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LITIGATION TECHNICAL SUPPORT AND SERVICES

ROCKY MOUNTAIN ARSENAL

FINAL
WESTERN TIER
TRICHLOROETHYLENE INVESTIGATION
TECHNICAL PLAN
VERSION 3.1

October 1987
Contract No. DAAK11-84-D-0017
TASK NO. 38

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

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DAAK11-84-D-0017

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

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Prepared by:

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Prepared for:

U.S. ARMY PROGRAM MANAGER'S OFFICE FOR
ROCKY MOUNTAIN ARSENAL CONTAMINATION CLEANUP

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13. ABSTRACT *(Maximum 200 words)*

THIS FINAL TECHNICAL PLAN DESCRIBES THE WORK THAT WILL BE UNDERTAKEN TO INVESTIGATE TRCLE CONTAMINATION IN THE WESTERN TIER OF RMA. THE OBJECTIVES OF TASK 38 ARE TO:

1. DETERMINE THE SOURCE(S) OF TRCLE IN THE WESTERN TIER
2. FOR EACH SOURCE, DEFINE THE CONTAMINANT PLUME
3. ESTIMATE THE PERCENT CONTRIBUTION OF RMA TRCLE CONTAMINATION TO SOUTH ADAMS COUNTY TRCLE CONTAMINATION
4. OBTAIN ALL DATA NECESSARY TO DETERMINE APPROPRIATE REMOVAL OR FINAL REMEDIAL ACTIONS.

SECTIONS OF THIS REPORT DETAIL INFORMATION ON THE FOLLOWING: FIELD SAMPLING, CHEMICAL ANALYSIS, QUALITY CONTROL, HEALTH AND SAFETY, DATA COMPILATION AND MANAGEMENT, AND CONTAMINATION ASSESSMENT.

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1.0 INTRODUCTION

1.1 Background

The Program Manager's Office for the Rocky Mountain Arsenal Contamination Cleanup (PM-RMA) is overseeing efforts by two contractor teams to identify the nature and extent of contamination at selected sites on the Rocky Mountain Arsenal (RMA). This technical plan describes the work that the contractor team headed by Ebasco Services Incorporated (Ebasco) will undertake to investigate trichloroethylene (TCE) in the Western Tier of RMA. The Western Tier is typically considered to include Sections 33, 4, and 9, but this task also includes investigations of portions of Section 3, namely the rail classification yard area and abandoned officer's housing areas. This work was awarded as Task Order Number 38.

The need for this work came about as a result of the discovery, in July of 1985, of TCE in municipal water supply wells west of RMA in Adams County. The U.S. Environmental Protection Agency (EPA) initiated investigations focusing on determining possible sources of the TCE detected in Adams County wells. In September 1985, to support these investigations, EPA requested the Army to supply any and all data available regarding the use and presence of TCE along the Western Tier of RMA. In addition to this data compilation, EPA requested that additional water quality data be collected in this area. In October 1985 nearly all wells in the western sections of RMA were sampled and anaylzed tc determine if TCE was present.

TCE was found in numerous wells along the Western Tier with the highest concentrations located in the general vicinity of the RMA motor pool (Building 627). Data are not available to clearly define a source of a plume of TCE on RMA. Further investigations are necessary before a conclusion can be drawn about RMA's contribution to the TCE contamination existing off-post.

This plan is one of a series that has been and will continue to be proposed by Ebasco to describe its planned activities at RMA. Ebasco's Final Technical Plan for the South Plants Contamination Survey and Remedial Action Assessment (Ebasco, 1985) was the first of these plans and serves as a reference document for all plans subsequently generated. The South Plants Technical Plan contains detailed background information on the general contamination problems at RMA and for this reason is routinely referenced by this Western Tier TCE Investigation Technical Plan.

1.2 Technical Approach

The objectives of Task 38 are as follows:

- Determine the source(s) of TCE in the Western Tier;
- For such source(s), define the contaminant plume between the source and the RMA boundary;
- Estimate the percent contribution of RMA TCE contamination to off-post South Adams County TCE contamination; and
- Obtain all other data necessary for the Army, in consultation with EPA, Colorado, and Shell, to determine appropriate removal or final remedial action to be taken with respect to the TCE source and/or the TCE plume of contamination.

These objectives are accomplished through the conduct of a remedial investigation and preliminary remedial alternatives assessment as described briefly below and in more detail later in this plan. The remedial investigation includes a detailed review of historical records, personal interviews, geophysics studies, soil gas studies, soil borings and analysis, well installation, groundwater sampling and analysis, and building (sumps, drains, etc.) sampling and analysis.

A historical record search will be conducted to help identify possible sources of TCE. Records to be searched will include operation records for all buildings in the rail classification yard area, purchasing records for all supplies used in this area, engineering drawings for buildings in this area, documents produced in United States vs. Shell Oil Company, and depositions taken in that context. Personal interviews will also be conducted where appropriate. Information collected during this record search will be documented in a report format similiar to the Damage Assessment Reports prepared for other remedial investigation tasks.

Geophysical studies will be required to clear boring and well drilling sites. In addition, geophysics will be used to aid in the understanding of the hydrogeology beneath the Western Tier. In particular, the locations of bedrock valleys (which may influence groundwater movement) will be defined to permit placement of groundwater monitoring wells within the channels. Soil gas studies will also be used to assist in the location of wells. Two soil gas methods are planned. The real time Tracer Research method will be used to track plumes and to identify sources. The static collection tube device marketed by PETREX will be used to screen large areas where contamination sources or plumes have not been previously identified.

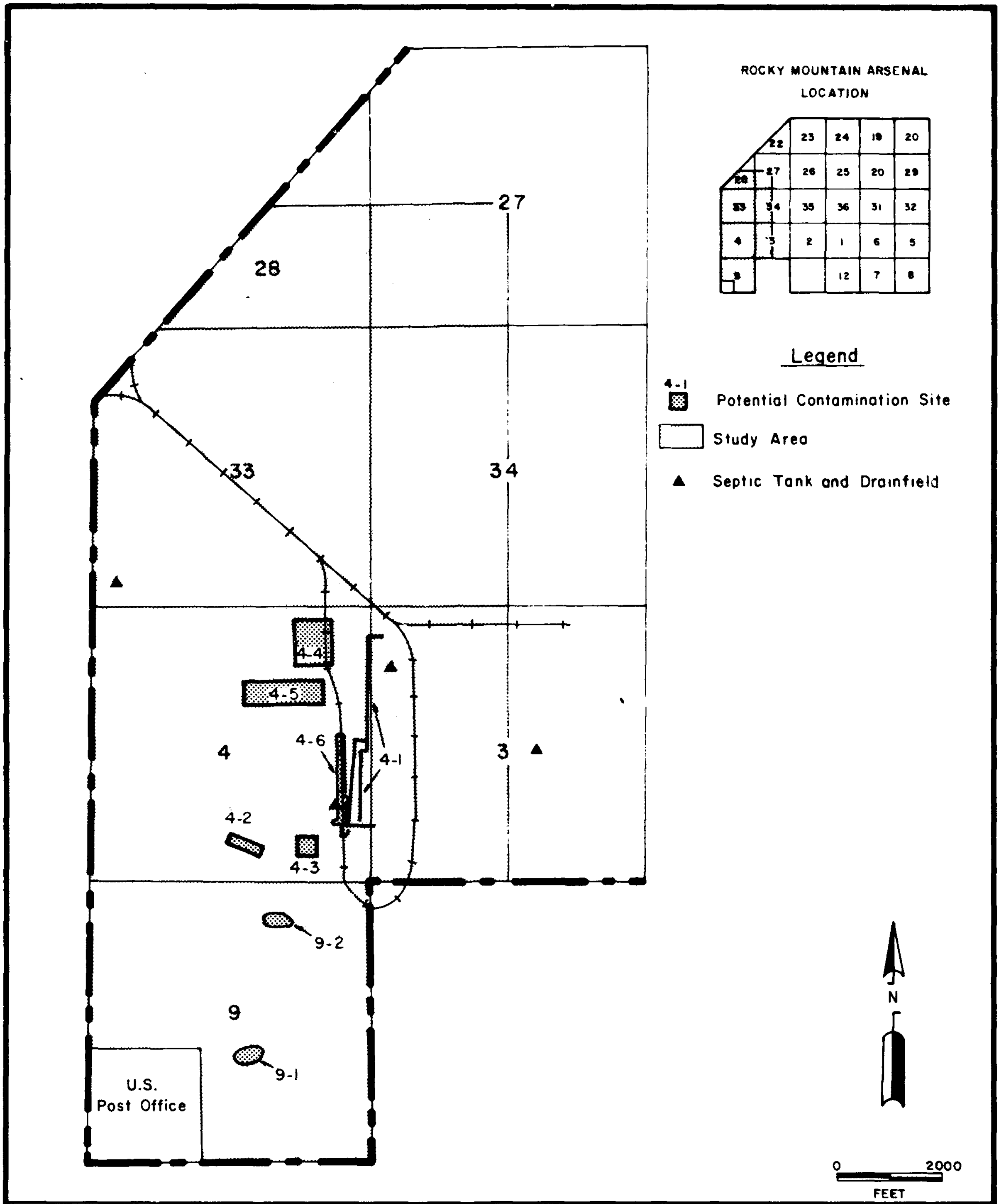
Soil borings will be placed in known or suspected contamination source areas to characterize the source areas and to determine the vertical distribution of the contamination within the unsaturated zone. These borings also will yield valuable stratigraphic information that will aid in understanding the hydrogeology of the study area. Groundwater monitoring wells will allow for regular measurement of groundwater table elevations, and can therefore be used to estimate the direction of groundwater flow. They also will permit sampling of the groundwater for chemical analysis to verify and define contaminant plumes. Building sampling will be conducted at selected locations to verify the presence or absence of contamination sources. Sections 2 and 3 of this Technical Plan describe these remedial investigation activities in more detail.

Once the contamination problem has been adequately defined, remedial alternatives will be developed and evaluated. These alternatives will be grouped into three categories, i.e., source control measures, management of migration measures, and receptor control measures. Preference will be given to proven, reliable mitigation techniques, but innovative structural and nonstructural alternatives will also be evaluated to arrive at the most effective, efficient, and inexpensive solution to the contamination problem.

1.3 Areas to Be Investigated

Figure 1.3-1 shows the Western Tier TCE Study Area. Site 4-1 is covered under the Task 10 Sewer Study, while Sites 4-2 through 4-5 and Sites 9-1 and 9-2 are covered under Task 15, Phase I - Army Sites South (Ebasco, 1986g). Although these sites are being investigated under other Task Orders, additional work at these locations may also be included in Task 38 if there is evidence of TCE migration.

Specific areas of interest for Task 38 include the motor pool and roundhouse areas in Section 4 (Figure 32-43, Section 3.2.4), the rail classification yard in Section 3, and septic tanks and drainfields in Sections 3, 4, and 33 (Figure 1.3-1.). The historical record search and soil gas sampling efforts will be expected to pinpoint additional areas of interest; however, because this task involves investigation of the groundwater transport of contaminants from source areas, and because groundwater movement can disperse contaminants over large areas, the entire Western Tier will be included in the Task 38 Study Area.



Prepared for:

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

FIGURE 1.3-1

Western Tier TCE Study Area

Rocky Mountain Arsenal, Task 38

Prepared by: Ebasco Services Incorporated

2.0 EVALUATION OF BACKGROUND DATA

2.1 Data Compilation

2.1.1 Initial Site Reconnaissance

Detailed field reconnaissance will be conducted to corroborate various sources of information. The reconnaissance will include both walking and driving tours of the motor pool area, rail classification yard, round house, septic systems, and other suspected TCE source areas. The locations of all such areas will be plotted on a base map incorporating field observations and background information. Particular emphasis will be given to sumps, disposal trenches, pits, and other structures that may have been used to hold solvents. Where possible, photographs will be taken to illustrate field conditions and to provide permanent documentation.

2.1.2 Literature Search

Prior to and during the field investigations, a thorough examination of all data pertaining to TCE usage and disposal in the Western Tier will be conducted. Background data to be examined includes: a) purchasing records for all supplies used in the Western Tier to determine whether TCE or other conpounds were used; b) operation records for activities in or around buildings in the rail classification yard, motor pool area, and defense reutilization and marketing office (DRMO, formerly known as the Defense Property Disposal Office or DPDO) area to help identify possible sources of TCE; c) engineering drawings to define probable pathways (such as sewers or drainages) from buildings through which contaminants may have migrated to the soils or groundwater; and d) depositions from the Department of Justice of past and current RMA or lessee employees who worked in the Western Tier. Review of the depositions will be augmented with personal interviews to help identify uses of TCE or other contaminants for which records were not preserved.

Information gathered from all available documents and related information will be presented in a Damage Assessment Report. Portions of this information which specifically address concerns of the State of Colorado and other organizations will be presented as separate documents.

2.2 Potential Contamination Sources

Possible contamination sources identified by reconnaissance, literature searches, and available groundwater chemical data include various locations within Site 4-6 (motor pool area). Other miscellaneous sites will be investigated as new field data become available.

3.0 FIELD SAMPLING PROGRAM

3.1 Sampling Strategy

3.1.1 Background

Unlike most other remedial investigation tasks being conducted by the PMO, the Western Tier TCE Study includes not only source characterization, but also tracking of contaminant migration to the RMA boundaries and preliminary assessment of remediation measures. Thus, information must be collected concerning those factors that influence the movement of contaminants and the performance of potential remediation measures.

Based on previous studies, a great deal is known about the hydrogeologic characteristics of this area and about TCE movement in groundwater. Much of this information was developed by Shell Chemical Company and the Army in relation to the dibromochloropropane (DBCP or Nemagon) spill in the rail classification yard area and its subsequent movement to the northwest across Sections 3, 4, and 33 (and across a bedrock valley believed to exist in this area). The Irondale groundwater extraction, treatment, and reinjection system was, in fact, installed to intercept and remove this DBCP plume. It has also been documented that pumping at the South Adams County Water and Sanitation District (SACWSD) municipal water supply wells affects water table levels on RMA and, by inference, that these wells draw water from the alluvial aquifer on RMA (Whitten & May, 1983). Finally, RMA groundwater level monitoring efforts by numerous parties have revealed a general north-northwesterly direction of flow in the Western Tier. The strategy to be used to investigate the Western Tier TCE contamination is based upon a review of these previous efforts, and represents an effort to supplement and confirm, rather than recreate existing information.

3.1.2 Source Concept

Trichloroethylene (TCE) has historically received widespread use for a variety of purposes such as the following:

- Metal degreasing
- Dry cleaning
- Solvent for fats, greases, and waxes

- Solvent for removal of caffeine from coffee
- Solvent for dyeing
- Refrigerant and heat exchange liquid
- Organic chemical synthesis
- Fumigant
- Anesthetic

TCE dissolves most oils, a characteristic that has made it ideal for use as a degreasing agent. TCE is a chlorinated aliphatic hydrocarbon with a specific gravity of 1.46. It is a colorless liquid with a boiling point of 188°F and a vapor pressure of 60 millimeters at 68°F. It is slightly miscible with a solubility in water of 1,100 milligrams/liter at 77°F. The saturation concentration of TCE in air is 415 grams/cubic meter at 68°F (Verschueren, 1977).

The EPA has established a Suggested No Adverse Response Level (SNARL) for TCE in water at 4.5 parts per billion (ppb) (UESPA, 1980a). The EPA has also proposed an enforceable Maximum Contaminant Level (MCL) of 5 ppb in drinking water, and because TCE is a possible human carcinogen, has promulgated a Recommended Maximum Contaminant Level (RMCL) of 0 ppb (USEPA, 1985a).

Given the physical and chemical characterizations of TCE, it is believed that any potential use of TCE at RMA would have been confined to degreasing. In particular, it would potentially have been used to clean engine and mechanical parts, metal surfaces prior to painting, and perhaps, to dissolve greases in septic tanks or septic system tile fields. Because activities of this type are expected to have occurred in the motor pool, round house, rail classification yard, and adjoining areas, because there are several septic systems in these areas, and because current groundwater data show positive results for TCE, efforts to find TCE sources will be concentrated in these areas.

3.1.3 Migration Concept

TCE is known to exist in the groundwater in discrete areas along the Western Tier and is likely to be migrating with the groundwater flow. Among the processes that influence TCE movement and degradation within groundwater are advection, dispersion, sorption, biodegradation, and volatilization. Advection refers to transport of dissolved chemicals (solutes) with the average groundwater flow. Dispersion results from molecular diffusion and mechanical mixing. Dispersion acts to spread and dilute dissolved contaminants within the aquifer and results in decreasing contaminant concentrations with increasing distance from the source. Contaminants tend to travel along paths of higher permeability (such as graded bedding or channel deposits), so lateral and vertical variations in concentrations can become quite significant.

Sorption refers to the interaction of groundwater contaminants with soil particles through adsorption, ion exchange, and other processes. These processes act to distribute the contaminant between the dissolved phase and the solid phase, and tend to lower the dissolved phase concentration and slow the movement of contaminants relative to the groundwater flow. The retardation factor is defined as the ratio of the rate of groundwater travel to the rate of solute travel reduced by sorption processes. For TCE in sand and gravel aquifers, the retardation factor is about 2 (Mackay et al., 1985), i.e., TCE moves about half as fast as the average groundwater velocity.

The groundwater velocity across the Western Tier area can be estimated based upon aquifer characteristics determined in 1953 using pump tests in Section 4 (USGS, 1953). The hydraulic conductivity of the alluvial aquifer was estimated to be about 2,900 gallons/day/square feet. Assuming uniform aquifer properties and an average aquifer porosity of 30 percent (typical for the materials in this alluvium), the velocity can be calculated using Darcy's Law and the continuity equation. The hydraulic gradient in the Western Tier alluvial aquifer is about 0.004 feet/foot (ESE, 1986), so the computed groundwater velocity is about 5.2 feet/day. The time required for a parcel of groundwater to move from the round house area to the vicinity of the SACWSD wells near Quebec Street and 77th Avenue, a distance of about 9,000 feet, is estimated to be nearly 5 years. With a retardation factor for TCE of 2, the transit time for this contaminant can be approximated as roughly 10 years.

Biodegradation can be an important breakdown process for organics in groundwater. In some cases the contaminants of concern are degraded to less toxic or nontoxic compounds, but in others the daughter products can be as bad as or worse than the original contaminants. The types and amounts of daughter products formed are highly site specific. Depending upon the existing microbial population and environmental conditions, all or none of the daughter compounds may be produced.

Volatilization of TCE from groundwater can only occur if the TCE is present at the surface of the aquifer. Under ideal conditions, the amount of TCE that will volatilize can readily be calculated using Henry's Law. Henry's Law states that at equilibrium, the amount of a compound in the air overlying a contaminated water is as follows:

$$C(air) = H \times C(water)$$

where: C(air) = air concentration of contaminant
H = Henry's Law constant
C(water) = water concentration of contaminant

For TCE, H is 0.01 atmosphere-meters cubed/mole (atm-m^3/mole) (Lyman et al. 1982). For a water TCE concentration of 5 ppb, the air TCE concentration above the water (at equilibrium) would be about 2 ppb. In a groundwater system, TCE would volatilize from the aquifer, and the gaseous TCE would then diffuse upward through the unsaturated zone under the driving force of the TCE concentration gradient between the water table surface and the atmosphere (assumed to have a TCE concentration of zero). Thus, under natural conditions, the TCE would slowly "leak" from the aquifer to the atmosphere. This has important implications in terms of tracing TCE plumes and in terms of possible site remediation, as will be discussed later.

In the Western Tier, it is likely that all of these processes are active to one degree or another. The situation is complicated by the presence of bedrock valleys that may, under some circumstances, influence the direction and rate of groundwater flow. Furthermore, pumping at the Irondale Groundwater Treatment System and at the SACWSD wells near 77th Avenue and Quebec Street are known to influence groundwater flow patterns on RMA. It is apparent that a great deal of information will be required to adequately address the complicating factors mentioned above, and to thereby define the TCE contamination problem in the Western Tier.

3.1.4 Approach

Definition of specific TCE source areas is an objective of this task; therefore, potential TCE source areas will be examined through historical record searches, personnel interviews, soil borings, and groundwater monitoring wells. In addition, because TCE is highly volatile, soil gas measurement techniques may be successful in locating source areas. Soil gas measurements will also provide information that will be useful in assessing remedial activities. Soil borings and analyses and sump, tank, or pit samples will be used to identify and confirm specific source areas, and, like soil gas sampling, can provide data (e.g., sorption estimates) valuable in evaluating potential mitigation measures.

Soil gas techniques can aid in locating contaminant plumes, and they will be used for this purpose. However, it is not possible to directly correlate soil gas contaminant measurements with groundwater contaminant concentrations, so groundwater monitoring wells will also be required. Because monitoring wells are expensive, and because it is desirable to locate these wells in the center(s) of any contaminant plume(s), soil gas results will be used to aid in the optimal placement of the wells. These wells, along with the soil borings, will aid in the understanding of the subsurface geology. In particular, aquifer characteristics and bedrock surface elevations can be determined. Aquifer characteristics must be known in order to properly evaluate remedial pumping alternatives. The monitoring wells also will permit measurement of water table elevations, and these elevations can aid in understanding groundwater flow across the Western Tier.

Geophysical techniques will be required to clear bore and well locations in areas where there are suspected buried metal objects or utilities. In addition, geophysical methods can help to define subsurface geology. In particular, the locations of bedrock valleys can be pinpointed to aid in placing monitoring wells within these valleys. Placement of wells in these valleys will be important for three reasons. First, there is some evidence to indicate that, under certain conditions, the water table can be drawn down to a point that these valleys are no longer submerged. As a result, they can potentially channel groundwater down their axes. Second, it is possible that these valleys may be more permeable than overlying saturated materials and may, therefore, act as conduits for groundwater movement. Third, the centers of these channels represent areas where the aquifer depth is greatest. Stratification of TCE in the aquifer is most likely to be apparent in these valleys.

Although many wells have been installed throughout the Western Tier for a variety of reasons, it is anticipated that additional wells will be required to adequately define and track contaminant plumes. Furthermore, these wells will be needed to more accurately define background groundwater quality, i.e., the quality of groundwaters moving onto RMA from the southeast. Proper placement of these wells also will aid in the understanding of groundwater flow patterns in areas where existing information is sparse, e.g., the eastern and southern portions of Section 9 and the southwestern portion of Section 4.

3.2 Definition of Source Areas (Sites)

3.2.1 Geophysics

Three geophysical methods will be tested to gather subsurface geologic data. Information gained from these surveys will be used to find bedrock valleys, thereby aiding in locating new groundwater monitoring wells. EM34 conductivity, resistivity, and microgravity surveys will be conducted to locate the center or deepest portions of suspected buried bedrock surface valleys. All three methods will be tested, because comparative data will be required to assess the effectiveness of each method under site-specific conditions. It is not possible to predict in advance which method(s) will prove to be effective. All three methods will be verified with existing bore-log data, and the most reliable of the methods used for the full-scale study effort. Conductivity will be used (if it proves to be successful) because it is the most cost-effective of these techniques.

Electrical conductivity is a function of the soil and rock type, porosity and permeability, and the fluids which fill the pore space. Electrical conductivity values are expressed in units of millimhos per meter (mmhos/m). The absolute values of conductivity for geologic materials are not necessarily diagnostic in themselves, but the lateral variations in conductivity and changes in conductivity with depth are significant. A more detailed description of the electromagnetic technique is given in Geophysical Techniques for Sensing Buried Wastes and Waste Migration (Benson et al., 1983).

Three separate electromagnetic measurements will be obtained at every conductivity station. Measurements will be carried out using a Geonics EM34 instrument at 10, 20, and 40 meter coil spacings, using horizontal coplanar coils (vertical dipole). Three different coil spacings allow measurements of conductivity from the surface to depths of approximately 50, 100, and 200 feet, respectively. The data will be recorded at 50 foot station intervals along each survey line.

The shallow EM measurements, made with a 10 meter coil spacing, will be taken to observe any geologic variation in shallow soil conditions above the water table (which is expected to be at a depth of about 60 feet in the proposed geophysics study area), and to check for possible buried material and cultural interferences which might impact the deeper measurements. The intermediate EM measurements, made with a 20 meter coil spacing, will be taken to observe any geologic variation in the eolian/alluvium over the bedrock (the bedrock is expected to be approximately 100 feet deep). The deepest EM measurements, made with a 40 meter coil spacing, will be taken to observe any variation in the bedrock profile. Comparison of these three measurements will provide an indication of geologic conditions with depth. Because the underlying bedrock is composed of different materials than the overlying eolian/alluvium, a conductivity contrast should exist between the two. If the conductivity contrast is great enough, the bedrock-alluvium contact can be defined with this method.

Resistivity measurements will be made using both sounding and profiling techniques. Subsurface resistivity is a function of the soil and rock type, porosity and permeability, and the fluids that fill the pore spaces. Resistivity values are expressed in units of ohm-feet. The absolute values of resistivity for geologic materials are not necessarily diagnostic in themselves, but their variations laterally and with depth are significant. Resistivity is the reciprocal of electrical conductivity, the parameter measured by the electromagnetic technique. Therefore, the term "high resistivity" used in the presentation of resistivity data means the same as "low conductivity." A more detailed description of the resistivity technique can be found in Geophysical Techniques for Sensing Buried Wastes and Waste Migration (Benson et al., 1983).

Resistivity sounding data is acquired as an aid to understanding the response of the electromagnetic data. Resistivity soundings will be made using a Wenner array of a Bison 2390 Resistivity Instrument and the data plotted on log-log paper in the field as the sounding measurement is made in order to quality-control the data.

A forward computer model will be used to determine the best fit section. Iterations of the forward model will be made to obtain a best fit, and sensitivity analyses are run to assess the fit. Boring and monitor well data will be used to provide water table and bedrock depth where this information is available.

The best fit forward model will then be used as input to an inversion program to optimize the fit. The final forward model will be run using the results of the inversion program to provide the final interpretation. The final models will represent the vertical sequence of "geologic" layers at a given location.

In the resistivity profiling technique, measurements will be made by changing the location of the spread while maintaining a fixed electrode spacing interval. This measurement is another means of defining channels in bedrock similar to the EM profiling technique. The station interval for the resistivity profiling will be based upon preliminary EM data and the suspected width of the anomalies. The "A" spacing (coil spacing) will be based upon the depth of rock and the results of sensitivity analysis of initial resistivity soundings. The same Wenner array and equipment used for soundings will be used for profile measurements.

Gravity measurements can be used to measure changes in the density associated with geologic conditions. Bedrock channels will, therefore, show up as negative values along a profile line. Since this method responds to a change in density, it provides an alternate, independent measurement to the electrical methods. The United States Geological Survey in Denver indicates a density contrast does exist between the eolian/alluvial (1.8 grams per cubic meter, gm/cm^3) and the Denver Formation bedrock (2.1 gm/cm^3)

Gravity measurements will be made at 100 foot intervals using a LaCoste and Romberg Model D micro gravimeter. Gravity data will be obtained to a precision of 5 microgals (ugals) and relative elevations surveyed to a precision of ±0.01 feet. A base station will be established at the center of the survey line to correct for instrument drift. Gravity readings will be made at the base station approximately every two hours to correct any instrument drift.

The field data will be reduced using an HP 85B computer. Tidal corrections will be made using the Longman computation. Since the gravity profile will be made along a single line of stations, a latitude correction will not be necessary, but instead a linear correction will be applied. A free-air correction will be computed to compensate for the change in gravity values due to elevation changes. A Bouguer correction is then added to compensate for the mass of sediments between the gravity station and the assigned datum. A specific gravity of 2.1 will be assumed for the bedrock (Denver Formation) under the site.

Any anomalies that result from the above corrections are called the total Bouguer anomaly. They may be considered to be made up of deep seated effects (the regional Bouguer anomaly) and shallow effects (the local Bouguer anomaly). It is the local Bouguer anomaly that is of interest to this investigation. When the various sources of error are taken into consideration, most of the Bouguer values are estimated to have a relative accuracy of ± 0.01 ugals.

After the most effective geophysical method is selected, it will be used to aid in the location of groundwater monitoring wells. Specifically, the geophysical technique will be used to locate the presence and alignment of suspected buried bedrock valleys. Monitoring wells will be preferentially placed in the center(s) of these valleys to investigate the possibility of stratified contaminant distribution and movement.

3.2.2 Building Sampling

Potential sources within buildings will be sampled in Site 4-6 and, possibly, within the rail classification yard. The objective of the building sampling program will be to determine if there are materials in the associated sumps, sewers, pipelines, etc., that may be contributing to soil and groundwater contamination. The building sampling program is designed to provide information about possible contamination in the buildings and disposal systems throughout the area. Historical information and field data including soil gas analyses will be used to select buildings for the sampling program. Buildings determined to have been possible contributors to contaminated soil or water will be investigated. Since several types of materials and structures will be sampled, various sampling techniques and devices will be used. An example of this is in the round house (Building 631). A sump within the roundhouse is to be sampled. The round house is large enough to permit a drilling rig to work within it. Therefore, a soil boring will be drilled in this sump as if it were an outdoor soil boring. Sumps or drains in smaller buildings will most likely be sampled with hand augers or hand-driven spoons, etc. Containers or drums within buildings also will be examined and sampled, if necessary, to determine their contents. Any visual spills or stained areas also will be sampled. Based on these investigations, future surveys of adjacent sewers and pipelines may be necessary. Samples collected in this program will be treated as soil or water samples for the purpose of chemical analysis.

3.2.3 Soil Gas

Soil gas methods have been developed by a number of companies. Two of these, Tracer Research Corporation of Tucson, Arizona and PETREX of Golden, Colorado, provide quick and relatively inexpensive methods for definition of volatile contaminants in the vadose zone. The principle on which soil gas methods operates is that volatile organic compounds present in the groundwater or vadose zone generate vapors that can migrate upward through the vadose zone atmosphere. The driving force behind this movement is created by the concentration gradient between the contaminated zones and the (essentially) contaminant-free atmosphere. Soil gas sampling intercepts the contaminants as they move through the vadose zone. Because this is a diffusion process, contaminant concentrations in the soil gas are highest near the contaminated zones (generally, in the deeper soils) and lowest near the soil surface. Although neither soil gas method provides a direct measurement of the contaminant concentration in the soil or groundwater, the concentration of the contaminant in the soil gas does give an indication of the relative magnitude of the contamination. Both methods have been used successfully at many contamination sites across the nation to detect sources and trace plumes of volatile organic compounds. Both methods were also successful in detecting volatile organic compounds present in the vadose zone and/or groundwater during a preliminary test program conducted by Ebasco at RMA (Ebasco, 1986b). Soil gas surveys can be used as a low cost reconnaissance tool from which more expensive drilling and sampling programs can be directed.

Soil gas analyses are highly quantitative and specific for individual compounds, but the extrapolation of soil gas contaminant concentrations to groundwater contaminant concentrations is not quantitative. Variables such as geology, soil moisture content, and the air/water partitioning coefficient of the particular contaminant all affect the relationship between soil gas concentrations and groundwater contaminant concentrations. Water, either in the vadose zone (i.e., a very wet clay or a perched water zone) or in the saturated zone (a contaminated zone below clean water) can be a major impediment to vapor movement.

Tracer Research Corporation Method

The Tracer Research Corporation (TRC) method utilizes a specially equipped van manned by a geologist and chemist to collect and analyze soil gas samples in the field. The samples are collected by driving a hollow probe 5 to 15 feet into the ground and evacuating a small amount of air. The probe is made of galvanized steel equipped with a steel drive point and is driven into the ground by use of a hydraulic jack mounted on the back of the van. The probe is driven a foot beyond the desired sampling depth then drawn back a foot leaving the drive point implanted at the bottom of the hole and creating a small void. A vacuum pump is then attached to the probe by silicone tubing and air is withdrawn (Figure 3.2-1). The sample is collected by inserting the needle of a glass syringe through the tubing during the evacuation step and withdrawing from 1 milliliter (ml) to 2 ml of air. The entire sampling operation, from probe insertion to probe removal, takes about 15 to 20 minutes. When access by the van is impossible, probes can be driven by hand and samples collected by use of a portable battery operated pump.

The sample is analyzed immediately after collection by injection into a portable gas chromatograph (GC) mounted in the van. The TRC GCs are equipped with four detectors: electron capture (ECD) for measurement of halogenated compounds; flame ionization (FID) for hydrocarbons; photoionization (PID) for aromatic compounds; and thermal conductivity (TCD) for measurement of the primary constituents of air. TRC utilizes a special analytical technology which does not require the use of purge and trap or preconcentrating techniques. This technology allows for a quick measurement of the contaminant with sensitivity and precision comparable to conventional methods.

Field Quality Assurance (QA) measures will be used for both the sampling and analysis phases. The probes, probe adapters, and sampling syringes are

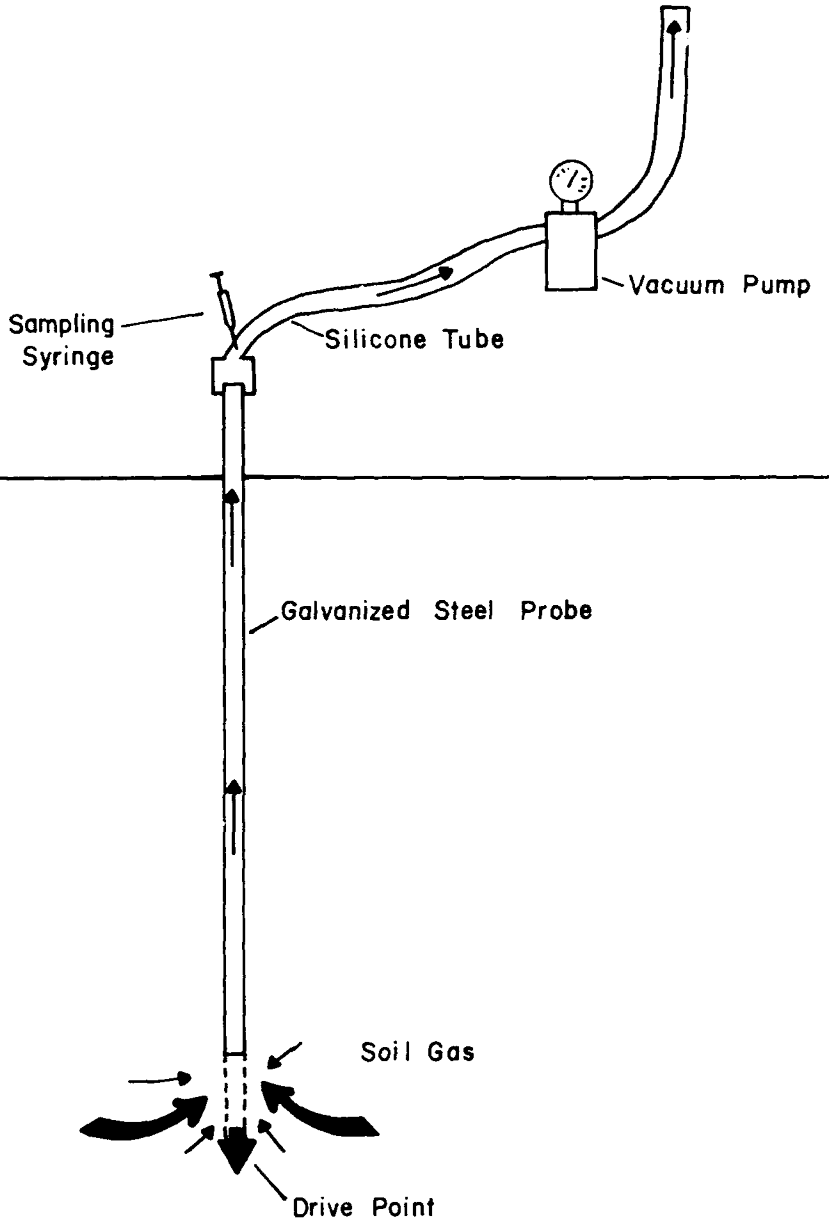


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FIGURE 3.2-1
Schematic Diagram of TRC Sampling Method

Rocky Mountain Arsenal, Task 38

Prepared by: Ebasco Services Incorporated

decontaminated after each use by steam cleaning. The GCs are calibrated each morning and recalibrated after every five samples by analyzing known standards. Duplicate samples are collected at various locations to further verify the accuracy of the method.

The TRC method provides real-time data, and field decisions can be made by the hydrogeologist regarding siting of additional points. This will allow for mapping of a plume and identification of a source while in the field. The GC analysis method will allow for the detection of specified contaminants at very low levels. The TRC method is ideal for mapping contaminant plumes and identifying sources of contamination when a known volatile contaminant is concerned and immediate results are required.

The TRC soil gas survey will begin at a site of known groundwater contamination, Well 4-30, in the motor pool area. Sampling will be conducted along transects perpendicular to the direction of groundwater flow, which has previously been determined to be to the north-northwest, and will continue along the transect at approximately 200 foot intervals until TCE can no longer be detected. New transects will be located approximately 400 to 600 feet south of the previous transects until a source has been defined (i.e., TCE is no longer detected). The soil gas plume then will be traced north to the RMA border. Similar soil gas surveys will be conducted around candidate source areas and at three septic systems located in Sections 3 and 4. The TRC soil gas results will be used to aid in the placement of observation wells in Sections 4 and 33.

PETREX Method

The PETREX method uses a surface static trapping/mass spectrometry technique to sample vapor phase contaminants that are present in the soil pores or that are migrating through the vadose zone in response to barometric pressure fluctuations and diffusion from zones of high concentration (e.g., contaminated groundwater) to zones of low concentration (e.g., the atmosphere). The sample collector is a ferromagnetic wire with an activated charcoal covered tip. The collector is heated to 358° C in a vacuum system and sealed in a culture tube with a Teflon lined cap under an inert atmosphere.

In the field, the collector will be placed in a hole approximately 10 inches deep. The cap is then removed from the collector immediately before it is placed in the hole, open end down, and the hole is then packed with dirt to the ground surface (See Figure 3.2-2). The collector will be left in place for 7 to 30 days and then retrieved, recapped, and transported to the laboratory for analysis.

The collector will be analyzed by Curie point desorption mass spectrometry. The compounds will be desorbed from the wire, ionized, separated according to mass, and counted, and ion counts from 29 to 240 will be reported. The mass spectra produced by this analysis will be compared with mass spectra derived from known volatile organic compounds and the compounds identified.

Field QA measures will include the placement of one duplicate sample for each 10 collectors placed. Laboratory QA consists of calibration and periodic background checks during mass spectral analysis. Care will be taken at all times to prevent or limit exposure of the collector wire to the atmosphere.

The PETREX method will provide an inexpensive means of screening a large area for previously unknown sources of contamination. The extended period that the samples will be left in place ensures time integrated collection of the gas flux data, while the mass spectrometry analysis method allows for the unbiased ability to detect unsuspected compounds. The lengthy sample collection and analysis period makes the PETREX method less suitable for plume tracking.

The PETREX soil gas method will to be used to screen large portions of the Western Tier for TCE contamination. The collectors will be placed in a 300 foot grid pattern in Sections 4, 9, and 33. Collectors will also be placed along the railroad tracks in Sections 3, 4, and 33, in a row at 150 foot centers up groundwater gradient of the tracks, and two rows at 300 foot centers downgradient of the tracks. Collectors will also be placed in the northeastern corner of Section 4 and in the rail switching yard in the

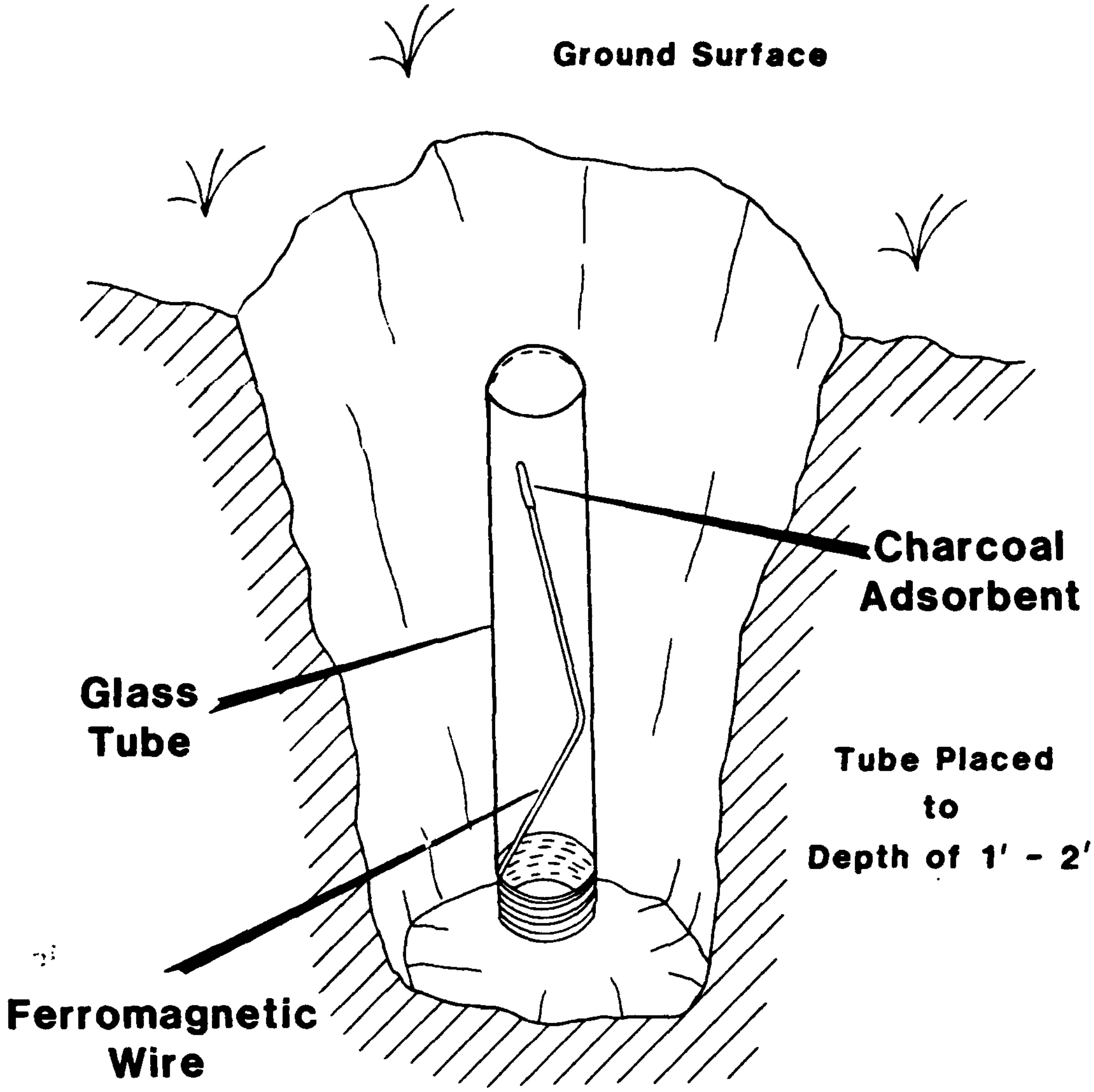

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FIGURE 3.2-2

Petrex Soil Gas Sampling Tube

Rocky Mountain Arsenal, Task 38

Prepared by: Ebasco Services Incorporated

southwestern corner of Section 3. Additional soil gas tubes will be placed in "hot spots" detected by the first set of samplers. The PETREX and Tracer study areas complement one another as shown in Figure 3.2-3.

3.2.4 Soil Borings

The objective of the boring program is to determine the location, volume, and extent of contaminated soil in identified source areas in the Western Tier. Secondly, it contributes to the local geologic data base. Small spills (both areally and volumetrically) could be responsible for the observed groundwater contamination in this area. Also, if the contaminants are volatile compounds (as is TCE), it is probable that they are no longer present in surface soils. Considering these parameters it is unlikely that a boring program based on a grid network will be successful. Therefore, historical data, soil gas surveys, geophysical surveys, and topographic considerations will be applied to design the boring program.

Hollow stem auger techniques will be used to drill in the alluvium and Denver Formation in the Western Tier of RMA. As the boreholes are drilled and as the samples are obtained, a volatile organic analyzer (sniffer) will be used to determine the presence of volatile organics. These meters will be used to determine the level of respiratory protection required. The meters will be used as the hole is being drilled to determine if there are changes in volatiles emanating from the hole. In addition, each sample will be scanned to determine qualitative information related to organics.

The auger rig will be equipped with a coring device which allows for the collection of a continuous relatively undisturbed sample. A core barrel located inside the hollow stem contains tubes manufactured from clear polybutyrate material which collects the core. The coring device will penetrate the formation in advance of the auger bit, therefore, the auger bit will not come into contact with the portion of the formation being sampled. This technique minimizes cross-contamination.

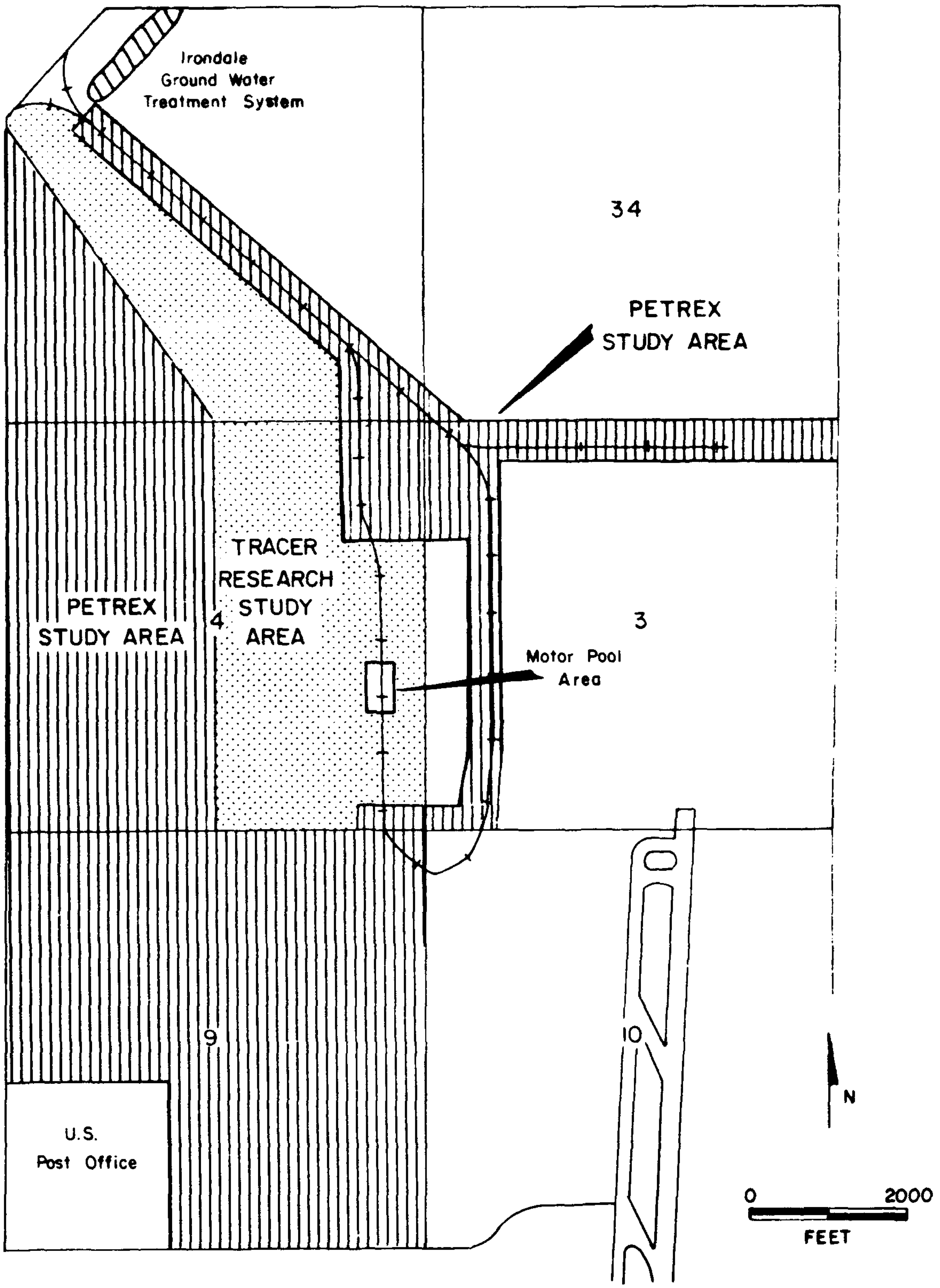

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FIGURE 3.2-3

Petrex and Tracer Research Study Areas - Proposed

Rocky Mountain Arsenal, Task 38

Prepared by: Ebasco Services Incorporated

Control tubes of polybutyrate material will be retained and sent to the laboratory for chemical analysis to determine if these tubes may contribute significant concentrations of organic compounds to soil in contact with the tube. The type and concentrations of such compounds will be reported.

The need to sample specific depth intervals, the desire for simplicity in core logging, and laboratory requirements for sample collection will necessitate the preparation of polybutyrate core tube prior to drilling. The team laboratories will require a 1 ft section of core to be removed from the core length, sealed, and remain sealed during shipment to the laboratory. Therefore, 1 ft sections of polybutyrate will be pre-cut and placed in the core barrel in positions appropriate to the predetermined sampling intervals. Once the core barrel has been removed from the borehole and opened, these pre-cut sections will be removed, sealed with Teflon sheets and plastic caps, and transported to the support facility for shipment. Control samples of the caps will be retained for possible future chemical analysis. Upon arrival at the laboratory, the sample will be subcored with a cork borer apparatus to obtain a soil sample that has not been in contact with polybutyrate. This procedure will minimize potential compatibility problems of soils and polybutyrate and reduce the chance of organic compounds being contributed to the soil sample from the core tube.

The remaining polybutyrate core tube, not designated for sample collection, will be placed in the core barrel. These core sections will be removed from the core barrel at the borehole, taped and capped to hold them shut, examined, and logged by the rig geologist to adjust the depth of borehole construction if necessary. The taped core section will be transported to the core storage area.

Task 38 results will provide a list of compounds present in Site 4-6 so that, if further chemical analyses are recommended, they can be individually tailored. Because the historical data regarding the types of contaminants present may be inaccurate or incomplete, all soil samples will be scanned for a wide variety of analytes. Chemical analyses performed will include a semi-quantitative gas chromatography/mass spectrometry (GC/MS) scan for volatile and extractable organics and a quantitative scan by inductively coupled argon plasma spectrophotometry (ICAP) scan for metals. In addition, these samples will be analyzed using quantitative methods for selected analytes which would not be detected by the above methods at the detection limits required. These methods will include analyses for arsenic and mercury. Volatile organics will not be analyzed in surface samples where they are unlikely to occur. Specific details concerning the Analytical Chemistry Program are presented in Section 4.0.

The motor pool area site (4-6), is the only contaminant source planned for the Task 38 soil boring investigation. It has an area of approximately 215,000 square feet. The method for determining boring density discussed in previous technical plans is not utilized at Site 4-6 for several reasons. First, unlike many other remedial investigation tasks, Phase I and Phase II efforts were to be combined to permit rapid identification and definition of source areas. Second, historical data and field reconnaissance suggest that various wastes (e.g., dilute wash waters that may have contained small quantites of solvents) may have drained into surface drainages and ditches near the motor pool and adjacent buildings. Therefore, special attention will be placed on drilling in drainages and near buildings where possible use of contaminants was suspected. Soil gas surveys will be conducted to further guide the location of bores and wells.

A total of 25 borings will be completed. Two borings will be drilled into the saturated zone in Site 4-6 where monitoring wells will be installed. A total of 6 deep borings (40 ft or greater) will be completed. This constitutes approximately 25 percent of the total number of Phase I borings planned at the site. Approximately 30 percent of the borings will be drilled to a depth of 20 to 30 ft and 30 percent to approximately 10 ft. The remaining samples will be taken from near-surface depths in ditches, sumps, and drainages.

The site map (Figure 3.2-4) indicates the depths to which the borings will be drilled. The deepest borings will be located in those portions of the site that are expected to be contaminated, and progressively shallower borings will be located where less contamination is expected.

If deemed necessary, more detailed sampling will be conducted. Samples will be collected as deep as possible; however, it is anticipated that little recovery of samples from below the water table will be possible. The wet unconsolidated sands typical of the aquifer in this area may flow out of the core barrel, thus reducing recovery.

For all borings, depending on the designated depth, samples will be obtained from the following depths: 0 to 1, 4 to 5, 9 to 10, 14 to 15, 19 to 20, 29 to 30, 39 to 40, 49 to 50, 59 to 60 ft and every 10 ft thereafter to the water table. All borings are drilled and sampled using a continuous core augering technique, except as noted below.

3.2.5 Monitoring Wells

Groundwater monitoring wells will to be installed and sampled to assess the degree and extent of groundwater contamination in the Western Tier. It is the intent of this study to verify the presence of contaminant sources and to determine whether migration of contaminants has occurred which may be contributing to low levels of contaminants measured in nearby SACWSD water supply wells.

Studies of the DBCP plume in Section 33 indicate that contaminant plumes will be narrow in the Western Tier. Wells must be placed in the centerline of the plume in order to accurately track contaminant movement. The present monitoring well network does not appear to adequately define TCE migration in the Western Tier area. Data from the new wells together with information collected from the present monitoring well network will help to further define the local groundwater flow system and the limits of contamination.

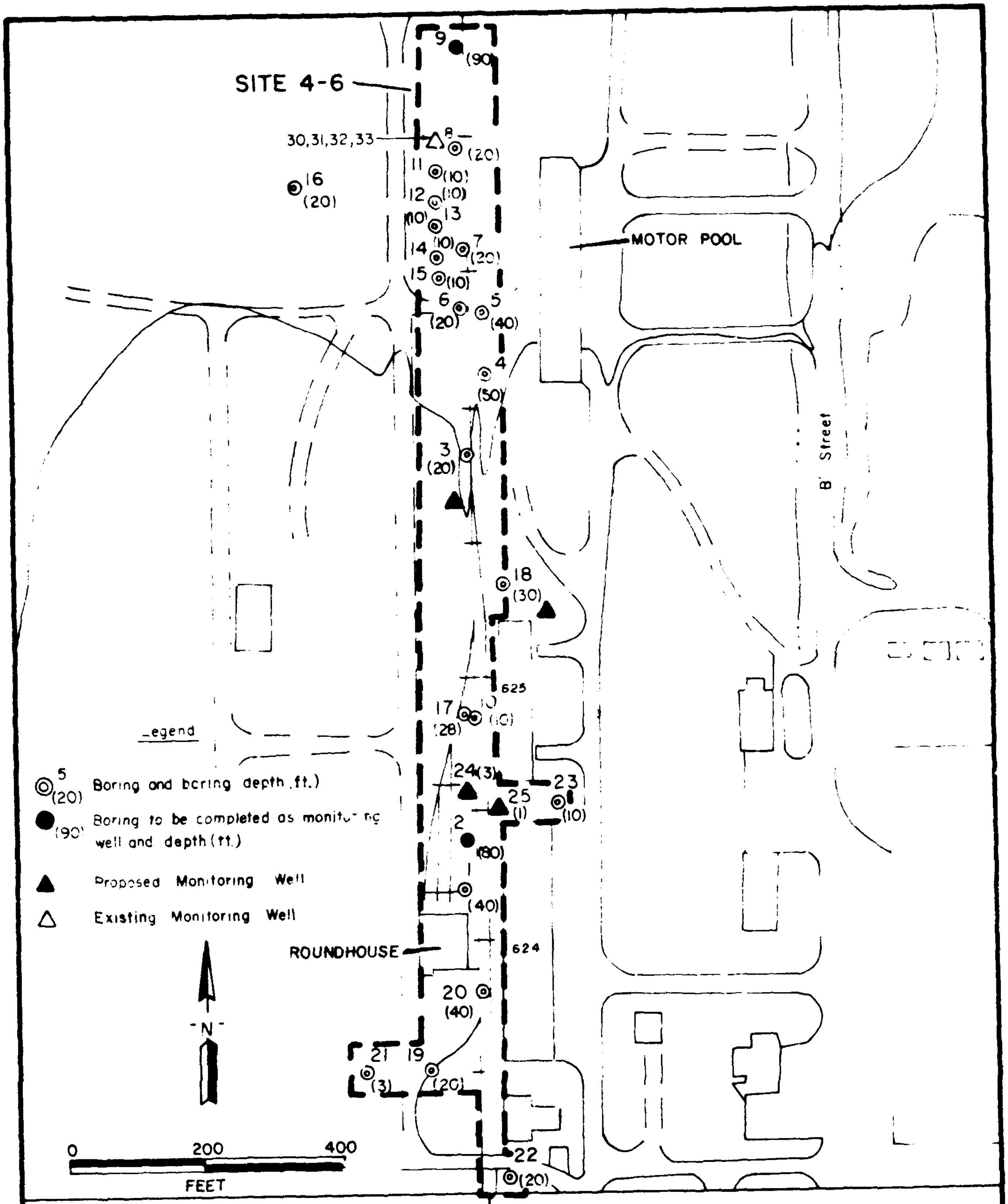

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FIGURE 3.2-4

Boring Location Map
Contamination Source 4-6

Rocky Mountain Arsenal, Task 38

Prepared by Ebasco Services Incorporated

Several of the wells in Task 38 will be installed in Task 15 boreholes. As in previous tasks, these bores will be drilled, logged, and sampled with an 8 inch continuous hollow stem auger. In order to install a 4 inch well in the Task 15 boreholes, the boreholes will be widened with a 12 inch auger to accommodate the 4 inch well casing and other construction materials. The remaining wells in this investigation will be drilled with a 12 inch plugged auger to bedrock (Denver Formation).

All of the new wells will have a diameter of 4 inches. Smaller (2 inch) wells are more difficult to develop and sample. The 4 inch wells may also permit limited pumping tests if the aquifer transmissivity is not excessively high and if they are determined to be necessary. This could be valuable in determining aquifer characteristics. The wells will provide data for the bedrock and will aid in identification of bedrock valleys and differences in permeabilities in these valleys. Samples will be taken with a 2 ft long spoon at 5 ft intervals to the water table. (Samples are usually not recoverable from the saturated zone.) These samples will be logged to help define the geology at the site. These samples will not be sent to the laboratory for chemical analysis.

Well installation and construction procedures will be followed as described in Section 1.2 of the Procedures Manual to the Technical Plan. Accompanying drilling, well construction, and well development logs will be maintained. In most wells, one 20 ft screen is sufficient to test the entire saturated thickness of alluvium. However, where the saturated thickness of alluvium exceeds 20 ft, well clusters will be installed. Each well in a cluster will have a 20 ft (or shorter) screen and as many wells as are necessary to test the entire saturated thickness will be installed. It is anticipated that three or more clusters of two or three wells each may be required to test the saturated thickness in areas of buried bedrock valleys. Slight modifications to the Procedures Manual may occur, such as selection of different slot sizes in the screens or selection of different protective casing sizes. Such modifications are discussed with the PMO in advance.

Well development performed on the completed monitoring wells to ensure a good hydraulic connection between the well and surrounding formation. Development will be started no sooner than forty-eight hours after mortar collar placement, and will be accomplished by means of pumps and/or bailers. A minimum of five times the volume of standing water in the well sand pack and annulus will be removed. Periodic pH and conductivity measurements of the well discharge will be taken during development, and detailed records of the development process will be maintained. Water discharged during development will be stored in 55 gallon drums.

Water levels will be measured in new monitoring wells during and after drilling, before and after development to determine the effectiveness of the well development, and before and after sampling to assess recovery characteristics of the aquifer. Water levels will be measured with an electronic sensing device, called an "m" scope, to the nearest 0.01 ft. Monthly water level measurements will be made at most wells in the Western Tier. One of the objectives of the water level study will be to assess the influence that the SACWSD production wells have had on the local groundwater flow. More frequent water level measurements will be recorded at selected wells that are located very close to the SACWSD wells.

Groundwater samples will be taken for chemical analysis no earlier than fourteen days after well development to allow the well to stabilize. Depth to water will be measured in each well prior to sampling and twenty-four hours after sampling. Fives times the volume of standing water in the well will be calculated, recorded, and removed. In instances where a well is slow to recover, the well will be completely dewatered and then allowed to fully recharge. As soon as the well has recharged, a sample will be collected. Water evacuated from potentially contaminated wells or wells within known plumes will be stored in 55 gallon drums.

A stainless steel or Teflon bottom filling bailer with a Teflon ball valve will be used to collect the groundwater sample. The line to raise and lower the bailer will consist of monofilament nylon. An unused portion of the nylon line will be retained for possible future use as a control sample. Before and after sampling, the bailer will be cleansed with a solution of trisodium phosphate and rinsed with distilled and then deionized water. Samples of the final rinse water (rinse blanks) will be analyzed on a weekly basis to test the effectiveness of the decontamination procedure. The nylon line will be replaced for each well and the old line disposed after use. A plastic sheet will be placed on the ground around the well to prevent soil contamination from tainting the groundwater samples. A used sheet of plastic will be retained for possible future use as a control sample. A total of five glass sample bottles will be filled at each well and these will constitute one sample. The bottles will be prepared and distributed by the laboratory and remain closed and sealed until the sampling event. The sampler will fill four 40 Teflon capped bottles. Two will be analyzed for volatile halogenated organics and two will be analyzed for volatile aromatic organics. A fifth one liter bottle will be filled and analyzed for dibromochloropropane. All sample bottles will be placed into a chilled cooler in the field and kept cold until analyzed.

A data sheet will be maintained which includes groundwater levels, time and data, sampling techniques, names of personnel, and water quality measurements (pH and conductivity).

A total of 17 groundwater monitoring wells or well clusters are expected to be installed and sampled to assess the degree and extent of groundwater contamination in the Western Tier (Figure 3.2-5). Note that locations shown in Figure 3.2-5 are tentative. Exact locations will be determined based upon information obtained during the study.

These wells will provide data for the evaluation of groundwater at the sites. Wells are also planned for the far western border of RMA where groundwater data are sparse. Analyses of samples from these wells are expected to define whether contaminants are migrating from the eastern side of Section 4 to the far western borders of Sections 4 and 33. Four wells/well clusters are planned for sites in Section 9. At least one well

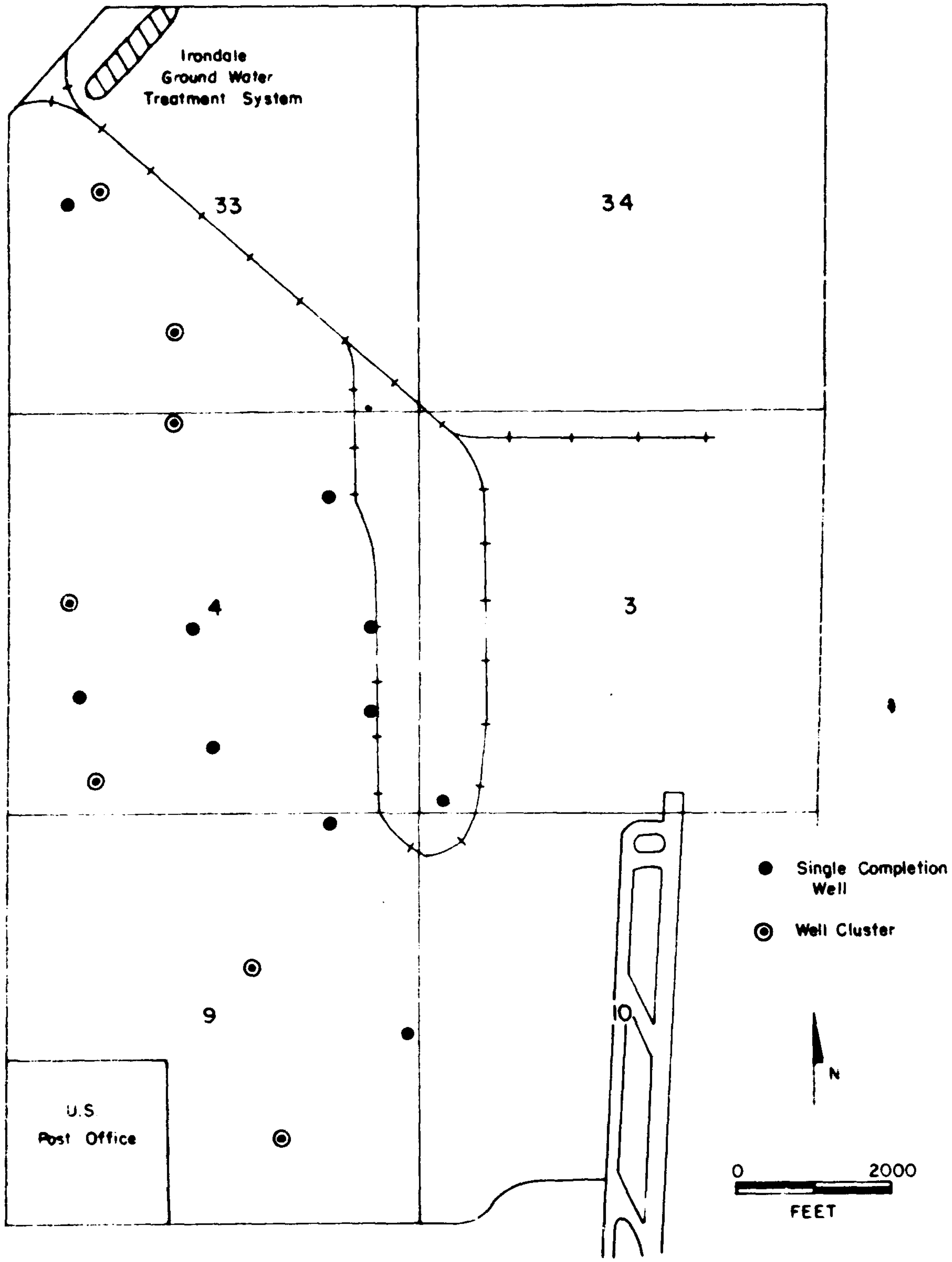

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FIGURE 3.2-5

Locations of Proposed Monitoring Wells

Rocky Mountain Arsenal, Task 38
Prepared by: Ebasco Services Incorporated

will be installed in the middle of a bedrock valley in the northwestern corner of Section 33, a valley which is to be mapped by geophysical methods. The SACWSD wells are located in this bedrock valley. Other wells will be located following further analysis of geophysical and hydrological data.

3.3 Definition of Contaminant Migration

Defining the direction and velocity of the contaminant migration will require the characterization of the geology and groundwater hydrology in the Western Tier. A review of historical data indicates that data needed for the characterization are presently insufficient and will need to be supplemented.

The geology will be defined by a program of soil borings, well drilling, and use of geophysical techniques. The soil borings planned for Site 4-6 and the well drilling throughout the Western Tier will provide information on the sediments overlying the Denver Formation. Each well, or if multiple completions, one well in each well cluster, will be drilled to bedrock (Denver Formation). These data will aid in the mapping of the bedrock surface and help identify bedrock channels that may affect groundwater movement.

EM34 conductivity, resistivity and microgravity surveys will be conducted in the western half of Sections 4 and 33. These geophysical techniques are to gather subsurface data that will be used with the well data to define the bedrock surface in these areas.

Monthly water level measurements will be made at all single completion wells and at the shallowest non-dry well in each multiple completion cluster in the Western Tier. One of the objectives of the water level study will be to assess the influence that the SACWSD production wells and the Irondale system have on the local groundwater flow. Weekly water level measurements will be recorded at Wells 33-11, 33-14, and 33-14, which are located closest to the SACWSD wells. Water levels in each well of a cluster will be individually monitored only if measurable head differences among the various completion points can be detected. These measurements will be taken until the end of 1986. These wells are located in the same bedrock valley as the SACWSD wells and will be monitored to determine the drawdown caused by the pumping of the SACWSD wells.

The TRC and PETREX soil gas programs will be used to define contaminant plumes in the subsurface. The shape and direction of movement of these plumes will provide indirect evidence of the flow direction of the groundwater.

Quarterly groundwater samples will be collected from all wells drilled for Task 38 until the end of 1986. The sampling will be coordinated with Environmental Science and Engineering (ESE) to allow for correlation with Task 4 sampling data. The groundwater quality data will allow mapping of the contaminant plume in the groundwater.

The monitoring well program will require the drilling of seventeen wells/well clusters, of which two are upgradient of bores drilled at Site 4-6. Soil samples will not be collected for chemical analysis during the drilling of the remaining wells because they will be located to track groundwater contaminant plumes rather than to define source areas.

Groundwater samples will be collected from the new monitoring wells as well as other existing wells selected to supplement this well network on a quarterly basis until the end of 1986. This will total approximately 80 samples including duplicates and blanks. Water level measurements will be collected from approximately 120 monitoring wells in Sections 4, 9, and 33 on a monthly basis, and from select wells in Section 33 on a weekly basis until the end of 1986.

The number of building samples to be collected cannot be determined at this time. Buildings to be sampled will be identified from historical information and preliminary site investigation.

3.4 Support

3.4.1 Facilities

Locations of the command center and support facilities are along the northern boundary of Section 1, approximately 2,500 ft east of its intersection with "D" Street, and north of Building 732 (Figure 3.4-1). RMA Facilities Engineering, with the support of Stearns-Roger, will provide 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 existing steam cleaning area. Personnel decontamination activities and facilities are described further in the Health and Safety Plan, located in the Litigation Technical Support and Services, Rocky Mountain Arsenal, Procedures Manual, Health and Safety Plan, Volume III (Ebasco, 1985b).

Heated and lighted warehouse space will be provided by RMA for the use of both Ebasco and ESE. The eastern half of Building 728 (see Figure 3.4-1) will be made available for this purpose. This building is divided in half by a firewall, and RMA has further subdivided the eastern half into three approximately equal areas by chain link fences. The central area is being used by RMA for miscellaneous equipment storage. The two outer areas will be used by Ebasco and ESE. Each of these outer areas can be accessed through separate 12 ft doors from separate loading docks on the north side of the building.

In addition to Building 728, RMA will provide warehouse space in Building 733C for storage of some sample cores obtained during this Task. Potentially hazardous solid materials such as cuttings and used protective clothing are placed in drums on pallets in Building 732 and stored in substantial compliance with applicable environmental regulations.

3.4.2 Activities

Surveying

Each soil boring, well, and soil gas sampling point will be surveyed to establish its elevation and map coordinates with respect to an appropriate,

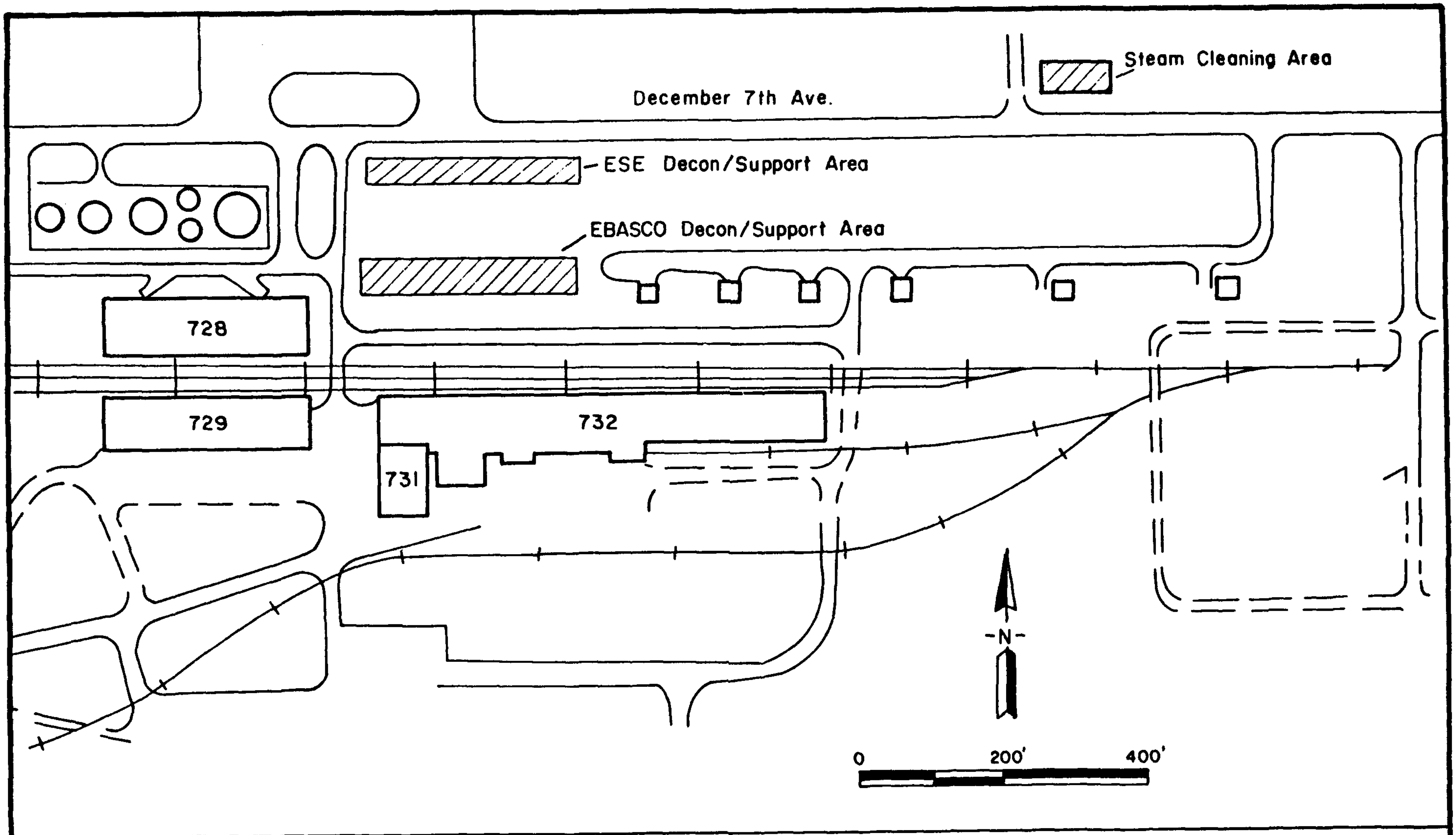

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FIGURE 3.4-1
Support Facility Locations in the
South Plants Area
Rocky Mountain Arsenal, Task 38
Prepared by: Ebasco Services Incorporated

established grid. Since most of the existing monitoring wells at the Arsenal have been located on the Colorado State Planar Coordinate System, this is the preferred grid. All locations will be surveyed to the nearest 0.1 ft (3 centimeters) vertically and 3 ft (1 meter) horizontally, consistent with PMO requirements. Because the PETREX soil gas technique is a reconnaissance tool, less accurate locations of sampling points are necessary. Therefore, PETREX sampling points need only be surveyed with the Brunton and chain method which is more cost effective than conventional surveying. Surveyed locations will be used to accurately map and calculate volumes of contaminated soils and to define groundwater contaminant plumes and flow patterns.

Borehole Clearing

Two geophysical methods will be used to locate potential borehole hazards such as buried ordnance and metallic objects. They are magnetics, using a magnetic field gradiometer, and resistivity, using a "pulse induction" metal detector. The same methods will be used to detect certain kinds of buried utilities. If the objects are within approximately 5 ft of the surface and are composed of ferrous (magnetic) material and/or electrically conductive material (iron, steel, aluminum, copper, etc.), they may be detectable; however, neither method is useful in detecting and locating nonferrous and/or nonmetallic objects. For example, some underground piping is known to consist of vitrified clay. This, as well as objects made of other nonconductive materials, is not detectable.

Decontamination

Decontamination of equipment and materials will be conducted in accordance with health and safety requirements and quality-control requirements. Equipment such as boring rigs and auger flytes will be maintained and decontaminated to preclude contamination between samples and from one site to another.

Some decontamination activities will take place at the boring locations. Major decontamination of equipment, particularly the larger pieces of equipment, will take place at the regional steam cleaning areas.

Waste Handling

At the direction of PMO, all contaminated wastes, including liquids, soils, and other solid wastes, will be containerized and stored at a designated central storage area that meets substantive RCRA requirements (U.S. EPA, 1985b). The following will be handled as contaminated wastes, unless they are sampled and confirmed to be free of any contamination:

- All soils not used for analysis purposes if they are from areas previously designated as contaminated;
- Disposable sampling gear;
- Liquids generated at the steam-cleaning pit; and
- Purge water from well development and sampling.

The solid materials will be placed in drums on pallets and removed to controlled storage sites (Building 732). Wastewater will be placed in a series of 1,500 to 2,500 gallon tanks. When the tanks are full, the water in the tanks will be analyzed. If it is free of contaminants, it will be disposed in the sanitary sewer. If it is contaminated, it will be disposed in the South Plants Laboratory Waste Treatment Facility.

Uncontaminated wastes will be disposed in the sanitary sewer system or in appropriate off-site trash disposal facilities. Portable or chemical toilet wastes will be disposed according to normal protocols.

Water Supply

Three types of water will be used for the sampling program. For steam cleaning, decontamination, and other related activities, the water to be used will be chlorinated city water, which will be obtained from the RMA fire department's water supply. Some sites require prior preparation, such as removal of concrete or asphalt above the soil boring area. Tools for cutting these hard materials often require cooling of the bits or blades with water. In these areas, where water might contact the underlying soil, unchlorinated clean water will be used. This water will come from an off-site uncontaminated source. Deionized water will be used for rinsing sampling equipment during decontamination procedures. This water will be provided by the RMA laboratory.

3.5 Summary

The assessment of the contamination of soils and groundwater in the Western Tier will require a multi-phase program of soil bores, well drilling, building sampling, geophysical surveys, soil gas surveys, groundwater sampling, and groundwater level measurements. The soil boring program at Site 4-6 will require drilling 25 bores and collecting 124 soil samples for chemical analysis. The depth and number of samples for each bore are summarized below.

No. of Bores	Depth (ft)	No. of Samples
1	1	1
2	3	4
7	10	21
7	20	35
2	30	12
3	40	21
1	50	8
2	80	22

4.0 CHEMICAL ANALYSIS PLAN

4.1 Introduction

The chemical analysis program is designed to be consistent with the sampling program for all other Remedial Investigation tasks at RMA. Analytical methods for this task are described in more detail below. These analytical methods identified in the Task 2 Technical Plan were divided between the four contract laboratories for method development prior to the initiation of Task 2 field activities. Once a method was developed it was distributed to all laboratories in the program for certification.

Samples collected from selected areas in Sections 3, 4, 9, and 33 will be screened for target analytes. Matrix samples will be assayed for analyte profiles identified in Table 4.1-1. A summary of laboratory analyses indicating preservation guidelines, analytical methods required, level of certifications, total analytical requirements, and weekly laboratory rates of analysis is given in Volume II of the RMA Procedures Manual (Ebasco, 1985b).

Soil will be sampled during Task 38. Soil and solid matrix samples (e.g. soil borings and sediments) will be assayed semi-quantitatively by gas chromatography/mass spectrometry (GC/MS) for volatile and semivolatile organic target analytes and by quantitative methods for target metals. Liquid matrix samples will be assayed by specific quantitative methods to provide data on the extent of contamination at each specific source of interest.

Tables 4.1-2 and 4.1-3 identify the analytical methods, desired analyte concentration, high range concentration, sample holding time, required level of certification, reference method, and principle of method for the Task 38 survey for soil and water analyses, respectively. Sample shipping and holding temperatures are indicated in the QA/QC plan of the RMA Procedures Manual (Ebasco, 1985b, Volume II). A summary of Task 38 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 of the RMA Procedures Manual (Ebasco, 1985b, Volume II).

TABLE 4.1-1
SAMPLE ANALYSES

MATRIX OF SAMPLES	
Soil, Sediments, and Sludge	Water
Volatile Organics	Vol. Halo. Organics
Semivolatile Organics	Vol. Arom. Organics
Metals by ICP	1,2-Dibromo-3-Chloropropane
Arsenic	
Mercury	

TABLE 4.1-2
ANALYTICAL METHODS/SOLID MATRIX (SOIL, SOLIDS, SEDIMENT) FOR TASK 38

Analysis/Matrix/Analytes	Detection Limit*	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Volatile Organics/Solids			7 days for the solid and 30 days for the extract (1)	Semi-Quantitative (A)	USATHAMA N9 for UBTL and K9 for CAL	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. Surrogates are: d_2 - Methylene chloride d_6 - Benzene d_{10} - Ethylbenzene The internal standard will be 1,2-dibromoethane-d_4.
1,1-Dichloroethane	0.6 ug/g	5 ug/g				
Dichloromethane	2.0 ug/g	25 ug/g				
1,2-Dichloroethane	2.0 ug/g	25 ug/g				
1,1,1-Trichloroethane	0.4 ug/g	10 ug/g				
1,1,2-Trichloroethane	0.4 ug/g	25 ug/g				
Carbon tetrachloride	0.3 ug/g	10 ug/g				
Chloroform	0.3 ug/g	5 ug/g				
Tetrachloroethylene	0.3 ug/g	25 ug/g				
Trichloroethylene	0.5 ug/g	25 ug/g				
Trans-1,2-Dichloroethylene	0.5 ug/g	25 ug/g				
Benzene	0.3 ug/g	25 ug/g				
Toluene	0.3 ug/g	25 ug/g				
m-Xylene	0.8 ug/g	10 ug/g				
o,p-Xylene	5.0 ug/g	50 ug/g				
Ethylbenzene	0.4 ug/g	25 ug/g				
Chlorobenzene	1.0 ug/g	10 ug/g				
Methylisobutyl ketone	0.7 ug/g	25 ug/g				
Dimethyldisulfide	20 ug/g	25 ug/g				
Bicycloheptadiene	0.4 ug/g	10 ug/g				
Dicyclopentadiene	0.7 ug/g	25 ug/g				
1,2-Dibromo-3-chloropropane	2.0 ug/g	25 ug/g				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 soxhelet with 300 ml of methylene chloride. The extract is reduced to a final volume of 10 ml in a K-D aparatus. An aliquot of the extract is analyzed by fused silica capillary GC/MS. Surrogates and internal standards are used. Unknowns are identified.
Semi-Volatile Organics/Solids			7 days for the solid & 30 days for the extract (1)	Semi-Quantitative (A)	USATHAMA L9 for UBTL, X9 for CAL and X9-A for HEA	
Aldrin	0.3 ug/g	100 ug/g				
Endrin	0.5 ug/g	25 ug/g				
Dieldrin	0.3 ug/g	100 ug/g				
Isodrin	0.3 ug/g	25 ug/g				
p,p'-DDT	0.5 ug/g	25 ug/g				
p,p'-DDE	0.6 ug/g	50 ug/g				
Chlorophenylmethyl sulfide	0.9 ug/g	100 ug/g				
Chlorophenylmethyl sulfoxide	0.3 ug/g	100 ug/g				
Chlorophenylmethyl sulfone (CPMSO)	0.3 ug/g	100 ug/g				

TABLE 4.1-2 (Continued)

Analysis/Matrix/Analytes	Detection Limit[a]	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Hexachlorocyclopentadiene	0.6 ug/g	25 ug/g				Surrogates are: d_4-1,3-Dichlorobenzene d_4-Diethylphthalate d_4-2-Chlorophenol d_4 Di-n-Octyl Phthalate
Oxathiane	0.3 ug/g	100 ug/g				
Dithiane	0.4 ug/g	100 ug/g				
Malathion	0.7 ug/g	25 ug/g				
Parathion	0.9 ug/g	25 ug/g				
Chlordane	2.0 ug/g	25 ug/g				
Vapona	3.0 ug/g	100 ug/g				The internal standard will be d_{10} Phenanthrene
Supona	0.6 ug/g	25 ug/g				
DIMP	1.0 ug/g	100 ug/g				
Atrazine	0.3 ug/g	100 ug/g				
1,2-Dibromo-3-chloropropane	0.3 ug/g	100 ug/g				
ICP Metal Screen/Solids			6 mos (3)	Quantitative (B)	USATHAMA P9 for UBTL and A9 for CAL	
Cadmium	0.7 ug/g	50 ug/g				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.
Chromium	6.5 ug/g	500 ug/g				
Copper	4.7 ug/g	500 ug/g				
Lead	8.4 ug/g	500 ug/g				
Zinc	8.7 ug/g	500 ug/g				
Aluminum	Interelement Correction					
Iron	Interelement Correction					

TABLE 4.1-2 (Continued)

Analysis/Matrix/Analytes	Detection Limit[a]	High Range Concentration	Hold Time	Level of Certification	Reference Methods	Principle of Method
Arsenic/Solids	2.5 ug/g	50 ug/g	6 mos	Quantitative (B)	USATHAMA B9 for UBTL and G9 for CAL	A one gram portion of the sample is digested with $H_2O_2 + HNO_3$. The digest is analyzed by GF/AA.
Mercury/Solids	0.1 ug/g	0.2 ug/g	28 days (3)	Quantitative (B)	USATHAMA Y9 for UBTL and J9 for CAL	A one gram portion is weighed out 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.
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.

TABLE 4.1-2 (Continued)

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

References:

(1) SW-846, 2nd ed., July 1982.

(2) EPA-600/4-82-057, July 1982 Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater.

(3) EPA-600/4-79-020, Revised March 1983 Methods for Chemical *Analysis of Water and Wastes*.

(4) ESE-AMD.2-UD-H_2O.1, July 22, 1982.

(5) Methods of Soil Analysis, Part 2: Chemical and Microbiological Properties-Agronomy Monograph No. 9, 2nd Edition. Published by the American Society of Agronomy, Inc. Madison, Wisconsin, 1965. Sixth Printing 1983.

Notes:

(A) Semi-Quantitative: See Section III of the Litigation Technical Support and Services Rocky Mountain Arsenal Procedures Manual, Section 11.2.2.1.

(B) Quantitative: See Section III of the Litigation Technical Support and Services Rocky Mountain Arsenal Procedures Manual, Section 11.2.2.2.

TABLE 4.1-3
ANALYTICAL METHODS/LIQUID MATRIX FOR TASK 38

Analysis/Matrix/Analytes	Detection Limit[a]	High Range Concentration[a]	Hold Time	Level of Certification	Reference Methods	Principle of Method[b]
Volatile Halo Organics/Water			14 days (1)	Quantitative	N8	Purge and Trap GC/Hall Detector with a packed column (1% SP-1000 on Carbopack B) 1,2-dibromoethane or other suitable internal standard will be used based on Phase 1 experience to monitor purge efficiency.
Chlorobenzene	0.8 ug/L	200 ug/L				
Chloroform	0.5 ug/L	200 ug/L				
1,1-Dichloroethane	0.7 ug/L	200 ug/L				
1,2-Dichloroethane	1.1 ug/L	200 ug/L				
1,1,1-Trichloroethane	0.8 ug/L	200 ug/L				
1,1,2-Trichloroethane	0.8 ug/L	200 ug/L				
Tetrachloroethylene	0.8 ug/L	200 ug/L				
Trichloroethylene	0.6 ug/L	200 ug/L				
Dichloromethane	1 ug/L	50 ug/L				
Carbon tetrachloride	1 ug/L	200 ug/L				
1,1-Dichloroethene	1.7 ug/L	200 ug/L				
Volatile Arom. Organics/Water			7 days (1)	Quantitative	C8	Purge and Trap/GC/PID with a packed column (1% SP-1000 on Carbopack B, to permit runs in conjunction with EPA 601). A suitable internal standard will be used based on Phase I experience to monitor purge efficiency.
Benzene	1.7 ug/L	25 ug/L				
Toluene	2.8 ug/L	25 ug/L				
Xylenes	3.2 ug/L	25 ug/L				
Ethyl benzene	1.4 ug/L	25 ug/L				

TABLE 4.1-3 (Continued)

Analysis/Matrix/Analytes	Detection Limit*	High Range Concentration[a]	Hold Time	Level of Certification	Reference Methods	Principle of Method
1,2-Dibromo-3-chloropropane/Water	0.2 ug/L	2 ug/L	Extract within 7 days, analyze within 30. See EPA 625 (1)	Quantitative	Developed by MRI for USATHAMA Certification	A 90 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.

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

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

References:
(1) EPA-600/4-82-057, July 1982 "Methods for Organic Chemical Analysis of Principal and Industrial Wastewater".

4.2 Sample Matrices

All soil, sludge, sediment, and solid matrices will be considered as soils for analytical purposes. Prior to sample collection, all soil and solid analytical methods had been USATHAMA/PMO Certified for a standard soil. This standard soil was a background soil collected from the RMA area. Data for soil and solid matrices initially will be reported on a dry weight basis and may be converted to a wet weight basis.

Similarly, aqueous analytical methods are USATHAMA/PMO Certified for all 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).

4.3 Analytical Methods for Solid Matrices

This section briefly describes the analytical methods for target analytes and their desired detection limits in the Task 38 survey. Table 4.1-2 summarizes each analytical method. USATHAMA/PMO Certified analytical methods for Task 38 are described in the order of occurrence as shown in Table 4.1-2. The noncertified method for volatile organics in air follows the certified methods described, as shown in Table 4.1-2. The specific protocol for each method may be reviewed in Volume IV: Project Specific Analytical Methods Manual, RMA Procedures Manual (Ebasco, 1985b).

4.3.1 Volatile Organics

The volatile organics method in solids is based on EPA Method 8240 (EPA, 1982b). This method is USATHAMA/PMO Certified for soils and solids at the semi-quantitative level for the Task 38 Program.

Due to their volatility, analysis for these compounds will be restricted to deep soils or surface soils contaminated with oil. A volatile organics analysis will be performed on oil contaminated surface soils because of the possibility that contaminating oils may trap volatiles in these soils.

In this method, a ten gram (g) 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 lid and shaken for four hours. A 20 microgram (ug) aliquot of the methanol extract will be removed, spiked with 200 ug 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 will then be 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 4.1-2.

In addition, the total ion current profile will be screened for major unknown peaks. An attempt will be made to identify the major unknown peaks that 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 concentration, fit, and probability to match for the most likely candidate compound from the Environmental Protection Agency/National Bureau of Standards/National Institute of Health (EPA/NBS/NIH) Mass Spectral library computer program.

4.3.2 Semivolatile Organics

This analytical technique is based on EPA Method 8270 in solids (EPA, 1982b) and is USATHAMA/PMO Certified in soils and solids at the semi-quantitative level for the Task 38 program.

Using this method, a fifteen gram portion of the sample obtained with a minimum of handling and spiked with the surrogates 1,3-dichloro-benzene-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 soxhelet extracted for eight hours with 300 ml methylene chloride. 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 analyzed on a fused silica capillary column by GC/MS. Samples will be assayed for target analytes at the detection limits shown in Table 4.1-2. In addition, the total ion current profile will be scanned for major unknown peaks and an attempt will be made to identify these unknown major peaks.

4.3.3 Metals

The ICP method, based on USATHAMA Method 7S, is USATHAMA/PMO Certified at the quantitative level. In this procedure, a one gram portion of sample is digested in a watch glass covered Griffin beaker with 3 ml of concentrated nitric acid. Contents of the beaker are heated to near dryness and repeated portions of concentrated nitric acid added until the sample is completely digested. The digestion process is finished with 2 ml of 1:1 nitric acid and 2 ml of 1:1 hydrochloric acid. The sample digest is 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 50 ml and assayed by ICP.

Samples will be assayed for target metals at detection limits identified in Table 4.1-2.

4.3.4 Arsenic

The arsenic method in soils and solids is developed from EPA Method 7060 (EPA, 1982b). Using this method, a one gram sample is digested with hydrogen peroxide and concentrated nitric acid. The digest is filtered and assayed by graphite furnace atomic absorption spectrometry. The target detection limit for arsenic is 1 microgram per gram (ug/g). This method is USATHAMA/PMO Certified at the quantitative level.

4.3.5 Mercury

This mercury method, developed from EPA Method 245.5 (EPA, 1982a), is USATHAMA/PMO Certified at the quantitative level. In the method a one gram sample portion is digested with aqua regia followed by treatment with potassium permanganate. Excess permanganate is reduced with hydroxylamine sulfate. Mercury is reduced with stannous chloride and assayed by cold vapor AA. The target detection limit for mercury is 0.1 ug/g.

4.3.6 Volatile Organic Compounds in Air Using Activated Charcoal and Tenax

This method was designed by DataChem for the National Institute of Occupational Safety and Health. It was 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 Task 38 program. The charcoal is desorbed with methylene chloride, and tenax with isooctane. Extracts are analyzed by packed column or fused silica capillary column GC/MS in order to identify significant unknown compounds. This method is not PMO Certified.

4.3.7 Nontarget Compounds

The total ion current profile will be screnned for all major nontarget peaks. The laboratories will report all nontarget analytes with peaks greater than 10 percent of the internal standard response (giving RT (retention time) Code, estimating concentrations, and printing MS (mass spectral) traces). Each of these major peaks greater than 10 percent of the internal standard response (excluding obviously meaningless peaks, e.g., column bleeds) will be reported as to the purity, fit, and probability to match for the three most likely candidate compounds from the EPA/NBS/NIH Mass Spectral library computer program.

4.4 Analytical Methods for Liquid Matrices

Analytical methods, target analytes, and desired detection limits for liquid samples are discussed in this section and summarized in Table 4.1-3. Groundwater samples will be subjected to volatile halogenated organics, volatile aromatic organics, and dibromochloropropane analyses.

4.4.1 Volatile Halogenated Organics

The analytical method for volatile halogenated organics in water is based on EPA Method 601 (USEPA 1982a). This analytical procedure is a purge and trap method, assayed on a packed column (1% SP-1000 on Carbopack B) by GC equipped with a Hall electrolytic conductivity detector. Water samples are spiked with 1,2 dibromomethane or other suitable internal standard. Volatile halogenated organic analyses and desired detection limits are identified in Table 4.1-3.

4.4.2 Volatile Aromatic Organics

The volatile aromatic hydrocarbon method is based on EPA Method 6-2 (USEPA 1982a) for water. Analysis of volatile aromatics in water is by a purge and trap method, analyzed by GC equipped with a photoionization detector using a packed column (1% SP-1000 on Carbopack B). Table 4.1-3 lists the volatile aromatic organic constituents and target detection limits.

4.4.3 Dibromochloropropane

A 90 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 is specified based on previous experience to monitor purge efficiency. The target detection limit for dibromochloropropane is 10 ug/l.

4.5 Analytical Methods for Soil Gas Samples

Two separate soil gas techniques will be used in the Task 38 investigation. The Tracer Research Corporation will use a portable gas chromatograph mounted in a truck which analyzes soil gases after they are drawn from a ground probe by a vacuum pump. The PETREX collector will consist of a ferromagnetic wire coated with activated charcoal. The collector will be placed in the ground for several weeks before laboratory analysis. In the laboratory, the collector will be analyzed by Curie point desorption mass spectrometry.

4.5.1 Tracer Research GC Technique

Tracer Research Corporation utilizes an analytical field van which is equipped with a Varian 6000 gas chromatograph and two Spectra-Physics SP4270 computing integrators. In addition, the van has two built in gasoline powered generators which provide the electrical power (110 volts AC) to operate all of the field equipment. During the soil gas evacuation, samples will be collected by inserting a syringe needle through the silicone evacuation line and down into the steel probe. Ten milliliters of gas will be collected for immediate analysis in the TRC analytical field van. Soil gas will be subsampled (duplicated injections) in volumes ranging from 1 ml to 2 ml, depending on the volatile organic compound concentration at any particular location. Detection limits for the halogenated hydrocarbons ranged from 0.01 to 0.0002 micrograms per liter of air (ug/l) using an electron capture detector. Detection limits are a function of the injection volume as well as the detector sensitivity for individual compounds. The minimum detectable quantity of halogenated hydrocarbons (e.g. tetrachloroethylene) is about 2×10^{-14} grams.

To prevent any cross-contamination of soil gas samples the following quality assurance procedures will be followed. Prior to sampling, syringes will be purged with nitrogen (i.e. carrier gas) and checked for contamination by injection into the gas chromatograph. System blanks will be run periodically to confirm that there is no contamination in the probes, adaptors, or 10 ml syringes. Soil gas probes will be used only once during the course of a working day and then cleaned with soap and high-pressure hot water or steam before use on the subsequent day. Analytical instruments will be checked continuously for calibration by the use of chemical standards prepared in water from commercially available pure chemicals. Soil gas pumping will be monitored by a vacuum gauge to ensure that an adequate gas flow from the vadose zone is maintained. A negative pressure (vacuum) greater than 15 in. of Hg usually indicates that a reliable gas sample cannot be obtained because of a clogged probe or because the soil has a very low air porosity.

4.5.2 PETREX GC/MS Technique

PETREX collector wires will be analyzed by Curie point desorption mass spectrometry. The compounds will be desorbed from the wire, ionized, separated according to mass, counted, and ion counts from 29 to 240 reported. The method of identification allows for determination of the proper isotopic distribution of masses (m/z) in each sample's mass spectrum. For all compounds, the most prominent peak which falls into a unique region of the mass spectrum with little or no interference from other compound fragmentation was used as the indicator peak for that compound. In the case of TCE, TCA, and PCE, the indicator peaks will be m/z 130, m/z 97, and m/z 164, respectively. Detected compounds are indicated as raw flux (ion count) values for each sampling collector. The raw ion count is a flux which is not a measure of concentration but rather an expression of a component's emanation rate at a given location. There is no method established to calculate subsurface contaminant concentrations levels from surficial flux levels. The ion counts merely give an indication of the relative presence of the compound of concern. Thus, the PETREX method is suitable only as a screening technique.

5.0 QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

5.1 Project QA/QC Plan

An integral part of this Task 38 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 38, Ebasco will adhere to and comply with the established QA/QC requirements. The plan is presented in the RMA Procedures Manual Volume II (Ebasco, 1985b). The specific objectives of the Ebasco Quality Assurance Program for RMA are to:

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

The overall project QA/QC responsibility will rest with the Project QA/QC Coordinator. He will be assisted by the Field and Laboratory QA/QC Coordinators. Each field sampling team will include a Field QA/QC Coordinator. The Field QA/QC Coordinator for each team will ensure 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 comply with the Project QA/QC Plan. Each laboratory has appointed a Laboratory QA/QC Coordinator. Their responsibilities will include:

- Monitoring the quality control activities of the laboratory;
- Recommending improvement in laboratory quality control protocol, when necessary;
- Logging in samples, introducing control samples in the sample train, and establishing sample testing lot sizes;
- Approving all data before submission to permanent storage;
- Maintaining all quality control records and chain-of-custody documents;
- Assuring document and sample security;
- Informing Ebasco's Project QA/QC Coordinator of noncompliance with the Project QA/QC Plan; and
- Preparing and submitting a weekly report of quality control data to the Ebasco Project QA/QC 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 (RMA Procedures Manual, Volume II). These requirements are based on the geotechnical guidelines established by PMO. 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 and monitoring of drilling operations.

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/QC Coordinators (FQA/QC). Samples will 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 taken. The FQA/QC will be responsible for field chain-of-custody documentation and transfer and 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/QC Program will begin with the receipt of the samples from the field. All samples will be shipped to DataChem for logging in, sample splitting, and distribution for analyses. The Laboratory QA/QC Coordinator will be responsible for monitoring the laboratory activities. He will also be responsible for determining testing lot sizes and introducing laboratory control samples into the testing lot in an inconspicuous manner.

The samples will be analyzed within the prescribed holding time by the approved analytical methods. Analytical methods are described in Section 4.0 of this 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 QA/QC Coordinator for each laboratory will monitor the analytical controls. The out-of-control situation can be detected by the control charts.

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

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

Sections 13 through 16 of the Project QA/QC Plan detail the procedures for laboratory data review, validation and reporting procedures. The laboratories will utilize highly automated systems for analytical data collection and reduction. The analytical supervisor along with the Laboratory QA/QC Coordinator will review all analytical data after data reduction and prior to the transfer of the data report to Ebasco. The laboratory data reporting procedure is described in Section 15 of the Project QA/QC Plan, which is based on the established PMO reporting procedures for analyses performed at quantitative and semi-quantitative levels. The laboratories will adhere to these reporting procedures.

6.0 DATA MANAGEMENT PROGRAM

6.1 Plan Overview

This plan presents the data management procedures to be used by Ebasco for the Environmental Program at Rocky Mountain Arsenal. As specified in the contract, all data are presented to PMO in appropriate format and entered into the IR-DMS UNIVAC 1100/61. PMO has provided a Tektronix 4051 system and IR Data Management User's Guide, Version 85.6 (PMO, 1985) to Ebasco for this purpose. Data will be controlled as necessary. Presentation of project management data and report communication is discussed in Ebasco's Management Plan.

Figure 6.1-1 shows schematically the process Ebasco will use to coordinate data management activities between itself, DataChem, CAL, and IR-DMS. This is detailed in Section 6.3. As shown in Figure 6.1-1, Ebasco's primary data entry terminal for the IR-DMS will be through the Army-owned Tektronix terminal in Ebasco's Denver office. A second Army-owned terminal will be maintained in Ebasco's Santa Ana office for backup data entry purposes. Specifics of data collection, data entry, data validation, and data analysis are discussed herein.

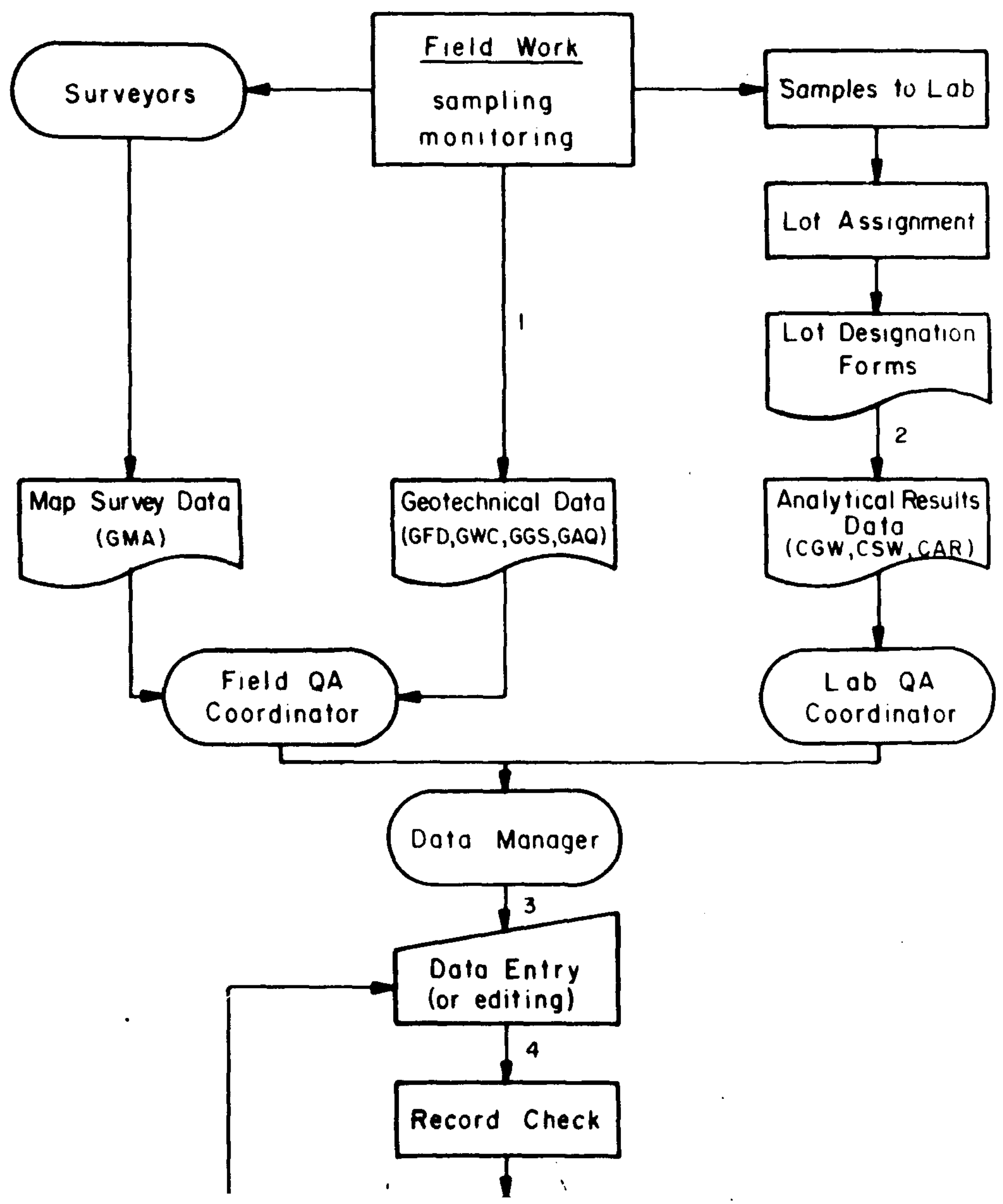
6.2 Field Activities

6.2.1 Sample Handling

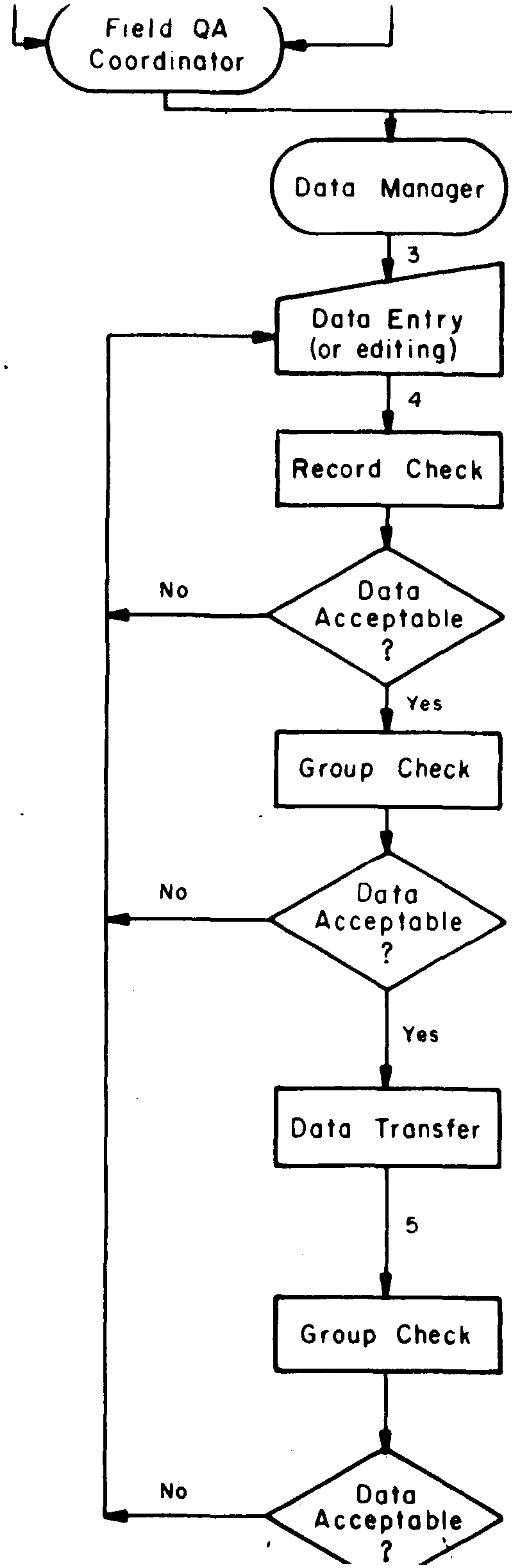
The Sample Coordinator is responsible for field data collection and logging of the sampling program. In addition, the Sample Coordinator will ensure that all field data are properly accounted for and transferred to the data manager for input into the computer at Ebasco's Denver office. To accomplish this, the Sample Coordinator will ensure that proper sample collection procedures, sample control identification procedures, and proper chain-of-custody procedures are followed.

Sample control identification numbers will be assigned to each sample collected in the field by the Sample Coordinator. These sample identifiers will 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 also will serve as the analytical request form, verifiable by the analytical request

DATA FLOW



1OF3



Numbers indicate points of entry of information onto the Data Management Tracking System.

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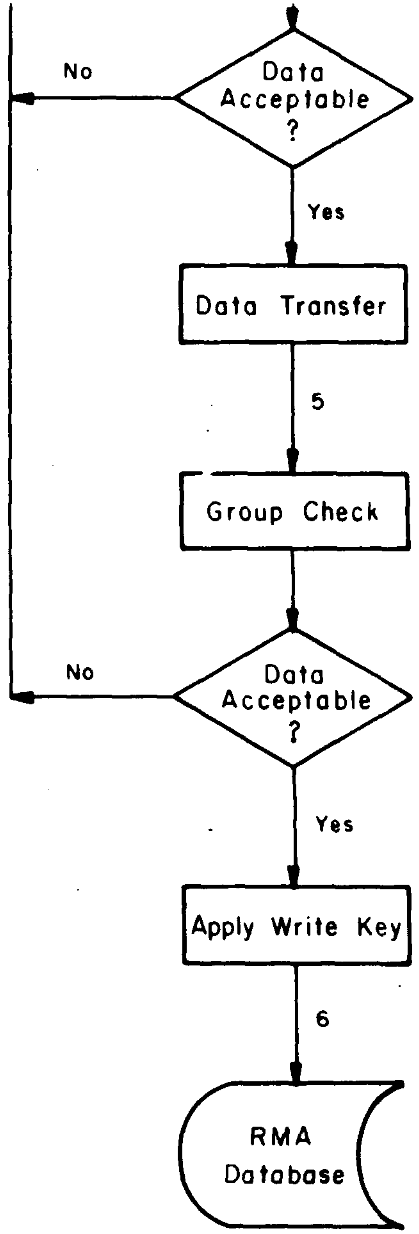
Prepared for:

3oF3



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Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

FIGURE 6.1-1

Data Flow Between Ebasco, DataChem, CAL and IR-DMS

Rocky Mountain Arsenal, Task 38

Prepared by Ebasco Services Incorporated list on the sample tag. The Sample Coordinator will check sample tags, chain-of-custody forms, and field data logs to ensure 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, packages and seals the samples for shipment to the laboratory, and assures 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.

6.2.2 Geotechnical Program

Geotechnical boring logs, containing pertinent data regarding bore-hole lithology, will be coded immediately upon receipt from the field onto PMO 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 PMO data coding sheets, and 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.

6.2.3 Laboratory

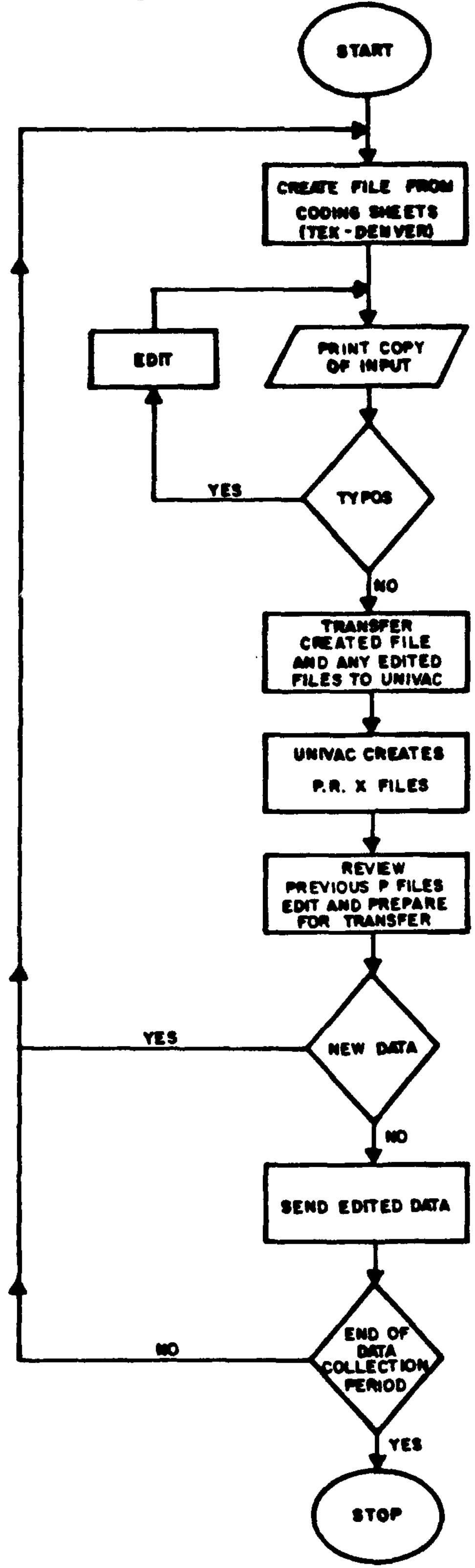
When samples are received at DataChem, the sample receipt officer signs the chain-of-custody record, logs in sample shipment, verifies sample integrity, assigns sample lots, prepares split samples, and identifies samples to be sent to CAL or to be retained by DataChem for chemical analysis. Each laboratory, DataChem 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 DataChem 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 illustrates the flow of data to enter laboratory results into the IR-DMS Univac 1100/60. 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 enters only a subset of a complete file at one time. These file subsets later will 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 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, and then obtain a second printing of the file to confirm that the changes were properly made. Methods certification data and map location data will be entered first because validation routines make use of it.

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



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Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

FIGURE 6.3-1

Laboratory Data Flow to the IR-DMS UNIVAC 1100/61 System

Rocky Mountain Arsenal, Task 38

Prepared by: Ebasco Services Incorporated

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

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

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

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

6.4 Analysis and Presentation

Ebasco scientists will access the PMO IR database and 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 database in order to perform analyses and prepare material for presentation. The Tektronix 4051 terminals in Denver and Santa Ana will also be used in a direct link to the UNIVAC to prepare analyses and graphic representations. Ebasco scientists may establish communication links between IBM PCs to interchange data and facilitate data analysis.

7.0 HEALTH AND SAFETY PLAN

7.1 General

A draft of the project Health and Safety Plan (HASP), prepared according to the Ebasco Corporate Health and Safety Program, is included in the RMA Procedures Manual, Volume III (Ebasco, 1985b). The purpose of this section is to provide an overview of the safety program that Ebasco will use 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 Western Tier Area investigative activities. These are:

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

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

- Characterizing the potential specific chemical and physical hazards to be encountered;

- Developing all safety procedures and operation on-site;

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

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

Based on the evaluation of historical data, Sites 4-2 and 4-6 appear to have the most potential for containing contaminants in the soils. 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 will be used for the RMA project. Basically, the training focuses 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:

- Zone approach for field work
- Personnel protection
- Communications

A three zone approach (Support Zone, Contamination Reduction Zone, and Exclusion Zone), where possible, will be used for field work at RMA. The Support Zone contains 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 the field team is operating downrange. Adjacent to the Support Zone is the Contamination Reduction Zone (CRZ) which contains 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 are considered the Exclusion Zone. For well drilling or soil boring operations, the Exclusion Zone will be established as a 30 ft radius from the drill rig. These support facilities are discussed and illustrated in Section III.

The level of protection to be worn by field personnel is defined and controlled by the on-site Health and Safety Coordinator and is specifically defined for each operation in an information sheet (Facility Information Sheet). The preliminary Facility Information Sheet (FIS) is developed based upon historical information and data. This will be upgraded and used for future operations based upon the results of the Health and Safety portion of the Soil Sampling programs. For these programs, Level "C" type protection generally will be provided for investigation team members; however, Level "D" type protection may also be used 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 "B" protection can be easily achieved in the field. This can be accomplished in a matter of hours. Basic levels 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:

- Walkie Talkies
- Air Horns
- Hand Signal
- Voice Amplification System

For external communication telephones and sirens will be used.

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:

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

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

- M18A2 Chemcial Agent Kit for Army Agents
- M8 Alarm for nerve agent
- Oxygen meter for oxgen level
- Combustible gas indicator for explosive condition
- PID and FID meters for organic vapors

- For inoganic 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.

7.2 Task 38 Site Specific Health and Safety Considerations

7.2.1 Boring Program

All RMA HASP requirements will be observed for invasive activities such as soil borings. Contaminated items may have been dumped at Sites 4-2 and 4-4, and the TCE investigations may extend into these sites. Additionally, materials from an old mustard plant may be buried at Site 4-4 (PMCDIR, 1977). As a result, Sites 4-2 and 4-4 are suspected army agent sites. Level C respiratory and dermal protection are required. Site 4-6 is located in the motor pool area. The level of protection is Level C with the option to downgrade if there are no detectable levels of contaminants on the monitors. Real-time monitoring equipment will be used to determine if the upgrading of protection levels is necessary. The remainder of the sites will be considered uncontaminated and Level D protection with monitoring is sufficient.

7.2.2 Building Investigations

The RMA HASP building entry provisions will be used for activities involving entry of buildings. Buildings initially will be entered at Level C protection with appropriate monitoring. Building entry may take place at Level D if sufficient data and information indicates the lack of contamination. Entry of buildings in Level D includes real-time monitoring for potential problems and provisions for upgrading of the levels of protection.

7.2.3 Soil Gas Sampling

Soil gas sampling will be conducted in Level D provided the operations take place in the uncontaminated areas. The special precautions required for this activity will be the care in observing for normal floral and fauna hazards such as poisonous plants and snakes.

7.2.4 Potential Dibromochloropropane Areas

In areas where groundwater is potentially contaminated with dibromochloropropane (DBCP), an evaluation of the potential airborne concentration will be conducted. If volatilization calculations (using worst-case conditions) indicate that airborne DBCP concentrations may be significant, then Level B protection will be used until the levels of DBCP can be determined to be significantly below the Permissible Exposure Levels set by OSHA. Air samples for DBCP will be collected at the breathing zone and analyzed. If the levels of DBCP are found to be insignificant then the level of protection will be downgraded as appropriate. Splash aprons and face shields will be used to prevent possible dermal contact with DBCP contaminated water.

Once results of the first round of groundwater sampling from potential DBCP areas have been received, the requirements for personal protection will be reassessed. If no DBCP or other significant contaminants are discovered through the sampling and analysis efforts, then Level D protection with monitoring will be employed.

8.0 CONTAMINATION ASSESSMENT/REMEDIAL ACTION

8.1 Objectives

The objectives of the Contaminant Assessment Program are to quantify the contaminants present; assess the extent of contamination; evaluate the factors that govern contaminant distribution and migration within potentially contaminated areas in Sections 3, 4, 9, and 33, and determine the severity and significance of the contamination. In order to accomplish objectives of the overall program, the contamination assessment consists of the following subtasks:

1. Determination of the magnitude, distribution, and extent of contamination;

2. Examination of the geologic and hydrogeologic influence on the spatial distribution of contaminants and on their movement within the alluvial aquifer;

3. Estimation of the impact of on-post soil and groundwater contamination to off-post drinking water supplies; and

4. Evaluation of the technical and economic feasibility of various contaminant remediation measures and recommendation of further actions.

8.2 Magnitude, Distribution, and Mobilization of TCE

The results of the soil boring and groundwater analyses will be examined to determine the presence, quantities, and extent of contamination within the Task 38 areas. Compilation of soil-contaminant data by source, location, and depth will provide examination of the areal and vertical extent of contamination. Chemical data from monitoring wells will provide information necessary to define the extent of migration of contaminants in the groundwater. The chemical data will be integrated with the soil 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.

The data obtained during Task 38 sampling will be used to determine the requirements for additional borings. Maps and cross-sections will be prepared to illustrate the spatial distribution and to delineate the existence of distinct contaminant concentration gradients in the proximity of sources and within the overall study areas.

8.3 Factors Influencing Contaminant Distribution and Migration

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 study areas.

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 logging (EM 34 conductivity) will be used to aid in mapping the groundwater flow system and contaminant migration patterns. These data will be used to complete the understanding of subsurface geology.

Hydrogeologic conditions of the Task 38 areas will be assessed following the evaluation of previously generated hydrogeologic data and data collected during this investigation. The groundwater flow and direction within the Task 38 areas will be estimated.

8.2.3 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 chemical characteristics and soil properties will be evaluated using field and laboratory results, and they will be used to assess the impact of the factors on the observed contaminant distribution.

8.4 Relationship of Contamination Sources to Past and Present Activities

The analysis of the contamination sources and soils data will be used to identify relationships between ambient soil and source contamination. These methods will allow for an estimate of the spatial extent of contamination 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.

8.5 Significance of Contamination (Criteria Development)

The contaminant of primary concern in this study is trichloroethylene (TCE). The U.S. Environmental Protection Agency has established health-based Maximum Contaminant Levels (MCLs) for a number of potential drinking water contaminants including TCE. The MCL is the legally enforceable limit established based on health considerations as well as economic and other factors. For TCE, the MCL is 5 ug/l. The South Adams County Water and Sanitation District must ensure that the water it delivers to its customers does not exceed the 5 ug/l limit. Although an activated carbon treatment system has been installed on this public water supply system to remove any TCE found in the raw water supply, the 5 ug/l MCL is to be used as the initial target action level for TCE on RMA. This study will include a risk assessment to aid in the establishment of a final action level to be used in any cleanup scenario.

8.6 Feasibility Study

Information developed during the field investigation efforts of Task 38 will be used to conduct a Preliminary Remedial Action Alternatives Assessment. Alternatives that will be considered include source control measures, management of contaminant migration, and receptor control, although emphasis will be placed on on-post alternatives. Technical evaluations of alternatives will be based upon recent published literature as can be applied to the Western Tier problem. Costs will be estimated based upon recent generally accepted cost guidelines such as those contained in Compendium of Costs Remedial Technologies at Hazardous Waste Sites

(USEPA, 1985c). The technical and cost analyses are conducted in general accordance with National Contingency Plan guidance (U.S. EPA, 1985d).

The final output of the feasibility study is a recommendation of which action(s) are most viable for mitigation of Western Tier TCE contamination, as well as a recommendation and draft plan for any further field or literature investigations necessary before a final remedial action is selected and designed. Details of the Feasibility Study approach will be provided to PMO if the Remedial Investigation activities reveal that mitigation measures are warranted.

9.0 SCHEDULE

A number of activities related to Task 38 (soil borings, literature search) have already been conducted for some areas in the Western Tier as part of the Scope of Work for Task 15. Information developed from these activities is used as a basis for many of the Task 38 efforts. Figure 9.1-1 presents the proposed schedule for conducting Task 38, and this schedule incorporates a number of pertinent Task 15 activities. Completion of Task 38 is anticipated on or before February 1, 1988.

Task 38 - Detailed Schedule
Litigation Technical Support
Rocky Mountain Arsenal

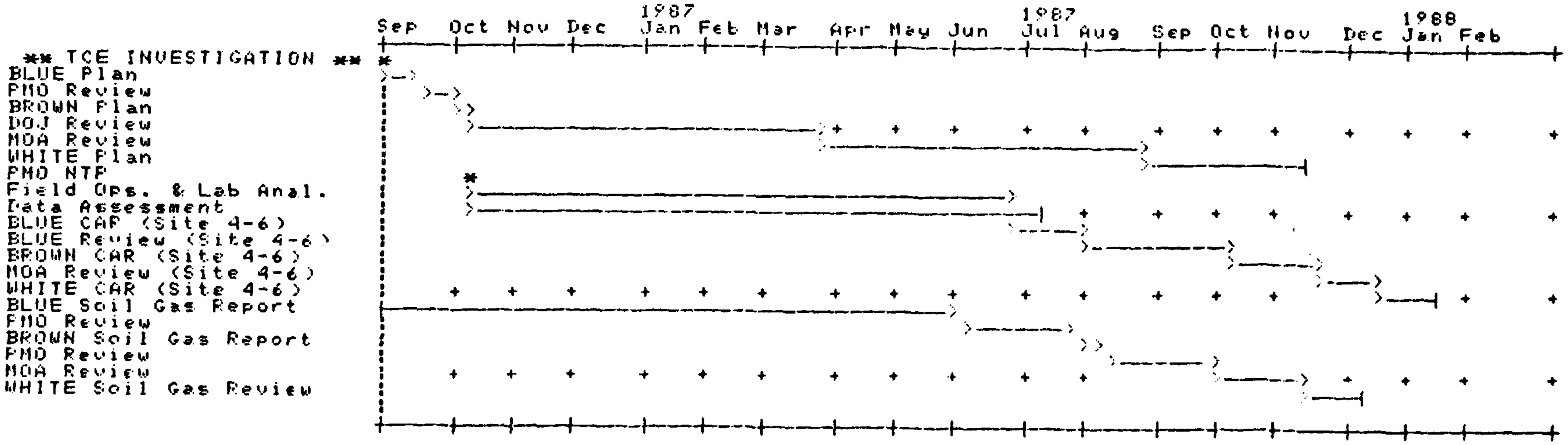

Figure 9.1-1

APPENDIX 38-A

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APPENDIX 38-B

ADDITIONAL WORK NOT COVERED BY TECHNICAL PLAN

ADDITIONAL WORK NOT COVERED BY TECHNICAL PLAN

Many of the specific work assignments accomplished by this task where not completely defined by the PM-RMA during the writing of the initial technical plan. A detailed description for each of these assignments was developed and submitted to PM-RMA for approval upon receipt of the specific work assignment and prior to completing the assignment. This appendix contains letter technical plans and memos describing the technical approach for each of these work assignments.

EBASCO SERVICES INCORPORATED EBASCO
3000 W. MacArthur Blvd., Santa Ana, CA 92704, (714) 662-4000

RMA38-EDEN-USA-T-011
January 9, 1987

Commander, Office of Program Manager
for Rocky Mountain Arsenal Contamination Cleanup
ATTN. AMXRM-EE/(C. Scharmann)
Building E4585 - DBL Trailer
Aberdeen Proving Ground
Maryland 21010-5401

RE: Drilling of additional wells in Section 9 for Task 38

Dear Charlie:

Analysis of recently collected samples from new monitoring wells installed in Section 9 indicate that Trichloroethylene (TCE) is present throughout the groundwater of the central part of this section.

The TCE was detected in samples from wells 09008 through 09012 in September and December of 1986 (Figure 1). TCE has also been detected in well 09001 during November 1985 and May 1986, and in well 09005 during May 1986. The source of the TCE is apparently located substantially south of wells 09008 and 09009 since the TCE appears to be rather evenly distributed (dispersed) throughout the depth of the aquifer. Ebasco proposes to drill a well or, if necessary, a well cluster near the southern boundary of Section 9, approximately 1000 feet southeast of well 09008, to aid in determining the origin of the TCE. The proposed well will be located hydraulically up gradient of the wells where TCE has been detected (Figure 1), and will confirm that the source of the TCE is indeed off-post.

The proposed well will be drilled by hollow-stem auger to bedrock. The lithology will be logged by a geologist who will also supervise the completion of the well. The well casing and screen will consist of 4-inch PVC, and an artificial gravel pack will be placed between the well screen and the boring annulus. A bentonite seal (or fine sand to the top of the water table with a bentonite seal above the sand) will be placed above the gravel pack, and grout will be placed above the bentonite to the ground surface. If greater than 30 feet of saturated thickness is encountered in the aquifer, a well nest of two or more wells will be installed. Each well will screen 20 feet of the aquifer (Figure 2). The wells will be developed within 14 days after completion. Water sampling of these wells will be conducted no sooner than 14 days after the wells are developed.

0754A
Rev. 1/9/87

To expedite drilling of these wells, we require your approval as soon as possible. If you have any questions, please call me immediately at 303/988-2202.

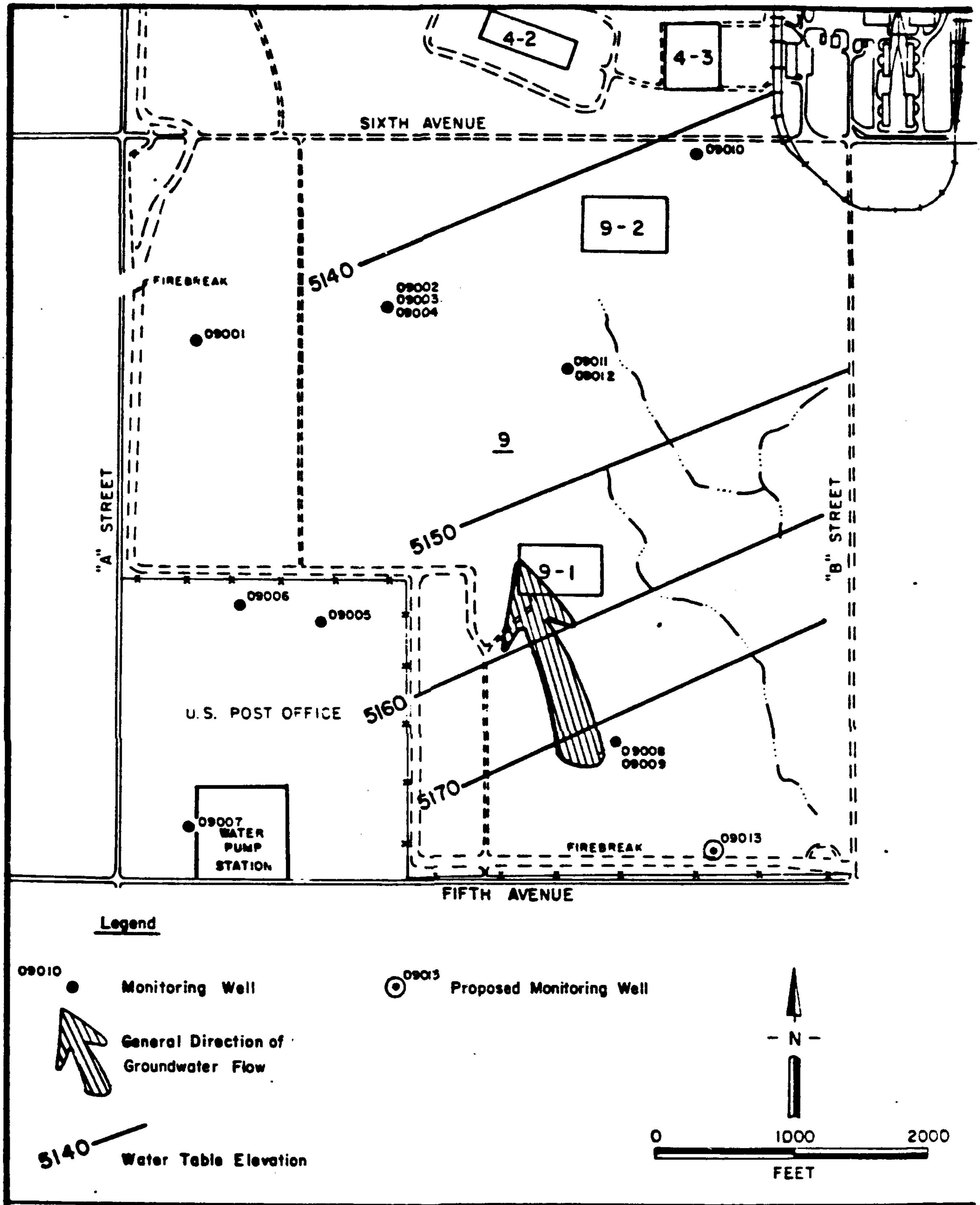
Sincerely,

Terry J. Sindelar
Groundwater Hydrologist

Enclosures

TJS:jah

cc: P. Chiaro
J. Keithley
K. Knirsch
J. Silvey
Chron File
DCC / Denver
DCC / Santa Ana



Prepared for:

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

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PRIVILEGED INFORMATION
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FIGURE 1

Water Table Elevations and Generalized Groundwater Flow Direction

Rocky Mountain Arsenal, Task 38

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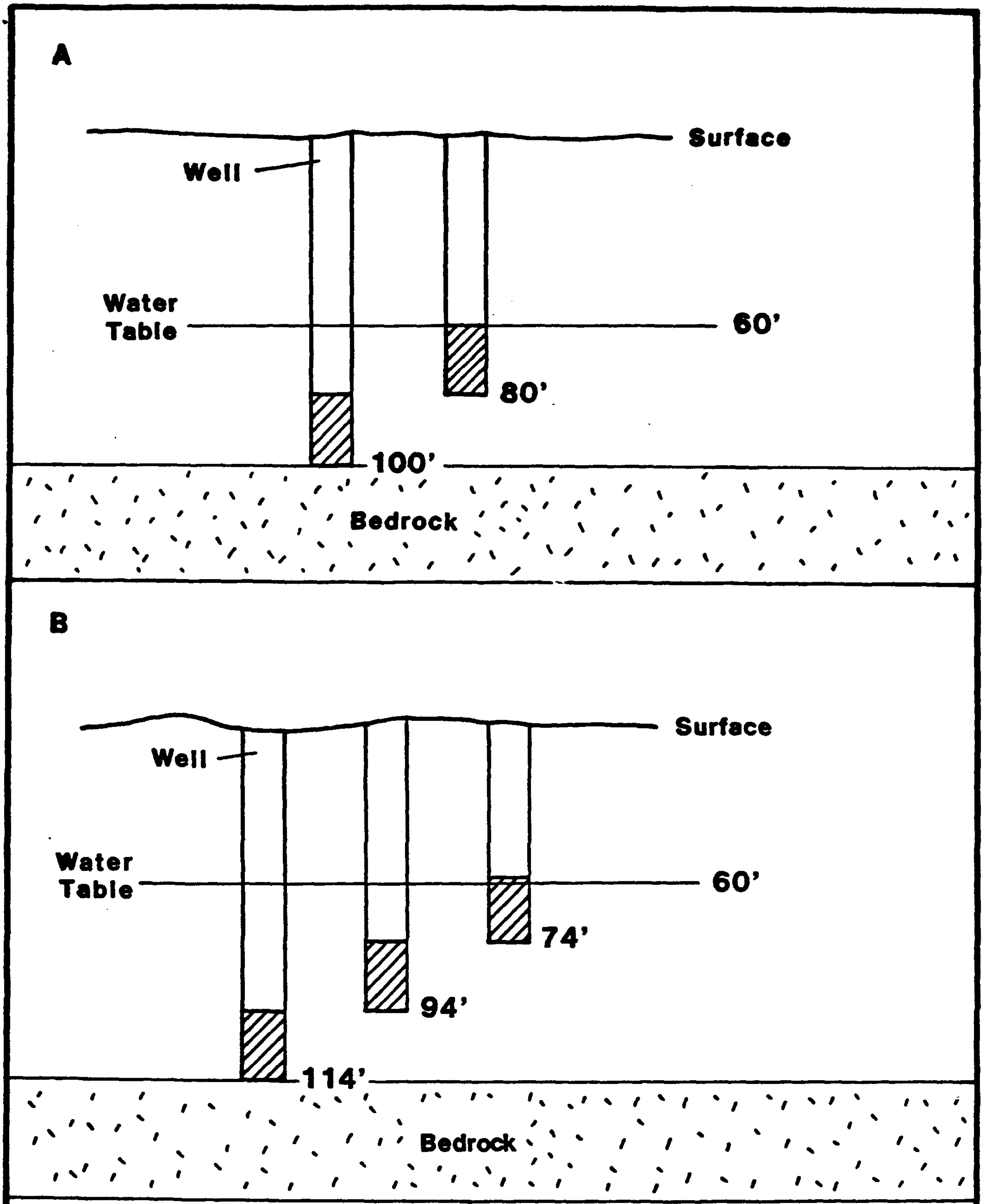

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Aberdeen Proving Ground, Maryland

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FIGURE 2
Schematic Drawing of Well Clusters

Rocky Mountain Arsenal, Task
Prepared by: Ebasco Services Incorporated

EBASCO SERVICES INCORPORATED **EBASCO**

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February 27, 1987
RMA38-EDEN-USA-T-015

Commander, Office of the Program Manager
for Rocky Mountain Arsenal Contamination Cleanup
ATTN: AMXRM-EE/Charlie Scharmann
Building E4585 - DBL Trailer
Aberdeen Proving Ground
Maryland 21010-5401

RE: Revised Technical Plan for Follow-on Phase I well drilling

Dear Charlie:

This letter technical plan for Task 38 is a revision of one dated January 30, 1987. Included in this revision are additional wells in Site 4-6, Section 9, and Section 10.

Site 4-6

The soil boring program conducted by Ebasco at Site 4-6, identified trichloroethylene (TCE) contamination in only one bore. Analysis of samples from Boring 24 detected 2.0 ug/g TCE in the 2 to 3 foot interval (Figure 3.2-4). Boring 24 was completed to 3 feet and is located in a ditch next to the outfall of a culvert which appears to drain the area around Boring 25 near Building 624. Boring 25 was only completed to one foot and analysis for volatiles was not conducted. Building 624 was once used by Field Equipment Repair (FER) and there is a possibility that the FER used TCE. In addition, a floor drain in Building 624 drains from the northwest corner of the building to someplace in the vicinity of Boring 25.

Ebasco proposes to conduct additional soil sampling and installation of several wells in the vicinity of Building 624. New borings will be drilled to the water table at Boring 24 and Boring 25. Soil samples will be collected at intervals as described in the Task 38 Technical Plan. Both borings will be completed as monitoring wells.

Two additional wells will also be installed to further define the TCE contamination detected in the groundwater at Wells 4-30 to 33, 4-35, and 4-36. One of these wells will be placed adjacent to the railroad tracks approximately midway between Well 4-30 and Well 4-35 (Boring 2). The remaining well will be placed near the northeast corner of Building 625. This well will aid in determining the eastern extent of the TCE in the groundwater. Soil samples will not be collected when these 2 wells are drilled.

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The proposed wells will be drilled by hollow-stem auger to 10 feet beneath the water table. Well screen will be placed 5 feet above the water table and 10 feet beneath the water table for a total of 15 feet of screen. The well casing and screen will consist of 4-inch PVC, and an artificial gravel pack will be placed between the well screen and the boring annulus. a bentonite seal will be placed above the gravel pack, and grout will be placed above the bentonite to the ground surface. A steel protective casing and locking cap will be placed over the well. The wells will be developed no sooner than 48 hours after completion. Water sampling of these wells will be conducted no sooner then 14 days after the wells are developed.

Section 9

Ebasco proposes to drill an alluvial well along the eastern side of Section 9 about midsection (Figure 3.2-5). This well will provide additional data on the water table elevation and will aid in further defining the groundwater hydrologic system in this area. The well will be constructed as described above.

Section 10

Ebasco also proposes to drill an alluvial well cluster in the northwest corner of Section 10 to provide additional information on the water quality and hydrology up-gradient of the rail yard and motor pool area in Sections 3 and 4 (Figure 3.2-5). If greater than 30 feet of saturated alluvium is encountered in the aquifer, a well nest of two or more wells will be installed. Each well will screen 20 feet of the aquifer. The wells will be constructed as described above except that for wells screened in the lower part of the alluvial aquifer, a fine sand will be placed between the gravel pack and the bentonite seal at the top of the water table to prevent the bentonite bridging problems we have experienced in the past.

The location of the official arsenal boundary will be verified before the wells are drilled to assure the wells are on arsenal property or that appropriate permission has been obtained to drill on airport property.

Sampling

Groundwater samples will be collected from Western Tier wells in March. Table 1 is a list of the wells to be sampled and their locations. The wells proposed in this Technical Plan will also be sampled as soon as possible after their development. The MOA parties will be notified as to when the sampling is conducted to allow them to collect sample splits.

The wells that are sampled will first be purged of five casing volumes of water by a submersible pump (4 inch wells), and a hand pump or bailer (2 inch wells). All samples will be collected using a teflon VOA-bailer.

Groundwater sampling collected from the monitoring wells will be analyzed for Phase I volatile halogenated organic compounds and Phase I volatile aromatic organic compounds and nitrates.

Soil samples will be collected only from the borings drilled near Building 624. The samples will be collected in polybutyrate tubes by hollow-stem auger. The samples will be collected from the standard sampling intervals as described in the Task 38 Technical Plan and will be analyzed for the Phase I analytes.

Water level measurements will be collected from all the western tier wells after the new wells are completed.

This letter technical plan will be distributed to the MOA parties and they should direct comments to you.

Please advise immediately regarding your concurrence with our proposed program. Thank you for your consideration.

Sincerely,

Terry J. Sindelar
Groundwater Hydrologist

TJS/sh
cc: Don Campbell
Kevin Blose
J. Silvey
K. Knirsch
P. Chiaro
J. Keithley
S. Turner
DCC/Denver
DCC/Santa Ana
Chron File

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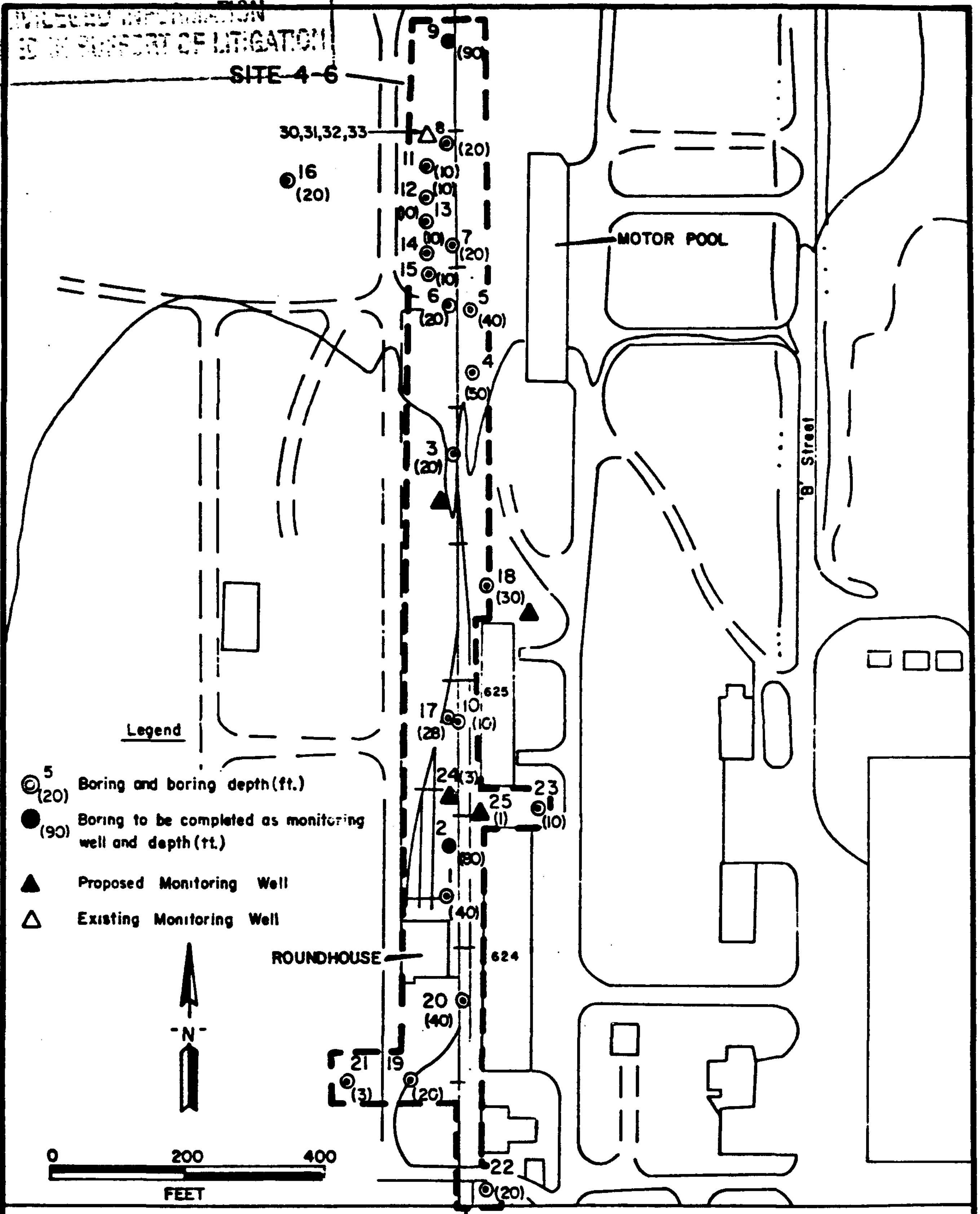
Rev. 2/27/87

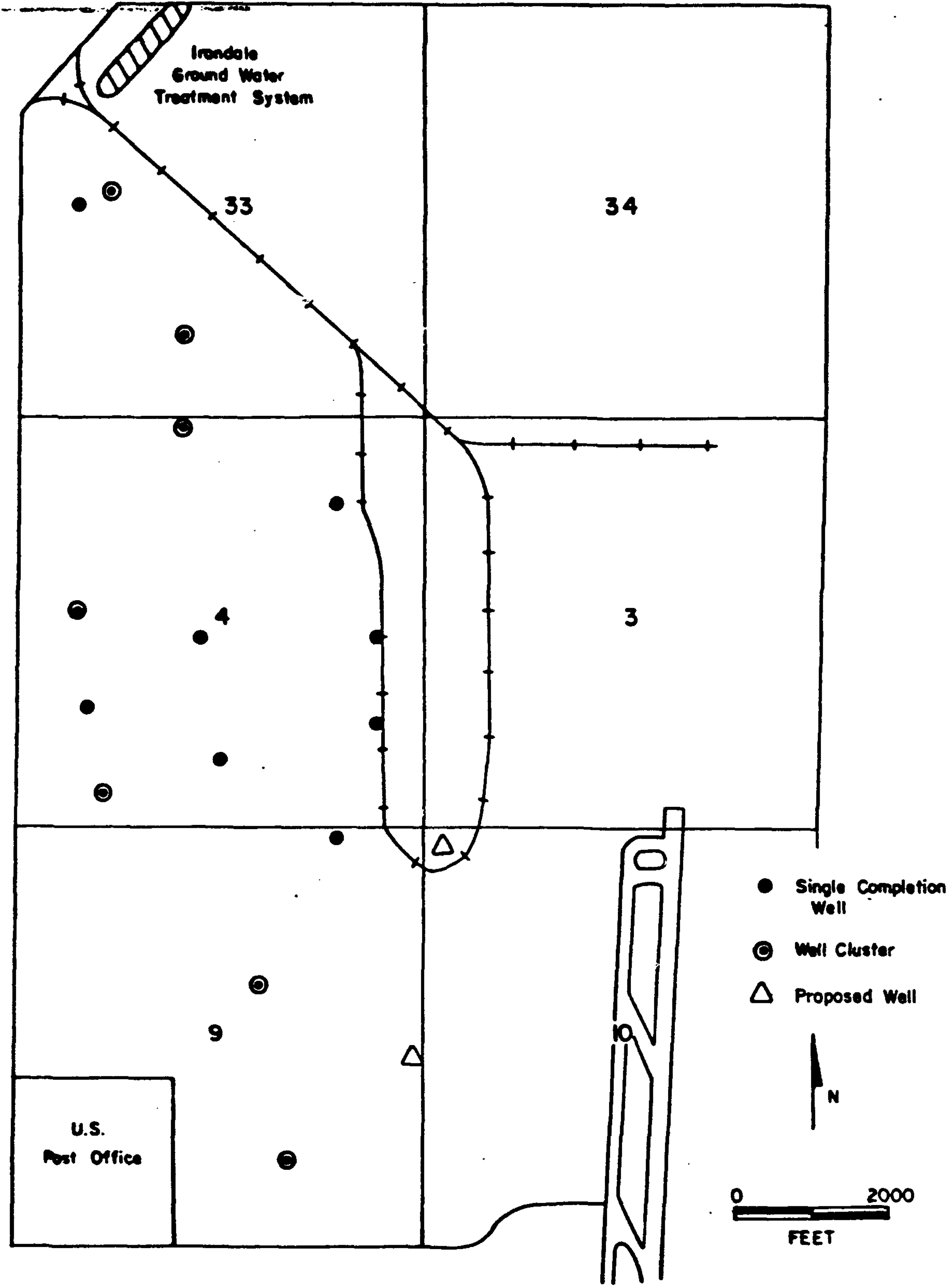


Prepared for:

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

FIGURE 3.2-4

Boring Location Map
Contamination Source 4-6
Rocky Mountain Arsenal, Task 38
Prepared by: Ebasco Services Incorporated



Prepared for:

Program Manager's Office for
Rocky Mountain Arsenal Cleanup
Aberdeen Proving Ground, Maryland

FIGURE 3.2-5
Locations of Proposed Monitoring Wells

Rocky Mountain Arsenal, Task 38
Prepared by: Ebasco Services Incorporated

TABLE 1 - WELLS TO SAMPLED BY EBASCO IN MARCH, 1987

WELL	CAS DIA (in)	EASTING	NORTHING
04-001	2.5	2169595.00	179096.00
04-002	2.0	2169204.00	179794.00
04-004	2.0	2168993.00	180101.00
04-007	2.0	2168064.00	179985.00
04-021	2.0	2171455.00	180456.00
04-022	2.0	2171465.00	180457.00
04-023		2171475.00	180457.00
04-030	2.0	2172458.00	177659.00
04-035	2.0	2172507.48	176626.29
04-036	4.0	2172520.38	177777.26
04-037	4.0	2171776.30	179385.15
04-038	4.0	2169802.17	180435.94
04-039	4.0	2169811.23	180435.05
04-040	4.0	2169978.35	177885.06
04-041	4.0	2170478.16	176099.11
04-042	4.0	2168974.41	175695.40
04-043	4.0	2168984.10	175697.84
04-044	4.0	2168788.53	177003.90
04-045	4.0	2168640.57	178218.42
04-046	4.0	2168650.03	178219.61
04-047	4.0	2168659.64	178220.80
09-001	2.0	2168240.00	173770.00
09-002	2.0	2169602.00	174028.00
09-008	4.0	2171411.17	171153.94
09-009	4.0	2171420.09	171156.78
09-010	4.0	2172016.26	175169.02
09-011	4.0	2171081.81	173597.88
09-012	4.0	2171081.81	173597.88
09-013	4.0	2171501.53	170073.44
09-014	4.0	2171514.27	170081.87
33-002	4.0	2168457.00	181181.00
33-016	2.0	2168211.00	182301.00
33-018	2.0	2168324.00	183672.00
33-020	2.0	2168324.00	183672.00
33-022	2.0	2168324.00	183672.00
33-024	2.0	2168324.00	183672.00
33-040	4.0	2170578.00	184355.00
33-046	4.0	2170730.00	181865.00
33-047	4.0	2170998.00	180910.00
33-065		2170151.00	183082.00
33-067		2170151.00	183082.00
33-069		2170151.00	183082.00
33-074	4.0	2169881.88	181530.40
33-075	4.0	2169891.22	181531.17
33-077	4.0	2169072.43	183423.28
33-078	4.0	2169063.22	183419.85
33-079	4.0	2169081.59	183426.39

WELLS SAMPLED BY ESE WILL NOT BE SAMPLED BY EBASCO

ENVIRONMENTAL PROGRAM AT ROCKY MOUNTAIN ARSENAL
EBASCO TEAM INTERNAL CORRESPONDENCE

DATE: August 26, 1987 FILE REF. RMA38-EDEN-T-025

TO: File

OFFICE LOCATION:

FROM: T. Sindelar

OFFICE LOCATION: Denver

SUBJECT: Additional Sampling in Site 4-6

Some soil and liquid samples were collected in Site 4-6 under the verbal direction of PM-RMA which are not listed in the Task 38 technical plan. These resulted from field situations and/or actions of other groups on the Arsenal which impacted Task 38. This memo describes the additional sampling locations and the reasons the samples were collected.

Soil Grab Sample G26

Soil grab sample G26 was collected from the ditch located west of the motor pool, Building 627, near the location of Boring 5. The ditch originally contained standing liquid which was pumped out in order to drill Boring 5. A grab sample was collected of the saturated material at the bottom of the ditch after the liquid was removed, before the ditch dried out.

Roundhouse Sump

The U.S. Army Environmental Hygiene Agency (AEHA) sampled liquid standing in the sump of Building 631 in March, 1986. The sample contained 500 to 1,000 ppb of TCE. After the sump was emptied, C. Scharmann of the PM-RMA directed Ebasco to drill through the sump and collect soil samples.

Two borings (26 and 29) were completed in the roundhouse sump. One additional water sample (28) was also taken in the sump. The first roundhouse boring (26) was drilled in the sump in June 1986, until a concrete layer was encountered at a depth of approximately 1 foot (ft). Upon drilling of the 1 ft boring, water seeped into the borehole through cracks in the concrete. A sample was then taken of that water. After removal of the concrete layer, drilling was continued in August 1986 to a depth of 59.5 ft (water table). No drain lines leading away from the sump were found.

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Prior to entering the roundhouse in June, the drill rig collapsed into a 3 by 4 ft cavity located approximately 15 ft north of the roundhouse. The cavity contained approximately 3 ft of water. The cavity was suspected to be a collapsed septic tank, but the cause of the cavity into which the rig collapsed could not be determined. A water sample (Sample 27) was taken from the cavity immediately after the collapse to determine if it contained solvents or other contaminants. Upon probing the cavity with a metal rod no evidence of concrete, metal, or other materials that would typically be associated with a septic tank was found; however, use of bathroom plumbing within the roundhouse demonstrated a clear hydraulic connection between the toilet and sink and the cavity. Personnel in the roundhouse were directed to use portable toilets.

Roundhouse Septic Tank Removal

In November 1986 RMA Installation personnel, under direction from PMO, excavated the cavity using a backhoe. A second water sample (Sample 30) was collected from the cavity and the liquid was removed from the cavity with a vacuum truck prior to the start of the excavation work. The excavation started at the cavity and proceeded south toward the roundhouse. A sewer line was found leading toward the bathroom in the roundhouse, but no lateral leading toward the rounhouse sump was found. The excavation then followed the sewer line from the cavity to the north. About 30 ft north of the roundhouse, the remains of a metal septic tank were found. The tank was rusted to the point where the hydraulic integrity of the tank was lost. The septic tank was removed by RMA personnel. PMO directed Ebasco to collect soil samples. Hand samples were collected from the resulting excavation, and Boring 31 was drilled at the location of the removed septic tank to a depth of 65 ft. After the excavation and removal of the septic tank, seven hand-augered borings (32-37) were taken in various locations to depths ranging from 4.5 to 10 ft.

TS:jh
cc: P. Chiaro
J. Keithley
K. Knirsch
DCC/Denver
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ENVIRONMENTAL PROGRAM AT ROCKY MOUNTAIN ARSENAL
EBASCO TEAM INTERNAL CORRESPONDENCE

DATE: August 27, 1987 FILE REF. RMA38-EDEN-T-026

TO: File OFFICE LOCATION:

FROM: T. Sindelar OFFICE LOCATION: Denver

SUBJECT: Task 38 Water Sampling and Water Level Measurements in 1987

The technical plan called for wells to be sampled and water levels measured through the end of 1986. During the early part of 1987, Ebasco recommended and PMO decided that additional sampling and water level measurements were required because additional wells were being installed. The letter technical plan dated February 27, 1987 states that the water sampling would be conducted in March. However, Ebasco, in concurrence with PMO, decided to delay the sampling until May to coordinate with the quarterly sampling of Task 44. Ebasco, with the approval of PMO, did not analyze for DBCP in these samples because three previous sampling rounds did not detect DBCP, except in a well near the intercept system in Section 33.

Water level measurements were collected both in February and June in 1987.

TS:jh

cc: P. Chiaro
J. Keithley
K. Knirsch
DCC/Denver
Chron File

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APPENDIX 38-C

EBASCO'S RESPONSES TO USEPA'S REVIEW COMMENTS OF THE TASK 38 TECHNICAL PLAN - VERSION 2.2

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Rev. 10/28/87

EBASCO'S RESPONSES TO USEPA'S
REVIEW COMMENTS OF THE TASK 38
TECHNICAL PLAN - VERSION 2.2

Comment #1	p.1-5, Section 1.3: Specific areas of interest for Task 38 include the septic tanks and drain-fields, which need further discussion. Drain field locations are not shown on either of the referenced Figures. The septic tank in the southwest corner of Section 33 (Figure 1.3-1) should be investigated in a fashion similar to the septic tanks in section 3 and 4.
Response	The drainfields mentioned in the technical plan are all associated with the septic tanks shown on Figure 1.3-1. Each septic tank has a drainfield. Figure 3.2-4 was referenced to illustrate the Motor Pool and Roundhouse areas which are mentioned in that same sentence. The reference has been changed to better reflect this intention. The septic tank in Section 33 was investigated in much the same manner as those in Sections 3 and 4. Whereas the septic systems in Section 3 and 4 were investigated only with the Tracer soil gas method, the septic system in Section 33 lies in an area that was blanketed with PETREX soil gas collectors. In addition, a number of Tracer soil gas samples were collected downgradient of the Section 33 septic tank.
Comment #2	p.2-1, Section 2.1-2: The literature search should include a discussion of existing air photos which were used to identify potential disposal sites.
Response	The objectives of Task 38 were to define the extent of trichloroethylene contamination in the groundwater of the western tier of RMA and to locate possible sources. The potential sources were identified either as a result of the records search or from the soil gas and/or groundwater investigation. Investigations of other potential disposal sites in the western tier were complete under Task 15. The objective of Task 15 was to identify all potential sources of contamination in this area. Since Task 15 preceded Task 38, information on potential sources was already compiled. The Task 15 data is reported in the Contamination Assessment Reports (CAR) for Sites 4-2, 4-3, 4-4, 4-5, and the reports for the uncontaminated areas in Sections 4, 9, and 33.

Comment #3	p.3-9, Section 3.2.1: Are the 100 foot gravity measurements intervals sufficient to define bedrock valley features?
Response	The 100 foot interval gravity measurements are sufficient to define a bedrock channel of the scale that has been mapped in this area. The objective of the geophysical study was to provide data where questions about the position of the known channel existed. These data was used in conjuntion with well log data in order to accurately locate new wells in the channels. The gravity method was used with the EM and resistivity methods for cross-verification and was not used alone.
Comment #4	p.3-22, Section 3.2.5: The text states that the wells must be placed in the centerline of the plume, yet no data are given and Figure 3.2-5 does not show contaminant plumes nor presumed bedrock channel configuration. To determine whether the proposed well locations are appropriate or adequate more information is necessary.
Response	The Task 38 technical plan proposed to conduct soil gas and geophysical programs prior to the well installation. The results of these programs were used to accurately locate the new wells. The well locations illustrated on Figure 3.2-5 were preliminary and were based on the locations of potential source areas 4-2 and 4-6; the direction of groundwater flow as determined from an ESE water table map for March 1986; and bedrock maps which have been prepared by WES and ESE. The well locations were refined based on additional soil gas, water level, and water quality data. The data from these new wells indicate that we found the plume but additional wells would be needed if the width and extent of the plume are to be refined. The Study Area Report (SAR) for the Western Tier and a Soil Gas Report will contain the results of the soil gas and geophysical programs including maps of the plumes and top of bedrock.
Comment #5	p.3-27, Section 3.3: The text indicates that monthly water level measurements will be made for the shallowest well of each cluster. Measurements should be made on all non-dry wells of a cluster to provide information on vertical hydraulic gradients.
Response	The text in the above referenced section also states that "Water levels in cluster wells are to be individually monitored only if measurable head differences among the various completion points can be detected." The intent of this statement was to indicate that we would measure all wells in select clusters to determine if there exists a vertical hydraulic gradient and that we would continue such measurements periodically if a gradient can be detected. The text has been changed to more clearly state this intention. In fact, we did measure all wells in selected clusters is Section 4 and 33 on several sampling rounds.

Comment #6 p.3-20, third paragraph: Information on number and depth of borings is inconsistent with Figure 3.2-4.

Response The text has been changed and now indicates the correct number and depth of borings consistent with Figure 3.2-4.

APPENDIX 38-D

EBASCO'S RESPONSES TO SHELL CHEMICAL COMPANY'S REVIEW COMMENTS OF THE TASK 38 TECHNICAL PLAN

VERSION 2.2

EBASCO'S RESPONSES TO SHELL
CHEMICAL COMPANY'S COMMENTS OF THE TASK 38
TECHNICAL PLAN - VERSION 2.2

Comment #1 Page 1-2, paragraph 1.2 - The second objective should be rephrased to determine the contaminant plume on the RMA, not just within one mile of the source. The third objective is not possible if the plume is defined only within one mile of the source.

Response We agree that the objective should state that we will trace the contaminant plume to it's source and not just within one mile of the source. The text has been changed to reflect this intention.

Comment #2 Section 4.3.7, Analytical Methods for Solid Matrices - Unknown Identification, is missing from the report.

Response Section 4.3.7 was unintentionally left out. The section has been added to the technical plan and the title has been changed to "Analytical Methods for Solid Matrices - Nontarget Compounds".

Comment #3 The Table of Contents for the Chemical Analysis Program is inconsistent with the body of the report.

Response The Table of Contents for the Chemical Analysis Program had not been updated from a previous version of this plan. We have since corrected this table.