< 2	16.2	0.3
SE -7.5'	#22	3.8	430	23	0.2	120	2520	< 2	0.94	< .1
S -6'	#17	6.4	33	5.0	52	200	450	13	20.0	0.8
Overall Average			235	10.4	33.0	140	1512	6.2	13.3	0.23
Neutralized Composite	#28	8.0	24	4.2	15	160	305	6.5	49.[1]	0.6

[1]Footnotes page 3.42.

TABLE 3.2.3g
TAILINGS SAMPLES
PILE 2

Sample Location	Sample Number	Analysis of Solids: ThO_2 (percent)	U_3O_8 (ppm)	Ra_{226} (pCi/g)	Ra_{224} (pCi/g)	Analysis of Leachate from RCRA Test: Initial pH	Radioisotopes: Th_{232} (pCi/ℓ)	Th_{230} (pCi/ℓ)	Th_{228} (pCi/ℓ)	U (μg/ℓ)	Ra_{226} (pCi/ℓ)	Ra_{224} (pCi/ℓ)
Surface (4") Samples												
N	#6	0.51	78	825	2952	4.2	22	9.2	170	26	2.9	0
S - Edge 20'	#3	0.62	47	837	1756	3.7	291	27	1330	15	27.7	1066
NE[1]	#5	0.48	28	894	2268	5.5	0.3	7.1	3.4	19	1.0	327
E[1]	#9	0.76	93	897	3087	4.0	239	19	357	20	6.5	346
E - Flat[1]	#7	0.91	270	4562	8353	5.5	3.4	7.7	21	18	0.9	1.4
S	#12	0.49	17	652	2341	3.6	21	8.6	184	17	9.4	153
SW	#11	0.48	19	689	1797	3.8	242	25	1020	27	17.4	428
Depth Samples												
N - 3'	#8	0.51	81	857	2734	6.8	2.2	5.9	5.6	34	0.6	1.3
S - Edge 20'; 3'	#2	0.52	28	608	1189	3.8	20	9.2	303	10	6.0	305
NE[1] - 3'	#10	0.49	62	838	1609	7.0	1.5	23	8.7	75	0.8	1.4
E[1] - 4'	#15	0.48	100	835	2703	7.4	2.4	6.6	29	36	10.8	629
E - Flat[1]; 3'	#20	0.77	160	2376	4533	5.7	0.2	3.8	3.9	33	1.2	6
S - 3'	#1	0.35	20	743	2174	3.5	117	11	446	13	6.7	302
SW - 3'	#19	0.53	32	747	1589	3.6	34	11	98	36	2.2	35
Overall Average		0.56	74	1172	2792		71	12	284	27	6.7	263
Neutralized Composite	#29	0.44	8				.045	.060	1.37	.018	37.8[2]	15.5

Notes: [1]These samples take in area where coal ash was spread to make road.
[2]Footnotes page 3.42.

TABLE 3.2.3g
TAILINGS SAMPLES
PILE 2

Analysis of Leachate From RCRA Test

Sample Location	Sample Number	pH	Heavy Metals - mg/ℓ											
			Ag	As	Ba	Cd	Cu	Cr	Fe	Hg	Ni	Pb	Se	Zn
Surface Samples														
N	#6	4.2	<.001	.003	.054	.018	.031	<.001	.076	<.001	.011	<.001	.002	.067
S - Edge 20'	#3	3.7	.062	.008	.130	.080	.160	.019	2.0	<.001	.017	1.2	.005	.082
NE	#5	5.5	<.001	.002	.018	.008	<.001	<.001	.002	<.001	.019	.71	<.001	.150
E	#9	4.0	<.001	<.001	.130	.065	.230	.027	.180	<.001	.024	1.7	.010	.120
E - Flat	#7	5.5	<.001	.002	.036	.008	<.001	<.001	<.001	<.001	.014	<.001	.002	.160
S	#12	3.6	.002	.005	.072	.012	.048	.003	1.3	<.001	.024	3.8	.008	.082
SW	#11	3.8	.009	.006	.120	.035	.180	.006	2.1	<.001	.019	1.4	.012	.110
Depth Samples														
N - 3'	#8	6.8	<.001	.003	.029	.022	.026	<.001	<.001	<.001	.041	<.001	.008	3.1
S - Edge 20';3'	#2	3.8	<.001	.003	.057	.058	.022	.027	.110	<.001	.070	1.3	.006	.086
NE - 3'	#10	7.0	<.001	.003	.027	.008	.23	<.001	.006	<.001	.015	<.001	.010	19.0
E - 4'	#15	7.4	<.001	.002	.096	.008	.004	<.001	<.001	<.001	.017	<.001	.002	.130
E - Flat; 3'	#20	5.7	<.001	<.001	.047	.004	.004	<.001	.007	<.001	.014	<.001	.002	.190
S - 3'	#1	3.5	.064	.006	.100	.320	.066	.015	.970	<.001	.039	3.6	.017	.170
SW - 3'	#19	3.6	<.001	.005	.140	.100	.084	.003	.072	<.001	.014	0.63	.012	.120
Overal Average			.011	.004	.075	.053	.078	.008	.488	<.001	.024	1.02	.007	1.7
Neutralized Composite	#29		<.001	.006	.100	<.001	.002	.002	.003	<.001	.007	.004	.013	.005

TABLE 3.2.3g
TAILINGS SAMPLES
PILE 2

Analysis of Leachate from RCRA Test

Sample Location	Sample Number	Initial pH	Other Ions, mg/ℓ							
			Ca^{++}	K^{+}	Mg^{++}	Na^{+}	$SO_4^{=}$	Cl^{-}	F^{-}	NO_3^{-}
Surface Samples										
N	#6	4.2	530	5.0	0.9	17	1470	< 2	1.84	<0.1
S - Edge 20'	#3	3.7	400	25	0.2	160	2740	< 2	1.05	0.1
NE	#5	5.5	29	4.4	29	84	280	< 2	16.4	0.2
E	#9	4.0	480	31	1.0	190	3200	< 2	2.49	<0.1
E - Flat	#7	5.5	29	2.5	16	39	160	10	19.5	0.1
S	#12	3.6	500	12	1.0	100	2340	< 2	0.99	<0.1
SW	#11	3.8	480	33	1.0	170	3150	< 2	2.97	<0.1
Depth Samples										
N - 3'	#8	6.8	50	3.8	61	280	280	< 2	17.5	0.2
S - Edge 20'; 3'	#2	3.8	480	2.7	0.2	23	1550	3	0.83	0.2
NE - 3'	#10	7.0	22	1.7	33	310	210	< 2	22.2	0.2
E - 4'	#15	7.4	100	3.7	95	160	110	2	13.4	0.3
E - Flat; 3'	#20	5.7	35	5.0	25	37	90	< 2	19.6	0.2
S - 3'	#1	3.5	500	14	1.0	180	2780	< 2	1.2	0.3
SW - 3'	#19	3.6	440	29	0.9	160	2700	< 2	1.13	<0.1
Overall Average			291	12.3	18.9	136	1504	< 2	8.7	0.2
Neutralized Composite	#29	8.0	100	31.0	1.5	210	1400	< 1	.12	<0.1

TABLE 3.2.3h

WEST CHICAGO

COMPOSITE OF 26 PILE SAMPLES

ISOTOPIC EVALUATION BY SCREEN SIZE

Sample Screen Size	Percent By Weight	Pb-210	Pb-214	Ra-223	Ra-226	Ra-228	Th-230	Th-234	U-235
+325 Mesh pCi/g	25.3	<227	319	512	452	2813	<717	<109	72.4
-325 + 400 Mesh pCi/g	80.6 -28.2	<218	326	473	479	2581	<700	<106	<16.6
-400 Mesh pCi/g	100	<287	935	947	1134	4971	<892	<141	21.1
Wet Screened (-400 Mesh Material split as follows)									
+ 10 μm pCi/g	14.5	257	68.5	78.6	118	403	<204	<36.4	<7.06
- 10 μm pCi/g	85.5	<343	804	840	970	4081	<919	<134	<21.6
Eluate (washings) pCi/g -400 Mesh	100	<104	51.9	85.2	<32.5	171	<535	<68.9	<15.3

TABLE 3.2.3i

WEST CHICAGO

COMPOSITE OF 36 SUMP SAMPLES

ISOTOPIC EVALUATION BY SCREEN SIZE

Sample Screen Size	Percent By Weight	Pb-210	Pb-214	Ra-223	Ra-226	Ra-228	Th-230	Th-234	U-235
+325 Mesh pCi/g	33.5	<66.7	<2.27	37.5	<16	140	<208	<30.2	<6.05
-325 + 400 Mesh pCi/g	69.5- 34.7	<71.9	12.8	57.4	60.8	329	<227	33.2	<5.33
-400 Mesh pCi/g	100	1680	39.2	511	177	2405	<434	83.9	<16.1
Wet Screened (-400 Mesh Material split as follows)									
+ 10 μm pCi/g	17.9	139	<2.16	55.3	<13.8	237	<172	<27.4	<5.06
- 10 μm pCi/g	82.1	<221	43.5	440	<37.4	2153	<595	<91.3	54
Eluate (washings) pCi/g	100	< 59.6	<3.29	<6.58	140	44.4	<407	<45.4	<11.3

TABLE 3 2.3j

SUMP RESIDUE

Analysis of Leachate from RCRA Test
Composite 36 Sump Residue Samples
Radioisotopes

Sample Location	Sample Number	ThO_2 (percent)	U_3O_8 (ppm)	Ra_{226} (pCi/g)	Ra_{224} (pCi/g)	Initial pH	Th_{232} (pCi/ℓ)	Th_{230} (pCi/ℓ)	Th_{228} (pCi/ℓ)	U (μg/ℓ)	Ra_{226} (pCi/ℓ)	Ra_{224} (pCi/ℓ)
Pond 1	30	2.1	320	105	708	5.9	.6	7.1	2.4	.019	.8	1.5

Analysis of Leachate from RCRA Test
Heavy metals - mg/ℓ

Sample Location	Sample Number	Ag	As	Ba	Cd	Cu	Cr	Fe	Hg	Ni	Pb	Se	Zn
Pond 1	30	<.001	.001	.26	.028	.18	<.001	.006	<.001	.048	.002	.014	2.6

Analysis of Leachate from RCRA Test
Other Ions, mg/ℓ

Sample Location	Sample Number	Initial pH	$SO_4^=$	$Cl^=$	F^-	NO_3^-
Pond 1	30	5.9	675	55	15.8	9.2

Footnotes to Tables 3.2.3f and g

The data shown on these two tables are the result of the application of the RCRA leach procedure to samples of the materials currently stored on the disposal area. It will be noted that the initial pH indicated that several samples contained sufficient hydrogen ion to result in the leach liquor having a pH of less than 7 (neutral).

The effect of neutralizing the materials prior to leaching was also investigated. As received samples were removed from containers, equal aliquots combined and mixed to provide the composite sample which was then subjected to the same leach test and the leachate neutralized with lime slurry. The results of this "neutralization composite" is shown at the bottom of each table.

Two anomalies appear in the results of these composites. The first is the fluoride on Table 3.2.3f; the second is Ra-226 on Table 3.2.3g. These anomalies are explained as follows:

1) The fluoride value resulting from the procedure described above was subsequently reduced to 2.9 mg/ℓ by increasing the pH to 11. Subsequently, it was determined that EDTA (ethylenediaminetetraacetic acid) and DTPA (diethylenetriaminepentaacetic acid) were present in the material and would act to complex calcium at the lower pH preventing formation of soluble calcium fluoride. Additional lime, raising the pH to 11, destroys these complexing agents with the resultant reduced fluoride. In addition, the reagent grade lime contained 25 ppm fluoride.

2) The elevated Ra, higher than the average of the several samples, is caused by the presence of 97 pCi/ℓ of Ra-226 in the analytical grade lime slurry used as a reagent for the neutralization test.

   Due to the presence of uranium in the earth's crust, most natural minerals contain Ra-226 in some measurable concentrations. The addition of lime in this instance only serves to increase the radium in the potential leachate. Therefore, during neutralization of the materials with lime on site, a lime source containing minimal levels of Ra-226 will be employed for neutalization.

Conclusions From RCRA Tests

These additional tests as described above demonstrate that the sludge and tailings piles are non-homogeneous in nature. Results of the samples must be viewed as representing only the material of the sample. This non-homogeneity is best illustrated perhaps by the variation in the initial pH of the solution as well as other constituents. Averaging the results of these tests as is shown on the tables should not be interpreted as being representative of the entire mass of material.

The feed materials were of natural origin and would tend to vary in composition and reactivity adding to the difficulty of interpretating these results.

It is known that during the life of the plant, various processes were employed to recover different compounds of the elements depending upon market conditions. Some non-homogeneity could be expected from this practice. It would appear that the penetration of rain and snow melt was not uniform; as indicated by the lack of uniformity in the pH of the samples.

It is not believed that additional sampling would add clarity to the interpretation but would only increase the amount of data.

The results of neutralizing test support the conclusions that neutralization would be effective in reducing the leaching potential to environmentally insignificant levels.

Three waste disposal areas covering approximately 10 acres will be constructed on the Site (Figures 4.1, 4.4 and 4.5): pond sediment, equipment and tankage disposal area (Area 1), an ore residue disposal area (Area 2) and a building demolition materials disposal area (Area 3). After Site preparation and waste material placement, the three disposal areas will be covered by a clay cap and topsoil.

The entire Site will be graded, landscaped and revegetated. Approximately 17 acres will be free of radioactive waste. Detailed drawings of the Disposal Site are attached to the Plan as an Appendix.

Area 1: The pond sediment, equipment and tankage disposal area is located on the northern portion of the Disposal Site (Figures 4.1 and 4.4). It will be stripped, excavated to 734.0 feet and filled with ten feet of compacted clay. This operation will be accomplished in two sequential actions. First, the western 1/2 of Area 1 (1W) will be excavated and lined with 10 feet of clay. The solids excavated from Pond #2 will be temporarily placed on the Pond #L solids. Next, the eastern 1/2 of Area 1 (1E) will be excavated placing the sediment removed from Area 1E into Area 1W. All solids in Pond #1 will be dredged out and backfilled with clean fill to 734 feet by end-dump methods. A 10-foot clay liner will then be placed in Area 1E thereby completing the operation. The clay liner will be 10 feet thick, bottom and sides, and will slope downward east to west, perforated pipes will be placed along the north and south sides, and sampling wells will be placed at the west end of each pipe extending through the clay cover and topsoil. Low specific activity process equipment, tankage, scrap metal and sediment from all ponds will be contained in Area 1. The average internal dimensions of the clay liner will approximate 450 feet in length (E-W), 250 feet in width (N-S), and 9 feet in depth, for an internal volume of approximately one million cubic feet.

Any accumulated liquids will be neutralized, removed and disposed of by evaporation in Pond #4.

Area 2: The ore residue disposal area is located on the central portion of the Disposal Site (Figures 4.1 and 4.4). All ore residue will be spread evenly over this area and capped with clay and topsoil.

Area 3: The building demolition materials disposal area is located on the southern portion of the Disposal Site (Figures 4.1 and 4.4). Low

4.4.4 PHASE II - BUILDING DEMOLITION AND WASTE CONTAINMENT

This section describes tasks associated with total building demolition, disposal of rubble and contaminated soil, construction of containment, Areas 1, 2 and 3, and placement of waste materials in these areas. These are the tasks required prior to backfill of the Factory Site, clay cover of the Disposal Site, topsoil placement, and landscaping and revegetating of the entire property.

Factory Site:

Demolition of the Factory Site will be accomplished in the following manner:

Dust Abatement:

A dust abatement system using fog nozzles will be constructed. A portion of the floor of the north end of Building No. 9 will be removed and a lagoon will be dug. This lagoon will be lined with a double plastic liner to contain water and preclude percolation. The fog nozzle system will be a pressure fed, gravity flow drainage and filtration system. The fog nozzle system will be employed in demolition of portions of buildings which are the most radioactive and prone to generate dust. Water will be neutralized to precipitate contaminants, and filtered. Water will meet release requirements for radiational chemical pollution.

Building Demolition:

Building and foundations will be demolished starting at the north end of the Site and moving south (Figure 4.2).

a) Low specific activity and clean rubble will be separated.
b) Clean rubble will be hauled to a local landfill for disposal.
c) Low specific activity rubble will be hauled to the Disposal Site and systematically placed in Area 3 (Figure 4.4).

Incineration System:

A large volume of organic combustible materials will be removed from the factory site. It is currently planned to box this contaminated organic and bury it as contaminated waste at a licensed burial ground. Available burial grounds have recently instituted a restriction by allocating the volume that a single firm ca bury on an annual basis. The current allocation for Kerr-McGee : Hanford, at Barnwell and any realistic allocation which may be authorized would stretch the shipment period to a significantly longer time than currently contemplated.* As a result, Kerr-McGee is consi ing the installation of an incinerator which would reduce such organic materials by a factor of approximately 10 in volume, thereby securing more rapid disposal. The incinerator will be designed to handle 1000 lbs per hour in a three chamber stationary grate machine. Cleanout chambers have a capacity for an eight hour day ash accumulation. Ash accumulation when cooled will be sprayed with water before the cleanout door is opened in order to control release of dust. Gas from the incinerator will be blended with cooling air and passed through a cooling jacket into a baghouse for the initial removal of entrained particles. Secondary filter composed of six (2' square by 12") thick HEPA filters will be provided to remove any extremely fine particles generated that pass through the baghouse.

The design is similar to an incinerator installed at the Cimarron Facility of Kerr-McGee Nuclear for the purpose of incinerating combustible materials generated in a fuel fabrication facility during approximately three years of operation, the maximum radioactive discharge of slightly enriched uranium measured 10^{-12} to 10^{-14} μCi/mℓ of gross alpha, well within 10 CFR 20 air concentration limits.

The installation of this system will require licensing by the NRC but permit the timely scheduled cleanup of the factory site.

Excavation:

a) All surface and subsurface earth which has levels of contamination in excess of thresholds outlined in Section 7.6 will be stripped and transported to the Disposal Site for burial.

*No change has been made in the time tables listed in Chapter 4.

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d) Sediment materials from ponds 2 and 3 will be excavated by dragline. Sediment will be placed in Area 1W.

e) The rare earth chemical compounds in Building 9 will be placed in Area 1W.

f) Low specific activity equipment, tankage, piping and other metals will be placed in Area 1W in such an arrangement as to stabilize the sediment from ponds 2 and 3. Equipment and tankage will be open or bottomless so that interstices can be filled.

g) The topsoil from pond 1 will be removed. Clean earth will be stockpiled along the eastern edge of Area 1 for future use as topsoil.

h) The sediment in pond 1 will be exhumed by dragline.

i) Upon completion of exhumation, the slurry in pond 1 will be neutralized by spreading a high density (50% solid) lime slurry on the surface of the pond with a hose. Material will be mixed using a drag line bucket with perferations in the rear wall to permit flow of the slurry through the perferations. Upon complete mixing of the initial layer of the material, slurry will be placed as described below. Completeness of neutralization will be ensured by initially sampling one bucket out of each five, testing it with phenolphthalein. Lessons learned as the neutralization and mixing procedure proceeds will be put into effect immediately to secure a more efficient operation.

j) Newly placed waste materials will be covered daily with 6 inches of soil to prevent disturbance by wind.

k) Pond 1 will be backfilled with clean soil to 734 feet elevation and then filled with 10 feet of compacted clay with a permeability of 10^{-8} cm/sec. or less (Figure 4.4). The balance of the sampling system will be installed.

l) Remaining equipment, tankage steel 55-gallon drums and assorted metal items will be placed in Area 1 as received. Interstices will be filled.

m) Radiological surveys will include the surveillance of tools and equipment and will predicate timely decontamination tasks. The final lime slurry rinse will effectively decontaminate the dragline bucket. Tools and other equipment will be hose sprayed onto the mixing pad with the wash water becoming part of the lime slurry. Small tools and other small items will be decontaminated in drums containing decontaminating solution. These solutions will be mixed with cement to meet NRC solidification and burial requirements. After solidification, waste containers will be shipped to a low-level (off-site) licensed disposal site.

Additionally, the decommissioning contractor has developed a policy and safety manual which establishes operational procedures associated with decommissioning operations.

Area 2: Ore Residue Disposal Area:

The operations plan for Area 2 will consist of the following:

a) Building 19 will be dismantled and organic low specific activity building material packaged and shipped to a licensed disposal site. The foundations of Buildings 17, 18 and 19 will be demolished and placed in Area 3.

b) Prior to contouring as described below, the ore residue and sediment piles will be neutralized with lime slurry. Neutralization will be accomplished by establishing a mixing pad on a flat area upon which a uniform layer of material can be deposited. This material will then be treated with a dense lime slurry (50% solids) at a rate of about 20 lbs. of calcium oxide per ton of sediment and tailings. Material will then be removed from the mixing pad by a scraper, being mixed as it is forced into the scraper and being mixed again as it is placed in its final position. Again, neutralization will be assured by 5 samples taken randomly per course and tested in the field in a 50% water slurry with phenolphthalein. In the event a course is not sufficiently neutralized, the procedure will be repeated. Lessons learned as the neutralization procedure is followed will be placed into effect immediately to secure more efficient operation.

c) Surface of piles will be dampened with water spray to prevent dust from becoming airborne.

d) Newly placed waste materials will be covered with 6 inches of soil.

Transportation of Materials

Offsite: Principal West Chicago truck traffic in support of Site stabilization will be of two types: 1) Transport of low specific activity materials to a licensed radioactive waste disposal area, which should be relatively light and require only slightly over a month to accomplish, and 2) the heavier truck traffic associated with hauling clean rubble to a local landfill and bringing in clean clay and topfill. Implementation of the proposed Plan, as with all alternatives, would involve significant truck traffic. Kerr-McGee is exploring means to minimize the inconvenience to the community, including the use of railroad transportation to bring clean material onsite. To minimize truck traffic through residential areas and school zones, Kerr-McGee propose to construct a new entrance road from the waste site to Joliet Street (page 4.6). Plans for this road and traffic pattern will be coordinated with the City Traffic Department. Kerr-McGee will maintain the road throughout the stabilization plan work period. Project work schedules will consider traffic coordination to and from the site.

West Chicago area engineers and contractors are confident that sources of clay and topsoil are available and for planning purposes assumed the material to be 2.5 miles from the site. The exact site has not yet been selected since some clay and topsoil maybe available from other construction projects in the area during the time of our project. Otherwise, clay and topsoil would be acquired from a borrow area, that has not yet been determined. The borrow area would be reclaimed if required in compliance with state and local regulations. The borrow area would then be planted with grass. The exact reclamation program would depend on the source.

Low Specific Activity Materials: During Phase I, approximately 188 truck loads of low specific activity materials will be generated. These will be shipped to the Barnwell, S.C. low level radioactive waste disposal facility. Truck traffic will be spread over 35 work days. This will average out to 5.4 trucks per day or about one truck every 90 minutes exiting the Disposal Site.

Clean Materials: The following table shows the estimated time frame, type of material, mode of transportation and frequency of trips associated with clean material movement.

Phase	Duration	Sequence	Truck Loads	Truck Frequency
A. Phase II	20 wks.	45 wks. after approval of plan	1,275	20 min.
B. Phase II	9 wks.	Concurrent with A	2,160	5 min.
C. Phase II	5 wks.	7 wks. after A	1,215	5 min.
D. Phase III	14 wks.	8 wks. after C	3,375	5 min.
E. Phase III	28 wks.	Immediately after A	9,850	5 min.
			17,875	

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Tests

Engineers will cause samples to be taken for the following purposes:

1) Two samples after initial placement to measure moisture content and judge the adjustment required.
2) Two samples for moisture content after the final placement each day.
3) Two samples after final discing each fourth lift for Atterberg limits.
4) Two samples per week for grain size distribution.
5) Two samples every fifth work day for compaction and laboratory permeability test.

Field Testing

Compacted density will be determined by the driven cylinder method (ASTM 2937) and nuclear densitometer (ASTM D2922). Density shall be determined on each three feet of compacted fill for each 4000 square feet of filled surface.

Three points shall be field checked by Standard Proctor Moisture using standard 5.5 lb. hammer and four inch thick split mold every other day.

All test results will be submitted to the Kerr-McGee Project Manager in a timely fashion and filed for inspection by appropriate regulatory agencies as required.

Source of Clay

A preliminary review of clay sources and availability was conducted by Soil Testing Services of Northbrook, Illinois. Their report, attached as Appendix 3, describes in detail their survey methods, sources sampling and testing procedures. Thirteen deposits were located and 10 deposits were sampled and 16 samples were tested for characteristics. Six of the samples showed permeabilities of 1×10^{-8} or less. It is their conclusion that in view of the amount of material required, it is likely that obtaining clay from more than one site would be necessary. Their data is summarized on Table 4.2.

**Table 4.2. Summary of Laboratory Test Results

Source	Visual Classification (USCS)*	Natural Water Content (%)	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plastic Limit (%)	Permeability Results: Test Density (PCF)	Permeability Results: Test Water Content (%)	K (cm/sec)
A-1	CL	17.7	34.0	18.0	109.2	17.2	7×10^{-9}
B	CH		NO TEST PERFORMED			est. less than	1×10^{-8}
C	CL	24.5	42.3	25.2	97.7	23.8	2×10^{-8}
D-1	CH	26.8	53.0	26.0	97.8	25.8	8×10^{-9}
D-2	CH	22.4	51.0	22.0	103.6	21.5	1×10^{-8}
E	CL-CH	29.4	49.0	22.0	92.5	28.9	2×10^{-8}
F			NO SAMPLE				
G	CH	34.3	55.0	30.0	86.1	33.4	4×10^{-8}
H	CL	25.3	38.0	24.0	96.9	25.2	7×10^{-8}
I	CL-CH	28.7	49.0	19.2	92.4	27.7	5×10^{-9}
J	CH	27.7	53.0	30.0	93.3	26.6	8×10^{-8}
K	CL-CH	26.6	45.0	25.0	95.6	26.4	2×10^{-8}
Mallard Lake							
1 (10')-1A	CL	18	38	17	113	17.8	7×10^{-9}
1 (10')-1B	CL	18	38	17	110	18.8	6×10^{-9}
2 (15')-2A	CL	--	36	17	116.4	15.7	2×10^{-8}
2 (15')-2B	CL	--	36	17	108.8	18.9	4×10^{-8}
2 (mod proc)	CL	4.7	36	17	108.3	18.9	1×10^{-8}
2 (w/bentonite)	CL-CH	4.7	45	21	134.6	19.2	1×10^{-9}
Feltes	CL-SC					estimated	1×10^{-6}

*Unified Soil Classification System, See Appendix.

Table 4.2 shows that most of the samples meet or are very close to the permeability requirement of 1×10^{-8} or less. Samples from Site G, H and J were not found to meet the requirements, and were not sufficiently close to warrant further study.

**This Table appears on page 17 of the Soil Testing Service Report, as Table 1.

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5.0 ENVIRONMENTAL IMPACTS

Impacts to the environment will be discussed for the period of implementation of the Plan and for the subsequent period.

5.1 AIR QUALITY

Implementation Period

The air quality immediately surrounding the Sites will be impacted to some extent during implementation of the Plan. Phase I of the Plan will involve the removal of equipment which will result in the generation of small amounts of dust from working within the buildings and subsequent demolition of the building structure. Some of these buildings have been in place for a period of over 90 years and have collected extensive amounts of natural and processing dust during this time. The generation of some dust is inevitable and will result in a slight deterioration of the air quality. Kerr-McGee knows of no data available that would permit the estimation of the quantity of dust generated. The mitigation measures planned will minimize the amount.

It should be noted that while the probability of increased particulate concentration exists, such increases are unlikely in view of the moisture content of the waste piles and the planned mitigation practices. Current moisture content of the pile is a minimum of 27% (See Table 3.2.3c). During rearrangement operations, materials will be moistened prior to moving and dumping operations conducted in a way to minimize wind-pickup of particulate. Dust generation factors given in EPA AP-42 were calculated as if the material was dry and loose and then reduced by a factor of 50% to recognize mitigation factors. This calculation results in the generation of approximately 12 tons of air particulates entrained, which is not excessive for this type of operation.

During the demolition phase, the operation of the diesel engine graders, bulldozers, dragline, backhoe, and trucks will result in the release of airborne effluents for portions of the working year. By the application

TABLE 5.1

CALCULATED RADIOLOGICAL DOSE RATE
PER YEAR
AT SITE BOUNDARY
(mrem)

	Lung	Bone	Whole Body
Existing Situation:			
Maximum/Individual	3.6		
Cumulative Population	1.3		
During Implementation:			
Maximum/Individual - Radon	1.34		
- Particulates	198.8	248.5	9.76
Cumulative Population - Radon & Particulates	164.0	205.0	8.05
After Stabilization:			
Maximum/Individual	.14		
Cumulative Population	.13		

The Disposal Site will remain under NRC license for an indefinite period as a waste area. During the first three years after completion of the Plan, the air, surface water, and groundwater quality will be examined and the Site monitored for stability and quality of revegetation. Prior to termination of the license, existing federal legislation requires deeding the Disposal Site to the State or Federal government.

5.4.1 SITE VICINITY

Kerr-McGee believes that the decommissioning of the Factory Site and stabilization of the Disposal Site will have no measurable adverse effect upon the land use of the immediate area. It is currently occupied by a number of beneficial uses in the form of housing, warehousing, manufacturing, transportation, culture, and open space. The implementation of the Plan should not in any way adversely affect the present or planned use of any area exterior to the Site.

5.5 WATER RESOURCES AND WATER QUALITY

It is contemplated that city water will be used during Phase I and Phase II and entail a small amount of discard to sewage systems. Except for the use of water in ponds on the Disposal Site for dust control, no other use of surface water or groundwater is planned.

5.5.1 SURFACE WATER

Surface water will be generated primarily by normal rainfall in the area and it will be discharged to existing storm sewers through disposal systems now available. A diversion system as described in Section 4.0 will be provided on the Disposal Site to provide a temporary sedimentation basin for any material eroded from the waste piles before the water can percolate into the ground or discharge offsite into existing water courses. None of the demolition and stabilization activities will contaminate in any way the surface water runoff from such rainfalls. A small increase in total suspended solids could occur during Phases II and III as fresh dirt is laid down as cover in the Disposal Site. However, the detention basin will provide adequate settling capacity to avoid an increase in solids in local storm water runoff.

Implementation of the proposed Stabilization Plan should not impact the water quality or discharge of Kress Creek and West Branch of the DuPage River. Upon completion of the Plan, the surface runoff characteristics of the site will be similar to that of historical times before ponds were constructed.

5.5.2 GROUNDWATER

As described in Section 2.6.3, groundwater quality seems to be gradually improving, thus demonstrating that a stable condition has been established in regard to the solubility of the tailings and sludge residue. The demolition and stabilization work planned for the Factory and Disposal Sites may temporarily change this stable condition.

Upon completion of the Plan, it is expected that the groundwater quality will continue to gradually improve as described in Section 2.0. The purpose of the cover and stabilization effort is to prevent any potential impact upon groundwater quality.

5.6 BIOTA

5.6.1 TERRESTRIAL

The implementation of the Plan will only marginally influence terrestrial biota on the project area and these effects will be temporary. Small animals currently inhabiting the Disposal Site, and birds will be dispossessed for the period of demolition and stabilization. Adequate adjacent open areas provide cover so no serious or permanent loss of populations should occur. A rodent elimination plan has been established to eliminate rodents from all buildings on the Factory and Disposal Sites.

5.6.2 AQUATIC

The aquatic biota existing in nearby Kress Creek will not be deteriorated by the demolition and stabilization activities. Decommissioning of ponds will cause the elimination of onsite aquatic biota. However, their elimination will not be of significance as the species inhabiting these ponds are common, and generally distributed over the Midwest. The aquatic biota existing in nearby Kress Creek will not be deteriorated by the demolition and stabilization activities. Groundwater quality will continue to gradually improve. It is believed that groundwater flow forms a recharge to some reaches of Kress Creek.

5.7 RADIATION ENVIRONMENT

5.7.1 DURING DECOMMISSIONING AND STABILIZATION

It is estimated that the onsite dust generation will amount to no more than 12 tons over the period of activity. During the first two years, part of this dust will be slightly contaminated with uranium, thorium and their daughters. Gross increases in particulates containing uranium, thorium and their daughters will be prevented, however, due to the planned mitigation measures and the natural moisture content of the residues. Control programs will insure that the limits of 10 CFR 20 are not exceeded.

5.7.2 FOLLOWING STABILIZATION

Upon the completion of the planned program all radioactive materials will have been buried under at least five feet of cover. The compacted clay will have a deterrent effect on the emissions of radon-222 derived from the uranium in the residues. The gamma flux originating from the area will be significantly reduced. The exact flux measurements cannot be predicted with accuracy, but should not exceed that of the surrounding West Chicago area.

the vortex dissipates, leaving a volume source to be dispersed by the trailing winds through an arc of 45^{o}. Using similar assumptions with an average specific activity of 6.3×10^{-9} Ci/g, the postulated tornado release for the Disposal Site will approximate 2.74 times that from the model uranium mill. The rationale used to arrive at this estimate is that the specific activity of the material in the Disposal Site is ~77 times less than uranium concentrate while the thorium constituent of the material has a rem dose to the lung per curie which is ~10 times greater than uranium concentrate. The disposal site quantity dispersed, compared to the 15% Uranium Mill GEIS, calculates to be nearly 10 times that of the model mill.

After the Disposal Site is stabilized, the estimated lung dose is reduced to background values.

6.2 ACCIDENTS NOT INVOLVING RADIOACTIVITY

The environmental effects of accidents involving non-radiological materials at the Disposal Site is expected to be small.

6.2.1 BUILDING AND STRUCTURE DEMOLITION

The frequency of accidental injuries to workers during demolition work approximates 20 disabling injuries per million work hours; somewhat greater than that for the general construction trades which have a frequency rate of 16.

The potential for the release of small quantities of alkalis and acids and cleaning chemicals exists. Asbestos is contained in siding and some wallboard and, without care, asbestos fibers might be released. Natural gas pipelines, although deactivated, may still contain some unvented gas which could pose the risk of explosion or fire.

resident caretaker will supervise this monitoring and Site maintenance. Additionally, for a three-year period, a professional earth scientist will inspect the Site for erosion, material wash, earth settling of excavated areas and of the incapsulated area, detention pond integrity, etc. These inspections will be conducted quarterly.

7.3 WATER

7.3.1 RUNOFF

Storm sewers adjacent to the Disposal Site discharge into Kress Creek which flows to the Du Page River. A pre-Phase I-B sample of the storm sewer outlet will be taken. During implementation of the Plan, the outlet to Kress Creek will be sampled at least quarterly. During excavation and grading activities, the samples will be obtained monthly. Samples will also be collected promptly after periods of heavy runoff. These samples will be analysed for suspended solids, dissolved solids, pH, sulfate and chloride. Analysis for radioactivity is described in Section 7.5. Sampling of the storm sewer discharge following completion of Phase III of the Plan will be conducted for at least three years on a quarterly basis.

A stormwater detention sump (settling basin) is to be constructed near the southwest corner of the Disposal Site. The basin will be kept operable by prompt repairs as necessary.

7.3.2 GROUNDWATER

The Plan calls for the detention basin to be constructed near monitor well #2. As a result, this well must be plugged with cement and abandoned. After completion of the Plan, two new groundwater wells will be installed (see Engineering Drawing C, in pocket). One well (B-6) will be placed approximately 50 feet beyond the southern extent of the clay cover, in a down-gradient position from the waste area. The second well (B-7) will be placed at the northwest corner of the Site to provide data at this boundary. Both wells will be completed at least 10 feet into the water table aquifer and have well casing perforations placed across the probable water table surface.

Monitoring wells will be maintained and will be routinely sampled before implementation, quarterly during implementation, and quarterly for three years following completion of this Plan. The samples will be analyzed for the following consitituents:

Liquid level
pH
Total Dissolved Solids
Sulfate
Chloride
Radioactive Elements (see Sec. 7.5)

On an annual schedule, through five years after decommissioning, nearby offsite wells completed in the dolomite aquifer, will be monitored for those parameters listed above.

Standard procedures will be followed for sampling and analyses. Results will be examined for trends by a professional hydrologist. In view of the factors described in Section 2.6, a period of record will be required to document the trends affecting the groundwater system.

The analytical data will be promptly submitted in writing to the Nuclear Regulatory Commission, the Illinois Department of Public Health, the Illinois EPA and the City of West Chicago.

The two sampling points for the encapsulated area (Area 1 of Disposal Site) will be sampled quarterly for the same constituents as the monitor wells, provided liquid is found at these points. This is also a three-year program after completion of the Plan.

A method of monitoring the integrity of the clay cover is to evaluate the responses in the monitor wells across the Site and the sampling wells in the encapsulated area. If fluid is found to be building up in the encapsulated area, indicating a failure in the clay cover, measures will be taken to repair the cover if the water analysis indicates the development of a leachate problem. Across the remainder of the area, failure of the clay cover will be manifested in both the fluid level and the chemical characteristics at the monitor wells. Remedial work on the clay cover will be made wherever and whenever the analytical data indicate the need.

7.4 BIOTA

After completion of Phase III, grass on the Disposal Site will be kept mowed and weeds and brush controlled. Services will be obtained to dis-

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The ANL has reported concentrations of insoluble thorium materials along the bottom of Kress Creek. The material most likely entered this stream (path) through surface water runoff and formed very slowly-moving placer deposits on the creek bed. This matter is discussed in Section 2.9.2.

(B) Terrestrial Monitoring

Fines and sediments of thorium residues have been detected in soils by monitoring programs conducted by Kerr-McGee and ANL. Other than the sediment located in the fenced-in area at Reed-Keppler Park and on the Kerr-McGee Sites, the other sediments which have been detected are considered more a nuisance than a radiological hazard. ANL has performed extensive surveys in surrounding Facility environment. The program consisted of a fly-over survey, followed by extensive ground surveys. Many areas greater than natural background have been detected. The findings have been summarized in the ANL report, which identified numerous anomalies, none which cause the 10 CFR 20 dose limits for any individual to be exceeded except for the fenced-in area at Reed-Keppler Park.

(C) Biota

No formal monitoring program has been undertaken regarding biota.

(D) Site Radiation

Loose surface and fixed contamination levels were determined for the buildings on the Factory Site and direct radiation measurements were made of the buildings on the Factory and Disposal Sites and the Disposal Site itself. This information is contained in Section 2.9 of this report.

7.5.2 DURING IMPLEMENTATION

During all phases of the operation, the following monitoring program will be carried out:

(A) Airborne Particulate

During work activity which might cause dust, air samples will be collected downwind using samplers similar to Eberline RAS-1. These samples will be promptly counted for gross alpha and logged. They will be recounted later to determine long-lived activity content. If quantities of long-lived activity are detected above twice background, the sample will be saved for possible alpha spectroanalysis to identify the specific isotopes contributing to the long-lived activity. See Section 5.1 for calculated dose. The background is determined by analysis of samples obtained at locations between 500 and 1000 meters distant from the plant.

Continuous air sampling will be conducted around the Site perimeter at appropriate locations during the time any work is being performed. These samples will be collected at least each work day and will be analysed the following work day. The sampling locations may vary depending on the work location.

Work area "breathing zone" samples will be collected routinely and workers exposure time will also be obtained.

A personnel air sampler of the lapel type will be issued to a member of the crew routinely to assist the evaluation of the workers potential for airborne exposure.

(B) Groundwater

Samples will be taken at least quarterly from the monitoring wells. These samples will be analyzed for long-lived gross alpha. Once per year a sample will be analyzed isotopically for individual radionuclides.

In addition, while the contents in Ponds No. 1 and No. 2 are being exhumed, weekly groundwater samples will be taken and counted for long-lived gross alpha.

Should a routine sample show a radiological concentration in excess of the Table II limits in Appendix B to 10 CFR Part 20, all of the locations will be immediately resampled to confirm this and these results reported by telephone as well as letter.

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(C) Surface Water

Water runoff from the Site will be directed into a detention basin, construction of which will be one of the first tasks undertaken and will be completed before Ponds Lagoons No. 1 and No. 2 sediments and ore residues are removed. This water will be sampled at least quarterly or more often depending upon the amount of rainfall. The samples will be analysed for long-lived gross alpha. This is in addition to the sampling of Kress Creek which is described in Section 7.3.1.

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(D) Site Gamma Radiation

Radiation surveys will be taken in all areas where work will be conducted to determine dose rates.

The fence line in the areas where active work is being conducted will be surveyed for gamma dose rates and results will be documented weekly.

(E) Sediment

Drainage around the Disposal Site will be arranged to direct water to the detention basin. The drainage may carry off sediment which could collect in these man-made drainage ditches. The sediment in the ditches and on the bottom of the retention basin will be surveyed for potential radioactive buildup. Surveys will be conducted quarterly. Representative samples will be analyzed by gamma spectroscopic analysis in terms of pCi/g.

7.5.3 POST PHASE III MONITORING

After completion of Phase III of the Plan, the following radiological monitoring program will be implemented during the three following years:

(A) Groundwater

Samples from the six monitor wells, the two sampling points over the encapsulated area, and the surge pond will be taken quarterly. The samples will be analyzed for gross alpha and compared with analyses which were taken during Phases I-B, II and III and pre-Phase I-A period. Once per year, these samples will be analyzed for individual radioisotopes.

(B) Radiation

Gamma scans over the surface of the Factory and Disposal Sites will be made to detect any anomalies higher than the general areas. These scans will be done each year using a "micro-R" type survey instrument.

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7.7 RADIOLOGICAL HEALTH PROGRAM

A comprehensive health physics program is established at the West Chicago Facility. Well trained and highly qualified health physics personnel administer the program. In addition, procedures are established whereby periodic health and safety audits are performed by a health physicists from the staff of the Kerr-McGee Nuclear Corporation.

The program includes:

1. Obtaining exposure histories for new-hires.
2. Personnel dosimetry and records and MPC-hr. records.
3. Required postings, labelings and placarding.
4. Anti-C clothing issue.
5. Respirator and other personal protective equipment issue.
6. Controlled and uncontrolled area designation.
7. Monitoring, survey and sampling equipment.
8. Sample counting and analysis laboratory.
9. Instrument calibration procedures.
10. Individual work area-time records.
11. Medical examinations for employees.
12. Emergency procedures coordinated with local police and fire departments and hospitals.
13. Bioassay provisions.
14. Contamination control procedures including special "work permits" for non-routine work.
15. Environmental sampling of air, water soils and sediments.
16. Decontamination procedures for facilities, equipment, personnel, etc.
17. Contamination monitoring, air sampling and dose-rate survey procedures.
18. Reporting procedures are established to notify the NRC I&E personnel of Region III as required by 10 CFR Part 20. (Other agencies as appropriate.)
19. Packaging procedures per DOT transportation regulations.
20. Waste handling procedures.
21. ALARA opportunities are sought and taken by upgrading engineering and administrative controls whenever possible.
22. Employee radiation safety training and training on all applicable program items listed above.

8.4 WATER USE

8.4.1 SURFACE WATER

Completion of the extreme modification proposed by Kerr-McGee for the Site will limit the potential of any adverse impact in runoff characteristics from Factory, Intermediate or Disposal Sites.

8.4.2 GROUNDWATER

Groundwater quality, as stated earlier in Section 2.6, should continue to improve upon the completion of the Plan. As described in Section 5.2, implementation of the Plan may temporarily influence groundwater levels and quality.

8.5 SITE AND MINERAL RESOURCES

No known mineral resources exist on the Factory or Disposal Sites currently, except the thorium and rare earth values found in the residues. These values are not permanently lost to recovery for beneficial use. Currently, no economic process for recovery of the mineral values exists. In the event one were discovered, the values could be recovered with a minimal effort at the Disposal Site compared with initial mining.

8.6 BIOTA

8.6.1 TERRESTRIAL

The results of physical observations of organisms within the Site and comparative physical observation of like organisms within and adjacent to the Site indicate that the operations of the Kerr-McGee facility have not adversely affected physically the biota on or near the facility. Conversely, the establishment of cleared Sites would result in significant improvement in the aesthetics and the ecological population of the terrestrial biota both in numbers and diversity.

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8.6.2 AQUATIC

Sediments in Kress Creek do not constitute a creditable public hazard. This evidence coupled with Kerr-McGee's modification of the Site will render any pollutant source less hazardous. On this basis, any result of an unavoidable adverse impact to the aquatic biota currently residing in Kress Creek and DuPage River will be lessened. A potential source of contamination will be removed by the stabilization and revegetation of the Disposal Site.

8.7 RADIOLOGICAL

The potential of radiological impact will be reduced by the decommissioning of the Factory Site and stabilization of the Disposal Site.

8.8 SOCIOECONOMIC AND POLITICAL

The main socioeconomic impact will result from the removal of the current deteriorating buildings, stabilization of the waste piles and the transformation of the Factory, Intermediate and Disposal Sites into attractive, landscaped areas. It is expected that the property values in the immediate neighborhood will increase. Other benefits could accrue to the neighborhood of West Chicago, dependent on ultimate disposition of the three Sites.

Kerr-McGee cannot foresee any significant adverse political effects from the decommissioning of the Factory Site and stabilization of the Disposal Site.

10.3 WATER

10.3.1 SURFACE WATER

A potential contamination source to surface water quality will be removed by implementation of the Plan. There is no permanent commitment of surface water.

10.3.2 GROUNDWATER

Groundwater quality should continue to improve in the absence of an industrial source of contamination as described in Section 2.0. There will be no permanent commitment of groundwater from the adoption of the Plan.

10.3.3 DRAINAGE PATTERN

Drainage pattern of the Disposal Site will be altered slightly by the clay and topsoil cover over the wastes. No serious discharge erosion will be experienced in view of the gradual gradient provided by recontouring. Revegetation should reduce the potential for drainage changes.

10.4 LAND

Approximately 27 acres of land will be permanently committed to the storage of waste. As a result of landscaping and revegetation, the environmental productivity will be improved.

10.5 BIOTA

10.5.1 TERRESTRIAL

No irreversible commitment of terrestrial biotic habitat will occur as a result of the adoption of this Plan. To the contrary, terrestrial biota environment will be improved.

APPENDIX II

ADDENDUM

The population distribution used in calculation of population dose is shown on the attached Table.

The population distribution was estimated as follows:

1. The "population forecast for municipal areas", August, 1976, from the Northeastern Illinois Planning Commission was used as a population base. The year 1980 was selected as the base year.

2. A USGS map of the West Chicago area was overlayed with 16 compass sections and one mile radius circles were shown out to five miles. The overlay centered on the West Chicago plant location.

3. The population for each municipality encompassed by the overlay was distributed on the overlay until total distribution matched the total projected population from the NIPC forecast.

4. The table was then derived up from the overlay.

POPULATION DISTRIBUTION BY DIRECTION IN 1980 KERR-McGEE WEST CHICAGO PLANT

MI	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1	1200	1500	800	800	500	400	200	300	300	50	300	300	100	1000	1000	1000
2	800	1500	1500	2000	800	1000	100	400	25	100	25	10	400	500	100	400
3	800	100	1500	50	2000	1500	800	1500	1000	100	10	10	50	50	400	800
4	2500	500	400	1500	3000	3000	800	2500	400	100	100	200	800	800	200	300
5	1500	200	1500	2500	3000	1000	800	3000	400	100	50	3000	3000	3000	100	100
SITE BOUNDARY																
	400'				300'				700'				400'			

POPULATION FORECAST FOR MUNICIPAL AREAS

On August 19, 1976, the Northeastern Illinois Planning Commission formally approved a revised set of township population forecasts. At the same time, the Commission authorized submittal of Estimated Future Water Supply Demands for Northeastern Illinois to the Division of Water Resources, Illinois Department of Transportation. This report, prepared by Commission staff under a November 12, 1975 contract between the Division of Water Resources and NIPC, included population forecasts for municipally-identified water demand areas.

These municipal forecasts are presented on the following pages. It should be noted that, while these results are derivatives of the township forecasts, only the township forecasts have official status. Likewise, while the water demand areas were designed as areas likely to be served by one of the existing municipal water systems, these in no way imply Commission policy or forecasts of what areas will be annexed or incorporated.

APPENDIX II

CALCULATION OF THE IMPACT OF RADON RELEASES ASSOCIATED WITH THE DECOMMISSIONING OF THE WEST CHICAGO MONAZITE SAND LEACHING FACILITY

PREPARED FOR:

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April 25, 1980

APPENDIX A - RADON FLUX ATTENUATION

APPENDIX B - CURRENT CONDITIONS - CASE 1

APPENDIX C - RELOCATION OPERATIONS
RADON/PARTICULATES - CASE 2

APPENDIX D - POST RECLAMATION - RADON - CASE 3

1.0 INTRODUCTION

The following sections present an estimate of the radionuclide source terms and resulting man-rem and critical organ doses associated with the monazite sand acid leach facility residual piles. The piles consist of a sludge pile and a tailings pile. The source and doses associated with these piles are evaluated for the following cases:

Case 1: Current conditions - radon

Case 2: During relocation operations - radon plus particulates

Case 3: Post reclamation - radon

In all three cases individual and population dose estimate are provided where applicable.

2.0 SOURCE TERMS

2.1 Radon

The annual radon release source term for the two piles on site at the present time is calculated by use of the solution of the diffusion equation for an infinite slab in the vertical direction.*

$$J = [C_{Ra}\ (E)\ (\rho)\ \sqrt{(\lambda)(D)}\ ](A)\ (k)\ (10^{-12} Ci/pCi) \qquad (2.1\text{-}1)$$

where:

- J = Annual radon release (Ci/yr)
- C_{Ra} = Radium-226 concentration in the pile (pCi/g)
- E = Emanation coefficient which is the fraction of the generated radon available for diffusion.
- ρ = Bulk density of the material, (g/cm^3)
- λ = Radon decay constant (sec^{-1})
- D = The effective radon diffusion coefficient (cm^2/sec)
- A = Area of the pile (cm^2)
- k = The number of seconds in a year, 3.154×10^7 sec/yr

Data regarding the physical and radiological characteristics of the waste material of concern is presented in Table 2.1-1.

It should be noted that the west Chicago area has a four month mean monthly snowfall of 5 inches and an average of 150 days/year of 0.01 inch of precipitation (Dept. of Commerce, 1974). This precipitation will act as a complete retarder of the short-lived Ra-220 while the snow cover will retard both Ra-220 and Ra-222.

* For radon-222 and radon 220, slabs greater than 6 feet and a few centimeters in thickness, respectively, are generally considered infinite, because the contribution to the surface flux from below this level is insignificant.

2.1.1 Radon Source Terms - Case 1

2.1.1.1 Radon Releases From the Sludge Pile

Radon-222

The following assumptions are made in the calculation of the radon-222 release terms from the sludge pile:

- o The sludge pile contains a volume of 86,000 ft^3 of material.
- o The shape of the pile is a spherical segment with a height approximately 20 feet.
- o From the first two assumptions, the area of the pile may be estimated at 9400 ft^2.

Based on these assumptions and using equation 2.1-1, maximum annual radon-222 release from the sludge pile, under present conditions is 0.19 Ci/year. Assuming a weather reduction factor of 2/3 (mean monthly snowfall of greater than 5 inches) leads to an average flux of 0.12 Ci/yr.

Radon-220

Using the same equations and assumptions, the maximum annual release of radon-220 is estimated at 352.0 Ci/yr. Because of its short half-life, 55 sec., only the top two centimeters contributes to the surface flux. Thus even a thin water barrier of the order of millimeters is sufficient to prevent Ra-220 emanation. Therefore, multiplying by a weather reduction factor 215÷365 (150 days of 0.01 inch or more precipitation) leads to a source of 207.3 Ci/yr.

2.1.1.2 Radon Release From the Tailings Area

Radon-222

The Rn-222 release from the tailings pile may be calculated using the values in Table 2.1-1 and the following assumptions:

TABLE 2.1-1

Parameters Values*

Parameter	Sand	Sediment
C_{Ra} Ra-226 (pCi/gm) (Reference 1)	1172	277
C_{Ra} Ra-224 (pCi/gm) (Attachment 1)	2792	5438
Emanation Coefficient E	0.092 (Baretto, 1973)	0.20 (NUREG-0511)
Bulk Density (gm/cc)**	2.07	2.68
Moisture Content (%) (Attachment 1)	36.5	40
Diffusion Coefficent (cm^2/sec)***	1.2×10^{-5}	1.6×10^{-5}
Decay Constant (sec^{-1}) Rn-222	2.111×10^{-6}	2.111×10^{-6}
Decay Constant (sec^{-1}) Rn-220	1.260×10^{-2}	1.260×10^{-2}

* Except when noted, these values are emphericalIy derived.

** Calculated from : 0.635x2.7 + 0.365x1 = 2.07 (sand)
0.600x3.8 + 0.400x1 = 2.68 (slime)

*** The diffusion coefficients were estimated from those quoted in the literature (10^{-6} cm^2/sec) for materials with high moisture content (NUREG/CR-1081). Because of the high moisture content of the sand and sediment, it is felt that these approximations are somewhat conservative.

- The tailings pile contains a volume of 636,000 ft^3 of material.
- The shape of the pile may be approximated as a frustum of a right cone whose height is 35 feet with radii of 50 and 100 feet.
- From the first two assumptions the area of the pile may be estimated at 28,761 ft^2.

Based on these assumptions and using equation 2.1-1 the maximum annual radon-222 release from the tailings pile, under present conditions is 0.92 Ci/yr. Assuming a weather reduction factor of 2/3 (mean monthly snowfall of greater than 5 inches) leads to an annual average flux of 0.61 Ci/yr.

Radon-220

Using the same equation and assumptions, the maximum annual release of radon-220 is estimated at 174 Ci/y. Multiplying by a weather reduction factor 215÷365 (150 days of 0.01 inch or more precipitation) leads to a source of 102 Ci/yr.

2.1.2 Radon Source Terms - Case 2

Radon-222

The one-time radon-222 source term released during the four weeks regrading of the tailings pile is estimated using the following data and assumptions.

- The radon-222 available for release is equal to $C = C_{Ra}\ E$ or 291 pCi/m^3.
- Approximately 50% of the 1800 9.5×10^6 cm^3 (636,000 ft^3) of the material will be moved.
- The pore space of the material is approximately 50%.

The one time radon-222 source term is calculated to be 0.3 Ci.

Radon-220

Because of mitigating measures to prevent dusting e.g., wetting the tails, no significant release of radon-220 is expected during this phase of reclamation.

2.1.3 Radon Source Terms - Case 3

Present tailings/sludge reclamation plans call for the residual materials to be formed into a single pile. The approximate dimensions of the pile will be 600 feet by 150 feet by 10 feet in height. Waste from the building demolition and metal parts from the processing facility will be placed along the sides of the pile. The resulting pile will be covered by 2 feet of compacted clay followed by 3 feet of top soil.

Radon-222

The radon-222 release term for the reclaimed pile plus cover material were calculated using Equation 2.1-1, a two-slab diffusion model (see Appendix A) and the following assumptions:

- o The loamy top soil bulk density is 1.6 gm/cm^3.
- o The radium-226 content of the topsoil and clay is 1.5 and 0.49 respectively.
- o The effective diffusion coefficient of the topsoil and clay is estimated at $5.0x10^{-3}$ cm^2/sec and $1x10^{-4}$ cm^2/sec.
- o The emanation coefficient of the topsoil and clay is 0.20 and 0.15.

Substituting in the equation in the appendix leads to a surface flux of approximately 0.49 pCi/m^2-sec or background. The principal reasons for this result is the high moisture content of the waste and the two foot thick clay cap. Thus, upon reclamation the source of radon is background or 0.13 Ci/y.

Although the calculations for radon-220 emissions are of a standard Ficken diffusion type, actual fluxes may be much smaller and may be governed by other phenomena. Experiments conducted by Druilhet, et. al., 1970 regarding radon-220 emanation as a function of soil moisture (natural soil) indicates that at an 18% moisture content the flux is below their threshold for detection (4 pCi/m^2-sec). Megumi and Mamuro (1973) also report radical decreases of radon-220 with soil moisture, a factor of 12 when the moisture content increases from 5 to 19%. As the material in question has a moisture content of about 40%, the calculated sources are considered very conservative.

2.2 Particulate Radionuclides

Particulate radionuclide source terms were developed only for Case 2, the relocation operation. The source terms were developed using the data presented in Tables 1 and 2 of Attachment 2 and the following assumptions:

- The dust emission rate cited in Table 2 of Attachment 2 is for particles <20 um all which are capable of migrating offsite.
- The radionuclide activity concentrations cited in Table 1 are equal to the activity concentration in the suspended dust.*
- 50% of the dust emission rate is attributable to the tailings, the other 50% is attributable to the sludge.
- The U-234 activity concentration in the dust emissions is equivalent to the U-238 activity concentration.

The calculated total particulate radionuclide activity emissions associated with residual material relocation operation are presented in Table 2.2-1. The total Th-232 emission is the sum of the average activity emissions calculated from Table 1 of Attachment 2. All emission values are based on 1440 hr emission period.

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* Updated values for Ra-224 and Ra-226 (Attachment 1) were used.

TABLE 2.2.-1

Total Particulate Radionuclide Activity Emissions - Case 2

Radionuclide	Activity Emission		Total Emission
	Sludge (pCi)	Tailings (pCi)	(pCi)
Pb-210	$1.95x10^{9}$	$1.90x10^{9}$	$3.85x10^{9}$
Pb-212	$3.97x10^{10}$	$3.44x10^{10}$	$7.41x10^{10}$
Pb-214	$2.04x10^{9}$	$8.74x10^{9}$	$1.11x10^{10}$
Ra-224	$5.33x10^{10}$	$2.74x10^{10}$	$8.07x10^{10}$
Ra-226	$2.71x10^{9}$	$1.15x10^{10}$	$1.42x10^{10}$
Ra-228	$5.61x10^{10}$	$3.03x10^{10}$	$8.64x10^{10}$
Th-228	$4.84x10^{10}$	$2.77x10^{10}$	$7.61x10^{10}$
Th-230	$4.84x10^{9}$	$5.19x10^{8}$	$5.36x10^{9}$
Th-232	$4.75x10^{10}$ $5.66x10^{10}$	$4.19x10^{9}$ $3.63x10^{9}$	$5.50x10^{10}$
U-234	$8.81x10^{10}$	$1.67x10^{10}$	$1.05x10^{11}$
U-238	$8.81x10^{10}$	$1.67x10^{10}$	$1.05x10^{11}$

3.0 DOSE ESTIMATES

3.1 Radiological Diffusion Model

The U.S. EPA program AIREM 3, is utilized in the determination of dose equivalents to the general population that result from atmospheric emission of radionuclides.(EPA, 1974) A standard, sector-averaged Gaussian diffusion equation is solved repeatedly for each radionuclide, with sector, stability class, and downwind distance. Radionuclide contributions to dose equivalents for as many as four critical organs are summed and printed by sector and downwind distance. Population dose equivalents (man-rem) are also calculated. The code accounts for the following physical processes: cloud diffusion, ground and inversion-lid reflections, radionuclide decay by time of flight, first daughter product buildup, ground deposition of particulates (independently), cloud depletion, in-plant holdup and decontamination factors, and sector-to-sector contributions to the external gamma dose. Dose conversions factors, provided as input data, are used for calculations of dose equivalents that are proportional to radionuclide concentrations in the cloud.

Idealization of all sources to point sources introduces singularities which result in calculations that are not reliable when near the source. This cannot be avoided and results should be interpreted accordingly. Dose equivalent estimates presented herein are in addition to the existing baseline radioactivity levels within the project site.

Table 3.1-1 lists the radionuclides and the associated adult whole body, bone and lung dose conversion factors used in the dose assessment. These values are based on the adult dose conversion factors presented in NUREG-0172 (1977). The Rn-222 dose conversion factor is based on the factor presented in USDA-FS-RZ-DES (1978). In all cases, an adult inhalation rate of 8,000 m^3/yr is assumed.

TABLE 3.1.-1

Dose Conversion Factors $\left(\frac{mrem - m3}{Ci - sec}\right)$

Radionuclide	Whole Body	Lung	Bone
U-238	.1440E+6	.1160E+8	.2403E+7
U-234	.1604E+6	.1320E+8	.2640E+7
Th-232	.2294E+7	.1512E+9	.6494E+9
Th-230	.1610E+8	.1580E+9	.5810E+9
Th-228	.1717E+7	.2562E+9	.5074E+8
Ra-228	.1213E+8	.4084E+8	.1119E+8
Ra-226	.2320E+8	.2970E+8	.3170E+8
Ra-224	.1004E+4	.2225E+7	.5022E+4
Pb-212	.1413E+4	.4433E+8	.4467E+8
Pb-210	.2123E+6	.6646E+7	.6697E+7
Rn-222		.3180E+5	

The source term release height for case 1 is 8 meters while the source term release height for cases 2 and 3 are 5 meters.

In addition to be compatible with the AIREM 3 capabilities, the source terms presented in Table 2.2-1 were modified by a factor of 0.164 to reflect a source that continuously emitted the radionuclides for a period of one year.

Appendices B, C and D contain the individual and population dose assessments for the cases of reference.

3.2 Individual 50-Year Dose Commitments*

Fifty-year dose commitments to an individual at the site boundary are developed. Table 3.2-1 through 3.2-3 present the fifty year dose commitment to the adult lung based on the radon sources calculated for each of the three cases.

The fifty-year dose commitments to organs of reference due to particulate radionuclide releases (case 2) are presented in Table 3.2-4. Review of the resulting dose commitments indicates present applicable dose guidelines are not to be exceeded.

3.3 Population Dose Commitments

Population dose commitments are estimated for sixteen compass directions out to a distance of 8036 meters (5 miles) from the site boundary. Table 3.3-1 presents the total population lung dose commitments for the three cases of reeference. The lung dose commitments developed for cases one and three are for radon only. The lung dose commitments developed for case 2 include radon plus particulate daughters. Table 3.3-2 presents the population dose commitments for the whole body and bone for Case 2.

---

* Give a one year dose or exposure.

TABLE 3.2-1

Individual Dose Commitments[1] to the Adult Lung at the Site Boundary as a Result of Radon Inhalation (Case 1)

Direction	Distance (m)	Dose Commitment (mrem)
N	122	2.93
NNE	131	3.96
NE	128	3.60
ENE	98	3.00
E	92	2.43
ESE	101	2.66
SE	128	2.09
SSE	232	1.41
S	213	1.30
SSW	232	1.82
SW	174	1.42
WSW	131	1.44
W	122	1.63
WNW	131	1.30
NW	171	0.79
NNW	131	1.91

[1] Fifty year commitment for 1 year dose.

TABLE 3.2-2

Individual Dose Commitments[1] to the Adult Lung at the Site Boundary as a Result of Rn-222 Inhalation (Case 2)

Direction	Distance (m)	Dose Commitment (mrem)
N	122	1.34
NNE	131	1.48
NE	128	1.36
ENE	98	1.31
E	92	1.17
ESE	101	1.19
SE	128	0.82
SSE	232	0.44
S	213	0.46
SSW	232	0.60
SW	174	0.44
WSW	131	0.47
W	122	0.58
WNW	131	0.48
NW	171	0.34
NNW	131	0.85

---

1 Fifty year commitment for 1 year dose.

TABLE 3.2-3

Individual Dose Commitments[1] to the Adult Lung at the Site Boundary as a Result of Radon Inhalation (Case 3)

Direction	Distance (m)	Dose Commitment (mrem)
N	122	0.13
NNE	131	0.14
NE	128	0.13
ENE	98	0.12
E	92	0.11
ESE	101	0.11
SE	128	0.08
SSE	232	0.04
S	213	0.04
SSW	232	0.06
SW	174	0.04
WSW	131	0.04
W	122	0.05
WNW	131	0.05
NW	171	0.03
NNW	131	0.08

[1] Fifty year commitment for 1 year dose.

TABLE 3.2-4

Critical Organ Dose Commitments at Site Boundary
Dose to Particulate Emission (Case 2)

Direction	Distance	Critical Organ Dose Commitment (mrem) Whole Body	Lung	Bone
N	122	8.82	179.97	224.60
NNE	131	9.76	198.80	248.50
NE	128	8.91	181.50	226.90
ENE	98	8.63	175.70	219.60
E	92	7.70	156.90	196.10
ESE	101	7.87	160.20	200.30
SE	128	7.50	110.30	137.90
SSE	232	2.90	59.10	73.87
S	213	2.99	71.92	76.12
SSW	232	3.93	80.06	100.10
SW	174	2.90	59.10	73.88
WSW	131	3.07	71.99	78.09
W	122	3.81	77.51	96.88
WNW	131	3.54	64.00	80.07
NW	171	2.21	45.10	56.37
NNW	131	5.60	114.00	14.26

TABLE 3.3-1

Total Population Lung Dose Commitments[a]
For Cases of Reference, (man-rem)

Distance (m)	Case 1	Case 2(b)	Case 3
300	0.00	0.00	0.00
600	0.00	0.00	0.00
1010	1.07	119.25	0.09
1609	1.07	119.25	0.09
3218	1.17	141.15	0.11
4828	1.21	149.90	0.11
6437	1.25	158.05	0.12
8036	1.28	163.95	0.13

(a) Sums all 16 compass directions.
(b) Includes radon plus particulate radionuclides.

TABLE 3.3-2

Total Population Whole Body and Bone Dose Commitments[a]
For Case 2, (man-rem)

Distance (m)	Whole Body	Bone
300	0	0
600	0	0
1010	5.86	149.20
1609	5.86	149.20
3218	6.93	176.66
4828	7.36	187.51
6437	7.76	197.70
8036	8.05	205.00

(a) Sums all 16 compass directions.

The comparison results indicate that reclamation (case 3) will result in approximately a ten fold decrease in the population lung dose commitment relative to the population lung dose commitment associated with Case 1.

Additional population dose commitment data are presented in Appendices B, C, and D.

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APPENDIX A

A.1 Radon Flux Attenuation By Cover Material

The model utilized to calculate the flux at the surface (J) of an infinite thickness of tailings covered by two finite thickness slabs (which are themselves radon flux sources) of differing diffusion properties is described by the following three diffusion equations:

$$\text{Layer 1:} \quad D_1 \frac{\partial^2 C_1}{\partial z^2} - \lambda C_1 + P_1 = 0$$

$$\text{Layer 2:} \quad D_2 \frac{\partial^2 C_2}{\partial z^2} - \lambda C_2 + P_2 = 0$$

$$\text{Tailings:} \quad D_3 \frac{\partial^2 C_3}{\partial z^2} - \lambda C_3 + P_3 = 0$$

where:

C_1, C_2, C_3 = Radon concentrations in the interstitial spaces of Cover layer 1, Cover layer 2, and Tailings, respectively.

D_1, D_2, D_3 = Effective diffusion coefficients of the three layers.

P_1, P_2, P_3 = Radon production rates in the three layers.

= Radon-222 decay constant = 2.1×10^{-6} $\sec^{-1}$

The six boundary conditions utilized are:

$$-D_1 \left.\frac{\partial C_1}{\partial z}\right|_{z = t_1} = -D_2 \left.\frac{\partial C_2}{\partial z}\right|_{z = t_1}$$

$$-D_2 \left.\frac{\partial C_2}{\partial z}\right|_{z = t_2} = -D_3 \left.\frac{\partial C_3}{\partial z}\right|_{z = t_2}$$

$$C_1 \ (z=t_1) = C_2 \ (z=t_1)$$

$$C_2 \ (z=t_2) = C_3 \ (z=t_2)$$

$$C_1 \ (z=0) = 0$$

$$\lim_{z \to} C_3 \ (Z) = J_3 / \lambda D_3$$

z -->

Solution of the three diffusion equations under the above boundary conditions yields a surface flux of:

$$J = \sqrt{D_1 D_2} \left\{ \frac{Bf\ (Ji) + Ag\ (Ji)}{\sqrt{D_2}\ B \sinh r_1 t_1 + \sqrt{D_1}\ A \cosh r_1 t_1} \right\}$$

where:

J_1, J_2, J_3 = The calculated surface fluxes for the materials if they were "infinite" in thickness.

$$f(Ji) = \frac{J_2}{\sqrt{D_2}} + \frac{J_1}{\sqrt{D_1}} \left(\cosh\ (r_1 t_1) - 1\right) + \left\{ \frac{J_3 \sqrt{D_2} - J_2 \sqrt{D_3}}{\sqrt{D_2\ D_3}} \right\} \cosh\ (r_2 t_2)$$

$$g(Ji) = \frac{J_1}{\sqrt{D_2}} \sinh\ (r_1 t_1) - \left\{ \frac{J_3 \sqrt{D_2} - J_2 \sqrt{D_3}}{D_2\ D_3} \right\} \sinh\ (r_2 t_2)$$

$$A = \sinh(r_2 t_2) + \sqrt{D_2/D_3}\,\cosh(r_2 t_2)$$

$$B = \cosh(r_2 t_2) + \sqrt{D_2/D_3}\,\sinh(r_2 t_2)$$

$$r_1 = \lambda/D_1$$

$$r_2 = \lambda/D_2$$

The unknown parameters within the model are the diffusion coefficient, of the tailings and the cover materials. The values selected for calculation of the flux are discussed in Section 2.1.

KERR-McGEE NUCLEAR CORPORATION
WEST CHICAGO STABILIZATION PLAN

APPENDIX B

INPUT DATA:

FACILITY	MONTHS	PERIOD	ENERGY
KERR CASE 1	0.0000/00/00	00/00/00	-0.00

SECTORS,STA.CLASSES,RADII,ISOTOPES,STACK HT.,INV.LIQ.HOLDUP(DAYS),RAIN FRAC,WASHOUT CO
16 6 6 2 .400E+01 .100E+04 0. .500E-01 .200E-03

WIND FREQ IN PERC BY STA. CLASS FOR EACH SECTOR AND TOTAL FREQUENCY

DIR	A	B	C	D	E	F	TOTAL
N	.01	.26	.76	2.03	2.50	2.91	8.46
NNE	.02	.32	1.19	3.44	3.48	3.21	11.66
NE	.02	.34	1.19	2.98	2.80	2.43	9.76
ENE	.03	.32	.83	2.33	2.30	2.68	8.49
E	.03	.25	.65	1.83	1.88	3.05	7.69
ESE	.02	.17	.66	2.28	2.10	2.53	7.77
SE	.02	.19	.47	1.72	1.75	1.39	5.54
SSE	.04	.14	.41	1.76	2.17	1.04	5.57
S	.01	.13	.35	1.44	1.87	1.16	4.97
SSW	.04	.22	.69	2.31	2.33	1.53	7.12
SW	.02	.23	.55	1.62	1.43	.74	4.59
WSW	.01	.18	.46	1.21	1.23	.57	3.66
W	.02	.17	.52	1.19	1.09	.70	3.68
WNW	.01	.15	.33	1.01	1.06	.79	3.34
NW	.02	.11	.29	.55	.64	.74	2.26
NNW	.01	.25	.54	1.23	1.38	2.05	5.46

WIND SPEEDS IN M/SEC BY STA.CLASS FOR EACH DIRECTION

DIR	A	B	C	D	E	F
N	2.42	2.88	4.12	5.92	5.40	2.94
NNE	2.21	3.09	4.32	6.53	5.92	3.26
NE	2.47	3.29	4.58	6.53	6.12	3.18
ENE	2.11	3.03	4.22	6.38	6.02	3.17
E	2.06	2.78	4.22	6.17	5.86	3.08
ESE	2.21	2.98	4.17	6.33	5.66	3.13
SE	1.85	2.83	4.06	6.12	5.66	3.06
SSE	2.21	2.93	4.22	6.53	5.86	3.13
S	2.21	2.88	3.96	5.92	5.61	2.87
SSW	2.16	2.98	4.63	6.17	5.76	3.07
SW	2.16	2.98	4.88	5.81	5.76	3.03
WSW	2.05	3.29	4.32	5.56	5.76	3.16
W	2.05	3.19	4.32	5.50	5.09	3.24
WNW	2.42	2.98	4.01	5.25	5.04	3.01
NW	2.42	2.83	3.76	4.84	4.48	2.62
NNW	2.16	2.98	4.01	5.14	4.94	2.85

POPULATIONS IN SEGMENTS, TWO LINES PER RADIUS (READ CLOCKWISE), AND TOTAL POPULATION IN ANNULI

1	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	1200.	1500.	800.	400.	500.	400.	200.	300.	
	300.	50.	300.	100.	100.	1000.	1000.	1200.	9950.
4	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	400.	1500.	1500.	2000.	800.	1000.	100.	400.	
	25.	100.	25.	10.	400.	1000.	100.	400.	10160.
6	400.	100.	1500.	50.	2000.	1500.	800.	1500.	
	1000.	100.	10.	10.	50.	50.	400.	800.	10670.
7	2500.	500.	400.	1500.	3000.	3000.	800.	2500.	
	400.	100.	100.	200.	800.	800.	200.	300.	17100.
8	1500.	200.	1500.	2500.	3000.	1000.	800.	3000.	
	400.	100.	50.	3000.	3000.	3000.	100.	100.	23250.

DISTANCES IN METERS : MIDPOINT, LOWER AND UPPER OF BINS

MM	X	XLOW	XUP
1	150.	0.	300.
2	450.	300.	600.
3	805.	600.	1010.
4	1359.	1010.	1609.
5	2413.	1609.	3219.
6	4023.	3218.	4828.
7	5632.	4828.	6437.
8	7241.	6437.	8046.

PARTICLE AND HALOGEN DEPOSITION VEL EXPANSION COEFF

.500E-02	.500E-02	.500E-02	.500E-02	.500E-02	.500E-02
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
.200E-01	.200E-01	.200E-01	.200E-01	.200E-01	.200E-01
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

NUMBER OF ISOTOPES PER SET OF ORGANS

0 2 0 0

LL	ISOTOPE	ORGAN	DCF	LAMDA	NDEP	NGAM	NOTH	SOURCE	DEC FACTOR
1	RN 222	LUNG	.318E+05	.210E-05	0	0	0	.730E+00 CI	0.00DEC
2	RN 220	LUNG	.318E+04	.126E-01	0	0	0	.109E+03 CI	0.00DEC

OUTPUT DATA:

SIGMA ZEE'S BY STABILITY CLASS AND RADIUS

A	B	C	D	E	F
.214E+02	.155E+02	.108E+02	.682E+01	.494E+01	.326E+01
.897E+02	.470E+02	.295E+02	.167E+02	.120E+02	.788E+01
.244E+03	.862E+02	.501E+02	.250E+02	.183E+02	.119E+02
.490E+03	.151E+03	.810E+02	.340E+02	.261E+02	.168E+02
.241E+04	.261E+03	.137E+03	.555E+02	.374E+02	.237E+02
.409E+04	.444E+03	.218E+03	.792E+02	.502E+02	.311E+02
.100E+05	.720E+03	.297E+03	.979E+02	.602E+02	.367E+02
.100E+05	.957E+03	.374E+03	.114E+03	.685E+02	.412E+02

CHIQ SUMMED OVER STA.CLASSES

N	.113E-04	.596E-05	.268E-05	.121E-05	.499E-06	.228E-06	.138E-06	.950E-07
NNE	.151E-04	.692E-05	.305E-05	.137E-05	.558E-06	.254E-06	.153E-06	.105E-06
NE	.129E-04	.558E-05	.245E-05	.109E-05	.444E-06	.201E-06	.121E-06	.832E-07
ENE	.110E-04	.531E-05	.237E-05	.107E-05	.437E-06	.199E-06	.120E-06	.827E-07
E	.962E-05	.539E-05	.245E-05	.111E-05	.459E-06	.211E-06	.127E-06	.879E-07
ESE	.109E-04	.505E-05	.226E-05	.102E-05	.418E-06	.191E-06	.115E-06	.794E-07
SE	.773E-05	.340E-05	.149E-05	.664E-06	.271E-06	.123E-06	.739E-07	.508E-07
SSE	.751E-05	.304E-05	.131E-05	.577E-06	.234E-06	.106E-06	.635E-07	.435E-07
S	.701E-05	.316E-05	.139E-05	.618E-06	.252E-06	.115E-06	.689E-07	.474E-07
SSW	.947E-05	.412E-05	.179E-05	.795E-06	.323E-06	.146E-06	.874E-07	.603E-07
SW	.645E-05	.251E-05	.107E-05	.467E-06	.188E-06	.844E-07	.503E-07	.344E-07
WSW	.557E-05	.200E-05	.844E-06	.369E-06	.148E-06	.666E-07	.397E-07	.271E-07
W	.574E-05	.213E-05	.908E-06	.398E-06	.160E-06	.722E-07	.431E-07	.295E-07
WNW	.521E-05	.215E-05	.935E-06	.415E-06	.168E-06	.762E-07	.457E-07	.314E-07
NW	.353E-05	.179E-05	.799E-06	.359E-06	.147E-06	.673E-07	.406E-07	.280E-07
NNW	.791E-05	.415E-05	.187E-05	.846E-06	.348E-06	.159E-06	.962E-07	.664E-07

AVERAGE ACTIVITY IN AIR. RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF RN 222

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.2627E+00	.3503E+00	.2975E+00	.2544E+00	.2226E+00	.2319E+00	.1790E+00	.1738E+00
450.	.1379E+00	.1601E+00	.1291E+00	.1230E+00	.1246E+00	.1168E+00	.7861E-01	.7025E-01
805.	.6211E-01	.7067E-01	.5658E-01	.5486E-01	.5671E-01	.5231E-01	.3447E-01	.3023E-01
1359.	.2803E-01	.3159E-01	.2520E-01	.2464E-01	.2571E-01	.2355E-01	.1536E-01	.1336E-01
2413.	.1152E-01	.1290E-01	.1026E-01	.1009E-01	.1061E-01	.9665E-02	.6257E-02	.5412E-02
4023.	.5264E-02	.5864E-02	.4653E-02	.4603E-02	.4863E-02	.4413E-02	.2841E-02	.2447E-02
5632.	.3176E-02	.3523E-02	.2791E-02	.2770E-02	.2936E-02	.2658E-02	.1705E-02	.1465E-02
7241.	.2189E-02	.2422E-02	.1917E-02	.1907E-02	.2027E-02	.1831E-02	.1172E-02	.1004E-02

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.1622E+00	.2284E+00	.1608E+00	.1290E+00	.1341E+00	.1205E+00	.8397E-01	.1830E+00
450.	.7302E-01	.9544E-01	.5818E-01	.4623E-01	.4938E-01	.4987E-01	.4137E-01	.9607E-01
805.	.3204E-01	.4146E-01	.2466E-01	.1954E-01	.2100E-01	.2164E-01	.1848E-01	.4334E-01
1359.	.1429E-01	.1840E-01	.1080E-01	.8544E-02	.9215E-02	.9595E-02	.8305E-02	.1957E-01
2413.	.5828E-02	.7470E-02	.4340E-02	.3428E-02	.3707E-02	.3892E-02	.3406E-02	.8050E-02
4023.	.2648E-02	.3383E-02	.1949E-02	.1538E-02	.1667E-02	.1761E-02	.1554E-02	.3681E-02
5632.	.1590E-02	.2027E-02	.1162E-02	.9158E-03	.9943E-03	.1055E-02	.9356E-03	.2220E-02
7241.	.1093E-02	.1391E-02	.7942E-03	.6257E-03	.6801E-03	.7234E-03	.6444E-03	.1530E-02

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF RN 220

DISTANCE	N	XNE	NE	ENE	F	ESE	SF	SSF
150.	.2584E+02	.36[illegible]7E+02	.3082E+02	.2569E+02	.2194E+02	.2348E+02	.1801E+02	.1809E+02
450.	.4771E+01	.6684E+01	.5459E+01	.4798E+01	.4368E+01	.4457E+01	.3129E+01	.3248E+01
805.	.7143E+00	.1123E+01	.4258E+00	.7819E+00	.6720E+00	.7127E+00	.5092E+00	.5722E+00
1359.	.7189E-01	.1301E+00	.1105E+00	.8789E-01	.6949E-01	.7721E-01	.5679E-01	.6999E-01
2413.	.2353E-02	.5338E-02	.4770E-02	.3547E-02	.2545E-02	.2902E-02	.2125E-02	.2941E-02
4023.	.2751E-04	.8814E-04	.8282E-04	.5753E-04	.3711E-04	.4296E-04	.2932E-04	.4770E-04
5632.	.4576E-06	.2028E-05	.1973E-05	.1282E-05	.7453E-06	.8938E-06	.5555E-06	.1075E-05
7241.	.8874E-08	.5494E-07	.5470E-07	.3313E-07	.1735E-07	.2203E-07	.1230E-07	.2863E-07

DISTANCE	S	SSW	SW	*SW	*	WNW	NW	NNW
150.	.1632E+02	.2346E+02	.1635E+02	.1314E+02	.1338E+02	.1181E+02	.7730E+01	.1730E+02
450.	.2841E+01	.4021E+01	.2507E+01	.2024E+01	.2016E+01	.1853E+01	.1179E+01	.2959E+01
805.	.4601E+00	.6726E+00	.4160E+00	.3348E+00	.3133E+00	.2766E+00	.1513E+00	.4027E+00
1359.	.5134E-01	.7783E-01	.4760E-01	.3756E-01	.3129E-01	.2630E-01	.1185E-01	.3396E-01
2413.	.1875E-02	.3031E-02	.1764E-02	.1332E-02	.8965E-03	.7051E-03	.2386E-03	.8140E-03
4023.	.2492E-04	.4350E-04	.2294E-04	.1641E-04	.8304E-05	.5839E-05	.1318E-05	.6136E-05
5632.	.4127E-06	.8543E-06	.4037E-06	.2755E-06	.1076E-06	.6619E-07	.1013E-07	.6383E-07
7241.	.8247E-08	.1956E-07	.9194E-08	.5357E-08	.1643E-08	.8697E-09	.9187E-10	.7703E-09

DOSE TO AN INDIVIDUAL IN THE INDICATED SECTOR AND ANNULAR RING(MREM)

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.2855E+01	.3968E+01	.3389E+01	.2832E+01	.2424E+01	.2587E+01	.1986E+01	.1989E+01
450.	.6167E+00	.8308E+00	.6769E+00	.6045E+00	.5630E+00	.5641E+00	.3926E+00	.3961E+00
805.	.1343E+00	.1835E+00	.1496E+00	.1334E+00	.1243E+00	.1239E+00	.8563E-01	.8770E-01
1350.	.3532E-01	.4472E-01	.3636E-01	.3352E-01	.3275E-01	.3136E-01	.2110E-01	.2042E-01
2413.	.1179E-01	.1347E-01	.1076E-01	.1048E-01	.1089E-01	.9984E-02	.6488E-02	.5722E-02
4023.	.5286E-02	.5889E-02	.4675E-02	.4621E-02	.4880E-02	.4429E-02	.2852E-02	.2459E-02
5632.	.3185E-02	.3533E-02	.2799E-02	.2778E-02	.2945E-02	.2665E-02	.1710E-02	.1469E-02
7241.	.2196E-02	.2429E-02	.1923E-02	.1913E-02	.2033E-02	.1836E-02	.1175E-02	.1007E-02

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.1799E+01	.2582E+01	.1901E+01	.1447E+01	.1477E+01	.1305E+01	.8594E+00	.1918E+01
450.	.3582E+00	.4989E+00	.3098E+00	.2493E+00	.2517E+00	.2359E+00	.1597E+00	.3930E+00
805.	.7827E-01	.1090E+00	.6646E-01	.5317E-01	.5248E-01	.4944E-01	.3370E-01	.8345E-01
1350.	.1948E-01	.2625E-01	.1561E-01	.1233E-01	.1238E-01	.1226E-01	.9517E-02	.2303E-01
2413.	.6032E-02	.7795E-02	.4529E-02	.3571E-02	.3808E-02	.3974E-02	.3439E-02	.8154E-02
4023.	.2658E-02	.3397E-02	.1957E-02	.1544E-02	.1672E-02	.1766E-02	.1558E-02	.3692E-02
5632.	.1594E-02	.2033E-02	.1165E-02	.9184E-03	.9971E-03	.1058E-02	.9383E-03	.2226E-02
7241.	.1096E-02	.1395E-02	.7965E-03	.6274E-03	.6820E-03	.7255E-03	.6462E-03	.1535E-02

POPULATION DOSE IN THE INDICATED SECTOR AND ANNULAR RING(MAN-REM)

DIS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	RUNNING TOTAL
400.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
600.	0.00	0.00	0.00	0.00	0.00	0.[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1010.	.16	.28	.12	.11	.06	.05	.02	.03	.02	.01	.02	.02	.01	.05	.03	.10	1.07
1609.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07
3218.	.01	.02	.02	.02	.01	.01	.0[illegible]	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.17
4828.	.00	.00	.01	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.21
6437.	.01	.00	.00	.00	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.25
8046.	.00	.00	.00	.00	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.28

THE CONTRIBUTING RADIONUCLIDES ARE

ISOTOPE	CRT ORGAN	DCF	CURIES RELEASED	DECAY CONSTANT (1/SEC)	DECON FACTOR
RN 222	LUNG	.3180E+05	.7300E+00	.210E-05	.100E+01
RN 220	LUNG	.3180E+04	.1093E+03	.126E-01	.100E+01

TOTAL CI.= .1100E+03

PROBLEM SUMMARY

FACILITY	PERIOD FROM	PERIOD TO	ENERGY (MWD(TH))
KERR CASE 1	00/00/00	00/00/00	-0.

MONTHS OF OPERATION	TOTAL FREQUENCY	TOTAL POPULATION	HOLDUP (DAYS)	HEFF (METERS)
0.00	100.0	71130.	0.0	8.

RADIONUCLIDE CONTRIBUTIONS TO POPULATION DOSES ARE

RN 222	LUNG	.66 MAN-REM
RN 220	LUNG	.62 MAN-REM

APPENDIX C

RELOCATION OPERATIONS
RADON/PARTICULATES - CASE 2

PREPARED FOR:

KERR-McGEE NUCLEAR CORPORATION
Kerr-McGEE BUILDING
OKLAHOMA CITY, OKLAHOMA 73125

PREPARED BY:

DAMES & MOORE
20 HAARLEM AVENUE
WHITE PLAINS, NEW YORK 10603

April 25, 1980

INPUT DATA:

FACILITY MONTHS PERIOD ENERGY
FOR CASE 2 0.0000/00/00 00/00/00 --.00

SECTORS.STA.CLASSES.RADII.ISOTOPES.STACK HT..INV.LID.HLDUP(DAYS).RAIN FRAC.WASHOUT CO
16 6 8 31 .500E+01 .100E+04 0. .500E-01 .200E-03

WIND FREQ IN PERC BY STA. CLASS FOR EACH SECTOR AND TOTAL FREQUENCY

DIR	A	B	C	D	E	F	TOTAL
N	.01	.26	.76	2.93	2.50	2.91	8.46
NNE	.02	.32	1.19	3.44	3.44	3.21	11.66
NE	.02	.34	1.19	2.94	2.40	2.43	9.76
ENE	.03	.32	.83	2.33	2.30	2.68	8.49
E	.04	.25	.55	1.83	1.88	3.05	7.69
ESE	.02	.17	.65	2.29	2.10	2.53	7.77
SE	.02	.19	.47	1.72	1.75	1.39	5.54
SSE	.04	.14	.41	1.76	2.17	1.04	5.57
S	.03	.13	.35	1.44	1.87	1.16	4.97
SSW	.04	.22	.69	2.31	2.33	1.53	7.12
SW	.02	.23	.55	1.62	1.43	.74	4.59
WSW	.00	.18	.40	1.21	1.23	.57	3.66
W	.02	.17	.52	1.19	1.09	.70	3.68
WNW	.01	.15	.33	1.01	1.06	.78	3.34
NW	.02	.11	.20	.55	.64	.74	2.26
NNW	.01	.25	.54	1.23	1.38	2.05	5.46

WIND SPEEDS IN M/SEC BY STA.CLASS FOR EACH DIRECTION

DIR	A	B	C	D	E	F
N	2.42	2.98	4.12	5.92	5.43	2.44
NNE	2.21	3.09	4.32	6.51	5.92	3.26
NE	2.47	3.29	4.53	6.53	6.12	3.18
ENE	2.11	3.03	4.22	6.38	6.02	3.17
E	2.06	2.78	4.22	6.17	5.86	[illegible]
ESE	2.21	2.98	4.17	6.33	5.66	3.13
SE	1.85	2.83	4.06	6.12	5.66	3.16
SSE	2.21	2.33	4.22	6.53	5.86	3.33
S	2.21	2.88	3.86	5.92	5.62	2.67
SSW	2.16	2.98	4.63	6.17	5.76	[illegible]
SW	2.16	2.98	4.48	5.81	5.75	[illegible]
WSW	2.05	3.29	4.32	5.56	5.76	3.15
W	2.05	3.19	4.32	5.50	5.09	3.24
WNW	2.42	2.93	4.01	5.25	5.04	3.01
NW	2.42	2.43	3.76	4.84	4.43	[illegible]
NNW	2.16	2.98	4.01	5.14	4.94	2.45

POPULATIONS IN SEGMENTS, TWO LINES PER RADIUS (READ CLOCKWISE), AND TOTAL POPULATION IN ANNULI

1	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	1200.	1500.	800.	400.	500.	400.	200.	300.	
	300.	50.	300.	300.	100.	1000.	1000.	1200.	9950.
4	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	800.	1500.	1500.	2000.	800.	1000.	100.	400.	
	25.	100.	25.	10.	400.	1000.	100.	400.	10160.
6	800.	100.	1500.	50.	2000.	1500.	800.	1500.	
	1000.	100.	10.	10.	50.	50.	400.	800.	10670.
7	2500.	500.	400.	1500.	3000.	3000.	800.	2500.	
	400.	100.	100.	200.	800.	800.	200.	300.	17100.
8	1500.	200.	1500.	2500.	3000.	1000.	800.	3000.	
	400.	100.	50.	3900.	3000.	3000.	100.	100.	23250.

DISTANCES IN METERS : MIDPOINT, LOWER AND UPPER OF BINS

RM	X	XLOW	XUP
1	150.	0.	300.
2	450.	300.	600.
3	805.	600.	1010.
4	1309.	1010.	1609.
5	2413.	1609.	3218.
6	4023.	3218.	4828.
7	5632.	4828.	6437.
8	7241.	6437.	8045.

PARTICLE AND HALOGEN DEPOSITION VEL EXPANSION COEFF

.500E-02	.500E-02	.500E-02	.500E-02	.500E-02	.500E-02
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
.200E-01	.200E-01	.200E-01	.200E-01	.200E-01	.200E-01
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

NUMBER OF ISOTOPES PER SET OF ORGANS
10 11 10 0

IC	ISOTOPE	ORGAN	DCF	LAMDA	NDEP	NGAM	NOTH	SOURCE	DEC FACTOR
1	U 238	WB	.144E+06	.490E-17	1	0	0	.170E-01 CI	0.00DEC
2	U 234	WB	.160E+06	.890E-13	1	0	0	.170E-01 CI	0.00DEC
3	TH 232	WB	.229E+07	.157E-17	1	0	0	.900E-02 CI	0.00DEC
4	TH 230	WB	.161E+08	.275E-12	1	0	0	.880E-03 CI	0.00DEC
5	TH 228	WB	.172E+07	.115E-07	1	0	0	.125E-01 CI	0.00DEC
6	RA 228	WB	.121E+08	.328E-08	1	0	0	.142E-01 CI	0.00DEC
7	RA 226	WB	.232E+09	.136E-10	1	0	0	.230E-02 CI	0.00DEC
8	RA 224	WB	.100E+04	.220E-05	1	0	0	.132E-01 CI	0.00DEC
9	PB 212	WB	.141E+04	.181E-04	1	0	0	.122E-01 CI	0.00DEC
10	PB 210	WB	.212E+06	.113E-08	1	0	0	.630E-03 CI	0.00DEC
11	RN 222	LUNG	.414E+05	.210E-05	0	0	0	.137E+01 CI	0.00DEC
12	U 238	LUNG	.116E+08	.490E-17	1	0	0	.170E-01 CI	0.00DEC
13	U 234	LUNG	.132E+08	.890E-13	1	0	0	.170E-01 CI	0.00DEC
14	TH 232	LUNG	.151E+09	.157E-17	1	0	0	.900E-02 CI	0.00DEC
15	TH 230	LUNG	.158E+09	.275E-12	1	0	0	.880E-03 CI	0.00DEC
16	TH 228	LUNG	.256E+09	.115E-07	1	0	0	.125E-01 CI	0.00DEC
17	RA 228	LUNG	.408E+08	.328E-08	1	0	0	.142E-01 CI	0.00DEC
18	RA 226	LUNG	.297E+08	.136E-10	1	0	0	.230E-02 CI	0.00DEC
19	RA 224	LUNG	.222E+07	.220E-05	1	0	0	.132E-01 CI	0.00DEC
20	PB 212	LUNG	.443E+05	.181E-04	1	0	0	.122E-01 CI	0.00DEC
21	PB 210	LUNG	.665E+07	.113E-08	1	0	0	.630E-03 CI	0.00DEC
22	U 238	BONE	.240E+07	.490E-17	1	0	0	.170E-01 CI	0.00DEC
23	U 234	BONE	.264E+07	.890E-13	1	0	0	.170E-01 CI	0.00DEC
24	TH 232	BONE	.649E+09	.157E-17	1	0	0	.900E-02 CI	0.00DEC
25	TH 230	BONE	.581E+09	.275E-12	1	0	0	.880E-03 CI	0.00DEC
26	TH 228	BONE	.507E+08	.115E-07	1	0	0	.125E-01 CI	0.00DEC
27	RA 228	BONE	.112E+08	.328E-08	1	0	0	.142E-01 CI	0.00DEC
28	RA 226	BONE	.317E+09	.136E-10	1	0	0	.230E-02 CI	0.00DEC
29	RA 224	BONE	.502E+04	.220E-05	1	0	0	.132E-01 CI	0.00DEC
30	PB 212	BONE	.447E+05	.181E-04	1	0	0	.122E-01 CI	0.00DEC
31	PB 210	BONE	.670E+07	.113E-08	1	0	0	.630E-03 CI	0.00DEC

OUTPUT DATA:

SIGMA ZEROS BY STABILITY CLASS AND RADIUS

A	B	C	D	E	F
.214E+02	.153E+02	.108E+02	.582E+01	.494E+01	.326E+01
.947E+02	.670E+02	.249E+02	.157E+02	.120E+02	.788E+01
.284E+03	[illegible]	.501E+02	[illegible]	.183E+02	.119E+02
.870E+03	.151E+03	.910E+02	.459E+02	.265E+02	.168E+02
.291E+04	.281E+03	.137E+03	.595E+02	.374E+02	.237E+02
.104E+05	.444E+03	.216E+03	.742E+02	.504E+02	.311E+02
.109E+05	.720E+03	.297E+03	.974E+02	.602E+02	.367E+02
.100E+05	.957E+03	.374E+03	.119E+03	.685E+02	.412E+02

CHI/Q SUMMED OVER STA.CLASSES

N	.283E-04	.746E-05	.247E-05	.120E-05	.512E-06	.232E-06	.139E-06	.959E-07
NNE	.340E-04	.852E-05	.336E-05	.143E-05	.572E-06	.258E-06	.154E-06	.105E-06
NE	.263E-04	.684E-05	.264E-05	.114E-05	.455E-06	.204E-06	.122E-06	.910E-07
ENE	.250E-04	.662E-05	.262E-05	.112E-05	.448E-06	.202E-06	.121E-06	.835E-07
E	.258E-04	.634E-05	.274E-05	.117E-05	.472E-06	.214E-06	.124E-06	.844E-07
ESE	.240E-04	.510E-05	.250E-05	.107E-05	.424E-06	.194E-06	.116E-06	.491E-07
SE	.171E-04	.416E-05	.163E-05	.696E-06	.277E-06	.125E-06	.747E-07	.512E-07
SSE	.159E-04	.384E-05	.142E-05	.603E-06	.230E-06	.107E-06	.640E-07	.434E-07
S	.150E-04	.346E-05	.152E-05	.647E-06	.258E-06	.116E-06	.694E-07	.478E-07
SSW	.211E-04	.500E-05	.195E-05	.832E-06	.331E-06	.148E-06	.887E-07	.618E-07
SW	.134E-04	.290E-05	.115E-05	.484E-06	.192E-06	.854E-07	.504E-07	.347E-07
WSW	.100E-04	.246E-05	.912E-06	.386E-06	.151E-06	.673E-07	.403E-07	.273E-07
W	.114E-04	.254E-05	.983E-06	.415E-06	.164E-06	.731E-07	.435E-07	.297E-07
WNW	.119E-04	.261E-05	.102E-05	.434E-06	.172E-06	.773E-07	.461E-07	.316E-07
NW	.953E-05	.224E-05	.882E-06	.376E-06	.151E-06	.684E-07	.410E-07	.282E-07
NNW	.173E-04	.522E-05	.209E-05	.893E-06	.358E-06	.162E-06	.373E-07	.670E-07

ACTIVITY DEPOSIT AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF U 234
DRY DEPOSITION

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	2404.	2912.	2134.	2142.	2125.	2059.	1451.	1342.	.1767E+05
450.	614.	703.	563.	545.	562.	519.	342.	301.	.5301E+05
805.	236.	263.	215.	209.	217.	200.	131.	115.	.1296E+06
1359.	98.	112.	89.	87.	90.	83.	59.	47.	.3080E+06
2413.	38.	43.	36.	36.	35.	32.	21.	18.	.1525E+07
4023.	16.	19.	15.	14.	15.	14.	9.	8.	.2544E+07
5632.	9.	10.	8.	8.	8.	8.	5.	4.	.3559E+07
7241.	6.	7.	5.	5.	6.	5.	4.	3.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	1362.	1793.	1149.	917.	868.	939.	735.	1669.	.4662E-03
450.	317.	412.	246.	195.	210.	215.	182.	428.	.8031E-03
805.	121.	157.	93.	73.	79.	82.	70.	165.	.1118E-02
1359.	50.	65.	38.	40.	33.	34.	29.	68.	.1429E-02
2413.	19.	25.	15.	12.	12.	13.	11.	26.	.2022E-02
4023.	8.	11.	6.	5.	5.	5.	5.	11.	.2441E-02
5632.	5.	6.	4.	3.	3.	3.	3.	6.	.2774E-02
7241.	3.	4.	2.	2.	2.	2.	2.	4.	.3057E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF U 234
WET DEPOSITION- WASHOUT= .200E-03 RAINF= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	59.	71.	54.	55.	53.	51.	36.	32.	.1767E+05
450.	19.	23.	19.	18.	18.	17.	13.	11.	.5301E+05
805.	11.	13.	11.	10.	10.	9.	6.	6.	.1296E+06
1359.	6.	7.	6.	6.	6.	5.	4.	3.	.3080E+06
2413.	3.	4.	3.	3.	3.	3.	2.	2.	.1525E+07
4023.	2.	2.	2.	2.	2.	2.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	1.	1.	.3559E+07
7241.	1.	1.	1.	1.	1.	1.	1.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	32.	41.	28.	22.	24.	23.	18.	42.	.1145E-04
450.	11.	14.	9.	7.	8.	8.	6.	14.	.2274E-04
805.	6.	8.	5.	4.	4.	4.	3.	8.	.3789E-04
1359.	3.	5.	3.	2.	2.	2.	2.	4.	.5863E-04
2413.	2.	2.	2.	1.	1.	1.	1.	2.	.1135E-03
4023.	1.	1.	1.	1.	1.	1.	1.	1.	.1643E-03
5632.	1.	1.	1.	0.	0.	0.	0.	1.	.2112E-03
7241.	0.	1.	0.	0.	0.	0.	0.	1.	.2546E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF U 234
DRY DEPOSITION

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	2904.	2912.	2344.	2192.	2125.	2059.	1451.	1342.	.1767E+05
450.	614.	703.	563.	565.	562.	519.	342.	301.	.5301E+05
805.	236.	269.	215.	209.	217.	208.	131.	115.	.1296E+06
1359.	98.	112.	89.	87.	90.	83.	54.	47.	.3080E+06
2413.	38.	41.	34.	34.	35.	32.	21.	18.	.1525E+07
4023.	16.	18.	15.	14.	15.	14.	9.	8.	.2544E+07
5632.	9.	10.	8.	8.	8.	8.	5.	4.	.3559E+07
7241.	6.	7.	5.	5.	6.	5.	3.	3.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	1362.	1793.	1148.	917.	968.	939.	735.	1669.	.4662E-03
450.	317.	412.	246.	195.	210.	215.	182.	428.	.8031E-03
805.	121.	157.	73.	73.	79.	82.	70.	165.	.1118E-02
1359.	50.	65.	39.	33.	33.	34.	29.	68.	.1429E-02
2413.	14.	25.	15.	12.	12.	13.	11.	26.	.2022E-02
4023.	8.	11.	6.	5.	5.	5.	5.	11.	.2441E-02
5632.	5.	6.	4.	3.	3.	3.	3.	6.	.2774E-02
7241.	3.	4.	2.	2.	2.	2.	2.	4.	.3057E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF U 234
WET DEPOSITION-- WASHCO= .200E-03 WAINF= .500E-01

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	59.	71.	69.	55.	53.	51.	36.	32.	.1767E+05
450.	19.	23.	19.	14.	18.	17.	12.	11.	.5301E+05
805.	11.	13.	11.	13.	10.	9.	6.	6.	.1296E+06
1359.	6.	7.	6.	6.	6.	5.	4.	3.	.3080E+06
2413.	3.	4.	3.	4.	3.	3.	2.	2.	.1525E+07
4023.	2.	2.	2	2.	2.	2.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	1.	1.	.3559E+07
7241.	1.	1.	1.	1.	1.	1.	1.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	32.	43.	28.	22.	24.	23.	18.	42.	.1145E-04
450.	11.	14.	9.	7.	8.	8.	6.	14.	.2274E-04
805.	6.	8.	5.	4.	4.	4.	3.	8.	.3789E-04
1359.	3.	5.	3.	2.	2.	2.	2.	4.	.5863E-04
2413.	2.	2.	2.	1.	1.	1.	1.	2.	.1135E-03
4023.	1.	1.	1.	1.	1.	1.	1.	1.	.1643E-03
5632.	1.	1.	1.	0.	0.	0.	0.	1.	.2112E-03
7241.	0.	1.	0.	0.	0.	0.	0.	1.	.2546E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF TH-232
DRY DEPOSITION

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	1272.	1542.	1262.	1169.	1125.	1090.	768.	711.	.1767E+05
450.	325.	472.	[illegible]	249.	247.	275.	181.	159.	.5301E+05
805.	125.	143.	114.	111.	115.	106.	69.	61.	.1296E+06
1359.	52.	59.	47.	45.	48.	44.	29.	25.	.3080E+06
2413.	20.	23.	18.	18.	19.	17.	11.	10.	.1525E+07
4023.	9.	10.	[illegible]	8.	8.	7.	5.	4.	.2544E+07
5632.	5.	6.	4.	4.	4.	[illegible]	3.	2.	.3559E+07
7241.	3.	4.	3.	3.	3.	3.	2.	2.	.4576E+07

	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	719.	949.	609.	445.	513.	497.	389.	884.	.2468E-03
450.	168.	218.	139.	103.	111.	114.	96.	227.	.4252E-03
805.	64.	81.	49.	39.	42.	43.	37.	87.	.5920E-03
1359.	27.	34.	20.	15.	17.	18.	15.	36.	.7563E-03
2413.	10.	13.	8.	6.	7.	7.	5.	14.	.1071E-02
4023.	4.	6.	3.	3.	3.	3.	2.	6.	.1292E-02
5632.	2.	3.	2.	1.	2.	2.	1.	3.	.1464E-02
7241.	2.	2.	1.	1.	1.	1.	1.	2.	.1618E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
(PICOCURIES/M**2) OF TH 232
WET DEPOSITION- WASHCO= .200E-03 WAIWE= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	31.	30.	31.	29.	28.	27.	19.	17.	.1767E+05
450.	10.	12.	10.	10.	9.	9.	6.	6.	.5301E+05
805.	6.	7.	6.	5.	5.	5.	3.	3.	.1296E+06
1359.	3.	4.	3.	3.	3.	3.	2.	2.	.3080E+06
2413.	2.	2.	2.	2.	2.	1.	1.	1.	.1525E+07
4023.	1.	1.	1.	1.	1.	1.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	0.	0.	.3559E+07
7241.	0.	1.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	17.	21.	15.	12.	13.	12.	10.	22.	.6064E-05
450.	6.	8.	6.	4.	4.	4.	3.	7.	.1204E-04
805.	3.	4.	3.	2.	2.	2.	2.	4.	.2006E-04
1359.	2.	2.	2.	1.	1.	1.	1.	2.	.3104E-04
2413.	1.	1.	1.	1.	1.	1.	1.	1.	.6011E-04
4023.	1.	1.	0.	0.	0.	0.	0.	1.	.8698E-04
5632.	0.	0.	0.	0.	0.	0.	0.	1.	.1118E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1348E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
(MICROCURIES/M**2) OF TH 230
DRY DEPOSITION

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	124.	151.	123.	113.	110.	107.	75.	69.	.1747E+05
450.	32.	36.	29.	28.	29.	27.	18.	16.	.5301E+05
805.	12.	14.	11.	11.	11.	10.	7.	6.	.1296E+06
1359.	5.	5.	5.	5.	5.	4.	3.	2.	.3080E+06
2413.	2.	2.	2.	2.	2.	2.	1.	1.	.1525E+07
4023.	1.	1.	1.	1.	1.	1.	0.	0.	.2544E+07
5632.	0.	1.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	69.	93.	59.	47.	51.	49.	38.	86.	.2413E-04
450.	16.	21.	13.	10.	11.	11.	9.	22.	.4157E-04
805.	6.	8.	5.	4.	4.	4.	4.	9.	.5789E-04
1359.	3.	3.	2.	2.	2.	2.	1.	4.	.7395E-04
2413.	1.	1.	1.	1.	1.	1.	1.	1.	.1047E-03
4023.	0.	1.	0.	0.	0.	0.	0.	1.	.1263E-03
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1436E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1582E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE

PICOCURIES/M**2 OF TH 230

WET DEPOSITION - WASHOUT= .200E-03 RAINF= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	3.	4.	3.	3.	3.	3.	2.	2.	.1767E+05
450.	1.	1.	1.	1.	1.	1.	1.	1.	.5301E+05
805.	1.	1.	1.	1.	0.	0.	0.	0.	.1296E+06
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.3080E+06
2414.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	2.	2.	1.	1.	1.	1.	1.	2.	.5929E-06
450.	1.	1.	0.	0.	0.	0.	0.	1.	.1177E-05
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1961E-05
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.3035E-05
2414.	0.	0.	0.	0.	0.	0.	0.	0.	.5877E-05
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.8504E-05
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1093E-04
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1318E-04

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF TH 228
DRY DEPOSITION

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	1906.	1800.	1474.	1355.	1313.	1273.	897.	830.	.1767E+05
450.	400.	434.	398.	337.	347.	321.	212.	196.	.5301E+05
805.	146.	167.	133.	129.	134.	123.	81.	71.	.1296E+06
1359.	61.	69.	55.	54.	56.	51.	33.	29.	.3080E+06
2413.	23.	27.	21.	21.	22.	20.	13.	11.	.1525E+07
4023.	10.	11.	9.	9.	9.	8.	5.	5.	.2544E+07
5632.	6.	5.	5.	5.	5.	5.	4.	3.	.3559E+07
7241.	4.	4.	3.	3.	3.	3.	2.	2.	.4576E+07

	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	830.	1108.	719.	567.	598.	581.	454.	1032.	.3428E-03
450.	196.	255.	152.	121.	130.	133.	111.	265.	.5905E-03
805.	75.	87.	57.	45.	49.	50.	43.	102.	.8222E-03
1359.	31.	40.	24.	19.	20.	21.	18.	42.	.1050E-02
2413.	12.	15.	9.	7.	4.	8.	7.	16.	.1487E-02
4023.	5.	7.	4.	3.	3.	3.	3.	7.	.1795E-02
5632.	3.	4.	2.	2.	2.	2.	2.	4.	.2040E-02
7241.	2.	2.	1.	1.	1.	1.	1.	3.	.2248E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF TH 228
WET DEPOSITION- WASHCO= .200E-03 RAINF= .500E-01

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	47.	44.	36.	34.	33.	31.	22.	20.	.1767E+05
450.	12.	14.	12.	11.	11.	10.	7.	7.	.5301E+05
805.	7.	8.	7.	6.	6.	6.	4.	4.	.1296E+06
1359.	4.	5.	4.	4.	3.	3.	2.	2.	.3080E+06
2413.	2.	2.	2.	2.	2.	2.	1.	1.	.1525E+07
4023.	1.	1.	1.	1.	1.	1.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	0.	0.	.3559E+07
7241.	1.	1.	1.	0.	0.	0.	0.	0.	.4576E+07

	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	20.	27.	17.	16.	15.	14.	11.	26.	.8422E-05
450.	7.	9.	6.	5.	5.	5.	4.	8.	.1672E-04
805.	4.	5.	3.	2.	3.	3.	2.	5.	.2786E-04
1359.	2.	3.	2.	1.	2.	1.	1.	3.	.4311E-04
2413.	1.	2.	1.	1.	1.	1.	1.	1.	.8348E-04
4023.	1.	1.	1.	0.	0.	0.	0.	1.	.1208E-03
5632.	0.	1.	0.	0.	0.	0.	0.	1.	.1553E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1872E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF RA 228
DRY DEPOSITION

SECTOR

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	1409.	2312.	1843.	1741.	1687.	1635.	1152.	1066.	.1767E+05
450.	484.	558.	447.	433.	446.	412.	272.	239.	.5301E+05
805.	188.	214.	171.	165.	172.	159.	104.	91.	.1296E+06
1359.	78.	89.	71.	64.	72.	66.	43.	38.	.3080E+06
2413.	39.	34.	27.	27.	28.	26.	17.	15.	.1525E+07
4023.	13.	15.	12.	11.	12.	11.	7.	6.	.2544E+07
5632.	7.	4.	7.	5.	7.	6.	4.	4.	.3559E+07
7241.	5.	6.	4.	4.	4.	4.	3.	2.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	1066.	1424.	412.	729.	769.	746.	584.	1326.	.3894E-03
450.	252.	327.	195.	155.	166.	171.	145.	140.	.6708E-03
805.	96.	125.	74.	59.	63.	65.	55.	131.	.9341E-03
1359.	40.	52.	40.	26.	26.	27.	23.	54.	.1193E-02
2413.	15.	20.	12.	9.	10.	10.	9.	21.	.1689E-02
4023.	6.	8.	5.	4.	4.	4.	4.	9.	.2039E-02
5632.	4.	5.	3.	2.	2.	2.	2.	5.	.2317E-02
7241.	2.	3.	2.	1.	2.	2.	1.	3.	.2553E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF RA 228
WET DEPOSITION- WASHOUT= .200E-03 RATIO= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	47.	57.	47.	43.	42.	40.	28.	25.	.1767E+05
450.	15.	19.	15.	14.	14.	13.	9.	8.	.5301E+05
805.	9.	10.	9.	8.	8.	7.	5.	5.	.1296E+06
1359.	5.	6.	[illegible]	5.	4.	4.	3.	3.	.3080E+06
2413.	3.	3.	3.	2.	2.	2.	2.	1.	.1525E+07
4023.	1.	2.	1.	1.	1.	1.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	1.	1.	.3559E+07
7241.	1.	1.	1.	1.	1.	1.	0.	0.	.4576E+07

	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	26.	35.	22.	19.	19.	18.	14.	33.	.9567E-05
450.	8.	11.	7.	6.	5.	6.	5.	11.	.1899E-04
805.	5.	5.	4.	3.	3.	3.	3.	6.	.3165E-04
1359.	3.	4.	2.	2.	2.	2.	1.	3.	.4897E-04
2413.	1.	2.	1.	1.	1.	1.	1.	2.	.9483E-04
4023.	1.	1.	1.	1.	1.	1.	0.	1.	.1372E-03
5632.	1.	1.	0.	0.	0.	0.	0.	1.	.1764E-03
7241.	0.	1.	0.	0.	0.	0.	0.	0.	.2126E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF RA 226
DRY DEPOSITION

DISTANCE (METERS)	SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	325.	394.	322.	277.	287.	274.	196.	182.	.1767E+05
450.	83.	95.	76.	74.	76.	70.	46.	41.	.5301E+05
805.	32.	36.	29.	24.	29.	27.	14.	15.	.1296E+06
1359.	13.	15.	12.	12.	12.	11.	7.	6.	.3080E+06
2413.	5.	0.	5.	5.	5.	4.	3.	2.	.1525E+07
4023.	2.	2.	2.	2.	2.	2.	1.	1.	.2544E+07
5632.	1.	1.	1.	1.	1.	1.	1.	1.	.3559E+07
7241.	1.	1.	1.	1.	1.	1.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	142.	243.	155.	124.	131.	127.	99.	226.	.5307E-04
450.	43.	56.	33.	25.	28.	29.	25.	58.	.1087E-03
805.	16.	21.	13.	16.	11.	11.	9.	22.	.1513E-03
1359.	7.	9.	5.	4.	4.	5.	4.	9.	.1933E-03
2413.	3.	3.	2.	2.	2.	2.	1.	4.	.2736E-03
4023.	1.	1.	1.	1.	1.	1.	1.	1.	.3302E-03
5632.	1.	1.	0.	0.	0.	0.	0.	1.	.3753E-03
7241.	0.	1.	0.	0.	0.	0.	0.	1.	.4136E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE

PICOCURIES/M**2 OF RA 226

WET DEPOSITION-- WASHCO= .200E-03 RAINF= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	8.	10.	8.	7.	7.	7.	5.	4.	.1767E+05
450.	3.	3.	3.	2.	2.	2.	2.	1.	.5301E+05
805.	1.	2.	1.	1.	1.	1.	1.	1.	.1296E+06
1609.	1.	1.	1.	1.	1.	1.	0.	0.	.3080E+06
2413.	0.	1.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	4.	6.	4.	3.	3.	3.	2.	6.	.1550E-05
450.	1.	2.	1.	1.	1.	1.	1.	2.	.3076E-05
805.	1.	1.	1.	1.	1.	1.	0.	1.	.5126E-05
1609.	0.	1.	0.	0.	0.	0.	0.	1.	.7932E-05
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1536E-04
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2223E-04
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.2857E-04
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.3444E-04

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF RA 224
DRY DEPOSITION

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	27.	33.	27.	25.	24.	23.	16.	15.	.1767E+05
450.	7.	8.	5.	6.	5.	6.	4.	3.	.5301E+05
805.	4.	3.	2.	2.	2.	2.	1.	1.	.1296E+06
1609.	1.	1.	1.	1.	1.	1.	1.	1.	.3080E+06
2414.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	18.	20.	13.	10.	11.	11.	8.	19.	.3619E-03
450.	4.	5.	3.	2.	2.	2.	2.	5.	.6235E-03
805.	1.	2.	1.	1.	1.	1.	1.	2.	.8681E-03
1609.	1.	1.	0.	0.	0.	0.	0.	1.	.1109E-02
2414.	0.	0.	0.	0.	0.	0.	0.	0.	.1569E-02
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.1893E-02
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.2152E-02
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.2370E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF RA 224
NET DEPOSITION - HALFLIFE= .290E-03 [illegible]= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	1.	1.	1.	1.	1.	1.	0.	0.	.1767E+05
450.	0.	0.	0.	0.	0.	0.	0.	0.	.5301E+05
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1296E+06
1459.	0.	0.	0.	0.	0.	0.	0.	0.	.3080E+06
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	0.	0.	0.	0.	0.	0.	0.	0.	.8893E-05
450.	0.	0.	0.	0.	0.	0.	0.	0.	.1765E-04
805.	0.	0.	0.	0.	0.	0.	0.	0.	.2941E-04
1459.	0.	0.	0.	0.	0.	0.	0.	0.	.4550E-04
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.8808E-04
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.1274E-03
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1637E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1973E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF PR /12
DRY DEPOSITION

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	4.	4.	3.	3.	3.	3.	2.	2.	.1767E+05
450.	1.	1.	1.	1.	1.	1.	0.	0.	.5301E+05
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1296E+06
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.3080E+06
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	2.	2.	1.	1.	1.	1.	1.	2.	.3343E-03
450.	0.	1.	0.	0.	0.	0.	0.	1.	.5756E-03
805.	0.	0.	0.	0.	0.	0.	0.	0.	.8009E-03
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.1022E-02
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1444E-02
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.1738E-02
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1972E-02
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.2169E-02

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF [illegible]
WET DEPOSITION- LAMBDA= .2[illegible]E-03 RATIO= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	0.	0.	0.	0.	0.	0.	0.	0.	.1767E+05
450.	0.	0.	0.	0.	0.	0.	0.	0.	.5301E+05
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1296E+06
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.3080E+06
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	0.	0.	0.	0.	0.	0.	0.	0.	.8214E-05
450.	0.	0.	0.	0.	0.	0.	0.	0.	.1630E-04
805.	0.	0.	0.	0.	0.	0.	0.	0.	.2713E-04
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.4192E-04
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.8090E-04
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.1167E-03
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1495E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1797E-03

ACTIVITY DENSITY AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF PB 210
DRY DEPOSITION

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	88.	106.	87.	80.	77.	75.	53.	49.	.1767E+05
450.	22.	26.	21.	20.	23.	19.	12.	11.	.5301E+05
805.	9.	10.	[illegible]	8.	8.	7.	5.	4.	.1296E+06
1287.	4.	4.	3.	3.	3.	3.	2.	2.	.3080E+06
2413.	1.	2.	1.	1.	1.	1.	1.	1.	.1525E+07
4023.	1.	1.	1.	1.	1.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	47.	55.	42.	33.	35.	34.	27.	61.	.1728E-04
450.	12.	15.	9.	7.	8.	8.	7.	16.	.2976E-04
805.	4.	6.	3.	3.	3.	3.	3.	6.	.4144E-04
1287.	2.	2.	1.	1.	1.	1.	1.	2.	.5294E-04
2413.	1.	1.	1.	0.	0.	0.	0.	1.	.7495E-04
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.9044E-04
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.1028E-03
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.1133E-03

ACTIVITY DEPOSITED AT END OF RELEASE PERIOD FOR A UNIFORM RELEASE RATE
PICOCURIES/M**2 OF PB 210
WET DEPOSITION- WASHOUT= .200E-03 RAINE= .500E-01

DISTANCE (METERS)	N	NNE	NE	ENE	E	ESE	SE	SSE	AREAS(M**2) SECTOR-SEGMENT
150.	2.	3.	2.	2.	2.	2.	1.	1.	.1767E+05
450.	1.	1.	1.	1.	1.	1.	0.	0.	.5301E+05
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1296E+06
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.3080E+06
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.1525E+07
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.2544E+07
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.3559E+07
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.4576E+07

DISTANCE (METERS)	S	SSW	SW	WSW	W	WNW	NW	NNW	CURIES DEPOSITED WITHIN RADII
150.	1.	2.	1.	1.	1.	1.	1.	2.	.4245E-06
450.	0.	1.	0.	0.	0.	• 0.	0.	0.	.8426E-06
805.	0.	0.	0.	0.	0.	0.	0.	0.	.1404E-05
1359.	0.	0.	0.	0.	0.	0.	0.	0.	.2173E-05
2413.	0.	0.	0.	0.	0.	0.	0.	0.	.4207E-05
4023.	0.	0.	0.	0.	0.	0.	0.	0.	.6088E-05
5632.	0.	0.	0.	0.	0.	0.	0.	0.	.7826E-05
7241.	0.	0.	0.	0.	0.	0.	0.	0.	.9434E-05

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF U 238

DISTANCE	N	NE	NE	ENE	E	ESE	SE	SSE
150.	.1524E-01	.1467E-01	.1512E-01	.1390E-01	.1343E-01	.1306E-01	.9200E-02	.8512E-02
450.	.3690E-02	.4657E-02	.3574E-02	.3458E-02	.3563E-02	.3289E-02	.2172E-02	.1909E-02
805.	.1493E-02	.1709E-02	.1365E-02	.1328E-02	.1377E-02	.1266E-02	.8290E-03	.7264E-03
1350.	.6225E-03	.7093E-03	.5653E-03	.5515E-03	.5739E-03	.5263E-03	.3432E-03	.3009E-03
2413.	.2409E-03	.2745E-03	.2143E-03	.2135E-03	.2224E-03	.2040E-03	.1326E-03	.1164E-03
4023.	.1014E-03	.1164E-03	.9233E-04	.9027E-04	.9377E-04	.8623E-04	.5602E-04	.4959E-04
5632.	.5767E-04	.6659E-04	.5271E-04	.5159E-04	.5340E-04	.4920E-04	.3197E-04	.2847E-04
7241.	.3749E-04	.4393E-04	.3477E-04	.3394E-04	.3512E-04	.3242E-04	.2107E-04	.1886E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.8513E-02	.1137E-01	.7290E-02	.5813E-02	.6139E-02	.5956E-02	.4661E-02	.1059E-01
450.	.2012E-02	.2615E-02	.1562E-02	.1237E-02	.1324E-02	.1362E-02	.1155E-02	.2716E-02
805.	.7660E-03	.9657E-03	[illegible]	.4661E-03	.5015E-03	.5177E-03	.4411E-03	.1044E-02
1350.	.3181E-03	.4111E-03	.2413E-03	.1917E-03	.2064E-03	.2137E-03	.1820E-03	.4324E-03
2413.	.1222E-03	.1580E-03	.9273E-04	.7357E-04	.7926E-04	.4228E-04	.7005E-04	.1670E-03
4023.	.5187E-04	.6725E-04	.3915E-04	.3110E-04	.3349E-04	.3468E-04	.2321E-04	.6998E-04
5632.	.2957E-04	.3841E-04	.2232E-04	.1776E-04	.1919E-04	.1975E-04	.1650E-04	.3966E-04
7241.	.1944E-04	.2534E-04	.1472E-04	.1173E-04	.1263E-04	.1300E-04	.1078E-04	.2599E-04

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
(MICROCURIES/M**3 OF U 234

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1555E-01	.1247E-01	.1112E-01	.1500E-01	.1343E-01	.1306E-01	.9230E-02	.8512E-02
[illegible]	.3406E-02	.4457E-02	.3574E-02	.3450E-02	.3563E-02	.3289E-02	.2172E-02	.1909E-02
805.	.1640E-02	.1709E-02	.1365E-02	.1320E-02	.1377E-02	.1266E-02	.8290E-03	.7264E-03
[illegible]	.6525E-03	.7093E-03	.5553E-03	.5515E-03	.5739E-03	.5263E-03	.3432E-03	.3009E-03
2413.	.2600E-03	.2746E-03	.2193E-03	.2135E-03	.2223E-03	.2040E-03	.1326E-03	.1164E-03
4023.	.1014E-03	.1166E-03	.9233E-04	.9027E-04	.9377E-04	.8623E-04	.5602E-04	.4959E-04
5632.	.5767E-04	.6654E-04	.5571E-04	.5150E-04	.5340E-04	.4920E-04	.3197E-04	.2847E-04
7241.	.3709E-04	.4393E-04	.3477E-04	.3394E-04	.3512E-04	.3242E-04	.2107E-04	.1886E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.8510E-02	.1137E-01	.7260E-02	.5413E-02	.5134E-02	.5956E-02	.4661E-02	.1059E-01
[illegible]	.2012E-02	.2615E-02	.1552E-02	.1237E-02	.1323E-02	.1362E-02	.1155E-02	.2716E-02
805.	.7603E-03	.9956E-03	.5664E-03	.4661E-03	.5015E-03	.5177E-03	.4411E-03	.1044E-02
[illegible]	.3101E-03	.4110E-03	.2413E-03	.1917E-03	.2064E-03	.2137E-03	.1820E-03	.4324E-03
2413.	.1229E-03	.1588E-03	.9370E-04	.7357E-04	.7526E-04	.8228E-04	.7005E-04	.1670E-03
4023.	.5187E-04	.6725E-04	.3315E-04	.3110E-04	.3343E-04	.3468E-04	.2921E-04	.6998E-04
5632.	.2967E-04	.3841E-04	.2212E-04	.1775E-04	.1910E-04	.1975E-04	.1650E-04	.3966E-04
7241.	.1940E-04	.2534E-04	.1472E-04	.1173E-04	.1260E-04	.1300E-04	.1978E-04	.2599E-04

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF TH 232

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1070E-02	.9775E-03	.1066E-02	.7360E-02	.7134E-02	.6913E-02	.4871E-02	.4506E-02
450.	.2052E-02	.2459E-02	.1342E-02	.1841E-02	.1986E-02	.1741E-02	.1150E-02	.1011E-02
805.	.7937E-03	.9845E-03	.7227E-03	.7033E-03	.7284E-03	.6702E-03	.4389E-03	.3846E-03
1159.	.3295E-03	.3755E-03	.2744E-03	.2920E-03	.3034E-03	.2786E-03	.1817E-03	.1593E-03
2413.	.1275E-03	.1450E-03	.1156E-03	.1130E-03	.1177E-03	.1080E-03	.7018E-04	.6165E-04
4023.	.5369E-04	.6161E-04	.4888E-04	.4779E-04	.4965E-04	.4565E-04	.2966E-04	.2626E-04
5632.	.3053E-04	.3524E-04	.2771E-04	.2727E-04	.2827E-04	.2604E-04	.1692E-04	.1507E-04
7241.	.2006E-04	.2126E-04	.1841E-04	.1797E-04	.1860E-04	.1716E-04	.1116E-04	.9987E-05

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.4505E-02	.6029E-02	.3864E-02	.3077E-02	.4250E-02	.3153E-02	.2468E-02	.5605E-02
450.	.1065E-02	.1384E-02	.3267E-03	.6548E-03	.7937E-03	.7211E-03	.6116E-03	.1438E-02
805.	.4057E-03	.5271E-03	.3115E-03	.2456E-03	.2655E-03	.2741E-03	.2335E-03	.5525E-03
1159.	.1694E-03	.2185E-03	.1281E-03	.1015E-03	.1093E-03	.1131E-03	.9537E-04	.2289E-03
2413.	.6594E-04	.8414E-04	.4917E-04	.3445E-04	.4195E-04	.4356E-04	.3709E-04	.8841E-04
4023.	.2746E-04	.3580E-04	.2572E-04	.1544E-04	.1772E-04	.1836E-04	.1546E-04	.3705E-04
5632.	.1565E-04	.2033E-04	.1102E-04	.9404E-05	.1011E-04	.1045E-04	.8733E-05	.2099E-04
7241.	.1011E-04	.1342E-04	.7732E-05	.6205E-05	.6671E-05	.6885E-05	.5707E-05	.1376E-04

AVERAGE ACTIVITY IN AIR = RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF TH 230

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.7931E-04	.2959E-03	.7025E-03	.7196E-03	.6975E-03	.6760E-03	.4763E-03	.4406E-03
450.	.2015E-03	.2307E-03	.1450E-03	.1730E-03	.1644E-03	.1702E-03	.1124E-03	.9883E-04
805.	.7760E-04	.8445E-04	.7957E-04	.6077E-04	.7127E-04	.6553E-04	.4291E-04	.3760E-04
1359.	.3222E-04	.3671E-04	.2326E-04	.2635E-04	.2986E-04	.2724E-04	.1777E-04	.1558E-04
2413.	.1247E-04	.1421E-04	.1130E-04	.1105E-04	.1151E-04	.1056E-04	.6862E-05	.6028E-05
4023.	.5258E-05	.6024E-05	.3779E-05	.4673E-05	.4954E-05	.4466E-05	.2400E-05	.2567E-05
5632.	.2995E-05	.3644E-05	.2729E-05	.2566E-05	.2764E-05	.2547E-05	.1555E-05	.1474E-05
7241.	.1362E-05	.2274E-05	.1400E-05	.1757E-05	.1414E-05	.1674E-05	.1091E-05	.9765E-06

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.4405E-03	.5986E-03	.3768E-03	.3009E-03	.3174E-03	.4084E-03	.2413E-03	.5481E-03
450.	.1042E-03	.1156E-03	.4043E-04	.6402E-04	.6809E-04	.7051E-04	.5980E-04	.1406E-03
805.	.3977E-04	.5153E-04	.1356E-04	.2413E-04	.2597E-04	.2680E-04	.2283E-04	.5403E-04
1359.	.1647E-04	.2113E-04	.1252E-04	.9924E-05	.1964E-04	.1106E-04	.9423E-05	.2238E-04
2413.	.6361E-05	.4227E-05	.5401E-05	.3609E-05	.5103E-05	.4259E-05	.3626E-05	.8644E-05
4023.	.2695E-05	.1681E-05	.2026E-05	.1616E-05	.1733E-05	.1795E-05	.1512E-05	.3622E-05
5632.	.1531E-05	.1940E-05	.1156E-05	.9145E-06	.9869E-06	.1023E-05	.8534E-06	.2053E-05
7241.	.1000E-05	.1312E-05	.7613E-06	.6070E-06	.6523E-06	.5732E-06	.5560E-06	.1345E-05

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF TH -28

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1121E-01	.1156E-01	.1112E-01	.1022E-01	.9908E-02	.9602E-02	.6765E-02	.6258E-02
450.	.2664E-02	.3277E-02	.2626E-02	.2542E-02	.2620E-02	.2418E-02	.1597E-02	.1404E-02
805.	.1102E-02	.1256E-02	.1004E-02	.9768E-03	.1012E-02	.9309E-03	.6096E-03	.5341E-03
1559.	.4577E-03	.5215E-03	.4157E-03	.4055E-03	.4213E-03	.3870E-03	.2524E-03	.2213E-03
2413.	.1771E-03	.2019E-03	.1605E-03	.1570E-03	.1635E-03	.1500E-03	.9748E-04	.8562E-04
4023.	.7657E-04	.8657E-04	.6703E-04	.6637E-04	.6895E-04	.6341E-04	.4119E-04	.3646E-04
5632.	.4240E-04	.4892E-04	.3876E-04	.3787E-04	.3926E-04	.3617E-04	.2350E-04	.2093E-04
7241.	.2786E-04	.3230E-04	[illegible]	.2446E-04	.2583E-04	.2384E-04	.1549E-04	.1387E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.8253E-02	.9461E-02	[illegible]	.4274E-02	.4514E-02	.4374E-02	.3427E-02	.7785E-02
450.	.1400E-02	.1927E-02	.1140E-02	.9094E-03	.9773E-03	.1002E-02	.8494E-03	.1997E-02
805.	[illegible]	.7420E-03	.4327E-03	.3427E-03	.3684E-03	.3906E-03	.3243E-03	.7674E-03
1559.	.2348E-03	.3022E-03	.1779E-03	.1410E-03	.1514E-03	.1571E-03	.1339E-03	.3180E-03
2413.	.9335E-04	.1160E-03	.6422E-04	.5409E-04	.5428E-04	.6050E-04	.5151E-04	.1228E-03
4023.	.3814E-04	.4740E-04	.2474E-04	.2287E-04	.2461E-04	.2550E-04	.2149E-04	.5145E-04
5632.	.2174E-04	.2824E-04	.1641E-04	.1306E-04	.1405E-04	.1452E-04	.1213E-04	.2916E-04
7241.	.1432E-04	.1863E-04	.1042E-04	.8623E-05	.9266E-05	.9562E-05	.7926E-05	.1911E-04

AVERAGE ACTIVITY IN AIR. RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
MICROCURIES/M**3 OF RA 228

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1273E-01	.1543E-01	.1255E-01	.1161E-01	.1126E-01	.1091E-01	.7685E-02	.7110E-02
650.	.3254E-02	.3723E-02	.2945E-02	.2688E-02	.2476E-02	.2747E-02	.1414E-02	.1595E-02
805.	.1262E-02	.1427E-02	.1140E-02	.1110E-02	.1150E-02	.1057E-02	.6325E-03	.6067E-03
1609.	.5193E-03	.5924E-03	.4725E-03	.4507E-03	.3786E-03	.4396E-03	.2467E-03	.2514E-03
2414.	.2012E-03	.2294E-03	.1823E-03	.1784E-03	.1857E-03	.1704E-03	.1107E-03	.9726E-04
4023.	.8471E-04	.9721E-04	.7712E-04	.7540E-04	.7833E-04	.7203E-04	.4680E-04	.4142E-04
5632.	.4817E-04	.5550E-04	.4403E-04	.4302E-04	.4460E-04	.4109E-04	.2670E-04	.2378E-04
7241.	.3165E-04	.3670E-04	.2906E-04	.2835E-04	.2934E-04	.2708E-04	.1760E-04	.1576E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.7103E-02	.3690E-02	.6061E-02	.4855E-02	.5128E-02	.4975E-02	.3893E-02	.8844E-02
650.	.1684E-02	.2184E-02	.1304E-02	.1033E-02	.1110E-02	.1138E-02	.9650E-03	.2264E-02
805.	.6417E-03	.8316E-03	.5215E-03	.3943E-03	.4190E-03	.4324E-03	.3685E-03	.8718E-03
1609.	.2657E-03	.3440E-03	.2170E-03	.1601E-03	.1724E-03	.1785E-03	.1521E-03	.3612E-03
2414.	.1026E-03	.1329E-03	.7750E-04	.6145E-04	.5523E-04	.6873E-04	.5851E-04	.1395E-03
4023.	.4333E-04	.5617E-04	.3270E-04	.2598E-04	.2795E-04	.2897E-04	.2440E-04	.5845E-04
5632.	.2473E-04	.3208E-04	.1465E-04	.1484E-04	.1596E-04	.1650E-04	.1178E-04	.3312E-04
7241.	.1627E-04	.2117E-04	.1229E-04	.9796E-05	.1053E-04	.1086E-04	.9004E-05	.2171E-04

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF RA 226

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.2062E-02	.2490E-02	.2045E-02	.1441E-02	.1824E-02	.1767E-02	.1245E-02	.1152E-02
450.	.5270E-03	.6013E-03	.4415E-03	.4678E-03	.4420E-03	.4450E-03	.2938E-03	.2583E-03
805.	.2020E-03	.2312E-03	.1647E-03	.1747E-03	.1863E-03	.1713E-03	.1122E-03	.9827E-04
1359.	.4422E-04	[illegible]	.7559E-04	.2462E-04	.7753E-04	.7120E-04	.4643E-04	.4072E-04
2413.	.3259E-04	.1715E-04	[illegible]	.2889E-04	.3004E-04	.2760E-04	.1794E-04	.1575E-04
4023.	.1372E-04	.1574E-04	[illegible]	.1221E-04	.1269E-04	.1167E-04	.7580E-05	.6710E-05
5632.	.7802E-05	.3002E-05	.7113E-05	.5464E-05	.7224E-05	.5656E-05	.4325E-05	.3851E-05
7241.	.5127E-05	.5944E-05	.4704E-05	.4592E-05	.4752E-05	.4386E-05	.2451E-05	.2552E-05

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.1151E-02	.1530E-02	.8643E-03	.7864E-03	.5106E-03	.8058E-03	.6306E-03	.1432E-02
450.	.2732E-03	.3540E-03	.2113E-03	.1674E-03	.1794E-03	.1843E-03	.1563E-03	.3675E-03
805.	.1013E-03	.1347E-03	.7361E-04	.6304E-04	.5787E-04	.7004E-04	.5368E-04	.1412E-03
1359.	.4396E-04	.5571E-04	.3273E-04	.2594E-04	.2742E-04	.2891E-04	.2463E-04	.5450E-04
2413.	.1663E-04	.2150E-04	.1255E-04	.9953E-05	.1072E-04	.1113E-04	.9477E-05	.2259E-04
4023.	.7014E-05	.7099E-05	.5256E-05	.4208E-05	.4524E-05	.4692E-05	.3952E-05	.9467E-05
5632.	.4000E-05	.5194E-05	.3023E-05	.2493E-05	.2585E-05	.2672E-05	.2232E-05	.5365E-05
7241.	.2635E-05	.3428E-05	.1941E-05	.1587E-05	.1705E-05	.1759E-05	.1458E-05	.3516E-05

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF HA ,24

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1164E-01	.1434E-01	.1174E-01	.1070E-01	.1066E-01	.1014E-01	.7143E-02	.6608E-02
450.	.3224E-02	.3460E-02	.2774E-02	.2694E-02	.2766E-02	.2551E-02	.1686E-02	.1492E-02
805.	.1163E-02	.1325E-02	.1069E-02	.1031E-02	.1066E-02	.9825E-03	.6434E-03	.5638E-03
1609.	.4470E-03	.5503E-03	.4406E-03	.4274E-03	.4446E-03	.4083E-03	.2663E-03	.2335E-03
2413.	.1864E-03	.2120E-03	.1650E-03	.1656E-03	.1724E-03	.1582E-03	.1028E-03	.9031E-04
4023.	.7856E-04	.9018E-04	.7154E-04	.6994E-04	.7265E-04	.6681E-04	.4341E-04	.3843E-04
5632.	.4463E-04	.5152E-04	.4071E-04	.3987E-04	.4133E-04	.3808E-04	.2475E-04	.2205E-04
7241.	.2941E-04	.3398E-04	.2690E-04	.2626E-04	.2717E-04	.2508E-04	.1630E-04	.1460E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.6609E-02	.4926E-02	[illegible]	.4513E-02	.4767E-02	.4624E-02	.3619E-02	.8220E-02
450.	.1562E-02	.2030E-02	[illegible]	.1601E-03	.1032E-02	.1057E-02	.8367E-03	.2109E-02
805.	.5463E-03	.7727E-03	.5267E-03	.3614E-03	.3843E-03	.4013E-03	.3423E-03	.9100E-03
1609.	.2360E-03	.3195E-03	.1877E-03	.1440E-03	.1602E-03	.1658E-03	.1412E-03	.3355E-03
2413.	.7520E-04	.1233E-03	.7145E-04	.5705E-04	.6146E-04	.6380E-04	.5430E-04	.1295E-03
4023.	.4013E-04	.5211E-04	.3133E-04	.2410E-04	.2594E-04	.2687E-04	.2262E-04	.5420E-04
5632.	.2280E-04	.2974E-04	.1728E-04	.1376E-04	.1474E-04	.1529E-04	.1276E-04	.3069E-04
7241.	.1507E-04	.1961E-04	.1133E-04	.9075E-05	.9750E-05	.1006E-04	.8333E-05	.2009E-04

AVERAGE ACTIVITY IN AIR. RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF KR 212

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1934E-01	.1324E-01	.1384E-01	.9473E-02	[illegible]	.9365E-02	.6598E-02	.6105E-02
450.	.2764E-02	.3142E-02	[illegible]	.2476E-02	.2351E-02	.2355E-02	.1555E-02	.1368E-02
805.	.1072E-02	.1222E-02	[illegible]	[illegible]	.9642E-03	.9051E-03	.5928E-03	.5196E-03
1159.	.4437E-03	.5060E-03	[illegible]	[illegible]	.4085E-03	.3753E-03	.2448E-03	.2148E-03
2414.	.1700E-03	.1950E-03	.1550E-03	.1516E-03	.1577E-03	.1447E-03	.9411E-04	.8277E-04
4023.	.7113E-04	.8211E-04	[illegible]	.6354E-04	.6603E-04	.6078E-04	.3950E-04	.3504E-04
5632.	.4031E-04	.4566E-04	[illegible]	.3607E-04	.3734E-04	.3445E-04	.2240E-04	.2000E-04
7241.	.2631E-04	.3062E-04	[illegible]	.2363E-04	.2440E-04	.2255E-04	.1467E-04	.1318E-04

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.6104E-02	.9155E-02	.5221E-02	.4159E-02	.4404E-02	.4271E-02	.3142E-02	.7593E-02
450.	.1441E-02	.1872E-02	.1110E-02	.8854E-03	.9520E-03	.9754E-03	.8269E-03	.1945E-02
805.	.5494E-03	.7113E-03	.4200E-03	.3334E-03	.3587E-03	.3701E-03	.3151E-03	.7458E-03
1159.	.2264E-03	.2930E-03	.1726E-03	.1368E-03	.1473E-03	.1524E-03	.1297E-03	.3081E-03
2414.	[illegible]	.1122E-03	.5590E-04	.5227E-04	.5624E-04	.5839E-04	.4960E-04	.1183E-03
4023.	[illegible]	.4745E-04	.2763E-04	.2196E-04	.2362E-04	.2444E-04	.2052E-04	.4921E-04
5632.	.2070E-04	.2693E-04	.1556E-04	.1247E-04	.1349E-04	.1383E-04	.1150E-04	.2768E-04
7241.	.1355E-04	.1765E-04	.1024E-04	.8183E-05	.8782E-05	.9045E-05	.7459E-05	.1801E-04

AVERAGE ACTIVITY IS [illegible] RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
[illegible] OF PH .10

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.5660E-03	.6844E-03	.5804E-03	.5152E-03	.4494E-03	.4839E-03	.3410E-03	.3154E-03
450.	.1444E-03	.1655E-03	.1124E-03	.1281E-03	.1320E-03	.1219E-03	.8048E-04	.7075E-04
805.	[illegible]	.6342E-04	.5059E-04	.4923E-04	.5102E-04	.4691E-04	.3072E-04	.2632E-04
1395.	.2397E-04	.3628E-04	[illegible]	.2044E-04	.2124E-04	.1950E-04	.1272E-04	.1115E-04
2413.	.8924E-05	.1914E-04	[illegible]	.7413E-05	[illegible]	.7559E-05	.4913E-05	.4115E-05
4023.	.3756E-05	.4315E-05	[illegible]	.3345E-05	.3475E-05	.3196E-05	.2076E-05	.1838E-05
5632.	.2137E-05	.2666E-05	.1954E-05	.1909E-05	.1979E-05	.1823E-05	.1185E-05	.1055E-05
7241.	.1404E-05	.1624E-05	.1249E-05	.1256E-05	.1302E-05	.1201E-05	.7809E-06	.6991E-06

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.3154E-03	.4214E-03	[illegible]	.2154E-03	.2275E-03	.2207E-03	.1727E-03	.3924E-03
450.	.7457E-04	[illegible]	[illegible]	.4543E-04	.4926E-04	.5044E-04	.4281E-04	.1007E-03
805.	.2847E-04	.3669E-04	[illegible]	.1727E-04	.1854E-04	.1918E-04	.1635E-04	.3868E-04
1395.	.1179E-04	.1526E-04	.9966E-05	.7105E-05	.7644E-05	.7920E-05	.6746E-05	.1603E-04
2413.	.4556E-05	.5090E-05	.3439E-05	.2726E-05	.2937E-05	.3049E-05	.2596E-05	.6188E-05
4023.	.1932E-05	.2442E-05	.1451E-05	.1154E-05	.1241E-05	.1285E-05	.1082E-05	.2593E-05
5632.	.1096E-05	.1423E-05	[illegible]	.6543E-06	.7080E-06	.7320E-06	.6113E-06	.1470E-05
7241.	.7218E-06	.9392E-06	[illegible]	.4346E-06	.4670E-06	.4819E-06	.3995E-06	.9630E-06

AVERAGE ACTIVITY IN ATM. RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF RN 222

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1220E+01	.1494E+01	.1218E+01	.1120E+01	.1086E+01	.1052E+01	.7414E+00	.6859E+00
[illegible]	.3267E+00	.3696E+00	.2365E+00	.2874E+00	.2967E+00	.2735E+00	.1805E+00	.1582E+00
805.	.1241E+00	.1455E+00	.1155E+00	.1117E+00	.1185E+00	.1085E+00	.7091E-01	.6164E-01
1609.	.5543E-01	.6224E-01	.5760E-01	.4886E-01	.5097E-01	.4652E-01	.3022E-01	.2616E-01
2414.	.2221E-01	.2481E-01	.1972E-01	.1445E-01	.2047E-01	.1862E-01	.1203E-01	.1038E-01
4023.	.1006E-01	.1117E-01	.9591E-02	.8771E-02	.9276E-02	.8409E-02	.5407E-02	.4651E-02
5632.	.6028E-02	.6691E-02	.5513E-02	.5254E-02	.5576E-02	.5043E-02	.3233E-02	.2774E-02
7241.	.4146E-02	.4584E-02	.3624E-02	.3611E-02	.3840E-02	.3466E-02	.2217E-02	.1849E-02

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.6950E+00	.9161E+00	.3966E+00	.4684E+00	.4947E+00	.4793E+00	.3756E+00	.8532E+00
[illegible]	.1675E+00	.2171E+00	.1236E+00	.1026E+00	.1104E+00	.1134E+00	.9672E-01	.2269E+00
805.	.6347E-01	.4495E-01	.3307E-01	.3959E-01	.4271E-01	.4433E-01	.3831E-01	.9026E-01
1609.	.2419E-01	.3611E-01	.2111E-01	.1664E-01	.1802E-01	.1884E-01	.1640E-01	.3874E-01
2414.	.1129E-01	.1434E-01	.7315E-02	.5564E-02	.7106E-02	.7474E-02	.6561E-02	.1552E-01
4023.	.5030E-02	.6435E-02	.1703E-02	.2920E-02	.3167E-02	.3349E-02	.2961E-02	.7019E 02
5632.	.4014E-02	.3142E-02	.2200E-02	.1733E-02	.1883E-02	.1998E-02	.1775E-02	.4213E-02
7241.	.2967E-02	.2631E-02	.1501E-02	.1182E-02	.1285E-02	.1368E-02	.1220E-02	.2898E-02

DOSE TO AN INDIVIDUAL IN THE INDICATED SECTOR AND ANNULAR RING (MREM)

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
[illegible]	[illegible]	[illegible]	[illegible]	.7407E+01	.7180E+01	.6958E+01	.4902E+01	.4535E+01
[illegible]	[illegible]	[illegible]	.1304E+01	.1842E+01	.1494E+01	.1752E+01	.1157E+01	.1017E+01
805.	[illegible]	.2190E+00	[illegible]	.7078E+00	.7335E+00	.6745E+00	.4417E+00	.3870E+00
1609.	.3417E+00	.3778E+00	[illegible]	.2939E+00	[illegible]	.2604E+00	.1829E+00	.1603E+00
2413.	[illegible]	[illegible]	[illegible]	.1139E+00	.1188E+00	.1087E+00	.7063E-01	.6204E-01
4023.	.5403E-01	.6201E-01	[illegible]	.4810E-01	.4495E-01	.4595E-01	.2965E-01	.2642E-01
5632.	.4072E-01	[illegible]	[illegible]	.2744E-01	.2845E-01	.2621E-01	.1703E-01	.1517E-01
7241.	.2014E-01	.2361E-01	[illegible]	.1808E-01	.1471E-01	.1727E-01	.1123E-01	.1005E-01

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
[illegible]	[illegible]	[illegible]	[illegible]	.3097E+01	.3271E+01	.3173E+01	.2483E+01	.5641E+01
[illegible]	.1073E+01	[illegible]	[illegible]	.5590E+00	.7082E+00	.7257E+00	.6155E+00	.1447E+01
805.	.4033E+00	.5304E+00	[illegible]	.2443E+00	.2573E+00	.2758E+00	.2350E+00	.5561E+00
1609.	[illegible]	.2194E+00	[illegible]	.1022E+00	.1100E+00	.1134E+00	.9599E-01	.2304E+00
2413.	[illegible]	[illegible]	[illegible]	.3420E-01	.4223E-01	.4384E-01	.3732E-01	.4497E-01
4023.	[illegible]	[illegible]	[illegible]	.1657E-01	.1784E-01	.1848E-01	.1556E-01	.3728E-01
5632.	[illegible]	[illegible]	[illegible]	.9464E-02	.1014E-01	.1052E-01	.8788E-02	.2113E-01
7241.	[illegible]	[illegible]	[illegible]	.5248E-02	[illegible]	.6928E-02	.5743E-02	.1384E-01

POPULATION DOSE IN THE INDICATED SECTOR AND ANNULAR RING(MAN-REM)

DIS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	RUNNING TOTAL
100.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
600.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1010.	[illegible]	1.47	.50	.57	.17	.27	.09	.12	.12	.03	.03	.07	.03	.28	.24	.67	5.84
1609.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.84
3218.	.10	.22	.17	.23	.09	.11	.01	.02	.00	.01	.00	.00	.02	.04	.00	.04	6.91
4828.	.04	.01	.07	.03	.10	.07	.02	.04	.03	.00	.00	.00	.00	.00	.01	.03	7.33
6437.	.04	.02	.01	.04	.09	.08	.01	.04	.01	.00	.00	.00	.01	.01	.00	.01	7.73
8046.	.03	.08	.03	[illegible]	[illegible]	.02	.01	.03	.00	.06	.00	.02	.02	.02	.00	.00	8.02

THE CONTRIBUTING RADIONUCLIDES ARE

ISOTOPE	CRT ORGAN	DCF	CURIES RELEASED	DECAY CONSTANT (1/SEC)	DECON FACTOR
U 235	[illegible]	.1440E+06	.1700E-01	.488E-17	.100E+01
U 238	[illegible]	.1604E+06	.1700E-01	.480E-13	.100E+01
TH 232	[illegible]	.2245E+07	.9000E-02	.157E-17	.100E+01
TH 230	[illegible]	.1519E+08	.8800E-03	.275E-12	.100E+01
TH 228	[illegible]	.1717E+07	.1250E-01	.115E-07	.100E+01
RA 228	[illegible]	.1213E+08	.1420E-01	.128E-08	.100E+01
RA 226	[illegible]	.2323E+08	.2300E-02	.136E-10	.100E+01
RA 224	[illegible]	.1004E+04	.1320E-01	.220E-05	.100E+01
PB 212	[illegible]	.1413E+04	.1220E-01	.181E-04	.100E+01
PB 210	[illegible]	.2123E+06	.6300E-03	.113E-08	.100E+01

TOTAL CI.= .9841E-01

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DOSE TO AN INDIVIDUAL IN THE INDICATED SECTOR AND ANNULAR RING(MREM)

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1664E+03	.2308E+03	.1661E+03	.1509E+03	.1462E+03	.1417E+03	.9984E+02	.9237E+02
450.	.4224E+02	.6437E+02	.4179E+02	.3753E+02	.3867E+02	.3570E+02	.2357E+02	.2072E+02
805.	.1622E+02	.1656E+02	.1452E+02	.1442E+02	.1495E+02	.1374E+02	.9000E+01	.7886E+01
1450.	.6769E+01	.7702E+01	.6113E+01	.5949E+01	.6224E+01	.5715E+01	.3727E+01	.3268E+01
2413.	.2517E+01	.2982E+01	.2371E+01	.2419E+01	.2415E+01	.2216E+01	.1440E+01	.1265E+01
4023.	.1102E+01	.1265E+01	.1053E+01	.9410E+00	.1019E+01	.9372E+00	.6088E+00	.5388E+00
5632.	.6271E+00	.7233E+00	.5731E+00	.5600E+00	.5807E+00	.5349E+00	.3475E+00	.3094E+00
7241.	.4123E+00	.4770E+00	.3761E+00	.3692E+00	.3822E+00	.3526E+00	.2292E+00	.2051E+00

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.4235E+02	.1234E+03	.7006E+02	.6304E+02	.6662E+02	.6464E+02	.5058E+02	.1149E+03
450.	.2194E+02	.2933E+02	.1665E+02	.1342E+02	.1443E+02	.1478E+02	.1254E+02	.2949E+02
805.	.8461E+01	.1081E+02	.6368E+01	.5060E+01	.5445E+01	.5620E+01	.4790E+01	.1133E+02
1450.	.3455E+01	.4472E+01	.2626E+01	.2082E+01	.2241E+01	.2321E+01	.1977E+01	.4696E+01
2413.	.1335E+01	.1726E+01	.1009E+01	.7990E+00	.8604E+00	.8938E+00	.7611E+00	.1814E+01
4023.	.5637E+00	.7305E+00	.4254E+00	.3379E+00	.3637E+00	.3769E+00	.3176E+00	.7607E+00
5632.	.3215E+00	.4175E+00	.2427E+00	.1931E+00	.2077E+00	.2148E+00	.1795E+00	.4313E+00
7241.	.2119E+00	.2756E+00	.1600E+00	.1275E+00	.1370E+00	.1414E+00	.1173E+00	.2828E+00

POPULATION DOSE TO THE INDICATED SECTOR AND ANNULAR RING(MAN-REM)

DIS		NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	RUNNING TOTAL
300.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
600.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1010.	19.54	27.82	11.86	[illegible]	7.67	5.59	1.80	2.37	2.50	.54	1.92	1.52	.54	5.62	4.79	13.60	118.92
1609.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	118.92
3214.	2.59	4.67	3.56	[illegible]	1.33	2.22	.14	.51	.03	.17	.03	.01	.34	.89	.08	.73	140.76
4828.	.64	.13	1.59	.35	2.94	1.41	.49	.91	.56	.47	.00	.00	.02	.02	.13	.61	149.48
6437.	1.57	.36	.23	.16	1.74	1.60	.28	.77	.13	.05	.02	.04	.17	.17	.04	.13	157.61
8045.	.62	.10	.57	.42	1.15	.35	.18	.62	.08	.03	.01	.38	.41	.42	.01	.03	163.49

THE CONTRIBUTING RADIONUCLIDES ARE

ISOTOPE	CAT ORGAN	DCF	CURIES RELEASED	DECAY CONSTANT (1/SEC)	DECON FACTOR
RN 222	LUNG	.3180E+05	.1370E+01	.210E-05	.100E+01
U 234	LUNG	.1160E+08	.1700E-01	.898E-13	.100E+01
U 238	LUNG	.1320E+08	.1700E-01	.480E-17	.100E+01
TH 232	LUNG	.1512E+09	.9000E-02	.157E-17	.100E+01
TH 230	LUNG	.1500E+09	.8800E-03	.275E-12	.100E+01
TH 228	LUNG	.2352E+09	.1250E-01	.115E-07	.100E+01
RA 226	LUNG	.4004E+08	.1420E-01	.328E-08	.100E+01
RA 228	LUNG	.2370E+08	.2300E-02	.136E-10	.100E+01
RA 224	LUNG	[illegible]E+07	.1320E-01	.220E-05	.100E+01
PB 212	LUNG	.4433E+05	.1220E-01	.181E-04	.100E+01
PB 210	LUNG	.6640E+07	.6300E-03	.113E-08	.100E+01

TOTAL CI.= .1469E+01

DOSE TO AN INDIVIDUAL IN THE INDICATED SECTOR AND ANNULAR RING(MREM)

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.2964E+03	.2509E+03	.2951E+03	.1886E+03	.1824E+03	.1771E+03	.1248E+03	.1155E+03
450.	.5284E+02	.6065E+02	.5149E+02	.4591E+02	.4833E+02	.4461E+02	.2946E+02	.2590E+02
805.	.2014E+02	.2319E+02	.1552E+02	.1802E+02	.1569E+02	.1717E+02	.1125E+02	.9953E+01
1609.	.9444E+01	.9621E+01	.7568E+01	.7482E+01	.7773E+01	.7139E+01	.4656E+01	.4082E+01
2414.	.4268E+01	.3725E+01	.2661E+01	.2897E+01	.3015E+01	.2767E+01	.1798E+01	.1580E+01
4023.	.1476E+01	.1570E+01	.1252E+01	.1224E+01	.1272E+01	.1170E+01	.7500E+00	.6727E+00
5632.	.7822E+00	.9026E+00	.7130E+00	.6996E+00	.7243E+00	.6673E+00	.4336E+00	.3862E+00
7241.	.5140E+00	.5260E+00	.4715E+00	.4594E+00	.4765E+00	.4397E+00	.2859E+00	.2559E+00

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.1154E+03	.1543E+03	.4475E+02	.7845E+02	.8324E+02	.4079E+02	.6323E+02	.1436E+03
450.	.2710E+02	.3547E+02	.2115E+02	.1574E+02	.1803E+02	.1844E+02	.1567E+02	.3685E+02
805.	.1042E+02	.1350E+02	.7882E+01	.6323E+01	.5804E+01	.7022E+01	.5984E+01	.1416E+02
1609.	.4115E+01	.5580E+01	.3281E+01	.2601E+01	.2800E+01	.2899E+01	.2469E+01	.5866E+01
2414.	.1567E+01	.2156E+01	.1259E+01	.9980E+00	.1075E+01	.1115E+01	.9502E+00	.2265E+01
4023.	.7036E+00	.9122E+00	.5313E+00	.4219E+00	.4541E+00	.4705E+00	.3962E+00	.9492E+00
5632.	.4011E+00	.5210E+00	.3026E+00	.2410E+00	.2591E+00	.2680E+00	.2238E+00	.5379E+00
7241.	.2642E+00	.3430E+00	.1447E+00	.1591E+00	.1708E+00	.1764E+00	.1462E+00	.3525E+00

POPULATION DOSE IN THE INDICATED SECTOR AND ANNULAR RING(MAN-REM)

DIS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	RUNNING TOTAL
300.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
804.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1610.	24.[illegible]	14.77	14.81	14.[illegible]	9.34	6.87	2.25	2.96	3.13	.58	2.39	1.90	.68	7.02	5.98	16.99	148.58
1609.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	148.58
3218.	2.61	5.59	4.44	[illegible]	2.41	2.77	.18	.63	.04	.22	.03	.01	.43	1.12	.19	.91	175.85
4828.	1.19	.16	1.89	[illegible]	2.54	1.75	.61	1.01	.70	.05	.01	.00	.02	.62	.15	.75	186.74
6437.	1.46	.45	.29	1.[illegible]	2.17	2.00	.35	.47	.16	.35	.03	.05	.21	.21	.04	.16	196.88
8046.	.77	.12	.71	1.15	1.43	.44	.23	.77	.11	.33	.01	.48	.51	.53	.01	.04	204.22

THE CONTRIBUTING RADIONUCLIDES ARE

ISOTOPE	CRIT ORGAN	DCF	CURIES RELEASED	DECAY CONSTANT (1/SEC)	DECON FACTOR
U 238	[illegible]	.2503E+07	.1700E-01	.488E-17	.100E+01
U 234	[illegible]	.2640E+07	.1700E-01	.880E-13	.100E+01
TH 232	[illegible]	[illegible]	.3000E-02	.157E-17	.100E+01
TH 230	[illegible]	.5410E+09	.8800E-03	.275E-12	.100E+01
TH 228	[illegible]	.5074E+08	.125[illegible]E-01	.115E-07	.100E+01
RA 228	[illegible]	.1119E+04	.1420E-01	.328E-08	.100E+01
RA 226	[illegible]	.3170E+08	.2300E-02	.136E-10	.100E+01
RA 224	[illegible]	.3022E+04	.1320E-01	.220E-05	.100E+01
PB 212	[illegible]	.4467E+05	.1220E-01	.181E-04	.100E+01
PB 210	[illegible]	.6697E+07	.6300E-03	.113E-08	.100E+01

TOTAL CI.= .9841E-01

PROBLEM SUMMARY

FACILITY	PERIOD FROM	TO	ENERGY (MWD(TM))
KERR CASE 2	00/00/00	00/00/00	-0.

MONTHS OF OPERATION	TOTAL FREQUENCY	TOTAL POPULATION	HOLDUP (DAYS)	HEFF (METERS)
0.99	100.0	71110.	0.0	5.

RADIONUCLIDE CONTRIBUTIONS TO POPULATION DOSES ARE

U 238	WB	.07 MAN-REM
U 234	WB	.06 MAN-REM
TH 232	WB	.38 MAN-REM
TH 230	WB	.40 MAN-REM
TH 228	WB	.60 MAN-REM
RA 228	WB	4.81 MAN-REM
RA 226	WB	1.49 MAN-REM
RA 224	WB	.00 MAN-REM
PB 212	WB	.00 MAN-REM
PB 210	WB	.00 MAN-REM
RN 222	LUNG	1.34 MAN-REM
U 238	LUNG	5.51 MAN-REM
U 234	LUNG	5.27 MAN-REM
TH 232	LUNG	38.00 MAN-REM
TH 230	LUNG	3.80 MAN-REM
TH 228	LUNG	67.44 MAN-REM
RA 228	LUNG	16.20 MAN-REM
RA 226	LUNG	1.71 MAN-REM
RA 224	LUNG	.02 MAN-REM
PB 212	LUNG	.01 MAN-REM
PB 210	LUNG	.12 MAN-REM
U 238	BONE	1.14 MAN-REM
U 234	BONE	1.25 MAN-REM
TH 232	BONE	163.22 MAN-REM
TH 230	BONE	14.28 MAN-REM
TH 228	BONE	17.71 MAN-REM
RA 228	BONE	4.44 MAN-REM
RA 226	BONE	2.04 MAN-REM
RA 224	BONE	.00 MAN-REM
PB 212	BONE	.32 MAN-REM
PB 210	BONE	.12 MAN-REM

POST RECLAMATION - RADON

CASE 3

APPENDIX D

INPUT DATA:

FACILITY	MONTHS	PERIOD	ENERGY
KERR CASE 3	0.0000/00/00	00/00/00	-0.00

SECTORS.STA.CLASSES.RADII.ISOTOPES.STACK HT..INV.LID.HOLDUP(DAYS).RAIN FRAC.WASHOUT CO

16 6 8 1 .500E+01 .100E+04 0. .500E-01 .200E-03

WIND FREQ IN PERC BY STA. CLASS FOR EACH SECTOR AND TOTAL FREQUENCY

DIR	A	B	C	D	E	F	TOTAL
N	.01	.26	.76	2.03	2.50	2.91	8.46
NNE	.02	.32	1.19	3.44	3.48	3.21	11.66
NE	.02	.34	1.19	2.98	2.80	2.43	9.76
ENE	.03	.32	.83	2.33	2.30	2.68	8.49
E	.03	.25	.65	1.83	1.98	3.05	7.69
ESE	.02	.17	.66	2.28	2.10	2.53	7.77
SE	.02	.19	.47	1.72	1.75	1.39	5.54
SSE	.04	.14	.41	1.76	2.17	1.04	5.57
S	.01	.13	.35	1.44	1.87	1.16	4.97
SSW	.04	.22	.69	2.31	2.33	1.53	7.12
SW	.02	.23	.55	1.62	1.43	.74	4.59
WSW	.00	.18	.46	1.21	1.23	.57	3.66
W	.02	.17	.52	1.19	1.09	.70	3.68
WNW	.01	.15	.33	1.01	1.06	.78	3.34
NW	.02	.11	.20	.55	.64	.74	2.26
NNW	.01	.25	.54	1.23	1.38	2.05	5.46

WIND SPEEDS IN M/SEC BY STA.CLASS FOR EACH DIRECTION

DIR	A	B	C	D	E	F
N	2.42	2.98	4.12	5.92	5.40	2.94
NNE	2.21	3.09	4.32	6.53	5.92	3.26
NE	2.17	3.29	4.58	6.53	6.12	3.18
ENE	2.11	3.03	4.27	6.38	6.02	3.17
E	2.06	2.78	4.22	6.17	5.86	3.08
ESE	2.21	2.98	4.17	6.33	5.66	3.13
SE	1.85	2.83	4.06	6.12	5.66	3.06
SSE	2.21	2.93	4.22	6.53	5.86	3.33
S	2.21	2.88	3.86	5.92	5.61	2.87
SSW	2.16	2.98	4.63	6.17	5.76	3.07
SW	2.16	2.98	4.48	5.81	5.76	3.03
WSW	2.05	3.29	4.32	5.56	5.76	3.16
W	2.05	3.19	4.32	5.50	5.09	3.24
WNW	2.42	2.98	4.01	5.25	5.04	3.01
NW	2.42	2.83	3.76	4.84	4.48	2.62
NNW	2.16	2.98	4.01	5.14	4.94	2.45

POPULATIONS IN SEGMENTS, TWO LINES PER RADIUS (READ CLOCKWISE), AND TOTAL POPULATION IN ANNULI

1	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	1200.	1500.	800.	800.	500.	400.	200.	300.	
	300.	50.	300.	300.	100.	1000.	1000.	1200.	9950.
4	0.	0.	0.	0.	0.	0.	0.	0.	
	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	800.	1500.	1500.	2000.	800.	1000.	100.	400.	
	25.	100.	25.	10.	400.	1000.	100.	400.	10160.
6	800.	100.	1500.	50.	2000.	1500.	800.	1500.	
	1000.	100.	10.	10.	50.	50.	400.	800.	10670.
7	2500.	500.	400.	1500.	3000.	3000.	800.	2500.	
	400.	100.	100.	200.	800.	800.	200.	300.	17100.
8	1500.	200.	1500.	2500.	3000.	1000.	800.	3000.	
	400.	100.	50.	3000.	3000.	3000.	100.	100.	23250.

DISTANCES IN METERS : MIDPOINT, LOWER AND UPPER OF BINS

NM	X	XLOW	XUP
1	150.	0.	300.
2	450.	300.	600.
3	805.	600.	1010.
4	1359.	1010.	1609.
5	2413.	1609.	3218.
6	4023.	3218.	4828.
7	5632.	4828.	6437.
8	7241.	6437.	8046.

PARTICLE AND HALOGEN DEPOSITION VEL EXPANSION COEFF

.500E-02	.500E-02	.500E-02	.500E-02	.500E-02	.500E-02
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
.200E-01	.200E-01	.200E-01	.200E-01	.200E-01	.200E-01
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.

NUMBER OF ISOTOPES PER SET OF ORGANS

0 1 0 0

LL	ISOTOPE	ORGAN	DCF	LAMDA	NUFP	NGAM	NDTR	SOURCE	DEC FACTOR
1	RN 222	LUNG	.318E+05	.210E-05	0	0	0	.130E+00 CI	0.00DEC

OUTPUT DATA:

SIGMA ZEES BY STABILITY CLASS AND RADIUS

A	B	C	D	E	F
.219E+02	.155E+02	.103E+02	.682E+01	.494E+01	.326E+01
.447E+02	.470E+02	.295E+02	.167E+02	.120E+02	.788E+01
.244E+03	.862E+02	.501E+02	.260E+02	.183E+02	.119E+02
.430E+03	.151E+03	.810E+02	.380E+02	.261E+02	.168E+02
.231E+04	.261E+03	.137E+03	.565E+02	.374E+02	.237E+02
.809E+04	.494E+03	.218E+03	.792E+02	.502E+02	.311E+02
.100E+05	.720E+03	.297E+03	.979E+02	.602E+02	.367E+02
.100E+05	.957E+03	.374E+03	.114E+03	.685E+02	.412E+02

CHIOQ SUMMED OVER STA.CLASSES

N	.243E-04	.748E-05	.297E-05	.128E-05	.512E-06	.232E-06	.139E-06	.959E-07
NNE	.343E-04	.852E-05	.336E-05	.143E-05	.572E-06	.258E-06	.154E-06	.106E-06
NE	.240E-04	.683E-05	.268E-05	.114E-05	.455E-06	.204E-06	.122E-06	.838E-07
ENE	.234E-04	.662E-05	.262E-05	.112E-05	.448E-06	.202E-06	.121E-06	.835E-07
E	.250E-04	.693E-05	.273E-05	.117E-05	.472E-06	.214E-06	.129E-06	.888E-07
ESE	.242E-04	.630E-05	.250E-05	.107E-05	.424E-06	.194E-06	.116E-06	.801E-07
SE	.171E-04	.416E-05	.163E-05	.696E-06	.277E-06	.125E-06	.747E-07	.512E-07
SSE	.154E-04	.364E-05	.142E-05	.603E-06	.239E-06	.107E-06	.640E-07	.439E-07
S	.154E-04	.386E-05	.152E-05	.647E-06	.258E-06	.116E-06	.696E-07	.478E-07
SSW	.211E-04	.500E-05	.196E-05	.832E-06	.331E-06	.148E-06	.887E-07	.608E-07
SW	.135E-04	.298E-05	.115E-05	.486E-06	.192E-06	.854E-07	.504E-07	.347E-07
WSW	.104E-04	.236E-05	.912E-06	.384E-06	.151E-06	.673E-07	.400E-07	.273E-07
W	.114E-04	.254E-05	.983E-06	.415E-06	.164E-06	.731E-07	.435E-07	.297E-07
WNW	.119E-04	.261E-05	.102E-05	.434E-06	.172E-06	.773E-07	.461E-07	.316E-07
NW	.855E-05	.223E-05	.882E-06	.378E-06	.151E-06	.684E-07	.410E-07	.282E-07
NNW	.196E-04	.522E-05	.208E-05	.893E-06	.358E-06	.162E-06	.973E-07	.670E-07

AVERAGE ACTIVITY IN AIR, RELEASE RATE(CI/SEC) TIMES X/Q(SEC/M**3)
PICOCURIES/M**3 OF RN 222

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1166E+00	.1412E+00	.1156E+00	.1063E+00	.1030E+00	.9985E-01	.7035E-01	.6508E-01
450.	.3081E-01	.3510E-01	.2814E-01	.2727E-01	.2815E-01	.2595E-01	.1713E-01	.1501E-01
805.	.1225E-01	.1383E-01	.1105E-01	.1079E-01	.1124E-0[illegible]	.1030E-01	.6728E-02	.5949E-02
1355.	.5260E-02	.5906E-02	.4706E-02	.4618E-02	.4937E-02	.4415E-02	.2867E-02	.2482E-02
2413.	.2103E-02	.2354E-02	.1872E-02	.1845E-02	.1943E-02	.1767E-02	.1142E-02	.9848E-03
4023.	.9530E-03	.1059E-02	.9405E-03	.8322E-03	.8802E-03	.7979E-03	.5131E-03	.4413E-03
5632.	.5720E-03	.6340E-03	.5022E-03	.4988E-03	.5291E-03	.4785E-03	.3068E-03	.2632E-03
7241.	.3934E-03	.4350E-03	.3443E-03	.3427E-03	.3543E-03	.3289E-03	.2104E-03	.1802E-03

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.6507E-01	.869[illegible]-01	.5567E-01	.4445E-01	.6695E-01	.4554E-01	.3564E-01	.8096E-01
450.	.1[illegible]E-01	.2060E-01	.1230E-01	.9733E-02	.1047E-01	.1076E-01	.9178E-02	.2153E-01
805.	.6250E-02	.8061E-02	.4751E-02	.3757E-02	.4053E-02	.4207E-02	.3635E-02	.8564E-02
1355.	.2667E-02	.3427E-02	.2003E-02	.1583E-02	.1710E-02	.1787E-02	.1556E-02	.3676E-02
2413.	.1963E-02	.1361E-02	.7891E-03	.6229E-03	.6743E-03	.7092E-03	.6226E-03	.1473E-02
4023.	.4781E-03	.6106E-03	.3513E-03	.2771E-03	.3005E-03	.3178E-03	.2810E-03	.6660E-03
5632.	.2860E-03	.3645E-03	.2087E-03	.1645E-03	.1787E-03	.1896E-03	.1685E-03	.3998E-03
7241.	.1961E-03	.2497E-03	.1424E-03	.1122E-03	.1220E-03	.1298E-03	.1158E-03	.2750E-03

DOSE TO AN INDIVIDUAL IN THE INDICATED SECTOR AND ANNULAR RING(M[illegible])

DISTANCE	N	NNE	NE	ENE	E	ESE	SE	SSE
150.	.1169E+00	.1416E+00	.1159E+00	.1066E+00	.1033E+00	.1001E+00	.7055E-01	.6527E-01
450.	.3090E-01	.3520[illegible]-01	.2822E-01	.2735E-01	.2823E-01	.2603E-01	.1718E-01	.1505E-01
805.	.1229E-01	.1347E-01	.1108E-01	.1082E-01	.1127E-01	.1033E-01	.6748E-02	.5866E-02
1359.	.5275E-02	.5922E-02	.4720E-02	.4631E-02	.4850E-02	.4427E-[illegible]	.2875E-02	.2489E-02
2413.	.2114E-02	.2361E-02	.1877E-02	.1851E-02	.1948E-02	.1772E[illegible]	.1145E-02	.9476E-03
4023.	.9557E-03	.1062E-02	.8429E-03	.834[illegible]-03	.8827E-03	.8002E-03	.5146E-03	.4425E-03
5632.	.5736E-03	.6358E-03	.5037E-03	.50[illegible]E-03	.5306E-03	.4799E-03	.3076E-03	.2640E-03
7241.	.3945E-03	.4362E-03	.3453E-03	.3436E-03	.3654E-03	.3298E-03	.2110E-03	.1807E-03

DISTANCE	S	SSW	SW	WSW	W	WNW	NW	NNW
150.	.6626E-01	.8720E-01	.5582E-01	.4457E-01	.4708E-01	.4567E-01	.3574E-01	.8119E-01
450.	.1594E-01	.2066E-01	.1233E-01	.9761E-02	.1050E-01	.1079E-01	.9204E-02	.2159E-01
805.	.6268E-02	.8084E-02	.4765E-02	.3768E-02	.4064E-02	.4219E-02	.3645E-02	.8589E-02
1359.	.2674E-02	.3437E-02	.2009E-02	.1587E-02	.1715E-02	.1792E-02	.1561E-02	.3686E-02
2413.	.1066E-02	.1365E-02	.7913E-03	.6246E-03	.6763E-03	.7112E-03	.6243E-03	.1477E-02
4023.	.4795E-03	.6124E-03	.3523E-03	.2779E-03	.3014E-03	.3187E-03	.2818E-03	.6679E-03
5632.	.2868E-03	.365[illegible]-03	.2093E-03	.1650E-03	.1792E-03	.1902E-03	.1689E-03	.4010E-03
7241.	.1967E-03	.2504E-03	.1428E-03	.1125E-03	.1223E-03	.1302E-03	.1161E-03	.2758E-03

POPULATION DOSE IN THE INDICATED SECTOR AND ANNULAR RING(MAN-REM)

DIS	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	RUNNING TOTAL
300.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
600.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1010.	.01	.02	.01	.01	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.01	.03
1609.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.09
3218.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.11
4828.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.11
6437.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.12
8046.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.13

THE CONTRIBUTING RADIONUCLIDES ARE

ISOTOPE	CRT ORGAN	DCF	CURIES RELEASED	DECAY CONSTANT (1/SEC)	DECON FACTOR
RN 222	LUNG	.3180E+05	.1300E+00	.210E-05	.100E+01

TOTAL CI.= .1300E+00

PROBLEM SUMMARY

FACILITY	PERIOD FROM	PERIOD TO	ENERGY (MWD(TH))
KERR CASE 4	00/00/00	00/00/00	-0.

MONTHS OF OPERATION	TOTAL FREQUENC	TOTAL POPULATION	HOLDUP (DAYS)	HEFF (METERS)
0.00	100.0	71130.	0.0	5.

RADIONUCLIDE CONTRIBUTIONS TO POPULATION DOSES ARE

RN 222 LUNG .13 MAN-REM

WASTE PILE CALCULATIONS
ISOTOPIC CONTENT

ATTACHMENT 1

KERR-McGEE NUCLEAR CORPORATION
KERR-McGEE CENTER • OKLAHOMA CITY, OKLAHOMA 73125

March 4, 1980

Mr. Irwin Spickler
Dames & Moore
Washington, D. C. 20014

Dear Mr. Spickler:

Please refer to the dose calculation prepared by your organization for the comtemplated reclamation of a West Chicago Thorim Plant. Your work has been reviewed by others in our organization and we request that it be done with the following modifications.

1. Use a O'Hare Airport (Chicago) weather record as a source of information instead of Midway.

2. Consider the source as an area source rather than a point source.

3. Modify the diffusion coefficients considering the particle density and moisture of the material as listed below.

	Density	Moisture
Pile 1 - Sediment	3.8 g/cc	40%
Pile 2 - Tailings	2.7 g/cc	36.5

   In addition, in view of our need to neutralize the material with lime slurry, assume a moisture factor of 40% as applicable for the material after contouring into final contour.

4. Consider thoron release, Rn^{220}, in addition to Rn^{222}.

5. Use the following quantities as measured by gamma spectrograph for the concentrations in each pile.

Tailings 1172 pCi/gm	Ra^{226}; 2792 pCi/gm Ra^{224}
Sediment 277 pCi/gm	Rn^{226}; 5438 pCi/gm Rn^{224}

6. Reconsider assumption of total release on moving material.

In addition, would you please calculate for a convenient distance the exposure to adjacent personnel on a highway over which a truck load of the residues are being transported in dump trucks covered with tarpaulins. In this manner, if a location is found off site, the total transportation exposure can be calculated.

Please provide a windrose of the O'Hare data.

Call me if you have any questions.

Yours very truly,

W. J. Shelley, Director
Regulation and Control

WJS/pls
cc: L. Skoski

TABLE 1

WEST CHICAGO WASTE PILE ANALYSIS

	Per Gram	SLUDGE P-1 No. 4 Top 18' Depth.	TAILINGS P-2 No. 8 Top of Hill 5' Depth	
Pb-210	pCi	<199	<194 @	25
Pb-212	pCi	4057	3512	0.5
Pb-214	pCi	208	892	1.5
Ra-224	pCi	4057	3512	0.5
Ra-226	pCi	208	892	1.5
Ra-228	pCi	5727	3089	1.1
Th-228	pCi	4937	2825	2
Th-230	pCi	494	53	17
Th-232	pCi	4847	428	6
Th-232	mg	53	3.4	
U-238	mg	27	5.1	

Source: Telecopy from Bill Shelley of Kerr McGee Nuclear 7/25/79

TABLE 2

Fugitive Dust Generation During Relocation of Waste Piles

Total Volume of Material in Piles = 48,556 yd^3

Estimated Equipment Use

Scraper	=	1280 hr
Dozer	=	1420 hr
TOTAL	=	2700 hr

Dust Emission Factor From Pedco 76

Scraper & Dozer E = 32 #/hr
Reduction of 50% for Watering

Dust Generation

$$(0.5) \times 32 \frac{\text{lbs}}{\text{hr}} \times \underline{2700} \text{ hr.} = 43{,}200 \text{ lbs dust}$$

Operation will take 36 weeks or 1440 hrs.

$$\frac{43{,}200 \text{ lbs}}{1440 \text{ hrs}} = 30 \frac{\text{lb}}{\text{hr}} \text{ avg. emission rate}$$

Source: Telecopy from Bill Shelley of Kerr McGee Nuclear 7/25/79

TABLE 3

ANALYSIS FOR CLAY AND SOILS

	CLAY	SUB SOIL	SOIL	TOP SOIL
ISOTOPIC (pCi/g)				
Radium 226	0.87	1.5	0.94	1.5
Thorium 230	0.82	0.98	0.89	0.72
Permeability Index	10^{-8}	10^{-6}	-	10^{-6}
Bulk Density (lb/ft^3)	120	105	-	105

Source: Telecom with Bill Shelley of Kerr McGee Nuclear 7/25/79

APPENDIX III

Location and Evaluation of IMPERMEABLE CLAY SOURCES

West Chicago, Illinois

For

KERR-McGEE CHEMICAL CORPORATION

Kerr-McGee Center
Oklahoma City, Oklahoma 73125

By

SOIL TESTING SERVICES, INC.

111 Pfingsten Road
Northbrook, Illinois 60062

[illegible] Job No. 21439

April 9, 1980

SOIL TESTING SERVICES
111 PFINGSTEN ROAD NORTHBROOK, ILLINOIS 60062
PHONE Chicago 312-273-5440 Northbrook 312-272-6520

April 9, 1980

Mr. Ivan Denny
Kerr-McGee Chemical Corporation
Kerr-McGee Center
Oklahoma City, Oklahoma 73125

STS Job No. 21439

Reference: Location and Evaluation of Impermeable Clay Sources in the West Chicago Area

Dear Mr. Denny:

In accordance with your instructions and authorization in your letter of March 5, 1980, we have completed our evaluation to locate clay sources in the West Chicago area to be used as a clay liner for your West Chicago plant. We have located several possible sources and have been able to complete laboratory tests on samples from each area.

We are submitting, herewith, our findings. Details of our study and our conclusions are outlined in the text of the report which follows. The report includes descriptions of the methods used in the evaluation, prime and alternative locations of the material, and a suggested site specific follow-up evaluation.

If you have any questions or comments concerning the contents of the report, please do not hesitate to contact us.

Very truly yours,

SOIL TESTING SERVICES, INC.

Barry R. Christopher

Barry R. Christopher, P.E.
Project Engineer

Safdar A. Gill KS

Safdar A. Gill, Ph.D., P.E.
Chief Engineer

BRC/kf

INTRODUCTION

This report presents a study by Soil Testing Services, to locate and evaluate sources of clay to be used as a landfill liner at the Kerr-McGee plant in West Chicago. Three to five source locations were to be identified. We understand that the clay must have a permeability of less than 1×10^{-8} centimeters per second (cm/sec) to meet the Environmental Protection Agency (EPA) requirements. Kerr-McGee has estimated that approximately 100,000 cubic yards (yd^3) of clay will be required during 1981 and 1982. Approval of each source by the Nuclear Regulatory Commission may be required; therefore, all laboratory tests performed in this study were in general conformance with Quality Assurance techniques.

Due to the relatively short time available for this initial study, only an overview of the possible available areas and limited laboratory testing of soil samples could be performed. A more detailed study would be necessary when the specific site is selected. The current study consisted of:

A. Literature search of available subsurface information including geologic maps, agricultural surveys, and previous subsurface explorations performed by Soil Testing Services;

B. Telephone communications with excavators and other earth handlers in or near the study area;

C. Site visits and collection of samples; and

D. Preliminary laboratory testing program.

EVALUATION PROCEDURES

There are three possible alternatives to obtain clay materials. These are: 1) clay materials can be obtained from the surface, utilizing stripping procedures and relatively shallow cuts such that the land can be reused once the source materials are acquired; 2) obtain clay from deep excavations using the excavated area as a disposal site or a retention basin; and, 3) acquire clay from commercial sources.

The first two alternatives require acquisition of the land by either leasing or purchasing. Regarding the third alternative, commercial sources are available, many times, from construction projects or gravel pits, once either the clay is obtained from initial stripping or subsequent overexcavation where the gravel supply has been exhausted. In addition, clay may be available where excavations for disposal areas are being made. Each of these alternatives were considered in this study.

Area of Study

For land acquisition, the area of study was limited to a 5 mile radius of West Chicago. This area is illustrated on the two aerial photographs, and accompanying overlays in the Appendix of this report. Commercial sources were evaluated within 10 miles of West Chicago.

The study was limited to the described 80 square mile area. We considered the haul distance of sites beyond this boundary to the Kerr-McGee West Chicago facility to be excessive and therefore, we would not evaluate these areas as primary sources unless closer sites proved inappropriate. In addition, due to the dense population east of West Chicago, it was not thought feasible to obtain an adequate supply of materials from that area.

Accessibility to source locations relates to the connections with transportation corridors which would be used by vehicles transporting the clay materials. Generally, it appears that almost any site within the study area is within approximately 1/2 mile of a roadway capable of accepting heavy truck traffic on a year round basis.

It should be noted that determination of the precise availability of sites is beyond the scope of this study. However, the search for available sites should be concentrated in the areas which were determined feasible by this study. Also, zoning patterns were not considered in this initial study. Zoning is a very important factor in the final selection of a source location. A 1971 zoning map of the West Chicago area is included in the Appendix. After specific sites have been selected, current zoning will have to be further established.

Literature Search

Geologic Maps

A study of the Illinois State Geologic Survey indicates that the surficial geology of the eastern half of the area surveyed is part of the Valparaiso Morainic System. This system consists largely of silty, sandy, or gravelly glacial till materials with local areas of silty clay tills. The West Chicago drift south of West Chicago and other Valparaiso drifts are slightly more silty and pebbly than lake border drifts common to the Chicago area and contain local areas of sandy to gravelly tills. The West Chicago drift includes extensive outwash plains and local lacustrine deposits along the front of the moraine to the west of West Chicago.

Other geologic units which were predominant in the western portion of the study area included the Batavia member of the Henry Formation and Manhattan-Minooka Ground Moraine of the Wedron Formation. The Batavia member of the Henry Formation consists mainly of well sorted sand and gravel which were deposited from glacial melt water rivers and streams in outwash plains. The Manhattan-Minooka drifts consist mainly of gray clay till that is locally silty.

The geologic information indicates that clay sources, both shallow and deep are more likely to be found in the eastern half and northern part of the study area. Clays that are found in the western portion of the site are likely to be highly silty, sandy or gravelly and of a higher permeability than the clays found in the other areas.

Agricultural Survey

In addition to the geologic maps, detailed surficial soil maps prepared by the U.S. Department of Agriculture, Soil Conservation Service were also studied. The Soil Conservation Service soils maps were of somewhat limited value since they are agriculturally directed and therefore pertain primarily to surficial soils. Typically, the Soil Conservation Service maps the soil only in the upper 6 ft. However, these maps have been found fairly accurate and could indicate land areas where stripping operations could be successful. Included with these maps are characteristics of the soils including Atterberg limit evaluation and permeability.

The soil survey maps tend to verify the geologic information. A variety of surface soil types are indicated in the study area. In the western half of the site, predominantly silty and sandy soils may be anticipated with only small concentrated areas of clay noted. For the eastern half of the site, predominantly silty clays were indicated with local deposits of relatively impermeable clay soils. The largest areas of potential impermeable clays are shown on the aerial photograph overlay entitled, "Possible Source Locations". The marked areas are thus possible source locations for the required clay.

Previous Subsurface Explorations By Soil Testing Services

Previous subsurface explorations performed by Soil Testing Services within the studied area are considered to be the most detailed source of information regarding soil deposits with depth. The borings in these explorations were drilled for the primary purpose of obtaining representative soil samples. The borings extended to depths generally between 10 to 42 ft. Soil Testing Services has drilled at numerous sites scattered throughout the study area. The locations of the exploration programs within the studied areas are also indicated on the photograph overlay previously discussed.

From the overlay, it can be seen that a large amount of information is available from our subsurface exploration for the Fermi National Accelerator Laboratory which is located in the southwestern portion of the studied area. A large number of laboratory tests were performed on selected samples, including permeability analysis. Also, field permeability tests were performed at several locations. The results of these tests indicate that clays with permeabilities of 1×10^{-8} cm/sec can be found locally in both shallow and deep deposits in that area.

Many borings performed at the Fermi site indicated deposits of gravel and sand, especially in the east-central, and northern portions of the National Accelerator Laboratory facility.

The other boring programs performed throughout the study area during the past 15 years verify the information obtained from the geologic and soil survey maps. Unfortunately, a majority of these boring programs encountered gravel and sand deposits as indicated by the geologic and agricultural surveys. Along the western side of the studied area, borings have encountered clay. However, the clay was typically low in plasticity and high in silt and sand content which characteristically would have permeabilities in the range of 10^{-6} to 10^{-7} cm/sec.

Few borings were performed in areas where relatively impermeable clay deposits had been anticipated. However, one of the explored areas was located within the Mallard Lake Disposal area. Permeability tests on a shallow deposit of clay (classified as relatively impermeable by the agricultural survey) indicated a permeability of less than 1×10^{-8} cm/sec. In another area, north of West Chicago, Soil Testing Services, Inc. borings encountered moderately plastic; relatively impermeable clays, as anticipated from the agricultural survey (see aerial photos and overlays).

Telephone Communications

In order to determine possible commercially available sources of clay, several telephone calls were made to excavators in the West Chicago area. The following excavators were contacted:

1. Lockertt Land Improvement - Tele. No. (312) 231-1840
2. H.W. Kuhn Company - Tele. No. (312) 293-1166
3. Riemer Brothers, Inc. - Tele. No. (312) 569-2010
4. E. and E. Hauling - Tele. No. (312) 894-9000

These excavators indicated that present construction activities in the area are limited and that clay supplies were not generally available from current construction excavations. However, several excavators indicated that clay may be available from gravel pits and waste disposal areas. In checking several gravel pits in the area, they were found not to have clay deposits available. However, further communications identified two possible sources of clay. Conversations with E. & E. Hauling personnel indicated that a source of blue clay was available at the Mallard Lake landfill site and that the Feltes Sand and Gravel Co. may have supplies of clay.

The Mallard Lake Disposal area is located approximately 5 miles north of West Chicago near the north part of the study area. The site belongs to the Cook County Forest Preserve and therefore, problems in utilizing the soil for private use may be encountered. Soil Testing Services, Inc. performed the subsurface exploration for the development of the disposal area. The drilling program indicated approximately one-half of the site consisted mainly of gravel, and the other one-half consisted of alternating layers of clay and silt.

Another potential source, Feltes Sand and Gravel, Co., is located approximately 12 miles west of West Chicago. Soil Testing Services, Inc. did not perform exploration services at this site. For this reason, although the Soil Survey indicates the presence of clay, detailed information is not available. Another gravel pit that may contain a source of clay is the Bald Mound Gravel Pit located 4 miles west of the study area on Fabyan Parkway. The pit was not accessible at the time this report was being prepared, however, the owner's advertise the sale of structural clay.

In addition to obtaining information on clay sources from contractors, costs for hauling and purchasing the clay were determined. Presently, cartage rates range from approximately $1.65 per ton for 5 miles to $3.26 per ton for 15 miles. Structural quality clay listed at $1.20 per ton at the pit at one of the gravel pits investigated.

Site Visits

Visits were made to West Chicago during two separate time periods to collect samples and to observe the possible source areas indicated by the soil survey and the commercial source contacts.

March 12 through March 14, 1980

Area reconnaissance during the period of March 12 through March 14, 1980 indicated that large parcels of land were commercially available within areas where impermeable clay sources may occur. An attempt was made to obtain samples from several of the areas indicated in the agricultural survey section; however, the ground was frozen and samples could not be obtained.

Visits to the commercial sites were found to be more beneficial. Excavation of areas were being performed at two out of three sites that were visited and clay samples were obtained from both sites. At the Mallard Lake site, a large excavation (over 50,000 ft^2 in plan) encountered a blue moderately plastic clay source at a depth of approximately 5 ft. The clay extended to the base of the excavation (varying from 10 to 15 ft) at the time of the visit. The clay appeared very uniform for the full depth. Bag samples of the clay at two locations were obtained.

At the Feltes Sand and Gravel Company, sandy clay was observed. However, the sandy clay reportedly overlies a deposit of moderately plastic, highly impermeable blue clay. Samples of the sandy clay were obtained and a follow-up site visit is planned to obtain several representative samples of the blue clay.

Samples from both sites were returned to our Northbrook laboratory for further examination and testing.

March 29 through March 30, 1980

During the second site visit, a photographic and visual survey of each of the potential source locations were made. The areas observed included the eleven (11) areas where shallow clay deposits were indicated by the literature review. Each site was given an alpha designator as indicated on the third aerial photo overlay. The overlay also shows congested or built up areas where it will probably not be possible to obtain materials. Representative photographs of the sites are included in the Appendix. The following presents a visual description of each site.

Site A - Except for a building located at the northeast corner of the site along Route 59, the site is vacant and appears to be unused. The area at the time of the visit was covered by tall grass and had approximately 1 inch of gravel and clay fill over a large portion of the area. The area appeared to have been stripped of topsoil. A water main was noted running through the site in a north/south direction directly south and in line with Sayre Road. There were also two, 1.5 ft diameter storm water drains running in an east/west direction through the site. The ground surface at the site could generally be described as flat.

Site B - The majority of Site B is presently used for agricultural purposes. The area was cultivated at the time of the site visit. As with Site A, the ground surface at Site B was relatively flat. Hand augering through the surface material indicated approximately 1 to 1.5 ft of topsoil which was underlain by fairly plastic clay.

Site C - The ground surface at Site C is fairly undulating. The entire area is on a slight rise. The land is presently used for agricultural purposes and at the time of the site visit, a hay field existed throughout a majority of the area. The southwest corner of the site is occupied by houses.

Site D - Site D occupies a very large area. As indicated on the aerial overlay by the crossed section, the southeastern and central portion of the site are either under development or completely developed and occupied by residential areas. Large areas of farm land occupy the western and southwestern parts of the site. A gravel pit was observed in the northeastern part of the site. The ground surface was generally flat with higher ground located in the north and eastern parts of the site.

Site E - As indicated on the aerial overlay, the northeastern corner of the site is under development at this time and the southern portion of the site is presently occupied by single family homes. The remainder of the site is farm land. The ground surface slopes down from the central portion of the site toward the southeast corner with an estimated surface elevation change of approximately 30 ft.

Site F - The majority of Site F was occupied by houses and does not offer any large areas for obtaining materials.

Site G - The entire north and eastern portion of Site G was occupied by houses. The southwest corner of the site was cultivated farm land and measured approximately 1500 ft X 1200 ft. A large manor occupies the south central portion of the site.

Site H - A large part of Site H was also occupied by houses. However, in several of the open areas, land is presently for sale. Two separate sections located in the central portion of the site contain for sale signs that indicated approximately 6 to 9 acres were for sale. One of these sections was a 55 acre area which is thickly wooded.

Site I - The majority of Site I was occupied by cultivated farm land. The ground surface was fairly level and sloped down from east to west. An excavation indicated approximately 2 to 2.5 ft of topsoil at the ground surface.

Site J - The central portion of the Site J was open land and was covered with weed and grass vegetation. One section of the site in the north central section was noted to be occupied by 2 to 3 ft of silty clay fill. Homes occupied the perimeter sections of the site.

Site K - Housing or other types of development occupied the northeast and southwest parts of Site K. However, a large expanse in the central part of the site was open cultivated farm land. The extent of the open area was approximately 2 square miles. One farm in the northwest part of the open area contained a "for sale" sign. The ground surface at the site may be described as fairly undulating as compared to the other sites.

Collection of Soil Samples

At the time of the second site visit, the ground surface had thawed and collection of samples was possible. A hand auger was used to obtain samples of the clay directly beneath the topsoil. Generally, samples were collected from a depth of 1 to 3 ft. The test hole for each sample were located on the basis of accessibility and were generally closer to the center of the site where possible. The approximate location of the sample hole is indicated on the third aerial overlay. The samples were sealed in plastic bags and returned to our Northbrook laboratory for further examination and testing.

No samples were obtained from Site F since that area was completely occupied by residential structures.

Due to the large number of sites and the limited time schedule, sampling at each site was limited to one or two locations. Approximately 5 lbs of material was collected from each location.

Laboratory Testing

The laboratory testing program consisted of performing visual classifications, Atterberg limit analysis, moisture vs. densitiy tests and permeability analysis on representative portions of the collected samples. Laboratory tests were performed on both samples of "blue clay" obtained from the Mallard Lake disposal area as well as on samples from each of the shallow clay source locations. Tests on the shallow source samples were restricted to visual classification and permeability analysis due to the limited amount of sample obtained from those areas. To obtain the results for this preliminary study, the tests were performed with a rapid program and all the requirements of the Quality Assurance procedures could not be strictly followed. The method of analysis used in this study was necessary to provide timely results and meet the requirements of this project.

The soils were classified using both visual and Casagrande classification methods. An experienced soil engineer classified each soil sample on the basis of texture and plasticity in accordance with the Unified Soil Classification System. With this system, the soils are grouped into various soil types based on its visual appearance and/or the results of the Atterberg limit determinations. A brief explanation of the Unified System is included with this report.

The Atterberg limits consisted of performing three liquid limit tests and two plastic limit tests. From this data, the plastic index of the specific soil can be obtained. These tests were performed in accordance with the procedures as outlined in the Appendix.

Moisture-density tests were performed on the Mallard Lake samples by two methods in accordance with ASTM Specifications D 698-70 and D 698-78. The former is a rapid method which allows for faster processing of the sample, thus resulting in a shorter turn around time. In this method, a single sample is used throughout the test, increasing its water content with each compaction point. The laboratory test was later repeated utilizing the longer term procedures presently recommended in ASTM Specification D-698-78 in which a new sample is used for each compaction point. In this method, each sample is prepared to have a unique water content and allowed to stand a minimum of 36 hours before compaction.

Back pressure falling head laboratory permeability tests using triaxial cells were performed on all samples. Performing the permeability tests in the triaxial cell offers better control of density, degree of saturation, confining pressure and minimizes possible leakage around the sides of the sample when compared to performing the test in other permeability equipment. By applying back pressure, an increase in pressure in the pore fluid results in the compression of undissolved gas bubbles in the pore fluid. This increases the solvency of the gas, increasing the saturation level of the specimen. Incomplete initial saturation of the specimen may tend to invalidate the results obtained from the permeability tests. For each degree of saturation, there is a corresponding additional pressure, which, if applied to the pore fluid in the specimen, will cause complete saturation. For this study, all samples were saturated at a confining pressure of 4.1 kg/cm^2 (ksc) and a back pressure of 4.0 ksc. The permeability was determined using an effective head differential of approximately 1 kg/cm^2 on all samples.

The permeability tests were performed on remolded, recompacted samples. For the Mallard Lake samples, permeability tests were performed at various densities in order to obtain a relationship between the relative density and the permeability of the soil. The tests were performed at the maximum density and corresponding "optimum" water content obtained from the Standard Proctor evaluation. Tests were also performed using Standard Proctor compactive effort at a moisture content of 3% on the wet side of optimum. A test was also performed on a specimen that was compacted at optimum moisture from Standard Proctor, however, utilizing a compactive effort equivalent to Modified Proctor (ASTM D-1557). One other test was performed in which 5% bentonite (a highly expansive montmorillic clay) was added to the sample at its natural moisture content.

For the shallow source samples, permeability specimens were prepared by compacting the specimens generally at their natural moisture content utilizing Standard Proctor compactive effort. It was felt that this would best model the actual field compaction conditions. The samples at their natural moisture content generally appeared to be on the order of 3 to 5% on the wet side of Standard Proctor optimum moisture. In several cases, the samples appeared to be very wet, greater than 5% on the wet side of Standard Proctor optimum. Wet samples, such as these, would be difficult to place and compact in the field without some drying. Therefore, samples that were judged "too wet" were allowed to air dry to a lower, more workable water content.

The sandy clays that were present at Feltes Sand and Gravel were visually inspected. Based on the observation, it is estimated that these soils would have a higher permeability, on the order of 10^{-5} to 10^{-6} cm/sec. Therefore, tests were not performed on these materials. When samples of the underlying "blue clay" deposits are available, we will perform permeability vs. density relationship tests on these soils.

Clay mineralogy and ionic exchange capacity of representative samples are presently being performed by an outside laboratory. As soon as the results of these tests are available, they will be forwarded to you.

Test Results

The results of all laboratory tests are included in the Appendix of this report. A summary of the test results is presented below in Table 1.

Table I. Summary of Laboratory Test Results

Source	Visual Classification	Natural Water Content	Atterberg Limits Liquid Limit	Atterberg Limits Plastic Limit	Permeability Results Test Density	Permeability Results Test Water Content	Permeability Results K
	(USCS)*	(%)	(%)	(%)	(PCF)	(%)	(cm/sec)
A-1	CL	17.7	34.0	18.0	109.2	17.2	7×10^{-9}
B	CH		NO TEST PERFORMED			est. less than	1×10^{-8}
C	CL	24.5	42.3	25.2	97.7	23.8	2×10^{-8}
D-1	CH	26.8	53.0	26.0	97.8	25.8	8×10^{-9}
D-2	CH	22.4	51.0	22.0	103.6	21.5	1×10^{-8}
E	CL-CH	29.4	49.0	22.0	92.5	28.9	2×10^{-8}
F			NO SAMPLE				
G	CH	34.3	55.0	30.0	86.1	33.4	4×10^{-8}
H	CL	25.3	38.0	24.0	96.9	25.2	7×10^{-8}
I	CL-CH	28.7	49.0	19.2	92.4	27.7	5×10^{-9}
J	CH	27.7	53.0	30.0	93.3	26.6	8×10^{-8}
K	CL-CH	26.6	45.0	25.0	95.6	26.4	2×10^{-8}
Mallard Lake							
1 (10')-1A	CL	18	38	17	113	17.8	7×10^{-9}
1 (10')-1B	CL	18	38	17	110	18.8	6×10^{-9}
2 (15')-2A	CL	--	36	17	116.4	15.7	2×10^{-8}
2 (15')-2B	CL	--	36	17	108.8	18.9	4×10^{-8}
2 (mod proc)	CL	4.7	36	17	108.3	18.9	1×10^{-8}
2 (w/bentonite)	CL-CH	4.7	45	21	134.6	19.2	1×10^{-9}
Feltes	CL-SC					estimated	1×10^{-6}

*Unified Soil Classification System, See Appendix.

Table I shows that most of the samples meet or are very close to the permeability requirement of 1×10^{-8} or less. Samples from Site G, H and J were not found to meet the requirements, and were not sufficiently close to warrant further study.

Permeability tests on samples fom site C, E, and K at their prepared densities and moisture content also did not meet the requirement, but are sufficiently close to warrant further analysis. Lower permeabilities can probably be obtained by lowering the water content and/or increasing the compactive effort applied to the samples. This is demonstrated by the test performed on Mallard Lake sample number 2-B, which was compacted using a higher compactive effort. The permeability of the sample was decreased to an acceptable level. This indicates that careful field compaction control will be necessary to obtain the required permeability. However, the required permeability does appear to be attainable on these samples utilizing normal compaction procedures. Additional testing will be required to determing the optimum compactive effort to obtain repeatable acceptable permeability values.

The test on the Mallard sample to which bentonite was added indicates a significant permeability decrease that was achieved by mixing the soils with montmorillic clays. The permeability was decreased from 1×10^{-8} cm/sec to 1×10^{-9} cm/sec.

Summary and Conclusions

Two alternatives to obtain clay materials with the desired characteristics are technically available in the West Chicago area. Clay sources with the required properties may be available in the form of both shallow and deep deposits.

Based on a literature review, eleven (11) areas of potential shallow sources of clay have been delineated. Site visits and laboratory testing indicate that seven of these areas contain clay with the desirable characteristics and provide potentially available (non-developed) land. These areas are designated on the third aerial overlay and are Areas: A, B, C, D, E, I and K. Laboratory analysis on randomly selected samples from each of the seven sites indicates that clay with the desirable characteristics appears to be available at each of these sites. The samples, when compacted to a moderate density, at or near their natural moisture content were found to have a permeability on the order of 10^{-8} or less. Several tests indicate that good compaction control will be required; however, with normal compaction procedures, the required permeability should be obtained.

In addition to the shallow sources, potential sources of deeper deposits of impermeable clay material are located at the Mallard Lake Solid Waste Disposal site, the Feltes Sand and Gravel Company, and possibly at the Bald Mound gravel pit. These areas appear to contain "blue clay" which consists of a moderate to high plasticity, silty clay. Tests on the blue clay at the Mallard Lake landfill indicate permeabilities on the order of 10^{-8}cm/sec or less. Tests indicate that the soils may require good compaction control to achieve the required permeabilities; however, the required permeability does appear to be obtainable under normal compaction procedures. Further study of the Mallard Lake area would be required to determing if material from that area can be acquired. The property presently belongs to the Cook County Forest Preserve.

Several alternatives for obtaining the required permeability for liner and cover materials exist. One such alternative would be to provide an additive to decrease the permeability of the natural clay materials. This can be accomplished by adding a montmorillonite clay to the already relatively impermeable natural clays. This is demonstrated by the permeability tests performed on the sample from the Mallard Lake landfill. Adding 5% by weight bentonite to the sample decreased the permeability of the material by an order of magnitude (from 1×10^{-8} to 1×10^{-9} cm/sec). By alternating highly impermeable montmorillonite clay layers with natural clay layers, an effective total depth of liner and cover with a permeability less than 10^{-8} cm/sec may be achieved.

Due to the natural heterogeneity of soil deposits and the variations inherent in all laboratory testing, the permeability results are not necessarily absolute values. The results obtained are such that additional testing of the clay stratum at various locations and depths in each of the sample area will be required to achieve enough data to statistically indicate the overall soil characteristics. Additional exploration of the sites which are, at this time, inaccessible, will be provided once access has been obtained by Kerr-McGee. This exploration should consist of obtaining large samples, either from surface or through the use of excavation equipment such as a backhoe. This will enable us to investigate the near surface deposits. Basically, this analysis would consist of performing an exploration program designed to evaluate the depth and aerial extent of the suitable clay deposits. Borings or excavations should be performed on a specific grid interval with continuous sampling. Also, several deep borings, at each site, are recommended to possibly identify an alternative deep clay source. In addition, an extensive laboratory program consisting of defining moisture vs. density vs. permeability relations of the soils encountered should be performed. Of the seven sites, Site C, Site D, Site I and Site K, are recommended as first alternatives for an extended survey due to their accessibility, size, and other characteristics. We will be happy to provide a proposal for further analysis of these sites when you are ready to proceed with the project.

Since there is a need for approximately 100,000 cubic yards of clay materials, during the next two years, it is likely that the material would have to be obtained from several sites within a feasible development area. For this reason, we suggest that our study be continued to investigate other potential sources for this clay material. In doing so, we will continue to contact contractors, excavators and other developers in this area who may have information regarding the location and/or potential for the occurence of acceptable clays. In addition, we will obtain several suitable samples from alternative source locations. These would include the sand and gravel companies in the area and other public sites.

APPENDIX

4. Laboratory Test Results

SOIL TESTING SERVICES

JOB: 21439 MALLARD LAKE SANITARY LANDFILL   WEST CHICAGO, ILL.   DATE: 3-20-80
SOIL: SILTY CLAY, TR SAND, TR GRAVEL, TR SHALE - GRAY (CL)
METHOD: ASTM D 698 STANDARD PROCTOR METHOD A
OWNER: KERR-MCGEE CHEMICAL CORP., OKLAHOMA CITY, OKLAHOMA

BALANCE: METTLER #3
BALANCE: #5
PROCTOR HAMMER: #1
MOLD: #3
OVEN: #1

SAMPLE NO. 1

MOISTURE-DENSITY RELATION OF SOILS

CASE	------PROCTOR WEIGHTS-----			-----WATER CONTENT TOP----------				-WATER CONTENT BOTTOM----				AVG W/C	QP	DRY DENSITY
	CYL+SOIL	- CYLINDER	= SOIL	WET/TARE	DRY/TARE	TARE	W/C	WET/TARE	DRY/TARE	TARE	W/C	%	TSF	LBS/FT3
1	5990	4208	1782	150.58	136.39	21.0	12.3	126.51	115.03	21.0	12.2	12.3	7	105.10
2	6044	4208	1836	233.88	206.80	20.9	14.6	169.45	150.21	20.6	14.8	14.7	7	105.97
3	6110	4208	1902	223.55	195.79	20.7	15.9	255.84	223.91	20.9	15.7	15.8	6.2	108.75
4	6164	4208	1956	229.89	199.95	21.0	16.7	232.91	202.38	20.5	16.8	16.8	4.9	110.91
5	6190	4208	1982	212.09	182.77	21.0	18.1	240.15	207.23	20.8	17.7	17.9	2.5	111.30
6	6158	4208	1950	207.30	177.78	20.6	18.8	196.46	168.43	20.0	18.9	18.8	1.9	108.64

TEST RESULTS: MAXIMUM DRY DENSITY= 112 PCF   OPTIMUM WATER CONTENT= 17%

SOIL TESTING SERVICES

JOB: 21439 MALLARD LAKE, WEST CHICAGO, ILL.

SOIL: SILTY CLAY, TR SAND, TR GRAVEL, SHALE - GRAY (CL) DATE: 3-14-80

METHOD: ASTM D 698 STANDARD PROCTOR METHOD A

OWNER: KERR-MCGEE CHEMICAL CORP. OKLAHOMA CITY, OKLAHOMA

MOLD: #3

BALANCES: STS #3, STS #5

PROCTOR HAMMER #1 SAMPLE 2

MOISTURE-DENSITY RELATION OF SOILS

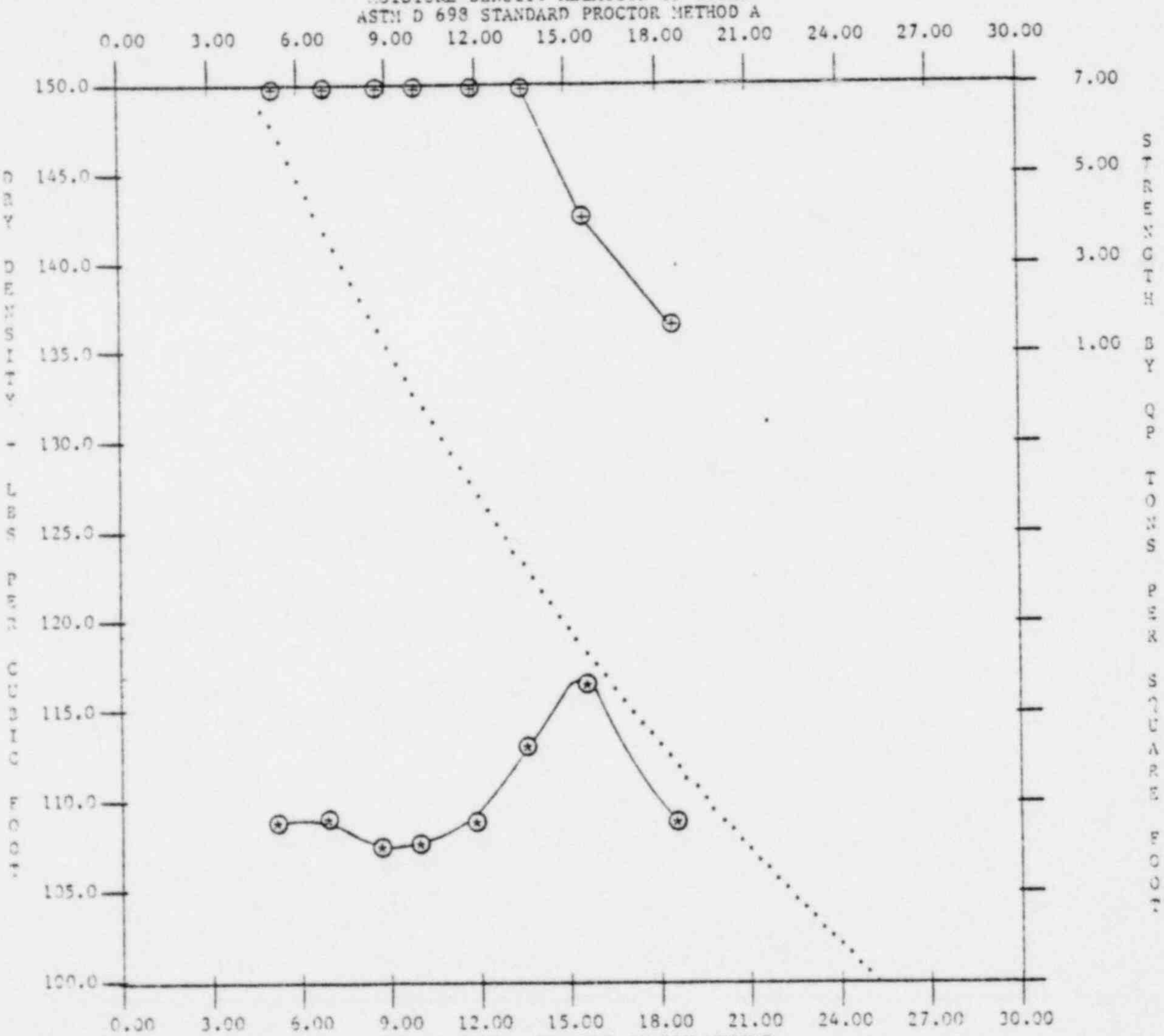
CASE	------PROCTOR WEIGHTS-----			-----WATER CONTENT TOP				----------WATER CONTENT BOTTOM----				AVG W/C	QP	DRY DENSITY
	CYL+SOIL	- CYLINDER	= SOIL	WET/TARE	DRY/TARE	TARE	W/C	WET/TARE	DRY/TARE	TARE	W/C	%	TSF	LBS/FT3
1	5941	4208	1733	93.83	90.23	21.0	5.2	124.36	119.16	20.8	5.3	5.2	7	109.02
2	5970	4208	1762	124.48	117.94	21.1	6.8	128.51	121.31	20.5	7.1	6.9	7	109.07
3	5970	4208	1762	122.38	114.42	19.9	8.4	127.30	118.44	20.8	9.1	8.7	7	107.27
4	6000	4208	1792	130.92	120.68	20.6	10.2	146.94	135.65	21.1	9.9	10.0	7	107.81
5	6050	4208	1842	127.71	116.40	21.2	11.9	124.47	113.47	20.9	11.9	11.9	7	109.00
6	6150	4208	1942	126.49	113.83	21.1	13.7	114.93	103.66	20.3	13.5	13.6	7	113.19
7	6244	4208	2036	123.65	109.77	20.6	15.6	115.82	102.84	20.1	15.7	15.6	4	116.57
8	6155	4208	1947	119.62	105.45	29.1	18.6	121.52	107.06	29.2	18.6	18.6	1.6	108.72

TEST RESULTS: MAXIMUM DRY DENSITY= 117 PCF OPTIMUM WATER CONTENT= 15.5%

SOIL TESTING SERVICES

JOB: 21439 MALLARD LAKE, WEST CHICAGO, ILL DATE: 3-14-80
SOIL: SILTY CLAY, TR SAND, TR GRAVEL, SHALE - GRAY (CL)
OWNER: KERR-MCGEE CHEMICAL CORP. OKLAHOMA CITY, OKLAHOMA
MOLD: #3
BALANCES: STS #3, STS #5
PROCTOR HAMMER #1

SAMPLE 2
MOISTURE-DENSITY RELATION OF SOILS
ASTM D 698 STANDARD PROCTOR METHOD A



* PROCTOR RESULTS
. ZERO AIR VOID CURVE FOR SG= 2.70
\+ PENETROMETER RESULTS-QP

TEST RESULTS: MAXIMUM DRY DENSITY= 117 PCF OPTIMUM WATER CONTENT= 15.5%

Input By Cynthia Bongkewicz

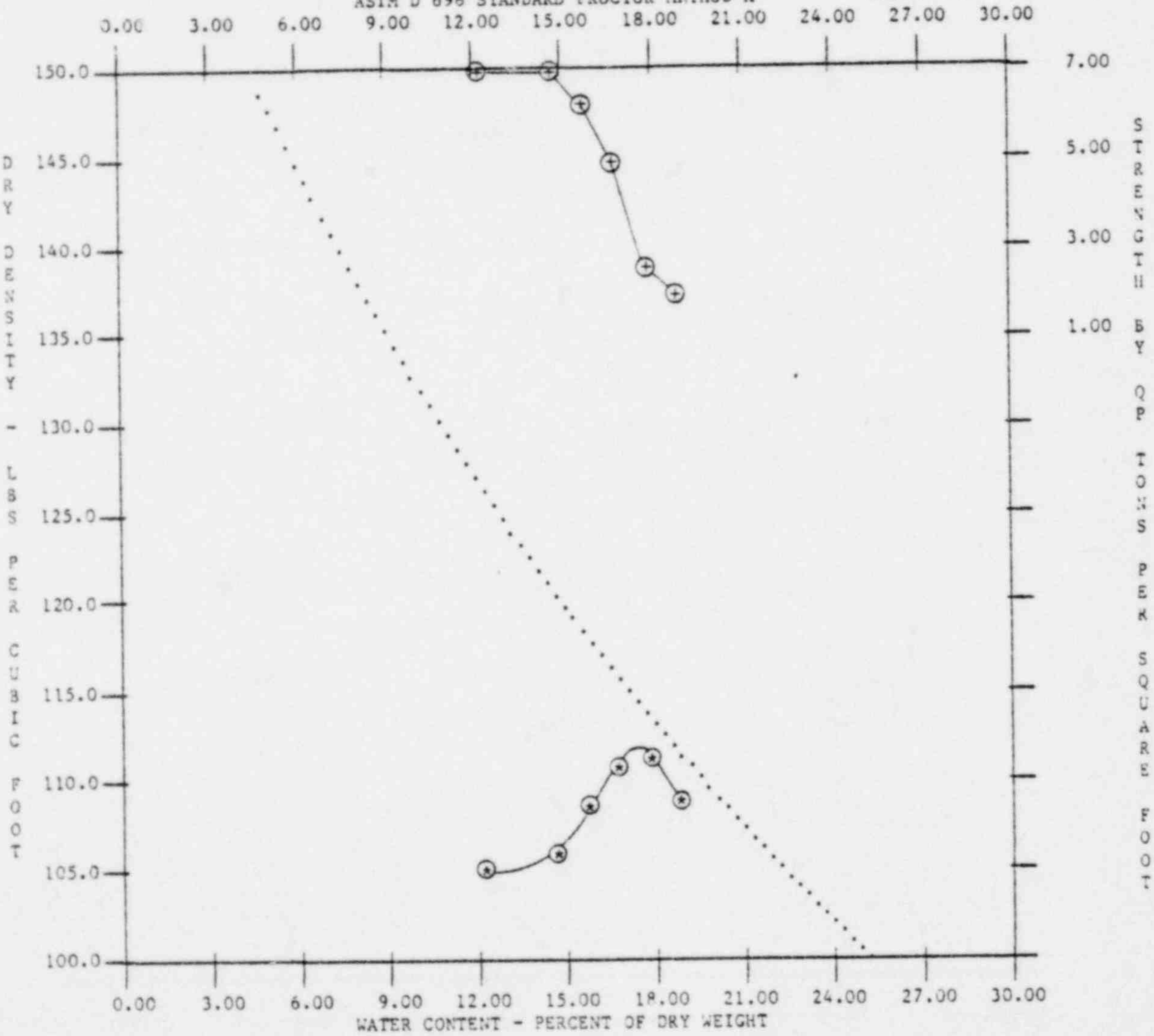
SOIL TESTING SERVICES

JOB: 21439 MALLARD LAKE SANITARY LANDFILL   WEST CHICAGO, ILL.   DATE: 3-20-80
SOIL: SILTY CLAY, TR SAND, TR GRAVEL, TR SHALE - GRAY (CL)   SPECIFIC GRAVITY= 2.70
OWNER: KERR-MCGEE CHEMICAL CORP., OKLAHOMA CITY, OKLAHOMA

BALANCE: METTLER #3
BALANCE: #5
PROCTOR HAMMER: #1
MOLD: #3
OVEN: #1

SAMPLE NO. 1

MOISTURE-DENSITY RELATION OF SOILS
ASTM D 698 STANDARD PROCTOR METHOD A



* PROCTOR RESULTS
. ZERO AIR VOID CURVE FOR SG= 2.70
\+ PENETROMETER RESULTS-QP

TEST RESULTS: MAXIMUM DRY DENSITY= 112 PCF   OPTIMUM WATER CONTENT= 17%

COMPUTER INPUT BY ____________

STS Job No. 21439
Project Mallard Lake
Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	Mallard Lake	Mallard Lake
Sample No.	"Modified" – Nr. 2	w/Bentonite – Nr. 2
Depth (ft)	--------	---------
Classification	CL	CL-CH
Dry Unit Weight (pcf)	108.3	134.6
Water Content (%)	18.9	19.2
Diameter (cm)	4.756	4.278
Length (cm)	9.199	9.118
Saturation B Value	0.98	0.96
Permeability K cm/sec	1×10^{-8}	1×10^{-9}

EQUIPMENT:

BALANCE:	STS #1
OVEN:	STS #1
PI TAPE:	2753
CALIPER:	R82372

TESTED BY: William [illegible]
DATE: 4-7-80
CALCULATED BY: T. A. [illegible]
DATE: 4-9-80
PREPARED BY: C. Borzykiewicz
DATE: 4-4-80

STS Job No. 21439
Project Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	A-1	B
Sample No.	----------	---------
Depth (ft)	----------	---------
Classification	CL	---------
Dry Unit Weight (pcf)	109.2	---------
Water Content (%)	17.2	---------
Diameter (cm)	4.863	---------
Length (cm)	8.414	---------
Saturation B Value	0.98	---------
Permeability K cm/sec	7×10^{-9}	Estimated less than 1×10^{-8}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [illegible signature]

DATE: 4-3-80

CALCULATED BY: [illegible signature]

DATE: 4-4-80

PREPARED BY: C. Bongkewitz

DATE: 4-2-80

STS Job No. 21439
Project Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	C	D-1
Sample No.	---------	--------
Depth (ft)	---------	--------
Classification	CL	CH
Dry Unit Weight (pcf)	97.7	97.8
Water Content (%)	23.8	25.8
Diameter (cm)	7.326	4.752
Length (cm)	11.832	11.377
Saturation B Value	0.96	0.97
Permeability K cm/sec	2×10^{-8}	8×10^{-9}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [signature]

DATE: 4-2-80

CALCULATED BY: T. A. [signature]

DATE: 4-1-80

PREPARED BY: C. [signature]

DATE: 3-31-80

STS Job No. 21439
Project Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	D-2	E
Sample No.	-------	-------
Depth (ft)	-------	-------
Classification	CH	CL-CH
Dry Unit Weight (pcf)	103.6	92.5
Water Content (%)	21.5	28.9
Diameter (cm)	7.195	4.790
Length (cm)	13.216	8.650
Saturation B Value	0.97	0.98
Permeability K cm/sec	2×10^{-8}	2×10^{-8}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [signature]

DATE: 4-3-80

CALCULATED BY: [signature]

DATE: 4-5-80

PREPARED BY: [signature]

DATE: 4-3-80

STS Job No. 21439
Project Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	G	H
Sample No.	-------	---------
Depth (ft)	-------	---------
Classification	CH	CL
Dry Unit Weight (pcf)	86.1	96.9
Water Content (%)	33.4	25.2
Diameter (cm)	7.292	4.792
Length (cm)	13.058	11.090
Saturation B Value	1.00	0.95
Permeability K cm/sec	4×10^{-8}	7×10^{-8}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [signature]

DATE: 4-7-80

CALCULATED BY: T. J. [signature]

DATE: 4-9-80

PREPARED BY: C. Bu[signature]

DATE: 4-1-80

STS Job No. 21439
Project Kerr-Mcgee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	I	J
Sample No.	--------	------
Depth (ft)	--------	------
Classification	CL-CH	CH
Dry Unit Weight (pcf)	92.4	93.3
Water Content (%)	27.7	26.6
Diameter (cm)	4.813	4.741
Length (cm)	8.290	10.590
Saturation B Value	0.98	0.98
Permeability K cm/sec	5×10^{-9}	8×10^{-8}

EQUIPMENT:

BALANCE:	STS #1
OVEN:	STS #1
PI TAPE:	2753
CALIPER:	R82372

TESTED BY: [signature]
DATE: 4-5-80
CALCULATED BY: T.A. [signature]
DATE: 4-7-80
PREPARED BY: C. [signature]
DATE: 4-2-80

STS Job No. 21439
Project Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	K
Sample No.	
Depth (ft)	
Classification	CL-CH
Dry Unit Weight (pcf)	95.6
Water Content (%)	26.4
Diameter (cm)	7.273
Length (cm)	6.656
Saturation B Value	0.99
Permeability K cm/sec	2×10^{-8}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [signature]

DATE: 4-4-80

CALCULATED BY: T. A. [signature]

DATE: 4-7-80

PREPARED BY: C. Bagkiewicz

DATE: 4-2-80

STS Job No. 21439
Project Mallard Lake-
Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	Mallard Lake	Mallard Lake
Sample No.	1-A	1-B
Depth (ft)	10	10
Classification	CL	CL
Dry Unit Weight (pcf)	113	110
Water Content (%)	17.8	18.8
Diameter (cm)	4.772	4.758
Length (cm)	10.763	10.654
Saturation B Value	1.00	0.96
Permeability K cm/sec	7×10^{-9}	6×10^{-9}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [illegible signature]

DATE: 3-25-80

CALCULATED BY: T. A. [illegible]

DATE: 3-27-80

PREPARED BY: C. Bongkerwicz

DATE: 3-19-80

STS Job No. 21439
Project Mallard Lake
Kerr-McGee Chemical Corp.
Date 4-9-80

SUMMARY OF PERMEABILITY TEST RESULTS

SOURCE LOCATION	Mallard Lake	Mallard Lake
Sample No.	2A	2B
Depth (ft)	15	15
Classification	CL	CL
Dry Unit Weight (pcf)	116.4	108.8
Water Content (%)	15.7	18.9
Diameter (cm)	4.789	4.815
Length (cm)	9.508	7.277
Saturation B Value	0.96	0.98
Permeability K cm/sec	2×10^{-8}	2×10^{-8}

EQUIPMENT:

BALANCE: STS #1

OVEN: STS #1

PI TAPE: 2753

CALIPER: R82372

TESTED BY: [signature]

DATE: 3-17-80

CALCULATED BY: T. J. [signature]

DATE: 3-19-80

PREPARED BY: C. [signature]

DATE: 3-14-80

5. Laboratory Procedures

GEOTECHNICAL LABORATORY

TEST PROCEDURES

Name of Test Visual Engineering Classification

Procedure Unified Soil Classification Sheet (see attached sheet) and ASTM Designation D-2488

Data Sheets: Data Summary

Exceptions to Standard Procedure: (Exceptions and procedures can be altered at the written request of the Client.)

1. None

References: American Society for Testing and Materials (1979) "Soil and Rock; Building Stones; Peats," 1979 Annual Book of ASTM Standards, Part 19, Philadelphia, PA

By: Barry Christopher Date: 9/4/79

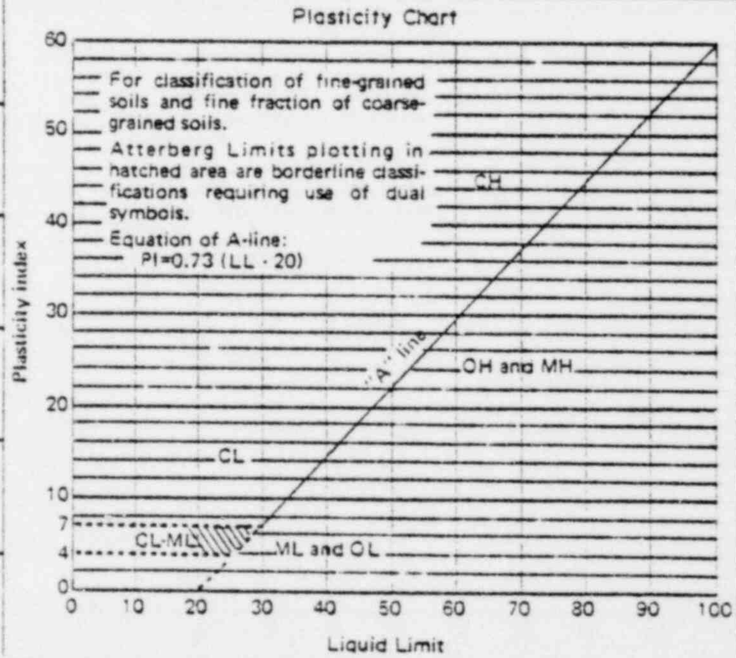
Approved: Marshall R. Silver Date: 9/4/79

UNIFIED SOIL CLASSIFICATION SYSTEM

Major divisions			Group symbols	Typical names	Laboratory classification criteria	
Coarse grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravels (More than half of coarse fraction larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines	Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM (d, u)	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines	$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM (d, u)	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are *borderline* cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
Fine grained soils (More than half of material is *smaller* than No. 200 sieve)	Silts and clays (Liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	See Plasticity Chart	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
			OL	Organic silts and organic silty clays of low plasticity		
	Silts and clays (Liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity, organic silts		
Highly organic soils			Pt	Peat and other highly organic soils		

Determine percentages of sand and gravel from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
Less than 5 per cent . . . . GW, GP, SW, SP
More than 12 per cent . . . . GM, GC, SM, SC
5 to 12 per cent . . . . *Borderline* cases requiring dual symbols

Plasticity Chart



SOIL TESTING SERVICES, INC.
NORTHBROOK ILLINOIS 60062

GEOTECHNICAL LABORATORY

TEST PROCEDURES

Name of Test: Atterberg Limits

Procedure: ASTM Designations D-423 and D-424

Data Sheets: Atterberg Limits (1 sheet) (Liquid Limit - Plastic Limit - Plastic Index) or Data Summary

Exceptions to Standard Procedure: (Exceptions and procedures can be altered at the written request of the Client.)

1.) Liquid Limit test procedure consist of three (3) points; One point method used only as a check.

2.) Two (2) tests are performed to obtain Plastic Limit.

3.) ASTM Designation D-421-78, Dry Preparation Method, is utilized unless otherwise indicated by engineer or when sample appears to be effected by air drying (i.e. contains organic material). Wet Preparation performed as per ASTM Designation D-2217-78.

References: American Society for Testing and Materials (1979) "Soil and Rock; Building Stones; Peats," 1979 Annual Book of ASTM Standards, Part 19, Philadelphia, PA.

By: Barry Christopher Date: 6/7/79

Approved: Marshall R Silver Date: 6/7/79

STS No. 605-79

GEOTECHNICAL LABORATORY

TEST PROCEDURES

Name of Test Standard Proctor (Rapid Method)

Procedure ASTM Designation D-698-78 (see exceptions)

Data Sheets: Moisture-Density Relation of Soils

Exceptions to Standard Procedure: (Exceptions and procedures can be altered at the written request of the Client.)

The following exceptions allow for faster processing of the sample resulting in "rapid" turnaround time for test results and until 1978 was an accepted ASTM procedure (ASTM D-698-70).

1. If the material is not a heavy-textured clayey material into which it is difficult to incorporate water and/or the material is not fragile in character such that it will reduce significantly in grain size due to repeated compaction, then a single sample that is increased in moisture immediately to each compaction will be repeatedly used for each compaction test.

2. Our Laboratory Engineer will select the ASTM method (A,B,C or D) based on the communication with the project engineer unless otherwise specified.

References:

American Society for Testing and Materials (1979), "Soil and Rock; Building Stones; Peats," 1979 Annual Book of ASTM Standards, Part 19, Philadelphia, PA

American Society for Testing and Materials (1977), "Soil and Rock; Building Stones; Peats," 1977 Annual Book of ASTM Standards, Part 19, Philadelphia, PA

By: Barry L. Christy Date: 9/4/79

Approved: [signature] Date: 9/4/79

STS No. 606-79

GEOTECHNICAL LABORATORY

TEST PROCEDURES

Name of Test Standard Proctor Method

Procedure ASTM Designation D-698

Data Sheets: Moisture-Density Relati·ı of Soils

Exceptions to Standard Procedure: (Exceptions and procedures can be altered at the written request of the Client.)

1. Our Laboratory Engineer will select the ASTM method (A,B,C or D) based on the communication with the project engineer unless otherwise specified.

References: American Society for Testing and Materials (1979) "Soil and Rock; Building Stones; Peats," 1979 Annual Book of ASTM Standards, Part 19, Philadelphia, PA

By: Barry L. Christ... Date: 9/4/79

Approved: Marshall L. Silver... Date: 9/4/79

STS No. 611-79

GEOTECHNICAL LABORATORY

TEST PROCEDURES

Name of Test Falling Head Permeability Test

Procedure MLS Procedures and Army Corps of Engineers Manual EM 1110-2-1906

Data Sheets: Time versus Log (H) and Summary of Permeability Test Results

Exceptions to Standard Procedure: (Exceptions and procedures can be altered at the written request of the Client.)

1. All permeability tests performed on materials with a permeability of 10^{-4} cm/sec or less will be performed in a triaxial chamber.

References: Office of the Chief of Engineers (1972), "Laboratory Soils Testing," Manual EM 1110-2-1906, Headquarters, United States Department of the Army.

By: Barry L. Christopher Date: 9/4/79

Approved: Marshall L. Silver, Jr. Date: 9/4/79