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THE OBJECTIVE OF THE PRESENT TASK IS TO CONDUCT CONTAMINATION SURVEYS AND REMEDIAL ACTION ASSESSMENTS FOR THE SOUTH PLANTS AREA. THE CONTAMINATION SURVEYS ARE DESIGNED TO 1) ASSESS THE DEGREE AND TYPES OF CONTAMINATION WITHIN THE SOUTH PLANTS AREA AND 2) SUPPORT THE DEVELOPMENT AND ASSESSMENT OF FEASIBLE REMEDIAL ACTIONS. THE FOCUS OF THE STUDY WILL BE CONTAMINATION SOURCES RATHER THAN CONTAMINANT PATHWAYS. THUS, THE ACTIVITIES TO BE CONDUCTED WITHIN THE SCOPE OF THIS TECHNICAL PLAN WILL CONSIST PRIMARILY OF THE COLLECTION OF SOIL SAMPLES AND VARIOUS BUILDING SAMPLES FOR CHEMICAL ANALYSIS. BASED ON THE RESULTS OF CHEMICAL ANALYSES, THE SEVERITY AND SIGNIFICANCE OF CONTAMINATION WILL BE ASSESSED. IN A PARALLEL EFFORT, EBASCO WILL IDENTIFY VIABLE REMEDIAL ACTION MEASURES AND ASSESS THEIR COST-BENEFIT IMPLICATIONS.

SECTIONS OF THIS REPORT DETAIL INFORMATION ON THE FOLLOWING PLANS:

1. FIELD SAMPLING
2. CHEMICAL SAMPLING

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AUGUST 1985
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TASK NO. 2 (SOUTH PLANTS)
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1.0 INTRODUCTION

1.1 Description of the RMA Problem

The Rocky Mountain Arsenal (RMA) is located in western Adams County, northeast of Denver, Colorado. RMA was established in 1942 as a manufacturing facility for the production of mustard gas. Subsequent military uses included the production, handling, or demilitarization of GB nerve agent, Lewisite, arsenous chloride, chlorine, cyanogen chloride (CK), phosgene (CG), and incendiary bombs. In 1946, excess facilities at the South Plants area were leased by the Julius Hyman Co. for the production of insecticides. The chemical division of the Colorado Fuel and Iron Company leased several facilities in the South Plants area in the early 1950's. Products manufactured by CF&I included chlorobenzene, DDT, naphthalene, chlorine, and fused caustic. In the early 1950's, the Shell Chemical Company (SCC) began insecticide production in leased facilities within the South Plants area, generally as successor to the Julius Hyman Co. This activity continued until recent years, and SCC still leases facilities at the South Plants area. SCC has also reportedly constructed 66 buildings and 108 tanks in the South Plants area.

The industrial wastes from all operations of the government and its lessees were initially discharged just north of the South Plants area into Basin A, an unlined basin in Section 36. Subsequently, wastes were discharged into four other unlined basins, as well as Basin F which was constructed with an asphalt liner. Some of the basins, pits, burn sites, sewers, and structures (buildings, pipes and tanks) became sources of ground-water contamination.

In 1954, farmers near RMA claimed that their crops had been damaged by ground water used for irrigation. In May of 1974, diisopropylmethylphosphonate (DIMP) and dicyclopentadiene (DCPD) were detected in surface water at the northern boundary of the arsenal. Later that year the Colorado Department of Health (CDH) detected DIMP in a well north of the arsenal. As a result, the CDH issued cease and desist orders in April, 1975, directing SCC and RMA to immediately stop the off-post discharge of DIMP and DCPD in surface and subsurface water.

As a result of the COH cease and desist orders, a contamination control program at RMA was established to insure compliance with Federal and State environmental laws. As a result of this program, sources of contamination have been identified, pathways by which contaminants migrate into the environment have been delineated, and three ground-water treatment systems have been installed at the northern and northwestern boundaries of RMA to intercept, treat, and replace contaminated ground water.

Two law suits have been filed as a result of the contamination at RMA. The first suit was filed by the Department of Justice on behalf of the Department of the Army against Shell Chemical Company for reimbursement of environment response costs and for damage to the natural resources at RMA. The second suit was filed by the State of Colorado on behalf of the Colorado Department of Health against the Shell Chemical Company and the U.S. Department of the Army for environmental damages both on and off RMA.

1.2 South Plants Area

1.2.1 Building Usage

More than 300 buildings, tanks, and foundations have been identified in the South Plants area. The Army used the South Plants for the production, filling and storage of mustard, lewisite, phosgene, white phosphorous, chlorine, incendiary mixtures, hydrazine, and explosive button bombs. Since 1946, parts of the South Plants have been leased to private companies for the manufacture of chlordane, DDT, dieldrin, aldrin, and other pesticides. Shell Chemical Company, which has leased several of the South Plants buildings for almost 40 years, has also constructed over 150 buildings and tanks in the South Plants area. Additional details regarding the usage and nature of buildings and other structures in the South Plants area are given in Appendix A of this Technical Plan.

1.2.2 Waste Disposal

Most of the waste products generated at the South Plants area were disposed of in Section 36. Liquid wastes were conveyed by ditches and pipelines to

Basin A, and later to Basin F. Potentially contaminated surface water runoff was channeled through drainage ditches toward the Sand Creek lateral and Upper and Lower Derby Lakes. Solid wastes were generally buried in pits or trenches in Section 36, although some disposal pits and trenches were occasionally dug in the South Plants area. A salt storage area and two sanitary landfills were also located in the South Plants area. Further details regarding waste-disposal practices in the area are given in Section 3.3.

1.2.3 Groundwater Conditions

The ground-water conditions in the South Plants area are quite complicated. The movement of contaminants is affected by the existing ground-water mound, interaquifer flow between the alluvium and the Denver Formation, ground-water and lake interactions, and surface-water ground-water interaction.

The major water bearing geologic formations in the South Plants area consist of the alluvium and the Denver Formation. The alluvium consists of clay, silt, sand and gravel. The underlying formation is the Denver Formation, which consists of carbonaceous shale and claystone with sandstone and siltstone lenses.

A water-table mound, believed to have been created by leaking water lines, has formed below the South Plants area with flow lines radiating out from the top of the mound in all directions. A ground-water divide (or no-flow boundary) has been created at the confluence of the regional flow system and that of the mound. As a result, underflow entering RMA from the southeast is forced to turn either east or west around the South Plants area. Water flowing south from the mound area is forced to change direction. As the regional underflow moves away from the mound, flow is toward the west to northwest and the northeast.

Vertical flow conditions also occur under the Arsenal. The results of different programs indicate that there is much interchange of ground water between the stringers of Denver Sands and the alluvium.

In addition, many of the analyses of subsurface fluids in the South Plants area indicate high concentrations of hydrocarbon products such as benzene. Petroleum products, such as benzene, are less dense than and are relatively immiscible in water (there are also products, such as carbon tetrachloride, that are more dense than water and sink to the bottom of the aquifer). As a consequence of this, the product itself, oil or its derivative, migrates in the unsaturated zone, above the water table. At the water table, some of the product does go into solution, and then migrates with the ground water.

1.3 Summary of Technical Approach

The objectives of the present task are to conduct contamination surveys and remedial action assessments for the South Plants area. The contamination surveys are designed to assess the degree and types of contamination within the South Plants area, and to support the development and assessment of feasible remedial actions. Although ground water has been determined to be the principal environmental pathway for contamination from RMA and SCC facilities, the current study will focus on the sources of contamination at the South Plants area rather than contaminant pathways. Consequently, the activities to be conducted within the scope of this Technical Plan will primarily consist of the collection of soil samples and various building samples for subsequent chemical analysis. A limited number of new ground water monitoring wells will also be constructed in areas where ground-water contamination is believed to be likely but where previous investigations may have been inadequate to characterize local ground-water contamination. Soil samples will generally be collected from the unsaturated zone extending from land surface down to the local water table. However, where contamination sources may lie below the water table (e.g., trenches or buried pipelines), soil samples will be collected from the saturated zone below the water table. Building samples will be taken from dust during Phase IA and liquids, tanks, vats, sumps, sewer lines, and other sources during Phase IB. Ground-water samples will be collected from those new monitoring wells installed in the South Plants area during the course of this activity.

Based on the results of chemical analyses, the severity and significance of contamination will be assessed according to criteria developed by a separate joint group of experts designated by USATHAMA. In a parallel effort, Ebasco will identify viable remedial action measures and assess their cost-benefit implications. Based on these considerations, feasible remedial action alternatives will be determined.

2.0 EVALUATION OF BACKGROUND DATA

2.1 Data Compilation

2.1.1 Initial Site Reconnaissance

Between October 29 and November 2, 1984, several members of the Ebasco team including representatives from Ebasco, R.L. Stollar and Associates, Geraghty & Miller, Inc., and Technos, Inc., visited RMA. The purposes of these visits were to allow Ebasco project team members to meet with their counterparts from RMA; to begin to initiate activities required for mobilization of field sampling teams, decontamination facilities, and health and safety activities at the South Plants area; to begin to coordinate field activities between Ebasco and ESE; and to afford Ebasco team members an overview of RMA and the South Plants areas by driving and walking through those areas.

On October 29, 1984, members of the project team toured the western half of RMA by automobile. The team viewed the Section 36 and Basin A areas from 8th Avenue, the Basin F area from D street, the north boundary groundwater treatment system and the northwest boundary groundwater treatment system, the South Plants area, and Lower Derby Lake. On October 30, 1984, members of the project team toured the South Plants area on foot, generally walking along areas of paved streets and parking lots, viewing buildings and other facilities from the exterior. This tour was conducted by Mr. Kevin Blose of USATHAMA. On November 1, 1984, a smaller group of Ebasco project team members again toured the South Plants area on foot, this time accompanied by Dr. William Trautmann of RMA. Again, this tour was generally limited to viewing the exteriors of buildings and other facilities from paved roadways, walkways, and parking lots.

During the course of meetings at RMA, Ebasco project team members met with members of the RMA Safety Office, Security Office, Communications Office, Escort and Disposal Detachment, Technical Operations, and Installation Services, including the Facilities Engineering Division and the Fire Prevention Branch. Project team members also visited the RMA Information

Center (RIC), receiving an orientation into the use of RIC as well as registration as users of RIC. During the walking tours of the South Plants area, project team members, particularly those involved in the development of this Technical Plan, had the opportunity to observe the wide variety of facilities, building materials, tanks, vats, piping, and other structures within the South Plants area, as well as selected individual contamination sources within the South Plants area (for example, the salt storage area and the lime pond).

2.1.2 Literature Review

In addition to the site reconnaissance visit and discussion with RMA personnel during the week of October 29-November 2, 1984, the project team has also compiled and reviewed a large number of documents detailing the buildings and activities within the South Plants area. A bibliography of references consulted and cited in this report is given in Appendix A. In general, these documents have been reviewed in order to provide us with as complete as possible a picture of the construction, nature, use, history, and probable contamination at each of the buildings and other structures in the South Plants area. Particular attention has been paid to records of any spill occurrences within the South Plants area as well as records of any decontamination operations at any of the facilities. For example, buildings used by RMA for manufacture of chemical warfare agents were decontaminated prior to their being leased to Shell Chemical Co. and other lessees at the South Plants area. Where possible, attempts were made to determine the details of these and other building and facilities decontamination operations.

2.2 Building Profiles

More than 300 buildings, tanks, and foundations have been identified in the South Plants area. However, for almost half of these buildings and other structures, use and/or location information is incomplete. Based upon the information reviewed to date, a historical use profile has been prepared. The profile includes the following kinds of information: building identification number; descriptive information on type of construction, utilities,

facilities, and building contents; building condition; current and historical use; and type(s) of contamination. These building profiles are presented in Appendix B. Included with each building profile is a list of engineering drawings (such as floor plans, piping diagrams, plumbing plans, etc.) for that building. Copies of these drawings have been requested from RMA and are currently being produced. For buildings under lease to SCC, some original drawings are in the possession of SCC and have been requested through the RMA legal advisor. Additional information on building use, location, and condition will be obtained during the Phase IA building survey discussed in Section 3.4.3.

2.3 Specific Contamination Sources

Within the South Plants area, at least 24 specific sources of known or suspected soil contamination have been identified. These include drainage ditches; storage areas; lime pits; sanitary landfills; tank locations; a burn site containing possible UXO; a salt storage area; and various pits, trenches, basins, lagoons, and disposal areas. In addition, at least 47 recorded spills in the vicinity of 17 buildings and tank areas have been recorded. These various specific contamination sources are described in detail in Section 3.3.

3.0 FIELD SAMPLING PROGRAM

3.1 Introduction

The purpose of the field sampling program is to obtain data which will define the extent of contamination in the South Plants area to assist the Army in preparing remedial action plans. The program is comprised of two major components: a geotechnical and a building sampling program.

The purpose of the geotechnical program is to define the areal and vertical extent of contamination in the unsaturated zone at historical disposal sites and spill sites in the South Plants area. This will be accomplished through a two-phased soil boring program. Phase I will consist of a limited number of soil borings to obtain semi-quantitative geochemical data which will provide for a preliminary assessment of the nature of chemical compounds present and extent of contamination in each area. Phase I data will be used to modify the boring and sampling program in Phase II. Phase II will consist of a more detailed soil sampling program, in which quantitative analyses will confirm the amount of contamination present. Geophysical reconnaissance surveys will be performed to aid in siting specific borehole locations in areas where unexploded ordnance (UXO) and buried metal objects may be present, and to locate underground utilities. The rationale and procedures for these surveys are discussed in Section 3.2. The rationale for the soil boring program is discussed in Section 3.3.

The purpose of the building sampling program is to determine whether there are materials present in buildings which may be contributing to the contamination of the surrounding soil and the ground water.

The building sampling program contains two phases. Phase IA is required by the health and safety program to protect the sampling team from exposure to potential hazards and for reconnaissance of buildings. The health and safety survey will be conducted in each building to determine the level of safety protection required by sampling personnel and to determine if gross

contamination is present. Sampling points of potential contamination sources such as drains, pipes, tanks, and vats will also be identified during this survey. Detailed sampling of potential sources as well as soil borings adjacent to disposal systems such as chemical sewers will be conducted as part of a Phase IB survey subsequent to the health and safety survey. The health and safety reconnaissance is referred to as Phase IA and the contamination survey as Phase IB. The building sampling program is discussed in Section 3.4.

The field sampling program will be second only to the chemical analysis program in the intensity of day-to-day activities on this project. Furthermore, the field sampling program is likely to involve a much greater variety of activities than is the laboratory program. The field sampling program will be intimately involved with health and safety activities, quality assurance and quality control activities, and overall program management. Consequently, close coordination must be maintained between the field sampling program and these other programs. In addition, since laboratory throughput rates may provide a major constraint on the scheduling of field activities, it will be necessary that the field sampling program be developed with a thorough awareness of scheduling constraints likely to be imposed by laboratory activities.

3.1.1 Support Facilities

During the mobilization meetings at RMA held the week of October 29-November 2, 1984, the need for RMA support facilities was identified, and initial discussions were held with RMA Installation Services personnel regarding the location and establishment of appropriate facilities. The support facilities discussed included the availability of warehouse space, the availability of office space, provision of utilities (electric power, potable water, and sewer facilities) at warehouse and office facilities, and RMA's identification of a preferred location for decontamination facilities.

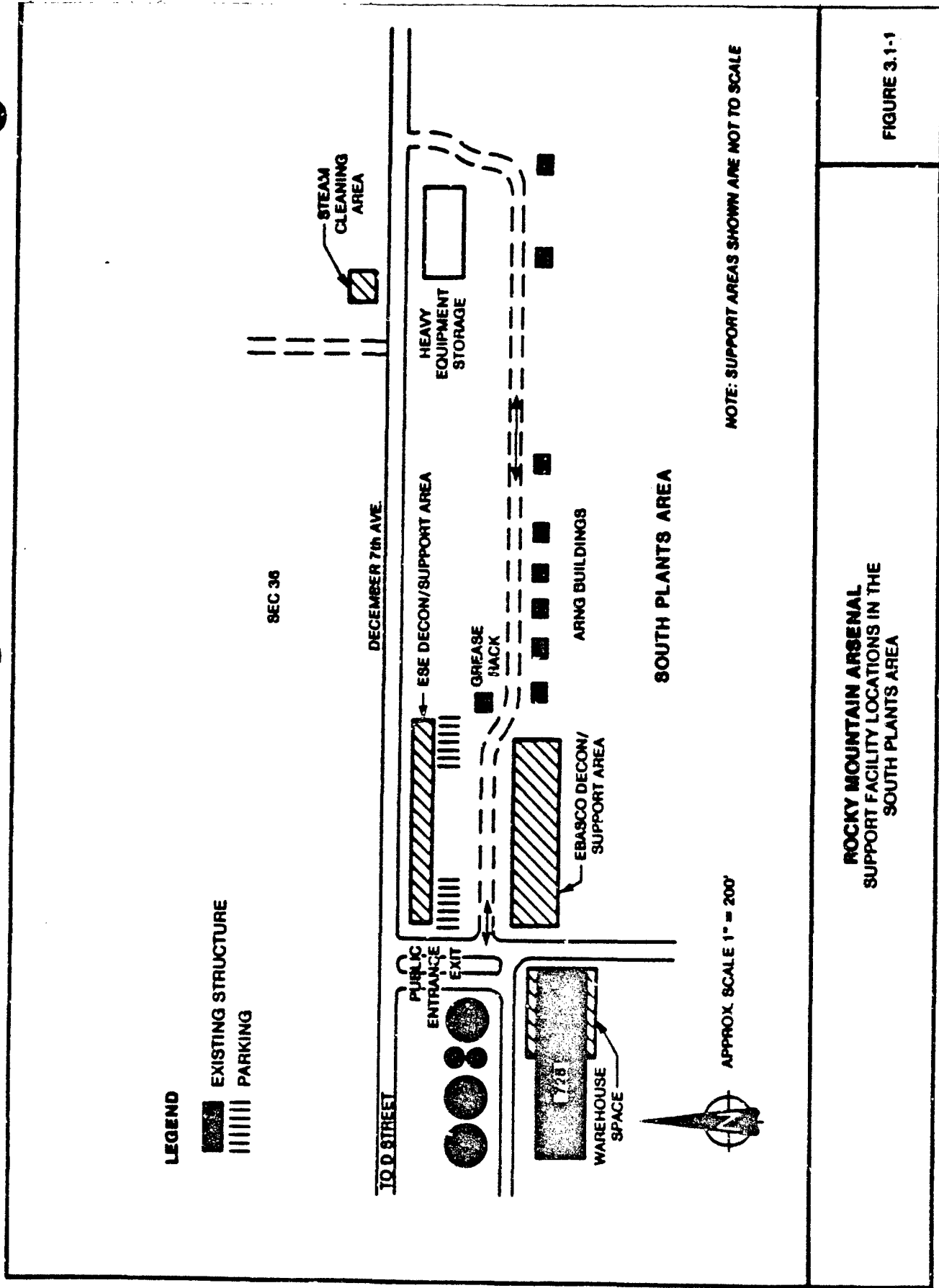
During subsequent meetings involving Ebasco, ESE, and RMA Facilities Engineering personnel, areas for location of steam cleaning operations and support trailers were agreed upon. The steam cleaning area will be located

along the southern boundary of Section 36, just north of December 7th Avenue, approximately 3,500 feet east of the intersection with D Street (Figure 3.1-1). The support trailer area will be located along the northern boundary of Section 1, approximately 2,500 feet east of the intersection with D Street, north of Building 731 (Figure 3.1-1). RMA Facilities Engineering, with the support of Stearns-Roger, has begun to implement provision of hookups for electricity, potable water, and sanitary sewer facilities for the Ebasco office trailer and ESE support facilities, as well as electricity and water supplies for the steam cleaning area. Ebasco and ESE will establish adjacent but separate steam cleaning areas to prevent cross-contamination. Common windbreak facilities will also be used.

- The Ebasco steam-cleaning area will be lined and sloped to a sump, from which contaminated water will be pumped into appropriate storage containers. At the direction of USATHAMA, it is currently planned to store the contaminated-water containers at the steam-cleaning site. Decontamination facilities are described further in the Health and Safety Plan, Section IV of the Task 2 Litigation Technical Support and Services Rocky Mountain Arsenal Procedures Manual (Task 2 RMA Procedures Manual).

In addition to the shared steam-cleaning site and the office trailer, Ebasco will also utilize mobile command post and decontamination trailers which can be moved from site to site within the South Plants area. Because of the unique nature of the building sampling activities, and the possibility that Level A or B personnel protection may occasionally be required, it is necessary that personnel decontamination facilities be located very near individual buildings to be investigated. The mobile trailers will be self-contained, including chemical toilets, heaters, and portable generators, so that RMA utility hook-ups will not be required. Water supplies will be brought by tank truck from the overhead filling spout located at the Fire Station. Personnel decontamination activities are described further in the Health and Safety Plan, Section IV of the Task 2 RMA Procedures Manual.

Heated and lighted warehouse space has been provided by RMA for the use of both Ebasco and ESE. The eastern half of Building 723 (see Figure 3.1-1)



has been made available for this purpose. Building 728 has been divided in two by a firewall, and RMA has further subdivided the eastern half of the building into three approximately equal areas by chain link fence. The central area is being used by RMA for miscellaneous equipment storage. The two outer areas will be used by Ebasco and ESE. Each subcontractor space can be accessed through separate 12-foot doors from separate loading docks on the north side of Building 728.

3.1.2 Support Activities

3.1.2.1 Topographic Surveys

Each soil boring and monitoring well will be surveyed to establish its elevation and map coordinates with respect to an appropriate established grid. Since most of the existing wells at the arsenal have been located on the Colorado State Plane Coordinate System, this will be the preferred grid to be used for orienting the new survey well and boring locations. All elevations will be surveyed to the nearest 0.1 foot (3 centimeters), and horizontal locations to the nearest 3 feet (1 meter), consistent with USATHAMA requirements.

3.1.2.2 Decontamination of Equipment and Materials

Decontamination of equipment and materials will be important for both health and safety requirements as well as quality control requirements. Contaminated equipment, such as boring rigs and auger flytes, will have to be maintained and decontaminated so as to preclude spreading contamination to previously uncontaminated areas. Furthermore, materials and equipment will have to be decontaminated in between borings so as to avoid cross-contamination from one site to another and thus invalidating the results of the sampling program.

Some decontamination activities will take place at the boring and/or building sampling locations. These activities will utilize the mobile decontamination facilities discussed in Section 3.1.1 and in the Health and Safety Plan, Section IV of the Task 2 RMA Procedures Manual. Major decontamination of

equipment, particularly larger pieces of equipment, will take place at the steam-cleaning area as discussed in Section 3.1.1.

3.1.2.3 Waste Disposal

At the direction of USATHAMA, all contaminated wastes, including liquids, soils, and other solid wastes, will be containerized and stored on site at the individual locations where the wastes were generated. The following items will be handled as contaminated wastes unless they are sampled and confirmed to be free of any contamination:

- o liquid wastes generated during decontamination operations
- o disposable sampling gear
- o water generated during well development and groundwater sampling
- o liquids generated at the steam cleaning pit
- o excess soils generated during drilling
- o all wastes generated in sampling and decontamination areas

Non-contaminated wastes will be directed to the sanitary sewer system or appropriate trash disposal facilities. Portable or chemical toilet wastes will be disposed of according to normal protocols.

3.2 Geophysical Program

3.2.1 Geophysical Reconnaissance Surveys

3.2.1.1 Preliminary Test Activities

Task 1 activities in Section 36 and Task 2 activities in the South Plants area will both require geophysical surveys. In order to coordinate the efforts of both of the team members who will be performing geophysical surveys, a test program has been conducted.

Rationale

Geophysical methods will be employed at RMA during this investigation in an attempt to achieve three objectives. These objectives are: 1) UXO

detection at selected sites, 2) location of buried metal objects at locations designated for borehole construction, and 3) location of buried utilities. The ability of geophysical methods to accomplish these objectives will depend on site specific soils conditions and the complexity of past disposal practices. The geophysical test program was conducted to evaluate various geophysical methods with respect to their usefulness at RMA sites.

Procedures

The geophysical test program was conducted at RMA from November 12 to 14, 1984. The test program consisted of surveys at known and unknown areas. The known areas consisted of material buried during this test as either discrete items in pits or bulk burial in trenches. The unknown site was an area where material was known to have been buried in the past, but the specific nature of the burial and the quantity of material was unknown. Test area locations were chosen in part on the basis of soil composition to evaluate the effect of the soil clay content on the techniques.

Test Area 1 was located in Section 36 in an open field southwest of the intersection of 8th Avenue and E Street. Soils at this location are classified as a Platner Series clay loam. Test Area 2 was situated in the southeast corner of Section 26 in an open field northwest of the intersection of 8th Avenue and D Street. Soils at this location are Ascalon Series sandy loams. Both Test Areas 1 and 2 were used as known sites with material buried in trenches or pits constructed for this test program. Test Area 3, the unknown site, was in the southwest quarter of the northeast quarter of Section 36. The soil at this location would be predominantly classified as Platner Series clay loam.

Two trenches were dug in each of Test Areas 1 and 2 (for a total 4 trenches), and various metallic objects were buried both vertically and horizontally at measured depths. Test Area 2 also had seven separate pits dug for grenade and artillery shell burial. A series of wooden stakes marked the location of each pit after burial. A set of grid lines was established approximately five feet apart and oriented both north-south and east-west over each trench.

Two trenches were constructed at Test Area 1. Trench 1 was 60 feet long and 5 feet deep. Representative samples of ordnance were placed in the bottom of the trench and their position and depth were recorded. Ordnance included a white phosphorus grenade, bomb bursters, 105 mm shell, aluminum rocket casing, 155 mm shell, rocket motor housing, and a 55 gallon drum. All ordnance samples were laid flat in the first 30 feet of the trench and duplicate ordnance were oriented vertically in the remaining 30 feet of the trench. Trench 2 was 20 feet long, 4 feet wide, and continuously varied in depth from 2 to 10 feet. Four 155 mm shells were placed at depths of 2, 4, 7.3 and 10 feet. Target sizes were kept constant to examine penetrations of geophysical methods.

Two trenches were also dug at Test Area 2 and the same suite of objects were buried in the same order as at Test Area 1. In addition, seven test pits were constructed primarily to determine size and depth detection limits for the three magnetometers (fluxgate gradiometer, fluxgate magnetometer, proton magnetometer). Three of seven test pits contained grenades buried 2.5, 5.0, and 7.5 feet deep; four of the pits contained 155 mm shells buried at 2.5, 5.0, 7.5 and 10 feet.

Techniques

A magnetometer measures the intensity of the earth's magnetic field. The Technos magnetometer is a gradiometer consisting of a nulled pair of magnetometers which detect changes in a null field. The changes in the null field are caused by small quantities of ferrous metal which can be UXO's (grenade, artillery shell, etc.). Magnetic response is proportional to the mass of the ferrous target and inversely proportional to the cube of the distance to the target.

The advantage of a gradiometer over a total field magnetometer is that correction for diurnal variations in the earth's field are not necessary (hence no base station is required). Another advantage is that surveys can be made in close proximity to fences, pipelines and buildings without impairing the detection capabilities. Finally, the data output from the gradiometer system can be continuously recorded, resulting in high resolution (more complete coverage) and rapid survey time.

LITIGATION TECHNICAL SUPPORT AND SERVICES

ROCKY MOUNTAIN ARSENAL

SOUTH PLANTS CONTAMINATION SURVEY AND REMEDIAL ACTION
ASSESSMENT

FINAL TECHNICAL PLAN, REVISION 1

TASK NUMBER 2 (SOUTH PLANTS)

AUGUST 1985

EBASCO SERVICES INCORPORATED

USATHAMA

Because non-ferrous metal in the form of aluminum rocket bodies and pot metal cannister UXO's was expected to be present, a metal detector was also tested. The metal detection response is proportional to the surface area of the metal target and inversely proportional to the distance from the target to the 6th power. Because of this, the detection capability of the metal detector is limited to shallower targets than the magnetometer.

The fluxgate gradiometer magnetometer with a sensitivity of one gamma per foot was coupled to a continuous strip chart recorder, was calibrated, and then run along the established grid lines to test its ability to define the outlines of the trench or pit as well as the relative quantity of buried material. The magnetometer was held at different fixed distances above the ground surface during subsequent runs to test the equipments' sensitivity to the targets. Continuous measurements were made along the grid alignment, and the burial locations (stakes) or grid intersections were marked on the chart paper. This continuous coverage is much more suitable for high resolution requirements, and the mapping of extensive areas in which complex anomalies are expected. In the area of the separate burial pits, magnetometer runs were made over and to either side of the alignment of the pits. Once the magnetometer survey was completed, the Technos pulse induction metal detector was calibrated, coupled to the chart recorder and run directly over the alignment of the trench or pits to judge its capabilities.

Results

Magnetometer Survey. The results of the magnetometer survey indicate that the fluxgate gradiometer magnetometer is capable of detecting a small hand grenade at a depth of 2.5 feet and a 155mm artillery shell at a depth of five feet.

The magnetometer responded to the two 55-gallon drums in Test Area 1 - Trench 1, buried 4.5 feet (lying flat) and 2.7 feet (upright). Because the response from the drums is so strong and is detected from a distance as far as five feet from the drums, any possible response from the other ferrous objects has been masked.

The magnetometer is also capable of detecting discrete, buried 155 mm artillery shells as deep as four feet below surface at a horizontal distance from the shell of approximately three feet. The magnetometer may have received signals from the shell in Test Area 2 - Trench 2 buried 5.3 feet below the land surface, but it is possible that its response is masked by the other signals.

At Test Area 3 (the "unknown" area), a surface-exposed steel barrel transmitted a strong response to the magnetometer during the survey run as would be expected. However, the magnetometer response also indicated that a significant amount of material is buried in this trench. Also, very little material appears to be within the adjacent berm.

At Test Area 2, identically sized UXO (155 mm shells) were buried at various depths in several burial pits. The Technos magnetometer was capable of locating an artillery shell at a depth of five feet. Harding Lawson Associates' (HLA) fluxgate magnetometers and proton magnetometers were able to detect only the 155 mm shell buried at 2.5 feet. The effects of the shell buried at 2.5 feet can be seen within 15 feet of the object.

Metal Detection Survey. The Technos pulse induction metal detection survey detected buried UXO as large as a 155mm artillery shell at a depth of five feet and as small as a hand grenade at a depth of 2.5 feet when passing directly over each.

The metal detector run over Test Area 2 - Trench 2 could not distinguish discrete buried UXO, but rather pegged offscale for the majority of the trench length. Onscale readings in the metal detection profile were caused by weaker signals from the smaller UXO. A profile of Test Area 2 - Trench 2 showed that the metal detector pegged offscale over the shallow end of the trench but came back onscale for targets buried deeper than a 155 mm shell at 5.0 feet.

At the seven burial pits at Test Area 2, the metal detector could only distinguish a grenade buried at 2.5 feet and a 155 mm artillery shell buried at 2.5 and five feet.

In summary, the metal detector had relatively shallow depth-sensing capability. Its output is usually qualitative and, therefore, has limited capability to evaluate the size and depth of targets. However, the metal detector does provide reasonably good spatial resolution to pinpoint the location of a target.

Ground Penetrating Radar (GPR). Test GPR traverses were run by HLA with 80, 120, 500 and 900 MHz antennas. The only distinguishable target at Test Area 1 was a 55 gallon drum in Trench 1. The drum was distinguishable only because its location was known. The GPR records showed a maximum penetration of about 3 feet with low frequency antennas (80 and 120 MHz) and no more than one-foot with higher frequency antennas (500 and 900 MHz). Unfortunately, anything shallower than 3 feet could not be resolved with the low frequency antennas because weak reflection is masked by the wide transmit pulse. Low frequency antennas are used for deeper penetration and they sacrifice near surface data to achieve it. It was not possible to identify trench boundaries with any degree of certainty with either the low or high frequency antennas.

At Test Area 2, a series of traverses showed that the GPR could pick up anomalies to a depth of 3 feet. As at Test Area 1, signatures were poor. Trench boundaries were poorly defined with GPR.

GPR proved ineffective at a known burial site where a drum is exposed at the surface (Test Area 3).

Earth Resistivity Method--Vertical Electrical Soundings (VES) and Electromagnetic (EM) Soundings. Both VES and EM soundings conducted by HLA at Test Area 1 showed why the GPR results were so inconclusive. The VES solution showed the ground resistivities to be relatively low at the site, because of high clay content in these soils. A thin surface veneer of 20 ohm-meter material overlies 80 ohm-meter soil that extends to below the maximum radar penetration depth. Experience has shown that GPR penetration is generally poor when ground resistivity is less than about 100 ohm-meters.

Geophysicists from Technos measured terrain conductivities of 25-30 millimhos per meter at Test Area 1 for the upper 7 meters of soils with an EM-31

terrain conductivity meter. Their experience indicated poor radar penetration is achieved when conductivities are greater than the 10 millimhos per meter (equal to 100 ohm-meter resistivity). The results of the VES and EM measurements showed that the soil at Test Area 1 is too conductive to perform successful GPR exploration.

VES and EM soundings suggested that Test Area 2 was slightly better for GPR. Soil resistivities ranged between 61 ohm-meters in the upper foot of soil to 118 ohm-meters from there down to 10 feet. EM soundings showed soils conductivities ranged between 23 and 63 millimhos per meter.

Conclusions

Efficient UXO detection depends on the ability to conduct searches in a reasonable time that are cost effective in all areas of the site. The Technos fluxgate gradiometer magnetometer and the metal detector coupled to a continuous strip chart recorder showed the most promise in locating buried UXO at the RMA site. Data suggest that the more sensitive magnetometer and gradiometer systems will detect large projectiles at much greater ranges than will metal detectors. However, the metal detector shows excellent performance for near-surface detection.

The practical detection capabilities for the continuously recorded gradiometer and metal detector systems tested at the RMA are 2.5 feet deep for a single, small hand grenade and five feet deep for a single, 155mm artillery shell. This practical detection limit is a function of the sensitivity of the instruments coupled with the continuous data output. If either system were used in a station measurement mode (i.e., non-continuous data), the practical detection capabilities for the same instrument would be reduced by half the depth, or more, depending upon the station spacings.

It appears that GPR will not be an effective geophysical method for clearing borings at RMA. Magnetometers can locate buried ferrous debris down to a depth of about 5 feet. The fluxgate gradiometer detected metal debris to a greater depth than either the fluxgate magnetometer or proton magnetometer. In addition, its strip chart recorded readout gives a continuous record

along a traverse line rather than the discrete measurements at 5 feet intervals with HLA's fluxgate and proton magnetometers.

3.2.1.2 Confirmation of Buried Utilities

Rationale

Buried pipelines are known to exist at various locations within the South Plants area. Removal of contaminated piping requires that its location be specified using remote sensing techniques. In some instances, pipes may have leaked resulting in areas of contamination in the vicinity of the pipelines. Detection of these conductive contaminants may also be made using geophysical methods.

The rationale for technique selection is based upon the possible metallic nature of the piping and the conductivity of the spill material. Metal pipes can be detected by a fluxgate gradiometer (magnetometer) or a metal detector. The gradiometer can be used in close proximity to buildings and other metallic materials. However, available information indicates that much of the underground piping (chemical, sanitary and storm sewers) consists of vitrified clay, rather than metal. Thus, this technique may be of limited usefulness.

Conductive material which has leaked from the buried pipes may result in increased conductivity of the subsurface materials and this can be detected using an EM device. However, EM measurements will be adversely affected by nearby metal objects (such as buildings) and power lines. Therefore, the use of the method will be evaluated on a case by case basis.

Procedures

The procedures will vary with the purpose of the technique and the technique itself. The detection of underground metallic pipes will be accomplished using a fluxgate gradiometer and the contaminated subsurface around leaking pipes will be identified using an EM-31.

Fluxgate gradiometry surveys are performed by sweeping an area with the device. Indications of buried pipes are marked by flags or paint and the trace of the pipe is developed by moving laterally away from the initial detection site. In order to focus the efforts, as-built drawings are consulted to determine the suspected location of pipes. The surveys consist of determining the general location of the pipes based on the as-built facility drawings and then employing the geophysical methods to locate the pipes in the field.

Once the location of piping has been developed from record searches and the fluxgate gradiometer work and the alignments marked in an area, EM-31 measurements may be made to check for contaminated soil along the pipeline route. Continuous measurements are made along either or both sides of the alignment and anomalies marked. These zones of contaminated soils will be identified to the soil sampling team for further investigation. In some areas, buildings, power lines or other cultural features prevent the usage of the EM technique and only the gradiometry will be possible.

3.2.1.3 Survey of UXO and Other Buried Objects

Rationale

At least one area of UXO has been identified in the South Plants area and others may exist but have not been identified. The known site of UXO's should be defined in areal extent, and targets identified in order to facilitate subsequent removal. Any as yet unspecified UXO areas are potential hazards to the soil boring crews. As a result, soil boring sites should be cleared using remote sensing methods.

Similar techniques will be applied to specific contaminant sources in the South Plants area where buried metallic objects are suspected to possibly occur. Such sources include landfills, trenches, and pits whose detailed history is not known. Areas subject to these geophysical surveys, which are discussed in more detail in Section 3.3, include the following:

- o Site 2-14 Sanitary Landfills, north and south
- o Site 2-2 Burn Site
- o Site 1-11 Sanitary Landfill
- o Site 2-5 Trench
- o Site 2-13 Open Storage Area

The selection of geophysical techniques is based on the nature of the UXO or other buried metallic material. Previous experience and the geophysical test program indicate that unexploded projectiles can be identified by magnetometry and metal detection techniques. The latter is most effective when the ordnance consists of nonferrous shells. We also understand that rocket casings and aluminum rocket warheads may be present.

The methodology used to detect buried metallic material is based on the sensitivity of a fluxgate gradiometer magnetometer and a sophisticated metal detector. The gradiometer consists of a nulled pair of magnetometers which detect changes in the null field caused by small quantities of ferrous metal. Existing information indicates that the UXO material may exist at depths ranging from near the surface to as deep as 10 to 15 feet. This type of system is sensitive enough to detect ordnance at the anticipated depths.

In some cases, the metal may be non-ferrous and it will be necessary to search for the UXO using a metal detector which can detect both ferrous and non-ferrous material. Because the nature of the material will not be known beforehand, both gradiometry and metal detection will be required.

Procedure

For the techniques which may be used to detect UXO's, only one procedure is required. The gradiometry and metal detection surveys will be done by establishing a series of grid lines, north-south in orientation, and approximately three feet apart. The gradiometer will be passed along each grid line and moved from side to side in order to sweep the area between adjacent grid lines. Targets identified will be flagged. The metal detector will be moved along the grid line in the same manner and targets confirmed, or new targets defined.

3.2.1.4 Borehole Surveys

Borehole geophysical surveys can provide information to supplement soil sampling, geologic logging, and groundwater sampling data. Current instructions from USATHAMA indicate that borehole geophysical logging will not be required unless a well is greater than 50 feet deep, penetrates different geological material, or penetrates into the Denver Formation. This last condition is likely to be met for several of the proposed new wells in the South Plants area.

Each of the monitor wells satisfying the above conditions will be logged from a geological standpoint and geophysical logging will also be done in order to provide as much information as possible regarding the boring. The suite of logs is restricted because of the drilling methods used (no drilling fluids) and the use of PVC casing. The geophysical logs proposed under these conditions are natural gamma and neutron logs. The natural gamma technique will be sensitive to the changes in the clay content of the subsurface soils. Those sections containing higher amounts of clay will produce a greater response in the gamma tool sensor. The neutron log is designed to measure the changes in hydrogen ion concentration within the near vicinity of the boring. The concentration can be correlated to the density of the soil and its water content once the effects of the hydrogen concentration in the PVC pipe are removed. At the completion of the analyses of Phase I data, the geophysical logging program will be re-evaluated.

3.3 Soil Boring Program

3.3.1 Program Objectives

The objective of the soil boring program is to define the type and spatial (lateral and vertical) extent of contamination at historical disposal and spill sites. The Phase I study is an effort to determine whether the sites are contaminated and to determine what chemicals are at these sites through the screening of pollutants with a limited number of borings. At most sites the disposal or spill history is unknown or incomplete. Phase II is

designed to more accurately define the geometry of contamination at the sites. In general, Phase II will have a greater number of borings than Phase I at each site which is shown to be contaminated in Phase I, and the chemical analyses performed on Phase II samples will be oriented toward those pollutants found in Phase I. The exact structure of the Phase II soil sampling program will be determined from the results of the Phase I.

The areas to be investigated as potential contamination sources are shown in Figure 3.3-1. These areas were identified from historical data and were classified by USATHAMA and D'Appolonia in a 1984 report as 'potentially contaminated' sites and 'balance of the sites investigated'.

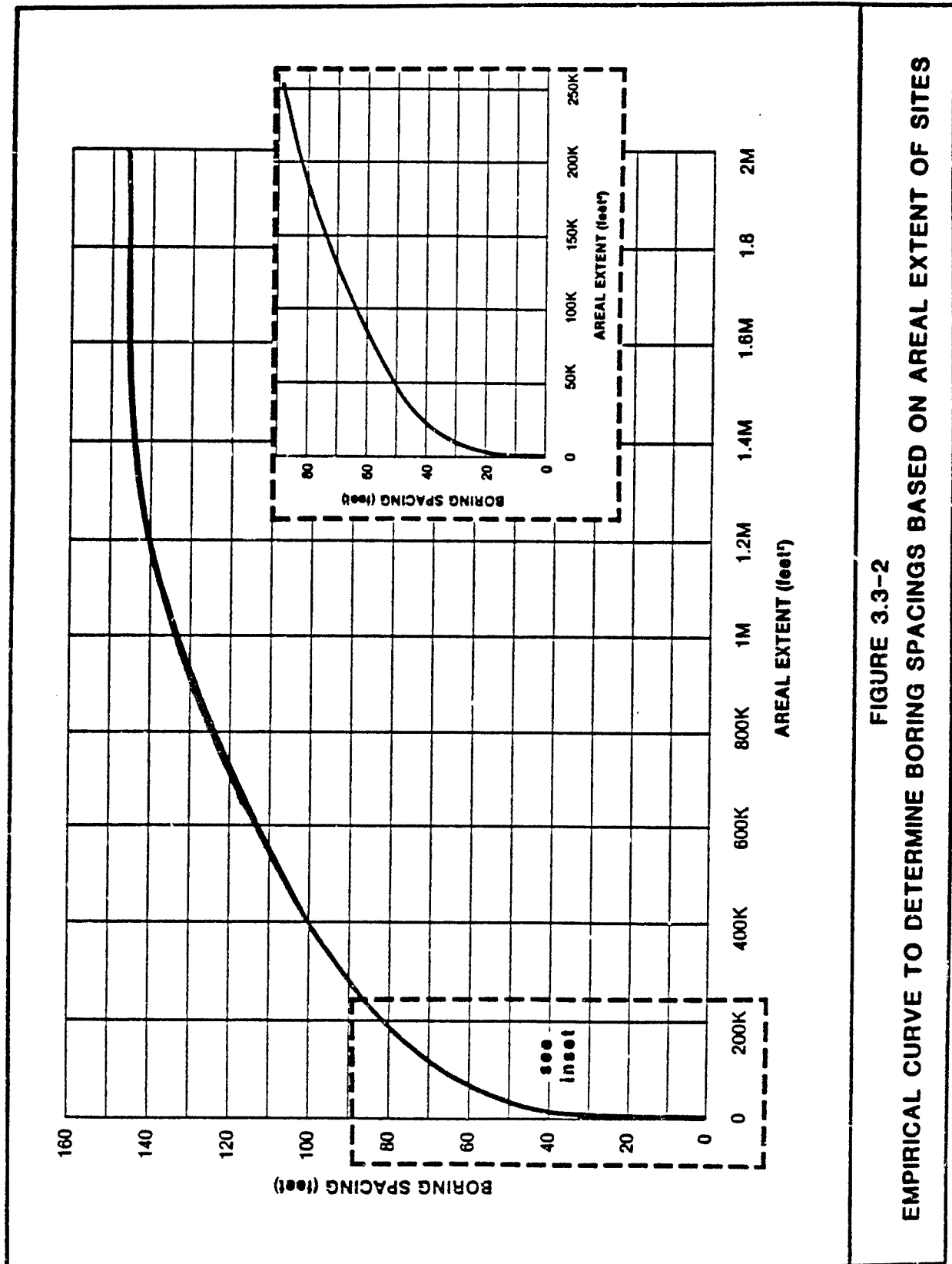
Priorities for each site were established based on the expectation of encountering contamination as recorded in the literature. High priority sites are those which have an established record of contamination of ground water beneath or near the site and which have few records concerning soil contamination. Low priority sites have no records of either soil or ground water contamination, due to lack of study, but have been considered potentially contaminated based on records of spills and/or waste disposal at the site. Uncontaminated sites are those that may possibly be contaminated due to their physical nature but at which preliminary investigation revealed no reason to suspect contamination.

USATHAMA has requested a general uniformity of approach between the soil boring activities of Ebasco in the South Plants area and those of ESE in Section 36. To this end, members of the Ebasco and ESE teams, and of USATHAMA conferred to develop a common strategy to determine boring densities and vertical sampling intervals in Phases I and II of the program. These criteria were established prior to a thorough physical reconnaissance of the sites and are based exclusively on the literature and professional judgment. As the soil boring program progresses and additional information is determined, modifications to the program may be made by Ebasco in writing to achieve the stated objectives.

The general approach to the soil boring program and the method to determine boring density was developed jointly by USATHAMA, Ebasco and ESE and is fully

described later in this section. The boring density method is based on estimated areal extent of contamination, suspected compounds and historical disposal practices. By integrating these data with prior experience at RMA and best professional judgment, Figure 3.3-2 was developed. This curve represents selected boring spacing for the total (Phases I and II) program as a function of the areal extent and priority of contaminated sources. This total number of borings per site was distributed into Phases I and II by a ratio that varies according to the priority of the site. The priority of the site was determined from the available data. The vertical soil sampling interval and the sampling technique were developed for both the South Plants and Section 36 areas during meetings involving the different contractors and USATHAMA. These criteria have been applied to the South Plants sites in a strict manner. Some modifications will have been made to account for actual or unexpected conditions as in many cases the actual field conditions are unknown. The chemical analyses for the Phase I soil samples requested by USATHAMA are semi-quantitative analyses of volatile organics and semivolatile organics and quantitative analyses of DBCP, metals, and mercury. Upon examination of the chemical data generated from the Phase I soils, more specific constituents for Phase II sample analyses will be determined.

As mentioned above, the total (Phase I and II) boring density at each site was determined from the area of the site utilizing the curve shown in Figure 3.3-2. The area of each site was determined by using a 1983 aerial photograph. The curve in Figure 3.3-2, which relates the boring spacing in feet to the area of the site in square feet, was developed empirically by members of the Ebasco and ESE teams. Modifications to the boring spacing at each site, as found by the curve, were made based on the priority of the site. For high priority sites, the curve was used without modification. For low priority sites, the resulting boring spacing was multiplied by a factor of 1.25. For uncontaminated sites, the resulting boring spacing was multiplied by a factor of 1.5. The boring density was divided into the total area of the site to obtain the total number of borings at the site. A grid for each boring spacing was made and placed over the site maps to roughly locate the borings.



The relative numbers of borings in Phases I and II were determined according to an empirical scheme designed by USATHAMA, the expert witnesses, and Ebasco and ESE that is based on the site priority. At high priority sites with areas of less than 1,000,000 square feet, Phase I will contain 30% of the borings and Phase II, 70%. At high priority sites with an area greater than 1,000,000 square feet, Phase I will contain 25% and Phase II will contain 75%. At low priority sites the Phase I borings will be 30% of the total and Phase II, 70%. At uncontaminated sites, Phase I borings will be 30% of the total and there are no Phase II borings currently planned. The locations of the Phase I borings are indicated on the individual site maps in Section 3.3.3. These locations were chosen to be evenly distributed across the sites. The majority of the Phase I borings will be located in portions of the site where contamination appears most likely upon review of the site history. Also, a few of the Phase I borings will be located near the site boundaries.

The vertical soil sampling interval was established by USATHAMA and the expert witnesses. These intervals are indicated in Table 3.3-1. The depths of the borings in each phase were also established by USATHAMA. In high and low priority sites, 20% of the borings will be constructed to the water table. The remaining 80% of the Phase I boring will be constructed to shallower depths within the unsaturated zone. For example, 20% will be constructed to 5 feet above the water table, 20% will be constructed to 10 feet above the water table, 20% will be constructed to 15 feet above the water table and 20% will be constructed to 20 feet above the water table.

TABLE 3.3-1

Soil Sampling Intervals (feet)	
0.0 - 1.0	
4.0 - 5.0	
9.0 - 10.0	
14.0 - 15.0	
19.0 - 20.0	
24.0 - 25.0	

In the uncontaminated sites, 30% of the Phase I borings will be constructed to the water table and the remaining borings will be distributed in the same general order. The site maps in section 3.3.3 also indicate the depths to which the boreholes will be drilled. Borings that extend to the water table have been located in the portions of the site that are expected to be contaminated and the progressively shallower borings are in the less contaminated areas. Where there is no accurate information as to the contaminated portion of the site, the deeper borings are placed evenly across the site as are the progressively shallower borings. The depths of these Phase I borings are shown on the site maps later in this section. The Phase II boring locations are also shown on the site maps but the projected depths of the borings will be determined from the Phase I results. For planning purposes, 25% of the Phase II borings will go to the water table and the remaining 75% will be distributed evenly to increasingly shallower 5 foot intervals above the water table.

All test borings will be constructed and sampled using a continuous core augering technique. The entire length of the boring will be examined and the locations of contacts will be more precisely determined by using this technique. Five-foot length cores within clear plastic (polybutyrate) liners will be obtained. Although specific sampling intervals have been predetermined by USATHAMA and the expert witnesses, the method of obtaining soil core in clear polybutyrate tubes will allow the field geologist to select samples from horizons of visually observable contamination. These samples will be sent to the laboratory for chemical analysis in addition to those from the predetermined sampling intervals. Using an OVA or HNU instrument, field measurements of volatile organics will be used to assess the presence of contamination during coring and in the non-sample portions of the cores.

A detailed description of the coring and sample handling procedure can be found in Sections I and II of the Task 2 RMA Procedures Manual.

As soon as the samples for chemical analysis are obtained, the cores will be resealed and stored. Therefore, the cores will be available if additional core interpretation is deemed necessary. However, it may not be possible to

send additional samples to the laboratory for chemical analyses if sample holding times are exceeded.

3.3.2 Phase I Program

The objective of the Phase I soil boring program is to determine if contamination is present in the soil at historical waste disposal sites and reported spill sites through the screening of pollutants. Phase I chemical analyses include screening techniques for volatile and semivolatile organics and quantitative analyses for arsenic, mercury, metals, dibromochloropropane (see Table 4.2).

The purpose for drilling these borings is threefold:

- 1) to determine the exact depth of the water table in order to plan the depths of the remaining site borings;
- 2) to obtain at least one soil sample directly at the water table;
- 3) to obtain chemical, geologic and hydrologic control at a site.

The depth of Phase I borings have been predetermined based on an assumed water-table depth and are shown on maps later in this section. If the assumed water-table is very different from the measured depth, the depths of the remainder of the Phase I borings will be estimated. The purpose of these shallower borings is to develop lateral control across a site.

This sampling rationale will be followed in high, low and uncontaminated areas. At some sites, such as landfills, surficial soil samples may not be reliable indicators of contamination. To decrease the number of samples analyzed at these sites, no soil samples will be taken in the zero to one foot sampling interval.

The depths of the soil borings will range from 5 to 25 feet depending on the estimated depth to water. Preliminary estimates of water-table depths have made for each site, using the most recent South Plants water-level data obtained from the Rocky Mountain Arsenal Information Center (RIC) library.

These estimates were used to develop the cost estimates for the soil boring program.

3.3.3 Site Descriptions and Locations of Soil Borings

The nineteen sites that will be investigated in this soil sampling programs are individually described in this section. Each potentially contaminated site (high or low priority) was identified by USATHAMA as being operated by either Shell or the Army. There are five Shell operated sites, two Army operated sites and three joint Shell/Army sites. The remaining nine sites are considered uncontaminated and no responsible party was assigned. The site summaries presented here represent the sum of the information on these sites found in the literature. The accompanying figures are preliminary sketches of the sites for use in preparing this plan. The first step in the Phase I soil boring program is a thorough physical reconnaissance of each site and an update of these maps. Some planned boreholes may be difficult to drill due to physical conditions and will be relocated during the field reconnaissance. Other boreholes may prove to be very near the existing boreholes that may have been incorrectly located and will need to be shifted. Power lines, cement slabs, discovered UXO's, topography and underground utilities will be reasons for relocating the boreholes that are currently unknown. The nineteen sites to be investigated are listed and discussed in the order: Shell only, Joint Shell and Army, Army only, and Unassigned.

SHELL OPERATED SITES

Site I-8 Salvage Yard

A salvage yard, consisting of approximately 299,000 ft², is located south of the old lime pits (Site 1-5) and east of the South Tanks Farm. Liquid wastes and products were stored in the western section of this yard. In 1971, leakage was observed from some of the drums, and these were removed. Possible contaminants include both organic and inorganic compounds. The ground water is at a depth of approximately 14 feet at this location. This is a high priority sampling site, and a boring density of 1/8,100 ft² was

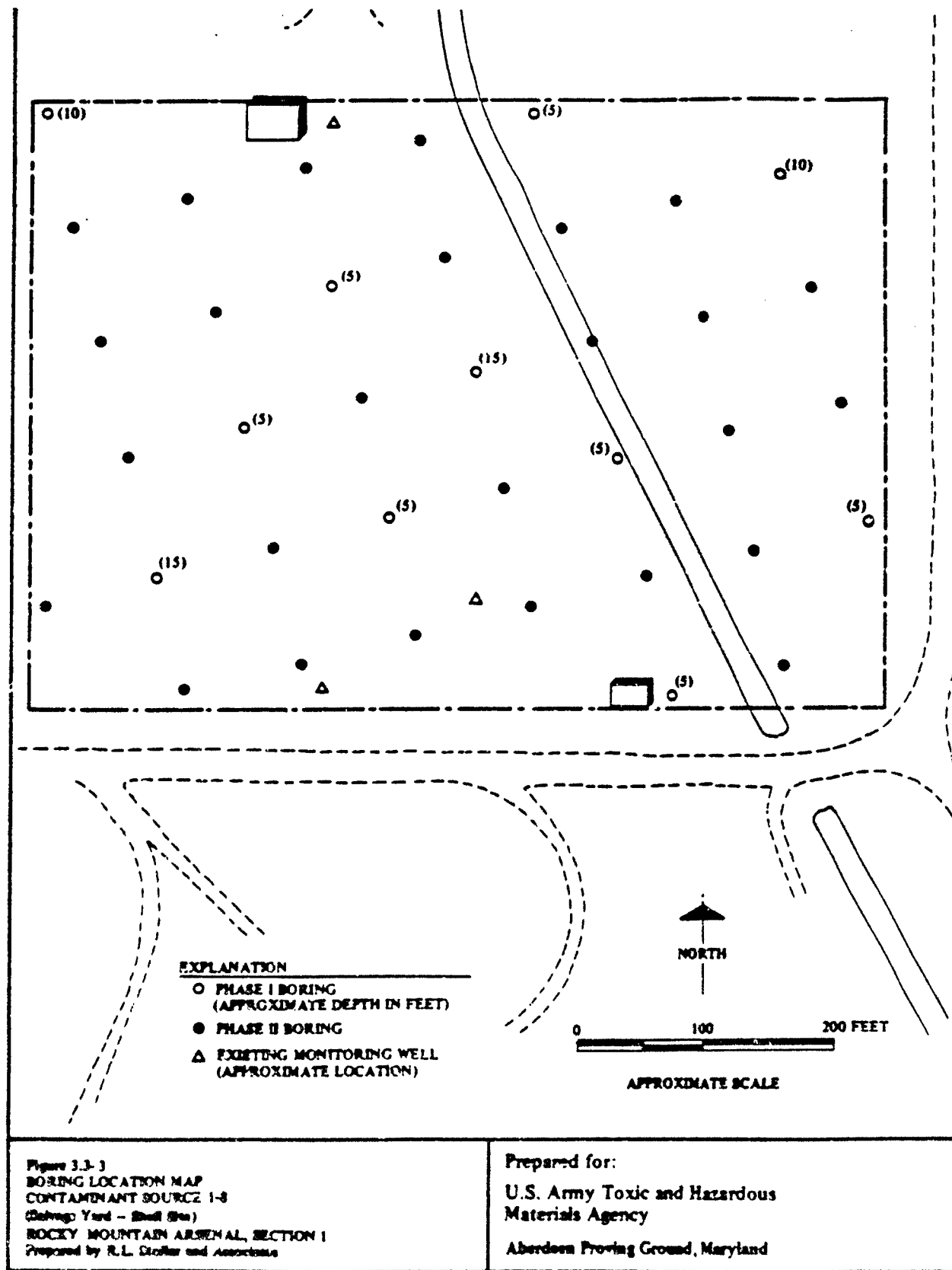
used. Boring locations for Site 1-8 are shown on Figure 3.3-3. A total of 11 borings will be drilled in Phase I as follows:

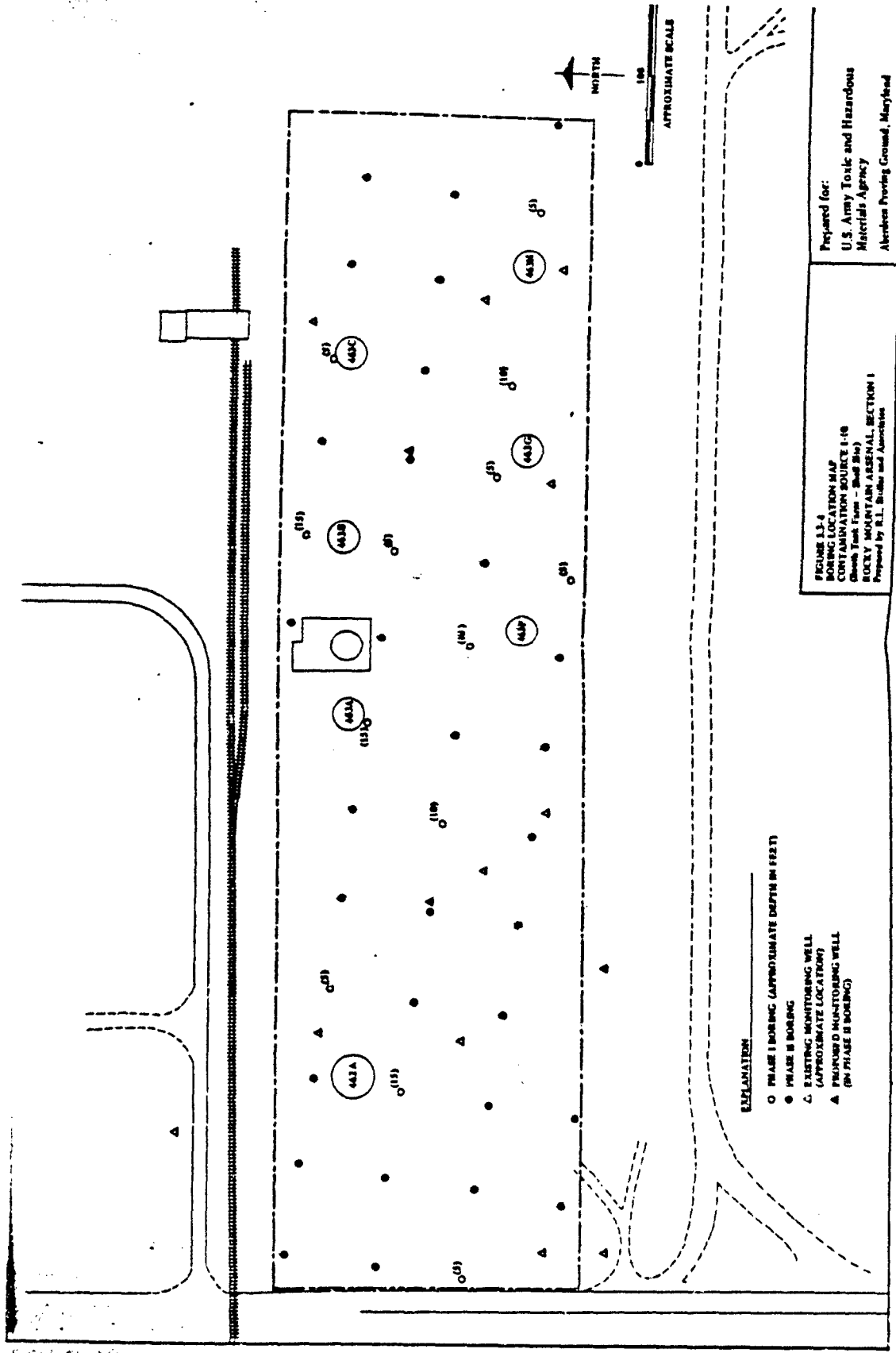
	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	15	8
	2	10	6
	7	5	14
Totals:	11		28

Site 1-10 South Tank Farm Storage Area

The South Tank Farm Storage Area has an area of approximately 600,000 ft², and the area not currently occupied by tanks is approximately 442,500 ft². Tanks 462A and B were used for the storage of fuel oil, and Tanks 463A-H were used to store ethyl alcohol from December 1942 through May 1943. Tank cars of fuel oil and ethyl alcohol were unloaded through a nearby pumphouse, Building 461. Tank 462B was removed, and relocated to Site 321E, prior to 1982. Tanks 463D and E have also been removed. In 1948, a 100,000 gallon benzene spill occurred in this area. A 1,548 gallon DCPD/No. 6 fuel oil spill was reported to have occurred in this area on August 8, 1976; and a 50,864 gallon BCH spill was reported in September 1978. This area has a high sampling priority. The water table is at a depth of approximately 15 feet. The boring density is 1/10,000 ft². Figure 3.3-4 shows the boring locations for Site 1-10. Thirteen borings will be drilled in Phase I as follows:

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	3	15	12
	3	10	9
	7	5	14
Totals:	13		35





EXPLANATION

- PHASE I BORING (APPROXIMATE DEPTH IN FEET)
- PHASE II BORING
- △ EXISTING MONITORING WELL (APPROXIMATE LOCATION)
- ▲ PROPOSED MONITORING WELL (IN PHASE II BORING)

Prepared for:

U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

FIGURE 13-4
BORING LOCATION MAP
CONTAMINATION SOURCE 1-10
(South Tank Farm - Shell Site)
ROCKY MOUNTAIN ARSENAL, SECTION 1
Prepared by R.L. Butler and Associates

Site 1-13 South Plants Spill Sites Section 1

Numerous spills and leaks have occurred in the South Plants area and many have been documented in the literature. An initial literature review indicated 50 spill sites that were investigated further due to the size and type of the spill. Since March, 1985 additional spill information has been received. This included Shell responses to Interrogatories 18-20 of the Army's first set of interrogatories, and a letter from Shell dated May 1, 1985 that provided a better definition of some of the sites. All of the sites reviewed are briefly described in this section. The number of borings has been estimated for each site based on the apparent accuracy of the spill location from literature and a recent field check. If the spill location is not definite, then three borings with the prescribed sampling interval have been planned. With two exceptions, no more than three borings are used to locate a spill due to cost constraints.

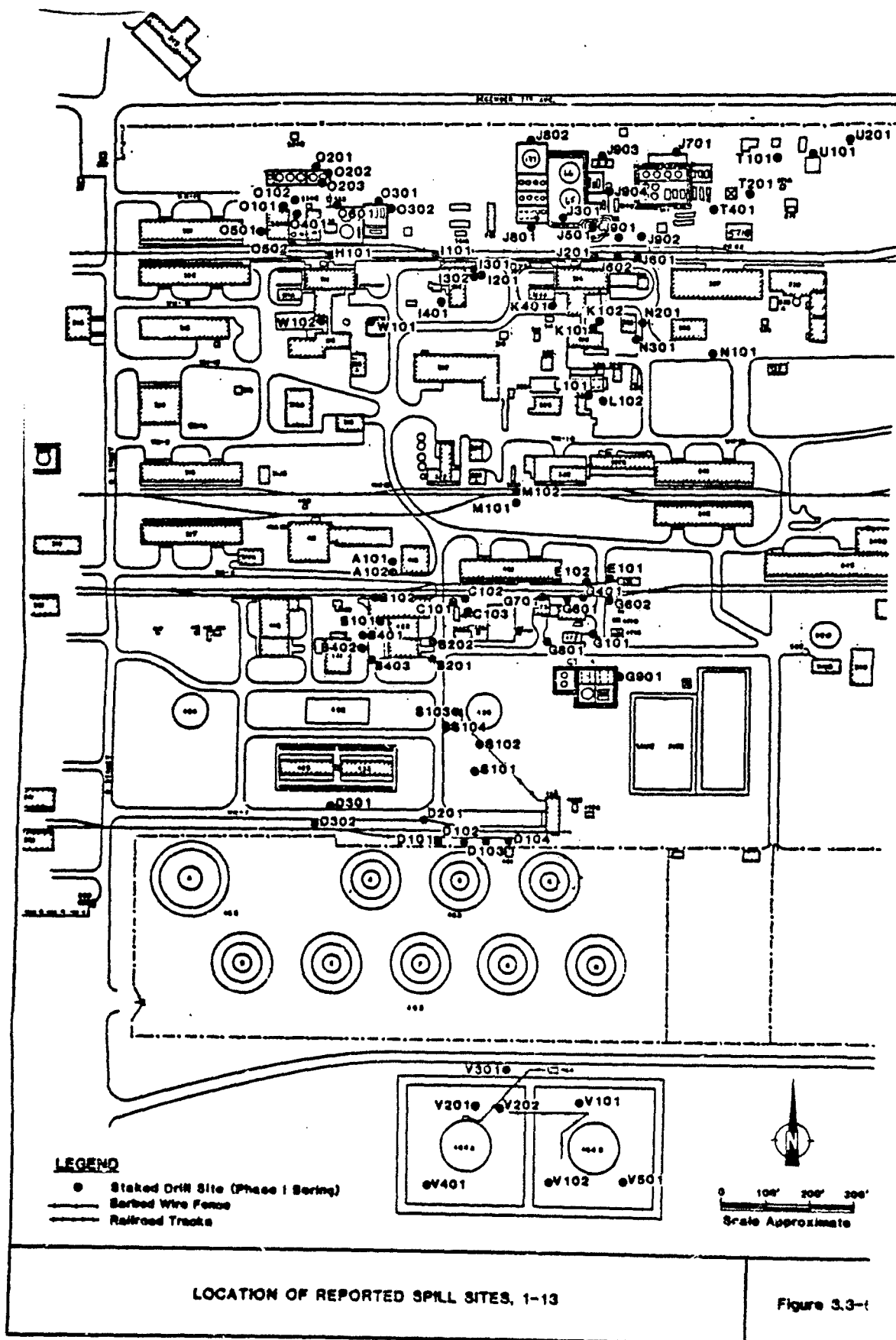
The following is a brief description, by area, of the investigated spills in Section 1. Approximate locations of the spill sites are shown on Figure 3.3-5.

A. Building 413

An estimated 16,000 gallons of aldrin-benzene (60% w) leaked from an overhead pipeline during an unfreezing operation on a water line in 1952. Cleanup consisted of removal of the solidified aldrin. Shell indicated the remains of the pipeline supports west of the building. Two boreholes are planned under the pipeline and in a nearby drainage.

B. Building 422

1. Between 1951 and 1953 an estimated 1500 gallons of aldrin-benzene (60% w) was spilled in the tank area northwest of Building 422. The tank area is now underneath the northwest wing of the building. Two boreholes, one north of the wing and one south, are to be drilled.
2. In 1951 an explosion of an aldrin reactor (R-19) with a capacity of 10,500 gallons occurred in the eastern side of Building 422. Shell indicated that a basement sump collected the resulting aldrin-benzene, BCH and HCCPO mixture and pumped it to the waste ditch east of the buildings. The building was



TASK 2 TECHNICAL PL.
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washed down and Shell reports the contaminated soil was removed. Two boreholes are located in the ditch.

3. A sewer line reportedly leaked near this building between 1950 and 1974. No cleanup is recorded. A contaminated waste line runs north-south east of Building 422. The sewers will not be examined in this task. The interrogatory responses and the May 1, 1985 letter indicate this is a spill related to the Building 422 sump pumping to the ditch examined in the 1951 explosion, B2.
4. A spent acid line leak west of Building 422 is recorded in 1973 as spilling 100 gallons. The line parallels a north-south sanitary sewer. Three boreholes will be drilled between the line and the sewer.

C. Building 424A

A 200 gallon BCH spill Tanks 120 and 121 occurred east of Building 424A in 1960 in the northern portion of an equipment yard (70 feet by 30 feet) as seen on a 1982 aerial photograph. Three boreholes are planned.

D. Building 433

1. In 1971 190 gallons of D-D soil fumigant was spilled during a tank care overflow on the south side of the railroad tracks at one of four rail car load spots west of Building 461. Four boreholes, one at each load spot are to be drilled.
2. In 1975 250 gallons of D-D soil fumigant was spilled at the tank truck load spot southeast of Building 433 and flowed into a ditch. The dirt was removed from the ditch. One borehole is to be drilled at the load spot.
3. In 1973 greater than 55 gallons of DCPD was spilled when a previously unmarked pipe was punctured. The pipe lies north-south, south of the center of Building 433. Two boreholes will be drilled in the ditch north and south of the road.
4. In 1981 or later approximately 1 quart of D-D soil fumigant was spilled west of Building 461 during a tank car unloading. This spill is investigated with the boreholes used to investigate spill D1.

E. Building 451

Greater than 55 gallons of Azodrin spilled from leaking 5 and 30 gallon containers on a flat car in a hot house southeast of Building 451 in 1974. The dirt was removed from this site, and the area was spread with soda ash. Two boreholes are planned on the railroad track between Buildings 451 and 475.

F. Tanks 462 A, B; 463 A-H

Six reported spills occurred in the south tank farm (Site 1-10). They are a 100,000 gallon benzene spill in 1948; a 1,400 gallon spill of BCH bottoms in 1956; a 1,500 gallon spill of DCPD bottoms/No. 6 fuel oil in 1967; a 1,548 gallons dicyclopentadiene (DCPD) Bottom/No. 6 fuel oil on August 8, 1976; 50,864 gallons BCH Bottom/No. 6 fuel Oil in September, 1978. In addition, between 1967 and 1975 an estimated 55 gallons of spent acid was spilled. These spills are located within Site 1-10. The sampling scheme is shown in the site discussion and Figure 3.3-4.

G. Building 471

1. A leak from Tank 132 southeast of Building 471 spilled approximately 100 gallons of allyl chloride in 1972. One borehole is planned east of the tank.
2. In an overflow of Tank 132, 550 gallons of allyl chloride was spilled in 1976. The affected soil was removed. The borehole planned in the previous incident will look for evidence of this spill also.
3. A 200 gallon Vapora spill that occurred between 1960 and 1980 south of Building 471 is too indefinitely located in the records to drill. This drilling program already has three boreholes planned for south of Building 471.
4. Leaks from a tank car containing Nemagon at a loading spot north of Building 471 totaled less than 93 gallons in 1971 and affected a 25 square foot area. No clean up action is recorded. The unload spot was indentified as 2-471 by Shell in the May 1, 1985 letter. One borehole will be drilled at this unload spot.
5. In 1973 over 1000 gallons of Nemagon were spilled at a loading spot north of Building 471 identified by Shell as 2-471. One borehole is already planned at this unload spot.
6. A tank car overflow at an unload spot between Buildings 451 and 473 spilled over 2000 gallons of allyl chloride in 1975. The allyl chloride drained off the area via the surface drainage and some was recovered. A borehole has been sited at unload spot 3-471 intercept the effect of this spill.
7. Overflow of Tank 133 during filling spilled 300 gallons of mineral spirits in 1975 near an unload spot between Buildings 451 and 471. Corrective measures are listed by Shell as recovery of 1000 gallons that were trapped in the trench and clean up of the rocks and dirt. One borehole is located at unload spot 4-471 to intercept this spill.
8. Several spills are recorded as occurring sometime between 1950 and 1981 in the tank farm associated with Building 471. The

farm was reportedly concrete lined but not completely. Many of the spills were readily trapped and recovered. Others were in contact with the soil. One borehole is planned south of Building 471 near an existing monitoring well (571).

9. An acetone spill of a few gallons was associated with the tank farm in 1977 or 1978 from Tank 1173. A single borehole east of the large concrete lined tank farm south of Building 471 will be drilled.
10. A 1981 spill of 500 gallons of chloral bottoms on the ground under Building 471 was mentioned by Shell. Boreholes associated with G1 through G7 are around the building, but the most likely area south of the building and north of Building 472 is inaccessible to the rig.
11. An underground leak from a sump and sewerline spilled an estimated 300 gallons of NaOH and acid near Building 471 in September, 1981. No record of cleanup is found. The boreholes associated with G1 to G9 cover this area.
12. Over 1000 gallons of Nemagon was spilled in a tank car unloading north of Building 471 in 1974. Boreholes G7, G6 and G4 drill at unload spots 4-471, 3-471 and 2-471 respectively. One borehole will be added at unload spot 1-471. It will be labelled G602.
13. Chloral distillation bottoms were spilled on the ground under Building 471 in 1981 from a broken pipe in the process sewer line. Over 500 gallons are recorded spilled and no cleanup is indicated. The area around the building is covered by seven boreholes. An uninvestigated area that is inaccessible to the rig is south of the building and north of Building 472 as mentioned under spill G10.
14. An open valve during a product transfer operation spilled 53,397 pounds of Vapona into the ground in diked area in the tank farm south of Building 472 in 1980. A sump removed the product and soil was removed to a depth of 3 or 4 feet. This tank farm is now concrete lined. Boreholes investigating spills G8 and G9 will investigate this spill.
15. Several spills of unknown amounts of bromine occurred near Building 471 between 1955 and 1975. Boreholes used to investigate spills G1, G4, G6, G7 and G8 will be used to investigate this spill.
16. In 1981 or later 1/2 pint of chloral was spilled on to concrete in the Building 471 tank farm. The area was washed and cleaned up. This spill is very small; it will possibly be investigated by the boreholes used to investigate G8 and G9.

17. In 1981 or later 20 drops of trimethyl phosphite were spilled on the ground and 1/2 cup spilled on the pump base due to a valve malfunction on a loadline at tank car load spot 1-471. No clean up is recorded. This spill is investigated by the borehole used to investigate spill G12.

H. Building 511

A 1200 gallon hexane spill from a broken line during a tank car unloading occurred on the railroad tracks north of Building 516 in 1958. No cleanup action is recorded. In addition, Kuznear and Trautmann (1980) cite that large amounts of Lewisite were lost through leakage of pipes and tanks in the area. Shell indicated in the May 1 letter this spill occurred near unload spot 1-534 near the switch area. One borehole is planned.

I. Building 512

1. In 1965 500 gallons of chlorothiophenol (CTP) were spilled unloading a tank car northwest of Building 512. Shell interrogatory response incident number 25 indicates several such spills occurred between 1966 and 1975. The bad odor of this chemical makes it likely to have been removed. One boring has been located at this spill.
2. Several HCCPD spills in the form of tank overflows occurred between 1953 and 1964 in the reactor area east of Building 512. The concrete pad below the reactor reportedly caught most of the spill and drained it to the chemical sewer. The splashed soil was removed. One borehole in the reactor area is planned.
3. Several spills occurred between 1953 and 1964 that are listed as around Building 512. The spills involve 400 gallons of isopropanol, 1500 gallons of HCCPD and unknown amounts of compound 773. Some of the HCCPD was removed. In addition, overflows of tank vents onto the roof and the ground below the roof around Building 512 are recorded. Two boreholes are planned in the reactor area.
4. Mercury is reported spilled around and behind Building 512. One borehole is located on the west side of the building.

J. Building 514

Several spills are associated with Building 514. The spills, which are in scattered locations, are:

1. Overflow of 500 gallons of acetone from tank 178 in 1979 was contained in a diked area around the tank. Boreholes under spill sites J3 and J5 are planned to include this spill.
2. Drum washing on the north dock of Building 514 between 1963 and 1981 spilled dilute amounts of azodrin, acetone,

chloroform and MCAA onto the surrounding area. One borehole is located north of this dock.

3. Leakage of 500 gallons of caustic soda (20% w) from tank 65 in 1978 spilled onto the ground. The dirt was replaced in the immediate vicinity. One borehole is located south of this tank.
4. Regular or continuous leakage from Tank 65 from 1978 to 1981 of caustic soda (20% w) was reported. The dirt was replaced in the immediate vicinity. The borehole drilled under spill site J3 investigates this spill also.
5. Failure of a high level cutoff on Tank 116 north of Building 514 spilled 7400 gallons of caustic soda (20% w) on December 29, 1971. The tank has been removed and one borehole is located on its previous location.
6. In the mid-1960's tank car overflows of caustic soda (50% w) of at least 200 gallons occurred at unload spots 1-514 and 2-514. One borehole is planned for each unload spot.
7. Tank 1140 in the center of the tank farm overflowed on the north side in 1976, spilling 960 gallons of chloroform on to the ground. The existing concrete beams were not there when the spill occurred. One borehole is planned north of this tank farm.
8. A tank car overflow in September 1963 spilled 1700 gallons of DCPD in what is labelled the south tank farm north of Building 514. Two boreholes are located north and south of the west end of the tank farm north of Building 514.
9. Overflow of Tanks 1272 and 1273 north of Building 513 spilled 3000 gallons of trimethyl phosphite (TMP) onto the surrounding soil in 1970. Dirt was removed to a depth of 2 to 3 feet. One borehole (J903) is planned north of the tanks. Two additional boreholes labelled J901 and J902 are used to investigate spill J11 and J904 is used to investigate spill J12 for numbering convenience only.
10. Spill of 1000 gallons from overflow of a benzene tank in the tank farm north of Building 514 is reported in 1955. The affected soil was removed. As no specific tank is indicated, boreholes at sites J3, J5, J7, J8 and J9 are placed to find this spill as well.
11. Approximately 900 gallons of caustic soda (20% w) spilled east of Building 514 in 1969 while thawing a frozen line from Buildings 514, 515, 516 and 534 to the tank farm. Boreholes J901 and J902 are planned to investigate this spill.
12. A 200 to 500 gallon spill of MMA (mono methyl/amine) occurred in 1980 in the northeast end of the tank farm north of

Building 514. One borehole is planned east of the tank farm north of Building 5140. This borehole is labelled J904.

13. In 1978 a 100 gallon dimethylamine (DMA) spill is recorded in the Building 514 tank farm. Boreholes for spills J8, J9, and J10 are also investigating this spill.
14. A large spill of Bidrin (1300 gallons) was reported for 1978 in the vicinity of Building 514. The spill is reported going to the chemical sewer, no further information is given. This spill may be investigated by boreholes for spills K1, J2, and J6.

K. Building 516

1. Several incidents occurred between 1952 and 1970 of sump overflow to the contaminated sewers north of Building 516. Acetic acid, aldrin, benzene, caustic soda (20% w), dieldrin, endrin, and xylene were spilled. Two boreholes north of the sump and along the surface route to the chemical sewer are planned.
2. In 1970 spills from vat 1096 in Building 516 of 1500 gallons of sulfone reached the surface drains and sewers outside and north of the building through the sump system. This spill is investigated by boreholes for spill K1.
3. HCCPD and water would occasionally flow out the north side of Building 514 north of Building 516 between 1949 and 1955 related to phase separator spills on the northeast dock. This spill is investigated by boreholes for spills J2 and J6.
4. In 1952 a chemical reaction explosion in Building 516 spilled hydrogen peroxide, acetic acid, sulfuric acid, possibly Aldrin and Dieldrin in benzene, chlorine and HCCPD in an unknown volume. The explosion was possibly contained within the building. In which case it will be investigated by the boreholes for spill K1 which are near the sumps. The explosion may have reached outside the building by a direct route and one borehole west of the building is planned.

L. Building 521

1. Five hundred gallons of cyclopentadiene (CPD) and DCPD spilled between 1949 and 1974 north of Building 521 on the west end of the tank farm. Two boreholes are located northeast of the building south of the tank farm.
2. A 200 gallon HCCPD spill (overflows of Tanks 111 and 112) occurred between 1949 and 1955. These tanks were located between Buildings 521 and 525, and partially under Building 525. No bore holes will be drilled in Phase I here.

M. Building 522A

1. A 16,000 gallon benzene spill from a gasket failure in an overhead line covered the railroad tracks with frozen benzene between 1951 and 1953, south of Building 522A. Two boreholes north and south of the tracks are planned.

N. Building 528

1. In December 1958 a leak in an underground transfer line released 650 or 5105 gallons of CPD bottoms southeast of Building 536. No cleanup is indicated and the underground line was replaced by an above-ground line. One borehole is located southeast of Building 536.
2. Overflow of a sulfuryl chloride recovery unit east of Building 528 in 1958 spilled 200 gallons. One borehole is located east of 528.
3. Overflows of Tanks 6 and 7 south of Building 528 spilled greater than 55 gallons of DCPD between 1949 and 1974. The chemical flowed east to the ditch on the east side of Building 528. One borehole is planned in the tanks area.

O. Building 534

1. In 1949 2,000 gallons of heptane was drained from the chlordane process north of Building 534B. No cleanup actions are recorded. Two boreholes are planned north of Building 534B.
2. Tank overflows of 100 gallons of mixed acid in 1969 are reported in the tank farm north of Building 534A. The floor of the tank area was flooded and seepage may have occurred through cracks. Cleanup consisted of washing the acid to the contaminated sewer. Three boreholes in the tank are planned.
3. Overflow of Tank 15 east of Building 534 occurred in 1974. There is no reported cleanup of the 1,000 gallons of hexane spilled from the tank. Two boreholes near the tank are planned.
4. An explosion of crystallizer on the northeast side of Building 534B released 400 gallons of 4-chloro-3,5-dinitrophenyl methyl sulfone and mixed acid in 1975. One borehole is located east of Building 534B.
5. Mercury is reported spilled around Building 534 during the period 1969-1978. Since several boreholes are scheduled northeast of Building 534B, two additional boreholes southwest of Building 534B are planned.
6. Three times in 1981 near Tank 161 east of Building 534 a tank overflowed 500, 10 and 5 gallons into a concrete dike within a

6 by 60 foot earthen area. The spills were diluted and flushed to the chemical sewer. One borehole north of the tanks east of Building 534 is planned.

R. Building 514

1. In 1966 a tank explosion occurred in the northwest room in Building 514 which blew the tank through the wall spilling approximately 1,000 gallons of azodrin. Most of the spill was inside the building. Boreholes north of the building include those investigating spills J2 and J6. A borehole west of the building used to investigate spill K4 will be used to investigate this spill.

S. Building 435

1. In 1973 approximately 100 gallons of spent acid leaked from a corroded line southwest of the east gas holder (Building 435). There was no reported cleanup at this site. Four boreholes are planned in the field south of Building 435 and north of the railroad tracks along pipeline and in poorly vegetated areas.

T. Building 571B

1. In 1960 near the flare between Buildings 571, 571B and 504 a release from an experimental Hex-Acetylene reactor spilled 150 gallons of HCCPD (hexachlorocyclopentadiene). One borehole north of the flare is planned.
2. Approximately 100 gallons of sulfuryl chloride spilled due to the overpressuring of a tank trailer during loading in 1978. This occurred north of Building 571B near the flare. Cleanup consisted of soil removal. One borehole east of the flare is planned.
3. Between 1950 and 1952 J. H. Hyman had a landfill on the east side of the flare tower in the DET area. Chemicals disposed in the landfill included HCCPD, tetrachlorocyclopentane, octachlorocyclopentene, hexachlorobutadiene, perchlorobenzenes and resinous materials composing hex bottoms. Groundwater monitoring was installed in 1978-1979 and the wastes are reportedly not migrating from the site. The borehole T2 which is east of the flare will be used to investigate this spill.
4. West of Building 571B in 1982 a 5 to 10 gallon mixture of water and methylisobutyl ketone was spilled in 1982. The spill affected 25 square feet from which the soil and rock was removed. A single boring in the incinerator area northwest of Building 571B is planned.
5. In the incinerator area in 1981, 200 to 300 pounds (25 gallons) of a water/methylisobutyl ketone mixture was spilled

through a leaking filter gasket. The area was decontaminated with bleach and the dirt removed. The borehole drilled for spill T4 will investigate this area.

U. Building 506

1. North of Building 506, 200 gallons of Shell fertilizer solution 8-0-0-15 was spilled in 1979. The contaminated soil and fertilizer was removed. One borehole north of Building 506 is planned.
2. In the same area vat 1255 filled with DET effluent overflowed an estimated 1,000 gallons onto the surrounding gravel in 1981. One borehole is located near this tank.

V. Building 464

1. About 1960 a quarter inch drain line froze and broke allowing an unknown amount of BCH bottoms to spill onto the gravel below Tank 464B south of Building 464. No cleanup is recorded. Two boreholes north and south of Tank 464B are planned.
2. In 1967 spills from cleaning out Tank 464 south of Building 464 of 1,500 gallons of DCPD bottoms and No. 6 fuel oil flowed to a low spot in the tank farm area. The material was picked up, drained and removed around 1974. Two boreholes in the low area north of Tank 464A are planned.
3. Between 1967 and 1975 spent acid was spilled during tank truck loading near Tank 464A west of Building 464. One borehole is planned in this area.
4. In 1976 a line holed out during transfer of DCPD bottoms from Tank 321E to Tank 464A spilling 1,548 gallons onto the soil. The affected soil was removed. One borehole is located southwest of Tank 464A. Boreholes investigating spills V2 and V3 are located north of Tank 464A.
5. In 1956 1,400 gallons of BCH bottoms were lost cleaning Tank 464B. No cleanup is recorded. One borehole will be used to investigate this spill.

W. Building 515

1. In 1957 an endrin vent line overflow north of Building 515 spilled 3,000 gallons of benzene onto the ground. No cleanup is recorded. Two boreholes are planned east and west of the north wing of Building 515.

X. Railyards

1. Incident 56 in the Shell Interrogatory Responses 13 to 20 recounts the spills assumed responsible for the DBCP plume

migrating to the northwest boundary. The source is considered to probably be the rail classification yard in Section 3 west of the South Plants. These spills will not be investigated in Task 2.

Y. Section 36

1. Between 1962 and 1973 surface waste drum storage in the southwest quarter of Section 36 spilled unknown amounts of varying Shell chemicals as reported in the incident 57 of the Shell Interrogatory Responses 18 to 20. These spills will not be investigated in Task 2.
2. From the early 1950s to the mid-1960s, 18 trenches in Section 36 of varying sizes were used to dispose of bulk waste as reported in incident 58 of the Shell Interrogatory Responses 18 to 20. These spills will not be investigated in Task 2.

Z. Tank 1315

1. In 1981 a leak in a hose allowed a spill of one pint of Nudrin heavy ends near Tank 1315. This spill is too small to drill a borehole in this investigation.

Site 2-14 Sanitary Landfill

Two separate landfills are considered to be Site 2-14. One landfill is west of Building 347, and is comprised of approximately 147,200 ft². This is shown as Site 2-14a in Figure 3.3-6. The other landfill is south and east of Building 362, and comprises approximately 42,300 ft². This is shown as Site 2-14b in Figure 3.3-7. Contaminants may include both organic and inorganic compounds. Very little historical information is available. Because the ground has been disturbed, and unknown materials are buried, a geophysical reconnaissance is requested before drilling can proceed. Depth to water at Site 2-14a is approximately 20 feet. A boring density of 1/4,900 ft² will be used, resulting in ten borings to be drilled during Phase I as follows:

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	20	8
	2	15	6
	2	10	4
	4	5	4
Totals:	10		22

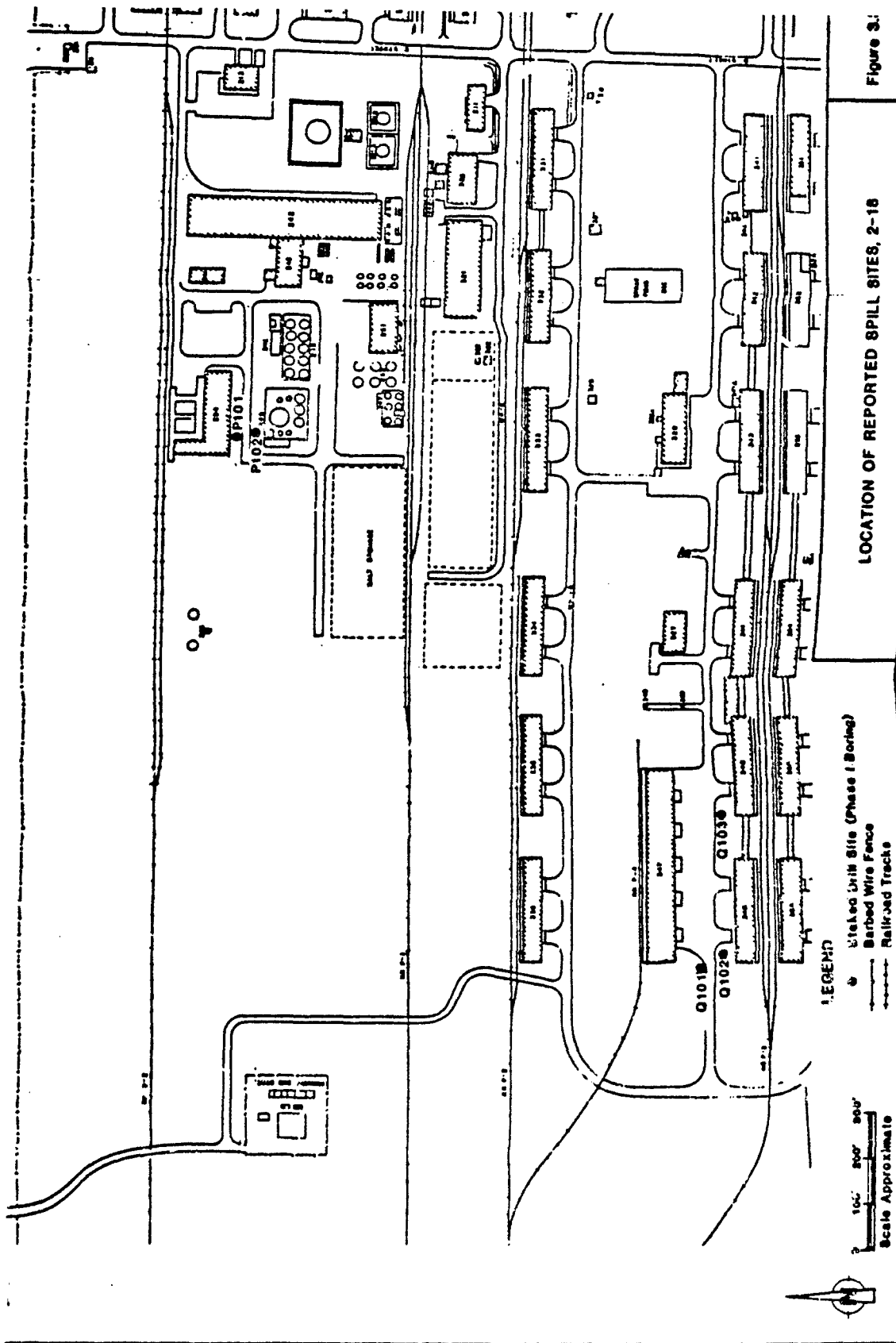
Depth to water at Site 2-14b is approximately 12 feet. A boring density of $1/1,600 \text{ ft}^2$ will be used, resulting in eight Phase I borings.

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	15	6
	2	10	4
	4	5	4
Totals:	8		14

No surface samples (0-1.0 feet) will be taken from any of the borings drilled at Sites 2-14a or 1-14b.

Site 2-18 South Plants Spill Sites Section 2

Numerous spills and leaks have occurred in the South Plants area in Section 2, but few have been documented in the literature. The information sources for spill site location in Section 2 are the same as those for spill sites areas in Section 1 described in the text for Site 1-13. The following is a brief description of the spills in Section 2. Approximate locations of the spill sites are shown on Figure 3.3-8.



P. Building 254

1. In 1964 30 gallon drums of Naled (DIBROM) stacked on the southwest wall of Building 254 leaked over 200 gallons. No cleanup is recorded. Two boreholes are planned in the ditches north and south of the road south of Building 254.
2. Sometime between 1968 and 1972, Naled leaked from thirty gallon drums stacked south of Building 254. The leaking drums were contained and removed along with the contaminated soil. This spill is investigated using boreholes used to investigate spill P1.

Q. Building 347

1. In 1973 two thirty gallon drums of Nemagon (DBCP) south of Building 347 were punctured by a forklift spilling 60 gallons of liquid across the blacktopped loading area and into the ditch. The area was diked and sand swept over the spill and the dirt removed. Three boreholes are planned in this area south of Building 347. One is located in the ditch north of Building 345, and two are located in ditches at the west end of Building 347.

JOINTLY OPERATED SITES

Site 1-5 Lime Pits and Storage Area

Two revetted storage areas, comprising a total of over 96,000 ft² have been identified from 1982 aerial photographs, historical records, and the South Plants location map. These pits were filled with both organic and inorganic compounds, including heavy metals, from 1943 through the late 1950s. Waste products of slate, lime, and acetylene were also disposed of at this location until the 1950s when this settling basin was abandoned and the lime pits in Section 36 were opened. Leakage from Site 1-5 was suspected to have contributed to contamination in Lower Derby Lake. A boring density of 1/3,600 ft² was used to determine total number of sampling locations. The water table is estimated to be at a depth of about 15 feet. Figure 3.3-9 shows the boring locations for Site 1-5. Eight borings will be drilled and sampled in Phase I as follows:

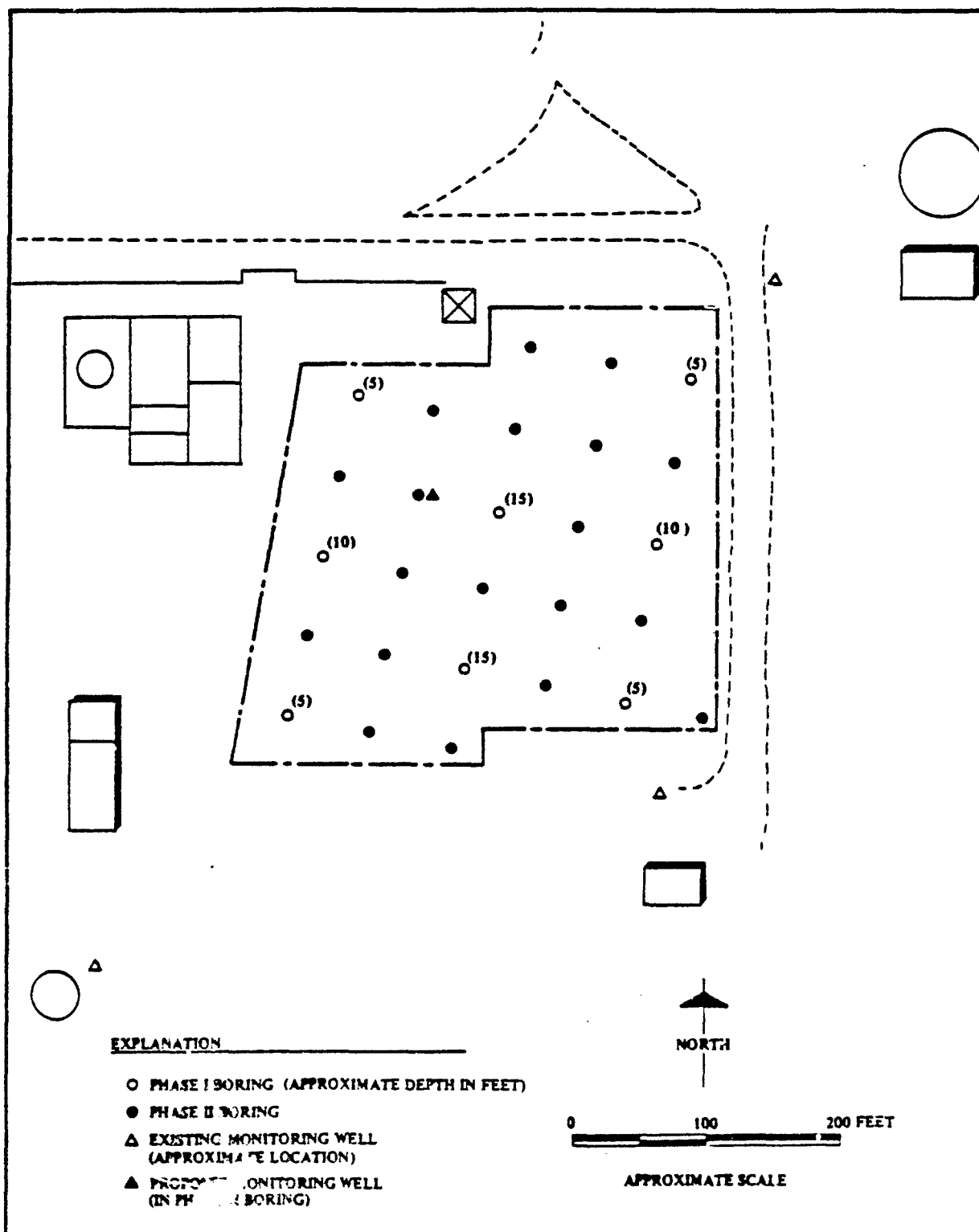


Figure 3-9
BORING LOCATION MAP
CONTAMINANT SOURCE 1-5
(Lime Pits and Storage Area - Job 1 Site)
ROCKY MOUNTAIN ARSENAL, SECTION I
Prepared by R.L. Stollar and J. Stollar

Prepared for:
U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	15	6
	2	10	4
	4	5	4
Totals:	8		14

No samples will be taken from the 0 to 1 foot interval because the lime ponds were covered at the surface.

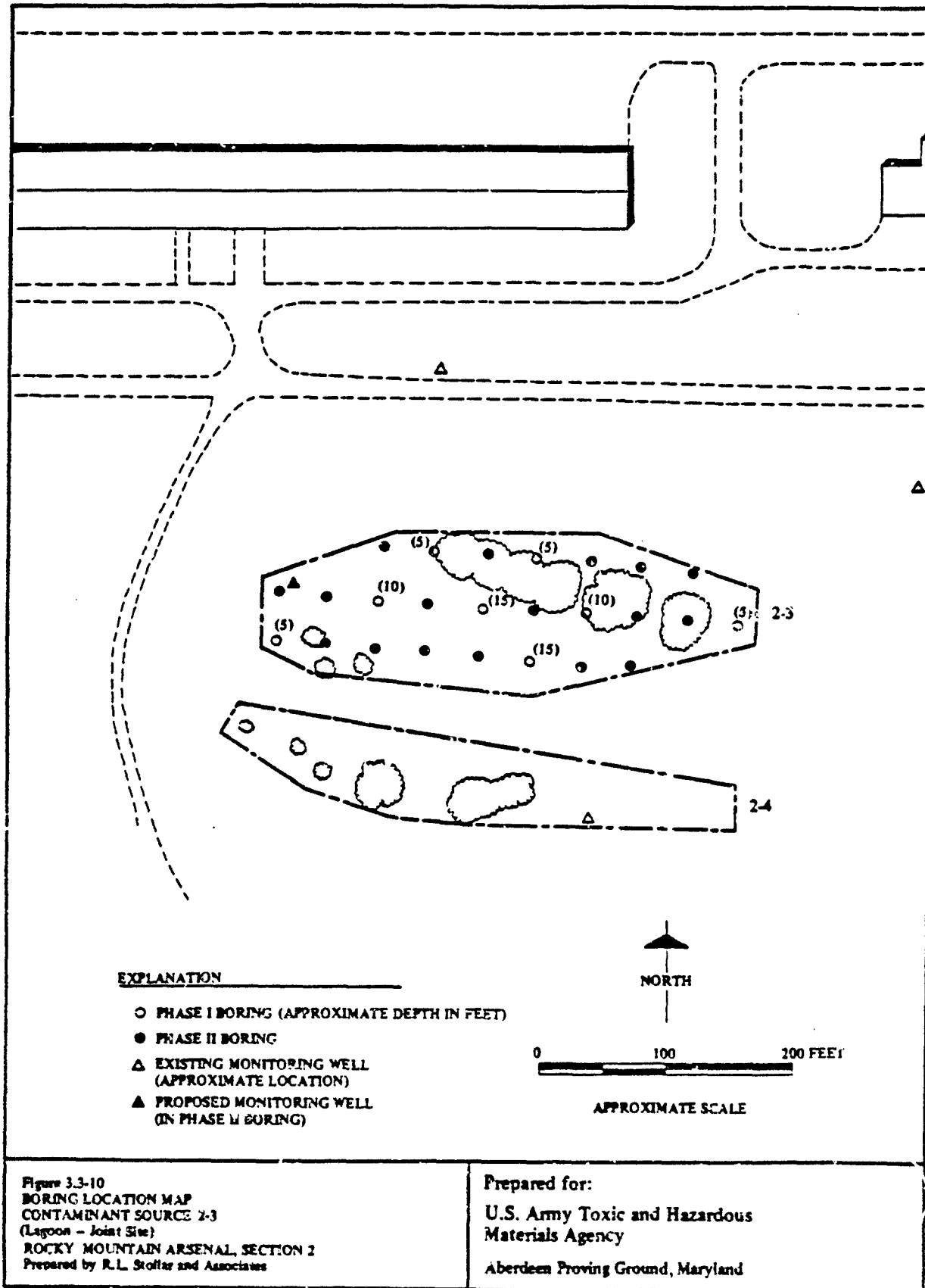
Site 2-3 Lagoon

A small lagoon, approximately 39,500 ft² in area, contained standing liquid in the 1940s. Potential contaminants include both organic and inorganic compounds. This area was covered or filled in by 1955; therefore, no samples from the 0-1.0 foot interval will be taken. A boring density of 1/1,600 ft² will be used. Depth to water is approximately 15 feet. Figure 3.3-10 shows the boring locations for Site 2-3. Eight borings will be drilled in Phase I as follows:

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	15	6
	2	10	4
	4	5	4
Totals:	8		14

Site 2-7 Aeration Basin

The aeration basin site is located south of Building 326 and is approximately 25,200 ft² in area. It consists of a 5 foot deep concrete basin with four north-south rows of twelve and one foot square concrete



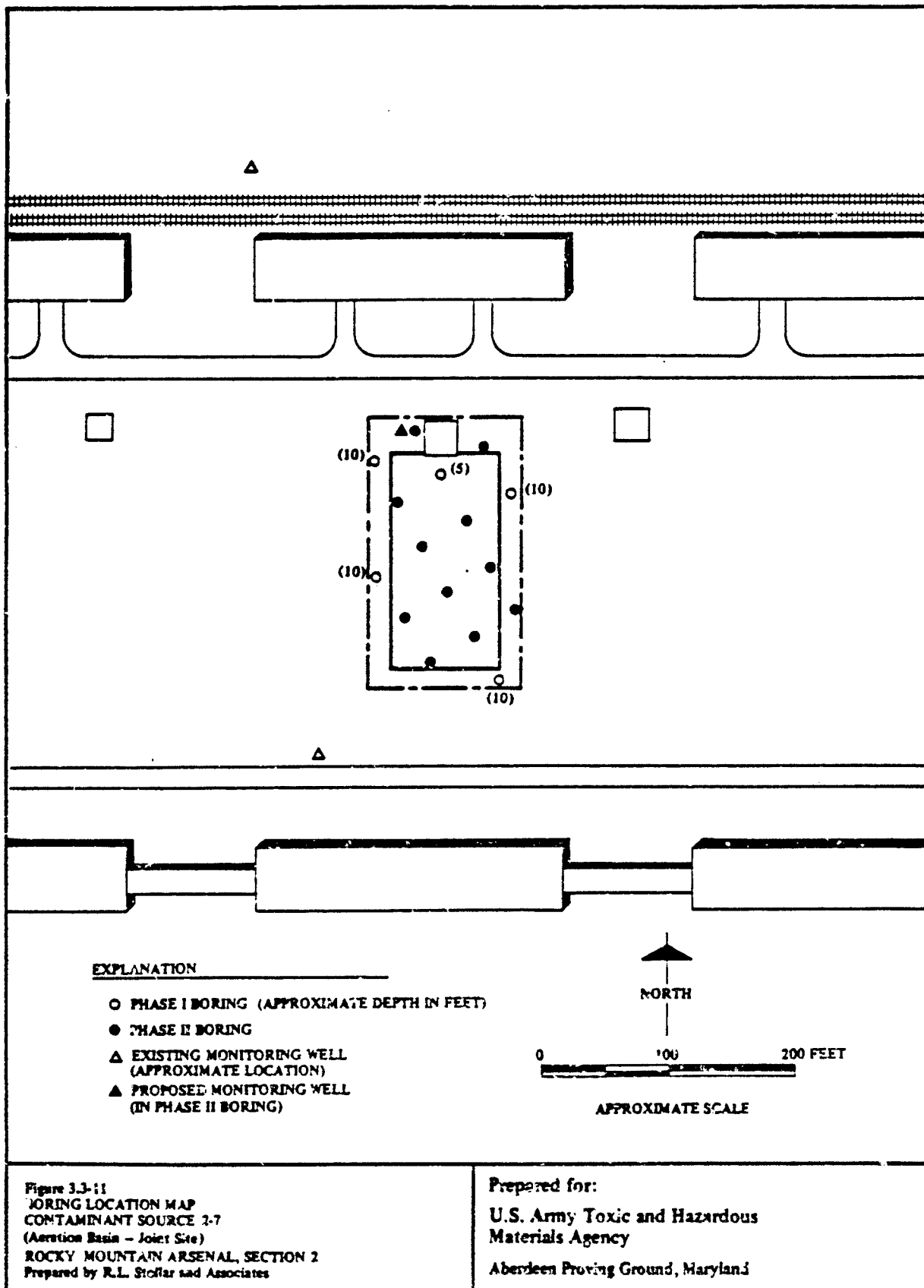
pillars spaced evenly supporting a piping system. Open storage, mounded materials, and pits have been observed west of this basin. Depth to water at this site is approximately 10 feet. Figure 3.3-11 shows the boring locations for Site 2-7. Using a boring density of $1/1,600 \text{ ft}^2$, five borings will be drilled to a maximum depth of 10 feet during Phase I as follows:

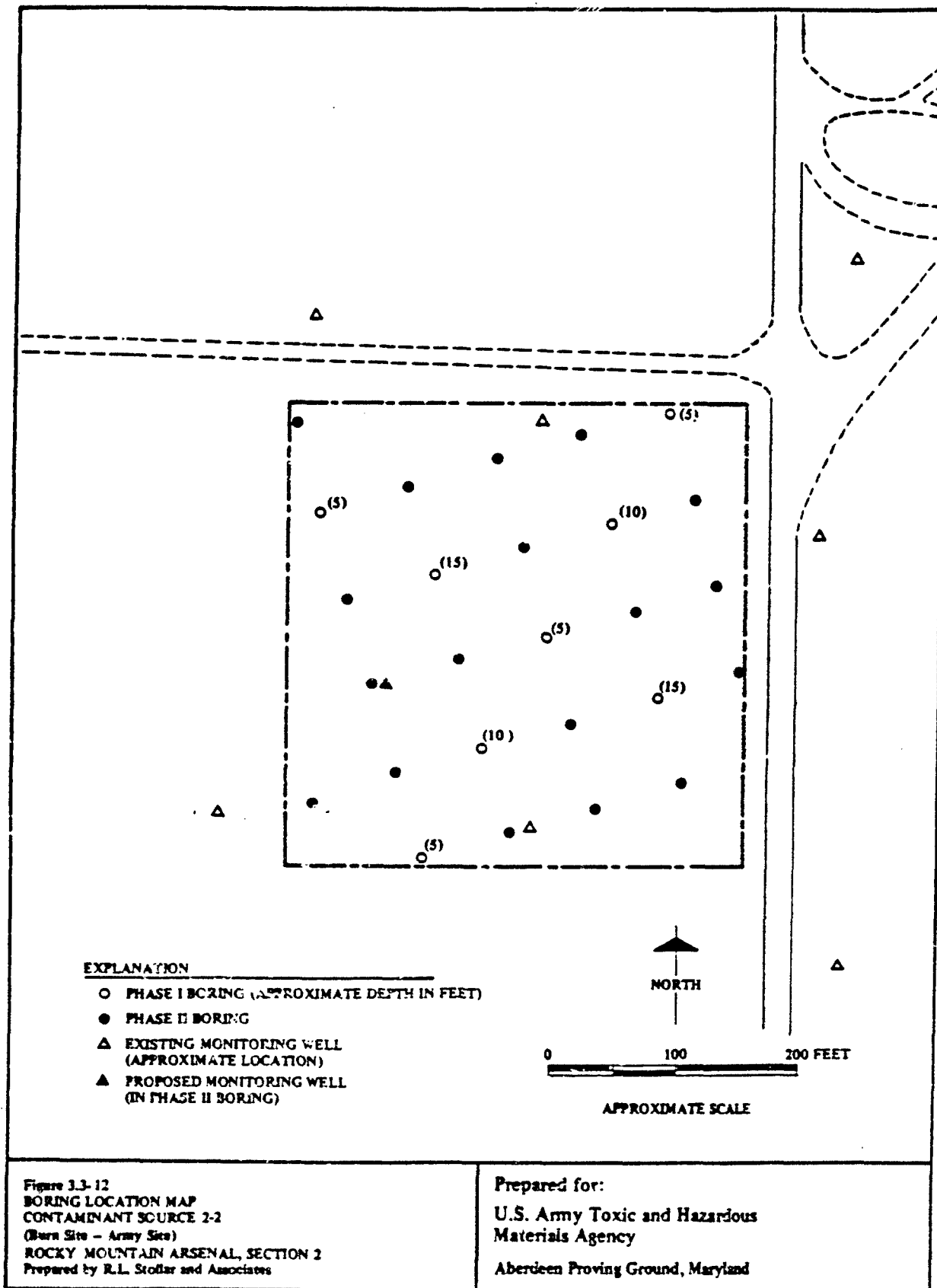
	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	4	10	12
	1	5	2
Totals:	5		14

ARMY OPERATED SITES

Site 2-2 Burn Site

This site is located west of D Street and the South Tank Storage Area in Section 1. Its approximate size is $128,000 \text{ ft}^2$. It was used as a firebreak in the 1940s and early 1950s and may have been a testing site for munitions and/or incendiaries. Potential contaminants are both organic and inorganic compounds. There is also a strong possibility that unexploded ordnance are present, and a geophysical survey will be performed before drilling occurs. The water table is anticipated at a depth of 15 feet. A boring density of $1/4,900 \text{ ft}^2$ will be used. The boring locations are shown on Figure 3.3-12. Eight borings will be drilled in Phase I as follows:





	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	2	15	2
	2	10	6
	4	5	8
Totals:	8		22

Site 2-6 Salt Storage Area

This area is located west of Building 247, and consists of approximately 54,000 ft². The area is known to have contained standing liquid and material. Contaminants include both organic and inorganic compounds. During a site reconnaissance in October 1984, the area was full of standing liquid. Depth to ground water is approximately 25 feet. A boring density of 1/2,500 ft² will be used. Figure 3.3-13 shows the boring locations for Site 2-6. Seven borings will be drilled in Phase I as follows:

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
	1	25	6
	1	20	5
	1	15	4
	1	10	3
	3	5	6
Totals:	7		24

UNASSIGNED SITES

Site 1-3 Mounded Material

Two areas east (1-3a) and northeast (1-3b) of Building 541, a white phosphorus filling warehouse, were identified in a 1948 aerial photograph as areas which contained man-made mounds of unknown origin. These mounds were

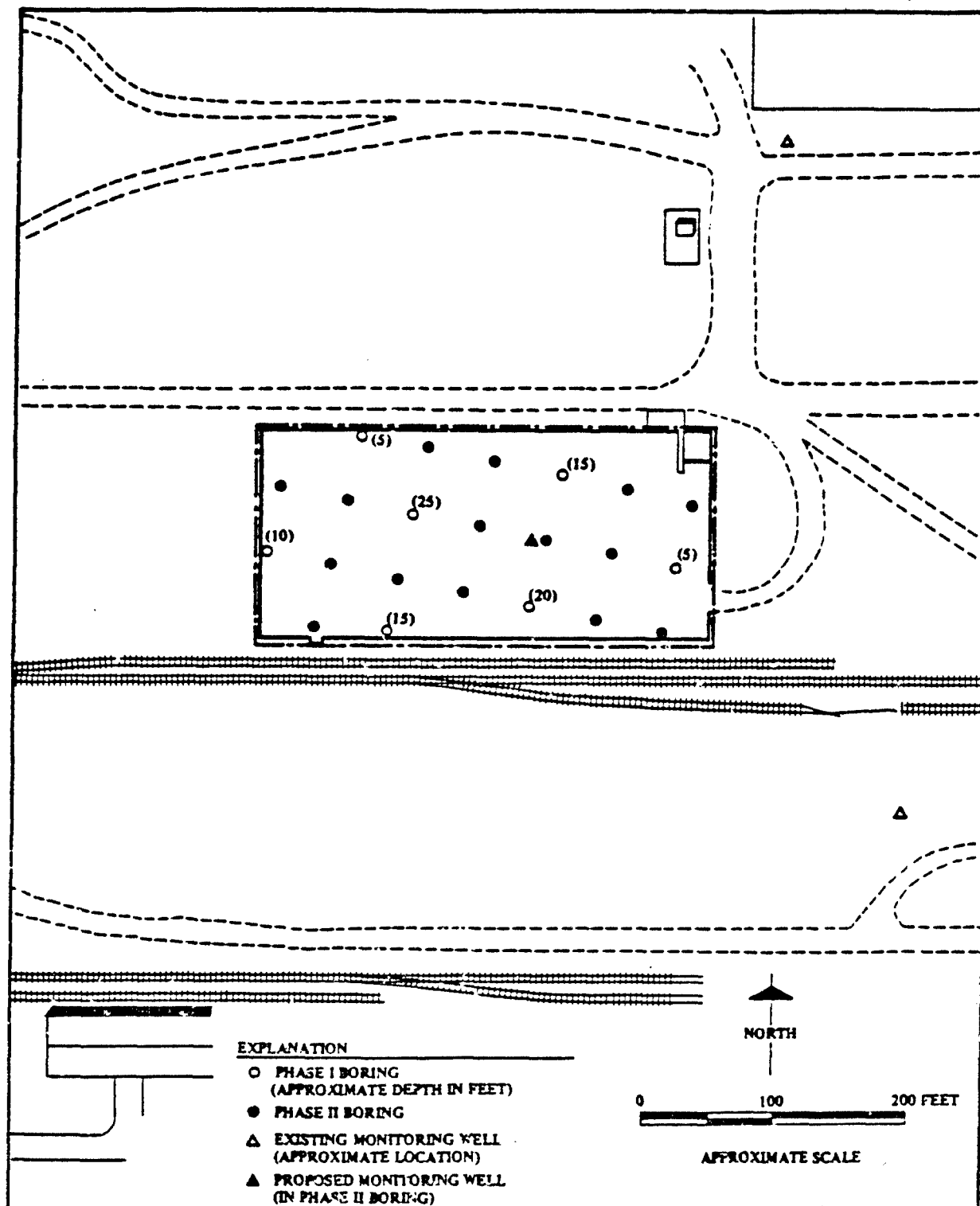


Figure 3.3-13
BORING LOCATION MAP
CONTAMINANT SOURCE 2-6
(Salt Storage Area - Army Site)
ROCKY MOUNTAIN ARSENAL, SECTION 2
Prepared by R.L. Stoller and Associates

Prepared for:
U.S. Army Toxic and Hazardous
Materials Agency/
Aberdeen Proving Ground, Maryland

missing on a 1955 photo. All of the unassigned sites are considered uncontaminated and the boring spacing was determined using that assumption. Site 1-3a consists of approximately 25,350 ft², and a boring density of 1/1300 ft² was used. Estimated depth to water is 15 feet.

Site 1-3b is approximately 2,500 ft² in areal extent. A boring density of 1/900 ft² was used. One Phase I boring will be drilled. Figure 3.3-14 shows the boring locations for these sites. A summary is as follows:

	<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
Site 1-3a	1	15	4
	1	10	3
Site 1-3b	1	15	4
Totals:	3		11

Site 1-4 Borrow Pit

A borrow pit, identified in a 1980 photograph, is located to the southeast of Site 1-5, the lime pits. The borrow pit was presumably used to obtain material for fill or cover, and no documentation of spills or dumping has been located. However, the pit is a topographic depression, and may have received some surface water runoff from the South Plants.

One boring will be drilled at the topographically low area of the pit. It is anticipated that this will be drilled to a depth of 10 feet. Site 1-4 is shown in Figure 3.3-15.

1-11 Sanitary Landfill

A sanitary landfill, located north of Building 732, was identified in a 1980 photograph. The approximate size of the disturbed area is 12,500 ft². The nature of buried material is unknown, therefore a geophysical reconnaissance survey is recommended prior to drilling. The depth to water is about 10 feet. No samples will be collected between 0 and 1 feet. This site is

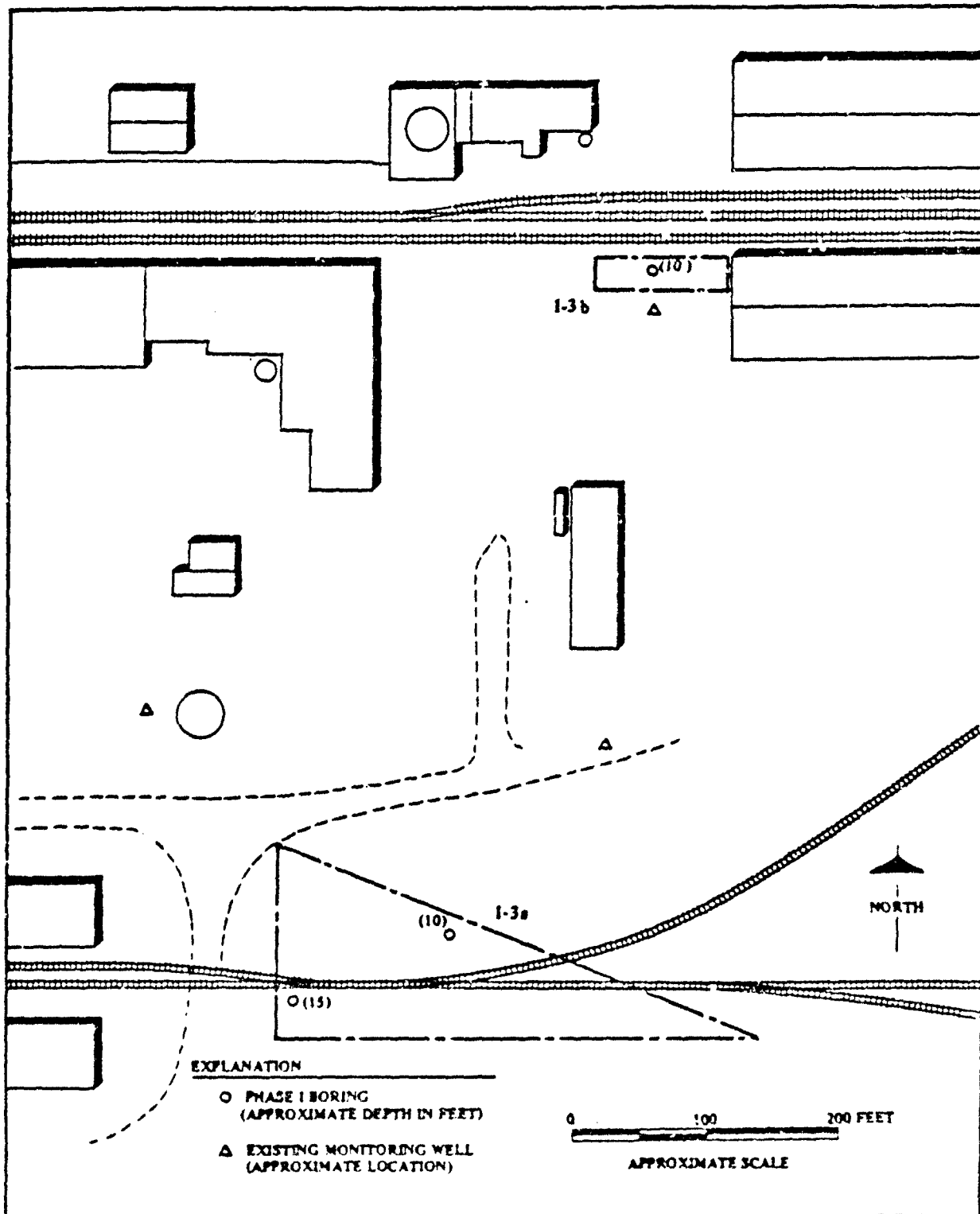


Figure 3.3-14
BORING LOCATION MAP
CONTAMINANT SOURCE 1-3a and 1-3b
(Mounded Area - Unassigned)
ROCKY MOUNTAIN ARSENAL SECTION 1
Prepared by R.L. Stollar and Associates

Prepared for:
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Materials Agency
Aberdeen Proving Ground, Maryland

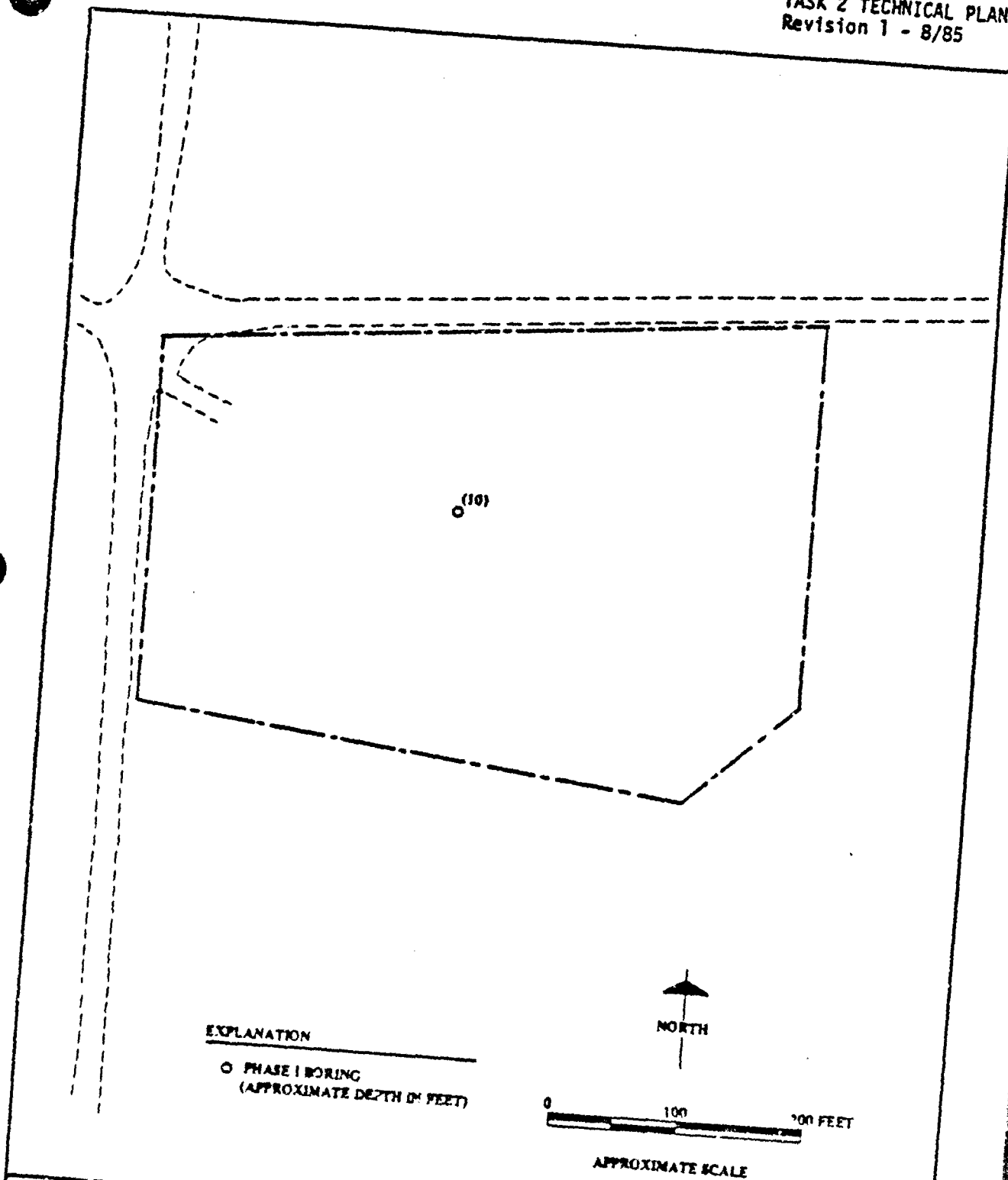


Figure 3.3-15
BORING LOCATION MAP
CONTAMINANT SOURCE 1-4
(Borrow Pit - Unassigned Site)
ROCKY MOUNTAIN ARSENAL, SECTION I
Prepared by R.L. Stollie and Associates

Prepared for:
U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

considered uncontaminated, therefore, a boring density of $1/600 \text{ ft}^2$ will be used. Figure 3.3-16 shows boring locations for Site 1-11. Three borings will be drilled during Phase I as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	10	2
2	5	2
Totals: 3		4

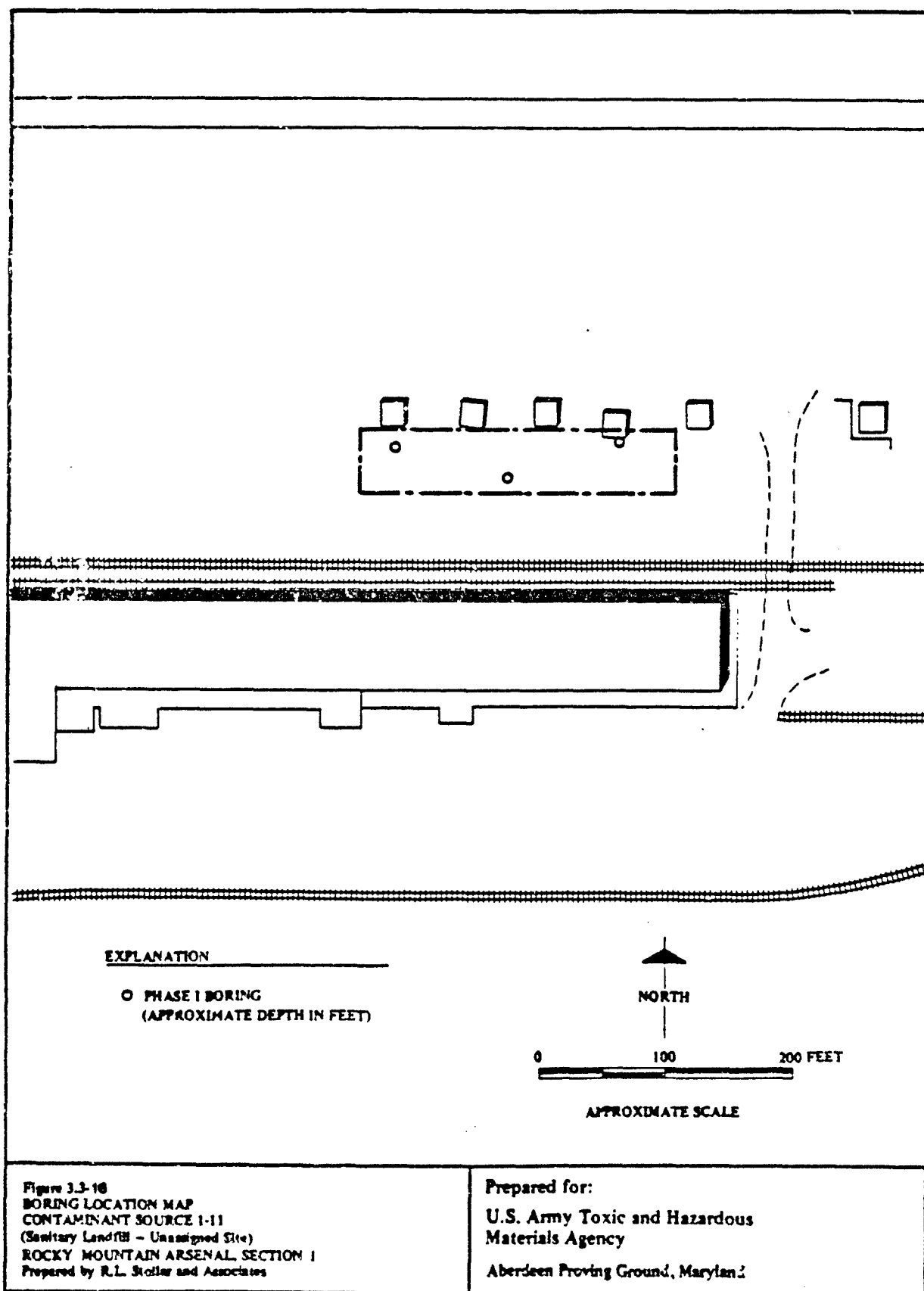
Site 2-4 Excavation Pit

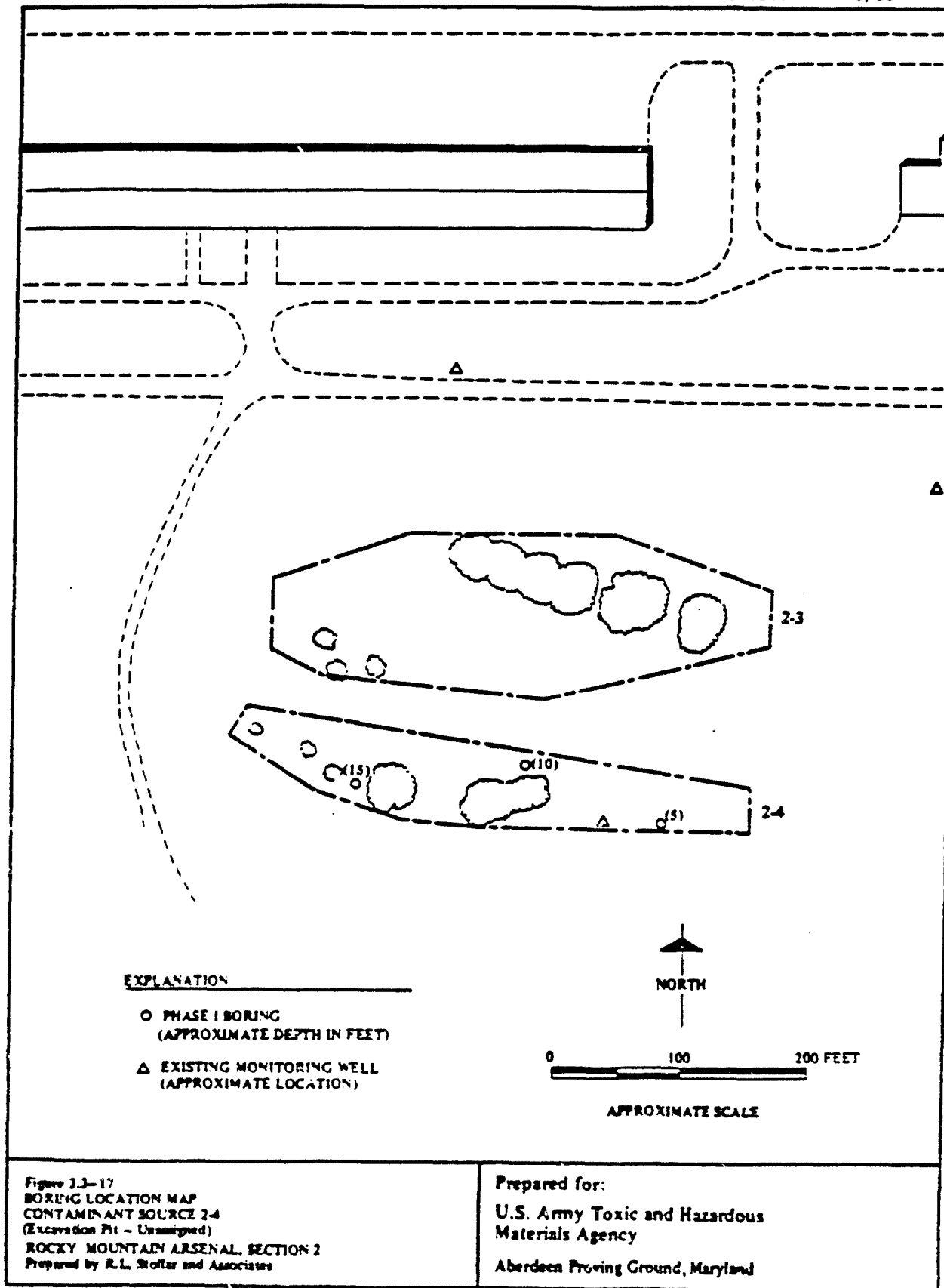
An excavation pit approximately $21,850 \text{ ft}^2$ in area, is located due south of Site 2-3. The disposal history is unknown. Depth to water is approximately 15 feet. This site is considered uncontaminated, therefore, a boring density of $1/2025 \text{ ft}^2$ will be used. One boring will be drilled to 15 feet, one to 10 feet, and one to 5 feet. Boring locations are shown on Figure 3.3-17. The three borings will be drilled during Phase I as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	15	4
1	10	3
1	5	2
Totals: 3		9

Site 2-5 Trench

A small trench, approximately $7,500 \text{ ft}^2$, was located near the northwest corner of Lower Derby Lake in a 1973 photograph. The disposal history of this trench is unknown. No surface samples will be taken. A geophysical reconnaissance is recommended. This site is considered uncontaminated,





therefore, a boring density of $1/1225 \text{ ft}^2$ was used. Depth to water in this area is approximately 15 feet. Boring locations are shown on Figure 3.3-18. Two borings will be drilled during Phase I as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	15	3
1	10	2
Totals: 2		5

Site 2-8 Former Tank Storage Area

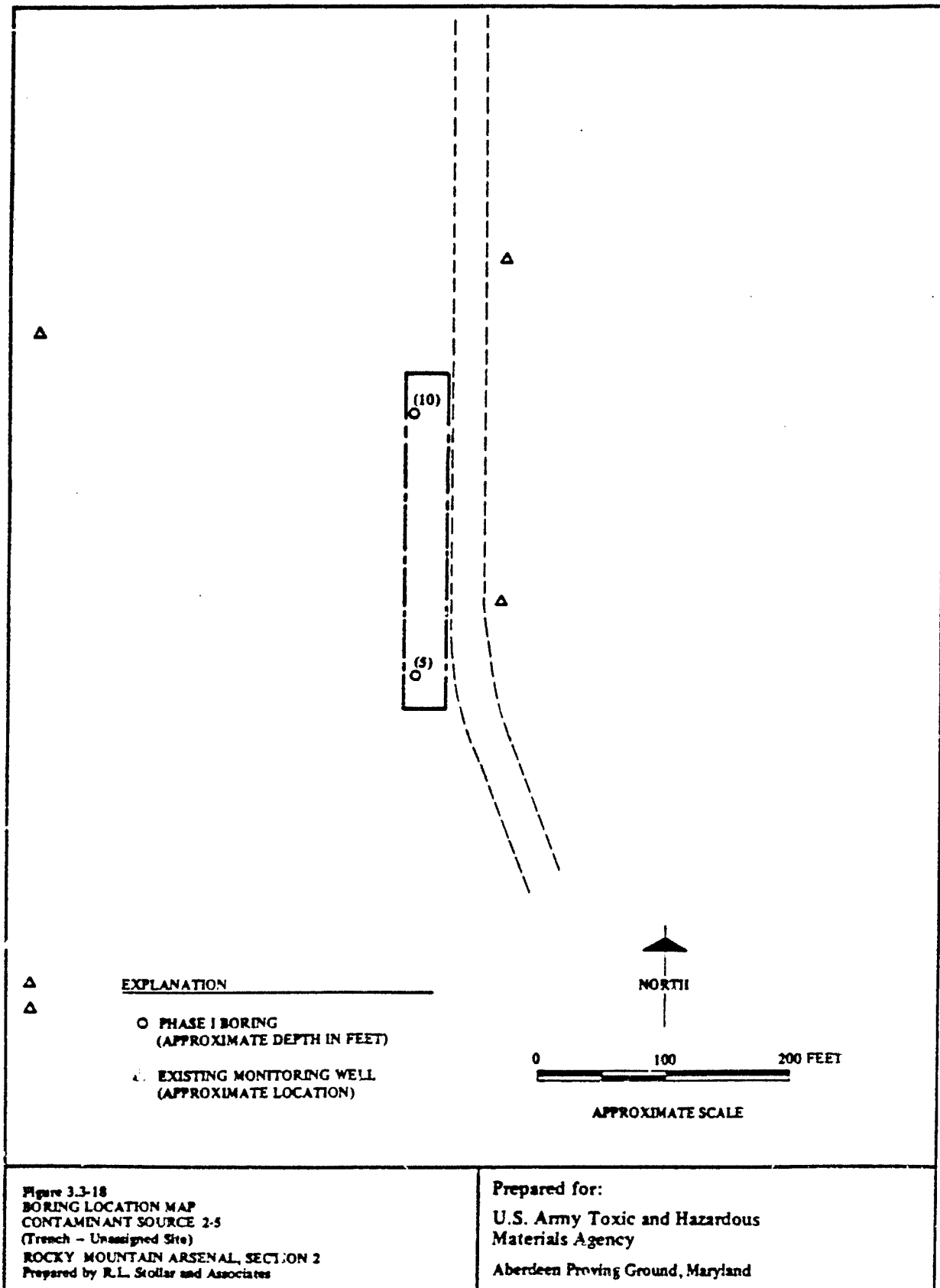
A former tank storage area of approximately $3,300 \text{ ft}^2$ is located west of Building 243, in the chlorine manufacturing area. A 1982 photograph shows the foundations of ten to twelve tanks.

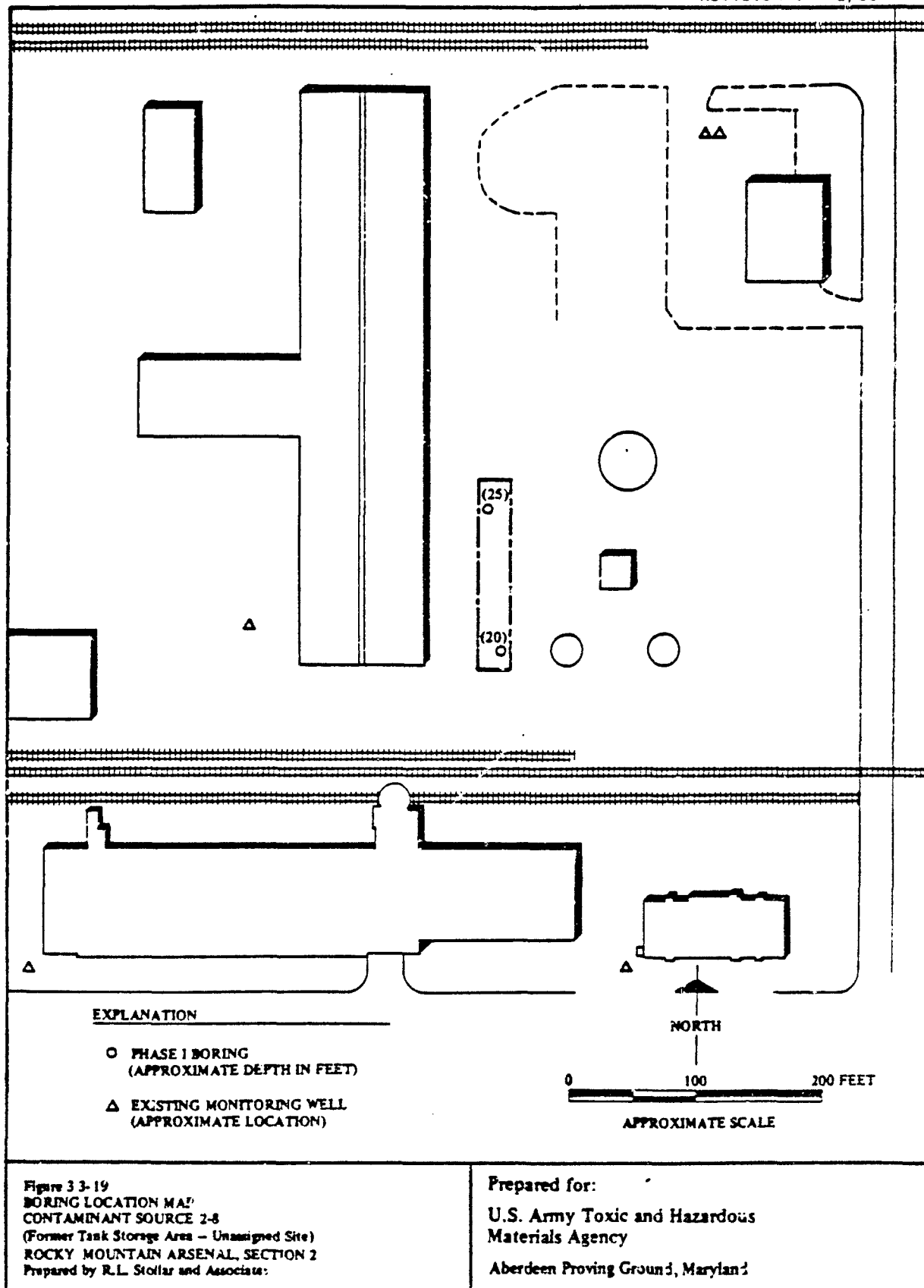
This site is considered uncontaminated, therefore, a boring density of $1/900 \text{ ft}^2$ results in two Phase I borings. Estimated depth to water is 25 feet. The boring locations are shown on Figure 3.3-19. A summary of Phase I boring is as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	25	6
1	20	5
Totals: 2		11

Site 2-9 Open Storage Area

This site, comprising approximately $57,000 \text{ ft}^2$ is located due east of the aeration basin. A 1982 photograph shows storage of pallets or possibly ammunition boxes. Historical usage is not documented. This site is not considered contaminated and a boring density of $1/5,625 \text{ ft}^2$ will be used,





resulting in three sample locations for Phase I. Estimated depth to water is ten feet. Figure 3.3-20 shows the boring locations for this site. A summary of Phase I borings is as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	10	3
2	5	4
Totals: 3		7

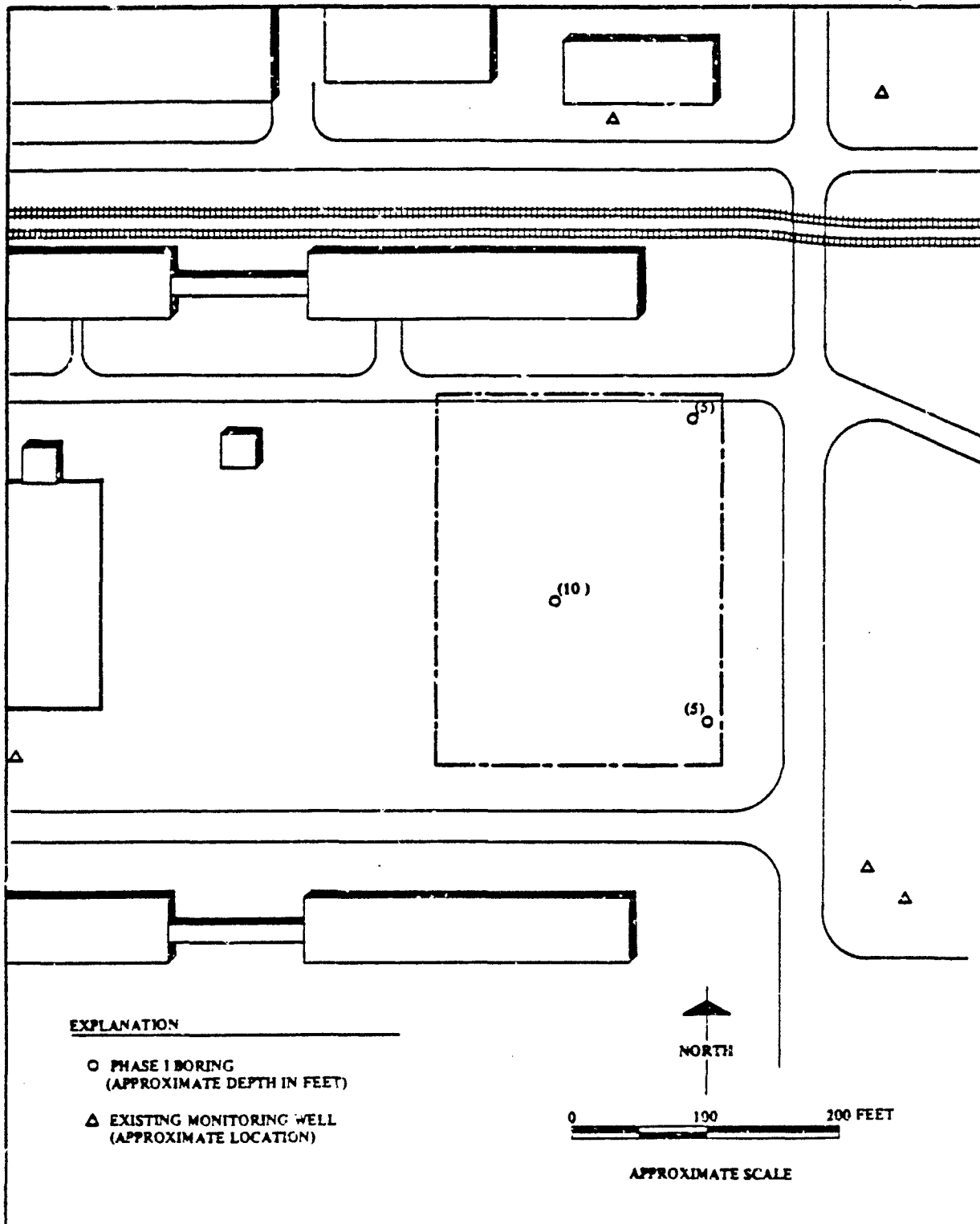
Site 2-12 Former Tank Location

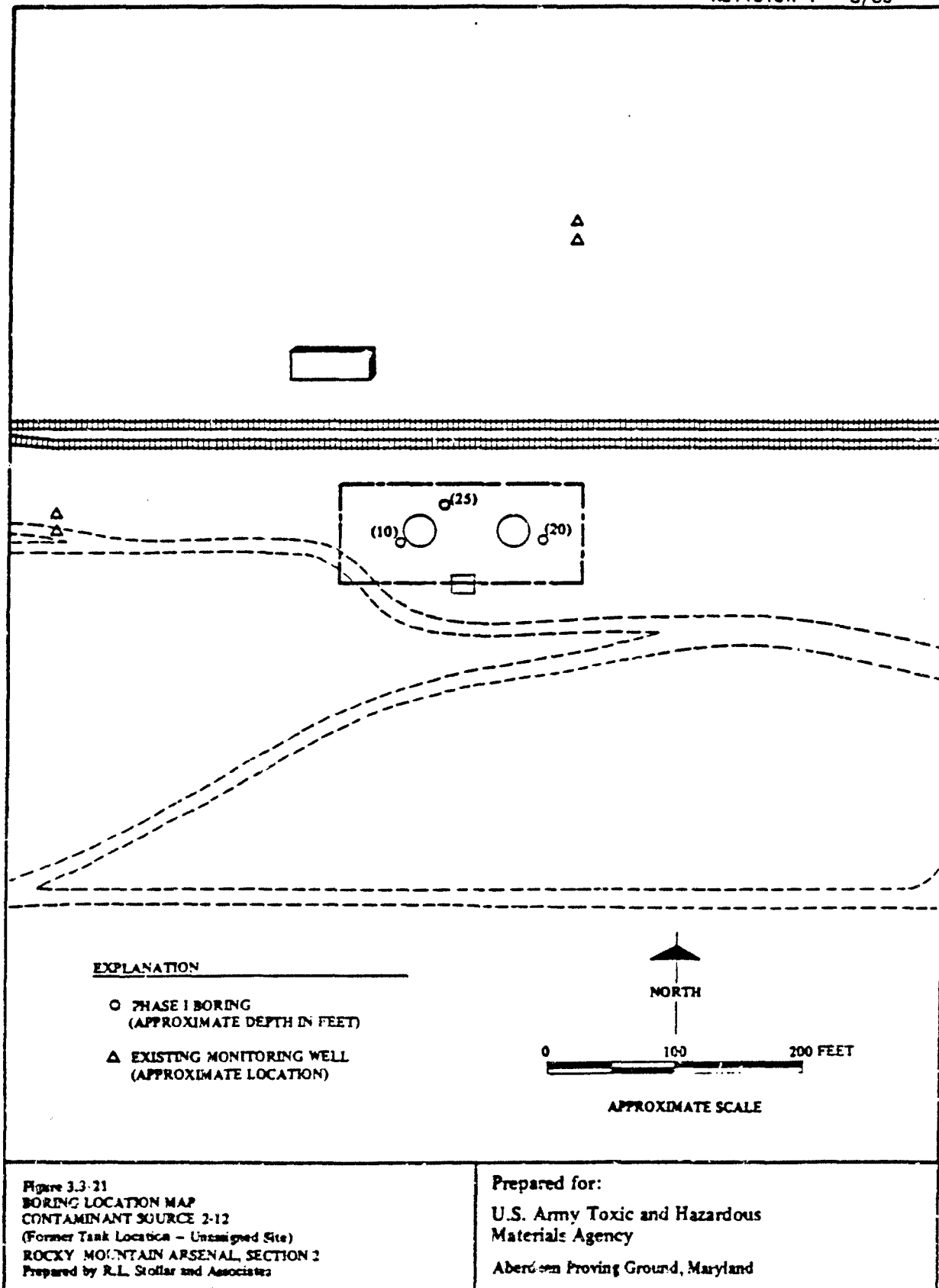
This area is located due northwest of Site 2-6. Two tanks, whose contents were unknown, were removed in the 1970s. The areal extent of this site is approximately 15,000 ft². Building 254, approximately 350 feet east of the area, was the site of a 1964 Naled spill of 200 gallons. This site is considered uncontaminated, therefore, a boring density of 1/600 ft² was used resulting in three Phase I boring locations. Estimated depth to water is 25 feet. The boring locations are shown on Figure 3.3-21. A summary of Phase I borings is as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	25	6
1	20	5
1	15	4
Totals: 3		15

Site 2-13 Open Storage Area

This area is located north of Site 2-2 and west of Sites 1-9 and 1-10. The boundaries and materials stored are unknown. This area was used prior to 1970. A 1982 photograph shows that some trenching may have occurred in this





area. A geophysical reconnaissance is recommended before drilling. The areal extent is approximately 180,000 ft², and depth to water is approximately 15 feet. This site is considered uncontaminated, therefore, a boring density of 1/14,400 ft² was used. Figure 3.3-22 shows the boring locations for this site. Three borings will be drilled during Phase I as follows:

<u>Number of Borings</u>	<u>Total Depth (ft)</u>	<u>Number of Samples</u>
1	15	4
1	10	3
1	5	2
Totals: 3		9

Table 3.3-2 summarizes the number of borings and samples for Phase I.

3.3.4 Evaluation of Phase I Soil Boring Data

The primary objectives of the Phase I Soil Boring Program are to determine if soil contamination exists and the types of contaminants present. These interpretations will be made and key data gaps will be developed. From these evaluations, the locations of, depths of, and types of chemical analyses that will be carried out for the Phase II Soil Boring Program will be designed.

After the soils and geologic data are collected and processed through the QA/QC and data management routines as described in Sections 5.0 and 6.0, they will be analyzed. Maps and cross-sections of soils and geologic materials will be prepared illustrating the soil properties that have a direct impact on the retardation or mobility of the contaminants. The chemical data will be integrated with the soils and geologic data as soon as it becomes available. With these data, the types and concentrations of contaminants present, estimates of the lateral and vertical extent of the contaminants and definition of contaminant boundaries will be evaluated.

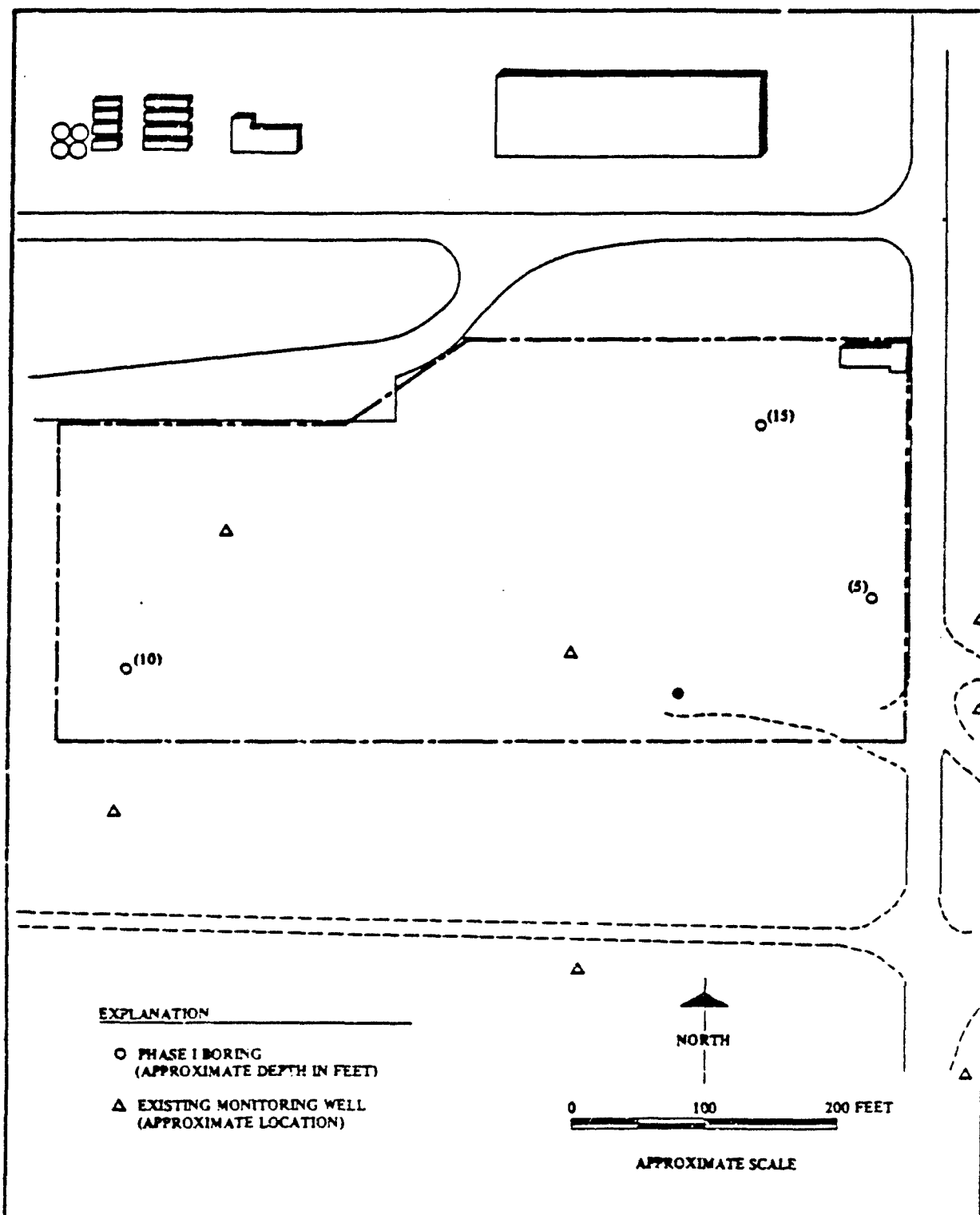


Figure 3.3-22
BORING LOCATION MAP
CONTAMINANT SOURCE 2-13
(Open Storage Area - Unassigned Site)
ROCKY MOUNTAIN ARSENAL, SECTION 3
Prepared by R.L. Stollar and Associates

Prepared for:
U.S. Army Toxic and Hazardous
Materials Agency
Aberdeen Proving Ground, Maryland

TABLE 3.3-2

PHASE I SOIL BORING AND SAMPLING PROGRAM

Site Number	Site Name	Borings	Samples
<u>SHELL OPERATED SITES</u>			
1-8	Salvage Yard	11	28
1-10	South Tank Storage	13	35
1-13	Section 1 Spillsites	84	252
2-14a	Sanitary Landfill North	10	22
2-15b	Sanitary Landfill South	8	14
2-18	Section 1 Spillsites	3	9
<u>JOINTLY OPERATED SITES</u>			
1-5	Lime Pits	8	14
2-3	Lagoon	8	14
2-7	Aeration Basin	5	14
<u>ARMY OPERATED SITES</u>			
2-1	Burn Site	8	22
2-6	Salt Storage	7	24
<u>UNASSIGNED SITES</u>			
1-3a	Mounded Area - south	2	7
1-3b	Mounded Area - north	1	4
1-4	Borrow Pit	1	3
1-11	Sanitary Landfill	3	4
2-4	Borrow Area	3	9
2-5	Trench	2	5
2-8	Former Tank Storage	2	11
2-9	Open Storage	3	7
2-12	Former Tank Location	3	15
2-13	Open Storage Area	2	9
Totals - Phase I		188	522 Samples

Each source, spill, or ditch will be analyzed in a sequence linked to the field activities and schedule. For example, the first site where borings have been completed will be the first site analyzed. This Phase I data from the first site will probably be analyzed four to six weeks after the drilling is completed. Therefore, the schedule of site evaluations can be derived from and linked to the field schedule.

As soon as the drilling of Phase I borings is complete, the data for the first sites will have been analyzed. The locations of Phase II borings will have been selected, and drilling teams can immediately mobilize to Phase II sites.

3.3.5 Phase II Program

The objective of the Phase II soil boring program is to confirm the amount of contamination present through quantitative chemical analyses. In addition, the vertical and lateral extent of the contaminated sources will be estimated. Approximately twice the number of borings drilled at contaminated sites in Phase I will be drilled during Phase II. Tentative locations of Phase II borings are shown on the figures in Section 3.3.2; final locations will be determined after evaluation of Phase I data. The samples will be quantitatively analyzed for contaminants found in the Phase I study. The total number of soil samples for both phases are illustrated on Table 3.3-3.

3.3.6 Locations and Number of Phase II Soil Borings

The remainder of the soil borings for each source will be completed during the Phase II boring program. The number, depth of each boring, and number of samples per boring are shown in Table 3.3-4. It is estimated that a total of 262 borings will be carried out during Phase II.

TABLE 3.3-4

PHASE II SOIL AND SAMPLING PROGRAM

Site Number	Site Name	Number of Borings	Total Depth (ft)	Number of Samples
<u>SHELL OPERATED SITES</u>				
1-8	Salvage Yard	5	15	20
		10	10	30
		<u>11</u>	5	<u>22</u>
	Total/Site	26		72
1-10	South Tank Storage	6	15	24
		12	10	36
		<u>13</u>	5	<u>26</u>
	Total/Site	31		86
1-13	Section 1 Spillsites	<u>84</u>	10	<u>252</u>
	Total/Site	84		252
2-14	Sanitary Landfills	4	20	16
		9	15	27
		12	10	24
		<u>13</u>	5	<u>12</u>
	Total/Site	38		80
2-18	Section 2 Spillsites	<u>3</u>	10	<u>9</u>
	Total/Site	3		9
<u>JOINTLY OPERATED SITES</u>				
1-5	Lime Pits	4	15	12
		7	10	14
		<u>8</u>	5	<u>8</u>
	Total/Site	19		34
2-3	Lagoon	3	15	9
		7	10	14
		<u>7</u>	5	<u>7</u>
	Total/Site	17		30
2-7	Aeration Basin	4	10	12
		<u>7</u>	5	<u>14</u>
	Total/Site	11		26

TABLE 3.3-4 (Continued)

PHASE II SOIL AND SAMPLING PROGRAM

Site Number	Site Name	Number of Borings	Total Depth (ft)	Number of Samples
<u>ARMY OPERATED SITES</u>				
2-2	Burn Site	4	15	16
		7	10	21
		<u>7</u>	5	<u>14</u>
	Total/Site	18		51
2-6	Salt Storage	3	25	18
		3	20	15
		3	15	12
		3	10	9
		<u>3</u>	5	<u>6</u>
	Total/Site	15		60
	Totals - Phase II	262		700

3.3.7 Monitoring Wells

3.3.7.1 Location of Observation Wells

The objective for constructing observation wells is to identify and relate the effect of confirmed contaminants on the shallow aquifer beneath the contaminated source. Wells have been preliminarily located within the potentially contaminated areas that do not already have monitoring wells. The exact locations and number of new monitor wells will be determined upon completion of Phase I. Preliminary sites are shown on the boring location maps, Figures 3.3-3 through 3.3-22. It is estimated that nine wells will be completed for Phase II. The source areas for wells are listed in Table 3.3-5.

3.3.7.2 Aquifer Testing

Slug tests for determining hydraulic conductivity in a single well will be carried out. The test usually involves injecting or removing a slug of water instantaneously from a well and measuring the rate of recovery of water levels in the well.

Data are interpreted by comparison with empirical equations and graphs previously developed. The hydraulic conductivities generated primarily reflect the value within a few feet of the screen zone in a horizontal direction. Reliable results have been obtained in formations ranging in hydraulic conductivity from less than 0.1 gpd/ft (gallons per day per foot) to more than 100 gpd/ft. The test procedures are described in detail in Section I of the Task 2 RMA Procedures Manual.

3.3.7.3 Groundwater Sampling

One groundwater sample will be collected from each new monitoring well installed. Sampling procedures, including field measurement of parameters which can change during sample preservation, shipment, and storage, are described in Section I of the Task 2 RMA Procedures Manual. Formal QA/QC procedures for sample handling are described in Section 8 of the QA/QC Plan,

TABLE 3.3-5

PHASE II MONITOR WELLS

Site Number	Site Name	Number of Wells
<u>SHELL OPERATED SITES</u>		
1-8	Salvage Yard	0
1-10	South Tank Storage	2
1-13	Section 1 Spillsites	0
2-14	Sanitary Landfill	2
2-18	Section 2 Spillsites	0
<u>JOINTLY OPERATED SITES</u>		
1-5	Lime Pits	1
2-3	Lagoon	1
2-7	Aeration Basin	1
<u>ARMY OPERATED SITES</u>		
2-2	Burn Site	1
2-6	Salt Storage	1
<u>UNASSIGNED SITES</u>		
1-3	Mounded Area	0
1-4	Borrow Pit	0
1-11	Sanitary Landfill	0
2-4	Borrow	0
2-5	Trench	0
2-8	Former Tank Storage	0
2-9	Open Storage Area	0
2-12	Former Tank Location	0
2-13	Open Storage Area	0
Total		9

Section III of the Task 2 RMA Procedures Manual. Chemical analysis of groundwater samples is discussed in Section 4.0.

3.4 Building and Disposal System Sampling

The objective of the building and the disposal system sampling program is to determine if there are materials in the buildings or disposal systems which may be contributing to soil and ground-water contamination. The building sampling program in the South Plants is designed to provide information about the building structures, possible contamination in the buildings, and disposal systems throughout the area. The disposal systems include: (1) drains and sumps in and around buildings; (2) the sanitary sewer system throughout South Plants; (3) the storm drainage system throughout the area; (4) the original contaminated waste system constructed by the Army; and (5) the contaminated waste system constructed by Shell. These disposal systems will be sampled directly at drains, manholes and sumps. Soil borings will be sited to facilitate identification of contamination in soils surrounding disposal facilities.

The proposed program is presented schematically in Figure 3.4-1. The overall sampling, Phase I, will be performed in two subphases. The purpose of Phase IA is for a determination of personal protection need of the sampling teams and for a reconnaissance of the buildings. Phase IB will carry out the sampling program to meet the task's objectives.

3.4.1 Sampling Plan Summary

During Phase IA, the air, composite dust samples and visual observations will provide the data required to identify gross contamination of the structures. Health and safety data will be used to determine level of protection for building entry during Phase IB. Where gross contamination is not detected, the sampling conducted during Phase IA will not facilitate conclusive characterization of the buildings as uncontaminated.

Storage tanks, vats, disposal drains, and sumps will be located and visually examined during the Phase IA survey. In this manner, available building

information will be updated and the sampling locations for Phase IB sampling and the Soil Sampling Program (Phase I) will be verified. Any relevant liquid samples will be sampled, at the discretion of the field sampling team during Phase IB assuming the laboratories are already certified for analysis of liquids.

The data obtained during Phase IB will be used to further assess contamination of buildings: (1) relate soil contamination to potential sources; (2) identify additional locations where soil contamination is possible; and (3) obtain data required to plan remedial activities related to buildings and process equipment.

All buildings and associated structures/soil in the South Plants area will be sampled in a similar manner; however buildings which were occupied by Shell or jointly by both Shell and the U.S. Army will be sampled first (see Figure 3.4-2). The sampling of Army occupied buildings (see Figure 3.4-3) is planned to coincide with the Phase II geotechnical program.

3.4.2 Program Design

The sampling design for the buildings and disposal systems in the South Plants area was based on the following factors:

- o Historical use and content of each building and adjacent areas
- o Size and number of stories in each building
- o Type and degree of expected chemical contamination
- o Extent and location of disposal facilities

Each of these factors is addressed in the paragraphs that follow.

A total of 185 buildings, foundations, and tanks for which both use and location are known have been identified in Sections 1 and 2 of the Arsenal. The locations of these structures are identified in Figures 3.4-2 and 3.4-3. For each building a historical use profile was generated. The profile included the following information: the building identification number; descriptive information on type of construction, utilities, facilities and

1 INCH = 400 FEET
(Approximate)

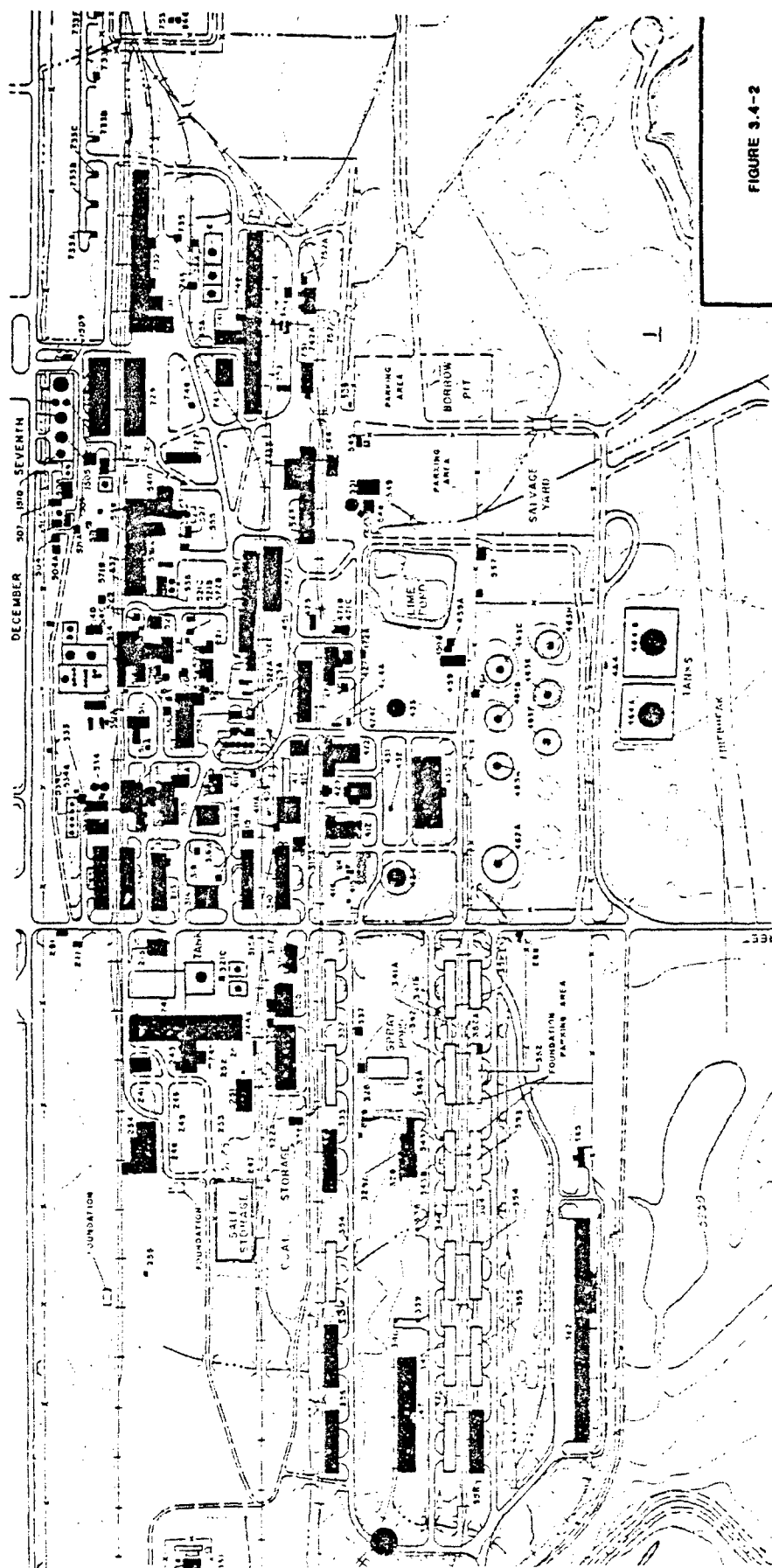


FIGURE 3-4-2

PHASE I SAMPLING PROGRA
FOR BUILDINGS JOINTLY OCCU
BY SHELL AND ARMY
& BY SHELL ONLY

[Thick black outline] BUILDINGS TO BE SAMPLED

building contents; building condition; current and historical use; and the type(s) of contamination expected. The building profiles are presented in Appendix B. This information was used to design the Phase IA and IB Surveys as described in Sections 3.4.3 and 3.4.4.

The information available to date was obtained from the building plan index obtained from the Facility Engineering Section of RMA, historical records search documentation (USATHAMA, 1977), property inventory documents (Harland Bartholomew & Associates, Inc., 1982), the Shell lease supplements, building specific pollution source identification surveys and hazard assessments (Kuznear and Trautmann, 1980), the Damage Assessment Report performed by Geraghty and Miller, Inc. (1984)* and RMA Master Plan Basic Information Maps prepared by the U.S. Army Corps of Engineers. The information compiled was used to generate the building summary list presented in Table 3.4-1. Each building is described according to its identification number, associated contamination, floor area, occupancy (Army, Shell, combined), availability of specifications, use, area code designation (as reported by Geraghty and Miller, 1984)* and known chemical spill occurrences. Available building and chemical process plans have been requested and will be reviewed and used to update the building profiles. The selected building plans which have been requested are also presented in Appendix B. Additional information pertaining to building use, location and condition will be obtained during the Phase IA reconnaissance survey. All new information obtained will be incorporated in the building profiles. The selected building plans which have been requested are also presented in Appendix B.

For planning the Phase IA Survey, all buildings have been segregated into three risk categories: high, medium and low. This designation was used to estimate the magnitude and significance of contamination expected, and help anticipate the complexity of sampling to be conducted in the buildings. Building risk designations were derived as follows:

*Privileged information prepared in support of litigation.

TABLE 3.4-1
ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Area** Listed in DAR	Reported Spills (8/26/82 Shell Letter)
211	#107*	--	Low			Yes?	Yes	Gas meter house	N/A	
213	#107	All types of agents	Medium			Yes	Yes	X-ray lab	Between 1, 6, 5 1-Cl ₂ and Caustics	
241	#107	Chlorine	Medium		Yes-I	Yes	Yes	Chlorine Plant Admin. and Labs	1-Cl ₂ + Caustics	
242	#107, RFP	Chlorine	Medium	41,515 ft ²	Yes-I	Yes	Yes	Denver Mint Cell Bldg	1-Cl ₂ + Caustics	
243	#107, RFP	Chlorine	Medium	2 floors; 14,360 ft ²	Yes-I	Yes	Yes	Compressor Bldg Cl ₂ liquification	1-Cl ₂ + Caustics	
244	Bldg Plans	Chlorine	Medium		Yes-I	Yes	Yes	Liquid Chlorine Storage	1-Cl ₂ + Caustics	
244A	RMA OSA 07/26				Yes-III	Yes	?	Track scales, disposed		
245SS	#107	--	Low		Yes-IV	Yes	Yes	Electric substation	1-Cl ₂ + Caustics	
246	Bldg Plans, Shell Memo		Low			Yes?	Yes	Foundation only Centrifuge Bldg	1-Cl ₂ + Caustics	
247	Bldg Plans, Shell Memo		Low		Yes-I	Yes	Yes	Foundation only Brine storage tanks	1-Cl ₂ + Caustics	
248	Bldg Plans, Shell Memo		Low		Yes-I	Yes	Yes	Foundation only Brine storage tanks	1-Cl ₂ + Caustics	
249	Bldg Plans		Low		Yes-I	Yes	Yes	Foundation only Brine storage tanks	1-Cl ₂ + Caustics	
251	#107, Vol 7 HMA***	Chlorine	Medium	22,692 ft ²	Yes-I	Yes	Yes	General storage, Evaporation building	1-Cl ₂ + Caustics	

**From Garaghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Areas** Listed in DAR	Reported Spills (8/26/82 Shell Letter)
252	Bldg Plans, Shell Memo		Low		Yes-I	Yes	Yes	Tanks pads only Housed dilute caustic tanks	1-Cl ₂ + Caustics	
253	Bldg Plans		Low		Yes-I	Yes	Yes	Tank pads only	1-Cl ₂ + Caustics	
254	6/07, Vol 4 HDA, Shell Memo	--	Medium	20,837 ft ²	Yes-I	Yes	Yes	Warehouse for product storage and empty drums	1-Cl ₂ + Caustics	Mailed (OIBROM) 1964-200 gal
255	6/07	--	Low		Yes-I	Yes	Yes	Tank pad only	1-Cl ₂ + Caustics	
256	Bldg Plans		Low		Yes?	Yes?	Yes	Fuel Oil Tank	Not shown on map	
281	6/07	--	Low		Yes?	Yes?	Yes	Gate house	N/A	
286	6/07	--			Yes?	Yes?	Yes	Not present	Adj. to 3, 4 3-4-74 Incendiary bomb filling 4-Mustard production	
307	6/07	--	High		Yes?	Yes?	No	Meter pit	Sewer Conduit	
T-309	6/07	All types of agents			Yes?	Yes?	Yes	Not present		
311	6/07, HEP Vol 4 HDA	--	Low	1 floor 4,597 ft ²	Yes-II	Yes	Yes	Stearns & Rogers Office	N/A	
313	6/07, HEP	All types of agents	Medium		Yes-I	Yes	Yes	Laboratory	5-Laboratory - Inspection Laboratory	
314	6/07, HEP	All types of agents	High			Yes	Yes	Laundry	6-Laundry	
T-316A	6/07, HEP	--	Medium			Yes	Yes	Misc. storage	5-Laboratory	
315	6/07, HEP	--	Medium		Yes?	Yes?	Yes	Warehouse	N/A	

**From Geography & Miller 1984 Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential.
Information prepared in support of litigation.

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Area** Listed in DAR	Reported Spill (8/26/82 Shell Letter)
315A	#107, RFP	--	Medium			Yes	No	Steam meter pit	N/A	
316	#107, RFP, Vol 3 H&MA	--	Low	2,745 ft ²	Yes-I	Yes	Yes	Dispensary	N/A	
316A	Vol 5 H&MA	--	Low	5,210 ft ²	Yes-built		?	Change House	N/A	
316B	Shell Memo							Temporary Contractor Storage Bldg, torn down		
317	#107, RFP, Vol 3 H&MA, Shell Memo	--	Low	11,037 ft ²	Yes-I	Yes	Yes	Shop, E & P Core Storage	N/A	
317A			Low			Yes?		Tank pad only	N/A	
318	Bldg Plans		Low			Yes?	Yes	Gas Station House	Building gone, used to be between 331 and 434*	
319	#107, RFP	--	Low			Yes	Yes	Magazine	N/A	
321	#107, RFP, Vol 1 H&MA	--	Low	56,479 ft ²	Yes-IV	Yes	Yes	Boiler plant	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
321A-E	Vol 3 H&MA			400,000 gal	Yes-IV	Yes		Not present		
322	#107, RFP, Vol 5 H&MA, Shell Memo	--	Low	336 ft ²	Yes-IV	Yes	Yes	Coal Sampling Building, storage	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
322A	#107, RFP	--	Low	556 ft ²	Yes-IV	Yes	Yes	Tractor storage	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
323	#107, RFP	--	Low	3,600 ft ²	Yes-IV	Yes	Yes	Ash Dump	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
324	Bldg Plans				Yes-IV	Yes	Yes	Locomotive Coal Hopper	North of 321*	

**From Caregity & Miller (5th Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo 0440436201 (12/27/04).

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POKEY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Page 4 of 25 Pages

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Areas** Listed in DAR	Reported Spills (8/26/82 Shell Letter)
325	#107, RFP, Vol 2 HBIA	--	Low	16,500 ft ²	Yes-IV	Yes	Yes	Power Plant High pressure boiler	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
326	#107, RFP	--	Low	613 ft ²	Yes-IV	Yes	Yes	Power Plant Spray Pond	Between 1 and 2 1-Cl ₂ + Caustics 2-Phosgene filling	
327	Bldg Plans					Yes?	Yes	Cafeteria	Now shown on map	
328	#107, RFP	All types of agents	High			Yes?	Yes	Mfg. Building GUP	3-M-7A incendiary bomb filling	
328A	#107, RFP	--	Low			Yes?	Yes	Toilet Building	3-M-7A incendiary bomb filling	
329	#107, RFP	--	Medium			Yes	Yes	Pump House Gasoline	3-M-7A incendiary bomb filling	
331	#107, RFP	Phosgene	Low	11,640 ft ²		Gov't Agency(?)	Yes	Not present	2-Phosgene filling	
332	#107, RFP	--	Low			Gov't Agency(?)	Yes	Warehouse	2-Phosgene filling	
333	#107, RFP, Vol 4 HBIA, Shell Memo	--	Low	11,037 ft ²	Yes-II	Yes	Yes	Warehouse, stored drummed pesticide and empty drums	3-M-7A incendiary bomb filling	
334	#107, RFP	--	Low			Gov't Agency(?)	Yes	Warehouse	West and north of 3 3-M-7A incendiary bomb filling	
335	#107, RFP, Vol 4 HBIA, Shell Memo	--	Low	11,037 ft ²	Yes-II	Yes	Yes	Warehouse, stored drummed pesticide and empty drums	West and north of 3 3-M-7A incendiary bomb filling	
336	#107, RFP, Vol 4 HBIA, Shell Memo	--	Low	11,037 ft ²	Yes-II	Yes	Yes	Warehouse, stored drummed pesticides and empty drums	West and north of 3 3-M-7A incendiary bomb filling	
337	#107, RFP, Vol 4 HBIA,	--	Low	612 ft ²	Yes-IV	Yes	Yes	Change house 2-Phosgene filling	Adj. to 2, north of 3 3-M-7A incendiary bomb filling	

**From Garaghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo BR88436201 (12/27/84).

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ROCKY MOUNTAIN ARMY AIRCRAFT BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Flare Area	Shell Groupings	Army Designated Building	Plans, Diagrams Available	Building Description/Use	U.S. Army Listed in JED	Remarks (Shell Count)
330	0107, RFP	-	Low			Yes	Yes	Negative	Sub-70 Secondary Tank Filling	
330	0107, RFP	-	Low			Yes	Yes	Negative	Sub-70 Secondary Tank Filling	
340	0107, RFP	-	Low			Yes	Yes	Negative	Sub-70 Secondary Tank Filling	
341	0107, RFP	-	Low			Yes?	Yes	Change Status	Sub-70 Secondary Tank Filling	
341A	0107, RFP	-	Low			Yes	Yes	Change Status	Sub-70 Secondary Tank Filling	
341B	0107, RFP, Shell Count	-	Medium			Yes	Yes	Change Status	Sub-70 Secondary Tank Filling	
342	0107, RFP	SP	Low			Marine Corps	Yes	Change Status	Sub-70 Secondary Tank Filling	
342S	RFP, 004 0040	-	Low		Yes-IV	Yes	-	Substation	Sub-70 Secondary Tank Filling	
343	0107, RFP	SP	Low	11,040 ft ²		Gov't Agency(?)	Yes	Change Status	Sub-70 Secondary Tank Filling	
343A	0107, RFP	-	Low			Yes	Yes	Point Storage	Sub-70 Secondary Tank Filling	
343B	0107, RFP	SP	Low			Yes	Yes	Point Storage	Sub-70 Secondary Tank Filling	
344	0107, RFP	SP	Low	11,040 ft ²		Gov't Agency(?)	Yes	Change Status	Sub-70 Secondary Tank Filling	
345	0107, RFP	SP	Low	11,040 ft ²		Yes?	Yes	Change Status	Sub-70 Secondary Tank Filling	

by the Emergency & Miller 1984 Design Assessment Report, Vol. III, Working Draft. See area profile in table notes. Privileged and confidential information presented in support of litigation.

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*From Currenthy & Miller 1964 Omega Assessment Report, Vol. III, Working Draft. See also profiles in table below. Printed by and under license to the U.S. Navy.

ROCKY MOUNTAIN ARCADE BUILDINGS IN SECTIONS I AND J

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	Q & A Answer Listed in RMR	Superfund Status (8/78-8/85 Shell Letters)
342	#107, RFP	--	Low			Gov't Agency	Yes	Warehouse	Stack of 3 3-in secondary tank filling	
343	RFP	--	Low			Gov't Agency	No	Warehouse	Stack of 3 3-in secondary tank filling	
344	#107, RFP	--	Low			Yes	Yes	Storage LIFT Station	Stack of 3 3-in secondary tank filling	
345	#107, RFP	--	Low			Yes	Yes	Cyprus. Blending Building	Stack of 3 3-in secondary tank filling	
346	#107	--				Yes?	Yes	Soda Feed House	Not in study area	
349	#107	--				Yes?	Yes	Soda Valve Concrete Vault and Gate Structure	Not in study area	
371	#107 Vol 3 HMAA, Shell Memo	--		3,300 ft ²	Yes-IV	Yes	Yes	Pump Station Motor Loaders Pump House	Not in study area	
372	#107 Vol 3 HMAA	--		1,000,000 gal	Yes-IV	Yes	Yes	Potable Water Reservoir	Not in study area	
372A	#107 Vol 3 HMAA, IF No. 017 0480-0453	--		64 ft ²	Yes-IV	Yes	Yes	Chlorinating Station	Not in study area	
T-373	#107	--				Yes?	Yes	Officers Quarters	Not in study area	
T-373A	Bldg Plans					Yes?	Yes	Garage and Storage	Not in study area	
373B	#107	--				Yes?	Yes	Garage	Not in study area	
374	Bldg Plans, Shell Memo				Yes-IV	Yes	Yes	South Lake Water Treatment Plant	Not in study area	

*From Gerdaghy & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

ROCKY MOUNTAIN REGIONAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied	Army Occupied	Plans, Diagrams Available	Building Description/Use	OSR Reports Listed in 1988	Superfund Status 10/24/88 (Shell Letters)
375	Shell Lease Book Shell Memo			56 ft ²	Yes-IV	Yes	Yes	Not present, Shell Memo at West Gate of Ash	Not in study area	
376	Shell Lease Book Vol 5 HMA	Chlorine?		64 ft ²	Yes-IV	Yes		Water treatment plant chlorination station #1	Not in study area	
379	Shell Lease Book			64 ft ²	Yes-I	Yes?		Water treatment plant chlorination station #2	Not in study area	
381	Shell Lease Book Vol 5 HMA, Shell Memo				Yes-IV	Yes		Not present Water chlorination station #3	Not in study area	
382	Shell Lease Book Vol 5 HMA, Shell Memo			68 ft ²	Yes-IV	Yes	No	Standby chlorinator building in water treatment plant	Not in study area	
383	#107	—			Yes?	Yes?	Yes	Officers Club	Not in study area	
383A	#107	—			Yes?	Yes?	No	Officers Club Storage Trailer	Not in study area	
385	Bldg Plans			146 ft ²	Yes-IV	Yes	Yes	Shell Pump House	Not in study area	
386	Bldg Plans			146 ft ²	Yes-IV	Yes	Yes	Shell Pump House	Not in study area	
387	Bldg Plans			143 ft ²	Yes-IV	Yes	Yes	Pump House	Not in study area	
389	Vol 6 HMA				Yes-Build			Garage, not on map or found in field	Not in study area	
391	Bldg Plans				Yes?	Yes?	Yes	Sewage Treatment Plant	Not in study area	
392	Bldg Plans				Yes?	Yes?	Yes	Sewage Lift Station	Not in study area	
393	Bldg Plans				Yes?	Yes?	Yes	Sewage Lift Station, Warehouse & Shop Area	Not in study area	

**From Geraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

ROCKY MOUNTAIN ARSENAL BUILDINGS BY SECTION 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	OSM Areas** Linked in GDS	Assessed Spills (8/26/92 Shell Letter)
394	Blgd Plans				Yes?	Yes	Yes	West Gate Treatment Plant	Not in study area	
395	Blgd Plans				Yes?	Yes	Yes	Toxic Yard Treatment Plant	Not in study area	
402	Blgd Plans				Yes?	Yes	Yes	Unloading docks	Not in study area	
I-409	0107, NFP RMA OSA 0736	--	High		Yes-IV	Yes	Yes	Carbonate Pump House	16-Sulfur area + dichloride production	
411	0107, NFP	MP	High		Yes?	Yes	Yes	SP Manufacturing and Storage	16-Sulfur area + dichloride production	
411A	0107, NFP Vol 1 HBA	--	Medium	70 ft ²	Yes-I	Yes	Yes	Steam Meter	16-Sulfur area + dichloride production	
411B	0107, NFP Vol 1 HBA	--	High	68 ft ²	Yes-I	Yes	Yes	Steam Meter	16-Sulfur area + dichloride production	
412	0107, NFP	H	High	2 floors, 21,536 ft ²		Yes?	Yes	H Filling and Manufacturing/ Di-chloro compound	16-Sulfur area + dichloride production	
413	0107, NFP RMA OSA 0539 RMA OSA 0746	MP	High	1 floor, 3,432 ft ²		Yes?	Yes	MP Storage, Waste Recycling/Concrete Control Building	16-Sulfur area + dichloride production	
413A	0107, NFP	MP	Low		Yes-I	Yes	Yes	Water Tank/Phoney Water Tank	Not shown on map	ALR 36 - 1972, 34,000 gal
413B-J	Shell Memo				Yes?			Storage Tanks		
414	NFP	H	Medium		Yes?	Yes	Yes	Foundation only	16-Sulfur area + dichloride production	
415	NFP	H	Medium		Yes?	Yes	Yes	Foundation only	16-Sulfur area + dichloride production	
416	NFP	H	Medium		Yes?	Yes	Yes	Foundation only	16-Sulfur area + dichloride production	
417	NFP	H	Medium		Yes?	Yes	Yes	Foundation only	16-Sulfur area + dichloride production	

**From Groggity & Miller 1994 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo 8940436201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Page 10 of 25 Pages

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Drawings Available	Building Description/Use	Q & A Areas** Listed in DAP	Reported Spills (10/26/82 Shell Letter)
422	#107, RFP Vol 3, HAAA	H, pesticide	High	2 floors and basement 32,115 ft ²	Yes-I	Yes	Yes	H Filling and manufacturing/pesticide manufacturing Tank Room stored pesticides, assembly of finished products	6-Mustard production	100 gals, 100 gals - 1976, 1971, 10,000 gals; 100 gals, 1971, 100 gals
424	#107, RFP	H, pesticide		308 ft ²	Yes-I	Yes	Yes	Not present	6-Mustard production	8 gals; 8 gals, 1976, 1971, 10,000 gals; 100 gals, 1971, 100 gals
424A	Shell Memo							Control Room Building and Lab for Aldrin, not present		
424B	Shell Memo							Aldrin Unit Benzene Dryer Building		
424C	Shell Memo							Aldrin Filler Building		
425	#107, RFP, Shell Memo	H, pesticide		291 ft ²	Yes-I	Yes	Yes	Not present Aldrin Reactor	Not shown on map	
426	#107, RFP, Vol 3 HAAA, Shell Memo	H, pesticide	High	Tank-8, 245 gal	Yes-I	Yes	Yes	H Disposal reactor	6-Mustard production	
427	#107, RFP, Vol 3 HAAA, Shell Memo	H, pesticide		711-390 ft ²	Yes-I	Yes	Yes	H Decon pit Water Pump	6-Mustard production Not west of 427, has been filled in	
428	RFP					Yes?		Inclinometer	Not shown on map	
429	#107, RFP	H, pesticide	High	540 ft ²	Yes	Yes	Yes	H Salt storage/ pesticide manufacture	6-Mustard production	
431	#107, RFP, Shell Memo	H	High	5,430 ft ²	Yes	Yes	Yes	H Refrigeration Building Ethylene Compressor building	6-Mustard production	
431S	#107, RFP		Low		Yes-IV	Yes	--	Electric substation	6-Mustard production	

**From Orlanthy & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential
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*From Shell Memo BR008-3620 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	8 & M Area** Listed in OAR	Reported Spills (8/26/82 Shell Letter)
432	#107, RFP, Vol 7 HBA, Shell Memo	--	Medium	8,700 ft ²	Yes-I	Yes	Yes	Foundation and floor, originally warehouse, now used to store blast and clean equipment	4-Mustard production	5 Bldg, DCPD - 1973, 55 gal; SE Bldg, D-O Soil Fuelignit, 1971, 100 gal; 5 Bldg, D-O Soil Fuelignit, 1973, 250 gal
433	#107, RFP, Shell Memo	DCPD, Soil Fuelignit	High		Yes-I	Yes	Yes	Ethylene Generator Research Dept. Building	4-Mustard production	
435S	#107, RFP	--	Low		Yes-IV	Yes	--	Electric substation	Not shown on map	
434	#107, RFP, Vol 7 HBA	--	Medium	300,000 ft ³	Yes-I	Yes	Yes	Ethylene/acetylene holder	4-Mustard production	
435	#107, RFP, Vol 7 HBA	--	Medium	300,000 ft ³	Yes-I	Yes	Yes	Ethylene/acetylene holder	4-Mustard production	
1-451	#107, RFP, Vol 7 HBA, Shell Memo	--	High	11,037 ft ²	Yes-I	Yes	Yes	Warehouse where all liquid pesticides were drummed	Neer 1, 5, 7 1-Cl ₂ and Caustics 5-Laboratory 7-Chlorinated paraffin	SE Bldg, AZURM, 1974, 55 gal
459	Shell Lease Book, Vol 6 HBA		Medium	3 floors 11,607 ft ²	Yes-built			Acetylene generator building	4-Mustard production	
459A	Vol 6 HBA, Shell Memo			120 ft ²	Yes-built			Lime Slurry Pumphouse	East of 459	
459B	Vol 6 HBA, Shell Memo			120 ft ²	Yes-built			Acetylene Equipment Bldg.	East of 459	
461	#107, RFP, Vol 7 HBA	All types of agents	High	648 ft ²	Yes-I	Yes	Yes	Pump House (Tank farm)	4-Mustard production	
462A	#107, RFP, Vol 7 HBA, Shell Memo	--	Low	417,000 gal	Yes-I	Yes	Yes	Fuel Oil Tank Storage Tank for DCPD	4-Mustard production	

**From Garaghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo BRH4436201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied	Army Diagrams Occupied	Plans, Diagrams Available	Building Description/Use	S & S Areas Listed in OOT	Assessed Shell (6/24/82 Shell Letter)
462B	Shell Memo							Storage for crude oil bottoms for Shell		
463A	8107 WTP Vol 1, H&A	--	High	196,000 gal	Yes-1		Yes	Alcohol Storage Tank Water storage and spent sulfuric acid	6-shutdown production	
463B	Shell Memo			196,000 gal	Yes-1			Alcohol storage tank stored spent sulfuric		
463C	Shell Memo			196,000 gal	Yes-1			Stored nitrogen and Alcohol Storage tank		
463D	Shell Memo			196,000 gal	Yes-1			Alcohol Tank, storage of BOM bottoms		
463E		Soil Runlight		196,000 gal	Yes-1	Yes		Soil Runlight tank	6-shutdown production	
463F	Shell Memo			196,000 gal	Yes-1			Alcohol Tank and BOM		
463G	Shell Memo			196,000 gal	Yes-1			Alcohol Tank and stored BOM and Sulfuric Acid		
					Yes-1			Alcohol Tank and Sulfuric		

ROCKY MOUNTAIN ARSENAL BUILDINGS IN STATIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	S & M Areas** Listed in DOD	Reported Spills (8/76/82 Shell Letter)
T-471A	Swamp map		High		Yes-built	Yes?		Dioxane Vaporizer	16-thionyl chloride	
T-471B	Vol 6 HBAA		High	120 ft ²	Yes-built			Electrical Vault	16-thionyl chloride	
T-471C	Vol 6 HBAA		High	120 ft ²	Yes-built			Refrigeration Building	16-thionyl chloride	
T-472	0107, RFP, Vol 7 HBAA	Industrial chemicals	Low	1,144 ft ²	Yes-1	Yes	Yes	Thionyl Chloride Refrigeration	Adjacent to 3, 16 3-4-74 incendiary bomb filling 16-thionyl chloride	
472A	Vol 6 HBAA			400 ft ²	Yes-built			Maintenance, storage, and lunchroom	Adjacent to 16-thionyl chloride	
T-473	0107, RFP, Vol 7 HBAA	Industrial chemicals	Low	1,520 ft ²	Yes-1	Yes	Yes	Thionyl Chloride Drum Loading. Shell packaged and stored products here (Hexagon, Dioxane, DOWP, Supura, and Chloroform)	Adjacent to 3, 16 3-4-74 incendiary bomb filling 16-thionyl chloride	
T-474	Shell Lease Book, Vol 7 HBAA		Low	80 ft ²	Yes-1	Yes		Electric control house	Not shown on map	
474SS	0107, RFP	--	Low		Yes-IV	Yes	--	Electric substation	South of 471 ^a	
475	0107, RFP, Vol 7 HBAA	--	Low	971 ft ²	Yes-1	Yes	Yes	RM car warmer shed	16-thionyl chloride	
476	Shell Lease Book				Yes-built			Not present		
502	Vol 6 HBAA, Shell Memo			280 ft ²	Yes-built			West Chemical Meter Pit	South of Dec. 7th Ave ^b	
503	Vol 6 HBAA, Shell Memo			280 ft ²	Yes-built			East Chemical Meter Pit	South of Dec. 7th Ave ^b	
504	Vol 6 HBAA, Shell Memo		High	320 ft ²	Yes-built	No		DET Generator	N/A	

**From Gershteyn & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

*From Shell Memo BRN6A36201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/ Use	S & M Areas-- Listed in DMR	Reported Spills (8/26/82 Shell Letter)
504A	Vol 6 HBA, Shell Memo		High	700 ft ²	Yes-built	No		DET Maintenance	N/A	
505	Blkg Plans, Shell Memo		High		Yes-built	No	Yes	DET Pretreatment Pumps	N/A	
506	Vol 6 HBA, Shell Memo		High	816 ft ²	Yes-built	No		DET Control Room	N/A	
507	Vol 6 HBA, Shell Memo		High	512 ft ²	Yes-built	No		DET Separator Pump House	N/A	
508	Vol 6 HBA, Shell Memo		High	4,000 ft ²	Yes-built	No		DET Copper Recovery	N/A	
509	Vol 6 HBA, Shell Memo			432 ft ²	Yes-built	No		DET Compressor/ Liquifier for Methyl Chloride	Southeast of north 514 tank farm	
510	Vol 6 HBA, Shell Memo			300 ft ²	Yes-built	No		MDC Refrigeration and Storage Unit	Between 514 and 541 on north side of tracks	
511	0107, RFP	M-1, HD	High	21,327 ft ²	Yes-II	Yes	Yes	M-1, prior use Chlorinated Paraffin Manufacturing	7-chlorinated paraffin	in Blkg. Memo, 1950, 1200 gal
511A	0107, RFP, Vol 3, HBA	M-1, HD	High	3,429 ft ²	Yes-I	Yes	Yes	M-1, crude storage Chlorinated Paraffin Tank room	7-chlorinated paraffin	
511S	0107, RFP	--	Low		Yes-IV	Yes	--	Electric substation	Not shown on map	
512	0107, RFP, Vol 3, HBA	M-1, HD, pesticides, herbicides	High	4,156 ft ²	Yes-I	Yes	Yes	M-1, MC bulk filling/ manufacture chlordanes, aldrin, dieldrin	9-mustard distillation	in Blkg. 1957, chlorinated paraffin, 200 gal; Around Blkg. MDCPO-1953-54, 1300 gal; 6 Blkg. MDCPO, 1953-54, 100 gal; Around Blkg. Inoperational, 1953-54, 430 gal
513	0107, RFP	L	High		Yes	Yes	Yes	L disposal plant	9-mustard distillation	

**From Garaghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

*From Shell Memo BRHMA56201 (12/27/84).

TASK 2 TECHNICAL PLAN
Revision 1 - 8/85

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Page 15 of 25 Pages

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	S & M Areas Listed in OAR	Reported Spills (6/26/82 Shell Letter)
514	0107, RFP, Vol 7, HBAA	M-1, H, pesticides	High	3 floors, 21,527 ft ²	Yes-1	Yes	Yes	M-1 manufacture/ M distillation/ chlordane, aldrin, dieldrin, endrin	9-Mustard distillation	Acetone, 1979, 300 gal; AZODIN-M room, 1946, 1000 gal; AZODIN-M dock, 1963-65, washing of facilities, M Bldg; Caustic soda 208-1978-81, 1948, M Bldg, 1971, 7400 gal; M Bldg, Caustic Soda-208, 1945, 200 gal; M Bldg, chlordane, 1976, 960 gal; M Bldg, HP, 1970, 3000 gal; M Bldg, toluene, 1955, 1000 gal; M Bldg, DCPD, 1963, 1700 gal
514A	0107, RFP, Vol 7, HBAA	M-1 diphenyl, diphenyl oxide	High	3,889 ft ²	Yes-1	Yes	Yes	M-1 crude storage Duthers Bldg	9-Mustard distillation	
514C	Vol 6 HBAA, Shell Memo			100 ft ²	Yes-built			Pumphouse for raw materials	9-Mustard distillation	
514D	Vol 6 HBAA, Shell Memo			304 ft ²	Yes-built			Compressor Building	9-Mustard distillation	
514E	Vol 6 HBAA, Shell Memo			80 ft ²	Yes-built			M-1 (Raw material for Aldrin) diluted	9-Mustard distillation	
514SS	0107, RFP	--	Low		Yes-1V	Yes	--	Electric substation	Not shown on map	
515	0107, RFP	M-1, pesticides	High	10,045 ft ²	Yes-1	Yes	Yes	M-1 and Chlorinated Pesticides manufacturing building	9-Lewisite	
515A	Shell Lease Book, Vol 6 HBAA	MERIN	High	2 floors, 2,892 ft ²	Yes-built		Yes	Mud-in and Endrin Storage	9-Mustard distillation	M Bldg, Benzene, 1957, 3000 gal
516	0107, RFP, Vol 7, HBAA	M-1, HD, H, pesticides	High	3 floors, 10,045 ft ²	Yes-1	Yes	Yes	M-1, M distillation/ pesticide manufacture	12-acetylene plant	M Bldg, Acetic acid-leaking sewer line, 1952-70; M Bldg, HCPD, 1948-55, leak
516B	Vol 6 HBAA				Yes-built			Unknown	12-acetylene plant	

*from Dorethy & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

TASK 2 TECHNICAL PLAN
Revision 1 - 8/85

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Areas** Listed in Doc	Reported Spills (8/25/82 Shell Letter)
517	#107, RFP, Vol 7 HBA	--	Medium	8,751 ft ²	Yes-1	Yes	Yes	Administration/Laboratories	15-MP cup filling	
518	RFA OTO ODB, Shell Memo							Outrigger Plant, Cafeteria		
518A	8100 Plan		High			Yes?	Yes	Unknown	9-Mustard distillation	
519	Vol 6 HBA			320 ft ²	Yes-built	No		Hydrogen peroxide storage	9-Mustard distillation	
519A	Vol 6 HBA			154 ft ²	Yes-built	No		Hydrogen peroxide purphouse	West of 51A rent to tanks	
520	Vol 6 HBA			30 ft ²	Yes-built			Storage of sample pumps and pH probes	East of 521C	
521	#107, RFP, Vol 7 HBA	L, H, pesticides	High	3 floors, 2,436 ft ²	Yes-1	Yes	Yes	MO 1-uracil/chloride, other pesticides Acetylene prior use compressor	12-Acetylene plant	H Bldg, cyclopentadiene, 1943-74, 500 gal; H Bldg, HODPO, 1943-55, 200 gal
521A	Vol 6 HBA, Shell Memo			300 ft ²	Yes-built			Used to crack DOPD to CPO; used for Thermal Max	N/A	
521B	Vol 6 HBA, Shell Memo			576 ft ²	Yes-built			Compressor House	N/A	
521C	Vol 6 HBA, Shell Memo			608 ft ²	Yes-built			Lunchroom and Field Foreman office	N/A	
522	#107, RFP	WP	Medium	1 floor, 4,800 ft ²		Yes	Yes	Acetylene manufacture/MP filling	15-MP cup filling	
522A	#107, RFP	WP	Low			Yes?	Yes	Froxy water tank	15-MP cup filling	S of Bldg, 1951-53, 16,000 gal
522B	#107, RFP	--	Medium			Dead?	Yes	Change house	15-MP cup filling	

**From Geraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential

*From Shell Memo 08848436201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied*	Plans, Diagrams Available	Building Description/Use	6 M Area** Listed in Ode	Reporter 116 (8/78 at Shell, Action)
523	0107, MFP	WP	Low	4,000 ft ²		Yes	Yes	WP filling; reconstructed after fire	13-Aa C13	
523A	0107, MFP	WP	High	1,440 ft ²		Yes	Yes	WP filling, all storage; damaged by fire	13-Aa C13	
523C-D	0107, MFP, Vol 1 HSLA	--	Low	130 tons	Yes-1	Yes	Yes	Arsenic trichloride dry storage, misc. storage	13-Aa C13	
524	0107, MFP	WP	Low			Yes	Yes	In use as laboratory WP bomb filling	13-Aa C13	
525	0107, MFP, Vol 1 HSLA	HD, pesticides	High	3 floors, 9,637 ft ²	Yes-1	Yes	Yes	HD in manufacture, Laboratory-HD testing, pesticide testing	13-Acetylene plant	8 524g, 678 bottom, 1978, 688 gal
525A	Vol 1 HSLA, Shell Memo		High	480 ft ²	Yes-built			Refrigeration Building	13-Acetylene plant	
526	Shell Memo							Filter Building for various pesticides, foundation only		
527	0107, MFP	--	High			Build?	Yes	Change house	WP	
528	0107, MFP, Vol 1 HSLA, Shell Memo	HD, pesticides, ammonia, freon	High	2,024 ft ²	Yes-1	Yes	Yes	Residue burning area, refrigeration units	9-Acetylene distillation	5-Acetylene, 1978-200 gal, 1978-200 gal
529	0107, MFP, Vol 1 HSLA, Shell Memo	--	High	833 ft ²	Yes-1	Yes	Yes	Caustic mixed, tempered water system for Acetylene	8-Landfill production	
531	0107, MFP, Vol 1 HSLA	--	Low	11,037 ft ²	Yes-1	Yes	Yes	Warehouse	North of 6 6-Laundry	
532	0107, MFP, Vol 1 HSLA, Shell Memo	--	Low	11,037 ft ²	Yes-1	Yes	Yes	Warehouse, stored empty containers and used for pesticide packaging	North of 6 6-Laundry	

*From Corroghy A Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

ROCKY MOUNTAIN MEDICAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied*	Plans, Diagrams Available	Building Description/Use	3 & 4 Range Listed in DB	Reported Spills (08/25/87 Shell Letter)
533	#107, RFP Vol 7 HBA	--	Medium	128 ft ²	Yes-I	Yes	Yes	Inflatable Storehouse for paint	3-Chlorinated paraffins	
534	#107, RFP Vol 7 HBA	Shell operations/Industrial chemicals	High	600 ft ²	Yes-I	Yes	Yes	Storage	7-Chlorinated paraffins	
534A	Shell Lease Book, Vol 6 HBA, Shell Memo		High	2,633 ft ²	Yes-built		Yes	General purpose warehouse, drum storage facility	7-Chlorinated paraffins	Report 10/25/87 Contamination Shell, 1974, 428 gal.; 8 drums, 1974-1987, 200 gal.; 5 drums, 1974, 1320 gal.; 8 drums, 1974, 1320 gal.; 8 drums, 1974, 1320 gal.
534B	Shell Lease Book, Vol 6 HBA		High	3 floors 12,420 ft ²	Yes-built		Yes	Plasma manufacturing building	7-Chlorinated paraffins	
534C	Shell Memo			200 ft ²	Yes-built			Electric vault	Not shown on map	
534D	Shell Memo			400 ft ²	Yes-built			Emergency generator	15-AP filling	
535	RFP, Shell Memo	--			Yes-I	Yes	Yes	Not present, former refrigeration unit		
536	#107, RFP	HO	High	2 floors 6,120 ft ²		Yes	Yes	Radio H storage	10-mustard shell	
537	#107, RFP	H, HO	High	13,700 ft ²		Yes	Yes	Power house/Shell	10-mustard shell	
537A	#107, RFP	H	High			Yes	Yes	Condensate pump/Shell	10-mustard shell	
538	#107, RFP	H	High	9,000 ft ²		Yes	Yes	Drum disposal/Shell	11-mustard filling	
538A	#107, RFP	H	Medium			Yes	Yes	Compressor house/Shell	11-mustard filling	
539SS	#107, RFP	--	Low		Yes-IV	Shell	Yes	Electric substation	Not shown on map	
540	#107, RFP	--	High		Shell		Yes	Recon building	11-mustard filling	

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ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/ Use	E & H Areas** Listed in DHA	Reported Spills (08/26/82 Shell Letter)
541	#107, RFP	WP	Low	11,040 ft ²		Yes	Yes	WP filling warehouse	15-WP filling	
541A	#107, RFP	--	Low				Yes	Magazine	East of 541 ^o	
542	#107, RFP, Shell Memo	--	Low		Yes	Gov't agency	Yes	Warehouse for drummed product storage	15-WP filling station	
543	#107, RFP	All types of agents	Low			Yes	Yes	Maintenance Shop	18-Maintenance shop and Equipment renovation area	
543A	#107, RFP	--	Low			Yes	No	Steam meter pit	Equipment renovation area	
543B	#107, RFP	All types of agents	Low			Yes?	Yes	Maintenance Office	18-Maintenance shop and Equipment renovation area	
544	#107, RFP	All types of agents	Low			Yes?	Yes	Maintenance Office Heavy Equipment Shop	18-Maintenance shop and Equipment renovation area	
545	#107, RFP	--	Low			Yes?	Yes	Paint Shop	18-Maintenance shop and Equipment renovation area	
546	#107, RFP	--	Low				Yes	Sewage Lift Station	18-Maintenance shop and Equipment renovation area	
548	#107, RFP, Vol 3 HBJA, Shell Memo	--	Low	2,206 ft ²	Yes-IV	Yes	Yes	Pump House for cooling water	18-Maintenance shop and Equipment renovation area	
549	#107, RFP, Vol 3 HBJA	--	Low	8,802 ft ²	Yes-IV	Yes	Yes	Cooling Tower	18-Maintenance shop and Equipment renovation area	
550	#107, RFP	--	Low			Yes	No	Lift Station	Not shown on map, uncertain	

**From Geraughty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo 88048A36201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

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Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Acry Occupied	Plans, Diagrams Available	Building Description/Use	S & H Areas** Listed In DCR	Reported Spills (8/26/82 Shell Section)
550A	#107, Vol 5 HBLA	--	Low		Yes-I		No	Valve pit	Not shown on map, unknown?	
551	#107, RFP, Vol 5 HBLA	--	Low	500,000 gal	Yes-IV	Yes	Yes	Water Storage	18-Maintenance shop and equipment renovation area	
552	#107, RFP, Vol 5 HBLA	--		236 ft ²	Yes-IV	Yes	No	Valve pit	18-Maintenance shop and equipment renovation area	
553	Vol 6 HBLA				Yes-built			Vault	Not shown on map	
555	#107, RFP	--	High		Yes?		Yes	Hazardous waste tank	South of 11 11-Mustard filling	
557	Vol 6 HBLA, Shell Memo			700 ft ²	Yes-built			Salvage yard shelter storage and repair shop	Not shown on map	
561	Vol 6 HBLA, Shell Memo				Yes-built			BOH Process Unit	North of 512	
561A	Vol 6 HBLA, Shell Memo				Yes-built			Acetylene compressor	Next to 541	
571	Vol 6 HBLA, Shell Memo			500 ft ²	Yes-built			Incinerated waste vent	N/A	
571A	Vol 6 HBLA, Shell Memo				Yes-built			Electric Vault	N/A	
571B	Vol 6 HBLA			2,400 ft ²	Yes-built			Heavy and light organics tank room	N/A	
724	Vol 6 HBLA, Shell Memo				Yes-built	No		DET Salt Handling Bldg, Incinerator Precipitator Building	N/A	
727	Shell Lease Book		Low	4,169 ft ²	Yes-built			Facilities eny. maintenance division	N/A	

**From Deraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.
*From Shell Memo 8040436201 (12/27/84).

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ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS I AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/Use	G & M Area** Listed In DMR	Reported Spills (8/26/82 Shell Letter)
728	#107, RFP, Shell Memo	--	Low	22,735 ft ²	Yes-II	Yes	Yes	Warehouse for pesticide storage	North of 11 11-Mustard filling	
729	#107, RFP, Shell Memo	--	Low	22,775 ft ²	Yes-I		Yes	Warehouse, Maintenance Shop, Change House and Office	North of 11 11-Mustard filling	
731	#107, RFP	--	Low			Yes	Yes	Army Reserve Change House	North of 11 11-Mustard filling	
732	#107, RFP	--	Low			Yes	Yes	Manufacturing Building Army Reserve	North of 11 11-Mustard filling	
732SS	#107	--			Yes-IV	Yes		Electric substation	Not shown on map	
733A-F	#107, RFP	--	Low			Yes	Yes	Magazine	North of 11, 19 11-Mustard filling 19-unsymmetrical dimethyl hydrazine	
734	BLDG Plans		Low			Yes?	Yes	WP Pump House	Not shown on map, unknown*	
735	#107, RFP, Shell Memo	--	Low	156 ft ²	Yes-I	Yes	No	Foamite Building, Firefighting House	17-M-76 incendiary bomb filling	
741	#107, RFP	Small TX	Low			Yes	Yes	MIC Library, Refrigeration Building	11-Mustard filling	
742	#107, RFP	HD	Medium	48,840 ft ²		Yes	Yes	Manufacturing/storage	11-Mustard filling Filling & Storage (HD)	
742A	#107, RFP	--	Low			Yes?	Yes	Tank House	South of 11, 17 11-Mustard filling 17-M-76 incendiary bomb filling	
742SS	#107, RFP	--	Low		Yes-IV	Yes	No	Electric substation	Not shown on map	
743	#107, RFP	All types of agents	Medium		Yes-I	Yes (Small)	Yes	Soil laboratory Change House	17-M-76 incendiary bomb filling	

**From Geraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

*From Shell Memo BRHQA36201 (12/27/84).

ROCKY MOUNTAIN MISCELLANEOUS BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied*	Plans, Diagrams, Available	Building Description/Use	G & M Areas** Listed in DMR	Reported Spills (8-76/82 Shell Letter)
744	#107, RFP	--	Low		Yes-I	Yes	Yes	Gas pump house	17-44-74 Incendiary bomb filling	
745	#107, RFP	--				Yes	Yes	Fire fighting manifold	Not shown on map	
745A-C	#107, RFP, Shell Memo	--	Low		Yes	Yes	Yes	Gas storage tank, also storage tanks for DDT	17-44-74 Incendiary bomb filling	
746	#107, RFP	--	Low		Yes-I	Yes	Yes	Gas unloading facility	17-44-74 Incendiary bomb filling	
747	RFP	--			Yes?	Yes	Yes	Cafeteria	Not shown on map	
748	#107, RFP	--	Low		Yes?	Yes	Yes	Paint storage	17-44-74 Incendiary	
751	#107, RFP	--	Low		Yes	Yes	Yes	Maintenance Shop	South of 11, 17 11-Mustard filling 17-44-74 Incendiary bomb filling	
752	#107, RFP	--	Low		Yes	Yes	Yes	Maintenance Shop	South of 17 17-44-74 Incendiary bomb filling	
752A	#107, RFP	--	Low		Yes	Yes	No	Storage	South of 17 17-44-74 Incendiary bomb filling	
753	#107, RFP	Herbicides Pesticides	Low		Yes	Yes	No	Herbicide and pesticide storage	South of 17 17-44-74 Incendiary bomb filling	
754	#107, RFP	--	Low		Yes	Yes	No	Lumber Storage	South of 17 17-44-74 Incendiary bomb filling	
761	#107	--	Low		Yes?	Yes?	Yes	Gate House	N/A	
847	#107	--			Yes?	Yes?		Range House	Not shown on map, unknown*	

**From Geraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

*From Shell Memo BRWNS436201 (12/27/84).

ROCKY MOUNTAIN ARSENAL BUILDINGS IN SECTIONS 1 AND 2

Building Number	Source of Information	Potential Contaminants	Contamination Assessment	Floor Area	Shell Occupied*	Army Occupied	Plans, Diagrams Available	Building Description/ Use	G & H Area** Listed In DRI	Reported Spills (8/26/82 Shell Letter)
T1505- T1510	Vol 6, H&A	All types of agents	High		Yes-built			Chemical tanks		
Unknown		All types of agents	High		Yes			Incrinerator	Section 36	
DET Units	Shell Memo				Yes-built	No		Pretreatment of Effluent and Incineration		
DET Tanks	Shell Memo				Yes	No		Held DET Feed - 2 tanks		
DET Tank	Shell Memo				Yes	No		Held M ₂ Fertilizer		

*From Geraghty & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. See area profiles in table notes. Privileged and confidential information prepared in support of litigation.

**From Shell memo 8446A36201 (12/27/84)

HP = White Phosphorous

H = Mustard

HP = Distilled Mustard

L = Lewisite

TX = Biological Agent (Wheat Rust)

*#107 = Installation Assessment of Rocky Mountain Arsenal, March 1977, USAFWM Report No. 107.

**Reference for HFP = Army Material Command, "Contamination Survey, Rocky Mountain Arsenal, August 1977.

***84A = Harland Bartholomew & Associates and Commonwealth Associates, Inc., 1982. Property Inventory and Survey Report for Selected Shell Constructed Buildings within The Shell Oil Company Leasehold Area at US Army Rocky Mountain Arsenal, Commerce City, CO. Volume I-VII.

Shell Lease Building Categories

I - Chemical Plant Property on Shell Leasehold

II - Chemical Plant Property on Shell Leasehold Returnable with 120 days written notice

IV - Utility Systems property

DAR = Damage Assessment Report, Working Draft, September 1984, by Geraghty & Miller, Inc.

WF No. H&A 054 0730-0741. 29 December 1949 Lease Document for Julius Hymen.

Shell Memo - Shell Interrogatory #3 Response, Entitled South Plant Structures Used by Shell.

From Geography & Miller 1984 Damage Assessment Report, Vol. III, Working Draft. Privileged and confidential information prepared in support of litigation.

1. Cl₂ and Caustic Plant - Chemical Materials: Salt (NaCl), sodium bicarbonate (NaHCO₃), sodium carbonate (Na₂CO₃), sodium hydroxide (NaOH), sulfuric acid (H₂SO₄), fuel oil, water. Wastes: salt brine, liquid caustic waste, neutralized sulfuric acid, wastewater to contaminated sewer. Calcium, magnesium and sulfate sludges to Section 36 pits (Chlorine, 3/43-8/45; caustic 10/44-9/45).
2. Propane Filling - Chemical Materials: Propane, naphtha, calcium chloride brine, paint, thinners. Wastes: Spent caustic, naphtha, paint thinners, oils to contaminated sewer casings, packing materials, spent coke, and caustics sludges to Section 36 for burning or burial (1/44-12/44).
3. M-74 Incendiary Bomb Filling - Chemical Materials: Gasoline, benzol, QDP (magnesium dust paste), isobutylmethacrylate polymer, magnesium (coarse and dust) petroleum oil extract, sodium nitrate. Wastes: Waste gasoline (equipment wash), floor sweepings, rejected bombs and incendiaries to Section 36 burning pits, waste water discharged through contaminated sewer to Basin A (Section 36) (3/45-9/45).
4. Mustard Production - Chemical Materials: Sulfur monochloride, ethylene, ethyl alcohol, fuel oil, salt brine, aluminum oxide. Wastes: Unacceptable batches of mustard were neutralized with caustic and flushed through contaminated sewer to Basin A (Section 36) (12/42-5/43).
5. Laboratory - Chemical Materials: All chemical raw materials and final products used, produced or stored at R&D. Wastes: Waste water from sink to Basin A (Section 36), later by sewer to Basin A, other waste to Section 36 burning pits and burial pits.
6. Laundry - Chemical Materials: Sodium hypochlorite, soaps, phosphate detergents, CC2-octachlorocarbonilide, CC3-octachloronilide and zinc oxide, chlorinated paraffin, trichloroethylene. Wastes: Waste water to open drainage ditch, spent lepregnite solutions went to industrial sewer system.
7. Chlorinated Paraffin Production - Chemical Materials: Paraffin, chlorine, triethanolamine. Wastes: Paraffin, chlorine gas, hydrogen chloride gas, triethanolamine, waste water from waste sumps to Basin A, slop from sump burned or burned in Section 36 (1/45-6/45).
8. Lewisite Production - Chemical Materials: Acetylene (C₂H₂), arsenic trichloride (AsCl₃), thionyl chloride (SOCl₂), hydrochloric acid (HCl), mercuric chloride (HgCl₂). Wastes: 183,000 lbs HgCl₂ lost in waste, large losses of AsCl₃ as As oxides, large reactor losses of Lewisite through paper and spills, liquid wastes went to two unlined settling basins in South Plant area. Wastes eventually went to Basin A. (4/43-11/43).
9. Mustard Distillation - Chemical Materials: Crude mustard, caustic, sulfuric acid, nitric acid, Dacron (diphenyl and diphenylonide), Tret-O-Lite (unsulfurizing agent), chloride of lime (bleaching powder - CaOCl₂).
10. Mustard Qualification - Chemical Materials: Crude mustard, crude mustard plus bis, 2-chloroethylmercapto (ethyl) ether, sulfuric acid, nitric acid, sodium hydroxide solution. Wastes: Waste waters containing sulfuric and nitric acids, sodium hydroxide and mustard flushed by contaminated sewer to Basin A and F, decontamination residues and furnace ash to Section 36 pits.
11. Mustard Filling - Building 742, Wastes: Sodium and calcium hypochlorite solutions containing mustard and decontamination products by industrial sewer to Basin A or F, solid wastes to Section 36 for burning or burial.
12. Acetylene Plant - Chemical Materials: Calcium carbide, water sulfuric acid. Wastes: Sulfuric acid, acetylene polymerization products washed by contaminated sewer to Basin A (4/43-11/43).
13. Arsenic Trichloride Plant - Chemical Materials: Arsenic trioxide, sulfur, chlorine, sulfur monochloride. Wastes: Spent lime and sulfite pumped to Lewisite disposal basin (Section 8 and Lewisite production) (4/43-11/43).
14. Sulfur Mono and Dichloride Production - Chemical Materials: Sulfur, chlorine, sulfur monochloride, sulfur dichloride. Wastes: Spent caustic washed by contaminated sewer to Basin A (4/43-11/43).

15. White Phosphorus Dip Filling - Chemical Materials: Alcohol, copper sulfate, sodium silicate, white phosphorus, sealing compound. Wastes: Waste water containing phosphates, copper sulfate and other materials released by contaminated sewer to Basins A or F, solid wastes to pits in Sections 4 and 36.
16. Thionyl Chloride - Chemical Materials: Sulfur dichloride (SCl_2), chlorine gas (Cl_2), caustic, oil 65% (44504 9503), monochlorobenzene (concent), antimony trichloride ($SbCl_3$), aluminum chloride ($AlCl_3$). Waste: Water from equipment wash and spills flushed by contaminated sewer to Basin A, spent caustic slurry and solid waste to Section 36 for burning or burial.
17. M-76 Incendiary Bomb Filling - Chemical Materials: Gasoline, benzol, napalm (M-1), paint, lacquer, thinner. Wastes: Waste water and liquid waste from paint lines flushed by industrial sewer to Basin A. Rejected lots of M-1, thickener, gasoline and thickener, and bombs sent to Section 36 for burning and burial.
18. Maintenance Shop and Equipment Renovation Area - Wastes: deteriorated paints, lacquer, thinner, solvents, unsaleable chemicals, waste oil, grease and spilled gasoline. Wastewater containing these chemicals discharged to Basin A or F by industrial sewer, flammable waste burned in Section 36.
19. Unsymmetrical Dimethylhydrazine Plant - Chemical Materials: Hydrazine, dimethyl hydrazine, unsymmetrical dimethylhydrazine (UDMH). Wastes: Calcium hypochlorite wastes discharged by chemical sewer to Basin 8. Solid sludges (UDMH sludge) discharged to Section 36 pits.

- o High Rated Buildings include: all buildings in which surety agents have been produced, stored or are suspected; all buildings in which pesticides have been produced; all buildings expected to contain complex process equipment.
- o Medium Rated Buildings include: buildings in which severe contamination is not expected, but is possible due to the area in which the building is located. For example, an empty warehouse in an area in which mustard was produced is a medium risk building.
- o Low Rated Buildings include: foundations, gate houses, power plants, pump houses, change houses, electric substations, loading docks, maintenance shops, small storage structures, currently occupied buildings, warehouses, and miscellaneous tanks and structures which are not expected to exhibit significant contamination or present any special difficulties during sampling.

These initial designations will be revised, as required, based upon the information obtained during Phase IA and as other sources of information are made available.

An additional 145 buildings and/or structures have been identified for which use and/or location information is incomplete. For these buildings it was not possible to assign a relative ranking or to compute the required number of samples. The buildings for which sampling requirements were not estimated are detailed in Tables B-1 and B-2 in Appendix B. It is likely that many of these structures have been dismantled or are not located in the study area. This will be confirmed during the reconnaissance survey.

3.4.3 Phase IA Building Sampling Program (Reconnaissance and Health Safety Program)

The Phase IA--Building Reconnaissance Survey Team will consist of the Health and Safety Officer, the sampling team supervisor, and an air sampling technician. A structural engineer will join this survey team when buildings of questionable structural integrity are inspected. In all instances, the

Health and Safety Officer and the air sampling technician will be the first team members to enter a structure.

They must insure that the building's atmosphere is acceptable to proceed with other sampling requirements. The Health and Safety Officer and air sampling technician will be present throughout this phase; other team members will enter the building only as required to complete their designated tasks. At any one time, a maximum of three team members will be inside a building. All building reconnaissance survey work will be conducted using Level C protection. Back-up personnel (those who remain outside of buildings prepared to offer emergency assistance) will be prepared to enter buildings in Level B protection, if required.

Level A and Level B sampling equipment will be available at the site. If it is determined that to sample a building will require an upgrade of protective equipment to Level B or Level A, and that the sampling of this building is necessary to carry out the objective of the building sampling program, the Health and Safety Officer will make the necessary adjustments so that this building can be safely sampled.

The field sampling supervisor and the Health and Safety officer will be responsible for proper sample collection, sample labeling, chain of custody records and field analysis. The air sampling technician will assist during the sampling effort. The field sampling supervisor will also assure that the building data log for each structure examined and record the details of plumbing, tanks, tank contents, vats, vat contents, etc., are properly maintained.

Phase IA--Sampling

Non-invasive sampling will be conducted during the reconnaissance survey for volatile organics in air, organic residues in dusts, toxic metals in dust, asbestos in dust and Army surety agent in dusts. At least one composite dust sample will be collected from each building using a portable, high-flow sampling pump and preloaded filter cassettes.

The field sampling supervisor and air sampling technician will utilize real time monitors during the building inspection to ascertain the presence of airborne toxic contaminant levels. These monitors may include:

- a. Photoionization detector (PID) calibrated in the office to a benzene standard and in the field to an isobutylene standard. The PID will be used in the survey mode in conjunction with the OVA for the reconnaissance survey.
- b. Flame ionization detector (FID) or organic vapor analyzer (OVA) calibrated to methane. The FID or OVA will be used in the survey mode in conjunction with the PID for the reconnaissance survey.
- c. M-260 meter calibrated to propane or other suitable gas functions as a combustible gas indicator and oxygen alarm.
- d. M-8 meter, no calibration required. The M-8 detects the presence of Nerve Agent (GB). The detection of GB will initiate immediate evacuation of the building by the reconnaissance team and immediate notification of the Army Technical Escort Team.
- e. M-18A2 field kit required for the detection of Army surety agent.
- f. Inorganic gases meter. Monitors the level of inorganic gases or vapors, for instance chlorine gas or mercury vapor.

One of the composite dust filter cassettes will be used to field test for Army surety agents. Detection of Army agents will require that the Army Technical Escort be notified and cause the Health and Safety officer to close the building to further sampling until the Army can clear the building of detectable agents.

Section 4.0 contains a discussion of the analytical protocol for Phase IA samples. All samples will be placed in a temperature controlled (4°C) ice chest immediately after collection, labeled for shipment, and shipped to Ebasco's Project Team laboratories by an overnight express service (e.g., Federal Express) for analysis.

Building samples, locations and field analytical results for each structure will be recorded in the building data log book. Entries to each log will be in waterproof ink. Preliminary reconnaissance samples will be processed as soil samples. Analytical procedures will not be USATHAMA Certified for samples obtained for health and safety evaluations; however, they will be EPA or NIOSH certified methods. These methods will be used for the air organic screen and asbestos. These data will not be used for contamination assessment or technical matters in litigation. Army certified analyses will be performed for ICP screen of composite dust samples and semi-volatile organics in composite dust samples.

Structural Engineering Evaluations

The structural engineer will perform a nondestructive investigation of each high and medium risk building in the presence of the site Health and Safety officer. Building main support structures will be identified. Stairways, scaffolding and flooring will be examined for structural integrity and personnel maneuverability. The location of all tanks, vats, attendant plumbing, connecting floor drains and sinks to vats, tanks or sewer lines, waste storage areas and known spill areas will be identified by building and sample number, and will be photographed and recorded in the building data log as potential sample points. Potential access routes to identified sampling points will be marked. Any building areas or construction within buildings (e.g., scaffolding, stairs, etc.) found to be unsafe will be marked on the building floor plan and roped off. If the structural engineer determines that a building is unsafe to enter, he will order the building cleared of all reconnaissance personnel. The structural engineer will prepare a report to the Health and Safety Officer identifying the reasons for declaring an area or building unsafe.

No Ebasco employee or Ebasco subcontractor may enter a structure or portion of structure that has been declared unsafe by the structural engineer. Neither may an Ebasco employee or Ebasco subcontractor sample a building area or structure declared unsafe by the structural engineer.

Health and Safety Evaluations

The Health and Safety Officer will identify to the Army within 48 hours of receiving the structural engineer's report which building, structure or building areas were found unsafe to sample. This report will include in its write-up, and by appendix, the structural engineer's report on building integrity. The health and safety officer will identify in the building data log for each structure those areas excluded from sampling. In addition, if an entire building or structure is found unsafe, the health and safety officer will mark that specific building log with a strip of transparent red tape. Sampling teams may not enter buildings so marked by the Health and Safety Officer without his written approval. The Army, at its discretion, may chose to sample any structure designated as unsafe themselves or take no action at all. Refer to Section IV of the Task 2 RMA Procedures Manual for the details of the Ebasco Health and Safety Plan.

3.4.4 Phase IB Sampling

The purpose of Phase IB is to determine if any of the buildings being sampled are contributing to soil and ground water contamination. During the Phase IB Survey, several types of samples will be collected. These include samples from:

- o Building drains, foundations and sumps.
- o The sanitary sewer system throughout the South Plants.
- o The original contaminated waste system constructed by the U.S. Army.
- o The contaminated waste system constructed by Shell.
- o The storm drainage system in the South Plants.
- o Soils surrounding the sanitary and contaminated waste lines.

The samples to be obtained from buildings and disposal facilities are described in Section 3.4.4.1 below. Soil borings to be drilled in the vicinity of these disposal facilities are discussed in Section 3.4.4.2. All samples collected during the Phase I Screening Survey will be analyzed as identified in Table 4-2. Procedures for use of sampling equipment are presented in Section II of the Task 2 RMA Procedures Manual.

3.4.4.1 Process/Disposal Facility Sampling Locations

Building Foundations and Process Equipment

Available information and maps have been used to identify buildings which are, or may be, connected to sanitary sewer lines and the original buried contaminated waste system. This information is reported on the building profiles presented in Appendix B.

Disposal drains, sewer connections and process equipment will be located and reviewed during the Phase IA Survey. Additionally, process equipment will be subject to visual inspection during the Phase IB program to identify equipment condition and likely contributions to soil contamination by a chemical engineer.

Current Phase IB sample estimates are based on the following assumptions:

- o No screening samples will be required from structures which have been designated as low risk/difficulty.
- o A maximum of 3 foundation samples will be collected in each building to determine if the building is grossly contaminated.

In addition to samples obtained from building foundations, 36 Shell and jointly utilized tanks, pumps and valve pits and 55 contaminated waste sumps have been identified. A single sample will be collected from each of the facilities identified in Appendix C, Table C-3.

Sanitary Sewer System

The sanitary system lines, manholes, lift stations and septic tanks located in the South Plants area are shown in Figure 3.4-4. Samples will be collected from the lift stations (3 samples) and from 10 manholes. The manholes to be sampled have been selected by reviewing the system configuration and direction of flow. Manholes at, or just below, junctions and at least one manhole on lengths of sewer line greater than 1/3 mile long have

been selected. The locations of manholes to be sampled are identified on Figure 3.4-4. The identification numbers of these 10 manholes are 100, 102, 104, 106, 108, 113, 116, 119A, 123 and an un-numbered manhole 2 blocks west of #SA3. Individual manhole numbers are not presented on Figure 3.4-4, but are available on the RMA basic information maps.

It is possible that some of the identified manholes may be rusted shut or that a manhole cannot be located. In this instance, the sampling team coordinator will select an alternate sampling point.

Contaminated Waste System

Two contaminated waste systems are located in the South Plants area. The original system was constructed by the Army and consists of buried lines and associated sumps. The locations of the original lines are shown in Figure 3.4-5.

The second system was constructed by Shell. The Shell system consists of 14 below-grade collection tanks in concrete sumps. These 14 sumps collected aqueous effluent from 20 process buildings and laboratories via underground hard piping. An overhead pressure header from the sumps to the effluent treatment facility is still in place. Another 34 Shell built sumps which were designed to collect washdowns, spills and rainwater from tanks farms, truck loading/unloading areas, and nonprocess buildings. Effluent from these sumps was removed with vacuum trucks.

Samples from the original contaminated waste system will be obtained from twelve manholes and seven sumps. The selected manhole sampling locations are shown on Figure 3.4-5. Additional samples will be collected at manholes to facilitate characterization of chemical constituents present in these lines. Sampling locations have been selected based on system configuration and direction of flow to allow characterization of the system with a limited number of samples.

The Shell contaminated waste system will be characterized by sampling the 48 sumps described above. It is assumed that all contaminants identified in

these sumps will be present in the header lines. Therefore, it will not be necessary to sample these header lines. The locations of all 55 contaminated waste system sumps located in the South Plants area are presented in Appendix C, Table C-2. Sumps are differentiated as original and Shell-built.

Storm Drainage System

In Section 1 of the South Plants area, most storm runoff is to a drainage collection system which discharges to the Derby Lakes. In the northwest area of Section 1, overland drainage is towards Sections 36 and 6. The collection system in the northwest area is minimal (collection lines in the vicinity of buildings 741 and 742 only); overland flow is channeled under roads via culverts.

In Section 2, storm drainage collection pipes and culverts are located under the railroad tracks in the vicinity of the 341-346 warehouses. Drainage throughout the remainder of Section 2 is via overland flow channeled under roads with culverts. Drainage from Section 2 is primarily to the San Creek lateral. The storm drainage collection system located in the South Plants area is illustrated in Figure 3.4-6. Individual road culverts are not detailed on Figure 3.4-6 unless a sample will be collected from the culvert.

Ten samples will be collected from the storm drainage system. This data will be used to characterize contaminants in the collection pipes and culverts. Additionally, contaminants potentially transported out of the South Plants area via runoff will be identified.

The approximate locations of samples to be obtained from the storm drainage system are shown on Figure 3.4-6. These sampling locations have been selected to characterize the major collection pipes and culverts. The primary consideration for storm drainage sample site selection was the direction of flow. Downstream samples were selected in order to permit identification of contamination originating within the system with a minimal number of samples.

3.4.4.2 Soil Borings in Vicinity of Disposal Facilities

A number of soil borings will be drilled in the vicinities of the chemical sewers, sanitary sewers, storm drains, tanks, pits, and vats to determine if these facilities have leaked and if contaminants are present in the soil. The number of borings has been estimated to be one-third the total number of samples obtained from the disposal systems. As it has been planned to obtain 137 samples from disposal facilities, the total number of boreholes associated with sewers will be 46. Thirty percent or 16 borings will be drilled during Phase I. Borings will be drilled and samples will be collected using the techniques outlined in Section 3.3. Soil samples will be taken at both the water table at a depth just below the sewer, resulting in 2 samples per borehole.

A summary of the boring program is as follows:

<u>Phase I</u>		<u>Phase II</u>		<u>Total</u>	
<u>Number of Borings</u>	<u>Number of Samples</u>	<u>Number of Borings</u>	<u>Number of Samples</u>	<u>Borings</u>	<u>Samples</u>
16	32	30	60	46	92

3.4.4.3 Data Analysis for Phase IA and Phase IB

Data obtained from Phase IA will be used to plan for Phase IB sampling. The health and safety data obtained from real time instrumentation and the organics in air samples will be used to determine the level of protection needed to enter buildings during Phase IB. The information will help define special sampling considerations to obtain Phase IB samples.

In addition, data from visual observations and from the composite dust samples will help characterize the contamination inside the buildings. Observations by the sampling team will further clarify the existing conditions of the buildings in the South Plants area.

Phase IB sampling is to determine if contamination exists in buildings that can contribute to soil and ground water contamination at RMA. These samples are to be sludge and soil samples. Any liquid samples identified and thought to be important will be sampled. The present schedule indicates that the laboratories will be certified for liquid analyses by the initiation of Phase IB.

The data obtained from Phase IB samples will be correlated with soil sample data outside the buildings. Any relationship relating the two will be determined and presented as part of the findings of the Phase I program at RMA. Specifics of this contamination assessment are discussed in Section 8.

4.0 CHEMICAL ANALYSIS PLAN

4.1 Introduction

The chemical analysis program is designed to be consistent with the sampling program and is similarly divided into two phases. The first is a screening phase analysis and the second is a quantitative phase analysis. Each of these phases is described in more detail below. Published U.S. EPA and USATHAMA analytical methods are identified as method of choice when available. Where a reference method is not available, contractor methods are proposed that will be developed to conform with Sample and Chemical Analyses Quality Assurance Program for U.S. Army, section C, Development of Analytical Methods (USATHAMA, 1982). The referenced analytical methods in this Technical Plan were those specified during the meeting of the Analytical Services Teams for this Rocky Mountain Arsenal Project.

Phase I will screen samples collected at known or suspected contaminant sources for target analytes and unknown contaminants. Phase I analytical methods, including desired analyte concentration, high range concentration, sample holding times, reference method and principle of method, are identified in Table 4-1 and Table 4-2.

Table 4-1 identifies all Phase IA analytical methods. Buildings will be sampled for volatile organics in air; and semivolatiles, toxic metals and asbestos in dust. Data from these samples will be used as an initial building contamination assessment and to identify the potential for worker exposure to organic vapors, toxic metals and asbestos.

Phase IA methods for worker exposure (e.g., volatile organics in air and asbestos) will not be USATHAMA Certified. Other Phase IA analytical methods for initial building contamination assessment will be USATHAMA Certified as indicated in Table 4-1. Building contamination assessment samples will be assayed by the semiquantitative gas chromatography/mass spectroscopy (GC/MS) technique for semivolatile organic target compounds. An attempt will be made to identify the largest of major unknown peaks present in the GC/MS

TABLE 4-1
PHASE 1A ANALYTICAL PROGRAM

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Organics Screen/Air-Charcoal	-	-	4 weeks in freezer	None	UBTL method developed for NIOSH	The front and back sections of the charcoal tubes are combined and extracted with 1 ml of methylene chloride. The extract is analyzed by GC/MS using a fused silica capillary column. Significant unknowns are identified.
Organics Screen/Air-Tenax	-	-	4 weeks in freezer	None	UBTL method developed for NIOSH	The front and back sections of the Tenax tubes are combined and extracted with 1 ml of isooctane. The extract is analyzed by GC/MS using a fused silica capillary column. Significant unknowns are identified.
Asbestos/Composite Dust	1%	100%	None	None	EPA-600-M-82-020, Dec 1982	Polarized light microscopy with dispersion staining.
Soil-Volatile Organics/Composite Dust						
Aldrin	0.5 µg/g	100 µg/g	14 days for the solid & 40 days for the extract (1)	Quantitative	EPA 8270 with EPA 3540 extraction (1)	A 25 gram portion of the sample is obtained with a minimum of handling. The sample is extracted for 8 hours in a Soxhlet with 300 ml of dichloromethane. The extra
Endrin	0.5 µg/g	100 µg/g				extract is reduced to a final volume of 10 ml in a K-D apparatus. An aliquot of the extract is analyzed by capillary GC/MS. Surrogates and internal standards are used. Unknowns are identified.
Dieldrin	0.5 µg/g	100 µg/g				
Isodrin	0.5 µg/g	100 µg/g				
p,p'-DDT	0.5 µg/g	50 µg/g				
p,p'-DDE	0.5 µg/g	100 µg/g				
Chlorophenylmethyl sulfide	0.5 µg/g	100 µg/g				
Chlorophenylmethyl sulfoxide	0.5 µg/g	50 µg/g				
Chlorophenylmethyl sulfone	0.5 µg/g	100 µg/g				

TABLE A-1 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Hexachlorocyclopentadiene	0.5 µg/g	100 µg/g				
Oxathiane	0.5 µg/g	100 µg/g				
Dithiane	0.5 µg/g	100 µg/g				
Malathion	0.5 µg/g	100 µg/g				
Parathion	0.5 µg/g	100 µg/g				
Chlordane	0.5 µg/g	100 µg/g				
Azodrin	0.5 µg/g	100 µg/g				
Vapona	0.5 µg/g	100 µg/g				
Supona	0.5 µg/g	100 µg/g				
DIMP	0.5 µg/g	50 µg/g				
Atrazine	0.5 µg/g	100 µg/g				
Surrogates are: d ₄ -1,3-Dichlorobenzene d ₄ -Diethylphthalate d ₄ -2-Chlorophenol d ₄ Di-n-Octyl Phthalate						
The internal standard will be d ₁₀ Phenanthrene						
ICP Screen/Composite Dust			6 mos (3)	Quantitative	EPA 200.7 (3) USATHWA 75	A 1 gram portion is digested with 3 ml repeated portions of HNO ₃ and finished with HCl. The sample is filtered to a final volume of 50 ml. The sample is analyzed by ICP.
Calcium	0.5 µg/g	500 µg/g				
Chromium	5 µg/g	500 µg/g				
Copper	5 µg/g	500 µg/g				
Lead	5 µg/g	500 µg/g				
Zinc	5 µg/g	500 µg/g				
Aluminum	Interference Correction	Interference Correction				
Iron	Interference Correction	Interference Correction				
Arsenic/Solid	1 µg/g	10 µg/g	6 mos	Quantitative	EPA 7060 with EPA 3050 extraction (2)	A one gram portion of the sample is digested with H ₂ O ₂ + HNO ₃ . The digest is analyzed by GF/AA.

References:

- (1) SM-846, 2nd ed., July 1982
- (2) EPA-600/A-82-057, July 1982 Methods for Organic Chemical Analysis of Water and Wastes
- (3) EPA-600/A-79-020, Revised March 1983 Methods for Chemical Analysis of Water and Wastes

TABLE 4-2
PHASE 1.8 ANALYTICAL METHODS/SOLID MATRIX (SOIL, BUILDING MATERIAL, SEDIMENT)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Volatile Organics/Solids						
1,1-Dichloroethane	0.5 µg/g	25 µg/g	7 days for the solid and 30 days for the extract (1)	Quantitative	EPA 624 (2) EPA 8240 with EPA 5030 extraction (1)	A 10 gram portion of the sample is obtained with a minimum of handling. The sample is shaken for 4 hours with 10 ml methanol. An aliquot of the methanol extract is injected into 5 ml of water and analyzed by purge-trap GC/MS using a packed column. Surrogates and internal standards are used. Unknowns are identified.
Dichloroethane	0.5 µg/g	25 µg/g				Surrogates are: d ₂ - Methylene chloride d ₆ - Benzene d ₁₀ - Ethylbenzene
1,2-Dichloroethane	0.5 µg/g	25 µg/g				The internal standard will be 1,2-dibromomethane-d ₄ , or another of the ESE team's choice.
1,1,1-Trichloroethane	0.5 µg/g	25 µg/g				
1,1,1,2-Trichloroethane	0.5 µg/g	25 µg/g				
Carbon tetrachloride	0.5 µg/g	25 µg/g				
Chloroform	0.5 µg/g	25 µg/g				
Tetrachloroethylene	0.5 µg/g	25 µg/g				
Trichloroethylene	0.5 µg/g	25 µg/g				
Trans-1,2-Dichloroethylene	0.5 µg/g	25 µg/g				
Benzene	0.5 µg/g	25 µg/g				
Toluene	0.5 µg/g	25 µg/g				
Xylene (3 isomers)	0.5 µg/g	25 µg/g				
Ethylbenzene	0.5 µg/g	25 µg/g				
Chlorobenzene	0.5 µg/g	25 µg/g				
Methylisobutyl ketone	0.5 µg/g	25 µg/g				
Dimethyldisulfide	0.5 µg/g	25 µg/g				
Bicycloheptadiene	0.5 µg/g	25 µg/g				
Dicyclopentadiene	0.5 µg/g	25 µg/g				
Semi-Volatile Organics/Solids						
Aldrin	0.5 µg/g	100 µg/g	7 days for the solid & 30 days for the extract (1)	Quantitative	EPA 8270 with EPA 3540 extraction (1)	A 15 gram portion of the sample is obtained with a minimum of handling and mixed with 30 grams of anhydrous sodium sulfate. The sample is extracted for 8 hours in Soxhlet with 300 ml of dichloromethane. The extract is reduced to a final volume of 10 ml in a K-D apparatus. An aliquot of the extract is analyzed by fused silica capillary GC/MS. Surrogates and internal standards are used. Unknowns are identified.
Endrin	0.5 µg/g	100 µg/g				
Dieldrin	0.5 µg/g	100 µg/g				
Isodrin	0.5 µg/g	100 µg/g				
p,p'-DDT	0.5 µg/g	50 µg/g				
p,p'-DDE	0.5 µg/g	100 µg/g				
Chlorophenylmethyl sulfide	0.5 µg/g	100 µg/g				
Chlorophenylmethyl sulfoxide	0.5 µg/g	50 µg/g				
Chlorophenylmethyl sulfone	0.5 µg/g	100 µg/g				

TABLE A-2 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Hexachlorocyclopentadiene	0.5 µg/g	100 µg/g				Surrogates are: d_4-1,3-Dichlorobenzene d_4-Diethylphthalate d_4-2-Chlorophenol d_4-Di-n-Octyl Phthalate The internal standard will be d_{10} Phenanthrene
Oxathiane	0.5 µg/g	100 µg/g				
Difluore	0.5 µg/g	100 µg/g				
Melathion	0.5 µg/g	100 µg/g				
Parathion	0.5 µg/g	100 µg/g				
Chlordane	0.5 µg/g	100 µg/g				
Azodrin	0.5 µg/g	100 µg/g				
Vapona	0.5 µg/g	100 µg/g				
Supona	0.5 µg/g	100 µg/g				
Dibp	0.5 µg/g	50 µg/g				
Atrazine	0.5 µg/g	100 µg/g				
1,2-Dibromo-3-chloropropane/ Solids	0.01 µg/g	1.0 µg/g	7 days for the solid and 30 days for the extract See (1)	Quantitative	Developed by MRL for USATHMMA Certification	A 10 gram portion of the sample is obtained with a minimum of handling. The sample is shaken with 20 ml of 50/50 hexane/acetone for 4 hours. The extract is rinsed with distilled water and analyzed by GC/ECOD using a fused silica capillary column.
ICP Metal Screen/Solids			6 mos (3)	Quantitative	USATHMMA 75	A 1 gram portion is digested with 3 ml repeated portions of HNO_3 and finished with HCl. The sample is filtered to a final volume of 50 ml. The sample is analyzed by ICP.
Cadmium	0.5 µg/g	500 µg/g				
Chromium	5 µg/g	500 µg/g				
Copper	5 µg/g	500 µg/g				
Lead	5 µg/g	500 µg/g				
Zinc	5 µg/g	500 µg/g				
Aluminum	Interferent	Correction				
Iron	Interferent	Correction				

total ion current profile. In addition to a GC/MS screen, samples will also be assayed quantitatively for target metals, as identified in Table 4-1, using inductively coupled argon plasma (ICP) emission spectroscopy and atomic absorption (AA) spectrometry.

Phase IB will be a survey of known or suspected contamination sources. Mainly soil and solid matrices (e.g., soil borings, sediments, dusts and building materials) will be sampled during Phase IB. Liquids found in tanks, vats, sewers, sumps, basements or other sources will be noted for possible sampling in Phase II or, if thought to be critical, will be sampled in Phase IB. The present schedule indicates that the laboratories will be certified for liquids by the initiation of Phase IB. Soil and solid matrix samples will be assayed semiquantitatively by GC/MS for volatile and semi-volatile organic target analytes. An attempt will be made to identify other major unknown peaks present in the GC/MS total ion current profile. These samples will also be assayed quantitatively by gas chromatography (GC) for 1,2-dibromo-3-chloropropane (DBCP); by graphite furnace atomic absorptive spectroscopy for arsenic; by cold vapor atomic absorption spectroscopy for mercury; and other target metals by ICP. Additionally, selected RMA soils will also be assayed for organic materials in soils. Table 4-2 identifies the analytical method, desired analyte concentration, high range concentration, sample holding time, required level of certification, reference method and principle of method for the Phase IB survey.

The Phase II Program involves analyzing soil, solid and liquid matrices by specific quantitative methods to provide data on areal and vertical extent of contamination at each specific source of interest identified during the Phase I Program. Table 4-3 identifies the analytical method, desired analyte concentration, high range concentration, sample holding time, required level of certification, reference method and principle of method for Phase II. A summary of Phase I and II laboratory analyses indicating preservation guidelines, analytical methods required, level of certifications, total analytical requirements, and weekly laboratory rates of analysis is given in the QA/QC Plan, Section III of the Task 2 RMA Procedures Manual.

TABLE 4-3
PHASE II ANALYSES SOIL AND WATER MATRICES

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Methods
Volatile Halo Organics/Water			14 days (1)	Quantitative	EPA 601 (1)	Purge and Trap GC/Hall Detector with a packed column (1% SP-1000 on Carbowack 8) 1,2-dibromoethane or other suitable internal standard will be used based on Phase I experience to monitor purge efficiency.
Chlorobenzene	1 µg/L	50 µg/L				
Chloroform	1 µg/L	50 µg/L				
1,1-Dichloroethane	1 µg/L	50 µg/L				
1,2-Dichloroethane	1 µg/L	50 µg/L				
1,1,1-Trichloroethane	1 µg/L	50 µg/L				
1,1,2-Trichloroethane	1 µg/L	50 µg/L				
Tetrachloroethylene	1 µg/L	50 µg/L				
Trichloroethylene	1 µg/L	50 µg/L				
1,2-trans-Dichloroethylene	1 µg/L	50 µg/L				
Dichloromethane	1 µg/L	50 µg/L				
Carbon tetrachloride	1 µg/L	50 µg/L				
Volatile Halo Organics/Solid			14 days (2)	Quantitative	EPA 8010 with EPA 5030 extraction (2)	A 10 gram portion of the sample is obtained with minimum handling. The sample is shaken for 4 hours with 10 ml methanol. An aliquot of the extract is injected into 5 ml of water and analyzed as described above for water. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Chlorobenzene	1 µg/g	50 µg/g				
Chloroform	1 µg/g	50 µg/g				
1,1-Dichloroethane	1 µg/g	50 µg/g				
1,2-Dichloroethane	1 µg/g	50 µg/g				
1,1,1-Trichloroethane	1 µg/g	50 µg/g				
1,1,2-Trichloroethane	1 µg/g	50 µg/g				
Tetrachloroethylene	1 µg/g	50 µg/g				
Trichloroethylene	1 µg/g	50 µg/g				
1,2-trans-Dichloroethylene	1 µg/g	50 µg/g				
Dichloromethane	1 µg/g	50 µg/g				
Carbon tetrachloride	1 µg/g	50 µg/g				

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Method ^b
Volatile Arom. Organics/Water			7 days (1)	Quantitative	EPA 602 (1)	Purge and Trap/GC/PID with a packed column (LS SP-1000) on Carbowack 8, to permit purge in conjunction with EPA 601). A suitable internal standard will be used based on Phase I experience to monitor purge efficiency.
Benzene	1 µg/L	50 µg/L				
Toluene	1 µg/L	50 µg/L				
Xylenes	1 µg/L	50 µg/L				
Ethyl benzene	1 µg/L	50 µg/L				
Volatile Arom. Organics/Solid			7 days (2)	Quantitative	EPA 8020 with EPA 5030 extraction (2)	A 10 gram portion of the sample is obtained with minimum handling. The sample is shaken for 4 hours with 10 ml methanol. An aliquot of the extract is injected into 5 ml of water and analyzed as described above for water. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Benzene	1 µg/g	50 µg/g				
Toluene	1 µg/g	50 µg/g				
Xylenes	1 µg/g	50 µg/g				
Ethyl benzene	1 µg/g	50 µg/g				
Organochlorine Pesticides/Water			7 days for the water and 40 days for the extract (1)	Quantitative	EPA 606 (1)	An 600 ml portion of water is extracted with 3 x 50 ml methylene chloride. The extract is reduced in volume and exchanged with hexane. The final volume is 10 ml or less. The concentrated extract is analyzed by GC/EC using a fused silica capillary column. Cleanup procedure will be applied as required. (1) A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Alorin	0.1 µg/L	10 µg/L				
Endrin	0.1 µg/L	10 µg/L				
Dieldrin	0.1 µg/L	10 µg/L				
Isodrin	0.1 µg/L	10 µg/L				
Chlordane	0.1 µg/L	10 µg/L				
Hexachlorocyclopentadiene	0.1 µg/L	10 µg/L				
p,p'-DDT	0.1 µg/L	10 µg/L				
p,p'-DDE	0.1 µg/L	10 µg/L				

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentrations	Hold Time	Level of Certification	Reference Methods	Principle of Methods
Organochlorine Pesticides/Solid			7 days for solid and 21 days for extract (2)	Quantitative	EPA 8080 (2)	A 10 gram portion of the sample is shaken with 20 ml hexane/acetone (1:1) for 4 hours. The extract is analyzed by GC/EC using a fused silica capillary column. Hexane/acetone extraction method was selected for compatibility of extraction procedure with organophosphorous and organosulfur compounds/solids. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Aldrin	1 µg/g	100 µg/g				
Endrin	1 µg/g	100 µg/g				
Dieldrin	1 µg/g	100 µg/g				
Iaadrin	1 µg/g	100 µg/g				
Chlordane	1 µg/g	100 µg/g				
Hexachlorocyclopentadiene	1 µg/g	100 µg/g				
p,p'-DDT	1 µg/g	100 µg/g				
p,p'-DDE	1 µg/g	100 µg/g				
1,2-Dibromo-3-chloropropane/Water	0.1 µg/L	10 µg/L	Extract within 7 days, analyze within 30. See EPA 625 (1)	Quantitative	Developed by MRL for USAMVMA Certification	A 30 ml portion of sample saturated with NaCl is extracted twice with 1 ml of hexane. The combined extracts are brought to a final volume of 2 ml and analyzed by GC/EC using a packed column. A suitable internal standard will be specified based on Phase I experience to monitor purge efficiency.
Dicyclopentadiene and Bicyclopentadiene/Water	0.3 µg/L	25 µg/L	Extract within 7 days, analyze within 40. See 4 (1)	Quantitative	Developed by MRL for USAMVMA Certification	A 100 ml portion of sample is extracted with 5 ml of methylene chloride. The extract is analyzed by GC/FID using a fused silica capillary column. A suitable internal standard will be specified based on Phase I experience to monitor purge efficiency.

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Methods
Dicyclopentadiene and Bicyclopentadiene/Solids	10 µg/g	500 µg/g	7 days for the solid and 30 days for the extract. See (1)	Quantitative	Developed by MRL for USATHENA Certification	A 10 gram portion of the sample is obtained with a minimum of handling. The sample is shaken with sodium sulfate 20 ml of methylene chloride for 4 hours. The extract is analyzed directly by GC/MSD using a fused silica capillary column.
Organosulfur Compounds/Water			Extract within 7 days, analyze within 30. See EPA 625 (1)	Quantitative	USATHENA 4P	An 800 ml portion is extracted three times with 30 ml methylene chloride. The volume is reduced in a K-D apparatus and exchanged for Isocare. The Isocare extract is analyzed by GC/MSD-S using a packed column (2% SP-1000 on Chromosorb). A suitable internal standard will be specified based on Phase I experience to monitor purge efficiency.
Organosulfur Compounds/Solid			7 days for solid, 30 days for extract. See EPA 8270 (2)	Quantitative	USATHENA 1C	A 10 gram portion of sample is allowed with 10 grams anhydrous sodium sulfate and shaken with 20 ml hexane/acetone (1/1) for 4 hours. The extract is analyzed by GC/MSD-S using a packed column (2% SP-1000 on Chromosorb). Hexane/acetone extraction method was selected for compatibility of extraction procedure with organochloride pesticides and organophosphorus compounds/solids. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Chlorophenylmethyl sulfide	1 µg/g	25 µg/g				
Chlorophenylmethyl sulfoxide	1 µg/g	25 µg/g				
Chlorophenylmethyl sulfone	1 µg/g	25 µg/g				
1,4 oxathiane	1 µg/g	25 µg/g				
dithiane	1 µg/g	25 µg/g				

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Methods
Phosphonates/Water						
Disopropylmethylphosphonate	2 µg/L	100 µg/L	7 days See EPA 625 (1)	Quantitative	USATHEMA AS for DMAP	A 800 µl portion of water is extracted three times with 50 ml methylene chloride. The volume is reduced in a K-D apparatus and exchanged with isooctane. The extract is analyzed by GC/AFD using a fused silica capillary column. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Dimethylmethylphosphonate	2 µg/L	100 µg/L			ESE will develop method for DMAP	
Phosphonates/Solid						
Disopropylmethylphosphonate	1 µg/g	25 µg/g	7 days frozen, 30 days for extract (3)	Quantitative	USATHEMA IH	A 20 gram portion of sample is prepared for analysis by extraction with 20 ml methylene chloride with sodium sulfate. The extract is analyzed by GC/AFD using a fused silica capillary column. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Dimethylmethylphosphonate	2 µg/g	25 µg/g				
Organophosphorous Pesticides/Water						
Malathion	0.1 µg/L	5 µg/L	7 days See EPA 625 (1)	Quantitative	EPA 8140(2) modified for water	An 800 µl portion of the sample is extracted three times with 50 ml methylene chloride. The extract is reduced in volume and exchanged with isooctane. The final volume is 5 ml. The extract is analyzed by GC/AFD using a fused silica capillary column. Vapone will be added if indicated by Phase I experience. A suitable internal standard will be specified based on Phase I experience to monitor purge efficiency.
Parathion	0.1 µg/L	5 µg/L				
Azinphos	0.1 µg/L	5 µg/L				
Superon	0.1 µg/L	5 µg/L				
Vapone	0.1 µg/L	5 µg/L				

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Methods
Organophosphorous Pesticides/Solid						
Malathion	1 µg/g	50 µg/g	7 days frozen, 30 days for extract (3)	Quantitative	EPA 8140 (2)	A 10 gram portion of the sample is mixed with 10 grams of anhydrous sodium sulfate and shaken with 20 ml of hexane/acetone (1/1) for 4 hours. The extract is analyzed by GC/MSD using a fused silica column. Hexane/acetone extraction method was selected for compatibility with organochloride pesticides and organosulfur compounds/solids. A suitable internal standard will be selected based on Phase I experience to monitor purge efficiency.
Parathion	1 µg/g	50 µg/g				
Azinphos	1 µg/g	50 µg/g				
Supona	1 µg/g	50 µg/g				
Vapona	1 µg/g	50 µg/g				
Metals by AA/Water						
Arsenic	10 µg/L	100 µg/L	6 mos (4)	Quantitative	EPA 205.2 (4)	A 100 ml aliquot of sample is digested with H ₂ O ₂ & HNO ₃ . The digest is analysed by GF/AA.
Mercury	0.1 µg/L	10 µg/L	28 days (4)	Quantitative	EPA 245.1 (4)	A 100 ml aliquot is treated with H ₂ SO ₄ , HNO ₃ , KMnO ₄ , K ₂ S ₂ O ₈ . Excess KMnO ₄ is destroyed with hydroxylamine sulfate. The mercury is reduced with stannous sulfate and analyzed by CV/AA.
Metals by AA/Solid						
Arsenic	1 µg/g	10 µg/g	6 mos	Quantitative	EPA 7060 with EPA 3050 extraction (2)	A one gram portion of the sample is digested with H ₂ O ₂ + HNO ₃ . The digest is analyzed by GF/AA.
Mercury	0.1 µg/g	1 µg/g	28 days (3)	Quantitative	EPA 245.5 (3)	Triplicate 0.2 gram portions are weighed into a BOD bottle and treated with aqua regia followed by potassium permanganate. Excess permanganate is reduced with hydroxylamine sulfate. The mercury is reduced with stannous chloride and determined using the cold vapor technique.

TABLE A-3 (Continued)

Analysis/Matrix/Analytes	Desired Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Method
Metals by ICP/Water						
Chromium	50 µg/L	5000 µg/L	6 mos (4)	Quantitative	EPA 200.7 (4)	All samples will be treated by adding HNO ₃ + H ₂ O ₂ and heating before analysis to dissolve precipitates that may have formed after sampling. Magnesium, calcium and sodium may be certified at lower levels if required.
Cadmium	50 µg/L	5000 µg/L				
Lead	50 µg/L	5000 µg/L				
Zinc	50 µg/L	5000 µg/L				
Copper	50 µg/L	5000 µg/L				
Magnesium	10 mg/L	1000 µg/L				
Calcium	100 mg/L	1000 µg/LA				
Sodium	100 mg/L	1000 µg/L				
Metals by ICP/Solid						
Chromium	5 µg/g	500 µg/g	6 mos by comparison	Quantitative	Developed from USATHMA 75	A one gram portion is digested with HNO ₃ & finished with HCl. The sample is brought to a final volume of 50 ml. Refer to Table 2 from EPA Method 200.7 (4) for inter-element correction.
Cadmium	5 µg/g	500 µg/g	with water.			
Lead	5 µg/g	500 µg/g	See EPA			
Zinc	5 µg/g	500 µg/g	200.7 (4)			
Copper	5 µg/g	500 µg/g				
Magnesium	10 µg/g	500 µg/g				
Calcium	10 µg/g	500 µg/g				
Sodium	10 µg/g	500 µg/g				
Anions/Water						
Sulfate	2 mg/L	200 mg/L	28 days (4)	Quantitative	EPA 300 (4) and Contractor developed method	The sample is filtered and analyzed by ion chromatography using suppressor/separators columns for sulfate, chloride and fluoride. Nitrate and phosphate are assayed by auto-analyzer. Sulfate, chloride and fluoride ions are determined in a single run without post-column reaction using peak areas. Nitrate and phosphate ions are determined colorimetrically. Alternative analytical methods may be proposed based on Phase I experience.
Nitrate	2 mg/L	200 mg/L	48 hrs (4)			
Chloride	1 mg/L	100 mg/L	28 days (4)			
Fluoride	2 mg/L	200 mg/L	28 days (4)			
Phosphate	1 mg/L	100 mg/L	48 hrs (4)			

TABLE 4-3 (Continued)

Analysis/Matrix/Analytes	Detection Limit	High Range Concentration ^a	Hold Time	Level of Certification	Reference Methods	Principle of Methods ^b
Anions/Solid			Water	Quantitative	Developed by Contractor for USAF/WHH	A one gram portion of sample is combined with 10 ml water in a screw cap tube and extracted in an ultrasonic bath for 30 minutes. The water extract is filtered and analyzed by ion chromatography using suppressor/separators columns for sulfate, chloride and fluoride. Nitrate and phosphate are assayed by autoanalyzer. Sulfate, chloride and fluoride ions are determined in a single run without post-column reaction using peak areas. Nitrate and phosphate ions are determined colorimetrically.
Sulfate	10 µg/g	1000 µg/g	extracts as above ?			
Nitrate	1 µg/g	100 µg/g				
Chloride	10 µg/g	1000 µg/g				
Fluoride	1 µg/g	100 µg/g				
Phosphate	1 µg/g	100 µg/g				
GC/MS Confirm/Extracts	--	--	40 days (1)	None	EPA 624 + 625 (1)	Ten percent of total number of samples which are positive will be confirmed by GC/MS for component identity and purity. The GC/MS confirmation will be carried out using columns and conditions similar to those used in the original GC analysis. If certification of method is required the Ebasco team recommends the semi-quantitative level.

^a Reflects an estimate of the linear range of the method and is proposed to minimize dilutions.

^b To be developed during USAF/WHH Phase II certification.

References:

- (1) EPA-600/4-82-057, July 1982 "Methods for Organic Chemical Analysis of Principal and Industrial Wastewater".
- (2) EPA SA-846, 2nd ed., "Test Methods for Evaluating Solid Waste".
- (3) Personal Communication from Chris Weatherington, Ebasco QA Manager.
- (4) EPA-600/4-79-020, Revised March 1983, "Methods for Chemical Analysis of Water and Wastes".

4.2 Sample Matrices and Summary of Analytical Methods

4.2.1 Sample Matrices

All soil sludge, sediment (e.g., buildings and soils) and solid matrices will be considered as soils for analytical purposes. Prior to sample collection, all soil and solid analytical methods (e.g., Phases I and II) will be USATHAMA Certified for a standard soil. This standard soil will be a background soil collected from the RMA area. Data for soil and solid matrices will initially be reported on a dry weight basis and may be converted to a wet weight basis as required by the Army COR.

Similarly, aqueous analytical methods will be USATHAMA Certified for all Phase II analyses for a standard water matrix prior to sampling. A standard water will be prepared as described in: Sampling and Chemical Analysis Quality Assurance Program for U.S. Army Toxic and Hazardous Materials Agency (Pages 63-64).

4.2.2 Summary of Phase I Analytical Methods

This section briefly describes the analytical methods for target analytes and their desired detection limits in the Phase I survey. Tables 4-1 and 4-2 summarize each Phase I analytical method. The non-Certified Phase IA methods for volatile organics in air and asbestos are described in order, as shown in Table 4-1. USATHAMA Certified analytical methods for Phase IA and IB are described in the order of occurrence shown in Table 4-2. Lastly, a noncertified method for organic materials in soil is described. The specific protocol for each Phase I method may be reviewed in the Project Specific Analytical Methods Manual for an Environmental Program in Support of Litigation at RMA (see Section III of the Task 2 RMA Procedures Manual).

Volatile Organic Compounds in Air Using Activated Charcoal and Tenax

This method was designed by UBTL for the National Institute of Occupational Safety and Health. It is designated for use in this program as a screening tool to identify the potential for each sampling team's exposure to volatile

organic contaminants in air during the Phase I program. The charcoal is desorbed with methylene chloride, and tenax with isooctane. Extracts will be analyzed by fused silica capillary column GC/MS in order to identify significant unknown compounds. This method will not be USATHAMA Certified.

Asbestos in Solid Samples

This procedure will be a screen for the building sampling team to identify potential exposure to asbestos. The procedure will not be USATHAMA Certified. A polarizing light microscope will be used to observe the specific optical characteristics of the sample. Fiber morphology, color and refractive indices along specific crystallographic axes will be determined. Orientation of polarizing filters such that vibration planes are perpendicular will allow birefringence and extinction characteristics of anisotropic particles to be observed. Quantitative analyses of asbestos will involve the use of point counting. The point counting method will be used for analysis of samples containing from 0 to 100 percent asbestos.

Volatile Organics in Soil and Solid Samples by GC/MS

The volatile organics method was based on EPA Method 8240 in solids (EPA SW-846) and EPA Method 624 in liquids (EPA 600/4-82-057). This method was USATHAMA Certified for soils and solids at the semiquantitative level for the Phase I Program.

Due to this volatility, analysis for these compounds will be restricted to building sediments from confined spaces (e.g., sewer lines, sumps, etc.), deep soils or surface soils contaminated with oil. Dust samples from buildings and surface soils not contaminated with oil will not be assayed for volatile organics by this technique.

In this method, a ten gram portion of the sample will be obtained with minimum of handling and placed into 10 ml methanol in a volatile organic acid (VOA) septum vial, spiked with the surrogates: methylene chloride- d_2 ; benzene- d_6 ; and ethyl benzene- d_{10} , capped with a teflon lined septum lid and shaken for four hours. A 20 μ g aliquot of the

methanol extract will be removed, spiked with 200 µg of 1,2-dibromoethane- d_4 as an internal standard and injected into 5 ml of organics-free water contained in a syringe. The contents of the syringe are then injected into a purging device, purged and analyzed on a packed column (1% SP-1000 on Carbopack B) by GC/MS. Each sample will be assayed for target compounds at detection limits identified in Table 4-2.

In addition, the total ion current profile will be screened for up to five major unknown peaks. An attempt will be made to identify the largest of these major unknown peaks which are present in excess of ten percent of the area of the internal standard peak. Each of these major unknown peaks will be reported as the purity, fit and probability to match for the three most likely candidate compounds from the Environmental Protection Agency/National Bureau of Standards/National Institute of Health (EPA/NBS/NIH) Mass Spectral library computer program. Unknowns identified during the Phase I survey may be incorporated as analytes into the Phase II Program if deemed significant by areal and vertical extent or frequency of occurrence.

Semivolatile Organics in Soil and Solid Samples by GC/MS

This analytical technique was based on EPA Method 8270 in solids (EPA SW-846) and EPA Method 624 in water (EPA 600/4-82-057) and was USATHAMA Certified in soils and solids at the semiquantitative level for the Phase I program.

Using this method, a fifteen gram portion of the sample will be obtained with a minimum of handling and spiked with the surrogates: 1,3-dichlorobenzene- d_4 ; diethylphthalate- d_4 ; 2-chlorophenol- d_4 ; and di-N-octylphthalate- d_4 . The sample will be mixed with anhydrous sodium sulfate (30 grams or more depending on sample moisture content) then Soxhlet extracted for eight hours with 300 ml hexane/acetone (1:1 mixture). The extract is reduced to a final volume of 10 ml in a Kuderna-Danish (K-D) apparatus. An aliquot of this concentrate will be spiked with phenanthrene- d_{10} as an internal standard and analysed on a fused silica capillary column by GC/MS. Samples will be assayed for target analytes at the detection limits shown in Table 4-2. In addition, the total ion current profile will be scanned for

major unknown peaks. As discussed for volatile organics, an attempt will be made to identify these unknown major peaks. This method will be USATHAMA Certified at the semiquantitative level.

Metals in Soil and Solid Samples by Inductively Coupled Argon Plasma (ICP) Emission Spectrometry

The ICP method, based on USATHAMA Method 7S, is USATHAMA Certified at the quantitative level.

In this procedure, a one gram portion of sample will be digested in a watch glass covered Griffin beaker with 3 ml of concentrated nitric acid. Contents of beaker will be heated to near dryness and repeated portions of concentrated nitric acid added until the sample is completely digested. The digestion process is finished with two ml of 1:1 nitric acid and 2 ml of 1:1 hydrochloric acid. The sample digest will be filtered, the beaker and watch glass rinsed with deionized water and rinsate passed through the filter. The digestate is brought to a final volume of fifty ml and assayed by ICP. Samples will be assayed for target metals at detection limits identified in Table 4-2.

Arsenic in Soil and Solid Samples by Graphite Furnace Atomic Absorption Spectroscopy (AA)

The arsenic method in soils and solids will be developed from EPA Method 7060 (EPA-SW-846). Using this method, a one gram sample will be digested with hydrogen peroxide and concentrated nitric acid. The digest will be filtered and assayed by graphite furnace atomic absorption spectrometry. The target detection limit for arsenic will be 1 µg/g. This method will be USATHAMA Certified at the quantitative level.

Mercury in Soil and Solid Samples by Cold Vapor Atomic Absorption Spectroscopy (AA)

This mercury method, developed from EPA Method 245.5 (EPA 600/4-82-057), will be USATHAMA Certified at the quantitative level. In the method

triplicate 0.2 gram sample portions will be placed into a BOD bottle and digested with aqua regia followed by treatment with potassium permanganate. Excess permanganate will be reduced with hydroxylamine sulfate. Mercury will be reduced with stannous chloride and assayed by cold vapor AA. The target detection limit for mercury will be 0.1 µg/g.

1,2-Dibromo-3-chloropropane (DBCP) in Soil and Solid Samples by Gas Chromatography (GC)

This method, used to assay for DBCP, is based on a method developed by Midwest Research Institute and is USATHAMA Certified at the quantitative level.

Using this procedure, a ten gram portion of the sample will be obtained with minimum handling and shaken for four hours with 20 ml of hexane/acetone (1:1) mixture. The extract will be rinsed with distilled water, brought to a final volume of 10 ml with hexane and assayed by a GC equipped with an electron capture detector and using a fused silica capillary column. The target detection limit for this compound will be 0.01 µg/g as identified in Table 4-2.

Organic Materials in Soil Samples

The organic materials in soil method was developed by Utah Biological Testing Laboratories for use in their agricultural soils analytical program. The procedure is derived from Methods in Soils Analysis, Part 2 (American Society of Agronomy [1965]). In this method, a sample of <100-mesh soil will be weighed into an Erlenmyer flask, exactly 10 ml 0.5 N Potassium dichromate solution and 15 ml concentrated sulfuric acid added. The flask is connected to a West condenser and heated to dichromate oxidize all organic matter. The flask will then be cooled and the condenser rinsed with deionized water. Contents of the flask will be brought to a 60 ml volume with deionized water and titrated with a 0.2 N ferrous ammonium sulfate hexahydrate solution using N-phenylanthranilic acid as indicator. Concentrations of organic matter in soil ranging from 0.1 to 99.9 percent may be detected by this procedure. This method will not be USATHAMA Certified.

4.2.3 Summary of Phase II Analytical Methods

Analytical methods, target analytes, and desired target detection limits for Phase II analytes are discussed in this section and summarized in Table 4-3. All Phase II methods will be USATHAMA Certified at the quantitative level for soil, solid and water matrices. Referenced methods are being prepared in a specific USATHAMA format as per the instructions of the Army COR by the program contractor laboratories. Phase II analytical methods will be included in the Project Specific Analytical Methods Manual for an Environmental Program in Support of Litigation at RMA (see Section III of the RMA Procedures Manual) when they have been developed for certification. This Technical Plan document will be modified at that time to reflect the inclusion of all Phase II reference methods.

Volatile Halogenated Organics in Phase II Samples

The analytical method for volatile halogenated organics in water will be based on EPA Method 601 (EPA-600/4-82-057). This analytical procedure will be a purge and trap method, assayed on a packed column (1% SP-1000 on Carbowack B) by GC equipped with a Hall electrolytic conductivity detector. Water samples will be spiked with 1,2-dibromomethane or other suitable internal standard based on Phase I experience to monitor purge efficiency.

Analyses of volatile halocarbons in soil and solid samples will be based on EPA Method 8010 (EPA SW-846) with an extraction procedure based on EPA Method 5030 (EPA SW-846). A ten gram portion of a soil or solid sample will be obtained with minimum handling and shaken for four hours in ten ml methanol. An aliquot of the extract will be injected into five ml organic free water and spiked with 1,2-dibromoethane or other suitable internal standard. This spiked water will be transferred to a purging device, purged and analyzed on a packed column (1% SP-1000 on Carbowack-B) by GC with detection by a Hall electrolytic conductivity detector.

Volatile halogenated organic analyses and desired detection limits are identified in Table 4.3.

Volatile Aromatic Organics in Phase II Samples

The volatile aromatic hydrocarbon methods will be based on EPA Method 602 (EPA-660/4-82-057) for water and EPA Method 8020 (EPA-SW-846) for soil and solids. Extraction of solid samples will be based on EPA Method 5030 (EPA-SW-846). Analysis of volatile aromatics in water will be by a purge and trap method, analyzed by GC equipped with a photoionization detector using a packed column (1% SP-1000 on Carbopack B).

In soil and solid matrices a ten gram portion of sample will be obtained with minimum handling and shaken for four hours with ten ml methanol. An aliquot of the extract shall be injected into five ml of organics free water. The spike water will be transferred to a purge device, purged and assayed on a packed column (1% SP-1000 on Carbopack B) by a GC with a photoionization detector.

Table 4.3 lists the volatile aromatic organic constituents and target detection limits.

Organochlorine Pesticides in Phase II Samples

The analytical methodology for organochlorine pesticides will be based on EPA Method 608 (EPA-600/4-82-057) for water and EPA Method 8080 (EPA SW-846) for soil and solid samples. An 800 ml portion of water will be extracted three times with 50 ml methylene chloride. The extract shall be reduced in volume and exchanged with hexane to a final volume of 10 ml or less. The concentrated extract will be analyzed by GC with an electron capture detector using a fused silica capillary column.

Analyses of solid matrices for organochlorine pesticides will involve shaking a ten gram portion of sample with 20 ml hexane/acetone (1:1) for four hours. The extract will be assayed using a fused silica capillary column by GC with an electron capture detector. The hexane/acetone extraction method was selected for compatibility with extraction procedures for organophosphorous and organosulfur compounds in solid matrices.

Organochlorine pesticides and their target detection limits are listed in Table 4.3.

1,2-Dibromo-3-chloropropane (DBCP) in Phase II Samples

The procedure for the analyses of DBCP was developed by Midwest Research Institute for both water and soils. A 90 ml portion of water sample will be placed in a 100 ml volumetric and saturated with sodium chloride. The sample will be extracted twice with one ml hexane, the extracts combined and brought to a final volume of 2 mls. An aliquot of the extract is analyzed on a fused silica capillary column by GC equipped with an electron capture detector. The target detection limit for DBCP will be 0.1 µg/l.

The analytical methodology for DBCP in soils and solids has been described previously in Section 4.2.2 and Table 4-2.

Dicyclopentadiene (DCPD) and Bicycloheptadiene (BCHD) in Phase II Samples

The specific procedures for DCPD and BCHD were developed by Midwest Research Institute for both water and soil matrices.

A 100 ml portion of water sample will be extracted with five ml methylene chloride. The extract will be assayed on a fused silica capillary column by GC equipped with a flame ionization detector. The target detection limit for both DCPD and BCHD will be 10 µg/l.

The methodology for DCPD and BCHD in soil and solids involves obtaining a ten gram portion of sample with a minimum of handling, blending with ten grams anhydrous sodium sulfate and shaking the mixture with 20 ml methylene chloride for four hours. An aliquot of the extract is assayed directly on a fused silica capillary column by GC equipped with a flame ionization detector. The target detection limit for DCPD and BCHD in soil will be 10 µg/g.

Organosulfur Compounds in Phase II Samples

The organosulfur compounds that will be target analytes in Phase II are listed in Table 4.3. Methodologies for organosulfur analyses will be developed from USATHAMA Method 4P for water and USATHAMA Method 1G for solids.

In a water matrix an 800 ml sample will be extracted three times with 50 ml methylene chloride. The extract volume shall be reduced in a K-D apparatus and exchanged for isooctane. The isooctane extract will be assayed on a packed column (5% SP-1000 on Chromosorb) by GC with a flame photometric detector. The target detection limit for organosulfur compounds in water will be 2 µg/l.

For solid matrix (USATHAMA Method 1G) samples a ten gram portion of soil will be mixed with ten grams of anhydrous sodium sulfate and extracted with 20 ml hexane/acetone (1:1) with shaking for four hours. An aliquot of the extract will be injected onto a packed column (5% SP-1000 on Chromosorb) and analyzed by GC equipped with a flame photometric detector. The hexane/acetone extraction method was selected for compatibility of extraction procedure with organochloride pesticides and organophosphorous compounds in solids. Target detection limits for organosulfur compounds in solids will be 1 µg/g.

Phosphonates in Phase II Samples

The phosphonates include diisopropylmethylphosphonate (DIMP) and dimethylmethylphosphonate (DMMP). Specific analytical methodologies for phosphonates will be developed from USATHAMA Method 4S for water and USATHAMA Method 1H for soils.

Water analysis for phosphonates will involve extracting an 800 ml sample three times with methylene chloride. The extract shall be combined, the volume reduced in a K-D apparatus and exchanged with isooctane. The isooctane extract will be analyzed on a fused silica capillary column by GC equipped with a nitrogen/phosphorous detector. The target detection limit for phosphonates in water will be 2 µg/l.

In a solid matrix, a 20 gm sample will be prepared for phosphonate analyses by extraction with 20 ml methylene chloride with sodium sulfate. The extract will be assayed on a fused silica capillary column by GC using a nitrogen/phosphorous detector. Target detection limits for phosphonates in soils will be 1 ug/g from DIMP and 2ug/g for DMMP.

Organophosphorous Pesticides in Phase II Samples

Organophosphorous compounds targeted for Phase II analyses are listed in Table 4.3. Analytical methods for these compounds are derived from EPA Method 8140 (EPA SW-846) for both water and soil matrices.

In a water matrix the five organophosphorous compounds will be extracted from an 800 ml sample with three 50 ml volumes of methylene chloride. The extract will be concentrated and exchanged with isooctane to a final volume of 5 ml. An aliquot of the extract will be assayed on a fused silica capillary column by GC equipped with a nitrogen/phosphorous detector. Target detection limits for the five organophosphorous pesticides in water will be 0.1 ug/l.

The analysis of organophosphorous compounds in soil will involve mixing ten grams of anhydrous sodium sulfate and extracted with 20 ml of hexane/acetone (1:1) for four hours. Aliquots of the extract will be assayed by GC with a nitrogen/phosphorous detector using a fused silica column. The desired target detection limit for organophosphorous compounds in solids will be 1 ug/g.

Metals in Phase II Samples

Eleven metals will be assayed in Phase II matrices. The metals and principal analytical method will be as follows: arsenic and mercury by atomic absorption; and chromium, cadmium, copper, lead, zinc, magnesium, calcium and sodium by ICP.

The method for arsenic analysis will be derived from EPA Method 206.2 (EPA-600/4-79-020) for water and EPA Method 7060 with extraction by EPA

Method 3050 (EPA SW-846) for solids. Using EPA Method 206.2 (EPA-600/4-79-020), a 100 ml sample of water will be digested with hydrogen peroxide and concentrated nitric acid. The digest will be assayed by graphite furnace atomic absorption spectrometry. Target detection limits for arsenic in water will be 10 µg/l. For arsenic in soils a one gram sample will be digested with hydrogen peroxide and concentrated nitric acid and the digest assayed by graphite furnace atomic absorption spectrometry. The desired detection limits for arsenic in soils will be 1 µg/g.

The mercury methods will be derived from EPA Method 245.1 (EPA-600/4-79-020) for water and EPA Method 245.5 (EPA-600/4-79-020) for solids. In the water method a 100 ml sample will be treated with sulfuric acid, nitric acid, potassium permanganate and potassium persulfate. Excess permanganate will be destroyed with hydroxylamine sulfate. Mercury will be reduced with stannous sulfate and assayed by cold vapor atomic absorption spectrometry. The target detection limit for mercury in water will be 0.1 µg/l.

Mercury analysis in solids has been discussed previously in Section 4.2.2.

The method for ICP metals in water was derived from EPA Method 200.7 (EPA-600/4-79-020). An ICP method in solids was developed from a modified USATHAMA 7S Procedure. Target analytes and desired detection limits for ICP metals in each matrix are shown in Table 4.3.

All water samples for ICP metals will be digested by adding nitric and hydrochloric acid and heating before analyses to dissolve any precipitates that may have formed after sampling. The sample digest will be filtered, brought to a final volume of 50 ml and assayed by inductively coupled argon plasma emission spectrometry.

Phase II soils will be assayed for ICP metals by digesting one gram of soil with repeated portions of nitric acid and finishing the sample with hydrochloric acid. The sample digest will then be filtered, brought to a final volume of 50 ml and assayed by inductively coupled argon plasma emission spectrometry.

Anions in Phase II Samples

Five anions, including sulfate, nitrate, chloride, fluoride and phosphate, will be surveyed in selected Phase II samples. Detection limits for these anions are listed in Table 4.3. For sulfate, chloride and fluoride in water, EPA Method 300 (EPA 600/4-79-020) will be used. Nitrates and phosphates in water and all five anions in soils will be assayed by contractor developed methods will be USATHAMA Certified.

In water, the sample will be filtered and analyzed for sulfate, chloride and fluoride directly by ion chromatography using suppressor/separator columns. Nitrate and phosphate will be assayed on an autoanalyzer. Sulfate, chloride and fluoride ions will be determined in a single run without post column reaction using peak areas to determine concentration. Nitrate and phosphate ions will be determined colorimetrically.

In soils, a one gram portion of sample will be combined with 10 ml water in a screw cap tube and extracted in an ultrasonic bath for 30 minutes. The water extract will be filtered and the filtrate assayed by ion chromatography using suppressor/separator columns. Nitrate and phosphate will be assayed on an autoanalyzer. Sulfate chloride and fluoride ions will be quantified in a single run without post column reaction using peak areas. Nitrate and phosphate ions will be determined colorimetrically.

GC/MS Confirmation of Phase II Samples

Approximately ten percent of the total number of Phase II samples which were found to contain quantifiable target organic compounds by GC will be screened by GC/MS to confirm analyte identity and purity. The presence or absence of co-eluting unknown peaks will be the single criterion used to confirm purity of target analytes. The GC/MS confirmation will be performed within the prescribed holding time for sample extracts using columns and conditions similar to those used in the original Phase II GC analyses. This GC/MS confirmation method will provide positive or negative verification of target compound identity and purity only and will be performed without prior

certification. New unknowns will not be identified during the GC/MS confirmation program. It is anticipated that low concentrations of certain target analytes may not be applicable to this confirmation technique.

5.0 QUALITY ASSURANCE/QUALITY CONTROL PLAN

5.1 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 Ebasco's procedures to monitor and control field and analytical efforts at RMA. Ebasco has developed a Project QA/QC Plan applicable to geotechnical, sampling and analytical activities for Task 2. The plan is presented in Section III of the Task 2 RMA Procedures Manual. The specific objectives of the Ebasco Quality Assurance Program for RMA are to:

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

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

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

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

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

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

5.2 Specific Project Requirements

5.2.1 Geotechnical Requirements

The project geotechnical requirements are described in Section 7 of the QA/QC Plan (Section III of the Task 2 RMA Procedures Manual). These requirements are based on the geotechnical guidelines established by USATHAMA. Specifically, this chapter addresses the geotechnical requirements for well drilling operations, borehole logging, well installation and development, well diagrams, well acceptance, topographic surveying, selected data management entries and geotechnical reports. Ebasco will have a geologist present and responsible at each operating drill rig for the logging of samples, monitoring drilling operations, recording of water losses/gains and groundwater data, preparing the boring logs and well diagrams and recording the well installation procedures of that rig. The ultimate responsibility of accepting a monitoring well for groundwater sampling rests with the Ebasco field QA/QC Coordinator. In accepting a monitoring well the field QA/QC Coordinator will use established criteria. Wells not meeting these minimum criteria may be rejected by the field QA Coordinator.

5.2.2 Field Sampling

The management of samples, up through the point of shipment from the field to the laboratory, will be under the supervision of Ebasco's Field QA Coordinators (FQAC). 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 FQAC 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 FQAC will introduce field control samples into the sample flow in an inconspicuous fashion. The FQAC is responsible for field chain-of-custody documentation and transfer and will supervise the strict adherence to chain-of-custody procedures.

5.2.3 Laboratory Quality Assurance Procedures

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

The Laboratory QA Program begins with the receive of the samples from the field. All samples will be shipped to UBTL for logging in, sample splitting and distribution for analyses. The Laboratory Quality Assurance Coordinator is responsible for monitoring the laboratory activities. He is also responsible for determining testing lot sizes and introducing laboratory control samples into the testing lot.

The samples must be analyzed within the prescribed holding time by the approved analytical methods. Analytical methods are described in Section 4.0 of the Technical Plan.

5.2.4 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.

The laboratory coordinator for each laboratory will monitor the analytical controls. The out-of-control situation can be detected by the control charts.

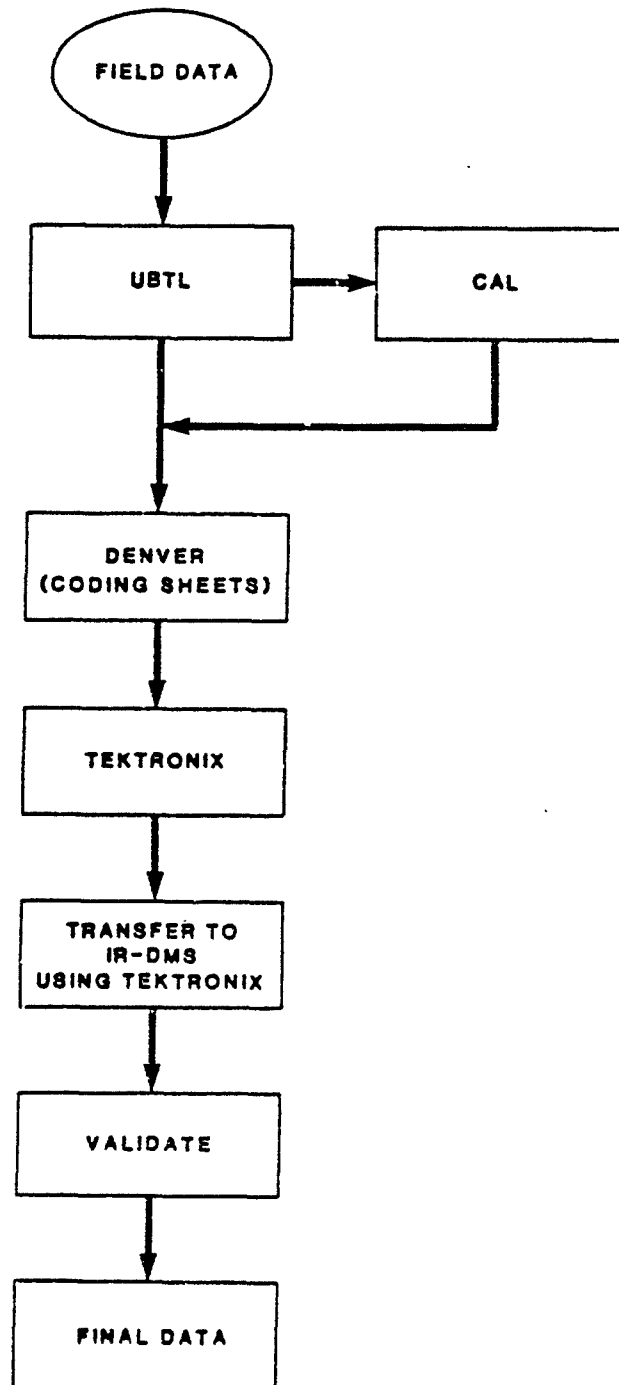
When an out-of-control situation is detected, efforts will be initiated to determine the cause. Corrective actions will be taken to bring the process under control. Full documentation of an out-of-control situation and the subsequent corrective action will be recorded by the Laboratory Quality Assurance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

5.2.5 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 highly automated system for analytical data collection and reduction. The analytical supervisor along with the Laboratory QA 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 USATHAMA reporting procedures for analyses performed at quantitative and semi-quantitative levels. The laboratories will adhere to this reporting procedures.

FIGURE 6.1-1

DATA FLOW BETWEEN EBASCO, UBTL, CAL AND IR-DMS



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

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

Geotechnical Program

Geotechnical boring logs, containing pertinent data regarding borehole lithology, will be coded immediately upon receipt from the field onto USATHAMA data coding sheets. These data will be entered into the Field Drilling Files by the Ebasco Denver office.

Upon completion of the drilling of borings at each site, a surveying crew will determine map coordinates and ground elevations for the location of each boring. These survey data will be coded immediately onto USATHAMA data coding sheets, and will be entered into the IR-DMS Map Files by the Ebasco Denver office. It is critical that these files be entered into the data management system before the completion of chemical analyses, as each sample location must be associated with a map location.

Nine ground water monitoring wells are planned for the Phase II program of Task 2. Upon completion of the well construction, data such as total depth of well, casing and screen length, and location of sand pack, bentonite, and

grout seals will be coded and entered into the Field Drilling File. Water levels will be determined and will be entered into the Ground Water Stabilized File.

Laboratory

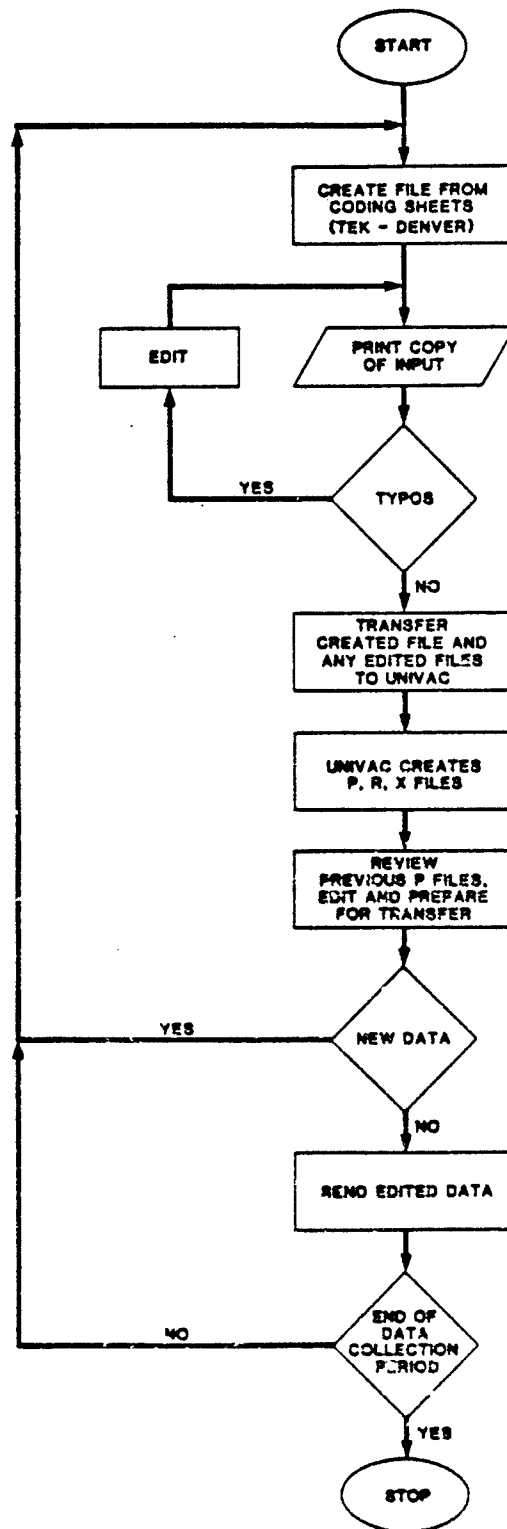
When samples are received at UBTL, the sample receipt officer will sign the chain of custody record, log in sample shipment, verify sample integrity, assign sample lots, prepare split samples and identify samples to be sent to CAL or to be retained by UBTL for chemical analysis. Each laboratory, UBTL and CAL, will submit weekly sample status reports to Ebasco's data manager. This weekly status report will be used to aid in planning the rate of field sampling and the distribution of laboratory workloads.

Field and laboratory sample control identification and chemical analysis data will be transcribed to the data coding sheet by UBTL and CAL, then verified using the program's laboratory control procedures. The verified data coding sheets will then be delivered, by courier, to Ebasco's data manager for entry into the IR-DMS data base.

6.3 Data Entry and Validation

Figure 6.3-1 describes the flow and decisions necessary to successfully enter laboratory results into the IR-DMS Univac 1100/61. The first step in data entry will be to create a magnetic tape copy of the coding sheets on the Tektronix 4051 terminal by keypunching. The Tektronix operator will enter only a subset of a complete file at one time. These file subsets will later be merged to a single file using the UNIVAC. After keypunching, the operator will obtain a printed copy of the data subset using the Tektronix printer, and will verify that the data in the Tektronix tape file is identical to that on the coding sheets. The operator will correct any data entry typographic errors using the Tektronix editor, then obtain a second printing of the file to confirm that the changes were properly made. Methods certification data and map location data will be entered first because validation routines make use of it.

FIGURE 6.3-1
LABORATORY DATA FLOW
TO THE IR-DMS UNIVAC 1100/61 SYSTEM



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

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

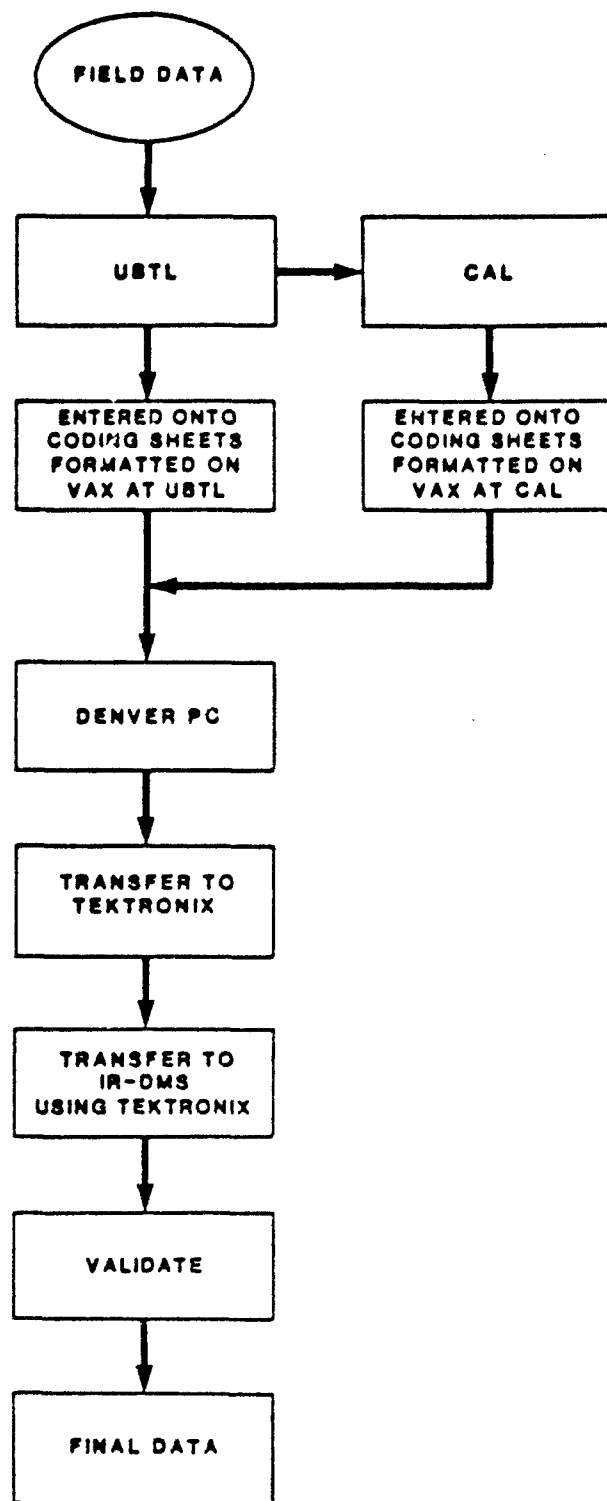
Next, the operator will invoke the IR-DMS data acceptance routines to perform the final data verification and create a Level 2 (temporary read-only) file. The acceptance routines will identify any errors in format or coding and any inconsistencies with corresponding map records previously loaded. If the acceptance routine does find errors at this stage, the operator will check the "R" file. The "R" file contains the rejected records that the acceptance routine creates. The UNIVAC editor is used to correct the verified entries, then they are resubmitted to the UNIVAC for acceptance. After acceptance, the operator will run the Level 2 transfer routine to create a Level 2 file for geological data. (The IR-DMS automatically creates chemical and geological Level 2 files.) Ebasco's operators will run the Level 1 data files through the data acceptance routines within seven days of their transfer to the UNIVAC system. They will delete Level 1 files once this data is accepted at Level 2.

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

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

FIGURE 6.3-2

STREAMLINED DATA COLLECTION/ ENTRY PROCEDURE



Ebasco intends to develop a streamlined data collection/entry procedure during the course of this program. Figure 6.3-2 illustrates the basic approach to be followed in streamlining this data collection/entry procedure. This procedure will involve data entry and verification on the VAX computers at UBTL and CAL with subsequent data transfer to an IBM PC or Tektronix computer at Ebasco's Denver office. Data is then entered into the UNIVAC. The system is expected to increase the efficiency and reliability of the collection/entry process without any adverse cost impacts to USATHAMA. While this streamlined system is being developed, the data flow to the UNIVAC will be maintained via the Tektronix-UNIVAC hardware (Figure 6.3-1).

6.4 Analysis and Presentation

Ebasco scientists will access the USATHAMA IR data base and will perform analyses as required to support all contamination assessment work. The data analysis efforts will include graphic representations of data using data gridding, contouring, and three-dimensional surface representations. (Specifics of the contamination assessment work are presented in Section 8.)

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

7.0 HEALTH AND SAFETY PLAN

A draft of the project Health and Safety Plan (HASP), prepared according to the Ebasco Corporate Health and Safety Program, is included in Section IV of the Task 2 RMA Procedures Manual. The purpose of this section is to provide an overview of the safety program that Ebasco will employ to ensure the safety of its employees and that of subcontractors engaged in the field investigation activities at RMA. All personnel working at RMA are or will be familiar with this document and they are and or will be indoctrinated in all aspects of the safety program.

In particular, the following specifics of this document are especially important to the South Plants Area investigative activities. These are:

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

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

- o Characterizing the potential specific chemical and physical hazards to be encountered;
- o Developing all safety procedures and operation on-site;
- o Assuring that adequate and appropriate safety training and equipment are available for project personnel;

- o Arranging for medical examinations for specified project personnel;
- o Arranging for the availability of on-site emergency medical care and first aid, as necessary;
- o Determining and posting locations and routes to site work zones;
- o Notifying installation emergency officers (i.e., police and fire departments) of the nature of the team's operations and making emergency telephone numbers available to all team members;
- o Indoctrinating all team members in safety procedures.

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

The South Plants Area consists of over 300 buildings formerly housing various commercial chemical (pesticides) manufacturing process and laboratories as well as military production (military ordinance and chemical agents) and storage facilities. Based on the evaluation of past activities, incidents and, accidents and investigations, the presence of chemicals and wastes were found to be present randomly throughout the South Plants area in the form of solid, liquid and gases. The characteristics of these waste are known to be toxic and hazardous to the human health. The conclusion on 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 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 Personnel 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 team are operating downrange. Adjacent to the Support Zone will be the Contamination Reduction Zone (CRZ) which will contain the contamination reduction corridor for the decontamination of equipment and personnel (the actual decontamination procedures are discussed in Section X of the HASP). All areas beyond the CRZ will be considered the Exclusion Zone. For any building investigation, the building itself will be defined as the Exclusion Zone. For well drilling or soil boring operations the Exclusion Zone will be established as a 30 foot radius from the drill rig. These support facilities are discussed and illustrated in Section 3.

The level of protection to be worn by field personnel will be defined and controlled by the on-site Health and Safety Coordinator and will be specifically defined for each operation in an information sheet (Facility Information Sheet). The preliminary Facility Information Sheet (FIS) will be developed based upon historical information and data. This will be upgraded and utilized for future operations based upon the results of the Health and Safety portion of the Buildings and Soil Sampling programs. For these programs, Level C type protection will generally be provided for investigation team members, however, Level D type protection may also be utilized as appropriate based on assessment by the Health and Safety Officer and the on-site Health and Safety Coordinator. If determined necessary, changing from Level C to A protection can be easily achieved in the field. This can be accomplished 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 (investigation team and Health and Safety team members) during field investigation work is of utmost importance for the protection of investigation team members. The methods of communication that will be employed are:

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

For external communication telephones and sirens will be utilized.

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

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

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

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

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 event. It describes the safety procedures to be followed for drilling operations, soil, surface water and liquid waste sampling, building sampling, and sampling in a confined space.

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

8.0 CONTAMINATION ASSESSMENT

The objectives of the South Plants Contaminant Assessment Program are to quantify the contaminants present, reference the extent of contamination, evaluate the factors that govern contaminant distribution within the South Plants Area, determine the severity and significance of the contamination, and apportion contamination by source. In order to accomplish these objectives, the contamination assessment will consist of the following subtasks:

1. Determination of the type, magnitude, distribution, and extent of contamination
2. Examination of the geologic and hydrogeologic influence on the spatial distribution of contaminants
3. Determination of the relationship between the contamination of existing buildings with historical and current contamination of the surrounding area
4. Estimation of the significance of soil contamination (criteria development)

8.1 Type, Magnitude, Distribution, and Extent of Contamination

The results of the soil boring analyses will be examined to determine the presence, quantities and extent of contamination within the South Plants area. Compilation of soil-contaminant data by source, location and depth will provide examination of the areal and vertical extent of contamination. The chemical data will be integrated with the soils and geohydrologic data as described in Section 8.2. From this information, the types and concentrations of contaminants present, estimates of the lateral and vertical extent of the contaminants and definition of contaminant boundaries will be evaluated. Various statistical techniques will be used to determine confidence levels of the data.

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The data obtained during Phase I sampling will be used to determine the final locations of Phase II borings. Depending upon the results of the Phase I survey, it will either be necessary to extend sampling locations outward of the suspected contaminated zone boundary or to use Kriging techniques to site the Phase II borings. Various statistical techniques such as analysis of variance and Kriging will be used to determine the confidence levels of the Phase II data and identify the boundaries of contaminated zones. Kriging methods will be employed in a manner consistent with that described in the ESE Technical Plan.

Maps and cross-sections will be prepared to illustrate the spatial distribution and to delineate the existence of distinct contaminant concentrations gradients in the proximity of sources and within the overall South Plants area.

8.2 Factors Influencing Contaminant Distribution and Mobilization

8.2.1 Geologic and Hydrologic Conditions

The hydrological data will be analyzed in conjunction with the historical information to determine the influence of the subsurface geology and hydrology in the distribution of contaminants in the ambient soils within the South Plants area.

Borehole logs of both cuttings and cores will be compiled, integrated, and interpreted to formulate a site-specific evaluation of geologic conditions. In addition to soil logs, geophysical borehole logging (gamma and neutron logs) in the groundwater monitoring wells will be examined. These data will be used to complete the understanding of subsurface geology. Data will be presented by means of maps and cross sections of soils and geologic materials will be prepared, illustrating the soil properties that have a direct impact on the retardation/or mobility of contaminants. These graphical presentations will be developed for each source area or areas corresponding to cluster of sources. Cross sections and contaminant profiles to the designated depth of sampling (groundwater surface) will be developed detailing each material type.

Hydrogeologic conditions of the South Plants Area will be assessed following the evaluation of previously generated hydrogeologic data and data collected during this investigation. Groundwater elevation contour maps will be constructed using measurements from newly installed and existing wells of acceptable construction. The groundwater flow rates and direction within the South Plants Area will be estimated. Specific aquifer characteristics will be determined, from slug tests, for both alluvium and the Denver Formation including values for hydraulic conductivity and transmissivity; estimates of porosity and storage coefficients also will be made.

Borehole logs and hydrologic data will be evaluated to assess the interconnectiveness of alluvium and the Denver Formation within the South Plants Area. Groundwater quality data from this and previous studies will be examined to confirm the relationship between water from the alluvial and Denver Formations and to assess the impact that the specific contaminant sources have on groundwater quality in both formations.

8.2.2 Contaminant Properties and Geochemistry of Ambient Soils

The distribution and mobilization of contaminants are functions of both the molecular characteristics of the target chemicals and the physical/chemical properties of the soils. These variables will be examined as applied to the contaminants of concern from literature data and measured sedimentary properties (soil texture, organic carbon content, pure water pH, and temperature). Processes such as biodegradation and sorption will be estimated from literature data (wherever available) and incorporated in the data analyses to estimate the contribution of these processes to the observed gradients.

8.3 Relationship of Existing Building Contamination to Past and Present Soil Contamination

The analysis of the Phase IA and IB building and Phase I and Phase II soils data will be used to identify relationships between ambient soil and source (building) contamination. This relationship will be determined by comparison of the chemical fingerprint of each source to the chemical constituents

measured in the surrounding soils. This source-soil methodology will be accomplished by pattern recognition methods applied to the computerized data base. These methods will allow for an estimate of the spatial extent of contamination associated with a building and/or cluster of buildings and define the areas which may require cleanup. In addition, these analyses will identify the need for additional soil borings (increase in sampling density and change of grid configuration) to better delineate the contamination boundaries.

8.4 Significance of Soil Contamination (Criteria Development)

Action levels for the target chemicals are currently being developed by USAMBRDL in coordination with the "How Clean is Clean" Committee. The approach being used is the Preliminary Pollution Limit Values (PPLV) method applied to five contaminant transport pathways consistent with the proposed land use scenarios. The pathways are: 1) drinking of groundwater, 2) inhalation of soil particles (dust), 3) soil ingestion by children, 4) ingestion of vegetables, and 5) uptake by fish and wildlife.

To date, physical/chemical and toxicological summaries of 55 target chemicals have been prepared by USAMBRDL and are currently being reviewed by the members of the "How Clean is Clean" Committee together with the overall PPLV methodology. So far, a number of problems have been identified with the method as currently implemented by USAMBRDL. These are related to: the mathematics of the model equations, the computation of partition coefficients, the assumptions in estimating dose rates and the treatment of uncertainty.

Ebasco will prepare a careful and rigorous technical review of both the general methodology and the specific PPLV calculations performed for each chemical to provide USATHAMA with a scientifically sound set of values. The review and computational refinements will address:

- o Correctness of mathematical expressions and units
- o Validity of assumptions and reasonableness
- o Estimation of uncertainty in all variables and constants used, especially the ADI values and partition coefficients

The uncertainty in the computed PPLV's for soils for each pathway model will be estimated by using a probabilistic model. This method involves specifying the inputs as probability distributions and propagating them through the model using Latin Hypercube Sampling (LHS) with random pairing of the inputs. These analyses will produce a distribution of soil concentrations vs. the cumulative probability that the soil concentration is safe. Figure 8.4-1 shows the results of this methodology for a hypothetical contaminant X and three different pathways. The abscissa is the log maximum allowable contaminant concentration in the soil and the ordinate is the probability that a given soil concentration will result in an exposure equal to the acceptable value. The plot is read by picking a desired confidence level and reading off the corresponding soil concentrations.

Also indicated on the figure is the maximum soil concentration of contaminant X measured at the hypothetical site. This concentration is the relevant comparison point for the drinking water pathway. For the inhalation pathway, safe soil concentrations should be compared to site specific concentrations at the surface and the crop pathway should be compared to maximum concentration in the root zone, i.e., the top 0.5 meters. As shown for contaminant X, there is a 95 percent probability that the maximum contaminant soil concentration is unsafe through the ingestion of groundwater. There is a 60 percent chance that the crop pathway will lead to an unacceptable dose. Note also that there is no chance that the levels of contaminant X are unsafe through inhalation of resuspended soil.

The information depicted in these distributions indicates the remedial objectives for such a site even when significant technical uncertainties exist. Any remedial action chosen for this site must prevent or mitigate the migration and exposure through the ingestion of crops grown onsite and the ingestion of groundwater from the underlying aquifer, given that probabilities of unsafe doses discussed above exceeds the required confidence level to provide adequate protection.

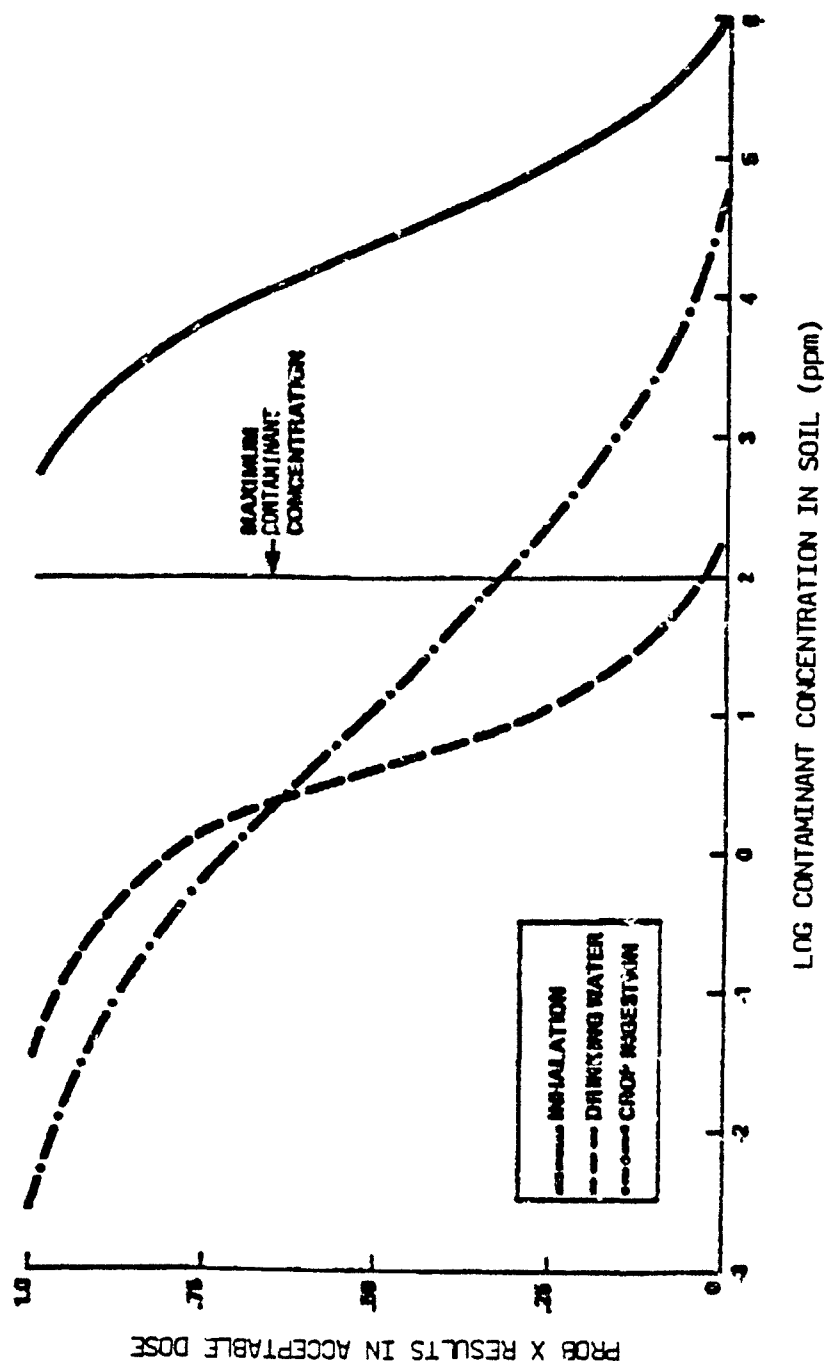


FIGURE 8.4-1 PROBABILITY DISTRIBUTIONS REPRESENTING DEGREE OF CERTAINTY THAT VARIOUS CONTAMINANT (X) SOIL CONCENTRATIONS WILL RESULT IN AN ACCEPTABLE DOSE LEVEL

Figure 8.4-1 shows that the distribution of soil concentrations over the range of 0 to 100 percent probability of acceptable dose have a high variance. The crop pathway spans over five orders of magnitude and the drinking water and inhalation pathways span over three orders of magnitude. This indicates that selecting a remedial action based on the median value of the soil concentration could lead to a dose above the maximum allowed.