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TASK 34 INVOLVES THE DEVELOPMENT OF METHODS FOR THE DECOMMISSIONING AND FINAL REMEDIATION OF THE HYDRAZINE BLENDING AND STORAGE FACILITY. PART OF THE HBSF STUDY WILL BE AN EVALUATION OF OPTIONS FOR THE TREATMENT/REMOVAL OF ASSOCIATED WASTEWATER. THE SPECIFIC OBJECTIVES OF THE STUDY ARE TO:

1. INVESTIGATE ALTERNATIVE APPROACHES FOR TREATMENT/REMOVAL OF WASTEWATER CONTAMINATED WITH LOW LEVELS OF HYDRAZINE RELATED COMPOUNDS
2. CONDUCT SUFFICIENT TREATABILITY STUDIES WITH THE MOST PROMISING CANDIDATE TECHNOLOGIES TO VERIFY TREATMENT LEVELS AND IDENTIFY KEY DESIGN VARIABLES
3. DEVELOP A COMPREHENSIVE DECOMMISSIONING ASSESSMENT.

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December 1986

TASK NO. 34

HYDRAZINE BLENDING AND STORAGE FACILITY
WASTEWATER TREATMENT AND DECOMMISSIONING ASSESSME

Contract No. DAAK11-84-D-0017

EBASCO SERVICES INCORPORATED
R.L. STOLLAR AND ASSOCIATES
CALIFORNIA ANALYTICAL LABORATORIES, INC.
UBTL INC. TECHNOS INC. GERAGHTY & MILLER, INC.

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PREPARED FOR

**PROGRAM MANAGER'S
OFFICE FOR
ROCKY MOUNTAIN ARSENAL CLEANUP**

US ARMY
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DRAFT
TECHNICAL PLAN

December 1986

TASK NO. 34

HYDRAZINE BLENDING AND STORAGE FACILITY WASTEWATER TREATMENT AND DECOMMISSIONING ASSESSMENT

Contract No. DAAK11-84-D-0017

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

1.0 INTRODUCTION

1.1 STUDY OBJECTIVES

Task Order No. 34 involves the development of methods for the decommissioning and final remediation of the Hydrazine Blending and Storage Facility (HBSF). Part of the HBSF study will be an evaluation of options for the treatment/removal of associated wastewater. The specific objectives of the study are:

- To investigate alternative approaches for treatment/removal of wastewater contaminated with low levels of hydrazine and hydrazine related compounds. Technologies will include those listed in Table 1-1 and shall be compared to the present baseline treatment approach of off-site incineration.

- To conduct sufficient treatability studies with the most promising candidate technology(s) to verify treatment levels and identify key design variables. The design information will support a Removal Action for the HBSF wastewater.

- To develop a comprehensive decommissioning assessment. The decommissioning assessment will support and be incorporated into the Arsenal wide Feasibility Study Alternative Assessment, i.e., Task 28.

1.2 PROCESS DESCRIPTION AND PHYSICAL FACILITY

The Rocky Mountain Arsenal (RMA) is located in Adams County, Colorado about 10 miles northeast of the central business district of Denver and encompasses an area of 17,238 acres (Figure 1-1). The HBSF is located east of the South Plants area in the northeast corner of Section 1 (Figure 1-2).

TABLE 1-1

POTENTIAL TREATMENT TECHNOLOGIES

- o BIOLOGICAL TREATMENT
  - CONVENTIONAL TECHNOLOGIES
  - DISCHARGE TO PUBLICLY OWNED TREATMENT WORKS (POTW)
- o CHEMICAL TREATMENT
  - CHLORINE (VARIOUS FORMS) AND CHLORINE/ULTRAVIOLET LIGHT (UV)
  - OZONE AND OZONE/UV
  - PERMANGANATE
  - HYDROGEN PEROXIDE AND HYDROGEN PEROXIDE/UV
  - REDUCTION PROCESSES
- o PHYSICAL TREATMENT
  - ACTIVATED CARBON ADSORPTION
  - METAL OXIDE ADSORPTION/CATALYSIS
  - EVAPORATION POND
  - AIR STRIPPING
  - STEAM STRIPPING
  - SPRAY IRRIGATION
- o THERMAL TREATMENT
  - OFF-SITE INCINERATION
  - ON-SITE INCINERATION
    - -- NORTH PLANTS INCINERATOR
    - -- OTHER

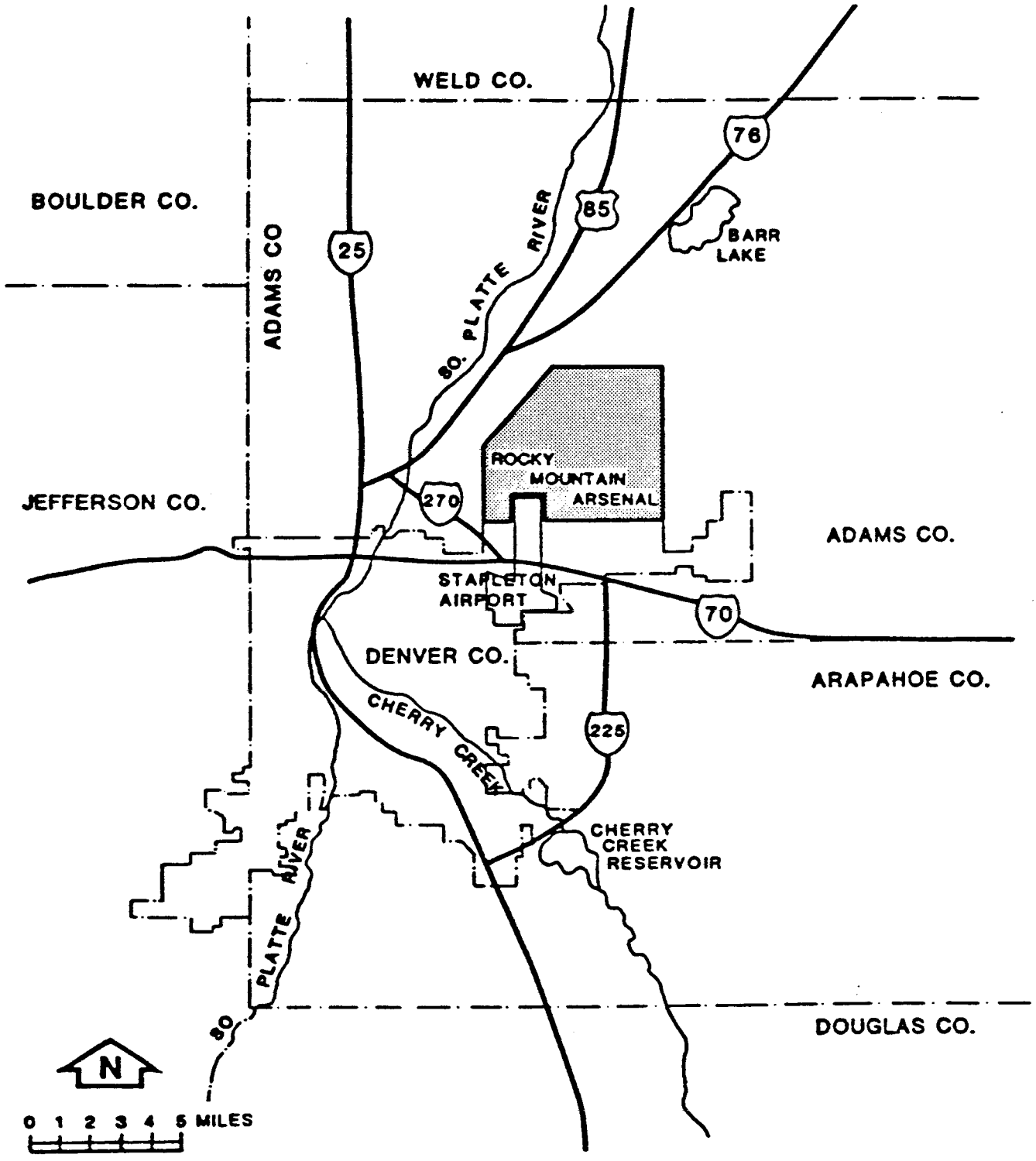

FIGURE 1-1
ROCKY MOUNTAIN ARSENAL LOCATION MAP

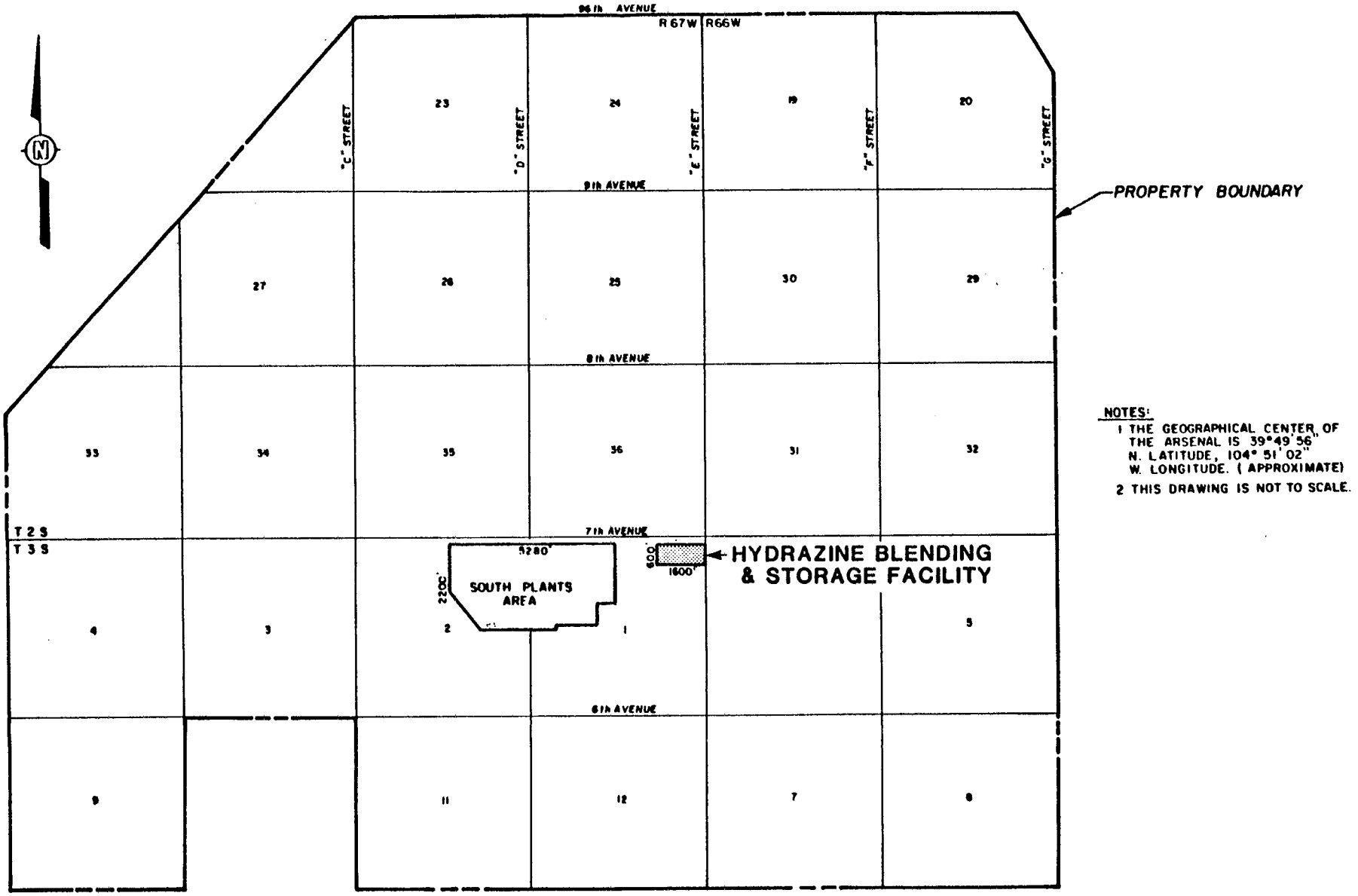

FIGURE 1-2
LOCATION OF HYDRAZINE BLENDING & STORAGE FACILITY AT RMA

The HBSF was constructed in 1959 for the U.S. Air Force (USAF) as a depot to receive, store, and blend hydrazine fuels and to issue these fuels to various customers. The facility is owned by the USAF, but has been operated by the RMA, a U.S. Army operation under an Interservice Support Agreement (ISSA) since 1960 (Hazard Abatement Plan, 1982).

The primary objective of the HBSF was the production of the rocket fuel Aerozine 50. Aerozine 50 was produced at the facility by blending anhydrous hydrazine (AH) with unsymmetrical dimethylhydrazine (UDMH). These constituents were manufactured elsewhere and shipped to the RMA for the purpose of rocket fuel production.

Hydrazine operations consisted of downloading/uploading of railroad cars and tanker trucks, storage of rocket fuel and rocket fuel constituents, and blending of rocket fuels. Chemicals stored at the facility for fuel production included AH, UDMH and Aerozine 50. This facility was also used to store other fuels such as monomethyl hydrazine (MMH), monopropellant hydrazine (MPH) and hydrazine 70 (a hydrazine/water mixture). Chemicals to be transported were removed from bulk storage and placed in drums, rail cars or trucks (Hazard Abatement Plan, 1982).

The existing hydrazine blending facility area is a limited access site which occupies approximately 960,000 square feet (see Figure 1-3), (1,600 ft x 600 ft). It is completely enclosed by two concentric security fences.

The facility consists of four carbon steel tanks (one of 50,000, one of 200,000, and two of 19,000-gallon capacity) that are compatible with UDMH and water only; four stainless steel tanks (each of 24,900-gallon capacity) compatible with all of the fuels; a 44,000-gallon capacity inground concrete tank for the collection of wastewaters and area runoff; a blender; a drum filling station; truck and railcar loading/offloading station; concrete pads and dikes; a drum storage pad; a storage shed; a tool shed; an office shed and associated piping. The two carbon steel storage tanks (one of 50,000 and one of

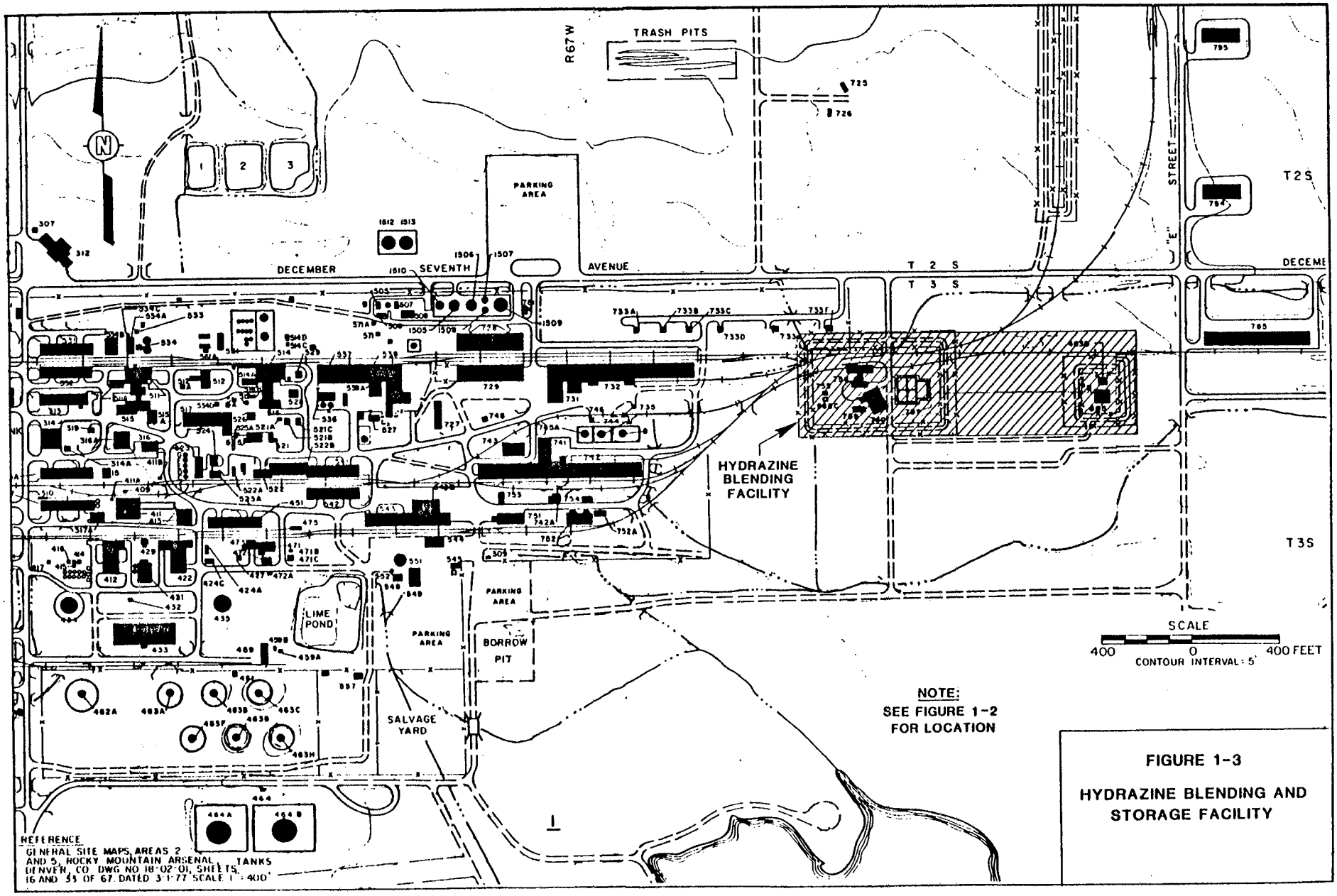

FIGURE 1-3

HYDRAZINE BLENDING AND STORAGE FACILITY

200,000-gallon capacities), located on the eastern end of the facility, have been used since 1982 only for wastewater storage. Each group of tanks has its own catch basin which drains to the main inground concrete tank (44,000 gal). Figure 1-4 presents a schematic layout of the HBSF. A process flow schematic for the HBSF is shown in Figure 1-5.

Railroad tracks pass through the facility area. The HBSF also is served by water, electric power, and steam lines, and a nitrogen gas storage and feed system. The fuel handling facilities contain waterflood type fire protection fixtures and a circulating ethylene glycol-based heating system. Table 1-2 lists the major equipment and structures of the hydrazine blending and storage facility.

1.3 OPERATING HISTORY

This section provides a brief background on the operating history of the hydrazine blending facility: the types of materials processed, the wastes generated, the disposal methods used, a description of major spills and other events that happened prior to the shutdown of the facility, and activities which have occurred since the shutdown.

1.3.1 Types of Material Processed

The hydrazine blending facility has been used primarily for the production of Aerozine 50 missile fuel which is approximately 50 percent AH and 50 percent UDMH. Blending operations were not continuous, but occurred in response to requests by the USAF. The facility also has been used to store other fuels such as monopropellant hydrazine (MPH) and hydrazine 70 (hydrazine/water mixture). The USAF utilized the RMA facility as a depot to receive, store, blend and issue hydrazine fuels to various customers.

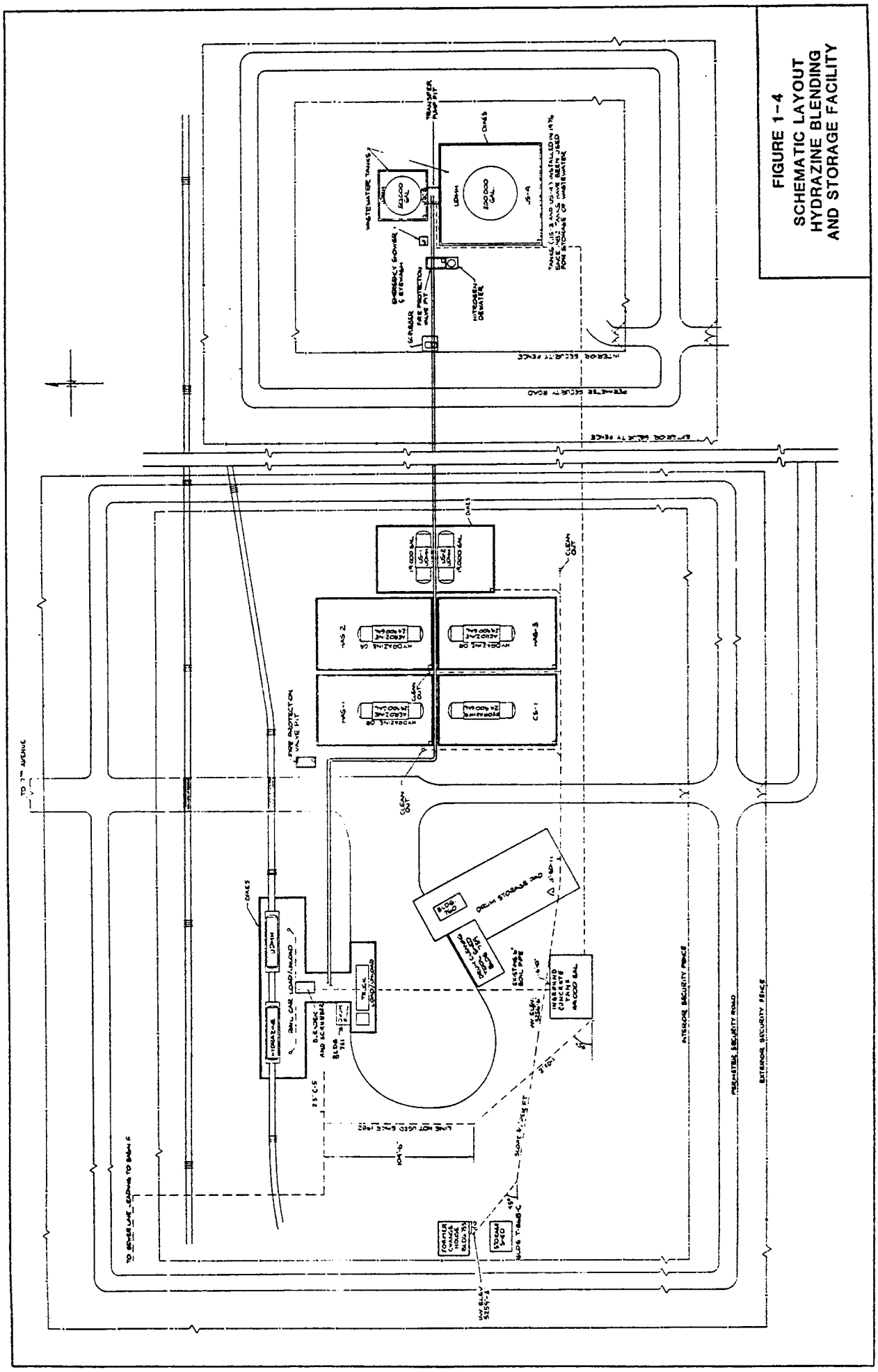

FIGURE 1-4
SCHEMATIC LAYOUT
HYDRAZINE BLENDING
AND STORAGE FACILITY

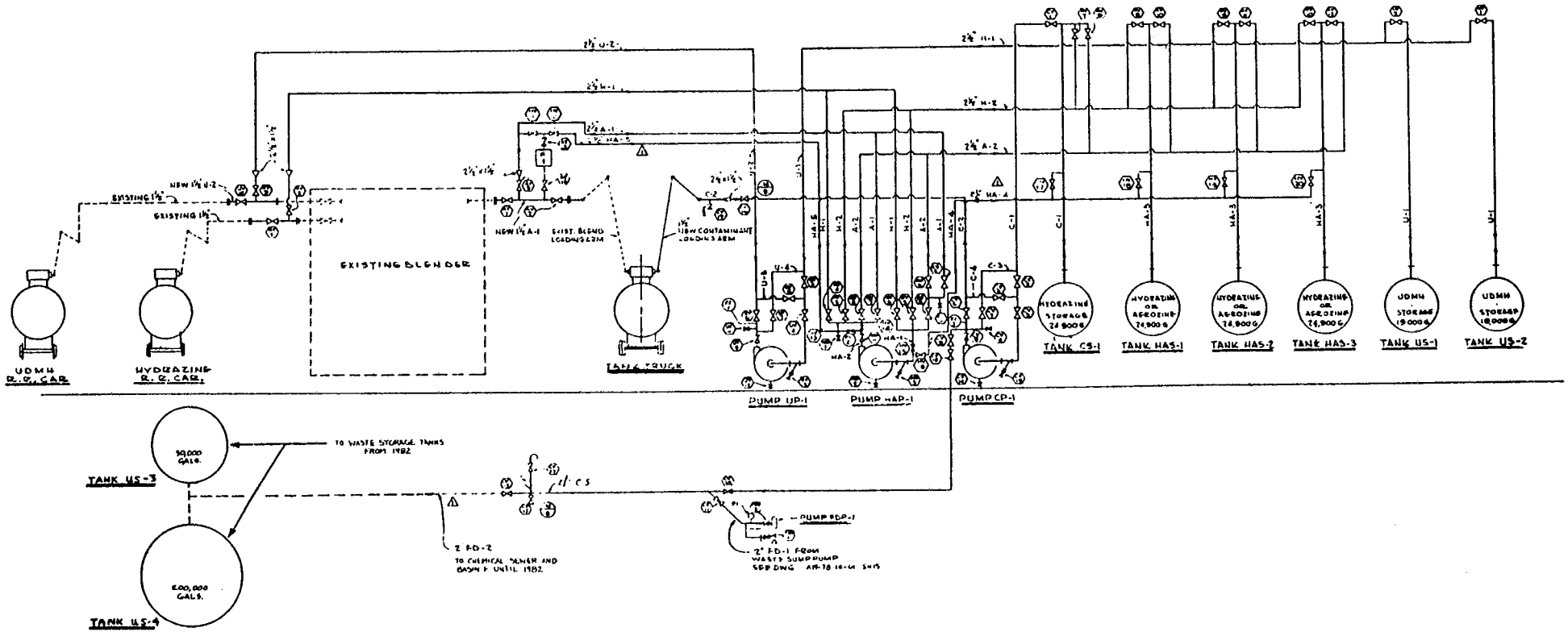

FIGURE 1-5

PROCESS FLOW DIAGRAM
HYDRAZINE BLENDING AND
STORAGE FACILITY

TABLE 1-2

MAJOR EQUIPMENT AND STRUCTURES OF THE HYDRAZINE BLENDING AND STORAGE FACILITY

	Item	Description
1.	Railroad Tank Car Facility	
	Enclosed Area	120'-0" x 30'-0"
	Function	Unloading of anhydrous hydrazine and UDMH from railroad tanker cars
	Construction Material	Reinforced concrete. Metal sheets.
2.	Blender	
	Function	Blend Hydrazine and UDMH to produce Aerozine 50
	Construction Material	Reinforced concrete. Metal sheets
3.	Drum Loading Station (Bldg 761)	
	Area	22' - 0" x 10'0"
	Function	Loading of Aerozine 50
	Construction Material	Reinforced concrete
4.	Truck Loading Station	
	Area	60'-0" x 18'-0"
	Function	Loading of Aerozine 50 into tanker trucks
5.	Office Shed/Change House (Bldg 755)	
	Size	20'-0" x 24'-0" x 9'-0"
	Function	Clothing change and showers (until late 1970's). Glycol recirculating pump and heat exchanger housing.
	Construction Material	8" masonry (concrete block)
6.	Inground Concrete Tank	
	Area	40'-0" x 26'-0"
	Volume	44,000 gallons
	Function	Receive wastewater and stormwater runoff
	Construction Material	Concrete
7.	Building 759	
	Size	40'-0" x 20'-0" x 10'-0"
	Function	Drum cleaning
	Construction Material	Metal siding/metal roofing

TABLE 1-2 (Continued)

MAJOR EQUIPMENT AND STRUCTURES OF THE HYDRAZINE BLENDING AND STORAGE FACILITY

	Item	Description
8.	Shelter (Bldg. 760)	
	Location	In drum storage area
	Function	Forklift storage
	Size	20' x 0" x 10'-10"
9.	Storage Shed (Bldg. T-868-C)	
	Size	13'-6" x 22'-0" (estm.)
	Function	Storage of miscellaneous building materials
	Construction Material	Wood
10.	Drum Storage Pad	
	Size	70'-0" x 45'-0" x 6"
	Function	Storage of drums
11.	Aerozine Storage Tanks	
	Number of Tanks	3 (HAS 1, HAS 2, HAS 3)
	Geometric Shape	Cylindrical, Horizontal
	Volume	24,900 gallons
	Construction Material	Stainless steel
	Location	Inside concrete dikes
	Size of Dike	53'-6" x 47'-0" x 5'-0"
12.	Anhydrous Hydrazine Storage Tank	
	Number of Tanks	1 (CS 1)
	Geometric Shape	Cylindrical, Horizontal
	Volume	24,900 gallons
	Construction Material	Stainless steel
	Prior use	Wastewater storage
	Location	Inside concrete dike
	Size of Dike	53'-6" x 47'-0" x 5'-0"
13.	UDMH Storage Tanks	
	Number of Tanks	2 (US-1, US-2)
	Geometric Shape	Cylindrical, Horizontal
	Volume	19,000 gallons
	Construction Material	Carbon steel
	Location	Inside concrete dike
	Size of Dike	43'-0" x 77'-0" x 5'-0"

TABLE 1-2 (Continued)

MAJOR EQUIPMENT AND STRUCTURES OF THE HYDRAZINE BLENDING AND STORAGE FACILITY

	Item	Description
14.	Wastewater Tanks	
	Number of Tanks	2 (US-3, US-4)
	Geometric Shape	Cylindrical, Vertical
	Volume	50,000 gallons and 200,000 gallons
	Construction Material	Carbon Steel
	Prior use	UDMH storage
15.	Pumps	
	Number	6 (HWP-1, HWP-2, UP-1, HAP-1, CP-1, FDP-1)
	Liquids	Hot water, wastewater, UDMH, hydrazine, aerozine, contaminants
16.	Pipes* (Above Ground)	
	Diameter	2.5"
	Number	18 (U-1, U-2, U-3, U-4, HA-1, HA-2, HA-3, HA-4, HA-5, A-1, A-2, H-1, H-2, C-1, C-2, C-3, C-4, C-5)
	Diameter	3.0"
	Number	2 (HWR-1, HWS-2)
	Diameter	4.5"
	Number	1 (V-1)
17.	Scrubbers	
	Number	2
	Location	One at blender area, one at wastewater tank area
18.	Fire Protection Valve Pit	
	Number	2
	Location	One near hydrazine/aerozine tank area and one near wastewater tank area

*There is a variety of underground piping at the HBSF. This piping will also be removed as part of the decommissioning activities.

1.3.2 Generation and Disposal of Wastes

It was estimated that a maximum of approximately 300,000 gallons of wastewater had been generated annually from the HBSF (USATHAMA, 1979). Most of the wastewater from this facility was generated during blending operations. During the blending process, the off-gases were scrubbed with water. This water was then collected by gravity in the 44,000-gallon inground concrete tank located south of the hydrazine blender (Figure 1-4). The storage area catch basins, waste drains in the blender facility, and the steam expansion line from Building 755 also drained into the inground concrete tank. Waste materials were carried to the inground concrete tank by underground pipes.

During more active years of facility production, a hydrazine drum filling operation was also conducted. Dirty drums and drums to be refilled with a different fuel were cleaned before filling. Residues from these operations were poured into the inground concrete tank. These drums were then washed in the open area south and east of Building 759 (Figure 1-4).

The contents of the inground concrete tank were neutralized by batch treatment with solid calcium hypochlorite to oxidize the hydrazine to ammonia, nitrogen, and water. It was necessary to maintain a pH between 7 and 10 for effective neutralization to occur. Mixing of the waste and hypochlorite was accomplished by recirculating the inground concrete tank contents through a transfer pump, located in the southwest corner of the inground concrete tank. The neutralization process resulted in the accumulation of large amounts of sediment or solid sludge in the inground concrete tank. This sludge was collected and transported to pits in Section 30 and 36 for disposal from 1975 through 1978 (Kuznear and Trautmann, 1980). Until 1982 the treated wastewater from the inground concrete tank was pumped into Basin F (located in Section 26) via the industrial sewer. In 1982, the industrial waste discharge into Basin F was eliminated by excavating the portion of industrial (chemical) sewer feeding the basin. After that time, the neutralized wastewater from the inground concrete tank

was pumped to two storage tanks (Tanks US-3 and US-4) originally used for UDMH storage. An exception was about 10,000 gallons of wastewater which was shipped to Lowry Air Force Base.

1.3.3 Spill History

In November 1975, the fire protection system at the hydrazine facility malfunctioned due to a power outage. Several hundred thousand gallons of water filled the pit around the largest UDMH storage tank causing it to float. No fuels or wastewaters were spilled. To remedy this situation, the water from the pit area was pumped onto the fields to the east and south of the east yard (Trautmann, undated).

In May 1976, approximately 4 inches of UDMH leaked from the largest tank within the surrounding dike area. The UDMH was pumped to the inground concrete tank and was neutralized for disposal into Basin F (Trautmann, undated).

1.3.4 U.S. Occupational Safety and Health Agency Survey

During January, February, and March 1982, the U.S. Occupational Safety and Health Agency's (OSHA) District Office conducted sampling of the HBSF work area during both operational and nonoperational periods. The sampling and analysis were limited to hydrazine, UDMH, and N-nitrosodimethylamine (NDMA). Analysis of the OSHA sample indicated the presence of airborne NDMA at various locations within the HBSF. Table 1-3 presents the location and concentration of contaminants found by OSHA at the HBSF (Hazard Abatement Plan, 1982). OSHA advised RMA to upgrade worker health and safety protection level before continuing operation of the HBSF.

TABLE 1-3

RESULT OF ANALYSIS OF SAMPLES TAKEN BY OSHA AT VARIOUS LOCATIONS AT HBSF

Date	Sample ID	Type	Operation	Location of Sampler	Sampling Period (Min)	Contaminant	Exposure	Time Weighted Average (TWA)
01/28/82	RMA 1 and 3	Area	Transfer from storage tank	In Office	50	Dimethyl Amine	N.D.	--
	RMA 2 and 4	Area	to truck tanker	Sump (North side)	50	Dimethyl Amine	N.D.	--
	RMA 11	Area		Office	200	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 17	Area		Office	51	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 12	Area		Sump (north side)	200	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 18	Area		Sump (north side)	43	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 13	Area		Support beam near office	200	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 19	Area		Support beam near office	41	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 23	Area		Office	252	NDMA	10.0 ug/m^3	5.25 ug/m^3
	RMA 24	Area		Sump (north side)	242	NDMA	4.1 ug/m^3	2.1 ug/m^3
	RMA 25	Area		Support beam near office	240	NDMA	1.5 ug/m^3	0.25 ug/m^3
02/25/82	RMA 40	Area	Background levels	N.W. Corner Tank Farm	276	NDMA	0.58 ug/m^3	0.33 ug/m^3
	RMA 41	Area		Office	274	NDMA	2.7 ug/m^3	1.54 ug/m^3
	RMA 42	Area		Sump (N.E. corner)	274	NDMA	2.7 ug/m^3	1.54 ug/m^3
	RMA 43	Area		Sump (S.W. coner)	274	NDMA	1.8 ug/m^3	1.03 ug/m^3
	RMA 44	Area		North Out Building	270	NDMA	0.37 ug/m^3	--
	RMA 45	Area		Truck Loading Bay	269	NDMA	2.6 ug/m^3	1.46 ug/m^3
	RMA 46	Area		Rail Car Loading Bay	268	NDMA	1.5 ug/m^3	0.84 ug/m^3
	RMA 47	Area		Control Station	267	NDMA	2.6 ug/m^3	1.45 ug/m^3
	RMA 48	Area		Drum Storage	266	NDMA	0.43 ug/m^3	0.74 ug/m^3
	RMA 49	Area		Tank Farm Between NAS and CS 1	265	NDMA	2.3 ug/m^3	1.3 ug/m^3
	RMA 50	Area		S.E. Corner Tank Farm	263	NDMA	1.0 ug/m^3	0.55 ug/m^3
	RMA 51	Area		Outer Gate (North)	262	NDMA	0.30 ug/m^3	--
03/10/82	RMA 55	Area	Background Levels at	North side building 111	252	NDMA	N.D.	--
	RMA 56	Area	other parts of the Arsenal	N.E. side basin "F"	198	NDMA	N.D.	--
	RMA 58	Area		South side building 831	193	NDMA	N.D.	--
	RMA 60	Area		E. side building 1710 (Clinic)	191	NDMA	N.D.	--
	RMA 62	Area		S. of building 538	172	NDMA	N.D.	--
	RMA 64	Area		Building 314 in lunch room	171	NDMA	N.D.	--
	RMA 57	Area		N.E. side basin "F"	193	Hydrazine	N.D.	--
						UDMH	N.D.	--

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TABLE 1-3 (Continued)

RESULT OF ANALYSIS OF SAMPLES TAKEN BY OSHA AT VARIOUS LOCATIONS AT HBSF

Date	Sample ID	Type	Operation	Location of Sampler	Sampling Period (Min)	Contaminant	Exposure	Time Weighted Average (TWA)
	RMA 59	Area		South side building 831	193	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 61	Area		E. side building 1710 (Clinic)	190	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 63	Area		South of building 538	172	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 65			Building 314 in lunch room	170	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 69	Area	Draining Sump	On retaining wall of storage tank east of hydrazine facility	60	NDMA	N.D.	--
	RMA 68	Area		On retaining wall of storage tank east of hydrazine facility	60	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 93	Area	Transfer UDMH from rail car to storage tank	Near scrubber vent	183	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 94	Area		Near scrubber vent	120	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 95	Area		Near scrubber vent	186	NDMA	1.3 ug/m^3	1.81 ug/m^3
	RMA 96	Area		Near scrubber vent	118	NDMA	5.3 ug/m^3	--
	RMA 98	Area		In office	235	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 99	Area		In office	66	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 100	Area		In office	303	NDMA	1.1 ug/m^3	0.69 ug/m^3
	RMA 102	Area		At control panel	230	Hydrazine	16.0 ug/m^3	9.9 ug/m^3
						UDMH	56.0 ug/m^3	43.01 ug/m^3
	RMA 103	Area		At control panel	67	Hydrazine	N.D.	--
						UDMH	116.0 ug/m^3	--
	RMA 104	Area		At control panel	298	NDMA	30.0 ug/m^3	18.63 ug/m^3
3/82	RMA 78	Area	Draining Sump	In office near drain	240	NDMA	3.5 ug/m^3	1.25 ug/m^3
	RMA 79	Area		North out building on refrigerator	240	NDMA	0.42 ug/m^3	--
	RMA 81	Bulk		Sump water		NDMA	180.0 ug/m^3	--
	RMA 82	Bulk		Sump water		Hydrazine		
						UDMH		

TABLE 1-3 (Continued)

RESULT OF ANALYSIS OF SAMPLES TAKEN BY OSHA AT VARIOUS LOCATIONS AT HBSF

Date	Sample ID	Type	Operation	Location of Sampler	Sampling Period (Min)	Contaminant	Exposure	Time Weighted Average (TWA)
3/82	RMA 92	Area	Transfer of rail car of UDMA	Scrubber near vent pipe (Bubbler)	300	NDMA	1.8 ug/m^3	1.13 ug/m^3
	RMA 97	Area		Office (bubbler)	298	NDMA	0.27 ug/m^3	0.17 ug/m^3
	RMA 101	Area		Control panel (bubbler)	249	NDMA	16.9 ug/m^3	10.35 ug/m^3
	RMA 105	Area		Tank farm, east side of US 1	293	NDMA	0.14 ug/m^3	0.045 ug/m^3
	RMA 106	Area		On top tank CS 1	228	Hydrazine	N.D.	--
						UDMH	N.D.	--
03/17/82	RMA 107	Area	Transfer UDMH from rail car to storage tank	On top tank CS 1	66	Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 108	Area		On top tank CS 1	294	NDMA	N.D.	--
	RMA 112	Wipe		Abe Padilla's apron	N/A	NDMA	N.D.	--
						Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 113	Wipe		Rudy Martinez's apron	N/A	NDMA	N.D.	--
						Hydrazine	5.7 ug/m^3	--
						UDMH	N.D.	--
	RMA 114	Wipe		Dip sticks used to gauge tanks	N/A	NDMA	N.D.	--
						Hydrazine	N.D.	--
						UDMH	N.D.	--
	RMA 115	Wipe		Desk in office	N/A	NDMA	N.D.	--
						Hydrazine	N.D.	--
						UDMH	N.D.	--

Source: Hazard Abatement Plan, 1982.

1.3.5 U.S. Army Environmental Hygiene Agency Survey

In December 1982, U.S. Army Environmental Hygiene Agency (AEHA) conducted a sampling program at the HBSF to quantify worker exposures to NDMA, UDMH, and hydrazine (AEHA, 1982). AEHA collected samples at specific work locations based on known or potential hydrazine, UDMH and/or NDMA release or contamination. Figure 1-6 presents sampling locations used by AEHA. Results of this sampling program are presented in Tables 1-4 and 1-5.

The significant findings of this sampling program were:

a. The samples from the general area contained insignificant levels of both hydrazine and UDMH as indicated in Table 1-4. (The detectable limits were 0.05 ug/m^3 for hydrazine and 0.1 ug/m^3 for UDMH.

b. The wipe samples from the drum filling nozzles and connectors and the mixing and blending area showed relatively low levels of hydrazine and UDMH as indicated in Table 1-5.

c. The atmosphere samples taken from the work area showed low but detectable levels of contamination with NDMA as indicated in Table 1-4.

Based on these findings AEHA concluded:

a. There were no sources of detectable quantities of hydrazine or UDMH contamination identified by air sampling.

b. Wipe sampling identified the drum loading station filler nozzles and connectors, the control panel of the mixing and blending area, and the electrical outlet north of Tank HAS-1 as sites of potential hydrazine/UDMH contact exposure.

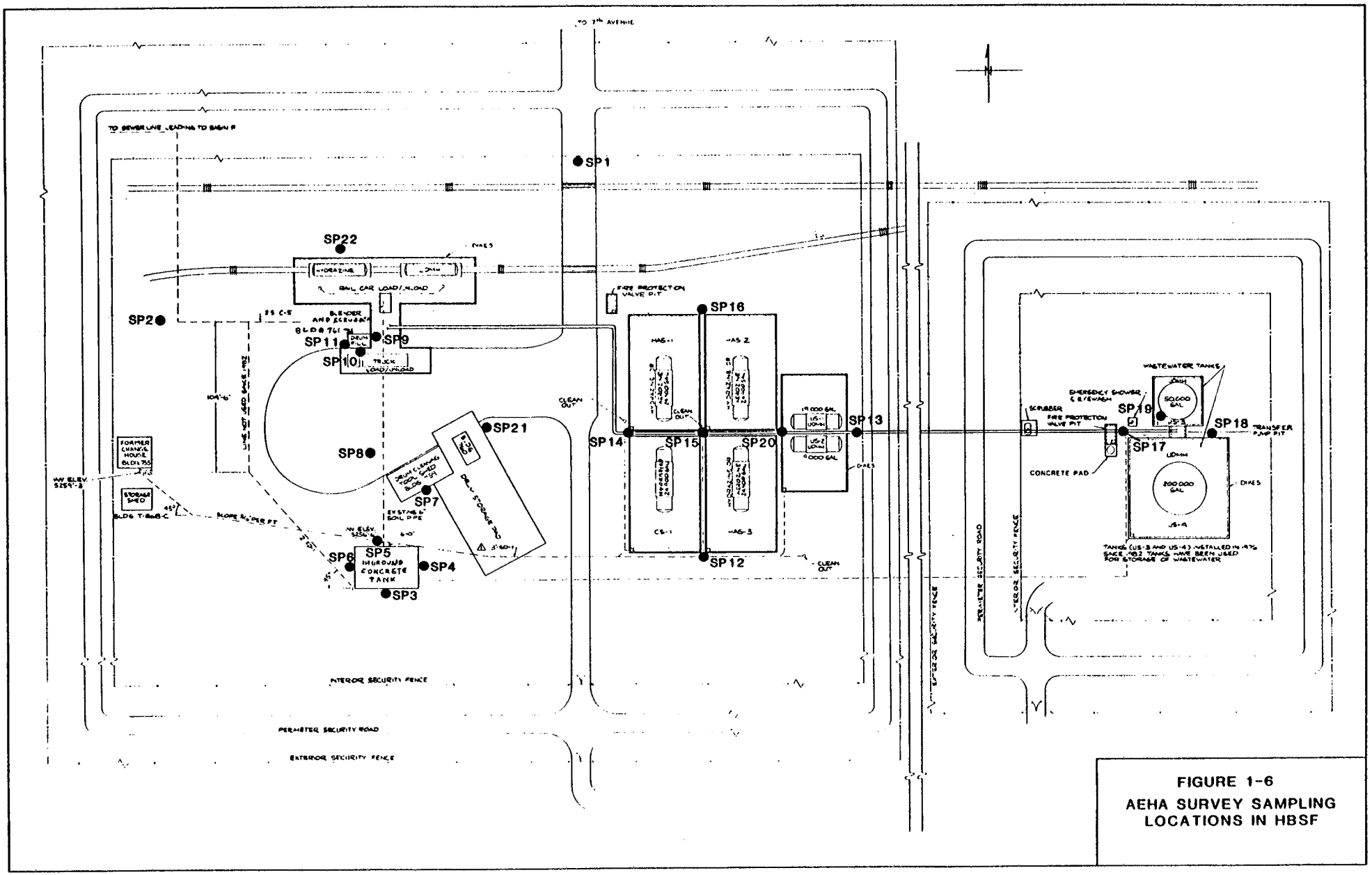

FIGURE 1-6
AEHA SURVEY SAMPLING LOCATIONS IN HBSF

TABLE 1-4

RESULTS OF ANALYSES OF ATMOSPHERIC SAMPLES
COLLECTED BY U.S. ARMY ENVIRONMENTAL HYGIENE AGENCY, DECEMBER 1982

Sampling Point	Simultaneous Samples		Sample Results		
	Hyd/UDMH Sample No.	NDMA Sample No.	Hydrazine (in micrograms/cubic meter-ug/m^3)	UDMH	NDMA
SP-1	SG-47, FB-03, FB-38	AO 3489, AO 3407	< 0.05	< 0.10	ND - Traces
SP-2	FB-07, FB-09	AO 3410, AO 3486	< 0.05	< 0.10	ND
SP-3	SG-10, SG-37, FB-23, FB-52, FB-36	AO 3066, AO 3475, AO 3401, AO 3480	< 0.05	< 0.10	Trace - 1.70
SP-4	SG-06, SG-36, FB-08 FB-10, FB-42	AO 3061, AO 3476, AO 3478, AO 3488	< 0.05	< 0.10	0.18 - 1.50
SP-5	SG-09, SG-38, FB-24, FB-16, FB-13	AO 3063, AO 3491, AO 3399, AO 3482	< 0.05	< 0.10	Trace - 2.60
SP-6	SG-08, SG-33, FB-31, FB-22, FB-41	AO 3059, AO 3073, AO 3409, AO 3481	< 0.05	< 0.10	ND - 1.50
SP-7	SG-03, SG-12	AO 3071, AO 3069	< 0.05	< 0.10	1.30 - 1.70
SP-8	SG-07, SG-18	AO 3058, AO 3070	< 0.05	< 0.10	4.20 - 10.0
SP-9	SG-11, SG-34, SG-32 FB-21, FB-12	AO 3064, AO 3068, AO 3490, AO 3411, AO 3427	< 0.05	< 0.10	3.40 - 18.0
SP-10	SG-13, SG-16, SG-31 FB-01, FB-40	AO 3072, AO 3060, AO 3479, AO 3406	< 0.05	< 0.10	0.27 - 12.0
SP-11	SG-14, SG-15, SG-39 FB-02, FB-43	AO 3074, AO 3065, AO 3477, AO 3402	< 0.05	< 0.10	0.55 - 20.0

Trace - Value between 0.05 and 0.15 ug/m^3.
ND - None Detected, value < .05 ug/m^3.

TABLE 1-4 (Continued)

Sampling Point	Simultaneous Samples: Hyd/UDMH Sample No.	Simultaneous Samples: NDMA Sample No.	Sample Results: Hydrazine (in micrograms/cubic meter-ug/m^3)	Sample Results: UDMH (in micrograms/cubic meter-ug/m^3)	Sample Results: NDMA (in micrograms/cubic meter-ug/m^3)
SP-12	FB-04, FB-15	AO 3487, AO 3398	< 0.05	< 0.10	0.50 - 1.90
SP-13	FB-63, FB-18	AO 3393, AO 3396	< 0.05	< 0.10	1.00 - 4.70
SP-14	FB-47, FB-27	AO 3397, AO 3394	< 0.05	< 0.10	0.63 - 1.20
SP-15	FB-58, FB-37	AO 3404, AO 3484	< 0.05	< 0.10	0.92 - 1.00
SP-16	FB-45, FB-36	AO 3392, AO 3483	< 0.05	< 0.10	0.62 - 1.10
SP-17	FB-33, FB-59	AO 3413, AO 3417	< 0.05	< 0.10	Trace 0.16
SP-18	FB-39, FB-17	AO 3412, AO 3416	< 0.05	< 0.10	0.24 - 0.62
SP-19	FB-06, FB-28	AO 3415, AO 3418	< 0.05	< 0.10	0.17 - 0.50
SP-20	FB-49, FB-29	AO 3395, AO 3400	< 0.05	< 0.10	0.92 - 1.20
SP-21	SG-04, SG-19, SG-46, FB-44, FB-46	AO 3057, AO 3062, AO 3473, AO 3405	< 0.05	< 0.10	1.00 - 1.40
SP-22	SG-20, SG-17, SG-36, FB-20, FB-65	AO 3067, AO 3056, AO 3472, AO 3408	< 0.05	< 0.10	ND - 0.94
SP-FH	SG-05, SG-51, FB-05	AO 3075, AO 3474	< 0.05	< 0.10	ND
SP-NQ	SG-55, FB-26, Fb-32	AO 3485, AO 3403	< 0.05	< 0.10	ND

Trace - Value between 0.05 and 0.15 ug/m^3.
ND - None Detected, value < .05 ug/m^3.

Detection Limits
- Hydrazine 0.05 ug/m3
- UDMH 0.10 ug/m3
- NDMA 0.05 ug/m3

TABLE 1-5

RESULTS OF WIPE SAMPLES FOR HYDRAZINE AND
UNSYMMETRICAL DIMETHYLHYDRAZINE

Sample Number	Location	Results (in micrograms-total) Hydrazine	UDMH 1/
W-100	Electrical control panel (west fence)	<5	0.2
W-101	Ground wipe, Drum Steamout (SP-8)	<5	<0.2
W-102	Electrical outlet north of Tank HAS-1	<5	0.3
W-103	Desktop and telephone inside Building 759	<5	<0.2
W-104	Empty barrel storage south of SP-21	<5	<0.2
W-105	Gauges and piping around sump pump at Waste Sump	<5	<0.2
W-106	Control Panel (SP-9)	<5	6
W-107	Water Sample from Waste Sump	<5	<0.2
W-108	Drum loading station (wipe of drum filling nozzles/connectors)	3,475	19.0
W-109	Tank HAS-2, drain value (Tank pit valve)	<5	<0.2
W-110	Tank HAS-1, control valve (on top)	sample bottle broken	
W-111	Tank Truck Station, Truck loading filler nozzle and boom	sample bottle broken	

1/ UDMH - 1,1-Dimethylhydrazine

Detection Limits: Hydrazine 5.0 ug
UDMH 0.2 ug

Source: AEHA, 1982.

c. Detectable quantities of NDMA were present, as air contaminants, throughout the HBSF.

d. The potential exists for worker exposure to "detectable amounts" of NDMA at the Personnel Change Facility Trailer located approximately 50 feet from the north fence entrance (SP-1).

1.3.6 Current Status

The RMA stopped routine HBSF operations after the OSHA and AEHA Surveys. The USAF and RMA jointly developed a hazard abatement plan for the facility, and removal of remaining fuels and fuel residuals is complete. Currently, the facility is regularly inspected to check the automatic sprinkler system, the ethylene glycol heating system, the nitrogen storage tank and the nitrogen blanket for the storage and fuel transfer system, and the inground concrete tank level. The USAF commissioned a study to recommend a detailed cleanup procedure for the severable equipment at the HBSF; a draft report was released in October 1985. In September 1985, the Program Manager for RMA Contamination Cleanup (PM-RMA) initiated the preparation of a preliminary cleanup plan which was completed and submitted to the U.S. Environmental Protection Agency (EPA) and the Colorado Department of Health (CDH) in December of 1985 (U.S. Air Force, 1985). PM-RMA also initiated a soil and groundwater study, which was completed September 1986. RMA personnel have completed a rinsing of all accessible piping and tanks with the stored wastewater to remove any residual fuel from these structures (James, 1986). An additional cleaning and flushing process using a sodium hypochlorite solution was accomplished during August 1986 (James, 1986). Fuel and heel removal, and equipment rinsing are consistent with the initial decontamination steps specified in the December 1985, Preliminary Cleanup Plan.

1.4 PREVIOUS INVESTIGATIONS

1.4.1 OSHA/AEHA Reports

During 1982, the U.S. Occupational Safety and Health Agency (OSHA) and the U.S. Army Environmental Hygiene Agency (AEHA) conducted surveys to quantify exposures of hydrazine related compounds. The findings of these surveys which led to the cessation of operations at the HBSF have been described in Section 1.3.

1.4.2 HBSF Preliminary Cleanup Plan

In December, 1985, PM-RMA submitted a Preliminary Cleanup Plan for the HBSF to EPA and CDH (PM-RMA, 1985). The report included a site description and process history, a characterization of all wastes, and a cleanup plan with attendant schedule. Materials which were listed and described include:

- Hydrazine, UDMH, Aerozine 50, and MMH Fuels;
- Wastewater in Concrete Tanks and Storage Tanks;
- Surface Contamination, Contaminated Construction Materials, Asbestos, and Possibly PCB Containing Transformers.

The cleanup plan was developed to meet the goals of health protection, control of waste releases, and reuse of the site. Essential components of the cleanup plan include:

- Sampling and Analysis Program to determine the extent of contamination;
- Cleanup Procedures, including Wastewater Treatment, Air Monitoring, Decontamination, Dismantling, and Removal.

1.4.3 U.S. Air Force Decommissioning Study

Sampling activities were performed for the USAF at the HBSF on June 11-13, 1985. The objective of the field sampling program was to sample surfaces and bulk materials of unknown contamination. Those surfaces and bulk materials that were known to be contaminated (i.e., inside surfaces of fuel storage tank) were not sampled. Samples of various insulation materials present on the site were obtained for asbestos analysis. The results of chemical analyses of wipe, bulk, asbestos, and PCB samples are discussed below. Table 1-6 is a summary of the analytical results that were above the method detection limit (U.S. Air Force, 1985).

Wipe Samples

The purpose of a wipe sample was to provide an indication of contaminant presence on material surfaces, not a quantitative measure of its concentration. Each wipe sample consisted of wiping a 100 cm^2 area (10 by 10 cm) with a dry Whatman No. 41 filter paper. Two adjacent 100 cm^2 area were sampled at each sample location. Due to different extraction and analytical procedures, one wipe sample, or filter paper, was analyzed for NDMA and the other for hydrazine, MMH, and UDMH.

Wipe sample locations included: product tank exterior surfaces (cladding); pipe supports; handrails; office building; glycol building; storage shed; blending skid; railroad rails; liquid nitrogen tank; concrete containment dikes; inground wastewater tank; chain link fence supports; drum storage pad; and east scrubber.

With the exception of two samples (Samples 42B and 43B) all of the wipe samples analyzed were below the detection limit for hydrazine, NDMA, MMH, and UDMH (5.0, 0.6, 25, and 25 ug/sample, respectively). Samples 42B and 43B had reported MMH concentration of 26 and 25 ug/sample, respectively, near the limit of detection for MMH.

TABLE 1-6

ANALYTICAL RESULTS OF WIPE, BULK AND ASBESTOS SAMPLES
(ABOVE METHOD DETECTION LIMITS)

Sample Number	Sample Type	Parameter	Method	Unit	Detection Limit	Concentration
42B	Wipe	MMH	S149 1/	ug/sample (ug/100 cm^2)	25	26
43B	Wipe	MMH	S149	ug/sample (ug/100 cm^2)	25	25
2B	Bulk	Hydrazine	S149	ug/g	0.02	350
2B	Bulk	UDMH	S149	ug/g	0.05	2.3
2B	Bulk	MMH	S149	ug/g	0.05	18
ASB-1	Insulation	Asbestos	---	percent	0.5	5 - 10

1/ NIOSH Method S149, USAFSAM Report TR-82-29 and USAF "The Firebrick Method" by Tom Thomas.

Source: U.S. Air Force, 1985

Bulk Samples

The collection of bulk samples was very limited due to the requirements of working in a spark-free environment and avoiding destruction of facilities.

Bulk samples could only be taken where materials were easily obtainable, since no chipping, sawing, or use of power tools was allowed. The two bulk samples that were taken included: 1) loose concrete near the drum weigh scale, and 2) wood from the railroad ties opposite and north of the drum blend pumping skid.

The concentrations of hydrazine, UDMH, and MMH detected in Bulk Sample 2, pieces of wooden railroad tie, were 350, 2.3, and 18 ug/g (equivalent to ppm), respectively. NDMA was below the detection limit for this sample.

Contaminant levels in Bulk Sample 1, a piece of loose concrete near the drum scale, were all below the detection limit (hydrazine 20 ug/g, NDMA 0.1 ug/g, UDMH 50 ug/g, MMH 50 ug/g).

Asbestos Samples

Several samples were obtained of insulation materials suspected of containing asbestos. Two types of insulation material were sampled above the northwest Aerozine tank HAS-3, on an inlet pipe located near the catwalk. One sample was of a hard, matrix type of insulation, and the other was of a fiberglass-like piece of insulation. The other sample location was piping insulation south of the blend pump building. Each sample was placed in a plastic screw-top container. Additional samples were not obtained due to the limited amount of accessible, visible insulation.

The only insulation sample that had reported levels of asbestos was ASB-1. This sample was taken from an inlet pipe near the catwalk above Tank HAS-3 and contained both fibrous and solid gray material. The fiber material did not contain any detected asbestos; however, the gray material was determined to contain 5 to 10 percent Chrysolite, a common form of asbestos. Split samples of ASB-1 both resulted in 5 to 10 percent asbestos.

Wastewater Treatment

Wastewater treatment possibilities were also reviewed as part of this study. The ultimate disposal of the treated or untreated wastewater and treatment alternatives were discussed separately. Four disposal options were listed:

- Discharge via natural drainage to a surface water
- Transport to a POTW
- Discharge through an NPDES permitted outfall
- Transport to an off-site treatment/disposal facility

The regulatory, scheduling, and cost issues of each option were discussed along with the level of treatment which would be required prior to disposal.

Several methods were presented in the report for treatment and disposal of the wastewater:

- Activated carbon adsorption
- Chlorination
- Ozonation
- Chemical oxidation
- Biological treatment
- Incineration
- Deep well injection

On-site and off-site implementation of these options were investigated along with the technical feasibility of each and potential suppliers for options judged to be feasible.

The report stated that activated carbon adsorption of hydrazine type compounds and NDMA is low and excluded this option. Chlorination was listed as a viable option, although the reaction pH and hypochlorite dosing must be carefully controlled and undesirable reaction products were noted. The availability of portable chlorination units was discussed, and it was anticipated that chlorination would treat contaminants to sub-detection levels.

Several chemical oxidation processes were included. Ozonation was determined to be a feasible treatment option. Combined ozone and ultraviolet light exposure was reported to degrade hydrazine compounds and also undesirable reaction products by the IIT Research Institute (IITRI). A mobile treatment unit utilizing ozone/UV was identified, although it has not been used to treat hydrazine wastewater. Hydrogen peroxide and potassium permanganate were listed as other chemical oxidants available to treat hydrazine related compounds, but no information was provided regarding their effectiveness.

Biological oxidation was discussed as a treatment method. Based on studies of the effects of hydrazine compounds on bacterial metabolism, The report concluded that although low concentrations (less than 1 ppm) may be successfully treated, the potential toxicity of higher concentrations precluded utilization of biological waste treatment.

Incineration of the wastewater was another treatment option offered, but was considered economically infeasible for both on- and off-site application. Deep well injection was also considered, but was not recommended due to the absence of treatment or destruction of the wastes.

1.4.4 PM-RMA Task 11: Hydrazine Blending and Storage Facility

The PM-RMA conducted a contamination survey of soils and groundwater at the HBSF through Task 11 during early 1986. Based on a review of existing data, literature, and contamination sources, a field sampling program was designed to assess the extent of contamination. Soil and groundwater chemical analyses were conducted. Following data analysis, the following contamination issues were addressed:

- o Local Geologic and Hydrologic Conditions
- o Extent of Contamination
- o Probable Causes of Detected Contamination
- o Contaminant Mobility, Persistence, and Reactivity
- o Future Monitoring Requirements
- o Hazard Evaluation

This study will be used to develop the detailed decommissioning plan.

1.4.5 Wastewater Characterization Studies

The waters in the inground concrete tank were analyzed on several occasions for hydrazine, UDMH and NDMA concentrations by the Analytical Systems Branch Laboratory of the Environmental Division at RMA. The analyses of samples indicate the following results (PM-RMA, 1983):

pH (standard units)	7.1
Hydrazine (ug/l)	0.69.-0.73
UDMH (ug/l)	1.81-2.40
NDMA (ug/l)	0.3

The wastewater in the inground concrete tank has also been analyzed for EP toxicity parameters (Table 1-7). Concentrations of parameters of interest did not exceed the substantive RCRA criteria (PM-RMA, 1983). GC/MS analyses indicated the presence of dimethylcyanamide,

TABLE 1-7

RESULTS OF ANALYSES OF EXTRACTS FROM EP TESTS
INGROUND CONCRETE TANK WASTEWATER[1/]

Parameters	Units	Substantive RCRA Concentration Limits [2/]	Inground Concrete Tank Wastewater
pH	s.u.	-- [3/]	--
TRACE METALS:			
Arsenic	mg/l	5.0	0.007
Barium	mg/l	100	--
Cadmium	mg/l	1.0	0.0022
Chromium	mg/l	5.0	<0.001
Lead	mg/l	5.0	0.001
Mercury	mg/l	0.2	<0.005
Selenium	mg/l	1.0	<0.0004
Silver	mg/l	5.0	0.002
ORGANICS:			
Endrin	ug/l	20	<0.01
Lindane	ug/l	400	<0.01
Methoxychlor	ug/l	10,000	<0.2
Toxaphene	ug/l	500	<0.01
2, 4-D	ug/l	10,000	0.5
2, 4, 5-TP (Silvex)	ug/l	1,000	<0.1

1/ The samples were analyzed by Environmental Laboratory Analytical Laboratory Group, Waterways Experiment Station, Vicksburg, Mississippi.

2/ CDH Part 261.24.

3/ "--" = Not determined.

Source: PM-RMA, 1983.

N,N-dimethylformamide, tetrachloroethane, and 1-ethyl-1H-1,2,4,-Triazole. However, the concentrations of these organic compounds were very small (less than 20 ug/l) and, therefore, they were not quantified (PM-RMA, 1983).

The results of 1983 and 1985 analyses of the wastewater stored in the 50,000- and 200,000- gallon storage tanks are presented in Table 1-8. The 1983 analyses were performed by the RMA laboratory. The 1985 analytical results were performed for the USAF (U.S. Air Force, 1985).

The reason for the variations between the 1983 and 1985 data is not clear. Possible explanations include additional pumping of wastewater to the tanks; different analytical methods; different sampling techniques; chemical reactions and degradation; and interferences during either set of laboratory analyses.

1.5 ACTION LEVELS

In any contamination situation, there is the potential for adverse impacts to human health or the environment due to exposure to the contaminants. The amount of contaminant which poses a significant risk depends not only on its concentration and disposition but also on the routes of exposure, that is, the fraction of the contaminant which leaves the site and through various transport mechanisms reaches the receptors. The determination of action levels for cleanup relies first on potential human and environmental risks associated with the contaminant. In addition, practical constraints exist such as treatment technology and analytical detection limitations.

The contaminants of concern at HBSF include hydrazine, MMH, UDMH, and NDMA. These substances, especially NDMA, have carcinogenic potential through several modes of contact, such as ingestion and dermal exposure. The wastewater, soil, groundwater, and equipment and building surfaces may all be contaminated by these compounds. Soil,

TABLE 1-8

ANALYTICAL RESULTS - WASTEWATER
HYDRAZINE BLENDING AND STORAGE FACILITY

Parameter	50,000-Gallon Tank mg/l	Date	200,000-Gallon Tank mg/l	Date
Hydrazine	444.4	6-83	2.96	6-83
	225.36	8-83	0.71	8-83
	140.	6-85	*	6-85
MMH	505.3	6-83	28.4	6-83
	1,300.	6-85	8.	6-85
UDMH	4-5.6	6-83	3.04	6-83
	213.58	8-83	2.03	8-83
	470.	6-85	*	6-85
NDMA	<1.	6-83	<1.	6-83
	0.805	8-83	0.134	8-83
	0.021	6-85	0.007	6-85

* Below detection limit. Detection limits for 6/85 analyses are:

Hydrazine	0.2 mg/L
MMH	1.0 mg/L
UDMH	1.0 mg/L
NDMA	0.0002 mg/L

Sources: PM-RMA 1983 and U.S. Air Force 1985

groundwater, and equipment and building material will be addressed as part of the RMA site-wide RI/FS program. Thus, the only material for which action levels are applicable for this study is the wastewater.

Of the contaminants in the wastewater, NDMA is the most toxic and often the most resistant to treatment. Accordingly, action levels are initially defined for NDMA. Generally, destruction of NDMA to desired levels ensures that hydrazine, MMH, and UDMH are destroyed virtually completely. Even so, action levels will be determined for other contaminants of concern in a manner similar to the process used for NDMA.

Precedent for NDMA action levels has been set in the issuance of the NPDES permit for Aerojet-General Corporation in Sacramento, CA. There, a Method Detection Limit (MDL) of 500 parts per trillion (ppt) limited the desired health-based limit of "zero," and because of analytical uncertainty, a limit of 1000 ppt was designated (CA. Wat. Qual. Crtl. Bd., 1985). A similar rationale balancing health-based treatment levels, analytical limits of detection, and the uncertainty of analytical values is used here to establish an action level for NDMA. From a health perspective, the allowable concentration of NDMA in water has been calculated as 1.4 ppt based on valued computed by the USEPA Cancer Assessment Group (CAG) and assuming a cancer incidence after consuming contaminated water of one out of a million persons. Although treatment to this level is desirable, analytical detection limitations preclude measurement of such low concentrations. The analytical method certified for use at RMA has a detection limit of 200 ppt. However, even this value is associated with a significant amount of uncertainty (Lessley, 1986). Therefore, a more verifiable value of 500 ppt is selected as the NDMA treatment action level.

The action levels for hydrazine, MMH, UDMH are set at their respective MDLs of 2.5 parts per billion (ppb), 20 ppb, and 25 ppb. Although no allowance is made for quantitative uncertainty near the detection

limits, it is anticipated that since NDMA is generally the compound most resistant to destruction, the remaining hydrazine compounds will be destroyed well below detection limits.

1.6 SUMMARY OF TECHNICAL APPROACH

The plans for disposal of wastewater at the HBSF and decommissioning of the facility will be developed according to the following technical approach:

- Wastewater treatment assessment, in which applicable treatment methods will be ranked. Treatability studies to support the ranking and to identify key design criteria may be performed.
- Decommissioning plan development.
- Final detailed decommissioning report preparation.

1.7 TASK SCHEDULE

The projected schedule for the HBSF wastewater treatment and decommissioning assessment is depicted in Figure 1-7.

FIGURE 1-7

TASK 34 - HYDRAZINE BLENDING AND STORAGE FACILITY WASTEWATER TREATMENT AND DECOMMISSIONING ASSESSMENT SCHEDULE.

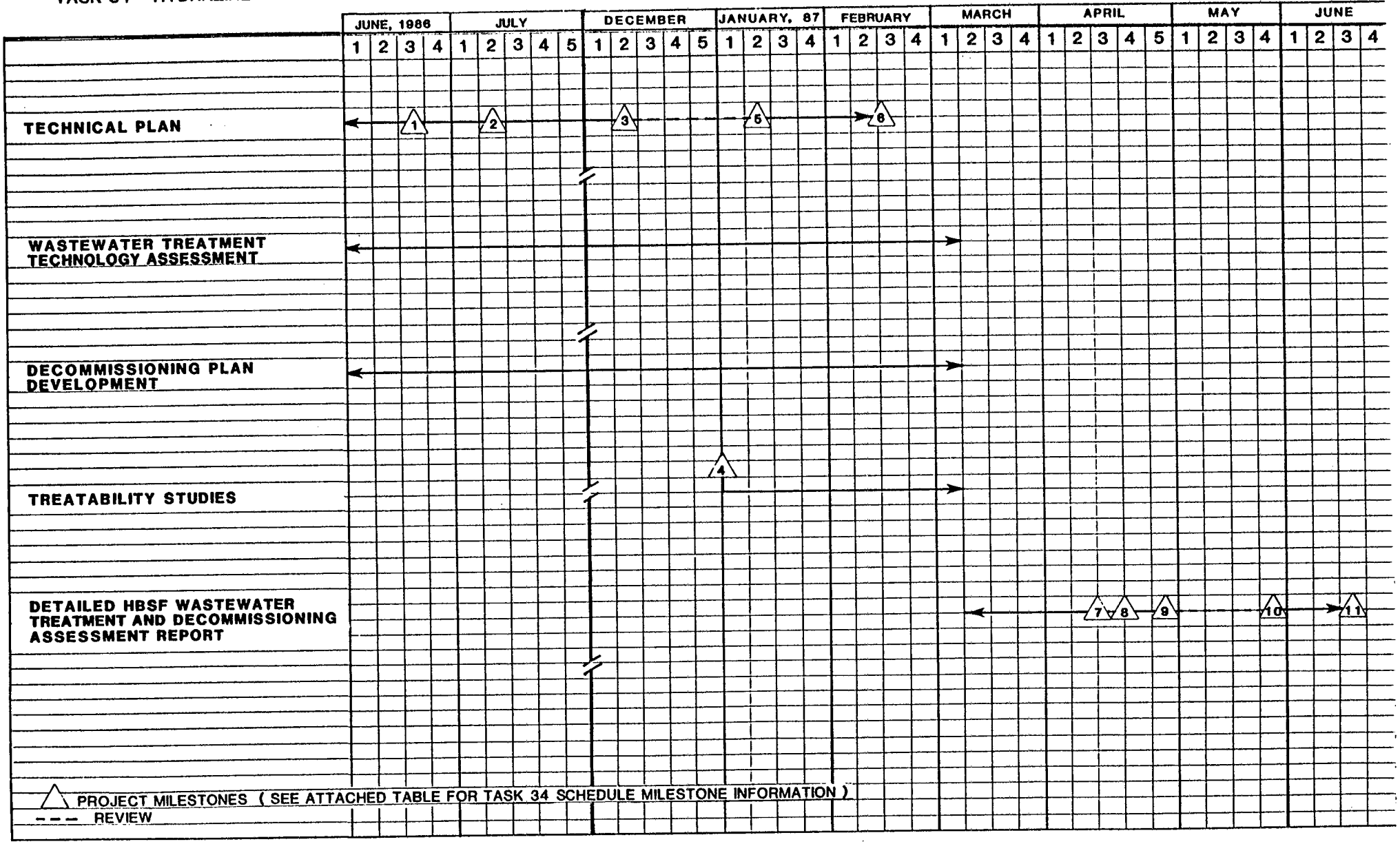

FIGURE 1-7 (Continued)

TASK 34 PROJECT MILESTONES

1	June 20	-	Submittal of Blue Cover Technical Plan without technology screening and action levels.
2	July 8	-	Presentation of Technical Plan to PMO and submittal of technology screening and action level sections.
3	December 10	-	Submittal of Brown Cover Technical Plan.
4	January 5	-	PMO approval of Treatability Studies.
5	January 14	-	Receipt of MOA comments.
6	February 17	-	Submittal of White Cover Technical Plan.
7	April 20	-	Submittal of Blue Cover HBSF Wastewater Treatment and Decommissioning Assessment Report.
8	April 24	-	Receipt of PMO comments.
9	April 29	-	Submittal of Brown Cover HBSF Wastewater Treatment and Decommissioning Assessment Report.
10	May 27	-	Receipt of MOA comments.
11	June 17	-	Submittal of White Cover HBSF Wastewater Treatment and Decommissioning Assessment Report.

2.0 WASTEWATER TREATMENT ASSESSMENT

2.1 PURPOSE

Wastewater generated from operations at the Hydrazine Blending and Storage Facility will be addressed as a removal action under CERCLA. The purpose of the Wastewater Treatment Assessment is to identify the most favorable treatment alternative to be used in the removal action. The Assessment process begins with a statement of specific treatment objectives. All candidate technologies are identified. Those technologies which clearly cannot meet the treatment objectives are eliminated from further consideration. The remaining treatment technologies are then described in more detail. A second screening is conducted to eliminate less favorable technologies, which leads to identification of the final candidate technologies. These final technologies are then the subject of a detailed analysis which focuses on cost, ease of implementation, and treatment effectiveness as well as on the performance of treatability studies for certain technologies. Based on this analysis, a ranking of technologies will be presented.

2.2 TREATMENT OBJECTIVES

Past activities at the HBSF produced wastewaters from container rinsing and air scrubbing. The quantities of wastewater and concentrations of hydrazine contaminants are listed in Tables 1-7 and 1-8 of the previous chapter. Various chlorinated compounds may also be present in the wastewater from past practices of decontamination using chlorination. More wastewater may be generated from decontamination during the facility cleanup. In its current location in the storage tanks and inground concrete tank, the wastewater presents little hazard. Nonetheless, the wastewater cannot be stored indefinitely but rather must be treated and disposed. The primary concern with the wastewater is the impact hydrazine, MMH, UDMH, and NDMA may have on human health and the environment if released. Among other hazards, human carcinogenesis is a potential outcome of exposure to these substances.

NDMA has the greatest toxicity and may be the most resistant to degradation, so it receives particular attention. UDMH is also a significant concern as it may be volatilized and oxidized to NDMA.

The overall treatment objective is to treat the wastewater such that the contaminants of concern will not endanger human health or the environment. Specifically, the hazardous compounds present must be destroyed to the action levels defined in Section 1.6, for example 500 ppt NDMA, without producing equally hazardous end-products. As well as meeting treatment objectives, rapid implementation as a removal action is required. Thus, processes which have been demonstrated as effective are favored while processes which require considerable development are eliminated. Cost is an important factor insofar as the lowest cost technologies which meet the treatment and implementation objectives are preferred.

2.3 CANDIDATE TREATMENT TECHNOLOGIES

As determined from technical papers, previous hydrazine wastewater treatment studies, a review of existing treatment processes, and personal communication with a number of research scientists, several candidate technologies are available to treat the wastewater at the HBSF (Table 2-1). In the following section, a review of these technologies is presented. The review is restricted to a discussion of major process reactions and operations and is intended only as a means to identify which options clearly cannot meet the treatment and implementation requirements. If the process does not remove the hydrazine and related compounds efficiently or reliably without producing hazardous by-products, or if much development would be required to evaluate treatment efficiency and implement the process, the technology is eliminated from further consideration. Specifically, the technology or the reactions comprising the technology must have been demonstrated in the laboratory or in practice as effective in destroying hydrazine, MMH, UDMH, and NDMA to detection limits so that major experimentation is not required to prove process feasibility.

TABLE 2-1

CANDIDATE TREATMENT TECHNOLOGIES

- BIOLOGICAL TREATMENT
  - ON-SITE BIOLOGICAL TREATMENT
  - DISCHARGE TO A PUBLICLY OWNED TREATMENT WORKS (POTW)
- CHEMICAL TREATMENT
  - CHLORINATION AND CHLORINATION/ULTRAVIOLET LIGHT (UV)
  - OZONATION AND OZONE/UV
  - PERMANGANATE
  - HYDROGEN PEROXIDE AND HYDROGEN PEROXIDE/UV
  - REDUCTION PROCESSES
- PHYSICAL TREATMENT
  - ACTIVATED CARBON ADSORPTION
  - METAL OXIDE ADSORPTION/CATALYSIS
  - EVAPORATION POND
  - AIR STRIPPING
  - STEAM STRIPPING
  - SPRAY IRRIGATION
- THERMAL TREATMENT
  - OFF-SITE INCINERATION
  - ON-SITE INCINERATION
    - -- NORTH PLANTS INCINERATOR
    - -- OTHER

Also, technologies which generate hazardous by-products in quantities requiring supplemental treatment are rejected. Those technologies which can attain the desired level of treatment and which can be rapidly implemented are carried forward for a more detailed analysis.

2.3.1 On-site Biological Treatment

Biological treatment, such as activated sludge, trickling filters, and rotating biological contactors, has been successfully applied to a number of organic and industrial chemicals. Packaged treatment plants or existing RMA facilities could potentially be utilized to treat the wastewater. Kane and Williamson (1980) performed batch bioassay studies on many of the hydrazine compounds of concern with several bacteria common in biological treatment plants. Their results are presented below:

EFFECTS OF HYDRAZINE, MMH, AND UDMH
ON BACTERIAL METABOLISM

	Concentration Causing 50 Percent Reduction in Metabolism (mg/l)		
Bacteria	Hydrazine	MMH	UDMH
Nitrobacter	15	15	1800
Nitrosomas	165	1	35
Anaerobic Bacteria	100	75	2300
Denitrifying Bacteria	100	10	12,500

Since the HBSF wastewater contaminant concentrations (see Table 1-8) exceed most of the levels identified as reducing metabolic rates, undiluted wastewater would inhibit, if not destroy, bacterial activity. A combination of dilution and acclimation may result in successful biodegradation of the contaminants. Based on the Kane and

Williamson results, a dilution of at least 100 to 1 may be required. Assuming biological treatment at 100 to 1 dilution is effective, a package or mobile treatment operation with a minimum capacity of 70,000 gallons per day and a source of dilution water would be required if on-site biological treatment is utilized and completed in one year. NDMA, however, does not appear amendable to biodegradation. Studies by Tate and Alexander (1975, 1976) indicate that NDMA incubated with numerous bacterial strains for 72 hours is not degraded and its destruction in sewage is 50 percent in 14 days. Thus, although biological degradation of the contaminants may be successful under the proper conditions, the treatment effectiveness, especially regarding NDMA, is uncertain at best. Therefore, on-site biological treatment as the primary treatment operation is eliminated from further consideration, although it may be utilized as a disposal option for treated wastewater.

2.3.2 Discharge to a Publicly Owned Treatment Works (POTW)

Discharge to a publicly owned treatment works (POTW) is merely biological treatment performed by an existing public facility. One improvement over on-site biological treatment is that the wastewater can be diluted to virtually any level. However, dilution is not generally accepted as a treatment option and it does not ensure that degradation will occur. In addition, regulatory complications associated with acceptance of the wastewater would arise. Therefore, this alternative is considered unacceptable as a complete treatment option. As with on-site biological treatment, discharge to a POTW may be useful for disposal of treated wastewater.

2.3.3 Chlorination and Chlorination/UV

Chlorination of hydrazine compounds is a commonly suggested hydrazine decontamination and spill mitigation measure in which the compounds are oxidized. Chlorination can be effected using different forms of chlorine, specifically, chlorine gas, hypochlorous acid, hypochlorite,

or chlorine dioxide. If oxidation proceeds to completion, the expected reaction products are hydrochloric acid, methanol, and nitrogen gas, all of which would require relatively minor treatment. In practice, however, oxidation is often incomplete and miscellaneous undesirable chlorinated compounds are produced.

Brubaker et al. (1985) reported that hydrazine was completely oxidized by chlorination; on the other hand, chlorination of MMH and UDMH was both incomplete and produced chloroform, various hydrazones, several miscellaneous chlorinated compounds, as well as NDMA in the case of UDMH chlorination. Castegnaro et al. (1986) reported similar findings using sodium and calcium hypochlorite; part per million concentrations of NDMA and the related NMEA (N-Nitrosomethylethylamine) were generated from UDMH and MMH solutions originally in the 1,000 part per million concentration range. NDMA may also be oxidized by chlorination, as has been demonstrated by Neumann and Jody (1986), who removed NDMA to below 20 parts per trillion (ppt). Again, though, undesirable chlorinated organic compounds including chloroform were generated during the course of treatment. When a solution of hydrazine, MMH, and UDMH with concentrations in the 1,000 ppm range was first subjected to ozonolysis, then chlorination, chlorinated compounds in the part per million concentration range resulted. Chlorine dioxide utilized in drinking water and wastewater treatment produces substantially less chloroform and other trihalomethanes (THM) than other forms of chlorine (Lykins and Griese, 1986). Reduced generation of chlorinated by-products may hold for hydrazine related wastewater, but this has yet to be confirmed.

Although chlorination may destroy the hydrazine related compounds, the resulting chlorinated side-products would be present in concentrations such that additional treatment would be required. Thus, chlorination alone produces an unacceptable end-product and is excluded as an alternative.

Ultraviolet light used in conjunction with chlorination may destroy the chlorinated side products. Fochtman and Koch (1979) found that chlorinolysis/UV treatment of hydrazine compounds produced undetectable chloroform (less than 0.3 ppm), carbon tetrachloride (less than 0.3 ppm), and chlorinated amines (less than 0.1 ppm), while chlorinolysis minus UV did generate part per million concentrations of these compounds. Prengle et al. (1976) demonstrated that UV exposure contributes significantly to the degradation of chlorinated compounds. In experiments with sequential ozone and UV exposure, the ultraviolet portion of the treatment successfully removed chlorine atoms from pentachlorophenol, chloroform, and other chlorinated compounds. UV treatment may in general complement chlorination to provide effective destruction of the contaminants of concern and by-products. Therefore, chlorination/UV will be considered further as a treatment alternative.

2.3.4 Ozonation and Ozone/UV

Ozonation is another oxidation process which can and has been utilized to treat aqueous hydrazine compounds. Ozone is a stronger oxidizing agent than the various chlorine compounds (Table 2-2) and the process is not constrained by the formation of chlorinated by-products. There is formation of miscellaneous side-products following ozonolysis and UDMH may be converted to tetramethyltetrazone (TMTZ) and NDMA. Continued ozonation converts TMTZ and NDMA to carbon dioxide, water, nitrogen, and nitrates, and may destroy other side products. In one experiment, a solution of MMH and hydrazine in the 1,000 ppm range with trace quantities of UDMH was oxidized with ozone. The hydrazine, MMH, and UDMH were destroyed to concentrations below detection limits of 5 ppm, 50 ppb, and 10 ppb, respectively, while the NDMA which was produced (approximately 150 ppm) was oxidized to less than 2.4 ppb in 20 hours (Neumann and Jody, 1986). Because of its success in destroying hydrazine related compounds, ozonolysis will be further investigated as a treatment alternative.

TABLE 2-2

OXIDATION POTENTIAL OF OXIDANTS[1/]

Species	Oxidation Potential (Volts)
Fluorine	3.03
Atomic Oxygen (singlet)	2.42
Ozone	2.07
Hydrogen Peroxide	1.78
Perhydroxyl Radical	1.70
Permanganate	1.68
Chlorine Dioxide	1.56
Hypochlorous Acid	1.49
Hydroxyl Radical	1.40
Chlorine (gas)	1.36

1/ The oxidation potential of a compound is a relative measure of its ability to remove electrons from (oxidize) a second compound. Generally, the higher a compound's oxidation potential, the more likely it is to convert a second compound to simpler, common molecules.

Source: Hunsberger 1978

In conjunction with UV light, ozonation provides a very effective treatment system. Extensive research and pilot scale studies have been conducted on simulated hydrazine wastewater by IIT Research Institute (IITRI) (Neumann and Jody, 1986). Hydrazine, UDMH, and MMH are rapidly oxidized with this system, and NDMA has been oxidized to below a detection limit of 16 ppt. In addition, miscellaneous by-products of ozonolysis are readily destroyed by ultraviolet light. Gas chromatography/mass spectrophotometry (GC/MS) scans done on simulated hydrazine wastewater following ozone/UV treatment indicate that very few compounds at very low concentrations remain. Ozone/UV is currently used in conjunction with other treatment units at the Aerojet-General Corporation facility in Sacramento, CA, for wastewater containing hydrazine and NDMA. Discharge limits of 1 ppb (2 ppb daily maximum) and 10 ppm hydrazine (20 ppm daily maximum) are achieved by the facility. Thus, ozone/UV has been demonstrated as an effective treatment process for hydrazine and related compounds and will be reviewed in more detail.

2.3.5 Permanganate

Other chemical oxidants are available and potentially applicable in treating the HBSF wastewater. Permanganate, a common, strong oxidizing agent (Table 2-2) has been examined for treatment of hydrazine compounds. Potassium permanganate added to an acidified solution of NDMA destroyed the NDMA, apparently without production of harmful end-products (Castegnaro et al. 1982). However, in a later study, permanganate and sulfuric acid added to solutions of hydrazine, MMH and UDMH destroyed much of the original compound but resulted in the formation of NDMA from MMH and UDMH. Continued reaction time resulted in some degradation of the NDMA from the MMH solution, but no significant degradation of NDMA in the UDMH solution (Castegnaro et al., 1986). It is not clear why the NDMA generated from the UDMH solution resisted further oxidation while NDMA produced from other solutions was degraded -- it may be that more NDMA was formed from the

UDMH than from the hydrazine and MMH and insufficient permanganate was present in the former case. Permanganate treatment may be capable of destroying the contaminants of concern, but this has not been confirmed entirely. In addition, manganous oxide solid is produced as the permanganate is reduced and would require disposal. Preliminary estimates indicate that 2,700 kg of manganous oxide would be generated. The potential failure of permanganate in treating the wastewater and the requirement for disposal of a solid waste are judged to be constraints which dismiss this alternative as a promising treatment method.

2.3.6 Hydrogen Peroxide and Hydrogen Peroxide/UV

Hydrogen peroxide is an oxidizing agent receiving increasing attention for treatment of various chlorinated compounds and other chemicals. Used alone, hydrogen peroxide destroyed NDMA with an efficiency of about 60 percent (Castegnaro and Walker, 1976). However, combined ultraviolet light and hydrogen peroxide has a much greater destruction efficiency and rate than peroxide alone, as has been demonstrated by Sundstrom and Klei with trichloroethylene and dichloromethane (1983). Hydrogen peroxide/UV successfully destroyed 100 ppm hydrazine in wastewater to below detection limits (Hager and Smith, 1985). One potential drawback is that few, if any, experiments have been conducted using hydrogen peroxide/UV on MMH, UDMH, and NDMA. Nevertheless, the mechanism of action of hydrogen peroxide/UV is suspected to be similar to ozone/UV, with the primary difference being that ozone is a somewhat stronger oxidizing agent than hydrogen peroxide; therefore, the MMH, UDMH, and NDMA treatment capabilities of ozone/UV are likely to be closely approximated by hydrogen peroxide/UV. Because of the success in treating hydrazine and the likelihood of efficient oxidation of MMH, UDMH, and NDMA, the hydrogen peroxide/UV process will be considered in more detail.

2.3.7 Reduction Processes

Miscellaneous reduction processes have been studied for converting hydrazine compounds and NDMA to their corresponding amines. Of these processes, reduction with nickel or aluminum-nickel based catalysts in an alkaline solution appears to be the most promising of the reduction processes. Lunn et al. (1983b) observed complete reduction of 11 nitrosamines including NDMA. Products included amines, ammonia, and alcohols, and hydrogen gas is evolved during the reaction. Lunn et al. (1983a) successfully reduced hydrazine, MMH, UDMH, and other hydrazine compounds to corresponding amines. The method is a one step process utilizing common reagents; potassium hydroxide is first added to elevate the solution pH and is followed by addition of aluminum-nickel alloy powder to produce reducing conditions. However, the process has not been developed beyond the laboratory stage. Furthermore, reduction of NDMA and UDMH generates equal quantities of dimethylamine, which is listed as a hazardous waste under 40 CFR 261. Thus, subsequent treatment of a hazardous substance would be required if reduction procedures are utilized, so this method is eliminated from further consideration.

2.3.8 Activated Carbon Adsorption

Activated carbon adsorption is an effective treatment process for removing high molecular weight organic compounds. However, the chemical structures of the hydrazine related compounds are such that adsorption is unfavorable. Research conducted by IITRI (USEPA, 1979) indicates that NDMA is poorly adsorbed onto activated carbon. Activated carbon also was found to adsorb "very little" MMH or UDMH (Fochtman and Koch, 1979). Thus, this process is eliminated based on ineffective waste treatment capability.

2.3.9 Metal Oxide Adsorption/Catalysis

Metal oxide adsorption is a potential treatment technology based on studies of the adsorption of hydrazine compounds to soils (Braun and Zirroli, 1983; Hayes et al., 1982; Heck et al., 1983). In addition, the metal oxide surface may also catalyze the destruction of the hydrazine related compounds. Studies by Hayes et al. (1982) and by Braun and Zirroli (1983) indicate that partitioning of hydrazine and MMH onto iron oxides and silicates is favorable. In the former study, it was shown that at pH 8, hydrazine absorbs to iron oxide with greater than 99 percent efficiency and hydrazine and MMH exhibit the same high absorption onto clay materials. Two complications arise, however, with the potential utilization of absorption to treat the wastewater. First, absorption of NDMA onto metal oxides has not been well studied and removal efficiency is uncertain. Second, although absorption is accompanied by catalytic oxidation of the contaminants to a limited degree, absorption onto metal oxides essentially transfers the hydrazine compounds to a different media (liquid to solid) rather than destroying them. Thus, metal oxide absorption is eliminated from further consideration since it does not attain the treatment objective of reliably destroying the contaminants of concern.

2.3.10 Evaporation Pond

Evaporation of the wastewater after transfer to a shallow pond relies on natural degradation of the hydrazine compounds. The net annual evaporation rate at RMA exceeds 40 inches, with the main contributions occurring during May through September (NOAA, 1983). Exposure of hydrazine, MMH, and UDMH to air allows the oxidation of these compounds while sunlight provides ultraviolet photolysis of NDMA. The oxygen scavenging properties of the hydrazine compounds suggest that oxidation should be successful; vapor-phase NDMA is reported to have a half-life of 30 minutes in sunlight (Hanst et al., 1977). An evaporation pond may also be used in conjunction with other treatment processes. For

example, it may be utilized as a disposal method following treatment by another technique. As a result, evaporation with natural oxidation and photolysis is retained for further consideration, either as the primary treatment system or as a follow-up process to other treatment.

2.3.11 Air Stripping or Steam Stripping

Air or stream stripping of the hydrazine compounds is another possible treatment method. Stripping operations rely on the preferential partitioning of one or more compounds of a mixture into a vapor phase relative to a liquid phase. With the HBSF wastewater, the hydrazine and related compounds must partition favorably into the vapor phase for successful stripping to occur. Based on vapor-liquid equilibrium diagrams (Wilson, et. al. 1955), hydrazine partitions strongly into water at low concentrations, implying that stripping would be unfavorable. Along with the difficulty of stripping is the problem of lack of destruction of the contaminants. Stripping, for the most part, transfers the contaminants from one media (water) to a second (air). Thus, inefficient separation and lack of contaminant destruction exclude stripping as an acceptable alternative.

2.3.12 Spray Irrigation

The HBSF wastewater may be treated by spray irrigation. This technique relies on several natural mechanisms to destroy the hydrazine related compounds. Adsorption and catalyzed oxidation by soils, oxidation by air, photolysis by sunlight, and perhaps biological degradation are contributing factors in the destruction. Results of soil surveys on the HBSF grounds indicate no contamination by hydrazine, MMH, and UDMH (Bradbeer, 1986), suggesting that spray irrigation would be effective. Despite the strong likelihood of success, the consequences should the method fail are undesirable. Potential groundwater contamination is the most significant consequence. Although contaminated groundwater could be treated, the goal of avoiding endangerment of the environment and human health would not be met. Therefore, spray irrigation is eliminated as a viable alternative.

2.3.13 Incineration

Incineration of the contaminated water is another available option, either in an on-site incinerator or at an off-site facility. The existing RMA North Plants incinerator is likely inadequate for assured destruction of the hydrazine compounds (Tillman, 1986). Utilization of a mobile incinerator or construction of a new on-site incinerator would be accompanied by a test burn, and mobilization or construction time delays. Thus, on-site incineration cannot meet the need for rapid implementation. Off-site incineration is a favorable treatment process. Two facilities contacted (SCA, Chicago and Rollins, Deer Park, TX) have the capability, capacity, and availability to incinerate the wastewater and contaminants with essentially 100 percent efficiency. The high degree of destruction and the assurance of rapid implementation makes off-site incineration a promising alternative which will be further investigated.

2.3.14 Summary of Initial Screening

Of the preliminary candidate technologies listed in Table 2-1, only six are judged to be capable of achieving the desired level of destruction of hydrazine, MMH, UDMH, and NDMA without generating hazardous by-products and can be implemented in a time frame of a few months (Table 2-3). These alternatives are chlorination/UV, ozonation, ozone/UV, hydrogen peroxide/UV, evaporation pond, and off-site incineration.

2.4 SECONDARY SCREENING OF TECHNOLOGIES

The six technologies identified in the previous section which meet the treatment and implementation time requirements are reviewed in this section to determine the final candidate technologies. The technologies are first described according to their major components and ancillary operations, and various pertinent aspects of the treatment are discussed. A discussion follows in which the

TABLE 2-3

SUMMARY OF INITIAL TECHNOLOGY SCREENING

Technology	Effective Destruction of Hydrazine-Related Compounds	Rapid and Simple Implementation	Non-hazardous By-Products and End-Products
On-Site Biological Treatment	Uncertain	Yes	Uncertain
Discharge to a POTW	Uncertain	Yes	Uncertain
Chlorination	Yes	Yes	No
Chlorination/UV	Yes	Yes	Yes
Ozonation	Yes	Yes	Yes
Ozone/UV	Yes	Yes	Yes
Permanganate	Uncertain	No	Uncertain
Hydrogen Peroxide	Uncertain	Yes	Uncertain
Hydrogen Peroxide/UV	Highly Probable	Yes	Yes
Reduction Processes	Yes	No	No
Activated Carbon Adsorption	No	Yes	No
Metal Oxide Adsorption/Catalysis	No	No	No
Evaporation Pond	Highly Probable	Yes	Likely; Potential Residues Easily Disposed
Air Stripping or Steam Stripping	No	Yes	No
Spray Irrigation	Uncertain	Yes	Uncertain
Incineration	Yes	Yes	Yes

technologies which consist of similar operations are compared for treatment effectiveness, as indicated by reaction rate and destruction of by-products. Those technologies found to be inferior to similar processes are eliminated. Technologies which are distinctly different or which have similar treatment effectiveness are retained. The remaining "final candidate" technologies will subsequently will be reviewed in detail to provide a basis for ranking.

2.4.1 Descriptions of Technologies

Six technologies, chlorination/UV, ozonation, ozone/UV, hydrogen peroxide/UV, evaporation pond, and off-site incineration, can effect the desired destruction of the hydrazine compounds in a time frame of a few months. These technologies are described below in more detail in order to compare the processes. First, the major and ancillary components and a brief description of the system operation are presented for each technology. For technologies in which a treated water product results, there are a number of disposal options available including discharge to a waterway, a sanitary waste treatment plant, or to an evaporation pond. The specific disposal method is not determined at this stage; rather, the need for disposal or lack thereof is mentioned. Then, each technology is evaluated according to treatment capabilities and side reactions, subsequent treatment requirements, the need for treatability studies, potential hazards, MOA requirements, and ease of implementation.

2.4.1.1 Chlorination/UV

The chlorination/UV treatment option consists of a recirculating or batch wastewater system incorporating chlorine contact followed by ultraviolet light exposure. Treatment may be performed by contacting and recirculating the wastewater using the existing piping and tanks, or a mobile treatment system operating in a batch mode may be utilized. If the recirculating system is used, a chlorine contact

chamber and a UV light chamber may be installed on existing piping or may require new piping. A pH-monitoring and control system is necessary and a sulfite system may be required to eliminate residual chlorine prior to discharge to a waterway, although chlorine will dissipate if the water is retained. Gas vents and possibly scrubbing units are necessary for release of reaction gases. Treatment is continued until an acceptable product is generated, after which the treated wastewater is discharged. Use of a mobile treatment system involves the same process operations as does the recirculating system, but may be operated in a batch mode with intermittent discharge.

As has been discussed, chlorination can destroy NDMA to 20 ppt and is effective in destroying hydrazine, MMH, and UDMH. However, miscellaneous chlorinated by-products are produced which may require subsequent treatment. UV light exposure aids in the destruction of the contaminants and by-products, but additional treatment of the chlorinated by-products may still be required. Treatability studies are required to determine the identity of the chlorinated by-products and the effect of UV exposure on degradation. MOA approval is required if discharge of the treated water to a sanitary treatment facility or waterway occurs, as is the case with all water discharge during hazardous waste cleanup operations. There are no significant hazards associated with implementing this system, as the reaction is contained, the reactants are easily handled, and contaminant releases are unlikely. Implementation of chlorination/UV requires installation of a chlorine dispensing system and a UV contact chamber along with the associated monitoring equipment and piping and possibly a sulfite dispensing unit. A moderate amount of effort and time may be required to install the equipment assuming personal protection is required. Alternatively, the use of a mobile treatment unit only requires hookup to the existing piping or tanks.

2.4.1.2 Ozonation

The ozonation option consists of generation of ozone on-site with its introduction either into a recirculating flow of the wastewater through existing piping or directly into the tanks and sump. It is also possible to treat the wastewater internally within a mobile treatment system. Venting, scrubbing, and possibly recycling of off-gases is necessary to release reaction products and recover oxygen. A pH monitoring and control system may be necessary. Treatment is continued until the wastewater meets concentration requirements, after which the water is discharged.

Ozonation is a very effective means of oxidizing hydrazine, MMH, and UDMH to primarily nitrogen, water, carbon dioxide, and some nitrate. Oxidation of UDMH also produces NDMA which can eventually be destroyed by continued ozonation. Most of the miscellaneous side-products produced during the reactions are also oxidized in time to innocuous end-products. Prengle et al. (1976) demonstrated that ozonation aids in the destruction of chloroform and other chlorinated compounds, so such compounds present in the wastewater will also be destroyed to some extent. If ozonation is successful, no further treatment is necessary and the treated water can be discharged either to a waterway or sanitary treatment plant following MOA approval or to an evaporation pond. Only minor treatability studies must be performed to determine the effectiveness of ozonation on the actual wastewater as ozonation has already been performed on simulated hydrazine wastewaters. If ozonation were to be found in practice to not produce the desired level of treatment, a supplementary or alternate system could be easily installed and no adverse impacts would result. Hazards associated with ozone are avoidable with proper generation, dispensing, and degeneration of unreacted ozone. Installation complexity and time requirements are minor due to the utilization of existing tanks and piping and the simplicity of the operation. A mobile treatment system would be even simpler and less time consuming to implement.

2.4.1.3 Ozone/UV

This technology is virtually identical to the preceding ozonation alternative except for the addition of an ultraviolet light contact chamber. The operation is comprised of recirculating water with initial ozone contact, pH control, and venting of off-gases. UV light exposure follows the ozonation step and may be performed in the same chamber. Recirculation of water and treatment continues until the desired removal is achieved, after which the treated water is discharged. Again, mobile treatment systems are available to perform these same operations.

The treatment capabilities of this system are improved over ozonation alone. The UV light assures rapid and complete destruction of NDMA and side-products of the oxidation reactions. Furthermore, combined ozone/UV exposure is effective in oxidizing chlorinated compounds which may be present. No subsequent treatment is required, and the treated water may be discharged following MOA approval or may be evaporated in a pond. Possible, though unlikely, failure of the system would produce no hazardous releases. Fugitive ozone releases are a concern, but are avoidable with proper equipment connections and degeneration of unreacted ozone. Treatability studies are necessary to verify the treatment effectiveness with actual wastewater, especially for chlorinated compounds. Installation time requirements are minor, as the equipment is simple and existing tanks and piping are utilized or a mobile treatment facility is brought on-site.

2.4.1.4 Hydrogen Peroxide/UV

This alternative is similar to the ozone/UV process, differing primarily in that hydrogen peroxide solution is substituted for gaseous ozone. A single chamber is used for the UV exposure and for addition and mixing of hydrogen peroxide. This chamber and the necessary reaction monitoring appurtenances may be hooked up to existing piping

and used to treat the wastewater in a recirculation mode. Also, the treatment equipment may be brought on-site in a mobile unit and the wastewater treated in a batch mode. Treatment is conducted until the action levels are attained, after which the water is discharged or evaporated in a pond.

The treatment effectiveness of this method is believed to be similar to ozone/UV, although the oxidation potential of hydrogen peroxide is slightly less than for ozone. The hydroxyl radicals formed from the hydrogen peroxide/UV oxidize the contaminants, and continuation of the treatment likely destroys by-products and chlorinated compounds which may be present. It is expected that the treated water will require no additional treatment. MOA approval is then necessary if the water is discharged to a waterway. The hazards associated with this alternative are very low, as the wastewater treatment is conducted within the equipment, accidental releases are unlikely, and the hydrogen peroxide and UV light present little hazard. Treatability studies are necessary to verify the treatment effectiveness of hydrogen peroxide/UV on MMH, UDMH, and NDMA, as well as other contaminants which may be present. Implementation of this process involves either installation of the UV contact equipment, hydrogen peroxide dispensing system, and the necessary monitoring devices to existing piping or use of a mobile treatment system. In the former case, time requirements will be modest while in the latter, minimal set-up is required.

2.4.1.5 Evaporation Pond

In this alternative, a lined pond is constructed into which the HBSF wastewater is pumped. Alternatively, existing containment structures at the HBSF may be modified to create a pond. Access control devices such as fencing and air guns to frighten birds may be necessary. A pump is available to return the water to the tanks in case treatment is incomplete and to avoid accidental overflowing. Natural degradation processes destroy the hydrazine compounds while the water evaporates.

Air monitoring devices may be placed around the pond to measure fugitive contaminant releases. Treatment continues until all the water is evaporated, after which residues are disposed along with the liner as hazardous waste.

Although the treatment level is not easily quantifiable using this method, it is believed that virtually complete destruction of the hydrazine related compounds and possible chlorinated compounds can be assured. The exposure of the wastewater to air should provide sufficient oxidation. Releases of the compounds into the atmosphere actually facilitates destruction by increasing the contact with oxygen and the ultraviolet fraction of sunlight. Potential fugitive emissions can be monitored and if found to be excessive, the water can be returned to the tanks. Since no water discharges occur, there are no associated impacts and MOA approval requirements for discharges. Implementation of this treatment option involves only excavation of a shallow pond, placement of an impermeable liner, fencing, pumping of the wastewater, and possibly air monitoring. One possible advantage of this option is that much of the implementation can be conducted outside of the restricted HBSF area, so little personal protection equipment will be required. On the other hand, it may be more desirable to construct the pond within the HBSF boundaries in order to contain potential contaminants within this area or use existing bermed areas surrounding the fuel tanks. If existing containment structures are utilized, these will have to be inspected and sealed prior to use.

2.4.1.6 Off-Site Incineration

Off-site incineration is a means to quickly and reliably destroy all contaminants present. Wastewater is pumped into tanker trucks which transport the contaminated water to a RCRA approved incineration facility. Tanker trucks of 3000 to 5000 gallon capacity would transport the wastewater to the Rollins incinerator in Deer Park,

Texas, or the SCA facility in Chicago. Approximately 50 to 80 loads would be required to transport 250,000 gallons. Incineration would be conducted after a test burn and could be completed within 60 days.

Essentially 100 percent destruction of all possible contaminants is guaranteed with incineration. A very small possibility for health hazards exist due to the handling and transport of the wastewater in the event of a spill or a motor vehicle accident. Otherwise, risk of exposure is permanently eliminated. Other than a test burn and chemical analysis of the wastewater, no treatability studies are required. If the incineration is not sufficiently complete, which is highly unlikely, burn conditions would have to be modified or an alternate treatment utilized, which may involve further transport of the water. No monitoring of discharges is required beyond that required by the incineration facility. Implementation of the process involves pumping of wastewater into tanker trucks and transport to the incinerator locations.

2.4.2 Discussion and Secondary Screening of Technologies

The six technologies described in the preceding section are all capable of destroying the hydrazine compounds to the defined action levels (Section 1.5). In some cases, undesirable intermediates are generated but these substances can be treated as well. Despite the capacity of each technology to produce an acceptable product, clearly some technologies are more advantageous than others from a standpoint of overall treatment efficiency.

Ozonation combined with UV differs from ozonation alone only in the addition of a UV contact chamber or UV lamps placed in the main reaction vessel, yet provides enhanced treatment. The UV light accelerates NDMA destruction, which is the treatment rate limiting step, and facilitates destruction of reaction by-products (Neuman and Jody 1986). Thus ozonation is excluded in favor of ozone/UV.

Combined chlorination and UV is also a reliable method, yet it has complications which are not inherent in the ozone/UV process. For example, there is generation of undesirable chlorinated compounds which does not occur with ozone/UV. The amount of chlorinated compounds generated may be small in comparison to the quantities already present due to past chlorination activities; nonetheless, while chlorination contributes undesirable chlorinated compounds, ozonation destroys them. Although the UV light destroys some of these chlorinated products, the time required to do so may be extensive. Additionally, a sulfite contact dechlorination system or extended time for residual chlorine dissipation may be required but is unnecessary with ozone/UV. Thus, ozone/UV is preferred over UV/chlorination because it does not require extended treatment to destroy refractory chlorinated compounds generated during the initial reaction.

Hydrogen peroxide/UV has similar advantages to ozone/UV, although it has yet to be demonstrated as effective on MMH, UDMH, and NDMA. Since the reaction mechanisms of hydrogen peroxide and ozone are probably similar, hydrogen peroxide/UV may be nearly as effective as ozone/UV. In addition, peroxide is generally easier to handle than ozone, and has fewer potential safety complications. Therefore, hydrogen peroxide/UV will be studied in more detail as a treatment method.

The evaporation pond has the advantages of simplicity, speed, and safety in its implementation. There is no concern in this alternative with discharge of treated water. Some residual hazardous waste may be generated along with the pond liner which can be easily disposed of along with demolition debris. Therefore, this alternative is retained for detailed evaluation.

Off-site incineration is another promising cleanup method. It offers ease and rapidity of implementation, requires no monitoring of releases beyond that required of the incineration facility, and assures

destruction. Only minor hazards associated with handling and transport exist. Because of its favorable treatment effectiveness, off-site incineration will also be evaluated in detail.

A summary of the secondary screening of the treatment technologies is presented in Table 2-4.

2.5 FINAL CANDIDATE TECHNOLOGIES

Of the original candidate technologies, six can provide adequate destruction of hydrazine, MMH, UDMH, and NDMA and be implemented in a few months time. Of these six, four are found superior because of simplicity, treatment efficiency without the need for subsequent treatment, and rapid implementation. These four final candidate technologies are:

- o Ozone/UV
- o Hydrogen Peroxide/UV
- o Evaporation Pond
- o Off-Site Incineration

The first two of these require treatability studies to verify treatment effectiveness with the actual wastewater, and to identify key design parameters. These four technologies will be discussed in more detail in order to assess each and weigh their relative merits.

2.6 DETAILED EVALUATION OF TECHNOLOGIES

The four final candidate technologies, ozonation/UV, hydrogen peroxide/UV, evaporation pond, and off-site incineration, will be evaluated in detail. Components of the evaluation will include:

- o Conceptual Engineering

TABLE 2-4

SUMMARY OF SECONDARY TECHNOLOGY SCREENING

Technology	Criteria: Treatment Efficiency - Rate of Destruction, Destruction of Undesirable Intermediates, Process Simplicity
Chlorination/UV	Chlorinated intermediates formed which may not be rapidly or completely destroyed.
Ozonation	Destruction of hydrazine-related compounds assured but destruction of intermediates may be slow or incomplete.
Ozone/UV	Destruction of hydrazine compounds and intermediates assured; process is simple.
Hydrogen Peroxide/UV	Destruction of hydrazine compounds and intermediates highly probable; ease of implementation improved over ozone/UV.
Evaporation Pond	Destruction of hydrazine-related compounds highly probable; process is easily implemented; potential hazardous residues easily disposed.
Off-Site Incineration	Assured destruction of all contaminants and rapid implementation.

- o Human and Environmental Health Assessment
- o Cost Evaluation

2.6.1 Conceptual Engineering

Each final candidate alternative will be the subject of a conceptual engineering analysis. The level of detail will be such that all process components and a basic understanding of the operation will be known. This task will entail compilation of the following information:

- o Major Equipment Components
- o Accessory Equipment Required to Produce an Acceptable End-product
- o Preliminary Process Layout
- o Implementation Schedule
- o Monitoring Requirements

2.6.2 Human and Environmental Health Assessment

Based on the conceptual engineering analysis, a qualitative assessment of human and environmental health impacts will be provided. The cleanup operations may adversely impact cleanup workers, and the treated wastewater, if it is discharged, must not contain contaminants at concentrations which could adversely impact the environment or potential users of the water. The following issues have been considered in the initial screening and will be expanded as necessary in the detailed evaluation:

- o Efficiency and Reliability of Treatment

- o Production of Harmful Chemical Intermediates
- o Potential Releases and Short-term Exposure During Cleanup
- o Potential Hazard Should The Technology Fail
- o Acceptability and Long-term Health Impacts of the Final Products

2.6.3 Cost Evaluation

The conceptual engineering analysis will also provide the basis for the estimate of costs. The accuracy of estimates will be approximately ±30% in order to compare the final candidate technologies and to provide an indication of the actual cost. Costs will include capital and operation and maintenance expenditures. Most costs will be based on quotations from established, reputable suppliers, while the remaining costs will be derived from recent studies. Future expenditures will be discounted at 10 percent as recommended by OMB (USEPA 1985). Cost elements which will be included are:

- o Capital Equipment
- o Operation and Maintenance
- o Transport
- o Disposal
- o Chemical Supply
- o Engineering, Supervision
- o Contractor's Fees
- o Contingencies

2.7 CHEMICAL ANALYSIS AND TREATABILITY STUDIES

To assure that the most appropriate treatment technologies are investigated, it is necessary to perform chemical analyses on the wastewater. Previous analyses focused on the hydrazine compounds and

NDMA. However, these analyses may not be representative of the wastewater, as the contaminants may be stratified in the tanks and inground concrete tank. Furthermore, continued use of the water to rinse the fuel tanks and lines may have altered the composition. Because of the practice of decontamination using chlorination, the presence of chlorinated compounds is suspected. Thus, sampling and chemical analyses will be performed. Sampling will be conducted such that a sample representative of a container's entire contents is obtained or samples from different heights will be taken. Chemical analyses will include hydrazine, MMH, UDMH, NDMA, and representative chlorine compounds resulting from the chlorination of hydrazine compounds, such as chloroform and methylene chloride.

Concurrent with the wastewater treatment assessment study, treatability studies will be conducted to assess the destruction of the contaminants identified in the chemical analyses. The primary purpose of the treatability studies is to verify the effectiveness of ozone/UV and hydrogen peroxide/UV in oxidizing not only hydrazine compounds and NDMA, but also chlorinated contaminants, if present. Ozone/UV has been demonstrated as effective on simulated hydrazine, MMH, UDMH, and NDMA wastewaters (Neuman and Jody, 1986); however, the presence of other compounds may affect the treatment, so studies conducted on samples of the actual wastewater are required. Hydrogen peroxide/UV destroyed hydrazine to below detection levels in a simulated wastewater (Hager and Smith 1985); similar destruction of MMH, UDMH, and NDMA is likely achievable by this process, but this possibility must be confirmed in the laboratory, particularly with the actual wastewater.

Following determination of the general treatment effectiveness, additional batch studies will be conducted to identify key process variables. Contact time, UV dosage and lamp spacing, ozone or hydrogen peroxide dosage, and concurrent use of ozone or hydrogen peroxide and UV will be examined. These process variables are easily adjusted within any given treatment system by controlling flow rates, reactor

size, dosing, and detention time and may be scaled to virtually any size operation. Additionally, results are applicable not only to batch operations but also to continuous flow systems. Therefore, results from a lab scale, batch process will be useful for the configurations envisioned for the actual wastewater treatment operations.

2.8 RANKING OF TREATMENT TECHNOLOGIES

The detailed evaluation of technologies supplemented by the treatability study results will provide the information necessary to rank the technologies. The criteria to be used in the ranking will be:

- Treatment Performance, including contaminant destruction efficiency and rate, process reliability, and permanence of treatment.
- Implementation, including ease of mobilization, health and safety, compatability with overall site decommissioning, and operation and maintenance requirements.
- Cost, including capital expenditures, lease costs, operation and maintenance costs, and associated labor and fees to estimate the present worth.

The pertinent criteria will be established and weighted, and a composite score will be generated in order to rank the final candidate technologies.

3.0 DECOMMISSIONING ASSESSMENT

3.1 PURPOSE

The decommissioning assessment will provide input for the Arsenal-wide Feasibility Study. Eight major items must be addressed, as listed below:

- o Develop a current waste and operable equipment inventory
- o Specify a decontamination procedure
- o Identify equipment and support facilities
- o Identify residuals disposal options
- o Develop quality assurance and quality control procedures
- o Develop health and safety plan requirements
- o Establish a project schedule
- o Develop a preliminary cost estimate

These items are discussed in more detail in the following sections.

3.2 WASTE INVENTORY

3.2.1 Facilities and Equipment

A facilities and equipment inventory will be developed based upon a review of existing HBSF drawings and an on-site inventory of useful existing equipment. During the development of this inventory, equipment, structures, and facilities will be classified according to waste types or forms, and the division of financial responsibility between the Air Force Logistic Command and the PMO will be further refined based upon the existing division of responsibilities as described in Appendix A. An example of such an inventory form is presented in Table 3-1. The review of the drawings will provide the basis for preliminary waste material estimates and will also provide information on wastewater tank capacities, as well as connections between the tankage and the above and below ground piping and equipment.

TABLE 3-1

EXAMPLE OF A WASTE CLASSIFICATION CHECKLIST

Items	Condition	Responsibility

I. Buildings and Debris

A. Building 755 Change House
B. Building 759 Drum Cleaning
C. Building 760 Fork Lift Storage
D. Building 868 Storage Shed

II. Equipment

A. Mechanical and Civil

1. Piping and Fittings
   i. Process Equipment
   ii. Fire Protection
   iii. Other Utilities
      a) Severable
      b) Nonseverable

2. Piping Supports

3. Pumps

4. Tanks and Platforms
   i. Waste Water
   ii. Equipment

5. Propellant Blending and Scrubbing System
   i. Waste Water
   ii. Equipment

6. Nitrogen Inerting System
   i. Compressed Gases
   ii. Equipment

7. Heat Transfer System
   i. Ethylene Glycol
   ii. Equipment

8. Unloading/Loading Station

TABLE 3-1 (Continued)

EXAMPLE OF A WASTE CLASSIFICATION CHECKLIST

Items	Condition	Responsibility
9. Insulation i. Piping ii. Tanks iii. Buildings		
10. Foundations, Containment Areas, Vaults, Sumps and Roadways		
11. Railroad Track		
12. Fencing		
13. Miscellaneous Chemical Storage		
14. Decontamination Support Equipment and Facilities		
B. Electrical		
1. Telephone i. Poles ii. Lines iii. Miscellaneous Equipment		
2. Electric Power i. Transformer a) PCB Items b) Non-PCB Items ii. Miscellaneous Equipment a) Mercury Vapor Lamps b) Fluorescent Light Ballast c) Oil Filled Capacitors, Electrical Switch Gear, Etc. iii. Poles iv. Lines		

3.2.2 Soil

Soil samples analyzed as part of the Task 11 soil investigation contain no detectable hydrazine, MMH, UDMH, or NDMA (Bradbeer, 1986). Therefore, soil excavation will not be included as part of the facility decommissioning.

3.2.3 Wastewater

Wastewater removal, treatment, and disposal can be divided into three phases during the decommissioning of the HBSF. The first phase consists of handling wastewater that is presently in the hydrazine wastewater tanks and inground concrete tank. The second phase includes management of wastewater that may be generated from additional HBSF equipment cleansing and flushing. The third phase includes management of wastewater from the decontamination of workers, equipment and facilities used in the decommissioning of the HBSF. Current wastewater volumes can readily be defined from tank level readings and estimates of wastewater volumes in the process piping. Volumes of phase two and three wastewaters will be estimated based upon the decontamination methods specified in the decommissioning plan. Waste characteristics will be defined for the existing wastewaters by sample collection and analysis. For the phase two and three wastewaters, it will only be possible to estimate waste characteristics based upon an evaluation of flushing and decontamination procedures.

3.2.4 Additional Sampling

It is anticipated that the waste inventory may reveal the need for additional sampling at the HBSF. This sampling is expected to be required for the following items and reasons:

- Unsampled transformers to determine whether or not PCB fluids are present;

- o Ethylene glycol in the heating system due to regulatory restrictions placed on the disposal of liquid hazardous waste in landfills; and
- o Asbestos in piping, tank, and building insulation to determine the need for personnel monitoring and handling and disposal requirements during demolition.

Although this sampling is not crucial to the development of a detailed decommissioning plan for the HBSF facility, it can help to define the extent of problems that may be associated with these materials.

3.3 DECOMMISSIONING PLAN DEVELOPMENT

3.3.1 Hazard Reduction Plan

The initial goal of the HBSF decommissioning effort is to reduce the hazards associated with the HBSF chemical contaminants. This plan is envisioned as a four step process of equipment cleaning, asbestos removal, other organic liquid removal, and wastewater treatment and disposal. These steps would comprise individual components of the overall cleanup. These steps are consistent with plans for reducing the personnel protective clothing from level B requirements to a level C or modified level D. Chemical hazards will be defined and evaluated so that decontamination plans can be developed to clear the site of hazardous materials prior to dismantling and demolition. RMA activities to date have cleared HBSF of known hydrazine fuel. The interior of fuel tanks and piping has been flushed with existing wastewater, and the horizontal tanks, loading arms, and connecting piping have been flushed again with a hypochlorite solution.

The disposal of hydrazine wastewater is an important step in the decommissioning process. This activity will establish the wastewater treatment and disposal needs for the overall decommissioning plan. The wastewater will be treated by processes identified during the wastewater treatment assessment. The recommended choices for wastewater treatment and disposal will be incorporated into the decommissioning plan.

3.3.2 Severable Facilities and Equipment (Above Ground)

This activity will establish the need for additional cleaning and flushing of equipment, tank and piping interiors. Work zones will be established for exclusion, contaminant reduction, and support activities. In addition to work zones, the site may be divided into sectors to facilitate the sequencing of the demolition work. Acceptable dismantling and demolition methods will be developed, but every effort will be made to give the demolition contractor maximum flexibility in approaching this project. In general terms, the demolition process will include pretreatment of contaminated residues; dismantling and removal of structures; demolition; debris collection; and waste treatment and/or disposal. Having developed acceptable dismantling and demolition methods, a sequence will be established for the demolition process for both hazardous material handling and, perhaps, a sector by sector decommissioning of equipment and structures. With the methods established for severable equipment decommissioning, the storage and transportation requirements will be determined for the decontaminated waste. All severable decontaminated equipment is assumed to be disposed of at a hazardous waste landfill.

3.3.3 Nonseverable Facilities (Surface and Below Ground)

This activity will evaluate decontamination methods for nonseverable facilities. The nonseverable facilities include roadways, railway, foundations, and below ground utilities. Methods of demolition and removal will be established again with an effort to permit maximum flexibility in the choice of demolition methods by the contractor. The sequence of removal will be coordinated with the removal of severable equipment. Storage and transportation requirements for the wastes will be determined and the wastes will be disposed of as if they were hazardous materials.

3.3.4 Site Restoration

Having decontaminated and demolished the HBSF, site restoration will begin. The first step in this activity is for the off-site piping, electrical and telephone lines and poles to be secured. The removal of fences and decontamination of decommissioning equipment is another step in site restoration. In addition to these steps, revegetation and grading/fill plan criteria will be developed for the site. Post cleanup care and monitoring efforts will also be established.

3.4 EQUIPMENT AND SUPPORT FACILITIES

This activity will identify equipment and support facilities needed to perform the HBSF decommissioning. It is anticipated that both heavy equipment, cranes, front end loaders, back hoes and steam cleaners will be used for the demolition and excavation work. Along with the equipment, there are personnel support requirements such as trailers, decontamination showers and staging areas, and air and water supplies.

3.5 RESIDUAL DISPOSAL

This task will investigate the acceptable methods for disposal of wastewater and solid waste. It is anticipated that the wastewater treatment assessment will describe the disposal needs for the chemical wastewater.

3.6 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Quality assurance/quality control procedures will be developed during this task. These procedures will involve sampling and analysis and construction supervision as well as allocation of costs to the Air Force Logistic Command and PMO-RMA. These procedures will be based upon existing RMA quality assurance and quality control procedures to ensure adherence to safe working practices and proper demolition and disposal of hazardous wastes.

3.7 HEALTH AND SAFETY PLAN REQUIREMENTS

A health and safety plan will be developed under the direction of a Certified Industrial Hygienist; however, RMA specific guidelines will be followed in relation to the particular hazards and site safety concerns of the HBSF. This activity will use the RMA Health and Safety Plan (HASP) to develop a sample HASP for contractor guidance. The HASP will cover personnel training, medical surveillance, personnel protective equipment, and site safety issues.

3.8 SCHEDULE

A schedule will be developed for the decommissioning activities, which will consist of hazard reduction (including wastewater treatment), dismantling and demolition of equipment, waste transportation and disposal, and site restoration. Details of the schedule will depend on the specific decommissioning operations developed.

3.9 PRELIMINARY COST ESTIMATE

A preliminary cost estimate for HBSF decommissioning will be developed based on demolition calculations, decontamination takeoffs from existing HBSF plans, and unit costs. This effort will assist in the development of plans for the HBSF decommissioning. As much as possible, the existing RMA drawings and aerial photographs will be used to accomplish the cost estimation work.

4.0 FINAL REPORT

The results of the wastewater treatment assessment, decommissioning plan development, and the treatability study(s), will be incorporated in discrete sections into the detailed HBSF Wastewater Treatment and Decommissioning Assessment Report. Each assumption, criteria, approach, information source, basis for decision, and conclusion will be clearly documented to allow questions and/or comments to be directed toward specific portions of the study rather than the study in general. This report will be reviewed by PM-RMA and other agencies as appropriate.

The HBSF Wastewater Treatment and Decommissioning Assessment Report will generally follow the outline of this technical plan. The wastewater treatment assessment and decommissioning plan sections will be expanded to accommodate the information generated during this effort.

5.0 FIELD SAMPLING PROGRAM AND CHEMICAL ANALYSIS PROGRAM

5.1 FIELD SAMPLING PROGRAM

The recent flushing of the HBSF tanks and piping with stored wastewaters followed by flushing with a sodium hypochlorite solution (James 1985) may result in a wastewater with different characteristics from those identified in previous studies (See Section 1.4). To ensure meaningful results from the wastewater treatment assessment, duplicate samples from each of the wastewater tanks will be obtained and analyzed after completion of the flushing and cleansing operation.

Should wastewater treatability studies be required, additional samples (large volume) will be collected and transported to the designated laboratory.

5.2 CHEMICAL ANALYSIS PROGRAM

Wastewater samples from the two wastewater storage tanks, and treatability study samples (if necessary) will be analyzed for the hydrazine-related parameters identified below. Additional parameters may be recommended following the results of the wastewater treatment screening process.

Hydrazine
1,1-Dimethylhydrazine (UDMH)
Methylhydrazine (MMH)
N-Nitrosodimethylamine (NDMA)

Table 5-1 identifies the analytical method, detection limit, high range concentration, sample holding time, level of certification, reference method and method principal for the parameters of interest.

TABLE 5-1

ANALYTICAL METHODS/LIQUID MATRIX FOR TASK 34

Analysis/Matrix/Analytes	Detection Limit*	High Range Concentration[a]	Hold Time	Level of Certification	Reference Methods	Principle of Method[b]
Hydrazines/Water						
Hydrazine	2.5 ug/l	100 ug/l	7 days	Quantitative	Developed by UBTL for USATHAMA certification	Coloring reagents are added to 10 - 15 ml of an acidified liquid sample. The resulting solution is analyzed with spectrophotometric methods at characteristic wavelengths.
1,1-Dimethylhydrazine	20 ug/l	100 ug/l	See (1)			
Methylhydrazine	25 ug/l	100 ug/l				
Nitrosamines/Water						
N-Nitrosodimethylamine	0.5 ug/l	50 ug/l	7 days (2)	Quantitative	EPA 607(2)	Approximately 1 liter of water is extracted 3x with 60 ml methyline chloride by shaking for 30 seconds in a separatory funnel. The combined extract is washed with HCl (1:1) to remove free amines, dried and concentrated. Concentrate is cleaned on a florisil column and assayed by GC/NPD on a chromosorb W-AW (80/100 mesh) 10 percent carbowax column.

*Actual detection limits for certified methods are identified in Volume IV of the RMA Procedures Manual (Project Specific Analytical Methods Manual) for each laboratory. Detection limits for uncertified methods and methods to be certified are desired detection limits.

a Reflects an estimate of the linear range of the method and is proposed to minimize dilutions.
b To be developed during USATHAMA Phase II certification.

References:
(1) ESE-AMP.2-UD-H_2O.1, July 22, 1982.
(2) EPA SW-846, 2nd ed., "Test Methods for Evaluating Solid Waste".

Sample shipping and holding temperatures are indicated in the QA/QC plan (see Volume II of the RMA Procedures Manual). Analytical methods for worker exposure (e.g., volatile organics in air) will not be USATHAMA Certified. Data from these samples will be used as an initial assessment to identify the potential for worker exposure to organic vapors.

All liquid matrix methods will be USATHAMA Certified at the quantitative level. Referenced methods have been prepared in a specific USATHAMA format as per the instructions of the PMO by the program contractor laboratories.

Hydrazine, MMH, and UDMH by Colorimetric Analysis

The colorimetric technique for hydrazine analysis is based on the ASTM method D1385 for hydrazine in industrial waters. In this method, the color reagent paradimethylaminobenzaldehyde is added to 10 ml of liquid sample. The resulting colored complex is analyzed in a spectrophotomer utilizing 458 nm wavelength light. The USATHAMA certified detection limit is 2.5 ppb.

The MMH liquid analysis technique is derived from NIOSH method S-149 for MMH in air. Phosphomolybdic acid is added to 15 ml of an acidified water sample. Spectrophotometric readings are taken at 730 nm wavelength. The USATHAMA certified detection limit is 20 ppb.

The USAFSAM report TR-82-89, Field Sampling and Analysis of Hydrazine and UDMH Vapors in Air: The Firebrick Method, provides the basis for the analysis of UDMH in water. A 15 ml sample is acidified and buffered with citric acid phosphate buffer prior to addition of trisodium pentacyanoaminoferrate. The resulting solution is analyzed at 500 nm wavelength using spectrophotometry. The certified detection limit is 25 ppb.

Nitrosamines in Liquid Samples by Gas Chromatography (GC)

This gas chromatography (GC) method was developed from EPA method 607 (EPA 600/4-82-057) and will be USATHAMA certified at the quantitative level.

In the method one liter of the sample will be obtained with a minimum of handling and shaken for 30 seconds with 60 ml methylene chloride. The organic layer is allowed to separate from the water phase for ten minutes, then filtered through glass wool into a 250 ml Erlenmeyer flask. The extraction/filtration procedure is repeated for a second and third time. All three extracts are combined in an Erlenmeyer flask. These combined extracts are washed with 10 ml dilute HCl (1:1) to remove free amines, dried with anhydrous sodium sulfate and concentrated in a Kuderna-Danish (K-D) apparatus to a volume of 10 ml or less for storage.

Prior to analyses the extract is concentrated to 2 ml in a K-D apparatus. Concentrated extract is cleaned on a florisil column and assayed by gas chromatography on a chromosorb W-AW (80/100 mesh) coated with 10 percent carbowax column using a nitrogen phosphorous detector.

6.0 QUALITY ASSURANCE PROGRAM/DATA MANAGEMENT PROGRAM

6.1 PROJECT QA/QC PLAN

An integral part of the Technical Plan is the project specific Quality Assurance/Quality Control (QA/QC) Plan describing the application of PMO procedures to monitor and control field and analytical efforts, and monitor and control data acquisition and design efforts at RMA. For Task 34, personnel will adhere to and comply with the established QA/QC requirements. The plan is presented in the RMA Procedures Manual. The specific objectives of the Quality Assurance Program for RMA are to:

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

The overall project QA/QC responsibility rests with the Project QA/QC Coordinator, who will be assisted by the Field and Laboratory QA/QC Coordinators. The Field QA/QC Coordinator will assure that all quality control procedures are implemented for sampling, field blanks, duplicate samples, chain-of-custody and documentation.

6.2 SPECIFIC PROJECT REQUIREMENTS

6.2.1 Field Sampling

The management of samples, up through the point of shipment from the field to the laboratory, will be under the supervision of the Field QA/QC Coordinators (FQA/QC). 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/QC Plan describes the procedures to monitor adherence to approved sampling protocol. If the FQA/QC 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 FQA/QC is responsible for field chain-of-custody documentation and transfer and will supervise the strict adherence to chain-of-custody procedures.

6.2.2 Laboratory Quality Assurance Procedures

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

The samples must be analyzed within the prescribed holding time by the approved analytical methods. Analytical methods are described in Section 5.0 of the Technical Plan.

6.2.3 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/QC Plan.

6.2.4 Laboratory Data Management, Data Review and Validation and Reporting Procedures

Sections 13 to 16 of the Project QA/QC 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/QC Plan which is based on the established PMO reporting procedures for analyses performed at quantitative and semi-quantitative levels. Target compounds will be reported by formatting analytical data onto USATHAMA standardized coding forms. The laboratories will adhere to these reporting procedures.

6.3 DATA MANAGEMENT PROGRAM

The data management aspects of this task will generally be limited to the wastewater analyses and other sampling which may be required, such as for PCB and asbestos. Data from laboratory analyses will undergo a sequence of collection, validation, and storage QA/QC checks. Any data transfer or reduction will be accompanied by validation of the transfer or computations and will include statistical analysis when appropriate. In addition, the representativeness, completeness, and comparibility of sample data will be assessed.

7.0 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 wastewater sample collection activities during Task 34. 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.

In particular, the following specifics of this document are especially important to Task 34 sample collection 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;

- Assuring that adequate and appropriate safety training and equipment are available for project personnel;

- Arranging for medical examinations for specified project personnel;

- Arranging for the availability of on-site emergency medical care and first aid, as necessary;

- Determining and posting locations and routes to site work zones;

- 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

- 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, whose 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 the HASP.

Based on the evaluation of past activities, incidents, accidents and investigations, the presence of chemicals and wastes may be found in the area surrounding the wastewater storage tanks, and definitely in the wastewater itself. The characteristics of these wastes are known to be toxic and hazardous to human health. The conclusion of the site hazard assessment based on historical evidence is that the overall site hazard assessment is extremely variable and is entirely location and operation dependent. Section V of the HASP describes the procedures to

be employed to determine the 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). A hotline for operations within the HBSF will be established as the fence line of the HBSF. All areas beyond the CRZ will be considered the Exclusion Zone. For wastewater sampling the Exclusion Zone will be established as a 30 foot radius from the tanks. 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 the Facility Information

Sheet (FIS). The preliminary 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. All operations targeted within the HBSF will be conducted in level "B" protective equipment. Level "B" protection requirement is based on several factors including: previous data for the area indicating the need for level "B"; an extremely low Threshold Limit Value (TLV) of 0.1 ppm for hydrazine (ACGIH 1985); and the absence of a non-SCBA type respirator for hydrazine. In the case of all but the geophysical survey operations, the level "B" protection will employ the use of dual purpose SCBA used mainly in the airline mode. This will include the technician assigned the responsibility of tending the breathing air cascade manifold system. Dual purpose SCBA will provide the necessary mobility to the field team in order to stage equipment down range and deploy the cascade manifold system. It should be noted that the breathing air tender will have his own breathing air cylinder separate from the cascade system due to equipment limitations. The geophysical survey within the confines of the HBSF will be conducted at level "B" using SCBA because of the necessary mobility associated with the task. If determined necessary, changing to Level C or A protection can be easily achieved in the field in a matter of hours. Basic level of protection (i.e., Levels A, B, C or D) for general operations are defined in Section VII.

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

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

For external communication telephones and sirens will be utilized.

Section VIII of the HASP 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 agents;
- 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 Tenax and acid washed fire brick sampling media. 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 outside of the HBSF; 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.

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 wastewater survey to be conducted for the HBSF area will be similar to that which has been conducted for other RMA tasks, with the exception that these will be conducted under level "B" protection. Because of the need to change SCBA bottles, or use air lines, this operation will require significant logistical support. In addition, it should be noted that the advanced training requirements apply in this situation.

An investigation of useful equipment for the HBSF area will be performed. Precautions similar to those employed for sampling will be employed.

In addition to the wastewater sampling and treatability studies, additional sampling described in Section 3.2.4 may be considered to fast track the program. As in the case of wastewater sampling, all fluids and solids produced must be collected for subsequent disposal and the employees must be protected from making contact with those same fluids and solids. Monitoring of each tank will precede this operation and personnel sampling will be performed.

The mobile decon trailer will be stationed in the CRZ, outside and upwind of the HBSF during the course of all operations conducted within that area. While hydrazine and its products are not considered "Army Agents" the same decon solutions that have been used to neutralized

potential agent contamination will be used for the hydrazine group. The H&S Supervisor will assure that those decon solutions are placed at both the gross boot and glove wash stations of the decon line.

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.

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APPENDIX A

MEMORANDUM OF UNDERSTANDING BETWEEN PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP AND HEADQUARTERS, AIR FORCE LOGISTICS COMMAND

MEMORANDUM OF UNDERSTANDING
BETWEEN
PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP
AND
HEADQUARTERS, AIR FORCE LOGISTICS COMMAND

SUBJECT: HYDRAZINE BLENDING AND STORAGE FACILITY DECOMMISSIONING AND CLOSURE

1. PURPOSE

The purpose of this Memorandum of Understanding is to delineate the management, technical, and financial responsibilities for the decommissioning and closure of the Hydrazine Blending and Storage Facility (HBSF) at Rocky Mountain Arsenal.

2. REFERENCES:

a. InterService Support Agreement, No. W51 QP5-81290-003, between RMA and the Directorate for Energy Management, San Antonio Air Logistics Center, Kelly AFB.

b. Meeting at Rocky Mountain Arsenal - 10 December 1985, Subject: Hydrazine Blending and Storage Facility Closure Plan.

3. GENERAL:

a. Rocky Mountain Arsenal has operated the Hydrazine Blending and Storage Facility under the InterService Support Agreement's (ISSA's), with Director of Energy Management, San Antonio Air Logistics Center, Kelly AFB, since 1960. In September 1982, RMA was advised by Director of Energy Management, AFLC, of their plan to phase out the HBSF at RMA. Subsequent actions by RMA and the Air Force have been directed towards this goal.

b. On 8 July 1985, the concept plan establishing the Program Manager for RMA Contamination Cleanup as the central manager of all RMA contamination cleanup activities to include the HBSF closure, was approved by Department of the Army.

c. The reference b meeting was held to review and discuss the HQs, AFLC Plan of Action for Severable Equipment Dismantlement at the HBSF and to develop a coordinated DA/AF plan for the preparation of the closure plan. At this meeting it was agreed by both HQs AFLC and the PM for the RMA cleanup representatives that, in order to delineate the management, technical, and financial responsibilities of each party, a Memorandum of Understanding should be established between the parties.

4. APPLICABILITY:

This Memorandum of Understanding applies to all work efforts required for the decommissioning and closure of the HBSF at Rocky Mountain Arsenal. This MOU does not apply to any current or future remedial investigations or remedial actions conducted at RMA by the Program Manager for RMA cleanup which are outside the HBSF area, to include such areas as:

a. The rail storage siding north of the HBSF.

b. The furnace in B-538 previously used to dispose of off-specification hydrazine.

c. The underground piping from the HBSF to the chemical sewer north of B-538.

d. Ground water contamination assessment and remedial action, if required, within the HBSF area.

5. RESPONSIBILITIES:

a. Program Manager for RMA Contamination Cleanup will:

(1) Act as Project Manager providing overall project guidance, coordination and direction for the decommissioning and closure of the HBSF.

(2) Coordinate with the Air Force all Scope of Works, technical work plans, and the other technical/project documentation for Air Force funded work efforts.

(3) Provide overall technical direction foR the remedial action work effort, incorporating technical guidance provided by the Air Force for the Air Force funded work efforts.

(4) Prepare Scope of Work and contract for both Army and Air Force; contractual work efforts required for closure.

(5) Administer all contractual efforts involved in closure and provide technical expertise and assistance to contractors as required.

(6) Approve all technical plans prepared and submitted by contractors for all closure work efforts, incorporating Air Force technical guidance concerning Air Force funded work efforts.

(7) Provide justification and obtain funding for the Army portion of the closure effort as delineated under Financial Responsibilities.

(8) Monitor the Environmental program for the HBSF and prepare and submit all required Environmental documentation.

b. Headquarters, Air Force Logistics Command will:

(1) Provide project guidance, coordination, and technical direction to all Air Force elements involved in the decommissioning and closure of the HBSF.

(2) Act as technical consultant and represent the Air Force for all coordination, review, and concurrence of project/technical documentation submitted to the Air Force by the Program manager for RMA Contamination Cleanup for Air Force funded work efforts.

(3) Provide technical expertise and assistance to the Program Manager for RMA Contamination Cleanup, if required, concerning remedial action closure efforts involving Air Force funded work efforts.

(4) Review and approve technical plans prepared and submitted to the Program Manager for RMA Contamination Cleanup for Air Force funded work efforts.

(5) Provide justification and obtain funding for the Air Force portion of the closure work efforts as delineated under Financial responsibilities.

(6) Provide technical procedures for the removal of remaining fuel at RMA and the initial decontamination of the fuel distribution and storage system.

(7) Monitor closure plans and work efforts insuring that all applicable Air Force policies, procedures, and regulations are complied with.

6. FINANCIAL PLAN:

a. The Air Force shall be responsible for providing funds required to implement the Air Force designated decommissioning and closure work efforts as described in the appendix.

b. The Program Manager for RMA Contamination Cleanup shall be responsible for providing funds required to implement the Army designated decommissioning and closure work efforts as described in the appendix.

c. The Program Manager the RMA Contamination cleanup will provide initial funding for the preparation of a decontamination plan and associated Scope of Work for the contractual effort required to decommission and close the HBSF.

d. The Air Force will reimburse the Program Manager for RMA cleanup for their share of the cost to develop the decontamination plan and SOW required for the contractual effort to decommission and close the HBSF based on the relative cost of each parties work effort to decommission and close the HBSF.

e. The Program Manager for RMA Contamination Cleanup will provide to the Air Force the cost to develop the decontamination plan and SOW and a cost estimate for each party's work effort to decommission and close the HBSF when the decontamination plan and the SOW have been completed.

7. INTERSERVICE SUPPORT AGREEMENT:

The current ISSA (reference a) between RMA and the Directorate for Energy Management, Kelly AFB provides for RMA support to operate and maintain the HBSF. This agreement shall remain in effect during the decommissioning and closure work effort until RMA support is no longer

required. Modifications to the ISSA may be negotiated during this timeframe. Any modifications to the ISSA shall be approved by the Program Manager for RMA Contamination Cleanup.

8. TERM:

This Memorandum of Understanding is effective as of the date of the last signature and will remain in effect until all decommissioning and closure actions have been completed and the area certified closed in accordance with applicable regulations or until it is terminated by mutual consent of both parties.

APPENDIX A

HYDRAZINE BLENDING AND STORAGE FACILITY
DECOMMISSIONING AND CLOSURE
FINANCIAL RESPONSIBILITY

1. Headquarters, Air Force Logistic Command will have financial responsibility for the following work efforts required in the decommissioning and final closure of the HBSF at RMA.

   a. The dismantlement, decontamination and final disposal of all severable equipment to include the following:

      (1) All propellant storage tanks and associated platforms.

      (2) All propellant pumps, piping, and pipe support, to include piping and piping supports connecting main plant with east storage area.

      (3) Propellant blender and scrubber equipment, associated piping, controls, weather cover.

      (4) All waste water storage tanks and associated platforms, at east end of facility including scrubber, piping, pumps, and piping supports.

      (5) Nitrogen pressurization system except supply tank which is leased equipment.

      (6) Propellant heating system (heating equipment and piping, controls).

      (7) All unload/loading stations (truck, railcar, drums).

(8) All above ground electrical distribution systems within HBSF (conduit, junction boxes, poles, wire, transformers, controls), including electrical distribution system at east storage tank area.

(9) Waste sump pump, piping and metal fencing around sump.

(10) All above ground fire protection system and fire inground vault equipment, piping, and electrical controls.

b. The treatment (if required) and final disposal of all hyrazine/UDMH/NDMA contaminated waste water generated during dismantlement, decontamination and disposal of above severable equipment.

c. The treatment (if required) and final disposal of all hydrazine/UDMH/NDMA contaminated waste water currently in storage at the HBSF (estimated at 254,000 gallons).

2. Program Manager for Rocky Mountain Arsenal Contamination Cleanup, will have financial responsibility for the following work efforts required in the decommissioning and final closure of the HBSF at RMA.

a. All below ground piping, electrical conduits, equipment/piping foundations, sumps, vaults, concrete/asphalts pads, etc. to include the following:

(1) All propellant and waste water tank concreted foundations, pads, and dikes.

(2) All concrete foundations for equipment and pipe supports.

(3) All concrete and asphalts pads throughout facility to include drum storage area.

(4) All underground piping to include potable water supply, fire protection water supply, and waste water piping and connections throughout main plant and east storage area.

(5) All underground electrical conduits.

(6) Above ground electrical supply to primary transformers located at B-755 and to the primary transformer in the east area.

(7) The railroad track and associated foundation within the facility to include replacement of track if required.

(8) All support buildings to include B-755 change house, B-759 drum cleaning, B-T-868C storage shed, and B-760 Fork lift storage.

(9) Double fencing around main plant and east storage areas.

(10) Above ground steam supply piping supports to B-755.

(11) Perimeter earthen security roads between fences around hydrazine main plant and east area.