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Agency

Office of
Emergency and
Remedial Response

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September 1991

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Superfund Record of Decision:

Maxey Flats Nuclear Disposal, KY

50272-101

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Maxey Flats Nuclear Disposal, KY
First Remedial Action - Final

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

The 280-acre Maxey Flats Nuclear Disposal site is an inactive low-level radioactive waste disposal facility in Fleming County, Kentucky. Land use in the area is predominantly agricultural and residential, with mixed woodlands surrounding the site. The estimated 663 people who reside within 2.5 miles of the site use the public water supply for drinking purposes. From 1962 to 1977, Nuclear Engineering Company, Inc. (NECO), operated a solid by-product, source, and special nuclear material disposal facility under a license with the State. During this time, NECO disposed of approximately 4,750,000 cubic feet of low-level radioactive waste in an approximately 45-acre area, designated as the "Restricted Area". The majority of the waste was disposed of in unlined trenches, but concrete capped "hot wells" consisting of coated steel pipe, tile, or concrete also were used for disposal of small-volume wastes with high-specific activity. The wastes were deposited in 52 disposal trenches within 27 acres of the Restricted Area in both solid and solidified-liquid form and were both containerized and deposited loosely. Several State investigations in the 1970's revealed that leachate contaminated with tritium and other radioactive substances was migrating from the disposal trenches to unrestricted areas. In 1977,

(See Attached Page)

17. Document Analysis a. Descriptors
Record of Decision - Maxey Flats Nuclear Disposal, KY
First Remedial Action - Final
Contaminated Media: soil, debris
Key Contaminants: VOCs (benzene, TCE, toluene), metals (arsenic, lead), radioactive materials

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 197
	20. Security Class (This Page) None	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

Abstract (Continued)

the State ordered NECO to cease the receipt and burial of radioactive waste. From 1973 to 1986, an evaporator was operated onsite as a means of managing the large volume of water infiltrating the disposal trenches as well as wastewater generated by onsite activities. The evaporator processed more than 6,000,000 gallons of liquids, leaving behind evaporatory concentrates that were stored in onsite above-ground tanks, and eventually disposed of in an onsite trench. In 1979, the State initiated stabilization and maintenance activities including installing a temporary PVC cover over the disposal trenches to minimize rainfall infiltration. In 1988, EPA conducted a two-phase removal action to handle the threat posed by 11 onsite 20,000-gallon tanks of questionable structural integrity located in a tank farm building. Phase I consisted of installing a heater in the tank farm building to prevent the freezing and rupturing of tank valves and fittings. Phase II consisted of solidifying approximately 286,000 gallons of radioactive liquids stored in the 11 tanks and water on the floor of the tank farm building. The solidified blocks will be disposed of onsite in a newly constructed trench. This Record of Decision (ROD) addresses final remediation of soil, debris, and associated leachate. The primary contaminants of concern affecting the soil and debris are VOCs including benzene, TCE, and toluene; metals including arsenic and lead; and radioactive materials.

The selected remedial action for this site includes extracting, solidifying, and disposing onsite of approximately 3,000,000 gallons of trench leachate; demolishing and disposing of site structures onsite; excavating additional disposal trenches for disposal of site debris and solidified leachate; installing an approximately 50-acre initial cap consisting of a clay and synthetic liner after disposal of solidified leachate and debris in the trenches; maintaining and periodically replacing the initial cap synthetic liner as needed every 20 to 25 years; re-contouring the capped disposal area as needed to enhance the management of surface water run-on and runoff; temporarily storing any additional wastes generated after constructing the initial cap onsite, followed by solidification and onsite disposal of those wastes in a newly constructed disposal trench; installing a ground water flow barrier, if necessary; installing an infiltration monitoring system to continuously verify remedy performance and detect the accumulation of leachate in disposal trenches; installing a final engineered multi-layer cap once natural subsidence of the trenches has nearly ceased, which could take 100 years; installing permanent surface water control features; monitoring soil, sediment, surface water, ground water, leachate, air, selected environmental indicators, and rates of subsidence; procuring a buffer zone adjacent to the site to prevent deforestation or erosion of the hill slopes, which could affect the integrity of the selected remedy, and to provide an area for monitoring; and implementing institutional controls including land use restrictions. The estimated present worth cost for this remedial action is $33,500,000, which includes a present worth O&M cost of $10,097,549.

<u>PERFORMANCE STANDARDS OR GOALS</u>: Implementation of this remedy will result in the reduction of risk from 10^{-1} to 10^{-4}.

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION

RECORD OF DECISION
REMEDIAL ALTERNATIVE SELECTION

MAXEY FLATS DISPOSAL SITE
FLEMING COUNTY, KENTUCKY

PREPARED BY:
U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION IV
ATLANTA, GEORGIA

DECLARATION STATEMENT

RECORD OF DECISION

MAXEY FLATS DISPOSAL SITE
FLEMING COUNTY, KENTUCKY

SITE NAME AND LOCATION

Maxey Flats Disposal Site, Fleming County, Kentucky

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Maxey Flats Disposal Site, developed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The remedy selection is based upon the Administrative Record for the Maxey Flats Disposal Site.

The Commonwealth of Kentucky has concurred in the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF REMEDY

This final remedy substantially controls and reduces site risks to an acceptable level through treatment, engineering and institutional controls, and containment. The major components of the selected remedy include:

- Excavation of additional disposal trenches for disposal of site debris and solidified leachate

- Demolition and on-site disposal of site structures

- Extraction, solidification and on-site disposal of approximately three million gallons of trench leachate
- Installation of an initial cap consisting of clay and a synthetic liner
- Maintenance and periodic replacement of initial cap synthetic liner
- Re-contouring of capped disposal area to enhance management of surface water runon and runoff
- Improvements to existing site drainage features to enhance management of surface water runoff
- Installation of a ground water flow barrier, if necessary
- Installation of an infiltration monitoring system to continuously verify remedy performance and detect the accumulation of leachate in disposal trenches
- Monitoring of ground water, surface water, air, selected environmental indicators, and rates of subsidence
- Procurement of a buffer zone adjacent to the existing site property boundary, estimated to range from 200 to 400 acres, for the purposes of preventing deforestation of the hillslopes or other activities which would accelerate hillslope erosion and affect the integrity of the selected remedy, and to provide for frequent and unrestricted access to areas adjacent to the site for the purpose of monitoring
- Five year reviews to evaluate the protectiveness of the remedy and to ensure the selected remedy is achieving the necessary remedial action objectives
- Institutional controls to restrict use of the Maxey Flats Disposal Site and to ensure monitoring and maintenance in perpetuity.

The estimated cost of the selected remedy is $ 33,500,000.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, attains Federal and State requirements that are applicable or relevant and appropriate to the remedial action, or obtains a waiver of specified requirements, and is cost effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for the Maxey Flats Disposal Site. Because treatment of the principle threats of the site was not found to be practicable; however, this remedy does not satisfy the statutory preference for treatment as a principle element of the remedy.

Because this remedy will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of remedial action, and every five years thereafter, to ensure that the remedy continues to provide adequate protection of human health and the environment.

Patrick M Tobin / Deputy for
Greer C. Tidwell
Regional Administrator

SEP 30 1991
Date

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FLEMING COUNTY, KENTUCKY

SECTION 1.0 - SITE LOCATION AND DESCRIPTION

1.1 Location

The Maxey Flats Disposal Site (MFDS) is located on County Road 1895, approximately 10 miles northwest of the City of Morehead, Kentucky and approximately 17 miles south of Flemingsburg in eastern Fleming County. Figures 1 and 2 illustrate the site location and site vicinity. The MFDS itself occupies 280 acres of land. Approximately 4.8 million cubic feet of low-level radioactive waste is buried in an approximate 45-acre area, designated as the Restricted Area. Approximately 27 acres within the Restricted Area have been used for the construction of 52 disposal trenches. The Restricted Area also contains storage and warehouse buildings, liquid storage tank buildings, gravel driveways and a parking area. Figure 3 depicts the trenches, trench sumps, and structures within the Restricted Area as well as the extent of a polyvinylchloride (PVC) cover over the 27-acre trench disposal area[1].

1.2 Demographics

Approximately 57 residential structures exist within a 1.0 mile radius of the MFDS, housing approximately 152 persons. In an area between 1.0 and 2.5 miles from the MFDS, 192 residential structures house approximately 511 persons. Therefore, an estimated total of 663 persons live within 2.5 miles of the MFDS (This 2.5 mile radius is hereafter referred to as the study area). Of the estimated 663 persons, an estimated 148 (22.3 percent) are women of childbearing age (15 to 44 years old) and an estimated 148 (22.3 percent) are children (under the age of 14).

Within a one-half mile radius of the MFDS, there exist approximately 11 residences. The actual population of this area is 25 people, 14 male and 11 female. Of the eleven females, seven are of childbearing age. Only two children are present in the population.

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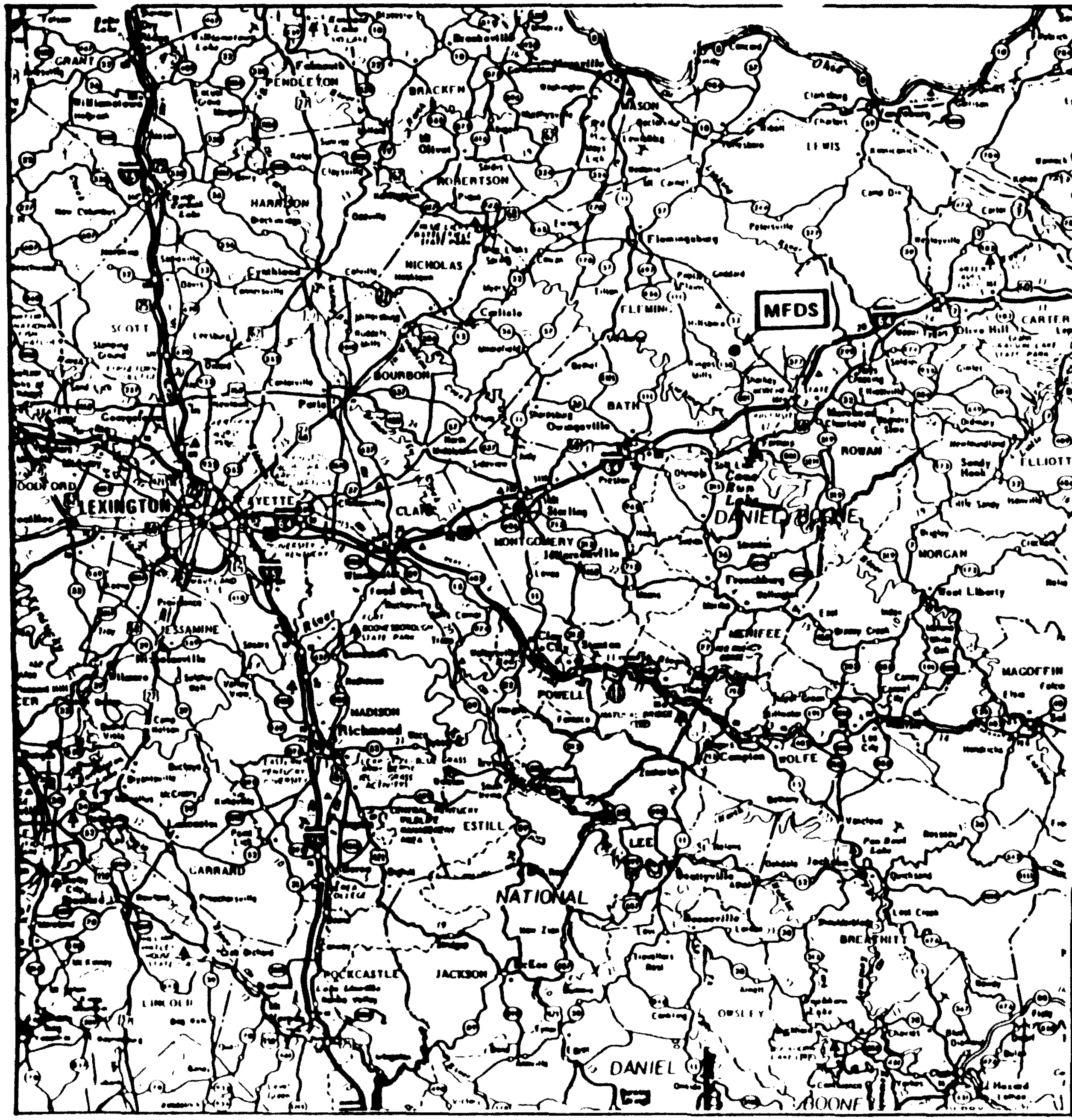
1 - The PVC cover over the trench disposal area currently covers the access road between the trenches; thus, Figure 3 is slightly outdated and does not reflect all of the areas currently covered by the PVC liner.

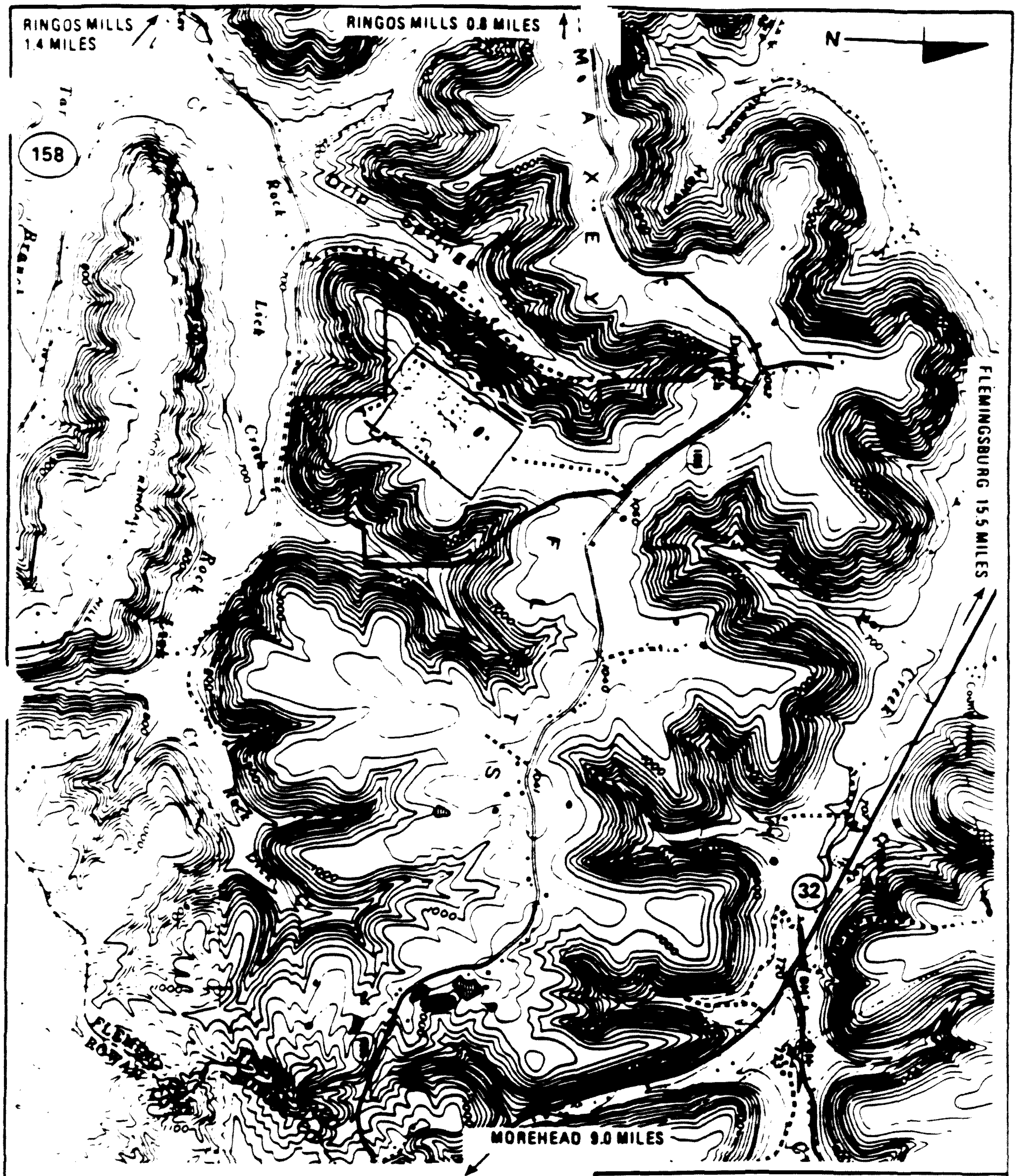


MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS

EBASCO SERVICES INCORPORATED

MAXEY FLATS DISPOSAL SITE LOCATION MAP

FIGURE 1



EXPLANATION

—— *MFDS RESTRICTED AREA*

▬▬ *MFDS PROPERTY BOUNDARY*

1000 0 1000 2000 3000

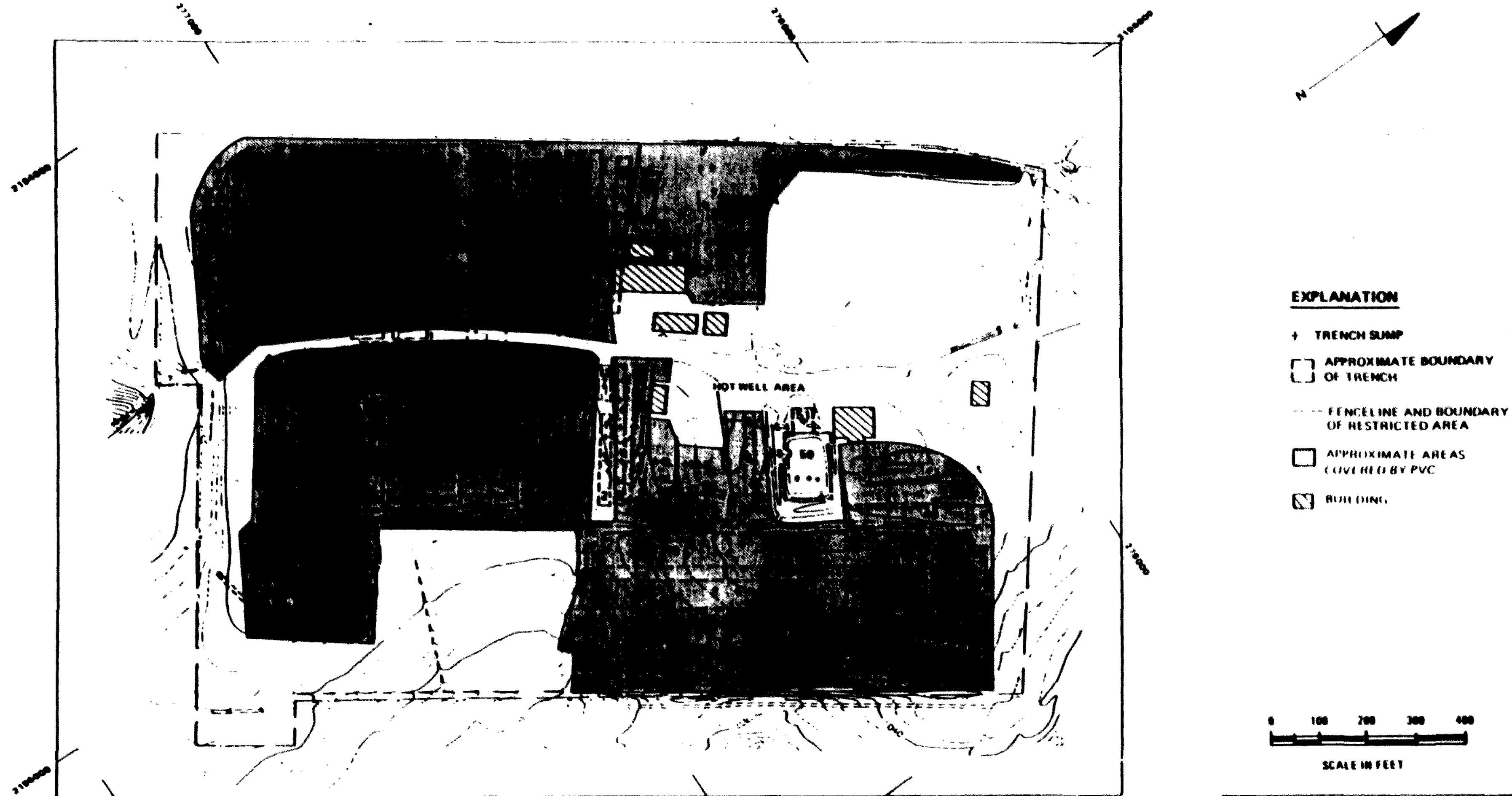
SCALE IN FEET

MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS

EBASCO SERVICES INCORPORATED

MAXEY FLATS DISPOSAL SITE
VICINITY MAP

FIGURE 2



MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS

EBASCO SERVICES INCORPORATED

LOCATION OF TRENCHES, TRENCH SUMPS, AND BUILDINGS IN RESTRICTED AREA

The MFDS study area population represents approximately 5.3 percent of the total Fleming County population. The projected population of the 2.5 mile radius study area will increase from 663 persons in 1985 to a projected population of 767 in 2020, an increase of approximately 15 percent. Additionally, a projected population of 171 women of childbearing age and 171 children will reside in the study area surrounding the MFDS by the year 2020.

1.3 Topography

The MFDS is located in the Knobs physiographic region of Kentucky, an area characterized by relatively flat-topped ridges (flats) and hills (knobs). The MFDS is located on a spur of Maxey Flats, one of the larger flat-topped ridges in the region. The site is bounded by steep slopes to the west, east, and south and is approximately 350 feet above the adjacent valley bottoms.

1.4 Land Use

The land surrounding the MFDS is primarily mixed woodlands and open farmland. A number of residences, farms, and some small commercial establishments are located on roadways near the site.

The two nearest municipalities, the cities of Morehead (approximately 10 miles southeast of the MFDS) and Flemingsburg, Kentucky (approximately 17 miles northwest of the MFDS) have populations of 7,196 and 2,721, respectively. The closest major cities are Lexington to the west, and Huntington, West Virginia, to the east, both about 65 miles from the MFDS.

Transportation in the immediate vicinity of the site is based on a network of secondary roadways, the routes of which are dictated by the local topography of relatively level stream valleys and steep plateau slopes.

The region around the site is rural in character, primarily due to topographic restrictions that limit access to the area and the shortage of land available for development. In the immediate vicinity of the MFDS, within one-half mile, approximately one dozen homes are located along the unpaved roads at the base of the site in Drip Springs Hollow and along Rock Lick Creek, and on top of the plateau along Maxey Flats Road. The slopes in the vicinity of the MFDS are covered mostly with mixed evergreen and deciduous forest land. Wooded areas in the region provide a supply of hardwood timber for the local sawmills and logging industry.

Four small family farms are located within a one-half mile radius of the site. These farms raise beef cattle, swine, goats, and sheep for meat and sale; poultry for eggs; tobacco for sale; and hay and silage as food for their livestock. In addition to the farms, most of the local residences have small vegetable gardens for their private use. Table 1 summarizes the land use within a 2.5 mile radius of the MFDS.

The Maxey Flats region has a public water supply system that is operated by the Fleming County Water Association. Essentially all residents in the area are served by this water system, much of which was installed in 1985. The extent of the water supply system is illustrated in Figure 4.

There are no large-scale commercial and industrial developments, or higher density residential developments in the area within 2.5 miles of the site. In summary, the area surrounding the MFDS is best characterized as a rural, undeveloped area distinguished by low-density housing and rugged topography.

The limited employment base of the area, along with the limited roadway and utilities access, makes large-scale economic expansion in this region unlikely. Future land use can be expected to follow the same historical patterns for the area: small family farms, crop raising, logging activities and moderate growth in population.

1.5 Natural Resources

1.5.1 - Surface Water

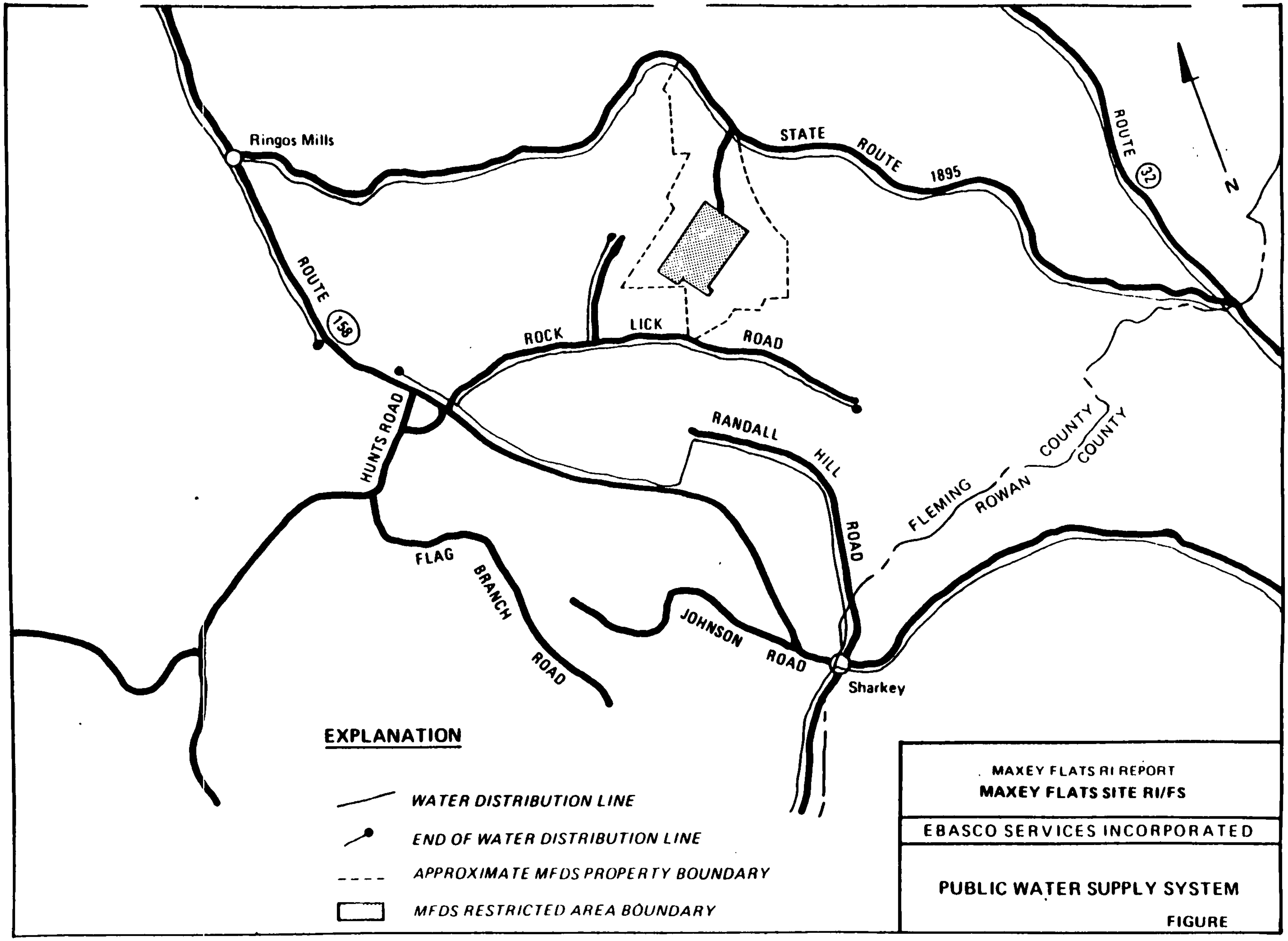
Hillslope runoff at the MFDS typically travels in narrow, high gradient, steep walled channels. These drainage channels connect to the perennial streams that flow along the base of the plateau at the periphery of the MFDS area. These streams, Drip Springs, No Name, and Rock Lick Creeks, flow through relatively level valleys bordered by steep hillslopes. Drip Springs Creek, located on the west side of the site, and No Name Creek, located on the east side of the site, flow into Rock Lick Creek to the southwest of the site. Rock Lick Creek flows into Fox Creek approximately two miles southwest of the MFDS. Fox Creek flows into the Licking River, approximately 6.5 miles west of the MFDS, which in turn empties into the Ohio River near Cincinnati, Ohio, approximately 100 miles from the MFDS.

The perennial streams at the base of the plateau are used as freshwater supplies for livestock raised in the valleys. Fox

TABLE 1

ACREAGE-TABULATION FOR THE AREA WITHIN 2.5 MILES OF THE MFDS

Land Use	Total Acres	Percentage of Primary Study Area
Residential	132	1.0
Other Urban or Built Up Land	44	0.3
Cropland and Pasture	4,885	39.6
Brush Covered Land	167	1.3
Evergreen Forest Land	254	2.1
Deciduous Forest Land	597	4.8
Mixed Forest Land	6,128	49.6
Streams	161	1.3
Primary Study Area	12,368	100


Ringos Mills
ROUTE 158
STATE ROUTE 1895
ROUTE 32
N
ROCK LICK ROAD
HUNTS ROAD
RANDALL HILL ROAD
FLEMING COUNTY
ROWAN COUNTY
FLAG BRANCH ROAD
JOHNSON ROAD
Sharkey
EXPLANATION
WATER DISTRIBUTION LINE
END OF WATER DISTRIBUTION LINE
APPROXIMATE MFDS PROPERTY BOUNDARY
MFDS RESTRICTED AREA BOUNDARY
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
PUBLIC WATER SUPPLY SYSTEM
FIGURE

Creek is also used for light recreational fishing. The Licking River is used both for recreational purposes and as a source of public drinking water through municipal water systems upstream and downstream of the MFDS. The nearest municipal water intake downstream of the MFDS on the Licking River is located approximately 54 miles from the site.

1.5.2 - Geology and Ground Water

Potential geological resources in the area of Fleming County around the MFDS include building stone, clay and shale, petroleum, oil shale and ground water. With the exception of small amounts of building stone and ground water for private residential use, these geological resources are currently not being exploited.

Ground water resources in the area are very limited, with residential supplies generally available only in the valley bottoms. Ground water quality in the area is generally poor.

Residents in the immediate vicinity of the MFDS have been on public water supply since 1985. Prior to 1985, water was typically obtained from shallow dug wells which reportedly supplied sufficient quantities of water for household use.

1.5.3 - Biota

The region surrounding the MFDS includes many woodlots that are periodically logged for timber. The wooded areas in this region are classified as deciduous, evergreen, or mixed forest land. The hillslopes adjacent to the MFDS are primarily deciduous and include hickories, oak, ash, maple, black gum, tulip-poplar, and beech. Because much of the hillslopes are privately owned, and logging is an active industry in the immediate area, it is possible that the standing timber on these slopes could be harvested in the future.

Wildlife species common to the MFDS area are those associated with the oak-hickory forest of the ridge slopes, the adjacent farmlands, or a mix of these two habitats. This mix benefits such game species as white-tailed deer, woodchuck, opossum, fox squirrel, and migrating woodcock, as well as furbearers such as red fox, gray fox, long-tailed weasel, raccoon, and striped skunk. Rough grouse and gray squirrel are also hunted in the more extensively wooded areas. During late autumn and winter, numerous Canada geese, as well as mallards, wood duck, green-winged teal, and other game waterfowl feed on open crop lands of the region. The acorn and hickory mast produced on the hillslopes of the MFDS probably constitutes an important part of the diet for white-footed mice, deer, squirrel, and turkey.

Several species of sport fish that are native to the Licking River drainage have been collected from Fox Creek including muskellunge, channel catfish, rockbass, spotted bass, largemouth bass, white crappie, various sunfish, and sauger.

There are no federal threatened or endangered species known to exist within the vicinity of the MFDS. Blazing Star, a plant species listed as being of special concern by the Kentucky Preserves Commission, does occur within a 2.5 mile radius of the site, but would not be threatened by any physical activities at the MFDS due to its distance (approximately 1.5 miles) from the site.

1.6 Climate

The climate of the MFDS area is classified as Temperate Continental. The summers are warm with temperatures above 90°F occurring approximately 30 days per year. The winters are cold but not extreme, as temperatures below zero generally occur only a few times per year. Temperatures above 100°F and minimum temperatures as low as -22°F have been recorded in the region.

Average annual precipitation in the MFDS area is approximately 44 inches. A maximum 24-hour precipitation total of 5.8 inches would be expected for a 100-year return period in the area. However, the possibility exists for extreme rainfall events to exceed the 100 year maximum in the MFDS area. Snowfall in the area averages approximately 18 inches per year with the highest monthly average occurring during January.

Wind distribution data for the MFDS area reveals a fairly even annual distribution of wind direction, with the greatest frequency from the south and southwest directions. The average wind speed observed over a 10-year period was 9.7 miles per hour. Average wind speeds are greater during the spring and winter seasons and the greatest percentage of calm wind conditions occur during the summer months. A maximum wind speed of 90 miles per hour associated with a return period of 100 years is estimated for the MFDS area.

SECTION 2.0 - SITE HISTORY AND ENFORCEMENT ACTIVITIES

In 1954, the U.S. Congress passed the Atomic Energy Act which provided for the development and utilization of atomic energy for peaceful purposes. In 1959, Congress amended the Atomic Energy Act of 1954 to provide for State participation in certain regulatory controls on the use of atomic energy. Provisions were made for the federal government to enter into agreements with states on such participation.

As part of a program to encourage nuclear industry in Kentucky, the Kentucky General Assembly created the Division of Nuclear Information in the Kentucky Department of Commerce. The Kentucky General Assembly then passed legislation in 1960 which provided power to the Governor to enter into an agreement with the federal government for the transfer of certain regulatory powers in atomic energy to Kentucky. Also in 1960, the Governor of Kentucky charged the Department of Health with the responsibilities of providing regulations for the licensing of radioactive materials. The Kentucky General Assembly passed legislation in 1962 enabling the Commonwealth of Kentucky (Commonwealth) to purchase lands for the disposal of radioactive waste; the land to be owned and controlled in perpetuity by the Commonwealth. Also in 1962, the Commonwealth became the first state to sign an agreement with the federal government for the transfer of certain regulatory powers in atomic energy and, thus, became what is referred to as an "agreement state". In this agreement, authority was vested in the Commonwealth to license the disposal of low-level radioactive waste. The Atomic Energy Commission retained authority to license the burial of waste from the reprocessing of spent nuclear fuel.

The Kentucky Division of Nuclear Information was succeeded by the Division of Atomic Development, whose responsibilities were then transferred to the newly created Kentucky Atomic Energy Authority in 1962, which eventually became the Kentucky Science and Technology Commission. In 1962 a commercial organization, Nuclear Engineering Company, Inc. (NECO), purchased 252 acres of land in Fleming County, Kentucky, in a knob area known as Maxey Flats and submitted an application to the Kentucky Department of Health for a license to bury radioactive waste at Maxey Flats. Following site evaluations and approval, the Commonwealth issued a license, effective January 1963, to NECO for the disposal of solid by-product, source and special nuclear material at the proposed site, and a contract was negotiated between the Commonwealth (Kentucky Atomic Energy Authority) and NECO. Issuance of this license was contingent upon conveyance of the title of the site to the Commonwealth in accordance with state and federal regulations.

The Kentucky Atomic Energy Authority, in turn, leased this tract of land back to NECO for a twenty-five year period with the option for NECO to renew the lease for another twenty-five year period thereafter. The lease agreement provided for the establishment of a perpetual care fund, requiring a cost per cubic foot of waste disposed, to be paid to the Commonwealth by the operator (NECO).

The first radioactive material was disposed at the Maxey Flats Disposal Site in May 1963. From May 1963 to December 1977, NECO managed and operated the disposal of an estimated 4,750,000 cubic feet of low-level radioactive waste (LLRW) at the MFDS.

In order to protect public health and the environment from exposure, low level radioactive waste must be isolated during the time that its radioactivity is decaying. To achieve this isolation at the MFDS, low level radioactive waste was disposed at the site using shallow land burial. The waste was disposed of in 46 large, unlined trenches (some up to 680 feet long, 70 feet wide and 30 feet deep) which cover approximately 27 acres of land within a 45-acre fenced portion of the site known as the Restricted Area. However, "hot wells" were also used at the MFDS for the burial of small-volume wastes with high specific activity. Most of the "hot wells" are 10 to 15 feet deep, constructed of concrete, coated steel pipe or tile, and capped with a large slab of concrete.

The trench wastes were deposited in both solid and solidified-liquid form. Some wastes arrived at the site in containers such as drums, wooden crates, and concrete or cardboard boxes. Other wastes were disposed of loosely. Fill material (soil), typically 3 to 10 feet in thickness, was then placed over the trenches to serve as a protective cover. After 1977, six additional trenches were excavated for the disposal of material generated on-site, bringing the total number of trenches at the site to 52.

Environmental monitoring, in 1972, by the Kentucky Department of Health (Department for Human Resources) revealed possible migration of radionuclides from the Restricted Area. This monitoring indicated that water entering the trenches had become the pathway by which radioactive contaminants, primarily tritium which is a radioactive form of hydrogen, were beginning to migrate out of the disposal trenches. A special study of the site was conducted by the Commonwealth of Kentucky in 1974 to determine whether the MFDS posed any contamination problem. The study confirmed that tritium and other radioactive contaminants were migrating out of the trenches and that some radioactive material had migrated into unrestricted areas. Various other studies of the MFDS were initiated by the U.S. EPA, U.S. Nuclear Regulatory Commission, U.S. Geological Survey, and the Kentucky Department for Human Resources during the 1970's and 1980's.

The Kentucky Science and Technology Commission was abolished in 1976 and the perpetual care and maintenance responsibilities for the MFDS were transferred to the Kentucky Department of Finance.

In 1977, during construction of Trench 46, it was determined that leachate was migrating through the subsurface geology (approximately 25 feet below ground surface). Subsequently, in December 1977, the Commonwealth ordered NECO to cease the receipt and burial of radioactive waste.

In 1978, the Commonwealth and NECO entered into an agreement under which NECO's twenty-five year contract/lease was terminated. After disposal operations ceased and the lease with NECO was terminated, NECO's license remained in effect, with certain modifications, until 1979 at which time the license was transferred to the Commonwealth. The Commonwealth's operational responsibilities at the MFDS were transferred from the Department of Finance to the Department for Natural Resources and Environmental Protection in 1979, with regulatory responsibilities remaining with the Kentucky Department for Human Resources. Upon transfer of NECO's license to the Commonwealth, private companies such as Westinghouse Electric Corporation (the current site custodian) were hired to stabilize and maintain the site. Stabilization and maintenance activities have included installation of temporary covers over an approximate 27-acre trench disposal area, surface water controls, subsidence monitoring and contaminant monitoring.

From 1973 through April, 1986, an evaporator was operated at the site as a means of managing the large volume of water infiltrating the disposal trenches as well as waste water generated by on-site activities. The evaporator generally operated 24 hours per day, approximately 250 days of the year until 1986, when it was shut down. The evaporator processed more than 6,000,000 gallons of liquids, leaving behind evaporator concentrates which were then stored in on-site, above-ground tanks. Evaporator concentrates were eventually disposed of by the Commonwealth in Trench 50, which was constructed in 1985 and 1986.

In 1981, a polyvinylchloride (PVC) cover was placed over the disposal trenches as a means of minimizing the infiltration of rainfall into the trenches. Liquid storage tanks remained on-site for future storage of site-generated liquids and emergency trench overflow pumping operations. Those steps, however, were temporary.

In 1983, at the request of the Commonwealth, EPA began the process of determining whether the MFDS would be eligible for remediation under CERCLA. In 1984, EPA proposed the MFDS for inclusion on the National Priorities List (NPL) of hazardous waste sites to be addressed under the federal Superfund Program and, in 1986, this listing was finalized.

The MFDS was a primary disposal facility for low-level radioactive waste in the United States during its period of operation. As a result, the list of parties potentially liable for site cleanup, known as Potentially Responsible Parties ("PRPs"), includes more than 650[2] radioactive waste generators and transporters. The generator PRPs[3] include many private companies in the nuclear industry as well as numerous hospitals, research institutions and laboratories. Several federal agencies, including the U.S. Department of Defense (DOD) and U.S. Department of Energy (DOE) are also generators of site waste. The Commonwealth of Kentucky, as the site owner[4] and a generator, is also a PRP.

In 1986, EPA issued general notice letters notifying 832 Potentially Responsible Parties of their potential liability with respect to site contamination and offering them an opportunity to conduct and fund a Remedial Investigation/ Feasibility Study (RI/FS) of the MFDS. In March 1987, eighty-two PRPs signed an Administrative Order by Consent (EPA Docket No. 87-08-C) to perform the RI/FS. This group of PRPs

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2 - If each facility or division of a PRP is treated as a single entity, the number of PRPs totals more than 800.

3 - Some of these radioactive waste generators also disposed of chemical wastes at the MFDS.

4 - The Commonwealth was required by state and federal regulations to own the MFDS property, as is required for all low-level radioactive waste disposal sites.

formed the Maxey Flats Steering Committee (Committee). The Committee has conducted and partially funded the technical work required for the Remedial Investigation/Feasibility Study performed at the site. The largest portion of costs incurred in conducting the RI/FS was paid by DOD and DOE, both named as PRPs but not members of the Maxey Flats Steering Committee.

In November 1988, EPA notified the PRPs of an imminent threat to public health, welfare and the environment posed by the potential release of liquids stored in the on-site storage tanks. The threat arose from the presence of eleven 20,000 gallon tanks in the tank farm building that had been present on-site for 10 to 15 years and whose structural integrity was of great concern. The unstable condition of the filled-to-capacity tanks posed an immediate threat to public health and the environment. The PRPs declined the offer to participate in the removal actions; thus, on December 19, 1988, EPA initiated phase one of the removal.

Phase one consisted of the installation of heaters in the tank farm building to prevent the freezing, and subsequent rupturing, of tank valves and fittings which were submerged under water that had infiltrated the tank farm building. Phase one, which was completed in February 1989, also included the installation of additional storage capacity on-site.

Phase two of the removal was initiated by EPA in June 1989. Phase two began with the solidification of approximately 286,000 gallons of radioactive liquids stored in the eleven tanks and of water that had accumulated on the floor of the tank farm building. Solidification activities were completed in November 1989 and resulted in the generation of 216 blocks of solidified tank and tank floor liquids. Burial of these blocks, which were stored on-site and above-ground, was initiated in August 1991 with completion scheduled for November 1991. Solidification blocks will be disposed in a newly constructed trench within the MFDS Restricted Area.

The Remedial Investigation Report for the MFDS was approved by EPA in July 1989. The Feasibility Study for the MFDS was finalized and, along with the Administrative Record file for the site to date, was submitted to the public in May 1991.

SECTION 3.0 - HIGHLIGHTS OF COMMUNITY PARTICIPATION

Community interest and concern about the MFDS began in 1963 shortly after approximately 252 acres of land was purchased for radioactive waste disposal operations. Area residents reported initially that they were not informed of plans for the property and that authorities provided little or no opportunities for community input to the decision-making process. Area residents also were concerned with methods used to place wastes in the disposal trenches. When the Commonwealth released its 1974 study of the site, findings of elevated radionuclide levels drew the attention of local and national media. In response, citizens in the site community formed The Maxey Flats Radiation Protection Association to investigate site conditions and publicized the need for protection of nearby residents. Organized citizen concern declined for a period after the Commonwealth closed the site to the receipt of wastes in late 1977.

Concern resurfaced in 1979 when area residents learned that tritium was escaping from an evaporator used at the site to reduce the volume of liquids that had accumulated from trench pumping operations. A second group, called the Concerned Citizens for Maxey Flats, formed to organize citizen concerns regarding the tritium releases. This group requested that public water be provided to residents in the Maxey Flats site vicinity. Public water was extended in 1985, by the Fleming County Water Association, after which organized community efforts again subsided. Community members remained concerned, however, that the site should be cleaned up.

The present-day Maxey Flats Concerned Citizens, Inc. (MFCC) has been very active throughout the Remedial Investigation (RI) and Feasibility Study (FS). The MFCC submitted an application to EPA for a Technical Assistance Grant (TAG) in 1988, and on January 13, 1989, EPA provided $ 50,000 to the MFCC for the purpose of hiring technical advisors to help the local community understand and interpret site-related technical information and advise the community on its participation in the decision-making process.

A Community Relations Plan for the MFDS was developed and finalized in 1988, which described the proposed community relations activities, along with a Work Plan describing the technical work to be performed as part of the RI/FS. Pursuant to the Community Relations Plan, information repositories were established into which EPA could place information to keep the public apprised of developments related to the MFDS. Due to the proximity of the site to both the cities of Morehead and Flemingsburg, and the locations of interested citizens, two information repositories were established for the MFDS; one located in the Fleming County Public Library, 303 South Main Cross Street, Flemingsburg, KY 41041; and the second, located in the Rowan County Public Library, 129 Trumbo Street, Morehead, Kentucky, 40351.

Beginning with the Community Relations Plan and the RI/FS Work Plan in February 1988, a number of site-related documents have been placed in the repositories. A draft version of the RI Report was placed in both repositories in November 1988 and the final RI Report was placed in the repositories in September 1989. The revised draft Feasibility Study Report was provided to the MFCC in September 1989; revision pages to the revised draft FS Report were also provided to the MFCC in December 1989, and the final FS Report was submitted to the MFCC and to both information repositories in June 1991. The Administrative Record file, which is a compilation of documents and information considered during the selection of the site remedy, was placed in the Fleming County Public Library on June 12, 1991, and on June 14, 1991 at the Rowan County Public Library.

In addition to the technical reports and documents placed in the repositories, fact sheets summarizing particular site developments have periodically been issued to help keep the public informed about activities at the MFDS. Fact sheets were issued by EPA in September 1987, July 1989 and May 1991. Additionally, fact sheets have been periodically distributed by the MFCC and the Maxey Flats Steering Committee throughout the RI/FS process. On May 30, 1991, EPA mailed more than 600 Proposed Plan Fact Sheets to members of the community, interested parties, and Potentially Responsible Parties, informing them of EPA's preferred remedy and announcing the holding of a public meeting on June 13, 1991.

A number of meetings have also been held regarding developments at the MFDS. EPA held a citizen's information meeting in January 1988, and again in September 1988 at the Fox Valley Elementary School in Wallingford, Kentucky to discuss the activities to be performed as part of the RI/FS. A meeting was held with the MFCC in September 1989 to discuss the development of remedial alternatives in the Feasibility Study. A citizens rally was put on by the MFCC in October 1989 to discuss the RI findings, risk assessment conclusions, and remedy options. In October 1990, the MFCC sponsored a forum on the MFDS (which included EPA, Commonwealth and PRP participation) to discuss the site status. On May 22, 1991, EPA and the Commonwealth of Kentucky held a meeting with landowners adjacent to the MFDS for the purpose of discussing the buffer zone component of the preferred remedy and, on June 13, 1991, EPA sponsored a public meeting at the Ersil P. Ward Elementary School in Wallingford, KY to discuss EPA's preferred remedy for site cleanup as well as other alternatives considered during the FS process. Press conferences and site tours were conducted in October 1987 and June 1991.

The public meeting on the preferred remedy/Proposed Plan, which was held on June 13, 1991, initiated a public comment period which concluded on August 13, 1991. A press release and three local newspaper notices were published announcing the meeting. Prior to the initiation of the public comment period, EPA extended the usual 30-day public comment period on the preferred remedy/Proposed Plan to 60 days due to site complexity, numerous issues involved, number of documents in the Administrative Record file, and a high level of community interest at the site.

A response to the comments received during the public comment period is included in the Responsiveness Summary, which is Appendix A to this Record of Decision. A transcript of the June 13, 1991 public meeting on the preferred remedy/Proposed Plan is included as Appendix C of this Record of Decision.

SECTION 4.0 - SCOPE AND ROLE OF RESPONSE ACTION

The selected remedy presented in this decision document serves as the first and final remedial action for the Maxey Flats Disposal Site. The treatment, containment, engineering and institutional control components of the selected remedy will reduce the potential risks from the site to an acceptable level upon remedy completion. As part of the selected remedy, EPA will require further data collection and analyses to determine the necessity of a horizontal flow barrier as a component of the remedy. If, based on this data collection and analyses, EPA determines that a horizontal flow barrier is necessary, it will be installed as part of this remedial action. The type and location of the barrier will be determined by EPA in consultation with the Commonwealth.

SECTION 5.0 - SUMMARY OF SITE CHARACTERISTICS

The Remedial Investigation (RI), which was initiated at the Maxey Flats Disposal Site (MFDS) in 1987, included the collection of more than 700 samples at, and adjacent to, the MFDS, from environmental media such as trench leachate, ground water, soil and soil water, surface water, and stream sediment. The samples were analyzed for a variety of radiological and non-radiological (chemicals, metals, etc.) constituents. A summary of the sample matrix, number of samples, and type of sample analyses performed during the Remedial Investigation is presented in Table 2.

The environmental analyses conducted during the RI complemented the extensive sampling activities previously performed by the Commonwealth, the United States Geological Survey and national laboratories. The data collected prior to the RI was utilized in the RI to the exent practicable. Sampling activities by the Commonwealth are still continuing.

5.1 Nature and Extent of Contamination

Most of the waste disposed of at the MFDS was in solid form, although some container-enclosed liquids and solidified liquid wastes were accepted during the earlier years of site operation. The wastes were in a variety of containers including cardboard or fiberboard boxes, wooden crates, shielded drums or casks, and concrete blocks. Wastes of low specific activity which were buried in the Restricted Area include paper, trash, cleanup materials and liquids, packing materials, protective apparel, plastics, laboratory glassware, obsolete equipment, radiopharmaceuticals, carcasses of animals, and miscellaneous rubble. Higher activity waste buried in the Restricted Area included sealed sources, irradiated reactor parts, filters, ion-exchange resins, and shielding materials. Transuranic waste, generally associated with glove boxes, gaskets, plastics, rubber tubing, paper, and rags, was also buried at the MFDS.

Information on the types and quantities of chemical wastes buried at the MFDS was generally not recorded at the time of waste burial. However, some Radioactive Shipment Records note the disposal of "Liquid Scintillation Vials" ("LSVs"). LSVs are small vials, generally containing a solvent and a radioactive constituent. LSVs are used in laboratories to count the amount of radioactivity in laboratory samples for diagnostic tests, environmental monitoring and in other industrial and medical applications. The principal hazardous organic constituents associated with liquid scintillation fluids are toluene and xylene.

TABLE 2

REMEDIAL INVESTIGATION SAMPLING AND ANALYSIS PROGRAM

SAMPLE MATRIX	NUMBER OF SAMPLES COLLECTED	CHEMICAL ANALYSES[a]	RADIONUCLIDE ANALYSES[b]
LEACHATE			
15 Trench Sumps	15 + 1 dup[c]	Complete, RCRA	H-3,IG,EXP,C-14
MONITORING WELLS			
8 Producing Wells	16 + 2 dup	Complete, RCRA	H-3,IG,EXP,C-14
2 USGS Wells	4	Complete, RCRA	H-3,IG,EXP,C-14
1 Producing Background Well	2	Complete, RCRA	H-3,IG,EXP,C-14
BOREHOLE SAMPLES			
Soil and Rock	261	none	H-3[t]
SOIL			
Round 1	218 + 12 dup	none	H-3
Round 2	132 + 7 dup	none	H-3,IG
Round 2 (select samples)	16 + 2 dup	Complete, RCRA*	H-3,IG
Food Crop Samples	5 + 1 dup	Complete	H-3,IG
Background	3	Complete	H-3,IG,EXP
SOIL WATER			
1 Producing Well Point	2 + 2 dup	Complete, RCRA	H-3,IG,EXP
SURFACE WATER			
Surface Water	20 + 2 dup	Complete	H-3,IG
Background SW	2	Complete	H-3,IG,EXP
STREAM SEDIMENT			
Sediment	20 + 2 dup	Complete	H-3,IG
Background Sed.	2	Complete	H-3,IG,EXP

a) Chemical Analyses:
- Complete - Target Compound List (TCL) organic chemicals
  - Target Analyte List (TAL) inorganic chemicals
- RCRA - pH, sulfide screen, ignitability screen
- RCRA* - pH, sulfide screen, ignitability screen, acid reactivity, base reactivity, water reactivity

b) Radionuclide Analyses:
- H-3 - Tritium
- H-3[t] - Tritium analyzed by on-site laboratory
- IG - Isotopic Gamma
- EXP - Expanded: Sr-90 and gross alpha; if gross alpha was greater than 0.015 pCi/ml, then analyses for Ra-226, and isotopic Pu and U were also performed
- C-14 - Carbon-14

c) dup = duplicate sample

The total volume of waste received from off-site and buried at the MFDS has been estimated at approximately 4.8 million cubic feet. Of this volume, the activity of by-product material alone (material that has become radioactive by neutron activation in nuclear reactors), disposed of at the MFDS, has been estimated at 2.4 million Curies. Much of this material was reported as mixed fission products; thus, the total activity from by-product waste may be underestimated. Other wastes disposed of at the MFDS include Special Nuclear Material (Plutonium, Uranium-233 and enriched Uranium-235) and source material (Uranium and Thorium, not including Special Nuclear Material).

In addition to the wastes received from off-site sources, on-site operations have generated material which includes waste from ground surface grading, trench leachate pumping, evaporator operation, and general waste handling. Wastes generated from on-site activities have been disposed of, in solid form, in newly constructed trenches within the site's Restricted Area. Trenches 48 and higher contain waste generated from on-site activities. Trench dimensions and volumes are presented in Table 3.

5.1.1 - Trench Characteristics

The RI estimated that a total of approximately 2.8 million gallons of leachate are in the disposal trenches. The RI, as well as previous investigations, concluded that there is a large range of contaminant concentrations in samples collected from trenches in different parts of the Restricted Area. Additionally, site records indicate that samples (tritium, gross alpha and beta particle analyses) from the same trench sump yield varying concentrations at different times.

Fifteen trench sumps were sampled during the RI. Trench sump sampling locations are illustrated in Figure 5. The trench leachate was found to contain a variety of radionuclides (of which tritium is the most predominant), as presented in Table 4. In general, the non-radiological, chemical concentrations in trench leachate samples were low. The dominant chemical constituents detected were solvents, chelating agents, phthalate esters, hydrocarbons, phenolics, ethers, and carboxylic acids. Concentrations of chemical constituents ranged from non-detect to less than 10 ppm. (See Table 5.) A review of pre-RI trench data indicates that the total organic carbon (TOC) concentration was variable among the trenches sampled, with TOC values ranging from 460 to 3300 ppm. The results of inorganic sample analyses are presented in Table 6. In general, trench leachate appeared

TABLE 3

TRENCH DIMENSIONS, VOLUMES AND BURIAL PERIODS[1]

Trench Number	Dimensions L x W x D (feet)	Trench Volume (cu ft x 1000)	Trench Number	Dimensions L x W x D (feet)	Trench Volume (cu ft x 1000)
1	162 x 10 x 15	24	26	300 x 50 x 10	150
1S	78 x 25 x 15	29	27	350 x 70 x 18[2]	441
2	79 x 25 x 15	30	28	350 x 70 x 18	441
3	275 x 15 x 15	62	29	350 x 70 x 18	441
4L	44 x 15 x 15	10	30	360 x 75 x 22	594
5S	68 x 15 x 14	14	31	360 x 76 x 22	602
6L	44 x 15 x 14	9	32	350 x 70 x 22	539
7	242 x 15 x 15	54	33L	350 x 50 x 10[3]	150
8L	50 x 15 x 13	10	34	140 x 24 x 10[4]	34
9L	32 x 15 x 12	6	35	300 x 70 x 20	420
10	300 x 30 x 15	135	36	200 x 20 x 18	72
11S	300 x 30 x 12	108	37	200 x 20 x 18	72
12L	35 x 10 x 8	3	38	200 x 50 x 17	68
13L	15 x 10 x 8	1	39	200 x 50 x 16	160
14L	15 x 9 x 5	1	40	686 x 70 x 30	1,441
15	300 x 50 x 12	180	41	255 x 20 x 10	51
16L	15 x 10 x 8	1	42	650 x 70 x 30	1,365
17L	30 x 15 x 10	5	43	614 x 50 x 30	921
18	275 x 40 x 9	99	44	681 x 55 x 30	1,124
19S	300 x 40 x 10	120	45	145 x 55 x 32	255
20	300 x 40 x 12	144	46	190 x 50 x 15	143
21L	300 x 42 x 15	189	47	150 x 34 x 15	77
22	300 x 20 x 12	72	48	100 x 40 x 15	60
23	300 x 60 x 10	180	49	200 x 30 x 15	90
24	300 x 50 x 10	150	50	65 x 45 x 20	58
25	300 x 30 x 11	99	51	43 x 46 x 15	30

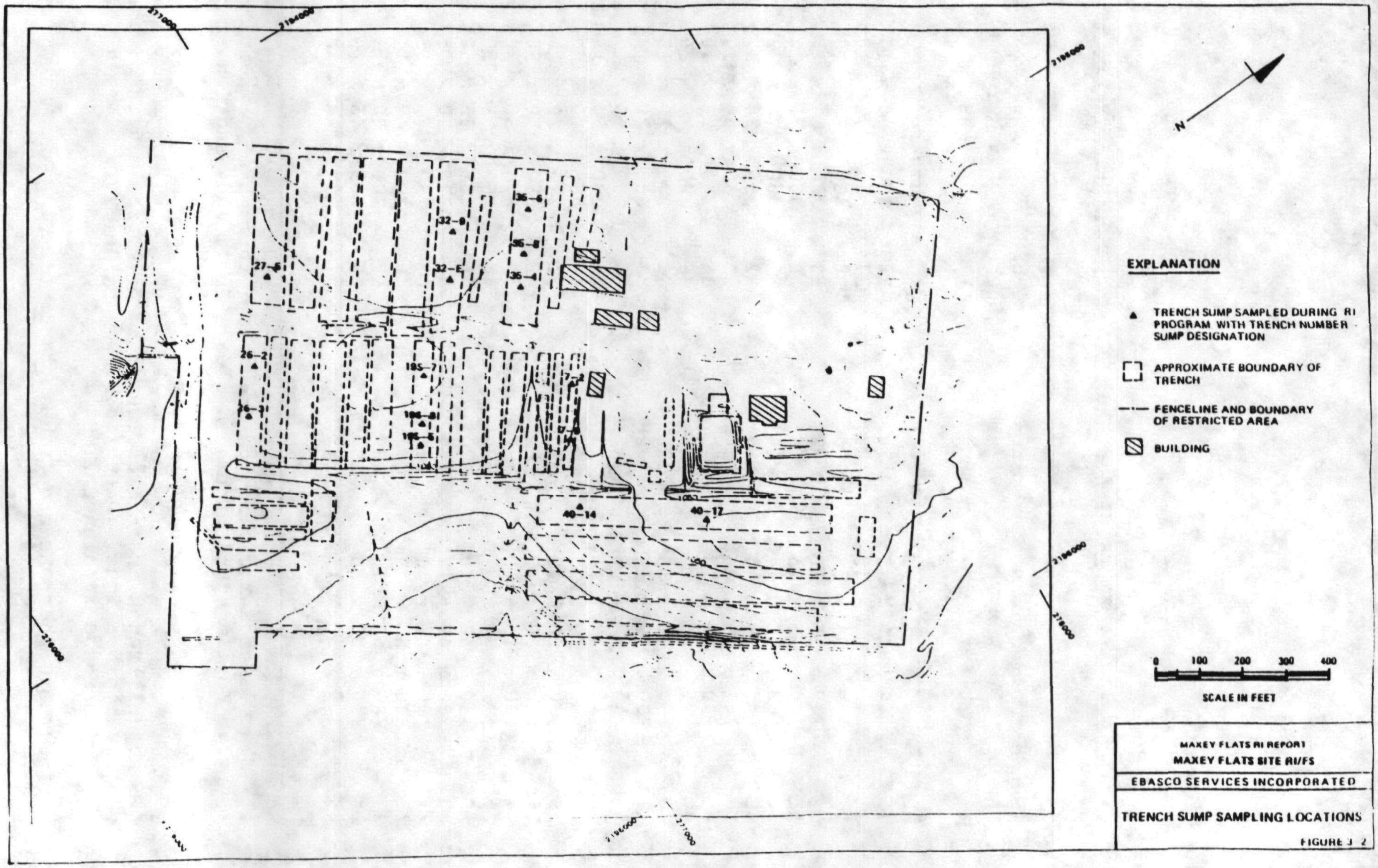
[1] - Source for information on Trenches 1 through 46, except Trench 34, from Westinghouse Hittman Nuclear, Inc., 1984 and Zehner, 1983.

[2] - East end of Trench 27 is deeper than west end.

[3] - Actual trench area is estimated to be approximately 33 percent of the areal dimensions. Depth is based on the average depth of sumps and depth range in Zehner (1983).

[4] - Source: Photo Science, Inc., 1983.

FIGURE 5



27-6
32-9
32-E
35-6
35-8
35-4
26-2
26-3
19S-7
19S-8
19S-5
40-14
40-17
N
EXPLANATION
TRENCH SUMP SAMPLED DURING RI PROGRAM WITH TRENCH NUMBER - SUMP DESIGNATION
APPROXIMATE BOUNDARY OF TRENCH
FENCELINE AND BOUNDARY OF RESTRICTED AREA
BUILDING
0 100 200 300 400
SCALE IN FEET
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
TRENCH SUMP SAMPLING LOCATIONS
FIGURE 3-2

TABLE 4

RADIONUCLIDES IN TRENCH LEACHATE (RI PROGRAM ANALYSES)
(concentrations in pCi/ml)

SUMP #	TRITIUM	C-14	Na-22	Co-60	Sr-90	Cs-137	Ra-226	U-233/234	U-235	U-238	Pu-238	Pu-239/240
7-2	230000+/- 10000	<10	<0.1	0.4+/-0.1	830 +/- 40	1.5+/-0.1	0.030+/-0.002	0.26 +/- 0.01	0.012 +/-0.001	0.106 +/-0.005	0.042+/- 0.004	0.0009+/-0.0005
7-9	162000+/- 8000	<10	<0.1	1.5+/-0.1	380 +/ 20	9.9+/-0.5	0.161+/-0.008	0.160+/ 0.008	0.039 +/-0.001	0.169 +/-0.008	0.025+/- 0.002	0.0004+/ 0.0002
19S-6	62000+/- 3000	<10	<0.1	0.3+/-0.1	2000 +/-100	<0.1	0.660+/ 0.03	0.05 +/- 0.02	<0.002	0.008 +/-0.005	60 +/- 7	0.07 +/-0.04
19S-7	58000+/- 3000	20+/-10	<0.1	0.5+/-0.1	185 +/ 10	18 +/-4	0.560+/-0.03	0.080+/- 0.004	0.002 +/-0.001	0.003 +/-0.001	7.4 +/- 0.7	0.09 +/-0.01
19S-8	190000+/- 10000	<10	0.07+/-0.02	1.4+/-0.1	190 +/- 10	<0.1	0.320+/-0.02	0.40 +/- 0.04	0.023 +/-0.007	<0.005	92 +/-20	<0.02
26-2	152000+/- 8000	<10	<0.1	0.5+/-0.1	0.07+/- 0.2	4.3+/-0.2	0.050+/-0.003	0.012+/- 0.002	<0.0004	0.0007+/-0.0005	1.6 +/- 0.7	4 +/-2
26-3	260000+/- 10000	<10	<0.1	2.5+/-0.2	144 +/- 72	4.4+/-7	0.350+/-0.002	0.006+/- 0.002	<0.0005	0.0008+/-0.0005	3.1 +/- 0.3	1.3 +/-0.1
27-5	1370000+/- 70000	<10	<0.1	0.3+/-0.1	2.6 +/- 0.2	5.7+/-0.2	0.630+/-0.03	0.26 +/- 0.01	0.0020+/-0.0008	0.0006+/-0.0005	64 +/-22	0.7 +/-0.2
32-9	2200000+/- 500000	<10	<0.1	0.7+/-0.1	3.2 +/- 0.2	<0.1	0.008+/-0.004	9.4 +/- 0.7	0.12 +/ 0.03	0.03 +/-0.02	34 +/- 4	1.3 +/-0.2
32-9[d]	2600000+/- 800000	<10	0.06+/-0.02	0.9+/-0.1	2.4 +/- 0.1	<0.1	0.003+/-0.002	9.1 +/- 0.3	<0.02	0.029 +/-0.006	26 +/- 2	1.0 +/ 0.1
32-8	6300000+/-1500000	<10	0.05+/-0.03	2.0+/-0.2	68 +/- 4	1.0+/-0.1	0.002+/-0.002	130 +/-12	<0.1	0.18 +/ 0.04	32 +/- 5	0.24 +/ 0.05
35-4	8700000+/- 400000	<10	<0.1	0.5+/-0.1	3.1 +/- 0.2	30 +/-2	0.042+/-0.006	2.3 +/- 0.1	0.100 +/-0.01	0.77 +/-0.05	320 +/-60	0.6 +/-0.1
35-6	12000000+/-5000000	<10	<0.1	1.0+/-0.1	6.4 +/- 0.3	7.4+/-0.2	0.022+/-0.001	1.18 +/- 0.06	0.022 +/-0.007	0.49 +/-0.02	2.9 +/- 0.2	0.035 +/-0.004
35-8	2100000+/- 100000	<10	<0.1	0.1+/-0.2	14.1 +/- 0.7	0.5+/-0.1	0.005+/-0.003	14.2 +/- 0.7	0.440 +/-0.06	4.00 +/-0.03	0.42 +/- 0.03	0.021 +/-0.005
40-14	3300000+/-1000000	<10	<0.1	1.7+/-0.1	3.7 +/- 0.2	0.2+/-0.2	0.014+/-0.004	0.12 +/- 0.01	0.008 +/-0.004	<0.005	6.2 +/-0.4	0.027 +/-0.007
40-17	2400000+/- 300000	<10	<0.1	4.2+/-0.2	0.96+/- 0.2	7.0+/-0.4	0.037+/-0.002	0.21 +/- 0.01	0.012 +/-0.003	0.075 +/-0.007	90 +/-10	1.6 +/-0.2

d = Duplicate sample

TABLE 5

RESULTS OF ORGANIC CHEMICAL ANALYSES FOR TRENCH LEACHATE (RI PROGRAM ANALYSES)
(concentrations in ppb)

Sump	Acetone	Benzene	Toluene	Xylene	Ethyl-benzene	Methylene chloride	Chloro-form	Vinyl chloride	Chloro-ethane	1,1 Dichloro-ethane	1,2 Dichloro-ethene	Phthalate esters	Naph-thalene	2-Methyl phenol	4-Methyl phenol
07-2	<10	<5	<5	51	21	<5	<5	<10	<10	<5	<5	<10	<10	<10	<10
07-9	<10	<5	<5	10	<5	<5	<5	<10	12	<5	<5	<10	<10	<10	<10
19S-6	<10	<5	<5	77j	<5	<5	<5	<10	2700	210	<5	<10	<10	<10	<10
19S-7	<10	290	2900	300	<5	120j	<5	150j	<10	54j	75j	<10	770j	48	100
19S-8	<10	12	6j	12	<5	6j	<5	12j	250	140	11	390	<10	<10	<10
26-2	200j	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<10	<10	<10	<10
26-3	<10	<5	<5	<5	<5	<5	<5	<10	<10	36j	<5	<10	<10	<10	<10
27-5	<10	100	810	400	50	<5	<5	<10	66j	<5	<5	<10	300j	<10	<10
32-9	130j	21j	1300	150	<5	<5	<5	41j	<10	<5	<5	<10	59	<10	45
32-9[d]	120j	29j	1700	270	22j	<5	23j	61j	<10	24j	<5	<10	58	74	380
32-E	<10	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<10	<10	<10	<10
35-4	<10	<5	<5	<5	<5	<5	<5	<10	<10	<5	<5	<10	160	140	320
35-6	<10	22	1500	3100	43	<5	<5	24	<10	13	<5	<10	420	31	<10
35-8	<10	<5	5300	4400	35	<5	<5	<10	<10	<5	<5	<10	280	100	130
40-14	<10	<5	<5	8j	<5	17j	<5	<10	540	120	<5	<10	<10	<10	<10
40-17	170j	48	11	93	10	<5	<5	<10	<10	22	<5	<10	<10	<10	<10

Miscellaneous Organic Chemicals Present in Only a Few Trenches

Sump	Chemical	concentration	Chemical	concentration	Chemical	concentration	Chemical	concentration
07-2	Bis(2Cl-Et)ether	210						
07-9	Bis(2Cl-Et)ether	10	Benzyl alcohol	16				
19S-7	Bis(2Cl-Et)ether	14	1,2-Dicl-benzene	35	2,4-Dimethylphenol	85		
19S-8	Tricl-ethene	10						
27-5	1,2-Dicl-benzene	11j	2,4-Dimethylphenol	42j	1,4-Dicl-benzene	10j		
32-9[d]	Benzoic acid	300j						
35-4	2-4 Dimethylphenol	1500						
35-6	Carbon disulfide	11	4-Me-2-pentanone	21	Tetracl-ethene	7	2,4-Dimethylphenol	32
	1,2-Dicl-ethane	6						
35-8	4-Me-2-pentanone	27						
40-14	1,1,1-Tricl-ethane	27						

Note: Cl = chloro Et = ethyl Me = methyl

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.

d) Duplicate Sample

TABLE 6

RESULTS OF INORGANIC ANALYSES FOR TRENCH LEACHATE (RI PROGRAM ANALYSES)

(concentrations in ppb)

SUMP	Al	Sb	As	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
07-2	<200	<60	<10	3310[j]	<5	<5	28910	<10	<50	<25	12280[j]	<5	44540	43	<0.2	<40	156330[j]	5.4[r]	<10	285500	<10	<50	23[j]
07-9	<200	<60	<10	15937[j]	7.6	<5	7350	19	<50	<25	ND	9.2[r]	64190	34	<0.2	157[j]	140630[j]	<5	<10	479800	<10	<50	20[j]
19S-6	<200	<60	<10	1163[j]	<5	<5	30380	14	<50	<25	23120[j]	17.6[r]	139520	50	0.2[jn]	1066[j]	20400[j]	<5	<10	282400	<10	<50	38[j]
19S-7	<200	70	<10	1850[j]	<5	<5	41350	15	<50	<25	27800[j]	6.9[r]	168220	62	<0.2	624[j]	45940[j]	<5	<10	ND	<10	<50	416[j]
19S-8	<200	<60	<10	824[j]	<5	<5	24350	13	86	150[j]	11110[j]	18.0[r]	171020	148	0.5[jn]	1264[j]	23440[j]	<5	<10	ND	<10	<50	206[j]
26-2	<200	<60	<10	994	<5	<5	10220	<10	<50	<25	14910	6.1[j]	90070	42[j]	<0.2	78[j]	39910[j]	<5	<10	290000[j]	<10	<50	279[j]
26-3	<200	<60	<10	457	<5	<5	9670	16	<50	<25	9840	5.2[j]	161750	46[j]	<0.2	253[j]	51410[j]	<5	<10	366000[j]	<10	<50	121[j]
27-5	<200	<60	<10	16270	<5	13[j]	199120	<10	<50	<25	93940	<5	290430	4490[j]	<0.2	118[j]	82480[j]	<5	<10	520000[j]	<10	<50	980[j]
32-9	<200	<60	12[r]	1364	<5	<5	21040	42	<50	<25	9170[j]	7.1[r]	109240	99400	<0.2	63[j]	276090[j]	<5	<10	1591300	<10	<50	223[j]
32-9[d]	<200	<60	<10	1038	<5	<5	18460	45	<50	<25	7810[j]	<5	98600	79	<0.2	63[j]	223270[j]	<5	<10	1593500	<10	<50	176[j]
32-E	<200	<60	20[r]	410	<5	<5	10100	11	<50	<25	1670[j]	<5	177890	62	<0.2	160[j]	129360[j]	<5	17[j]	1649300	45[r]	<50	28[j]
35-4	390	<60	341[r]	1956	<5	<5	24370	13	<50	<25	3580[j]	<5	246090	185	<0.2	76[j]	202370[j]	<5	13[j]	1601100	<10	<50	21[j]
35-6	<200	<60	56[r]	439	<5	<5	26260	<10	<50	<25	1020[j]	<5	218550	300	<0.2	<40	63880[j]	<5	<10	1340500	<10	<50	<20
35-8	<200	<60	72[r]	<200	<5	<5	7000	16	<50	268[j]	7580[j]	19.3[r]	33670	106	<0.2	<40	47840[j]	7.6[r]	<10	2870900	<10	<50	22[j]
40-14	<200	<60	<10	298	<5	<5	23990	<10	<50	<25	11830	6.0[j]	155670	63[j]	<0.2	109[j]	116040[j]	<5	<10	633000[j]	<10	<50	176[j]
40-17	<200	<60	22[r]	2680	<5	<5	19200	11[j]	<50	<25	14900	22.1[j]	106000	67	<0.2	100[j]	150000[j]	<5	<10	866000	<10	<50	<20

RESULTS OF CYANIDE AND TOTAL PHENOLICS ANALYSES FOR TRENCH LEACHATE (RI PROGRAM ANALYSES)

(concentrations in ppb)

Sump	Cyanide	Total Phenolics
07-2	<10	34[r]
07-9	<10	24[r]
19S-6	<10	41[r]
19S-7	10[j]	128[r]
19S-8	21[j]	16[r]
26-2	<10	81[r]
26-3	<10	36[r]
27-5	<10	111[r]
32-9	129[j]	147[r]
32-9[d]	90[j]	31[r]
32-E	179[j]	67[r]
35-4	<10	35[r]
35-6	17[j]	13[r]
35-8	<10	22[r]
40-14	<10	20[r]
40-17	<10	17[r]

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.
jn) Estimated value and tentative identification
r) Rejected result due to exceeding a data validation criterion.
ND) No Data
d) Duplicate sample

to be highly buffered and exhibited near-neutral pH values. The trench samples yielded negative results for RCRA screening tests for sulfide and ignitability. Additionally, organic and inorganic analyses performed on the trench leachate samples indicated that EP Toxicity and Toxicity Characteristic Leachability Procedure (TCLP) test results would also be negative for those samples. Table 7 presents the results of RCRA analyses performed on trench leachate samples.

5.1.2 - Geology and Ground Water

Maxey Flats is located in the Appalachian Plateau, in the Knobs physiographic region of northeast Kentucky. The MFDS lies in a tectonically stable region of North America with few exposed faults and relatively infrequent earthquakes. However, minor damage from earthquakes has been reported in the region from recent earthquakes, one of which occurred in 1988, having a magnitude of 4.5 on the Richter Scale with an epicenter approximately 25 miles southwest of the MFDS.

Figure 6 illustrates the rock units exposed in the area surrounding MFDS which consist of shale, siltstone, and sandstone ranging in age from the Silurian to Mississippian (320 to 430 million years old). In the MFDS area, the rock units dip 25 feet/mile (0.3 degrees); regionally they dip to the east at 30 to 50 feet/mile.

The Nancy Member of the Borden Formation is exposed on the hilltop at the MFDS and is 27 to 60 feet thick. The unit is mostly shale with two laterally extensive siltstone beds, the Lower Marker Bed (LMB) and Upper Marker Bed (UMB). These beds are 0.2 to 2.8 feet thick where encountered during drilling operations at the MFDS.

Underlying the Nancy Member, the Farmers Member of the Borden Formation is characterized as an interbedded siltstone and shale, approximately 29 to 42 feet thick. Underlying the Farmers Member is the four to seven feet thick shale of the Henley Bed, 17 to 18 feet thick Sunbury Shale, and 21 feet thick Bedford Shale.

Fractures are present in all rock units at the MFDS, with fracture sets oriented, in descending order, northeast-southwest, northwest-southeast, and north-south. The fracture sets are generally within 20 degrees of vertical. The weathered shale of the Nancy Member is the most highly fractured. Most ground water available for sampling during the RI was obtained from fractures of geologic units. Figure 7 identifies the location of monitoring wells sampled for ground water.

TABLE 7

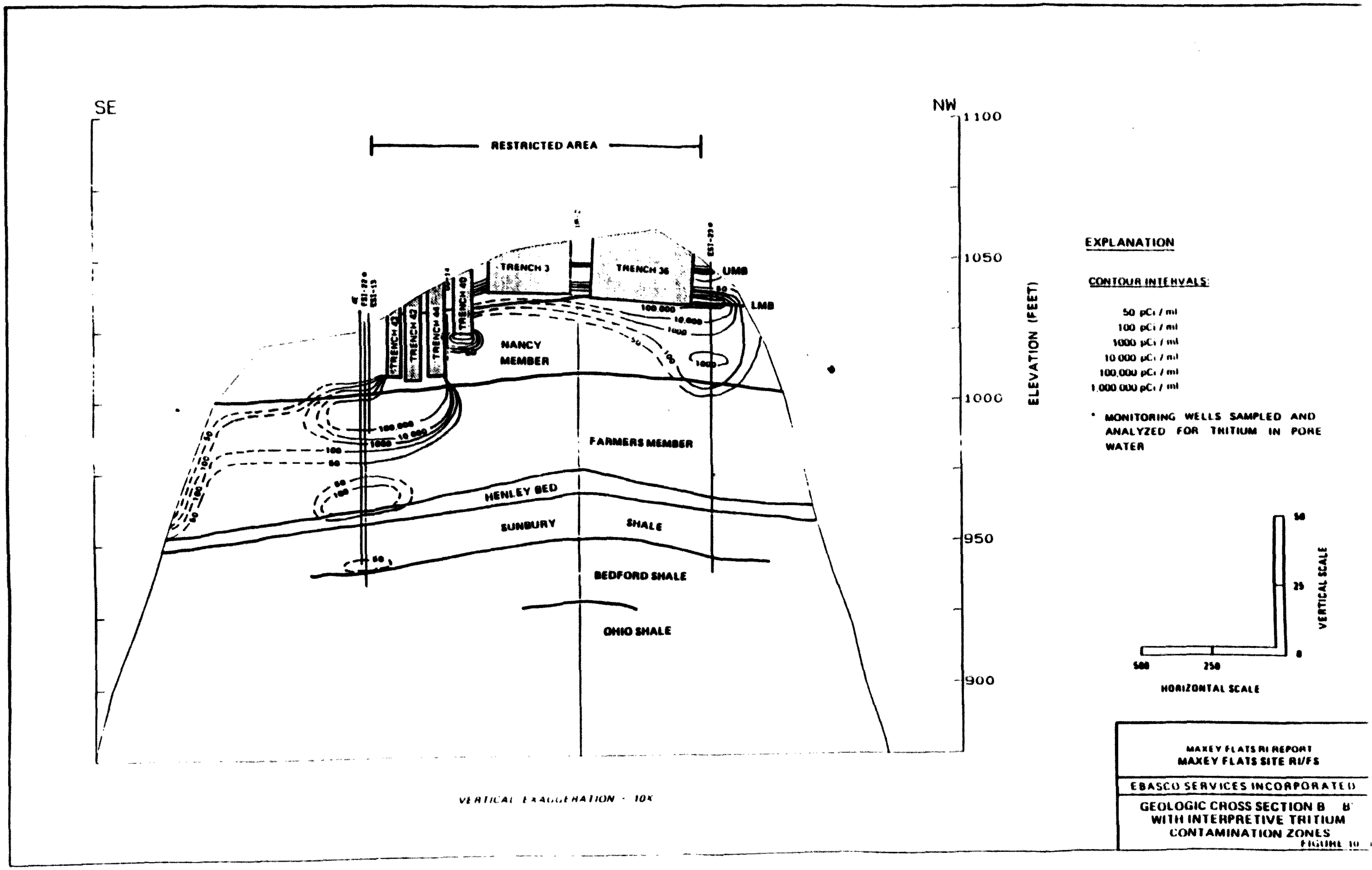
RESULTS OF RCRA ANALYSES FOR TRENCH LEACHATE

TRENCH SUMP	pH	SULFIDE SCREEN	IGNITABILITY SCREEN
7-2	7.50	Neg	Neg
7-9	7.83	Neg	Neg
19S-6	7.32	Neg	Neg
19S-7	7.33	Neg	Neg
19S-8	7.66	Neg	Neg
26-2	7.80	Neg	Neg
26-3	8.03	Neg	Neg
27-5	5.07	Neg	Neg
32-9	7.83	Neg	Neg
32-9[d]	7.89	Neg	Neg
32-E	8.49	Neg	Neg
35-4	8.05	Neg	Neg
35-6	8.24	Neg	Neg
35-8	8.65	Neg	Neg
40-14	7.57	Neg	Neg
40-17	8.14	Neg	Neg

Neg) Negative results
d) Duplicate sample

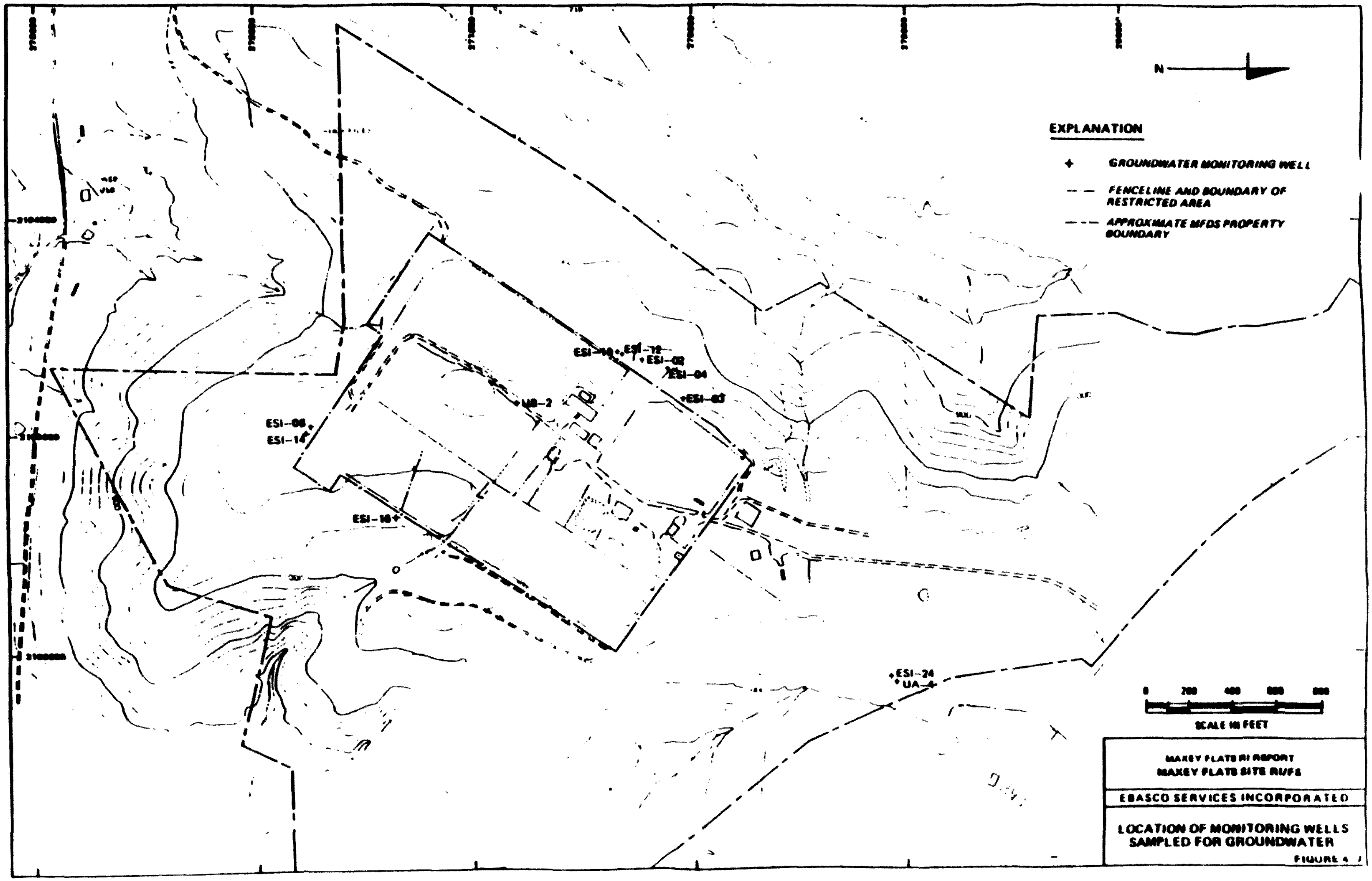
Note: Organic and inorganic analyses performed on the trench leachate samples indicated that EP Toxicity test results would be negative.

FIGURE 6



SE
NW
RESTRICTED AREA
TRENCH 3
TRENCH 36
TRENCH 42
TRENCH 44
TRENCH 40
UMB
LMB
NANCY MEMBER
FARMERS MEMBER
HENLEY BED
SUNBURY
SHALE
BEDFORD SHALE
OHIO SHALE
1100
1050
1000
950
900
ELEVATION (FEET)
EXPLANATION
CONTOUR INTERVALS:
50 pCi / ml
100 pCi / ml
1000 pCi / ml
10 000 pCi / ml
100,000 pCi / ml
1,000,000 pCi / ml
* MONITORING WELLS SAMPLED AND ANALYZED FOR TRITIUM IN PORE WATER
VERTICAL SCALE
HORIZONTAL SCALE
VERTICAL EXAGGERATION - 10X
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
GEOLOGIC CROSS SECTION B B'
WITH INTERPRETIVE TRITIUM
CONTAMINATION ZONES

FIGURE 7


N
EXPLANATION
GROUNDWATER MONITORING WELL
FENCELINE AND BOUNDARY OF RESTRICTED AREA
APPROXIMATE MFDS PROPERTY BOUNDARY
ESI-10
ESI-12
ESI-02
ESI-04
ESI-03
UB-2
ESI-08
ESI-14
ESI-16
ESI-24
UA-4
SCALE IN FEET
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
LOCATION OF MONITORING WELLS
SAMPLED FOR GROUNDWATER

The distinguishing feature of the Nancy Member, and perhaps that of the site's geology, is the Lower Marker Bed of the Nancy Member. The LMB is a thin siltstone layer that is generally flat-lying (some local undulations of the bed are present, however), fractured and weathered, and lies approximately 15 to 25 feet below ground surface. The LMB is the principal leachate flow pathway at the MFDS and underlies or intersects the majority of disposal trenches. Consequently, the LMB is a highly contaminated geologic unit at the MFDS. Another distinguishing characteristic of the LMB is that underlying units are hydraulically connected to the LMB. However, rates and quantities of flow to the underlying units are, most likely, low.

It is estimated that the maximum total flow rate away from the Restricted Area and through the LMB represents 70 percent of the entire flow system at the MFDS. The volume of LMB exfiltration to the hillslopes has been estimated at approximately 159 gallons per day, at a minimum. The total flow from the LMB and lower lying beds has been estimated at 227 gallons per day.

Vertical migration between geological strata is limited by shale layers of low permeability, which act as aquitards. On the west side of the site, trench leachate migrates horizontally through fractures of the Lower Marker Bed, which lies approximately 15 feet below ground surface in that area. On the east side of the site, the 40 series trenches, which commonly bottom near the top of the Farmers Member (approximately 40 feet below ground surface), leach tritium and other contamination to the Farmers Member. Because the MFDS is bounded on three sides by steep slopes, the contaminated leachate migrating horizontally through the fractured siltstone layers generally moves into the bottom of the soil layer on these hillslopes. However, as evidenced by the occurrence of seeps on the east hillside, not all leachate migrates to the bottom of the soil layer on the hillslopes.

Hydrogeologic evaluations of the MFDS indicate that ground water movement through the rock strata to the disposal trenches may be negligible. However, a potential pathway for ground water flow into the trenches would be through the narrow neck at the north side of the site where the MFDS trench area is connected to the main portion of the Maxey plateau. Because of present water mounding at the site (i.e., there is a higher potentiometric surface at the center of the site than at the edges), the tendency is for water/leachate to migrate outwardly from the site rather than into it. Furthermore, even if the trend were reversed, the ground water migration into the trenches is anticipated to be minimal for two reasons. First, the very limited permeability of the various rock strata (except through fractures) would preclude significant migration. Second, due to the natural geological configuration of the MFDS plateau and the narrow land bridge connecting the MFDS to the remainder of the plateau, ground water flowing south toward the trenches would very likely migrate and drain into the natural gullies to the east and west of the connecting land bridge rather than migrate the longer distance into the trenches. Further modeling, monitoring, and data evaluation are planned to assess hydrogeologic conditions at the MFDS.

Tritium is the predominant radionuclide detected in ground water, as confirmed during the RI. Samples taken from monitoring wells in the Lower Marker Bed had higher tritium concentrations (up to 2,000,000 pCi/ml) than samples taken from deeper geologic units, with the highest tritium concentrations detected on the west side of the Restricted Area. Other radionuclides detected include cobalt-60, carbon-14, strontium-90, radium-226, uranium-233/234, uranium-235, uranium-238, plutonium-238, and plutonium-239/240. These tritium concentrations and the presence of other radionuclides indicate that the contamination was caused by trench leachate. Table 8 summarizes the results of radionuclide analyses on ground water samples collected during the RI.

Non-radionuclide analyses in monitoring wells indicate the presence of organics and inorganics such as benzene, toluene, xylenes, arsenic, total phenolics and cyanide. The highest concentrations of non-radionuclides were detected in wells completed in the LMB on the west side of the Restricted Area, which also had the highest radiological contamination. Tables 9 through 11 present the results of organic, inorganic and RCRA analyses on ground water samples collected during the RI.

The LMB and the Farmers Member are the two principal geological formations at the MFDS by which leachate migrates to the hillslopes.

5.1.3 - Soils

Soil cover on the hillslopes in the MFDS area averages five feet thick, but ranges from 0.5 to greater than 18 feet thick. The soil types are generally an upper soil unit of clayey silt, and a lower soil unit of silty clay.

TABLE 8

RADIONUCLIDE CONCENTRATIONS IN GROUND WATER
(concentrations in pCi/ml)

Well	Sampling Date	Tritium	C-14	Sr-90	Co-60	Cs-137	Ra-226	U-233/234	U-235	U-238	Pu-238	Pu-239/240
ROUND 1												
ESI-02	03/05/88	1200000+/-200000	<10	0.03 +/-0.02	0.4 +/-0.1	<0.1	0.0008+/-0.0003	0.025 +/-0.003	0.0008+/-0.000[illegible]	0.0013+/-0.0006	0.14 +/-0.01	0.002 +/-0.001
ESI-03	03/03/88	880000+/-120000	<10	0.19 +/-0.01	0.6 +/-0.1	<0.1	0.0008+/-0.0003	0.105 +/-0.007	<0.0008	0.0024+/-0.0009	0.134 +/-0.009	0.0010+/-0.0008
ESI-03[d]	03/03/88	880000+/-120000	<10	0.09 +/-0.01	0.5 +/-0.1	<0.1	0.0008+/-0.0004	0.100 +/-0.008	<0.0007	0.0016+/-0.0010	0.14 +/-0.01	0.0024+/-0.0008
ESI-04	03/08/88	300000+/-40000	<10	0.007+/-0.002	0.5 +/-0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-08	03/02/88	730+/-100	<10	0.25 +/-0.01	<0.1	<0.1	0.0012+/-0.0003	0.0014+/-0.0005	<0.0002	0.0005+/-0.0003	0.009 +/-0.002	0.0012+/-0.0008
ESI-12	03/08/88	11000+/-2000	<10	0.049+/-0.005	0.004+/-0.02	<0.1	ND	ND	ND	ND	ND	ND
ESI-14	02/24/88	970+/-100	<10	12.6 +/-0.6	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-16	03/15/88	<10	<10	0.010+/-0.003	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-19	03/04/88	2000000+/-300000	<10	0.013+/-0.007	0.7 +/-0.1	<0.1	0.0007+/-0.0004	0.092 +/-0.005	<0.0006	0.0029+/-0.0007	0.36 +/-0.04	0.003 +/-0.002
ESI-24	03/15/88	<10	<10	0.01 +/-0.01	<0.1	<0.1	ND	ND	ND	ND	ND	ND
UB-2	03/22/88	<10	<10	0.017+/-0.002	<0.1	<0.1	0.013 +/-0.001	0.010 +/-0.001	<0.0003	0.005 +/-0.001	<0.003	0.005 +/-0.002
UA-4	03/20/88	<10	<10	0.027+/-0.002	<0.1	<0.1	0.42 +/-0.02	0.0034+/-0.0007	0.0003+/-0.0002	0.0018+/-0.0005	0.00005+/-0.0002	<0.0001
ROUND 2												
ESI-02	04/19/88	940000+/-50000	<10	<0.004	0.4 +/-0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-03	04/20/88	660000+/-30000	<10	0.16 +/-0.01	0.5 +/-0.1	<0.1	0.0005+/-0.0001	0.092 +/-0.005	<0.0004	0.0017+/-0.0005	0.049 +/-0.004	<0.002
ESI-04	04/19/88	350000+/-20000	<10	0.005+/-0.002	0.5 +/-0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-08	04/20/88	630+/-30	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-12	04/21/88	14000+/-700	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-14	04/21/88	620+/-30	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-16	04/22/88	98+/-5	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
ESI-19	04/22/88	260000+/-10000	<10	0.44 +/-0.03	0.8 +/-0.1	<0.1	0.00044+/-0.00009	0.091 +/-0.005	<0.0003	0.0024+/-0.0005	0.18 +/-0.01	0.0012+/-0.0003
ESI-19[d]	04/22/88	270000+/-10000	<10	0.10 +/-0.01	0.8 +/-0.1	<0.1	0.00048+/-0.0001	0.094 +/-0.006	0.004 +/-0.001	0.0043+/-0.0008	0.20 +/-0.01	0.0012+/-0.0003
ESI-24	04/22/88	<10	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
UB-2	04/26/88	<10	<10	<0.005	<0.1	<0.1	ND	ND	ND	ND	ND	ND
UA-4	04/25/88	170[a]+/-10	<10	<0.005	<0.1	<0.1	0.066 +/-0.003	0.008 +/-0.001	0.0008+/-0.0004	0.0051+/-0.0008	0.0023 +/-0.0007	<0.0004

a) Result suspect; independent analyses performed in the Kentucky Cabinet of Human Resources laboratory on a duplicate sample had a tritium concentration of 2.0 +/-0.2 pCi/ml (Volpe, 1988)
d) Duplicate sample
ND) No Data, analyses not performed for these alpha emitters (Ra-226 and isotopic U and Pu) because gross alpha was less than 0.015 pCi/ml

TABLE 9

ORGANIC CHEMICAL CONCENTRATIONS IN GROUNDWATER
(concentrations in ppb)

ORGANIC CHEMICAL	LOWER MARKER BED													
	ESI-3		ESI-3[d]	ESI-4		ESI-2		ESI-19		ESI-19[d]	ESI-8		ESI-14	
	R1	R2	R1	R1	R2	R1	R2	R1	R2	R2	R1	R2	R1	R2
Acetone	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzene	86	66	86	<5	9	18	25	65	96	84	<5	<5	<5	<5
Toluene	7	<5	9	<5	<5	<5	<5	<5	6	<5	7	<5	<5	<5
Naphthalene	<10	<10	<10	<10	<10	<10	<10	10[j]	<10	<10	<10	<10	<10	<10
Vinylchloride	76	45	97	<10	<10	<10	<10	29	40	37	<10	<10	<10	<10
Chloroform	<5	<5	<5	24	21	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1 Dichloroethane	6	<5	8	<5	<5	6	6	9	<5	<5	<5	<5	<5	<5
1,2 Dichloroethane	12	12	13	<5	6	<5	<5	5	8	7	<5	<5	<5	<5
1,2 Dichloroethene	57	48	69	6	11	6	9	34	57	52	<5	<5	<5	<5
Trichloroethene	100	93	96	9	17	<5	7	32	63	55	<5	<5	<5	<5
Chlorobenzene	<5	9	11	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

ORGANIC CHEMICAL	LOWER MARKER BED/ LOWER NANCY		LOWER NANCY		UPPER FARMERS		OHIO SHALE		OHIO SHALE	
	ESI-24		ESI-12		ESI-16		UB-2		UA-4	
	R2	R2	R1	R2	R1	R2	R1	R2	R1	R2
Acetone	<10	<10	<10	<10	14[j]	<10	200[j]	2200[j]	<10	<10
Benzene	<5	<5	<5	<5	<5	<5	<5	<5	12	12
Toluene	<5	<5	<5	<5	<5	22	5	<5	12	7
Phenol	<10	<10	<10	<10	<10	<10	<10	500	<10	290
Carbon disulfide	<5	<5	<5	<5	<5	<5	<5	<5	<5	8
Vinylchloride	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chloroform	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,1 Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2 Dichloroethane	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
1,2 Dichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Trichloroethene	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Chlorobenzene	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.
R1) Round 1 Sample
R2) Round 2 Sample
d) Duplicate Sample

TABLE 10

INORGANIC CHEMICAL CONCENTRATIONS IN GROUNDWATER
(concentrations in ppb)

LOWER MARKER BED

INORGANICS	ESI-03 R1	ESI-03 R2	ESI-03[d] R1	ESI-04 R1	ESI-04 R2	ESI-02 R1	ESI-02 R2	ESI-19 R1	ESI-19 R2	ESI-19[d] R2	ESI-08 R1	ESI-08 R2	ESI-14 R1	ESI-14 R2
Al	<200	<200	<200	4100[j]	469[j]	2110[r]	852[j]	<200	<200	<200	1260[j]	<200	<200	<200
Sb	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
As	57	44[r]	57	25[j]	29[r]	46	60[r]	66	67[r]	90[r]	<10	<10	<10	<10
Ba	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
Be	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cd	<5	<5	<5	<5	<5	<5	<5	6	<5	<5	<5	<5	<5	<5
Ca	150000	147000	149000	151000	156000	139000	143000	109000	98900	103000	64610	62400	63910	61100
Cr	<10	<10	<5	19[j]	<10	17[j]	<10	<10	<10	<10	24[j]	46[j]	<10	<10
Co	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Cu	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Fe	5860	5460	5670	5680	1110	19100[r]	12900	3540[j]	3190	3320	2750	661	<100	<100
Pb	<5	<5	<5	<5	<5	46[j]	<5	66	<5	<5	<5	<5	<5	<5
Mg	157000	162000	155000	140000	154000	216000	218000	158000	154000	161000	115000	110000	96440	95900
Mn	4870	4780	4770	282	429	4040	3980	3840	3470	3640	44	29	3615[j]	3680
Hg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.4[jn]	<0.2	<0.2	<0.2
Ni	60[j]	61	66[j]	65	55	178[j]	120	<40	<40	<40	<40	59	74[j]	90
K	9780	8610	9800	13300	12900	14600	9820	14900	14300	13700	8380	7020	8690[j]	7290
Se	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Ag	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Na	361000	344000	362000	288000	272000	425000	394000	466000	399000	415000	280000	261000	237000[j]	204000
Tl	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
V	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50
Zn	<20	<20	<20	31	782[r]	<20	<20	<20	65[r]	<20	34	<20	<20	<20
Cyanide	<10	<10	<10	<10	<10	<10	<10	10[j]	12[j]	12[j]	<10	<10	<10	<10
Phenolics	<10	<10	<10	<10	<10	<10	<10	32[r]	17[j]	14[j]	<10	<10	<10	10[j]

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.
jn) Estimated value and tentative identification.
r) Rejected results due to exceeding a data validation criterion.
R1) Round 1 Sample.
R2) Round 2 Sample.
d) Duplicate Sample.

TABLE 10 (CONTINUED)

INORGANIC CHEMICAL CONCENTRATIONS IN GROUNDWATER
(concentrations in ppb)

INORGANICS	LOWER MARKER BED/ LOWER NANCY ESI-24 R1	LOWER MARKER BED/ LOWER NANCY ESI-24 R2	LOWER NANCY ESI-12 R1	LOWER NANCY ESI-12 R2	UPPER FARMERS ESI-16 R1	UPPER FARMERS ESI-16 R2	OHIO SHALE UB-2 R1	OHIO SHALE UB-2 R2	OHIO SHALE UA-4 R1	OHIO SHALE UA-4 R2
Al	4670	2740	3960[j]	1390[j]	700[j]	2470[j]	<200	2060[j]	50[j]	1960[j]
Sb	<60	<60	<60	<60	<60	<60	<60	<60	<60	<60
As	<10	<10	<10	<10	<10	<10	16[r]	<10	<10	<10
Ba	<200	<200	<200	<200	<200	<200	1140	3380	7270	3770
Be	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cd	<5	<5	<5	<5	<5	<5	<5	<5	8	5[j]
Ca	126000	109000	366000	319000	196000	173000	295000	211000	NA	1800000
Cr	32[j]	23[j]	23[j]	10[j]	<10	13[j]	<10	<10	11[j]	19[j]
Co	<50	<50	<50	<50	<50	<50	<50	66	<50	64
Cu	<25	<25	<25	<25	<25	<25	101	203	1730	974
Fe	11200	6850	7070	3380	1440	5180	2270	40700	34700	54500
Pb	<5	<5	<5	<5	<5	<5	<5	77	107[j]	353
Mg	145000	136000	379000	349000	292000	279000	70900	53600	517000	372000
Mn	406	377	164	127	112	140	235	806	2080	2170
Hg	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ni	52[j]	45	<40	<40	47[j]	49	<40	67	54[j]	105
K	21400	11700	16600	13700	26200	23000	28000	19300	70500	53300
Se	<5	<5	<5	<5	<5	<5	110	<5	219	<5
Ag	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Na	268000	222000	295000	264000	279000	251000	3940000	2460000	12900000	9450000
Tl	<10	<10	<10	<10	<10	<10	<10	<10	39[j]	<10
V	73	66[r]	<50	<50	<50	<50	<50	<50	<50	<50
Zn	<20	<20	20	<20	<20	<20	159	384[r]	770	2670[r]
Cyanide	<10	<10	<10	<10	<10	<10	34[j]	56[j]	<10	<10
Phenolics	<10	<10	<10	<10	<10	<10	89[r]	1020[j]	54[r]	487[j]

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.
r) Rejected results due to exceeding a data validation criterion
NA) Not Analyzed
R1) Round 1 Sample
R2) Round 2 Sample
d) Duplicate Sample

TABLE 11

RESULTS OF RCRA ANALYSES FOR GROUND WATER

WELL	pH	SULFIDE SCREEN	IGNITABILITY SCREEN
ESI-2	8.13	Neg	Neg
ESI-3	8.04	Neg	Neg
ESI-3[d]	8.08	Neg	Neg
ESI-4	7.61	Neg	Neg
ESI-8	7.20	Neg	Neg
ESI-12	8.00	Neg	Neg
ESI-14	6.85	Neg	Neg
ESI-16	NA	NA	NA
ESI-19	8.02	Neg	Neg
ESI-24	7.26	Neg	Neg
UA-4	6.77	Neg	Neg
UB-2	7.25	Neg	Neg

Neg) Negative Results
NA) Not Analyzed
d) Duplicate Sample

Note: Organic and inorganic analyses performed on these samples indicated that EP Toxicity test results would be negative.

Figure 8 identifies the locations of soil samples obtained from hand augers during the RI. In the soils on the three slopes adjacent to the site, tritium is the predominant contaminant, with the largest contaminated areas and highest levels of tritium contamination on the upper part of the northwest side of the site (north of the Western Series trenches). Tritium concentrations ranged from non-detect to 560,000 pCi/ml. The soil analyses, in conjunction with the ground water and trench leachate analyses, indicate that tritium has migrated through the fractured LMB from the trenches toward the west hillslope and has subsequently migrated down-slope along the soil/rock interface. Additionally, elevated tritium concentrations (50 to 420 pCi/ml) were observed near the center of the east slope, below an outcrop of the fractured Farmers Member. See Figure 9. This tritium originated in the 40 Series trenches on the east side of the site, which were excavated to near the top of the upper Farmers Member. Other site-related radionuclides detected in soils at the MFDS include cobalt-60 (0.3 pCi/gram) and cesium-137 (0.1 - 0.8 pCi/gram). Previous testing along the soil-rock interface by the Commonwealth indicated the presence of additional radionuclides such as strontium-90, carbon-14, and plutonium-238 and -239. Table 12 provides the concentration ranges of radionuclides in RI soil samples.

Toluene was the most widely detected chemical contaminant at the MFDS, ranging from 40 to 250 ppb. Other volatile organic contaminants detected in soils include acetone and methylene chloride in low concentrations. Pesticides, PCBs, and semi-volatile contaminants were not detected in soils of the MFDS study area, with the exception of one pesticide, Dieldrin, which was detected in a food crop study area (See discussion below). All soil samples displayed inorganic concentrations within ranges considered normal for soils, with the exception of Arsenic, which was detected at 60 to 106 ppm. Tables 13 and 14 provide the concentration ranges for organic and inorganic analyses, respectively, performed on site soil samples during the RI. As indicated in Tables 15 and 16, negative results were reported for the RCRA parameters tested for soil and soil water. Organic and inorganic analyses performed on these soil samples indicate that EP toxicity and TCLP test results would also be negative.

Samples collected in the food crop study area (See Figure 10 for sample locations) indicate no site-related contamination in these off-site locations. Dieldrin, a pesticide, was detected in one food crop sample but is related to farming activities rather than the site.

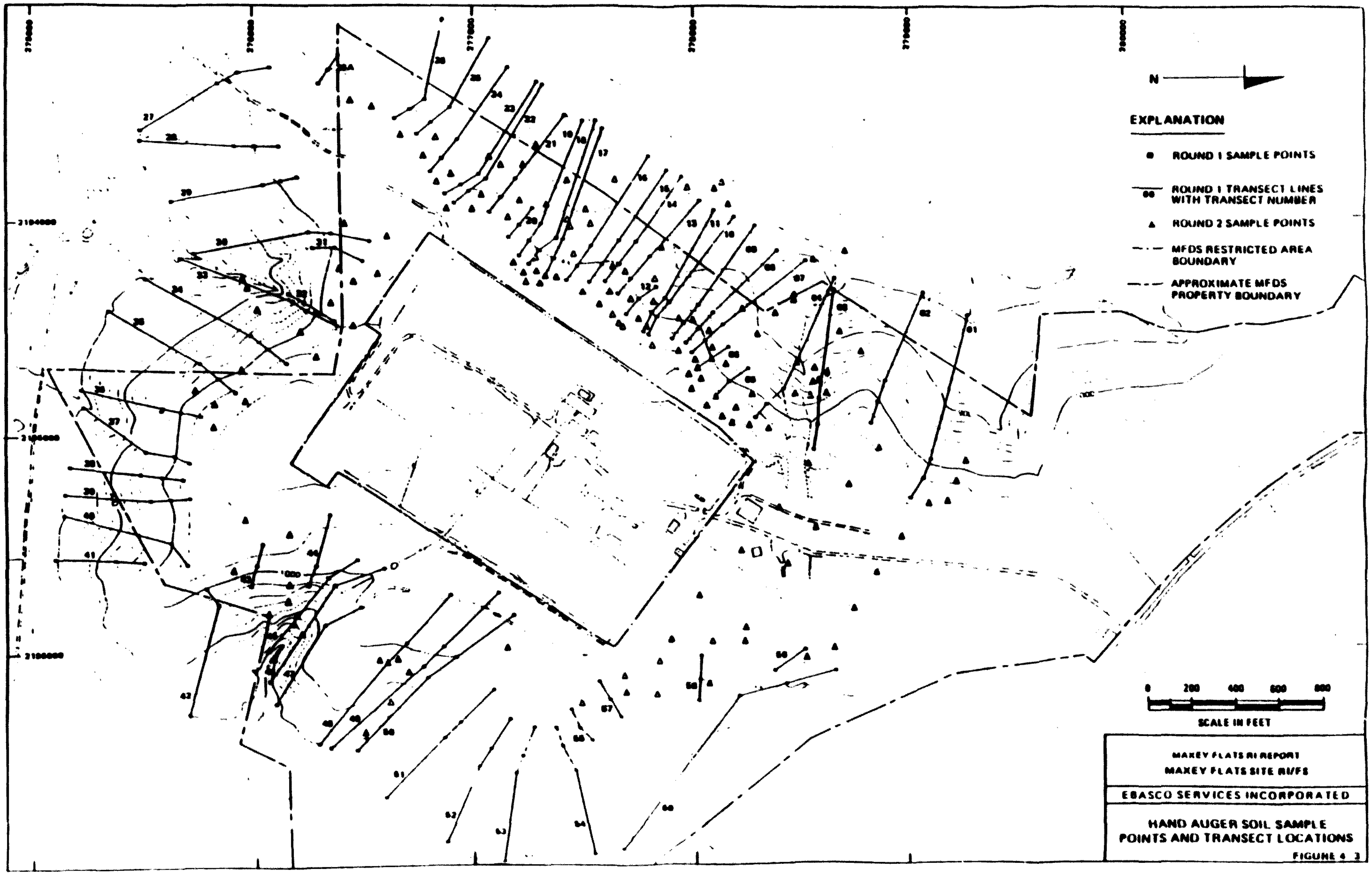

N
EXPLANATION
ROUND 1 SAMPLE POINTS
ROUND 1 TRANSECT LINES WITH TRANSECT NUMBER
ROUND 2 SAMPLE POINTS
MFDS RESTRICTED AREA BOUNDARY
APPROXIMATE MFDS PROPERTY BOUNDARY
0 200 400 600 800
SCALE IN FEET
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
HAND AUGER SOIL SAMPLE POINTS AND TRANSECT LOCATIONS
FIGURE 4 3

FIGURE 9

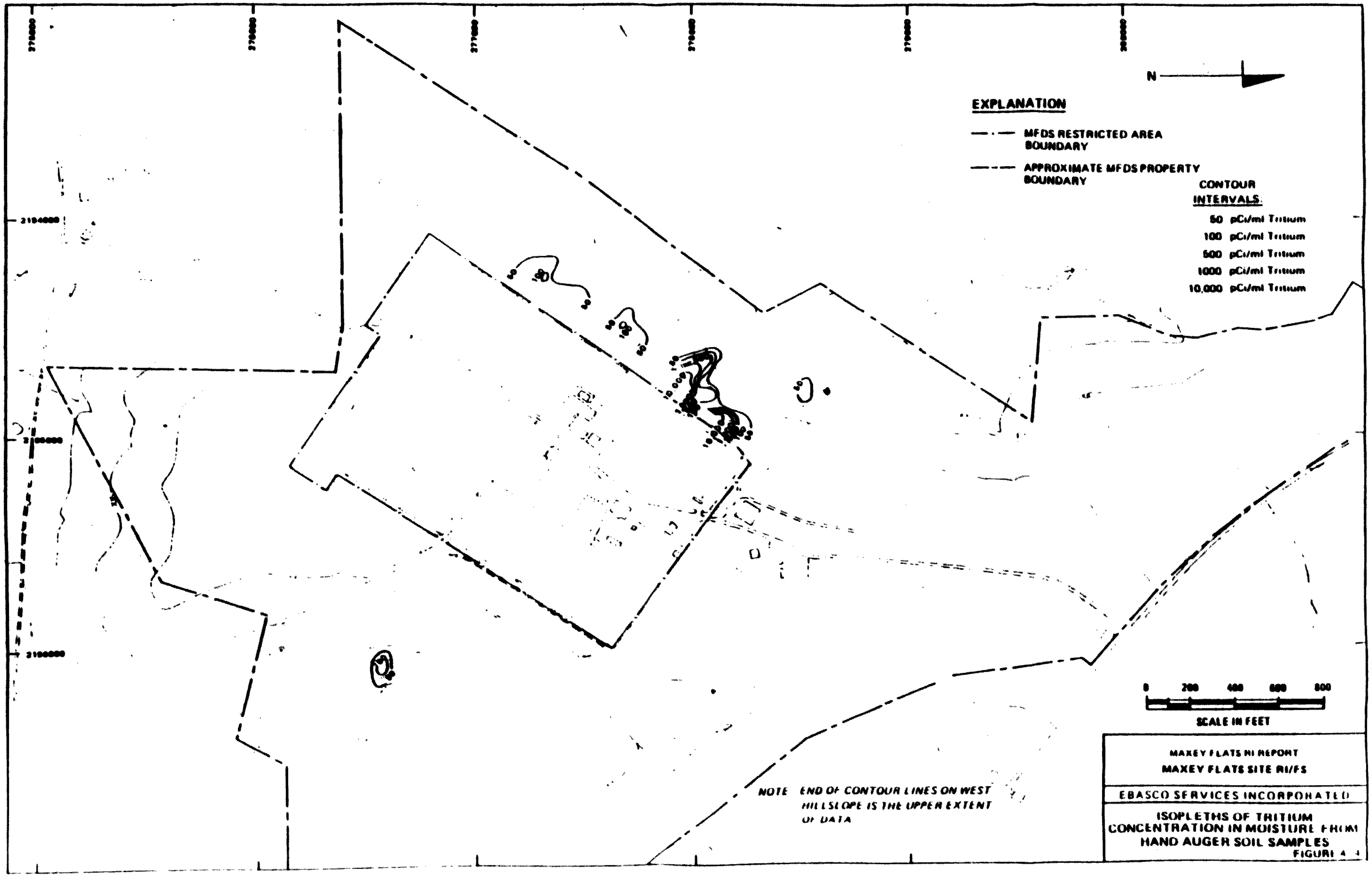

N
EXPLANATION
MFDS RESTRICTED AREA BOUNDARY
APPROXIMATE MFDS PROPERTY BOUNDARY
CONTOUR INTERVALS:
50 pCi/ml Tritium
100 pCi/ml Tritium
500 pCi/ml Tritium
1000 pCi/ml Tritium
10,000 pCi/ml Tritium
0 200 400 600 800
SCALE IN FEET
NOTE END OF CONTOUR LINES ON WEST HILLSLOPE IS THE UPPER EXTENT OF DATA
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
ISOPLETHS OF TRITIUM CONCENTRATION IN MOISTURE FROM HAND AUGER SOIL SAMPLES
FIGURE 4-4

TABLE 12

CONCENTRATION RANGES OF RADIONUCLIDES IN SOIL
(concentrations in pCi/ml or pCi/gram)

Radionuclide	Background Soil[a]	Food Crop Study Area	Hand Auger Soils
Tritium	<10[b]	<10	<10-560,000
K-40	20.0-26.0	7.0-22.0	<1.0-31.0
Cs-137	<0.1	<0.1-0.30	<0.1-0.80
Ra-226	0.80-1.10	<0.1-0.30	<0.1-9.40
Th-232	1.10-1.40	0.70-1.50	0.50-1.80
U-238	<2.0	<2.0	<2.0-14.0
Co-60	<0.1	<0.1	<0.1-0.3

a) Daniel Boone National Forest
b) One background tritium analysis discounted by laboratory review (Sample BK-3, See Appendix B, Section 4.2.1 of RI Report)

TABLE 13

CONCENTRATION RANGES OF ORGANIC CHEMICALS IN SOIL SAMPLES
(concentrations in ppb)

Chemical	Background Soil[a]	Food Crop Study Area	Hand Auger Soils
Methylene Chloride	<5	<5	<5-6
Chloroform	<5	<5	<5
Toluene	5[j]-35	7-180	<5-250[b]
Acetone	<10	<10	<10-36[j]
2-Butanone	<10	<10	<10
Di-n-octyl phthalate	<330	<330	<330
Dieldrin	<16	<16-290	<16
Phenanthrene	<330	<330	<330
Fluoranthene	<330	<330	<330
Pyrene	<330	<330	<330

a) Daniel Boone National Forest
j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution
b) Estimated value due to the detector's response being outside of the detector's linear range

TABLE 14

CONCENTRATION RANGES OF INORGANIC CHEMICALS IN SOIL SAMPLES
(concentrations in ppm)

Analyte	Background Soil[a]	Food Crop Study Area	Hand Auger Soils
Al	8540-11100	7090-10100	2980-10900
Sb	<12	<12	<12
As	<2-14.6[j]	<2-27.1[r]	6.7[j]-106.0[j]
Ba	45[j]-64	<40-95	<40-163
Be	<1	<1	<1-8.8
Cd	<1	<1	<1
Ca	<1000	<1000-1330	<1000-2180
Cr	15.0-18.4	10.5-16.5	6.4-18.8[j]
Co	11.3-14.6	<10-26.2	<10-25.5
Cu	9.3-15.7	<5-61.2	<5-53.7
Fe	21400-28500[j]	15200-31400	16000-95200
Pb	<1-19.8	12.7-33.2	2.4-39.6
Mg	2770[j]-3030	<1000	<1000-4260
Mn	98[j]-250[j]	371[j]-850[j]	8[j]-538[j]
Hg	<0.04	<0.04-0.06[jn]	<0.04-0.20[jn]
Ni	28-44[j]	<8-22	<8-63[j]
K	<1000-1890[j]	<1000-1280	<1000-2160
Se	<1	<1	<1-4.2[j]
Ag	<2	<2	<2
Na	<1000	<1000	<1000-1880
Tl	<2-5.2[j]	<2	<2-3.4
V	21-28[j]	24-72	<10-276
Zn	49-67	<4-90	6-298
Cyanide	<2	<2	<2
Phenolics	<2	<2	<2

a) Daniel Boone National Forest
j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution
jn) Estimated value and tentative identification

TABLE 15

RESULTS OF RCRA ANALYSES FOR HAND AUGER SOIL SAMPLES (ROUND 2)

LOCATION	pH	SULFIDE	IGNITABILITY	ACID REACTIVITY HCL / H2SO4	BASE REACTIVITY	WATER REACTIVITY
03T-32	3.9	Neg	Neg	Neg / Neg	Neg	Neg
05-10	4.6	Neg	Neg	Neg / Neg	Neg	Neg
05A-35	4.0	Neg	Neg	Neg / Neg	Neg	Neg
06-10	5.5	Neg	Neg	Neg / Neg	Neg	Neg
06-10[d]	5.7	Neg	Neg	Neg / Neg	Neg	Neg
06-20	6.2	Neg	Neg	Neg / Neg	Neg	Neg
11A-00	4.4	Neg	Neg	Neg / Neg	Neg	Neg
12A-30	4.4	Neg	Neg	Neg / Neg	Neg	Neg
12A-30	4.5	Neg	Neg	Neg / Neg	Neg	Neg
13A-38	4.2	Neg	Neg	Neg / Neg	Neg	Neg
17-10	5.2	Neg	Neg	Neg / Neg	Neg	Neg
17-10[d]	4.5	Neg	Neg	Neg / Neg	Neg	Neg
18A-00	4.6	Neg	Neg	Neg / Neg	Neg	Neg
43A-10	4.6	Neg	Neg	Neg / Neg	Neg	Neg
48-30	5.4	Neg	Neg	Neg / Neg	Neg	Neg
50A-05	5.5	Neg	Neg	Neg / Neg	Neg	Neg
58A-05	3.9	Neg	Neg	Neg / Neg	Neg	Neg
58A-15	6.8	Neg	Neg	Neg / Neg	Neg	Neg

Neg = Negative test results
d = Duplicate sample

Note: Organic and inorganic analyses performed on these samples indicated that EP Toxicity test results would be negative.

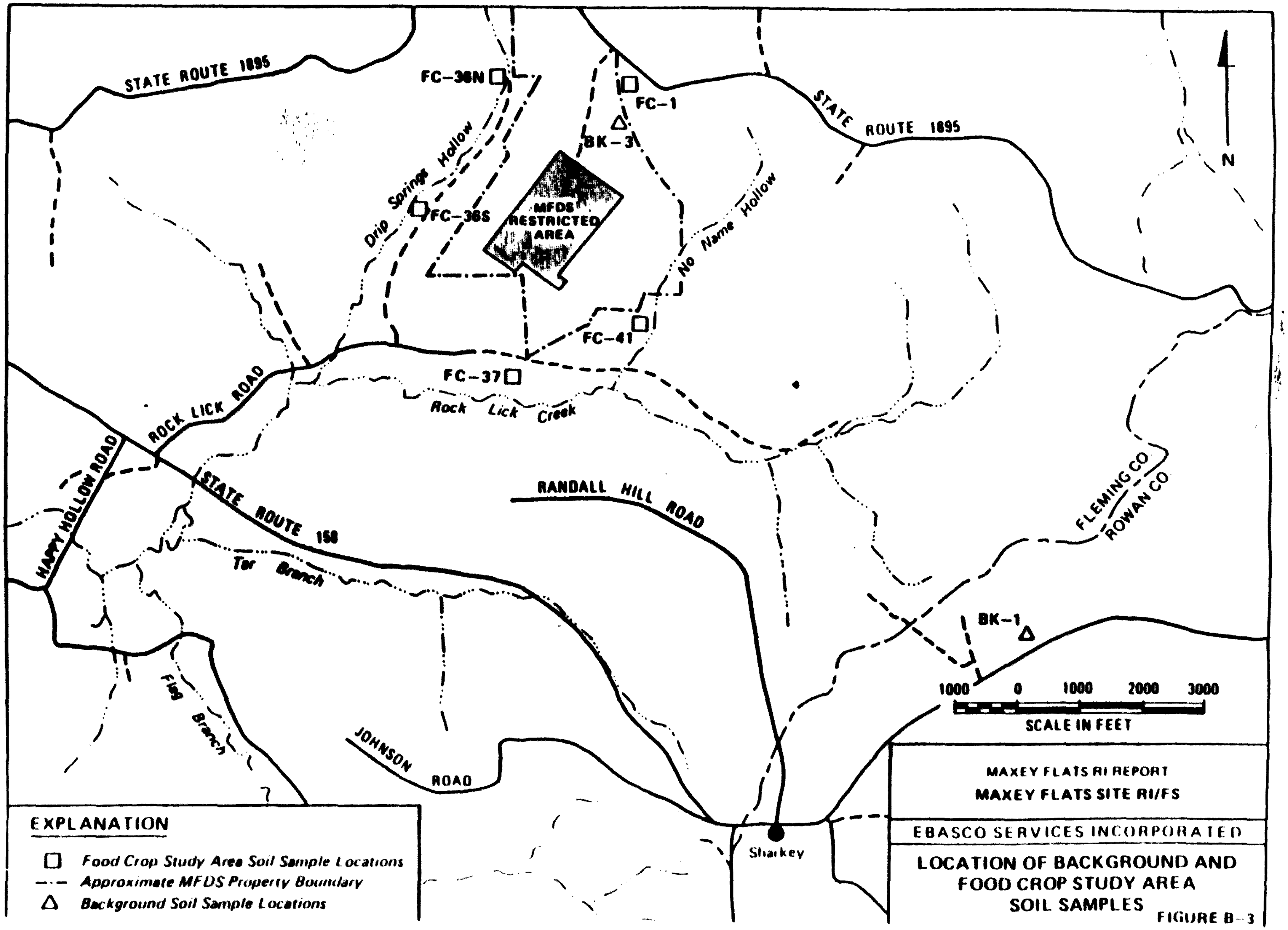
TABLE 16

RESULTS OF RCRA ANALYSES FOR SOIL WATER

	Date Sampled	pH	Sulfide Screen	Ignitability Screen
WP-1	03/07/88	7.39	Neg	Neg
WP-1[d]	03/07/88	7.44	Neg	Neg
WP-1	04/19/88	6.40	Neg	Neg
WP-1[d]	04/19/88	6.30	Neg	Neg

d) Duplicate sample
Neg) Negative results

Note: Organic and Inorganic analyses performed on these samples indicated that EP Toxicity test results would be negative.


STATE ROUTE 1895
FC-36N
FC-1
BK-3
STATE ROUTE 1895
N
Drip Springs Hollow
FC-36S
MFDS RESTRICTED AREA
No Name Hollow
FC-41
FC-37
Rock Lick Creek
ROCK LICK ROAD
HAPPY HOLLOW ROAD
STATE ROUTE 158
RANDALL HILL ROAD
FLEMING CO
ROWAN CO
Tar Branch
BK-1
1000 0 1000 2000 3000
SCALE IN FEET
Flag Branch
JOHNSON ROAD
Sharkey
EXPLANATION
Food Crop Study Area Soil Sample Locations
Approximate MFDS Property Boundary
Background Soil Sample Locations
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
LOCATION OF BACKGROUND AND FOOD CROP STUDY AREA SOIL SAMPLES
FIGURE B-3

5.1.4 - Surface Water and Sediments

Surface water and sediment investigations during the RI involved the collection and analyses of samples from surface water runoff leaving the Restricted Area (which exits through three water control structures located at the periphery of the Restricted Area) and off-site creeks which receive runoff from the MFDS as well as from off-site sources. Figure 11 illustrates the locations of surface water and sediment sample collection during the RI.

Tritium (10 to 60 pCi/ml) and Radium-226 (0.26 pCi/gram [Rock Lick Creek] and 0.29 pCi/gram [Drip Springs Hollow]) were the only radionuclides detected in the surface water samples during the RI. Concentrations of tritium were highest at the water control structures adjacent to the Restricted Area and decreased with distance away from the Restricted Area. The principal sources of tritium entering these structures are contaminated liquids that have migrated from the trenches to the hillslopes through fractured bedrock and atmospheric releases of tritium from the trenches. The concentration ranges of radionuclides in surface water samples are presented in Table 17.

The Commonwealth of Kentucky has detected Strontium-90 in surface water in the East Main Drainage Channel. The Commonwealth has also detected Strontium-90 in the east pond, at the east pond outlet, and in the south drainage area. Additionally, the Commonwealth has detected tritium concentrations in various site drains in excess of 1000 pCi/ml.

Analytical results from the RI indicate low concentrations (ranging from 5 ppb to 98 ppb) of chemical constituents in surface water. Chemical contaminants detected in surface water samples were limited to acetone, 2-butanone, chloroform, toluene, bis(2-ethylhexyl)phthalate, and hexachlorobenzene. Concentration ranges of organic and inorganic chemicals are presented in Tables 18 and 19, respectively.

In conjunction with the surface water sampling program during the RI, sediment samples were collected at the same locations (See Figure 11). Sediment sample analyses indicated tritium in concentrations ranging from 10 to 70 pCi/ml. Tritium concentrations were greater at the water control structures adjacent to the Restricted Area than at the more distant stream sampling stations. Other radionuclide concentrations in sediment moisture were within the range of background concentrations. (See Table 20 for concentration ranges of radionuclides in stream sediment samples.)

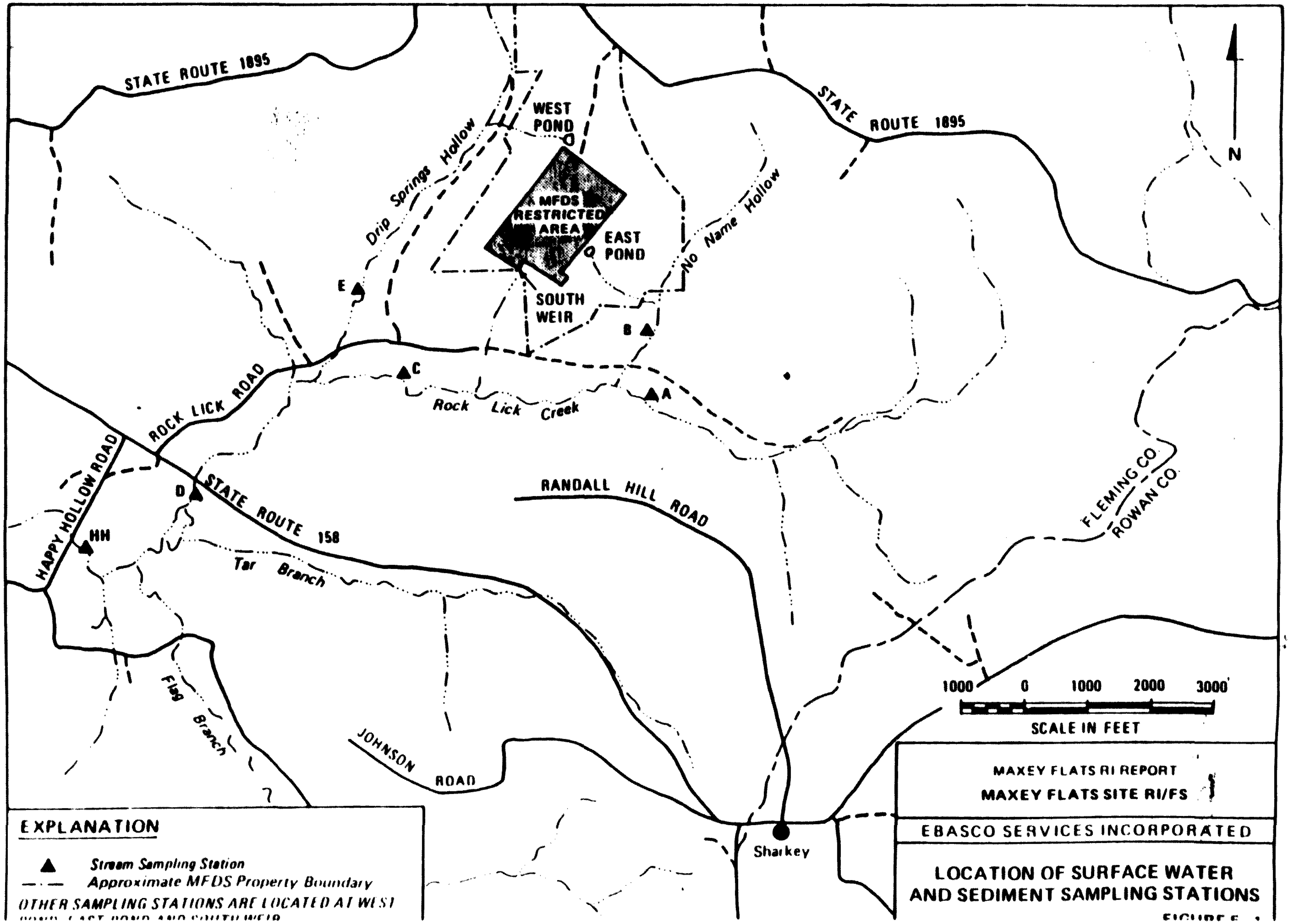

STATE ROUTE 1895
STATE ROUTE 1895
N
WEST POND
MFDS RESTRICTED AREA
EAST POND
SOUTH WEIR
Drip Springs Hollow
No Name Hollow
E
B
C
A
Rock Lick Creek
ROCK LICK ROAD
HAPPY HOLLOW ROAD
D
HH
STATE ROUTE 158
Tar Branch
RANDALL HILL ROAD
FLEMING CO
ROWAN CO
Flag Branch
JOHNSON ROAD
Sharkey
1000 0 1000 2000 3000
SCALE IN FEET
MAXEY FLATS RI REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
LOCATION OF SURFACE WATER AND SEDIMENT SAMPLING STATIONS
EXPLANATION
Stream Sampling Station
Approximate MFDS Property Boundary
OTHER SAMPLING STATIONS ARE LOCATED AT WEST

TABLE 17

CONCENTRATION RANGES OF RADIONUCLIDES IN SURFACE WATER
(concentrations in pCi/ml)

	Background[a] Surface Water	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Tritium	<10-40[b]	<10-31[b]	<10-30	<10-60
K-40	<1.0	<1.0	<1.0	<1.0
Cs-137	<0.1	<0.1	<0.1	<0.1
Ra-226	<0.1	<0.1-0.29	<0.1	<0.1
Th-232	<0.2	<0.2	<0.2	<0.2
U-238	<2.0	<2.0	<2.0	<2.0
Co-60	<0.1	<0.1	<0.1	<0.1

a) Daniel Boone National Forest and Stream Sampling Station A (upstream of Site Area).

b) High value suspect, see Appendix E, Section 4.1 of MFDS RI Report for discussion.

TABLE 18

CONCENTRATION RANGES OF ORGANIC CHEMICALS IN SURFACE WATER
(concentrations in ppb)

Organic Chemical	Background[a] Surface Water	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Acetone	<10	<10	<10-68	<10-14
Toluene	<5-9	<5-5	<5	<5-42
Chloroform	<5	<5	<5-5	<5
2-Butanone	<10	<10-36[j]	<10	<10
Bis(2-ethyl hexyl)-phthalate	<10	<10	<10	<10-98
Hexachloro-Benzene	<10	<10-29[j]	<10	<10
Heptachlor	<0.05	<0.05	<0.05	<0.05-0.09
Endosulfan 1	<0.05	<0.05	<0.05-0.08	<0.05

a) Daniel Boone National Forest and Stream Sampling Station A (upstream of Site Area)

j) Estimated value because of exceeding a data validation criteria, or below detection limit due to laboratory sample dilution.

TABLE 19

CONCENTRATION RANGES OF INORGANIC CHEMICALS IN SURFACE WATER
(concentrations in ppb)

Analyte	Background[a] Surface Water	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Al	<200	<200-430	<200-880	<200-1820
Sb	<60	<60	<60	<60
As	<10	<10	<10	<10
Ba	<200	<200	<200	<200
Be	<5	<5	<5	<5
Cd	<5	<5	<5	<5-5
Ca	<5000-9540	11700-24400	5390-26200	<5000-40500
Cr	<10	<10	<10	<10
Co	<50	<50	<50	<50
Cu	<25	<25	<25	<25
Fe	<100-660	<100-2490	360-560	<100-1090
Pb	<5	<5	<5	<5
Mg	<5000	<5000-10200	<5000-5260	<5000
Mn	88-341[j]	<15-961[j]	<15-310	<15-172
Hg	<0.2	<0.2	<0.2	<0.2
Ni	<40	<40	<40	<40
K	<5000	<5000-7450	<5000	<5000
Se	<5	<5	<5	<5
Ag	<10	<10	<10	<10
Na	<5000	<5000-6920	<5000	<5000
Tl	<10	<10	<10	<10
V	<50	<50	<50	<50
Zn	<20-85	<20-43	<20-33	<20-22
Cyanide	<10	<10	<10	<10
Phenolics	<10	<10	<10	<10

a) Daniel Boone National Forest and Stream Sampling Station A (upstream of Site Area)

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.

TABLE 20

CONCENTRATION RANGES OF RADIONUCLIDES CHEMICALS IN STREAM SEDIMENTS
(concentrations in pCi/ml or pCi/g)

Radionuclide	Background[a] Sediments	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Tritium	<10	<10	<10-20	<10-70
K-40	8.0-16.0	12.0-30.0	17.0-22.0	12.0-21.0
Cs-137	<0.1-1.30	<0.1-0.10	<0.1	<0.1-0.40
Ra-226	0.90-2.50	1.50-2.40	1.70-3.70	0.60-1.10
Th-232	0.80-1.20	0.80-1.40	0.80-1.20	1.00-1.30
U-238	<2.0	<2.0	<2.0	<2.0
Co-60	<0.1	<0.1	<0.1	<0.1

a) Daniel Boone National Forest and Stream Sampling Station A (upstream of Site Area)

Volatile organic chemicals (acetone, 2-butanone, methylene chloride, and toluene) detected in sediment samples ranged from 5 ppb to 170 ppb. Semi-volatile organic chemical constituents (phthalate esters, phenol, phenanthrene, fluoranthene, and pyrene) ranged from 5 ppb to 1800 ppb. The highest concentration detected was phthalate esters. Phthalate esters were only detected in samples associated with surface water runoff from the Restricted Area and the probable source of the phthalate esters is the PVC used to cover the trenches. (See Tables 21 and 22 for concentration ranges of organics and inorganics, respectively, in stream sediment samples.)

5.1.5 - Air

Although an air quality investigation was not performed during the Remedial Investigation of the MFDS, atmospheric data is available for the site from 1983 to present. For the years 1983 to 1987, the average gross alpha, gamma, and beta concentrations measured at the air monitoring stations around the perimeter of the Restricted Area were three to five times lower than the maximum concentration permitted by Commonwealth regulations outside the Restricted Area for individual radionuclides. The average tritium activity measured at the air monitoring stations ranged from 240 to 3,000 pCi/m^3 during the years 1983 to 1986, and averaged 275 pCi/m^3 in 1987. For comparative purposes, the average tritium activity for 1987 is less than 0.2 percent of the maximum permissible concentration (200,000 pCi/m^3) for areas outside the Restricted Area. The highest average airborne tritium concentration measured at a single location during 1987 was 1,260 pCi/m^3, 0.6 percent of the average annual maximum permissible concentration.

The primary source of airborne radiation prior to 1987 was the evaporator system. (The site evaporator ceased operation at the MFDS in 1986). The trend of airborne tritium concentrations has closely followed the release of tritium by the site's evaporator system. Tritium concentrations measured at the air monitoring stations markedly decreased during 1983 and 1987 when the evaporator was not operating, and again in 1986 when the evaporator was operating at lower capacities. Other potential sources of airborne radiation are tritium transpired by trees, diffusion of tritium vapor directly through the trench cap, and the ascension of tritium-bearing gases escaping from trench sumps.

TABLE 21

CONCENTRATION RANGES OF ORGANIC CHEMICALS IN STREAM SEDIMENTS
(concentrations in ppb)

Organic Chemical	Background[a] Sediments	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Methylene Chloride	<5	<5-10	<5	<5
Chloroform	<5	<5	<5-10[j]	<5
Toluene	<5-75	<5-10	<5-5	<5
Acetone	<10-72	<10-170	<10-20	<10
2-Butanone	<10	<10-31	<10	<10
Di-n-octyl phthalate	<330	<330	<330	<330-1800
Dieldrin	<16	<16	<16	<16
ʾhenanthrene	<330	<330	<330	<330-510
Fluoranthene	<330	<330	<330	<330-410
Pyrene	<330	<330	<330	<330-380[j]

a) Daniel Boone National Forest and Stream Sampling Station A (upstream of Site Area)

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.

TABLE 22

CONCENTRATION RANGES OF INORGANIC CHEMICALS IN STREAM SEDIMENTS
(concentrations in ppm)

Analyte	Background Sediments[a]	Downstream of Site Area	Site Area Streams	MFDS Ponds and Weir
Al	4800-8140	5820-8390	3750-8230	8000-11400
Sb	≤12	≤12	<12	<12-13
As	13.3[j]-38.9	10.8[j]-59.3	14.2-38.0[j]	<2-39.0
Ba	<40-96	<40-63	43-83	<40-230
Be	<1-1.5	1.3-2.6	<1-1.8	<1
Cd	<1	<1	<1	<1
Ca	<1000	<1000-18200	1250-30800	<1000-39900
Cr	14.3[j]-30.0	16.4-30.7	9.5-24.1	17.2-39.6
Co	<10-59.2	21.4-40	10.5-26.9	<10-65.0
Cu	8.6-27.3	23.2-54.9	23.2-46.7[j]	8.5-41.0[j]
Fe	4300-73200	36600-71300	22300-65400	22200-70700
Pb	19.4-42.1	9.8-30.7	21.2-23.9	<1-46.6
Mg	<1000	<1000-2310	<1000-5070	1240-3940
Mn	261-682	295[j]-999	330-784[j]	92[j]-3530
Hg	<0.04	<0.04-0.07[jn]	<0.04	<0.04-0.07[jn]
Ni	16-42.0	52[j]-86[j]	31-74[j]	14-48[j]
[illegible]	<1000-1570	<1000-1950[j]	<1000-1220[j]	<1000-1500[j]
Se	<1	<1	<1	<1
Ag	<2	<2	<2	<2
Na	<1000	<1000-1390	<1000	<1000-1490
Tl	<2	<2	<2	≤2
V	28-76	62-109	39-81[j]	28[j]-66
Zn	55[j]-163[j]	177-297[j]	<4-236[j]	40-123[j]
Cyanide	<2	<2	<2	<2
Phenolics	<2	<2	<2	<2

a) Daniel Boone National Forest and Stream Sampling Station (upstream of Site Area)

j) Estimated value because of exceeding a data validation criterion, or below detection limit due to laboratory sample dilution.

jn) Estimated value and tentative identification.

SECTION 6.0 - SUMMARY OF SITE RISKS

As part of the RI/FS, an assessment of site risks was performed by the Maxey Flats Steering Committee (Committee) using existing site data and information gathered during the Remedial Investigation. The Committee's Appendix D to the Feasibility Study Report, and EPA's Addendum Report to the FS Report, may be consulted for a more in-depth explanation of both the process and results of the risk assessment for the Maxey Flats Disposal Site. The dose estimates presented in this section are median doses, unless otherwise noted. Additionally, the assumptions employed in the calculation of site risks and resultant dose estimates, provided in this section, are derived from the Committee's final, April 1991 risk assessment, unless otherwise noted.

The risk assessment identified the contaminant sources and exposure pathways which pose the greatest potential threat to human health and the environment and then evaluated the baseline risks associated with a No Action alternative; i.e., a scenario which assumed that the site would be abandoned. The risk assessment assumed exposure scenarios that involved (1) the degradation of the existing soil cap and the subsequent leaching and transport of radionuclides offsite, and (2) individuals trespassing and establishing residence at the site.

Potential contamination sources at the MFDS were determined to include trench material, leachate, site structures, above-ground tanks, ground surfaces, ground water, and soil. Potential routes of exposure to contaminants, called exposure pathways, were developed based on both the current site conditions and future, potential pathways typically examined in a public health evaluation. For the MFDS, two sets of potential pathways were evaluated - intruder (on-site) pathways and non-intruder (off-site) pathways. For the intruder scenario, it was assumed that the site would be abandoned and an individual would occupy an area of the site which is currently known as the Restricted Area. The non-intruder scenario, like the intruder pathways, assumed the site would be abandoned, but involved pathways (primarily off-site pathways) other than those associated with occupying the site.

Of the contaminants identified at the MFDS, two sets of contaminants representing the greatest potential for impacting human health, called indicator contaminants, were developed. Table 23 identifies the two groups of indicator contaminants selected for the Maxey Flats Disposal Site, radionuclide and non-radionuclide indicators.

TABLE 23

INDICATOR CONTAMINANTS

Radionuclides	Non-Radionuclides
Hydrogen-3 (Tritium)	Arsenic
Carbon-14	Benzene
Cobalt-60	Bis(2-Ethylhexyl) Phthalate
Strontium-90	Chlorobenzene
Technetium-99	Chloroform
Iodine-129	1,2-Dichloroethane
Cesium-137	Lead
Radium-226	Nickel
Thorium-232	Toluene
Plutonium-238	Trichloroethylene
Plutonium-239	Vinyl Chloride
Americium-241	

6.1 Off-Site Exposure Scenario

The pathways evaluated for the off-site exposure scenario are listed in Table 24, and described below. In order to evaluate the potential off-site exposure scenario, it was assumed that the site was abandoned and no measures are in place to control or mitigate site releases. Approximately 10% of rainwater was assumed to penetrate deep into the trenches and leach radionuclides from the waste. The contaminated rainwater was assumed to percolate down into the strata underlying the trenches and migrate laterally beneath the trenches to the MFDS hillslopes. From here, the contaminated water was assumed to partially evaporate and partially to be transported down the hillslopes to the valley below. As a result of evapotranspiration, tritiated water becomes airborne and is transported off-site to receptor locations.

6.1.1 - Well Water Pathway

The off-site well water pathway includes the following assumptions:

- A drinking water well in the alluvium becomes contaminated; leachate migrates in ground water from the trenches through the Lower Marker Bed (LMB), lower Nancy and Farmers Members to the hillslope; migration down the hillslope is via surface water runoff in washes; dilution by surface runoff water, evapotranspiration losses on the hillslope, infiltration into the alluvium at the bottom of the hillslope, and dilution in the alluvial ground water by additional recharge and upstream ground water occur.

- The MFDS and surrounding area are divided into eight sub-basin drainage areas, which carry different proportions of runoff and contaminants and are analyzed individually for contributions to alluvial ground water in the stream valleys.

- Individuals use a well in the alluvium for drinking water over a lifetime and consume two liters per day.

- No contaminants migrate via ground water through the colluvium, soil, or bedrock into the alluvial aquifer.

- Radioactive decay reduces radionuclide concentrations over the estimated travel time for the pathway.

TABLE 24

OFF-SITE (NON-INTRUDER) PATHWAYS

- Well Water Pathway -- involves the movement of contaminants in ground water to the hillsides adjacent to the site and into the surface water system moving down the hillsides. At the bottom of the hillsides, the contaminated runoff recharges the alluvium (soils). A well is excavated in the contaminated alluvium and a family uses the well as a source of drinking water.

- Surface Water Pathway -- in this pathway, contaminants move off-site in ground water and enter the surface water system. The stream water is then used as a drinking water and irrigation source for beef and milk cows and their forage. Humans then ingest the animal products.

- Soil Erosion Pathway -- this pathway actually is a combination of pathways. It involves the resuspension in air of soil particles contaminated with radionuclides and the washing of soil into the surface water. It is assumed that the trenches overflow with contaminated liquids. Dry contaminated soil is then suspended in air and carried to a person and inhaled or washed away in runoff. Also, crops are grown in the alluvium contaminated by surface runoff. A person ingests contaminated farm products and is exposed to external radiation.

- Sediment Pathway -- involves the movement of contaminants in ground water to the hillsides adjacent to the site and into the surface water system (streams). As the contaminated surface water moves through the stream bed, some of the contaminants adhere to the soils in the stream bed. Through the course of play in the stream beds, a child ingests the contaminated soils.

- Deer Pathway -- Contaminated water moves through the ground water system to the hillsides adjacent to the site. Upon reaching the hillside, the contamination is incorporated into plants. The contaminated plants are then eaten by deer foraging on the hillslopes. Also, the deer drink contaminated water from the streams. The contaminants are then incorporated into the meat of the deer. A hunter kills the deer and ingests the meat.

TABLE 24 (Continued)

OFF-SITE (NON-INTRUDER) PATHWAYS

- Evapotranspiration Pathway -- this pathway involves the uptake of contaminated liquid into plants; the liquids are released from the plants to the environment. Tritium is the only contaminant to move by this pathway. Once released to the air, the tritium could be incorporated into food and drinking water sources or directly inhaled by a human.

- Trench Sump Pathway -- This pathway involves the escape of tritiated water from trenches via trench sumps and cracks in the trench cap. A person then inhales the contaminated air.

- Radionuclides and other contaminants are subject to retardation by sorption effects.

Figure 12 illustrates the projected extent of potentially contaminated alluvium, under a No Action alternative, used in evaluating exposures associated with the well water pathway.

6.1.2 - Surface Water Pathway

This pathway begins in the same manner as the well water pathway; that is, contaminated runoff travels down the hillslope. However, unlike the well water pathway, where the flow is divided into eight regions, all the radioactivity is assumed to be deposited into a creek, and the creek water is used as a source of drinking water for livestock. In addition, grass in the vicinity of the creek is ingested by the livestock. Humans then ingest the contaminated milk and beef.

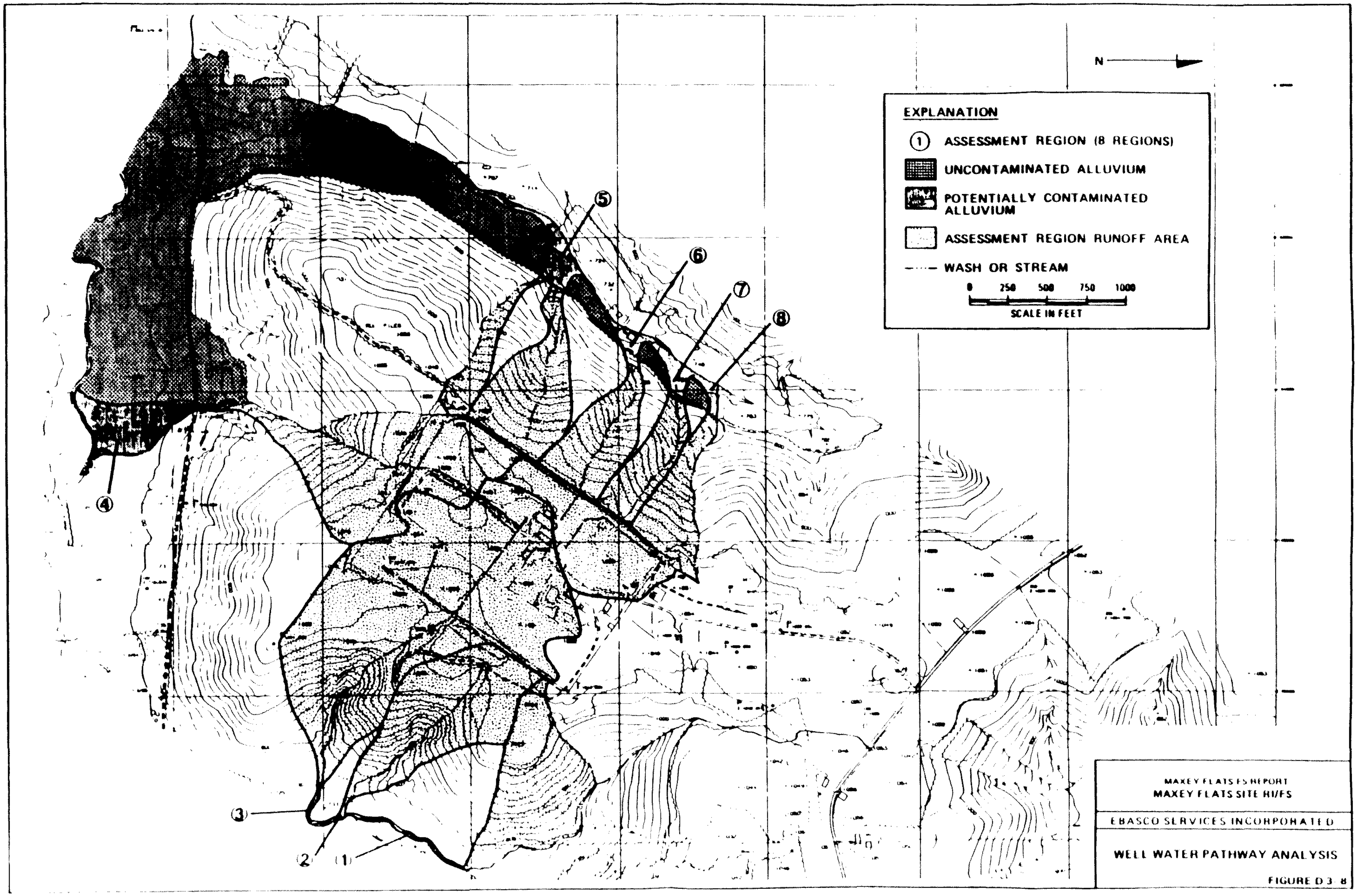
6.1.3 - Erosion Pathway

Another pathway included in the off-site exposure scenario is the erosion pathway. The erosion pathway assumed that, without erosion controls, surface and hillslope soil will be transported to the alluvial valley. The analysis is based on the assumption that no steps are taken to prevent the "bathtub" effect or to protect the overlying soil from erosion. As a result of the "bathtub" effect, leachate is assumed to rise up periodically, saturate the overlying soil, and overflow the trenches. The overlying soil thereby becomes contaminated and, when eroded down to the alluvial valley, becomes a source of exposure to individuals living in the valley.

The erosion pathway actually consists of a subset of pathways which include the following: (1) direct radiation from living on contaminated alluvium, (2) the ingestion of contaminated surface water, (3) the ingestion of vegetables grown in contaminated alluvium, and (4) the ingestion of beef and milk obtained from cattle and milk cows raised on water obtained from the creek and fodder from the contaminated alluvial plain.

The drinking water pathway of the erosion pathway is based on the assumption that an individual obtains all his drinking water from a local creek. Doses from the ingestion of vegetables are based on the assumption that all vegetables are obtained from gardens located on the contaminated alluvium. Similarly, milk and beef doses are based on the assumption that the cattle and cows obtain all their drinking water from the creek and fodder

FIGURE 12


N
EXPLANATION
1 ASSESSMENT REGION (8 REGIONS)
UNCONTAMINATED ALLUVIUM
POTENTIALLY CONTAMINATED ALLUVIUM
ASSESSMENT REGION RUNOFF AREA
WASH OR STREAM
0 250 500 750 1000
SCALE IN FEET
1
2
3
4
5
6
7
8
MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
WELL WATER PATHWAY ANALYSIS
FIGURE D.3-8

from grass growing in the contaminated alluvium. The doses also include direct radiation from continual exposure from living on contaminated alluvium. These doses were based on the assumption that the contamination is an effective infinite plane, with no credit taken for shielding.

The exposures associated with the erosion pathways were performed for a range of time periods that reflect a decaying source term and a changing erosion rate. The results of the analyses for the upperbound estimate for the erosion pathway are presented in Table 25. EPA believes that the upperbound estimates are the appropriate values associated with the erosion pathway due to the number of uncertainties in the erosion pathway analysis. See Section 6.3 - Risk Uncertainties, for a discussion of risk assessment uncertainties.

6.1.4 - Sediment Pathway

Another off-site pathway evaluated in the MFDS baseline risk assessment was that of a child ingesting contaminated sediments. Contaminants travel to the hillslopes and into the surface water system. As the contaminated surface water moves over the stream beds, some of the contaminants adhere to the sediments of the stream bed. Then, through the course of play in the stream beds, a child ingests 0.7 grams of contaminated sediments per day. It was assumed that the sediments are approximately 50% water, which contains tritium at the same concentration as the surface water.

6.1.5 - Deer Pathway

This pathway involves the migration of contaminants to the hillslopes. Upon reaching the hillslopes, the contamination is incorporated into plants. Approximately 150 kilograms/year of contaminated plants are then eaten by deer foraging on the hillslopes. Also, the deer drinks 3650 liters/year of contaminated water from the streams. The contaminants are then incorporated into the meat of the deer. A hunter kills the deer and ingests 5 kilograms of deer meat per year.

6.1.6 - Evapotranspiration Pathway

This pathway involves the uptake of contaminated liquids into plants. Through the process of evapotranspiration, which is the release of water vapor from the plants to the atmosphere, tritium is released to the air and incorporated into food and drinking water sources, or directly inhaled by a human. Tritium is the only contaminant to move by this pathway.

Table 25

EROSION PATHWAYS

PATHWAY	DOSE (MREM/YEAR)
External Exposure	160
Drinking Water	440
Vegetables	11
Milk	1.4
Meat	1.9

6.1.7 - Trench Sump Pathway

This pathway involves the escape of tritiated water from trenches via trench sumps and cracks in the trench cap. A person then inhales the contaminated air. Tritium is the only contaminant to move by this pathway.

6.1.8 - Conclusions of the Off-Site Exposure Scenario

The results of the risk assessment revealed that, for off-site exposure pathways, tritium is the critical radionuclide. The well water pathway is, by far, the dominant off-site pathway. If no action is taken at the site, the total dose equivalent from all indicators from all combined off-site pathways to individuals would be 75 mrem per year for the average case, almost half of which is attributable to tritium. The upper bound estimate of exposure from such a scenario would total 4300 mrem per year. For each year of exposure under a No Action alternative, it is estimated that the lifetime risk of fatal cancer would be 3×10^{-5} for the average case (75 mrem) and 1.7×10^{-3} for the upperbound case (4300 mrem). (EPA's target risk range is 1×10^{-4} to 1×10^{-6} which equates to one additional cancer in 10,000 for 1×10^{-4} and one additional cancer in 1,000,000 for 1×10^{-6}.)

The lifetime risk of cancer from prolonged exposure (many years of exposure) from off-site pathways would be approximately 1×10^{-3} (average case) and 6×10^{-2} (upperbound case). The well water pathway contributes the single highest dose among pathways, with soil erosion contributing almost all of the remaining dose. Both the average and upper bound estimates of off-site exposure exceed the MFDS remediation goal of 25 mrem per year for the entire site.

During the 70-year timeframe (the period of time typically used in evaluating risks at Superfund sites) for a No Action alternative, tritium and strontium-90 would exceed drinking water limits in water extracted from wells located at the base of the hillslopes and the 4 mrem/yr Maximum Concentration Limit for beta activity would be exceeded.

Over the 500-year time frame (which is a more lengthy period of time than typically used at Superfund sites, but necessary due to the presence of long-lived radionuclides at the MFDS), tritium, strontium-90, and radium-226 would exceed the drinking water limits in water extracted from wells located at the base of the hillslopes during the initial part of the 500-year timeframe, before tritium and strontium-90 have decayed away.

6.2 On-Site Exposure Scenarios

Table 26 lists the on-site (intruder) pathways evaluated in the MFDS baseline risk assessment, as described below. Evaluation of the on-site exposure scenarios involved the assumption that the site is abandoned and no institutional controls are in place to prevent site access.

For the intruder scenarios, which consist of a number of exposure pathways, a broad range of potential on-site exposures were evaluated in order to gain insight into the full range of potential impacts of the site and how those impacts may change with time.

It is unlikely that the Intruder-Discovery, Intruder-Construction, and Intruder-Agriculture scenarios could occur today or in the immediate future; however, these scenarios were included in the risk assessment to characterize fully the range of potential exposures that could be associated with the site. As time passes, these scenarios would become more likely.

6.2.1 - Intruder-Trespasser Scenario

Under the Intruder-Trespasser Scenario, a trespasser who occasionally gains access to the site would be exposed to direct external radiation and perhaps the inhalation of radioactive particulates that may become airborne through suspension processes. In addition, it is likely that the trespasser would also be exposed to airborne tritiated water vapor due to the evaporation of leachate.

6.2.2 - Intruder-Discovery Scenario

This pathway involves the assumption that no controls exist for the site and an intruder inadvertently occupies the disposal site and begins construction activities. The intruder contacts solid remains of waste or barriers, realizes that something is wrong, and ceases construction activities. Human exposure to radiation is assumed to result for a short time from external exposure to the contaminated soils and inhalation of contaminated air.

6.2.3 - Intruder-Construction Scenario

For the Intruder-Construction scenario, it is assumed that, in the scenario described for the Intruder-Discovery above, the construction worker continues construction activities. In the Intruder-Construction scenario, the builder is assumed to be exposed from the following pathways:

TABLE 26

ON-SITE (INTRUDER) PATHWAYS

- Intruder-Trespasser Scenario: This scenario involves the assumption that no controls exist for the site and a trespasser occasionally gains access to the site.

- Intruder-Discovery Scenario -- This scenario assumes that no controls exist for the site and an intruder inadvertently occupies the site and begins construction activities. The intruder contacts solid remains of waste or barriers, realizes that something is wrong, and ceases construction activities. Human exposure would occur through the external exposure to contaminated soil pathway and through the inhalation of contaminated air pathway.

- Intruder-Construction Scenario: This scenario assumes that, in the scenario described for the intruder-Discovery Scenario above, the construction worker continues construction activities. Construction activities penetrate and expose the waste. Human exposure would occur through the external exposure to contaminated soil pathway and through the inhalation of contaminated air pathway.

- Intruder-Agricultural Scenario -- This scenario involves the assumption that no controls exist for the site and an inadvertent intruder occupies the site. After some construction activities, the intruder (site resident) begins agricultural activities. It is assumed that some percent of the intruder's annual diet comes from crops raised in the contaminated soil and from food products produced by animals. External exposure and ingestion of contaminated ground water from a well are two pathways included in this scenario. It is also assumed that a quantity of contaminated soil is ingested by a child during play or an adult at work in the fields. Inhalation of resuspended contaminated soil and the migration of radon into the intruder's basement are additional pathways of the Intruder-Agriculture Scenario.

- Direct Gamma - Direct radiation from standing in the excavated hole.

- Suspension of Particulates from Construction - Inhalation of particles suspended during construction, external exposure from suspended particulates, and exposure to an area source consisting of particles deposited on the soil following suspension during construction.

- Airborne tritium - Inhalation and skin absorption of airborne tritiated water vapor.

6.2.4 - Intruder-Agriculture Scenario

The Intruder-Agriculture scenario was based on the assumption that an individual builds a home and lives on the site beginning today. It was also assumed that the intruder obtains his food locally and sinks a well into the aquifer underlying the site to obtain drinking water. In the Intruder-Agriculture scenario, the intruder is assumed to live in the house, plant a garden in soil excavated from the waste disposal site during construction, use water from an on-site well, and raise cattle and milk cows on the contaminated soil at the site. In addition, a child in the family is assumed to ingest contaminated soil, and products of radon decay are assumed to build up indoors due to the radium contamination in the waste.

6.2.5 - Conclusions of the On-Site Exposure Scenarios

For the Intruder-Trespasser scenario, the direct external radiation dose rate to a person standing on the trenches depends on whether the soil overlying the trenches is intact and uncontaminated. If the overlying soil becomes contaminated as a result of the "bathtub" effect which is known to occur at the site, the shielding effectiveness of the overlying soil is markedly reduced, resulting in dose rates up to approximately 1.4 mrem/hour. If it were assumed that the trespasser frequents the site, on the average, once per week, spending one hour per visit, the resultant dose from the Intruder-Trespasser scenario would be approximately 73 mrems/year.

If the overlying soil is contaminated as a result of the "bathtub" effect, wind and mechanical erosion processes could cause contaminated soil particles to become airborne. Once airborne, they could cause internal exposures due to inhalation and also external exposures from immersion in the airborne particulates.

Individuals standing in the vicinity of the trenches would likely be exposed to airborne tritiated water vapor. If the trench cap degrades and/or the trench leachate overflows, evaporation processes will result in airborne tritiated water vapor. The dose to a trespasser from airborne tritiated water vapor is presented in Table 27.

For the Intruder-Construction scenario, the results revealed that if a home were constructed at the site today, the dose to the construction worker over the 500 hours required for construction is estimated to be 3.2 rems and the lifetime risk of fatal cancer is approximately 1.2×10^{-3}. Most of this dose and risk is due to direct radiation, primarily from cobalt-60, cesium-137, and radium-226. The doses associated with the Intruder-Discovery scenario are substantially less than the Intrduer-Construction scenario due to less duration of on-site activities.

If a 100-year period of institutional control[5] is assumed, the dose and risk to a construction worker at the site decrease by about an order of magnitude, to 320 mrem. The decrease is due primarily to the decay of cobalt-60 and cesium-137. However, direct radiation is still the major contributor to dose, though the dominant radionuclide is now radium-226.

After a 500-year period of institutional control, the dose and risk to the construction worker decrease further, but by less than a factor of about 2, to 210 mrem. Direct radiation is still the major contributor to dose, and radium-226 is still the dominant radionuclide.

For the Intruder-Agriculture scenario, the results revealed that if a person were to live in a home constructed directly over the waste trenches today, the dose equivalents to an adult from all pathways, not including radon, total 26,000 mrem per year for the average case, with the upperbound estimate totalling 1,000,000 mrem per year. Forty-three percent of the impact would be derived from drinking water, 47 percent from food produced on-site, and 10 percent from external exposure. Tritium, carbon-14, strontium-90, and radium-226 dominate the

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[5] - As it is used here, institutional controls includes access restrictions such as fences, on-site personnel, land use and deed restrictions and maintenance activities such as fence repair and limited custodial maintenance and monitoring activities.

TABLE 27

EFFECTIVE DOSE EQUIVALENTS (MREM/HOUR) FOR TRANSIENT INTRUDER

	1	2	3	4
Years	Direct Gamma		Resuspension	
Decay	Waste	Soil	Inhalation[1]	Immersion[2]
0	4.5E-04	1.4E+00	1.4E-01	4.9E-08
10	1.7E-04	1.3E+00	1.3E-01	4.5E-08
20	9.7E-05	1.3E+00	1.3E-01	4.4E-08
30	7.8E-05	1.3E+00	1.3E-01	4.4E-08
40	7.3E-05	1.3E+00	1.3E-01	4.4E-08
50	7.1E-05	1.3E+00	1.3E-01	4.4E-08
75	6.8E-05	1.2E+00	1.3E-01	4.3E-08
100	6.7E-05	1.2E+00	1.3E-01	4.3E-08
200	6.4E-05	1.2E+00	1.2E-01	4.3E-08
300	6.1E-05	1.2E+00	1.2E-01	4.3E-08
400	5.9E-05	1.2E+00	1.2E-01	4.3E-08
500	5.6E-05	1.2E+00	1.2E-01	4.2E-08

1 Major Contributors are Th-232 and Pu-238
2 Major contributor is Th-232

ingestion doses, with cobalt-60, cesium-137, and radium-226 dominating the external exposure.

For each year a person lives on-site, the average case lifetime risk of fatal cancer would be approximately 1×10^{-2}, or one in 100. Under the same scenario, the upperbound case lifetime risk of developing fatal cancer would be 4×10^{-1}, or four in 10. Both cases significantly exceed EPA's target risk range.

Prolonged exposures (many years of exposure) result in a lifetime risk of cancer approaching 1. The exposure to radon progeny was conservatively estimated to be 50 WLM per year, which corresponds to a lifetime risk of fatal lung cancer of close to 1.0.

If a period of 100 years of site institutional control were assumed before a person constructs and occupies a home on-site, the dose decreases and the longer-lived radionuclides such as radium-226, thorium-232, and plutonium-238 become the significant radionuclides. Tritium and strontium-90 no longer contribute to the dose because they have decayed away. Cesium-137 will have decayed to less than 90% of its original activity.

Assuming occupancy of the site does not begin for 100 years or more, the doses and associated risks decrease, but by only a small margin since most of the exposure is associated with the relatively long-lived radionuclides. If a 100-year period of institutional control is assumed, the dose associated with an intruder-agriculture scenario decreases by a factor of approximately 3, to 7.2 rem/year. Of this dose, the direct radiation exposures have declined by about a factor of 10, to 780 mrem/year, primarily due to the decay of Cobalt-60. Radium-226 is now the dominant source of external exposure. At 100 years, the lifetime risk of fatal cancer (not including radon progeny) due to continual exposure decreases to approximately 4×10^{-2}. The exposures and risks associated with elevated levels of radon progeny indoors decrease only slightly, as expected, given the long half-life of Radium-226.

If a 500-year period of institutional control is assumed, the dose decreases to 5.1 rem/year, and the risk (not including radon progeny) is approximately 3.1×10^{-2}. The reason for the small decrease is that the dose from drinking water is dominated by very long-lived radionuclides. If uncontaminated sources of drinking water are used, the dose is approximately 600 mrem/year. This dose is primarily due to direct radiation, which is dominated by Radium-226. The food ingestion pathways contribute less than 100 mrem/year.

Even after 500 years, on-site occupancy would result in risks exceeding the acceptable risk range. See Figures 13 and 14 for an illustration of the decay of radionuclide indicators with time. It can be seen that beyond 100 years the risks associated with the MFDS remain unacceptably high and tend to become constant rather than decreasing significantly; thus, the need for institutional controls, maintenance and monitoring to be implemented and funded in perpetuity is apparent.

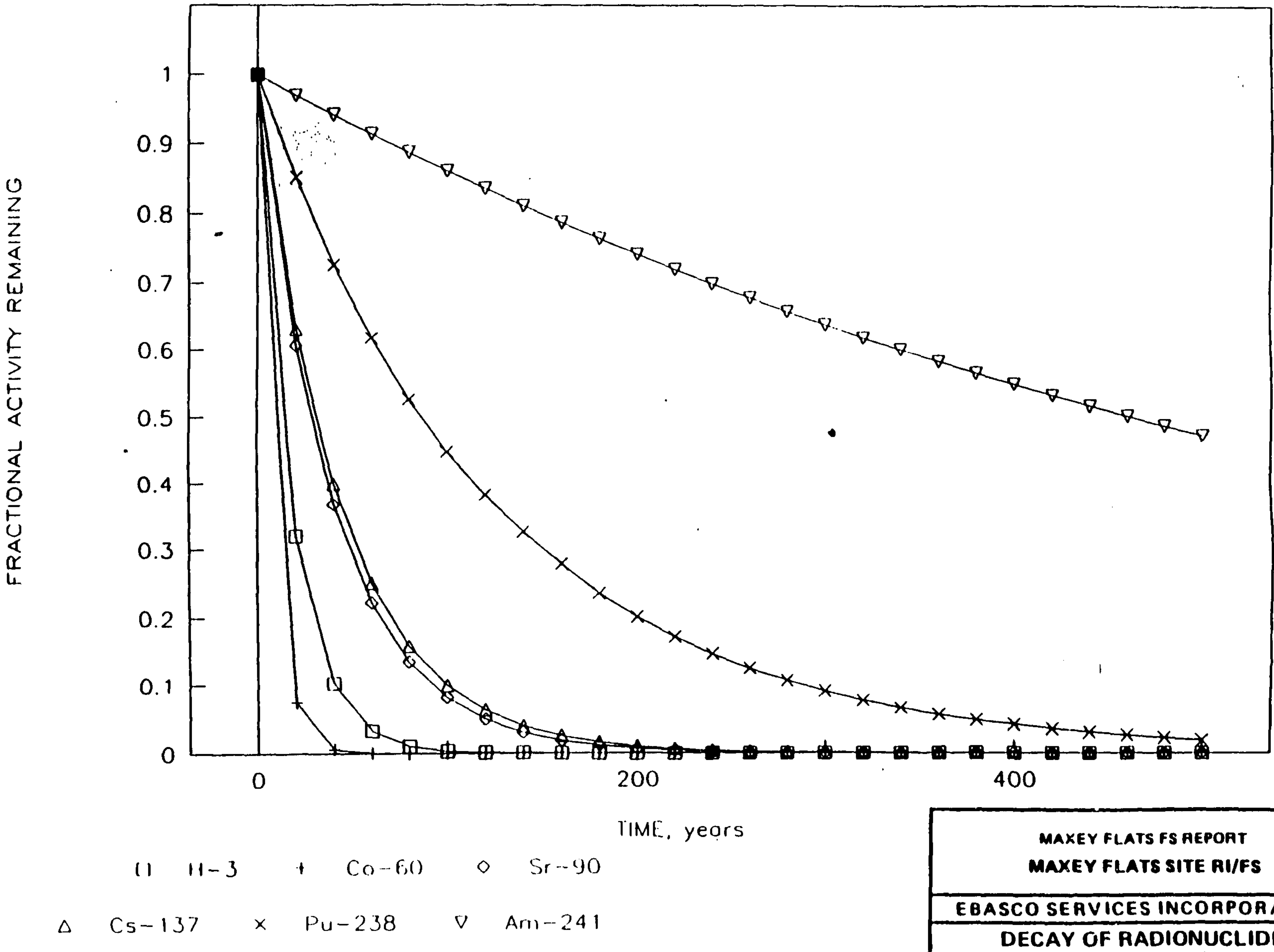
As the foregoing discussion demonstrates, the threatened release of hazardous substances from the MFDS, if not addressed by the preferred alternative or one of the other active measures considered, may present an imminent and substantial endangerment to public health, welfare, or the environment.

6.3 Risk Assessment Uncertainties

As with most baseline risk assessments, a number of uncertainties are associated with the MFDS risk assessment. The following discussion describes some of those uncertainties which may have led to an underestimation of the estimated exposures associated with some of the pathways evaluated:

In the April 1991 final risk assessment, in-transit decay is assumed for the transport of the radionuclides from the trenches to the receptor location. The in-transit time for water is assumed to be several years, and the transit time for many radionuclides is much longer due to the radionuclide binding coefficients. For some radionuclides, this in-transit decay assumption results in substantial decay. If the MFDS were to experience "bathtubbing" (trench overflow) conditions under a No Action scenario, the radionuclide transit time would be substantially reduced and, consequently, the concentrations of radionuclides reaching the potential receptors would be much greater.

Additionally, the magnitude of retardation for some of the radionuclides, such as plutonium and carbon-14, may have been overestimated in the risk assessment. Retardation of plutonium is complex and poorly understood. Plutonium is known to be fairly mobile under some conditions of valence, complexation, and colloidal suspension. Plutonium has also been shown to be in a micro-particulate form in the MFDS trench leachates rather than in a typical ionic solution state; this may make it more mobile. Plutonium has also been detected in ground water migrating away from the trenches in the LMB, indicating that plutonium is more mobile than would be indicated by the high Kd values assumed in the risk assessment. Thus, the risk



MAXEY FLATS FS REPORT

MAXEY FLATS SITE RI/FS

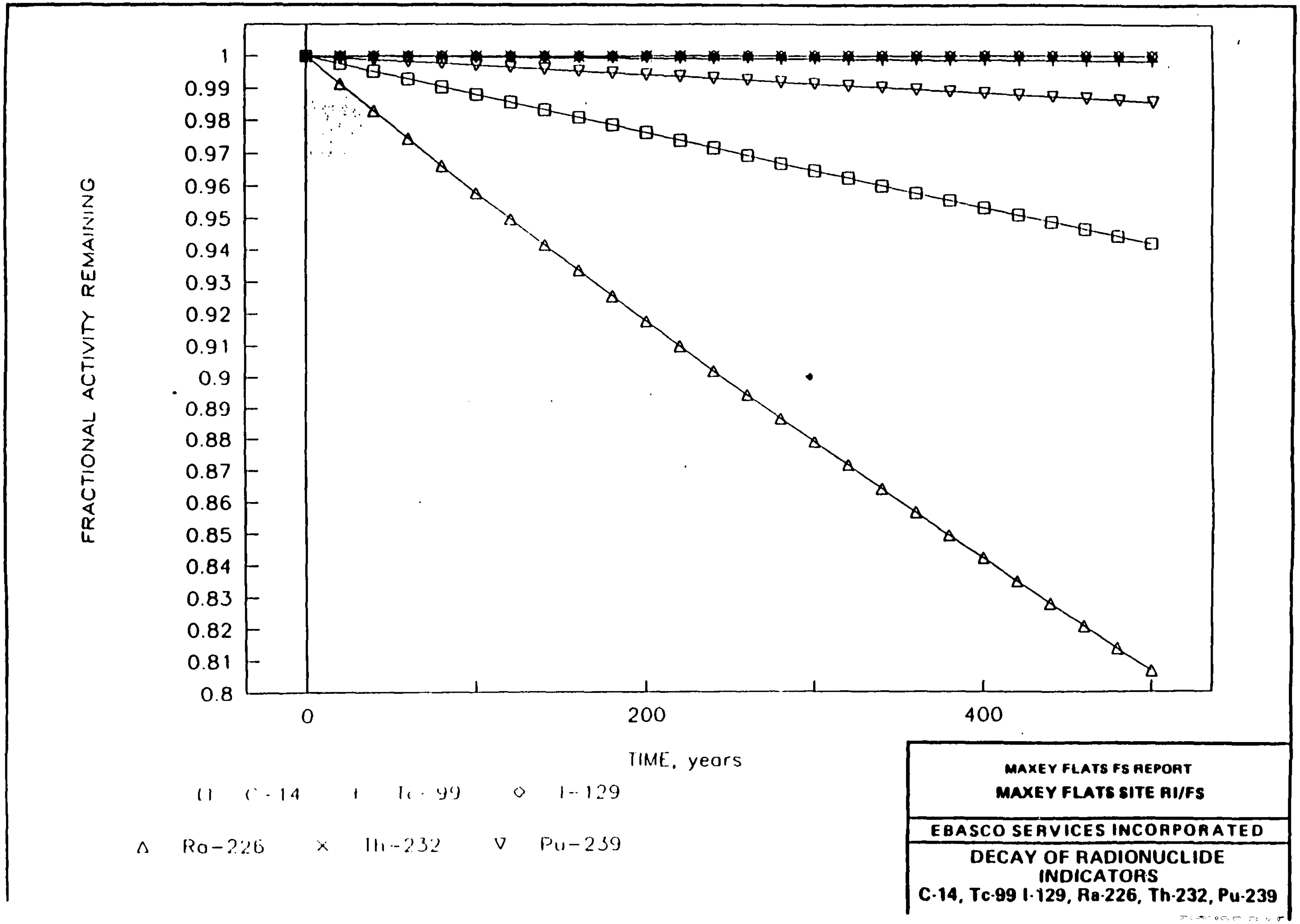
EBASCO SERVICES INCORPORATED

DECAY OF RADIONUCLIDE INDICATORS

H-3, Co-60, Sr-90, Cs-137, Pu-238, Am-241

FIGURE D.1-4

FIGURE 14


FRACTIONAL ACTIVITY REMAINING
1
0.99
0.98
0.97
0.96
0.95
0.94
0.93
0.92
0.91
0.9
0.89
0.88
0.87
0.86
0.85
0.84
0.83
0.82
0.81
0.8
0
200
400
TIME, years
□ C-14 + Tc-99 ◇ I-129
Δ Ra-226 × Th-232 ∇ Pu-239
MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
DECAY OF RADIONUCLIDE INDICATORS
C-14, Tc-99 I-129, Ra-226, Th-232, Pu-239

assessment may have underestimated the doses associated with some of the off-site pathways, in particular, the erosion pathway. It is for these reasons that EPA feels that the upperbound dose estimates for the erosion pathway are appropriate.

The risk assessment assumes migration of leachate to the hillslope drainage channels with subsequent migration of leachate to the alluvium, quickly, via surface water runoff. However, it is likely that leachate will also migrate down the entire hillslope through the shallow soil-colluvium layer and enter directly into the alluvial aquifer without major dilution from uncontaminated surface water. The risk assessment also assumes that a significant portion of alluvial ground water is recharged and diluted by stream water. A more appropriate assumption is that no recharge filtration from upstream water occurs to the band of contaminated ground water passing through the alluvium to the creek. This is more appropriate because, in the MFDS hydrogeological environment, alluvial ground water flows from the alluvium into the creek (rather than the reverse, as was assumed in the risk assessment). These factors, as well as the points made previously with regard to the in-transit decay and retardation factors, may have resulted in an underestimation of the potential doses associated with the off-site well water pathway.

The following uncertainties may have led to an overestimation of the exposures associated with some of the pathways evaluated:

The average case values for the Intruder-Agriculture well analysis are all greater than the maximum concentrations detected in the Remedial Investigation (RI) well sampling, with the exception of tritium. The tritium data from the RI may have been skewed by a well near a trench with very high tritium concentrations. Additionally, trench leachate data is also skewed toward high concentrations of certain radionuclides, since specific trenches were targeted during the RI because of the elevated radionuclide concentrations. Since the generation of leachate is a major component of most of the pathways modeled in the risk assessment, the model results may be conservative compared to previous field measurements.

The impacts for individual pathways for the 500-year timeframe are the sums of all radionuclides that impact the receptor at any time during that 500 year span. In other words, impacts seen from tritium in the early part of the time frame are added to those from radium-226, which are seen at the end of the time frame. This approach tends to overestimate the total dose, which is used to estimate exceedance ratios.

The I-129 source term has probably been significantly overestimated in the risk assessment. The source of three curies for the MFDS is based on the assumption that I-129 was at its detection limit in the waste. Preliminary results of a recent study indicate that the I-129 source could be as much as 1000 times lower than its detection limit in low-level radioactive waste. The industry is still uncertain about the I-129 source term in low-level waste. However, since I-129 does not contribute significantly to the impacts estimated at the MFDS based on the three curie value, there is no real effect of adopting the overestimate.

Another uncertainty deals with the B_{iv} value for carbon-14. A recent study has shown that the B_{iv} for carbon-14 reported in Regulatory Guide 1.109 is as much as 50 times too high. However, the traditional value was employed in the MFDS risk assessment. It was thought that the traditional value would be used until the recent work becomes more widespread. As a consequence, the dose for carbon-14 from the ingestion of plants and deer meat may be overestimated.

SECTION 7.0 - DESCRIPTION OF ALTERNATIVES

7.1 Remedial Action Objectives

As previously discussed, the primary mechanism for release of contaminants to the environment from the MFDS is the migration of leachate from the disposal trenches, through the underlying, fractured bedrock, to the hillslopes surrounding the site. The major cause of leachate generation is the infiltration of precipitation through the subsided trench cover. Historically, trench leachate pumping operations at the MFDS have been necessary to address trench overflow conditions; thus, trench overflow is a pathway of concern as well.

Trench subsidence is the lowering of the trench caps due to trench waste consolidation over time. Areas affected by subsidence can range in size from a few square feet of a cap to the entire area of a trench or group of trenches. Subsidence can cause cap failures by cracking or deforming of the cap materials. Depressed areas commonly result in ponding of rain water, which would have run off naturally if subsidence had not occurred. Both subsidence and ponding can lead to increased rates of water infiltration into the waste. Subsidence is evident in most waste disposal trenches. After a few years, therefore, soil must be added to the trench surfaces and the caps must be regraded to maintain surface water runoff.

The objectives of remedial action at the MFDS are to:

- Minimize the infiltration of rainwater and ground water into the trench areas and migration from the trenches;
- Stabilize the site such that an engineered cap that will require minimal care and maintenance over the long term can be placed over the trench disposal area;
- Minimize the mobility of trench contaminants by extracting trench leachate to the extent practicable;
- Promote site drainage and minimize potential for erosion to protect against natural degradation;
- Implement institutional controls to permanently prevent unrestricted use of the site;
- Implement a site performance and environmental monitoring program;

As with any remedial action under Superfund, these objectives must be met in ways that are protective of human health and the environment and achieve applicable or relevant and appropriate federal and state requirements.

7.2 Alternatives

Eighteen potential remedial alternatives to achieve the remedial action objectives for the MFDS were developed and evaluated during the FS. These 18 alternatives were then screened on the basis of their effectiveness, implementability and cost. This screening produced a manageable group of seven alternatives. Each of the seven alternatives was then subjected to a detailed analysis which applied the nine evaluation criteria established by the Superfund Amendments and Reauthorization Act (SARA).

The No Action alternative, which is required to be evaluated at all Superfund sites, serves as a baseline for comparison against the other alternatives and must be carried through the detailed analysis of alternatives. The No Action alternative is not an action-based alternative but rather consists solely of monitoring and activities in support of monitoring.

With the exception of the No Action alternative, each of the alternatives evaluated incorporates technologies for trench stabilization as well as horizontal and vertical flow barriers. These technologies are discussed in the following sections.

7.2.1 - Stabilization Technologies

Stabilization at the MFDS refers to the consolidation and densification of trench soils and/or waste materials. The purpose of stabilization at the MFDS is to achieve trench stability such that a vertical infiltration barrier (cap) can be placed over the trench disposal area which requires minimum repair and maintenance over the long term.

The dynamic compaction technology is a stabilization method common to Alternatives 4, 10, and 17. The dynamic compaction technology involves the repeated dropping of a large weight on each trench cover (except for those trenches where it is not appropriate) until the waste and trench cover are sufficiently consolidated. The weight, or tamper, is dropped using a crane specially designed for that purpose. As the trench contents densify, backfill soil is added to the resulting depressions. The backfill soil is then compacted so that a stable cap can be constructed over the compacted trenches.

The natural subsidence technology is common to Alternatives 5 and 8. Natural subsidence is the natural densification and consolidation of soils and waste materials in the trenches over time. As the waste mass densifies by natural processes, causing subsidence, the overall rate of subsidence would decrease and the waste mass would become more stable. As natural subsidence continues, depressions would form in the overlying cap and these depressed areas would require backfilling with soil to prevent the ponding of rainwater and subsequent infiltration of rainwater into the trenches. Because of the many physical and chemical variables involved and the limited quantitative information available, it is not possible to predict accurately how long it would take for waste trenches to naturally subside at the MFDS.

Alternative 11 employs the grouting technology as a means of trench stabilization. The grouting technology would consist of injecting grout, a mixture of materials (e.g., cement, bentonite, fly ash, etc.) and water, through specially inserted probes into the majority of trenches to fill voids and other openings in the waste. Grouting would stabilize the trenches by reducing the subsidence that might otherwise occur as the trench contents settle into the voids. Stabilization could be only partially achieved by this technology because, although it might retard deterioration significantly, grouting would not likely prevent the continuing deterioration and collapse of the waste.

7.2.2 - Flow Barriers

Each action-based alternative that is described in the following sections utilizes barriers to prevent (1) vertical infiltration of precipitation to the trench waste, and (2) horizontal infiltration of ground water through subsurface strata to the trench waste.

7.2.2.1 Vertical Infiltration Barriers

The following four types of vertical infiltration barriers are included among the action-based alternatives evaluated: Structural Cap, Initial Cap, Engineered Soil Cap With Synthetic Liner, and Engineered Soil Cap (with all natural materials).

Alternative 4 employs a structural cap for minimizing vertical infiltration. The structural cap would consist of a two-foot-thick reinforced concrete slab over the trenches with a two-foot-thick clay layer elsewhere. The concrete/clay layer would be topped by a drainage layer and a topsoil layer to support a vegetative cover. The topsoil and drainage layers would protect the concrete/clay layer against weathering. They would also control excessive runoff rates which would minimize damaging erosive forces. Prior to placement of an initial layer of compacted soil over the existing trench cover, the trenches would be dynamically compacted to provide a stable support for the structural cap. A structural cap would then be placed over both the compacted trenches and the initial layer of compacted soil.

Alternative 5 employs an initial cap to serve as a barrier to vertical water infiltration while the natural stabilization process takes place, after which a final, multi-media cap would be installed. The initial cap would consist of a compacted soil layer covered with an approximate 30-40 mil thick synthetic cover[6]. The clay and synthetic material cover would cover an approximate 40 to 50 acre area. The intent of this approximate two-foot thick cap is to allow subsidence to occur naturally, while adding backfill material as necessary to maintain proper grading for drainage and repairing the synthetic cover as required. The final cap would be the engineered soil cap with synthetic liner described below.

Alternatives 8, 10, and 11 employ an engineered soil cap with synthetic liner as a barrier to vertical water infiltration. Alternative 5 also employs an engineered soil cap with synthetic liner, to be installed upon completion of the natural stabilization process. This type of vertical infiltration barrier consists (from bottom to top) of an initial layer of compacted soil placed over the existing trench cover, a two-foot-thick clay layer, an 80 mil (or sufficiently similar) synthetic liner, a geotextile fabric layer, a one-foot-thick drainage layer, a geotextile fabric layer, and a two-foot-thick soil layer supporting a vegetative cover. The composition of

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6 - The Commonwealth has proposed use of an initial cap consisting of: compacted soil cover over the trench disposal area, topped with a 25-year life, 60 to 80 mil thick, synthetic liner with a drainage layer/filter fabric on top, followed by a layer of topsoil to support a vegetative cover. As discussed in Section 10.1, the selected remedy includes an initial cap that does not employ a drainage/vegetative cover. However, an alternate design, such as the one proposed by the Commonwealth, may be used if the selected remedy's initial cap can not effectively control anticipated rates of surface water runoff and consequent erosion.

this cap would be designed to provide the most suitable soil properties and conditions to support and maintain a healthy vegetative cover (e.g., provide adequate moisture during prolonged rainless periods). Table 34 provides a description of the contribution of each layer contained in this type of vertical infiltration barrier.

Alternative 17 employs an engineered soil cap consisting of all natural materials as a barrier to vertical water infiltration. This type of barrier consists of several layers of natural materials designed and arranged to promote drainage, minimize infiltration, and provide protection from erosion. The layers (in order of placement from bottom to top) are: a four-foot-thick infiltration barrier consisting entirely of clay or a combination of clay and soil-bentonite (or equivalent) layers with a permeability of 1×10^{-7} cm/sec or less to provide a barrier against infiltration of precipitation; a four-foot-thick drainage layer consisting of a mixture of sand, crushed rock and gravel of high permeability to drain water off the cap into drainage ditches and away from the disposal trenches; and, a three-foot-thick soil layer with an eight-inch topsoil layer which would support a vegetative cover and allow infiltration of water (to be carried off through the underlying drainage layer), thus minimizing surface runoff and consequential erosion problems.

7.2.2.2 Horizontal Flow Barriers

Two types of potential horizontal flow barriers are included among the action-based alternatives evaluated: (1) a lateral drain and cutoff wall combination that encircles the entire trench area and (2) a cutoff wall that extends from the east slope to the west slope of the site, beneath the cap and along its north perimeter (north cutoff wall). Alternatives 4 and 17 employ the lateral drain/cutoff wall combination; Alternatives 5, 8, 10, and 11 employ the north cutoff wall flow barrier.

The lateral drain/cutoff wall would block exfiltration of any remaining leachate in the unlikely event that, without a hydrostatic head, the leachate could flow through tight fissures in the rock formations beneath the trenches. Specifically, the barrier would intercept leachate flow originating from shallow trenches and block or contain any leachate originating from deeper trenches. The lateral drain component of this horizontal flow barrier would involve excavation of a trench around the perimeter of the desired trench group and installation of a perforated pipe at the bottom of the trench to collect any liquids flowing into the drain. Crushed rock or gravel would surround the perforated pipe to allow flow into the pipe without clogging from soil particles. Sumps would be placed at specified intervals to collect leachate in the pipe; the leachate would then be solidified and disposed on-site. The lateral drain would be limited to the more shallow trenches in the western and central trench series due to practical equipment limitations.

The cutoff wall component of the lateral drain/cutoff wall barrier would consist of two sections: an upper section cut into the surface soil strata and a lower, much deeper section extending into the rock strata down to the desired depth. The upper section of the cutoff wall would consist of either a compacted clay key trench or a slurry wall with a permeability of 1×10^{-7} cm/sec or less. The upper section would block ground water flow at the interface of the soil cover and the Lower Marker Bed. The lower section of the cutoff wall would consist of a grout curtain utilizing a cementitious grout or a cement/bentonite grout. The lower portion, or grout curtain, would form a barrier against ground water flow into the trenches and/or outflow of leachate from the trenches. The cutoff wall design would include a series of collection wells near the inside of the wall to facilitate the removal of water mounding against the barrier. Water collected from these wells would be solidified for disposal in new trenches.

The second horizontal flow barrier evaluated consists of a cutoff wall without the lateral drain component[7]. The cutoff wall in this barrier is somewhat different than the previously described cutoff wall. This cutoff wall, sometimes referred to as a north cutoff wall, would be a slurry trench (identical to the upper section of the cutoff wall described above, except that a gravel drain would be installed near the bottom along its exterior side) without the grout curtain (lower section of the cutoff wall described above). The gravel drain along the exterior side of the wall (exterior to the trench disposal area)

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7 - The Commonwealth has proposed the installation of a horizontal flow barrier that would extend down to the Henley Bed if site monitoring data indicates that lateral recharge of the trenches is occurring. The selected remedy does not specify the type, exact location or extent of the horizontal flow barrier, if one is needed. The Commonwealth's proposal will be considered during evaluation of the necessity of a horizontal flow barrier.

would shunt ground water toward the hillslopes and prevent its seepage under the wall. By preventing water from entering the trenches, no new leachate would be generated in the trenches. The wall would be designed for a permeability of 1×10^{-7} cm/sec or less.

7.2.3 - Baseline Features

Each alternative also includes baseline features - features that are common to all alternatives, with the exception of the No Action alternative. The baseline features are as follows:

- Non-functional and unstable site structures would be decommissioned, demolished and buried on-site.
- Additional trenches would be constructed for disposal of solidified trench leachate and/or waste generated during site remediation.
- A buffer zone, contiguous to the existing site licensed property boundary, would be acquired. The buffer zone would encompass an approximate 200-acre area, at a minimum, and would: (1) ensure long-term access for the purpose of monitoring to assess remedy compliance; and, (2) control activities on the hillslopes adjacent to the MFDS to minimize hillslope erosion.
- Institutional controls would be established and maintained in perpetuity to prevent unauthorized and/or inappropriate use of the site.
- Monitoring and maintenance activities would be conducted routinely, and in perpetuity, to assess remedy performance and to preserve the integrity of the remedy, respectively.
- A remedy review would be performed by EPA at least every five years to ensure the remedy continues to meet the remedial action objectives, including compliance with state and federal ARARs and protection of human health and the environment.

The remedial alternatives receiving detailed analysis in the Feasibility Study are summarized in the following sections; estimated costs and design/construction times are summarized in Table 29, following the Description of Alternatives.

7.2.4 - ALTERNATIVE 1 - NO ACTION

Estimated Construction Cost:	$ 636,000
Estimated O & M Cost:	$ 6,167,000
Estimated Present-Worth Total Cost:	$ 6,803,000
Estimated Implementation Time:	6 months

Alternative 1 consists of the following activities:

- Site Monitoring
- Installation of Additional Monitoring Wells
- Repair, Maintenance and Replacement of Monitoring Equipment

Monitoring activities would consist of the installation of additional monitoring wells, sample collection and analyses on a frequent basis, and repair, maintenance and replacement of monitoring equipment as needed. The estimated cost of 6.8 million dollars for an alternative involving only monitoring activities arises from the need to monitor this site in perpetuity. The No Action alternative is not an engineered remedial alternative, and it would not satisfy the remedial objectives. The No Action alternative does not comply with ARARs and would, likewise, not provide overall protection of human health and the environment.

7.2.5 - ALTERNATIVE 4 - STRUCTURAL CAP/DYNAMIC COMPACTION/ HORIZONTAL FLOW BARRIER

Estimated Construction Cost:	$ 59,332,000
Estimated O & M Cost:	$ 6,175,000
Estimated Present-Worth Total Cost:	$ 65,507,000
Estimated Implementation Time:	38 months

Alternative 4 includes the following remedial activities:

- Trench Leachate Removal
- Solidification Of Leachate And Disposal In New Trenches
- Installation Of Horizontal Flow Barrier (Lateral Drain/ Cutoff Wall), If Necessary
- Dynamic Compaction Of Existing Disposal Trenches Concurrent With Addition Of Compacted Soil And Sand Backfill
- Installation Of A Two-Foot-Thick Reinforced Concrete (Structural) Cap Over The Compacted Trenches And A Two-Foot-Thick Low-Permeability Clay Cap Over The Rest Of The Trench Disposal Area.

- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

This alternative combines the technologies of trench leachate removal, dynamic compaction and structural capping. Leachate would be extracted, solidified, and disposed in newly-constructed trenches on-site. After leachate removal and dynamic compaction of the disposal trenches, a reinforced concrete structural slab and several feet of soil cover would be placed over the disposal trenches. The use of dynamic compaction on the trench area prior to placement of the structural cap would provide a stable foundation for the cap and minimize future subsidence. The reinforced concrete cap would not be capable of spanning the wide trenches without the support provided by stabilization.

The lateral drain/cutoff wall, if found to be necessary, would help reduce the off-site migration of contaminants and prevent the infiltration of subsurface water.

7.2.6 - ALTERNATIVE 5 - NATURAL SUBSIDENCE/INITIAL CAP AND FINAL ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER - "NATURAL STABILIZATION"

Estimated Construction Cost:	$ 23,910,000
Estimated O & M Cost:	$ 9,643,000
Estimated Present-Worth Total Cost:	$ 33,553,000

Estimated Implementation Time: 22 Months For Initial Closure Period;

35 - 100 Years For Interim Maintenance Period Following Initial Closure Period;

10 Months For Final Closure Period Following Interim Maintenance Period

The implementation of this alternative would involve the following activities:

- Trench Leachate Removal
- Solidification Of Leachate And Disposal Into New Trenches
- Installation of An Initial Cap And Periodic Replacement Of Synthetic Liner
- Installation of Horizontal Flow Barrier (North Cutoff Wall), If Necessary

- Natural Subsidence With Active Maintenance And Monitoring
- Installation Of A Final Engineered Soil Cap with Synthetic Liner
- Initial and Final Cap Grading And Contouring To Control Surface Water Flow And Erosion
- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

The "Natural Stabilization" alternative[8] combines elements of containment, leachate removal, and treatment. Following leachate extraction, solidification and disposal, an initial cap would be installed over the trench disposal area to prevent infiltration of precipitation into the trenches. The distinguishing feature of this alternative is the use of an initial cap during the period of natural subsidence, estimated to take approximately 35 to 100 years (the Interim Maintenance Period). This cap would be designed to prevent the infiltration of rainfall and surface water into the disposal trenches while subsidence and maintenance are taking place. Cap grading and contouring would be performed to enhance the control of surface water flow, better distribute the flow of surface water, and control and minimize, to the extent practicable, erosion of hillslopes. Improvements to drainage channels would be performed to enhance distribution of surface water runoff and to minimize erosion. Cap repairs and backfilling of subsided areas would be performed during the Interim Maintenance Period.

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8 - The term "closure", in the "Initial Closure Period" and "Final Closure Period" components of the Natural Stabilization Alternative, is used in a generic sense to denote sets of remedial activities to be implemented during those limited time periods. Neither the term closure nor the designations "Initial Closure Period" and "Final Closure Period" are used in any specific regulatory sense (i.e., AEC or RCRA closure).

The type of initial cap utilized would be contingent upon its ability to control surface water runon and runoff. Accelerated rates of hillslope and/or drainage channel erosion would necessitate a modification to the proposed initial cap design.

A final, multilayer cap with synthetic liner would be installed at the completion of natural subsidence, at which time the trenches would form a stable foundation for the final cap.

Additionally, a north cutoff wall would be constructed, if determined to be necessary, to prevent lateral ground water infiltration into the disposal trenches. Other types of horizontal flow barriers, such as a lateral drain/cutoff wall, could also be considered.

Maintenance requirements for this alternative would be significant during the interim maintenance period. Once the trenches have sufficiently stabilized, the final cap would be installed and maintenance requirements would be minimal. The timing of final cap construction would be based upon specific subsidence criteria developed in the remedial design.

7.2.7 - ALTERNATIVE 8 - NATURAL SUBSIDENCE/ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER

Estimated Construction Cost:	$ 34,302,000
Estimated O & M Cost:	$ 13,105,000
Estimated Present Worth Total Cost:	$ 47,407,000
Estimated Implementation Time:	23 months

Alternative 8 includes the following remedial activities:

- Leachate Removal
- Solidification Of Leachate And Disposal In New Trenches
- Installation Of A Horizontal Flow Barrier (North Cutoff Wall), If Necessary
- Installation Of An Engineered Soil Cap With Synthetic Liner
- Cap Grading And Contouring To Control Surface Water Flow And Erosion
- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

Following leachate extraction, solidification and disposal, an engineered soil cap with synthetic liner would be placed over the trench disposal area to prevent infiltration of precipitation into the trenches. The cap utilized in this alternative is identical to the final cap described in Alternative 5. Alternative 8 is identical to Alternative 5 except for the time of placement of the final cap. Alternative 8 places the final cap over the trench disposal area immediately, rather than waiting for subsidence to run its course during the estimated 35 to 100 year subsidence period as in Alternative 5. Trench stabilization would be accomplished by natural subsidence as in Alternative 5 with repairs to the final cap being made over the period of subsidence.

The required maintenance activities for this alternative would be high since trench subsidence and resulting repair of the complex final cap would be significant. Surface water control would be addressed through cap grading and contouring and drainage channel improvements. The north cutoff wall would provide a barrier against infiltration of ground water into the trench area.

7.2.8 - ALTERNATIVE 10 - DYNAMIC COMPACTION/ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER

Estimated Construction Cost:	$ 39,538,000
Estimated O & M Cost:	$ 4,790,000
Estimated Present-Worth Total Cost:	$ 44,328,000
Estimated Implementation Time:	35 months

Alternative 10 includes the following remedial activities:

- Leachate Removal
- Solidification Of Leachate And Disposal Into New Trenches
- Installation Of A Horizontal Flow Barrier (North Cutoff Wall), If Necessary
- Dynamic Compaction Of Existing Trenches With Concurrent Addition Of Compacted Soil And Sand Backfill
- Installation Of An Engineered Soil Cap With Synthetic Liner
- Cap Grading And Contouring To Control Surface Water Flow And Erosion
- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

With Alternative 10, the dynamic compaction technology would be employed to stabilize the trench wastes artificially rather than relying on natural subsidence. Prior to dynamic compaction of the trenches, leachate would be extracted, solidified and disposed on-site in new disposal trenches.

Upon compaction of the trenches, an engineered soil cap with synthetic liner would be placed over the trench disposal area to minimize vertical infiltration of water into the disposal trenches. The cap would be graded and contoured to control the rate of surface water flow and minimize erosion to the extent practicable.

A north cutoff wall (or other sufficient horizontal flow barrier) would be installed, if determined to be necessary, to control the infiltration of ground water into the disposal trenches.

7.2.9 - ALTERNATIVE 11 - TRENCH GROUTING/ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER

Estimated Construction Cost:	$ 61,870,000
Estimated O & M Cost:	$ 6,989,000
Estimated Present-Worth Total Cost:	$ 68,859,000
Estimated Implementation Time:	46 months

Alternative 11 includes the following remedial activities:

- Trench Leachate Removal
- Installation Of A Horizontal Flow Barrier (North Cutoff Wall), If Necessary
- Grouting Of Accessible Voids In The Existing Disposal Trenches With Grout Made From Potable Water And/Or Leachate
- Installation Of An Engineered Soil Cap With Synthetic Liner.
- Cap Grading And Contouring To Control Surface Water Flow And Erosion
- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

Alternative 11 would achieve trench stabilization by injecting grout through lances or probes into the majority of trenches for the purpose of filling voids and other openings in the trenches. Trench leachate would be extracted and would then be used in the grout mix for injection into the trenches. Once injected with grout, the trenches would provide a stable foundation for a trench cover. An engineered soil cap with synthetic liner would be placed over the trench disposal area to prevent infiltration of precipitation into the trenches. The cap would be graded and contoured to enhance control of surface water runon and runoff and improvements to drainage channels would be performed to enhance distribution of surface water runoff and to minimize erosion.

A north cutoff wall (or other sufficient horizontal flow barrier) would be installed, if necessary, to prevent the infiltration of ground water into the disposal trenches

7.2.10 - ALTERNATIVE 17 - DYNAMIC COMPACTION/ENGINEERED SOIL CAP/ HORIZONTAL FLOW BARRIER

Estimated Construction Cost:	$ 51,920,000
Estimated O & M Cost:	$ 4,634,000
Estimated Present-Worth Total Cost:	$ 56,554,000
Estimated Implementation Time:	38 months

Alternative 17 includes the following remedial activities:

- Leachate Removal
- Solidification Of Leachate With Disposal Into New Trenches
- Installation Of A Horizontal Flow Barrier (Lateral Drain/ Cutoff Wall), If Necessary
- Dynamic Compaction Of Existing Disposal Trenches Concurrent With The Addition Of Compacted Soil And Sand Backfill
- Installation Of An Engineered Soil Cap (With All Natural Materials)
- Cap Grading And Contouring To Control Surface Water Flow And Erosion
- Drainage Channel Improvements And Other Necessary Surface Water Control Features
- Baseline Features

Alternative 17 combines the remedial technologies of capping and dynamic compaction to stabilize the trenches. Prior to dynamic compaction of the trenches, leachate would be extracted, solidified and disposed on-site in new disposal trenches. The differences between this alternative and Alternative 10 are the types of horizontal flow barrier and cap employed. This alternative would involve installation of a lateral drain/cutoff wall rather than the north cutoff wall used in Alternative 10 and the engineered soil cap would be made of all natural materials and would not contain a synthetic liner as in Alternative 10.

The cap would be installed over the trench disposal area to minimize infiltration into the trenches. The cap would be graded and contoured to enhance control of surface water runon and runoff and improvements to drainage channels would be performed to enhance distribution of surface water runoff and to minimize erosion.

Table 28 lists the alternatives that underwent a detailed analysis for the MFDS.

TABLE 28

SUMMARY OF ALTERNATIVES
THAT UNDERWENT A DETAILED ANALYSIS

ALTERNATIVE 1	NO ACTION
ALTERNATIVE 4	STRUCTURAL CAP/DYNAMIC COMPACTION/ HORIZONTAL FLOW BARRIER
ALTERNATIVE 5	NATURAL SUBSIDENCE/INITIAL CAP AND FINAL ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER - "NATURAL STABILIZATION"
ALTERNATIVE 8	NATURAL SUBSIDENCE/IMMEDIATE ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER
ALTERNATIVE 10	DYNAMIC COMPACTION/ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER
ALTERNATIVE 11	TRENCH GROUTING/ENGINEERED SOIL CAP WITH SYNTHETIC LINER/HORIZONTAL FLOW BARRIER
ALTERNATIVE 17	DYNAMIC COMPACTION/ENGINEERED SOIL CAP/ HORIZONTAL FLOW BARRIER

TABLE 29

COST/SCHEDULE SUMMARY FOR
REMEDIAL ALTERNATIVES

Alternative	Cost[1]	Implementation Time[2]
1	$ 6,803,000	6 Months
4	65,507,000	38 Months
5	33,553,000	22 Months[a] 35 - 100 Years[b] 10 Months[c]
8	47,407,000	23 Months
10	44,328,000	35 Months
11	68,859,000	46 Months
17	56,554,000	38 Months

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1 - Cost estimates for the alternatives are present worth costs which include capital costs and operation and maintenance costs. All alternatives assume a 4% discount rate for the purpose of alternative comparison. The actual discount rate used to establish the remedy trust fund may differ from the 4% discount rate used here.

2 - Includes design and construction time.

a - The Initial Closure Period would be completed in 22 months.
b - The Interim Maintenance Period would commence upon completion of the Initial Closure Period and would take approximately 35 to 100 years for completion.
c - A 10 month Final Closure Period would follow the Interim Maintenance Period.

SECTION 8.0 - APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

CERCLA Section 121(d)(2) requires that the selected remedy comply with all federal and state environmental laws that are applicable or relevant and appropriate to the hazardous substances, pollutants, or contaminants at the site or to the activities to be performed at the site. Therefore, to be selected as the remedy, an alternative must meet all ARARs or a waiver must be obtained. Tables 30 and 31 summarize the action-specific and contaminant-specific applicable or relevant and appropriate requirements (ARARs) identified for the MFDS. A discussion of how each ARAR applies to the MFDS is also provided below.

8.1 Action-Specific ARARs

An action-specific ARAR is a performance, design, or other similar action-specific requirement that impacts particular remedial activities. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. These requirements do not in themselves determine the remedial alternative; rather, they indicate how a selected alternative must be achieved. The following are action-specific requirements for the Maxey Flats Disposal Site remedy:

- Occupational Safety and Health (OSHA) Standards (29 CFR Sections 1910.120, .1000 - .1500, Parts 1926.53, .650 - .653)

The OSHA hazardous substance safety standards, 29 CFR 1910.120, .1000 - .1500, are applicable, action-specific requirements for remedial activities at the MFDS. The OSHA standards (1910.120) for hazardous substance response actions under CERCLA establish safety and health program requirements that must be implemented in the cleanup phase of a CERCLA response. Under the regulations, a health and safety program will be required for employees and contractors working at the MFDS. The standards found in 1910.1000 - .1500 govern CERCLA response actions involving any type of hazardous substance that may result in adverse effects on employees' health and safety. These standards also incorporate all of the requirements of 29 CFR Part 1926, the OSHA health and safety standards for construction. The provisions of 29 CFR 1926.650 - .653 are applicable to any excavation, trenching, and shoring that is undertaken as part of the construction of trenches, cut-off walls, etc.

TABLE 30

SUMMARY OF ACTION-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Applicable	Relevant and Appropriate
Occupational Safety and Health (OSHA) Standards (29 CFR Parts 1910 and 1926, both in part)	Occupational Safety and Health (OSHA) Standards (29 CFR 1926, in part)
National Emission Standards for Hazardous Air Pollutants (40 CFR Part 61, Subpart I)	Federal Standards for Protection Against Radiation (Allowable Doses in Restricted Areas) (10 CFR Part 20)
Kentucky Standards for Protection Against Radiation (Allowable Doses In Restricted Areas) (902 KAR 100:020)	Federal Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61)
Kentucky Standards for the Disposal of Radioactive Material (902 KAR 100:021)	Kentucky Licensing Requirements for Land Disposal of Radioactive Waste (902 KAR 100:022)
General Kentucky Requirements Concerning Radiological Sources (ALARA) (902 KAR 100:015)	Kentucky Soil and Water Conservation Requirements (KRS 262)
Kentucky Hazardous Waste Management Regulations (401 KAR Chapter 34, In Part)	Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Standards (40 CFR Part 264, In Part)
Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Standards (40 CFR Part 268)	
Kentucky Fugitive Air Emissions Standards (401 KAR 63:010)	

TABLE 31

SUMMARY OF CONTAMINANT-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Applicable	Relevant and Appropriate
Kentucky Standards for Protection Against Radiation (Allowable Doses in Unrestricted Areas) (902 KAR 100:020, Table II of 902 KAR 100:025)	Federal Standards for Protection Against Radiation (Allowable Doses in Unrestricted Areas) (10 CFR Part 20.105, .106 and Appendix B, Table II)
Kentucky Surface Water Quality Standards (401 KAR 5:026 - :035)	Ambient Water Quality Criteria (Section 304(a)(1) of the Clean Water Act)
Kentucky Hazardous Waste Management Regulations (401 KAR 34:060, Section 5)	Kentucky Drinking Water Standards-Maximum Contaminant Levels (401 KAR 6:015)
	Federal Drinking Water Regulations - Maximum Contaminant Levels and Maximum Contaminant Level Goals (40 CFR Parts 141, 142 and 143)
	National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR Part 61.92)
	Kentucky Licensing Requirements for Land Disposal of Radioactive Waste (902 KAR 100:022)
	Federal Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61.41)
	Federal Standards for Uranium and Thorium Mill Tailings (40 CFR Part 192)

The OSHA standards found in 29 CFR 1926.53 are relevant and appropriate requirements for construction and related activities involving the "use" of ionizing radiation. While the actions to be pursued at the MFDS do not, necessarily, involve the"use" of sources of ionizing radiation or radicactive materials, these standards do pertain to the substances involved at the site and to the activities of the workers in undertaking any part of the remedial action in the restricted area.

- National Emission Standards for Hazardous Air Pollutants (NESHAPS) (40 CFR Part 61, Subpart I)

The NESHAPS standards found in 40 CFR Part 61, Subpart I, are applicable to those portions of remedial action that would result in fugitive emission of radionuclides into an unrestricted area. Compliance with this applicable requirement is determined by calculating the dose to members of the public at the point of maximum annual air concentration in unrestricted areas, using EPA-approved sampling procedures and computer codes. The air emission standard for NRC licensees, which includes the MFDS, is set at 25 mrem per year to the whole body and 75 mrem per year to the critical organ of any member of the public[9].

- Kentucky Standards for Protection Against Radiation (Allowable Doses in Restricted Areas) (902 KAR 100:020)

The Kentucky regulations found in 902 KAR 100:020 are applicable requirements for any employee performing work and for any other individual occupying the restricted area during remediation of the MFDS. These regulations include: limits to total occupational dose received, limits to airborne exposure in restricted areas, required surveys to establish compliance, and the use of appropriate signs, labels, signals and controls to minimize exposure to radiation.

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9 - A revision to this Subpart, changing the emission standard to 10 mrem/year effective dose equivalent, has been promulgated but the effective date has been stayed.

- Federal Standards for Protection Against Radiation (Allowable Doses in Restricted Areas) (10 CFR Part 20)

The requirements found in 10 CFR 20.101 - .103, .210(b)(1), .202, .203(a) - (c)(5), (d), and Appendix B, Table I are relevant and appropriate for the MFDS. Because Kentucky is an Agreement State, its radiation protection standards for protecting against radiation in restricted areas (902 KAR 100:020 above), as opposed to the federal standards, are the applicable standards.

- General Kentucky Requirements Concerning Radiological Sources (ALARA) (902 KAR 100:015)

The requirement found in 902 KAR 100:015, Sections 1 and 2, which requires that all persons "who receive, possess, use, transfer, own, or acquire" any radioactive sources must make every reasonable effort to maintain radiation exposures and releases in unrestricted areas to "as low as reasonably achievable" (ALARA), is applicable to the MFDS.

- Kentucky Fugitive Air Emissions Standards (401 KAR 63:010)

The fugitive air emissions standards found in 401 KAR 63:010 are applicable to the MFDS remedial activities because they apply to potential operations such as cap installation, excavation of disposal trenches, demolition activities, and other activities that may emit dust and other air contaminants. The standards require individuals to take reasonable precautions to prevent particulate matter from becoming airborne when material is handled or processed, a building is constructed, altered, or demolished, or a road is used. Visible fugitive dust emissions must be contained within the lot line of the property on which the emissions originate.

- Kentucky Standards for the Disposal of Radioactive Material (902 KAR 100:021)

The radioactive waste classification system and the radioactive waste characteristics requirements, found in Sections 7 and 8 of 902 KAR 100:021, are applicable requirements for the waste disposed of during the remediation of the MFDS. Section 7 provides the criteria for classifying waste for near-surface disposal. Section 8 contains minimum waste handling requirements for waste disposed of in new trenches, packaging requirements, permissible waste characteristics, and stability requirements of waste generated during remediation of the MFDS.

- Kentucky Licensing Requirements for Land Disposal of Radioactive Waste (902 KAR 100:022)

Sections 14, 19, 21, 23, 24(1) - (11), 25(3) and 27(2) of 902 KAR 100:022 are relevant and appropriate requirements for the disposal of waste generated during remediation in new units at the MFDS. The Kentucky Licensing Requirements for Land Disposal of Radioactive Waste specify that closure shall be designed to achieve long-term stability and isolation of the radioactive waste, to protect against inadvertent intrusion, and to eliminate, to the extent practicable, the need for on-going, active maintenance of the disposal site so that only surveillance, monitoring, and minor custodial care is required. The regulations further provide for post-closure surveillance of the site, which includes a monitoring system that provides early warning of releases of radionuclides before they reach the site boundary, and institutional control requirements.

- Federal Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61)

The requirements found in 10 CFR Part 61.29, .42, .44, .51(a), .52(a)(1) - (11), .53(d), .55 and .56 are relevant and appropriate for new disposal units at the MFDS. Section 61.41 will be treated as relevant and appropriate provided the new trenches are located in a manner that allows compliance with the standard to be measured at the boundary of the Restricted Area without interference from radionuclides migrating from existing trenches. Sections 61.42, .44, .51(a), .52(a)(6), .53(d), and .59(b) are relevant and appropriate with respect to the caps, monitoring system and institutional controls at the MFDS.

- Kentucky Soil and Water Conservation Requirements (Chapter 262 of Kentucky Revised Statutes)

Chapter 262 of the Kentucky Revised Statutes, which provides for the establishment of soil and water conservation requirements to prevent and control soil erosion, are relevant and appropriate requirements for the MFDS. Remedial activities could create changes in soil conditions and surface water flow. Thus, the generally applicable requirements for the technologies/actions that could lead to large-scale soil disturbance are relevant and appropriate.

- Kentucky Hazardous Waste Management Regulations (401 KAR Chapter 34)

Federal regulations under the Resource Conservation and Recovery Act (RCRA) establish minimum national standards defining the acceptable management of hazardous waste. States can be authorized by EPA to administer and enforce RCRA hazardous waste management programs in lieu of the Federal program if the States have equivalent statutory and regulatory authority. If the CERCLA site is located in a State with an authorized RCRA program, the State's promulgated RCRA requirements will replace the equivalent Federal requirements as potentially ARAR. If the State is authorized for only a portion of the RCRA program, both Federal and State standards may be ARARs.

Since EPA has delegated the Resource Conservation and Recovery Act (RCRA) program to Kentucky, the Kentucky hazardous waste management regulations are applicable, except for requirements such as those promulgated under the Hazardous and Solid Waste Amendments of 1984 (HSWA), which have not yet been delegated to Kentucky.

Radioactive Shipment Records for the MFDS indicate the disposal of Liquid Scintillation Vials (LSVs) at the site. LSVs, during the 1963 to 1977 site disposal period, typically contained a xylene or toluene solvent base. The fluids from LSVs containing xylene and toluene are considered RCRA spent solvent, listed hazardous waste. Sample analyses detected the presence of low levels of toluene and xylene in trench leachate during the MFDS Remedial Investigation. Consequently, the leachate at the MFDS is considered to be a listed hazardous waste.

Although disposal of the LSVs at the MFDS originally occurred prior to the effective date of RCRA Subtitle C regulations (November 19, 1980), the selected remedy for the MFDS will constitute disposal of a hazardous waste via the extraction, solidification and disposal of approximately three million gallons of trench leachate on-site. Thus, the RCRA requirements, or their Kentucky counterparts, are applicable to the MFDS.

The following Kentucky Hazardous Waste Management regulations are ARARs that must be met by the selected remedy:

- 401 KAR 34:060 - Ground Water Protection: Sections 8 and 9 set forth general ground water monitoring requirements and detection monitoring program requirements. Sections 10 and 11 set forth standards for the compliance monitoring program and corrective action programs which establish how the data gathered will be evaluated and what actions must be taken to eliminate contamination of ground water. Should ground water monitoring in the alluvium indicate Maximum Concentration Limits (MCLs/MCLGs) have been exceeded, the selected remedy must implement corrective action to comply with the MCLs/MCLGs.

- 401 KAR 34:070 (Sections 2, 5, 7, 8 and 10) - Closure and Post-Closure: Section 2 sets out closure performance standards which, among other requirements, are intended to minimize the need for further maintenance and control, minimize or eliminate to the extent necessary post-closure escape of hazardous constituents to ground or surface water or through the atmosphere, to protect human health and the environment.

Section 5 provides for the disposal or decontamination of equipment, structures, and soils. Section 7 requires a survey plat to be submitted to the local zoning authority and the Commonwealth. Section 8 provides for post-closure care and use of property. Section 10 requires a notation on the deed to the property noting the previous management of hazardous wastes thereon and the land use restrictions resulting from that use.

- 401 KAR 34:190 - Tanks: 401 KAR 34:190 regulates tank systems that are used for treatment and storage of hazardous waste.

- 401 KAR 34:230 Landfill Closure Standards: Section 6 provides standards for covers (caps) for sites where waste is left in place. These standards will apply to the design of the final cap at the MFDS.

- <u>Resource Conservation and Recovery Act (RCRA) Hazardous Waste Management Standards (40 CFR Part 268)</u>

Although EPA has delegated the RCRA program to Kentucky, those federal hazardous waste management regulations promulgated under HSWA, which have not been delegated to Kentucky, are also applicable to the MFDS. Specifically, 40 CFR Part 268, which sets out Land Disposal Restrictions (LDRs), is applicable to the MFDS. The LDRs require hazardous wastes to be treated to specified levels prior to land disposal. The LDRs are waived for remedial action at the MFDS; see Section 8.3 - ARARs Waiver of this Record of Decision.

The requirements of 40 CFR 264, related to minimum technology trench design requirements, are neither applicable nor relevant and appropriate to the remedial actions at the MFDS for those disposal trenches constructed within the Area of Contamination[10] (AOC) for the MFDS. The RCRA minimum technology requirements are not applicable because disposal of solidified trench leachate will not occur in a new RCRA unit, a lateral expansion of an existing unit, or a replacement unit. The selected remedy presumes that sufficient space is currently available within the AOC for the desired number of new disposal trenches to be constructed. However, if spacial limitations necessitate construction of new disposal trenches <u>outside</u> the Area of Contamination, minimum technology trench design requirements would be applicable requirements. For the MFDS, the AOC is best described as the entire area of the Restricted Area, an approximate 400 foot wide area parallel to the entire western boundary of the Restricted Area, an area 400 feet by 400 feet at the northwest corner of the Restricted Area, and an approximate 700 feet wide area parallel to the entire east boundary of the Restricted Area. The AOC, as illustrated in Figure 15, is subject to redefinition should new information become available, through additional site sampling, which indicates the presence of additional areas of contamination contiguous to the current AOC.

While minimum technology trench design requirements might be considered relevant to the disposal of hazardous waste at the MFDS, EPA does not consider them appropriate for the MFDS based upon such factors as the very low concentrations of chemical constituents relative to the threat posed by the radioactivity at the MFDS; the potentially significant increased infiltration into the trenches as a result of the much greater surface area that minimum technology trenches would require at the MFDS due primarily to the restrictive site geology; and, EPA's assessment that no appreciable additional level of protection to public health or the environment will be gained by imposing these requirements at the MFDS.

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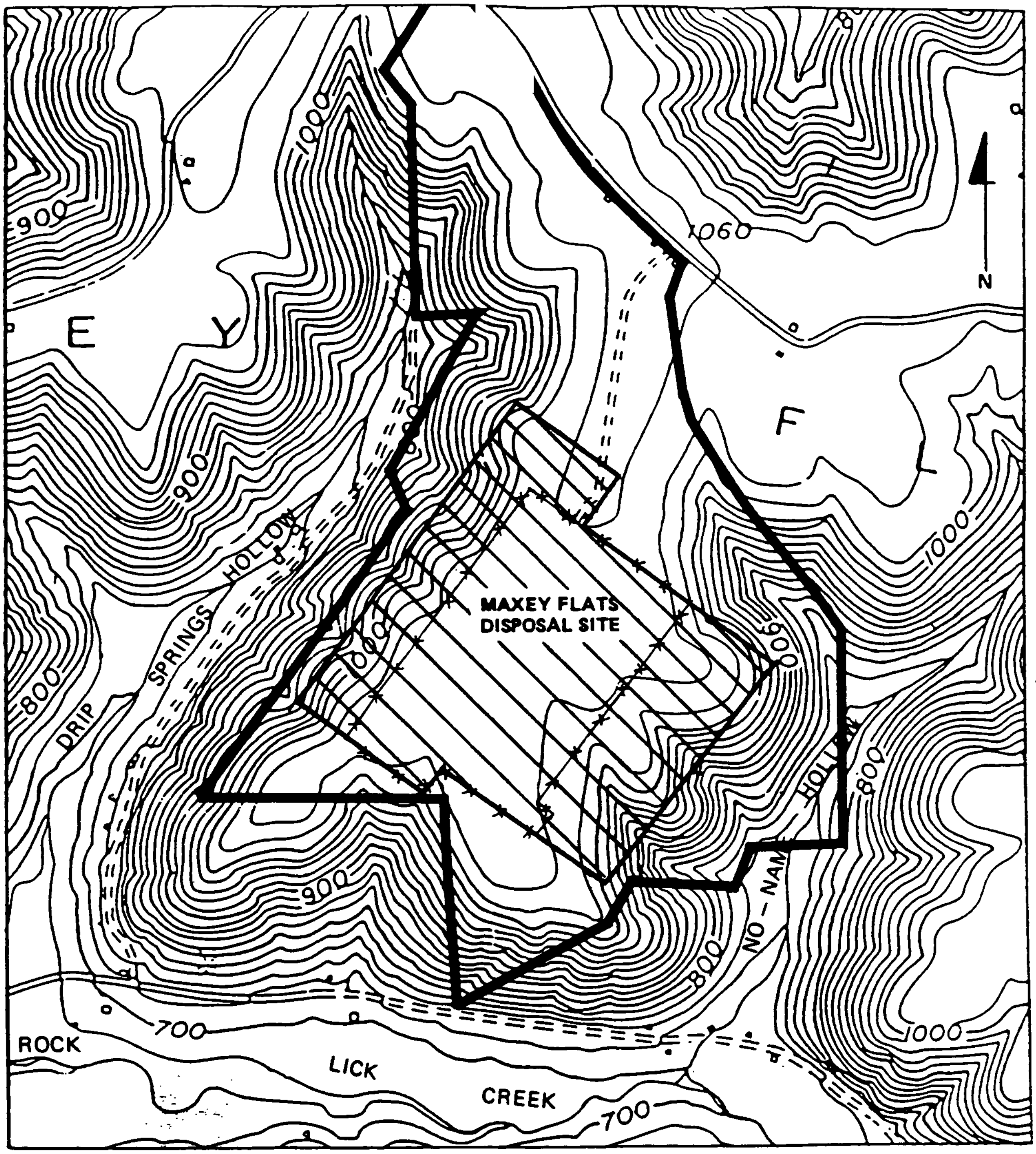
10 - An Area of Contamination (AOC) is delineated by the areal extent (or boundary) of contiguous contamination. Such contamination must be contiguous, but may contain varying types and concentrations of hazardous substances. An example of an Area of Contamination includes a landfill and the surrounding contaminated soil.



EXPLANATION

-x-x-x-x- *FENCE ENCLOSING BURIAL AREA*

▬▬▬ *MFDS PROPERTY BOUNDARY*

MAXEY FLATS EXECUTIVE SUMMARY **MAXEY FLATS SITE RI/FS**
EBASCO SERVICES INCORPORATED
MAXEY FLATS DISPOSAL SITE – SITE MAP FIGURE 1

8.2 Contaminant-Specific ARARs

Contaminant-specific ARARs set health or risk-based concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Examples of such media are air and water. These ARARs set protective cleanup levels for the contaminants of concern in the designated media or indicate an acceptable level of discharge into a particular medium during a remedial activity.

- Kentucky Standards for Protection Against Radiation (Allowable Doses in Unrestricted Areas) (902 KAR 100:020 and Table II of 902 KAR 100:025)

Sections 7 and 8 of 902 KAR 100:020 and Table II of 902 KAR 100:025, Section 2, provide general and isotope-specific radiation protection standards for individuals in unrestricted areas, and are applicable requirements for the radioisotopes at the MFDS. Section 7 requires that individuals in unrestricted areas should not receive a dose to the whole body in excess of 500 mrem in any year. Section 8 establishes limits, on an isotope-by-isotope basis, on the amount of radiation that can be released to unrestricted areas. Specifically, the section provides that radioisotopic concentrations in air and water above natural background cannot exceed the limits in 902 KAR 100:025, Table II.

- Federal Standards for Protection Against Radiation (Allowable Doses in Unrestricted Areas) (10 CFR Part 20.105, .106 and Appendix B, Table II)

Because of Kentucky's Agreement State status, its radiation protection standards provide the applicable requirements for protection against radiation in unrestricted areas at the MFDS. The analogous federal radiation protection standards found in 10 CFR Part 20.105, .106, and Appendix B, Table II are relevant and appropriate contaminant-specific standards for the MFDS. The federal standards were lowered in May 1991 so as to limit the allowable dose in unrestricted areas to 100 mrem/year and to provide specific radionuclide concentrations in Appendix B, Table II. In that these new federal standards are more stringent than the Kentucky regulations, the federal standards shall be the governing ARARs for allowable doses in unrestricted areas.

- Kentucky Surface Water Quality Standards (401 KAR 5:026 - :035)

Kentucky's Surface Water Quality Standards, set out in 401 KAR 5:026 - :035, set "minimum criteria applicable to all surface waters". These criteria include specific limits on radionuclides. These standards are applicable contaminant-specific standards for the surface water streams (i.e., Drip Springs Hollow, No Name Hollow, and Rock Lick Creek) surrounding the MFDS. In addition, to the extent that the site contains surface waters as defined by 401 KAR 5:029 Section 1(bb), including intermittent streams with well defined banks and beds, the surface water standards are, likewise, applicable contaminant-specific standards.

- Ambient Water Quality Criteria (Section 304(a)(1) of the Clean Water Act)

The EPA water quality criteria found in Section 304(a)(1) of the Clean Water Act are relevant and appropriate criteria for the MFDS. The EPA criteria for protection of aquatic life from acute or chronic toxic effects or the human health criteria for consumption of fish, whichever is more stringent, is the relevant and appropriate requirement for the surface waters at and around the MFDS.

- Kentucky Drinking Water Standards - Maximum Contaminant Levels (401 KAR 6:015)

The Kentucky drinking water standards establish maximum concentration levels for a number of inorganic, organic, and radionuclide contaminants. The MCLs established in 401 KAR 6:015 are relevant and appropriate requirements for the MFDS. Compliance with these ARARs will be judged beginning at the contact of the alluvium with the hillside and ending at the streams. Figure 16 provides an outline of alluvial deposits where drinking water standards will be enforced.

- Federal Drinking Water Regulations - Maximum Contaminant Levels and Maximum Contaminant Level Goals (40 CFR Parts 141, 142, and 143)

On January 30, 1991, EPA promulgated the new Safe Drinking Water Act (SDWA) National Primary Drinking Water Regulations (Phase II). See 56 Federal Register 3526 (January 30, 1991) (to be codified at 40 CFR Parts 141, 142, and 143). The Phase II National Primary Drinking Water Regulations establish Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs) for 31 contaminants, which are effective July 30, 1992. A second regulation, promulgated in July 1991, established MCLGs and MCLs for five additional contaminants. MCLs are enforceable standards that apply to specified contaminants which EPA has determined have an adverse effect on human health above certain levels. MCLGs are non-enforceable health-based goals that have been established at levels at which no known or anticipated adverse health effects occur and which allow an adequate margin of safety.

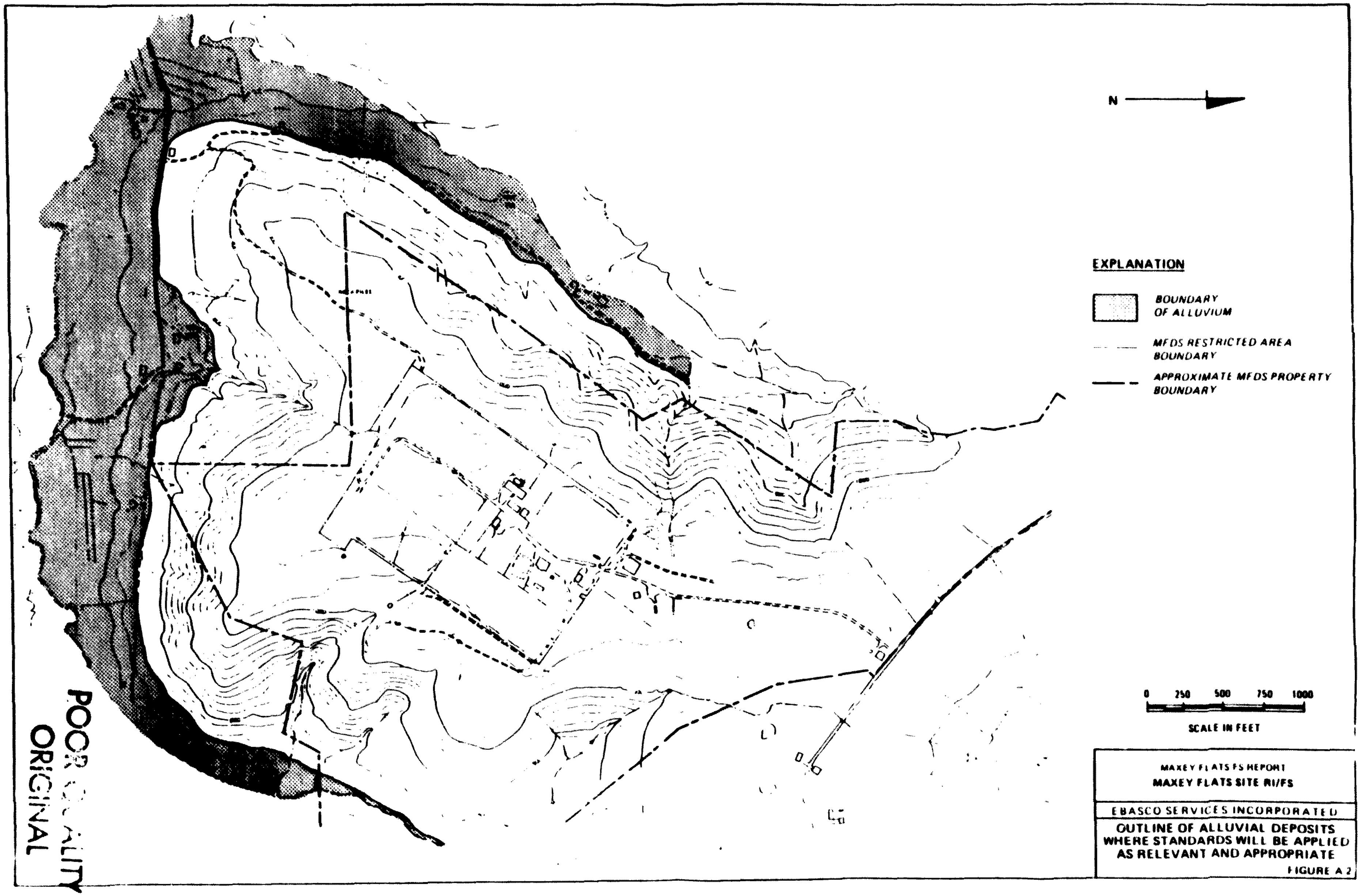

N
EXPLANATION
BOUNDARY OF ALLUVIUM
MFDS RESTRICTED AREA BOUNDARY
APPROXIMATE MFDS PROPERTY BOUNDARY
0 250 500 750 1000
SCALE IN FEET
MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
OUTLINE OF ALLUVIAL DEPOSITS WHERE STANDARDS WILL BE APPLIED AS RELEVANT AND APPROPRIATE
FIGURE A 2

FIGURE 16

Under the NCP, EPA requires that MCLGs set at levels above zero (non-zero MCLGs) be attained during a CERCLA cleanup where they are relevant and appropriate. Where the MCLG is equal to zero, EPA sets the cleanup level to be the corresponding MCL. The MCLs and all non-zero MCLGs are relevant and appropriate requirements that must be achieved at the MFDS because ground or surface waters at the site are current or potential sources of drinking water. The recently added MCLs and MCLGs will supplement the Kentucky MCLs as relevant and appropriate requirements at the MFDS, and compliance with these ARARs will be judged at the contact of the alluvium with the hillside and ending at the streams. These criteria are presented in Appendix B to this Record of Decision.

- Kentucky Hazardous Waste Management Regulations (401 KAR Chapter 34)

- 401 KAR 34:060 (Section 5) - Ground Water Protection: Section 5 establishes maximum ground water concentration limits for certain metals and organic compounds. Given the specific characteristics of site topography and geology, the first point beyond the waste management area boundary at which corrective action would be technically practicable is at the contact of the alluvium with the hillslopes. Given the institutional control and perpetual maintenance features of the remedy to be implemented, this is also the first point at which the public could be exposed to contaminated ground water. Compliance with maximum ground water concentration limits will, therefore, be judged at the contact of the alluvium with the hillslopes.

- National Emission Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61, Subpart H)

The NESHAPs for radionuclides in 40 CFR Part 61, Subpart H, establish an effective dose equivalent of 10 mrem/year for Department of Energy facilities. This standard is relevant and appropriate to the MFDS and compliance with this requirement will be judged at the current site licensed property boundary.

- Kentucky Licensing Requirements for Land Disposal of Radioactive Waste (902 KAR 100:022)

The 25 mrem/year dose limit found in Section 18 of 902 KAR 100:022 is a relevant and appropriate requirement for the MFDS. Compliance with the 25 mrem/year standard will be judged on the combined doses contributed by air, water, drinking water and soil pathways. The point of compliance for this requirement will be the current site licensed property boundary.

- Federal Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR Part 61.41)

Because Kentucky is an Agreement State, its radiation protection standards provide the standards for protecting against radiation in the general environment. Nevertheless, the analogous federal standard (10 CFR Part 61.41) to 902 KAR 100:022, Section 18 is relevant and appropriate.

- Federal Standards for Uranium and Thorium Mill Tailings (40 CFR Part 192)

The UMTRCA standard found in 40 CFR Part 192.12(a)(1), which applies to remedial actions at inactive uranium processing sites, limits radium-226 concentrations in soil to 5 pCi/gram in the top 15 centimeters. Radium-226 is present at the MFDS. Therefore, EPA has determined that the referenced UMTRCA standard is relevant and appropriate for the MFDS remedial action and is a contaminant-specific ARAR for soils at the Maxey Flats site.

8.3 ARARs Waiver

CERCLA Section 121(d) provides that, under certain circumstances, an ARAR may be waived using one (or more) of the following waivers:

- Interim Remedy Waiver - The remedial action selected is only a part of a total remedial action that will attain such a level or standard of control when completed. (CERCLA 121(d)(4)(A).)

- Greater Risk to Health and the Environment Waiver - Compliance with such requirement at the facility will result in greater risk to human health and the environment than alternative options. (CERCLA 121(d)(4)(B).)

- Technical Impracticability Waiver - Compliance with such requirement is technically impracticable from an engineering perspective. (CERCLA 121(d)(4)(C).)

- Equivalent Standard of Performance Waiver - The remedial action selected will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, criteria, or limitation, through use of another method or approach. (CERCLA 121(d)(4)(D).)

- Inconsistent Application of State Standard Waiver - With respect to a State standard, requirement, criteria, or limitation, the State has not consistently applied (or demonstrated the intention to consistently apply) the standard, requirement, criteria, or limitation in similar circumstances at other remedial actions. (CERCLA 121(d)(4)(E).)

- Fund-Balancing Waiver - In the case of a remedial action to be undertaken solely under Section 104 using the Fund, selection of a remedial action that attains such level or standard of control will not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of amounts from the Fund to respond to other sites which present or may present a threat to public health or welfare or the environment, taking into consideration the relative immediacy of such threats. (CERCLA 121(d)(4)(F).)

At the MFDS, fifteen trench leachate samples were collected and analyzed for a variety of organics and inorganics during the RI. Additionally, RCRA analyses (pH, sulfide screen, ignitability screen) were performed on all fifteen samples. All samples tested negative for the RCRA parameters analyzed. Very low levels of organics were detected during the RI (e.g., toluene ranged from not detected to 5.3 parts per million, xylene ranged from not detected to 4.4 parts per million). The organic and inorganic analyses performed on the trench leachate indicate that Extraction Procedure (EP) Toxicity tests and Toxicity Characteristic Leachability Procedure tests would be negative for the fifteen samples. Therefore, RCRA characteristic levels would not be expected in the leachate once it is extracted and batched during RD/RA. Nontheless, the documented disposal of a listed waste at the MFDS (liquid scintillation vials containing xylene and toluene), and the presence of xylene and toluene in trench leachate, triggers RCRA requirements (or their Kentucky counterparts) as applicable to the MFDS.

Based on the very low levels of chemical constituents detected in trench leachate during RI sampling, it is unlikely that batched leachate would contain hazardous waste at levels above those which trigger prohibition of land disposal under Part 268. No further leachate testing for listed constituents or for waste at potentially characteristic levels is planned because, based on factors including those discussed below, EPA has determined that it is appropriate to invoke a waiver at this time.

During remedial action, approximately three million gallons of trench leachate will be extracted, batched, mixed with solidifying agents, and then disposed on-site in new disposal units. The leachate to be solidified includes concentrations of tritium as high, or higher than, 12,000,000 pCi/ml, Strontium-90 up to 2,000 pCi/ml, Plutonium-238 up to 320 pCi/ml, and Uranium-233/234 up to 130 pCi/ml. The objective of the leachate solidification program is to produce a solid, physically stable form of the leachate, thereby minimizing the mobility of radionuclides within the newly-constructed trenches. Treatment processes intended to remove the chemical portion of the leachate will significantly increase site worker exposure to radiation. In addition, by-products from treatment processes would require further handling, treatment and disposal, thereby further increasing worker exposure to radiation.

Risks associated with the MFDS are primarily due to potential exposure to radionuclides rather than the very low concentrations of chemical constituents detected at the site. However, measures taken to contain the radionuclides within the site (e.g., solidification and capping), will be effective in containing the chemical constituents as well. Thus, the implementation of treatment processes to remove the minor fraction of chemical constituents is not necessary to protect human health and the environment.

EPA has determined that compliance with 40 CFR Part 268 during remedial action at the MFDS would result in a greater risk to human health and the environment due to the volume of leachate to be treated and nature of the leachate and is hereby invoking a waiver of these requirements.

SECTION 9.0 - SUMMARY OF THE COMPARATIVE ANALYSIS OF ALTERNATIVES

9.1 Evaluation Criteria

Nine criteria are used to evaluate alternatives at Superfund sites. These nine criteria are categorized into three groups: threshold criteria, primary balancing criteria, and modifying criteria. The threshold criteria must be satisfied in order for an alternative to be eligible for selection. The primary balancing criteria are used to weigh major tradeoffs among alternatives. Generally, the modifying criteria are taken into account after public comment is received on the Proposed Plan. The nine criteria are as follows:

Threshold Criteria:

- Compliance with ARARs - Compliance with ARARs addresses whether a remedy will meet all of the ARARs of Federal and State environmental laws and/or justifies a waiver.

- Overall protection of human health and the environment - Overall protection of human health and the environment addresses whether a remedy provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

Primary Balancing Criteria:

- Short-term effectiveness - Short-term effectiveness addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until remedial action objectives are achieved.

- Long-term effectiveness - Long-term effectiveness refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time.

- Reduction of toxicity, mobility or volume - Reduction of toxicity, mobility, or volume through treatment is the anticipated performance of the treatment technologies a remedy may employ.

Primary Balancing Criteria (Continued):

- Implementability - Implementability is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- Cost - Cost includes estimated capital and O & M costs, also expressed as net present-worth costs.

Modifying Criteria:

- State acceptance - State acceptance indicates whether, based on its review of the RI/FS Reports and Proposed Plan, the State concurs with, opposes, or has no comment on the preferred alternative.

- Community acceptance - Community acceptance summarizes the public's general response to the alternatives, based on public comments received during the public comment period.

9.2 Comparative Analysis

Compliance With ARARs

All of the alternatives, with the exception of Alternative 1, No Action, comply with all ARARs for the MFDS, or obtain an ARARs waiver as allowed under CERCLA Section 121(d). Since Alternative 1, the No Action alternative, does not meet the threshold criteria (does not achieve ARARs, does not provide overall protection of human health and the environment), Alternative 1 will not be evaluated further in this comparative analysis.

Overall Protection of Human Health and the Environment

All of the remedial alternatives provide overall protection of human health and the environment. However, the remedial alternatives have varying degrees of uncertainty associated with with long-term stability and potential release of contaminants. Alternative 5 provides the best assurance that, once the final cap is installed, cap maintenance will be at a minimum. Additionally, Alternative 5 is the least likely to involve container rupture and subsequent contaminant release.

In that wastes would be left at the site above health-based levels under each of the alternatives, the selected remedy will necessarily undergo an EPA-conducted review every five years following commencement of remedial action. The purpose of this review process is to ensure that the remedy prevents water infiltration into the trenches, mitigates hillslope erosion to the extent practicable, and minimizes the migration of site contaminants. Modifications to the remedy would occur through a Record of Decision amendment process if it were determined during a five-year review, or at any point between, that the remedy was not providing overall protection of human health and the environment.

Short-Term Effectiveness

Alternative 5 provides the greatest short-term effectiveness of the seven alternatives evaluated because it achieves initial capping of the trench disposal area earlier than any other alternative and with less exposure of site workers to radiation. Alternative 8 is only slightly less effective than Alternative 5, the principal difference being the greater amount of materials handling required for Alternative 8. Both of these natural subsidence alternatives (5 and 8) provide greater short-term effectiveness than Alternatives 4, 10 and 17, which use dynamic compaction to achieve stabilization, because dynamic compaction has a greater potential for exposing workers to direct radiation. Alternatives 4, 10 and 17 are roughly equal with respect to short-term effectiveness, but 10 provides a slightly greater degree of short-term effectiveness. The lack of a synthetic liner feature of Alternative 17 and the structural cap component of Alternative 4 make them less effective in the short term.

Alternative 11, grouting, is clearly the most hazardous to implement of the six alternatives and, therefore, is the least effective in the short term. Injecting more than 21 million gallons of grout into LLRW trenches at high injection rates and high pressures would be far more hazardous than any other activity considered for remediation of the site.

Long-Term Effectiveness

Alternative 5 provides a greater degree of long-term effectiveness overall than do the dynamic compaction alternatives even though, during the interim maintenance period of Alternative 5, a maintenance staff would be required to perform frequent inspections and to make prompt repairs following subsidence. This is because when the final cap is installed after an approximate 35 to 100 years, the amount of data that would be available for assessing stability would likely provide more certainty of stability than can be predicted about the dynamic compaction alternatives (10 and 17). Moreover, the dynamic compaction alternatives could result in the release of additional radionuclides due to container rupture during the compaction process, whereas Alternative 5 would allow for continued radionuclide decay and containerization for a longer period of time. Thus, while initial maintenance requirements are more intense for Alternative 5, the dynamic compaction alternatives may result in increased monitoring and maintenance to address the potential increased source term and long-term stability.

Alternative 10 provides a slightly greater degree of long-term effectiveness than Alternative 17 because Alternative 10 has the synthetic liner in the cap to provide a back-up to the clay layer.

Alternative 11 provides less long-term effectiveness than Alternative 5. While grouting (Alternative 11) would provide greater stability than natural stabilization during the early years, and possibly well beyond the early years, ultimately, natural stabilization would provide more stability. Because grout used in Alternative 11 would fill only the accessible voids at the time of grout injection, at some unpredictable time, one or more trenches might have a major subsidence and permit water to infiltrate the trenches. By contrast, Alternative 5 would be easy to repair, and the maintenance staff would likely discover the subsidence before water infiltrated the trenches.

Alternative 8 would require more frequent maintenance than Alternative 4; however, two potential major repair problems with Alternative 4 - concrete cracking and water infiltration - result in it providing a lesser degree of long-term effectiveness.

Reduction of Toxicity, Mobility or Volume

Because radioactivity is an intrinsic property of the nuclides in the trench leachate and other media at the site, leachate toxicity cannot be altered by treatment. Time is the principal means by which the toxicity of radionuclides is reduced. Toxicity is reduced by decay of the radionuclides to concentrations at which they no longer present a threat to human health and the environment. None of the alternatives evaluated employ a treatment technology aimed at satisfying the reduction of toxicity evaluation factor. However, mobility and volume can be addressed by treatment; decreasing mobility has a direct impact on health and safety since decreased mobility results in longer travel times for radionuclides and a decrease in activity resulting from radionuclide decay.

Reduction of the mobility of site radionuclides is achieved in varying degrees by each of the alternatives evaluated. All remedial alternatives involve the extraction, solidification and on-site disposal of solidified trench leachate. The solidification of radioactively contaminated water does not destroy or alter the radioactivity, but changes its form to a physically stable mass which binds the radionuclides so that they are far less mobile than they were in their liquid form. Approximately three million gallons of trench leachate will be solidified and disposed; thus, a significant reduction of the mobility of trench leachate would be accomplished by each of the alternatives. However, other factors, as discussed below, result in some alternatives being more acceptable than others in terms of mobility.

Other than exhumation and off-site disposal of the contaminated media at the site, a significant reduction in volume at the MFDS is not currently attainable. Exhumation and off-site disposal, while physically possible to perform, would result in unacceptably high doses to site workers involved in excavation of the solid wastes in the trenches. Additionally, due to the activity of some of the waste present at the site, and the volume of waste involved, no present-day commercial low-level waste facility would likely accept the waste. Furthermore, exhumation would not meet 902 KAR 100:015 which, as an applicable action-specific requirement for the MFDS. 902 KAR 100:015 requires exposures to be kept to as low as reasonably achievable.

The following factors were used to evaluate the alternatives against the reduction of toxicity, mobility or volume criteria: release of trench contaminants due to waste container rupture, the ability of an alternative to prevent infiltration of water and subsequent generation of new leachate, and the generation of contaminated material (increase in the volume of waste). Alternatives 5 and 8 are the superior alternatives in terms of reducing mobility and volume for several reasons. First, they do not involve the forced consolidation of trench waste;

therefore, the potential for release of radionuclides is not as great as the dynamic compaction alternatives (4, 10 and 17). Second, Alternatives 5 and 8 are superior to the grouting alternative (11) because they do not generate waste grout resulting from grout setup prior to injection or grout break-through, which must then be disposed of on-site.

Alternative 11 is more effective than Alternatives 4, 10 and 17 because the grout would solidify and may fixate the contaminants and would result in a more predictable trench chemistry. Alternatives 10 and 17, which utilize dynamic compaction, result in a more complex trench chemistry with a less than predictable impact on the environment. Alternative 4 is less effective than Alternatives 10 and 17 because it would be more difficult to keep water out of the trenches and to prevent contamination or construction runoff water when installing the structural cap.

Implementability

Alternative 5 would be the easiest to implement because it would be a continuation of the present operation but with improvements. Alternative 8 would be more difficult than Alternative 5 because of the problems associated with repair of the final cap over the period of trench subsidence. Both Alternatives 5 and 8 would be easier to implement than the alternatives involving grouting, dynamic compaction, or structural concrete, all of which are more complicated technologies. The dynamic compaction alternatives (4, 10 and 17) would be more easily implemented than the grouting alternative (11). Nevertheless, dynamic compaction would require pilot scale demonstrations of the suitability of this technology to the MFDS.

Alternative 11 is the least implementable of the alternatives evaluated at the MFDS. High production grouting (large volumes, high injection rates, high pressures), although technically feasible, has experienced difficulties at other similar sites. Additionally, the scale to which it would be employed at the MFDS is much greater than other sites where it has been applied. Significant difficulties could be expected during attempts to drive injection lances into the trenches. Grouting would require additional research and testing at the MFDS due to the complexities associated with grouting in trenches.

Cost

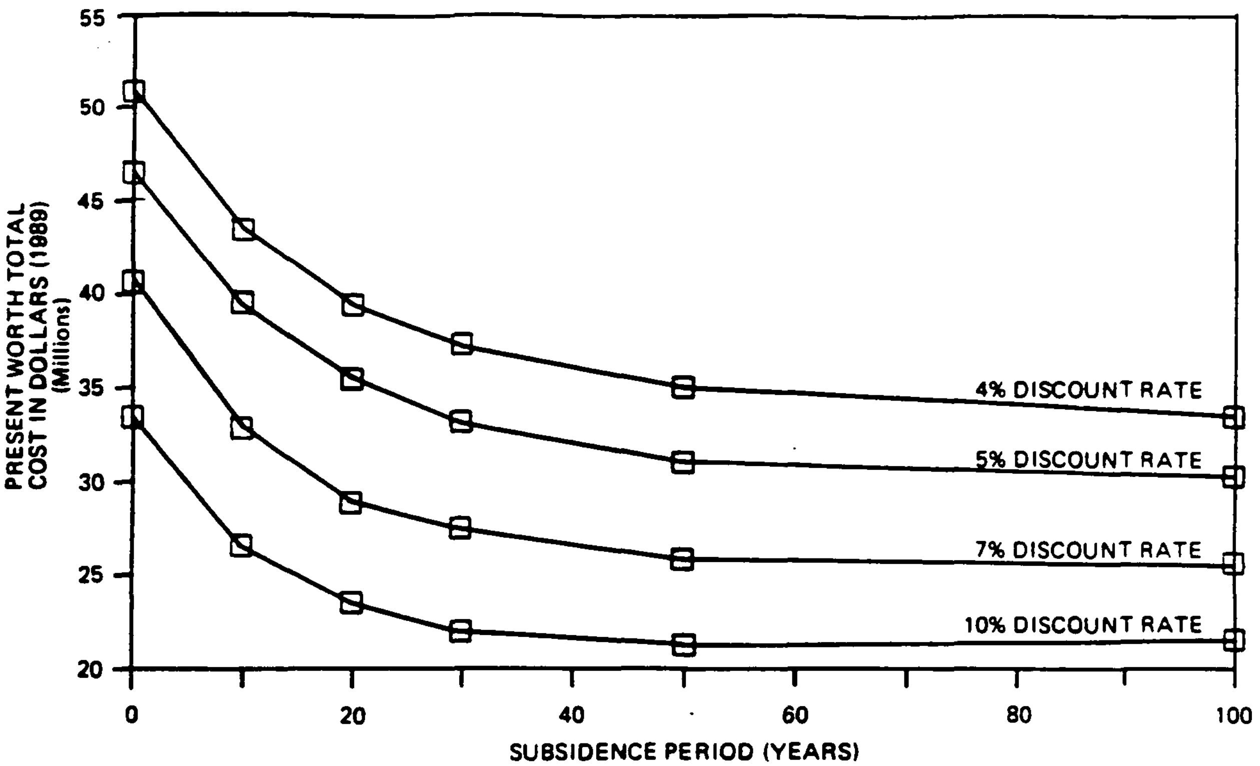
The present worth total cost of Alternative 5 depends on the period assumed for interim maintenance and is a maximum when the interim maintenance period equals zero years. Nevertheless, comparing the maximum present worth total costs of Alternative 5 with those of other alternatives shows that Alternative 5 has the lowest present worth total cost of any alternative regardless of the length of the interim maintenance period. Figure 16 illustrates the differences in total present worth for four assumed discount rates over the projected subsidence period.

Table 32 provides a cost breakdown for Alternative 5 and provides cost estimates for Alternative 5 using four different discount rates, 4%, 5%, 7%, and 10%. The $ 33,500,000 cost estimate for Alternative 5 is based upon a 4% discount rate, which is the most conservative rate of the four rates used in the Feasibility Study. A 4% discount rate was used to compare alternatives. The actual discount which will be used to establish the MFDS trust fund has yet to be determined.

Furthermore, the cost estimate for Alternative 5 assumes a 10% contingency and installation of a North Cutoff Wall. The actual contingency factor employed in the establishment of the MFDS trust fund may be higher than 10%. The necessity of a horizontal flow barrier and type of horizontal flow barrier (i.e., North Cutoff Wall, Lateral Drain/Cutoff Wall, etc.) will be determined during the Interim Maintenance Period; therefore, the cost estimate for Alternative 5 is subject to change.

State Acceptance

The Commonwealth generally endorses the selection of Alternative 5 (Natural Stabilization) as the remedy for the Maxey Flats Disposal Site. The Commonwealth considers trench cover repair and a horizontal flow barrier, if needed, to be integral features of the remedy chosen for the site. The Commonwealth rejects the use of Alternative 10 and 17 (dynamic compaction) for either a site demonstration or for total site remediation due to potential release of contaminants into the environment and uncertainties regarding dynamic compaction's effect on the underlying geologic strata. The Commonwealth also rejects the use of grouting (Alternative 11) for implementation at the MFDS due to potential unacceptable releases to the environment, implementability problems, and required demonstration of this technology prior to implementation.



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ALTERNATE 5 SUBSIDENCE PERIOD PRESENT WORTH SENSITIVITY CURVES

040191 FIGURE G-2

ALTERNATIVE-5: NATURAL STABILIZATION (50-ACRE CAP)

CAPITAL COSTS AND COST LAYOUT	Estimated Total	Year 1 1990	Year 2 1991	Year 3 1992	Year 4 1993	Interim Period	Year 103 2092	Year 104 2093
A. Construction Cost								
Site Preparation and Support								
1. Road Construction (Cut, Gravel, Fabric)	$530,000	$0	$0	$430,000	$0		$0	$100,000
2. Decon. Facility(Equip't & Personnel)	$130,000	$0	$0	$80,000	$0		$0	$50,000
3. Utilities	$50,000	$0	$0	$30,000	$0		$0	$20,000
4. Field Offices & Construction Fence	$200,000	$0	$0	$120,000	$0		$0	$80,000
5. Topographic & Bkgd Radiation Survey	$140,000	$0	$0	$70,000	$0		$0	$70,000
6. Ground Penetration Radar Survey	$150,000	$0	$0	$150,000	$0		$0	$0
7. Construction Erosion Control	$200,000	$0	$0	$100,000	$0		$0	$100,000
8. Health and Safety	$2,000,000	$0	$0	$1,000,000	$500,000		$0	$500,000
9. QA/QC	$1,080,000	$0	$0	$450,000	$250,000		$0	$380,000
Sub-total	$4,480,000	$0	$0	$2,430,000	$750,000		$0	$1,300,000
Specific Construction Activities								
1. Leachate Removal	$1,252,000	$0	$0	$1,252,000	$0		$0	$0
2. Contaminated Liquid Handling and Disposal	$4,079,000	$0	$0	$4,079,000	$0		$0	$0
3. Contaminated Soil Disposal	$174,000	$0	$0	$174,000	$0		$0	$0
4. Existing Tank Leachate-Rem'l, Solid'n & Disp'l	$0	$0	$0	$0	$0		$0	$0
5. Horizontal Flow Barrier (North Cutoff Wall)	$1,156,000	$0	$0	$1,156,000	$0		$0	$0
6. Additional Backfill	$0	$0	$0	$0	$0		$0	$0
7. Dynamic Compaction	$0	$0	$0	$0	$0		$0	$0
8. Trench Grouting	$0	$0	$0	$0	$0		$0	$0
9. Site Grading	$160,000	$0	$0	$160,000	$0		$0	$0
10. Demol'n, Material Handling & Decon.	$740,000	$0	$0	$450,000	$0		$0	$290,000
11. Leachate Solidificat'n/Add'l Disposal Trenches	$4,706,000	$0	$0	$4,706,000	$0		$0	$0
12. Drainage Ditches	$889,000	$0	$0	$0	$215,000		$0	$674,000
13. Initial and Final Closure Caps	$17,489,000	$0	$0	$0	$3,449,000		$0	$14,040,000
14. Cap Erosion Control	$1,445,000	$0	$0	$0	$204,000		$0	$1,241,000
15. Long Term Monitoring	$691,000	$0	$0	$0	$626,000		$0	$65,000
16. Security Fence	$120,000	$0	$0	$60,000	$60,000		$0	$0
Sub-total	$32,901,000	$0	$0	$12,037,000	$4,554,000		$0	$16,310,000
Total Construction Cost	$37,381,000	$0	$0	$14,467,000	$5,304,000		$0	$17,610,000
B. Engineering and Management Cost								
1. Engineering & Design (1)	$2,990,480	$0	$1,581,680	$0	$0		$1,408,800	$0
2. Construction Management (2)	$11,214,300	$0	$0	$4,340,100	$1,591,200		$0	$5,283,000
Total Engineering & Management Cost	$14,204,780	$0	$1,581,680	$4,340,100	$1,591,200		$1,408,800	$5,283,000
Total Capital Cost	$51,585,780	$0	$1,581,680	$18,807,100	$6,895,200		$1,408,800	$22,893,000
10% Contingency	$5,158,578	$0	$158,168	$1,880,710	$689,520		$140,880	$2,289,300
Total Capital Cost with Contingency	$56,744,358	$0	$1,739,848	$20,687,810	$7,584,720		$1,549,680	$25,182,300

TABLE 32 (CONTINUED)

ALTERNATIVE-5: NATURAL STABILIZATION (50-ACRE CAP)

PRESENT WORTH CALCULATION - CAPITAL COSTS

Assumptions:

1. Estimated Engineering and Design cost is based on 8% of total construction
2. Estimated construction management cost is based on 30 % of total construction
3. Scheduled construction period for Alternative 5 is 20 months for initial construction and 10 months for final capping.

	Discount Rates			
	4%	5%	7%	10%
PW of Total Capital Costs	$25,900,882	$24,625,424	$22,632,720	$20,147,951

PRESENT WORTH CALCULATION - O & M COSTS

Assumptions:

1. Present worth of O&M costs is based on perpetual annual maintenance and subsidence repair as required
2. All O&M costs include inflation at 0% per year.
3. O&M begins in December of Year 4 (1993).
4. Cost of yearly custodial maintenance excluding subsidence repair is $385,000 for years 1 to 10, $295,000 for years 11 to 100, $240,000 years 101 to 110, and $190,000 years 111 onwards in perpetuity. In addition, $40,000 is applied every 5 years for the first 100 years for leachate pumping and solidification.
5. O&M costs do-not include taxes, insurance and license fees.

	Discount Rates			
	4%	5%	7%	10%
PW of Total O&M Costs	$10,097,549	$7,692,612	$4,924,075	$2,921,415

PRESENT WORTH - TOTAL COST

	Discount Rates			
	4%	5%	7%	10%
PW of Total Cost	$35,998,431	$32,318,036	$27,556,795	$23,069,366

Community Acceptance

Verbal comments received at the Proposed Plan public meeting, held on June 13, 1991 in Wallingford, Kentucky, and on comments submitted to EPA during the public comment period on the Proposed Plan, indicate that the community favors Alternative 5, Natural Stabilization, over the other alternatives considered. However, the community urged inclusion of a number of features in the Record of Decision and RD/RA Consent Decree. The community's comments and suggestions, as well as EPA responses, can be found in the Responsiveness Summary section of this Record of Decision.

The community opposes the dynamic copaction alternative (Alternatives 4, 10 and 17) for the MFDS, primarily because of concerns over accelerated release of contaminants to the environment during the compaction process. The community does not favor the grouting alternative due to concern over potential contaminant release from intact containers during the grout injection process and uncertainties over the ability of grout to adequately fill void spaces within the trenches.

9.3 Conclusions of the Comparative Analysis Summary

Of the nine criteria described above, the differences between the six remedial alternatives evaluated are not great, except with respect to the following four criteria: 1) Implementability; 2) Reduction of Toxicity, Mobility or Volume; 3) State Acceptance, and 4) Community Acceptance. All remedial alternatives provide for roughly the same degree of long-term and short-term effectiveness. All remedial alternatives provide for overall protection of human health and the environment and all achieve ARARs. Although cost estimates differ amongst the remedial alternatives, none differ by more than an order of magnitude.

Therefore, Implementability, Reduction of Toxicity, Mobility or Volume, State Acceptance, and Community Acceptance weighed heavily in favor of selection of Alternative 5. Alternative 5 is the least difficult remedy to implement, utilizing proven and reliable technologies to achieve final remediation, while not requiring time-consuming research and development prior to implementation. It is less likely to result in container rupture and, therefore, benefits from the added protection of containers within the trenches. Both the State and Community favor the Natural Stabilization technology.

SECTION 10.0 - THE SELECTED REMEDY

Based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, EPA has determined, and the Commonwealth agrees, that Alternative 5, Natural Stabilization, is the most appropriate remedy for the Maxey Flats Disposal Site.

The natural stabilization process at Maxey Flats will allow the materials to subside naturally to a stable condition prior to installation of a final engineered cap. It is not known how long it will take for waste trenches to stabilize because of the many physical and chemical variables involved and the limited trench-specific information upon which predictions are based. However, it has been estimated that this stabilization process could potentially take 100 years before the final cap is placed.

Stabilization of the trenches by natural subsidence over a relatively long time period will virtually eliminate the potential problem of future subsidence expected with other alternatives in which the trenches would be stabilized by mechanical means and a final cap installed within a few years. Therefore, the natural stabilization alternative will reduce the redundancy of efforts necessary to construct and maintain the final cap. Natural stabilization does not disrupt intact metal containers such as 55-gallon drums and, therefore, provides an extra measure of protection to prevent movement of radionuclides to the hillsides. The other alternatives have the potential of rupturing intact containers, thereby releasing radioactive material immediately to the trenches. Additional benefits of the natural stabilization alternative will be the opportunity for continued data collection and analyses and the ability to take advantage of technological advances during the subsidence period.

Alternative 5 can be divided into the following four phases which together comprise the CERCLA remedial action for the MFDS:

- Initial Closure Period (22 months)
- Interim Maintenance Period (35 - 100 years)
- Final Closure Period (10 months)
- Custodial Maintenance Period (in perpetuity)

10.1 - Initial Closure Period

The initial closure period will consist of the design and implementation of remedial activities appropriate to the early stages of site remediation. An Interim Site Management Plan will also be developed to define the maintenance and monitoring tasks to be conducted during the subsequent interim maintenance period.

The following remedial activities will be performed during the initial closure period:

- Baseline Topographic Surveys
- Geophysical Surveys
- Ground Water Monitoring
- Ground Water Modeling
- Trench Leachate Extraction and Solidification
- Disposal of Solidified Leachate Into New Trenches On-Site
- Demolition of Existing Buildings and Structures With On-Site Disposal
- Installation of an Initial Cap
- Grading and Recontouring of the Initial Cap to Enhance Surface Water Flow
- Improvements to Site Drainage
- Installation of Subsidence Monitors
- Closure of Selected, Poorly Designed, Historical Wells
- Monitoring, Maintenance, and Surveillance
- Procurement of a Buffer Zone Contiguous to the Existing Site Property
- Posting and Repairing of Signs and Fences, Road Maintenance
- Development of the Interim Site Management Plan

Baseline Topographic and Geophysical Surveys will be conducted prior to design of the initial cap. Topographic surveys will be performed prior to installation of the initial cap and following construction of the cap to be used as a baseline survey for subsidence monitoring. A geophysical survey will enhance the definition of trench boundaries to ensure that the initial cap will adequately cover the trenches.

Historical site monitoring data, the Commonwealth's site database, and ground water models will be used to determine the appropriate areal extent of the initial cap, to evaluate the need for a horizontal ground water flow barrier, and to develop an effective ground water monitoring plan for the Interim Maintenance and Custodial Maintenance Periods. The ground water monitoring program will involve installation of new monitoring wells, as appropriate, in the alluvium of the surrounding stream valleys, and in other areas as required, to ensure compliance with drinking water standards and to achieve RCRA monitoring requirements.

Trenches will be dewatered to help prevent the migration of contaminants by ground water flow. A trench dewatering test program will be conducted either during the design phase or during initial remedial activities to provide information on the most effective design of the dewatering program, to determine the need for new sumps, and to provide an estimate of the duration of the dewatering program.

Leachate pumped from the trenches will be extracted simultaneously from multiple trenches and batched prior to solidification. Additional sumps will be added in select trenches with significant quantities of leachate in order to facilitate the dewatering of trenches. Trench dewatering is the most time-consuming component of the Initial Closure Period. A minimum of nine months will be required to dewater the trenches.

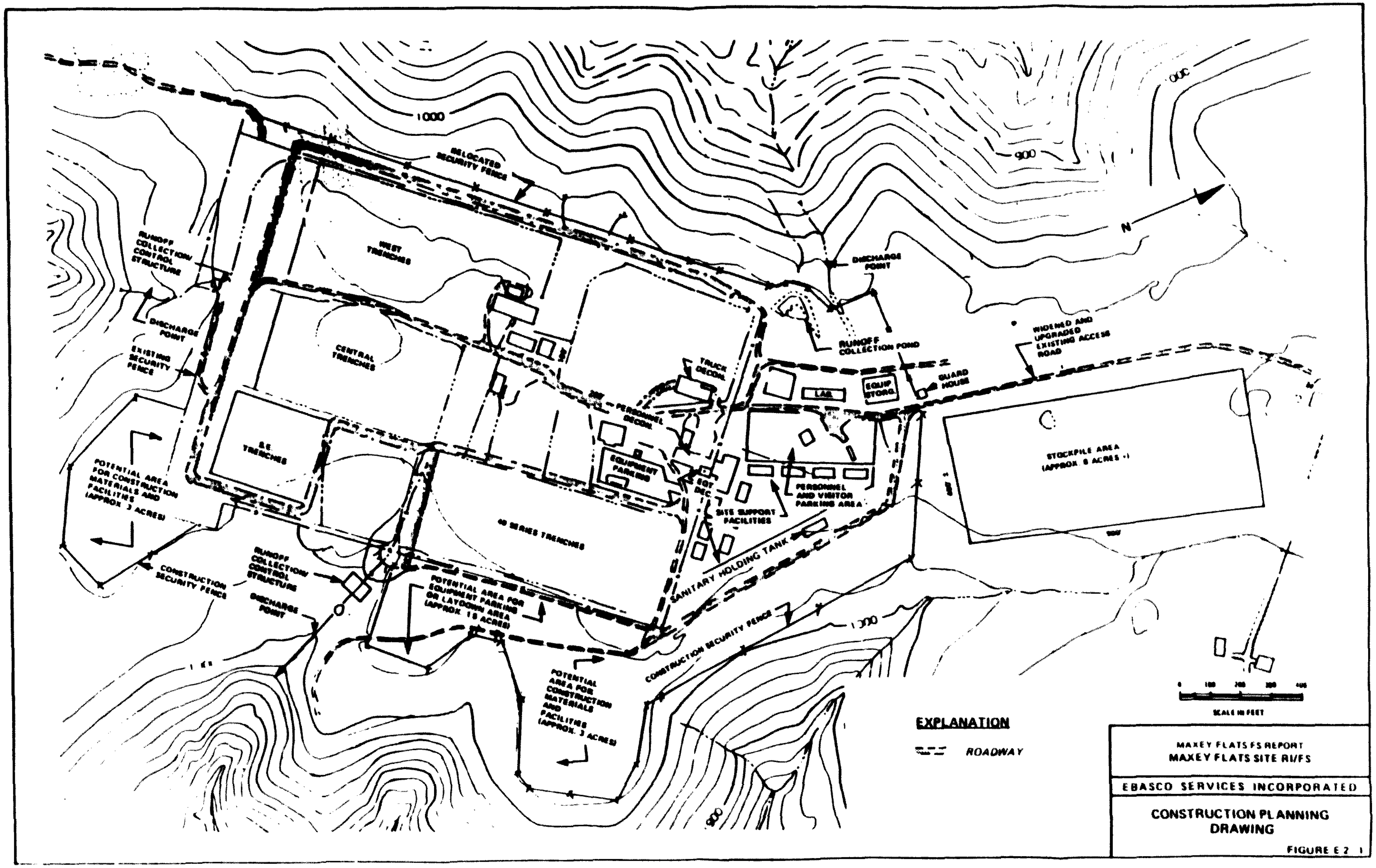
Once batched, the leachate will undergo testing for NRC classification purposes. Once classified, the leachate will be solidified using an NRC-approved mix. The waste form will likely be in block form, provided an acceptable leachability index and cumulative fraction leached can be achieved. However, high activity leachate will be required to be placed in a primary container and solidified. The solidified leachate will also be designed to achieve a sufficient minimum compressive strength. The objectives of the leachate solidification will be to produce a solid, physically stable form of the leachate, thereby minimizing the mobility of the contamination within the trenches. During the leachate solidification operations, external exposure to ionizing radiation will be kept as low as reasonably achievable by using engineering safeguards, such as shielding, and administrative safeguards such as detailed health and safety procedures for all operations. Internal exposure to radioactivity should be insignificant, since the systems that handle radioactivity would be designed to minimize leakage.

The solidified leachate will then be placed into new disposal trenches on-site and within (or in close proximity to) the current Restricted Area. Grout will be used in the newly constructed trenches to fill the void spaces between the solidification forms, in effect, creating a monolith within the trench. Each new disposal trench will, at a minimum, include a sump and a synthetic liner (unless it is later determined by EPA and the Commonwealth that use of a liner is inappropriate).

Non-functional and unstable buildings and structures will be dismantled, decommissioned and buried in a trench on-site during the Initial Closure Period. Such buildings and structures will probably include: the storage building, evaporator building, garage building, radiological control building, the sewage treatment plant, and tank farm buildings. Those buildings necessary to the management and maintenance of the site will be moved to a new location that will not impede remedial activities. Figure 18 is a typical construction planning drawing that may be employed during the Initial Closure Period.

An initial cap, consisting of a soil layer of compacted clay (averaging 21 inches thick) and covered with a synthetic liner, will be installed toward the end of the Initial Closure Period. Soil will be added to the site and graded and compacted in preparation for the installation of the synthetic cover over the trench disposal area. Conceptual cross-sections of both the initial cap and the final cap are presented in Figure 19. The areal extent of the interim cover will be based upon geophysical surveys, ground water modelling and other parameters evaluated during design. It has been estimated that the interim cap will cover approximately 40 to 50 acres. Fugitive dust problems during earth-moving operations will be controlled by using water or other dust suppressants. Kentucky Soil and Water Conservation requirements for controlling soil erosion will be met by designing and locating technologies and activities to minimize potential erosion.

The surface will be graded to design specifications to allow for adequate drainage and to minimize surface water velocities and consequent erosion. Lined drainage ditches will be incorporated in the trench cap to channel the surface water runoff to the three existing discharge basins located along the periphery of the trench disposal area. Improvements will also be made to the existing site drainage channels on the hillslopes. These erosion protection measures could include, but will not necessarily be limited to, stabilization of the drainage channels where necessary by such measures as rock rip-rap or gabions to reduce the velocity of flow. Additional drainage channels in the vicinity of the site may be added if found to be necessary to control, and more equitably distribute, the anticipated increased rates of surface water runoff. Because of the high peak discharge volumes resulting from the initial cap, the capacity of the retention ponds will be increased to improve control of stormwater runoff. Approval of the initial cap design will be contingent upon the ability of the surface water controls to adequately maintain rates of surface water runoff throughout the anticipated duration of the Interim Maintenance Period.


RELOCATED SECURITY FENCE
WEST TRENCHES
CENTRAL TRENCHES
S.E. TRENCHES
40 SERIES TRENCHES
RUNOFF COLLECTION/ CONTROL STRUCTURE
DISCHARGE POINT
EXISTING SECURITY FENCE
POTENTIAL AREA FOR CONSTRUCTION MATERIALS AND FACILITIES (APPROX. 3 ACRES)
CONSTRUCTION SECURITY FENCE
POTENTIAL AREA FOR EQUIPMENT PARKING OR LAYDOWN AREA (APPROX. 1.5 ACRES)
TRUCK DECON
PERSONNEL DECON
EQUIPMENT PARKING
SITE SUPPORT FACILITIES
SANITARY HOLDING TANK
PERSONNEL AND VISITOR PARKING AREA
RUNOFF COLLECTION POND
LAB
EQUIP STORG.
GUARD HOUSE
WIDENED AND UPGRADED EXISTING ACCESS ROAD
STOCKPILE AREA (APPROX. 8 ACRES +)
N
1000
900
EXPLANATION
ROADWAY
SCALE IN FEET
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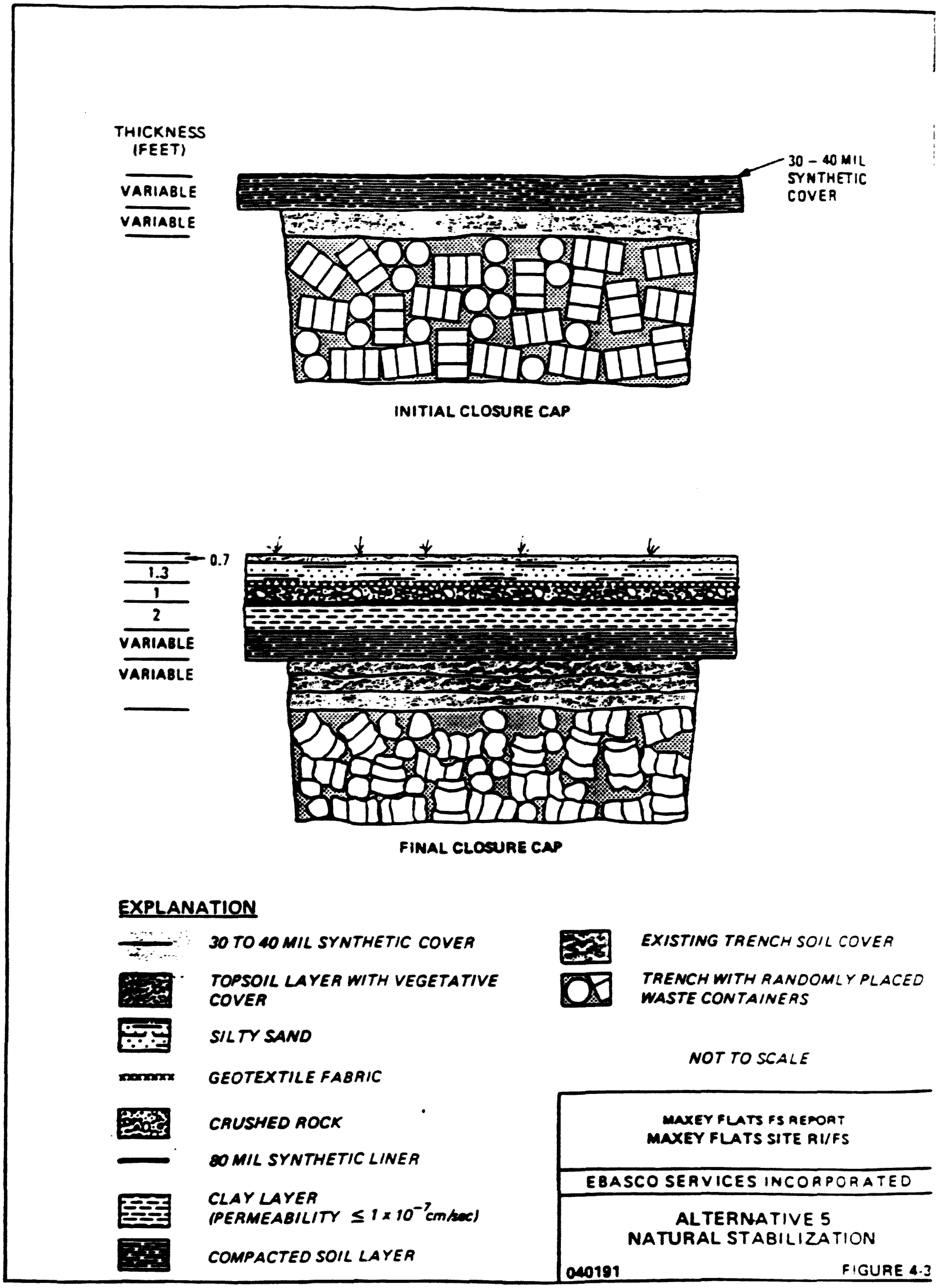
CONSTRUCTION PLANNING DRAWING
FIGURE E 2 1

FIGURE 19


THICKNESS
(FEET)
VARIABLE
VARIABLE
30 – 40 MIL
SYNTHETIC
COVER
INITIAL CLOSURE CAP
0.7
1.3
1
2
VARIABLE
VARIABLE
FINAL CLOSURE CAP
EXPLANATION
30 TO 40 MIL SYNTHETIC COVER
TOPSOIL LAYER WITH VEGETATIVE COVER
SILTY SAND
GEOTEXTILE FABRIC
CRUSHED ROCK
80 MIL SYNTHETIC LINER
CLAY LAYER
(PERMEABILITY ≤ 1 x 10⁻⁷ cm/sec)
COMPACTED SOIL LAYER
EXISTING TRENCH SOIL COVER
TRENCH WITH RANDOMLY PLACED WASTE CONTAINERS
NOT TO SCALE
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EBASCO SERVICES INCORPORATED
ALTERNATIVE 5
NATURAL STABILIZATION
040191
FIGURE 4-3

Subsidence monitors will be installed on the initial cap and on natural soils in the vicinity of the Restricted Area as a method of determining when the trenches have stabilized to an acceptable degree and final cap installation can begin.

A limited number of existing, poorly designed, wells (i.e., E-Wells) could potentially allow contaminants in ground water to migrate downward into the lower geologic units and will, therefore, be decommissioned and sealed. Existing sumps and wells (i.e., UE, UF UG, UK, etc.) that are deemed beneficial to the leachate extraction process, as well as those necessary for trench monitoring, will not be decommissioned.

Water monitoring equipment, as part of an Infiltration Monitoring System, will be installed in trenches, under the cap and within wells, to detect potential accumulation of leachate in trenches. Vibrating wire piezometers, such as the one illustrated in Figure 20, will be installed in riser pipes after construction of the initial cap. Riser pipes will be installed during cap construction and will be used to extend the monitoring wells through the cap. Water level data from the trenches and wells will be collected by data logging equipment located at the site. This data, in conjunction with other information, will be used to assess the degree to which infiltration is occurring, if any.

The monitoring program developed for the MFDS will, at a minimum, include the following objectives:

- Demonstration of compliance with the applicable or relevant and appropriate regulations, environmental standards, and other operational limits.

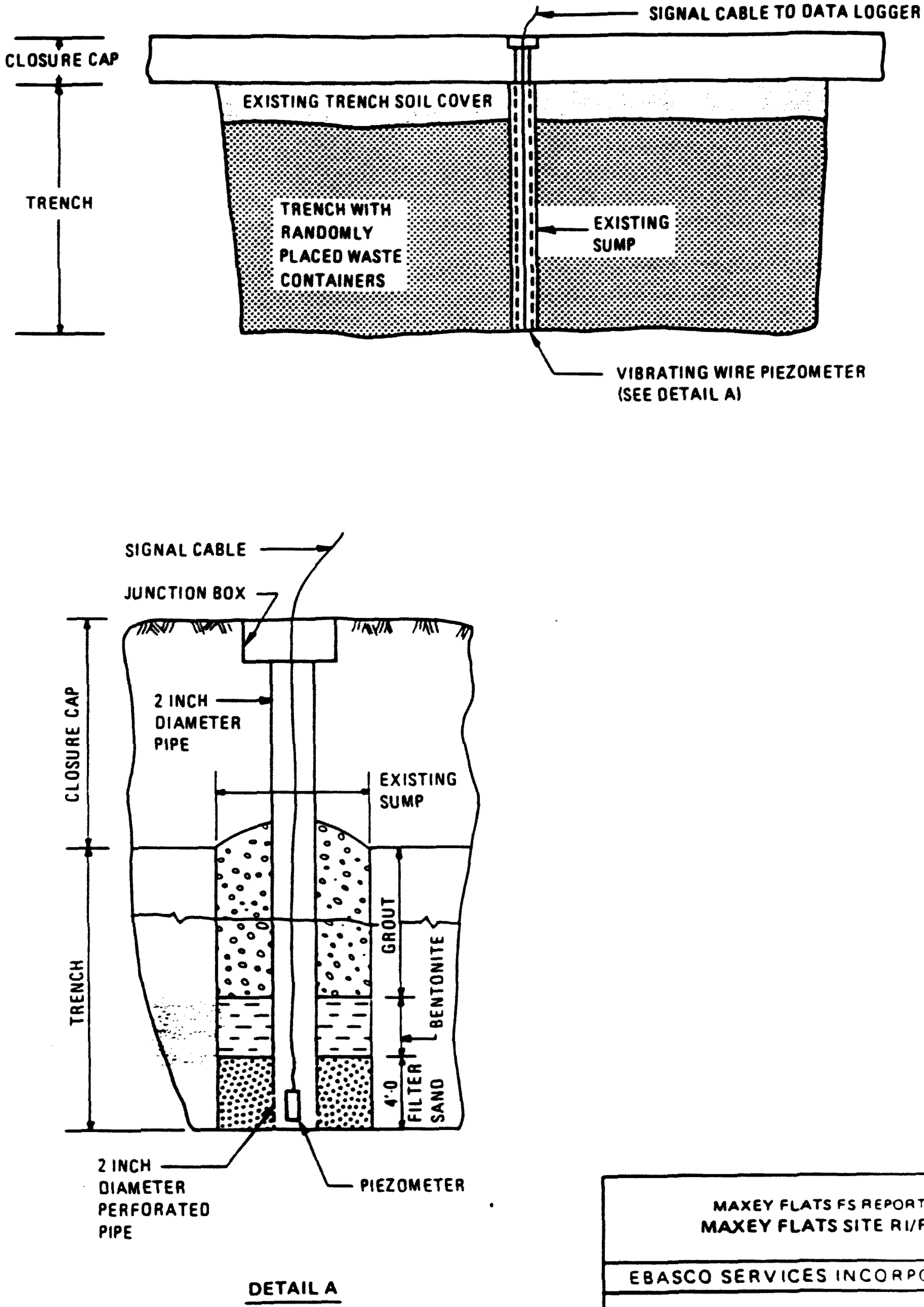
- Assessment of the actual or potential exposure of man to radioactive materials or chemical constituents in the environment.

- Detection of any possible long-term changes or trends in the environment resulting from the site.

- Assessment of the performance (adequacy) of design features that limit the release of radioactive materials to the environment.

Radionuclide and chemical constituent testing of ground water, surface water, soil, sediment and air will be performed, as appropriate and on a routine basis, to ensure that the remedy

FIGURE 20



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VIBRATING WIRE PIEZOMETER THROUGH TRENCH SUMPS

FIGURE E.11-1

for the MFDS is achieving all ARARs and continues to be protective of human health and the environment. Monitoring of leachate levels in trenches, subsidence monitoring and erosion and siltation monitoring will be routinely conducted. A program will be established to assess and track the impact of site remediation on local wildlife and vegetation and to confirm the assumptions and conclusions of the MFDS risk assessment. These monitoring programs will be established during the Initial Closure Period (as specified in the Interim Site Management Plan) and continued through the Interim Maintenance Period and on into the Custodial Maintenance Period.

A buffer zone, adjacent to the existing site property boundaries, will be acquired. The primary purpose of a buffer zone is to protect environmentally sensitive areas such as the hillslopes from detrimental activities such as logging. Without control of activities on the hillslopes, increased erosion due to deforestation could severely affect the integrity of the remedy.

The buffer zone will not extend the current licensed site property boundary, although control over the property would likely be in the hands of the Commonwealth of Kentucky. Moreover, the points of compliance for ARARs will not be extended by procurement of the buffer zone. Monitoring of streams, ground water and other media will be conducted in the buffer zone and other areas deemed necessary to assure that the selected remedy achieves ARARs. Indeed, the secondary purpose of the buffer zone is to ensure unrestricted, long-term access to areas necessary for full and effective monitoring.

At a minimum, the buffer zone will extend from the current site property boundary to Drip Springs, No Name, and Rock Lick Creeks to the west, east, and southwest of the site, respectively. The tentatively identified Buffer Zone, illustrated in Figure 21, is a conceptual delineation of the minimum boundary of the buffer zone.

Signs will be posted warning potential trespassers of the presence of site contaminants. Fences will be constructed, repaired and/or re-aligned as needed to prevent unauthorized access to the capped trench disposal area, construction areas established during the Initial Closure Period, and other areas deemed inappropriate for access. Access to the MFDS from Interstate 64 is via State Road 32 to County Road 1895, which runs to the entrance of the MFDS. County Road 1895 is a two-lane paved road suitable for the maximum legal load allowed

EXPLANATION

MFDS RESTRICTED AREA

MFDS PROPERTY BOUNDARY

PROPOSED BUFFER ZONE

MAP PRODUCED BY EBASCO SERVICES INCORPORATED AND LABELLED FOR THIS REPORT BY BOOZ, ALLEN & HAMILTON, Inc

MAXEY FLATS DISPOSAL SITE
PROPOSED BUFFER ZONE MAP

MAP 6

by Kentucky's Department of Transportation and appears to be in good condition. Well in advance of construction activities, the need to upgrade County Road 1895 will be discussed with Fleming County officials. Should it be determined that site activities are having a detrimental effect on County Road 1895, the authority(ies) responsible for remediation of the MFDS will be responsible for funding such repairs.

A comprehensive Interim Site Management Plan will be developed during the Initial Closure Period to define the maintenance and monitoring tasks to be conducted during the Interim Maintenance Period.

10.2 Interim Maintenance Period

Upon installation of the initial cap, the Interim Maintenance Period will commence. The primary objective of the Interim Maintenance Period is to let the trenches stabilize by natural subsidence. The Interim Site Management Plan will provide the basis for work activities during the interim maintenance period. During this period, the initial cap will continue to be maintained to prevent infiltration of water into the trenches, maintenance of the site will continue, and the site will be monitored by an enhanced monitoring/surveillance program.

During the Interim Maintenance Period, the following activities will be performed as prescribed by the Interim Site Management Plan:

- Periodic Topographic Surveys and Subsidence Monitoring
- Initial Cap Maintenance
- Continuing Assessment of the Adequacy of the Initial Cap, Surface Water Control Measures and Erosion Control Measures
- Improvements to Site Drainage Features, As Needed
- Trench Leachate Management and Monitoring
- Monitoring, Maintenance, and Surveillance
- Enhanced Ground Water Monitoring
- Installation of a Horizontal Flow Barrier, As Required
- Five Year Reviews

Topographic surveys and elevation surveys of the subsidence monitors will be conducted routinely to evaluate subsidence. Settlement plates and slope inclinometers (and/or other subsidence monitoring instruments) will be installed at the MFDS to measure vertical movement, tilt or subsidence of the trench contents and trench cap over time. This information will form a database to be used to assess cap stability and the degree to which trench subsidence has occurred.

The initial cap will be routinely inspected to ensure that it has not failed and it is effectively controlling surface water runoff. As needed, the cap will be repaired and the synthetic liner replaced in accordance with the Interim Site Management Plan. Currently, it is anticipated that the synthetic liner will require replacement at 20-25 year intervals. Liner replacement will be performed in response to liner condition and the manufacturer's warranty and specifications. The specific liner type will be determined during development of the Interim Site Management Plan; however, the liner will be of the type to require replacement no more often that the afore-mentioned 20-25 year interval. The drainage ditches and retention ponds will also be cleaned and maintained as needed. Erosion damage to the cap and drainage systems will be repaired as needed.

The Infiltration Monitoring System, installed during the Initial Closure Period, will detect the accumulation of leachate in the trenches and provide a warning if leachate begins to accumulate in the trenches. This monitoring system will be used as a supplement to the Commonwealth's current trench leachate monitoring program. Measures could then be taken to eliminate the cause of the infiltration. If trench recharge is occurring, the leachate management plan, developed as part of the Interim Site Management Plan, will be implemented to remove, solidify, and dispose of the leachate. The data from the monitoring and leachate extraction program will be used to adjust the frequency of inspections, data collection, sample analyses, and planned leachate pumping and solidification.

Trench leachate recharge should be kept to a minimum, once the disposal trenches have been pumped to the extent practicable and the initial cap has been placed over the disposal area. However, should conditions warrant re-initiation of a trench leachate extraction program, trench leachate will be solidified and disposed in on-site trenches. On-site activities during the Interim Maintenance Period may generate additional wastes requiring disposal. Liquids will be temporarily stored until sufficient quantities have accumulated to warrant resumption of solidification processes. Once liquids have been solidified, a new disposal trench will be constructed to dispose of the solidified liquids and any solids generated during on-site activities.

Site monitoring activities will be performed as defined in the Interim Site Management Plan and established during the Initial Closure Period. Site maintenance activities will include custodial care such as grass cutting, ditch cleaning, and fence repairing. On a less frequent basis, repairs will be made to the erosion control system, the initial cap, and monitoring instruments. Additionally surveillance activities will be performed on a routine basis to inspect the site. Maintenance and monitoring activities will be conducted in compliance with the Federal and Kentucky Licensing Requirements for Land Disposal of Radioactive Waste.

For those remedial actions that allow hazardous substances to remain on-site, Section 121(c) of CERCLA requires EPA to conduct a review of the remedy within five years after initiation of remedial action and at least once every five years thereafter. The purpose of this review is to evaluate the remedy's performance - to ensure that the remedy has achieved, or will achieve, the remedial action objectives set forth in the Record of Decision and that it continues to be protective of human health and the environment. Additionally, the Commonwealth will continue an environmental program to evaluate all aspects of the remediation during the five year review periods.

During any of the five year reviews, or at any point between the five year reviews, if the remedy is not meeting the defined remedial action objectives, a more detailed sampling program will be undertaken to determine the cause of the failure. Specifically, the reviews may focus on, among other things, the selected remedy's ability to prevent entry of water into the disposal trenches, to mitigate erosion to the extent practicable, and to minimize migration of radionuclides and chemicals.

Should site monitoring and surveillance demonstrate a failure of the remedy to achieve ARARs or remedial action objectives (e.g., alluvial ground water monitoring indicates Maximum Concentration Limits have been exceeded), the appropriate remedial steps will be taken, such as notification of regulatory agencies, public safeguards, repair of the remedial technology, or cleanup of the environmental medium.

The uncertainties of hydrogeologic flow conditions at the MFDS (as discussed in the RI Report for the MFDS and Section 5.1.2 - <u>Geology and Ground Water</u> of this document), as well as the uncertainties related to the impact of the leachate extraction operations on the hydrogeologic flow conditions, necessitate further evaluation of data in order to assess the necessity and likely effectiveness of a horizontal flow barrier. Sufficient data should be available from the trench dewatering program, information contained in the Commonwealth's historical leachate level database, the Infiltration Monitoring System, ground water monitoring, and the ground water modeling program to determine the necessity of a horizontal flow barrier before or in conjunction with the first five year review. If statistical analysis of trench data (to include water level data, regression slopes, etc.) indicates that lateral recharge of the disposal trenches is occurring, a horizontal flow barrier will be installed to curtail ground water recharge of the disposal trenches. The necessity, location, depth, and extent of this horizontal flow barrier will be determined through ground water modeling and review of historical site monitoring data.

Two types of horizontal flow barriers were evaluated in the Feasibility Study, as discussed in Section 7.2.2.2 (Horizontal Flow Barriers of this document), and illustrated in Figures 22 through 24; a north cutoff wall and a lateral drain/cutoff wall. The type of horizontal flow barrier installed at the site will be one of the two described barriers or another design determined to be sufficient for prevention of lateral infiltration.

The decisions as to whether and what type of horizontal flow barrier to construct will be made by EPA, in consultation with the Commonwealth of Kentucky.

10.3 Final Closure Period

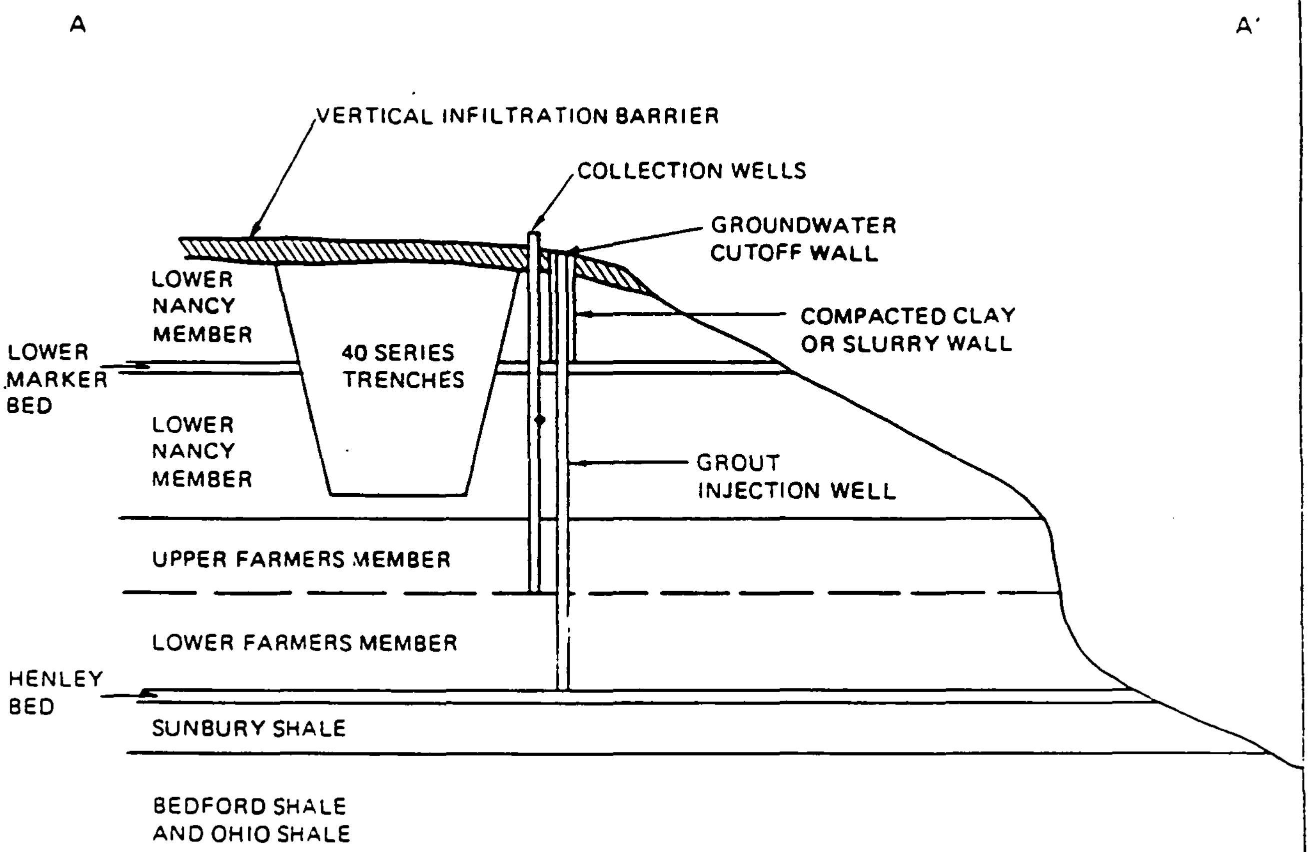
The end of the Interim Maintenance Period and the beginning of the Final Closure Period is defined as the time when subsidence of the trenches has nearly ceased and final cap installation can begin. The criteria for determining when this time has come could include such factors as acceptable void fraction, defined rate of minimal subsidence, defined backfilling rate to maintain design grade, etc. EPA, in consultation with the Commonwealth, will determine the acceptable subsidence criteria during remedial design and/or development of the Interim Site Management Plan.

The following activities will be undertaken during the Final Closure Period:

- Waste Burial
- Installation Of Final Cap
- Installation Of Permanent Surface Water Control Features
- Installation Of Surface Monuments

Prior to installation of the final cap, contaminated materials at the site will be buried in a new disposal trench on-site. These materials could include solidified leachate, leachate storage tanks, and on-site buildings which will be demolished during final remediation.

FIGURE 22



DIAGRAMATIC CROSS SECTION A – A'

LOCATION OF CROSS SECTION
SHOWN ON FIGURE 3-2

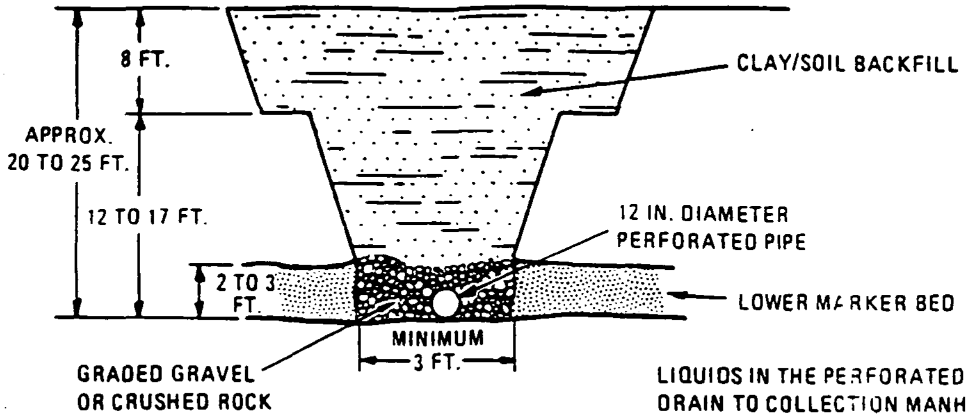
MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS

EBASCO SERVICES INCORPORATED

GROUNDWATER CUTOFF WALL AND COLLECTION WELLS FOR 40 SERIES TRENCHES

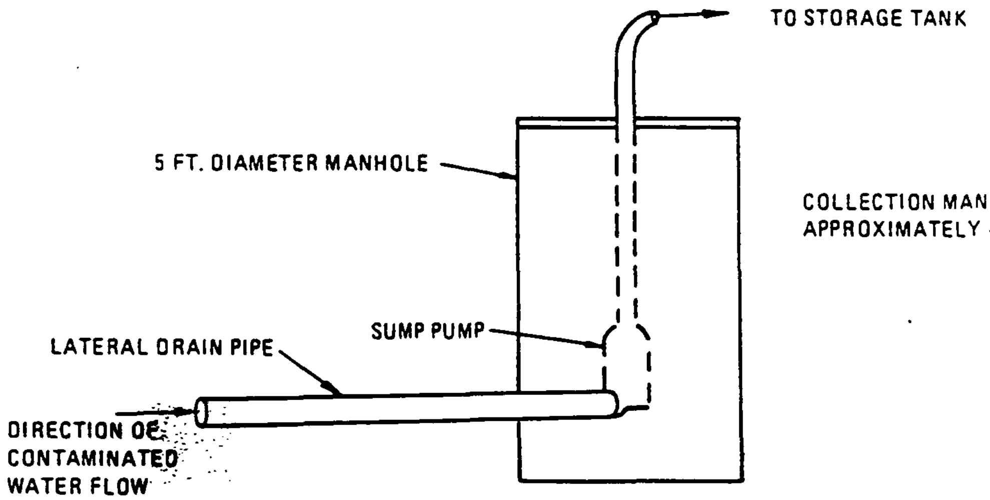
FIGURE 3-4

FIGURE 23



LIQUIDS IN THE PERFORATED PIPE WILL DRAIN TO COLLECTION MANHOLE (SEE DETAIL BELOW) AND PUMPED INTO A STORAGE TANK FOR TREATMENT AND DISPOSAL.

DETAIL 1



COLLECTION MANHOLES WILL BE SPACED APPROXIMATELY 400 FEET APART.

DETAIL OF COLLECTION MANHOLE

MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS

EBASCO SERVICES INCORPORATED

LATERAL DRAIN

FIGURE 3-3

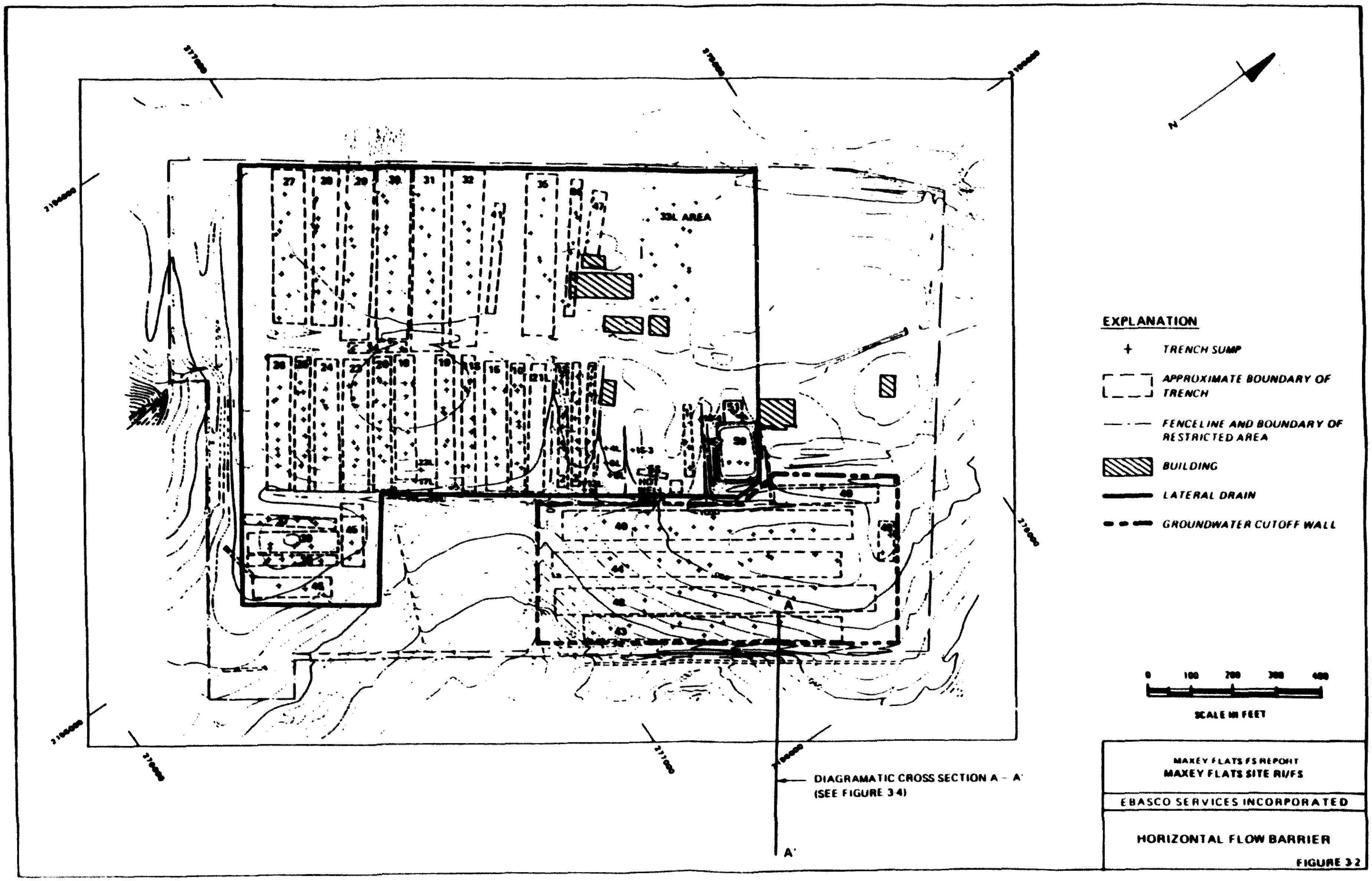

N
33L AREA
EXPLANATION
TRENCH SUMP
APPROXIMATE BOUNDARY OF TRENCH
FENCELINE AND BOUNDARY OF RESTRICTED AREA
BUILDING
LATERAL DRAIN
GROUNDWATER CUTOFF WALL
0 100 200 300 400
SCALE IN FEET
DIAGRAMATIC CROSS SECTION A - A'
(SEE FIGURE 3.4)
A
A'
MAXEY FLATS FS REPORT
MAXEY FLATS SITE RI/FS
EBASCO SERVICES INCORPORATED
HORIZONTAL FLOW BARRIER
FIGURE 3.2

FIGURE 24

Because the selected remedy involves disposal of a RCRA listed hazardous waste, the RCRA Subtitle C closure standards are applicable to the MFDS. Consequently, the final cap will be designed and constructed to promote drainage, minimize erosion of the cover, and provide long-term minimization of migration of liquids. The design criteria and allowable soil loss for the final cap will conform, at a minimum, to the standards established in EPA's "Cover for Uncontrolled Hazardous Waste Sites", EPA/540/2 - 85/002 (USEPA, 1985).

The trench disposal area and appropriate areas contiguous thereto will be covered by an engineered soil cap with a synthetic liner. It is expected that this cap, as described in Table 33, will consist of (from top to bottom) an initial layer of compacted soil placed over the existing trench cover, a two-foot thick clay layer, an 80 mil (or sufficiently similar) thick synthetic liner, a geotextile fabric layer, a one-foot-thick drainage layer, a geotextile fabric layer, and a two-foot thick soil layer supporting a vegetative cover. The compacted clay layer will have a permeability of 1×10^{-7} (0.1 feet/year) or less.

The final cap will be constructed primarily of naturally occurring materials that are stable in the Maxey Flats environment. To provide additional protection against vertical infiltration of water and to provide additional durability during the first few decades following installation, some synthetic materials will be integrated within the multi-layered structure of the final cap. The engineered soil cap with synthetic liner, when installed, will provide an effective barrier against vertical infiltration of water. The cap should last for a long period of time if (a) repairs are performed promptly, as needed, during the first few decades following installation, and (b) minor custodial maintenance is provided. The cap will direct percolating water away from the disposed waste by drainage layers and its sloped design. The multi-layer construction will resist degradation through geological processes and biotic activity. Additionally, the seeded topsoil layer will enhance erosion control. Erosion control will be an integral component of the final cap design. Cap erosion, hillslope erosion, and rates of surface water runoff to downslope areas will be considered during final cap design.

Effective, permanent surface water control systems will also be installed to limit infiltration and control surface water runoff and minimize hillslope and cap erosion to the extent

TABLE 34

FINAL CAP COMPONENTS

- Vegetative Cover: Erosion control
- Geotextile Fabric: This fabric beneath the upper soil layer will keep soil fines from settling in the drainage layer and, thus, reducing the effectiveness of the drainage layer
- Drainage Layer: This will consist of suitably graded crushed rock with a minimum permeability of 1×10^{-3} cm/sec; will provide a stable drainage path to erosion control drains
- Geotextile Fabric: This fabric between the drainage layer and synthetic liner will protect the liner from puncture during installation of the drainage layer
- Synthetic Liner: Will provide a backup to the clay infiltration barrier for the purpose of minimizing infiltration of water to the disposal trenches
- Two-Foot-Thick Clay Layer: Will provide a barrier with a permeability of 1×10^{-7} cm/sec or less.
- Initial Soil Layer: Will provide support and establish the desired design grade for subsequent layers

practicable. After the final cap is constructed, channels and drainage ditches carrying storm water runoff from the site will be improved to ensure stability for runoff events up to that which would result from a 100-year, 24-hour storm. It is expected that a significant amount of research data and information on new technologies will be developed throughout the Interim Maintenance Period. Thus, the design of the final cap and surface water control features may reflect these technological advances.

The monitoring and surveillance program, established in the Initial Closure Period, will continue to ensure compliance with state and federal regulations, to ensure the remedy is meeting the remedial action objectives, and to ensure that the remedy continues to provide protection of human health and the environment. Surface monuments will be erected at the site to notify persons of the presence of site contaminants and the dangers posed by site contaminants if the site is disturbed.

10.4 Custodial Maintenance Period

After the final cap has been constructed, the Custodial Maintenance Period will begin. The following activities will be performed during the Custodial Maintenance Period:

- Monitoring and Surveillance
- Five Year Reviews

The monitoring and surveillance program will continue to be implemented at the site. The frequency of monitoring activities described for the Interim Maintenance Period will likely be reduced during the Custodial Maintenance Period due to the presumed reduction of water infiltration into the trenches (i.e., reduced contaminant mobility) and reduced radionuclide activity. Site monitoring and surveillance will be carried out in perpetuity. Maintenance activities will be carried out, as necessary, to preserve the integrity of the remedy.

The Custodial Maintenance Period will initiate the institutional control period which must be maintained for at least 100 years following completion of the site closure as required by 902 KAR 100:022 and 10 CFR part 61 for all low level radioactive waste disposal sites. In addition, the perpetual maintenance fund will ensure that institutional control activities, including fencing and other activities to control access to the MFDS, periodic surveillance, custodial care, and filing of notices, survey plats, and deed restrictions with the appropriate authorities, will accomplish the goal of preventing inadvertent intrusion onto the MFDS and providing of custodial care in perpetuity. The fund will also provide for collection and analysis of samples and data.

SECTION 11.0 - STATUTORY DETERMINATIONS

Under its legal authorities, the U.S. EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, Section 121 of CERCLA establishes several other statutory requirements and preferences. One of the requirements specifies that, when complete, the selected remedial action for this site must comply with applicable or relevant and appropriate standards established under Federal and State environmental laws unless a statutory waiver is justified. The selected remedy also must be cost effective and must utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment technologies that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

11.1 Protection of Human Health and the Environment

Protection of human health and the environment will be achieved through the treatment, containment, engineering and institutional control components of the selected remedy.

Based upon the site risk assessment, unless remedial action is taken, exposure to drinking water, surface water, soil and sediments at, and in close proximity to, the site in the future would pose an unacceptable risk to human health. The risk assessment estimates that the risk from all combined on-site pathways at the MFDS, if no action is taken, could approach 1 (i.e., one additional case of fatal cancer for each person who would reside on-site). The risk assessment estimates that the risk from all combined off-site pathways at the MFDS, if no action is taken, could approach 6×10^{-2} (i.e., six additional cases of fatal cancer for every 100 persons engaging in the off-site exposure pathways as described in Section 6 of this document). The selected remedy will reduce these risks to a risk of 1×10^{-4} or less. EPA deems a risk of 10^{-4} to be generally protective of human health and the environment.

The extraction, solidification, and re-disposal of trench leachate will significantly reduce the mobility of radionuclides. Initial and final caps will significantly reduce the amount of vertical infiltration into the disposal trenches, thereby minimizing the production of leachate, thereby minimizing the migration of site contaminants into the environment. Surface water drainage improvements will help maintain the integrity of the remedy by controlling the rate of site erosion. Site monitoring and maintenance and institutional controls, funded and conducted in perpetuity, will prevent unintended use of the site, minimize the amount of exposure to site contaminants, and maintain the integrity of the remedy.

There are no short-term threats associated with the selected remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the remedy.

<u>11.2 Compliance With ARARs</u>

The selected remedy will comply with all applicable or relevant and appropriate requirements (ARARs) except for the RCRA Land Disposal Restrictions which are being waived pursuant to CERCLA Section 121(d). ARARs identified for the MFDS are presented in Section 8.0 of this document.

<u>11.3 Cost Effectiveness</u>

The selected remedy provides overall effectiveness in proportion to its cost. Alternative 5 is the least costly of the seven alternatives that underwent a detailed analysis, with the exception of the No Action alternative.

<u>11.4 Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable and Statutory Preference for Treatment as a Principle Element</u>

EPA and the Commonwealth of Kentucky have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the final source control remedy at the Maxey Flats Disposal Site. Of the alternatives evaluated and presented in this decision document, EPA and the Commonwealth have determined that this selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume achieved through treatment, short-term effectiveness, implementability, cost, also considering the statutory preference for treatment as a principal element and considering State and community acceptance.

While the selected remedy does not reduce the volume of waste present at the site, or offer treatment as a principal element, Alternative 5 does address the primary threat associated with the site; that of the migration of contaminated leachate into the environment. The selected remedy will achieve a reduction of the mobility of the contaminated leachate through solidification and prevention of the generation of new leachate, and will minimize erosion to the extent practicable to preserve the integrity of the remedy. The initial and final caps, surface water control features, monitoring and maintenance components, and other engineering features, as well as institutional controls will reduce or control site risks to the extent practicable.

Treatment of site wastes is not practicable at the MFDS due to the nature and volume of waste involved. Excavation and off-site disposal are not feasible at the MFDS due to the lack of facilities that could accept the volume and activity of the waste present at the MFDS and the greater risk to human health and the environment which would be associated with such activities. Furthermore, excavation of site wastes would not achieve the Commonwealth's applicable requirement - 902 KAR 100:015, which requires exposures to be kept to "As Low As Reasonably Achievable".

APPENDIX B

NUMERIC CRITERIA FOR APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

RELEVANT AND APPROPRIATE CONTAMINANT-SPECIFIC REQUIREMENTS FOR THE MAXEY FLATS DISPOSAL SITE SELECTED REMEDY

Clean Water Act - Water Quality Criteria (ug/l)

Chemical	Aquatic Life: Acute (1-Hour Average)	Aquatic Life: Chronic (4-Day Average)	Human Health[a]: Fish Only
Nickel	790/1400/2500[d]	88/160/280[e]	100
Vinyl Chloride	b	b	5246[c]
Benzene	5300[f]	b	400.0[c]
Chloroform	28,900[f]	1240[f]	157.0[c]
1,2-dichloroethane	118,000[f]	20,000[f]	2430.0[c]
Trichloroethylene	45,000[f]	21,900[f]	807.0[c]
Arsenic	b	b	.175[c]
Lead	34/82/200[d]	1.3/3.2/7.7[e]	b
bis(2-ethylhexyl) phthalate	940	3	b
Chlorobenzene	250[f]	50[f]	488
Toluene	17,500[f]	b	424,000

Notes:

a) Assumed intake is 6.5 grams of fish per day for a 70-year lifetime. EPA assumes an adult body weight is 70 kilograms.
b) Clean Water Act - Water Quality Criteria are not available for this contaminant.
c) The value was calculated assuming risk levels of 10^{-5} per lifetime.
d) Because the toxicity of nickel is dependant on hardness, EPA's acute criterion is expressed as a formula: $e^{(0.8460 [\ln (hardness)] + 3.3612)}$. The criteria above were calculated using this formula, assuming hardness equal to 50, 100, and 200 mg/l as $CaCO_3$.
e) EPA's formula for calculating chronic criteria is: $e^{(0.8460[\ln (hardness)] + 1.1645)}$. The criteria above were calculated using this formula, assuming hardness equal to 50, 100, and 200 mg/l as $CaCO_3$.
f) Lowest observed effect level.

TABLE A-1

APPLICABLE ACTION-SPECIFIC AND CONTAMINANT-SPECIFIC REQUIREMENTS FOR REMEDIAL ALTERNATIVES AT MAXEY FLATS

RADIOLOGICAL CONTAMINANTS

Ky Average Radionuclide Concentrations[1]
(uCi/ml)
(902 KAR 100:025)

	Table I[2]		Table II[3]	
	Air	Water	Air	Water
Strontium-90	1×10^{-9} (S)[4] 5×10^{-9} (I)[5]	1×10^{-5} 1×10^{-3}	3×10^{-11} 2×10^{-10}	3×10^{-7} 4×10^{-5}
Plutonium-238	2×10^{-12} (S) 3×10^{-11} (I)	1×10^{-4} 8×10^{-4}	7×10^{-14} 1×10^{-12}	5×10^{-6} 3×10^{-5}
Thorium-232	3×10^{-11} (S) 3×10^{-11} (I)	5×10^{-5} 1×10^{-3}	1×10^{-2} 1×10^{-2}	2×10^{-6} 4×10^{-5}
Americium-241	6×10^{-12} (S) 1×10^{-10} (I)	1×10^{-4} 8×10^{-4}	2×10^{-13} 4×10^{-12}	4×10^{-6} 3×10^{-5}
Cobalt-60	3×10^{-7} (S) 9×10^{-9} (I)	1×10^{-3} 1×10^{-3}	1×10^{-8} 3×10^{-10}	5×10^{-5} 3×10^{-5}
Cesium-137	6×10^{-8} (S) 1×10^{-8} (I)	4×10^{-4} 1×10^{-3}	2×10^{-9} 5×10^{-10}	2×10^{-5} 4×10^{-5}
Carbon-14	4×10^{-6} (S) 5×10^{-5} (Sub)[6]	2×10^{-2} -	1×10^{-7} 1×10^{-6}	8×10^{-4} -
Hydrogen-3 (tritium)	5×10^{-6} (S) 5×10^{-6} (I) 2×10^{-3} (Sub)	1×10^{-1} 1×10^{-1} -	2×10^{-7} 2×10^{-7} 4×10^{-5}	3×10^{-3} 3×10^{-3} -

1. For any possession or use of any source of ionizing or electronic product radiation and for regulating the disposal and handling of radioactive waste in restricted areas. Average concentrations of radioactivity in air or water above natural background. Exceptions exist.

2. Used for limiting individual exposure in restricted areas, sanitary sewer releases, and others.

3. Used for exposure to minors (under 18), exposure in unrestricted areas, exposure at the boundary of a restricted area, incident notification, and others.

4. (S) means Soluble.

5. (I) means Insoluble.

6. (Sub) means Submersion.

Source: Radioactive Materials 1986 (possession, use and disposal of radioactive waste and material), 902 KAR 100, Kentucky Cabinet for Human Resources.

CURRENT and PROPOSED MCLs, MCLGs, and SMCLs

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
INORGANICS			
Aluminum (1/91)			0.05-0.2
Antimony (7/90)	* 0.01/0.005	* 0.003	
Arsenic (NPDWR)	0.050		
Asbestos (1/91)	7 million fibers/liter (>10 um)		
Barium (NPDWR)	1.00		
Barium (1/91 **)	* 2	* 2	
Beryllium (7/90)	* 0.001	* 0	
Cadmium (1/91)	0.005	0.005	
Chloride (NSDWR)			250
Chromium (1/91)	0.1	0.1	
Color (NSDWR)			15 color units
Copper (8/88)	* 1.3	* 1.3	1
Corrosivity (NSDWR)			Noncorrosive
Cyanide (7/90)	* 0.2	* 0.2	
Fluoride (4/86)	4.0		2.0
Foaming Agents (NSDWR)			0.5
Iron (NSDWR)			0.3
Lead (NPDWR)	0.050		
(8/88)	* 0.005	* 0	
(6/90)	0.015 (Action Level)		

* - Proposed MCL and MCLG

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
Manganese (NSDWR)			0.05
Mercury (1/91)	0.002	0.002	
Nickel (7/90)	* 0.1	* 0.1	
Nitrite (as N) (1/91)	1	1	
Nitrate (as N) (1/91)	10	10	
Total (as N) (1/91)	10	10	
Odor (NSDWR)			3 threshold odor #
pH (NSDWR)			6.5 - 8.5
Selenium (1/91)	0.05	0.05	
Silver (1/91)			0.1
Sulfate (NSDWR)			250
Sulfate (7/90)	*400/500	*400/500	
Thallium (7/90)	* 0.002/0.001	* 0.0005	
Total Dissolved Solids (NSDWR)			500
Zinc (NSDWR)			5

* - Proposed MCL and MCLG

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
ORGANICS			
Acrylamide (1/91)	TT	0	
Adipates [Di(ethylhexyl)adipate] (7/90)	* 0.5	* 0.5	
Alachlor (1/91)	0.002	0	
Aldicarb (1/91 **)	* 0.003	* 0.001	
Aldicarb sulfone (1/91 **)	* 0.003	* 0.002	
Aldicarb sulfoxide (1/91 **)	* 0.003	* 0.001	
Atrazine (1/91)	0.003	0.003	
Benzene (7/87)	0.005	0	
Carbofuran (1/91)	0.04	0.04	
Carbon Tetrachloride (7/87)	0.005	0	
Chlordane (1/91)	0.002	0	
2,4-D (1/91)	0.07	0.07	
Dalapon (7/90)	* 0.2	* 0.2	
Dibromochloropropane (DBCP) (1/91)	0.0002	0	
o-Dichlorobenzene (1/91,5/89)	0.6	0.6	0.01
p-Dichlorobenzene (7/87)	0.075	0.075	
p-Dichlorobenzene (1/91,5/89)			0.005
1,2-Dichloroethane (7/87)	0.005	0	
cis-1,2-Dichloroethylene (1/91)	0.07	0.07	
trans-1,2-Dichloroethylene (1/91)	0.1	0.1	
1,1-Dichloroethylene (7/87)	0.007	0.007	
Dichloromethane (Methylene chloride) (7/90)	* 0.005	* 0	
1,2-Dichloropropane (1/91)	0.005	0	
Diquat (7/90)	* 0.02	* 0.02	
Dinoseb (7/90)	* 0.007	* 0.007	
Endothall (7/90)	* 0.1	* 0.1	
Endrin (NPDWR)	0.0002		
Endrin (7/90)	* 0.002	* 0.002	

* - Proposed MCL and MCLG

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
ORGANICS			
Epichlorohydrin (1/91)	TT	0	
Ethylbenzene (1/91,5/89)	0.7	0.7	0.03
Ethylene dibromide (EDB) (1/91)	0.00005	0	
Glyphosate (7/90)	* 0.7	* 0.7	
Heptachlor (1/91)	0.0004	0	
Heptachlor epoxide (1/91)	0.0002	0	
Hexachlorobenzene (7/90)	* 0.001	* 0	
Hexachlorocyclopentadiene[HEX] (7/90)	* 0.05	* 0.05	0.008
Lindane (1/91)	0.0002	0.0002	
Methoxychlor (1/91)	0.04	0.04	
Monochlorobenzene (1/91)	0.1	0.1	
Oxamyl [Vydate] (7/90)	* 0.2	* 0.2	
PAHs: (7/90)			
Benzo(a)pyrene	* 0.0002	* 0	
Benzo(a)anthracene	* 0.0001	* 0	
Benzo(b)fluoranthene	* 0.0002	* 0	
Benzo(k)fluoranthene	* 0.0002	* 0	
Chrysene	* 0.0002	* 0	
Dibenzo(a,h)anthracene	* 0.0003	* 0	
Indenopyrene	* 0.0004	* 0	

* - Proposed MCL and MCLG

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
Pentachlorophenol (1/91 **,5/89)	* 0.001	* 0	0.03
Phthalates			
[Di(ethylhexyl)phthalate] (7/90)	* 0.004	* 0	
Picloram (7/90)	* 0.5	* 0.5	
Polychlorinated biphenyls(PCBs) (1/91)	0.0005	0	
Simazine (7/90)	* 0.001	* 0.001	
Styrene (1/91,5/89)	0.1	0.1	0.01
2,3,7,8-TCDD (Dioxin) (7/90)	* 5x10E-8	* 0	
Tetrachloroethylene (1/91)	0.005	0	
Toluene (1/91,5/89)	1	1	0.04
Toxaphene (1/91)	0.003	0	
2,4,5-TP Silvex (1/91)	0.05	0.05	
1,1,2-Trichlorethane (7/90)	* 0.005	* 0.003	
1,2,4-Trichlorobenzene (7/90)	* 0.009	* 0.009	
1,1,1-Trichloroethane (7/87)	0.20	0.20	
Trichloroethylene (7/87)	0.005	0	
Trihalomethanes (NPDWR)	0.100		
Vinyl Chloride (7/87)	0.002	0	
Xylenes (1/91,5/89)	10.00	10.00	0.02

* - Proposed MCL and MCLG

CHEMICAL	MCL (ppm)	MCLG (ppm)	SMCL (ppm)
MICROBIALS			
Coliform bacteria (6/89)	< 1/100 ml	0	
Giardia lamblia (6/89)	TT	0	
Heterotrophic bact. (6/89)	TT	0	
Legionella (6/89)	TT	0	
Viruses (6/89)	TT	0	
Turbidity	1 TU (up to 5 TU)	(units of turbidity)	
RADIONUCLIDES			
Beta particle and photon radioactivity	4 mrem	0	
Gross Alpha particles	15 pCi/l	0	
Radium-226 and Radium-228 (Total)	5 pCi/l	0	

* - Proposed MCL and MCLG

FOOTNOTES

11/85	50 Federal Register (FR), November 13, 1985
4/86	51 FR, April 2, 1987 - Final MCLs and SMCLs
7/87	52 FR, July 8, 1987 - Final MCLs and MCLGs
8/88	53 FR, August 18, 1988 - Proposed MCLs and MCLGs
5/89	54 FR, May 22, 1989 - Proposed SMCLs
6/89	54 FR, June 29, 1989 - Final MCLs and MCLGs
6/90	Action level for lead in drinking water, June 21, 1990, Memorandum from the Office of Emergency and Remedial Response and the Office of Waste Program Enforcement
7/90	55 FR, July 25, 1990 - Proposed MCLs, MCLGs, and SMCLs
1/91	56 FR, January 30, 1991 - Final MCLs, MCLGs, and Proposed SMCLs
1/91 **	56 FR, January 30, 1991 - Re-proposed MCLs and MCLGs

MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
NPDWR	National Primary Drinking Water Regulation
NSDWR	National Secondary Drinking Water Regulation
PAHs	Polynuclear Aromatic Hydrocarbons
SMCL	Secondary Maximum Contaminant Level
TT	Treatment Technique

* - Proposed MCL and MCLG

APPENDIX D

SUPERFUND FACT SHEET PROPOSED PLAN - MAXEY FLATS DISPOSAL SITE

Superfund Fact Sheet — Proposed Plan

EPA Region IV

Maxey Flats Disposal Site
Fleming County, Kentucky

May 1991

INTRODUCTION

This Proposed Plan identifies the preferred remedy for the Maxey Flats Low-Level Radioactive Waste Disposal Site (MFDS). In addition, the Proposed Plan includes summaries of other **remedial alternatives** that were analyzed for this site. This document was developed by the U.S. Environmental Protection Agency (EPA), the lead agency responsible for remediation of the MFDS. EPA, in consultation with the Kentucky Natural Resources and Environmental Protection Cabinet and the Kentucky Human Resources Cabinet, will select the remedy for the MFDS only after public comment on this Proposed Plan and the comments submitted during the public comment period have been reviewed and considered.

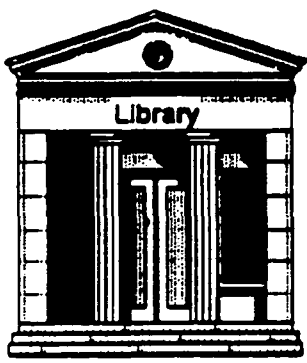
EPA will seek to resolve the question of financial responsibility for site remediation and implementation of **institutional controls** through settlement negotiations with the Commonwealth of Kentucky and other Potentially Responsible Parties (PRPs) after the **Record of Decision** is signed by EPA. Thus, this Proposed Plan is not intended to delineate the mechanism(s) by which a remedy will be implemented or to assess responsibility for site closure. Rather, it is intended to describe, primarily, the preferred remedy and the community's role in remedy selection. For reader information, terms highlighted in **bold** within this document are explained in the glossary at the end of the document.

EPA has issued this Proposed Plan as part of its public participation responsibilities under Section 117(a) of the **Comprehensive Environmental Response, Compensation and Liability Act** (CERCLA). Information contained in this Proposed Plan can be found in greater detail in the Remedial **Investigation and Feasibility Study** (RI and FS) Reports and other documents contained in the **Administrative Record** for this site. EPA encourages the public to review the other documents in order to gain a more comprehensive understanding of the site and Superfund activities that have been conducted thus far at the MFDS. The Administrative Record, which contains the information upon which the selection of a remedy is based, will be available on or before June 13, 1991at the following:

INFORMATION REPOSITORIES

Fleming County Public Library
303 South Main Cross Street
Flemingsburg, Kentucky 41041
(606) 845-7851

Hours: Monday - Saturday 9 - 5 p.m.
Thursday - 9 - 5 p.m. and 6:30 - 8:30 p.m.



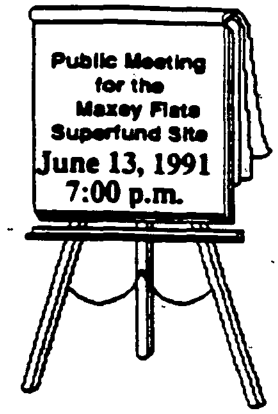
Rowan County Public Library
129 Trumbo Street
Morehead, Kentucky 40351
(606) 784-7137

Hours: Monday, Thursday	10 - 8 p.m.
Tues., Wed., Friday	10 - 5 p.m.
Saturday	9 - 3 p.m.
Sunday, Holidays	Closed

and

U.S. EPA Records Center
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365
(404) 347-0506
Hours: Mon. - Fri. 8:00 a.m. to 5: 00 p.m.

EPA may modify the preferred remedy or select another response action presented in this Proposed Plan and the FS Report based on new information or public comments. Therefore, the public is encouraged to review and comment on all the alternatives identified here. A Glossary of Terms can be found at the end of this Proposed Plan to define the highlighted terms used throughout this document.



Dates to remember:
MARK YOUR CALENDAR

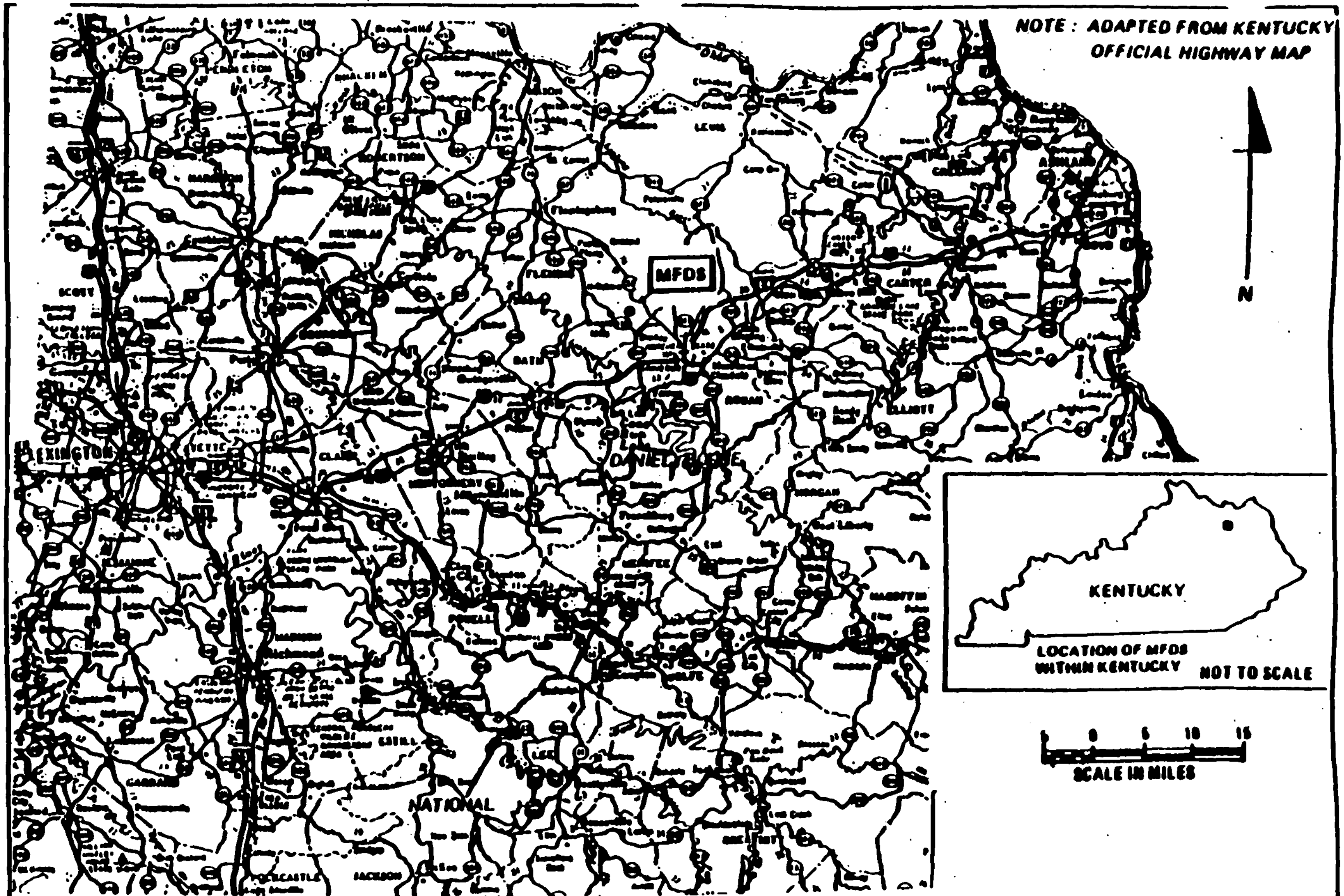
June 13, 1991.
Public Meeting at the Ersil P. Ward (formerly Fox Valley) Elementary School,
State Road 32, Fleming County, Kentucky
at 7:00 p.m.

SITE HISTORY

The Maxey Flats Disposal Site (MFDS) is located approximately 10 miles northwest of the City of Morehead, Kentucky and approximately 17 miles south of Flemingsburg. The MFDS itself occupies 280 acres in eastern Fleming County and is located on a ridge approximately 350 feet above the valley floor. (See site area maps One and Two on the following two pages.) The site was purchased by a private company, Nuclear Engineering Company (NECO, currently known as U.S. Ecology), and the ownership of the land was transferred to the Commonwealth in 1963. The Commonwealth issued a license, effective January 1963, to NECO to dispose of low-level radioactive wastes, and leased the property to NECO. From May 1963 to December 1977, NECO managed and operated the disposal of low-level radioactive waste at the MFDS. It is estimated that 4,750,000 cubic feet of waste materials were disposed of at the MFDS.

Low-level radioactive waste (LLRW) is material that has come in contact with radioactive material or that is, itself, a source of low levels of radiation. Among other sources, LLRW comes from nuclear power plants in the form of filter materials or protective clothing, from hospitals and universities as laboratory and diagnostic waste, and from diverse industries such as drug manufacturers and producers of well-drilling equipment that utilize radioactive sources. By definition, LLRW does not include spent nuclear fuel or weapons-grade nuclear material.

In order to protect public health and the environment from exposure, LLRW must be isolated while its radioactivity is decaying. To achieve this isolation at the MFDS, LLRW was deposited at the site using the shallow land burial disposal technology. The waste was disposed of in 46 large trenches (some up to 680 feet long, 70 feet wide and 30 feet deep) which cover approximately 27 acres of land within a 45-acre fenced portion of the site known as the **Restricted Area**. However, "**hot wells**" were also used at the MFDS for the burial of small-volume wastes with high specific activity. Most of the "hot wells" are 10 to 15 feet deep, constructed of concrete, coated steel pipe or tile, and capped with a large slab of concrete.



MAP PRODUCED BY EBASCO SERVICES INCORPORATED AND LABELLED FOR THIS REPORT BY BOOZ, ALLEN & HAMILTON, Inc.

MAXEY FLATS DISPOSAL SITE
LOCATION MAP

MAP 1

MAP PRODUCED BY EBASCO SERVICES INCORPORATED AND LABELLED FOR THIS REPORT BY BOOZ, ALLEN & HAMILTON, Inc

MAXEY FLATS DISPOSAL SITE
VICINITY MAP

MAP 2

The trench wastes were deposited in both solid and solidified-liquid form. Some wastes arrived at the site in containers such as drums, wooden crates, and concrete or cardboard boxes. Other wastes were disposed of loosely. Fill material (soil), typically 3 to 10 feet in thickness, was then placed over the trenches to serve as a protective cover. After 1977, six additional trenches were excavated for the disposal of material generated on-site. (See trench location map on following page.)

Unexpected problems arose at the site in the early 1970s. It then became apparent that water entering the trenches had become the pathway by which radioactive contaminants — primarily Tritium, a radioactive form of hydrogen — were beginning to slowly migrate out of the disposal trenches. The Commonwealth of Kentucky conducted a special study of the site in 1974 to determine whether the MFDS posed a contamination problem. The study confirmed that Tritium and other radioactive contaminants were migrating out of the trenches and that some radionuclides had migrated off-site.

In 1977, while constructing a new trench, it was discovered that leachate was migrating through the subsurface geology (approximately 25 feet below ground surface). Subsequently, the Commonwealth ordered NECO to stop receiving and burying radioactive waste. In 1978, the Commonwealth and NECO entered into an agreement under which NECO's lease was terminated. The Commonwealth then hired private companies such as Westinghouse Electric Corporation (the current site custodian) to stabilize and maintain the site.

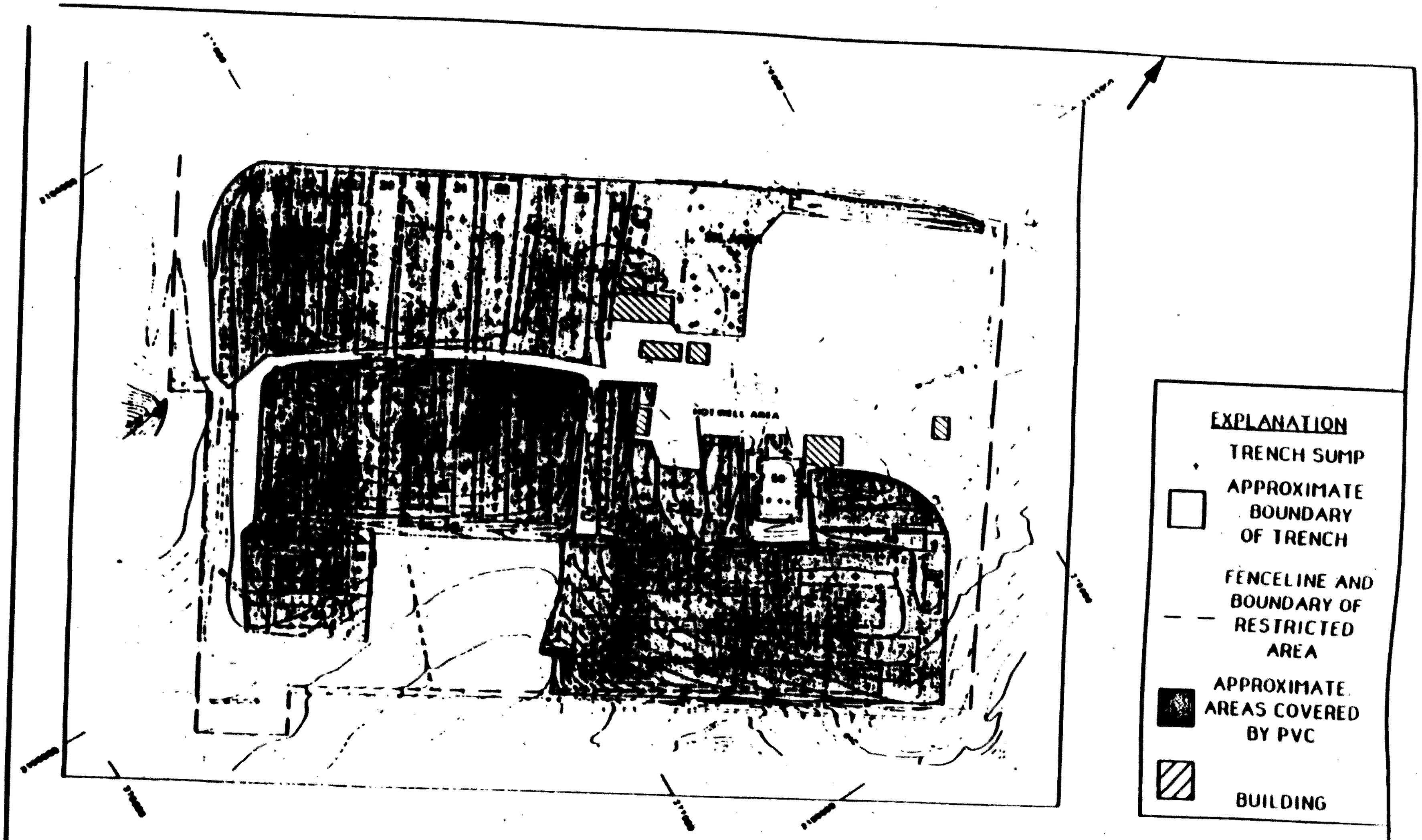
Those steps, however, were temporary and a final closure plan was needed to correct the problem at the MFDS. EPA, therefore, proposed the MFDS for inclusion on the National Priorities List (NPL) of hazardous waste sites to be addressed under the Superfund Program in 1984 and, in 1986, this action was finalized. A group of organizations who participated in waste disposal at the site (named as Potentially Responsible Parties [PRPs]) joined together as the Maxey Flats Steering Committee (Committee). The Committee conducted and partially funded the technical work required for the Remedial Investigation/Feasibility Study performed at the site. The largest portion of costs incurred in conducting the RI/FS were paid by the Department of Defense (DOD) and the Department of Energy (DOE), both named as PRPs but not members of the Committee. These actions have now culminated in a preferred remedy being prepared by the EPA.

On January 13, 1989, EPA, through the Technical Assistance Grant (TAG) program, provided $50,000 (the maximum available under the Superfund Program) to the Maxey Flats Concerned Citizens (MFCC). This money was granted to MFCC for the purpose of hiring technical advisors to help the local community understand and interpret site-related technical information and advise the community on its participation in the decision-making process.

REMEDIAL INVESTIGATION CONCLUSIONS

The Remedial Investigation (RI), which was initiated at the Maxey Flats Disposal Site (MFDS) in 1987, included the collection of more than 700 samples at, and adjacent to, the Maxey Flats site, from environmental media such as trench leachate, soil, ground water, surface water, stream sediment, and ground water. These samples were analyzed for a variety of radiological and non-radiological (chemicals, metals, etc.) constituents.

The RI identified a large range of contaminant concentrations in samples collected from trenches in different parts of the Restricted Area. In addition, site records indicate that sample analyses (Tritium, gross alpha and beta particle analyses) from the same trench sump yield varying concentrations at different times. Approximately 2.8 million gallons of leachate were calculated to be in the trenches. The trench leachate contains a variety of radionuclides (of which Tritium is the most predominant). In general, the non-radiological chemical concentrations in trench leachate samples were low (less than 10 parts per million for organics) and all samples analyzed in compliance with the Resource Conservation and Recovery Act (RCRA) yielded negative results.



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MAXEY FLAT DISPOSAL SITE
TRENCH SUMPS, AND BUILDINGS IN RESTRICTED AREA MAP

MAP 3

The RI demonstrated that on the west side of the site, trench leachate migrates horizontally through fractures in a thin siltstone geologic layer called the Lower Marker Bed, which lies approximately 15 feet below ground surface in that area. On the east side, the horizontal migration occurs in the fractured siltstone layers of another geologic layer, the Farmers Member, which begins approximately 40 feet below ground level. (See Geologic Cross Section of site on following page.) Vertical migration between geological layers is limited by shale layers of low permeability, which act as aquitards. Because the MFDS is bounded on three sides by steep slopes, the contaminated leachate migrating through the fractured siltstone layers moves into the bottom of the soil layer on these slopes. However, not all leachate migrates to the bottom of the soil layer on the slopes, as evidenced by the occurence of seeps on the east hillside.

The RI determined that ground water samples taken from monitoring wells in the Lower Marker Bed had higher Tritium concentrations (up to 2,000,000 pCi/ml) than samples taken from deeper geologic units. These Tritium concentrations and the presence of other radionuclides indicate that the contamination was caused by trench leachate. On the east side of the site, the Forty-Series trenches, which commonly bottom near the top of the Farmers Member, provide Tritium and other contamination to the Farmers Member.

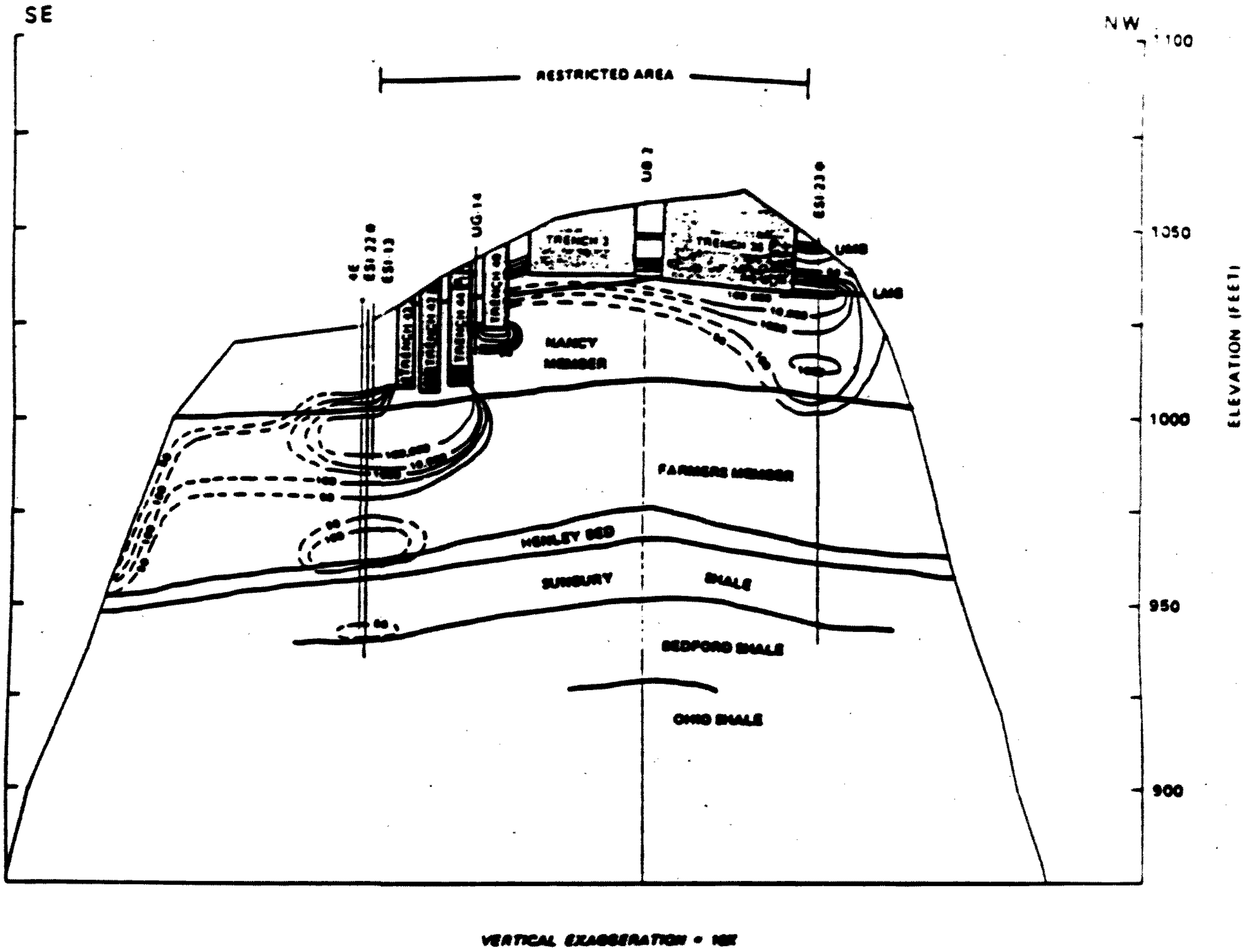
In the soils on the three slopes adjacent to the site, Tritium is the predominant contaminant, with the largest contaminated areas and highest levels of Tritium contamination on the upper part of the northwest side of the site. Other contaminants detected in soils which could be attributed to the MFDS include Cobalt-60, Toluene, and Arsenic. Previous testing along the soil-rock interface by the Commonwealth also indicated the presence of radionuclides such as Strontium-90, Carbon-14, and Plutonium-238 and -239.

Surface water and sediment investigations during the RI involved the collection and analyses of samples from three principal locations: Restricted Area surface water runoff (which exits the site through three water control structures located at the periphery of the Restricted Area), from off-site creeks, which receive runoff from the MFDS, and from off-site sources.

Tritium and Radium-226 were the only radionuclides detected in the surface water samples during the RI. Concentrations of Tritium were highest at the water control structures adjacent to the Restricted Area. The principal sources of Tritium entering these structures are contaminated liquids, which have migrated from the trenches to the slopes through fractured bedrock, and atmospheric releases of tritium from the trenches. Tritium levels in the surface water ranged from less than 10 pCi/ml to 60 pCi/ml. Tritium ranged in concentration from less than 10 pCi/ml to 70 pCi/ml in sediment moisture. Analytical results show low concentrations (ranging from 5 ppb to 98 ppb) of chemical constituents in surface water. Sediment sample analyses indicated chemical constituents ranging from 5 parts of the chemical per billion parts of the unit sampled (parts per billion or ppb) to 1800 ppb. The probable source of the higher concentrations (phthalate esters) is the PVC used to cover the trenches because the concentrations were highest at the sample stations adjacent to the Restricted Area, and the phthalate ester was only detected in samples associated with surface water runoff from the Restricted Area.

The Commonwealth of Kentucky has detected Strontium-90 in surface water in the East Main Drainage Channel. The Commonwealth has also detected Strontium-90 in the east pond, at the east pond outlet, and in the south drainage area. Additionally, the Commonwealth has detected Tritium concentrations in various site drains in excess of 1000 pCi/ml.

In summary, the decay of containers (cardboard, wooden, metal, etc.) over time has allowed the trench cover to settle because the containers no longer provide sufficient structural support for the trench cover. A ponding effect has resulted from the collection of rainfall and snowmelt in the subsided trench cover. The infiltration of precipitation through the cracked and subsided cover generates trench leachate which creates an additional hydraulic head, forcing more leachate out of the slopes into the environment. This decay, collapse, and ponding effect, as studied and docu-



EXPLANATION

CONTOUR INTERVALS:

50 pCi/ml
100 pCi/ml
1000 pCi/ml
10,000 pCi/ml
100,000 pCi/ml
1,000,000 pCi/ml

* MONITORING WELLS SAMPLED AND ANALYZED FOR TRITIUM IN PORE WATER

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MAXEY FLATS DISPOSAL SITE
GEOLOGIC CROSS SECTION MAP

MAP 4

mented during the Maxey Flats RI and numerous studies conducted previously, have resulted in the migration of radionuclides from the trench disposal area.

SUMMARY OF SITE RISKS

As part of the RI/FS, an assessment of site risks was performed using existing site data and information gathered during the Remedial Investigation, to evaluate the nature and extent of contamination at the Maxey Flats Disposal Site (MFDS) and to identify the contaminants, transport mechanisms, and exposure pathways which pose the greatest potential threat to human health and the environment. The Risk Assessment evaluated the risk associated with a No Action alternative, which assumed that the site would be abandoned and that no activity would take place, other than monitoring.

Potential routes of exposure to contaminants, or exposure pathways, were developed based on both the current site conditions and the traditional pathways examined for a public health evaluation. The potential contamination sources include trench material, leachate, site structures, above-ground tanks, ground surfaces, ground water, and soil. Potential exposure routes include the ingestion of crops and animal products, including fish, game and livestock; the inhalation of air; and direct contact (e.g., dermal contact, ingestion, intrusion) with contaminated media.

Two sets of potential exposure pathways were evaluated for the MFDS. The first, referred to as non-intruder pathways, assumed that the site would be abandoned, but then an individual would move onto and construct and occupy a dwelling in an area of the abandoned site, currently known as the Restricted Area.

Non-intruder pathways include the following:

- Surface Water Pathway -- In this pathway, contaminants move off-site in ground water and enter the surface water system. The stream water is then used as a drinking water and irrigation source for beef and milk cows and their forage. Humans then ingest the animal products.

- Evapotranspiration Pathway -- This pathway involves the uptake of contaminated liquid into plants and evapotranspiration of the contaminants to the environment. (Note: Evapotranspiration is the release of water vapor from plants to the atmosphere.) Tritium is the only contaminant to move by this pathway. Once released to the air, the tritium could be incorporated into food and drinking water sources or directly inhaled by a human.

- Deer Pathway -- In this pathway, contaminated water moves through the ground water system to the hillsides adjacent to the site. Upon reaching the hillside, the contamination is incorporated into plants. The contaminated plants are then eaten by deer foraging on the slopes. Also the deer drinks contaminated water from the streams. The contaminants are then incorporated into the meat of the deer. A hunter kills the deer and ingests the meat.

- Sediment Pathway -- This pathway involves the movement of contaminants in ground water to the hillsides adjacent to the site and into the surface water system (streams). As the contaminated surface water moves through the stream bed, some of the contaminants adhere to the soils in the stream bed. Then through the course of play in the stream beds, a child ingests the contaminated soils.

- Well Water Pathway -- This pathway involves the movement of contaminants in ground water to the hillsides adjacent to the site and into the surface water system moving down the hillsides. At the bottom of the hillsides, the contaminated runoff recharges the alluvium (soils). A well is excavated in the contaminated alluvium and a family uses the well as a source of drinking water for a family.

- Soil Erosion Pathway -- This pathway involves the resuspension in air of soil particles contaminated with radionuclides and the washing of soil into the surface water. It is assumed that the trenches overflow with contaminated liquids and radionuclides adhere to surface soils adjacent to the trenches. The leachate subsides in the trenches and the surface soils dry. This dry contaminated soil is then suspended in air and carried to a person and inhaled or washed away in runoff. Also, crops are grown on an area of alluvium (base of hillsides) contaminated by surface runoff. A person ingests contaminated farm products and is exposed to external radiation.

- Trench Sump Pathway -- This pathway involves the escape of tritiated water from trenches via trench sumps and cracks in the trench cap. A person then inhales the contaminated air.

The second set of potential pathways, the intruder pathways, also assumed that the site would be abandoned. Non-intruder pathways, however, primarily involve off-site paths of exposure, which are not associated with occupation of the site. The intruder pathways include the following:

- Intruder-Construction Scenario -- This pathway involves the assumption that no controls exist for the site and an intruder inadvertently occupies the disposal site and begins construction activities. Construction activities penetrate and expose the waste. Human exposure would occur through external exposure to the contaminated soil and inhalation of contaminated air.

- Intruder-Discovery Scenario -- This pathway assumes that, during the above-described construction scenario, the intruder contacts solid remains of waste or barriers, realizes that something is wrong, and ceases construction activities.

- Intruder-Agricultural Scenario -- This pathway involves the assumption that no controls exist for the site and an inadvertent intruder occupies the site. After some construction activities, the intruder (site resident) begins agricultural activities. It is assumed that some percent of the intruder's annual diet comes from crops raised in the contaminated soil and from food products produced by animals. External exposure and ingestion of contaminated ground water from a well are also included. It is also assumed that a quantity of contaminated soil is ingested by a child during play or an adult at work in the fields. Inhalation of resuspended contaminated soil and the migration of radon into the intruder's basement is also included in this pathway.

- Intruder-Well Scenario -- This pathway involves an intruder drilling a well near a disposal cell and consuming contaminated ground water.

Of the contaminants identified at the MFDS, a set of contaminants, called indicator contaminants, represent the greatest potential for impacting human health. Two groups of indicators were selected, radionuclides and non-radionuclides. The radionuclides chosen are Hydrogen-3 (Tritium), Carbon-14, Cobalt-60, Strontium-90, Technetium-99, Iodine-129, Cesium-137, Radium-226, Thorium-232, Plutonium-238, Plutonium-239, and Americium-241. The nonradioactive chemical indicators are Arsenic, Benzene, Bis(2-Ethylhexyl) Phthalate, Chlorobenzene, Chloroform, 1,2-Dichloroethane, Lead, Nickel, Toluene, Trichloroethylene, and Vinyl Chloride. These indicators were used in the analyses of potential risks associated with the exposure pathways described above.

<u>Non-intruder Risks</u>

If no action were taken at the site, the average exposure to off-site individuals from all indicators and from all combined non-intruder pathways would be a total dose equivalent of 75 millirems per year (mrem/yr), almost half of which is attributable to Tritium. The upper bound estimate for such a scenario would total 4300 mrem/year. For each year of exposure, under a No Action alternative, it is estimated that the average case (75 mrem) lifetime risk of cancer would be 3×10^{-5} (or three in 100,000) and for the upperbound case (4,300 mrem) it would be 1×10^{-3} (one in 1,000). EPA's target risk range is 1×10^{-4}, or one additional occurence of cancer in 10,000, to 1×10^{-6} which equates to one additional occurence of cancer in 1,000,000. The average case lifetime risk of cancer from many successive years of exposure would be approximately 1×10^{-3} or one in 1,000, and the upperbound cancer risk would be 6×10^{-2} or six in 100. In both cases, the risk significantly exceeds EPA's target risk range and the MFDS remediation goal of 25 mrem/year.

In addition, during the 70-year time frame, the time frame that is typically used to calculate risks at Superfund sites, Tritium and Strontium-90 would exceed drinking water limits in water extracted from wells at the base of the slopes. Furthermore, Tritium, Strontium-90, and Radium-226 would exceed drinking water limits at this location during the 500 year time frame. Assessments using the 500-year time frame were made for the MFDS because of the long-lived radionuclides present.

Intruder Risks

For the most significant of the intruder pathways, the Intruder-Agricultural Pathway, whereby a person occupies a house on-site, the average case exposure totals a dose equivalent of 26,000 mrem/year under a No Action alternative. Under the same scenario, the upperbound estimate would total 1,000,000 mrem/year. Forty-three percent of the impacts would be derived from drinking water, another 47 percent from food produced on-site, and 10 percent from external exposure. For each year a person would live on-site, under the no action alternative, the average case lifetime risk of cancer would be approximately 1×10^{-2} or one in 100. Under the same scenario, the upper bound case risk of cancer would be 4×10^{-1} or four in 10. Both cases significantly exceed EPA's target risk range. Prolonged exposures (many successive years) would result in a lifetime risk of cancer approaching one additional case of cancer for each person who would reside on the site.

Assuming that occupancy of the site would not occur for 100 years, the doses and associated risks under a No Action alternative would decrease, but only by a small margin because most of the exposure is associated with the relatively long-lived radionuclides. Tritium and Strontium-90 would no longer contribute to the dose because they would have decayed away, and the longer-lived radionuclides, such as Radium-226, Thorium-232, and Plutonium-238 would become the significant dose contributors. Beyond 100 years, the risks associated with the MFDS remain unacceptably high and tend to become constant rather than decreasing significantly. Even after 500 years, on-site occupancy would result in risks exceeding the acceptable risk range. For this reason, the need for implementation and funding of institutional controls, maintenance, and monitoring in perpetuity is apparent.

The threatened release of hazardous substances from the MFDS, if not addressed by the preferred remedy or one of the other active measures considered, may present a potential threat to public health, welfare, or the environment.

SUMMARY OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

Section 121(d) of CERCLA requires that at the completion of remedial action, the remedy should achieve a level of control which complies with federal and state environmental laws that are applicable or relevant and appropriate to the hazardous substances, pollutants, or contaminants at the site. Therefore, to be selected as the remedy, an alternative must meet all Applicable or Relevant and Appropriate Requirements (ARARs) or a waiver must be obtained. Appendix A of the Maxey Flats site Feasibility Study Report should be consulted for a complete discussion of ARARs that apply to the Maxey Flats site. The following is a list of major requirements that must be met by the selected remedy:

- Occupational Safety and Health (OSHA) Standards (29 Code of Federal Regulations or CFR, Parts 1910.120, .1000 - .1500, Parts 1926.53, .650 - .653)

- National Emission Standards for Hazardous Air Pollutants (40 CFR 61.92)

- Kentucky and Federal Radiation Protection Standards (902 KAR 100:020, :025, Table I, Table II, and 10 CFR 20.105)

- Kentucky Licensing Requirements for Land Disposal of Radioactive Waste (902 KAR 100:022)

- Kentucky Standards for the Disposal of Radioactive Material (902 KAR 100:021, Sections 7 and 8)

- General Kentucky Requirements Concerning Radiological Sources (ALARA) (902 KAR 100:015, Sections 1 and 2)

- Kentucky Fugitive Air Emissions Standards (401 KAR 6:015)

- Federal Drinking Water Regulations (40 CFR Part 141, Subpart G), and

- *Resource Conservation and Recovery Act (RCRA) (currently under consideration as a potential ARAR)

The points of compliance at the Maxey Flats Disposal Site for some of the previously ARARs are as follows:

- National Emissions Standards for Hazardous Air Pollutants - the effective dose equivalent of 10 mrem per year will be judged at the site property boundary

- Kentucky and Federal Drinking Water Standards - the point of compliance for these standards begins at the contact of the alluvium with the hillside and ending at the streams; compliance will be based on samples taken in the alluvium

- Kentucky Licensing Requirements for Land Disposal of Radioactive Waste - the 25 mrem per year dose limit set forth in this requirement will be judged on the combined doses contributed by the air, water, drinking water and soil pathways. The point of compliance for this requirement will be the maximum point of individual exposure which is at or beyond the site boundary.

Under the Superfund program, the selected remedy must meet all applicable or relevant and appropriate requirements (ARARs), which include federal and state standards, or a waiver must be obtained. If a state has a more stringent, promulgated standard than its federal counterpart, the more stringent state standard shall be used. The Commonwealth of Kentucky has identified a state standard, which it considers to be an ARAR: KRS 224.877(4). This is a narrative, non-degradation requirement which requires restoration of the environment to the extent practicable.

EPA considers KRS 224.877 to be a general goal, which does not set out a specific, enforceable cleanup standard that is more stringent than federal law, and which is not a binding requirement. For this reason, EPA does not consider it a cleanup ARAR.

* Because of the possible presence of hazardous wastes at the MFDS, EPA currently is considering whether RCRA is an ARAR and if so, EPA is considering the possibility of an ARARs waiverwith respect to the Land Disposal Restriction portion of RCRA. The partial RCRA waiver for the site would be based upon technical impracticability and/or greater risk to human health and the environment. Waivers of ARARs are allowed under CERCLA Section 121(d).

SUMMARY OF ALTERNATIVES

The primary objective of the Feasibility Study (FS) is to ensure that appropriate remedial alternatives are developed and evaluated such that relevant information concerning the remedial action options can form the basis for remedy selection. The FS describes and evaluates options for mitigating unacceptable levels of current or future potential risks associated with exposure to site contaminants. Information contained in the RI Report, Risk Assessment, and other site data are considered in the FS to develop these options. Subsidence of waste disposal trenches is the lowering of the trench caps due to waste and cap consolidation over time. Areas affected by subsidence can range in size from a few square feet of a cap to the entire area occupied by a trench or group of trenches. Subsidence can cause cap failures by cracking or deforming the cap materials. Depressed areas commonly result in ponding of rain water, which would have run off naturally if subsidence had not occurred. Both of these phenomena can lead to increased rates of water infiltration into the waste. Therefore, subsided areas may require repair to prevent accumulation of leachate in the trenches.

Slow subsidence is evident in most waste disposal trenches at the MFDS. After a few years, therefore, soil must be added to the trench surfaces and the caps must be regraded to maintain surface water runoff. Subsidence results from a complex interaction of physical and chemical processes in the waste mass and, in time, subsidence works to consolidate the waste and trench cap materials into a smaller volume, resulting in a denser, more consolidated mass.

The objectives of any remedial alternative considered for the MFDS are to:

- Stabilize the site such that an engineered cap could be placed over the trench disposal area with minimal long-term care and maintenance;
- Protect human health and the environment (meet all Applicable or Relevant and Appropriate Requirements);
- Control infiltration into the trenches and migration from the trenches;
- Address site concerns at the community, state and federal levels.

Eighteen potential remedial alternatives capable of achieving the remedial action objectives at the MFDS were developed and evaluated. These 18 alternatives were then screened on the basis of their effectiveness, implementability and cost. This screening produced a manageable group of seven alternatives. Each of the seven alternatives was then subjected to a detailed analysis which applied the nine evaluation criteria established by the Superfund Amendments and Reauthorization Act (SARA).

The nine criteria used to evaluate alternatives at Superfund sites are as follows:

- Short-term effectiveness -- addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until remedial action objectives are achieved.
- Long-term effectiveness -- refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time.
- Reduction of toxicity, mobility or volume -- is the anticipated performance of the treatment technologies a remedy may employ.
- Implementability -- the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

- Compliance with ARARs -- addresses whether a remedy will meet all of the ARARs of Federal and State environmental laws and/or justifies a waiver.
- Overall protection of human health and the environment -- addresses whether a remedy provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.
- Cost -- includes estimated capital and operation and maintenance (O & M) costs, also expressed as net present-worth costs.
- State acceptance -- indicates whether, based on its review of the RI/FS Reports and Proposed Plan, the State concurs with, opposes, or has no comment on the preferred alternative.
- Community acceptance -- Community acceptance summarizes the public's general response to the alternatives, based on public comment received during the public comment period.

Although overall protection of human health and the environment is the primary objective of the remedial action, the remedial alternative(s) selected for the site must achieve the best balance among the evaluation criteria, considering the scope and degree of the site contamination.

Certain components (baseline features) are common to all remedial alternatives in the FS Report for the MFDS, with the exception of the No Action Alternative. Thesebaseline features are as follows:

- Demolition of site structures and decommissioning of site facilities
- Construction of additional disposal trenches
- Procurement of a buffer zone adjacent to the existing site property, and
- Institutional controls.

The seven alternatives receiving detailed analysis in the FS Report are described below and the approximate cost figures and design/construction times for each alternative are presented in Table 1on page 18, following the description of alternatives.

ALTERNATIVE 1 - NO ACTION

The Superfund Program requires that the No Action alternative be considered at every site. It serves as a baseline by which other alternatives are compared and it must be carried through the detailed analysis of alternatives. No Action for the Maxey Flats Disposal Site consists solely of monitoring and activities in support of monitoring (e.g., installation of monitoring wells).

The seemingly high cost of 6.8 million dollars for an alternative involving only monitoring arises from the need to monitor this site in perpetuity. This monitoring would involve the installation of additional monitoring wells and sample collection and analyses on a frequent basis. Sample analyses would be conducted using a high level of quality assurance/quality control, thereby increasing the cost of the analyses and the remedy.

The No Action alternative is not an engineered alternative, and it would not satisfy the remedial objectives. The No Action Alternative does not comply with ARARs and would, likewise, not provide overall protection of human health and the environment.

Estimated Construction Cost: $ 636,000
Estimated O & M Cost: $ 6,167,000
Estimated Present-Worth Total Cost: $ 6,803,000
Estimated Implementation Time: 6 months

ALTERNATIVE 4 - STRUCTURAL CAP/DYNAMIC COMPACTION/ HORIZONTAL FLOW BARRIER

Alternative 4 includes the following remedial action:

- Baseline features
- Leachate removal from the trenches
- Solidification of leachate and disposal in new trenches
- Installation of horizontal flow barrier (if needed)
- Dynamic compaction of existing disposal trenches concurrent with addition of compacted soil and sand backfill
- Installation of a two-foot thick reinforced concrete cap over the trenches and a two-foot thick low-permeability clay cap over the rest of the closure area. Cap installation would include drainage, vegetative cover, and erosion control, and
- Remedy Review performed every five years.

This alternative combines the technologies of liquid waste removal, dynamic compaction and structural capping. After leachate removal and dynamic compaction, a reinforced concrete structural slab and several feet of soil cover would be placed over the disposal trenches. The use of dynamic compaction on the trench area prior to placement of the structural cap would provide a stable foundation for the cap and minimize future subsidence. Without the support provided by stabilization, the reinforced concrete cap would not be capable of spanning the wide trenches.

The horizontal flow barrier should help reduce the off-site migration of contaminants and prevent the infiltration of subsurface water.

Estimated Construction Cost: $ 59,332,000
Estimated O & M Cost: $ 6,175,000
Estimated Present-Worth Total Cost: $ 65,507,000
Estimated Implementation Time: 38 months

ALTERNATIVE 5 - NATURAL STABILIZATION

The Natural Stabilization alternative combines elements of containment, leachate removal, and treatment. The distinguishing feature of this alternative is the use of an initial closure cap during a period of natural subsidence and maintenance, estimated to be a period ranging from 35 to 100 years (the interim maintenance period). A final, multi-layer cap with synthetic liner would be installed at the completion of natural subsidence, at which time the trenches would form a stable foundation for the final cap. In addition, a horizontal flow barrier would be constructed, if required, to prevent ground water infiltration into the disposal trenches. With this alternative, a horizontal flow barrier could include a north cutoff wall or a cutoff wall which encircles the trenches.

The implementation of this alternative would involve the following activities:

- Baseline Features
- Excavation of Additional Disposal Trenches for Disposal of Solidified Leachate and Site Debris
- Leachate Removal from Disposal Trenches
- Leachate Solidification and Disposal in New Trenches
- Periodic Installation of Interim Trench Cover

- Installation of Horizontal Flow Barrier (if needed)
- Natural Stabilization With Active Maintenance and Monitoring
- Installation of a Final Engineered Cap with Synthetic Liner, and
- Remedy Review Performed Every Five Years.

Alternative 5 provides for the installation of an interim cap over the trench disposal area. Once the trenches achieve the degree of stabilization required, a final cap would be installed. Maintenance requirements for this alternative would be significant during the interim maintenance period. Once the trenches have sufficiently stabilized, the final cap would be installed and maintenance requirements would be minimal. Specific subsidence criteria would be developed in the remedial design.

Estimated Construction Cost:	$ 23,910,000
Estimated O & M Cost:	$ 9,643,000
Estimated Present-Worth Total Cost:	$ 33,553,000
Estimated Implementation Time:	35 - 100 years with 22 months for initial capping, 10 months for final capping

ALTERNATIVE 8 - <u>ENGINEERED SOIL CAP WITH SYNTHETIC LINER/ NATURAL SUBSIDENCE/HORIZONTAL FLOW BARRIER</u>

Alternative 8 includes the following remedial action activities:

- Baseline features
- Leachate removal
- Solidification of leachate into concrete blocks and disposal in new trenches
- Installation of Horizontal Flow Barrier (if needed)
- Installation of an engineered soil cap with synthetic liner, and
- Remedy Review Every Five Years.

Trench stabilization would be accomplished by natural subsidence, assumed to be completed in 35 to 100 years. Subsidence monitoring and water infiltration monitoring would be performed periodically and at other times when conditions are such that the potential for subsidence was high.

The required maintenance activities for this alternative would be significant because trench subsidence and resulting cap repair would be significant. The Horizontal Flow Barrier (assumed to be a North Cutoff Wall for this alternative) would prevent groundwater infiltration into the trench area.

Estimated Construction Cost:	$ 34,302,000
Estimated O & M Cost:	$ 13,105,000
Estimated Present Worth Total Cost:	$ 47,407,000
Estimated Implementation Time:	23 months

ALTERNATIVE 10 - <u>ENGINEERED SOIL CAP WITH SYNTHETIC LINER/ DYNAMIC COMPACTION/HORIZONTAL FLOW BARRIER</u>

Alternative 10 includes the following remedial action activities:

- Baseline features
- Leachate removal
- Solidification of leachate and disposal into new trenches
- Installation of a Horizontal Flow Barrier (if needed)
- Dynamic compaction of existing trenches with concurrent addition of compacted soil and sand backfill
- Installation of an engineered soil cap with synthetic liner, and
- Remedy Review Every Five Years.

Dynamic compaction involves the application of high-energy impacts to the ground surface; its primary purpose is to increase the ability of soil and waste to support a cap. The dynamic impact of a heavy weight transmits shock waves downward through the soil and wastes, rearranging the material into a denser configuration.

Prior to starting dynamic compaction, two feet of silty sand would be placed over the entire area to be dynamically compacted. The silty sand would supplement the existing soil cover over the trenches and prevent it being breached by the weight.

The cap would limit vertical infiltration; the existing contaminated leachate would be removed and immobilized; the cap stability would be established using dynamic compaction to minimize future subsidence; and ground water infiltration would be minimized due to installation of a horizontal flow barrier (it is assumed that a North Cutoff Wall would be installed with this alternative), as needed.

Estimated Construction Cost:	$ 39,538,000
Estimated O & M Cost:	$ 4,790,000
Estimated Present-Worth Total Cost:	$ 44,328,000
Estimated Implementation Time:	35 months

ALTERNATIVE 11 - ENGINEERED SOIL CAP WITH SYNTHETIC LINER/ TRENCH GROUTING/HORIZONTAL FLOW BARRIER

Alternative 11 includes the following remedial activities:

- Baseline features
- Leachate removal from existing trenches
- Installation of a Horizontal Flow Barrier (if needed)
- Grouting of accessible voids in the existing disposal trenches with grout made from potable water and/or leachate
- Installation of an engineered soil cap with synthetic liner, and
- Remedy Review Performed Every Five Years.

Alternative 11 would achieve containment with an engineered soil cap with synthetic liner and Horizontal Flow Barrier (it is assumed that a North Cutoff Wall with gravel drain would be installed with this alternative), as needed, and treatment through leachate removal and grouting. The distinguishing protectiveness feature of Alternative 11 is trench grouting.

Grouting would consist of injecting a mixture of materials (e.g., cement, bentonite, fly ash) and water through specially inserted probes into the majority of trenches to fill voids and other openings in the waste. The primary purpose for grouting at Maxey Flats is to provide a stable foundation for the final closure cap.

Estimated Construction Cost:	$ 61,870,000
Estimated O & M Cost:	$ 6,989,000
Estimated Present-Worth Total Cost:	$ 68,859,000
Estimated Implementation Time:	46 months

ALTERNATIVE 17 - ENGINEERED SOIL CAP/DYNAMIC COMPACTION/ HORIZONTAL FLOW BARRIER

Alternative 17 includes the following remedial activities:

- Baseline features
- Leachate removal
- Solidification of leachate and disposal into new trenches
- Installation of a horizontal flow barrier (if needed)
- Dynamic compaction of existing disposal trenches concurrent with the addition of compacted soil and sand backfill
- Installation of an engineered soil cap, and
- Remedy Review Performed Every Five Years.

Alternative 17 combines the remedial technologies of capping, dynamic compaction, and installation of a horizontal flow barrier to stabilize the site. The difference between this alternative and Alternative 10 is the type of horizontal flow barrier and cap. This alternative would involve installation of a **grout curtain** to encircle the disposal trenches rather than the North Cutoff Wall; the engineered soil cap would not contain the synthetic liner.

Estimated Construction Cost: $ 51,920,000
Estimated O & M Cost: $ 4,634,000
Estimated Present-Worth Total Cost: $ 56,554,000
Estimated Implementation Time: 38 months

TABLE 1

Maxey Flats Disposal Site Present Worth Cost and Remedial Design/Remedial Action Implementation Times for Alternatives

Alternative	Design and Construction Time (months)	Total Present Worth Cost (millions)
1	06	6.8
4	38	65.5
5	22[1]	33.5
8	23	47.4
10	35	44.3
11	46	68.9
17	38	56.5

[1] - Initial closure would be completed in 22 months, followed by a 35 - 100 year Interim Maintenance Period, followed by a 10 month Final Closure Period.

It is not known how long it will take for waste trenches to stabilize because of the many physical and chemical variables involved and the limited trench-specific information upon which estimates are based. The natural stabilization process at Maxey Flats would allow the materials to subside naturally to a stable condition prior to final closure with an engineered cap. It has been estimated that this stabilization process could potentially take 100 years before the final cap is placed.

Stabilization of the trenches by natural subsidence over a relatively long time period would virtually eliminate the potential of future subsidence problems encountered by alternatives that include mechanical stabilization of the trenches and installation of the final cap within a few years. Therefore, the natural stabilization alternative would reduce the redundancy of efforts necessary to construct and maintain the final closure cap. Natural stabilization does not disrupt intact metal containers such as 55-gallon drums; therefore, radioactive material is not immediately added to the trench. This containment provides an extra measure of protection to prevent movement of radionuclides to the hillsides. An additional benefit of the natural stabilization alternative would be the opportunity for continued data collection and analyses and evaluation of new technologies to optimize the final closure. Thus, EPA has preliminarily identified Natural Stabilization (Alternative 5) as the preferred remedy for the Maxey Flats Disposal Site. Alternative 5 has four key phases as follows:

- Initial Closure (22 months)
- Interim Maintenance Period (35 - 100 years)
- Final Closure (10 months), and
- Custodial Maintenance Period (in perpetuity).

Each of the four key phases is described below.

Initial Closure

This period would include a design phase followed by construction activities. Design of the initial closure would be performed and an Interim Site Management Plan developed for implementation during the Interim Maintenance Period.

During the Initial Closure Period, the following remedial activities would be performed:

- Baseline Topographic Surveys
- Geophysical Survey
- Subsidence Monitors
- Ground Water Monitoring
- Ground Water Modeling
- Initial Closure Cap and Surface Water Management and Control
- Trench Leachate Management and Monitoring
- Closure of Selected Wells
- Interim Site Management Plan
- Monitoring, Maintenance, and Surveillance
- Demolition of Existing Buildings and Structures With On-Site Disposal, and
- Procurement of Buffer Zone Adjacent to the Existing Site Property.

Baseline topographic and geophysical surveys would be conducted prior to design of the initial closure cap. Topographic surveys also would be performed prior to the initial closure cap installation, and following cap construction. The topographic surveys would be used as baseline information for subsidence monitoring. A geophysical survey would enhance definition of trench boundaries and ensure that the initial closure cap would adequately cover the trenches.

Subsidence monitors would be installed on the initial closure cap and on natural soils in the vicinity of the Restricted Area as a method of determining when the trenches have stabilized to an acceptable degree and final closure can begin.

A ground water model would be developed and used, in conjunction with historical RI and Commonwealth data, to determine the extent of the initial closure cap, evaluate the need for a horizontal ground water flow barrier, and to develop an effective ground water monitoring plan for use during the interim maintenance period and after closure. A ground water monitoring program would be developed, based on the results of the model and on existing knowledge of ground water and contaminant flow. In addition, new monitoring wells would be installed, as appropriate, using the results of the above evaluation. New monitoring wells also would be installed in the surrounding stream valley alluvium to ensure compliance with drinking water standards.

Soil would be added to the site, graded, and compacted in preparation for installation of a synthetic cover over the trench disposal area. (See next page for Cross-Section of Natural Stabilization.). The initial layer would have an average thickness of 21 inches. The extent of the interim cover would be based upon geophysical surveys, ground water modelling and other parameters evaluated during design. It has been estimated that the interim cap would cover approximately 40 to 50 acres. The surface would be graded to design specifications for improved drainage. Lined drainage ditches would be installed to channel the surface water runoff to the three discharge basins. Additional drainage channels in the vicinity of the site may be necessary to allow for increased control of the rates of surface water runoff. Because of the high peak discharge volumes resulting from the initial closure cap, the capacity of the retention ponds would be increased to improve control of storm-water runoff.

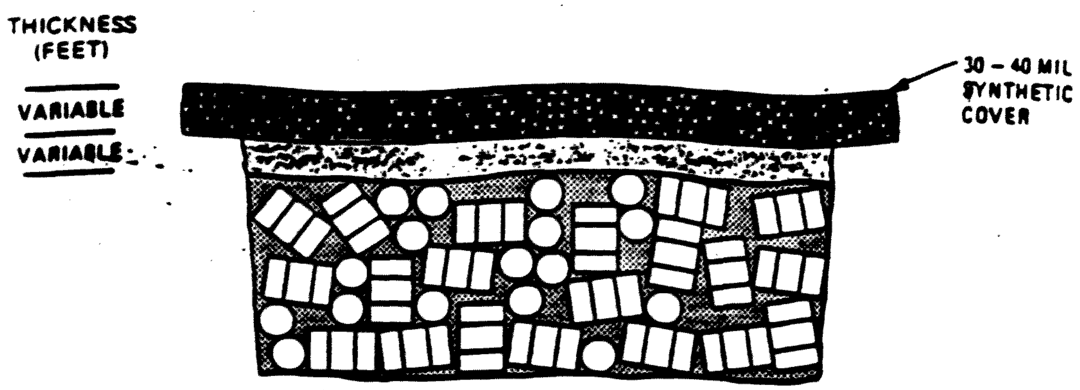
Trenches would be de-watered to control the migration of contaminants by ground water flow. A trench de-watering test program would be conducted either during the design phase or during initial closure activities to provide information on the most effective design of the de-watering program, to determine the need for new sumps, and to provide an estimate of the duration of the de-watering program. Leachate pumped from the trenches would be solidified and buried in new trenches.

Existing, poorly designed wells could potentially allow contaminants in ground water to migrate downward into the lower geologic units and would, therefore, be decommissioned and sealed. Water monitoring equipment, as part of the Infiltration Monitoring System, would be installed in trenches to detect the accumulation of leachate in trenches.

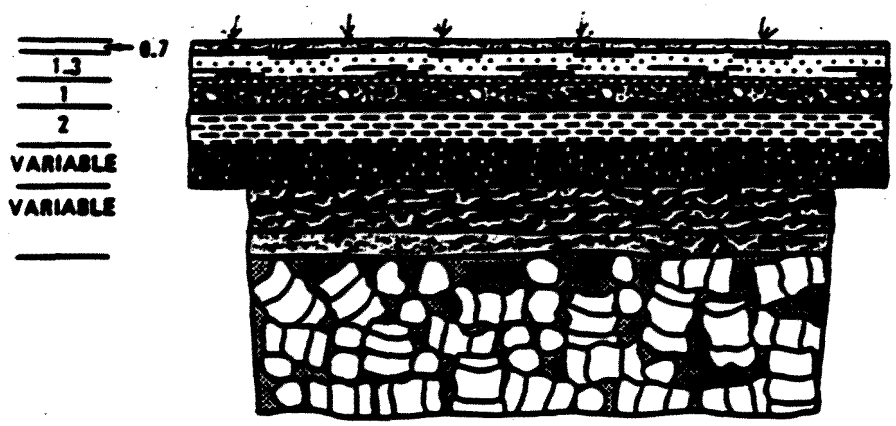
Non-functional buildings and unstable buildings and structures would be dismantled and buried in a trench on-site. Those buildings necessary to the management and maintenance of the site would be moved to a location that would not impede remedial activities. These buildings would then be dismantled, as necessary, during final site closure.

Land would be purchased adjacent to the existing site property boundaries. The purchase of this land would not extend the current site property boundary, although control over the property presumably would be in the hands of the Commonwealth of Kentucky. The purpose of a buffer zone is to protect environmentally sensitive areas such as the hill-slopes from detrimental activities such as logging, and to allow unrestricted access to areas adjacent to the MFDS for the purpose of monitoring. (See map on page 22 delineating buffer zone). Without control of activities on the hill-slopes, increased erosion due to deforestation could severely affect the effectiveness of the remedy. At a minimum, the buffer zone would extend from the current site property boundary to Drip Springs, No Name, and Rock Lick Creeks to the west, east, and southwest of the site, respectively.

A comprehensive Interim Site Management Plan would be developed during the design period to define the maintenance and monitoring tasks to be conducted during the interim maintenance period. A monitoring, maintenance, and surveillance program would then be implemented at the site following initial closure, as defined by the Interim Site Management Plan.



INITIAL CLOSURE CAP



FINAL CLOSURE CAP

EXPLANATION

- *30 TO 40 MIL SYNTHETIC COVER*
- *TOPSOIL LAYER WITH VEGETATIVE COVER*
- *SILTY SAND*
- *GEOTEXTILE FABRIC*
- *CRUSHED ROCK*
- *80 MIL SYNTHETIC LINER*
- *CLAY LAYER (PERMEABILITY ≤ 1 x 10^{-7} cm/sec)*
- *COMPACTED SOIL LAYER*
- *EXISTING TRENCH SOIL COVER*
- *TRENCH WITH RANDOMLY PLACED WASTE CONTAINERS*

NOT TO SCALE

MAP PRODUCED BY EBASCO SERVICES INCORPORATED AND LABELLED FOR THIS REPORT BY BOOZ, ALLEN & HAMILTON, Inc

MAXEY FLATS DISPOSAL SITE
ALTERNATIVE 5 - NATURAL STABILIZATION

MAP 5

EXPLANATION

MFDS RESTRICTED AREA

MFDS PROPERTY BOUNDARY

PROPOSED BUFFER ZONE

MAP PRODUCED BY EBASCO SERVICES INCORPORATED AND LABELLED FOR THIS REPORT BY BOOZ, ALLEN & HAMILTON, Inc

MAXEY FLATS DISPOSAL SITE
PROPOSED BUFFER ZONE MAP

MAP 6

Interim Maintenance Period

Upon construction of the initial closure cap, the interim maintenance period would commence. The Interim Site Management Plan would provide the basis for work activities during the interim maintenance period. During this period, the initial closure cap would continue to be maintained to prevent infiltration of water into the trenches, maintenance of the site would continue, and the site would be monitored by an enhanced monitoring/surveillance program. During the interim maintenance period the following activities would be performed as prescribed by the Interim Site Management Plan:

- Periodic Topographic Surveys and Subsidence Monitoring
- Ground Water Monitoring
- Initial Closure Cap and Surface Water Management and Control
- Trench Leachate Management and Monitoring
- Monitoring, Maintenance, and Surveillance, and
- Five Year Reviews.

The end of the interim maintenance period is defined as the time when subsidence of the trenches has nearly ceased and final closure begins. The criteria for final closure would be developed during the design phase and could include acceptable void fraction, defined rate of minimal subsidence, defined back-filling rate to maintain design grade, etc. The closure criteria would be dependant on the design of the final closure cap and can be based upon engineering evaluations during the development of the Interim Site Management Plan. The primary objective of the interim maintenance period is to let the trenches stabilize by natural subsidence. Thus, the criteria would be dependant on a minimal rate of subsidence and, when a final closure cap could be installed without having to repair it often due to continuing subsidence.

Topographic surveys and elevation surveys of the subsidence monitors would be made periodically to evaluate subsidence. This information would form a database to be used to determine if the trenches have stabilized and the criteria for final closure have been achieved.

The initial closure cap would be inspected periodically to ensure that it has not failed and is effectively controlling surface water runoff. As needed, the cap would be repaired and synthetic liner replaced according to the Interim Site Management Plan. Currently, it is anticipated that the synthetic liner would require replacement at 20-25 year intervals. Liner replacement would be performed in response to the liner condition and the manufacturer's warranty and specifications. The specific liner type would be determined during development of the Interim Site Management Plan; however, the liner would be of the type to require replacement no more often than the previously-stated 20-25 year interval. The drainage ditches and retention ponds would also be cleaned and maintained as needed. Erosion damage to the cap and drainage systems would be repaired as needed.

The Infiltration Monitoring System, installed to detect the accumulation of leachate in the trenches, would provide a warning if leachate began to accumulate in the trenches. This monitoring system would be used as a supplement to the Commonwealth's current trench leachate monitoring program. Measures could then be taken to eliminate the cause of the infiltration. If significant levels of leachate were detected, the leachate management plan, developed as part of the Interim Site Management Plan, would be implemented to remove, solidify, and dispose of the leachate. The results would then be used to adjust the frequency of inspections, data collection, sample analyses, and planned leachate pumping and solidification.

Site monitoring, maintenance, and surveillance would be performed as defined by the Interim Site Management Plan. Ground water samples would be collected periodically from specified monitor wells for analysis and water levels taken.

Section 121(c) of CERCLA requires EPA to conduct a review of the remedy five years after initiation of remedial action and once every five years thereafter for those remedial actions that allow hazardous substances to remain on-site. The purpose of this review would be to evaluate the remedy's performance to ensure that it has achieved, or will achieve, the objectives set forth in the Record of Decision and is protective of human health and the environment. If the remedy is not meeting the defined remedial action objectives during any of the five year reviews, or at any interim point between the five year reviews, or if the remedy fails to be protective of human health and the environment, a focused feasibility study would be conducted to determine available technologies that could be implemented at the site to achieve the defined remedial action objectives and protection of human health and the environment.

During the first five year review, sufficient data should be available from the trench de-watering program, information contained in the Commonwealth's historical leachate level database, Infiltration Monitoring System, ground water monitoring, and ground water modeling program to determine the necessity of a horizontal flow barrier. The decision to construct a horizontal flow barrier would be made by EPA, in consultation with the Commonwealth of Kentucky and industry experts. If analysis of this data indicates that significant ground water is accumulating in the disposal trenches, a horizontal flow barrier would be installed to curtail the ground water recharge. The location, depth, and extent of this horizontal flow barrier would be determined through ground water modeling and review of site data.

Two types of horizontal flow barriers were evaluated in the Feasibility Study. The type of horizontal flow barrier installed at the site, if needed, could include either the North Cutoff Wall or Lateral Drain with Cutoff Wall to encircle the trench disposal area.

Final Closure

When the results from the interim maintenance period monitoring show that the closure criteria have been achieved, indicating that the trenches have sufficiently stabilized by natural subsidence, the trenches would be capped by the final closure cap.

The following activities would be undertaken during final closure:

- Waste Burial
- Site Closure
- Monitoring and Surveillance
- Five Year Reviews

Any contaminated or potentially contaminated materials at the site would be buried in a new trench. These materials would include solidified leachate, leachate storage tanks, and on-site buildings which would be demolished during final closure.

The trenches would be covered by an engineered cap with synthetic liner and effective surface water control systems would be installed to limit infiltration. It is expected that a significant amount of research data and new technologies will be developed throughout the interim maintenance period. Thus, the design of the final closure cap could reflect the most advanced technology for vertical infiltration barriers.

A monitoring and surveillance program would be implemented. The program would be funded in perpetuity.

Custodial Maintenance Period

After the final closure cap has been constructed, a monitoring program would be implemented at the site. The frequency of monitoring activities described for the interim maintenance period would be reduced during the post-closure period due to the presumed reduction of water infiltration into the trenches and reduced waste volume. This monitoring would be carried out in perpetuity.

Cost

Cost analyses for Alternative 5 were based upon a discount rate of 4, 5, 7 and 10% over a period of 100 years (the estimated time for which stabilization of the trenches is assumed to occur). This Proposed Plan uses a discount rate of 4% for the alternatives, because it is the most conservative cost figure.

EVALUATION OF ALTERNATIVES

Alternative 1, the No Action alternative, would not comply with all Applicable or Relevant and Appropriate Requirements (ARARs) nor does it provide overall protection of human health and the environment. Alternative 4, which includes a structural cap comprised of a two-foot layer of concrete and a two-foot layer of clay, provides short- and long-term effectiveness relative to other alternatives; however, it is difficult to implement and is not cost-effective. Alternative 8, which is similar to Alternative 5, except that a final multimedia cap is immediately installed over the trench disposal area, provides a lesser degree of long-term effectiveness and is far less cost-effective than Alternative 5. Alternative 17, which includes a 12-foot thick engineered soil cap, is less protective of public health and less cost effective than alternatives 5, 10 and 11. The remaining three FS alternatives (5, 10, 11) differ in their approach toward achieving trench stabilization.

Alternatives 5 and 10 provide for (1) vertical infiltration barriers having permeabilities of 1×10^{-7} cm/sec or less, (2) trench leachate removal with disposal into new trenches, (3) a water management system to prevent contamination of rainwater during construction activities, (4) a horizontal flow barrier, if necessary, to prevent potential horizontal infiltration of ground water into the trenches, (5) environmental and performance monitoring systems, and (6) an operating and maintenance trust fund to ensure site care in perpetuity. Alternatives 5 and 10 differ principally in the means by which they achieve long-term site stability. Alternative 10 uses dynamic compaction to accelerate void reduction to limit significant subsidence in the future. Alternative 5, on the other hand, allows for natural subsidence to occur by providing for an interim maintenance period during which the site would be graded and modified, to provide improved surface runoff conditions, and covered by a synthetic cover that would prevent water from entering the trenches and provides for ongoing repair during the natural stabilization process. After subsidence has abated, a final cap would be installed on the site. Alternative 11 contains protective features similar to Alternatives 5 and 10, except that compaction of the trenches is not included in this alternative. Grout would be injected into the trenches to prevent subsidence.

Alternative 5 (Natural Stabilization) would achieve initial closure sooner than closure using other alternatives; however, final closure would be implemented at a much later date. With Alternative 5, proven technologies would be used during initial closure; new technologies could be considered at the time of final closure to take advantage of advances in research on low-level radioactive waste sites. Major weaknesses of this alternative are the lack of application of an immediate stabilization technology to the disposal trenches. However, this weakness is offset by maintaining the integrity of the waste form. Other technologies could lead to increased release of radionuclides without an alternative means to properly address migration from the disposal area.

Alternative 10 (Dynamic Compaction) utilizes a mechanical method for significantly accelerating trench stabilization. Weaknesses of this alternative include subsidence over trenches not dynamically compacted, minor subsidence over compacted trenches due to continued deterioration of trench waste, and the unproven nature of this technology at the MFDS. In addition, this technology currently lacks community and state acceptance at the MFDS.

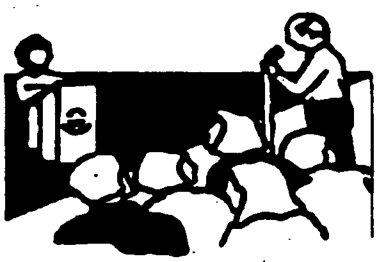
Alternative 11 (Trench Grouting) would achieve stability using the grouting technology that has been applied at low level radioactive waste disposal sites, including Maxey Flats. The technology has not, however, been applied at the scale required for stabilization of the entire site. The major weaknesses of this alternative are the implementability difficulties anticipated at the MFDS, and the lack of a method for determining the location and magnitude of voids before and after injecting grout. Subsidence would also occur over trenches not grouted and minor subsidence over grouted trenches due to continued deterioration of trench waste.

The Commonwealth endorses the use of natural stabilization for the Maxey Flats site. The Commonwealth considers trench cover repair and a horizontal flow barrier, as needed, to be integral features of the remedy to be chosen at the MFDS. The Commonwealth rejects the use of Dynamic Compaction (Alternative 10) for either a site demonstration or for total site remediation due to "potential release of leachate to the environment, potential fracturing of the underlying geologic strata, and lack of substantial information regarding trench waste location, waste condition, and waste contents". The Commonwealth also rejects grouting (Alternative 11) for implementation at Maxey Flats due to potentially unacceptable releases of leachate to the environment and the required, time-consuming demonstration of this technology prior to implementation.

Community responses to the alternatives will be discussed in the Record of Decision which follows the public comment period. Based on information currently available, EPA prefers Alternative 5, Natural Stabilization, as the most acceptable remedy for the MFDS. This preliminary finding was reached after careful consideration of the technologies and remedial alternatives presented in the Maxey Flats FS Report and information contained in the Administrative Record. The preferred alternative is believed to provide the best balance of trade-offs among alternatives, with respect to the evaluation criteria.

FUTURE ACTIVITIES

EPA will hold a public meeting on the preferred remedy for the MFDS on June 13, 1991. This meeting will give the public an opportunity to express their opinions and concerns about the preferred alternative and the other alternatives considered. The meeting also will serve to begin a 60-day public comment period. Due to the complexity of issues involved, the number of documents in the Administrative Record, and the level of community involvement at the site, EPA has granted a 30 day extension to the required minimum 30-day public comment period on the preferred alternative. **Therefore, a 60-day public comment period will be held.**



Issues raised by the public during the public comment period will be addressed by the EPA in a Responsiveness Summary that becomes an official part of the Agency's documented decision on the remedy. The Record of Decision is expected to be issued in late 1991. Negotiations between Potentially Responsible Parties (PRPs) and EPA may lead to an agreement, a Consent Decree, by which the PRPs may agree to design and implement the selected remedy. If a Consent Decree is settled upon, it would be lodged with a federal district court by the U.S. Department of Justice. Once the Consent Decree has undergone a 30-day public comment period and is approved by the Court, design work would commence.

Implementation of Alternative 5 would begin upon entering of the Consent Decree and the completion of the necessary work plan and design documents.

SUMMARY OF THE PREFERRED ALTERNATIVE

In summary, EPA's analysis of the currently available technologies for closure of low level radioactive waste disposal sites and review of information contained in the Administrative Record indicates that natural stabilization is the most appropriate technology for stabilization of the Maxey Flats Disposal Site. Alternative 5, Natural Stabilization, allows for quick implementation of remedial action because it does not require a demonstration of the technology and the actual site preparation presents few difficulties regarding implementation. Natural stabilization will allow settlement to continue in a gradual manner, and allow for timely monitoring and maintenance of the cover, which will be replaced after the synthetic liner is no longer useful.

Alternative 5 provides for flexibility in selecting the optimum interim cover. If, during the first five-year review conducted by EPA, it is determined that a synthetic cover alone is not effective, alternative cover options will be evaluated (e.g., soil cover over a synthetic liner). Alternative 5 also provides for flexibility in addressing the uncertainties associated with horizontal ground water flow. If, during the five-year review, it is determined that ground water is recharging the trenches, a horizontal barrier would be designed and constructed to divert ground water flow, to the extent practicable, away from the trenches.

It is anticipated that subsidence of the disposal trenches at the MFDS will continue to be a controlling factor with respect to installation of a final cap for the next 35 to 100 years. A final multi-layer trench cover with synthetic liner would be installed upon attainment of the stabilization criteria.

Site monitoring, environmental monitoring, remedy reviews, and site maintenance will provide the necessary assurance of design compliance with adequacy, health and safety of the public in the area, and compliance with all federal and state requirements.

Implementation of Alternative 5 would result in the reduction of risk from the approximate risk of 1×10^{-1}, or one in ten, if no action were taken at the MFDS, to an approximate risk of 1×10^{-4}, or one in 10,000.

THE COMMUNITY'S ROLE IN THE SELECTION PROCESS

EPA invites input from the community on the remedial alternatives proposed for each Superfund site. EPA has set a public comment period from June 13, 1991 to August 13, 1991 to encourage public participation in the selection process. The comment period will be initiated by a public meeting at which EPA will present the Proposed Plan, answer questions, and accept oral and written comments.

A public meeting is scheduled for 7:OO p.m., June 13, 1991, and will be held at the Ersil P. Ward (formerly known as Fox Valley) Elementary School in Fleming County, Kentucky, located onState Road 32, between Morehead and Flemingsburg.

EPA will summarize comments and EPA's responses in the Responsiveness Summary section of the Record of Decision (ROD). To send written comments or obtain further information, contact:

Dave Kluesner
Site Project Manager
North Superfund Remedial Branch
U.S. Environmental Protection Agency
345 Courtland Street, N.E.
Atlanta, Georgia 30365
(404) 347-7791

MAILING LIST ADDITIONS

If you did not receive this Proposed Plan by mail, or you know of others who wish to be placed on the mailing list for future publications pertaining to this site, please fill out, detach and mail this form to:

Suzanne Durham
Community Relations Coordinator,
North Superfund Branch,
U.S. Environmental Protection Agency,
345 Courtland Street, Atlanta, GA 30365

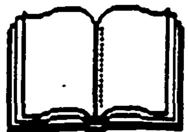
Name ______________________________

Address ______________________________

Affiliation ______________________________

Telephone ______________________________

GLOSSSARY



Administrative Record: An official compilation of documents, data, reports, and other information that was considered during the selection of response action(s) at a Superfund site. The record is placed in the information repository to allow public access to the material.

Alluvium: Sediment that has been deposited by rivers and streams in comparatively recent time.

Aquitard: A subsurface formation of low permeability which retards the migration of ground water through it to underlying formations.

Compaction: A process designed to increase the density of a substance by reducing voids.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA): A Federal law passed in 1980 and amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA). The Act created a Trust Fund, known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites.

Decommissioning: Preparations taken for retiring nuclear facilities from active service. The objective of decommissioning is to place the facility in such a condition that future risk to public safety from the facility is within acceptable limits.

Dose Equivalent: A quantity used in radiation protection standards. It expresses all radiations on a common scale for calculating the effective absorbed dose. It is defined as the product of the absorbed dose in rads and certain modifying factors. The unit of dose equivalent is the rem.

Evapotranspiration: The release of water vapor from plants to the atmosphere.

Exposure Pathways: The paths or routes by which contaminants are transferred from a source to a receptor (a hypothetical or actual individual). Pathways may be quite complex, involving ground water, surface water, the atmosphere, and food chains. Accidental or purposeful intrusion by humans into the waste is also a potential exposure pathway. Humans may have skin contact with, inhale, or ingest contaminants. In the case of radionuclides, a person also may be exposed to the radiation without directly contacting the waste. The path by which the contalso aminant reaches man, and the means by which it contacts or enters the body, combine to form exposure pathways.

Forty-Series Trenches: Refers to trenches 40 through 49 at the MFDS. These trenches can be characterized, generally, as the longest and deepest trenches at the MFDS. Some of the 40-series trenches are up to 686 feet in length, over 30 feet deep and 70 feet wide. The first of the 40-series trenches accepted waste beginning in 1973. Some of the 40-series trenches have individual trench volumes in excess of 1,000,000 cubic feet.

Grout Curtain: A physical barrier buried beneath the ground surface designed to prevent or control ground water flow into designated area. Installation of the grout curtain would involve rock coring into the bedrock followed by the injection of grout, which is a thin, course mortar or cement-mix, under high pressure until enough grout is in place to form a wall, or curtain to curtail ground water flow.

Horizontal Flow Barrier: For the MFDS, this refers to a lateral drain and cutoff wall combination that encircles the entire trench disposal area. The lateral drain component of the horizontal flow barrier would involve excavation of a trench around the perimeter of a group of trenches and installation of a perforated pipe at the bottom of the trench to collect any liquids flowing into the drain. The cutoff wall would consist of an upper section of compacted clay or cement-mix and a lower section, extending down to bedrock, or cement-mix. The purpose of the horizontal flow barrier is to prevent the infiltration of ground water into disposal trenches and the exfiltration of leachate from the disposal trenches.

Hot Wells: Refers to wells at the Maxey Flats Disposal Site that were used for the burial of small-volume radioactive wastes with high specific activity. Eight distinct wells were constructed adjacent to one another, in what is referred to historically as the "hot well area". Several other wells were located against the walls of trenches. The wells in the "hot well area" are vertical, 10 to 15 feet deep, 1 to 2 feet in diameter, and were constructed from concrete, coated steel pipe, or tile. They were capped with one large slab of concrete. Other wells were placed in trenches existing from the ground surface to the bottom of the trenches.

Hydraulic Head: The difference in water elevation between two points in a continuous water table.

Information Repository: A library or other location where documents and data related to a Superfund project are placed to allow the public access to the material. For the Maxey Flats Disposal Site, information repositories have been established at the Fleming County and Rowan County Libraries.

Institutional Controls: Refers to on-site activities and site access which are controlled by some authority. This authority can be state, federal, or local.

Leachate: Liquid that has become contaminated as a result of water coming in contact with wastes or with decomposed solid materials.

Media: Specific environments -- air, water, soil -- which are the subject of regulatory concern and activities.

Mrem: Abbreviation for millirem, which is one thousandth of a rem. Rem is an acronym for "roentgen equivalent man," which is a dosage of radiation that will produce the same biological effect as one roentgen (or type of unit) of X-ray or a gamma ray dosage. Rem is the conventional unit of dose equivalent.

Pico curie: Abbreviate as pCi. A common usage term for a unit of measurement for radioactivity. It represents 0.037 disintegrations of a radioactive atom per second, which equals one ten thousandth of a curie.

Radionuclide: A nuclide is a type of radioactive atom characterized by the number of protons, neutrons and the energy content which characterize its nucleus.

Radon: Rad[illegible] naturally occurring radioactive gas produced by the decay of uranium in rock and soil. A[illegible] decays, it produced radium, which in turn, releases radon gas. It is invisible, odorless, [illegible]. Once released, this gas migrates through permeable rocks and soil, eventually [illegible] atmosphere or buildings through cracks in foundations.

Record of Decision (ROD): A legal document prepared by the U.S. EPA that describes the remedial action selected for a Superfund site, why the remedial action was chosen and not others, how much it will cost, and how the public responded to the action selected.

Remedial Alternative: A remedial technology or a combination of remedial action technologies that will prevent or mitigate contaminant problems.

Remedial Investigation/Feasibility Study: A two-part study of a waste disposal site that provides the basis for selection of a remedial action for the site. The first part, or RI, identifies the nature and extent of contamination. The second part, or FS, identifies and evaluates alternatives for addressing site threats.

Resource Conservation and Recovery Act (RCRA): A Federal law that established a regulatory system to track hazardous wastes from the time of generation to disposal. The law specifies procedures to be used in treating, transporting, storing, and disposing of hazardous wastes.

Restricted Area: An area to which access is controlled by the licensee and limited to authorized personnel to protect individuals from being exposed to radiation and radioactive or chemical materials. At the MFDS, this area is the fenced area that includes the burial trenches.

Sediment: Materials that settle to the bottom of a stream, creek, lake, or other body of water.

Solidification: The process by which contaminants are mixed with a hardening agent, like cement.

Sump: An area lower than the surrounding area used to collect liquids. At the MFDS, sumps are pipes from the surface to the base of the trench where the pipes are slotted. They are used to collect and pump leachate from the trenches.

Superfund Amendments and Reauthorization Act (SARA): A Federal law passed in 1986 which modified the 1980 CERCLA Superfund law by strengthening EPA's authority, State involvement and opportunities for public participation. Additional Superfund revenues also were granted.