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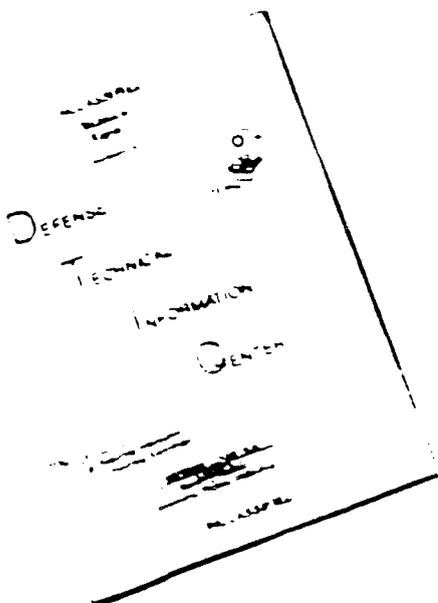
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13. ABSTRACT (Maximum 200 words) THIS FINAL TECHNICAL PLAN DESCRIBES THE WORK TO BE PERFORMED UNDER TASK 17. THE OBJECTIVES OF THIS STUDY ARE TO: 1. RECOMMEND A METHOD FOR INCINERATION/THERMAL TREATMENT OF BASIN F WASTES 2. PERFORM LABORATORY-SCALE INCINERATION OF BASIN F WASTES TO CONFIRM THE TECHNICAL FEASIBILITY OF THE RECOMMENDED TREATMENT 3. DETERMINE THE NECESSITY OF PILOT TESTING THE PREFERRED TREATMENT TECHNOLOGY 4. RECOMMEND SOLIDIFICATION/FIXATION METHODS FOR INCINERATION ASH 5. PROVIDE ENGINEERING COST ESTIMATES SECTIONS OF THIS REPORT PROVIDE INFORMATION ON THE FOLLOWING: BASIN F BACKGROUND DATA, SELECTION OF INCINERATION AND FIXATION TECHNOLOGIES, FIELD SAMPLING, CHEMICAL ANALYSIS, QUALITY ASSURANCE PROGRAM, DATA COMPILATION AND MANAGEMENT, HEALTH AND SAFETY PROGRAM.			
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FINAL  
TECHNICAL PLAN  
APRIL 1987  
TASK NO. 17  
INCINERATION/FIXATION AND BUILDING 1611  
PILOT STUDY FOR BASIN F WASTES  
CONTRACT NO DAAK11-84-D-0017

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SECTION 1

## 1.0 INTRODUCTION

### 1.1 DESCRIPTION OF PROBLEM

Rocky Mountain Arsenal (RMA) occupies more than 17,000 acres (27 square miles) northeast of Denver, Colorado. RMA is immediately south of the city of Henderson, Colorado and directly east of Commerce City, Colorado in western Adams County (Figure 1.1-1). RMA was established in 1942 and has been used for the manufacture of chemical and incendiary munitions as well as chemical munitions demilitarization. Industrial chemicals were manufactured at RMA from 1947 to 1982.

During the period from 1943 to 1950, RMA distilled stocks of Levinstein mustard, demilitarized several million rounds of mustard-filled shells, and test-fired mortar rounds filled with smoke and high explosives.

In 1947, portions of RMA were leased to the Colorado Fuel and Iron Corporation (CFI) and Julius Hyman and Company. CFI manufactured chlorobenzene, DDT, naphthalene, chlorine, and fused caustic. Hyman produced a variety of pesticides, insecticides, and herbicides. Hyman assumed the CFI lease in 1950. In 1951, Shell Chemical Company assumed the Hyman Lease and began insecticide production. Production by Shell ceased in 1982.

Waste and waste streams, from the various chemical processing operations conducted at RMA since its establishment in 1942, were discharged into unlined evaporation basins (surface impoundments), identified as basins A-E, until an asphalt-lined evaporation basin, designated as Basin F and designed for total retention, was completed in 1956. Basin F was designed with a thin asphalt lining covered by a layer of sand. All sources of incoming wastewater were stopped in 1982 with the removal of the chemical sewer line. The remaining Basin F liquid has been evaporating since that time.

Contaminants from Basin F have migrated to the groundwater underlying the basin. A comprehensive study conducted in 1982 revealed that overburden and soil underneath the liner of the basin also have been contaminated with various chemicals accumulated in Basin F during its operational period.

Under the Resource Conservation and Recovery Act (RCRA), RMA has identified Basin F as a hazardous waste surface impoundment and has submitted a closure plan to the Colorado Department of Health.

RMA is currently considering the identification of one or more permanent remedies for Basin F wastes (liquid, sludge, and solids) through incineration/thermal treatment and, if necessary, fixation of the incineration/thermal treatment residue. Accordingly, the Program Manager's Office for Rocky Mountain Arsenal Contamination Cleanup (PMO) is gathering information on the technical and economic aspects or viability of incineration/thermal treatment of Basin F wastes as the initial step towards developing a broad remedial action alternative for Basin F. This action is being taken in accordance with the National Contingency Plan, 50 Fed. Reg. 47912 (1985).

PMO has selected Ebasco to undertake this work effort under Task Order 17. This Technical Plan describes the activities that Ebasco will perform under Task 17.

## 1.2 PROGRAM OBJECTIVES

The objectives of this study are to:

- o Recommend a preferred method for incineration/thermal treatment of Basin F wastes, based on a literature review of previously defined incineration technologies;
- o Perform laboratory-scale incineration of Basin F wastes to confirm the technical feasibility of the recommended incineration/thermal treatment;

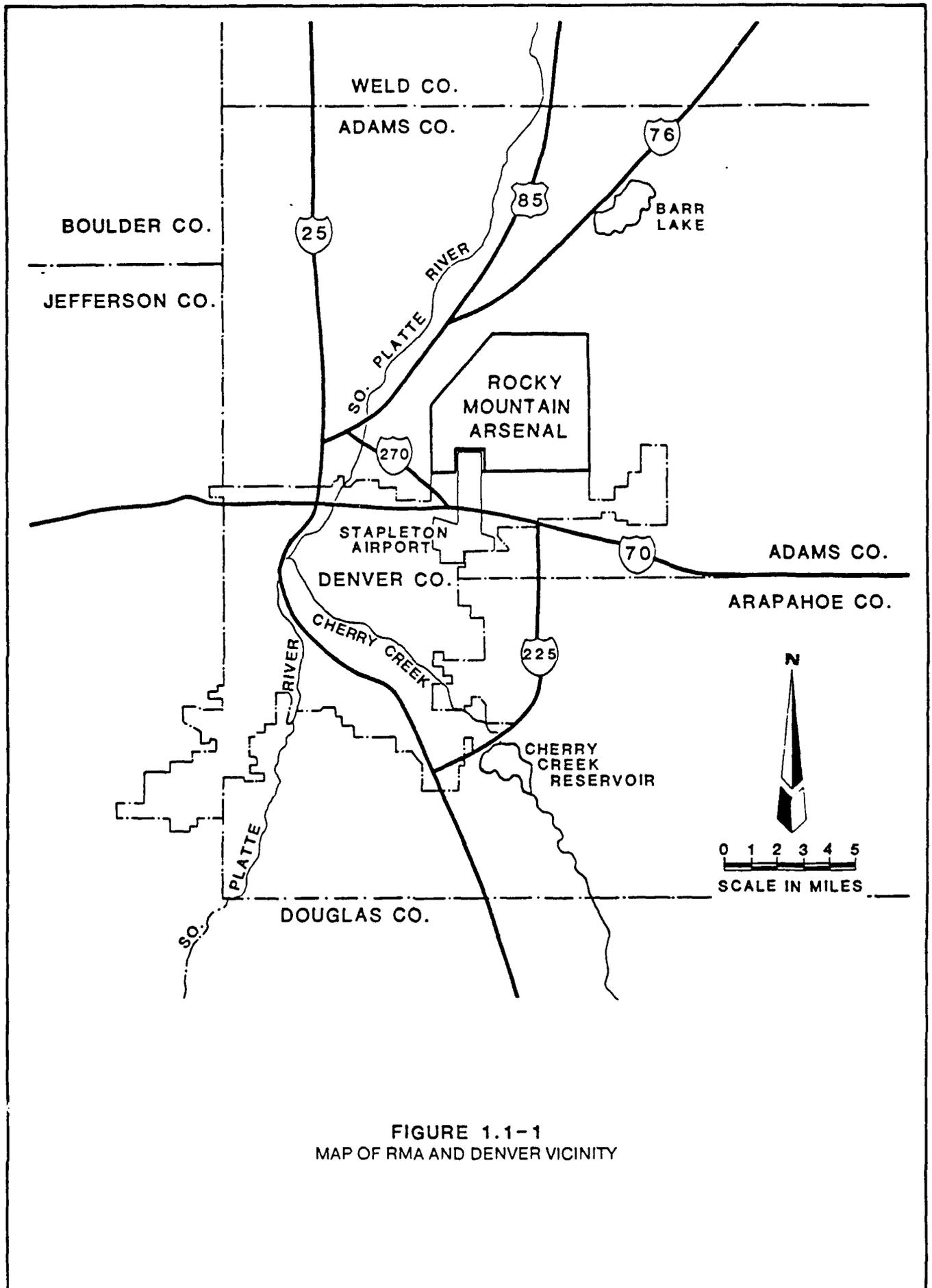


FIGURE 1.1-1  
 MAP OF RMA AND DENVER VICINITY

- o Determine, through an economic analysis and technical evaluation of alternatives, the necessity of pilot testing the preferred incineration/thermal treatment before commencing full-scale development of an incineration facility for Basin F wastes. Three alternatives to be investigated include: 1) the impacts of not pilot testing a future incineration facility; 2) the feasibility of using the existing North Plant Incinerator (Building 1611) following completion of necessary upgrading and repair; and 3) the effect of leasing an RCRA permitted mobile or modular incineration unit for the pilot program;
- o Investigate and recommend solidification/fixation methods for incineration ash; and
- o Provide engineering cost estimates (capital and operating costs) for the design, construction, and operation of a full-scale incineration/thermal treatment facility capable of processing Basin F wastes.

### 1.3 SUMMARY OF TECHNICAL APPROACH

To accomplish the objectives of this task, Ebasco will:

- o Perform a literature review to identify and select one or more candidate incineration technologies;
- o Conduct laboratory bench-scale incineration testing of Basin F wastes;
- o Evaluate the necessity for a pilot test program;
- o Investigate the feasibility of converting Building 1611 (North Plant Incinerator) into a pilot plant;
- o Determine economic trade-offs between using Building 1611 and a mobile incinerator; and
- o Develop capital and operating costs for a full-scale incinerator for treatment of Basin F wastes.

Initially, Ebasco will perform a literature search to identify the incineration technology or technologies likely to be suitable for handling Basin F wastes. Next, a selection process involving evaluation of candidate incineration technologies with a set of desired performance criteria will be implemented.

Upon selection of the final candidate incinerator type, Ebasco will undertake a laboratory bench-scale incineration program. Actual bench-scale testing will be performed by a laboratory engaged by Ebasco for Task 17. The objectives of the laboratory study are to determine:

- o Incinerability of the hazardous waste constituents present in Basin F wastes;
- o Optimal incineration operating conditions (temperature, residence time, oxygen requirements) for 99.99 percent destruction and removal efficiency (DRE) of hazardous organic constituents;
- o Incineration exhaust gas characteristics of Basin F wastes. Exhaust gas analysis will address concentration and mass emission of the primary organic hazardous constituents (POHC), any product of incomplete combustion (PIC), hydrogen chloride (HC), CO, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, O<sub>2</sub>, particulates, and determination of gas flow rate; and
- o Amount and characteristics of ash generated by incineration of Basin F wastes.

Measurements of these parameters will help to determine the DRE, effective combustion conditions, types of air pollution control equipment, and method of ash disposal required.

To perform laboratory testing, adequate waste samples from Basin F will be shipped to the laboratory. Ebasco's field team will conduct the sampling program at RMA. Sampling of liquid, sludges, and soils will

be performed with strict adherence to the Project Health and Safety and Quality Assurance Plans as specified in the four-volume Rocky Mountain Arsenal Procedures Manual to the Technical Plan (RMA Procedures Manual; Ebasco, 1985).

While the results of incineration tests obtained with a laboratory thermal destruction unit may resemble those from the performance of a full-scale incinerator, there are differences.

Given the difficulty of correlating laboratory bench-scale test results with full-scale incinerators, Ebasco (using subcontractor support) will evaluate the necessity of implementing an incineration pilot testing program of Basin F wastes. In considering a pilot testing program, Ebasco will investigate the feasibility of using Building 1611 (North Plant Incinerator) as a pilot unit. This investigation will identify any modifications or additions required to convert Building 1611 into a viable treatment facility. Ebasco also will perform economic trade-off analyses of converting and using Building 1611 as a pilot plant versus leasing an RCRA permitted mobile or modular incinerator. The comparative evaluation also will include the potential impact of not using a pilot program on the selection of a full-scale incinerator technology for Basin F wastes.

Final activities under this task will entail the development of capital and operating costs for a full-scale incinerator for Basin F wastes. To develop order-of-magnitude ( $\pm 25\%$ ) estimates, the Ebasco Team will prepare preliminary process flow diagrams, plant site layout drawings, and a preliminary equipment list. Ebasco will solicit preliminary price quotations from equipment manufacturers and vendors. For installation costs, Ebasco will use cost curves developed for similar facilities. Capital cost estimates also will include engineering design and construction management costs.

Ebasco also will investigate the necessity of solidifying or fixating the incinerator residue. This investigation will be performed only

upon laboratory confirmation that Basin F waste incineration residue is hazardous. If the laboratory test results identify Basin F waste incineration residue as hazardous, Ebasco will conduct a thorough literature search to determine the appropriate treatment (solidification/fixation) method to render incinerator ash nonhazardous.

Based on the results of this investigation, Ebasco will develop a cost estimate for the ultimate disposal of residue generated from an incineration/thermal treatment of Basin F wastes. The disposal cost will be estimated based on hauling incinerator ash to an off-site facility.

SECTION 2

## 2.0 EVALUATION OF BASIN F BACKGROUND DATA

### 2.1 DATA COMPILATION

The project team, during preparation of this Technical Plan has reviewed a number of documents detailing the history of Basin F and characteristics of wastes associated with the basin. A bibliography of these references can be found in Appendix A of this plan.

### 2.2 GENERAL SITE DESCRIPTION, LOCATION, AND HISTORY

#### 2.2.1 Site Description and Location

Basin F is located in the northwest part of the Arsenal in Section 26 (see Figure 2.2-1). Basin F, as designed, had a surface area of 90 acres at maximum fluid level with a capacity of approximately 243 million gallons. The basin, roughly oval in shape, was created in a natural depression by constructing a dike around the area. The basin measured approximately 2,900 feet across at the north end and 1,600 feet across at the south end. As designed, the average depth of the basin was approximately 10 feet. An asphaltic membrane (approximately 3/8 inch thick) was placed on the bottom of the basin extending to a projected high water elevation of 5,200 feet (MSL) at the edge of the sealed area. After the asphalt had been placed, an earth blanket approximately one foot thick was placed on top of the membrane to protect it. A vitrified clay chemical sewer line with chemically resistant sealed joints was installed between the industrial facilities where the wastes were generated and Basin F, to facilitate transfer of liquid wastes to the basin. In 1962, a low dike was placed across the southeast corner of the basin enclosing an area of approximately eight acres. This area is commonly referred to as "Little F".

The geohydrology and the climatic conditions of this area are described in Appendix B.

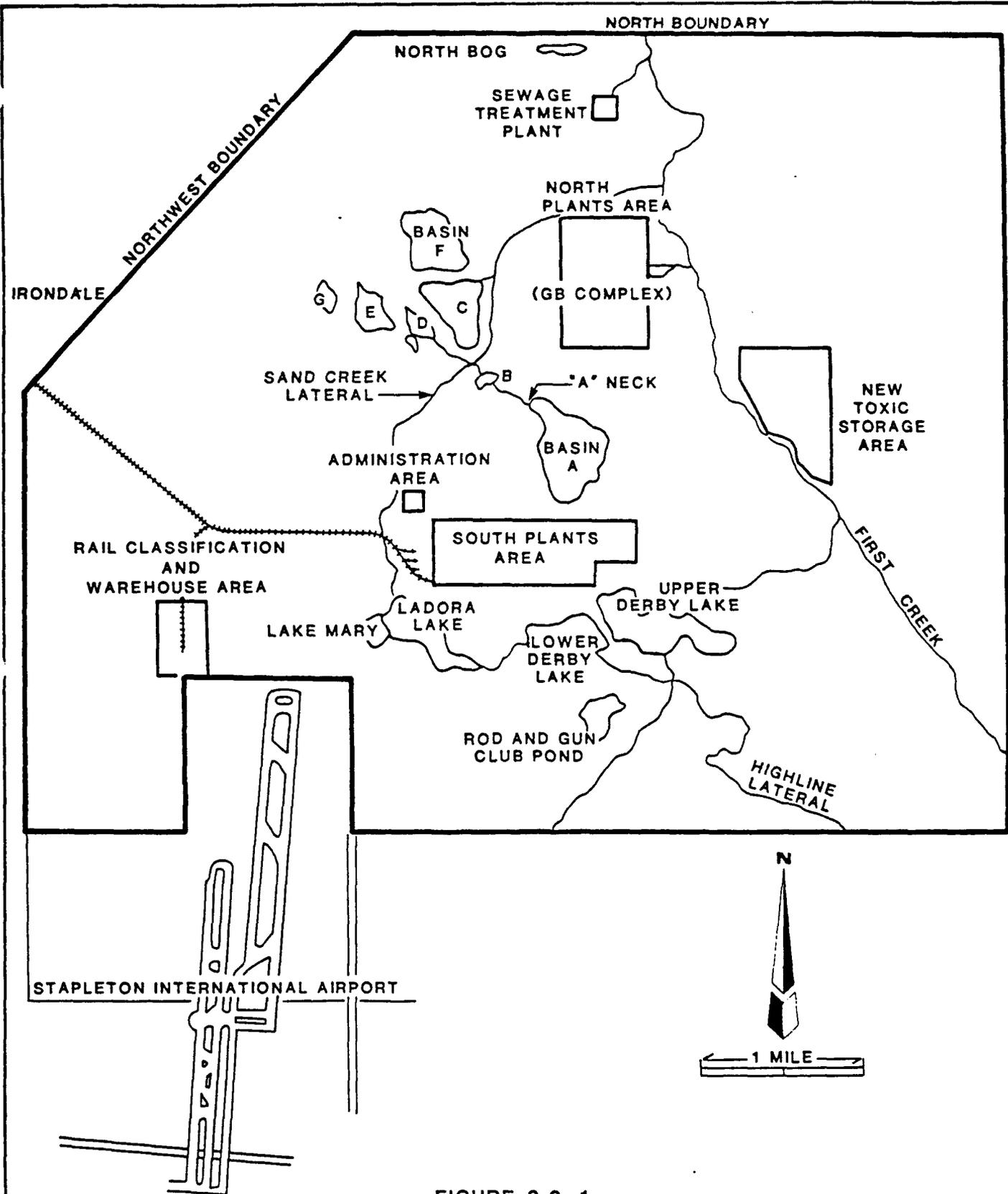


FIGURE 2.2-1  
GENERAL MAP OF RMA

SOURCE: RMA CONTAMINATION CONTROL PROGRAM MANAGEMENT TEAM, 1983

### 2.2.2 Basin F History of Use

By early 1957, approximately 60 million gallons of waste had been transferred to Basin F. This waste from Army and Shell operations consisted mainly of aqueous solutions of various sodium salts including chloride, fluoride, hydroxide, methyl phosphonate, acetate, sulfate, and pesticide.

Problems associated with the storage of liquid wastes in Basin F were encountered early in its operation and were caused by wave action against the shoreline that, at the time, had not been protected by riprap. In 1957, tears in the asphalt liner were found. The contents of Basin F were pumped into Basin C, an unlined facility, while repairs were made to the Basin F liner and riprap was installed. After repairs were completed, the contents of Basin C were pumped back into Basin F. Some of the other problems that have been discovered since construction are: (a) fluctuating liquid levels that have caused cyclical exposures of the basin floor to sunlight and weather conditions (see Figure 2.2-2), and (b) (evidence of groundwater contamination found as a result of chemical analysis of groundwater samples from monitoring wells immediately adjacent to the basin.

Through the years, various studies and activities have been proposed or conducted, aimed at eliminating industrial waste discharge into Basin F and accomplishing its final cleanup. An attempt was made between 1962 and 1965 to dispose of the liquid waste by injection into a deep well located adjacent to the basin. Because of a marked increase in the number and intensity of earth tremors in the Denver area, this operation was discontinued. Other disposal alternatives were evaluated, including treatment and enhanced evaporation, but none were implemented until 1982 when an enhanced evaporation system was installed. From 1978 to 1982, the primary flow of waste into Basin F was approximately 300,000 gallons per year from the Hydrazine Blending and Storage Facility, miscellaneous Army operations, and an undetermined amount of groundwater that infiltrated into the sewer line feeding the basin.

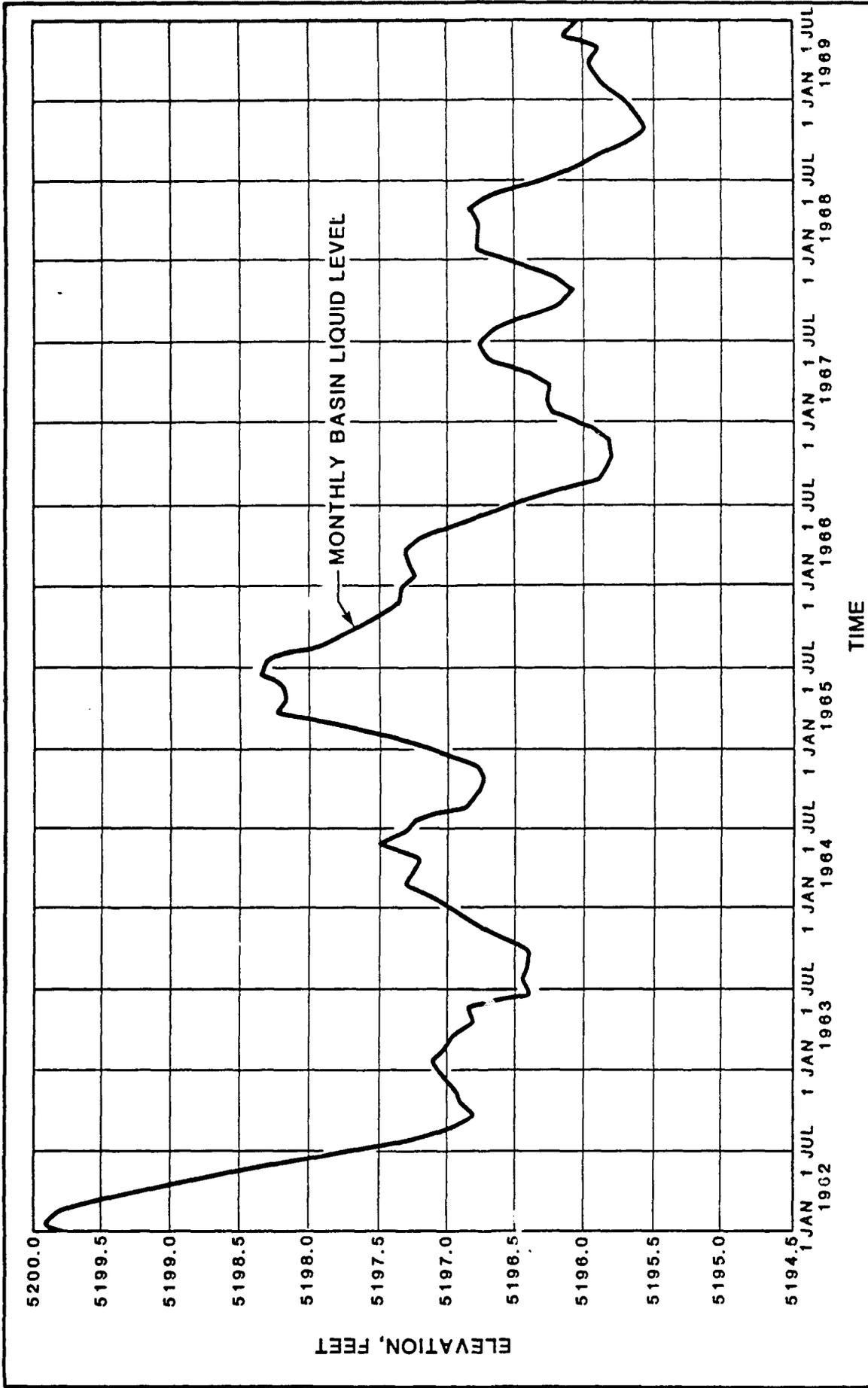


FIGURE 2.2-2  
VARIATION IN BASIN F LIQUID SURFACE ELEVATION

The potential for industrial waste discharge into Basin F was eliminated in 1982 when the chemical sewer line feeding the basin was excavated from a point immediately north of the South Plants Area to the southeast corner of the basin. A portion of the line from the North Plants Area also was excavated. The sewer line and associated contaminated soil excavated, consisting of approximately 12,000 cubic yards of material, were stored in a lined waste pile in the southeast corner of Basin F.

Natural evaporation of the liquid in the basin has exceeded the inflow of waste over the past few years, and, therefore, the volume of liquid in the basin has decreased significantly. As a result, the liquid pool has receded to the north end of the basin exposing the soil covering the liner in the southern end of the basin. An evaporation system, consisting of a newly constructed dike on the exposed surface of the basin, a large pump, and a pipe network for liquid distribution, was constructed in the basin to enhance evaporation of the liquid contents. A schematic of this system is presented in Figure 2.2-3. As designed, liquid from the existing pool is pumped through a supply line to two trickler lines which distribute the liquid over the exposed surface of the basin, thus increasing the area for evaporation. Liquid from the inner trickler line will flow back into the existing pool while liquid from the outer trickler line will pond behind the new dike, thus creating a new liquid pool and a larger exposed surface area for increased evaporation. This system was completely reconstructed during October 1985 and is now operable.

### 2.3 BASIN F WASTE CHARACTERISTICS AND INVENTORY

In addition to the actual liquid wastes contained within Basin F, three other categories of materials are present which may be considered waste materials. These are the basin liner itself, the overburden above the liner (including precipitates), and any contaminated soil adjoining the basin or beneath the liner. Overburden, liner and contaminated soils can be considered together for treatment and disposal.

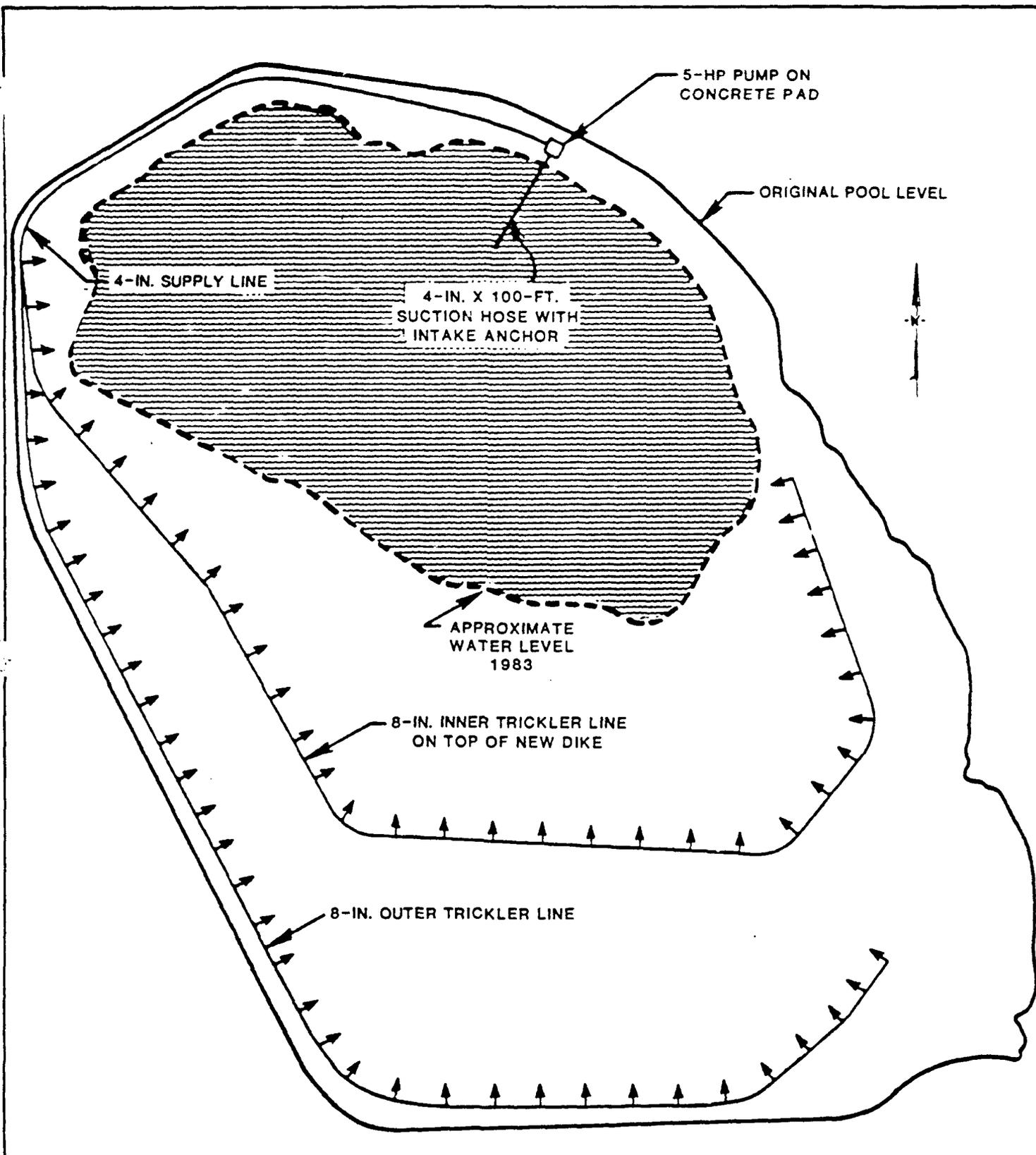


FIGURE 2.2-3  
SCHEMATIC DIAGRAM OF BASIN F ENHANCED EVAPORATION SYSTEM

### 2.3.1 Basin F Liquid

Numerous analyses have been conducted on Basin F liquid through the years. A comprehensive review of the previous analytical results was conducted in 1977 (Buhts et al., 1977). The results of this effort are summarized in Table 2.3-1. Contaminant concentrations in the liquid likely have increased since 1977 due to evaporation of water and the resulting concentration of the liquid. The liquid presently appears to be saturated with salts.

A crystalline precipitate forms in the liquid when a sample is taken and allowed to sit and evaporate for a short period of time. This crystalline precipitate is visible in the exposed area of the basin. As precipitation falls on the basin, some of the precipitated salts probably are redissolved, thus allowing the liquid to maintain a fairly constant chemical character.

Table 2.3-2 presents a summary of the relationships between surface elevation, surface area, and liquid volume for the basin. The volume fluctuates with respect to varying meteorological conditions which affect precipitation and evaporation. The majority of the precipitation that falls within the perimeter dike of the basin flows into the existing liquid pools, because the basin floor slopes to these areas. Rapid evaporation occurs in the hot, dry summer months. Energy absorption and, thus, evaporation of the liquid is enhanced by its dark color. This natural evaporation can be enhanced further through use of the pumping and distribution system described earlier.

As a result of natural evaporation and the elimination of waste flow to Basin F, the volume of liquid in the basin has been reduced significantly. The volume currently (November 1985) is estimated at approximately one million gallons or about 5,000 cubic yards (Ebasco 1985b).

TABLE 2.3-1  
CHEMICAL CHARACTERIZATION OF BASIN F LIQUID

Compound or Parameter.	Units	Concentration Range*
pH	-	6.9 - 7.2
Aldrin	ppm	50.0 - 400
Isodrin	ppb	2.0 - 15
Dieldrin	ppb	5.0 - 110
Endrin	ppb	5.0 - 40
Dithiane	ppb	30.0 - 100
DIMP	ppm	10.0 - 20
DMMP	ppm	500.0 - 2,000
Sulfoxide	ppm	4.0 - 10
Sulfone	ppm	25.0 - 60
Chloride	ppm	48,000.0 - 56,000
Sulfate	ppm	21,000.0 - 25,000
Copper	ppm	700.0 - 750
Iron	ppm	5.0 - 6
Nitrogen	ppm	120.0 - 145
Phosphorus (total)	ppm	2,050.0 - 2,150
Hardness	ppm	2,100.0 - 2,800
Fluoride	ppm	110.0 - 117
Arsenic	ppm	1.0 - 1.3
Magnesium	ppm	35.0 - 40
Mercury	ppb	26.0 - 29
Cyanide	ppm	1.45 - 1.55
COD	ppm	24,500.0 - 26,000
TOC	ppm	20,500.0 - 22,500

\*Based on the analysis of various samples from different locations and depths in the basin (Buhts et al., 1977).

TABLE 2.3-2  
VOLUME OF LIQUID CONTAINED IN BASIN F WITH RESPECT TO  
ELEVATION AND SURFACE AREA\*

Elevation of Liquid Surface (ft)	Surface Area (square feet)	Total Volume (cubic feet)	Total Volume (gallons)
5,187.5	0	0	0
5,187.6	32,902	1,695	12,679
5,187.7	62,946	6,537	48,897
5,187.8	116,719	15,520	116,090
5,187.9	164,922	29,602	221,423
5,188.0	235,113	49,604	371,038
5,188.1	298,899	76,305	570,761
5,188.2	377,015	110,101	823,555
5,188.3	477,189	152,811	1,143,026
5,188.4	594,049	206,373	1,543,670
5,188.5	692,788	270,715	2,024,948
5,188.6	801,146	345,411	2,583,674
5,188.7	877,780	429,357	3,211,590
5,188.8	949,218	520,707	3,894,888
5,188.9	1,021,813	619,258	4,632,050
5,189.0	1,095,872	725,142	5,424,062
5,189.1	1,162,585	838,065	6,268,726
5,189.2	1,226,092	957,499	7,162,093
5,189.3	1,285,126	1,083,060	8,101,289
5,189.4	1,312,055	1,212,989	9,073,158
5,189.5	1,345,228	1,345,783	10,066,457
5,189.6	1,371,633	1,481,626	11,082,562
5,189.7	1,398,556	1,620,135	12,118,610
5,189.8	1,426,007	1,761,363	13,174,995
5,189.9	1,453,997	1,905,363	14,252,115
5,190.0	1,482,537	2,052,189	15,350,374
5,190.1	1,501,403	2,201,386	16,466,367
5,190.2	1,520,510	2,352,482	17,596,565
5,190.3	1,539,859	2,505,500	18,741,140
5,190.4	1,559,455	2,660,466	19,900,286
5,190.5	1,579,300	2,817,404	21,074,182
5,190.6	1,599,397	2,976,338	22,263,008
5,190.7	1,619,751	3,137,296	23,466,974
5,190.8	1,640,363	3,300,302	24,686,259
5,190.9	1,661,238	3,465,382	25,921,057
5,191.0	1,682,378	3,632,562	27,171,564

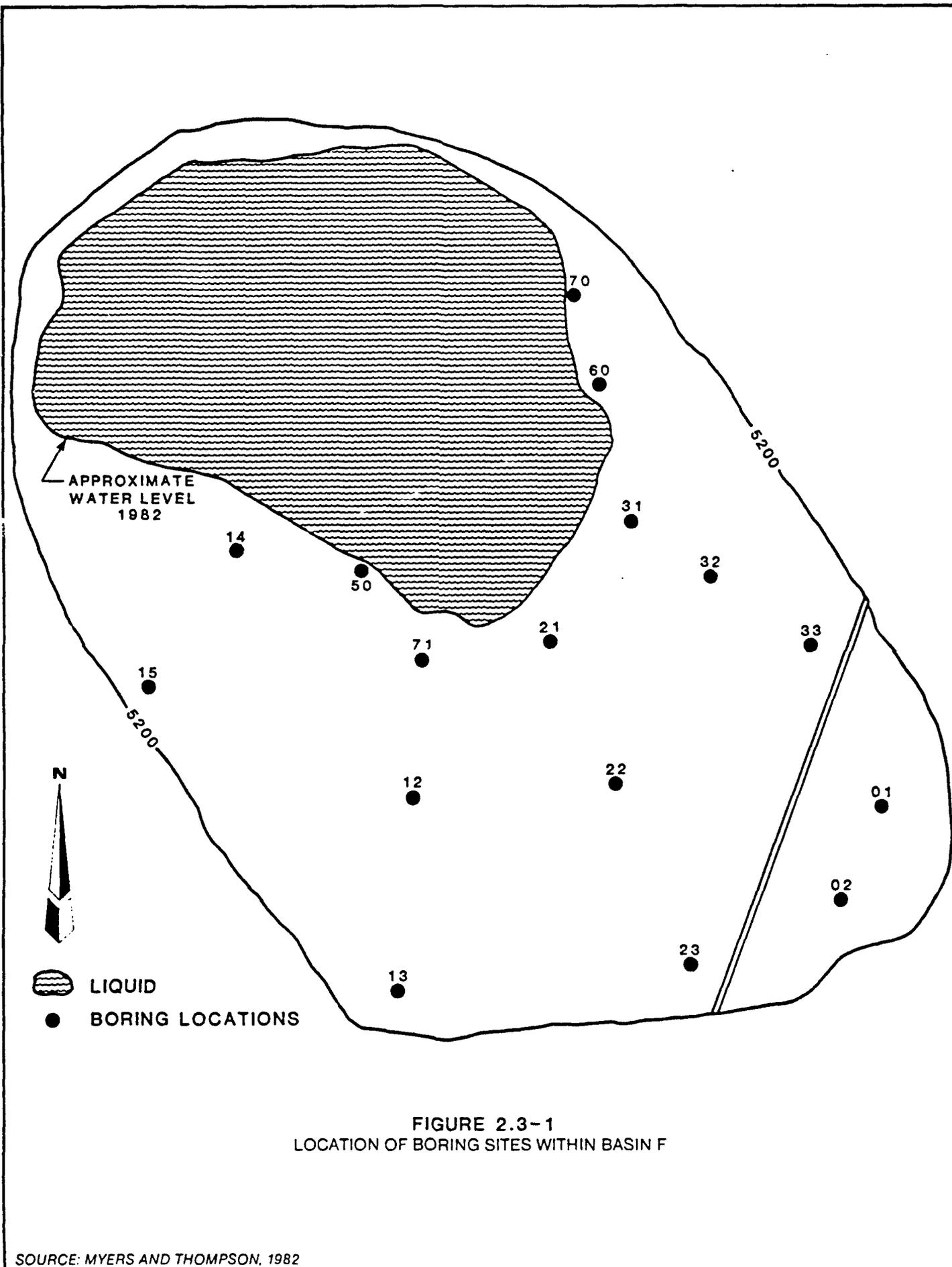
\* Based upon survey conducted June 1984.

### 2.3.2 Basin F Overburden, Liner, and Soil

A comprehensive study of Basin F was conducted in 1982 to determine the distribution of contaminants in the overburden and in the soil underlying the liner, and to assess the condition of the liner (Myers and Thompson, 1982). This study involved the placement of 16 shallow borings in the exposed portion of the basin as indicated in Figure 2.3-1.

The sample cores and samples of the overburden were subjected to a series of analytic extraction procedures. Among those initially considered were EP toxicity, solid waste leaching procedures (SWLP), and total extraction (bulk analysis). The EP toxicity procedure yields a determination of whether the waste would be considered hazardous under RCRA. The SWLP is similar to the EP toxicity test with the exception that water with a neutral pH is used as an extract to more accurately simulate migration potential (Myers and Thompson, 1982). Bulk analyses utilize a solvent rinse to correlate the gross amount of contaminant held within the waste matrix available for potential release. It was determined that the SWLP and bulk analysis would yield sufficient information to determine the areal extent and depth of concern for contamination beneath the basin.

The overburden in the basin is composed of the original sand placed over the liner during construction plus additional material deposited on the layer through time as a result of precipitation of salts from the liquid, deposition of wind blown soil, and dumping of waste solids into the basin. In certain areas of the basin where the overburden has been exposed for long periods of time, it appears that some of the original sand cover has been lost, probably due to wind erosion. In order to provide an overall picture of the depth of overburden in the exposed portion of the basin, a contour map of depth was developed based on measurements taken during field activities. This contour map is presented in Figure 2.3-2. The minimum depth found was 0.65 feet while the maximum depth found was 1.8 feet. No information was obtained on sediment depths under the existing liquid pool, however, they are likely to be as great or greater than those found in the exposed area of the basin.



**FIGURE 2.3-1**  
 LOCATION OF BORING SITES WITHIN BASIN F

SOURCE: MYERS AND THOMPSON, 1982



During placement of the borings in the basin, the liner at each boring location was inspected and its condition noted. Over most of the basin, the liner was found to be in good condition with a reported thickness of approximately 3/8 inch. The major exception was found in boring No. 2 (in "Little F") where the liner appeared to have been liquified and dispersed making it difficult to identify.

The soil cores taken in the basin were field classified using the Unified Soil Classification Systems (USCS). To illustrate the variations in soil types found with depth, a series of three horizontal cross-sections were prepared delineating the soil classification in the intervals 0-1 foot, 1-2 feet, and 2-3 feet. The horizontal cross-sections are presented in Figures 2.3-3, 2.3-4, and 2.3-5, in which specific soil groups are identified using a standard symbol. The predominant soil groups identified include silty clays, inorganic silts, and inorganic clays. Inorganic clays become more predominant with increasing depth. All of the soil types identified provide some capacity for holding-up or retaining contaminants because they are fine grained or contain clay or both.

The extracts from the SWLP tests conducted on subsamples of the cores were analyzed for a select group of contaminants which had been identified previously in the Basin F liquid. Detailed results of these SWLP tests can be found in Appendix B. The concentrations of many of the contaminants in the SWLP extracts were very low or below detectable limits (Myers and Thompson, 1982). A plan map was developed for the purpose of summarizing the SWLP results on the cores. This map is presented in Figure 2.3-6. All of the contaminants found to be above 100 times their respective water quality levels in the SWLP extracts of the boring cores from the first four, one-foot intervals under the liner are identified with respect to each boring site on the map. Those intervals from which samples were not analyzed or no contaminants were found in the extracts above their action levels also are identified.

The contaminants found in the extract above their respective action level concentrations include Aldrin, Dieldrin, Endrin, Isodrin, organo-sulfur compounds, DBCP, arsenic, and fluoride. Some of the borings (No. 21, 22,

BASIN F SUBLINER SOILS: 0-1 FT INTERVAL

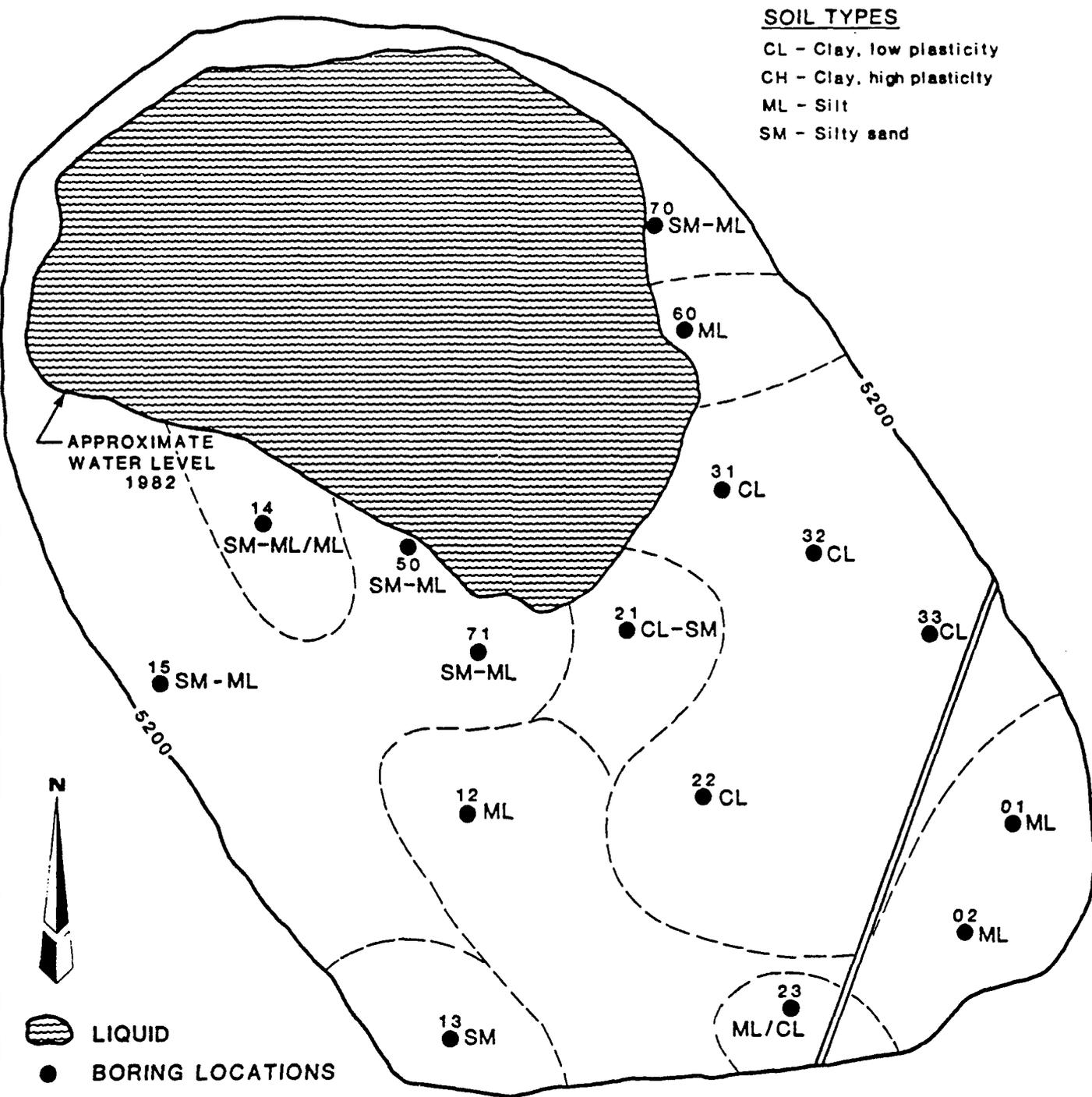
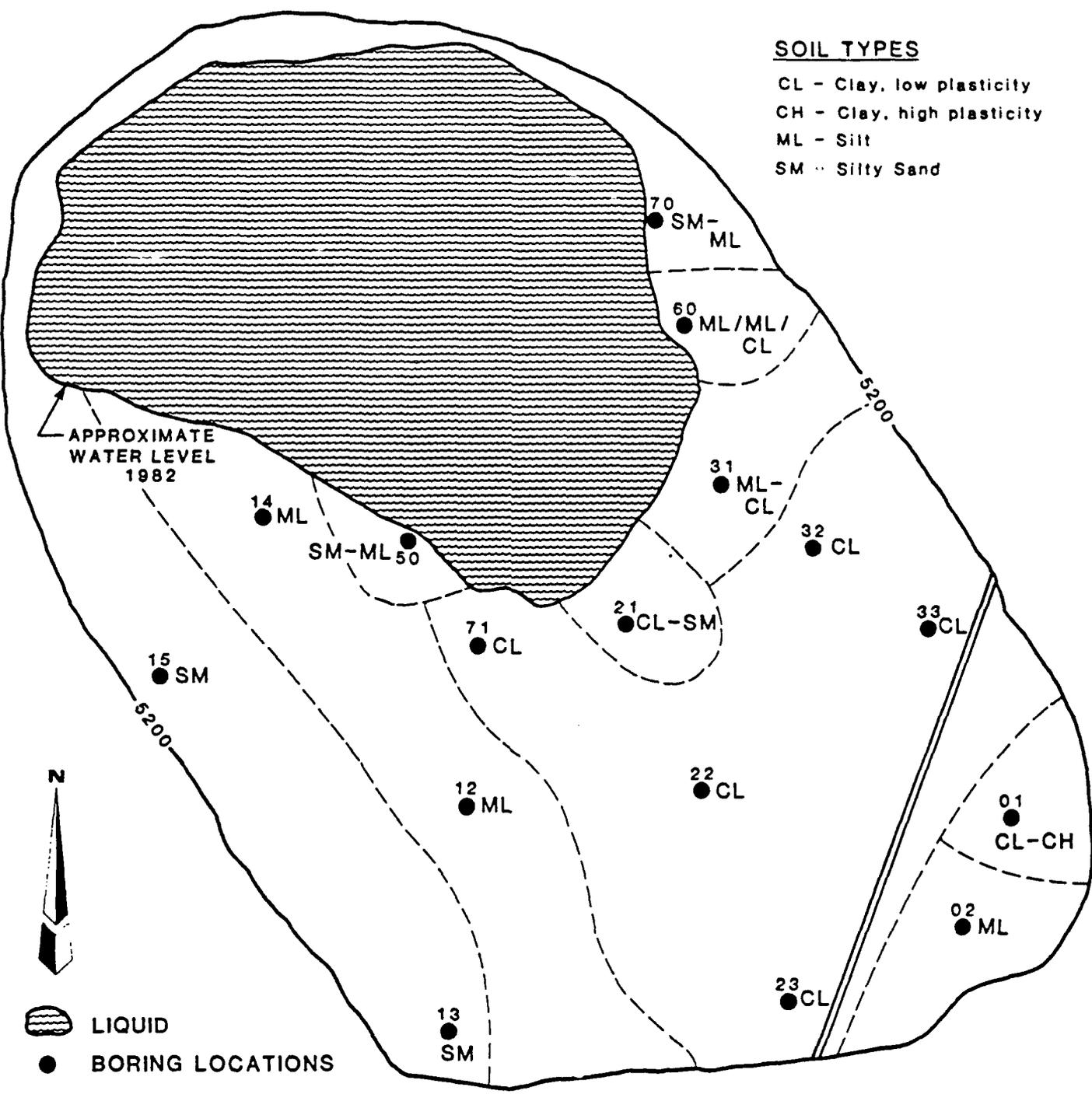


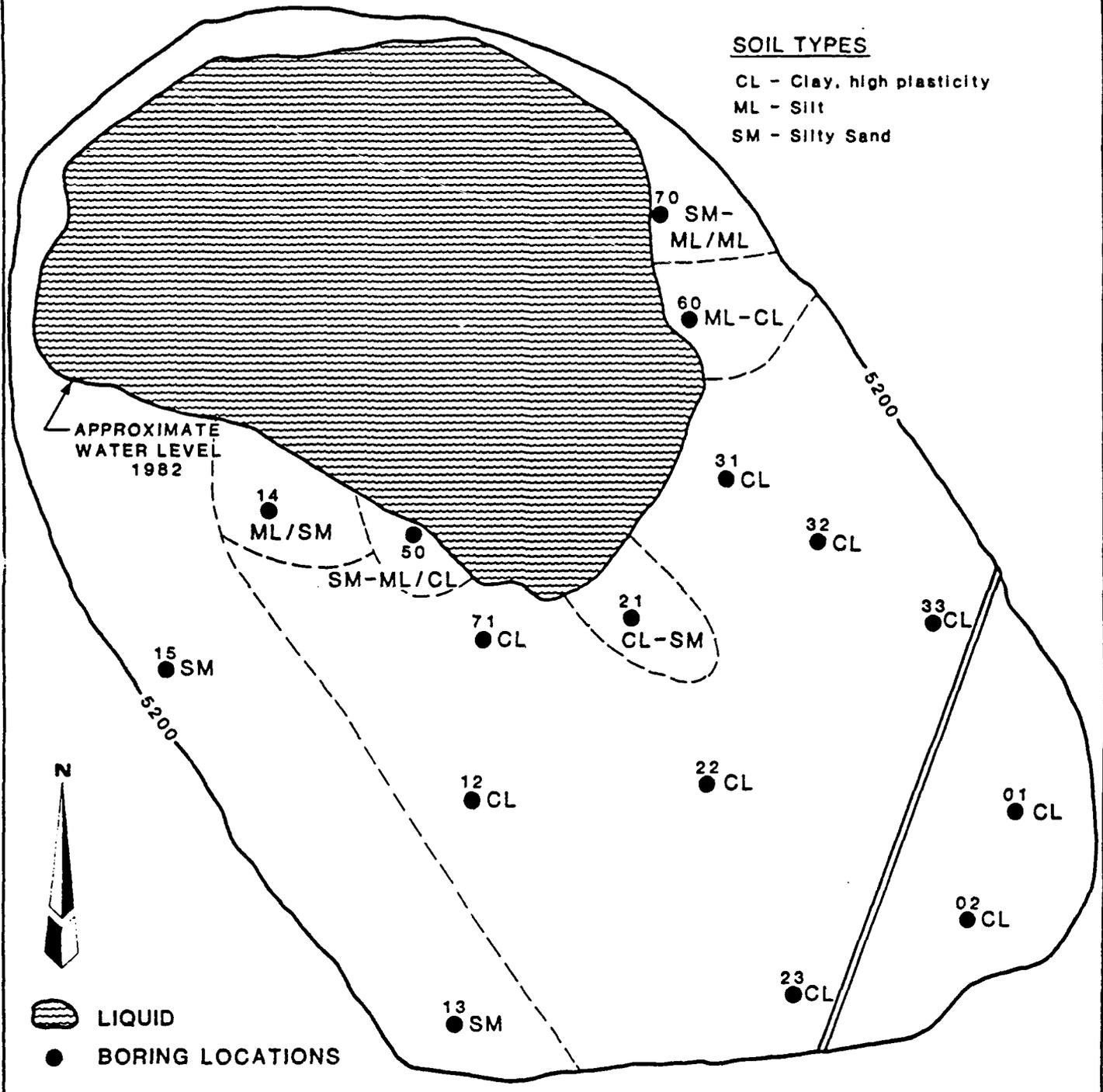
FIGURE 2.3-3  
 DISTRIBUTION OF SOIL TYPES IN BASIN F  
 0.0 - 1.0 FT BELOW THE LINER

**BASIN F SUBLINER SOILS: 1-2 FT. INTERVAL**

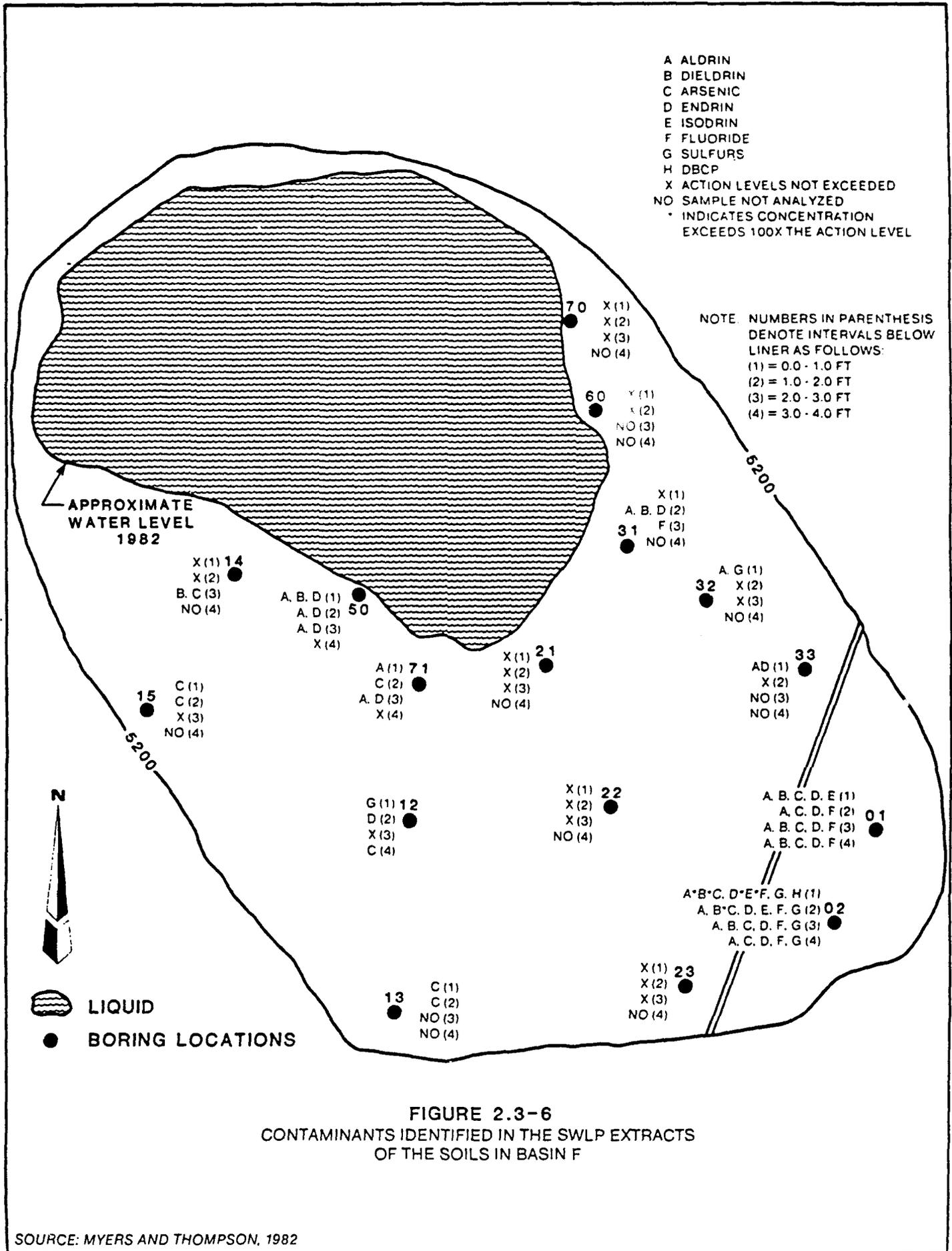


**FIGURE 2.3-4**  
 DISTRIBUTION OF SOIL TYPES IN BASIN F  
 1.0 - 2.0 FT. BELOW THE LINER

**BASIN F SUBLINER SOILS: 2-3 FT. INTERVAL**



**FIGURE 2.3-5**  
**DISTRIBUTION OF SOIL TYPES IN BASIN F**  
**2.0 - 3.0 FT BELOW THE LINER**



**FIGURE 2.3-6**  
 CONTAMINANTS IDENTIFIED IN THE SWLP EXTRACTS  
 OF THE SOILS IN BASIN F

SOURCE: MYERS AND THOMPSON, 1982

23, 60, and 70) had no associated extracts with contaminant concentrations above the criteria shown in Table 2.3-2. Borings No. 1 and 2 (in "Little F") were found to have the greatest number of contaminants in the extracts for all intervals. Also, the concentrations of the contaminants in the extracts from these two borings were, in general, higher than those associated with the other borings.

The SWLP tests, conducted on the overburden samples collected from five boring sites, resulted in much higher concentrations of contaminants in the extracts than in those associated with the soils underlying the liner. In addition to the contaminants identified in the SWLP extracts from the cores, concentrations of DIMP and DCPD were found in some of the extracts from the overburden. In previous testing (required for filing Part A of the RCRA permit for RMA), an EP extract of the overburden from the basin was found to contain Endrin in excess of the associated 0.02 ppm criterion.

Only the extracts from the cores collected at Boring No. 2 from the 0-1 foot and 1-2 foot intervals exhibited concentrations exceeding 100 times their respective water quality levels (see Figure 2.3-6). For the 0-1 foot interval, the concentrations of Aldrin, Dieldrin, Endrin, and Isodrin in the extract exceeded the criteria. In the 1-2 foot interval, only the concentration of Dieldrin in the extract exceeds the criteria.

As discussed previously, Boring No. 2 was the only boring location in the study where the liner was found to be in poor condition. Contamination in the overburden or contaminated liquid (when this area was inundated) probably was able to migrate in high concentrations into the soil due to the deteriorated condition of the liner. In the other areas of the basin evaluated in this study, the liner appears to have maintained sufficient integrity to prevent the migration of large amounts of contaminants to the underlying soils.

Based on the results of this preliminary soil sampling (Myers and Thompson 1982), the overburden above the liner is considered to be hazardous. The liner also may be considered to be contaminated. The total volume of the overburden and liner is approximately 240,000 cubic yards. This calculation is based on an estimated average overburden and liner thickness of 1.6 feet and a basin area of 93 acres (450,120 square yards).

The preliminary soil sampling analyses also provide a basis for estimation of the volume of soil to be excavated. The results from those SWLP tests suggest that approximately 6 feet of soil need to be removed from the "Little F Area" (approximately 8 acres), while 6 inches would be removed over the rest of the basin (approximately 85 acres).

This provides a minimum estimate of 146,000 cubic yards of soil that will have to be removed from the basin. A summary of the currently, estimated volume of raw waste materials within Basin F is as follows:

<u>Raw Waste Material</u>	Current (1985) <u>Estimated Volume, yd<sup>3</sup></u>
Liquid (1 million gal)	5,000
Overburden and Liner	240,000
Underlying Soils	146,000
Sewer Debris and Soils	<u>12,000</u>
Total	403,000*

\* Excludes adjoining soils which may have been contaminated by Basin F activities. Estimate is subject to refinement upon completion of Phase II.

The "sewer debris and soils" are potentially contaminated wastes that were generated during the removal of the chemical sewer leading to Basin F. These wastes were deposited within Basin F.

### 2.3.3 Incinerability of Basin F Waste

A laboratory incineration test was performed on "Basin F Fluids" by Midwest Research Institute (MRI) in 1982. The test included analysis of the waste sample, selection of principal organic hazardous constituents (POHCs), a bench-scale incineration test, analysis of the exhaust gas, and identification of products of incomplete combustion (PICs), as well as destruction and removal efficiencies (DREs). Test conditions were incineration temperatures of 1100°C and 900°C and residence times of 1.6 seconds and 1.7 seconds, respectively.

The results indicated the presence of ten organic compounds, three of which were identified as POHCs, Table 2.3-3 Parts A and B list these compounds. The identified POHCs include chlorobenzene, chloroform, and toluene. Most of the identified organic compounds were volatiles and were present in very small concentrations ( $\leq 4\mu\text{g/g}$ ) in the waste material. Some relatively large quantities of highly polar semivolatile sulfonated and oxygenated compounds (e.g., phenols, carboxylic acids, sulfonic acids, and organophosphates) also were determined to be present in the waste. Through thermogravimetric results, the heat-up rate of the sample in the pyrolyzing furnace was determined. The laboratory incineration test under the first conditions (1100°C incineration temperature and 1.6 second residence time) was performed on a 2.08 g sample of the waste. The test resulted in an integrated exhaust gas sample composition of 15.0%  $\text{O}_2$ , 0.6%  $\text{CO}_2$ , and 18.0 ppm CO for the temperature range of 90°C to 155°C.

The DRE of the incinerator also was analyzed. Chloroform appeared to be formed during the test and, therefore, could not be selected as a POHC. For chlorobenzene, DRE was determined to be 85% and for toluene, 87%.

The incineration test resulted in the formation of numerous PICs which are listed in Table 2.3-3, Parts C and D. Other combustion products included unidentified molecules containing sulfur, oxygen, and phosphorus and also large quantities of  $\text{NaCl}$  and  $\text{Na}_2\text{SO}_4$ . These molecules were assumed to be present in the starting material.

TABLE 2.3-3

MRI INCINERATION TEST RESULTS

(MRI, 1982)

Part A - POHCs Present in Waste and Incinerator Effluent

Volatile (V) or Semivolatile (SV)	Compound	Heat of Combustion (kcal/g)	Concentration in waste (ug/g)	1100°C Incineration Test		900°C Incineration Test			
				Quantity in Sample (ug)	Quantity in Effluent (ug)	DRE (%)	Quantity in Sample (ug)	Quantity in Effluent (ug)	DRE (%)
V	Chlorobenzene	6.60	3	6.2	0.96	85	7.1	0.25	96
V	Chloroform	0.75	0.3	0.62	2.0	- <sup>a</sup>	0.71	7.1	0
V	Toluene	10.14	4	8.3	1.1	87	9.5	0.54	94

Part B - Other (Non-POHC) Compounds Identified in Waste

Volatile (V) or Semivolatile (SV)	Compound	Concentration in Waste (ug/g)	1100°C Incineration Test		900°C Incineration Test	
			Quantity in Sample (ug)	Quantity in Effluent (ug)	Quantity in Sample (ug)	Quantity in Effluent (ug)
SV	Dihydroxy- benzoic acid	100	210	Not detected	240	Not detected
V	methyl ester	40	83	Not detected	95	Not detected
V	Dimethoxy- ethane	15	31	Not detected	35	Not detected
V	Ethoxyethyl- ene	1	2.1	Not detected	2.4	Not detected
V	Heptane	0.7	1.5	Not detected	1.7	Not detected
V	Unknown C <sub>3</sub> alkyl benzene	2.5	5.2	(0.16) <sup>f</sup>	5.9	(0.10) <sup>f</sup>
V	o-Xylene	2	4.2	-	4.7	-
V	m-Xylene	4	8.3	-	9.6	-

TABLE 2.3-3 (Continued)

Part C - PICs Formed (Listed as EPA POCs)

Volatile (V) or Semivolatile (SV)	Compound	1100°C Incineration Test		900°C Incineration Test	
		Quantity in Effluent (µg)	Quantity of Compound Per Mass of Sample (µg/g)	Quantity in Effluent (µg)	Quantity of PIC/ Mass of Sample (µg/g)
SV	Acetophenone	4.3	2.3	8.9	3.8
V	Benzene	1.2	0.58	>>1.7	>>0.72
V	Bromodichloromethane	Not detected	-	1.0	0.42
V	Carbon disulfide	3.9	1.8	2.2	0.93
V	Carbon tetrachloride	0.23	0.11	2.6	1.1
V	1,1-Dichloroethylene	0.11	0.05	1.6	0.68
V	1,2-Dichloroethylene	0.26	0.12	0.37	0.37
SV	Hexachlorobenzene	5.2	2.5	Trace	Trace
SV	Naphthalene	12	5.3	7.1	3.0
SV	Pentachloroethane	5.2	2.5	Trace	Trace
SV	Pentachlorobenzene	Not detected	-	1.0	0.42
SV	Phenol	4.0	1.9	3.1	1.3
SV	Tetrachlorobenzene <sup>c</sup>	1.3	0.62	Trace	Trace
SV	Tetrachlorobenzene <sup>i</sup>	2.5	1.2	Trace	Trace
V	Tetrachloroethylene	0.65	0.31	4.2	1.8
SV	Trichlorobenzene	2.5	1.2	Trace	Trace

TABLE 2.3-3 (Continued)

Part D - Other Compounds Formed (Not Listed as EPA POCs)

Volatile (V) or Semivolatile (SV)	Compound	1100°C Incineration Test		900°C Incineration Test	
		Quantity in Effluent (µg)	Quantity of Compound Per Mass of Sample (µg/g)	Quantity in Effluent (µg)	Quantity of Compound Per Mass of Sample (µg/g)
SV	Benzaldehyde	48	23	21	8.9
SV	Benzoic acid	75	36	250	100
V	Chlorobutane	1.2	0.58	0.22	0.09
V	Chlorohexane	1.5	0.72	0.19	0.08
V	Chloropentane	1.3	0.62	0.26	0.11
V	1-Chloropropane	0.44	0.21	Not detected	--
V	2-Chloropropane	1.6	0.77	0.36	0.15
V	Cyclohexane	< 7.3	< 3.5	0.65	0.28
SV	Dimethylacetophenone <sup>g</sup>	6.5	3.1	30	13
V	Dimethyl disulfide	0.23	0.11	0.87	0.37
SV	Diphenylethane	6.5	3.1	2.7	0.72
V	Hexane	0.73	0.35	0.58	0.25
V	Methyl acetate	Not detected	--	1.6	0.68
SV	Methylacetophenone <sup>g</sup>	26	12	21	8.9
SV	S6 (sulfur)	4.8	2.3	Trace	Trace
SV	S7 (sulfur)	7.8	3.7	5.0	2.1
SV	S8 (sulfur)	96	46	5.8	2.5
SV	Unknown N-containing aromatic compound	10	4.8	Not detected	Not detected

<sup>a</sup> Formed additional 220K

<sup>b</sup> Formed additional 900K

<sup>c</sup> Tetrachlorobenzene isomer No. 1.

<sup>d</sup> Tetrachlorobenzene isomer No. 2.

<sup>e</sup> Mass spectrometer was saturated.

<sup>f</sup> Total of xylene - unable to determine which isomer.

<sup>g</sup> Best judgment of compound's identity

A 2.36 g sample of waste was used for incineration under the second test conditions (900°C incineration temperature and 1.7 second residence time). An integrated gas bag sample was collected in the temperature range of 100° to 150°C and analyzed. The gas composition indicated 16.4% O<sub>2</sub>, 0.6% CO<sub>2</sub>, and 4 ppm of CO. The calculated DREs were 96% for chlorobenzene and 94% for Toluene, which was higher than the observed DRE at the higher temperature. The opposite would be anticipated. The report stated that since POHCs were present in such small quantities in the original waste, the resulting DREs may be only approximate. It also was stated that, because of small concentrations of POHCs, the difference in results between the two tests may not be significant. Previous experience with the laboratory incineration unit on waste, which also had been tested in a full-scale incinerator, has indicated that laboratory DRE results are generally less than full-scale results.

As in the 1100°C test, numerous PICs and daughter products were formed. The products, however, seemed to be present at lower quantities than in the 1100°C test, which again seems opposite of what would be expected.

Below are the conclusions of those tests as included in the laboratory report dated June 7, 1982.

#### Conclusions

1. DREs are low relative to the 99.99% level required under RCRA. However, this probably is not of major importance, because POHCs were present in the waste in extremely low concentrations, far below the usual 100 ppm lower limit of interest. Therefore, these compounds would not be selected as POHCs under the EPA selection criteria. Even though the DREs are less than 99.99%, this is not significant in terms of EPA regulations. Full-scale incineration test data indicate that at higher concentrations those compounds can be destroyed at DREs > 99.99%, based on tests in which they were present at concentrations above 100 ppm in the waste.

2. Although the quantity of PICs may appear large relative to the POHCs in the waste, the quantities are actually about the same as have been found in tests with other wastes in the incineration test unit. In fact, benzene and chlorinated benzenes are PICs that were commonly formed in other tests with organic waste containing high levels of chlorinated solvents.
3. We are unable to explain why the DREs were lower and the quantity of PICs higher at the highest incineration temperatures.
4. Based on the above discussion and test results and other tests with the laboratory test unit, it is our opinion that incineration of the RMA waste as a disposal method should not be eliminated from consideration. However, it must be recognized that the quantity of PICs formed may be large relative to the very small quantity of POHCs present in the waste.

#### 2.4 IDENTIFICATION OF DATA GAPS

The amount and concentration of Basin F wastes are variables which continually change with fluctuations in meteorological conditions throughout the year. These seasonal variations ultimately affect the characteristics of the waste.

In order to conduct a careful and accurate evaluation of candidate incineration technologies, more detailed and updated waste characteristic test data are required. Review of the Basin F waste inventory and parameters indicates the presence of certain gaps in the available data.

One important source of data, required prior to the start of the evaluation process, is the ultimate analysis of the waste for carbon, hydrogen, sulfur, oxygen, nitrogen, water, and ash contents. Other data gaps include kinematic viscosity, pH, density, and flash point of the waste.

Detailed information on the chemical and physical properties of the waste will provide a more meaningful evaluation of its combustion characteristics. This, in turn, will better define incineration requirements and facilitate the selection of the most applicable incineration technology.

SECTION 3

### 3.0 INCINERATION TECHNOLOGY SELECTION

#### 3.1 INTRODUCTION

This section describes the procedures Ebasco will employ to select an appropriate incineration technology for Basin F wastes. The technology selection will be based on a literature search.

#### 3.2 DATA COMPILATION

The technology selection process will begin with the collection, dissemination, review, and summation of current technical information on hazardous waste incineration technologies as applied in the United States. In addition to the open literature and manufacturers' information, Ebasco will search RMA and EPA databases for incineration technologies that have potential for treating Basin F wastes.

##### 3.2.1 RMA Database

Under the guidance of PMO, studies have been performed by other consultants on the selection of appropriate technology or technologies for clean-up of sites contaminated with hazardous waste at RMA. The reports entailing these studies can be found in the Rocky Mountain Arsenal Information Center (RIC). One such report that has direct relevance to Task 17 is entitled "Review and Assessment of Incineration As a Decontamination and Transportation Volume Reduction Technique for Rocky Mountain Arsenal" (RIC# 83313R01). Ebasco will review this report to screen applicable incineration technologies for Basin F wastes. In summary, this report discusses eight incineration technologies that have potential for application in arsenal wide clean-up activities.

These technologies are:

- o Rotary Kiln
- o Stationary hearth;

- o Mechanically agitated rotating hearth;
- o Multiple hearth;
- o Grate hearth;
- o Fluidized bed;
- o Modular (controlled air); and
- o Mobile incineration.

The report also presented the evaluation of existing thermal oxidation systems (eight) located at RMA. Of the eight systems, only two systems in Building 1611 (one deactivation furnace and one decontamination furnace) have been considered suitable for a small-scale application. The estimated capacities of the deactivation and decontamination furnaces in Building 1611 have been reported to be 0.6 yd<sup>3</sup>/hr and 0.3 yd<sup>3</sup>/hr, respectively, based on 24 hour per day operation.

The details of Building 1611 as discussed in this report (RIC #833 13R01) are included in Appendix D. It should be noted that the report was written in 1983. Therefore, conditions of Building 1611 as presented in Appendix D may not reflect the existing situation.

### 3.2.2 EPA Database

EPA publications are available from the National Technical Information Service (NTIS) database. Ebasco has performed a literature search for Task 17 on the NTIS database and has collected relevant documents for evaluation (see Appendix E). The evaluation of these reports will provide the following specific information necessary for the selection of an appropriate incineration technology.

Specific data to be collected on the incineration processes will include:

- o Type of HW processed (liquid, sludge, or solid);
- o Chemical composition of HW processed;
- o Performance characteristics (destruction temperature, residence time, throughput, etc.);

- o Fuel requirements;
- o Actual methods for feed and product handling;
- o Commercial maturity of incineration process;
- o Process capacity per unit;
- o Complexity of process steps; and
- o Operational aspects.

One particular report from the NTIS database that will be utilized extensively in selecting the appropriate incineration technology for Basin F waste is entitled "Profile of Existing Hazardous Waste Incineration Facilities and Manufacturers in the United States."

### 3.3 TECHNOLOGY SELECTION FOR TREATING BASIN F WASTE

A structured procedure will be developed for evaluation and selecting the most viable and applicable incineration option for treating Basin F waste. The following will serve as a guide for the selection. It should be noted that the technologies to be considered for final evaluation will have already passed the initial screening.

#### 3.3.1 Selection Criteria

A qualitative comparison will be developed to further assist in the selection of the most attractive and economical incineration option based on major design, safety, operational, environmental, maintenance, construction, and economics aspects for each process.

Table 3.3-1 tabulates some items to be considered during the evaluation phase. These items are both quantitative and subjective and will be used to aid in rating the systems as explained in paragraph 3.3.2. In the subsequent technology selection report, the rationale for selecting each criterion will be discussed.

TABLE 3.3-1  
SELECTION CRITERIA OF INCINERATION TECHNOLOGY ALTERNATIVES

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A. SAFETY ASPECTS

1. Operator Safety
2. Safety for off-site personnel
3. Environmental Safety
4. Explosive potential

B. DESIGN ASPECTS

1. Operating temperature
2. Residence time
3. Waste Feed Rate or Capacity
4. Atmosphere Effluent Treatment
5. Waste Water Effluent
6. Ash Treatment

B. OPERATIONAL ASPECTS

1. Proven operations
2. Equipment reliability
3. Sensitivity to feed composition
4. Sensitivity to feed consistency (i.e. viscosity or pumpability)
5. Sensitivity to pressure and temperature changes
6. Turndown ratio
7. Requirement for skilled operators
8. Storage and mixing of waste
9. Startup and shutdown time and sequence
10. External utility power required for startup
11. Fuel balance flexibility/heating valve (Btu/lb)
12. Pure water requirements
13. Air emission
14. Systems safety

D. ENVIRONMENTAL ASPECTS

1. Air pollution
2. Water pollution
3. Biological effects
4. Noise

E. MAINTENANCE ASPECTS

1. Corrosion problems anticipated
2. Need for specialized maintenance personnel
3. Arduous service for valves, instruments and seals
4. Heat exchanger maintenance
5. Rotating equipment maintenance
6. Refractory maintenance

F. COST ASPECTS

1. Capital cost
2. Operating cost

G. CONSTRUCTION ASPECTS

1. Special materials required in construction
2. Specialized construction personnel required
3. Large foot print (Layout Area)
4. Fabrication time
5. Erection time

### 3.3.2 Evaluation of Options

Incineration technology which passes the initial screening will be rated according to the developed criteria by a panel of Ebasco technical team members. The technical input to the evaluation procedures will be required to indicate weight importance to specific items on Table 3.3-2. Qualitative analyses of each team member for all the monitored incineration options will be collected and a summary of consensus established which will indicate the preferred option(s).

The following rating procedure is proposed:

Using the selection criteria specified in Table 3.3-1, each technology-specific safety, design, operation, construction, cost environmental, and maintenance aspects will be evaluated and ranked according to its relative importance using the paired comparison technique.

The paired comparison technique involves the comparison of each decision factor or aspect to each other decision factor or aspect in a systematic manner. The technique pairs each factor with every other factor and assigns to the pair member considered to be the most important a value of 1. The lesser important of the pair is given a value of 0. If the factors are of equal importance, each receives a relative value of 0.5. The use of this paired comparison technique is shown in Table 3.3-2. A dummy factor ( $F_n$ ) also is included in Table 3.3-2. The dummy factor precludes the net assignment of 0 to any of the basic factors during the pairs comparison. The dummy factor is defined as the least important member in each paired comparison within which it is included.

Following the factor pairing and assignment of relative importance, the individual weight assignments are summed, yielding a factor importance coefficient (FIC). The FIC is equal to the weight assignment sum for an individual factor divided by the sum total for all factors.

Next, candidate incineration technologies will be compared to each other and ranked. The technique used will be similar to the decision factor weighting, i.e., the most desirable technology

TABLE 3.3-2

## DETERMINATION OF FACTOR IMPORTANCE COEFFICIENT (FIC)

Factor	$F_1$	$F_2$	$F_3$	$F_n$	SUM	FIC
$F_1$ (Safety)	-	0.5	0.5	0	$N_1$	$N_1 / \sum_n = f_1$
$F_2$ (Design)	0.5	-	0	0	$N_2$	$N_2 / \sum_n = f_2$
$F_3$ (Operational)	0.5	1	-	0	$N_3$	$N_3 / \sum_n = f_3$
$F_n$ (Dummy)	0	0	0	-	$N_n$	0
TOTAL					$\sum_{n=1}^{n=n} N_n$	1.0

for a given decision factor will be assigned a value of 1, while the less desirable technology will be given a value of 0. If the technologies are judged equal, each will receive a value of 0.5. The total of the comparison will be normalized and the normalized total for each technology then will be multiplied by the FIC of the appropriate decision aspect or factor. In similar fashion, candidate incineration technologies will be evaluated for each decision aspect or factor and the assigned value for each technology will be summarized. The technology receiving the highest score will be recommended for selection. An example of this procedure is shown in Table 3.3-3.

### 3.3.3 Recommendation of Option(s) for Basin F Waste

Futher detailed development of the preferred option(s) will include a preliminary design, engineering, and vendor solicitations so that more accurate evaluations of operational and cost aspects can be developed.

TABLE 3.3-3

## RANKING OF INCINERATION TECHNOLOGY

Decision Factor Aspect	Technology		
	Rotary Kiln	Fluidized	Multiple Hearth
F <sub>1</sub>	X <sub>1</sub>	Y <sub>1</sub>	Z <sub>1</sub>
F <sub>2</sub>	X <sub>2</sub>	Y <sub>2</sub>	Z <sub>2</sub>
F <sub>3</sub>	X <sub>3</sub>	Y <sub>3</sub>	Z <sub>3</sub>
F <sub>4</sub>	X <sub>4</sub>	Y <sub>4</sub>	Z <sub>4</sub>
F <sub>5</sub>	X <sub>5</sub>	Y <sub>5</sub>	Z <sub>5</sub>
TOTAL	$\Sigma X$	$\Sigma Y$	$\Sigma Z$

Where  $X_1$ ,  $Y_1$ , or  $Z_1$  is equal to the sum of the paired score multiplied by the FIC of the decision factor.



#### 4.0 LABORATORY TESTING OF BENCH-SCALE INCINERATOR

A careful selection of the incineration process and equipment is required to achieve proper disposal of Basin F wastes. It is also essential to substantiate the adequacy, and advance the state of the selected technology through a variety of laboratory testings and trial burns. Bench-scale incineration will provide information about the waste and its combustion behavior, as well as the optimal operating conditions of the selected incinerator. The final design selection of the incinerator will be governed by the test parameter and results such as the waste incinerability, combustion air requirements, and combustion gas temperature and residence time.

The test results also will provide valuable information on Destruction and Removal Efficiency (DRE) of the incinerator and Products of Incomplete Combustion (PIC) from the incineration of the waste.

Ebasco has developed a test plan for the bench-scale laboratory incineration program. The plan entitled "Laboratory Test Plan for Incineration of Basin F Wastes at Rocky Mountain Arsenal." (Ebasco, 1986) is a separate companion document to this technical plan.



## 5.0 FIELD SAMPLING PROGRAM

### 5.1 PURPOSE

The purpose of the Field Sampling program is to obtain Basin F wastes in sufficient quantities for laboratory analysis and bench-scale incineration testing. Sampling operations will conform to the guidelines and procedures established for Task 2 (i.e. "RMA Procedures Manual, Volume I: Sampling" and "Sampling and Chemical Analysis Quality Assurance Program for U.S. Army Toxic and Hazardous Materials Agency").

Actual sample volumes will be determined upon finalization of a test plan for the laboratory bench-scale incineration program.

### 5.2 BASIN F LIQUID SAMPLING

Past sampling efforts have included collection of Basin F liquid samples. Results of this liquid sampling indicated that liquid present in Basin F is homogenous. Therefore, the sampling of Basin F liquid will be limited to grab samples from various locations of the liquid pool. Exact locations and sampling methods to be employed will be determined upon finalization of the test plan for the laboratory bench-scale plan for the laboratory bench-scale incineration program.

### 5.3 SOILS SAMPLING

It is not essential that the samples of soil used in the bench-scale incineration testing program contain a representative average of waste concentrations. Rather, it is essential that the severe problems be tested explicitly. For this reason, soils from the area of Borehole No. 01 will be used to test the adequacy of the incineration regimes available (See Figure 5.3-1). The area of Borehole No. 01 has been chosen because it has not lost its asphalt liner. The overburden is particularly contaminated,

- A ALDRIN
- B DIELDRIN
- C ARSENIC
- D ENDRIN
- E ISODRIN
- F FLUORIDE
- G SULFURS
- H DBCP
- X ACTION LEVELS NOT EXCEEDED
- NO SAMPLE NOT ANALYZED
- \* INDICATES CONCENTRATION EXCEEDS 100X THE ACTION LEVEL

NOTE: NUMBERS IN PARENTHESIS DENOTE INTERVALS BELOW LINER AS FOLLOWS:  
 (1) = 0.0 - 1.0 FT  
 (2) = 1.0 - 2.0 FT  
 (3) = 2.0 - 3.0 FT  
 (4) = 3.0 - 4.0 FT

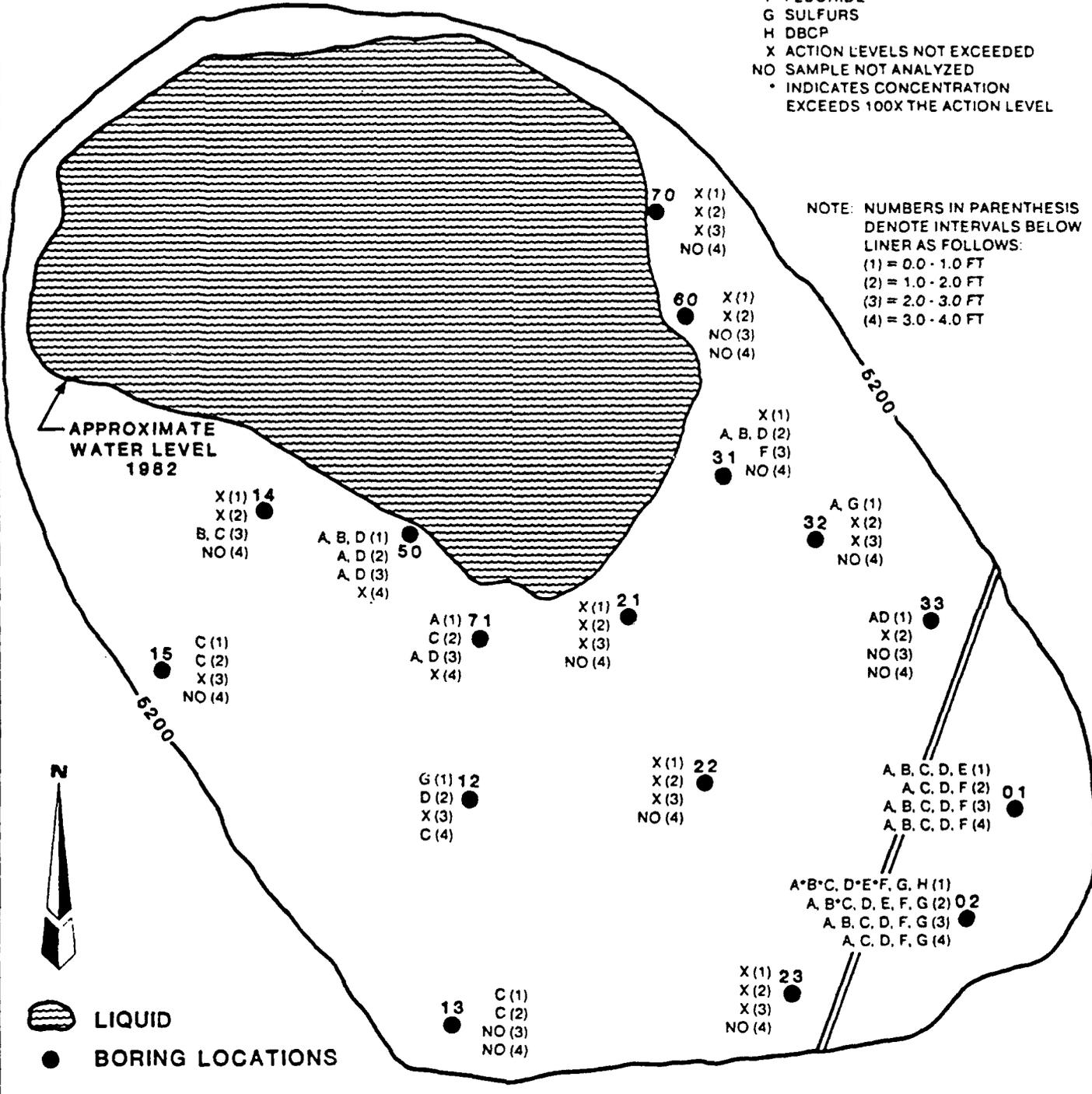


Figure 5.3-1  
 SOIL SAMPLING LOCATION

SOURCE: MYERS AND THOMPSON, 1982

and the soils beneath the liner also exhibit significant levels of contamination. It should be noted that under Task Order No. 6, Environmental Sciences and Engineering (ESE) is developing the contamination profile of Basin F and will soon submit its findings to PMO. Prior to sampling, Ebasco will review this ESE report and may change the location of soil sampling based on the evaluation of the report.

For the bench-scale test program, approximately 15 kilograms of soil sample will be necessary. Soil samples will be obtained by excavating soils using hand shovels.



## 6.0 ANALYTICAL PROGRAM

Analytical program for this task is described in Chapter 5.0 of the Test Plan, a separate companion document to this Technical Plan (Ebasco, 1986).



## 7.0 QUALITY ASSURANCE PROGRAM

### 7.1 PROJECT QA PLAN

An integral part of the Technical Plan is the project specific Quality Assurance (QA) Plan describing the application of Ebasco's procedures to monitor and control field and analytical efforts at RMA. Ebasco has developed a Project QA Plan applicable to geotechnical, sampling and analytical activities. For Task 17 Ebasco will adhere to and comply with the established QA requirements. The plan is presented in Volume II of the RMA Procedures Manual. The specific objectives of the Ebasco Quality Assurance Program for RMA are to:

- o Ensure adherence to established PMO QA/QC Program guidelines and standards;
- o Ensure precision and accuracy for measurement data;
- o Ensure validity of procedures and systems used to achieve project goals;
- o Ensure that documentation is verified and complete;
- o Ensure that deficiencies affecting quality of data are quickly determined;
- o Perform corrective actions that are approved and properly documented;
- o Ensure that the data acquired will be sufficiently documented to be legally defensible;
- o Ensure that the precision and accuracy levels attained during the PMO analytical certification program are maintained during the project.

The overall project QA responsibility rests with the Project Quality Assurance Coordinator. He will be assisted by the Field and Laboratory QA/QC Coordinators. Each field sampling team will include a Field QA/QC Coordinator. The Field QA/QC Coordinator for each team will assure that all quality control procedures are implemented for drilling, sampling, chain-of-custody and documentation.

Ebasco is using two laboratories for the performance of chemical analytical services. Both laboratories will comply with the Project QA Plan. Each laboratory has appointed a Laboratory QA/QC Coordinator. Their responsibilities include:

- o Monitor the quality control activities of the laboratory;
- o Recommend improvement in laboratory quality control protocol, when necessary;
- o Log in samples, introduce control samples in the sample train and establish sample testing lot sizes;
- o Approve all data before submission to permanent storage;
- o Maintain all quality control records and chain-of-custody documents;
- o Assure document and sample security;
- o Inform Ebasco's Project Quality Assurance Coordinator of non-compliance with the Project QA Plan; and
- o Prepare and submit a weekly report of quality control data to the Ebasco Project Quality Assurance Coordinator.

Prior to actual field program, a QA/QC training will be conducted by the Project Quality Assurance Coordinator to indoctrinate field, laboratory and project personnel in the specific procedures detailed in the Project QA Plan.

Also, prior to analysis of samples, the Project Quality Assurance Coordinator will visit the laboratories to review analytical procedures with chemical analysis personnel and instruct the Laboratory QA/QC Coordinators in the requirements of the Project QA Plan and data validation procedures. In addition, the Project Quality Assurance Coordinator will perform audits of field and laboratory work on a bi-monthly basis to ensure compliance with the Project QA Plan. Specific project QA/QC requirements are described in the following sections.

## 7.2 SPECIFIC PROJECT REQUIREMENTS

### 7.2.1 Field Sampling

The management of samples, up through the point of shipment from the field to the laboratory, will be under the supervision of Ebasco's Field QA/QC Coordinators. Samples must be collected in properly cleaned containers, properly labeled, preserved and transported according to the prescribed methods. Section 8.0 of the Project QA Plan describes the procedures to monitor adherence to approved sampling protocol. If the Field QA/QC Coordinator determines that deviations from the sampling protocol have occurred, resulting in a compromise of the sample integrity, all samples taken prior to the inspection will be discarded and fresh samples will be taken. The Field QA/QC Coordinator is responsible for field chain-of-custody documentation and transfer and will supervise the strict adherence to chain-of-custody procedures.

### 7.2.2 Laboratory Quality Assurance Procedures

Section 10 of the Project QA Plan describes the Laboratory Quality Assurance Procedures. Both laboratories along with their internal quality assurance programs will adhere to the Project QA Program.

The Laboratory QA Program begins with the receipt of the samples from the field. All samples will be shipped to UBTL for logging in, sample splitting and distribution for analyses. The Laboratory QA/QC Coordinator is

responsible for monitoring the laboratory activities. He is also responsible for determining testing lot sizes and introducing laboratory control samples into the testing lot in an inconspicuous manner.

The samples must be analyzed within the prescribed holding time by the approved analytical methods. Analytical methods are described in Section 6.0 of the Technical Plan.

### 7.2.3 Laboratory Analytical Controls

Daily quality control of the analytical systems ensures accurate and reproducible results. Careful calibration and the introduction of the control samples are prerequisites for obtaining accurate and reliable results. *Procedures for instrument calibration and analytical controls* are described in Section 12 of the Project QA Plan.

The Laboratory QA/QC Coordinator for each laboratory will monitor the analytical controls. The out-of-control situation can be detected by the control charts.

When an out-of-control situation is detected, efforts will be initiated to determine the cause. Corrective actions will be taken to bring the process under control. Full documentation of an out-of-control situation and the subsequent corrective action will be recorded by the Laboratory QA/QC Coordinator.

### 7.2.4 Laboratory Data Management, Data Review and Validation and Reporting Procedures

Sections 13 to 16 of the Project QA Plan detail the procedures for laboratory data review, validation and reporting procedures. The laboratories utilize a highly automated system for analytical data collection and reduction. The analytical supervisor along with the Laboratory QA/QC Coordinator review all analytical data after data reduction and prior to the transfer of the data report to Ebasco. The laboratory data reporting procedure is described in Section 15 of the Project QA Plan which is based

on the established PMO reporting procedures for analyses performed at quantitative and semi-quantitative levels. The laboratories will adhere to this reporting procedure.



## 8.0 DATA MANAGEMENT PROGRAM

### 8.1 PLAN OVERVIEW

This plan presents the data management procedures to be used by Ebasco for the Environmental Program at Rocky Mountain Arsenal. As specified in the contract, all data will be presented to PMO in appropriate format and entered into the IR-DMS UNIVAC 1100/60). PMO has provided a Tektronix 4051 system and IR Data Management User's Guide, Version 85.6 (PMO 1984) to Ebasco for this purpose. Data will be controlled as necessary. Presentation of project management data and report communication is discussed in Ebasco's Management Plan.

Figure 8.1-1 shows schematically the process Ebasco will use to coordinate data management activities between itself and UBTL, Hittman-Ebasco and IR-DMS. This is detailed in Section 8.3. As shown in Figure 8.1-1, Ebasco's primary data entry terminal for the IR-DMS will be through the Army-owned Tektronix terminal in Ebasco's Denver office. A second Army-owned terminal is maintained in Ebasco's Santa Ana office for backup data entry purposes. Specifics of data collection, data entry, data validation, and data analysis are discussed herein.

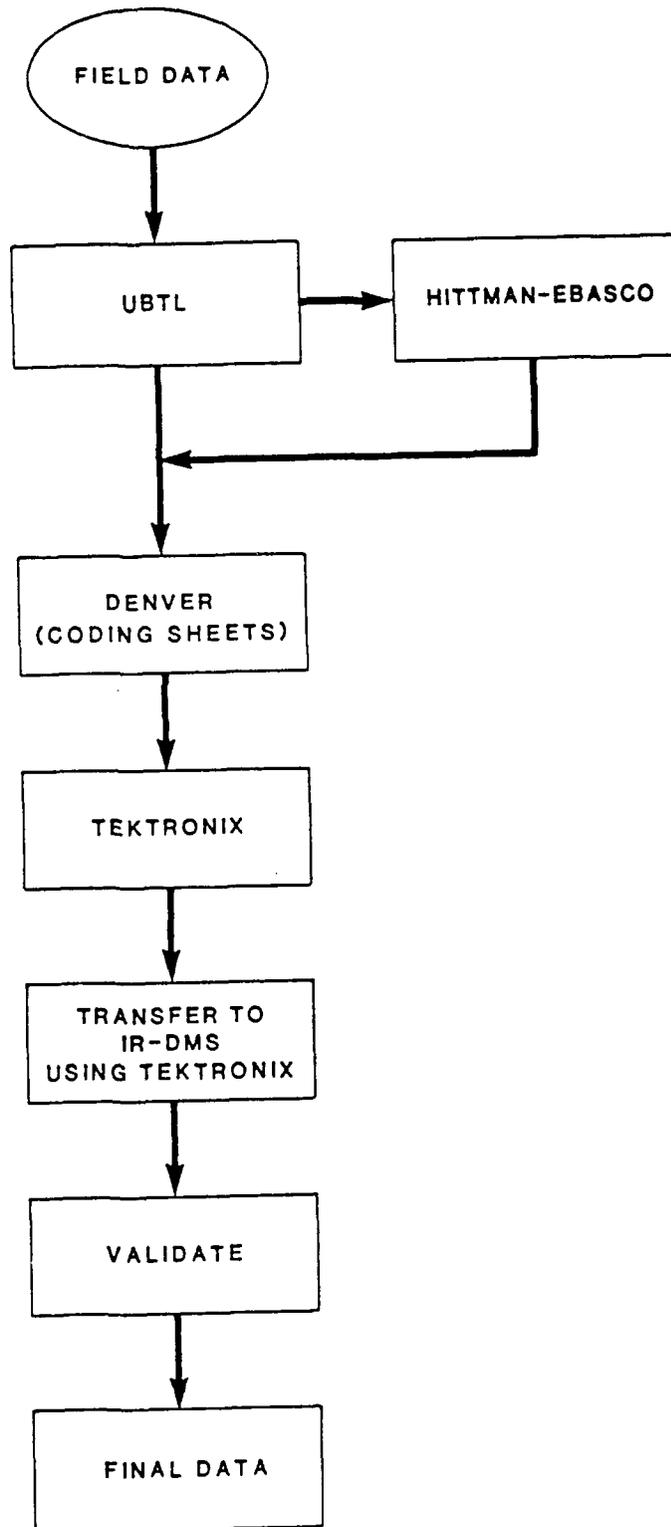
### 8.2 FIELD ACTIVITIES

#### 8.2.1 Sample Handling

The Sample Coordinator is responsible for field data collection and logging of the sampling program. In addition, the Sample Coordinator will assure that all field data are properly accounted for and transferred to the Data Manager for input into the computer at Ebasco's Denver office in a timely manner.

To accomplish this, the Sample Coordinator will assure that proper sample collection procedures, sample control identification procedures and proper chain of custody procedures are followed. (Specific procedures and reporting

FIGURE 8.1-1  
DATA FLOW BETWEEN EBASCO,  
UBTL, H-E AND IR-DMS



forms to be used for the management of field data are detailed in Appendix A, Volume II of the RMA Procedures Manual.)

Sample control identification numbers will be assigned to each sample collected in the field by the Sample Coordinator. These sample identifiers are to be recorded on the sample tag in the field data log book and on the sample chain of custody record at the time of sample collection. The chain of custody record will also serve as the analytical request form, verifiable by the analytical request list on the sample tag. The Sample Coordinator will check sample tags, chain of custody forms and field data logs to assure complete and correct field data entry. Field identification numbers will remain with each sample throughout the data collection, shipment, analysis and report phases of the program.

As part of the logging in of field data, the Sample Coordinator will copy each chain of custody form onto the field notebook, package and seal the samples for shipment to the laboratory and assure the shipment of these samples. The Sample Coordinator will forward the necessary written field records to the Data Coordinator at Ebasco's Denver office for entry into the computer.

### 8.2.2 Laboratory

When samples are received at UBTL or Hittman-Ebasco, the respective Sample Receipt Officer will sign the chain of custody record, log in sample shipment, verify sample integrity, and assign sample lots. Each laboratory will submit weekly sample status reports to Ebasco's Data Manager. This weekly status report will be used to aid in planning the rate of field sampling and the distribution of laboratory workloads.

Field and laboratory sample control identification and chemical analysis data, including unknowns, will be transcribed to the data coding sheet by the laboratories then verified using the program's laboratory control procedures. The verified data coding sheets will then be delivered, by courier, to Ebasco's Data Manager for entry into the IR-DMS data base. It should be noted that off-gas sample analytical results will not be entered into the IR-DMS database.

### 8.3 DATA ENTRY AND VALIDATION

The first step in data entry into the IR-DMS Univac 1100/60 will be to create a magnetic tape copy of the coding sheets on the Tektronix 4051 terminal by keypunching. The Tektronix operator will enter only a subset of a complete file at one time. These file subsets will later be merged to a single file using the UNIVAC. After keypunching, the operator will obtain a printed copy of the data subset using the Tektronix printer, and will verify that the data in the Tektronix tape file is identical to that on the coding sheets. The operator will correct any data entry typographic errors using the Tektronix editor, then obtain a second printing of the file to confirm that the changes were properly made. Methods certification data and map location data will be entered first because validation routines make use of it.

Once the operator is certain that there are no remaining data entry errors on the Tektronix tape, the operator will use the Tektronix 4051 as a remote terminal to transfer the data to the UNIVAC 1100/60. To do this, the operator will load the data entry software, catalog a Level 1 (pre-acceptance) file on the UNIVAC, and transmit the data over the telephone lines using a modulator-demodulator (modem). Ebasco's operators will transfer Tektronix entry tape files to Level 1 UNIVAC files at least once per week, and will maintain a log of terminal usage and communication with the UNIVAC.

Once data is transferred, the operator will make use of IR-DMS utilities provided to convert English units of measurement to SI units and to convert State Planar or UTM grid system coordinates to local origin coordinates, if necessary.

Next, the operator will invoke the IR-DMS data acceptance routines to perform the final data verification and create a Level 2 (temporary read-only) file. The acceptance routines will identify any errors in format or coding and any inconsistencies with corresponding map records previously loaded. If the acceptance routine does find errors at this stage, the operator will check

the "R" file. The "R" file contains the rejected records that the acceptance routine creates. The UNIVAC editor is used to correct the verified entries, then they are resubmitted to the UNIVAC for acceptance. After acceptance, the IR-DMS automatically creates chemical and geological Level 2 files. Ebasco's operators will run the Level 1 data files through the data acceptance routines within seven days of their transfer to the UNIVAC system. They will delete Level 1 files once these data are accepted at Level 2.

Once the Level 2 file is created, the data processing operator will create a printed copy of the data set on the UNIVAC 1100/60 and submit, within ten working days of the Level 2 transfer, this copy to PMO.

The final step in the data entry and validation process, the creation of a Level 3 (final version, read-only) file, is undertaken by the PMO APG-EA data processing staff.

#### 8.4 ANALYSIS AND PRESENTATION

Ebasco scientists will access the PMO IR data base and will perform analyses as required to support all incineration feasibility assessment work. The data analysis efforts will include graphic representations of data using data gridding, contouring, and three-dimensional surface representations.

Several techniques will be used to access the data. If possible, IBM PCs will be used in terminal emulation mode to capture Level 3 data from the IR data base in order to perform analyses and prepare material for presentation. The Tektronix 4051 terminals in Denver and Santa Ana will also be used in a direct link to the UNIVAC to prepare analyses and graphic representations. Ebasco scientists may establish communication links between IBM PCs to interchange data and facilitate data analysis.



## 9.0 HEALTH AND SAFETY PROGRAM

A draft of the project Health and Safety Plan (HASP), prepared according to the Ebasco Corporate Health and Safety Program, is included in the RMA Procedures Manual. The purpose of this section is to provide an overview of the safety program that Ebasco will employ to ensure the safety of its employees and that of subcontractors engaged in the field investigation activities at RMA. All personnel working at RMA are or will be familiar with this document and they are and or will be indoctrinated in all aspects of the safety program, which complies with OSHA guidelines and criteria.

The supervisor of the laboratory involved in sample incineration will receive a summary of the known contaminants in the samples with appropriate toxicological data. The laboratory also will be advised of all pertinent OSHA requirements regarding ventilation and materials handling. The Ebasco Health and Safety Project Officer will be available for further consultation.

The following specifics of the HASP are especially important to the investigative activities. These are:

- o Safety organization, administration and responsibilities;
- o Initial assessment and procedures for hazard assessment;
- o Safety training;
- o Safety operations procedures;
- o Monitoring procedures;
- o Safety considerations for sampling; and
- o Emergency procedures.

Overall responsibility for safety during the site investigation activities rests with the Project Health and Safety Officer. He is responsible for developing the site-specific HASP at RMA and through the on-site Health and Safety Coordinator assumes its implementation responsibility. Specifically, he and his staff are responsible for:

- o Characterizing the potential specific chemical and physical hazards to be encountered;
- o Developing all safety procedures and operation on-site;
- o Assuring that adequate and appropriate safety training and equipment are available for project personnel;
- o Arranging for medical examinations for specified project personnel;
- o Arranging for the availability of on-site emergency medical care and first aid, as necessary;
- o Determining and posting locations and routes to site work zones;
- o Notifying installation emergency officers (i.e., police and fire departments) of the nature of the team's operations and making emergency telephone numbers available to all team members; and
- o Indoctrinating all team members in safety procedures.

In implementing this safety program, the project Health and Safety Officer will be assisted by a field Health and Safety Coordinator. His function is to oversee that the established health and safety procedures are properly followed. The details of the safety organization, administration and responsibilities are described in Section I of this HASP.

Based on the evaluation of past activities, incidents, accidents and investigations, the presence of chemicals and wastes are expected to be found in the area that will be investigated under Task 17. The characteristics of these wastes are known to be toxic and hazardous to human health. Section V of the HASP describes the procedures to be employed to determine hazard of a specific building or a sampling location for the identification of the preliminary level of protection requirement.

Section VI of the HASP explains the training program that is planned for the RMA project. Basically, the training will focus on the general health and safety consideration and provide site specific safety instructions.

Section VII describes in detail the safety operations procedures. The important aspects of the safety operations procedures are:

- o Zone approach for field work;
- o Personal protection; and
- o Communications.

A three zone approach (Support Zone, Contamination Reduction Zone and Exclusion Zone), where possible, will be utilized for field work at RMA. The Support Zone will contain the Command Post with appropriate facilities such as communications, first aid, safety equipment, support personnel, hygiene facilities, etc. This zone will be manned at all times when field teams are operating downrange. Adjacent to the Support Zone will be the Contamination Reduction Zone (CRZ) which will contain the contamination reduction corridor for the decontamination of equipment and personnel (the actual decontamination procedures are discussed in Section X of the HASP). All areas beyond the CRZ will be considered the Exclusion Zone. For well drilling or soil boring operations the Exclusion Zone will be established as a 30 foot radius from the drill rig. These support facilities are discussed and illustrated in Section III.

The level of protection to be worn by field personnel will be defined and controlled by the on-site Health and Safety Coordinator and will be specifically defined for each operation in an information sheet (Facility Information Sheet). The preliminary Facility Information Sheet (FIS) will be developed based upon historical information and data. This will be upgraded and utilized for future operations based upon the results of the Health and Safety portion of the Soil Sampling programs.

Maintaining proper communications among team members (investigation team and Health and Safety team members) during field investigation work is of utmost importance for the protection of investigation team members. The methods of communication that will be employed are:

- o Walkie Talkies;
- o Air Horns;
- o Hand Signal; and
- o Voice Amplification System.

For external communication telephones and sirens will be utilized.

Section VIII explains the health and safety monitoring procedures. A continuous monitoring of the working environment will be performed to ensure the adequacy of the level of personnel protection. Depending on the history of the sampling location the presence of the following parameters will be monitored:

- o Army Agents;
- o Oxygen Level;
- o Explosive Conditions;
- o Organic Vapors Level;
- o Inorganic Gases Level; and
- o Dust Analyses.

The type of on-site monitoring instruments to be utilized includes but is not limited to the following and will be based on the potential for the instrument specific contaminants to be present:

- o M18A2 Chemical Agent Kit for Army Agents;
- o M8 Alarm for nerve agent;
- o Oxygen meter for oxygen level;
- o Combustible gas indicator for explosive condition;
- o PID and FID meters for organic vapors; and
- o For inorganic gases, a gold film mercury monitor, a chlorine monitor, a carbon monoxide monitor and a hydrogen sulfide monitor.

Air monitoring will be conducted using both direct reading instrumentation (the HNu and OVA predominately) and portable sampling pumps with sampling media appropriate for the contaminants of interest. Samples collected with the portable sampling pumps will be submitted for lab analysis when: 1) direct reading instruments indicate the presence of airborne contaminants

greater than the background level established 2) operations involve fluids that employees may contact; 3) any employee experiences respirator leakage; and/or 4) any employee experiences symptoms of exposure.

Based on the monitoring results (real time and field or laboratory analyses of the health and safety samples) the on-site Health and Safety Coordinator can stop field investigation work or upgrade and or downgrade the level of personal protection.

An air monitoring survey will be conducted in Buildings 1611, 1606, and the bulk agent incinerator, prior to allowing workers into these facilities. In this way levels of protection may be assessed, based on current data.

Section IX of the HASP explains the safety considerations during actual sampling events. It describes the safety procedures to be followed for drilling operations, soil, surface water and liquid waste sampling, building sampling, and sampling in a confined space.

The emergency procedures are described in Section XII to XIV of the HASP. Section XII explains the basic emergency scenarios and activities to be undertaken during each of these emergency situations; Section XIII describes how to get emergency services (i.e. medical, fire protection, ambulance, etc.) and Section XIV outlines the evacuation procedures in case of emergency such as fire, explosion, and/or a significant release of toxic gases.

Attachment 7 of the HASP describes the procedures to be implemented for operations involving confined space entry. The entry of workers into confined areas or facilities with limited egress will be avoided whenever possible. However, the inspection of incinerator facilities may require such work, in which case special training, monitoring, and use of protective clothing will be implemented as described.

## 10.0 INCINERATION/FIXATION FEASIBILITY

### 10.1 INCINERATION/THERMAL TREATMENT FEASIBILITY

The incineration technology for treatment of the Basin F waste will be selected for further evaluation based on the literature study previously discussed. The detailed evaluation of the selected technology will consist of laboratory study.

#### 10.1.1 Selected Technology for Basin F

The primary selection criteria for the system is the ability of the incinerator unit to thermally detoxify the waste. Secondary selection criteria will be cost, proven reliability, complexity of equipment systems, environmental emissions from the system, both air and water, and ease of operation.

The technology selections will not only include the incineration train but must address feed handling systems, ash handling and air pollution control equipment. Equipment specialists in ash handling and air pollution equipment will scrutinize and evaluate the incineration system and will provide recommendations.

In the evaluation of the preferred technologies, contamination of the incineration equipment is an important factor to be considered. The incineration system can be divided into four major processing units: feed handling, incineration, air pollution control, and ash handling units. The complexity of the feed handling unit, which is in direct contact with the hazardous waste, depends largely on the type of incineration selected. More complex equipment increases the probability of break-down increasing the rates of exposure, handling, and disposal of equipment replacement parts. It is therefore preferable to have an operationally reliable feed handling unit with a minimum of equipment.

### 10.1.2 Laboratory-Scale Incineration Testing of Basin F Wastes

The laboratory incineration tests will provide an indication of required temperatures at specific exposure times to obtain the required destruction of certain chemical compounds. Through laboratory test burns Ebasco will be able to collect off-gas and residue samples for laboratory analysis. The results of off-gas analysis will indicate the destruction efficiency of the incinerator, identify the products of incomplete combustion and identify the types of air pollution control necessary to meet the regulations. The results of residue analysis will govern the method of residue disposal.

## 10.2 EVALUATION OF ALTERNATIVES FOR PILOT TESTING OF INCINERATION/THERMAL TREATMENT

### 10.2.1 Introduction

The alternatives to pilot testing are to omit testing and proceeding directly to full scale design, to use Building 1611 equipment for pilot testing, or to use a mobile or modular unit of the preferred technology for testing.

### 10.2.2 Alternative 1 - No Pilot Program

To proceed directly to a full-scale design of the preferred incineration system can only be done if the incinerator supplier has experience in the destruction of hazardous wastes similar to Basin F. The supplier would have to guarantee capacity and destruction efficiency of Basin F waste, at a capital cost which provides a good return on investment, and adhere to a set delivery schedule.

It is very unlikely that this situation will happen because of the high responsibility of the supplier to meet these guarantees without pilot testing of Basin F wastes in their incineration system.

### 10.2.3 Alternative 2 - Building 1611 as a Pilot Unit

Time and money could be saved by using the available and operational incineration equipment in Building 1611 for pilot testing. This could only be done, however, if Building 1611 incineration unit is similar to the preferred technology. The supplier of the preferred incineration system would require a specific pilot testing program and might not be amenable to process guarantees based on equipment unfamiliar to the incineration supplier. Pilot testing of Basin F wastes would still be performed with one Building 1611 incineration system to obtain the destruction feasibility with the specific technology. Based on this pilot test, parameters for scale-up of the Building 1611 incineration type could be established. Ultimately, the supplier of the selected incineration technology still would require pilot testing as a basis for his process guarantees.

To determine the feasibility of Building 1611 as a pilot unit, Ebasco will engage a subcontractor. The selection of Building 1611 as a pilot unit will be made in two phases. Phase 1 will consist of (1) developing an equipment list for the process systems contained in Building 1611; (2) collecting any specifications, data sheets, etc. available on the equipment from archives, vendors, etc. and based on these data, develop descriptions; (3) determining what support systems (electrical, air, water, etc.) are available in the building; (4) physically inspecting the equipment condition as it exists; and (5) reporting findings. At the end of Phase I, Ebasco will submit an assessment report to PMO for evaluation and recommendation. The assessment report will include the extent of modification and replacement of equipment, piping, etc., necessary to make Building 1611 a viable pilot unit. The report will also identify the equipment that are presently in running conditions.

Upon evaluation of the report, if PMO decides to consider Building 1611 as a pilot unit, Ebasco will undertake the Phase 2 program, i.e., determine the cost to modify Building 1611 for the pilot program.

#### 10.2.4 Alternative 3 - Mobile/Modular Incineration

A number of incinerator suppliers or operators have mobile and/or modular units available for on-site testing at nominal expense. This mobile unit will usually have minimum equipment for feed handling and air pollution which would not be a big problem at this stage of the disposal program. The major parameters for destruction can be established and specific requirements of feed, ash and air pollution control handling will be designed for in the scale-up of the incinerator system.

In evaluating mobile incineration for the pilot program, Ebasco will consider the following:

- o Hauling Basin F wastes to an off-site mobile incinerator for the pilot program;
- o Locating the mobile incinerator near Basin F; and
- o Locating the mobile incinerator near Building 1611.

The final recommendation on deciding the location of the mobile incinerator for the pilot program will be based on economics.

#### 10.2.5 Evaluation and Recommendation of Alternative for Pilot Testing

The final recommendation will be based on a cost-benefit analysis of the alternatives.

### 10.3 SOLIDIFICATION/FIXATION FEASIBILITY

#### 10.3.1 Introduction

Treatment of hazardous waste is accomplished through degradation immobilization, and/or transformation. Degradation and transformation of hazardous waste should render the waste non-hazardous. However, for toxic

inorganic substances (e.g. heavy metals) and organic recalcitrant wastes, degradation and transformation are not applicable. Therefore, immobilization is the alternative for treatment. Solidification/fixation is a general term for describing immobilization techniques that chemically fix or structurally isolate hazardous constituents into a solid, crystalline, or polymeric matrix. The objective of solidification/fixation of hazardous waste is to either prevent it from coming into contact with water and/or prevent a pH and/or oxidation potential condition that increases solubility of hazardous constituents (pH-Eh).

Several solidification/fixation processes are available which can be grouped according to the principal additive as follows:

- o Silicate and cement-based process;
- o Lime-based (pozzolanic concrete) process;
- o Thermoplastic - based process;
- o Organic polymer-based process; and
- o Encapsulation techniques.

The advantages and disadvantages of each process are summarized in Table 10.3.1. Each process is suitable for certain types of wastes. Table 10.3.2 shows matching of generic waste type with each solidification technology.

The end product of a solidification/fixation process is either a soil-like material, or a monolithic mass. The former is suitable for a "non-degradation" to land approach. That is, no land is irreversibly removed from other usage. The limitation of a soil-like material is the susceptibility of fixed constituents to environmental changes. That is, with any changes in pH-Eh conditions, for instance, heavy metals will be mobile. On the other hand, a monolithic end product represents a better alternative in terms of isolation of hazardous constituents. Solid products can be used as a foundation for buildings or highways, or buried in a secure landfill. The disposal of solidified products will be part of the total engineering solution.

TABLE 10-3.1

TECHNICAL COMPARISON OF SOLIDIFICATION PROCESSES

Process	Advantages	Disadvantages
Cement-based	<ol style="list-style-type: none"> <li>1. Additives are available at a reasonable price.</li> <li>2. Cement mixing and handling techniques are well developed.</li> <li>3. Processing equipment is readily available.</li> <li>4. Processing is reasonably tolerant of chemical variations in sludges.</li> <li>5. The strength and permeability of the end-product can be varied by controlling the amount of cement added.</li> </ol>	<ol style="list-style-type: none"> <li>1. Low-strength cement-waste mixtures are often vulnerable to acid leaching solutions. Extreme conditions can result in decomposition of the fixed material and accelerated leaching of the contaminants.</li> <li>2. Pretreatment, more expensive cement types, or costly additives may be necessary for stabilization of waste containing impurities that affect the setting and curing of cement.</li> <li>3. Cement and other additives add considerably to weight and bulk of wastes.</li> </ol>
Lime-based	<ol style="list-style-type: none"> <li>1. The additives are generally very inexpensive and widely available.</li> <li>2. Equipment required for processing is simple to operate and widely available.</li> <li>3. Chemistry of pozzolanic reactions is well known.</li> </ol>	<ol style="list-style-type: none"> <li>1. Lime and other additives add to weight and bulk of wastes.</li> <li>2. Stabilized sludges are vulnerable to acid solutions and to curing and settling problems associated with inorganic contaminants in the waste.</li> </ol>
Inorganic	<ol style="list-style-type: none"> <li>1. Contaminant migration rates are generally lower than for most other techniques.</li> <li>2. End-product is fairly resistant to most aqueous solutions</li> <li>3. Thermoplastic materials adhere well to incorporated materials.</li> </ol>	<ol style="list-style-type: none"> <li>1. Expensive equipment and skilled labor are generally required.</li> <li>2. Sludges containing contaminants that volatilize at a low temperature must be processed carefully.</li> <li>3. Thermoplastic materials are flammable.</li> </ol>
Organic polymer	<ol style="list-style-type: none"> <li>1. Only small quantities of additives are usually required to cause the mixture to set.</li> <li>2. Techniques can be applied to either wet or dry sludges.</li> <li>3. End-product has a low density as compared to other fixation techniques.</li> </ol>	<ol style="list-style-type: none"> <li>1. Contaminants are trapped in only a loose resin matrix and product.</li> <li>2. Catalysts used in the urea formaldehyde process are strongly acidic. Most materials are extremely soluble at low pH and can escape in water not trapped in the mass during the polymerization process.</li> <li>3. Some organic polymers are biodegradable.</li> <li>4. End-product is generally placed in a container before disposed.</li> </ol>
Encapsulation	<ol style="list-style-type: none"> <li>1. Very soluble contaminants are totally isolated from the environment.</li> <li>2. Usually no secondary container is required, because the coating materials are strong and chemically inert.</li> </ol>	<ol style="list-style-type: none"> <li>1. Materials used are often expensive.</li> <li>2. Techniques generally require specialized equipment and heat treatment to form the jacket.</li> <li>3. The sludge has to be dried before the process can be applied.</li> <li>4. Certain jacket materials are flammable.</li> </ol>

TABLE 10.3-2

## MATCHING WASTE TYPES WITH SOLIDIFICATION PROCESS

Process	Major wastes treated	Untreatable wastes
Cement based	Toxic inorganics Stack gas scrubber sludges	Organics Toxic anions
Lime-based	Toxic inorganics Stack gas-scrubber sludges	Organics Toxic anions
Thermoplastic	Toxic inorganics	Organics Strong oxidizers
Organic polymer	Toxic inorganics	Acidic materials Organics Strong oxidizers
Encapsulation	Toxic and soluble inorganics	Strong oxidizers

### 10.3.2 Evaluation of Solidification/Fixation Methods Applicable to Incinerator Residue

Residue characterization is needed in order to determine the need for and initial screening of appropriate solidification/fixation technologies. A prior characterization of incineration ash is suitable but not practical, because ash characteristics will vary with each particular incineration technology. However, a qualitative description can be made from Basin F characteristics assuming complete destruction of organic constituents and no heavy metal losses with particulate emissions. It appears that a significant volume of ashes will be generated due to incineration of overburden and contaminated soil. However, the important issue will be the level of hazardous constituents present in the ashes and not the volume. The final selection process of an appropriate solidification technology is usually based on conducting a laboratory experiment. In this case, however, since much of the work needed to characterize the performance of waste solidification techniques on Basin F liquids has been conducted over the past several years, solidification technology for incinerator ash will be selected based on these studies. Although, these studies were conducted on Basin F liquid, they will guide in selecting an appropriate technology for incinerator ash. The rationale behind the approach is that the characteristics of the ash are correlated with Basin F liquid as far as the inert constituents are concerned. Further evaluation of incinerator residue solidification will not be addressed in this task, but may be the object of future actions.

### 10.3.3 Basin F Liquid Solidification/Fixation

The major waste solidification study completed to date (Myers and Thompson, 1983) examined eight basic solidification processes, some with a number of variations in solidification and absorbent chemical additions. Each of these processes was cement or pozzolonic based. Five commercial solidification processes and a non-proprietary solidification process satisfactorily converted "concentrated" Basin F liquid to a solid form. Tests were conducted on a sample of Basin F liquid that was concentrated via evaporation to approximate the concentrations of contaminants that would be

present if the volume of Basin F liquid were reduced to about 9 million gallons. (As noted earlier, it now appears that the total volume of liquid waste in Basin F is much less than 9 million gallons. As a result, contaminant concentrations would be expected to be higher now than those used in the solidification study. Despite this fact, it is believed that, perhaps with some slight modifications, the results of the solidification testing are still applicable).

This testing showed that the formulation of the solidification agents could be altered slightly to achieve desired variations in key parameters such as ultimate bearing capacity, permeability, ability to immobilize contaminants (as measured in leaching tests), release of ammonia gas, and others.

Materials costs for solidification additives ranged from \$0.10/gallon to \$1.00/gallon of Basin F liquid (1983 dollars). The volume increase resulting from solidification, expressed as a ratio of final volume of solidification waste to the original volume of Basin F liquid, ranged from 1.2 to 4.1, but seven of the ten variations on the six basic, acceptable processes had volume increases of 2.5 or less. Most of the solidified materials prepared in the study increased in strength with repeated wet/dry cycles, indicating that they would not deteriorate once emplaced in a landfill.

All of the solidified waste samples passed the EP toxicity test, but the limited statistical data indicate that there are real and substantial differences in the ability of the solidification processes to immobilize contaminants such as arsenic, copper, and mercury. On the other hand, the data also indicated that there are no substantial difference in the ability of the processes to immobilize gross organic contamination (as measured by TOC) in Basin F liquid. The leach data did demonstrate an order of magnitude reduction of contaminant levels in samples prepared by leaching of solidified Basin F liquid compared to the untreated liquid.

The only significant problem encountered in working with the solidification techniques was the release of large amounts of ammonia gas upon addition of the solidification agents. Formulations were developed, however, that minimized this problem, albeit at a higher expense in terms of

solidification agent costs. An alternate solution to this problem would be to employ ammonia scrubbing systems to capture and collect this compound.

#### 10.4 FULL-SCALE INCINERATION/THERMAL TREATMENT OF BASIN F WASTES

##### 10.4.1 Introduction

Current information is inadequate to prepare a concept design for a full-scale incinerator. Data from bench-scale tests should go a long way toward providing this information. To determine the capital and operating costs of a full-scale incineration system for treatment of Basin F wastes, Ebasco will perform a preliminary design of the incineration system. The methods Ebasco will employ in developing the preliminary design and cost estimate are described in the following sections.

##### 10.4.2 System Description

The system will consist of an incinerator train of the selected technology and all supporting subsystems to efficiently and safely thermally treat both the liquid and solid waste from Basin F. The equipment will be sized to meet the treatment schedule set for the project.

The incinerator train will consist of a primary and a secondary combustor (if required) with waste feed, supplemental fuel and air injected at designated points to ensure efficient burning of the waste. No energy or product recovery systems will be installed. Subsystems such as feed systems, ash handling systems, air pollution control systems will be discussed as separate subsystems.

##### 10.4.3 Subsystem Evaluation/Selection

Subsystems for waste handling, ash handling, air pollution control, waste water neutralization and disposal, and other such systems will be installed.

#### 10.4.3.1 Basin F Waste Handling

During the initial phase of the incineration of basin F waste, liquid waste must be handled. This waste is of particular concern in that it is super-saturated with salts. The liquid handling system and liquid injection system must be designed with this in mind. A desalting system may be required to pretreat the liquid. A good quality pump should be used for the liquid handling system. The pumping system should be completely leak free in order to prevent exposure of operating personnel.

An efficient and safe soils handling system will be designed. The relatively dry soil will probably be handled with machinery such as front end loaders and trucks. All efforts should be made to reduce exposure of operating personnel.

The soils will be deposited in a screening and grinding system. This system should be as closed as possible with automatic feed to the incinerator. The system should be designed to operate the initial soils handling (front-end loaders) only on one shift but the automatic feeder will operate on all three shifts.

#### 10.4.3.2 Ash Handling System

The ash handling system will be automated and will possibly include a system to recover heat from the ash to preheat air into the incinerator. This would reduce supplemental fuel required for treating the soils. The ash handling system will include a conveying system to transport the ash to the solidification/fixation system, if necessary, otherwise the ash will be hauled directly to an off-site facility for disposal.

#### 10.4.3.3 Air Pollution System

The most significant environmental concern associated with hazardous waste incineration is the generation of air contaminants. The majority of air contaminants generated during the incineration consist of the criteria pollutants including oxides of nitrogen ( $\text{NO}_x$ ) oxides of sulfur ( $\text{SO}_x$ ) and

particulate matter (PM). Also of great concern is the emission of noncriteria pollutants such as heavy metals, trace chlorinated organics and acid gases. The emissions of other criteria pollutants such as carbon monoxide (CO) and hydrocarbons (HC) are generally minimal due to the complete combustion and high destruction efficiency associated with a properly designed incinerator.

The actual emission rates depend on the incinerator type waste feed rate, waste compaction, operating parameters and air pollution control equipment. Particulate matter emissions consist of inert ash, condensible gaseous compounds and various salts. These emissions are also varied depending on the waste composition and the incineration type. The emissions of  $SO_x$  and other acid gases from incineration of Basin F waste will also depend on the waste composition.

Nitrogen oxides are either thermally generated or produced due to presence of nitrogen in the fuel or the waste. Thermal  $NO_x$  emission increase with an increase in the combustion gas temperature and residence time. High temperatures and residence times, however are desirable guidelines for achieving better destruction and removal efficiency. Fuel-Bond  $NO_x$  is formed by the reaction of nitrogen in the fuel and waste with available oxygen from combustion air. At temperatures below  $2800^{\circ}F$ , fuel-bond  $NO_x$  can be a major contributor to total  $NO_x$  emission. Therefore, the incinerator type and its feed composition effects the overall  $NO_x$  emission.

The current emission control systems for hazardous waste incineration are available for the control of particulate mater,  $SO_x$ , other acid gases, and  $NO_x$ .

Wet scrubbers control emissions of  $SO_x$  and acid gas as well as particulates. The removal efficiency of scrubber increases as the impact velocity between particle and liquid droplet increases. Based on the available data, for this type of operation where liquid waste is burning, particulate emissions are estimated to be at levels where it can be sufficiently controlled by wet scrubber. The 99% removal efficiency for hydrogen chloride (HCl) as required, can easily be achieved by wet

scrubbers. If waste feed analysis shows high solid contents, more effective means to remove particulate matters such as electrostatic precipitator (ESP) will be studied and included in the preliminary design.

NO<sub>x</sub> emissions control can be achieved by certain process modifications. Adequate modifications for NO<sub>x</sub> reduction in a hazardous waste incinerator would be staged combustion. Peak flame temperature reductions, low excess

air are all other process modifications which will result in lower NO<sub>x</sub> emissions. However they are in conflict with the required parameters for hazardous waste incineration, and therefore, would not be likely choices.

Staged combustion in hazardous waste incineration reduces NO<sub>x</sub> by carrying out the combustion process in two stages. In the first stage, waste is burned in an oxygen lean environment. Complete combustion takes place in the second stage where the required oxygen and addition waste (or fuel) are introduced. Other process modifications that may be feasible for hazardous waste incineration is the use of add-on non-catalytic control (thermal De-NO<sub>x</sub>).

Final design and selection of the air pollution control of technology to be applied for the incineration of Basin F waste will depend on the type of incineration proposed to be used as well as the analysis of flue gas and combustion products.

#### 10.4.3.4 Wastewater Treatment System

The preliminary design of the full-scale incineration system will also include waste treatment units for the scrubber effluent and wastewater generated from the decontamination of incineration facilities.

#### 10.4.3.5 Supplemental Fuel Subsystem

A system will be designed to supply required supplement fuel to the incineration system. The system will be selected based on its overall operability and cost, both initial capital and operating cost. The systems which will be considered are coal, oil or gas.

A coal system would require the greatest amount of initial capital to construct but probably would create the least operating cost. A coal system would require a coal receiving and storage facility; a coal feed system consisting of storage bins, a grinder and an automatic feed system. Use of coal as a fuel would also require more extensive air pollution control equipment and ash handling facilities. A system operating on coal would also require more labor.

A fuel oil system would probably be much less expensive to construct but would cost more per Btu for the fuel. Much of the storage tankage required for fuel oil already exists at RMA. A fuel oil system is easy to control and does not require as much labor to operate as a coal system.

A natural gas supplemental fuel system is the least expensive to construct but would probably be the most expensive to operate. A natural gas system is easy to control and does not require extensive labor.

An economic evaluation will probably be the deciding factor on which supplemental fuel system is selected.

#### 10.4.3.6 Miscellaneous Subsystems

Several subsystems such as decontamination facilities may be required. This will be designed to complement the selected system.

#### 10.4.4 Engineering Design

Before proceeding with any design calculations, a complete basis for the design will be written, which would include the characteristics of the Basin F waste material, the quantity and quality of waste destruction required, and the disposition of ash and volatile combustion products. Important factors to be determined in this phase are safety, constructability, operability and schedule of completion.

Based on the laboratory and pilot plant work, Process Flow Diagrams (PFD) with heat and material balances will be developed. These PFD's will

indicate all the unit operations required to produce the desired quantity and quality of Basin F waste detoxification.

Material and energy balances will be made around each unit and the results recorded in an orderly fashion and will form the basis for the design and operation of individual equipment items.

Piping and Instrumentation Diagrams (P&ID) will be developed after completion of all process calculations. These P&ID's form the central source of information for all design groups including electrical, piping, structural, instrumentation, and mechanical equipment groups.

On the P&ID's all equipment items are shown with pertinent equipment data noted on the drawings. Other information developed in this phase will be Plot Plans and General Arrangement drawings showing the layout of the individual process units and equipment of the plant.

#### 10.4.5 Economic Evaluation of Full-Scale Incinerator/Thermal Treatment of Basin F Wastes and Ultimate Disposal of Incineration Residue

##### 10.4.5.1 Capital Cost

The components of the total capital cost for the incineration system include all cost of equipment for the primary and sub-systems; bulk material for installing the equipment; subcontracts; labor, both direct and indirect; engineering fees; permits; spare parts inventory; technology fees and start-up expenses. Start-up expenses include chemicals for start-up; operator training, safety equipment, etc.

The capital cost will be estimated by utilizing firm vendor quotes for equipment and materials. The cost of bulks will be calculated from take-offs. Labor will be based on current and escalated labor cost in the Denver area.

#### 10.4.5.2 Operating cost

The operating cost includes all expenses associated with successful operation of the system. This includes labor, chemicals, fuel, power, and maintenance.

The operating cost for the system will be estimated based on historical data and known consumption values.



APPENDIX A

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APPENDIX B

GEOLOGY/HYDROLOGY AND CLIMATIC CONDITIONS  
OF THE BASIN F AREA



## APPENDIX B

### GEOLOGY AND GEOHYDROLOGY IN THE BASIN F AREA

Detailed information on the geology and geohydrology in the Basin F area was obtained from studies conducted from 1977 to 1979 which involved the placement of numerous borings around Basin F (Figure B-1) (Buhts, et al., 1979; U.S. Army Engineer Waterways Experiment Station Geotechnical Laboratory, 1979). The alluvium has been found to range in thickness from 32 feet at Deep Boring #1 (DB-1) to 40 feet at boring DB-3. The alluvium in this area consists of silty sands, clayey silts, clayey sands, and silty to clayey gravels. A few thin clay lenses and some cemented materials also were found. The first stratum encountered in the Denver formation in each boring was generally a clay shale. Underlying this first stratum were various layers or lenses of clay or clay shales, sand, siltstone, and sandstone, all of variable thickness. In the Basin F area, the surface of the Denver formation appears to have little relief and slopes generally to the north truncating strata that surface at the Denver-Alluvium contact in that area.

A detailed water table contour map, Figure B-2, was prepared based on data collected from a number of perimeter observation wells. The water table drops approximately 17 feet in elevation from south to north across the basin. The steepest gradient occurs in the southeast corner of the basin indicating an area of lower permeability. The saturated thickness in the alluvium under the basin was found to be 5 feet or less. The flow of groundwater beneath the basin has been estimated at approximately 50 gpm. The principal flow component beneath the basin is in a northwesterly direction. A groundwater divide occurs at the north end of the basin resulting in two major flow components out of the basin area, one toward the northwest and the other toward the northeast. The northwest component continues toward the northwest boundary of RMA while the northeast component turns to the north and continues toward the north boundary of the RMA.



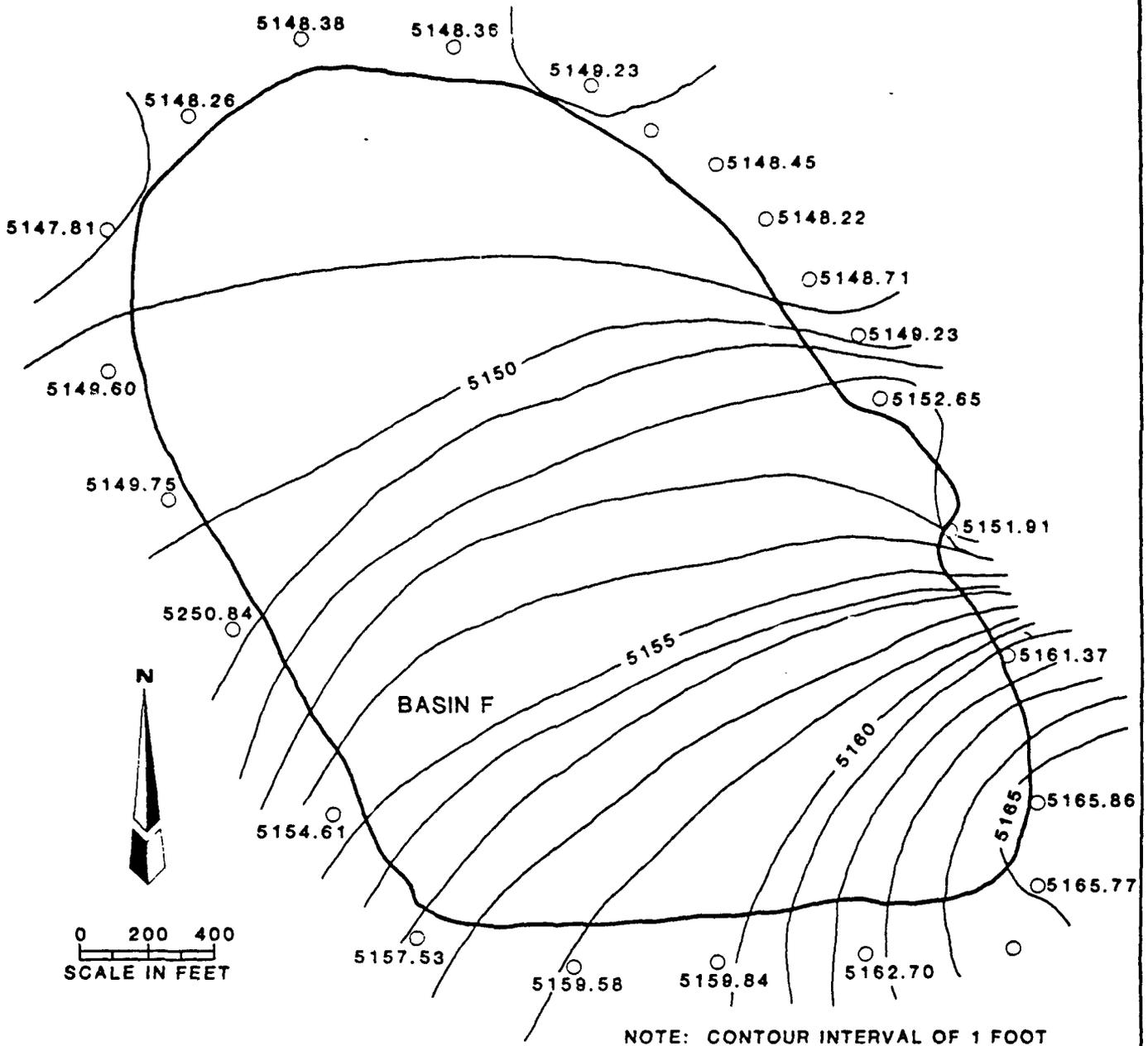


FIGURE B-2  
 WATER TABLE ELEVATIONS IN THE VICINITY OF BASIN F

## CLIMATIC CONDITIONS OF THE BASIN F AREA

The RMA area is generally classified as mid-latitude semi-arid i.e., an area with hot summers, cold winters, and relatively light rainfall. Mean maximum temperatures range from 43°F in January to 88°F in July. The mean minimum temperatures are -16°F in January and 59°F in July.

The annual precipitation at RMA (recorded at adjoining Denver-Stapleton Airport during 1977 to 1981) ranges from a low of 10 inches in 1977 to a little over 20 inches in 1979, (Resource Consultants, Inc., 1979). This precipitation data is presented in Figure B-3. Average annual precipitation recorded at Denver-Stapleton Airport, over a period of record from 1944 to 1983, is 14.59 inches. Most of the yearly precipitation at RMA occurs between March and August.

By comparison, average evaporation rates (for pure water) are higher than precipitation rates. Average monthly evaporation rates in inches for the period from 1959-1978 are as follows:

Jan.	0.80	May	6.96	Sept.	6.52
Feb.	1.00	June	8.68	Oct.	4.46
Mar.	1.74	July	9.54	Nov.	2.20
Apr.	4.34	Aug	8.78	Dec.	1.00

The annual average evaporation rate is more than 56 inches, which exceeds by more than 40 inches the annual average precipitation rate. It must be noted that evaporation of Basin F liquids does not necessarily reach the levels encountered for pure water. For example, a 1979 study estimated the annual evaporation rate from Basin F equal to 1.25 gpm per acre or about 24 inches (Buhts et al., 1979). It is likely that, due to concentration of the liquids over time, the present evaporation rate is somewhat less than this value.

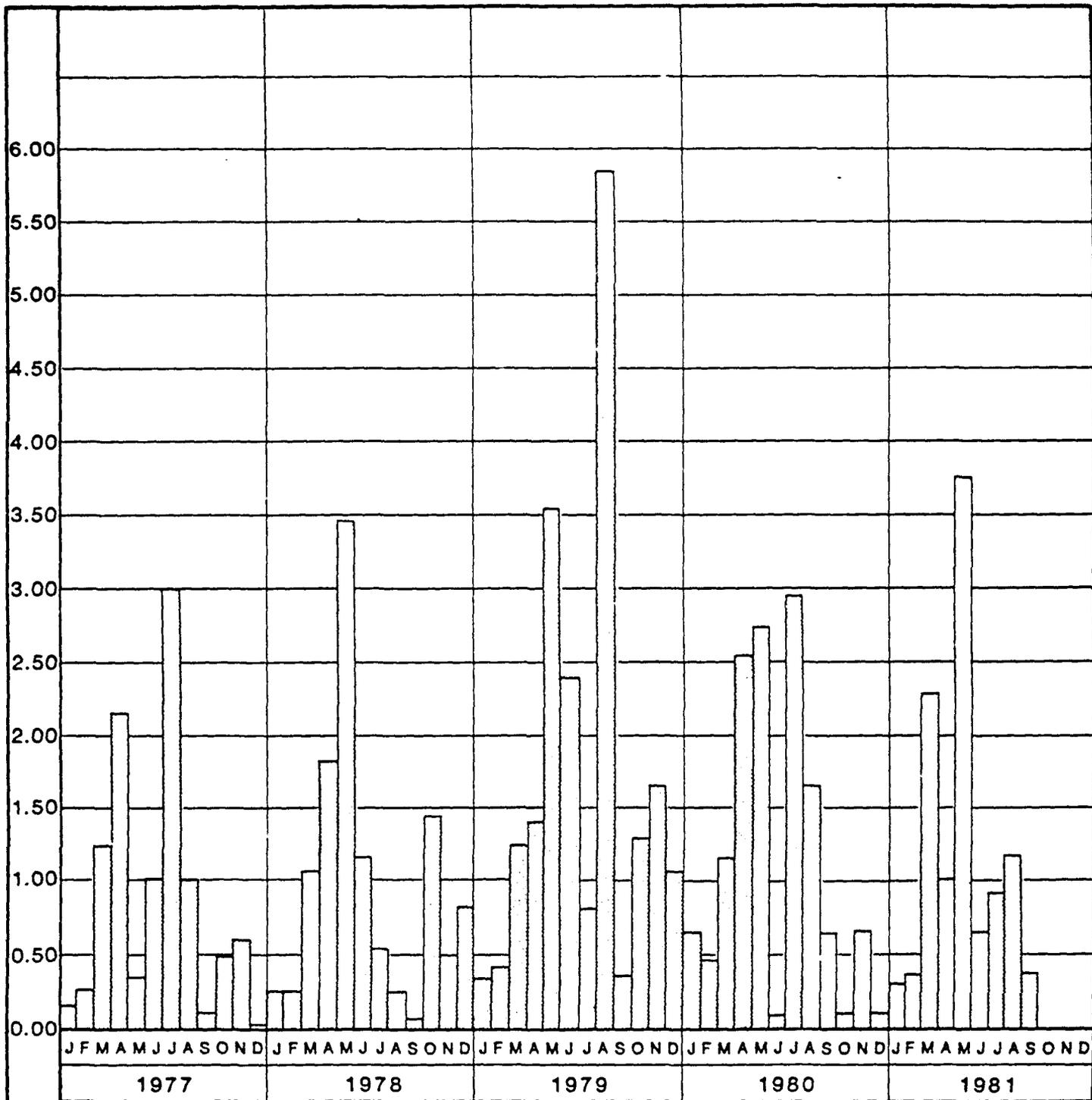


FIGURE B-3  
 PRECIPITATION DATA, 1977-1981  
 DENVER STAPLETON AIRPORT

As shown in Figure B-4, the prevailing winds at RMA (36.1 percent of the occurrences) are from the south through south-southwest direction. In addition, there are three secondary components including: (1) a north through north-northeast component which accounts for 16.9% of occurrences; (2) a west-northwest component, 8.3% of occurrences; and (3) an east-southeast component, 8.0% of occurrences. The occurrence of calms in the region is 7.0% of the time.

The predominant south through south-southwest component primarily is associated with the nocturnal, south to north pressure/temperature gradient. This gradient frequently is established along the Front Range in late afternoon when the higher temperatures to the south begin to interact with lower temperatures to the north. In addition, cold air drainage from the mountain valleys contributes to this southerly component because the cold air is channeled down the Platte River Valley.

A portion of the prevailing wind occurrences from the north through north-northeast are associated with the late morning gradient which forms when the eastern facing mountain slopes warm more rapidly than the flat terrain to the east. This air, rising over the mountains, causes a pressure void resulting in air movement up the Platte River Valley (from north to south). Also contributing to this north through north-northeast component is the passage of cold air fronts from Canada.

The west-northwest occurrences typically are associated with the tracking of Pacific low pressure across the continent. After the low pressure has passed through the Denver area, the east-southeast component is established. This wind direction often causes an "upslope condition" which results in precipitation to the area.

The high occurrence of calms is a result of the topographic barriers that exist in the Denver area. Cold, shallow air masses and cold air drainage from the mountain valleys move down from the north to the Denver area and stagnate in the topographic basin formed by the higher terrain which exists to the west, south, and east of Denver.





APPENDIX C

ANALYTICAL RESULTS

TABLE C-1

Analytical Results from SWLP Conducted on Samples from Boring No. 01

Analyte	Sample Identification				
	Core Subsamples				Overburden
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	3.0-4.0 ft	
pH	6.5*	8.2	8.2	8.7	7.2
Aldrin	0.30	0.61	0.71	0.40	5.07
Dieldrin	0.22	0.013	2.41	0.54	19.5
Endrin	0.40	0.20	2.22	0.91	24.4
Isodrin	0.11	0.005	0.005	0.11	0.41
DIMP	70	90	110	110	30
DMMP	***	-	-	-	-
Dithiane	-	-	-	-	-
Sulfone	-	-	-	-	710
Sulfoxide	-	-	-	-	-
DBCP	-	-	-	-	0.010
Mercury	-	-	0.12	0.12	0.22
Arsenic	95	110	110	90	110
Fluoride (ppm)	7.0	9.5	12.3	15.2	3.3

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-2

Analytical Results from SWLP Conducted on Samples from Boring No. 02

Analyte	Sample Identification			
	Core Subsamples			
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	3.0-4.0 ft
pH	9.1*	9.1	9.1	9.1
Aldrin	49.7	8.10	1.42	0.30
Dieldrin	59.1	19.5	4.19	0.12
Endrin	76.8	17.0	4.04	0.40
Isodrin	20.1	0.52	0.11	0.005
DIMP	20	30	30	10.8
DOMP	**	-	-	-
Dithiane	40	-	-	-
Sulfone	1600	630	550	760
Sulfoxide	1070	440	440	760
DBCP	0.60	0.09	0.09	0.17
Mercury	0.58	1.0	1.24	0.52
Arsenic	170	230	160	120
Fluoride (ppm)	6.1	4.8	7.8	4.3

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-3

Analytical Results from SWLP Conducted on Samples from Boring No. 11

Analyte	Sample Identification				
	Core Subsamples				Overburden
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	3.0-4.0 ft	
pH	5.3*	4.6	6.5	6.4	8.6
Aldrin	0.51	**	0.30	-	8.51
Dieldrin	0.12	0.013	0.12	-	23.6
Endrin	0.04	-	0.71	-	39.4
Isodrin	0.005	0.005	0.005	-	0.11
DIMP	30	20	20	7	20
DNMP	-	-	-	-	0.07
Dithiane	-	-	-	-	-
Sulfone	-	-	-	-	1710
Sulfoxide	-	-	-	-	-
DBCP	-	-	0.022	-	0.07
Mercury	0.12	0.12	0.20	0.16	1.20
Arsenic	-	90	-	20	280
Fluoride (ppm)	0.75	0.95	0.71	1.2	14.8

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-4

Analytical Results from SWLP Conducted on Samples from Boring No. 12

Analyte	Sample Identification			
	Core Subsamples			
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	3.0-4.0 ft
pH	5.8*	5.4	5.5	6.0
Aldrin	**	-	-	-
Dieldrin	-	0.12	-	-
Endrin	-	0.61	-	-
Isodrin	-	-	-	-
DIMP	30	10	10	6
DMMP	-	-	-	-
Dichlone	-	-	-	-
Sulfone	120	-	-	-
Sulfoxide	-	-	-	-
DBCP	-	0.013	-	-
Mercury	-	0.14	0.24	-
Arsenic	14	12	20	50
Fluoride (ppm)	0.48	0.54	0.95	1.95

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-5

Analytical Results from SWL? Conducted on Samples from Boring No. 13

<u>Analyte</u>	<u>Sample Identification</u>	
	<u>Core Subsamples</u>	
	<u>0.0-1.0 ft</u>	<u>1.0-2.0 ft</u>
pH	8.4*	8.2
Aldrin	-**	-
Dieldrin	-	-
Endrin	-	-
Isodrin	-	-
DIMP	40	40
DMIP	0.04	0.04
Dithiane	-	-
Sulfone	-	-
Sulfoxide	-	-
DBCP	-	-
Mercury	0.14	0.14
Arsenic	64	51
Fluoride (ppm)	1.7	1.1

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-6

Analytical Results from SWP Conducted on Samples from Boring No. 14

Analyte	Sample Identification			
	Core Subsamples			Overburden
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	
pH	5.6*	5.8	5.6	8.1
Aldrin	**	-	0.02	1.59
Dieldrin	-	0.10	0.21	3.24
Endrin	-	-	0.07	44.5
Isodrin	-	-	-	3.1
DIMP	20	20	20	120
DMMP	-	-	-	0.39
Dithiane	-	-	-	-
Sulfone	40	-	-	9160
Sulfoxide	-	-	-	1140
DBCP	-	-	-	1.01
Mercury	0.12	-	0.12	2.14
Arsenic	38	38	71	226
Fluoride (ppm)	1.9	2.1	2.0	15.2

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-7

Analytical Results from S.L.P. Conducted on Samples from Boring No. 15

Analyte	Sample Identification		
	Core Subsamples		
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft
pH	5.3*	5.6	5.7
Aldrin	-**	-	-
Dieldrin	0.10	0.10	-
Endrin	0.08	0.07	-
Isodrin	-	-	-
DMP	40	30	36
DMP	-	-	-
Dithiane	-	-	-
Sulfone	90	-	-
Sulfoxide	-	-	-
DBCP	-	-	-
Mercury	-	0.12	-
Arsenic	160	170	20
Fluoride (ppm)	0.42	0.40	0.52

\* All values other than pH are reported as ppm unless otherwise noted.

\*\* Less than detection limit.

TABLE C-8

Analytical Results from SWLP Conducted on Samples from Boring No. 21

Analyte	Sample Identification		
	Core Subsamples		
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft
pH	6.9*	4.8	4.9
Aldrin	**	0.01	-
Dieldrin	-	-	-
Endrin	-	-	-
Isodrin	-	-	-
DIMP	60	40	20
DDEP	-	-	-
Dithiane	-	-	-
Sulfone	-	-	-
Sulfoxide	-	-	-
DBCP	-	-	-
Mercury	0.58	-	-
Arsenic	-	14	11
Fluoride (ppm)	0.90	1.52	1.4

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-9

Analytical Results from SWP Conducted on Samples from Boring No. 22

Analyte	Sample Identification		
	Core Subsamples		
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft
pH	4.9*	4.8	4.4
Aldrin	0.03	**	-
Dieldrin	0.01	-	-
Endrin	-	-	-
Isodrin	0.06	-	-
DIMP	130	140	150
DMMP	-	-	-
Dithiane	-	-	-
Sulfone	-	-	-
Sulfoxide	-	-	-
DBCP	-	-	-
Mercury	-	-	-
Arsenic	-	-	14
Fluoride (ppm)	1.4	0.855	0.24

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-10

Analytical Results from SWLP Conducted on Samples from Boring No. 23

Analyte	Sample Identification		
	Core Subsamples		
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft
pH	4.8*	5.0	5.9
Aldrin	**	-	-
Dieldrin	-	-	0.01
Endrin	-	-	-
Isodrin	-	-	-
DIMP	60	40	30
DMMP	-	-	-
Dithiane	-	-	-
Sulfone	-	-	-
Sulfoxide	-	-	-
DBCP	-	-	-
Mercury	0.20	-	-
Arsenic	15	29	22
Fluoride (ppm)	0.48	0.64	0.59

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-11

Analytical Results from SWLP Conducted on Samples from Boring No. 31

Analyte	Sample Identification			
	Core Subsamples			Overburden
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	
pH	5.7*	5.5	5.6	8.5
Aldrin	**	0.30	-	28.4
Dieldrin	-	1.26	-	20.2
Endrin	-	2.22	-	17.7
Isodrin	0.10	0.005	0.10	8.1 <sup>a</sup>
DIMP	20	20	10	310
DMMP	-	-	-	60
Dithiane	-	-	-	-
Sulfone	-	-	-	3200
Sulfoxide	-	-	-	-
DBCP	-	0.03	-	0.46
Mercury	0.16	0.22	-	0.36
Arsenic	11	25	25	360
Fluoride (ppm)	0.66	1.0	3.9	7.8

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-12

Analytical Results from SWP Conducted on Samples from Boring No. 32

Analyte	Sample Identification		
	Core Subsamples		
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft
pH	5.5*	5.8	5.9
Aldrin	0.20	-**	0.10
Dieldrin	0.10	-	0.10
Endrin	0.10	-	0.10
Isodrin	-	0.10	0.10
DMP	170	150	150
DMMP	-	-	-
Dithiane	-	-	-
Sulfone	100	-	-
Sulfoxide	-	-	-
DBCP	-	0.006	-
Mercury	0.16	0.36	-
Arsenic	14	12	14
Fluoride (ppm)	0.57	0.63	0.41

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-13

Analytical Results from SWP Conducted on Samples from Boring No. 33

<u>Analyte</u>	<u>Sample Identification</u>	
	<u>Core Subsamples</u>	
	<u>0.0-1.0 ft</u>	<u>1.0-2.0 ft</u>
pH	5.5*	5.9
Aldrin	0.20	-**
Dieldrin	0.10	-
Endrin	0.20	-
Isodrin	0.10	-
DIMP	20	10
DDEP	-	-
Dithiane	-	-
Sulfone	-	-
Sulfoxide	-	-
DBCP	0.008	-
Mercury	-	0.16
Arsenic	14	28
Fluoride (ppm)	0.67	0.95

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-14

Analytical Results from SWLP Conducted on Samples from Boring No. 50

Analyte	Sample Identification			
	Core Subsamples			
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	3.0-4.0 ft
pH	6.2*	5.0	5.2	8.0
Aldrin	0.40	0.30	0.30	-**
Dieldrin	0.43	0.12	0.12	-
Endrin	0.71	0.30	0.50	-
Isodrin	0.11	0.11	0.005	-
DIMP	30	40	20	17
DMMP	-	-	-	-
Dithiane	-	-	-	-
Sulfone	40	-	-	-
Sulfoxide	-	-	-	-
DBCP	-	-	-	-
Mercury	0.12	0.12	0.40	0.38
Arsenic	-	-	-	20
Fluoride (ppm)	0.71	0.41	0.62	0.75

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-15

Analytical Results from SWLP Conducted on Samples from Boring No. 60

Analyte	Sample Identification	
	Core Subsamples	
	0.0-1.0 ft	1.0-2.0 ft
pH	5.2*	5.6
Aldrin	-**	-
Dieldrin	-	0.10
Endrin	-	0.10
Isodrin	0.10	-
DIMP	20	20
DMP	-	-
Dithiane	-	-
Sulfone	-	-
Sulfoxide	-	-
DSCP	0.01	-
Mercury	0.54	0.16
Arsenic	-	11
Fluoride (ppm)	0.63	0.41

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-16

Analytical Results from SWLP Conducted on Samples from Boring No. 70

Analyte	Sample Identification			
	Core Subsamples			Overburden
	0.0-1.0 ft	1.0-2.0 ft	2.0-3.0 ft	
pH	4.7*	5.6	5.5	8.5
Aldrin	**	0.10	-	0.27
Dieldrin	0.10	-	-	0.10
Endrin	0.70	-	-	0.61
Isodrin	-	0.10	0.10	-
DIMP	40	20	20	40
DMMP	-	-	-	-
Dithiane	-	-	-	-
Sulfone	-	-	-	340
Sulfoxide	-	-	-	-
DBCP	-	-	-	-
Mercury	0.22	-	0.42	0.28
Arsenic	12	11	11	81
Fluoride (ppm)	0.36	0.40	0.43	6.4

\* All values other than pH are reported as ppb unless otherwise noted.

\*\* Less than detection limit.

TABLE C-17

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 01

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g/g}</math>)</u>
Diisopropylmethylphosphonate	5
Toluene	0.6
1,1,2-Trichloroethane	2
Tetrachloroethylene	0.2
Unknown ( <u>m/e</u> 79 base)	1
Xylene	0.1
Xylene	0.1
1,1,2,2-Tetrachloroethane	4
Pentachloroethane	0.3
Acetophenone	0.1
Unknown ( <u>m/e</u> 79 base)	2
Unknown ( <u>m/e</u> 79 base)	2
Unknown ( <u>m/e</u> 79 base)	6
Unknown ( <u>m/e</u> 79 base)	1
S <sub>6</sub> (molecular sulfur)	1
S <sub>8</sub> (molecular sulfur)	16
Unknown ( <u>m/e</u> 275 base)	2
4- <u>tert</u> -Butyl-2-( <u>tert</u> -butylthio)pyridine	0.5

TABLE C-18

Bulk Metal Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 01

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.18
Aluminum	8750
Arsenic	<1.8
Boron	7.15
Barium	170
Beryllium	<0.08
Calcium	2130
Cadmium	<0.1
Cobalt	9.29
Chromium	13.1
Copper	<100
Iron	11300
Mercury	0.023
Potassium	2630
Magnesium	3050
Manganese	384
Molybdenum	6.19
Sodium	4250
Nickel	14.3
Phosphorus	579
Lead	27.1
Antimony	45.0
Selenium	<6.2
Tin	<50
Titanium	48.0
Thallium	24.4
Yttrium	16.2
Zinc	49.4
Fluoride	152

TABLE C-19

Bulk Organic Analysis of the Overburden from Boring No. 11

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g/g}</math>)</u>
Dimethylmethylphosphonate	40
Diisopropylmethylphosphonate	-
p-chlorophenylmethylsulfone	250
Chlorophenylmethylsulfone isomer	12
Aldrin	500
Isodrin	80
Dieldrin	530
Endrin	450
Benzene	20
Cyclohexene	130
Dimethyl disulfide	2
1,1,2-trichloroethane	6
Unknown (possibly N-methylacetamide)	80
MW 98 unknown	80
Weak unknown ( <u>m/e</u> 78 base)	30
2° or 3° amine unknown	20
Unknown ( <u>m/e</u> 57 base)	30
Alkane	5
Alkane	4
N-nitrosodipropylamine	200
2° or 3° amine unknown	25
N-containing unknown	20
2° or 3° amine unknown	30
Methylcyclopentadiene	2
Methylcyclopentadiene isomer	2
Unknown ( <u>m/e</u> 79 base)	270
Hexachlorobutadiene	70
Monochlorinated unknown (MW 155)	177
Alkane	3

(Continued)

TABLE C-19 (Continued)

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g}/\text{g}</math>)</u>
Hexachlorobicycloheptadiene	800
Alkane	8
Unknown	7
Aldrin-type pesticide (?), Weak!	7
Chlorinated unknown (MW 332)	300
Chlorinated unknown	19
Alkane	14
Alkane	8
Tetrachlorobenzene	70
Chlorinated unknown	250
Unknown ( <u>m/e</u> 57 base)	20
S <sub>8</sub> (molecular sulfur)	300
Unknown	35
2° or 3° amine unknown	10
2° or 3° amine unknown	13
2° or 3° amine unknown	40
Aldrin-type chlorinated pesticide	180

TABLE C-20

Bulk Mass Analysis of the Overburden from Boring No. 11

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	0.561
Aluminum	6830
Arsenic	<1.9
Boron	6.48
Barium	94.6
Beryllium	<0.08
Calcium	6110
Cadmium	0.55
Cobalt	5.66
Chromium	10.7
Copper	5220
Iron	7660
Mercury	0.057
Potassium	1810
Magnesium	2740
Manganese	180
Molybdenum	5.55
Sodium	23700
Nickel	13.8
Phosphorus	3100
Lead	35.6
Antimony	29.0
Seelenium	<6.2
Tin	<50
Titanium	63.6
Thallium	15.0
Yttrium	9.56
Zinc	60.7
Fluoride	404

TABLE C-21

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 12

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g/g}</math>)</u>
p-Chlorophenylmethylsulfone	2.1
Toluene	8
1,1,2-Trichloroethane	1.1
Tetrachloroethylene	0.2
MW 98 unknown	30
Xylene	0.2
Unknown ( <u>m/e</u> 79 base)	5
1,1,2,2-Tetrachloroethane	4
Pentachloroethane	0.2
MW 98 or 134 unknown	7.9
Unknown	2
$\text{S}_6$ (molecular sulfur)	1

TABLE C-22

Bulk Metal Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 12

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.26
Aluminum	7190
Arsenic	<1.8
Boron	6.31
Barium	133
Beryllium	<0.08
Calcium	18700
Cadmium	<0.1
Cobalt	6.34
Chromium	10.5
Copper	<100
Iron	10200
Mercury	0.010
Potassium	1840
Magnesium	3060
Manganese	257
Molybdenum	5.01
Sodium	811
Nickel	0.69
Phosphorus	558
Lead	10.7
Antimony	44.0
Selenium	<6.2
Tin	<50
Titanium	84.5
Thallium	22.9
Yttrium	11.8
Zinc	37.3
Fluoride	95.0

TABLE C-23

Bulk Organic Analysis of the Overburden from Boring No. 12

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g}/\text{g}</math>)</u>
Dieldrin	5.4
p-Chlorobenzene methyl sulfoxide	3.6
p-Chlorobenzene methyl sulfone	32
p-Chlorobenzene methyl sulfoxide isomer	1
Aldrin	1.4
Toluene	14
1,1,2-Trichloroethane	1
MW 98 unknown	3
Unknown	7
Xylene	0.3
N,N-dimethylacetamide	2
Unknown	5
N-nitrosodipropylamine	20
MW 127 unknown	4
Unknown 2° or 3° amine	24
Weak unknown	1
Unknown ( <u>m/e</u> 79 base)	8
Unknown	20
MW 153 chlorinated unknown	5
Methyl sulfonyl benzene (very weak)	0.3
Weak unknown	1
S <sub>8</sub> (molecular sulfur)	30
Unknown (275 base pk)	6
4- <u>tert</u> -Butyl-2( <u>tert</u> -butylthio)pyridine	8
Unknown MW 221 N-containing compound	4
Weak MW 131 unknown	4

TABLE C-24

Bulk Metal Analysis of the Overburden from Boring No. 12

<u>Analyte</u>	<u>Concentration (<math>\mu\text{z/g}</math>)</u>
Silver	1.15
Aluminum	7280
Arsenic	<1.8
Boron	8.08
Barium	115
Beryllium	<0.08
Calcium	4440
Cadmium	<0.1
Cobalt	5.57
Chromium	9.76
Copper	613
Iron	9640
Mercury	0.091
Potassium	1790
Magnesium	2350
Manganese	205
Molybdenum	4.97
Sodium	14100
Nickel	10.4
Phosphorus	1550
Lead	17.4
Antimony	18.0
Selenium	<6.2
Tin	<50
Titanium	84.4
Thallium	18.1
Yttrium	9.90
Zinc	41.5
Fluoride	217

TABLE C-25

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 14

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g/g}</math>)</u>
DNMIP	2.6
DIMP	1.5
p-Chlorophenylmethylsulfone	0.0
Toluene	4.7
1,1,3-Trichloroethane	3.1
Tetrachloroethylene	0.2
Possibly N-methylacetamide	0.3
MW 98 unknown	3.2
Xylene	0.2
Xylene	0.5
Weak unknown	1.3
Xylene	0.3
1,1,2,2-Tetrachloroethane	11
Pentachloroethane	0.7
Acetophenone	0.5
Unknown ( <u>m/e</u> 79 base)	7
S <sub>6</sub> (molecular sulfur)	5
S <sub>8</sub> (molecular sulfur)	20

TABLE C-26

Bulk Metal Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 14

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.53
Aluminum	6840
Arsenic	<1.8
Boron	9.82
Barium	120
Beryllium	<0.08
Calcium	9120
Cadmium	<0.1
Cobalt	7.90
Chromium	11.8
Copper	<100
Iron	10900
Mercury	0.015
Potassium	2200
Magnesium	4920
Manganese	294
Molybdenum	5.41
Sodium	896
Nickel	13.6
Phosphorus	606
Lead	22.5
Antimony	100
Selenium	<6.2
Tin	<50
Titanium	94.5
Thallium	28.3
Yttrium	14.5
Zinc	47.5
Fluoride	184

TABLE C-27

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 31

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{g/g}</math>)</u>
DNDP	1.9
p-Chlorophenylmet disulfone	0.6
Toluene	1
1,1,2-Trichloroethane	2
Unknown	3
Xylene	0.2
Unknown ( <u>m/e</u> 79 base)	1
Xylene	0.1
1,1,2,2-Tetrachloroethane	7
Pentachloroethane	0.3
Acetophenone	0.1
Unknown ( <u>m/e</u> 79 base)	4
Weak unknown (contains <u>m/e</u> 79)	2
S <sub>6</sub> (molecular sulfur)	2
S <sub>8</sub> (molecular sulfur)	6

TABLE C-28

Multielement Analysis of the 0.1-1.0 ft Core Subsample from Boring No. 31

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.47
Aluminum	9270
Arsenic	<1.8
Boron	14.6
Barium	177
Beryllium	<0.08
Calcium	18900
Cadmium	<0.1
Cobalt	8.81
Chromium	14.2
Copper	<100
Iron	12700
Mercury	0.030
Potassium	2680
Magnesium	5050
Manganese	329
Molybdenum	6.85
Sodium	655
Nickel	15.0
Phosphorus	562
Lead	23.6
Antimony	117
Selenium	<6.2
Tin	<50
Titanium	75.1
Thallium	35.2
Yttrium	14.9
Zinc	49.9
Fluoride	224

TABLE C-29

Bulk Organic Analysis of the Overburden from Spring No. 31

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{z/g}</math>)</u>
Aldrin	3,100
Isodrin	200
p-Chlorophenylmethylsulfone	70
Toluene	30
Hexachlorobutadien	220
Monochlorinated unknown (MW 158)	100
Hexachlorobicycloheptadiene	1,700
Chlorinated unknown	500
Tetrachlorobenzene	30
S <sub>8</sub> (molecular sulfur)	130
Unknown ( <u>m/e</u> 275 base)	30
Dieldrin	550
Chlorinated unknown	30
Aldrin-type chlorinated pesticide	200

TABLE C-30

Bulk Metal Analysis of the Overburden from Borine No. 31

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g}/\text{g}</math>)</u>
Silver	0.65
Aluminum	7460
Arsenic	<1.8
Boron	8.70
Barium	126
Beryllium	<0.08
Calcium	16100
Cadmium	0.21
Cobalt	6.03
Chromium	11.3
Copper	2110
Iron	9190
Mercury	0.031
Potassium	2050
Magnesium	3600
Manganese	219
Molybdenum	5.54
Sodium	32700
Nickel	13.1
Phosphorus	2980
Lead	25.4
Antimony	55.0
Selenium	<6.2
Tin	<50
Titanium	91.6
Thallium	19.1
Yttrium	9.72
Zinc	49.2
Fluoride	336

TABLE C-31

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 33

<u>Tentative Identification</u>	<u>Level (ug/g)</u>
p-Chlorobenzene methyl sulfone	0.4
Toluene	6
1,1,2-Trichloroethane	2
Tetrachloroethylene	0.2
MW 98 Unknown	30
Xylene	0.2
Unknown (m/e 79 base)	4
Tetrachloroethane	5
Pentachloroethane	0.4
MW 98 or 134 unknown	11
Alkane	0.3

TABLE C-32

Bulk Metal Analysis of the 0.8-1.0 ft Core Subsample from Boring No. 33

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.35
Aluminum	11500
Arsenic	<1.8
Boron	8.58
Barium	162
Beryllium	<0.08
Calcium	2990
Cadmium	<0.1
Cobalt	8.71
Chromium	14.8
Copper	<100
Iron	13600
Mercury	0.015
Potassium	2680
Magnesium	3380
Manganese	296
Molybdenum	8.31
Sodium	1030
Nickel	16.1
Phosphorus	432
Lead	24.6
Antimony	55.0
Selenium	<6.2
Tin	<50
Titanium	70.2
Thallium	32.9
Yttrium	15.0
Zinc	49.0
Fluoride	60.8

TABLE C-33

Bulk Organic Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 70

<u>Tentative Identification</u>	<u>Level (<math>\mu\text{z/g}</math>)</u>
Toluene	10
1,1,2-trichloroethane	3.0
Tetrachloroethylene	0.2
MW 98 unknown	30
Xylene	0.3
Unknown ( <u>m/e</u> 79 base)	9
1,1,2,2-Tetrachloroethane	13
Pentachloroethane	0.8
MW 98 or 134 unknown	30
Unknown	0.7
Alkane	2

TABLE C-34

Bulk Metal Analysis of the 0.0-1.0 ft Core Subsample from Boring No. 70

<u>Analyte</u>	<u>Concentration (<math>\mu\text{g/g}</math>)</u>
Silver	1.23
Aluminum	2590
Arsenic	<1.8
Boron	9.66
Barium	53.3
Beryllium	<0.08
Calcium	1300
Cadmium	<0.1
Cobalt	3.34
Chromium	4.49
Copper	<100
Iron	4040
Mercury	0.013
Potassium	885
Magnesium	1050
Manganese	123
Molybdenum	1.93
Sodium	124
Nickel	4.80
Phosphorus	230
Lead	12.4
Antimony	65.0
Selenium	<6.2
Tin	<50
Titanium	45.4
Thallium	3.77
Yttrium	5.63
Zinc	18.3
Fluoride	60.8



APPENDIX D

DESCRIPTION OF BUILDING 1611

(ADOPTED FROM RIC # 83313R01

## V. EXISTING THERMAL OXIDATION SYSTEMS

There are eight thermal oxidation systems located at RMA. Presently only two systems (the deactivation and decontamination furnaces) are in operation (located in building 1611), both of which connect to a common afterburner, electrostatic precipitator (ESP), wet scrubber, and stack. Figure 2 shows the building 1611 floor plan with the location of the major pieces of equipment. All eight of these facilities were designed as deactivation/decontamination furnaces capable of handling ordnance or contaminated equipment of limited size. None of the systems were designed to accommodate large volumes of contaminated soil.

## A. DEACTIVATION FURNACE - BUILDING 1611

The deactivation furnace system consists of the following major subsystems:

- Fuel oil supply
- Combustion air supply and exhaust
- Receiving and handling
- Retort
- Discharge/burner assembly
- Exit conveyors
- Controls

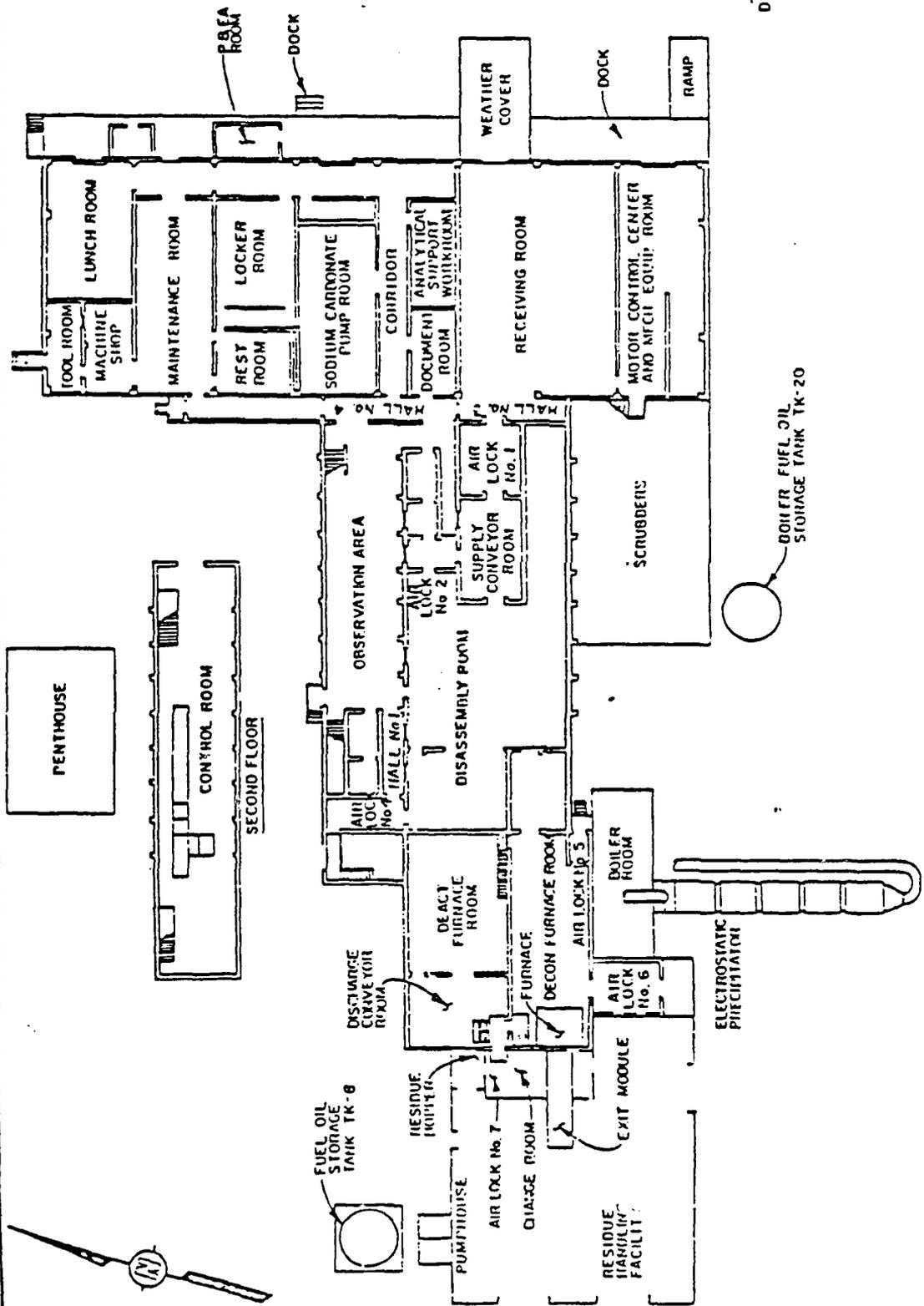
Figure 3 shows the layout and configuration of the deactivation furnace and the various subsystems. The furnace, feed, and discharge are contained in a steel reinforced concrete room, maintained at a negative pressure. The furnace and discharge conveyor rooms are located approximately nine feet below the other processing areas in a subbasement.

## 1. Fuel Oil Supply

Fuel oil is supplied to the facility from a tank that is automatically refilled on demand by low-level sensors from the complex main fuel oil system. A flow indicator is used to monitor the fuel oil feed to the furnace.

## 2. Combustion Air Supply and Exhaust

The combustion air/exhaust system consists of a blower, piping, control valve, exhaust duct, and pressure control damper. Inlet air is metered by a manually operated butterfly valve. The exhaust gas is ducted to the afterburner through the pressure control damper (12-in. butterfly valve). Furnace pressure is maintained at a nominal 3/4 in. w.c. below atmospheric pressure.



NOTE: DRAWING NOT TO SCALE.

Fig. 2.  
BUILDING 1611  
FLOOR PLAN

REFERENCE:  
SCOTT 91 91 PILOT TEST  
REPORT, FIGURE 1-21,  
DATED: 1980

DRAWN BY: [Illegible]  
CHECKED BY: [Illegible]  
DATE: [Illegible]

SOP NO: SARRM-T-ID-78 106 DATE: 13 APR 78  
 REVISION NO: DATE: 31 JUL 79

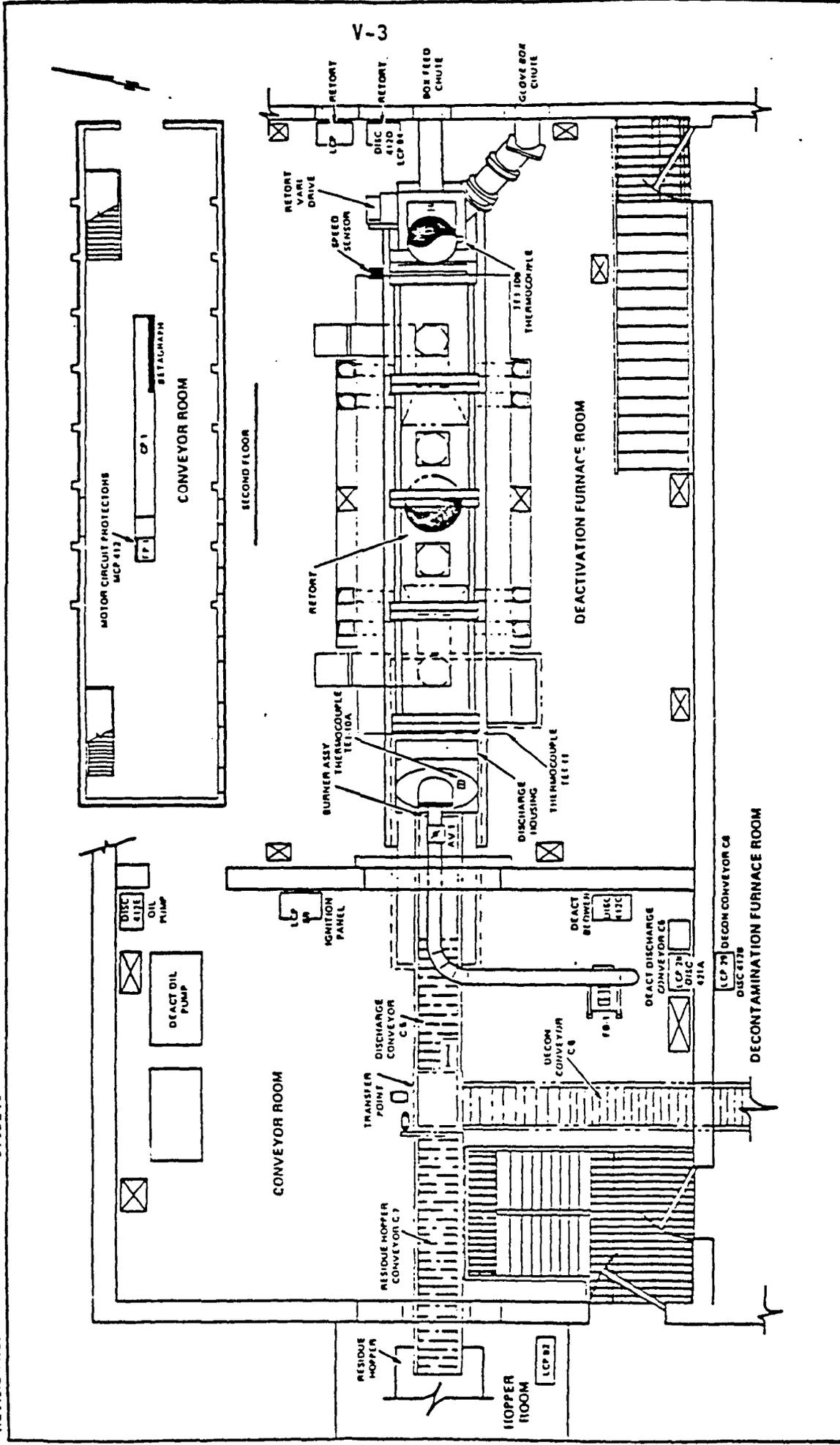


Fig. 3. DEACT FURNACE EQUIPMENT LOCATION

### 3. Receiving and Handling

Figure 4 shows the material handling process for both the deactivation and decontamination furnaces. Contaminated material in containers is delivered by truck, unloaded by monorail hoist/trolley at the dock, and moved into the receiving room (see Fig. 2). After inspection and inventory the material is moved through airlock no. 1 into the disassembly room.

One method of disassembling contaminated material, such as chemical agent filled cans from cylindrical steel shipping containers, in a safe manner is to use a glove box, which separates personnel from the containers. The shipping containers are conveyed to the decontamination furnace because they are too large to feed into the deactivation furnace. Figures 5, 6, and 7 show flow diagrams of available feed routes to the deactivation and decontamination furnaces depending on the type and size of the contaminated material and its containers.

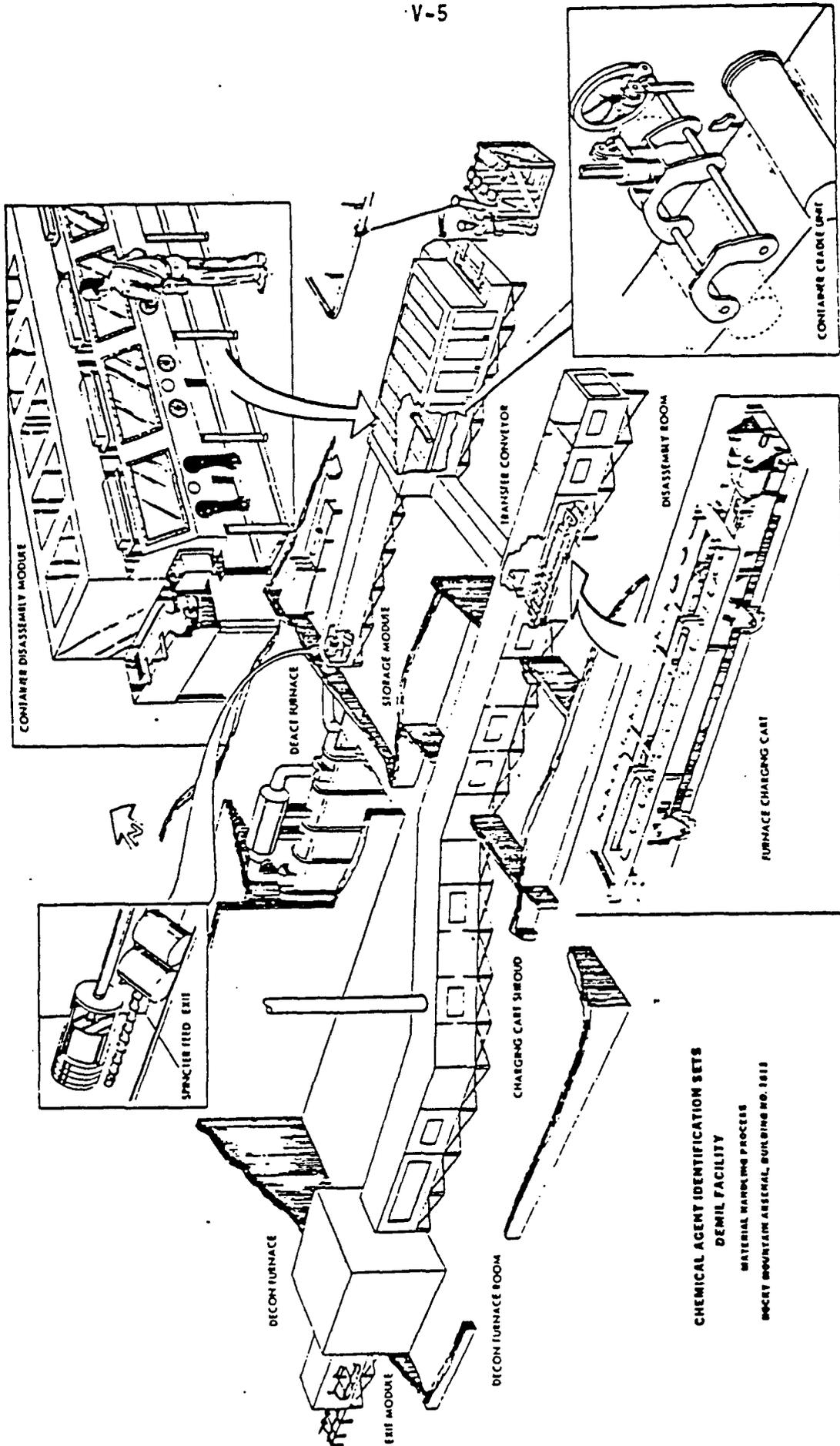
From the glove box the contaminated material is conveyed through an airlock device and ram mechanism to the glove box chute and into the deactivation furnace retort (see Fig. 3). Another method of feeding the retort with contaminated material that does not require disassembly is through a small airlock and down the box feed chute. Both feed systems have interlocked controls, air lock doors, and air purge systems. The box feed used to insert boxed contaminated material and the glove box feed used to insert canned contaminated material enter the retort at a common feed end assembly.

### 4. Retort

The retort consists of the following major segments (see Fig. 8):

- Frame
- Trunnion/variable speed drive
- Retort

The frame is constructed of 12-in. steel I-beams that support the entire assembly. Four trunnions with shafts and pillow block bearings and special cooling air ducting are provided. The variable speed drive system turns two of the trunnions which in turn rotate the retort. The retort is cast iron (4 1/2 in. thick), approximately 3 ft diameter by 20 ft long with internal spiral flights having a pitch of 2 1/2 ft. The retort can be oscillated approximately one revolu-



CHEMICAL AGENT IDENTIFICATION SETS  
 DEMIL FACILITY  
 MATERIAL HANDLING PROCESS  
 ROCKY MOUNTAIN ARSENAL, BUILDING NO. 1011

Fig. 4. CHEMICAL AGENT IDENTIFICATION SETS  
 DEMIL FACILITY  
 1-9

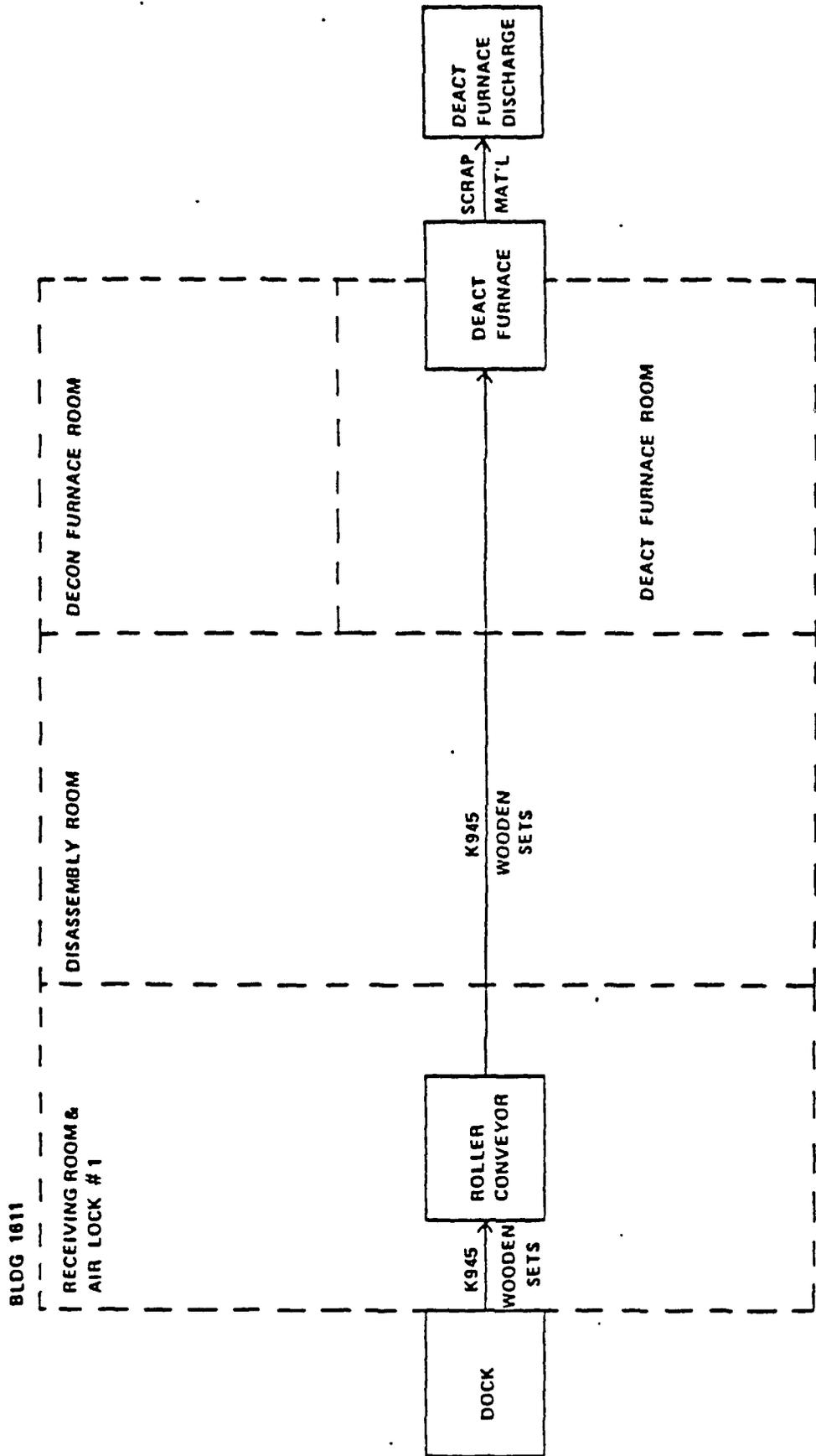


Fig. 5. ID SET PROCESS FLOW DIAGRAM (K945)

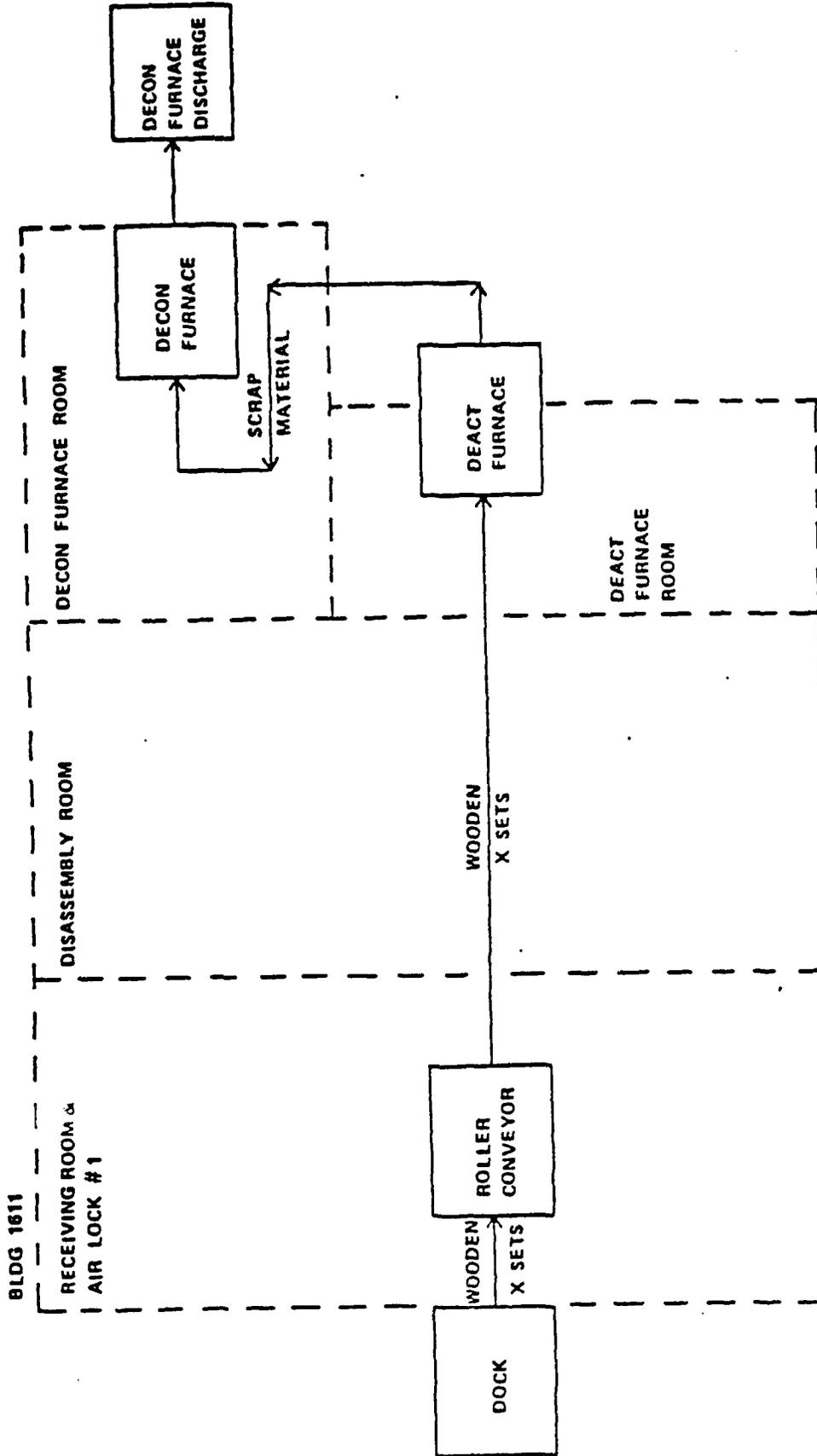


Fig. 6. ID SETS PROCESS FLOW DIAGRAM (X-SET)

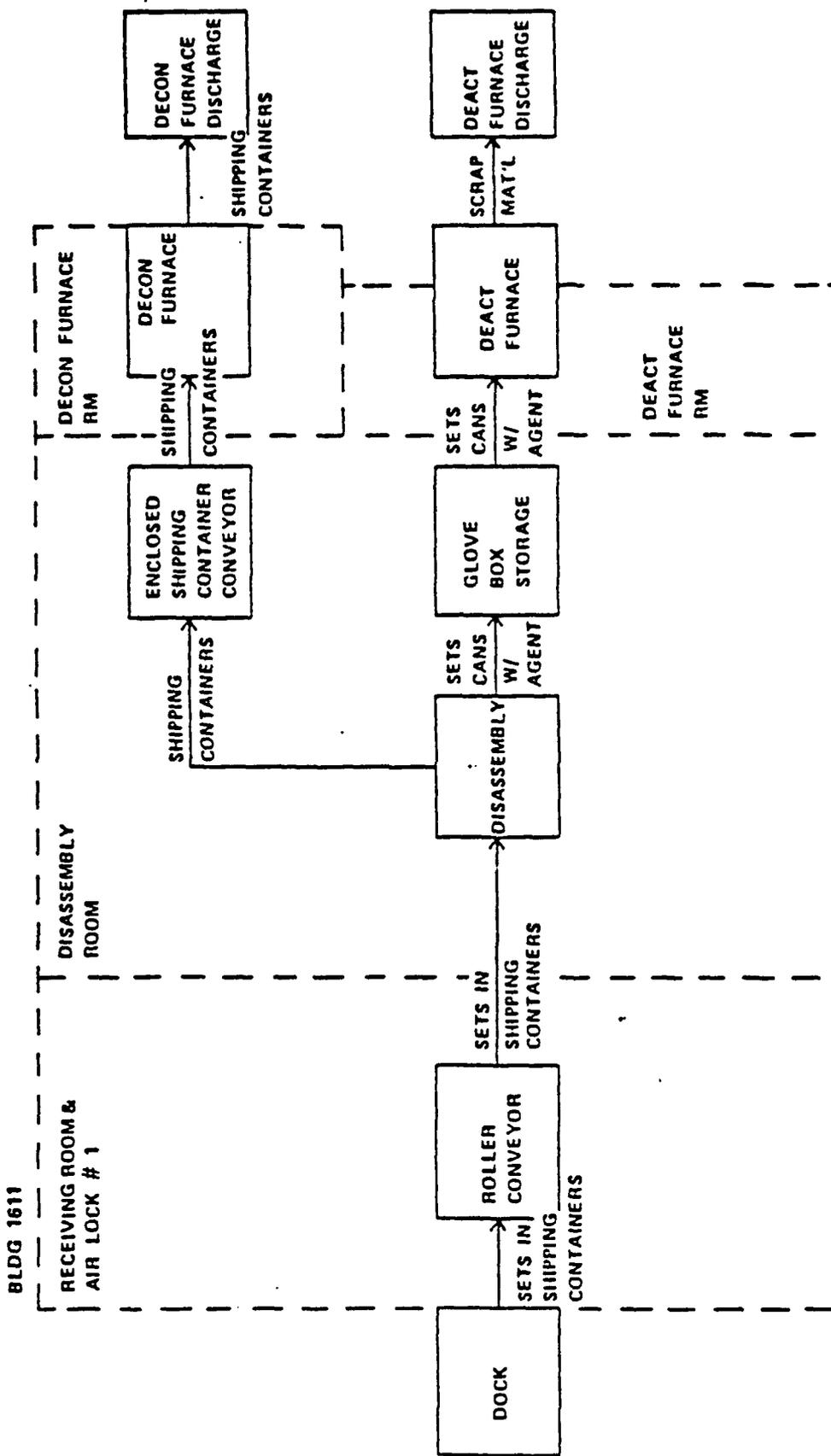


Fig. 7. ID SET PROCESS FLOW DIAGRAM  
(K941/K942, K951/K952, K953/K954)



tion forward and then in reverse when any unsafe residue discharge condition exists. This prevents the discharge of residue from the furnace until safe incineration conditions can be restored.

#### 5. Discharge/Burner Assembly

The discharge/burner assembly consists of the oil burner assembly and the exit residue chute to the discharge conveyor. The residue can be transferred to the residue hopper or to the decontamination furnace (see Figs. 5, 6, and 7) by moving metal-belt conveyors (see Figs. 9 and 10).

#### 6. Conveyors

The transfer of the residue from the deactivation furnace to the residue hopper or to the decontamination furnace is accomplished by a system of three conveyors as follows:

- Deactivation furnace discharge conveyor
- Decontamination furnace feed conveyor
- Residue hopper conveyor

All three units are moving metal-belt conveyors. The conveyor belts are made of steel slats to which 5 in. high cleats and 3 in. high side plates are attached. The cleats are spaced at 12-in. intervals. The deactivation furnace discharge conveyor is approximately 18 ft long and is inclined at 40 degrees. The decontamination furnace feed conveyor is approximately 30 ft long and is inclined at 45 degrees. The residue hopper conveyor is approximately 18 ft long and is inclined at 35 degrees. Controls are located in the control room and locally.

#### 7. Controls

Building 1611 has separate control and observation rooms which allow direct visual and television monitoring of operations. The control room is equipped with the necessary process monitors and alarms to assure correct operation of the various systems.

This facility is currently in operation as needed. Normal operating temperature is 1100°F with 1500°F considered maximum. Maximum solids hold time in the retort is approximately 60 min. Thermal capacity is approximately 2.2 M Btu/hr.

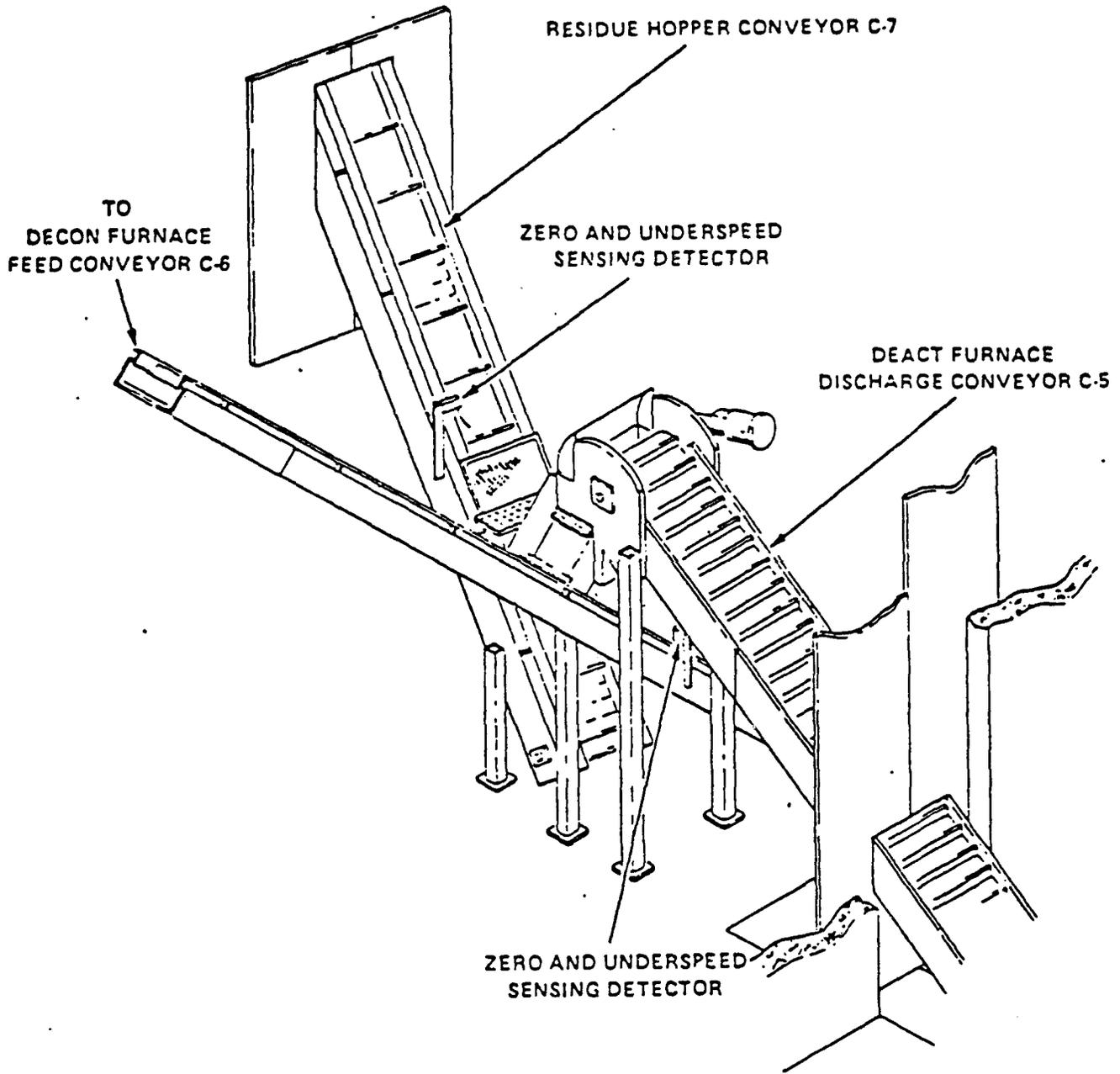


Fig. 9. DISCHARGE CONVEYORS

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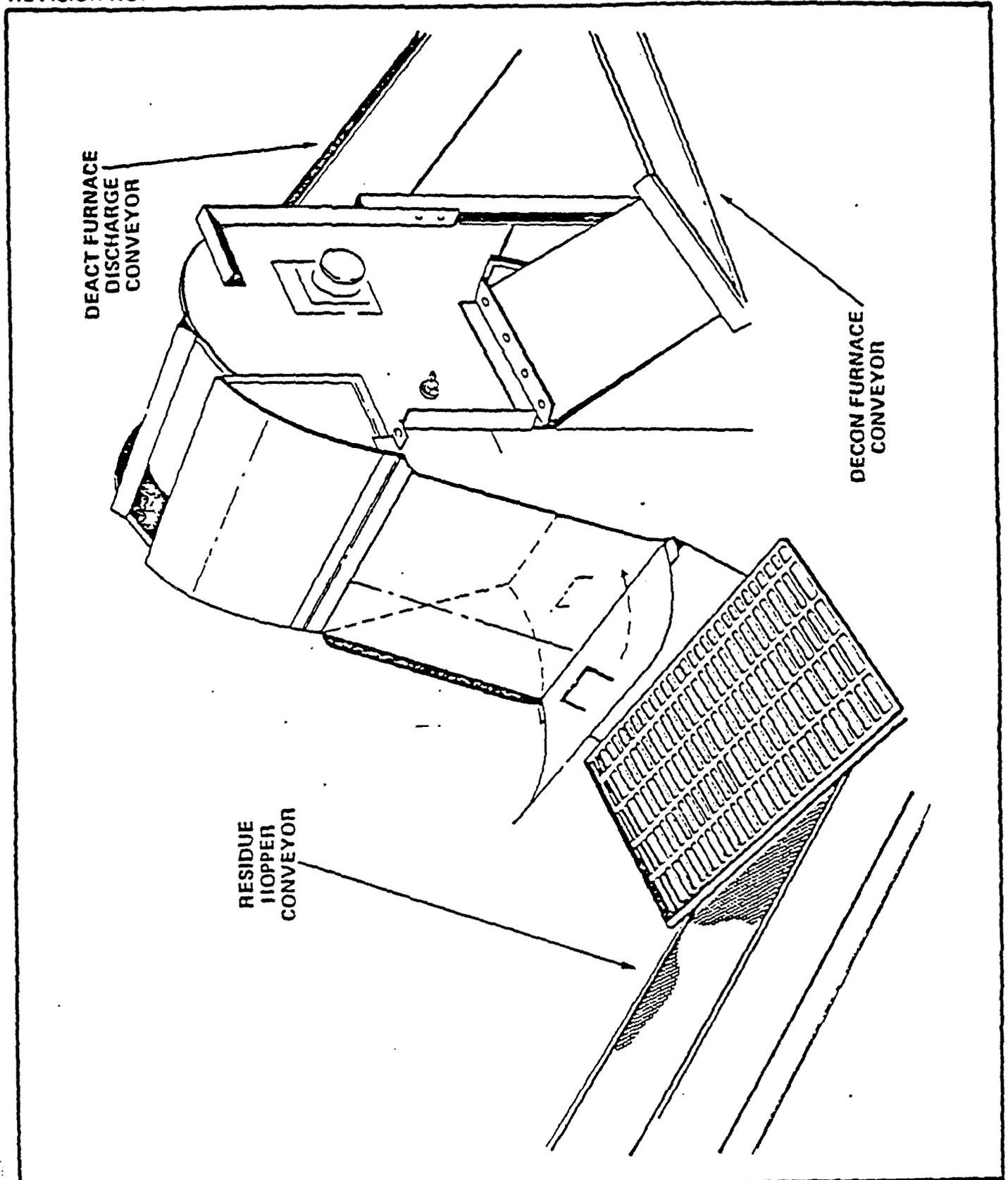


Fig. 10. .TRANSFER POINT

## B. DECONTAMINATION FURNACE - BUILDING 1611

The decontamination furnace is designed to handle contaminated material that is too large for the box feed chute on the deactivation furnace, and to further destroy residue from the deactivation furnace if necessary. Figures 11 and 12 show the location of the two furnaces.

The furnace has 5 oil-fired burners and a gas-fired pilot and is designed to burn all combustible material and decontaminate all noncombustible materials. Material is fed into the furnace by conveyors from the deactivation furnace, by a charging cart, or by the exit cart. All decontaminated materials are removed from the furnace by the exit or charging carts (see Figs. 13 and 14).

The furnace is rectangular, 11 ft long by 11 ft wide by 8 ft high (outside dimensions). Material to be charged is conveyed to a holding table where it is automatically (push button controls) picked up by the charging cart and deposited in the furnace through an air lock (see Fig. 15). The material is removed from the discharge end using the exit cart and another air lock. Figures 6, 7, and 13 show flow diagrams of the decontamination and deactivation furnaces. Each furnace is divided into two compartments (zones). Zone 1 (melting chamber) contains four burners and zone 2 (holding chamber) one burner. Normal operating temperatures are 1500°F in the melting chamber and 1800°F in the holding chamber. Thermal capacity is approximately 2 M Btu/hr.

### 1. Afterburner

Exhaust gases from both the decontamination and deactivation furnaces (see Fig. 16) pass through the afterburner to ensure complete combustion. There are two oil-fired burners and one gas-fired pilot. The afterburner is a carbon steel horizontal cylinder, refractory lined with an I.D. of 6 ft by 32 ft long. Operating temperatures can be adjusted but at 1850°F, dwell time of the gas is a minimum of two seconds. Normal operating temperatures are 1800°F but can be increased to a maximum of approximately 2600°F. Thermal capacity is approximately 6 M Btu/hr. Figure 17 shows the location of the afterburner.



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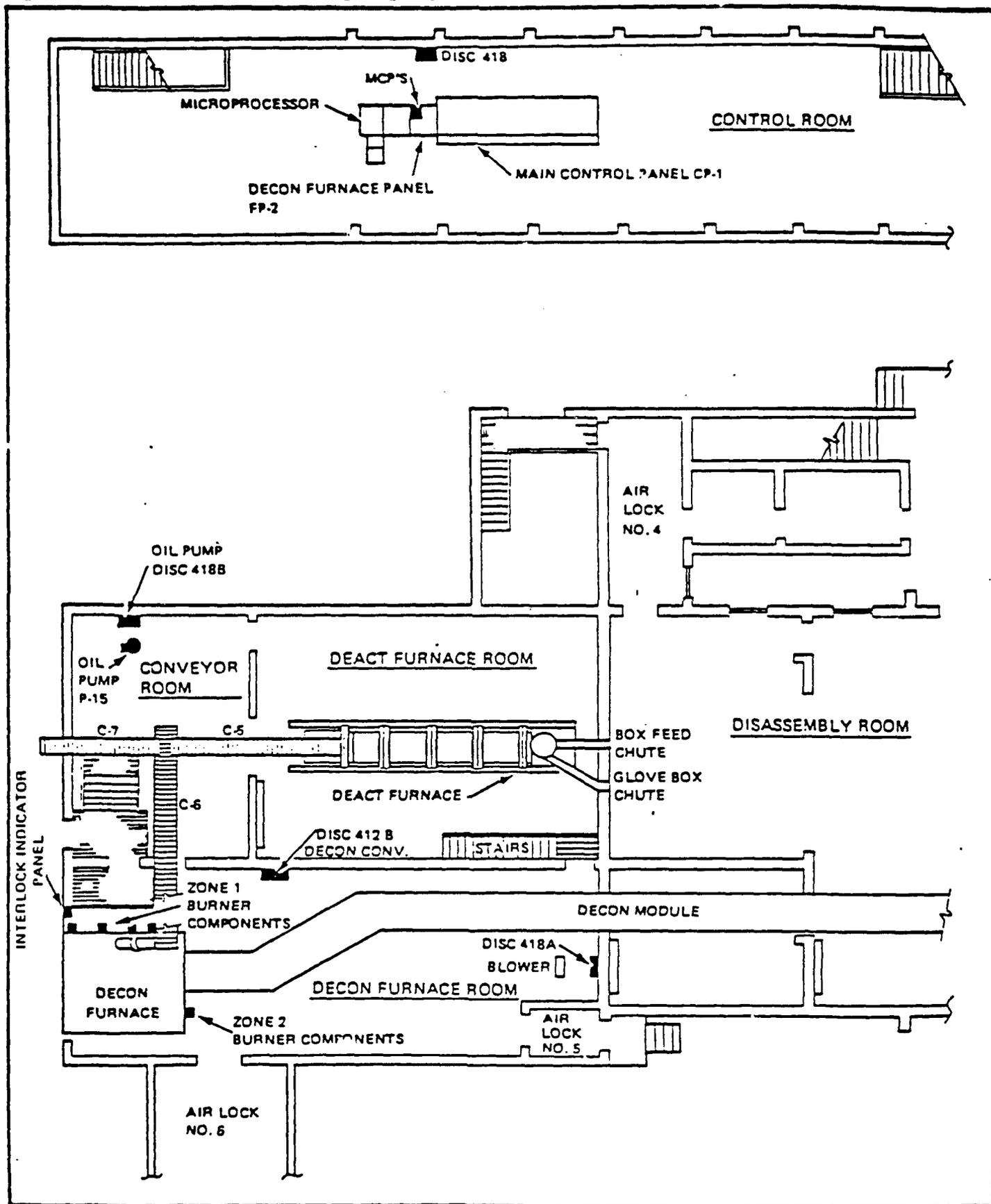


Fig. 12. DECON FURNACE EQUIPMENT LOCATION

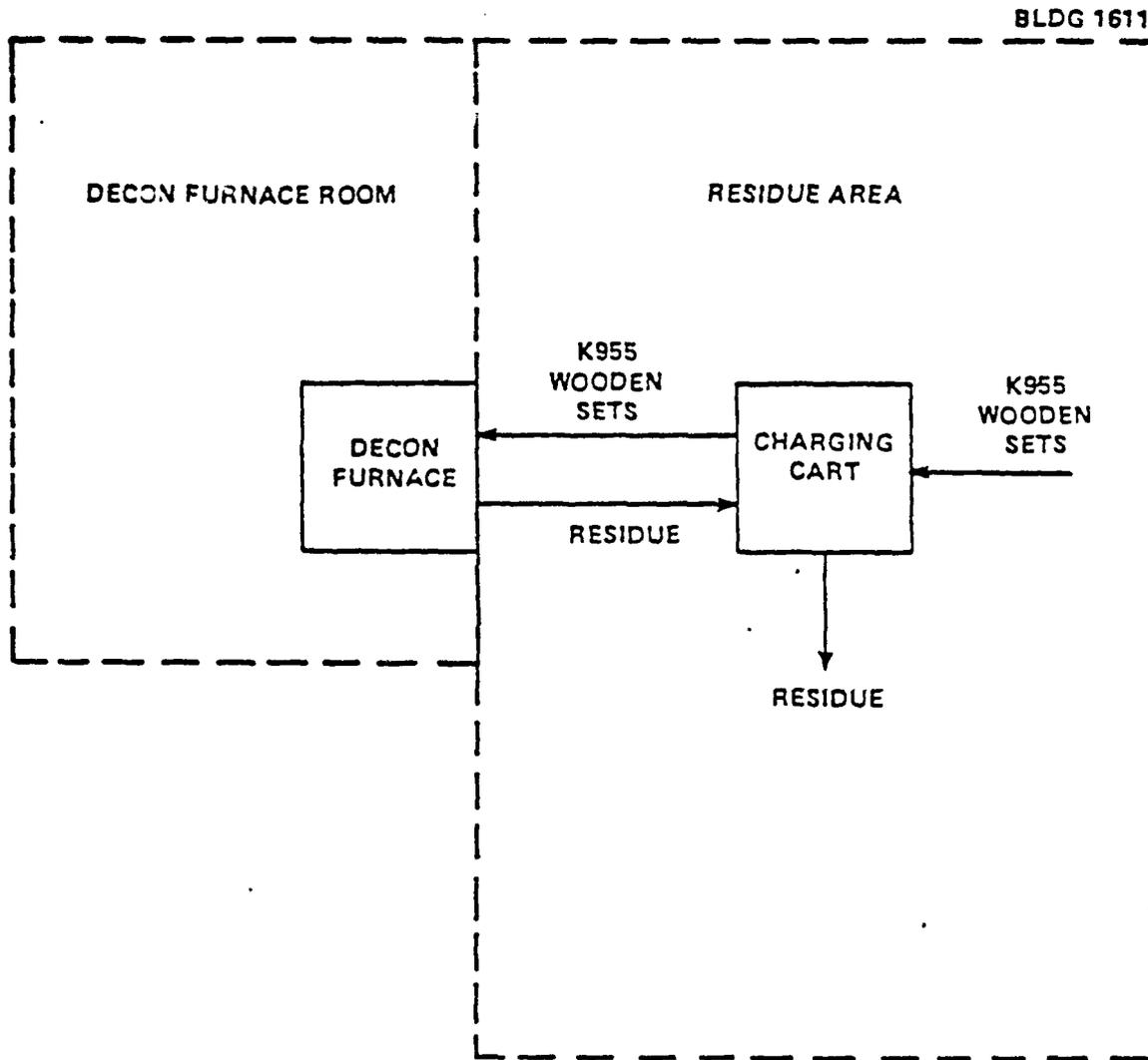


Fig. 13. ID SET PROCESS FLOW DIAGRAM (K955)

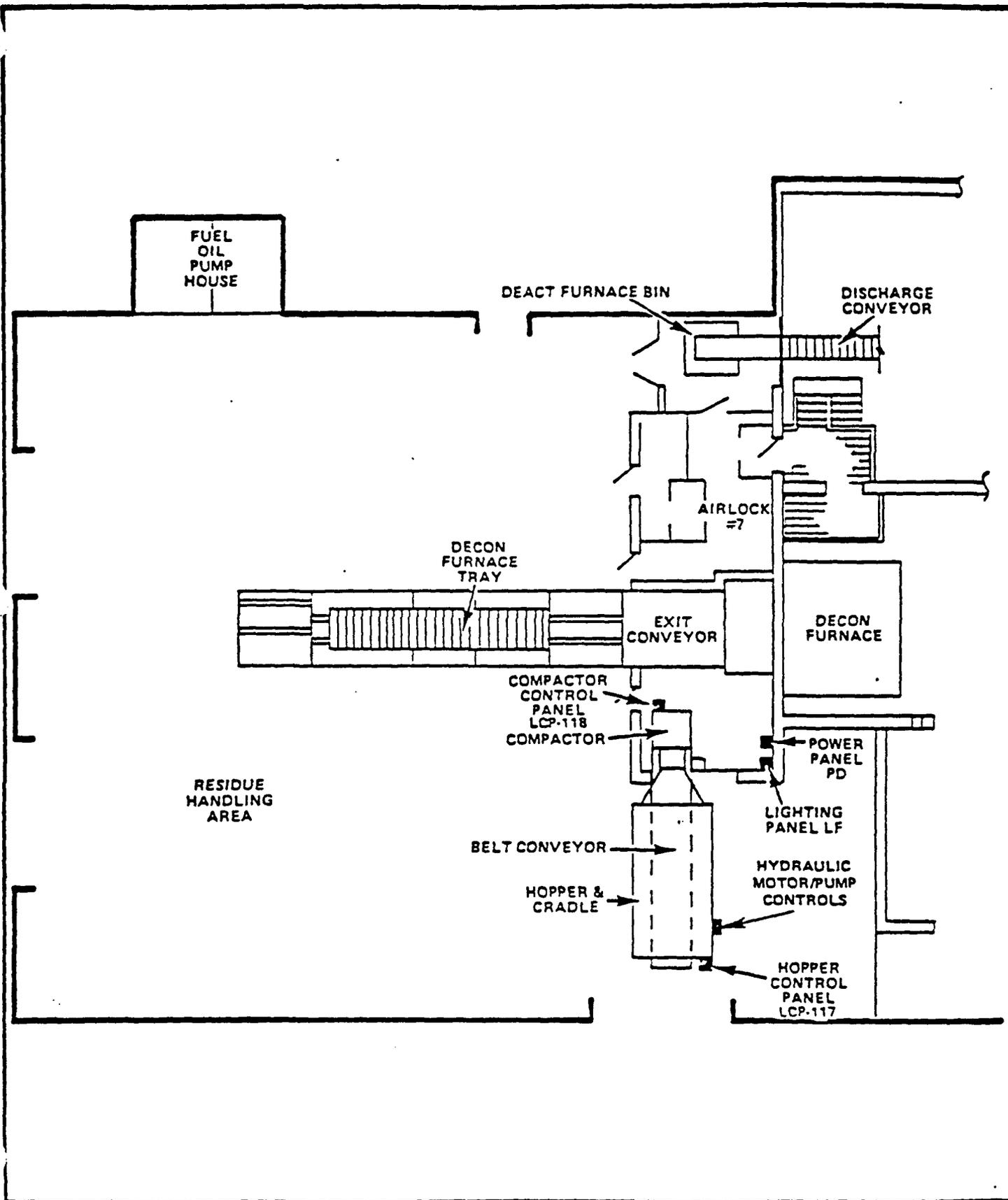


Fig. 14. RESIDUE HANDLING EQUIPMENT LOCATION

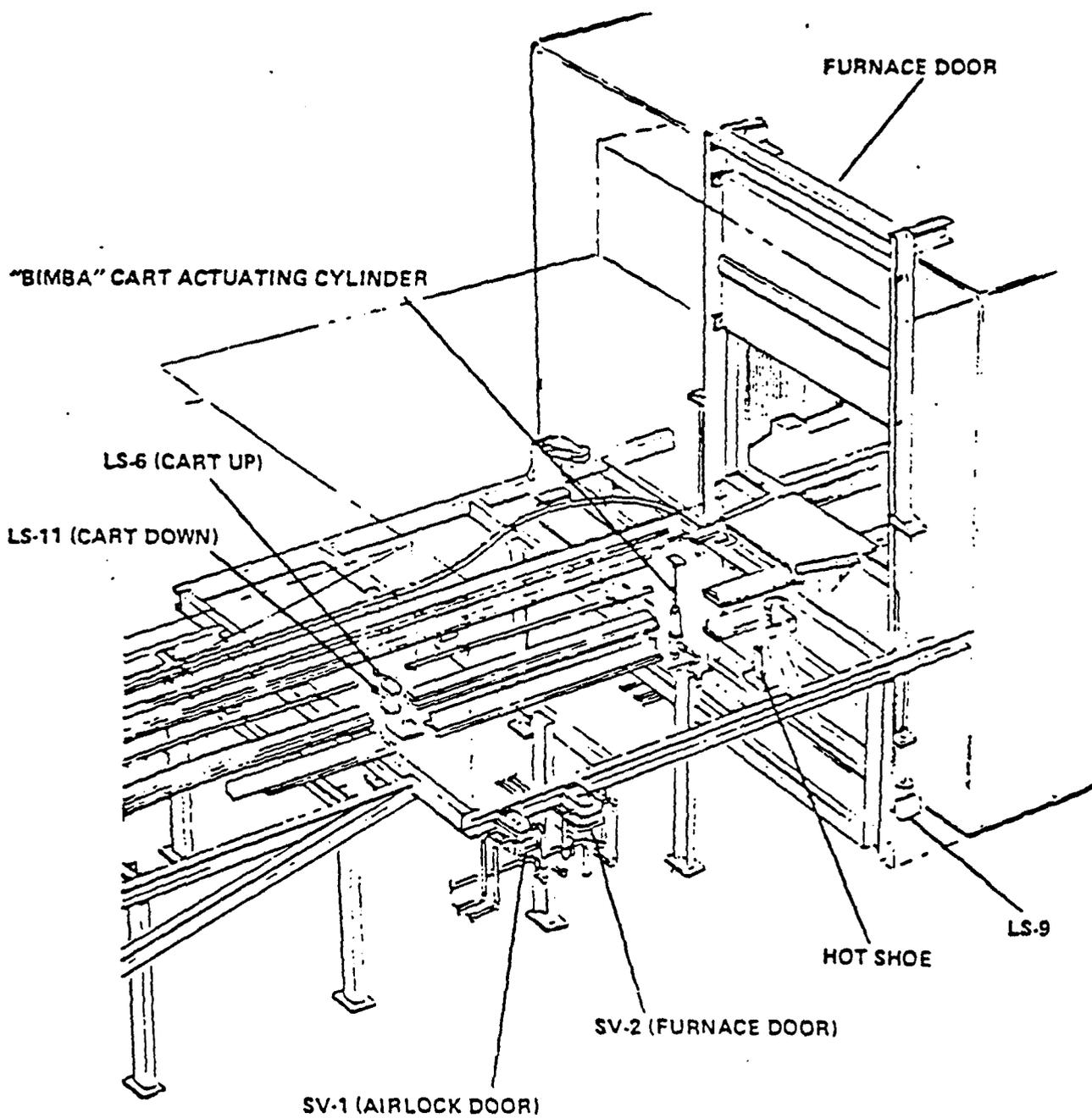


Fig. 15. ENTRANCE TO DECON FURNACE

DRAWING RM. 1981-A4  
 NUMBER 22/83  
 DATE 2/27/83  
 CHECKED BY [Signature]  
 APPROVED BY [Signature]  
 DR. b. 11-20-82

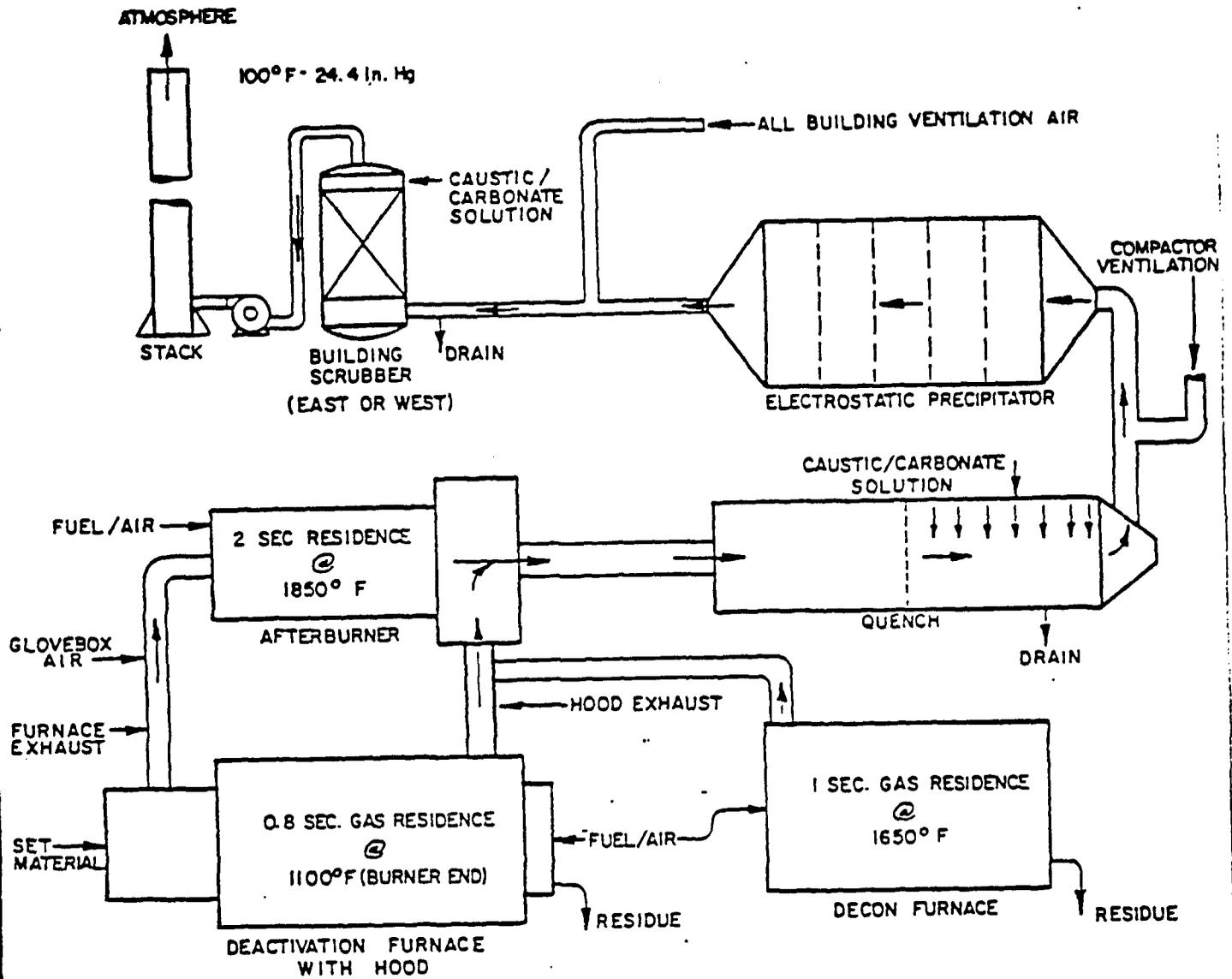


Fig. 16.

NORTH PLANTS INCINERATOR  
FLOW DIAGRAM

REFERENCE:

SCOTT et al. FINAL  
PILOT TEST REPORT.  
FIGURE 1-3, DATED: 1980.

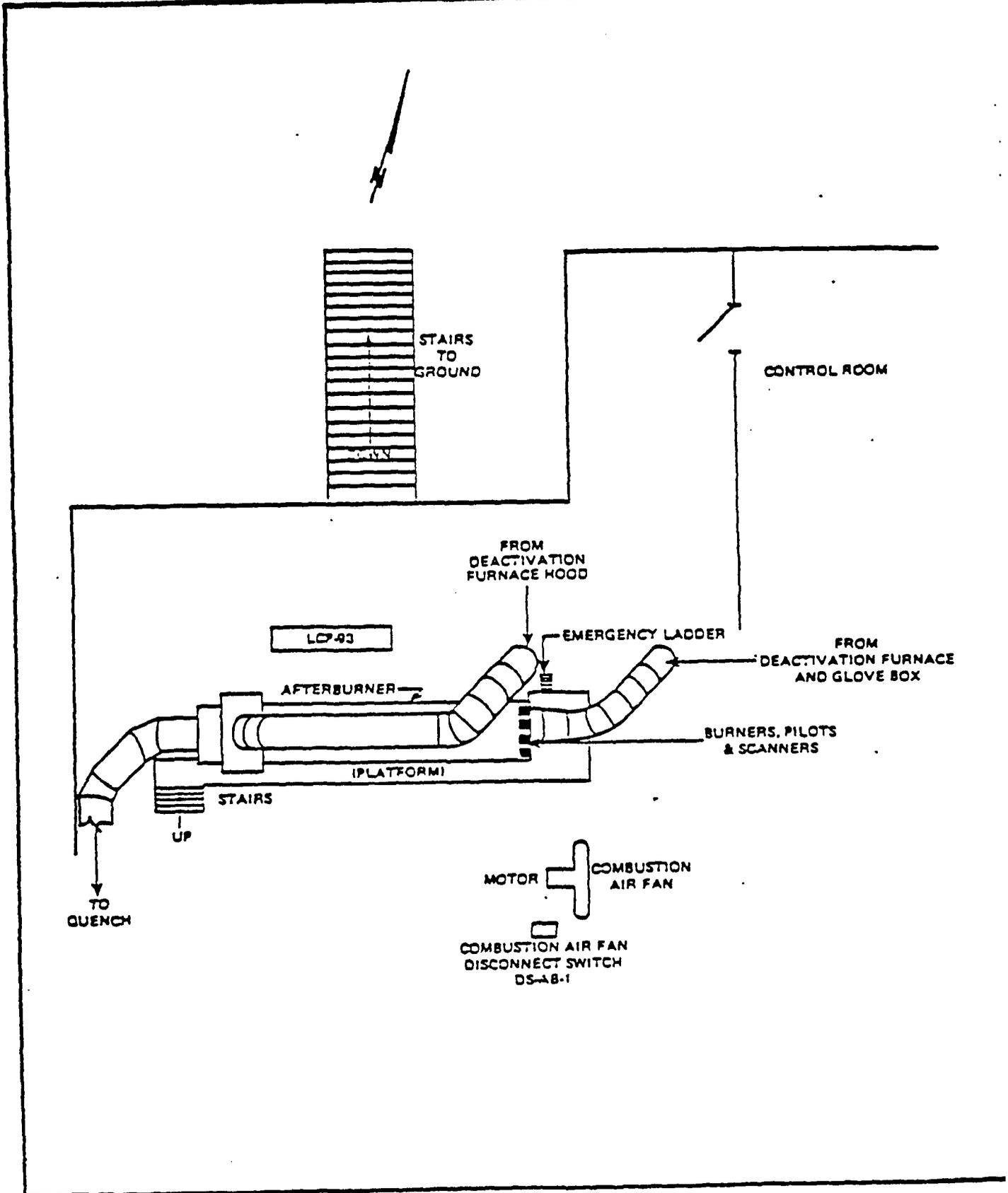


Fig. 17. - AFTERBURNER EQUIPMENT LOCATION  
(NORTHWEST ROOF CORNER)

## 2. Quench

The exhaust gases from the afterburner enter the quench chamber (see Figs. 16 and 18) where they are cooled to approximately 225°F and approximately 80 percent relative humidity. The chamber is a rectangular box made of 1/4-in. steel plate approximately 18 ft 9 in. long by 10 ft wide by 6 ft high. The gases enter through a series of mist eliminator baffles, then pass through a humidifying spray section. The quench liquid is maintained at a pH above 9 by the addition of sodium hydroxide, which neutralizes any acid gases produced by incineration. Figure 19 shows the quench system equipment location.

## 3. Electrostatic Precipitator (ESP)

The cooled and humidified gases from the quench pass through an ESP (dry type) to control particulate emissions. The collected dust is then removed from the collection plates by intermittently rapping the plates, resulting in the dust falling into a hopper from which it can be placed in containers for storage or transport to an approved landfill.

## 4. Scrubber System

The exhaust from the ESP passes through one of two tower scrubbers packed with 1 1/2-in. diameter polypropylene pall rings (see Fig. 20). The scrubbers have an internal diameter of 11 ft 5 in. and are approximately 65 ft high. The packed section is approximately 12 1/2 ft high and is designed to remove gas vapors and acid mists. A caustic/carbonate solution is used as the scrubbing fluid and collects in the sump at the bottom of the scrubber to be recirculated or pumped to the spray drier. The gases then pass through an induced draft fan and exit to the atmosphere through a 100 ft high exhaust stack.

## 5. Spray Drier

The spray drier removes water from the brine solutions resulting from quenching and scrubbing the flue gases with caustic/carbonate solutions. Figures 21 and 22 show block and flow diagrams of the spray dryer system.

The brine is atomized and evaporated. The salts are collected in four cyclones, received in a common hopper, compacted, placed in sealed drums, and stored. Figure 23 shows the residue disposal equipment. The air from the cyclones passes through a venturi scrubber that removes fine particulates, then through a



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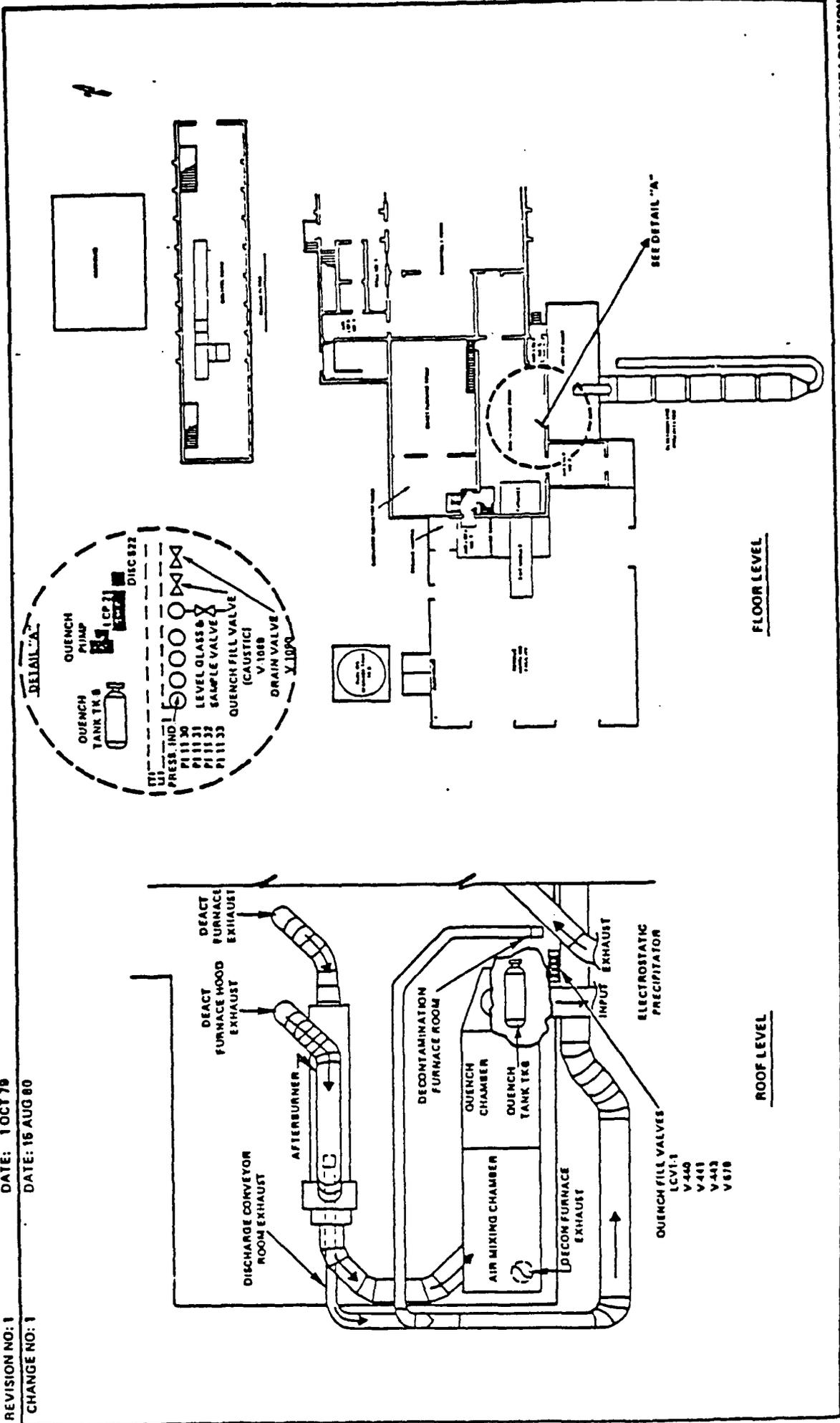


Fig. 19. . . QUENCH SYSTEM EQUIPMENT LOCATION

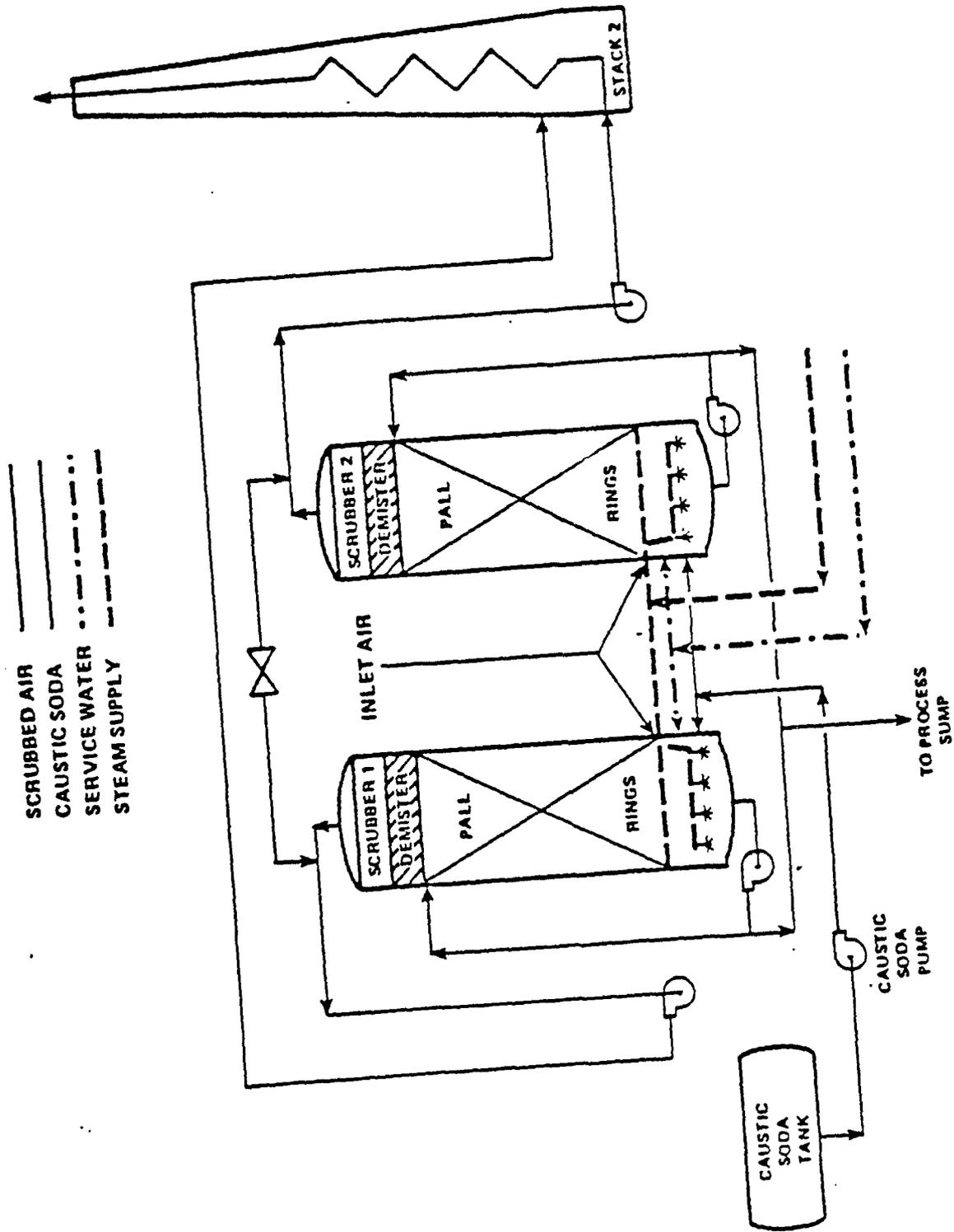


Fig. 20. . . AIR SCRUBBER SYSTEM SCHEMATIC

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 2/27/83  
 CHECKED BY PRF  
 APPROVED BY JKM 2/27/83  
 DR. BY J. Bricker  
 16 Nov 82

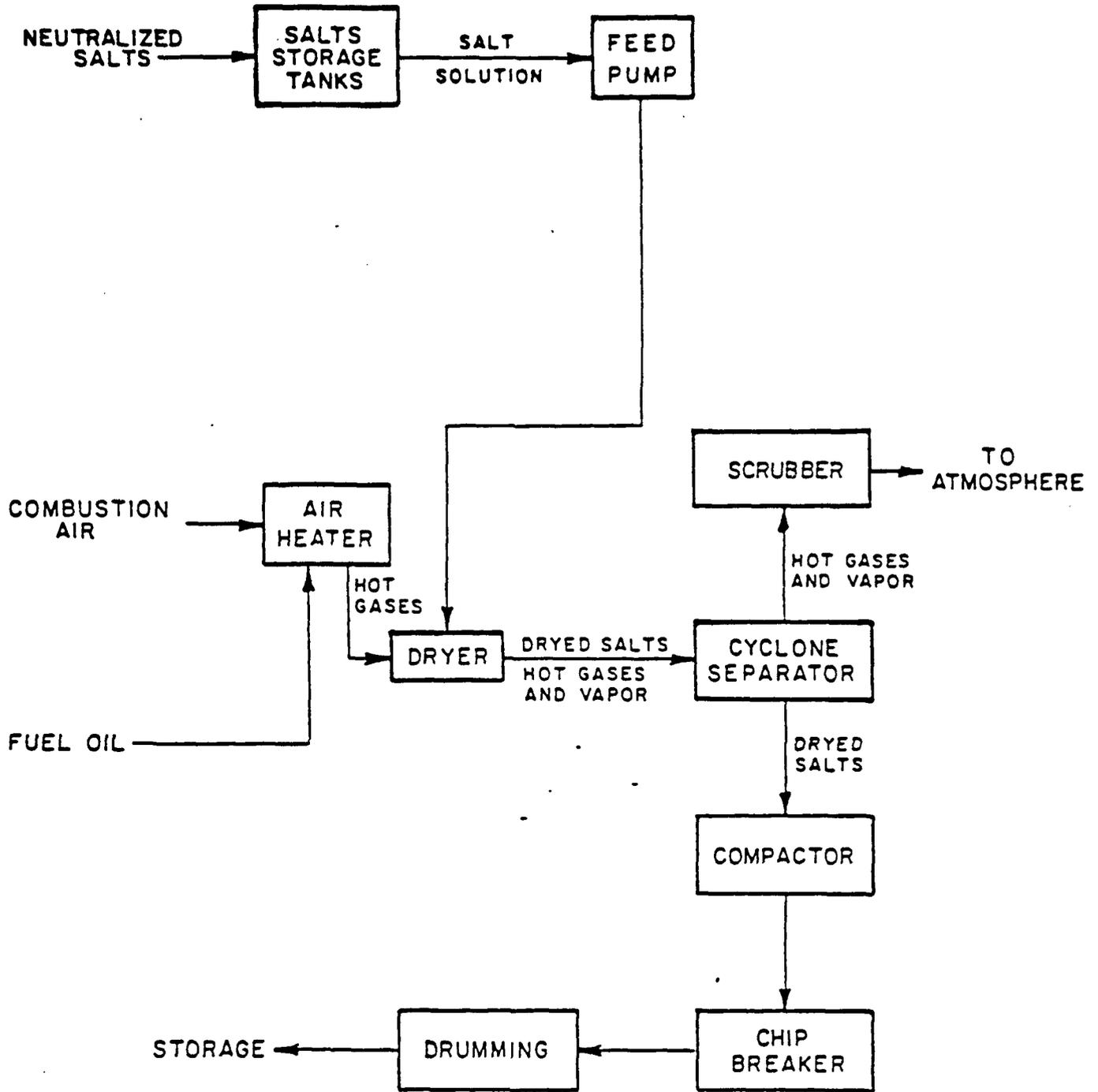


Fig. 21.  
SALT SOLUTION STORING,  
DRYING AND DRUMMING  
BLOCK DIAGRAM

**REFERENCE:**

DEMILITARIZATION AND DISPOSAL  
OF THE M34 CLUSTER AT ROCKY  
MOUNTAIN ARSENAL, FINAL PLAN.  
DATED: FEBRUARY 1973.

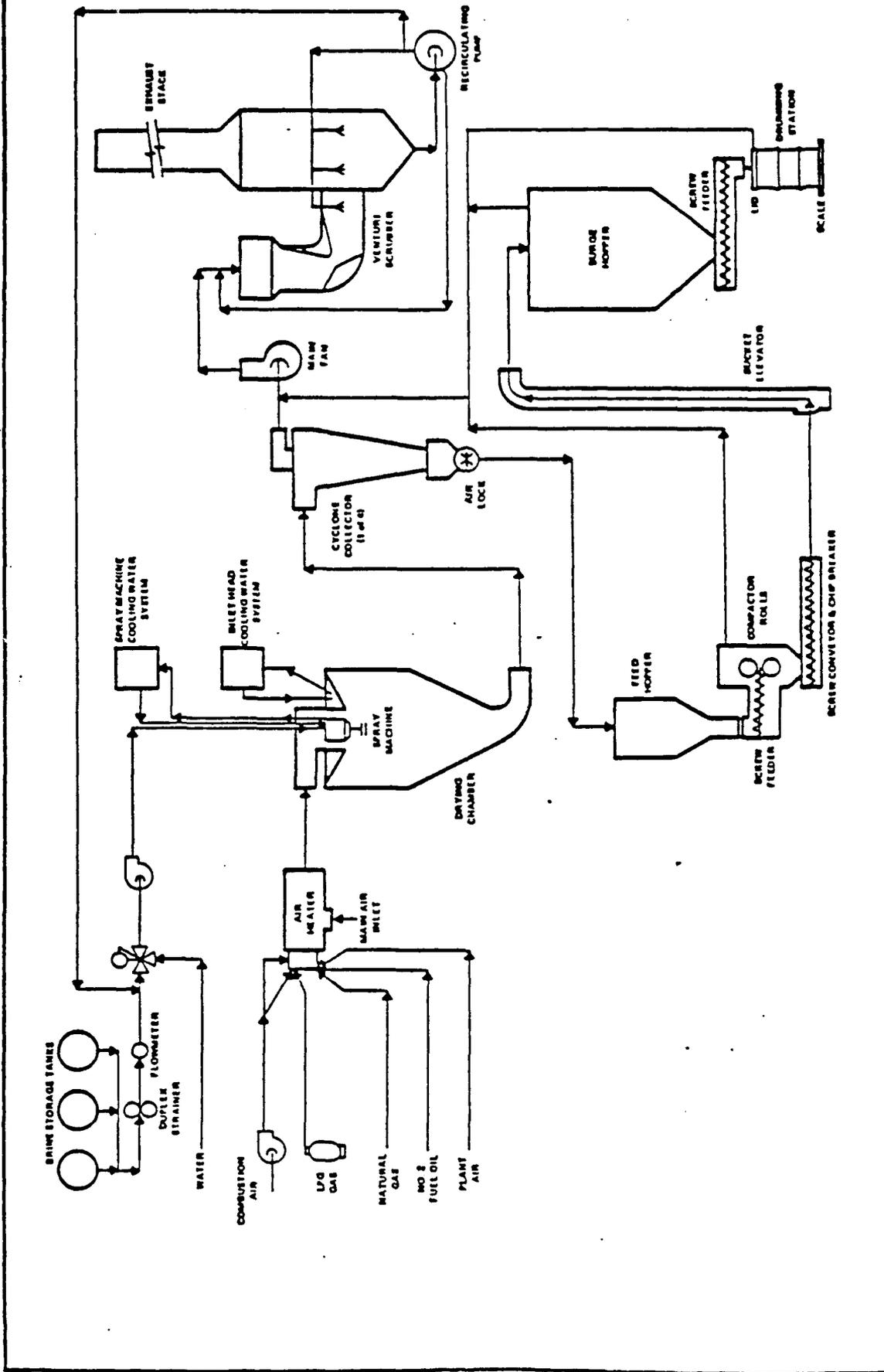


Fig. 22. SPRAY DRYER FLOW DIAGRAM

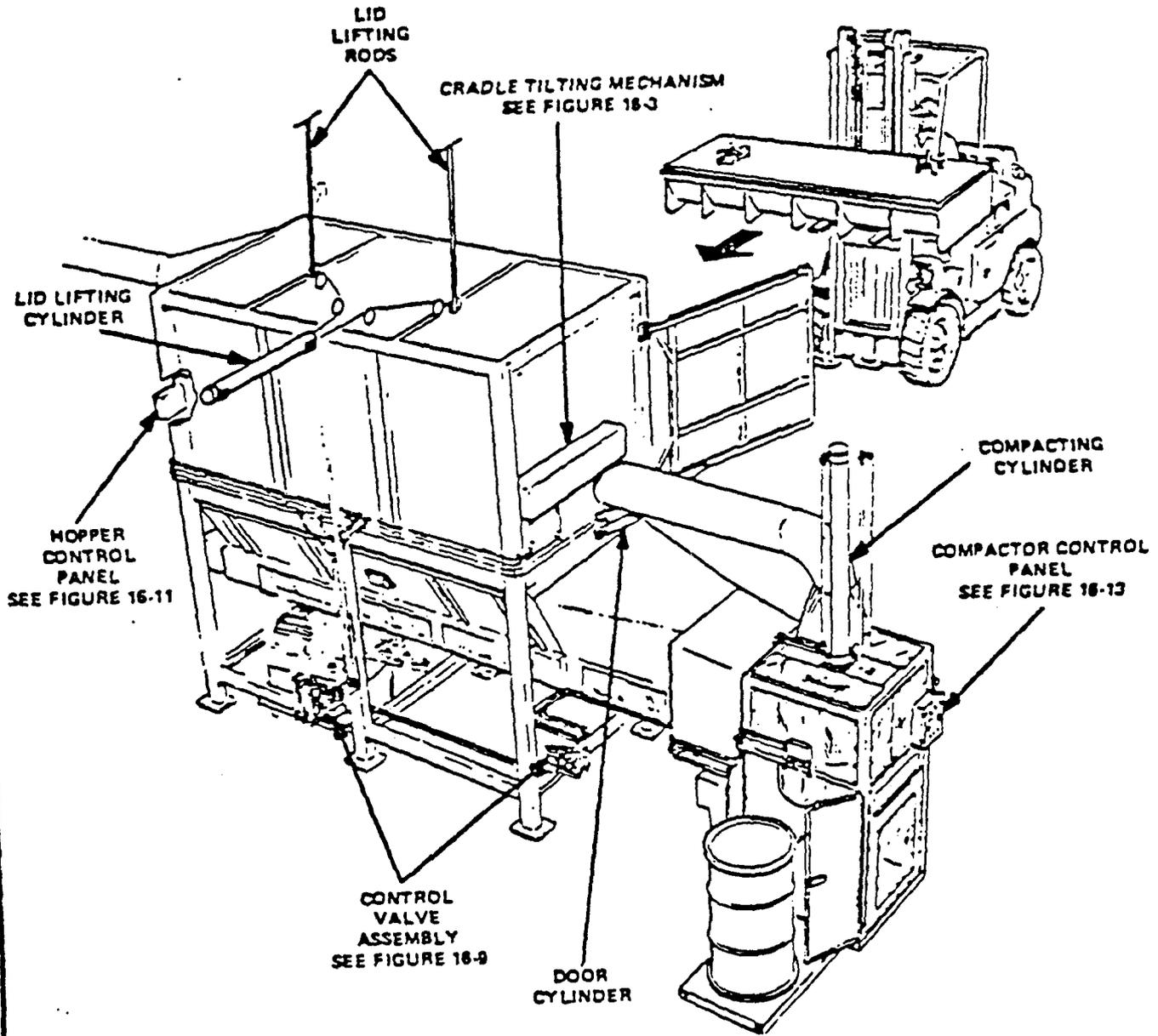


Fig. 23. RESIDUE DISPOSAL EQUIPMENT

cyclonic wash scrubber and finally out an exhaust stack. The water is returned to the spray drier feed system. Figure 24 shows the plan view of the spray drier system.

The dryer is fired with natural gas and/or fuel oil. Evaporating capacity is approximately 30 gal per min.

C. DEACTIVATION FURNACE - BUILDING 1606

This deactivation furnace system (M34 facility) is identical to the deactivation furnace in building 1611. There is, however, no afterburner and the facility is currently not in use. Renovation would be achievable for a price.

D. DECONTAMINATION FURNACES (2) - BUILDING 1606

There are two decontamination furnaces (north and south, M34 facility) identical in design and operation. They are enclosed steel structures lined with refractory brick and containing an endless wire-mesh stainless steel conveyor belt. These tunnel furnaces are 26 in. wide by 32 ft long by 3 ft high, are forced draft, gas-fired, and operate at approximately 1500°F. They can operate up to approximately 2300°F. There are 16 burners (8 on a side) firing along the length of each furnace. There is a low pressure drop venturi scrubber and an induced draft fan, but no afterburner or ESP for particulate removal. These furnaces are currently not in operation.

E. BULK AGENTS INCINERATOR - SOUTH PLANTS AREA

The bulk furnace (mustard facility) is a horizontal cylindrical refractory lined chamber with a steel external shell. It is designed to burn liquid wastes only through a compressed air-liquid atomized burner nozzle mounted on the end of the combustion chamber. There is also a gas-fired nozzle for auxiliary fuel. The furnace dimensions inside the refractory are 9 ft I.D. by 16 ft 11 in. long. Normal operating temperature is 1900°F with maximum above 2200°F. Thermal capacity is approximately 15 M Btu/hr. The furnace vents to a quench chamber and packed tower scrubbers. There is no afterburner or ESP (it was removed and installed at 1611 building). This facility is currently not in operation.



APPENDIX E

LIST OF AVAILABLE REFERENCES IN PROJECT FILE

LIST OF AVAILABLE REFERENCES IN PROJECT FILE

1. Profile of existing Hazardous Waste Incineration Facilities and Manufacturers in the United States (EPA-600/2-84-052).
2. Guidance Manual for Hazardous Waste Incineration Permits - EPA 1983.
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4. Sampling and Analysis Methods for Hazardous Waste Combustion (EPA-600/8-84-002).
5. Engineering Handbok for Hazardous Waste Incineration, USEPA. 1981.
6. Air Pollution Impacts of Hazardous Waste Incineration: A California Perspective California Air Resources Board, 1983.
7. Air Pollution Impacts of Hazardous Waste Incineration: A California Perspective, Technical Support Documents, 1983.
8. Surrogate Compounds as Indicators of Hazardous Waste Incinerator, Mournishan, R.E.; Olexsey, R. A., EPA/600/D-85/140.
9. Engineering Assessment Report--Hazardous Waste Cofiring in Industrial Boilers, Volume 2, Data Supplement (Research rept. 1981-84), Castaldini, C.; Unnasch, S.; Mason, H.B., EPA/600/2-84/177B.
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17. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemicals Manufacturing: Indepth Survey Report of Tennessee Eastman Company, Kingsport, Tennessee, Anastas, M., CT-103-19B.
18. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemical Manufacturing, Walk-Through Survey Report, Tennessee Eastman Company, Kingsport, TN, Anastas, M., CT-103-19A.
19. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemical Manufactured: Walk-Through Survey Report of Dow Chemical Company, Midland, Michigan, Anastas, M., CT-103-12.

20. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemical Manufacturing: Walk-Through Survey Report of 3M Company, Cottage Grove, Minnesota, Anastas, M, CT-103-11A.
21. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemicals Manufacturing: at 3M Company Chemolite Incinerator, Cottage Grove, Minnesota, Indepth Survey Report, Anastas, M., CT-103-11B.
22. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemicals Manufacturings: Walk-Through Survey Report of E. I. du Pont de Nemours and Company, Chambers Works, Deepwater, New Jersey, Anastas, M., CT-103-15A.
23. Control Technology Assessment of Hazardous Waste Disposal Operations in Chemicals Manufacturing: Walk-Through Survey Report of E. I. du Pont de Nemours and Company, Chambers Works, Deepwater, New Jersey, Anastas, M., CT-103-15A.
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APPENDIX F  
COMMENTS AND RESPONSES

COMMENTS FROM ENVIRONMENTAL PROTECTION AGENCY  
Region VIII

Point of Contact: Nat Muiillo  
Date: March 25, 1986  
Remarks: Comments were received by phone.

**TELEPHONE OR VERBAL CONVERSATION RECORD**

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE

25 March 1986

**SUBJECT OF CONVERSATION**

**INCOMING CALL**

<b>PERSON CALLING</b>	<b>ADDRESS</b>	<b>PHONE NUMBER AND EXTENSION</b>
<b>PERSON CALLED</b>	<b>OFFICE</b>	<b>PHONE NUMBER AND EXTENSION</b>

**OUTGOING CALL**

<b>PERSON CALLING</b>	<b>OFFICE</b>	<b>PHONE NUMBER AND EXTENSION</b>
Bruce Huenefeld	OPM	671-3261
<b>PERSON CALLED</b>	<b>ADDRESS</b>	<b>PHONE NUMBER AND EXTENSION</b>
Nat Muillo	EPA	FTS 564-1665

**SUMMARY OF CONVERSATION:**

On March 25, 1986 I called Mr. Nat Muillo of EPA VIII to discuss any comments comments EPA had on the Task 17 Technical Plan. Mr. Muillo stated that he had no substantial technical comments and considered the document a good vehicle for evaluating incineration of Basin F waste. He also stated that because of the sparsity of EPA comments, no written record would be provided at this time. Mr. Muillo then proceeded to convey his overall impressions of the Technical Plan and specific comments to it, listed below.

P. 2-5 & 2-8 Statements concerning Basin F waste volumes might be misleading. Present volumes are only estimates and subject to refinement when all Remedial Investigation Phase II work is completed.

P. 10-6 Previous EPA studies involving incineration in combination with solidification have been very successful. How far will the Army go in evaluating solidification of incineration residue in this task? (answer: no solidification in this task, but possible future actions)

P. 10-8 Is there enough data available right now to prepare a concept design for a full scale incinerator? (answer: not really, but this bench work will provide almost enough)

*Bruce M Huenefeld*  
 BRUCE M. HUENEFELD  
 Project Engineer

JOSEPH F. SILVEY

APR 02 1986  
 RECEIVED  
 EBASCO SERVICES, INC.

1. Comment

Statement concerning Basin F waste volume (pages 2-5 and 2-8) might be misleading. Present volumes are only estimates and subject to refinement when all remedial investigations (Phase II) work will be completed.

Response

True. However, for the purpose of this study, the estimated volumes as presented on page 2-8 will be used.

2. Comment (page 1-6)

Previous EPA studies involving incineration in combination with solidification have been very successful. How far will the Army go in evaluating solidification of incineration residue in this task?

Response

No solidification work is planned under this task. However, residue derived from the laboratory incineration program will be tested for EP-characteristics. Evaluation of solidification of incineration residue will be undertaken in a separate study by the Army's Waterways Experiment Station.

3. Comment (page 1-8)

Is there enough data available right now to prepare a concept design for a full-scale incinerator?

Response

No. Initial technology selection through the literature search and results of laboratory tests will allow PMO to develop a conceptual design of a full-scale incinerator.

COMMENT FROM COLORADO DEPARTMENT OF HEALTH

Point of Contact: Randy Jones

Date: June 10, 1986

Remarks: Comments were received by phone

# TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE

10 June 1986

**SUBJECT OF CONVERSATION**

Task 17 Technical Plan Comments

**INCOMING CALL**

PERSON CALLING	ADDRESS	PHONE NUMBER AND EXTENSION
Bruce Huenefeld	PM/RMA	(301) 671-3261
PERSON CALLED	OFFICE	PHONE NUMBER AND EXTENSION
Randy Jones	CDH	(303) 320-8333

**OUTGOING CALL**

PERSON CALLING	OFFICE	PHONE NUMBER AND EXTENSION
PERSON CALLED	ADDRESS	PHONE NUMBER AND EXTENSION

**SUMMARY OF CONVERSATION:**

Mr. Jones returned my earlier telephone call to inform me that Colorado Department of Health is planning to hold any comments on the Task 17 Technical Plan. They are choosing to interpret the Technical Plan as part of the Army's official response to the Colorado Department of Health's handwritten Basin F Closure Plan. When I tried to determine if anyone in the Program Manager's Office had implied this, Mr. Jones simply restated what he had said above. I then proceeded to tell Mr. Jones that the Task 17 Technical Plan was being revised to final white cover form, with or without Colorado Department of Health's input. Mr. Jones gave no response to that information.

*Bruce M Huenefeld*  
 BRUCE M. HUENEFELD  
 Project Engineer

CF:  
 COL Quintrell  
 Mr. Campbell

1. Comment

The Colorado Department of Health withheld comments on the technical plan as they chose to interpret the Task 17 technical plan to be a part of Army's response to the CDH's Basin F Closure Plan.

COMMENTS FROM SHELL CHEMICAL COMPANY

Point of Contact: Chris Hahn

Date: June 13, 1986

Remarks: Comments were received in writing  
(See attached letter from Shell)



June 13, 1986

Office of the Program Manager  
Rocky Mountain Arsenal Contamination Cleanup  
ATTN: AMXRM-PM: Col. Wallace N. Quintrell (Deputy)  
Aberdeen Proving Ground, MD 21010-5401

Dear Colonel Quintrell:

We have reviewed the Army's draft of the Task 17 Technical Plan for studies of the incineration of Basin F wastes. Our review raises a number of concerns.

Foremost of these is that no justification is provided for proposing the use of incineration to treat Basin F wastes. Furthermore, there is no analysis of or coordination of that proposal with remediation of other portions of the Arsenal. Application of incineration for Basin F wastes is a change from the Army's earlier approach as defined in reports RIC-84034RO1 and RIC-83313RO1, which did not consider Basin F wastes as candidates for incineration. Shell believes that short term measures can be taken which will alleviate concerns over current threats to public health and the environment from Basin F wastes. These measures will allow cost-effective integration of remediation measures to similar areas on the RMA and will be based on objective evaluation of alternatives in accordance with CERCLA, NCP and the MOA Agreement.

Despite often repeated Army assertions of commitment to the investigatory and analytical requirements of CERCLA and the NCP, Shell continues to be deeply concerned that the Army and possibly others are, and have been from the beginning, committed to excavation and incineration of massive quantities of material at the RMA, without any evaluation of alternatives. Shell has not been provided with any technical or legal justification for this approach to remediation at the RMA. Since we have not been able to identify any substantive effort to investigate alternate technologies, we believe our concerns to be founded on fact. If this is true, then the RI/FS program being conducted by the Army will not meet the criteria of the NCP and CERCLA.

On a technical level, we find that the Task 17 plan outlines a general and simplistic approach which does not address serious technical and environmental issues associated with the characteristics of Basin F wastes. Some examples of our concerns in this area are:

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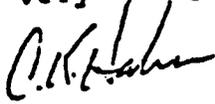
1. Justification for incineration has not been demonstrated, except for the Army's own policy relative to surety disposal. Moreover, Shell has found no indication that incineration, with respect to soils, is a proven technology.
2. Mobilization of contaminants into the environment via air or water is very likely during excavation, transportation and incineration. The potential exists to convert a soil pollution problem into an air/water pollution problem.
3. Fate of heavy metals and salts in the incineration process is a complex issue that will not be determined by the proposed program. In addition:
  - a) Materials of construction must be considered to reduce corrosion and wear of the incineration equipment.
  - b) The potential exists for the release of heavy metals to the environment.
4. Formation of products of incomplete combustion (PICS) will not be determined adequately by the proposed program. Due to the presence of chlorinated organics, the possibility of forming dioxins during the incineration process must be considered.
5. The test data obtained from small batch experiments will have limited value in the design of a large scale continuous incineration system. Scale up factors will approach 400,000 from the proposed study to the final conceptualized incinerator.
6. If incineration were to be utilized, the end product will be hazardous and therefore the material will be destined to a hazardous waste landfill. Thus incineration is redundant and not cost-effective.

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7. Incineration of soils would provide marginal (if any) volume reduction.
8. Using Building 1611 for incineration of Basin F materials could be problematic. Assuming that the existing equipment could be modified for pilot operation, the underlying process design of this kiln may not be optimal for its intended purpose and scale up of the pilot data obtained will present significant problems.
9. A full scale incinerator cannot be designed, built and operated to treat all the solid waste from Basin F in the time allowed.

For the above reasons, Shell feels that an improved, short-term remediation approach should be taken to the cleanup of Basin F. This approach should also include coordination with remediation on the RMA as a whole.

Very truly yours,



C. K. Hahn  
Manager  
Denver Site Project

CKH/mp/12700

cc: Tom Bick  
Bob Boonstoppel  
Don Campbell

1. Comment

Justification for incineration has not been demonstrated, except for the Army's own policy relative to surety disposal. Moreover, Shell has found no indication that incineration, with respect to soils, is a proven technology.

Response

There are justifications for investigating incineration as a treatment technology for soils and liquids (see Technical Plan pages 2-11). This Office agrees that incineration, with respect to Basin F soils and liquids, has not been proven, but that is exactly why a laboratory scale study is considered the proper level of investigation at this time.

2. Comment

Mobilization of contaminants into the environment via air or water is very likely during excavation, transportation and incineration. The potential exists to convert a soil pollution problem into an air/water pollution problem.

Response

Mobilization of contaminants into the environment via excavation and transportation have equal potential to occur in any treatment or disposal operation that is not an in-situ operation. Efforts will be undertaken, in any event, to minimize and to contain the mobilization of contaminants.

3. Comment

The fate of heavy metals and salts in the incineration process is a complex issue that will not be determined by the proposed program. In addition:

- a. Materials of construction must be considered to reduce corrosion and wear of the incineration equipment.
- b. The potential exists for the release of heavy metals to the environment.

Response

The purpose of the study is to gather data on the technical merit of use of incineration as a possible alternative remedial action treatment for Basin F waste. It is not the intention of this study to develop a design for a full scale treatment process. The laboratory setup for this study reasonably simulates rotary kiln operation. For this reason, it is felt that the partitioning of heavy metals and salts between the kiln off gas and residue can be effectively estimated by this study. It is noted that this study will not be able to predict the exact destination of the metals and salts in the off gas.

4. Comment

Formation of products of incomplete combustion (PICS) will not be determined adequately by the proposed program. Due to the presence of chlorinated organics, the formation of dioxin in the incineration process must be considered.

Response

This study proposes to identify, as much as practical, all constituents in the incineration off gas. In particular, the investigation will look for the presence of dioxin.

5. Comment

The test data obtained from small batch experiments will have limited value in the design of a large scale continuous incineration system. Scale up factors will approach 400,000 from the proposed study to the final conceptualized incinerator.

Response

This laboratory study has a primary objective of investigating the technical feasibility of incineration treatment. It is not intended to provide full scale design parameters.

6. Comment

If incineration were to be utilized, the end product will be hazardous and therefore the material will be destined to a hazardous waste landfill. Thus, incineration is redundant and not cost-effective.

Response

As mentioned in paragraph 4, one of the stronger points of this laboratory set up is its ability to simulate a rotary kiln. The residue will be analyzed to determine its hazardous nature. Additionally, an assessment of the potential to render the residue nonhazardous through follow-on treatment will be performed in a separate study.

7. Comment

Incineration of soils would provide marginal (if any) volume reduction.

Response

While significant volume reduction will not be achieved through incineration, some degree of detoxification will be achieved. This study will investigate the potential of incineration as a detoxification treatment for Basin F liquids and soils.

8. Comment

Using Building 1611 for incineration of Basin F materials could be problematic. Assuming that the existing equipment could be modified for pilot operation, the underlying process design of this kiln may not be

optimal for its intended purpose and scale up of the pilot data obtained will present significant problems.

Response

These and other similar conclusions can be reached under this task.

9. Comment

A full scale incinerator cannot be designed, built and operated to treat all the solid waste from basin F in the time allowed.

Response

Once the laboratory study is completed, the Army will have in its possession information by which to determine whether incineration of Basin F waste will be technically feasible, and if so, what general design, construction and operation considerations will need to be addressed by any incineration alternative to be considered in the context of the feasibility study.