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IN SITU VITRIFICATION
M-1 Settling Basins
FY91

Rocky Mountain Arsenal, Colorado

Prepared by

Woodward-Clyde Consultants

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Prepared for

U. S. Army Engineer District, Omaha
Corps of Engineers
Omaha, Nebraska

September 1990

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THIS CONCEPTUAL DESIGN DOCUMENT OUTLINES THE STEPS REQUIRED TO IMPLEMENT THE IN-SITU VITRIFICATION PROCESS IN THE M-1 SETTLING BASINS. THE REPORT IS DIVIDED INTO THE FOLLOWING SECTIONS:

1. INTRODUCTION
2. OVERVIEW OF CONCEPT DESIGN - GENERAL DESCRIPTION OF PROCESS, SITE SPECIFIC CONSIDERATIONS, OFF-GAS SYSTEM
3. DESIGN ANALYSIS - REQUIREMENTS
4. DRAFT SPECIFICATIONS
5. DRAWINGS - BOUND SEPARATELY
6. COST ESTIMATE.

APPENDICES INCLUDE:

A. DESIGN SUPPORT DOCUMENTATION - ARAR'S, VENDOR INFORMATION, DESIGN CALCULATIONS

B. VALUE ENGINEERING STUDY BY STANLEY CONSULTANTS.

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1.0
INTRODUCTION

This Interim Response Action (IRA) Concept Design Document for the M-1 Settling Basins at the Rocky Mountain Arsenal (RMA) is being prepared as part of the IRA process in accordance with the Federal Facility Agreement and the Technical Program Plan. Determinations concerning the implementation of this IRA have been reached through a consideration of the objectives of Sections 2.3(a), 22.5, and 22.6 of the Federal Facility Agreement and by application of the Decision Flow Chart for Other Contamination Sources IRAs adopted by the Organizations and the State in the June 7, 1989 Subcommittee meeting (WCC 1990, RAC 90002R05).

An alternative assessment was conducted as part of the IRA process in the fall of 1989. The recommended action at the M-1 Settling Basins is to isolate the waste materials from alluvial ground water through the use of a perimeter subsurface barrier, such as sheet piles driven, and to treat the waste materials by in situ vitrification (ISV).

1.1 HISTORY

Rocky Mountain Arsenal (RMA) occupies more than 17,000 acres (approximately 27 square miles) in Adams County, northeast of metropolitan Denver, Colorado (Figure 1.1-1). The property was purchased by the U.S. government in 1942 for use in World War II to manufacture and assemble chemical warfare materials, such as mustard and lewisite, and incendiary munitions. Starting in the 1950s, RMA produced the nerve gas agent GB (isopropyl methylphosphonofluoridate) until late 1969. A significant amount of chemical warfare materials destruction took place during the 1950s and 1960s. From 1970 to the early 1980s, RMA had primarily been involved with the destruction of chemical warfare materials. The last military operations at RMA ended in the early

1980s. In November 1988, the RMA was reduced to inactive military status reflecting the fact that the only remaining mission at the Arsenal is contamination cleanup. In addition to these military activities, major portions of the plant facilities were leased to private industries, including Shell Oil Company, for the manufacture of various insecticides and herbicides, between 1947 and 1982.

The M-1 Settling Basins are located in the South Plants area, just south of December 7th Avenue along the northern edge of the northwest quarter of Section 01 (Figure 1.1-2). The M-1 Settling Basins were constructed to treat waste fluids from the lewisite facility. Two basins were constructed in 1942, and a third basin was constructed in 1943 when the original two filled with solids. All three were unlined, and each measured approximately 90 feet wide, 115 feet long, and 7 feet deep according to as-built drawings. In addition to the waste fluids from the lewisite disposal facility, the basins may have contained lesser amounts of waste materials from alleged spills within the acetylene generation building, the thionyl chloride plant, and the arsenic trichloride plant, which may have been routed through floor drains and the connecting piping to the basins (Ebasco 1987, RIC 88286R06). The basins also received a considerable amount of mercuric chloride catalyst, possibly from a spill (Ebasco 1988, RIC 88286R10).

The liquids discharged into the basins first passed through a set of reactor towers where calcium carbonate was added, then through a wood trough into the M-1 Settling Basins where the arsenic precipitated out of solution. The liquid from the settling basins was decanted through an 18-inch-diameter pipe to the Lime Settling Basins in Section 36 where final treatment occurred, before being routed to Basin A (Ebasco, RIC 88286R06).

The M-1 Settling Basins were backfilled, probably in 1947, and are now covered with soil. Portions of the basins are covered with storage tanks and concrete containment berms. These tanks will be relocated before implementation of the IRA.

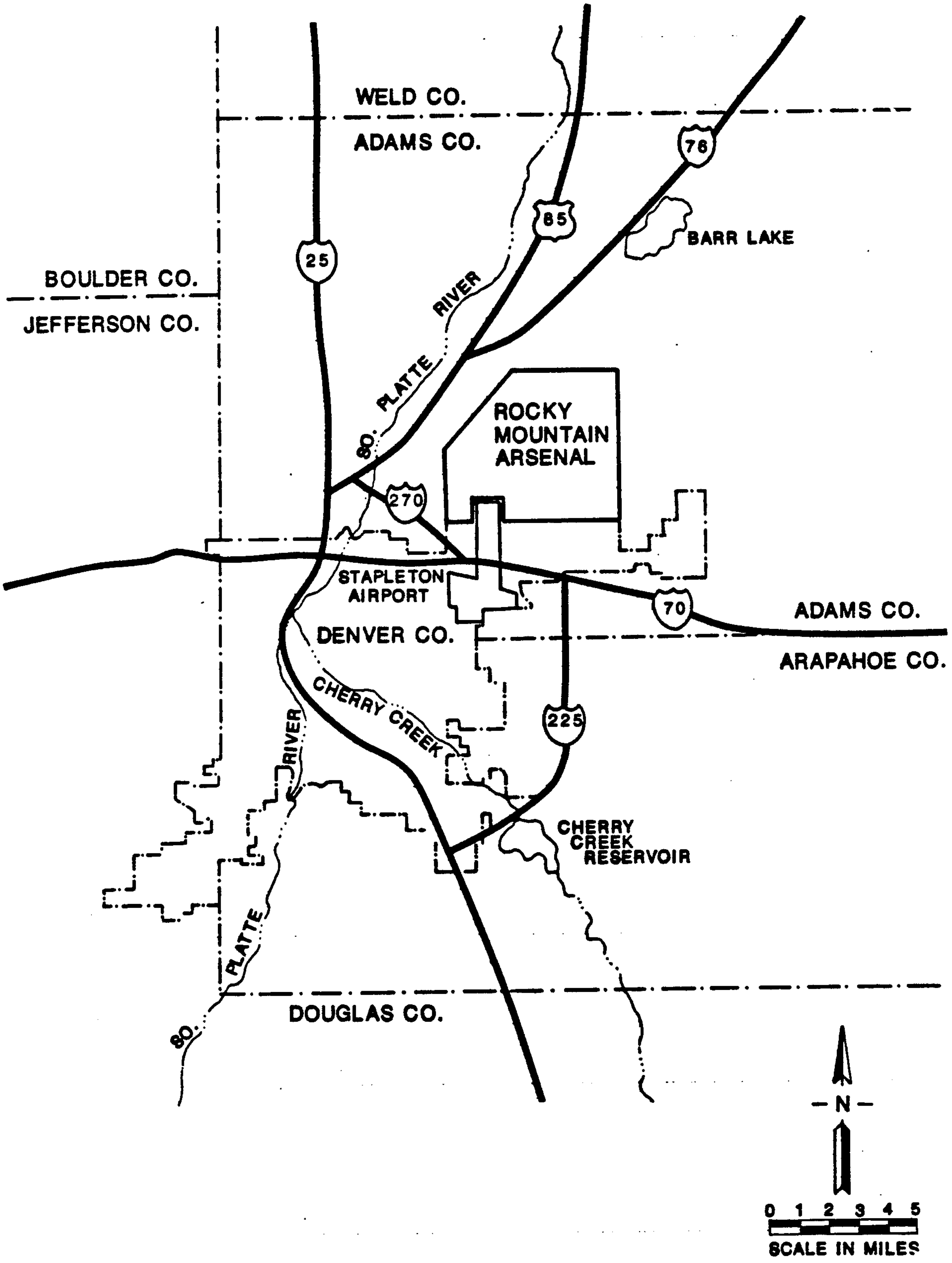
Based on several investigations, the contaminants in the waste material in the M-1 Settling Basins are primarily arsenic (about 4.5 percent) and mercury (about 0.5 percent), with the bulk of the material being oxides or carbonates of calcium. Organochlorine pesticides and other organics have also been found in the near-surface soils (Ebasco 1988, RIC 88286R10). The bottoms of the basins appear to be about 7.5 feet below ground surface, based on as-built drawings and field investigations. The ground water elevation in the vicinity of the M-1 Settling Basins is approximately 8 to 10 feet below ground surface, with some seasonal variation that may bring the water table into contact with the basin contents during parts of the year. The M-1 Settling Basins are a source of arsenic contamination to the ground water (RMA Environmental Data Base; WCC 1990, RIC 90002R05).

On February 1, 1988, a proposed Consent Decree was lodged in the case of United States v. Shell Oil Company with the U.S. District Court in Denver, Colorado. The proposed Consent Decree was revised after public comments were received, and a modified proposed Consent Decree was lodged with the Court on June 7, 1988. In February 1989, a Federal Facility Agreement was entered into between five federal agencies: the U.S. Environmental Protection Agency (EPA), the Army, the Department of the Interior, the Department of Health and Human Services, and the Department of Justice, which established procedures for implementing the Arsenal cleanup program as specified in the Technical Program Plan, and incorporated many provisions of the modified proposed Consent Decree. The Army and Shell Oil Company agreed to share certain costs of the remediation to be developed and implemented under the oversight of the EPA, with opportunities for participation by the State of Colorado. The long-term remediation is a complex task that will take several years to complete. The Federal Facility Agreement specifies 13 Interim Response Actions (IRAs) determined to be necessary and appropriate. The Remediation of Other Contamination Sources is one of the 13 IRAs. The M-1 Settling Basins area is one of several sites being addressed by the Remediation of Other Contamination Sources IRA.

As part of the IRA process, an alternative assessment was performed for the M-1 Settling Basins. An ISV engineering-scale treatability test was performed as part of this assessment in the summer of 1989. The Final Decision Document for the M-1 Settling Basins (WCC 1990, RIC 90002 R05) recommended in situ vitrification (ISV) as the preferred interim response action at the site, following public comment and comment by the Organizations and the State. This Concept Design Document has been prepared as part of the development of the Draft Implementation Document for this IRA.

1.2 DOCUMENT ORGANIZATION

This conceptual design document outlines the steps required to implement the ISV process. Section 2.0 is an overview of the conceptual design. Section 3.0 presents the design analysis. Draft specifications are in Section 4.0 and include a draft Chemical Data Management Specification and a Health and Safety Specification outline. Section 5.0 contains concept design drawings. Cost estimates are provided in Section 6.0.



Job No. : 89MC114B-302	IN SITU VITRIFICATION M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO RMA LOCATION MAP Figure 1.1-1
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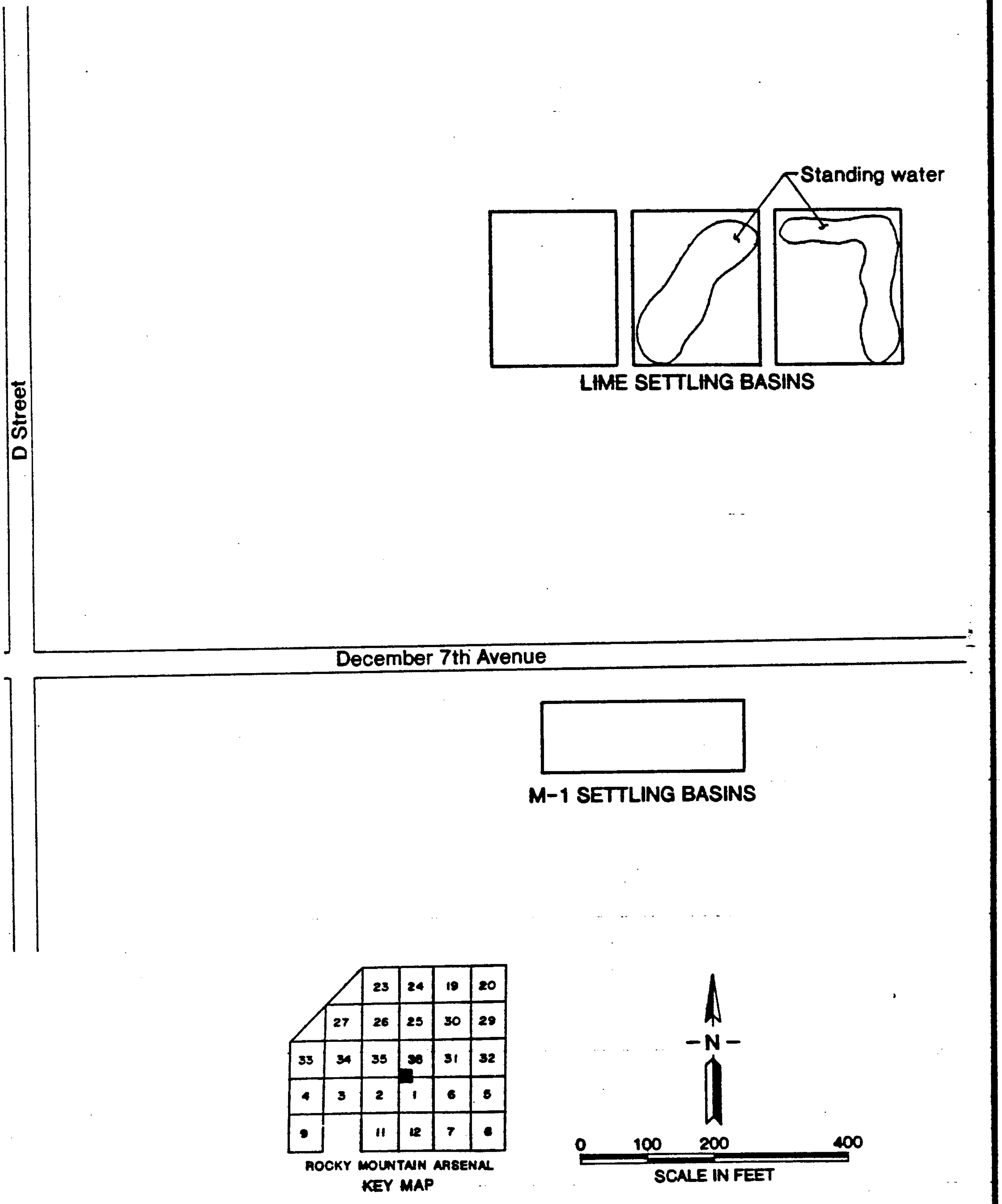
Date : 8/20/90	



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Date: 8/20/90

IN SITU VITRIFICATION
M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO
LOCATION MAP
Figure 1.1-2

2.0
OVERVIEW OF CONCEPT DESIGN

This section is an overview of the concept design for the implementation of in situ vitrification (ISV) as an interim response action (IRA) at the M-1 Settling Basins at Rocky Mountain Arsenal (RMA). The ISV process is described, and site-specific considerations are discussed. A construction schedule is provided. Finally, a site maintenance plan is presented.

2.1 GENERAL PROCESS DESCRIPTION

In situ vitrification (ISV) is a process that uses electrical energy to melt inorganic materials (e.g., soil) for the purpose of thermochemically treating free and/or containerized contaminants present within the treatment volume. Most ISV applications involve melting of natural soils; however, other naturally occurring or process residual inorganics (e.g., sludge, tailings, sediments), or process chemicals may be treated. For purposes of simplification, primarily soil applications are discussed hereafter in this section. It is noted that when other inorganics are treated in the ISV process, some variation of application detail may be necessary compared to soil applications. For soil, the process simultaneously destroys and/or removes organic contaminants while chemically incorporating (immobilizing) inorganic contaminants into a chemically inert, stable glass and crystalline residual product.

Figure 2.1-1 illustrates sequential stages of ISV processing. First an array (usually square) of four electrodes is placed to the desired treatment depth in the volume to be treated. Because soil typically does not have sufficient electrical conductivity to allow initiation of the process, a conductive mixture of graphite and glass frit is placed on the surface between the electrodes to serve as an initial conductive (starter) path. As electric potential is applied between the electrodes, current flows through the starter path, heating it and the adjacent soil to temperatures above 1,600° C, which is well above typical soil fusion temperatures. Upon melting, typical soils become quite electrically conductive; thus the molten mass becomes the primary conductor and heat transfer medium allowing the process to continue beyond startup.

Continued application of electric energy causes the molten volume to grow downward and outward encompassing the desired treatment volume. Individual settings (i.e., the melt involved with a single placement of electrodes) may grow to encompass a total melt mass of up to 1,000 tons and a maximum width of about 30 ft. Single setting depths as great as 30 ft are considered possible with the existing large-scale ISV equipment. Several methods, using geophysical, optical, and thermal principals, may be used to determine the physical extent of melting for control purposes. Figure 2.1-2 illustrates how adjacent settings are positioned to fuse to each other and to completely process the desired volume at a site.

The molten soil mass is typically in the 1,600 to 2,000° C temperature range; specific temperatures are dependent on the overall chemistry of the melt. Within the melt, a vigorous, chemically reducing environment is typical. Because soil typically has low thermal conductivity, a very steep thermal gradient (i.e., 150-250° C/in) precedes the advancing melt surfaces. Typically, the 100°C isotherm is less than 1 ft away from the molten mass itself.

The large-scale ISV system melts soil at a rate of 4 to 6 tons/hr. Accordingly, the rate of melt advance is in the 1 to 2 in/hr range. As the thermal gradient advances on solid or liquid organic materials, they first vaporize and then pyrolyze (i.e., decompose in the absence of oxygen) into elemental components. Organic pyrolysis products are typically gaseous; these gases move slowly (because of the high viscosity of the molten material) through the melt toward the upper melt surface. Some of these gases may dissolve into the molten mass; the remainder move to the surface where those that are combustible combust in the presence of air. Pyrolysis and combustion products are collected in an off-gas collection hood and are subsequently treated to ensure that process air emissions meet regulatory requirements. Because of the high temperature of the melt, no residual organic contamination remains in its original compound form within the vitrified product.

The behavior of inorganic materials, upon exposure to the advancing thermal gradient, is similar to that of the organics. Inorganic compounds may thermally decompose or otherwise enter into reactions with the melt. Nitrates and sulfates, for example, yield gaseous decomposition products (e.g., N_2, SO_2, O_2) which may dissolve into the melt or may evolve through it and be collected in the off-gas collection hood. Typically, the elements of the inorganic compounds originally present are incorporated into the vitrified residual at a high retention factor (greater than 90 percent).

Since the void volume present in particulate materials (e.g., 20 to 40% for typical soils) is removed during ISV processing, a corresponding volume reduction occurs. Also, since some of the materials (e.g., humus, organic contaminants, limestone) present in the soil are removed as gases and vapors during processing, further volume reduction occurs. The volume reduction creates a subsidence volume above the melt and an angle of repose in the soil adjacent to the melt.

As the melt grows in size, its electrical resistance decreases, making it necessary to periodically adjust the ratio between the voltage and the current to maintain operation at the desired power level. When the power is shut off, the extent of melting is limited to the point achieved at that moment, and the melt starts to cool. Within a few hours, gaseous emissions from the melt cease. After that time has passed, the off-gas hood may be removed and the subsidence volume filled to the desired depth with clean backfill.

No attempts are made to force cool the melt; slow cooling results in a vitreous (amorphous) and microcrystalline structure which is monolithic in nature (i.e., a single massive structure); and assuming contiguous (i.e., immediately adjacent) settings at a site, a single large monolith will be produced, as shown in Figure 2.1-2

The process uses an equipment system as illustrated in simplified form in Figure 2.1-3. Electric power is usually taken from a utility distribution system at typical transmission voltages of 12,500 or 13,800 volts; alternatively the power may be generated onsite by a diesel generator. The 3-phase power is supplied to a special multiple-tap transformer (Scott Tee) that converts the power to 2-phase and transforms it to the voltage levels needed throughout the processing. The electrical supply system utilizes an isolated ground circuit which provides appropriate operational safety.

Electric power is supplied to the array of electrodes through flexible conductors. The electrodes consist of 2-inch diameter molybdenum rods surrounded by a 12-inch diameter graphite collar. The electrodes are placed through a process utilizing casings that are vibrated or driven into place, followed by vibratory extraction after placement of the electrodes within the casings. Electrodes are typically left in place while the residual monolith cools; they may then be removed for recycling or partial reuse. The electrode locations may also be utilized as a penetration through the monolith for access to ground water, for example.

The maximum spacing between electrodes in the large-scale equipment system is about 18 ft, which allows formation of a maximum melt width of about 30 ft. The processing area is covered by a octagonal-shaped (nearly round) off-gas collection hood with a maximum dimension across the flats of 55 ft. The large distance between the edge of the hood and the edge of the melt ensures off-gas containment even under worst case angle of repose (from subsidence) conditions.

Flow of air through the hood is controlled to maintain a negative pressure (0.25 to 1.0 in H_2O). An ample supply of air provides excess oxygen for combustion of pyrolysis products and organic vapors, if any exist. The off-gases, combustion products and air are drawn from the hood (by induced draft blower) into the off-gas treatment system which uses the following unit processes to ensure compliant air emissions: 1) quenching, 2) pH controlled scrubbing, 3) dewatering (mist elimination), 4) heating (temperature and dewpoint control), 5) particulate filtration, and 6) activated carbon adsorption. A self-contained glycol cooling system cools the quenching/scrubbing solution; this avoids the need for a constant onsite water supply. The amount of moisture present in the exhaust air stream is controlled to accommodate the moisture that is removed from the treatment volume during processing.

Typically, the volume of gases evolving from the melt present less than 1 vol% of the total volume of air processed by the off-gas treatment system. Also typically, there is very little, if any, hazardous material that evolves from the melt during processing. In addition to pyrolysis and combustion products, some amount of particulate may be present in the off-gas. Substantially all of the off-gas contaminants are removed from the off-gas stream at the quenching and scrubbing stages. The filters and carbon adsorption columns are utilized as secondary stages (backup) to ensure safe air emissions. After processing for a time, the scrubber solution, filters, and activated carbon may contain sufficient contaminants to warrant treatment or disposal themselves. Typical treatment includes passing the scrubber water through diatomaceous earth (filter aid) and activated carbon, followed by reuse of the water or discharge to a sanitary sewer, and placement of the activated carbon and filters in a subsequent ISV setting for reprocessing. In this way, the destruction/chemical incorporation of contaminants collected in the off-gas treatment system is maximized, and the only secondary waste resulting from the ISV processing is that contained in the off-gas treatment system after the last setting at a site.

In addition to the primary off-gas treatment system, the ISV process system employs a backup off-gas treatment system for use in the event of power failure. The backup system employs a diesel-powered generator, blower, mist cooler, filter and activated carbon column. The backup system is capable of removing and treating off-gases for the period of time that a melt may release off-gases during a power outage or during the initial cooling time at completion of a setting.

The overall ISV process is monitored and controlled by a microprocessor system. The process equipment system uses a large number of safety methods and devices to ensure safety of operations. The process is monitored and controlled by two qualified operators at all times. The process operates around-the-clock with about 16-hours of downtime between settings. Advance preparatory work (e.g., electrode placement) during operation of the system minimizes the movement-associated downtime.

Ninety ISV tests have been performed at all scales, six of them full-scale. ISV has been selected as the remedial treatment at nine sites, either by a Record of Decision (ROD) or equivalent. An ISV demonstration test is being performed in early 1991 in support of a Toxic Substance Control Act (TSCA) permit application. Seventeen million dollars have been invested in ISV process development since 1980, with commercial operations commencing in 1990.

2.2 SITE-SPECIFIC CONSIDERATIONS

This section discusses considerations at the M-1 Settling Basins that are specific to the site, and therefore require site preparation or process modifications, or operational variations that are unique to this project. The section first provides the basis of design and the melt characteristics expected from the M-1 Settling Basins sludge. The section then describes design considerations including site conditions requiring specific site preparation, off-gas treatment system modifications, and site-specific operations requirements. This section also discusses monitoring and health and safety requirements during implementation of ISV

2.2.1 Design Basis

This section describes the design basis used in the Concept Design Document. Data from soil and sludge samples taken in August 1990 were not available in time for inclusion in this design basis. The design basis will be revised for the final design, if necessary, following receipt and analysis of those data.

The dimensions of the M-1 Settling Basins area are approximately 306 ft by 115 ft based on as-built drawings and aerial photographs. This results in a surface area of about 35,200 square feet, or slightly less than one acre. The sludge in the M-1 Settling Basins is estimated to be 5 to 6 ft thick. Depth from ground surface to the top of the sludge is estimated to be 2 ft and depth from ground surface to the bottom of the sludge is estimated to be 7.5 to 8.5 ft. Clean soil will be placed on the M-1 Settling Basins prior to the ISV. This soil would provide for adjustment of chemical composition of the melt to optimize ultimate vitrified glass characteristics, protect workers from possible surface contamination, and inhibit volatilization of organics from the rear-surface soil. The exact amount of soil to be added will be based on compositional considerations. For cost estimating purposes, one foot of soil has been assumed at this stage of the design. The total depth of the melt for the concept design and cost estimate is assumed to be 10 ft, or 9 ft below the current ground surface. This results in a total volume to be vitrified of approximately 13,000 cubic yards.

The depth to the water table in the vicinity of the M-1 Settling Basins is 8 to 10 ft below ground surface. The depth to the weathered bedrock is 10 to 25 ft.

The sludge material at the M-1 Settling Basins contains large amounts of arsenic and mercury. Chemical analysis of the sludge performed during the 1989 treatability test (Geosafe 1989; RIC 90043R01) showed approximately 5,200 to 5,600 mg/kg of mercury and 42,100 to 45,600 mg/kg of arsenic in the sludge. The concentrations used for design basis calculations are 5,400 mg/kg of mercury and 44,900 mg/kg of arsenic. Using as-built drawings and assuming an average sludge thickness of 5.5 feet, a total sludge volume of 6,600 cubic yards is estimated. Therefore, the total estimated arsenic and mercury in the sludge is 300 tons and 36 tons respectively.

Most of the volatilized arsenic and mercury should quickly condense to aerosol particles, leaving some remaining vapor, either in the off-gas collection hood or in the 12-inch collection line which routes vapors and particulates to the treatment trailer. Some mercury may oxidize in the hood, as it comes in contact with the excess air drawn into the hood. However, most of this oxide is likely to decompose, given its instability at the off-gas collection hood temperatures (about 200 °C). Therefore, the predominant chemical form of the volatilized mercury will be the elemental state. Volatilized arsenic is expected to be in the trioxide form.

Organic contaminants have been detected in the near surface soils in the vicinity of the M-1 Settling Basins. Concentrations of these contaminants are shown in Table 2.2-1. The exothermic heat value of these organics is expected to be inconsequential.

The M-1 Settling Basins sludge is a grey-to-white, very wet silty clay-like material with a density of approximately 0.84 tons per cubic yard and a moisture content of approximately 47 percent. The sludge is not expected to contain any rubble or void volumes. The location of underground piping and utilities in the vicinity of the M-1 Settling is currently being investigated. The soil surrounding the M-1 Settling Basins consists of gravelly-to-silty sands, with lesser amounts of clayey sand to silty sand. The density of the soil is estimated to be 1.4 tons per cubic yard and the moisture content is estimated to be 17 percent.

The design basis, including estimated chemical concentrations in the soil and sludge of the M-1 Settling Basins, is summarized in Table 2.2-1. Calculations used to develop the design basis are in Appendix A-3.4.

2.2.2 Melt Characteristics

Geosafe has received the boring logs which were obtained during recent sampling activities at the site. In addition, as-built drawings which illustrate the design of the M-1 Settling Basins have been examined.

Geosafe is currently waiting for the locations of the soil borings to be surveyed in order to accurately locate the borings on the site map. Once this is accomplished, then detailed cross-sections will be constructed which show the lateral and vertical distribution of the waste. These cross-sections will then be compared with the as-built drawings to verify the validity of the drawings.

Once the subsurface distribution of the waste is well understood, a series of geochemical programs will be run utilizing the analytical results of the samples obtained from the boring operation. By using the relative thickness, density and chemical composition of the sludge and soil at the site, these modeling efforts will provide accurate predictions regarding the chemistry of the materials once they are in the molten state and mixed together. Models will produce the predicted chemistry of ISV melts in the areas where the lime sludge is thickest, where it is the thinnest, and in areas where the thickness is intermediate. In this way, the total range of compositional variabilities can be anticipated and, if necessary, appropriate compositional modifications can be proposed.

The chemical models will be made by first performing a statistical analysis of the chemistry of the sludge, overlying soil, and soil surrounding the basins. Using the average chemical composition of these materials, the weighted averages of the chemistry of the mixtures described above will be calculated in order to arrive at the predicted melt chemistry. Since the moisture and a portion of the sludge (CO_2) will be volatilized, the model takes into account the removal of this material.

Since the locations of the boreholes are not currently surveyed and since the analytical results from the borehole samples is not yet available, Geosafe has prepared an expected worst-case (based on the thickest sludge layer) geochemical based analyses of samples collected for the treatability test. This model assumes that 1 ft of cover soil, 2 ft of surface soil and 6 ft of sludge will be processed. This model is presented in Table 2.2-2. The temperature/viscosity data and graph are shown in Table 2.2-3 and Figure 2.2-2 respectively. This is considered worst case because the sludge is 6 ft thick only at the center of the basins. In other areas, the sludge is thinner.

As the concentration of sludge (CaO) relative to the concentration of soil (SiO_2) changes, the chemical behavior of the melt and the resultant glass will also change. In the SiO_2, Al_2O_3, CaO, Na_2O system (which is basically what a melt from this site is considered to be), variations in the concentration of these components affects the propensity for the melt to crystallize. In the phase diagram (Figure 2.2-2), region I indicates the compositional range where stable glass will not form. Region II indicates the range where stable glass will form but also has a tendency to crystallize. Region III is the range where crystallization will not take place at all. Crystallization in the ISV product is primarily formed by the slow cooling of the glass. Prior studies have shown that crystallization is not detrimental to the durability of the ISV product.

The chemistry of the melt expected from the M-1 Settling Basins should fall within regions II and III, and will produce glass with acceptable, high quality, chemical durability. In consideration of the thickness of the sludge layer in different locations in the ponds, it is apparent from Figure 2.2-2 that development of a non-vitreous mass is unlikely. If crystallization does occur, the crystals that will form will be wollastonite, leucite, anorthite and one or several rare forms of calcium silicates. The crystals, if formed, will be small and encapsulated in glass.

The viscosity curves shown in Figure 2.2-1 illustrate the temperature difference between the molten soil and the soil/sludge mixture at equivalent viscosities. Most ISV melts and corresponding operation temperatures stabilize at a viscosity of about 100 poise. Therefore, based upon the data presented in Figure 2.2-1 when the full-scale ISV melt reaches the base of the sludge (assuming the sludge is 6 ft. thick) it will be at a temperature of approximately 1000°C. The underlying soil will need to reach a temperature of about 1700°C (about 300 poise) before it will begin melting and mixing into the molten mass. This may promote preferential lateral growth when the melt reaches the sludge/soil interface. This condition could affect the depth to which vitrification can be achieved at the site.

Examination of data from the July 1990 soil sampling will be necessary to determine if there is a depth limitation due to compositional concerns and what the depth limitation might be. If a depth limitation is identified, it may only be an issue in the center of the ponds (where sludge is thickest) and could be remedied with a combination of chemical/physical adjustments, such as increasing the thickness of the cover soil or blending materials with the sludge to adjust its resultant composition in the ISV melt.

2.2.3 Site Conditions

Clean soil will be placed over the entire M-1 Settling Basins area to be vitrified prior to implementation. This will 1) provide worker protection from possible surface contamination, 2) provide for adjustment of chemical composition of the melt to optimize ultimate vitrified glass characteristics, and 3) inhibit volatilization of organics from the near-surface soil. The amount of soil will be based on compositional considerations. For cost estimating purposes, one foot of soil has been assumed at this stage of the design.

The bottom of the sludge is about 7.5 feet below ground surface. The water table fluctuates between 8 to 10 feet below ground surface. Because of the close proximity of the water table to the sludge, vitrification below the water table may be necessary. A sheet pile wall keyed into the Denver Formation is planned around the M-1 Settling Basins to provide a cut-off of ground water flow into the area during ISV. Ground water generally slows the vitrification process, since the process requires that this water be vaporized prior to the melt progressing downward. If ground water is encountered during sludge vitrification, the process will slow and require more energy. The vitrification will be performed to the bottom of the basins.

The site has several aboveground and subsurface features which will need to be addressed prior to implementation of ISV. Five steel storage tanks complete with concrete support pads and containment walls are currently located over the east settling basin. The tanks and overhead piping will be removed prior to implementation of ISV. The concrete pads and containment walls will be demolished and vitrified. Shell Oil Company will be issuing a Technical Letter Plan for the disposition of the tanks and overhead piping.

Several utilities no longer in use will need to be either removed or abandoned in place prior to implementation. These include an 18-inch plastic sewer pipe extending along the north side of the basins, a steel water line extending into the middle of the basins that supplies water to a fire protection system water gun, and an aboveground insulated steam line extending along the north edge of the basins. Other operating underground utilities will need to be rerouted during installation of the sheet piles.

Sufficient electrical power (4.25 MW at 13.8 kV) is available from the overhead electrical line running parallel to and along the north side of December 7th Avenue. Water is available from a 6-inch underground line located along the south side of December 7th Avenue.

The most appropriate location for the ISV Service Units (trailers controlling the ISV processing) is on December 7th Ave. The trailers can not be located between the site and December 7th Avenue because of an existing underground gas line of unknown condition or cover. Locating the trailers to the west of the site would require longer piping and electrical connections between the hood and the trailers, which could result in both excessive off-gas condensation leading to greater volumes of secondary waste produced and higher costs. Therefore, a detour road will be constructed to the north of December 7th Ave (see Drawing C-1).

2.2.4 Off-Gas Treatment System

Section 2.1 generally describes the off-gas treatment system. This system consists of the following unit processes: 1) quenching, 2) pH controlled scrubbing, 3) dewatering (mist elimination), 4) heating (temperature and dewpoint control), 5) particulate filtration, and 6) activated carbon adsorption. The alkaline quench/scrub solution is circulated through glycol heat exchangers to control system temperature. This solution will contain the majority of particulates evolving from the melt.

Results of the 1989 treatability test show that virtually all of the mercury and 10 to 20 percent of the arsenic present in the sludge can be expected to volatilize and will need to be removed by the off-gas treatment system. The calculations presented in Appendix A-3.4 show that this results in approximately 1,500 lbs (683 kg) of mercury and approximately 1,200 to 2,400 lbs (500 to 1,120 kg) of arsenic evolving from the melt during each four-day setting. The removal efficiency (RE) of the quench and tandem nozzle scrubber is a minimum of 90 percent. This results in approximately 1,350 lbs of mercury and from 1,080 to 2,160 lbs of arsenic collecting in the scrub solution. The remaining arsenic, most likely in the form of particulate arsenic trioxide, will be captured by two high efficiency particulate aerosol (HEPA) filters in series located after the scrub step. Each HEPA filter has an estimated particulate removal efficiency of 99.9 percent. Therefore, the estimated overall off-gas treatment efficiency is in excess of 99.9999 percent. The calculations in Appendix A-3.4 show that the arsenic emissions measured at the release point will be within the OSHA permissible exposure limit (PEL) by a factor of approximately 22.

A similar removal efficiency of more than 99.9999 percent is achieved for the mercury emissions. The calculations in Appendix A-3.4 show that mercury removal efficiency will be within the OSHA PEL by a factor of approximately 370.

The existing off-gas treatment system includes activated carbon as a polishing step for the emissions control system. This polishing step will also be used for the ISV of the M-1 Settling Basins to provide an added factor of safety. Calgon Carbon Corporation manufactures a type of carbon, called HGR, that can be used to remove the residual organics and mercury. Product literature for the HGR carbon is in Appendix A-2.

The 1989 treatability test showed destruction efficiencies (DE) for dieldrin and aldrin of 98.3 and 96.3 percent respectively. Based on the amount of these compounds in the soil in the vicinity of the basins, ISV melt release concentrations were calculated and are presented in Appendix A-3.4. These estimates show that, exclusive of carbon adsorption, the emissions of dieldrin and aldrin should be within the OSHA PEL's by factors of approximately 64 and 324, respectively. The carbon adsorber will provide an additional one to two orders of magnitude safety factor.

OSHA permissible exposure limits have been used in this analysis as a conservative indicator of potential exposure but are not meant to replace a risk assessment calculation. This risk assessment is currently being performed by the Army and should be available prior to the Draft Implementation Document.

The majority of the mercury and arsenic present in the off-gas will be removed in the quench and scrub steps and will be collected in the recirculating scrub solution. These volumes of arsenic trioxide and liquid mercury may be in excess of what can practically circulate in the scrub solution without causing nozzle plugging in the quench unit and scrubber. Therefore, some mechanism of particulate removal will be required.

A study is currently being performed to evaluate particulate removal mechanisms in conjunction with mercury recovery. Mercury recovery may be more cost-effective than disposing of the mercury as part of a waste stream.

Promising mercury recovery techniques currently being evaluated include:

- Off-gas filtration
- Scrub solution filtration
- Scrub solution centrifugation
- Scrub solution decantation

An off-gas pretreatment filtration device is being considered for removal of the high concentrations of arsenic and mercury being generated during the ISV processing to prevent downstream loading of the standard wet quenching, scrubbing, and filtration treatment system. The filtration system, positioned in the off-gas line after the hood and ahead of the standard off-gas treatment system, consists of a Thin-Mat® Filter Machine. The Thin Mat® Filter Machine is an automatic roll-type unit which uses a selected media to filter the off-gas air stream. The unit is designed for use with ventilation air systems, in high temperature air (350°F), in high moisture conditions, in high static pressure operation (3 in. H_2O), and high velocity conditions (1000 fpm). The unit can be operated manually or automatically with either pressure control and/or timer control. The filter media can be installed to index the media on a vertical or horizontal plane. Each assembly has a power-on signal, filter media run-out signal, and media indexing signal. The filter assembly could also be incorporated with a scraper blade to remove the Hg and As filtered particulate into a storage container as it exits the filter roll-out machine.

The existing operation calls for filtration of spent scrub solution prior to disposal. Spent filters are typically added to a future designated melt and subsequently vitrified, resulting in minimal secondary waste production. Particulate capture in these filters may be effective but has two disadvantages: 1) subsequent mercury recovery from spent filter material could be difficult, and 2) adding spent filters to the melt would result in revolatilization of the mercury, and would not provide any mechanism for removing mercury from the system.

The addition of a centrifuge to the system to treat a side stream of the recirculating scrub solution is also being evaluated. The advantages of a centrifugation step is that the resultant effluent and sludge phases may be more amenable to mercury recovery and that a smaller volume of waste material would be generated, since the volume associated with the filter material would not be generated.

The main uncertainty associated with centrifugation is the disposition of the mercury. Whether appreciable amounts of mercury will accumulate in a solid phase, to be subsequently recovered from the sludge by a volatilization/condensation process, or in a liquid phase which may allow the mercury to be collected in a gravity separation step, has not been fully evaluated at this stage of the design.

Particulate material may be decanted from the spent scrub solution. This solution would be pumped to a phase separator sized with a sufficient residence time to allow the mercury and arsenic trioxide to gravity separate. The mercury and solids would be drawn off the bottom of the tank for recycle, disposal, or addition to a future, designated melt setting.

The main advantage to the alternative is that it could be easily implemented with minimal process modifications. Whether this material would phase separate within a reasonable time frame has not yet been determined. Additional testing would be required to estimate particulate settling velocities and therefore decantation tank size.

These alternatives will be investigated further. The one or two considered most feasible, based on a detailed technical evaluation, will be tested on a laboratory scale. This may require an additional small scale test melt at Geosafe's facilities in Seattle in order to generate a representative condensate sample.

2.2.5 Site-Specific Operations

This section presents detailed plans for the vitrification activities of the project.

2.2.5.1 Mobilization

Mobilization of equipment, personnel and utilities will occur in four stages: 1) connection of the 13,800 volt electric power supply, 2) non-processing site preparation activities, 3) support trailers and earth moving equipment, and 4) ISV processing and related equipment.

Power will be provided to the trailers from a pole drop north of December 7th Avenue to a three-fuse disconnect as shown on the electrical one-line diagram in Section 5.0.

Geosafe will issue procurement contracts for one office trailer and one decontamination trailer. These trailers will be mobilized to the site and placed in the approximate configuration illustrated in the site plan in Section 5.0. Both trailers will be equipped with electrical power, telephone lines and storage areas. Potable water for the site (including decontamination water) will be supplied from the 6-inch main along December 7th Avenue. Drinking water will be supplied in bottled form, both in the trailers and in the field. The office trailer will be equipped with tables, chairs, refrigerator, and microwave for use by the site personnel. Geosafe's site manager will oversee placement of the trailers and their connection to electrical and other services by the site preparation contractor.

Concurrent with mobilization of the support trailers and related equipment, the necessary excavation and earth moving equipment will be mobilized.

Geosafe will schedule preparation of the ISV processing trailers for mobilization to the site. In addition, all support equipment, material and supplies will be designated for shipment by contract haulers. Shipment of the ISV processing equipment to the site will be scheduled to coincide with completion of site preparation activities. Transport time from Geosafe's Richland, Washington base location to the site is expected to take no more than five days, assuming normal weather conditions. Geosafe operations and management staff will travel to the site, and establish temporary residence near the site, while the equipment is in transit.

Upon arrival at the site, the ISV processing equipment will be positioned and interconnected. Support materials and supplies will be placed at interim storage locations. Assembly and erection of the ISV processing equipment will include placement and interconnection of the three processing trailers, connection to support utilities, connection of the high voltage supply, electrical testing of the transformers and other electrical components, filling of processing tanks and the glycol cooling system with the required solutions, and performing preliminary equipment/system tests.

After the processing equipment and systems have undergone preliminary testing, the entire system will be placed into full operation, with the exception of the 3,750 kVA transformer system as a test to verify its readiness for operation. Any deficiencies noted during the testing and inspections will be documented, corrected/repaired, and recalibrated as necessary.

Upon completion of all operational testing and inspection activities, all operational staff members will attend on-site, pre-operational safety meetings. During these meetings, the operations staff will be presented with the final, site-specific, Health and Safety Plan for the project, and will undergo site-specific operations training.

2.2.5.2 Vitrification Processing

A general description of the ISV process and equipment was presented in Section 2.1. A discussion of specific process conditions to be employed during the proposed project follows:

The critical and important operating parameters of the process control system (PCS) are given in Table 2.2-4 with their normal operating values. Critical parameters are defined as those requiring an automatic equipment response in the event of a high/low alarm. Important parameters require specific operator action within a specified time period when an alarm is detected. The critical operating parameters of the PCS include the following:

- negative pressure in the hood
- pressure drop across the wet scrubber system
- scrubber pump pressure and electrical current draw

The important operating parameters of the PCS include the following:

- hood plenum temperature and off-gas inlet temperature
- pressure drop across filters
- scrub solution pH
- scrub solution tank liquid volumes
- HEPA filter liquid detection
- scrubber nozzle flows

- heater control differential temperatures
- blower inlet temperature (filter exit temperature)
- stack temperature
- stack flow
- inlet and outlet particulate concentrations.

Except for inlet and outlet contaminant concentrations, all the operating parameters are monitored continuously by the distributed PCS. The current value of each parameter is displayed on a centralized CRT screen. If any parameter exceeds the established operating range, an alarm flashes on the display screen. If the range is exceeded for a critical operating parameter, the PCS automatically initiates a response action. The response action may include a process adjustment, starting a backup system, shutting down power to the electrodes, or a combination of actions. The appropriate response action will be identified in the standard operating procedures for the ISV process.

2.2.5.3 Determination of Setting Completion

A depth monitoring system is used in conjunction with the ISV process to monitor the depth of the molten soil at specific times (typically 1 ft depth increments) during the ISV operation. The depth monitor consists of a signal processor and transmitter package mounted below one or more of the electrodes as shown in Figure 2.2-3. For operation, a series of fiber optic sensors runs from the signal processor to different levels on the electrode(s). As the ISV process melts downward, the sensors transmit a self-generated light to the signal processor to indicate that the molten soil has reached that depth. The depth data is then passed on to the transmitter, which sends the data on to the receiver located at the ground surface. The receiver then passes the depth data to a second processor, which decodes the data and displays it for the ISV operations personnel. Duplication of the depth monitors for each vitrification setting will be employed to assure complete treatment of the sludge depth for each melt setting prior to terminating power to the electrodes.

2.2.5.4 Off-Gas Treatment and Secondary Waste

The off-gas treatment system was described in Sections 2.2.4. The system will be operated to ensure stack air emissions are at acceptable levels. Process effluents and residuals from this system will include: stack emissions, scrubber solution, and filters/adsorbers. Stack emissions consist primarily of air and water vapor. Under maximum design conditions, water vapor flow is about half the total stack flow of 1,800 cfm. The expected stack temperature is 260°F. Concentrations of particulates, organics and other air contaminants are maintained below the limits identified by the ARARs (Appendix A-1).

A single set of off-gas filters and carbon adsorbers is expected to last through at least 1,000 cy of soil processing. A set consists of six HEPA filters and three carbon adsorbers. Some of the filters, adsorbers, and scrubber solution cleanup materials may be subjected to ISV processing. This processing would be done in a separate ISV setting following the processing of the M-1 Settling Basins. Upon completion of the vitrification settings, arrangements for final disposition of all remaining filters and adsorbers will be performed in a manner consistent with other waste management activities at RMA.

It is anticipated that approximately 600 gallons of spent scrubber solution will be disposed of at the end of each melt setting. The solution will be filtered to remove any remaining particulate, mercury, and organics and should therefore be an alkaline solution with a pH between 8 and 11. The spent solution will be stored in a 2000-gallon high-density polyethylene (HDPE) vessel located immediately north of December 7th Avenue for eventual transport by truck to a treatment facility. If the CERCLA wastewater treatment plant is operational during ISV processing, it may be used to treat the spent solution.

2.2.5.5 Equipment Movement Between Settings

After the desired vitrification depth has been accomplished for each setting, the power will be terminated to the electrodes. The process off-gas scrubber system will remain in operation for approximately three-hours. Once the power is off and while the off-gas system is still operating, a rod will be inserted into the melt to obtain a glass sample (as described in the Chemical Data Management Specification (Section 4.3). Also, a series of off-gas samples will be taken at different intervals to determine if the vitrified mass is emitting fugitive gases at unacceptable levels. Upon confirmation that any emissions from the melt, if present, are at acceptable levels, the off-gas hood, and processing trailers, if necessary, will be moved to the next setting location.

Hood movement involves disconnecting the power cables from the electrodes and the 3,750 kVA transformer, and disassembly of the off-gas line and all associated equipment between the off-gas hood and the processing trailers. After these procedures are completed and the position change is authorized by the Geosafe Site Manager, the hood will be moved. Electrode cables will be reconnected to the next set of electrodes and the 3,750 kVA transformer.

After the processing equipment has been repositioned, the upper portions of the electrodes from the completed melt will be removed to near the melt surface, and the subsidence volume will be backfilled with clean soil.

2.2.5.6 Demobilization

Demobilization of the ISV processing equipment will commence after confirmation has been obtained that any emissions from the final setting, if present, are at acceptable levels. Upon approval by the Site Manager, the operations staff will begin Geosafe's standard processing equipment flushing and decontamination procedures. Upon satisfactory completion of equipment decontamination, the process equipment will be disassembled and readied for transportation.

The ISV equipment decontamination procedure involves vigorous recirculation of scrubber solution through 55-gallon drums of diatomaceous earth (filter aid) and activated carbon. The recirculation will be continued until such time that the contamination level within the scrubber solution is acceptable. This will be a direct indication of the cleanliness of internal off-gas system surfaces, and transport readiness. Final disposition of all decontamination materials will be performed in a manner consistent with other waste management activities at RMA.

Decontamination of the off-gas line (from the hood to the treatment trailer) will be certified by taking wipe samples from the interior surfaces. Cleaning of the off-gas line sections will be performed, and repeated, as necessary to attain acceptable levels of residual contamination.

The off-gas collection hood fabric will also be tested for contamination. Geosafe plans to decontaminate the hood fabric if possible for use on subsequent projects. In the event that it cannot be satisfactorily decontaminated, Geosafe will sacrifice the used hood fabric at the conclusion of the project; in this case it would be considered as secondary waste for final disposition in a manner consistent with other waste management activities at RMA.

The system decontamination activity will also include collection and packaging of all other secondary waste generated during the project. This includes: the remaining off-gas filters and adsorbers, scrubber solution cleanup materials, and any protective clothing and other equipment not otherwise decontaminated or disposed. This material will be handled in a manner consistent with other waste management at RMA.

Upon completion of the ISV processing equipment demobilization, all remaining support equipment and facilities will be disconnected and demobilized. All Geosafe property will be transported off-site upon completion of the demobilization activities. Contract haulers will be utilized for this activity. At this point, site restoration can be conducted in those areas affected by the equipment and trailers.

2.2.5.7 ISV Processing Area Restoration

Any remaining affected areas will then be restored with the exception of revegetation directly over the treatment zone. Restoration will include backfilling with clean soil, surface grading as necessary, removal of the sheet piles, and revegetation. Restoration may also include removal of the detour road and secondary containment area.

2.2.5.8 Sampling and Analysis

Statistically based sampling and analysis in compliance with project Quality Assurance objectives is a major part of the proposed project. Sampling and analysis will be employed for the following purposes:

1) Determine the extent of contamination in soils to be treated, and the acceptability of residual contamination levels in the external areas (it is assumed that this will be performed prior to Geosafe's arrival).

2) Provide data regarding the physical/chemical properties of the soils to be treated
3) Confirm cleanliness (acceptability) of site obtained or purchased backfill materials
4) Confirm site activities are performed in compliance with air emissions standards
5) Determine acceptability of scrubber solution for continued use
6) Confirm gaseous emissions from treatment zone are acceptable prior to hood movement
7) Determine satisfactory completion of equipment decontamination
8) Identify secondary waste at project completion
9) Confirm the immobilization of contaminants in the residual ISV product through leach testing (e.g., TCLP)

The sampling and analytical effort is to be in accordance with an approved Quality Assurance Project Plan (QAPP); the QAPP is in like manner consistent with Geosafe's Quality Assurance Policy, Program Guidelines, and Procedures. This latter document requires that Geosafe comply with EPA guidance (SW-846, <u>Test Methods for Evaluating Solid Waste</u>), specifically as required to ensure adequate statistical significance, precision, accuracy, completeness, representativeness and comparability. Geosafe will employ off-site analytical laboratory(ies) for performance of analyses.

2.2.6 <u>Monitoring</u>

The work will be monitored during the implementation of the ISV process to ensure that all operational specifications and applicable regulatory requirements are met. Monitoring following implementation of the ISV process will be used to evaluate the effectiveness of the interim response action (IRA).

2.2.6.1 Operations Monitoring

Operations monitoring will include sampling and analysis of the vitrified mass, off-gas treatment scrub solution, and ambient air monitoring for each vitrification setting. Five percent of the ISV melts (four settings, including the Demonstration Test setting) will undergo extensive off-gas treatment system sampling and analysis of the gases and particulates released from the melt and at the stack. The requirements for operations monitoring are detailed in the Health and Safety Specification (Section 4.2) and the Chemical Data Management Specification (Section 4.3).

2.2.6.2 Post Operations Monitoring

Post operations monitoring will consist of ground water sampling and analysis. Data from the ground water monitoring will be used to evaluate the effectiveness of this IRA. Details of the post operations monitoring are described in the Site Maintenance Plan (Section 2.4).

2.2.7 Health and Safety

The work described in this Concept Design Document involves the interim remediation of a hazardous waste site and is within the scope of part 1910.120 of title 29 of the Code of Federal Regulations (29 CFR 1910.120), "Hazardous Waste Operations and Emergency Response". This regulation requires the development and implementation of a written health and safety program for employees involved in hazardous waste operations and also requires that a site-specific health and safety plan be written to address the hazards of each phase of the site operation. The site-specific health and safety plan must include requirements and procedures for employee protection and responses to spills and emergencies.

The in situ vitrification (ISV) of the M-1 Settling Basins will result in potential exposures to hazardous materials and physical hazards from which workers must be protected. The ISV process will involve the use of large electrical currents to "melt" the M-1 Settling Basins material. The M-1 Settling Basins material is believed to contain approximately one half percent mercury and approximately four and one half percent arsenic. The ISV operation will result in the generation and collection of large amounts of these elements. These substances pose health threats to workers through both inhalation and skin exposures. Specific hazards that must be addressed in the site-specific health and safety plan include, but are not limited to, electrical hazards, heat and cold stress, and potential exposure to hazardous substances. Field screening tests during intrusive work in the M-1 Settling Basins have sometimes yielded positive indications of lewisite and mustard, although laboratory analysis has not confirmed those results.

In planning for worker protection during the ISV, engineering controls to protect workers must be used whenever feasible, and personal protective equipment will be used only when engineering controls are not feasible. Exposures to hazardous materials will be kept as low as reasonably achievable and will in no case exceed the permissible exposure limits specified in 29 CFR 1910.1000.

The site-specific health and safety plan will be written by or under the direction of a American Board of Industrial Hygiene Certified Industrial Hygienist experienced in hazardous waste work. The plan will be signed by the responsible ISV contractor health and safety officer and project manager at a minimum. The ISV contractor will certify in writing to the Contracting Officer (CO) that a fully appropriate and compliant plan has been produced and will supply the CO with a copy of said plan.

This design includes specifications for the site-specific health and safety plan to be written and implemented by the ISV contractor. All items in the specifications must be addressed in the plan. If any items are determined to not be required, they will still be listed in the plan with an explanation as to why the topic of the item need not be addressed in the plan.

2.3 CONSTRUCTION SCHEDULE

The construction schedule for implementation of the in situ vitrification (ISV) interim response action at the M-1 Settling Basins is shown in Figure 2.3-1. The schedule is based on the number of months required to perform each activity from the time the contractor is given Notice-to-Proceed.

It is assumed that the following activities will have been completed by the Army prior to Notice-to-Proceed for the ISV:

- Installation of the sheet pile cut-off wall around the M-1 Settling Basins.
- Rerouting of any underground utilities within the proposed sheet pile containment area and rerouting of any impacted overhead utilities in the vicinity of the M-1 Settling Basins.
- Removal of the storage tanks on the M-1 Settling Basins.
- Removal of the steam line running parallel to the north side of the M-1 Settling Basins.

Site preparation will involve the following activities:

- Demolition of the concrete containment walls and support pads of the storage tanks.

- Placement of about one foot of clean soil over the area to be vitrified.
- Removal of the fence along December 7th Avenue.
- Construction of a detour of December 7th Avenue approximately 60 feet north of the current route along the M-1 Settling Basins.
- Construction of a fence around the ISV work area.
- Installation of the tanks to be used for the off-gas treatment system process water.
- Utility hookups.
- Installation of ground water monitoring wells, if necessary, for site maintenance.

An ISV Demonstration Test will be completed prior to full-scale implementation and will involve extensive sampling and analysis. Implementation of the ISV will continue during the analysis and reporting for the Demonstration Test. Sampling and reporting will continue during the ISV implementation, as described in the Chemical Data Management Specification (Section 4.3).

Ground water monitoring will be performed as specified in the Site Maintenance Plan (Section 2.4). One round of sampling is recommended prior to implementation of the ISV. Ground water monitoring for this interim response action will continue until such time as specified in the final on-post Record of Decision (ROD).

2.4 SITE MAINTENANCE PLAN

This section presents the Site Maintenance Plan to be implemented following completion of the ISV at the M-1 Settling Basins.

2.4.1 Site Maintenance Plan Objective

The objective of the Site Maintenance Plan is to provide data to evaluate the effectiveness of the interim response action (IRA) implemented at the M-1 Settling Basins. Ground water monitoring data were used during the IRA alternatives assessment to identify the M-1 Settling Basins as a source of arsenic contamination to the ground water (WCC 1990, RIC 90002R05). Ground water monitoring will also be used to evaluate whether the ISV at the M-1 Settling Basins is effective in treating this source of ground water contamination.

2.4.2 Current Ground Water Monitoring Program

Numerous ground water monitoring programs have been conducted at RMA from 1975 to the present. Currently, the Comprehensive Monitoring Program (CMP) provides both continual and long-term monitoring of ground water, surface water, air and biota.

Within the scope of the CMP, several of the wells in the vicinity of the M-1 Settling Basins are monitored on a regular basins. The following wells were included in the FY88 and FY89 CMP programs: 01511, 01516, 01524, 36001, 36076, and 36168. The locations of these wells are shown in Figure 2.4-3.

Ground water samples were analyzed for a full suite of chemicals. The suite includes arsenic and mercury which have been used as the indicator compounds for ground water contamination from the M-1 Settling Basins (WCC 1990, RIC 90002RO5). Details of the CMP are found in R.L. Stollar and Associates, Inc. Comprehensive Monitoring Program Annual Ground Water Report for 1988 (1989), Final Report, RIC 89213R01 (RIC90231RO1).

2.4.3 Proposed Ground Water Monitoring Plan

Prior to formulating a post-operations ground water monitoring plan for the M-1 Settling Basins, the geologic and hydrogeologic characteristics of the site were examined. Reports of recent soil and ground water investigations at the site were reviewed (WCC 1989, RIC90002R06) (RL Stollar 1990, RIC90231R01) to provide background information. In addition, the following maps and geologic cross sections were constructed from the interpretation of existing boring log and ground water elevation data.

- Two geologic cross-sections (Figures 2.4-1 and 2.4-2)
- Distribution of sandy sediments in the alluvial aquifer (Figure 2.4-3)
- Bedrock surface contour map (Figure 2.4-4)
- Potentiometric surface for the alluvial aquifer (Figure 2.4-5)
- Contour maps of arsenic and mercury concentrations in ground water (Figure 2.4-6 and 2.4-7)

The purpose of constructing the above support figures was to facilitate evaluation of the potential ground water migration pathways at the site. An effective ground water monitoring network could then be developed once the predominant pathways were identified. The geologic and hydrogeologic site characteristics are summarized below followed by a description of the proposed ground water monitoring plan.

2.4.3.1 Geologic Setting

The vicinity of the M-1 Settling Basins is underlain by Quaternary-age alluvial sediments that are approximately 10 to 25 feet thick (WCC 1989, RIC90002R06). The sediments consist of fine to medium-grained sands, silty sands, clays and occasional gravels. Representative types and thicknesses of alluvial materials are shown in geologic cross sections A-A', and B-B', (Figures 2.4-1 and 2.4-2, respectively). These alluvial sediments are generally heterogeneous mixtures of the geologic material listed above.

A map was constructed showing the interpreted distribution of sandy sediments within the alluvial aquifer at the site (Figure 2.4-3). The map was prepared by recording the number of feet of SM, SC, SP, and SW (USC- unified soils classification) material in the 10 ft interval immediately above bedrock and converting this number to percent. The purpose of constructing the map was to see if the sandier (i.e. more permeable) sediments occurred in trends that may provide a preferred ground water flow pathway. From Figure 2.4-3 it can be seen that clayey areas are found to the east-southeast and west-southwest of the M-1 Settling Basins, and a sandy zone trends to the north across the area between the two clayey areas. There is no evidence from potentiometric maps prepared for the area, however, that the clayey areas significantly impact ground water flow direction. Furthermore, based on existing data, no large-scale geologic features (i.e., paleochannels) exist cross-gradient to the apparent direction of ground water flow.

The bedrock underlying the alluvium consists of interbedded claystones, siltstones and sandstones of the Cretaceous-age Denver Formation. The bedrock surface was dissected by stream erosion prior to deposition of the overlying alluvial sediments. This has resulted in an irregular bedrock surface, as illustrated by the bedrock topography map shown in Figure 2.4-4. Figure 2.4-4 shows that the bedrock surface generally slopes to the north and is found at an approximate elevation of 5,248 ft mean sea level (MSL) underlying the M-1 Settling Basins. The upper most portion of the Denver Formation is typically weathered in the site vicinity. Weathering characteristics frequently noted on boring logs are; fracturing, iron oxidation, friable texture, and color changes (i.e. brown-orange to grey). The weathered bedrock sequence at the site ranges from 1 to 10 feet thick based on boring log data shown in Figures 2.4-1 and 2.4-2.

2.4.3.2 Ground Water Conditions

Ground water at the site occurs in both the alluvial sediment and permeable units within the bedrock. Ground water in the alluvial aquifer is generally found approximately 8 to 10 feet below ground surface at the M-1 Settling Basins. The average saturated thickness of the unconfined aquifer is approximately 8 to 10 ft in the vicinity of the M-1 Settling Basins. The weathered portion of the bedrock may also be water bearing and in communication with the unconfined alluvial aquifer system. Deeper aquifers within the unweathered portion of the Denver Formation may exist under confined or semi-confined conditions (WCC 1989, RIC90002R06). The unconfined aquifer (alluvial and weathered bedrock) is the focus of the ground water monitoring plan for the M-1 Settling Basins.

Potentiometric maps prepared for the unconfined aquifer in past investigations at RMA show a northerly gradient at the site with little seasonal change (RL Stollar 1990, RIC90231R01). A potentiometric map prepared for the Spring 1989 M-1 field investigation (WCC 1989, RIC90002R06) indicates a northerly gradient with a magnitude of approximately 0.018 (Figure 2.4-5). The monitoring wells currently existing at the site and nearby vicinity are shown in Figure 2.4-5.

Aquifer tests conducted within the alluvial aquifer at various locations at RMA indicate that a reasonable hydraulic conductivity estimate is 2.4×10^{-3} cm/sec to 6.0×10^{-3} cm/sec (WCC 1989, RIC90002R06). Using the gradient of 0.018, the above estimated hydraulic conductivity of 6.0×10^{-3} cm/sec, and an assumed effective porosity of 0.25, the estimated ground water flow velocity in the M-1 Settling Basins vicinity is approximately 1.2 feet per day. Contaminants in ground water will not necessarily move at this rate due to contaminant transport characteristics such as adsorption, retardation, biodegradation, and dispersion. Therefore, it may be several years before the impact of the interim response action can be detected in ground water monitoring wells.

Past ground water and soil sampling indicate mercury and arsenic are the chemicals of concern at the M-1 Settling Basin. Arsenic and mercury concentrations in ground water are shown in Figures 2.4-6 and 2.4-7, respectively, for the May and June 1989 sampling event. Figure 2.4-6 shows a high concentration of total arsenic of 20,000 μg/l (Well 01504) immediately downgradient of the M-1 Settling Basins. The arsenic concentration decreases dramatically to 110 μg/l (well 36054) approximately 350 feet to the north. The mercury ground water plume shown in Figure 2.4-7 also shows an elevated concentration immediately downgradient of the M-1 Settling Basin, then a rapid decrease in concentrations in the downgradient direction before the Lime Settling Basins are reached. The apparent direction of plume development compares favorably with the northerly ground water flow direction historically noted for the site. The arsenic and mercury plume maps prepared for the plan also generally agree with those shown in past reports (RL Stollar 1990, RIC90231R01).

2.4.3.3 Ground Water Monitoring Plan

The following existing wells will be used to monitor the effectiveness of the proposed treatment of the M-1 Settling Basin sludge (Figure 2.4-8).

- 36001 and 36193 (downgradient wells).
- 01524 and 01083 (upgradient wells).

The following wells will be installed to complete the ground water monitoring network (Figure 2.4-8).

- Locations A and B downgradient wells (replacements for 01503 and 01504 which will be destroyed during the ISV process)

If Well No. 01083 is destroyed or impacted by the ISV of the M-1 Settling Basins, a replacement well will be installed in the general vicinity. The proposed monitoring network will consist of two upgradient and four downgradient wells. The wells proposed for installation at locations A and B will be installed according to PMRMA approved methods.

Well Nos. 36001 and 01524 are currently used in the CMP and therefore their integrity appears to be suitable. Well No. 36001 is screened from 10.5 to 20.0 ft below ground surface; Well No. 01524 is screened from 13.3 to 23.3 ft. Existing Well Nos. 36193 and 01083 were recently installed (WCC 1989, RIC90002R06) and records indicate that the integrity of these wells is suitable for long term monitoring. Well No. 36193 is screened from 6.9 to 15.7 ft, Well No. 01083 is screened from 7.5 to 16.3 ft. Existing Well No. 36053 has questionable integrity and will not be used in the monitoring network (ESE 1986, RIC 87013R01).

Well Nos. 01083, 36193, and the proposed wells at locations A and B would provide data on ground water immediately upgradient and downgradient of the site. Well Nos. 01524 and 36001 are included because they provide an upgradient and downgradient well along the anticipated flow lines after the ISV, and because they have a history of sampling data (Well Nos. 01083 and 36193 were not installed until spring 1989).

The proposed monitoring well network will provide sufficient ground water data to evaluate the long-term effectiveness of ISV of M-1 Settling Basin sludge on the ground quality of the uppermost aquifer. Based on historic ground water flow directions and the current distribution of arsenic and mercury in ground water the proposed monitoring well network will be capable of comparing upgradient to downgradient ground water quality.

2.4.3.4 Sampling Frequency

The proposed monitoring program will include four existing wells and two new wells. Well Nos. 01083 and 01524 have been selected to monitor the upgradient water quality. Well Nos. 36001 and 36193 have been selected based on their locations and screened intervals. Other wells in the vicinity (01502 and 01077) have not shown concentrations of arsenic or mercury historically and are assumed not to be impacted by the IRA.

Implementation of the IRA is expected to begin in the fall of 1991. A round of ground water sampling should be scheduled just prior to implementation to determine the analyte concentrations prior to remediation.

Wells in the area of the M-1 Settling Basins have been sampled sporadically for arsenic and mercury since 1979, and seasonal variations in analyte concentrations are not evident. Ground water sampling of the six wells mentioned above should be initiated six months following the implementation of the IRA and continue on an annual basis there after to determine the effectiveness of remediation. Because of the hydraulic conductivity of the alluvium, more frequent sampling is not recommended since it may be several years before the impact of the interim response action can be detected in ground water monitoring wells. Required sampling frequency may be reevaluated as part of the CMP. Ground water monitoring for this IRA will continue until such time as specified in the final on-post Record of Decision (ROD).

2.4.3.5 Sampling Procedures

Water samples shall be collected for the analysis of arsenic and mercury to evaluate the effectiveness of this IRA. Samples shall be collected, filtered, and preserved in accordance with standard PMRMA procedures. Quality Assurance/Quality Control samples will be determined and collected at frequencies according to procedures outline in the PMRMA Chemical Quality Assurance Plan (CQAP) Version 1.0, July 1989. Laboratory analysis for arsenic and mercury shall be performed using approved PMRMA methodologies and in accordance with the CQAP.

TABLE 2.2-1

DESIGN BASIS

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

Dimensions	306 ft x 115 ft
Surface Area	35,190 ft^2 (about 1 acre)
Depth from ground surface:	
to top of sludge	2 ft
to bottom of sludge	7.5 ft
to bottom of melt	9 ft

Note: One foot of clean soil will be placed over the area to be vitrified prior to operations for health and safety reasons. The total depth of the melt is 10 ft, including this foot of clean soil.

Volume of Sludge	6,600 yd^3
Volume of material to be vitrified	13,000 yd^3
Depth of water table	8 to 10 ft below ground surface
Depth to confining layer	10 to 25 ft

Sludge Characteristics

Density	0.84 ton/yd^3
Moisture Content	47 percent

Grey-to-white, very wet silty clay like material.

Soil Characteristics

Density	1.4 tons/yd^3
Moisture Content	17 percent

Gravelly-to-silty sands, with lesser amounts of clayey sand to silty sand.

Sheet 1 of 2

TABLE 2.2-1
(Continued)

Contaminant Concentrations

	Soil (mg/kg)	Sludge (mg/kg)
Arsenic	78	44,900
Mercury	6	5,400
Aldrin	1.39	Non-detect
Dieldrin	3.54	Non-detect
Dicyclopentadiene	2.72	6.31
Hexachlorocyclopentadiene	2,600	Non-detect
Bicycloheptadiene	Non-detect	550

Sheet 2 of 2

TABLE 2.2-2
MAJOR OXIDE ANALYSIS AND WEIGHTED AVERAGE FOR WASTE LAYERS PRESENT IN TEST

SITE NAME	ROCKY MOUNTAIN ARSENAL M-1 BASINS			
CLIENT NAME	INTERNAL			
DATE FILE NAME	RMAD			
DATE FILE NUMBER	1			
ELECTRODE SPACING	25.4	CM	10	IN
LAYER 1 THICKNESS	91.44	CM	36	IN
LAYER 1 MASS, G	88490.15			
LAYER 1 DENSITY, G/CC	1.5			
LAYER 1 TYPE	BACKGROUND SOIL			
LAYER 2 THICKNESS	182.88	CM	72	IN
LAYER 2 MASS, G	68432.38			
LAYER 2 DENSITY, G/CC	.58			
LAYER 2 TYPE	RMA SLUDGE			
TOTAL THICKNESS =	274.32		CM	
TOTAL MASS =	156922.5		G	

OXIDE	LAYER 1	LAYER 2	LAYER 3	LAYER 4	WEIGHTED AVERAGE
SI02	70.34	3.48	0	0	41.183
TI02	.35	.05	0	0	.2191729
AL203	14.09	1.77	0	0	8.717368
FE203	2.39	0.52	0	0	1.574511
FEO	0	0	0	0	0
MNO	.06	0	0	0	3.383459E-02
MGO	1.27	.28	0	0	.8382706
CAO	2.97	92.53	0	0	42.02624
NA20	3.29	0	0	0	1.855263
K20	5.24	1.36	0	0	3.54797
P205	0	0	0	0	0
TOTAL	100	99.98	0	0	99.9913

Sheet 1 of 1

TABLE 2.2-3

M-1 SETTLING BASINS VISCOSITY ESTIMATES

Temperature (DEG. C)	Viscosity Soil (Poise)	Viscosity Mixture (Poise)
800		4000
900		901
1000		256
1100		88
1200		35
1300		
1400		
1500		
1600		
1700	712	
1800	293	
1900	131	
2000	63	
2100	32	

Sheet 1 of 1

TABLE 2.2-4

NORMAL OPERATING VALUES, DISPLAY RANGES AND OPERATING PARAMETER LIMITS

Variable Description	Tag	Display Range		Display Units	Operating Limits		Normal Operating Value
		Low	High		Low	High	
Tank 1 pH	AI-201	6	14	pH	8	11	8-11
Tank 2 pH	AI-301	6	14	pH	8	11	8-11
Wet Scrubber DP	DPI-201	0	90	in. H_20	50	70	60
Mist Eliminator DP	DPI-202	0	9	in. H_20	–	6	3
HEPA Filter DP	DPI-301	0	9	in. H_20	–	6	1.5
Carbon Filter DP	DPI-302	0	9	in. H_20	–	6	1.5
Scrub Liquid Flow	FI-201	0	75	gpm	30	52	44
Glycol Flow	FI-301	0	300	gpm	150	–	250
Pump 1 Amps	II-201	0	10	amps	3	6.5	5
Pump 2 Amps	II-301	0	10	amps	3	6.5	5
Blower Amps	II-302	0	150	amps	45	90	65
Glycol Fan 1 Amps	II-303	0	30	amps	–	21	18
Glycol Fan 2 Amps	II-304	0	30	amps	–	21	18
Tank 1 Volume	LI-201	0	1,300	gal	300	1000	700
Tank 2 Volume	LI-301	0	1,100	gal	300	900	600
Liquid Alarm	LAH-301	Dry	Liquid	signal	Dry	Liquid	Dry
Hood Vacuum	PI-101	0	5	in. H_20	0.25	2.0	0.5
Quench Nozzle P	PI-201	0	50	psig	15	26	20
Pump Discharge P	PI-202	0	50	psig	20	–	30
HSS Nozzle- 1P	PI-204	0	50	psig	15	26	20
HSS Nozzle- 2P	PI-205	0	50	psig	11	26	15
Filter Exit Vacuum	PI-301	0	90	in. H_20	–	–	70
Blower Vacuum	PI-303	0	90	in. H_20	–	–	70
Cooler Exit P	PI-304	0	80	psig	–	–	5
Cooler Inlet P	PI-305	0	80	psig	–	–	30
Compressed Air P	PI-401	0	200	psig	–	–	80

Sheet 1 of 2

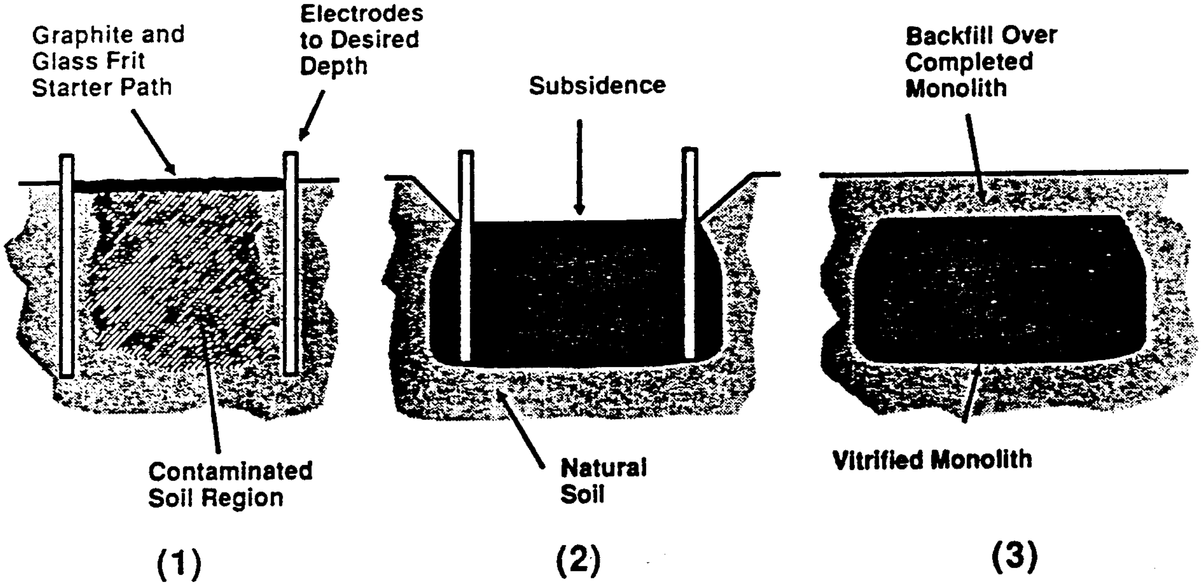
TABLE 2.2-4
(Continued)

		Display Range			Operating Limits		
Variable Description	Tag	Low	High	Display Units	Low	High	Normal Operating Value
Instrument Air P	PI-402	0	32	psig	–	–	15
Hood Skin T 1	TI-101	0	500	°C	–	470	200
Hood Skin T 2	TI-102	0	500	°C	–	470	200
Hood Skin T 3	TI-103	0	500	°C	–	470	200
Hood Skin T 4	TI-104	0	500	°C	–	470	200
Hood Plenum T 1	TI-105	0	500	°C	–	470	250
Hood Plenum T 2	TI-106	0	500	°C	–	470	250
OG Hood Exit T	TI-107	0	500	°C	–	470	250
OG Trlr Inlet T	TI-201	0	500	°C	–	400	175
Quench OG Exit T	TI-202	0	150	°C	–	100	66
Tank 1 T	TI-203	0	100	°C	5	60	55
HE-1 Inlet T	TI-204	0	100	°C	–	–	66
HE-2 Inlet T	TI-205	0	100	°C	–	–	65
HE-1 Exit T	TI-206	0	100	°C	–	–	41
HE-2 Exit T	TI-207	0	100	°C	–	–	41
Mist Elim. Exit T	TI-208	0	100	°C	–	–	65
Heater T Control	TIC-301	0	100	°C	–	90	80
Filter Exit T	TI-302	0	100	°C	–	90	80
Tank 2 T	TI-303	0	100	°C	5	60	25
Stack Exhaust T	TI-306	0	150	°C	–	140	118
Ambient Air T	TI-401	-40	40	°C	–	–	38

DP = differential pressure

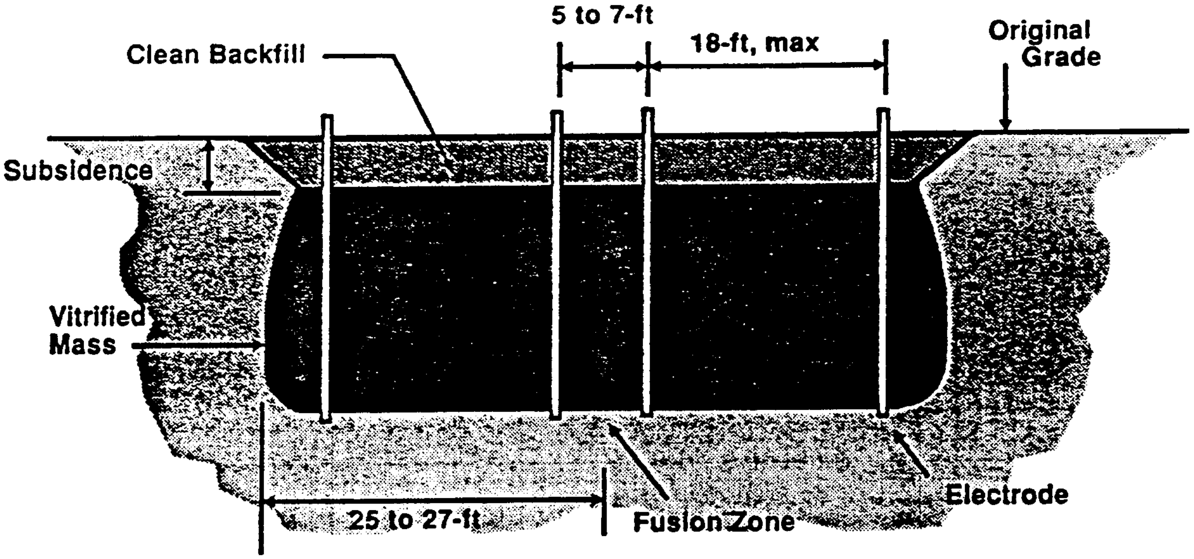
OG = off gas

P = pressure



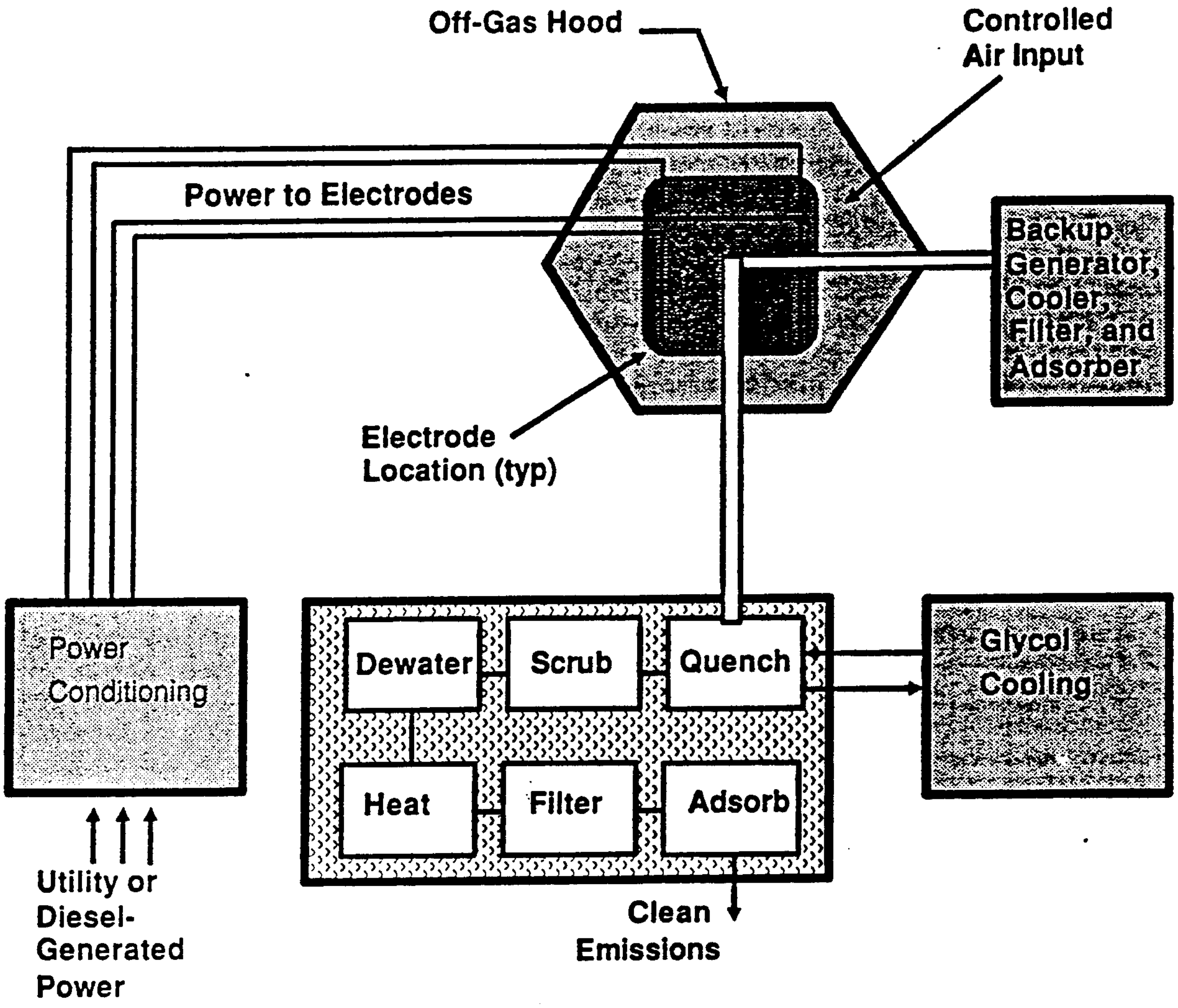
SOURCE: GEOSAFE CORP.

Job No. : 89MC114B-302	IN SITU VITRIFICATION M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO STAGES OF ISV PROCESSING Figure 2.1-1
Prepared by : K.A.S.	
Date : 8/20/90	



SOURCE: GEOSAFE CORP.

Job No. : 89MC114B-302	IN SITU VITRIFICATION M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO RELATIONSHIP OF ADJACENT SETTINGS Figure 2.1-2
Prepared by: K.A.S.	
Date: 8/20/90	



SOURCE: GEOSAFE CORP.

Job No. : 89MC114B-302

Prepared by : K.A.S.

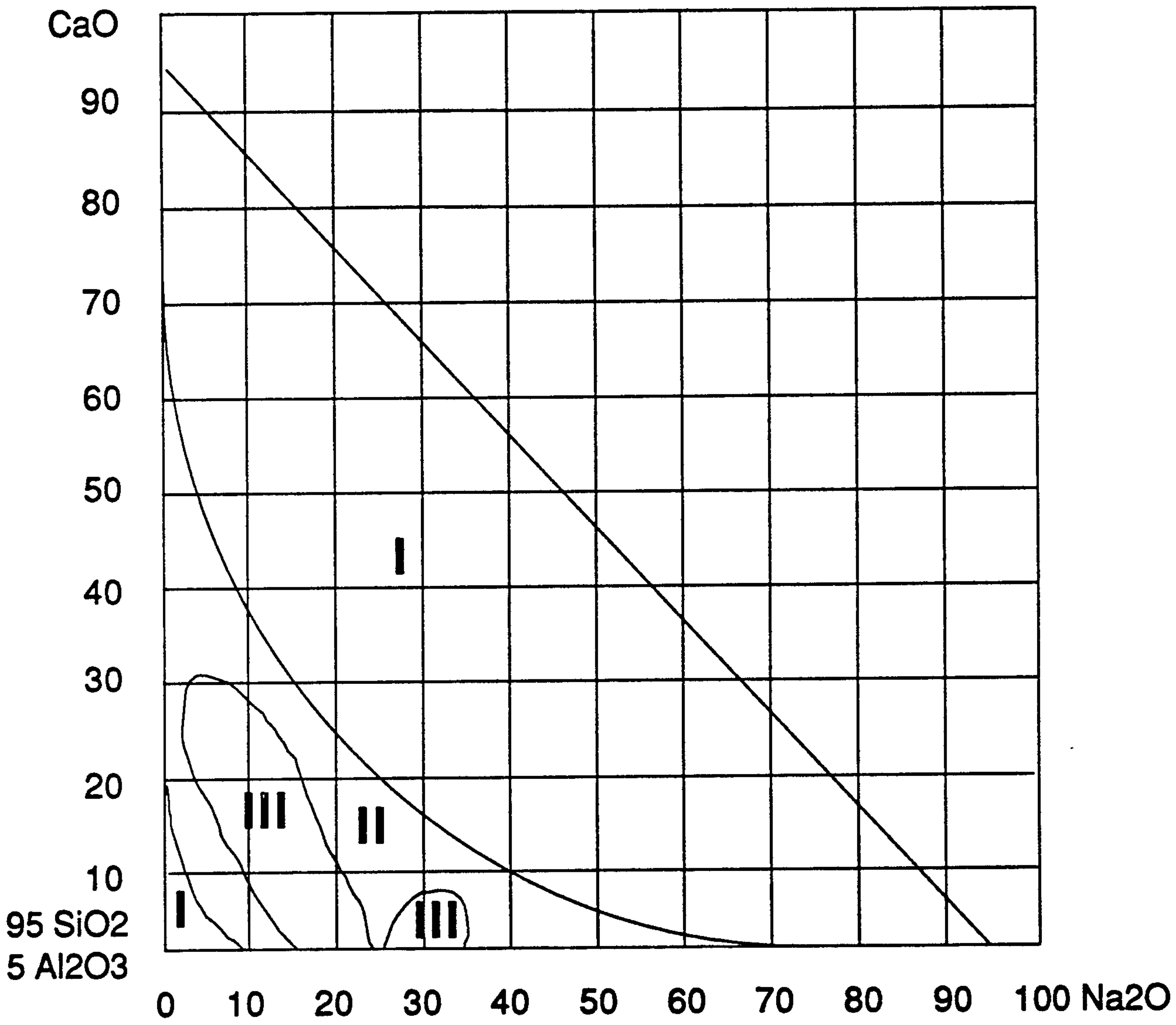
Date : 8/20/90

IN SITU VITRIFICATION
M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO
ISV EQUIPMENT SYSTEM
Figure 2.1-3

Silicate Phase Diagram

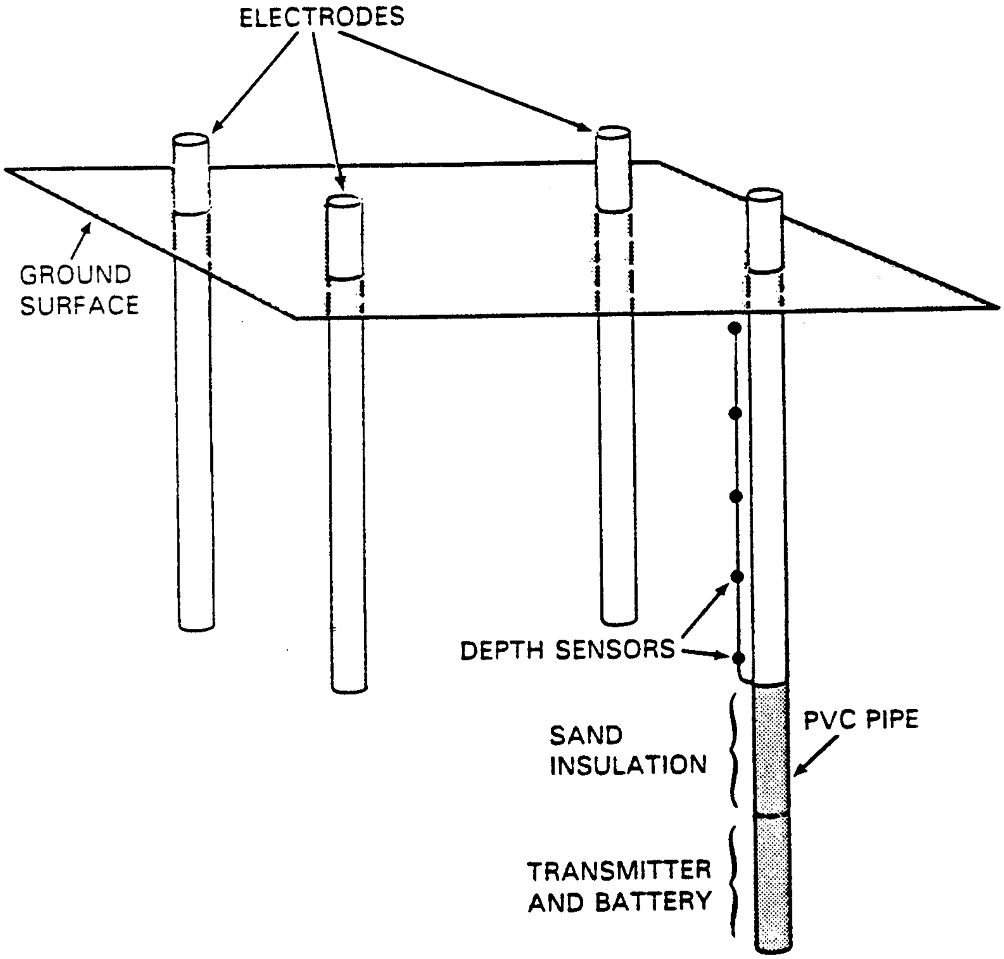
SiO2, Al2O3, CaO, Na2O System

(Modified From Volf, 1984)



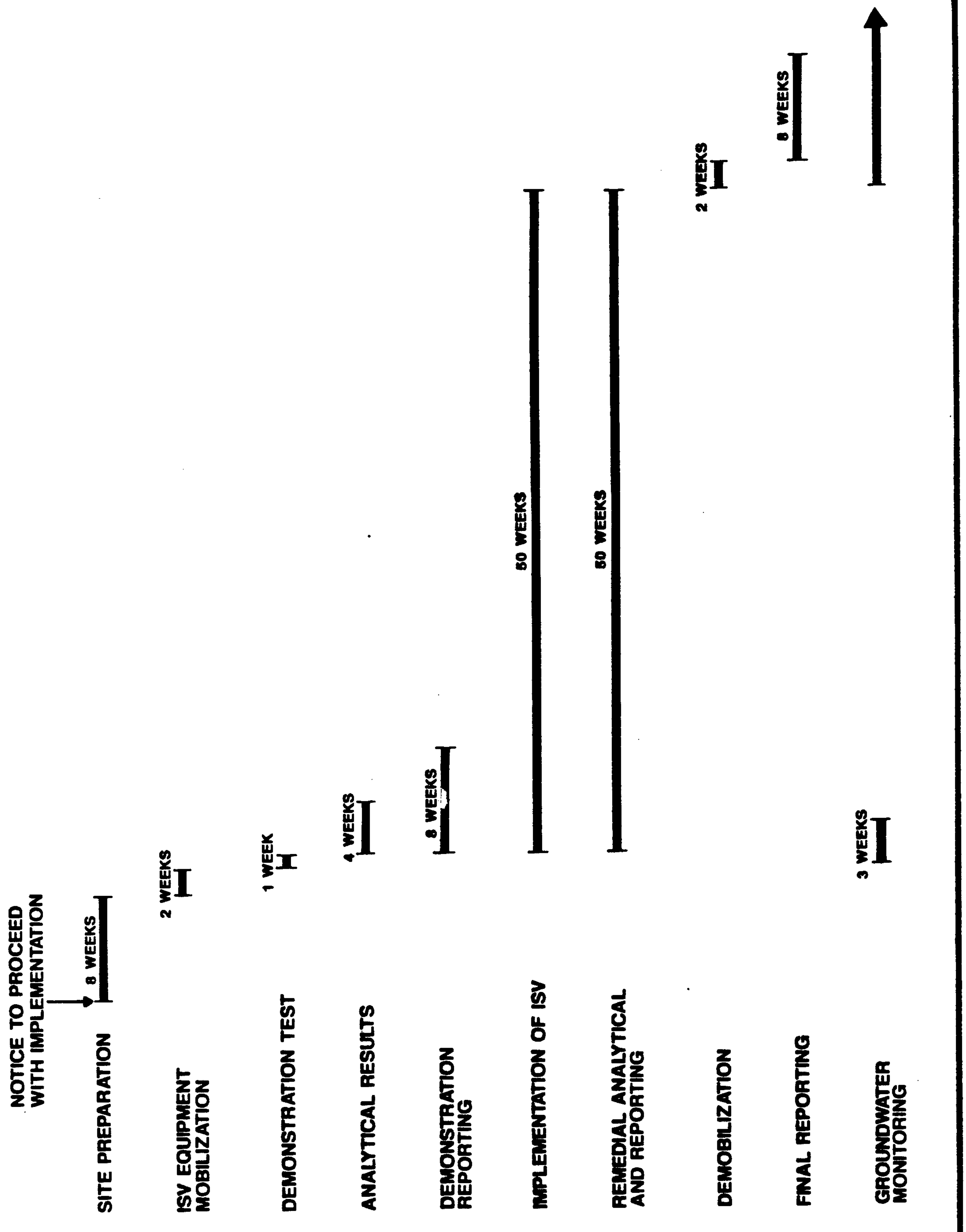
SOURCE: GEOSAFE CORP.

Job No. : 89MC114B	IN SITU VITRIFICATION M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO SILICATE PHASE DIAGRAM FIGURE 2.2-2
Prepared by : K.A.S.	
Date : 8-31-90	



SOURCE: GEOSAFE CORP.

Job No. : 89MC114B	IN SITU VITRIFICATION M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO ISV MELT DEPTH MONITORING SYSTEM FIGURE 2.2-3
Prepared by : K.A.S.	
Date : 8-31-90	

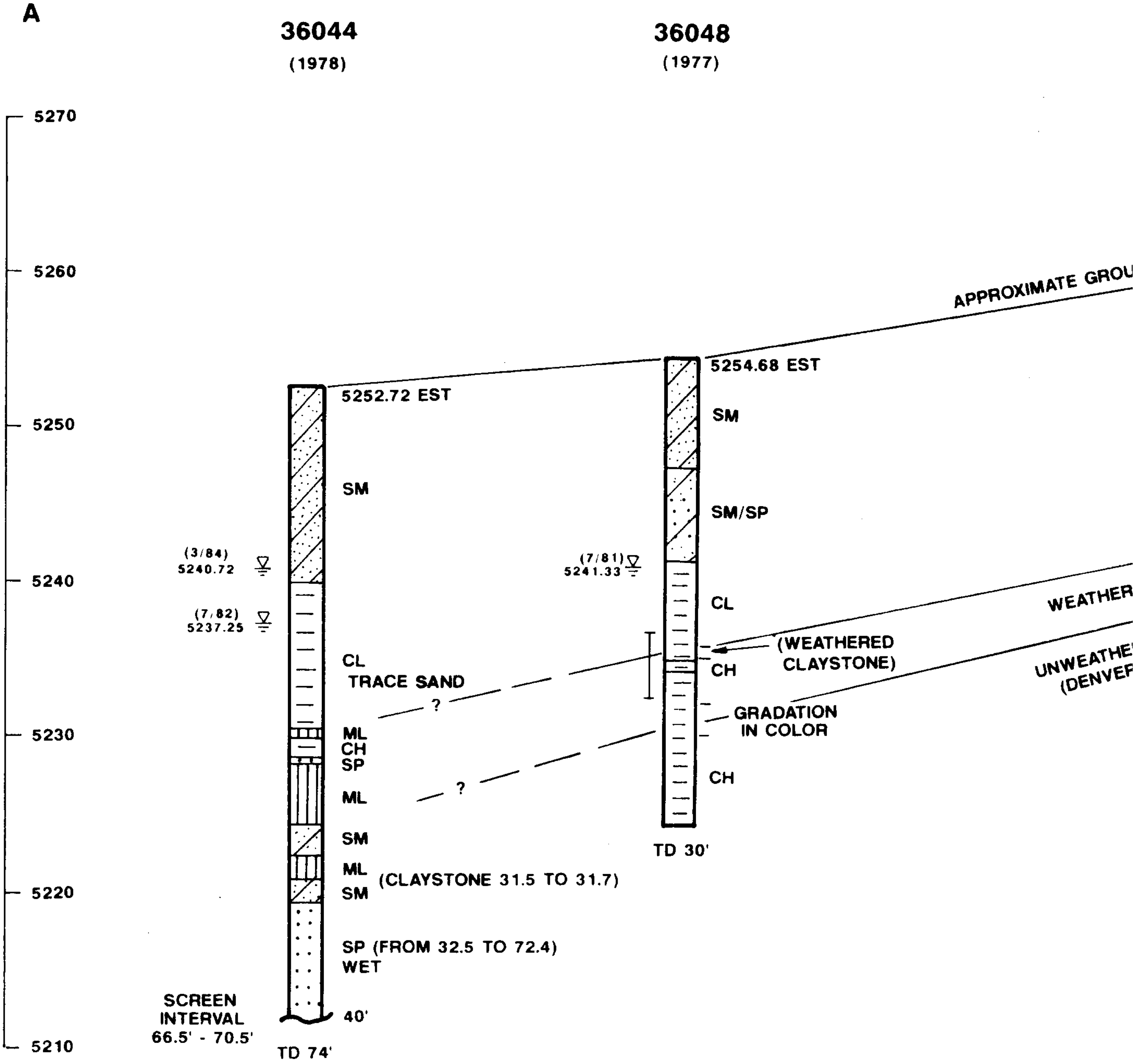


Job No. : 89MC114B-302

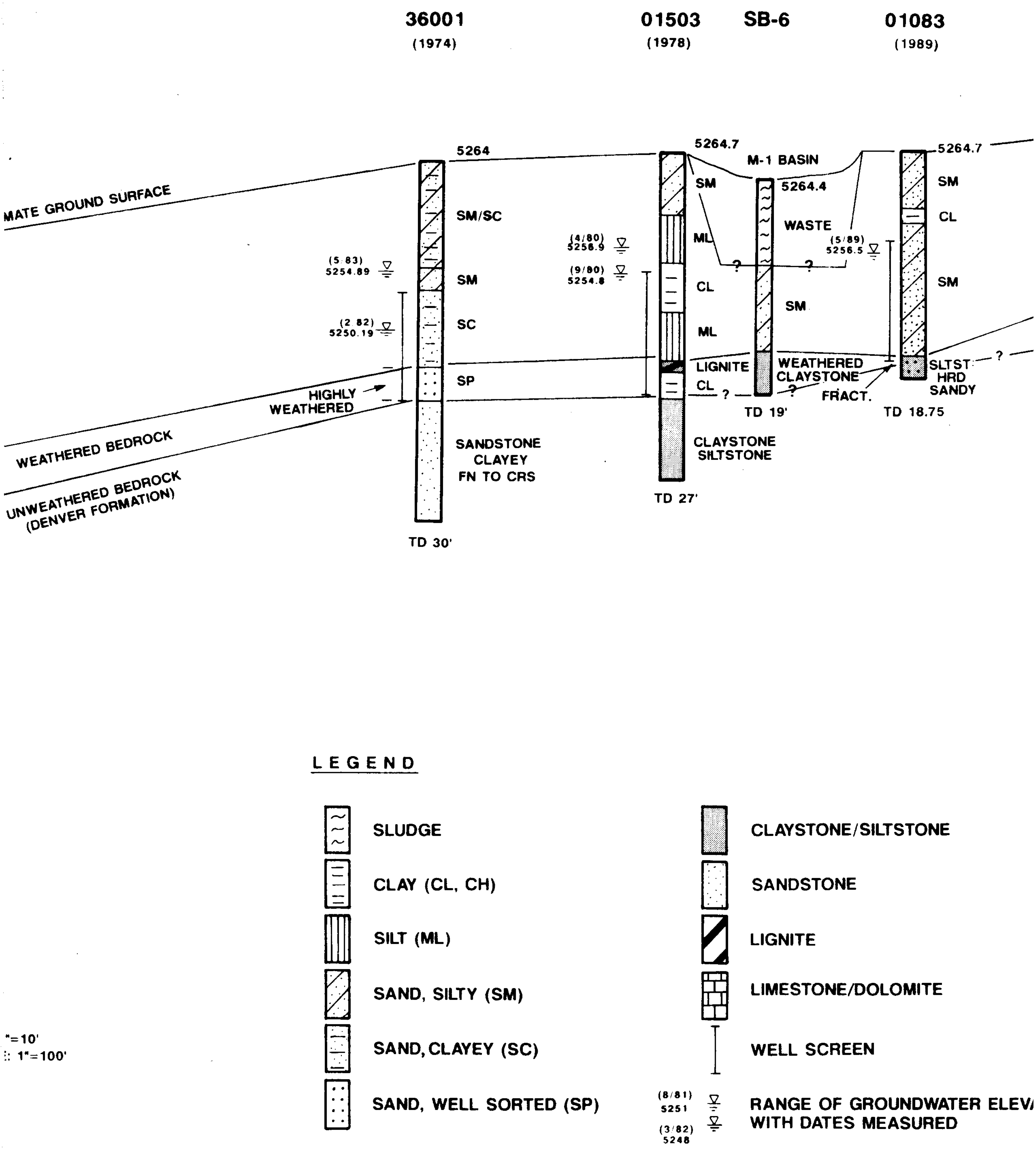
Prepared by: K.A.S.

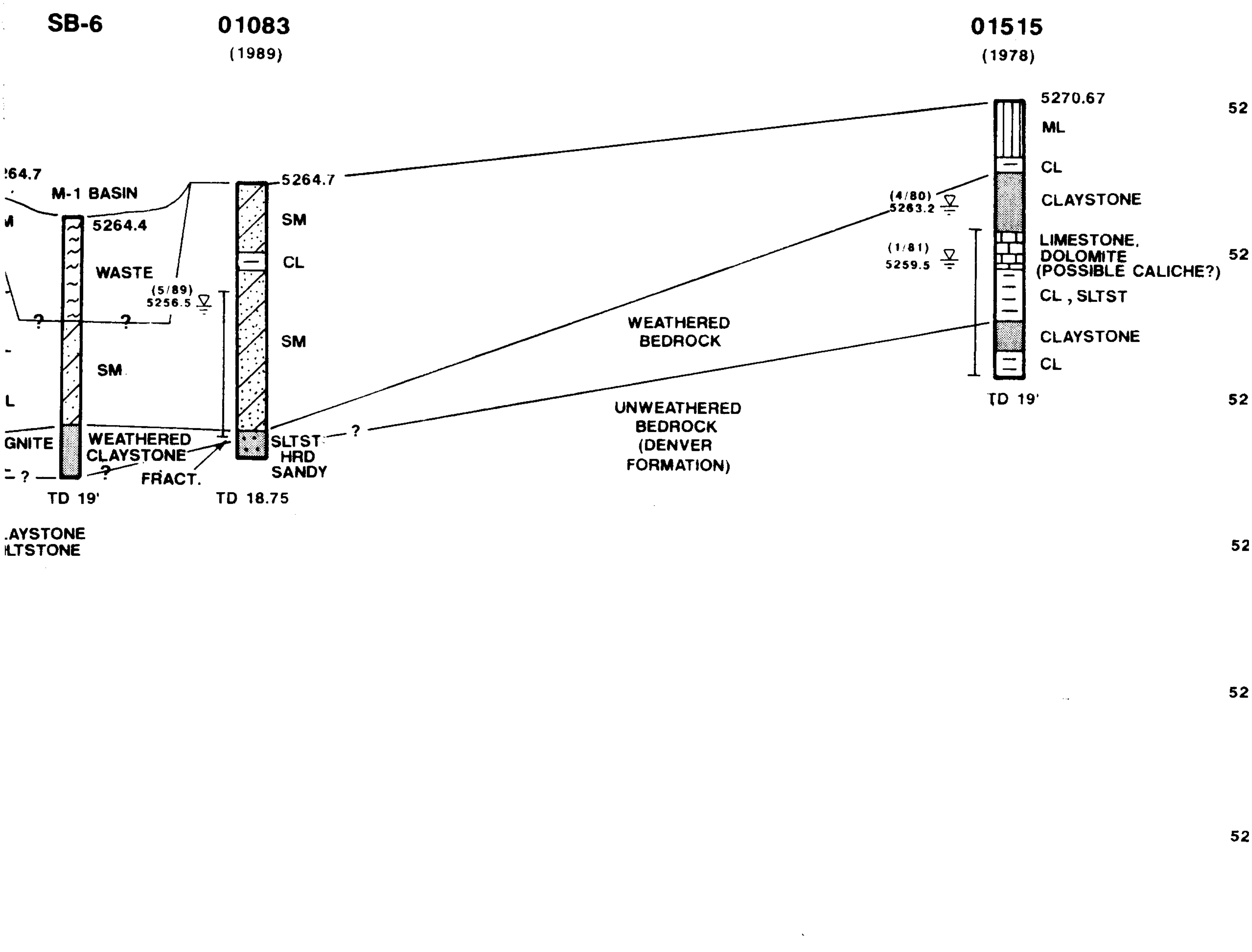
Date: 8/20/90

IN SITU VITRIFICATION
M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO
CONSTRUCTION SCHEDULE
Figure 2.3-1



VERTICAL SCALE: 1"=10'
HORIZONTAL SCALE: 1"=100'


36001
(1974)
01503
(1978)
SB-6
01083
(1989)
5264
5264.7
M-1 BASIN
5264.4
5264.7
MATE GROUND SURFACE
SM/SC
SM
SC
SP
(5 83)
5254.89
(2.82)
5250.19
HIGHLY WEATHERED
WEATHERED BEDROCK
UNWEATHERED BEDROCK
(DENVER FORMATION)
SANDSTONE
CLAYEY
FN TO CRS
TD 30'
(4/80)
5258.9
(9/80)
5254.8
SM
ML
CL
ML
LIGNITE
CL
?
CLAYSTONE
SILTSTONE
TD 27'
WASTE
?
?
SM
WEATHERED
CLAYSTONE
?
FRACT.
TD 19'
(5/89)
5256.5
SM
CL
SM
SLTST
HRD
SANDY
?
TD 18.75
LEGEND
SLUDGE
CLAY (CL, CH)
SILT (ML)
SAND, SILTY (SM)
SAND, CLAYEY (SC)
SAND, WELL SORTED (SP)
CLAYSTONE/SILTSTONE
SANDSTONE
LIGNITE
LIMESTONE/DOLOMITE
WELL SCREEN
(8/81)
5251
(3/82)
5248
RANGE OF GROUNDWATER ELEV
WITH DATES MEASURED
"=10'
: 1"=100'



▒ CLAYSTONE/SILTSTONE

⬚ SANDSTONE

◩ LIGNITE

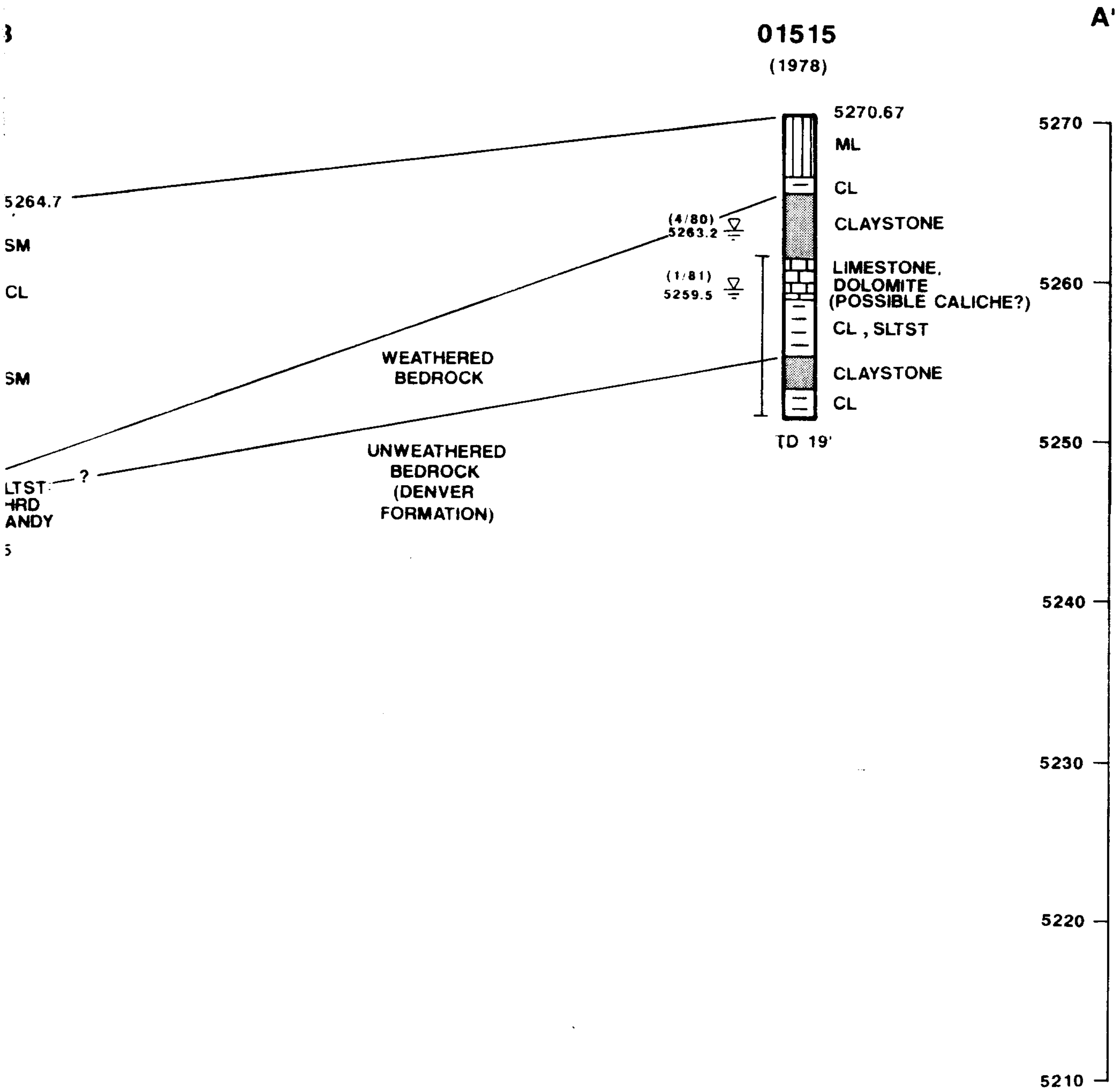
▦ LIMESTONE/DOLOMITE

⊥ WELL SCREEN

⊻ RANGE OF GROUNDWATER ELEVATIONS
WITH DATES MEASURED

NOTE: SEE FIGURE 2.4-3 FOR LOCATION
OF CROSS-SECTION

Job No. : 89MC114B	IN SITU VITRIFICATION, M-1 ROCKY MOUNTAIN ARSE
Prepared by: J.L.E.	GEOLOGIC CROSS-S
Date: 8/27/90	



E

:

NOTE: SEE FIGURE 2.4-3 FOR LOCATION OF CROSS-SECTION

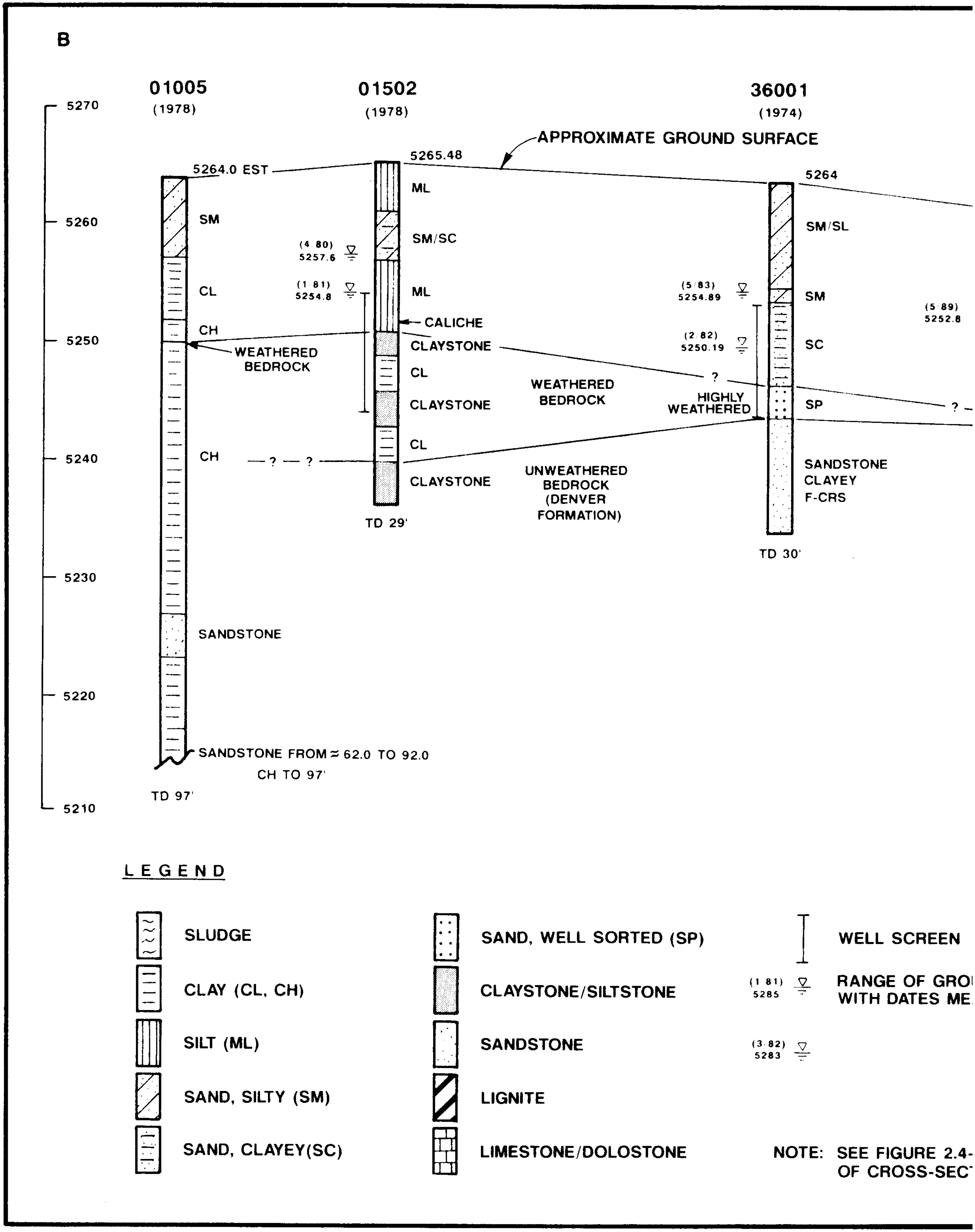
ATER ELEVATIONS
ED

Job No. : 89MC114B
Prepared by: J.L.E.
Date: 8/27/90

IN SITU VITRIFICATION, M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

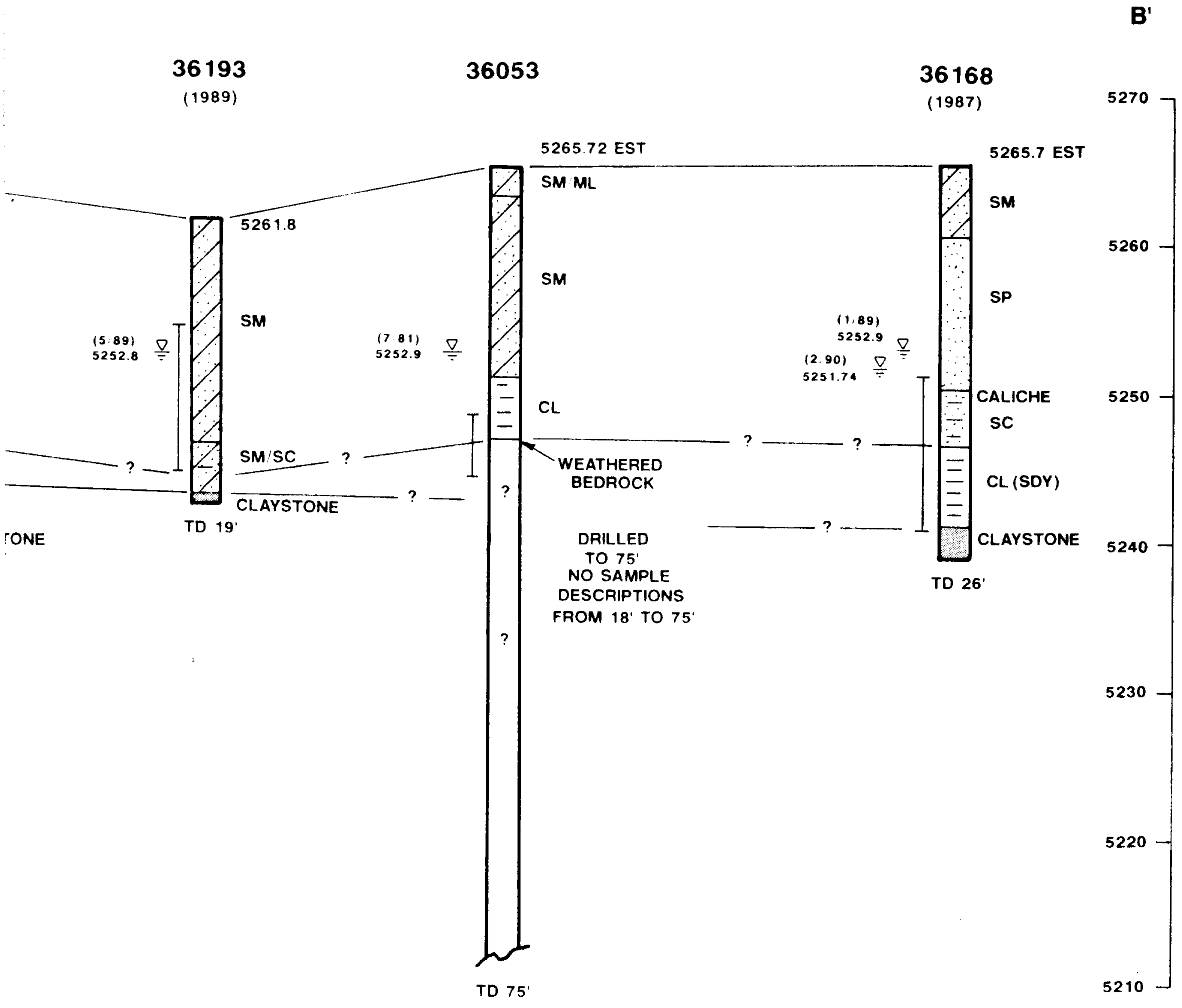
GEOLOGIC CROSS-SECTION A-A'

FIG. 2.4-1



NOTE: SEE FIGURE 2.4-
OF CROSS-SEC

Woodward-Clyde Consultants



ELL SCREEN

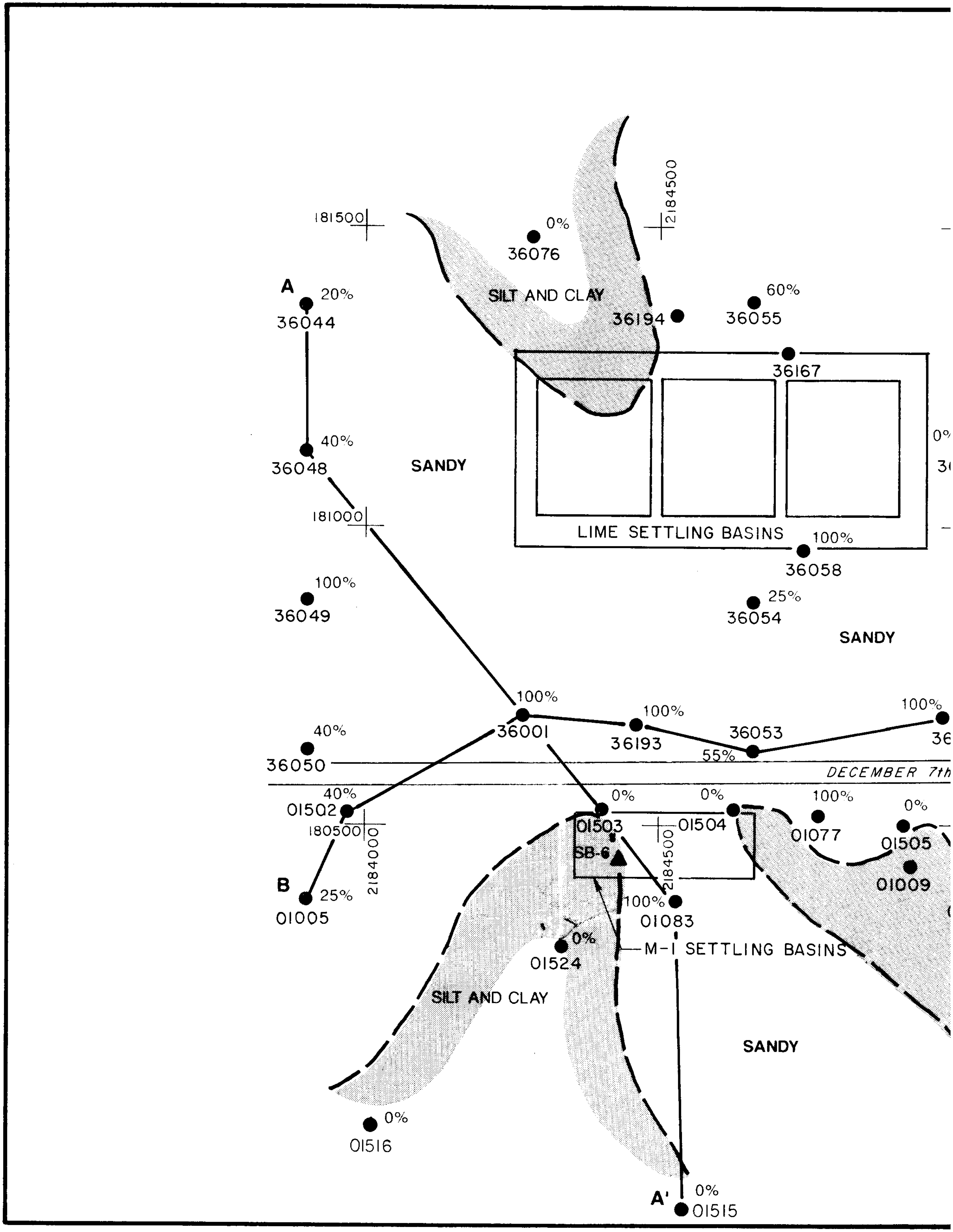
NGE OF GROUNDWATER ELEVATIONS
TH DATES MEASURED

VERTICAL SCALE: 1"=10'
HORIZONTAL SCALE: 1"=100'

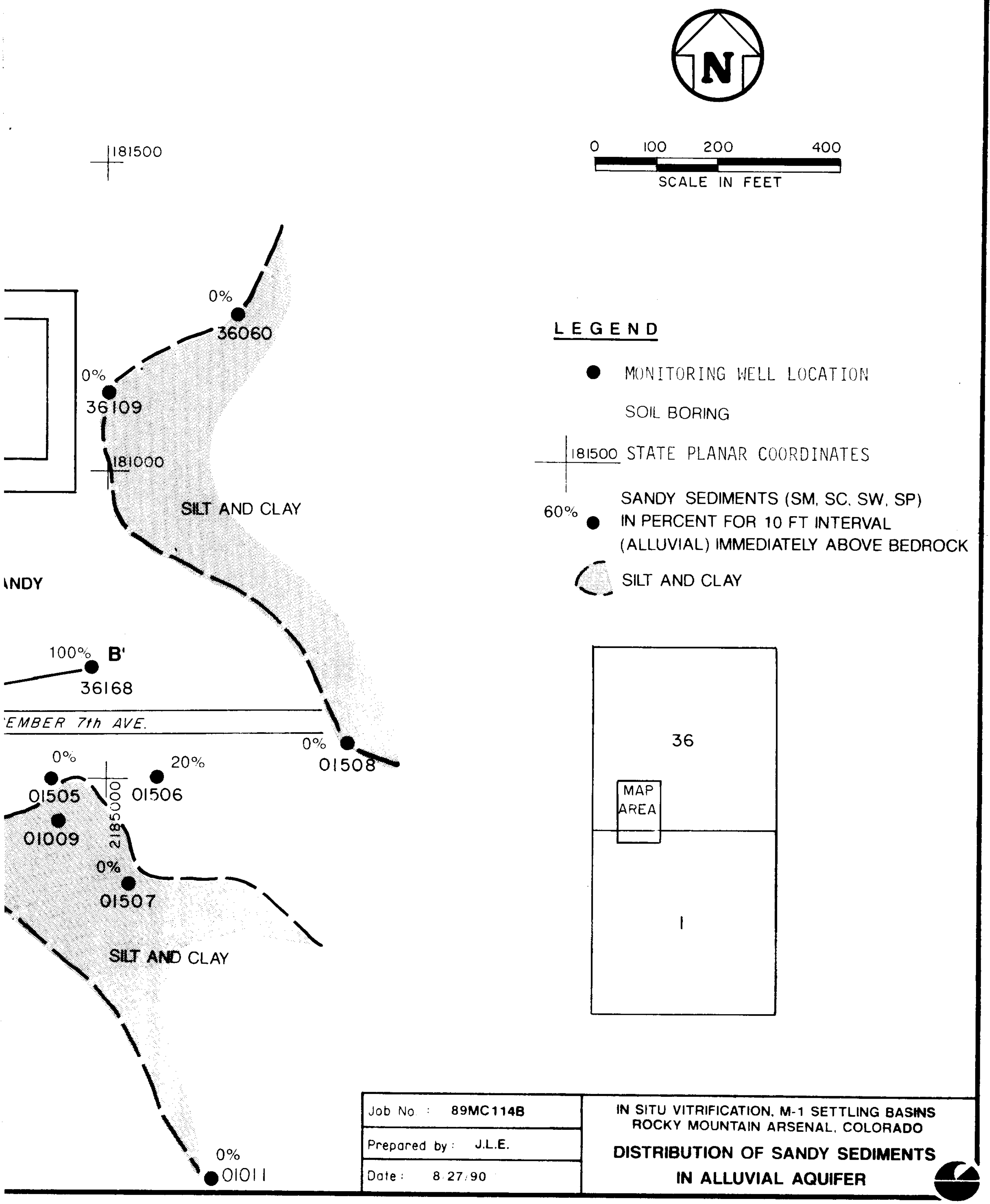
E FIGURE 2.4-3 FOR LOCATION
CROSS-SECTION.

Job No. : 89MC114B	IN SITU VITRIFICATION, M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO **GEOLOGIC CROSS-SECTION B-B'**
Prepared by: J.L.E.	
Date: 8/27/90	

FIG. 2.4-2


181500
2184500
0%
36076
SILT AND CLAY
A
20%
36044
36194
60%
36055
36167
40%
36048
SANDY
0%
3
181000
LIME SETTLING BASINS
100%
36058
100%
36049
25%
36054
SANDY
100%
36001
100%
36193
36053
100%
36
40%
36050
55%
DECEMBER 7th
40%
01502
0%
01503
0%
01504
100%
01077
0%
01505
180500
2184000
SB-6
2184500
01009
B
25%
01005
100%
01083
0%
01524
M-1 SETTLING BASINS
SILT AND CLAY
SANDY
0%
01516
A'
0%
01515

Woodward-Clyde Consultants

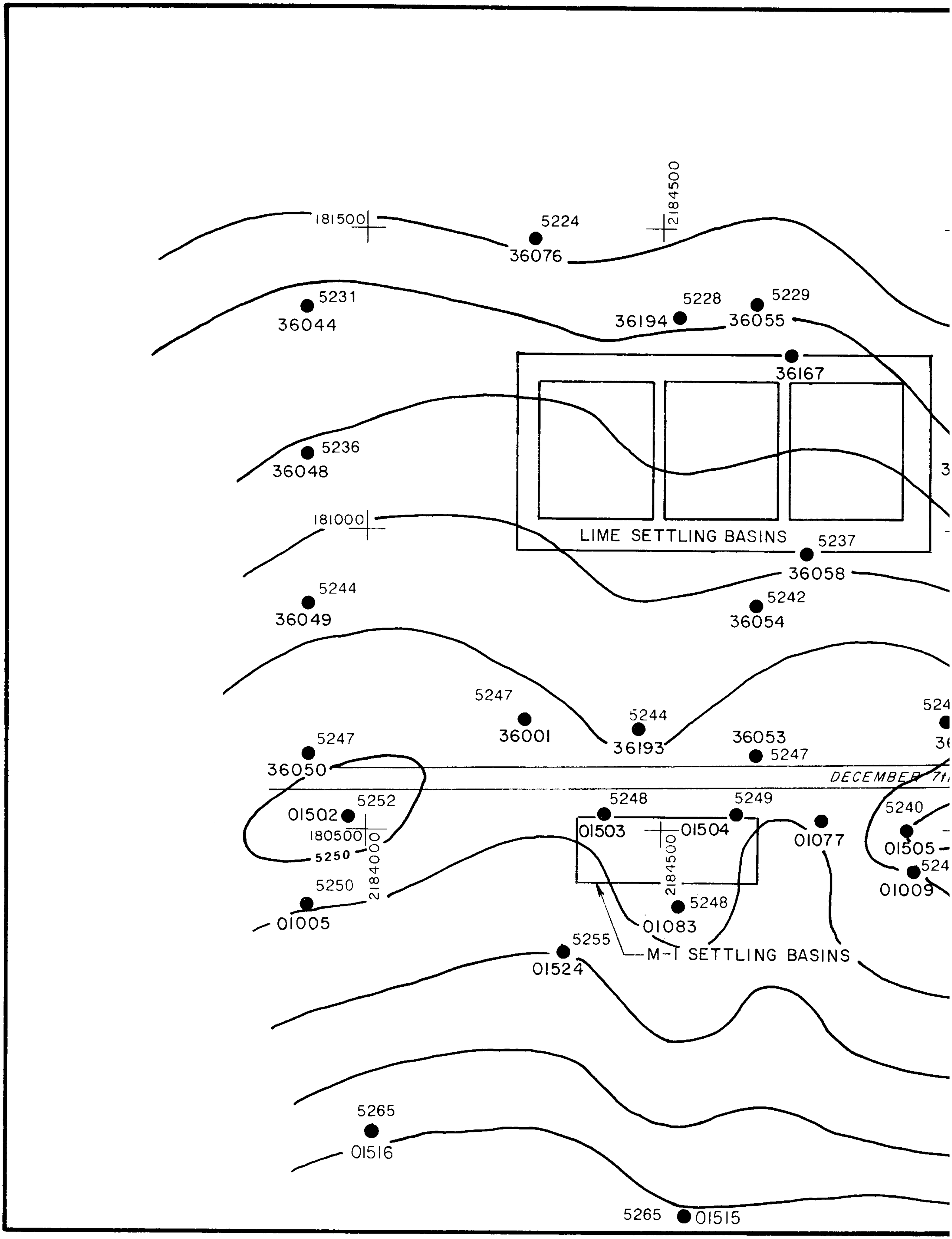


Job No. : 89MC114B	
Prepared by : J.L.E.	
Date : 8/27/90	

IN SITU VITRIFICATION, M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

DISTRIBUTION OF SANDY SEDIMENTS IN ALLUVIAL AQUIFER

FIG. 2.4-3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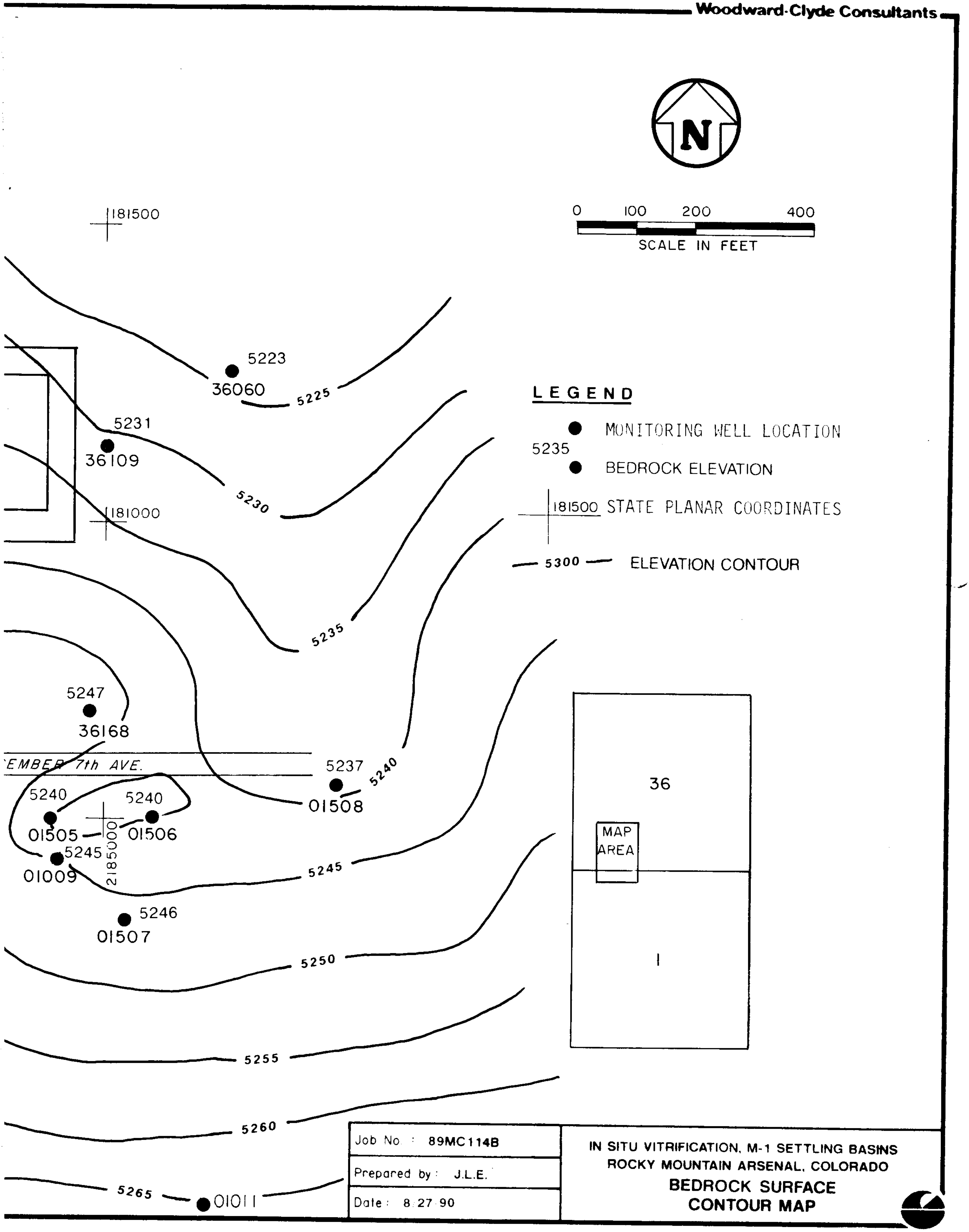
5224
36076
5231
36044
5228
36194
5229
36055
36167
5236
36048
181000
LIME SETTLING BASINS
5237
36058
5244
36049
5242
36054
5247
36001
5244
36193
36053
5247
5247
36050
DECEMBER 7t
5252
01502
180500
5250
2184000
5248
01503
01504
2184500
5249
01077
5240
01505
01009
5250
01005
5248
01083
5255
01524
M-1 SETTLING BASINS
5265
01516
5265
01515

Woodward-Clyde Consultants

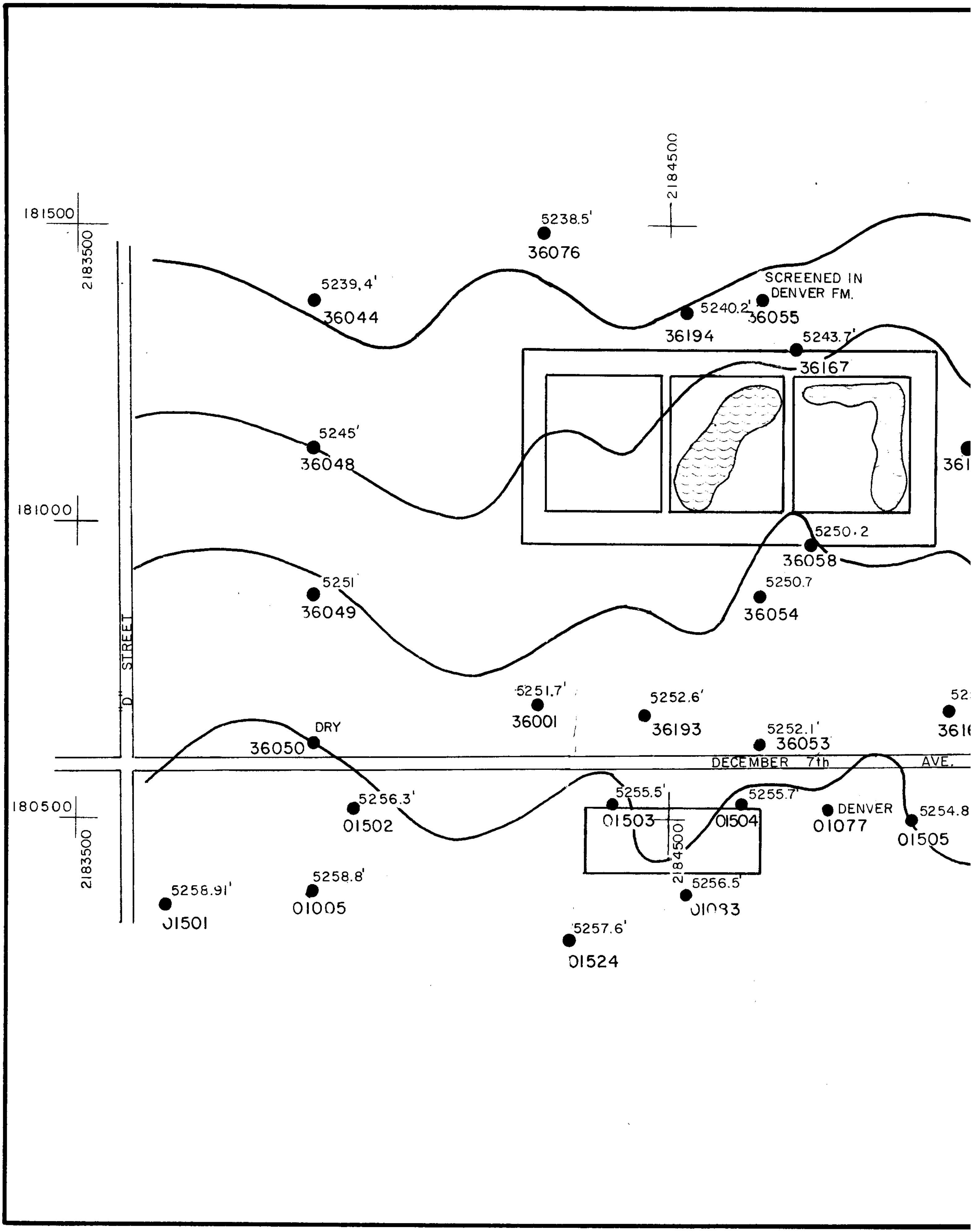


Job No. :	89MC114B
Prepared by :	J.L.E.
Date :	8 27 90

IN SITU VITRIFICATION, M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

BEDROCK SURFACE CONTOUR MAP

FIG. 2.4-4


181500
2183500
2184500
5238.5'
36076
5239.4'
36044
SCREENED IN
DENVER FM.
5240.2'
36055
36194
5243.7'
36167
5245'
36048
36I
181000
5250.2
36058
5251
36049
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36054
D STREET
5251.7'
36001
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36I
DRY
36050
5252.1'
36053
DECEMBER 7th AVE.
180500
2183500
5256.3'
01502
5255.5'
01503
2184500
5255.7'
01504
DENVER
01077
5254.8
01505
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01005
5258.91'
01501
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01083
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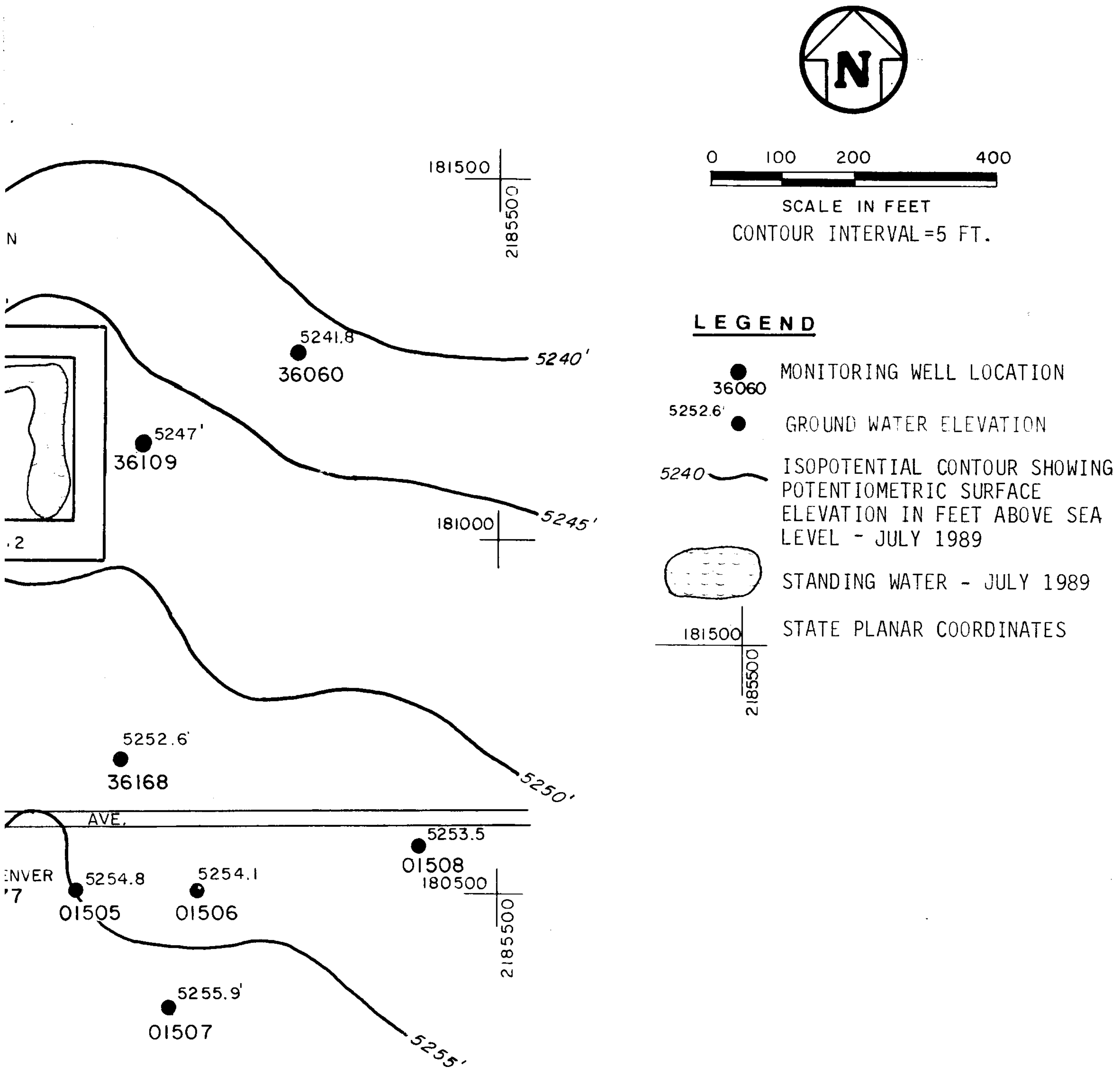
01524

111988



Job No. : 89MC114B

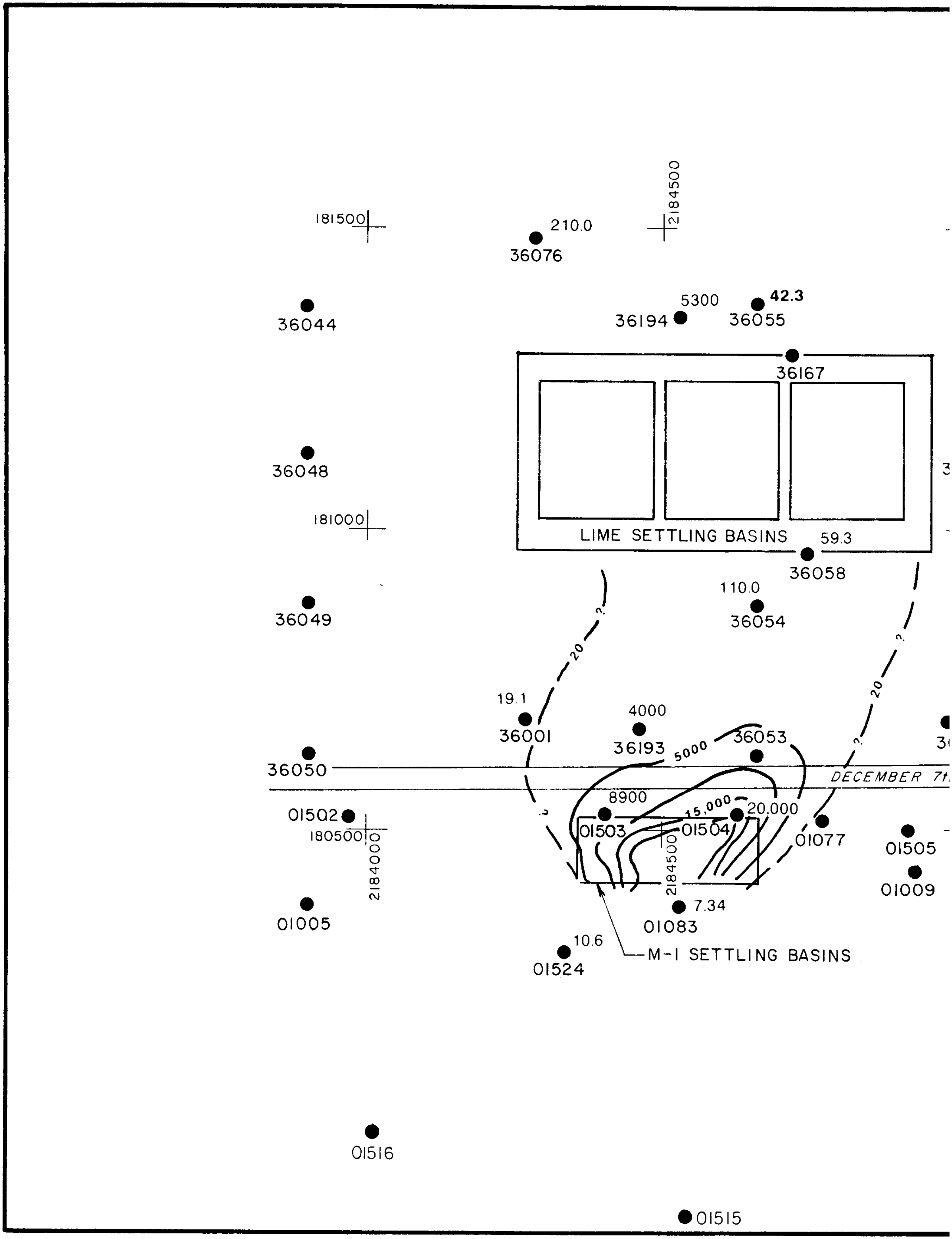
Prepared by : J.L.E.

Date : 8/27/'90

IN SITU VITRIFICATION M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

POTENTIOMETRIC SURFACE FOR ALLUVIAL AQUIFER JULY 1989

FIG. 2.4-5


181500
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36076
36044
5300
36194
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36055
36167
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LIME SETTLING BASINS
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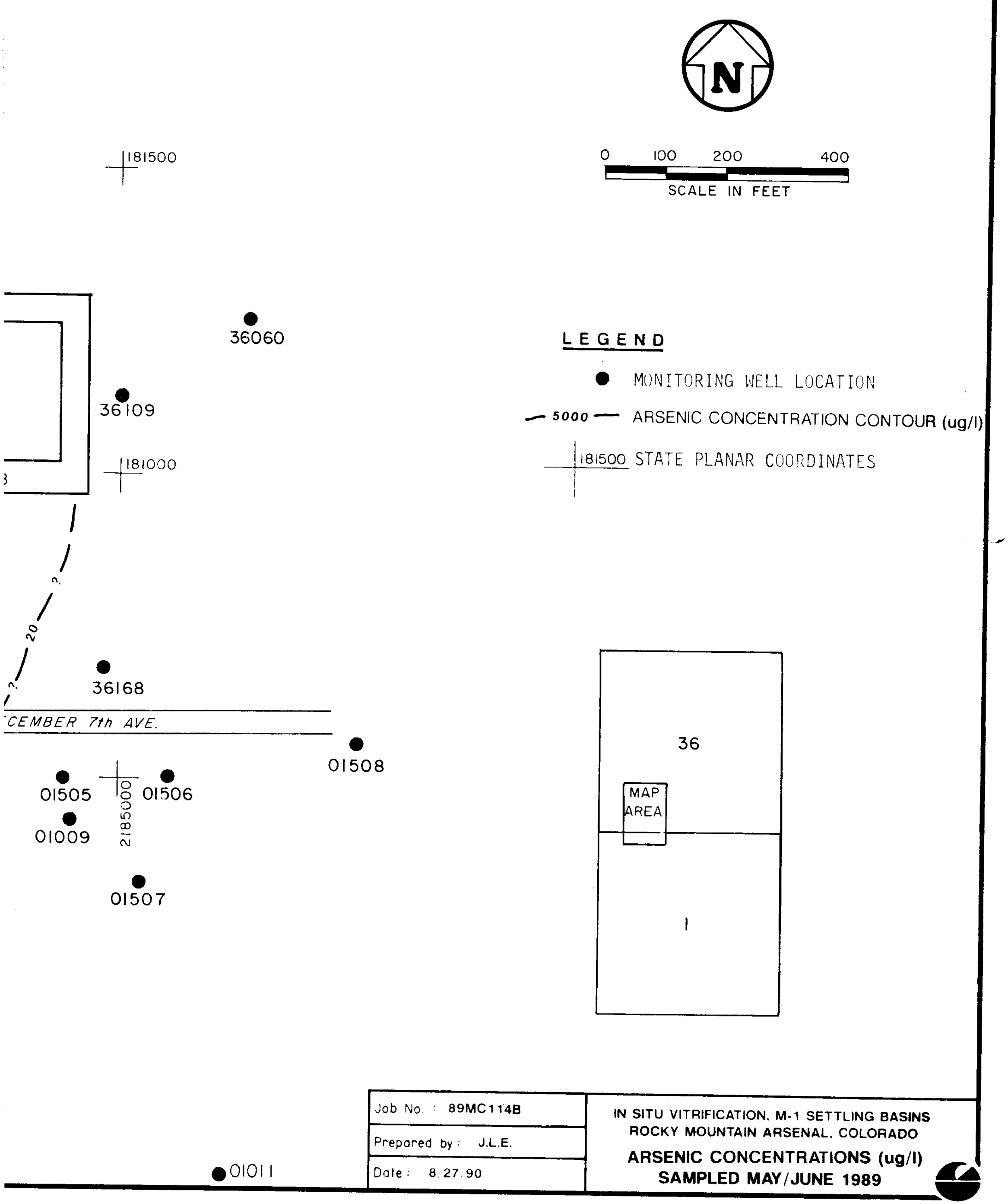
M-1 SETTLING BASINS
01516
01515



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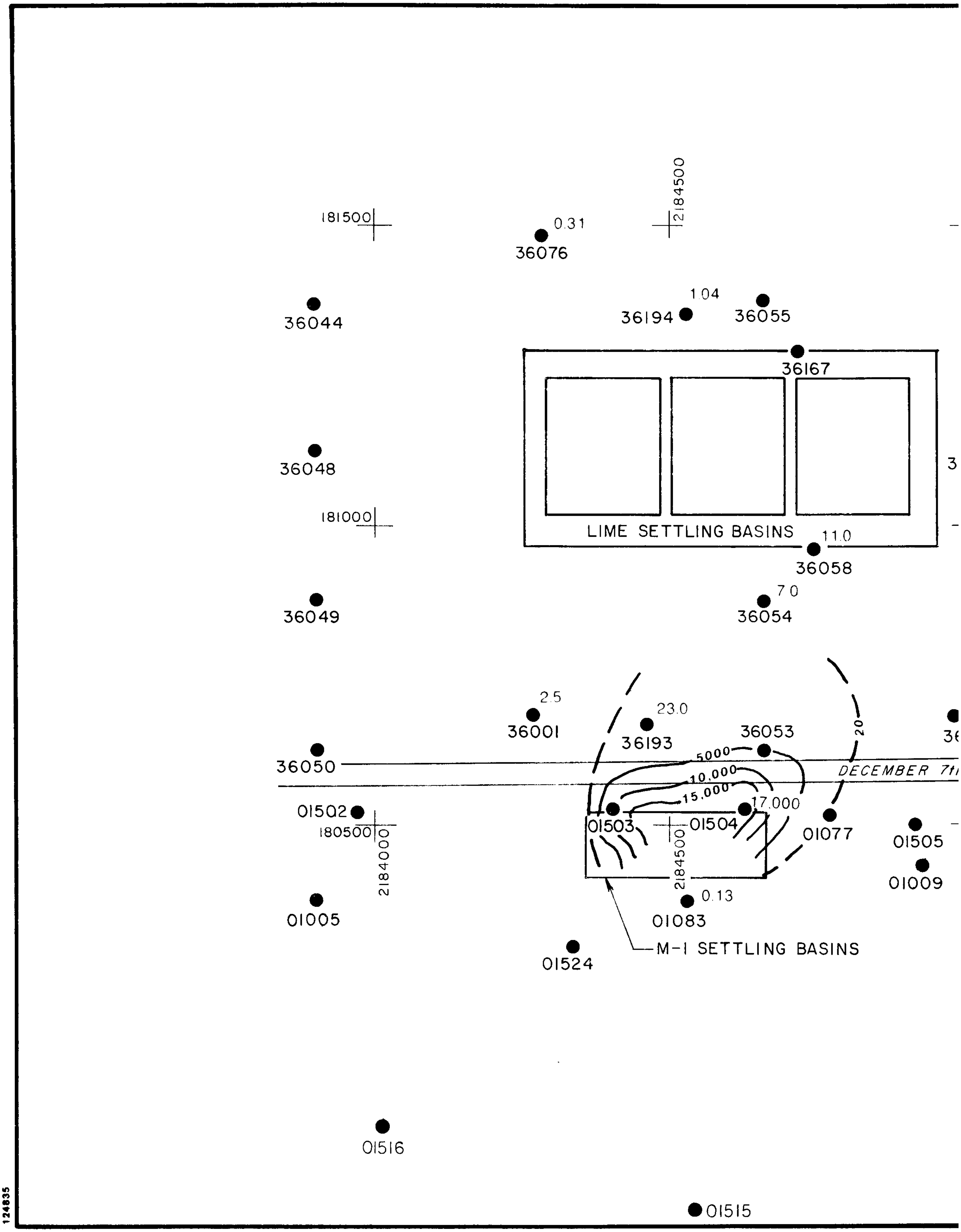
Prepared by : J.L.E.

Date : 8/27/90

IN SITU VITRIFICATION, M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

ARSENIC CONCENTRATIONS (ug/l)
SAMPLED MAY/JUNE 1989

FIG. 2.4-6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36076
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1.04
36194
36055
36167
3
36048
181000
LIME SETTLING BASINS
11.0
36058
7.0
36049
36054
2.5
36001
23.0
36193
36053
20
36050
5000
10,000
15,000
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DECEMBER 7t
01502
180500
2184000
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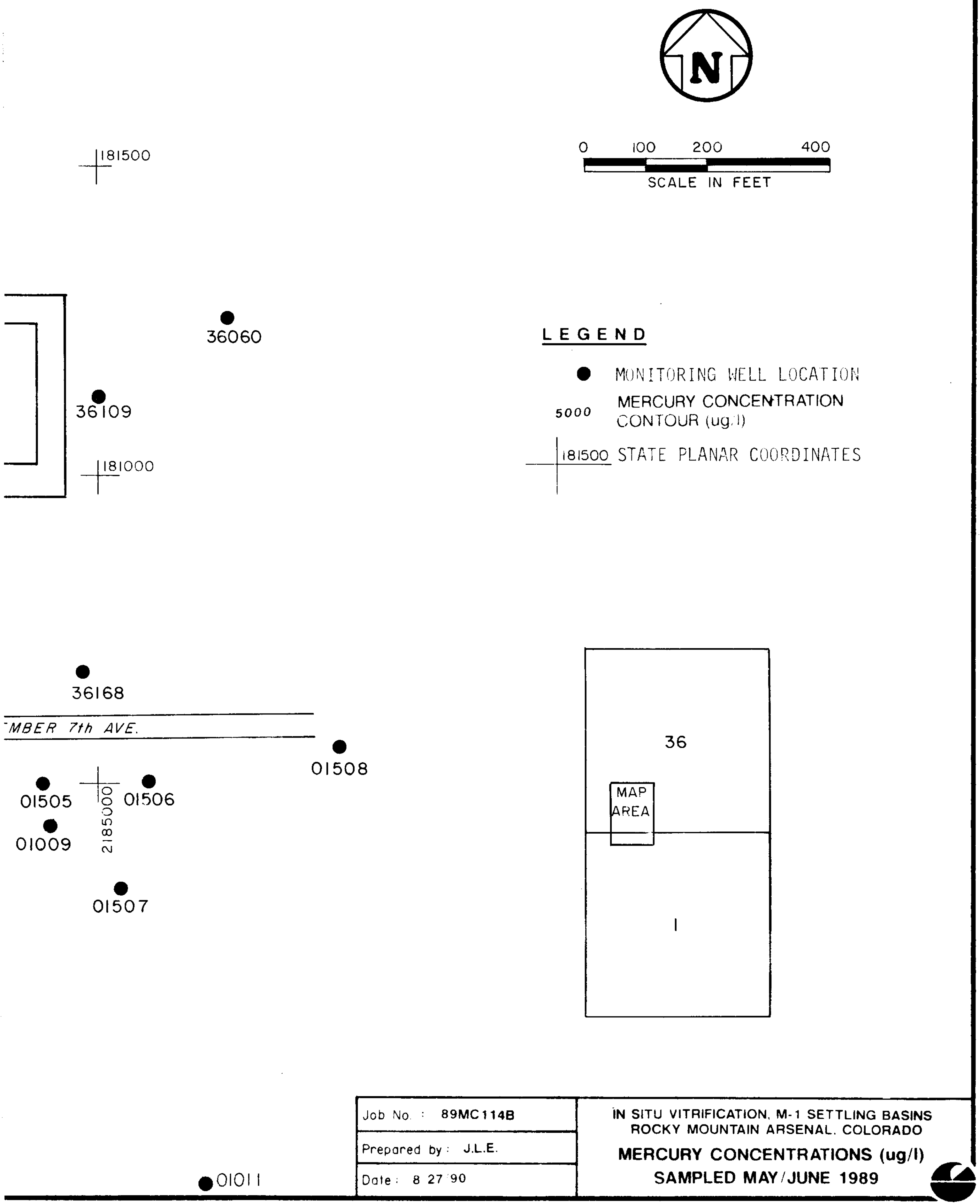
01524
M-1 SETTLING BASINS
01516
01515



Job No. : 89MC114B

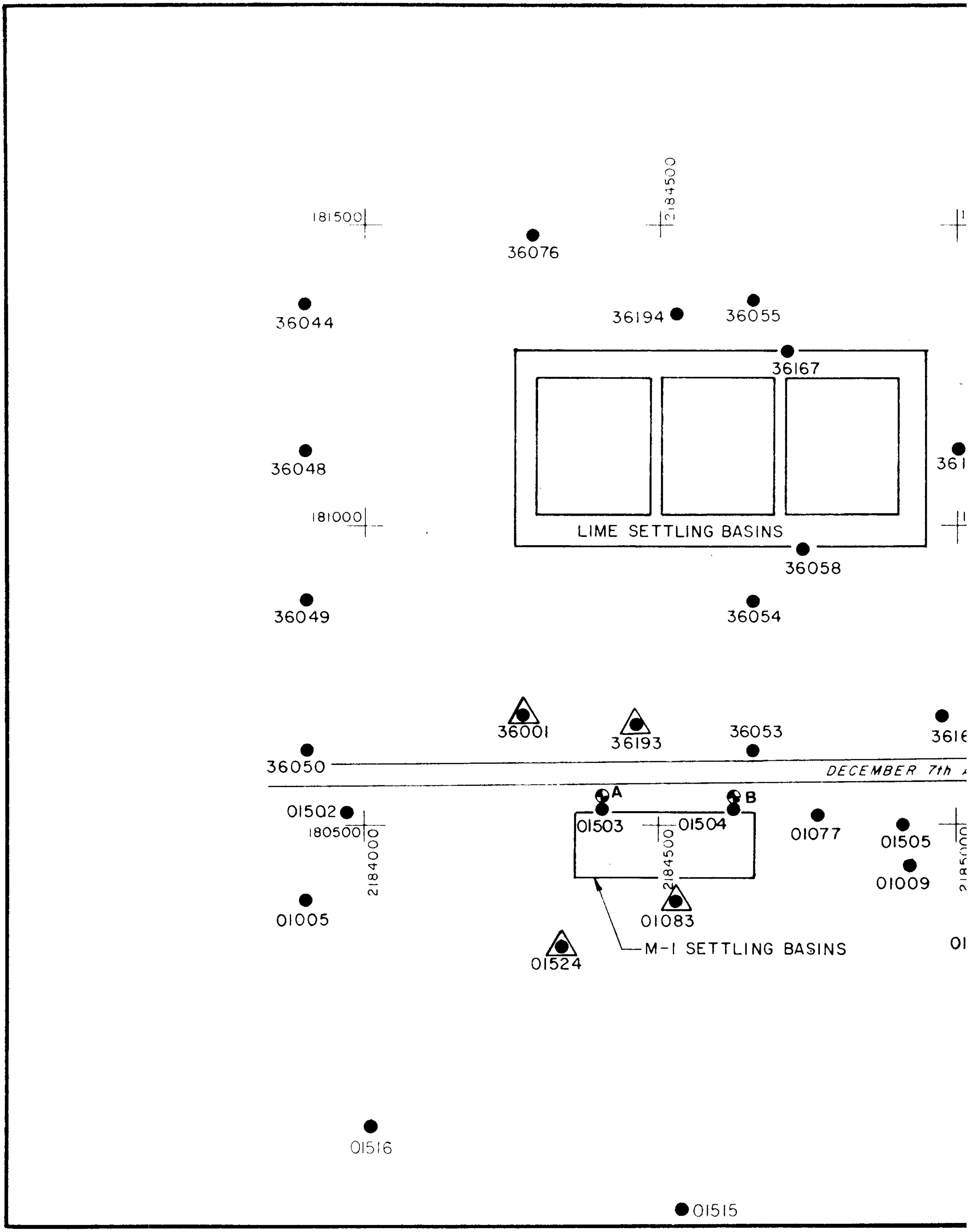
Prepared by : J.L.E.

Date : 8 27 90

IN SITU VITRIFICATION, M-1 SETTLING BASINS
ROCKY MOUNTAIN ARSENAL, COLORADO

MERCURY CONCENTRATIONS (ug/l)
SAMPLED MAY/JUNE 1989

FIG. 2.4-7


181500
2184500
36076
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36194
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181000
LIME SETTLING BASINS
36058
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M-1 SETTLING BASINS
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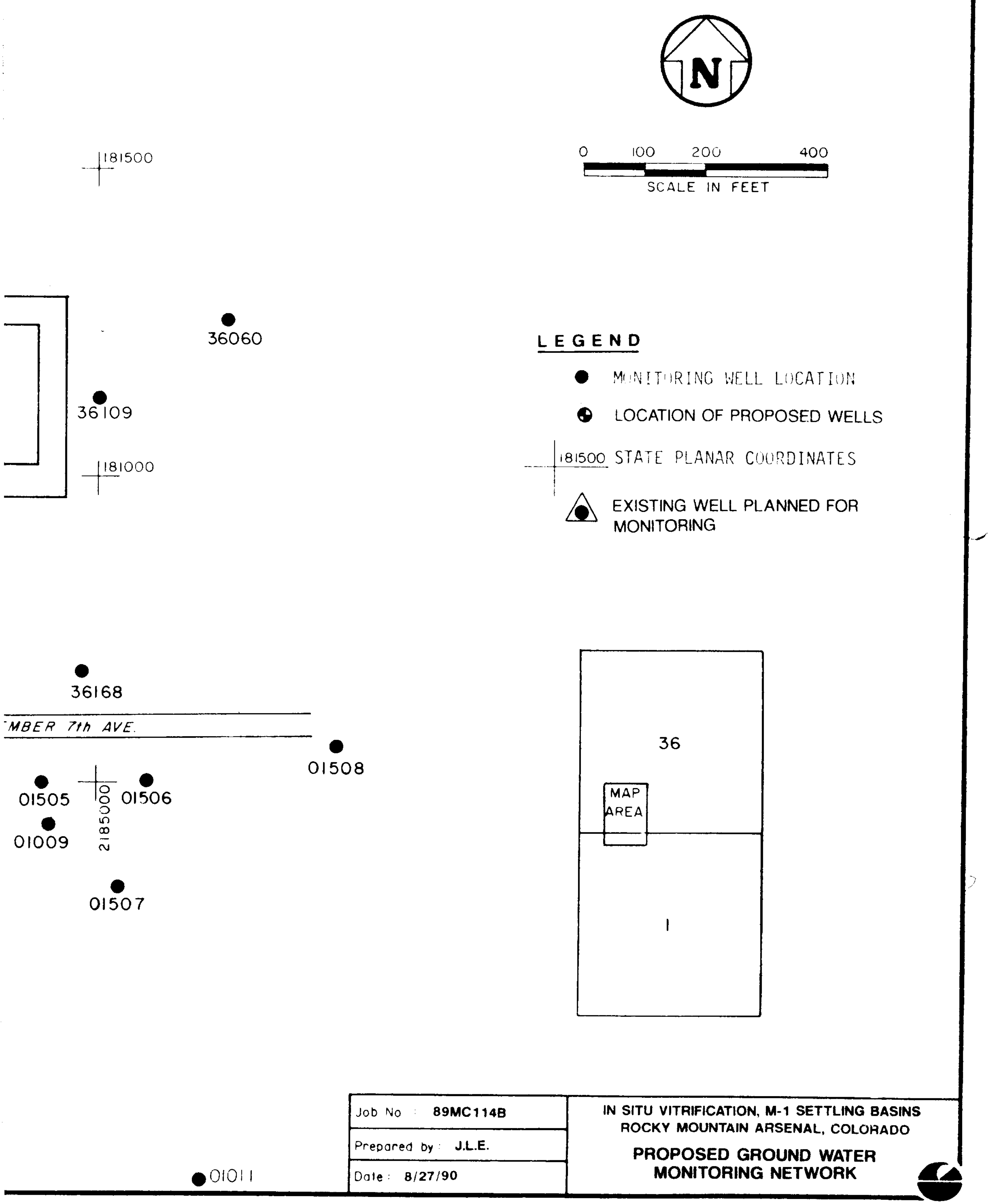

Job No : 89MC114B	IN SITU VITRIFICATION, M-1 SETTLING BASINS ROCKY MOUNTAIN ARSENAL, COLORADO
Prepared by : J.L.E.	
Date : 8/27/90	PROPOSED GROUND WATER MONITORING NETWORK

FIG. 2.4-8

3.0
DESIGN ANALYSIS

This section presents the design analysis for the engineering design of the in situ vitrification interim response action (IRA) at the M-1 Settling Basins, Rocky Mountain Arsenal (RMA), Colorado. This design analysis provides all functional and engineering criteria, design information, and calculations applicable to this project.

3.1 GENERAL DESCRIPTION

This section provides statements of purpose, authority, and applicable criteria, as well as a description of the project.

3.1.1 Purpose

The purpose of the interim response action for the M-1 Settling Basins is to contain and treat the M-1 Settling Basins sludge, which has been identified as a source of arsenic contamination to the ground water (WCC 1990, RIC 90002R05).

3.1.2 Authority

The implementation of this interim response action is being conducted as part of the IRA process for RMA in accordance with the Federal Facility agreement and the Technical Program Plan. Funding for this project is provided under funding identification number MIPR 0430.

3.1.3 Applicable Criteria

This project complies with:

- The 1989 Federal Facility Agreement.
- The Technical Program Plan for Remedial Investigation/Feasibility Study/Interim Response Actions, FY88 - FY92 (RIC 8811OR01).
- The Final Decision Document for the Interim Response Action at the M-1 Settling Basins, March 1990 (RIC 90002R05). This project will meet the substantive provisions of the Applicable or Relevant and Appropriate Requirements (ARARs) specified in the Decision Document. The section of the Design Document containing the ARARs is provided in Appendix A-1 of this Concept Design Document.

  The following is a listing of the ARARs identified in the Decision Document. Compliance with these ARARs will be shown in the Demonstration Test, to be conducted immediately prior to implementing the interim response action (IRA) at the M-1 Settling Basins.

  1) Arsenic emissions will be conveyed to a control device and reduced by at least 85%. Given this ARAR, it will be important to measure the Arsenic emissions before and after the off-gas treatment system.

  2) Mercury will not exceed 2,300 grams (5 pounds)/day, consistent with the requirements of 5 CCR 1007-3, regulation 8.

3) Particulate emissions from the treatment system will be limited to 0.08 grains per dry standard cubic foot, per 40 CFR 264.343.

4) Overall compliance with the appropriate paragraphs of the Federal Facility agreement on wildlife habitat(s) will be the responsibility of the Army's site manager. Geosafe will modify operational procedures to assure compliance as required.

5) All operations staff will be trained per the provisions of 29 CFR 1901.120 and the corresponding WISHA requirements - note the WISHA requirements are more restrictive than those in 29 CFR.

6) Backfilling and hood movement operations will be in compliance with 40 CFR 50.6 on construction type air particulates, and will not exceed the 50 microgram per cubic meter and 150 microgram limits.

7) Backfilling and hood movement operations will be in compliance with the Colorado Air Pollution Control Commission Regulation No. 1, 5 CCR 1001-3 Part III(D)(2)(b), Construction Activities: (c) Applicable Emission Limitation Guideline of 20 percent opacity and no off-property transport emission.

8) The operation of the emergency diesel generator is expected to comply with the requirements set forth in the Colorado Ambient Air Quality Standards, 5 CCR 1001-14, Air Quality regulation A, Diesel-Powered Vehicle Emission Standards for visible Pollutants.

9) The sound levels from the off-gas treatment system are expected to be in compliance with the Industrial levels listed in the Colorado Noise Abatement Statute, CRS, Section 25-12-103.

10) The destruction and removal efficiency for organics of 99.99 percent will be demonstrated, assuming sufficient concentrations in the soil and sludge to achieve the analytical sensitivity to make the measurements. The focus of this demonstration is the organics present in the soil(s). If the concentrations of target organics in the soil supplied for the treatability test are representative of the site, there could be difficulties with obtaining sufficient analytical sensitivity for measurements made at the exit of the off-gas system. Given a concentration of approximately 1 ppm of the target compound, the concentration at the exit of the off-gas treatment system could be as low as 0.000004 mg/m^3. Two methods of resolving this would be to make measurements at the inlet to the off-gas treatment system to measure the destruction efficiency, and/or to assume a non-detect at the exit of the off-gas treatment system indicated a level of 0 ppb for the target compound. These issues will be resolved prior to the 90 percent design report.

11) Emissions from the off-gas treatment system are expected to be substantially below the 20 percent opacity limits.

- The minutes of the pre-design conference (contract kick-off) meeting (27 July 1990).

3.1.4 Project Description

This project is the engineering design for the in situ vitrification (ISV) of the M-1 Settling Basins. This includes preparation of plans, specifications, and cost estimates for the site preparation and the ISV. The project also includes preparation of a Chemical Data Management Specification, a Health and Safety Specification, and a Site Maintenance Plan.

3.2 DESIGN REQUIREMENTS AND PROVISIONS

This section provides factors considered and provided in the design, including supporting justification of design decisions. Design calculations are provided in Appendix A-3.

3.2.1 Civil Paving, Grading, Drainage, Fence and Site Planning

3.2.1.1 Objective

To provide the facilities required for in situ vitrification of the M-1 Settling Basins.

3.2.1.2 Design Requirements

The site will need to be prepared for the following equipment.

1. ISV Service Units (Trailers)
    a. Length 126 ft total for the 3 trailers (process, support, and transformer)
    b. Weight 53,200 to 78,200 lbs.
    c. Width 8.5 ft

2. Support Vessels
   a. 1 - 2000 gal Scrub Solution Storage Vessel
   b. 1 - 2000 gal Make-up Water Storage Tank
   c. 2 - 7000 gal Conical Bottom Decant Vessels
   d. Assoc. Strainer or Centrifuge and Pumps

Items 2c. and d. are Concept Design considerations that may be required for particulate removal associated with the off-gas treatment system. The Final Design may not include these vessels. However, the Concept Design containment system has been designed to included capacity for all the above vessels.

Other site design requirements will include:

- Support utility access, including electrical, telephone, and water
- Traffic will need to be maintained on December 7th Avenue
- A secure perimeter will be needed

3.2.1.3 Design Analysis

1. Location of ISV Service Units - Underground utilities currently exist between December 7th Avenue and the M-1 Settling Basins, including a 6 inch diameter water line, a 3 inch diameter gas line, and a 12 inch diameter sanitary sewer. The exact amount of cover over these utilities is unknown, therefore, there is a possibility that the heavy loads of the ISV Service Units could damage these utility lines. Also, since the first consideration of this design is safety, the location of heavy equipment on an existing gas line is not recommended. Therefore, the ISV Service Units

will be located on the existing roadway. A detour road will be constructed to the north of December 7th Avenue along the length of the M-1 Settling Basins. This detour road will be designed to not affect the drainage in the area. The detour road will also reduce the space limitations for the storage tank containment areas that would be required if the ISV Service Units were located between the existing roadway and the M-1 Settling Basins.

2. Detour Road - The asphalt detour road to the north of December 7th Avenue will be designed using Corps of Engineers Geometrics for roads, streets, walks, and open storage areas (EM 1110-3-130-April 1984) Table 2-1, such that the centerline of the 22 foot roadway will satisfy a WB60 (full trailer combination) turning radius of 45 feet. The existing grade will be matched on tangent crown section toward the north to reduce additional surface drainage problems in the area between the existing roadway and the proposed detour.

3. Drainage - All existing surface runoff patterns will remain unchanged. An additional 24 inch diameter by 36 foot long pipe will be placed under the west portion of the detour road and placed to match the existing pipe and the existing ditch grade.

4. Intersecting Secondary Road - By using an existing ramp intersection at the northern detour road transition, the need for additional pipe for ditch drainage to the south will be eliminated. Minor grading will be necessary to facilitate access to the existing secondary road.

5. Support Vessels - By building the detour road, a containment area will be created between the detour road and the existing road. The east end will

be closed and used as a vessel location area by adding a small dike (north-south) between the existing roadway and detour road to provide containment for 1.5 times the capacity of the vessels. This allows a safety/splash factor.

6. ISV Service Units - To facilitate the staging of the ISV Service Units, the existing roadway will be segmented into three areas:

    1. Facilities Management Area - This area provides a specific location for the temporary buildings and parking. This area will be located on the west end of the roadway for ease of access and distance from the process until the final phases of the ISV processing.

    2. ISV Service Unit Area - This area is approximately 380 feet long and located to the north of the M-1 Settling Basins. The ISV Service Units will be located in this area. The ISV trailers will be moved in stages from east to west as the M-1 Settling Basins are processed to reduce the length of pipe and power cables.

    3. Unit Access Area - This 35 linear foot access area is parallel to the ISV Service Unit and is designated to allow support and direct perimeter access to the surface units.

7. Safety Fencing - Fencing will be required along the south side of the detour road with two double swing gates at each end of the support area across the existing roadway. The fence will continue around the M-1 Settling Basins approximately 20 ft from the containment wall to provide access and to allow placement of temporary lighting. The fence will restrict access by people and wildlife to the site during the interim

response action. All fencing will conform to Federal Specifications RR-F-191/1, typed to match the existing fence.

8. Temporary Construction Signing - 730 linear feet of 4 inch striping and 6 - 6 foot GM concrete barriers will be used to redirect travel lanes. Battery powered amber flashers and advance warning signing will be provided as per minimum required detour signing by the DOT Manual For Standard Traffic Control.

3.2.2 Water Supply and Wastewater Disposal

3.2.2.1 Objective

To provide the water and wastewater systems in support of the in situ vitrification activities at the M-1 Settling Basins.

3.2.2.2 Water Supply and Distribution Systems

This section describes the design criteria and assumptions which will be used to complete the design of the water supply and distribution systems.

3.2.2.2.1 Design Criteria. The water supply and distribution systems (potable, process) will be designed in compliance with applicable local, state and/or federal codes and regulations.

Materials and equipment in these systems will conform to the appropriate ANSI, ASTM, AWWA standards and applicable federal specifications or standards.

3.2.2.2.2 Existing Water Supply. At present, a 6 inch water main runs parallel to the M-1 Settling Basins north of the proposed sheet pile and south of December 7th Avenue. If possible, this line will be tapped, with an estimated 2 inch line, to provide water for the make-up water storage tank, administrative and change house trailers.

3.2.2.2.3 Distribution Systems. The water distribution will be accomplished by two (2) systems; (1) supply to the administration/changehouse facilities, while dependent upon population, will most likely be a 1-1/2 inch line tapped into the 2 inch line with branches of 1 inch to the changehouse and 3/4 inch to the administrative trailer. The quantity of water, pressure and flow rate supplied shall be adequate to operate fixtures and equipment contained in the facilities.

To supply the water make-up tank it is estimated that a 1 1/2 line will extend from the administrative area approximately 300 ft easterly to the containment area and water make-up tank.

The supply system to the vitrification equipment will be designed to transfer 35 GPM from the make-up water tank to the process trailer. With consideration that as vitrification progresses the process trailer will periodically be relocated, this distribution system will be designed as a manifold with quick connect/disconnect couplings located on 100 foot centers.

3.2.2.3 Wastewater Disposal

Two wastewater disposal systems will be designed in compliance with applicable local, state and/or federal codes and regulations. Materials used in this system will comply with appropriate federal specifications and ASTM standards.

Spent scrub solution waste, a liquid containing particulates, will be filtered and conveyed through a pressurized pipe system designed in compliance with applicable local, state and/or federal codes and regulations. Materials and equipment utilized in the spent scrub solution system will conform to the appropriate ANSI, ASTM, AWWA standards and applicable federal specifications or standards.

3.2.2.3.2 Existing Sanitary Sewer. At present a 12 inch sanitary sewer runs parallel to the M-1 Settling Basins north of the proposed slurry wall and south of December 7th Avenue. It is anticipated that non-hazardous sanitary waste will be discharged into this sewer line.

3.2.2.3.3 Wastewater Disposal Systems. The wastewater emanating from the administrative/changehouse facilities will be disposed of by one of two systems; (1) collection and discharge of domestic waste into the existing Rocky Mountain Arsenal sanitary system or, (2) the collection and containerization of hazardous waste, resulting from decontamination activities, for disposal in accordance with practices and procedures currently utilized at the arsenal.

In situ vitrification process waste, spent scrub solution, will be collected utilizing a manifold system and pumped to a spent scrub solution tank. The manifold system, similar to the process water distribution system, will probably utilize a diaphragm pump for pressurization and transport of what might be considered a dilute slurry solution.

Periodically, the spent scrub solution will be pumped from the storage tank into a transport vehicle for disposal in accordance with Rocky Mountain Arsenal practices and procedures. If the CERCLA waste water treatment plant is operational during ISV processing, it may be used to treat the spent solution.

3.2.3 Electrical

3.2.3.1 Objective-to provide the power, control and lighting required for the in situ vitrification of the M-1 Settling Basins.

3.2.3.2 Design Requirements

1. Power
    a. 4.25 MW
    b. 13.8/4.7 kV
    c. 60 Hz
    d. 3-phase

2. Lighting
   Sufficient to maintain 24 hour operations

3. Control
   Pumps associated with the support equipment would require control circuitry if the final design includes this equipment.

3.2.3.3 Design Analysis

1. Power - The proposed location for the ISV facilities lies next to an existing 13.8kV overhead power line. A review of RMA drawing General Electric Map, Area 5 #18-02-01, Sh. 44 of 71 shows that line to be 1/0 size cable. This is sufficient to power the facility with approximately 50% excess capacity. Due to the close proximity of the existing power lines an overhead service with three wood poles is sufficient to supply the facility.

2. Lighting - The area around the sludge beds is the only location requiring outside illumination. A bank of six 1000 watt high pressure sodium floodlights will be placed along the southern perimeter of the sludge beds to allow for night operations of the facility.

3. Control - Pumps associated with the support vessels will be powered from the Motor Control Center (MCC) in the ISV Service Unit, sufficient spare racks have been supplied with the MCC. Control wiring will be supplied to allow for manual operation of the pumps with tank low level pump shutoffs.

3.3 UNRESOLVED ITEMS

Several items require resolution prior to Final Design. Assumptions related to these items were made for the Concept Design, where appropriate. Upon resolution of these items, other dependent design considerations will be revised, as necessary. Following is a list of unresolved items:

1) Mercury recovery. Mercury recovery options are currently being evaluated. The decisions on whether and how to recover mercury will affect the design of the off-gas treatment system as well as residuals management requirements.

2) Particulate removal. Several alternatives are under consideration for solids removal from the recirculating scrub solution. These include filtration and centrifugation. Once the selected method has been incorporated into the process, resultant modifications to the final design will be included.

3) Chemical composition of sludge and soil. Whole rock analysis of samples taken in July 1990 of the sludge and surrounding soil will provide the inorganic chemical characteristics of the material to be vitrified. The results will help determine optimal operating conditions, melt sequencing and whether additives, such as silica sand, need to be included to achieve acceptable product durability and to reach the ultimate vitrification depth.

4) Electrode feeding. The current design and cost estimates include stationary electrodes which would be set in vibratory pile-driven boreholes. Geosafe and Battelle Northwest are currently developing a method for self-feeding electrodes which could result in significant cost savings and reduced worker exposure to hazardous materials. The decision of whether to use these electrodes will be made upon completion of development testing, which is expected prior to implementation of this IRA.

5) Water pressure of existing 6-inch distribution pipe. This will be required for final design of water supply system to trailers and make-up water tank.

6) Total water demand at trailers for showers, toilets, etc.

7) Concentrations of organic compounds are generally low in the surficial soils of the M-1 Setting Basins (Table 2.2-1). ARARs for the destruction and removal efficiency (DRE) of these compounds may require measuring concentrations of these compounds below realistic detection limits.

8) It has been assumed that secondary waste disposal (spent filters, hood fabric, etc.) would consist of adding these materials into a future designated melt setting. Approval of this waste disposal method, as well as where this would take place is unresolved at this time.

9) Sheet pile. The design currently assumes the need for a sheet pile cut-off wall to prevent inflow of ground water during vitrification. Water level monitoring will be performed quarterly over the next year in the immediate vicinity of the M-1 Settling Basins. If the water level is consistently below the proposed depth of the melt, a sheet pile cut-off wall would not be necessary.

4.0
DRAFT SPECIFICATIONS

This section contains the draft specifications for the in situ vitrification of the M-1 Settling Basins at Rocky Mountain Arsenal, Colorado, including a Construction Specification outline, a Health and Safety Specification outline, and a draft Chemical Data Management Specification.

4.1 CONSTRUCTION SPECIFICATION OUTLINE

This section contains the outline for the Construction Specification.

ZERO ACCIDENTS
CONSTRUCTION SPECIFICATION OUTLINE

Section 01401	Health and Safety (See outline in Section 4.2)
Section 01402	Chemical Data Management (See draft specification in Section 4.3)
Section 02050	Demolition 1. General Requirements 2. Submittals 3. Dust Control 4. Protection 5. Existing Facilities 6. Filling 7. Disposition of Material 8. Cleanup
Section 02100	Clearing and Grubbing 1. Definitions 2. Clearing 3. Grubbing 4. Disposal of Materials
Section 02210	Grading 1. Applicable Publications 2. Definitions

3. Excavation
4. Utilization of Excavated Materials
5. Conservation of Topsoil
6. Protection of Existing Service Lines and Utilities Structures
7. Preparation of Ground Surface for Fill
8. Fill
9. Compaction
10. Topsoil Placing
11. Finished Excavation, Fills and Embankments
12. Subgrade and Embankment Protection
13. Existing Manholes, Valve Boxes, or Inlets

Section 02221 Excavation, Trenching, and Backfilling for Utilities Systems

1. Applicable Publications
2. Definitions
3. Excavation
4. Backfilling
5. Special Requirements
6. Testing
7. Pavement and Walk Removal and Replacement

Section 02241 Crushed Aggregate Base Course

1. Applicable Publications
2. Equipment
3. Approval, Sampling, and Testing
4. Submittals
5. Weather Limitations
6. Aggregates

7. Construction
8. Maintenance

Section 02276 Geotextile for Retention Facilities
1. Scope
2. Applicable Publications
3. Submittals
4. Shipment and Storage
5. Materials
6. Preparation of Surface
7. Installation of the Geotextile

Section 02444 Chain Link Security Fence and Gates
1. Applicable Publications
2. Submittals
3. Installation
4. Materials
5. Grounding

Section 02555 Bituminous Surface Treatment
1. Applicable Publications
2. Equipment, Tools, and Machines
3. Safety Precautions
4. Sampling and Testing
5. Weather Limitations
6. Materials
7. Quantities of Materials Per Square Yard
8. Preparation of Surface

9. Application of First Bituminous Surface Treatment
10. Application of Second Course Bituminous Surface Treatment
11. Brooming and Rolling Second Course

Section 02713 Water Lines
1. Applicable Publications
2. General
3. Excavation, Trenching, and Backfilling for Water Lines
4. Submittals
5. Materials
6. Installation
7. Hydrostatic Tests
8. Disinfection
9. Cleanup

Section 03303 Concrete
1. Applicable Publications
2. General
3. Materials
4. Concreting Operations
5. Joints
6. Contractor's Quality Control

Section 11210 Pumps; Water, Centrifugal
1. Applicable Publications
2. General Requirements
3. Submittals
4. Manufacturer's Services

5. Delivery and Storage
6. Materials and Equipment
7. Centrifugal Water Pumps
8. Electrical Equipment
9. Equipment Appurtenances
10. Installation
11. Tests
12. Field Painting

Section 11310 Pumps; Sewage and Sludge
1. Applicable Publications
2. General Requirements
3. Submittals
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This section contains the outline for the Health and Safety Specification.

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HEALTH AND SAFETY SPECIFICATION OUTLINE

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4.3 CHEMICAL DATA MANAGEMENT SPECIFICATION

This section contains the draft Chemical Data Management Specification.

This specification includes details for sampling and chemical analyses specific to accomplishing treatment of the M-1 Settling Basins at the Rocky Mountain Arsenal using In Situ Vitrification (ISV) for the interim response action. The specification describes all contractor sampling, sample handling and custody, documentation, analytical procedures, and data reporting. The specification outlines the contractor quality control (QC) responsibilities and provides requirements for the Contractor Chemical Quality Control Section (CCQCS), of the Contractor Quality Control Plan (QCP). The CCQCS is a contractor submittal which will describe how the contractor will implement the chemical data acquisition portion of the specifications and assure the government that the contractor understands and follows the requirements of the specifications.

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SECTION 01402
CHEMICAL DATA MANAGEMENT

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Table 1 - ARAR Limits for Stack Gas Emissions
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1. GENERAL REQUIREMENTS. The "Final Decision Document For the Interim Response Action at the M-I Settling Basins," Rocky Mountain Arsenal, March, 1990 describes the selection and recommendations of In Situ Vitrification (ISV) as the remedy for the M-1 Settling Basins at the Rocky Mountain Arsenal. The soil and sludge contained in the basins will be completely vitrified to a depth of approximately 10 feet by the ISV process. Testing and monitoring of several different matrices such as the vitrified melt produced and the off-gas and stack gas emissions are required prior to, during, and after ISV operations at the basins. Complete remediation of the M-1 Settling Basins will require approximately 70 individual 25' x 25' x 10' melt settings. A Demonstration Melt will be

conducted prior to the full scale operation of the ISV process. The Demonstration Melt will require an extensive set of test parameters to demonstrate efficient on-site operation of the ISV process as an interim response action for this site and to demonstrate compliance with applicable regulatory standards. The regulatory standards, as discussed in the above referenced document, are shown in Table 1.

Full scale implementation of the ISV process can begin after completion of the Demonstration Melt and following confirmation of compliance with the regulatory standards. Each individual melt setting shall require monitoring to ensure the ISV process for each setting remains in compliance with the regulatory parameters. For monitoring purposes, a less extensive set of test parameters than those used for the Demonstration Melt shall be utilized, but as a minimum, those parameters listed in Table 1. Additionally, ten percent of the individual ISV melt settings shall undergo more rigorous monitoring as discussed below.

Based on previous soil sampling and testing at the M-1 Settling Basins, as referenced in paragraph 1.1, contaminants of concern include arsenic, mercury, and organochlorine pesticides. These contaminants shall be specifically tested for in each of the matrices described below.

1.1 PRE-TEST SOIL SAMPLING REQUIREMENTS. Extensive sampling and testing of the soil and sludge contained in the M-1 Settling Basins at the Rocky Mountain Arsenal has been performed. Data for this site are in the "RMA Environmental Data Base" as maintained by D.P. Associates, Inc. These data may be sufficient for purposes of this project and additional testing may not be required. Sampling of the soil and sludge shall be required if the data are deemed insufficient by the Contracting Officer or designee to assess the concentration and type of contaminants contained in the M-1 Settling Basins prior to ISV operations at this site. Soil and sludge samples shall be collected and analyzed for test parameters shown in Table 2 and in accordance with EPA procedures as referenced in

EPA SW-846, Third Edition, 1986. If methods other than EPA methods are chosen, those methods must be approved by the Contracting Officer.

1.2 VITRIFIED GLASS PRODUCT SAMPLING REQUIREMENTS. Sampling and testing of the vitrified glass product formed during ISV operations shall be required to ensure that contaminants encapsulated within the glass product are not leachable above the regulatory level for Toxicity Characteristics Constituents defined in the Federal Register, Vol. 55, No. 51, March 29, 1990. The Toxic Characteristic Leach Procedure (TCLP) test analysis shall be used to evaluate samples of the vitrified glass product formed.

1.2.1 Demonstration Melt Sampling. Samples of the vitrified glass shall be collected for chemical analysis from the Demonstration Melt. A random sampling approach shall be used with four (4) separate samples being obtained immediately after completion of the Demonstration Melt. Each sample shall be collected by insertion of a one-inch diameter steel rod into the melt. Following removal of this rod from the melt and cooling of the glass on the rod inside the hood, samples shall be taken of the glass at the following depths:

- 2 foot depth
- 5 foot depth
- 8 foot depth
- Depth of the melt

The chosen samples of the glass shall be removed from the rod and analyzed for the parameters shown in Table 3. The proposed sampling scheme and the analysis to be performed shall be included in the Contractor Quality Control Plan (CQCP).

1.2.2 Individual Melt Sampling. For monitoring purposes, three samples of the glass product formed from each of the individual melt settings shall be obtained. Additional glass samples may be archived. Samples will be collected as described above by inserting a rod to the depth of the melt. The glass will then be analyzed for the test parameters shown in Table 3. In addition, samples of the vitrified glass product obtained from five percent of the individual melt settings processed (approximately four out of seventy melts) shall be analyzed for the test parameters as the Demonstration Melt. The proposed sampling scheme and analysis to be performed for these settings shall be included in the CQCP.

1.3 OFF GAS SAMPLING REQUIREMENTS PRIOR TO OFF-GAS TREATMENT SYSTEM. Sampling of the off-gas, prior to the off-gas treatment system, shall be required for the Demonstration Melt. It is expected that the off-gases resulting from ISV processing of the M-1 Settling Basins may include organic pyrolysis products (e.g. CO_2, O_2, and CO), the volatile metals (e.g., mercury and arsenic), and possible metal oxides. Although organochlorine pesticides present will undergo pyrolysis reactions, low levels of organochlorine pesticides (e.g., aldrin and dieldrin) may evolve at the start of ISV process. The off-gas samples shall be collected and analyzed for these parameters using the methodology shown in Table 4. The data obtained from these samples shall be used to measure the efficiency of the off-gas treatment system. The proposed sampling scheme and the analysis to be performed shall be included in the CQCP.

1.4 STACK GAS MONITORING REQUIREMENTS. Sampling and monitoring of the stack gas emissions following off-gas treatment during ISV processing is required to ensure the efficient operation of the off-gas treatment system to remove potential contaminants and to confirm that emissions are within the limits shown in Table 1. As discussed in "Final Decision Document for the Interim Response Action at the M-1 Settling Basins," Rocky Mountain Arsenal, March 1990, sulfur oxides, carbon monoxide, ozone, nitrogen oxide and lead are not anticipated to be contained in significant amounts in any potential air emissions from the ISV process at this site. Sampling and monitoring requirements are as follows:

1.4.1 Demonstration Melt Stack Gas Monitoring. Air emission monitoring will include the measurements of velocity, temperature, airflow, combustion gas composition (O_2, CO_2, CO), metals (specifically arsenic and mercury), organochlorine pesticides, particulate matter, and opacity. The parameters to be analyzed and the methodologies recommended for the stack gas emissions are shown in Table 4. The proposed emission monitoring scheme and the analysis and methodologies to be performed shall be included in the CQCP.

1.4.2 Individual ISV Melt Setting Monitoring. A continuous air emission monitoring system shall be used during ISV operations to monitor the efficient operation of the off-gas treatment system during each ISV Melt. Monitoring shall include parameters listed in Table 4 including stack gas temperature, oxygen (O_2), carbon dioxide (CO_2), and carbon monoxide (CO). The parameters to be analyzed and the methodologies recommended are shown in Table 4. In addition, five percent of the other ISV Melts (aproximately four settings) processed shall be tested for the same parameters as the Demonstration Melt as indicated in Table 4. The proposed emission monitoring scheme and the analysis and methodologies to be performed shall be included in the CQCP.

1.5 POTENTIALLY CONTAMINATED WATER AND HAZARDOUS WASTE DISPOSAL. The Contractor shall ensure all contaminated wash water, scrubber water, equipment, personnel decontamination, sampling activities, and ISV operations are tested in accordance with 40 CFR Part 261 which defines Hazardous Waste according to RCRA. The water shall be disposed of as described in the "Final Decision Document for the Interim Response Action at the M-1 Settling Basins, Rocky Mountain Arsenal, March 1990."

2. PROJECT ORGANIZATION AND RESPONSIBILITIES. The Contractor shall submit for approval by the Contracting Officer a Contractor Quality Control Plan (CQCP) including a Chemical Quality Control Section (CQCP) as outlined in this specification. The

Contractor shall be responsible for providing the Chemical Quality Control Section (CQCS) of the CQCP, which shall delineate the methods the contractor intends to use to accomplish the chemical quality control items as indicated in the specifications to assure data of acceptable accuracy, precision, representativeness, and comparability. Project-related qualifications of the Contractor's laboratory facilities and analytical instrumentation shall be described in detail. The CQCP must be reviewed and approved by the Contracting Officer or his representative prior to the start of work. The Contractor will be responsible for the quality of all data produced by the Contractor's laboratory or subcontracted laboratories. The Contractor shall also develop and submit Standard Operating Procedures (SOP) for all repetitive tasks, e.g. sampling activities. Project management responsibilities shall be clearly defined in the CQCP along with a discussion of quality assurance/quality control (QA/QC) responsibilities.

2.1 ORGANIZATION. The project organization shall be described in the CQCP including the prime contractor and contractor-subcontractor interactions.

2.2 KEY INDIVIDUALS AND RELATED EXPERIENCE. Key personnel shall be identified and their function, responsibilities and qualifications to perform the tasks assigned shall be described. This description should include a comparison of the requirements of the job assignment with relevant experience and training of the prospective assignee including appropriate OSHA Health and Safety Training. It should also include an assessment of whether further training is required, and, if required, by what method.

2.3 CONTRACTOR LABORATORY QUALIFICATIONS. The Contractor shall inform the Contracting Officer, as early as possible, the analytical laboratory that will be used to perform the chemical analyses. The Contractor's designated lab shall submit a Laboratory Quality Management Plan (LQMP) and Laboratory Statement of Qualifications (SOQ) immediately upon designation of the laboratory to be utilized. Contracting officer or designee shall have final approval. The Contractor (or the subcontracted laboratory) shall be responsible for the following:

2.3.1 Facilities and Personnel. Provide all laboratory facilities and personnel qualified to perform the tasks to which they are assigned, and provide access to work, as required.

2.3.2 Sample Handling. Furnish labor, equipment, and facilities to obtain and handle samples at the project site, to facilitate inspections and analyses, and to provide storage, preservation (including refrigeration) of the samples, as necessary.

2.3.3 Sample Custody. Ensure that transportation, chain of custody, and ultimate disposal of samples take place in accordance with EPA procedures as referenced in EPA Guidelines, EPA SW-846 3rd. ed., or User's Guide to the Contract Laboratory Program.

2.3.4 Data Management and Validation. The contractor's laboratory (or the subcontracted laboratory) shall employ a specific information management system to assist in tracking the progress of each sample through the analytical process. All analytical data shall undergo a data validation process that shall ensure that documentation is complete and correct, that any anomalies in the preparation and analysis of samples are documented, that sample holding times are documented, analytical results are correct and complete, QC samples are within established control limits, blank correction procedures have been followed, and the data are ready for incorporation into the final report.

2.3.5 Inspections, Sampling, and Analysis. Comply with specified standards and methods for testing and analysis. Contractor shall ensure that field sampling, if performed by the laboratory, is performed in compliance with specified methods, and that the field instruments are properly calibrated. It is also required to ensure that sampling is performed in accordance with specified methods, that provisions are made to prevent sample contamination, and that samples are properly preserved.

2.3.6 Calibrations. The laboratory is required to provide for calibration and tuning of equipment to ensure that the analytical system is operating correctly and functioning at the proper sensitivity to meet established detection limits. Each instrument should be calibrated with standard solutions appropriate to the type of instrument and the linear range established for the analytical method. The frequency of calibration and the concentration of calibration standards is determined by the manufacturer's guidelines, the analytical method, or the requirements of special contracts.

2.3.7 Quality Assurance/Quality Control Samples. The laboratory will be required to provide for laboratory QA/QC samples including blanks, duplicates, and matrix spikes. As part of the internal laboratory QC program, an analytical blank should be analyzed with every batch of samples processed. Matrix duplicates should be prepared and processed separately for ten percent of the samples tested or as a minimum one duplicate per sample batch processed. The results should be compared to assess the effects of the matrix on the precision of the analysis.

2.3.8 Sample Containers. It is preferable to use containers supplied by the testing laboratory that have been cleaned prior to shipment to the field and that contain the required preservatives. Vitrified glass product samples should be collected in wide-mouth glass jars equipped with Teflon-lined screw caps. In general, environmental samples should be preserved by cooling with ice or refrigeration at 4° C. Hazardous samples, e.g. those containing medium or high concentrations of contaminants, should not be fixed with any chemical preservatives nor cooled. No chemical preservative should be added to the vitrified glass product samples for TCLP analysis. Sampling and sample containers for collection of the ISV off-gases and stack gas emissions should be in accordance with the specified EPA methodology.

2.3.9 Recordkeeping. Maintain internal recordkeeping, in accordance with good laboratory practices (GLP), as referenced in 40 CFR 792.

2.3.10 Chain of Custody. Follow chain of custody requirements in accordance with EPA protocols as referenced in National Enforcement Investigations Center, "Enforcement Consideration For Evaluations of Uncontrolled Hazardous Waste Disposal Sites by Contractors", Draft, dated April 1980. As a minimum, each sample set will include a chain-of-custody (COC) form transmitting the samples to the laboratory. The sample custodian at the chemical laboratory will accept custody of the samples and verify that the information on the sample labels matches that on the COC records. The custodian will than enter the appropriate data, including date and time of receipt, in the laboratory sample tracking system. A laboratory identification number will be assigned to each sample. The custodian will then either transfer the sample to the analyst or store the sample in an appropriate storage area. The COC procedures will track the sample from receipt through the laboratory system until the analytical process is complete and the sample is back in the custody of the lab custodian. Samples and extracts shall be retained by the laboratory for a period of sixty days after the written report is issued by the laboratory. Final disposition of all samples and extracts shall be documented and a certified copy of the COC form shall be included with the analytical data.

3. CONTRACTOR SAMPLING AND SAMPLE CUSTODY PROCEDURES

3.1 GENERAL. All sampling activities shall be performed according to protocols specific to each parameter of interest, promulgated by the USEPA and referenced in EPA SW-846, 40 CFR 60 Appendix A, and 40 CFR 61 Appendix B. Where such protocols have not been established by the U.S. Environmental Protection Agency, protocols established by some other recognized authority (e.g. ASTM) shall be utilized following approval by the Contracting Officer or designee. The CQCP shall fully describe all sampling procedures including those below.

3.2 SAMPLING AND CUSTODY PARAMETERS.

3.2.1 Sample Site Selection. The contractor shall provide a rationale for the proposed selection of sampling sites, as well as details concerning the method of site selection (random, stratified, grid, etc.). Final approval shall be given by Contracting Officer or designee.

3.2.2 Sampling Procedure. The contractor shall furnish all information relative to the sampling process, including equipment used, sample volume, and sampling technique. The contractor shall supply all references to the procedures used.

3.2.3 Sample Containers and Cleaning Procedures. The types of sample containers and procedures used for cleaning these containers shall be consistent with U.S. EPA requirements for the specific parameters of interest as referenced in U.S. EPA, Office of Solid Waste and Emergency Response, "Test Methods for Evaluating Solid Waste (SW-846)", Third Edition, 1986 and in U.S. EPA, National Enforcement Investigations Center, "Enforcement Consideration for Evaluations of Uncontrolled Hazardous Waste Disposal Sites by Contractors", Draft, dated April 1980.

3.2.4 Procedures Employed to Avoid Sample Contamination. During sampling activities, appropriate decontamination measures shall be taken to minimize sample contamination from external sources such as sampling equipment or sample containers, or cross contamination. These procedures shall be consistent with those outlined in "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods" (U.S. EPA SW-846, 3rd. ed.). The sampling program established for this project shall include provisions for generating the appropriate field QA/QC samples to monitor the effectiveness of the specific procedures employed in controlling external contamination.

3.2.5 Sample Preservation. All samples collected shall be preserved according to U.S. EPA protocols established for the parameters of interest as referenced in US EPA SW-846. Appropriate measures shall be taken to ensure that storage requirements with respect to temperature are maintained during transport to the laboratory, and prior to log-in and storage at the laboratory. In general, hazardous samples (those which contain medium or high concentrations of contaminants) should not be fixed with any chemical preservative nor cooled. Environmental samples should be cooled by ice or refrigeration to maintain the sample temperature near 4° C. Vitrified glass product samples for TCLP analysis should not be chemically preserved prior to TCLP extraction.

3.2.6 Sample Transportation. Samples shall be transported to the contractor laboratory via the most rapid means taking into account any holding time requirements. Samples shall be packaged and transported according to U.S. EPA, Contracting Officer, and Department of Transportation (DOT) regulations. These procedures are referenced in Code of Federal Regulations, Title 49 (Transportation), Parts 172 and 173; and NEIC, "Enforcement Considerations for Evaluation of Uncontrolled Hazardous Waste Disposal Sites by Contractors", draft, dated April 1980.

3.2.7 Chain of Custody Procedures. Samples shall be collected, transported, and received under strict chain of custody protocols consistent with procedures established by the U.S. EPA for litigation related materials as referenced in 2.3.10. Upon receipt at the laboratory, the laboratory shall provide a specific mechanism through which the deposition and custody of the samples are accurately documented during each phase of the analytical process. As a minimum, a chain-of-custody (COC) form will be filled out and will accompany every shipment of samples to the analytical laboratory. The COC form will contain the following information:

- Sample number or sample I.D.
- Signature of the sampler or collector
- Date and time of collection
- Sample type
- Type of analyses requested
- Signatures of persons involved in the chain of possession
- Dates of possession

The laboratory shall enter the following information:

- Name of persons receiving sample
- Date of sample receipt
- Sample condition

The originals will follow the sample to its final destination and copies documenting each custody change will be received and kept on file by the quality assurance manager. Samples and extracts shall be retained by the laboratory for a period of sixty days after the written report is issued by the laboratory. All leftover samples and extracts shall be returned to the M-1 site for final disposition. COC will be maintained until final disposition of the samples.

3.2.8 Sample Information Documentation. All information pertinent to the environmental samples, including sample descriptions, specific field collection data, and laboratory observations shall be recorded in permanently bound notebooks. The contractor laboratory shall also employ a specific information management system to assist in tracking the progress of each sample through the analytical process.

4. ANALYTICAL METHODS/PROCEDURES. Analytical methods presented in Tables 2, 3, and 4 shall be utilized for the project unless otherwise approved by the Contracting Officer or designee. EPA-certified methods have been specified for the testing and analysis of both the off-gases and stack gases emitted from the ISV process at the M-1 Settling Basins. USATHAMA does not currently have appropriate stack sampling methods and, therefore, EPA methodology was referenced. EPA-certified methods are also specified for the vitrified glass melt analyses. One of the goals for this project is eventual delisting of the vitrified glass melt as a hazardous waste and, therefore, EPA TCLP test procedures are recommended for the ISV vitrified glass analyses.

The CQCS of the CQCP shall specifically state the analytical procedures to be used. Other properly validated and standardized methods may be substituted subject to the Contracting Officer's approval. The contractor shall describe possible interferences based on the methods of analysis, matrices involved, and chemicals known to be present and shall describe methods of compensating for the interferences identified in the CQCP. Sensitivity and detection limits of the methods must be sufficient for the purpose of the analyses. At the end of the project, the contractor shall at the Contracting Officer's option provide a copy of all analytical data including log books, chromatograms, instrument outputs, and calculations.

5. ANALYTICAL/STATISTICAL/CONTROL PARAMETERS.

5.1 ACCURACY. Accuracy is a measure of the bias in a system and can be defined as the degree of agreement of a measurement with the accepted reference or true value. Although the exact bias of a system can never be known, inferences can be drawn from an examination of blank analysis and laboratory spiked analysis. Accuracy will be evaluated through the collection and analysis of matrix spike samples. Five percent of the samples collected shall be collected in sufficient quantity such that a matrix spike can be generated in addition to an aliquot reserved for actual sample analysis. The matrix spike sample shall be fortified with a series of method target compounds, while a second aliquot of the sample shall be analyzed unfortified. Accuracy shall be measured in terms of percent recovery of each of the fortified components in accordance with the method specified. Control limits shall be established in the CQCP.

5.2 SENSITIVITY. The sensitivity of each analytical method employed shall be determined according to protocols established in SW-846. Method detection limits determined in this manner shall be equivalent to those provided in each of the specific analytical methods.

5.3 PRECISION. Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. The measurement of precision is made through the use of duplicate or replicate samples, taken at regular intervals. Precision will be evaluated through the collection and analysis of field duplicate samples. Field duplicates during ISV operations shall be collected at a frequency of one per matrix type for each ten melt settings processed. One field duplicate per matrix type shall be collected during the Demonstration Melt operations. The relative percent difference between each sample and duplicate shall be calculated, and used as a measure of precision. Control limits used shall be specified in the CQCP.

5.4 CONTRACTOR INTERNAL QC CHECKS. The Contractor shall, as a minimum, analyze internal QC samples at a frequency of 10 percent. These QC samples shall include duplicates, method blanks, external reference samples, and laboratory control samples. In addition, field blanks and rinsates shall be analyzed at a frequency of 20 percent. Trip blanks shall accompany all volatiles samples and shall be analyzed at a frequency of 10 percent. Appropriate mechanism, including the definition of laboratory control limits for each of these elements and the use of control charts shall be established to ensure that control is maintained. A specific system detailing the protocols to be followed in the event that any internal QC Check sample does not meet laboratory acceptance criteria shall be implemented. This system shall include the mechanism by which corrective action taken in the event of any non-conformance event is documented and assurance provided that system in question remains in control.

5.5 FIELD QA/QC SAMPLES. Field duplicate/split samples to be analyzed by both the contractor laboratory and the QA laboratory shall be collected at a frequency of one per matrix type for each ten melt settings processed. The results from the subcontractor laboratory for such samples shall be reported in a timely manner to the Contracting Officer for comparison to the QA laboratory's results. It is the responsibility of the Contracting Officer to report any significant discrepancies between these two results to the Contractor laboratory. In the event of such an occurrence, the Contractor's laboratory shall initiate an investigation into possible reasons for the discrepancy, and submit a plan to resolve the problem. All such activities shall be considered as non-conformance events, and be supported by the appropriate documentation.

5.6 REPRESENTATIVENESS. Representativeness is the degree to which a set of data accurately represents the characteristics of a population, a process condition, or an environmental condition. Data are usually considered representative if the sample distribution is within statistically defined bounds. Representativeness should be defined in the CQCP. For field sample collection, it is the responsibility of the sampling team to conduct their activities such that representativeness is ensured when field duplicates or split samples are collected. This includes the use of appropriate sample homogenization procedures, that do not interfere with the particular parameters of interest, to ensure that each duplicate/split sample will be representative of the whole sample. Laboratory procedures shall be established to ensure that aliquots used for sample analysis are representative of the whole sample. Similarly, any such procedures employed at the laboratory level shall not interfere with the concentration or composition of the analysis in the sample.

5.7 DATA COMPARABILITY. Comparability expresses the confidence with which one data set can be compared with another. The contractor laboratory shall make the necessary provisions to ensure the comparability of all data. These procedures include, but are not limited to, the use of standard approved methodologies, the use of standard units, and report format, the use of calculations as referenced in the methodology for quantification, and the use of standard measures of accuracy and precision for quality control samples.

6. CALIBRATION PROCEDURES AND FREQUENCIES. A list of field and laboratory instrumentation (including details on manufacturer, models, accessories, etc.) procedures used for calibration and frequency of checks are required. The instrumentation and calibrations shall be consistent with the requirements of the contract, the EPA-approved analytical method requirements, and the manufacturer's guidelines. Calibration procedures and certification documents shall be submitted to the Contracting Officer. All primary reference standards and standard solutions should be obtained from the National Bureau of Standards, the EPA Repository, or other reliable commercial sources. Standard solutions used in analytical operations should be validated prior to use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Reagents are examined for purity by subjecting an aliquot or subsample to the analytical method corresponding as well. Information on laboratory instrumentation and calibration procedures can be referenced to the Laboratory Quality Management Plan (LQMP) instead of repeating it in the CQCP.

7. PREVENTIVE MAINTENANCE. A preventive maintenance program for all facilities and instrumentation used by the contractor for sampling and analyses shall be presented in the CQCS of the CQCP. The Contractor's laboratory shall maintain a bound logbook for each analytical instrument. This book serves as a permanent record documenting any

routine preventive maintenance performed, as well as any service performed by external individuals such as manufacturer's service representatives. All maintenance activities shall be performed by individuals qualified to perform the particular task involved. All records shall be made available for inspection upon request. To the extent that preventive maintenance is covered in the LQMP, this information can be reference by the CQCP instead of repeating it in the CQCP.

8. DATA ANALYSIS AND REPORTING. Reports shall include the validated results obtained from the analysis of samples, all pertinent data obtained from the analysis of both internal and external quality control samples, including, but not limited to, actual detection limits, surrogate spike data, matrix spike data, and method blank results. The Contractor shall provide in the CQCS of the CQCP for each analytical method and major measurement parameter the following:

8.1 CALCULATIONS. The contractor shall provide, for each analytical method, detail regarding the data analysis scheme including units and equations required to calculate concentrations or the value of the measured parameter.

8.2 PROCEDURES TO ENSURE DATA INTEGRITY. The contractor shall identify the principle criteria used to assure data integrity during collection and reporting. The means of establishing these criteria shall be identified as well as procedures implemented to provide corrective action when data or instrumentation do not meet these criteria.

8.3 TREATMENT OF OUTLIERS. The Contractor shall describe the specific mechanisms employed by which outlier data are identified. Details provided shall include a description of the phase of the analytical process where these mechanisms are employed, and the process by which subsequent decisions regarding the disposition of the outlier data in question are made.

8.4 DATA MANAGEMENT. The contractor shall provide detailed information regarding the handling of data, including the types and mechanisms of review processes and the qualifications of the various individuals involved in this activity.

8.5 DOCUMENTATION. The contractor shall describe the specific procedures employed to archive data including a description of any hardware involved (computers, etc.). Handling and storage procedures for all raw data and QC sample data shall also be described.

9. CONTRACTOR REPORTS.

9.1 CONTRACTOR QUALITY CONTROL SECTION (CQCS) OF THE CONTRACTOR QUALITY CONTROL PLAN (CQCP). The major items and organization of the CQCS includes project specific detail and shall include specific sampling points and rationale for selection of these sites, specific sampling procedures, specific packaging and chain-of custody procedures, specific analytical protocols, and specific control limits (acceptance criteria) to be employed by the validated contract laboratories. The CQCS shall contractually delineate details for accomplishing the chemical quality control items as directed in these specifications. The CQCS shall assure accurate, precise, complete and comparable data. External operations involving Government-Contractor intentions shall also be incorporated in the CQCS. The CQCS of the CQCP should include information as outlined in paragraphs 9.3.1 through 9.3.8 of this section.

9.2 DAILY QUALITY CONTROL REPORTS (DQCR). The Contractor shall prepare daily a report on each day of the project. Information contained in this report shall include, as a minimum (a) location of the work, (b) weather conditions, (c) work performed,

(d) results of inspections performed, (e) problems identified and associated corrective actions taken, including any QA/QC problems encountered, (f) any instruction received from government personnel for retesting (e.g., QA samples), (g) types of tests performed, the individuals performing the tests, and subsequent results, (h) general comments, (i) calibration procedures and recordings, and (j) the contractor's certification.

9.3 CONTRACTOR QUALITY CONTROL SUMMARY REPORT. At the completion of the ISV effort, a report summarizing the items discussed above for the ISV operating period shall be prepared by the contractor. This report shall be prepared by compiling information relative to the project according to the following outline:

9.3.1 Project Scope
9.3.2 Project Description
9.3.3 Sampling Procedures
9.3.4 Summary of Daily QC Reports (DQCR)
9.3.5 Analytical Procedures
9.3.6 Data Presentation
9.3.7 Quality Control Activities

9.3.8 Conclusions and Recommendations. (Include any pertinent observations made during this project that are of use to future site activities).

TABLE 1

ARAR LIMITS FOR STACK GAS EMISSIONS

Parameter	ARAR Limit
Arsenic (As)	85% Reduction[1] minimum[3]
Mercury (Hg)	2300 grams (five lbs)/day[4] of Hg
Organics	99.99% DRE[2] minimum[5]
Opacity	20% opacity minimum[6]
Particulate Matter	0.08 grains/dry SCF[5]

[1] Arsenic emissions will be conveyed to a control device and reduced by at least 85%.

[2] Destruction and removal efficiency (DRE), as calculated from the total in the soil before treatment through the venting of treated air to the atmosphere.

[3] 40 CFR 61.162 (b)

[4] 5 CCR 1007-3, Regulation 8

[5] 40 CFR 264.343

[6] Colorado Air Pollution Control, Regulation Number 1, Section II

TABLE 2

PRE-TEST SOIL ANALYSIS[A]

Parameter	Method
Metals except:	6010
Arsenic	7060
Mercury	7471
Volatile Organics	8240
Semi-Volatile Organics	8270
Pesticides/PCB	8080

A - "Test Methods for Evaluating Solid Waste (SW-846)", Third Edition, Office of Solid Waste and Emergency Response, U.S. EPA, November 1986.

TABLE 3

VITRIFIED GLASS PRODUCT ANALYSES[A]

Parameter	Glass from Demonstration Melt	Glass from Other ISV Melt Settings
Toxic Characteristics Leaching Procedure (TCLP)	1311	1311
TCLP Metals except:	6010	6010
TCLP Arsenic	7060	7060
TCLP Mercury	7471	7471
TCLP Volatile Organics	8240	NR
TCLP Semi-Volatile Organics	8270	NR
TCLP Pesticides/PCB's	8080	NR

A - "Test Methods for Evaluating Solid Waste (SW-846)", Third Edition, Office of Solid Waste and Emergency Response, U.S. EPA, November 1986.

NR - Analysis not requested.

TABLE 4

OFF-GAS AND STACK-GAS ANALYSES[A]

		Stack Gas	
Parameter	Off-Gas (Before Treatment)	Demonstration Melt	Other ISV Melt Settings (Continuous Monitoring)
Pesticides/PCB's[1]	0010/8080	0010/8080	NR
Arsenic[2,3]	108/200.7	108/200.7	NR
Mercury[2,3]	101A/245.1	101A/245.1	NR
Multiple Metals Screen[3,4]	12/200.7	12/200.7	NR
Volatile Organics[5]	TO-14	TO-14	NR
Velocity[4]	NR	1	NR
Temperature[4]	NR	2	2
Gas Composition (O_2/CO_2)[4]	NR	3A	3A
Carbon Monoxide (CO)[4]	NR	10	10
Particulate Matter[4]	NR	5	NR
Opacity[4]	NR	9	NR

A - EPA Method Numbers are shown
NR - Not Requested

[1] "Test Methods for Evaluating Solid Waste (SW-846)", Third Edition, Office of Solid Waste and Emergency Response, U.S. EPA, November 1986.

[2] 40 CFR 61, Appendix B

[3] "Methods for Chemical Analysis of Water and Waste," EPA-600/4-79-020 (Revised March, 1983).

[4] 40 CFR 60, Appendix A

[5] "Compendium of Methods For the Determination of Toxic Organic Compounds in Ambient Air," EPA-600/4-84-041.

Sheet 1 of 1

5.0
DRAWINGS

The Concept Design drawings are provided as an enclosure.

6.0
COST ESTIMATE

This section provides the cost estimate developed for the Concept Design of the in situ vitrification (ISV) of the M-1 Settling Basins at Rocky Mountain Arsenal, Colorado. This cost estimate has been prepared in accordance with the Estimating Guide V3.11, U.S. Army Corps of Engineers, CI #3403, M-1 Settling Basins, 3 January 1990. This section also provides an update of the Value Engineering Study conducted for this project.

6.1 COST ESTIMATE

This section contains the Concept Design cost estimate for the ISV of the M-1 Settling Basins, including all site preparation costs, as prepared by Stanley Consultants of Muscatine, Iowa on 31 August 1990. The estimated project cost shown is approximately $13,000,000 excluding electrical power. Power costs are estimated to be approximately $1,200,000.

Sheet 1 of 68

Conceptual Estimate
for
In-Situ Vitrification
Rocky Mountain Arsenal, Colorado

1. Work to be done: The work consists of furnishing all plant, labor, materials, and equipment, and performing all work in strict accordance with the specifications, schedules, drawings, and amendments forming part thereof.

2. Description of work: The work to be performed includes the following principal features: In-Situ Vitrification of containment soil. Provide access road, power supply, and fencing of contaminated area, so that the In-Situ Vitrification can be done.

3. Basis of estimate: This estimate is based on the best available data as to a fair and reasonable cost of doing the work by contract. Wage rates as used in this estimate are current Davis-Bacon Wage Rates. Equipment rental rates were obtained from Rental Rate Blue Book for Construction Equipment. Material prices were obtained from published sources and suppliers' quotations. Labor costs are based on 8-hour day and 40-hour work week, except for Item 9 - In-Situ Vitrification (Geosafe) which is an around-the-clock operation 7 days a week.

REASONABLE CONTRACT ESTIMATE

SHEET 2 OF 68

PROJECT IN-SITU VITRIFICATION

INVITATION NO.

ITEM NO.	DESCRIPTION	ESTIMATED QUANTITY	UNIT	UNIT PRICE	ESTIMATED AMOUNT
1	GENERAL CONDITIONS	—	LS	—	$ 566,291
2	ROADWAY DETOUR EARTHWORK	1,214	CY	5^{00}	6,070
3	ROADWAY DETOUR DRAIN	28	LF	57^{75}	1,617
4	SAFETY FENCE	—	LS	—	24,304
5	ELECTRICAL WORK	—	LS	—	54,220
6	MECHANICAL WORK	—	LS	—	16,441
7	REMOVAL & DISPOSAL OF				
	SUPPORT ITEMS FOR THE				
	IN-SITU VITRIFICATION	—	LS	—	12,786
8	FILL OVER BASINS PRIOR TO MELTING	1,550	CY	18^{75}	79,063
9	IN-SITU VITRIFICATION (GEOSAFE)	—	LS	—	10,263,601
	TOTAL				$ 10,975,393
	COST GROWTH:				
	MIDPOINT OF CONSTRUCTION	7/91 1729	=	1.024	$ 11,238,802
	DATE OF ESTIMATE	8/90 1689			
	CONTINGENCY (10%)				1,123,880
	SUBTOTAL				$ 12,362,682
	SIOH (5.5%)				679,948
	TOTAL				$ 13,042,630
	CURRENT WORKING ESTIMATE (CWE)		ROUNDED		$ 13,043,000

Computed by DR DRAKE Date 8/22/90

Checked by .... Date ....

Reviewed by .... Date ....

Approved by .... Date ....

Job No. 10742-02-697 Page No. ....

Subject IN-SITU VITRIFICATION ROCKY MOUNTAIN ARSENAL, COLORADO

Sheet No. 3 of 68

UNIT COST RECAP SHEET

ITEM Nº	DIRECT COST	INDIRECT COST	SUBTOTAL	PROFIT 5.8%	TOTAL COST	UNIT	UNIT COST
1	---	535,247	535,247	31,044	566,291	LS	$566,291
2	5,738	---	5,738	333	6,071	1,214CY	5^{00}
3	1,528	---	1,528	89	1,617	28CF	57^{75}
4	22,972	---	22,972	1,332	24,304	LS	24,304
5	51,248	---	51,248	2,972	54,220	LS	54,220
6	15,729	---	15,729	912	16,441	LS	16,441
7	13,030	---	13,030	756	13,786	LS	13,786
8	27,462	---	27,462	1,593	29,055	1,550CY	18^{75}
9	9,700,947	---	9,700,947	562,655	10,263,601	LS	10,263,601

Computed by D R DRAKE Date 8/22/90
Checked by J L Hansen Date 8/30/90
Reviewed by Date
Approved by Date

Job No. 10742-02-697 Page No.
Subject IN-SITU VITRIFICATION
ROCKY MOUNTAIN ARSENAL,
COLORADO
Sheet No. 4 of 68

DIRECT COST RECAP SHEET

ITEM Nº SHEET ( )	PLANT	LABOR	MATERIAL	SUPPLIES	AMOUNT
1 ( )	---	---	---	---	---
2 (17)	$ 3,441	$ 2,297	---	---	$ 5,738
3 (22)	291	466	771	---	1,528
4 (27)	---	---	---	---	22,972
5 (34)	---	---	---	---	51,248
6 (42)	---	---	---	---	15,729
7 (48)	---	---	---	---	13,030
8 (51)	14,443	7,431	5,588		27,462
9 (55)	1,292,339	1,813,525	6,595,083		9,700,947
				TOTAL	$ 9,838,654

Computed by D.R. DRAKE Date 8/22/90
Checked by J.F. Hanan Date 8/30/90
Reviewed by Date
Approved by Date

Job No. 10742-02-697 Page No.
Subject IN-SITU VITRIFICATION
ROCKY MOUNTAIN ARSENAL,
COLORADO
Sheet No. 5 of 68

INDIRECT COST RECAP SHEET

DIRECT COSTS = $ 9,838,654 (SHEET 4 OF 68)

		SHEET	
I.	DISTRIBUTIVE COSTS:		
	a. MOBILIZATION OF EQUIPMENT		$ 11,660
	b. MOBILIZATION OF PERSONNEL		4,160
	c. SITE PREPARATION		51,890
		TOTAL	$ 67,710

PERCENT APPLICABLE = 0.7 %

		SHEET	
II.	FIELD OVERHEAD:		
	a. FIELD PERSONNEL		$ 117,000
	b. TRANSPORTATION		1,000
	c. PER DIEM		75,600
	d. SURVEYING		1,755
	e. INSURANCE		125,000
	f. TRAINING		22,182
		TOTAL	$ 342,537

PERCENT APPLICABLE = 3.5 %

III.	OFFICE OVERHEAD		
	a. HOME OFFICE EXPENSE		$ 50,000
	b. BID & PERFORMANCE BOND		75,000
		TOTAL	$ 125,000

PERCENT APPLICABLE = 1.3 %

TOTAL INDIRECT % = 5.5 %

3004

SHEET 6 OF 68

WAGE RATE CALCULATIONS

For use of this form, see TM 5-800-2; the proponent agency is USACE.

EFFECTIVE PERIOD

OPERATIONAL SHIFTS

PROJECT IN-SITU VITRIFICATION

LOCATION ROCKY MOUNTAIN ARSENAL, COLO.

ESTIMATOR DR DRAKE

CHECKED BY JZ Hansen

LABOR COST

CRAFT DESCRIPTION	BASIC HOURLY WAGE RATE	OVERTIME		SUB-TOTAL (b + d)	TAXES & INS		SUB-TOTAL (e + g)	FRINGE BENE-FITS	TRAVEL OR SUB-SIST	TOTAL HOURLY COST (h + i + j)
		% OF (b)	AMT.		% OF (e)	AMT.				
a	b	c	d	e	f	g	h	i	j	k
LABOR FOREMAN	10^{77}			10^{77}	30.8	3^{32}	14^{09}	2^{34}		16^{43}
LABORER	10^{27}			10^{27}	30.8	3^{16}	13^{43}	2^{34}		15^{77}
TRUCK DRIVER LT	15^{51}			15^{51}	28.4	4^{40}	19^{91}	3^{64}		23^{55}
EQUIP OPER LT	12^{10}			12^{10}	25.4	3^{07}	15^{17}	3^{33}		18^{50}
EQUIP OPER MED	14^{10}			14^{10}	25.4	3^{58}	17^{68}	3^{33}		21^{01}
ELECTRICIAN	16^{95}			16^{95}	21.2	3^{59}	20^{54}	3^{79}		24^{33}
ELECTRICIAN FORE	17^{95}			17^{95}	21.2	3^{81}	21^{76}	3^{79}		25^{55}
PLUMBER	16^{77}			16^{77}	22.4	3^{76}	20^{53}	4^{83}		25^{36}
PLUMBER FORE	17^{77}			17^{77}	22.4	3^{98}	21^{75}	4^{83}		26^{58}

DA FORM 5420-R, Apr 86

6.2 VALUE ENGINEERING

In August 1990 a Value Engineering Study for the M-1 Settling Basins In Situ Vitrification was prepared by Stanley Consultants. Twelve items were evaluated that showed potential for cost savings. This section discusses the status of those items within the context of the Concept Design. The Value Engineering Study is in Appendix B.

6.2.1 Item 1 - Use Self-feeding Electrode vs. Fixed

The original design would require that electrodes be inserted into a predrilled hole. The Value Engineering (VE) Team proposal would require a self-feeding electrode that would eliminate the need for predrilling into the waste. This proposal would result in less possibility of contamination on the surface, but would require the addition of controls and mechanical systems to the hood to control the feed rate.

Geosafe is currently testing the use of self-feeding electrodes. Data will be available on the technical feasibility of self-feeding electrodes by the time the ISV is implemented at the M-1 Settling Basins. The Concept Design and Final Design will assume that electrodes will be fixed because data to the contrary will not yet be available.

6.2.2 Item 2 - Cut Down Size of Treated Area

The M-1 Settling Basins waste was originally deposited in basins with sloped sides. The original planned soil vitrification area starts at the top of the slope and extends across the trench to the top of the opposite side. There is about two feet of soil over the sludge. Therefore, the original melt line would vitrify soil beyond the lateral extent of the sludge. The VE Team proposal would reduce the planned dimensions of the vitrification. The melt line would be extended about one foot beyond the extent of the sludge, rather than the entire distance to the edge of the berms. This proposal would lower the cost of the ISV due to a smaller volume of material being vitrified, while still meeting the objective of treating the M-1 Settling Basins sludge.

This idea is recommended, and is being incorporated into the Concept Design.

6.2.3 Item 3 - Separate the Project into Two Contracts

The original design assumed that one contract would cover all work for the project, including site preparation and the vitrification process. The VE Team proposal would separate the project into a site preparation contract, that would include any road work, fences, lighting, bringing electrical power to the site, etc., and a general contract for the ISV process. This proposal would lower the total project costs because the prime contractor would otherwise subcontract the site work, although the proposal would add minor contract administration costs.

A recommendation was made at the pre-design conference that the COE and Geosafe discuss this idea between the Concept and 90% design phases of this project.

6.2.4 Item 4 - Recycle Waste Material into Next Set-up

Off-gases generated from the ISV process are collected and treated with scrubbing and filtering equipment. The sludge generated by this treatment is considered hazardous, and typical disposal would be in a hazardous waste landfill. The VE Team proposal would be to dispose of the waste material from the scrub/filter operation by recycling the waste into a future subsequent ISV setting. This proposal would save the costs associated with disposing of the material, although there would be a slight increase in cost for the additional ISV setting (the cost for the additional setting is not included in the Value Engineering cost estimate).

This idea is recommended, and is being incorporated in the Concept Design.

6.2.5 Item 5 - Recover Mercury

Based on the original design and the proposal presented in Item 4, mercury would be treated as a hazardous waste and handled with other off-gas contaminants. The VE Team proposal would be to recover the mercury from the off-gas collection and treatment system. The recovered mercury would then be sold. The possible disadvantages to this proposal are the increased manhours and equipment required to reclaim and handle the mercury, and that the recovered mercury may be considered a hazardous waste.

Mercury recovery options are currently being evaluated.

6.2.6 Item 6 - Cover Area with One Foot of Soil

The existing site has been classified as a potentially hazardous area requiring Level B personnel protection equipment. The VE Team proposal would be to cover the entire site with approximately one foot of clean compacted soil to reduce the required personnel protection equipment to Level D. Workers would need less protective equipment, could work more efficiently, and the decontamination areas required for Level B work would not be necessary. However, approximately 1,600 cubic yards of soils would need to be located, transported, placed, compacted, and vitrified.

This idea is considered necessary, and is being incorporated in the Concept Design.

6.2.7 Item 7 - Reuse Electrode

Stationary molybdenum/graphite electrodes are used in the present hood. The VE Team proposal is to modify the hood to use self-feeding graphite electrodes, reuse the electrodes to reduce the electrode cost. The anticipated maximum electrode reuse to be reliably implemented is twice. Electrode reuse has not been proven on large-scale operations.

Geosafe is currently testing electrode reuse. Data will be available on the technical feasibility of electrode reuse by the time the ISV is implemented at the M-1 Settling Basins. The Concept Design and Final Design will assume that electrodes will not be reused because data to the contrary will not yet be available.

6.2.8 Item 8 - Eliminate Sheet Pile Cut-off Wall

The original design requires that sheet pile be driven around the melt perimeter. The sheet pile will cut off water infiltration. A resulting reduction in energy costs will occur because excess water will not have to be boiled away. The VE Team proposal would eliminate the sheet pile cut-off wall and melt the perimeter of the site first to form a water cutoff to the center core.

The melt is not expected to extend to a low-permeability strata such as the Denver Formation, so water would still be able to infiltrate under the melt perimeter. If the melt extends below the water table, a cut-off to the Denver Formation is necessary. The exact depth of the melt has not yet been determined. Therefore, a sheet-pile has been incorporated in the Concept Design.

6.2.9 Item 9 - Use In Situ Slurry System In Place of Sheet Pile

The original design requires that sheet pile be driven as a water cut-off wall around the perimeter of the site. The VE Team proposal would replace the sheet pile with a slurry wall. Although the slurry wall could provide a better reduction of water flow, the slurry wall disturbs the soil and is more costly.

This idea is not recommended by the VE Team.

6.2.10 Item 10 - Use Cost Plus Contract In Place of Lump Sum

A lump sum contract is proposed for the soil vitrification. The VE Team proposal is to use a cost plus contract for the project. This proposal may result in a better ultimate price because the lump sum contract may be higher to account for the risks the contractor must accept. Risk associated with a cost plus contract is transferred to the government and contract management is increased.

This idea must be evaluated and accepted or rejected by the COE.

6.2.11 Item 11 - Use Gas Turbines

The original design assumes that power will be supplied to the site by tapping into the existing distribution system. The VE Team suggestion is to bring a natural gas line to the site and have the contractor provide a gas turbine for electrical power. This proposal would eliminate possible power spikes into the existing electrical power system. However, a gas line would need to be brought to the site.

Geosafe does not currently own a gas turbine. To purchase a gas turbine and amortize it for this project, or to lease a gas turbine, would probably not be cost effective given the electrical power costs projected by the Army ($0.045/kwh).

6.2.12 Item 12 - Multiple Melt Units

The original design assumes that one ISV unit would be used for multiple settings to vitrify the entire site. The VE Team proposal would be to build another melt unit and operate the two units at the same time. This proposal has an earlier completion date.

Geosafe does not currently have a second melt unit to commit to this site. One melt unit requires an operating crew of 11 people. If a second unit were brought to the site, 8 additional operators would be required. Therefore, the total manpower cost savings is minimal. The cost for mobilization/demobilization for the second unit is not included in the value engineering estimate. This idea is not recommended.

6.2.13 Conclusions

Several value engineering ideas have been identified and are being incorporated in the Concept Design. A second Value Engineering Team workshop will be held between the Concept Design and the 90% Design.

APPENDIX A
DESIGN SUPPORT DOCUMENTATION

APPENDIX A
DESIGN SUPPORT DOCUMENTATION

This appendix contains all design support documentation for this project, including vendor information, the Applicable or Relevant and Appropriate Requirements (ARARs) specified in the Final Decision Document for the Interim Response Action at the M-1 Settling Basins (RIC 90002R05), and all design calculations.

APPENDIX A-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

This section is taken from the Final Decision Document for the Interim Response Action at the M-1 Settling Basins, Rocky Mountain Arsenal, March 1990 (RIC 90002R05).

8.0
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR THE REMEDIATION OF OTHER CONTAMINATION SOURCES-M-1 SETTLING BASINS INTERIM RESPONSE ACTION

8.1 INTRODUCTION

These Applicable or Relevant and Appropriate Requirements (ARARs) address the M-1 Settling Basins, a specific area identified for remediation prior to the issuance of a Record of Decision (ROD) for the Onpost Operable Unit of the Rocky Mountain Arsenal. The action described in this document is interim, subject to further remediation as identified in the Onpost ROD.

8.2 AMBIENT OR CHEMICAL-SPECIFIC ARARS

Ambient or chemical-specific requirements set concentration limits or ranges in various environmental media for specific hazardous substances, pollutants, or contaminants. Such ARARs either set protective cleanup levels for the chemicals of concern in the designated media or indicate an appropriate level of discharge based on technological considerations.

The objectives of this IRA are discussed in the Final Assessment Document and Final Decision Document. This IRA will be implemented prior to the final remediation to be undertaken in the context of the Onpost Operable Unit ROD. The media of concern here are the air emissions from the system hood, the liquid effluent remaining after completion of the off-gas control process (see Section 6.0), any liquid generated through dewatering of the area, and the soils which will be subject to the vitrification process. However, no ambient or chemical-specific ARARs were identified concerning levels of contaminants for soils which have been vitrified. Section 8.4 discusses action-specific ARARs for the vitrified mass that remains after treatment. The liquid effluent and any other liquids generated are to be treated by the CERCLA Wastewater Treatment System under development at the Arsenal and treatment standards for liquids treated by that system are contained in the Final Decision Document for that IRA. These standards do not become final until the completion of the decision document process for that IRA, which is currently underway. The selected alternative does not include a groundwater treatment system.

8.2.1 Air Emissions

The treatment system will result in air emissions, which result from the treatment process. These emissions will be contained during the treatment process, be subject to treatment themselves and then be released to the atmosphere after treatment. The standards identified below address the emissions from the emissions control system which will operate as part of this IRA treatment system.

The standards contained at 40 CFR Part 50 were reviewed and determined to be neither applicable nor relevant and appropriate to apply in the context of this IRA. These standards apply to Air Quality Control Regions, large air masses which are markedly dissimilar from the area that may be affected by the operation of an off-gas control system which is intended to be used for treatment by this IRA system. The specific compounds addressed by these standards, sulfur oxides, carbon monoxide, ozone, nitrogen oxide and lead are not anticipated to be contained in significant amounts in any potential air emissions. These standards are defined in terms of measurements in large air masses and not generally applied to specific emissions sources, such as smokestacks and automobile tailpipes, but to the AQCR as a whole, so are not considered relevant and appropriate to apply to the type of emission source which is intended to be utilized in the context of this IRA. Other specific standards have been identified as being appropriate to apply to this IRA treatment system and are identified below.

The standards contained at 40 CFR Parts 60 and 61 were reviewed and determined not to be applicable to operations conducted as part of the treatment by this IRA system. These standards apply to specific sources of the listed pollutants. For example, Subpart E of 40 CFR Part 61 applies to sources which process mercury ore to recover mercury and other specific processes and the arsenic provisions of Subparts O and P of this part apply to very specific plants, smelters or facilities. Since the operations contemplated by this IRA treatment system are extremely dissimilar from the processes identified above as described in 40 CFR Part 61, these standards were also not considered to be relevant and appropriate to apply to this IRA treatment system. However, Subpart N of Part 61 applies to glass melting furnaces which use commercial arsenic as raw material. The treatment system contemplated by this IRA is neither a glass melting furnace nor uses commercial arsenic as raw material, making this subpart not applicable. The vitrification process does result in the creation of a glass-like material in the ground and there is a significant amount of arsenic in the soil which will undergo vitrification. These considerations lead to the determination that the arsenic emissions from the vitrification process should be subject to the emissions limitations contained in 40 CFR § 61.162(b) (2) and this section is considered relevant and appropriate to apply to this IRA. Accordingly, arsenic emissions will be conveyed to a control device and reduced by at least 85%. Specific monitoring and control devices to be utilized will be developed during the design and implementation process, as more information and test data is available.

The Army has identified the standard contained in 5 CCR 1007-3, regulation 8, as relevant and appropriate to apply to mercury emissions from the treatment system and as more stringent than comparable federal requirements. This regulation is not applicable since the IRA treatment system will not use mercury, as defined by the regulation. Mercury emissions will not exceed 2300 grams/five pounds per day, consistent with this requirement.

The Army has identified the standard for particulate emissions contained in 40 CFR § 264.343 as relevant and appropriate to apply to this IRA treatment system. This requirement is not applicable since it applies to incinerators, which are different from the treatment system to be installed as part of this IRA. However, the particulate emission standard is considered relevant and appropriate to apply to this IRA treatment system. Accordingly, particulate emissions from the treatment system will be limited to 0.08 grains per dry standard cubic foot.

The Army intends to develop performance standards for the system hood during the design and implementation phase of this IRA when more data is available concerning the specific equipment which is to be utilized for this IRA. The Army will coordinate this action with the other Organizations and the State.

Other standards for total organic destruction efficiency and opacity are discussed in section 8.4, action-specific ARARs.

8.3 LOCATION-SPECIFIC ARARS

Location-specific requirements set restrictions on activities, depending on the characteristics of the site or the immediate environment, and function like action-specific requirements. Alternative remedial actions may be restricted or precluded, depending on the location or characteristic of the site and the requirements that apply to it.

Paragraph 44.2 of the Federal Facility Agreement provides that "wildlife habitat(s) shall be preserved and managed as necessary to protect endangered species of wildlife to the extent required by the Endangered Species Act (16 U.S.C. 1531 et seq.), migratory birds to the extent required by the Migratory Bird Treaty Act (16 U.S.C. 703 et seq.), and bald eagles to the extent required by the Bald Eagle Protection Act, 16 U.S.C. 688 et seq."

While this provision is not an ARAR, the statutory requirements themselves are ARARs, applicable to this IRA and will be complied with. Based on where this treatment system is likely to be located the Army believes that this IRA will have no adverse impact on any endangered species or migratory birds or on the protection of wildlife habitats. Coordination will be maintained with the U.S. Fish and Wildlife Service to ensure that no such adverse impact arises from implementation of this IRA.

The Army considers relevant and appropriate and will comply with 40 CFR 6.302(a) and (b) concerning the location of this treatment system, avoiding the construction of such system in a manner the would have an adverse impact on wetlands or be within a flood plain.

The regulations at 40 CFR 230 were reviewed and determined not to be applicable within the context of this IRA because no discharge of dredged or fill material into waters of the United States is contemplated. Because these regulations address only the disposal of such materials into the waters of the United States, which is not contemplated, they are not considered to be relevant and appropriate to apply in the context of this IRA.

The regulations at 33 CFR 320-330 were reviewed and determined to be neither applicable nor relevant and appropriate because they address actions affecting the waters of the United States. No such actions are contemplated within the context of this IRA.

8.4 ACTION-SPECIFIC ARARS

8.4.1 Description

Performance, design, or other action-specific requirements set controls or restrictions on activities related to the management of hazardous substances, pollutants, or contaminants. These action-specific requirements may specify particular performance levels, actions, or technologies as well as specific levels (or a methodology for setting specific levels) for discharged or residual chemicals.

8.4.2 Construction of Treatment System

8.4.2.1 Air Emissions

The construction of an in-situ vitrification system does not involve significant excavation in the area on the M-1 Basins, providing very little potential for the generation of air emissions during construction. On the remote possibility that there may be air emissions during the course of the construction of this treatment system, the Army has reviewed all potential ambient or chemical-specific air emission requirements. As a result of this review, the Army found that there are, at present, no National or State ambient air quality standards currently applicable or relevant and appropriate to any of the volatile or semivolatiles chemicals in the ground water found in the area in which construction is contemplated.

In the context of this IRA, there is only a very remote chance of any release of volatiles or semivolatiles and, even if such a release did occur, it would only be intermittent and of very brief duration (because the activity that produced the release would be stopped and modified appropriately if a significant air emission, based upon specific standards contained in the Health and Safety Plan, was detected by the contractor's air monitoring specialist). The Army has significant experience with the construction of slurry walls, extraction and reinjection wells, which involve greater excavation than the construction of the treatment system contemplated by this IRA, and has not experienced any problems from air emissions during construction of such facilities. The site-specific Health and Safety Plan will adequately address these concerns. This plan to be developed for use in the IRA will detail operational modifications to be implemented in the event monitoring detects specific levels of such emissions.

The National Emissions Standards for Hazardous Air Pollutants (NESHAPS) were evaluated to determined whether they were applicable or relevant and appropriate to apply in the context of construction of this IRA. These standards were not considered applicable because they apply to stationary sources of these pollutants, not to construction activity. These standards were not considered relevant and appropriate because they were developed for manufacturing processes, which are significantly dissimilar to the short-term construction activity contemplated by this IRA.

The provisions of 40 CFR 50.6 will be considered relevant and appropriate. This standard is not applicable because it addresses Air Quality Control Regions, which are areas significantly larger than and different from the area of concern in this IRA. Pursuant to this regulation, there will be no particulate matter transported by air from the site that is in excess of 50 micrograms per cubic meter (annual geometric mean) and the standard of 150 micrograms per cubic meter as a maximum 24-hour concentration will not be exceeded more than once per year.

8.4.2.2 Worker Protection

The provisions of 29 CFR 1901.120 are applicable to workers at the site because these provisions specifically address hazardous substance response operations under CERCLA. It should be noted that these activities are presently governed by the interim rule found at 29 CFR 1910.120 but that by the time IRA activity commences at the site, the final rule found at 54 FR 9294 (March 6, 1989) will be operative. (The final rule becomes effective on March 6, 1990.)

8.4.2.3 General Construction Activities

The following performance, design, or other action-specific State ARARs have been preliminarily identified by the Army as applicable to this portion of the IRA and more stringent than any applicable or relevant and appropriate federal standard, requirement, criterion, or limitation:

- Colorado Air Pollution Control Commission Regulation No. 1, 5 CCR 1001-3, Part III(D)(2)(b), Construction Activities:

  a. Applicability -- Attainment and Nonattainment Areas

  b. General Requirement -- Any owner or operator engaged in clearing or leveling of land or owner or operator of land that has been cleared of greater than one (1) acre in nonattainment areas for which fugitive particulate emissions will be emitted shall be required to use all available and practical methods which are technologically feasible and economically reasonable in order to minimize such emissions, in accordance with the requirements of Section III.D. of this regulation.

  c. Applicable Emission Limitation Guideline -- Both the 20% opacity and the no off-property transport emission limitation guidelines shall apply to construction activities; except that with respect to sources or activities associated with construction for which there are separate requirements set forth in this regulation, the emission limitation guidelines there specified as applicable to such sources and activities shall be evaluated for compliance with the requirements of Section III.D. of this regulation. (Cross Reference: Subsections e. and f. of Section III.D.2 of this regulation).

  d. Control Measures and Operating Procedures -- Control Measures or operational procedures to be employed may include but are not necessarily limited to planting vegetation cover, providing synthetic cover, watering, chemical stabilization, furrows, compacting, minimizing disturbed area in the winter, wind breaks, and other methods or techniques.

- Colorado Ambient Air Quality Standards, 5 CCR 1001-14, Air Quality Regulation A, Diesel-Powered Vehicle Emission Standards for Visible Pollutants:

  a. No person shall emit or cause to be emitted into the atmosphere from any diesel-powered vehicle any air contaminant, for a period greater than 10 consecutive seconds, which is of such a shade or density as to obscure an observer's vision to a degree in excess of 40% opacity, with the exception of Subpart B below.

b. No person shall emit or cause to be emitted into the atmosphere from any naturally aspirated diesel-powered vehicle of over 8,500 lbs gross vehicle weight rating operated above 7,000 feet (mean sea level), any air contaminant for a period of 10 consecutive seconds, which is of a shade or density as to obscure an observer's vision to a degree in excess of 50% opacity.

c. Diesel-powered vehicles exceeding these requirements shall be exempt for a period of 10 minutes, if the emissions are a direct result of a cold engine start-up and provided the vehicle is in a stationary position.

d. This standard shall apply to motor vehicles intended, designed, and manufactured primarily for use in carrying passengers or cargo on roads, streets, and highways.

- Colorado Noise Abatement Statute, C.R.S. Section 25-12-103:

a. Each activity to which this article is applicable shall be conducted in a manner so that any noise produced is not objectionable due to intermittence, beat frequency, or shrillness.

Sound levels of noise radiating from a property line at a distance of twenty-five feet or more there from in excess of the db(A) established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance:

Zone	7:00 a.m. to next 7:00 p.m.	7:00 p.m. to next 7:00 a.m.
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light Industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

b. In the hours between 7:00 a.m. and the next 7:00 p.m., the noise levels permitted in subsection (1) of this section may be increased by ten db(A) for a period of not to exceed fifteen minutes in any one-hour period.

c. Periodic, impulsive, or shrill noises shall be considered a public nuisance when such noises are at a sound level of five db(A) less than those listed in Subpart (a) of this section.

d. Construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time for completion of the project.

e. For the purpose of this article, measurements with sound level meters shall be made when the wind velocity at the time and place of such measurement is not more than five miles per hour.

f. In all sound level measurements, consideration shall be given to the effect of the ambient noise level created by the encompassing noise of the environment from all sources at the time and place of such sound level measurements.

In substantive fulfillment of Colorado Air Pollution Control Commission Regulation No. 1, this IRA will employ the specified methods for minimizing emission from fuel burning equipment and construction activities. In substantive fulfillment of Colorado's Diesel-Powered Vehicle Emission Standards, no diesel motor vehicles associated with the construction shall be operated in manner that will produce emissions in excess of those specified in these standards.

The noise levels pertinent for construction activity provided in C.R.S. Section 25-12-103 will be attained in accordance with this applicable Colorado statute.

8.4.2.4 Wetlands Implications

Through estimation of the general area where any system would be located, the Army does not believe that any wetlands could be adversely affected. However, until a final design is selected and a final siting decision made, it cannot be definitively determined that no impact on wetlands will occur. If the final site selection and/or design results in an impact on wetlands, the Army will review the regulatory provisions concerning wetlands impact and other appropriate guidance, and will proceed in a manner consistent with those provisions. Coordination will be maintained with the U.S. Fish and Wildlife Service concerning any potential impacts on wetlands.

8.4.2.5 Land Disposal Restrictions and Removal of Soil and Debris

There are no action-specific ARARs that pertain to the excavation of soil during the construction of this treatment system which can be specifically identified at this time. In any event, very little such activity is contemplated by this IRA.

EPA is currently developing guidance concerning the Land Disposal Restrictions (LDR). While guidance is limited, the Army has not, at this time, made a determination that any materials subject to LDR will be present in the influent treated or soil removed by this IRA. More listings are scheduled to be completed prior to the implementation of this IRA and the Army will review these as they are released. If it is determined that a restricted disposal waste is present, the Army will act in a manner consistent with EPA guidance then in effect for the management of such within the context of CERCLA actions.

Soil removal from the area will be performed in accordance with the procedures set forth in the Task No. 32 Technical Plan, Sampling Waste Handling (November 1987), and EPA's July 12, 1985, memorandum regarding "EPA Region VIII Procedure for Handling of Materials from Drilling, Trench Excavation and Decontamination during CERCLA RI/FS Operations at the Rocky Mountain Arsenal." While not an ARAR, EPA's July 12, 1985 guidance memorandum applies to this action as a TBC. Soils generated by excavation during the course of this IRA, either at surface or subsurface, may be returned to the location from which they originated (i.e., last out, first in). Any materials remaining after completion of backfilling that are suspected of being contaminated (based on field screening techniques) will be properly stored, sampled, analyzed, and ultimately disposed as CERCLA hazardous wastes, as appropriate.

Hazardous waste resulting from construction activities will be managed in accordance with substantive Resource Conservation and Recovery Act (RCRA) provisions. These substantive provisions include but are not limited to: 40 CFR Part 262 (Subpart C, Pre-Transport Requirements), 40 CFR part 263 (Transporter Standards), 40 CFR Part 264 (Subpart I, Container Storage and Subpart L, Waste Piles) and any more stringent substantive provisions of comparable state regulations contained in 6 CCR 1007-3. The specific substantive standards applied will be determined by the factual circumstances of the accumulation, storage or disposal techniques actually applied to any such material.

As part of this IRA, some structures and remains of structures will be removed, resulting in debris. The Army will analyze this material to determine whether it is hazardous or subject to any restrictions concerning disposal. In managing and disposing of this material, the Army will act consistent with the EPA guidance then in effect concerning such material generated on CERCLA sites. Material determined to be hazardous will be managed and disposed of as discussed above.

8.4.2.6 Operation of Treatment System

As described in Section 6.0 of this document, the proposed treatment system will provide significant air pollution controls including a packed scrubber column and activated carbon adsorber.

The Army has identified the requirements of 40 CFR § 264.343 concerning the removal of organics as relevant and appropriate to apply as a performance standard for this IRA system. This requirement is not applicable because it specifically applies only to incinerators. In substantive fulfillment of this requirement, the IRA treatment system will be constructed to provide 99.99% destruction and removal of organics, as calculated from the total in the soil before treatment through the venting of treated air to the atmosphere. The complete process will be designed to attain this requirement.

The regulations contained in 40 CFR Parts 60 and 61, and the comparable State regulations were reviewed to determine whether any action-specific requirements were either applicable or relevant and appropriate to apply to this IRA treatment system. Chemical-specific determinations are discussed in Section 8.2, above. The processes discussed in those regulations were not considered sufficiently similar to the In Situ Vitrification process to make any action-specific provision relevant and appropriate to apply to this IRA. For example, Subparts F, I, Na and OOO of Part 61 were recommended for review by EPA in their comments on the Proposed Decision Document. These Subparts were reviewed and found to address very specific processes and to contain varying standards, indicating that the standards were developed specifically for the processes identified and were not appropriate to apply to other processes which are not extremely similar to the identified process. The primary focus of these provisions is on particulate emissions and opacity. The Army has identified a particulate emission standard for this IRA of 0.08 grams per dry standard cubic foot based on the incineration standard, as noted in Section 8.2, above. The Army considers the opacity standard contained in Colorado Air Pollution Control Regulation No. 1, Section II, as relevant and appropriate to apply to this IRA. Accordingly, the emissions from this IRA treatment system will not exceed 20% opacity.

8.2.4.7 Management of Vitrified Soil

The vitrified soil will remain, pending determination of final remedial action in the ROD for the On Post Operable Unit. During this period, the extensive Endangerment Assessment and Feasibility Study processes underway for the On Post Operable Unit will be used to evaluate the need for and type of further action appropriate for the vitrified soil. These processes will address most of the matters contained in 40 CFR Part 264, Subpart X. The Army will comply with the substantive requirements of 40 CFR § § 264.15, 264.33, 264.75 and 264.77 during the period of management of the vitrified soil while final remedial action is undergoing development.

The Army will comply with the substantive requirements of 40 CFR § 264.97 in conducting groundwater monitoring in the area of the M-1 Settling Basins in order to monitor the effectiveness of the vitrification process and determine any impacts on area groundwater from the vitrified mass.

8.4.2.8 Soil Treatment and Disposal

These proposed remedial actions do not include the possibility for onsite or offsite disposal of soils, debris or contaminated material excavated pursuant to this IRA, except those that may be generated from the construction activities discussed above.

8.5 COMPLIANCE WITH THE OTHER ENVIRONMENTAL LAWS

As is evident from the various portions of this document, this IRA was prepared in substantive compliance with 40 CFR 1502.16 (the regulations implementing the National Environmental Policy Act of 1969).

APPENDIX A-2
VENDOR INFORMATION

CALGON CARBON CORPORATION

CALGON

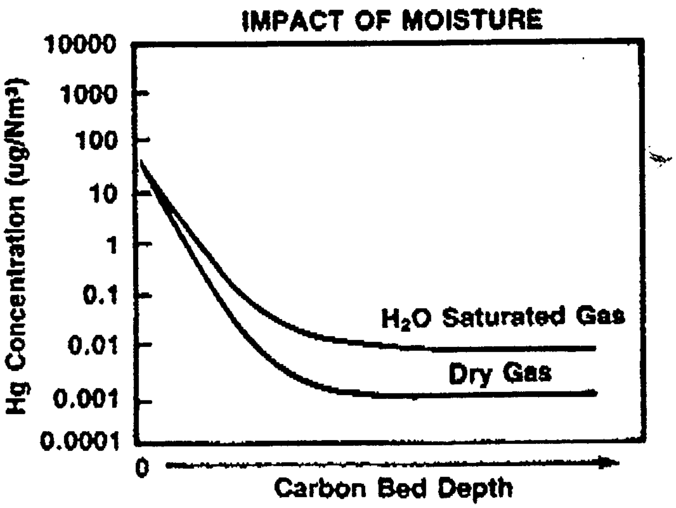
TYPE HGR FOR MERCURY REMOVAL

Calgon Carbon Type HGR granular activated carbon is a sulfur impregnated carbon. The base carbon is made from select grades of bituminous coal and suitable binders to create the unique pore structure and superior hardness necessary for the intended service. Activation is controlled to impart a pore structure that will both accept substantial quantities of impregnant and maintain access for the gas being treated to the complex pore structure. After activation, the sulfur is distributed in a thin layer over the extensive internal surface area of the carbon to provide it with the unique properties required for the removal of elemental and organic mercury from natural gas, air, and by-product hydrogen streams.

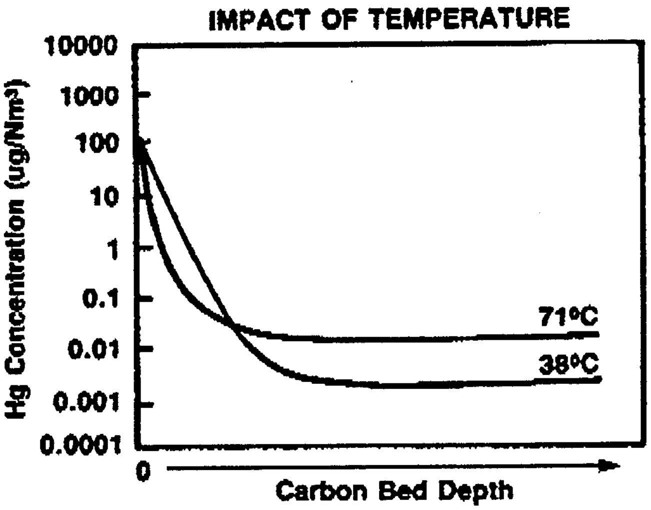
TYPICAL APPLICATIONS—THE MERCURY REMOVAL PROCESS

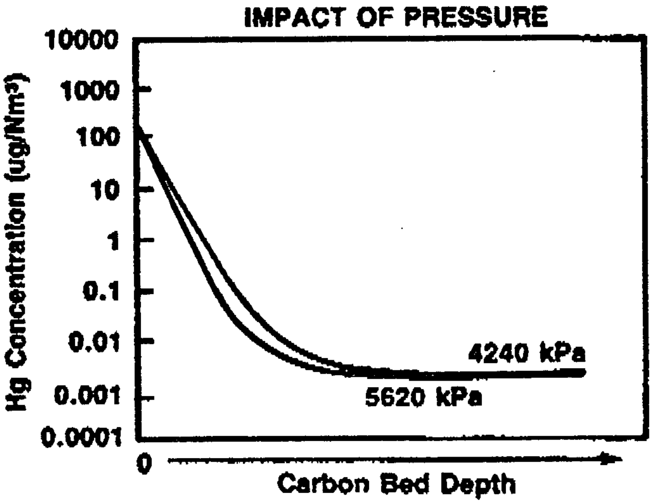
Mercury removal with Type HGR activated carbon is an established process for removal of mercury from natural gas and air as well as from by-product hydrogen streams. The mercury is removed from natural gas feedstocks to LNG and LPG plants to protect aluminum heat exchangers from corrosion. The exhaust air from mercury cell chlorine plants or metallurgical processing equipment can be treated to provide an environmentally safe athmosphere for employees and delicate instruments. Type HGR is also used in mercury cell chloralkali plants to remove mercury from by-product hydrogen streams.

The mercury removal process employs a single or dual vessel adsorption system designed to reduce concentrations to <0.001 ug/Nm³ in the treated gas. During the adsorption process, mercury is attracted to the activated carbon surface where a chemical reaction converts the mercury to mercuric sulfide. The sulfide product is then retained in the pores of the carbon granule. Mercury capacity of Type HGR activated carbon can be as high as 20 weight percent.


IMPACT OF MOISTURE

In a properly designed HGR carbon system, the maximum attainable mercury concentration in treated gas is not affected by changing the pressure or inlet mercury concentration of the gas. However, lowering the gas temperature or moisture content of the inlet gas will improve the process and further reduce the mercury concentration in the treated gas. For instance, a gas stream at 150ºF saturated with moisture will result in a treated gas containing 0.03 ug/Nm³ of mercury. The mercury level in the treated gas can be further reduced to <0.001 ug/Nm³ by reducing the temperature to 70ºF and the moisture to trace levels (see graphics).


IMPACT OF TEMPERATURE


IMPACT OF PRESSURE

SPECIFICATIONS

Mesh Sizes, U.S. Sieve Series	4 x 10
Larger than 4 mesh, Maxium, %	5%
Smaller than 10 mesh, Maximum, %	5%
Apparent Density—Lbs/Cubic Feet, Approximately	37
Sulfur Content, % Typical	15%

COMMERCIAL INFORMATION

Shipping Point:	Pittsburgh, PA
Packaging:	Type HGR is packed in 55 Gallon Steel Drums, 225 Lbs net, 265 Lbs Gross Weight.

CAUTION

Wet activated carbon preferentially removes oxygen from air. In closed or partially closed containers and vessels, oxygen depletion may reach hazardous levels. If workers are to enter a vessel containing carbon, appropriate sampling and work procedures for potentially low-oxygen spaces should be followed, including all applicable Federal and State requirements.

For information regarding incidents involving human and environmental exposure, call (412) 787-6700 and ask for the Regulatory and Trade Affairs department.

For additional information contact
Calgon Carbon Corporation
Box 717, Pittsburgh, PA 15230-0717
Phone: (412) 787-6700

CALGON
CALGON CARBON CORPORATION

CALGON

CALGON CARBON CORPORATION
P.O. BOX 717 • PITTSBURGH, PA 15230-0717

PRICE SCHEDULE

HGR SULFUR IMPREGNATED GRANULAR ACTIVATED CARBON

	Price Per Pound				
Product	30,000 lbs. or More	10,000 but less than 30,000 lbs.	2,000 but less than 10,000 lbs.	500 but less than 2,000 lbs.	less than 500 lbs.
					225 LBS. MINIMUM
HGR 4x10	$5.24	$5.51	$5.65	$5.80	$6.76

1. Prices per pound f.o.b. shipping point* and are subject to revision without notice. Terms are net 30 days.
2. Product shown is packaged in 55-gallon steel drums, 225 pounds net weight, 265 pounds gross weight.

*Shipping point: Pittsburgh, PA

23-1010

January 1, 1990

IMPACT OF PROCESS CONDITIONS ON MERCURY REMOVAL FROM NATURAL GAS USING ACTIVATED CARBON

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ABSTRACT

Purification of natural gas to remove mercury is essential to prevent corrosion of aluminum heat exchangers used in LNG production.[1,2] Sulfur impregnated activated carbon has been utilized effectively for this application since 1975. An LNG plant gas stream and mercury adsorber were simulated using a pilot plant apparatus to define carbon performance as a function of process conditions. Specifically, mercury removal efficiency was determined at various gas temperatures, pressures, flow rates, mercury influent concentrations, and moisture levels. Typically, the mercury mass transfer zone was contained in a 1.0 m column length and effluent concentrations were 0.01-0.03 μg Hg/Nm^3. Increases in gas temperature or moisture level decreased mercury removal performance while changes in pressure or influent concentration had little effect. Limited pilot studies with several experimental carbons indicate that effluent concentrations as low as 0.001 μg/Nm^3 are achievable even under adverse conditions.

L'ABSTRAIRE

La purification du gaz naturel pour éloigner de mercure est essentielle pour empêcher la corrosion des échangers de chaleur aluminum utilizés dans la production de LNG.[1,2] Le soufre imprégné avec le carbone activé était utilizé effectivement dans cette application depuis 1975. Un

courant de gaz et d'un adsorber de mercure dans une installation industrielle de LNG étaient simulés dans l'appareil d'une installation industrielle pilote pour définir l'accomplissment du carbone comme un fonction des conditions de procédé. Specificamente, l'éfficacité de d'éloignement du mercure était determinée à des temperatures du gaz divers, des pressions, des cours d'ecoulement, des concentrations du mercure influé et des niveaux d'humidité. Tipiquement, la zone de cession de la masse de gaz etait continuée dans une colonne de longueur de 1.0 m et des concentrations éffluentes étaient 0.01-0.03 ug Hg/Nm^3. Les augmentations dans la temperature du gaz ou le niveau d'humidité diminuaient l'execution d'elignement du mercure avaient pe d'effet pendant des changements dans la pression ou dans la concentration influée. Les études pilots limités, avec plusieurs carbones expérimentés, indiquent que les concentrations éffluentes à bas de 0.001 au/Nm^3 sont accomplies égal sous des conditions adverses.

IMPACT OF PROCESS CONDITIONS ON MERCURY REMOVAL FROM NATURAL GAS USING ACTIVATED CARBON

INTRODUCTION

Mercury adsorption from well-head natural gas is a challenging application in that essentially all mercury must be eliminated from the gas to effectively prevent corrosion of heat exchangers. Furthermore, the adsorption is carried out in a high moisture, and sometimes elevated temperature environment that will inhibit the performance of most adsorbents. Activated carbon is effective at physically adsorbing trace components from gas streams due to a high population of micropores. Mercury at low concentrations will be adsorbed but the capacity is limited. Impregnants (such as sulfur, copper, silver, and iodine) that can react or amalgamate with mercury are frequently employed to provide increased adsorption capacity. Physically adsorbed mercury is "fixed" by reaction with the impregnant which effectively increases the capacity. Relatively high levels of impregnant provide a long life while retaining the ability of the activated carbon to remove trace mercury. HGR carbon contains over 10 Wt. % sulfur and has been proven in the LNG application over many years. (Type HGR activated carbon is a product of Calgon Carbon Corporation, Pittsburgh, PA).

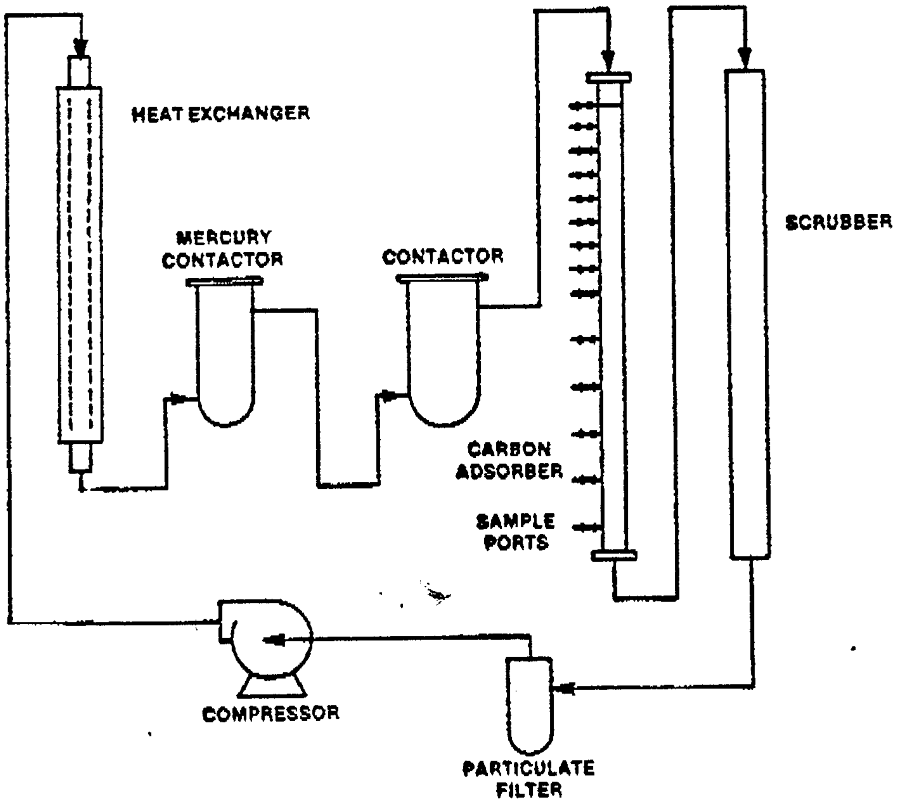
In a fixed bed adsorber, both the adsorption rate, as indicated by the mass transfer zone (MTZ) length, and the capacity or rate of MTZ movement are critical in defining adsorber performance. Measurement of carbon performance under simulated field conditions was undertaken to define its effectiveness and provide insight for the development of improved adsorbents. Performance tests were conducted at typical conditions using pilot-scale experimental apparatus and the results are discussed. Subsequent laboratory/pilot screening of improved adsorbents led to products that have the potential to reduce mercury concentrations to previously unattainable levels. Field tests of these products are critical to ensure that the pilot performance is indicative of what will be obtained under actual conditions.

EXPERIMENTAL

Pilot Plant Hardware and Procedures

The pilot test apparatus was basically a high pressure gas circulation loop. A diaphragm compressor was used to circulate nitrogen or natural gas through a series of conditioning vessels where the temperature and contaminant levels were adjusted. The contaminated gas was then passed through one of several carbon adsorber columns. Each column was 5 cm in diameter and 3 m in length. Up to three columns could be connected in series for a total carbon bed depth of 9 m. Gas sample ports spaced at 15 to 30 cm intervals along the column were used to determine mercury concentration as a function of bed depth. Adsorber effluent gas was returned to the compressor after being cleaned with a scavenger bed and particulate filter. A schematic of the apparatus is presented in Figure 1.

Figure 1
PILOT PLANT TEST APPARATUS— SCHEMATIC



Critical process variables and measurable dependent variables, along with experimental ranges are presented in Table 1.

Table 1
Process Variables

Process Variables	Range Studied
• Temperature	25-80°C
• Pressure	2000-6000 kPa
• Superficial Flow Velocity	0.05-0.50 m/s
• Adsorber Bed Depth	0-9.0 m
• Influent Mercury Concentration	1-1000 μg/Nm^3
• Influent H_2O Content	To Saturation
• Gas Type	N_2, Natural Gas
Measurable Dependent Variables	
• Effluent Mercury Concentration	To <0.001 μg/Nm^3
• MTZ (Mass Transfer Zone) Shape and Length	0-9.0 m
• Pressure Drop	0-225 kPa/m bed
• Mercury, H_2O - Loading on Carbon	O-Saturation

Analytical Methods

A Jerome Model 301[3] mercury vapor detector was used to analyze gas samples for mercury content. By varying sample volumes from 1.0 cm^3 to 2.5 m^3, and using appropriate calibration techniques, a mercury detection range of 1000 to 0.001 μg/Nm^3 was achieved. Special precautions, including clean gas purging between samples and multiple sampling, were taken to avoid sample line contamination problems.

DISCUSSION

Temperature

Adsorber temperature, over the range of 71° -38°C, was found to have a significant impact on both the length of the mass transfer zone or removal rate and the mercury concentration in the column outlet. As the temperature is increased, the chemical reaction rate (Hg+S=HgS) and mercury diffusion rate would be expected to increase and the transfer zone would shorten. With dry natural gas, this behavior was observed as illustrated below in Figure 2.

Figure 2

IMPACT OF TEMPERATURE ON THE MERCURY CONCENTRATION PROFILE OF HGR CARBON

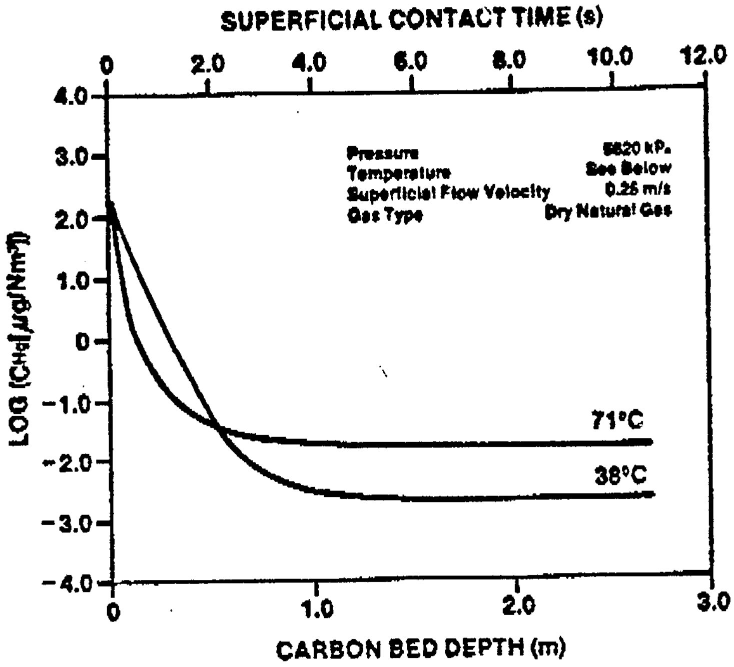
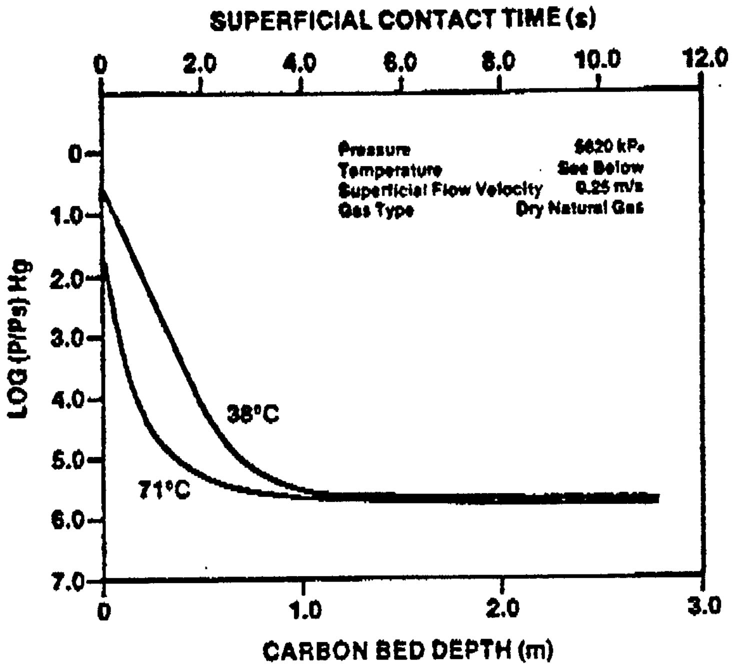


Figure 2 is a plot of the mercury vapor concentration (log (CHg[ug/Nm^3]) vs column bed depth (m), for a 4x10 mesh HGR carbon in dry natural gas. Pressure and superficial velocity (axial flow rate in empty bed) were held constant at 5620 kPa and 0.25 m/s, respectively. The initial slope of the curve at 71°C is greater, indicating a faster adsorption rate. However, the curves are unique in that one would expect to see reasonably constant adsorption rates with increasing bed depth and not the discontinuity that results in a mercury vapor concentration plateau. Additionally, the mercury outlet concentration at the higher temperature is observably higher than at the low temperature. Both effects may be explained on the basis of adsorption theory. As the temperature is increased, the relative pressure of mercury at a given concentration is reduced. In Figure 3, the same data as Figure 2 is plotted except that the mercury vapor concentration is expressed as relative pressure.

Figure 3
IMPACT OF TEMPERATURE ON THE MERCURY RELATIVE PRESSURE PROFILE OF HGR CARBON

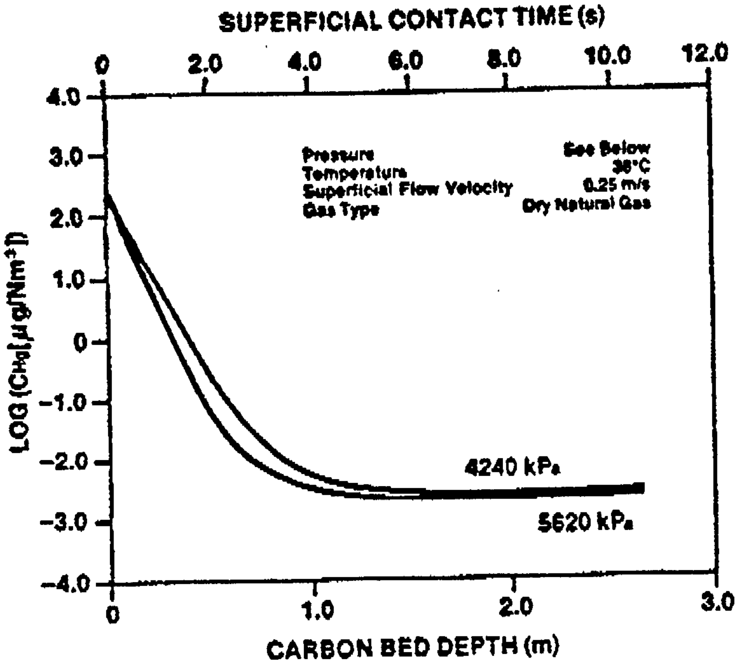


The column outlet concentrations or mercury removal limits in terms of relative pressure converge. This would indicate that an adsorption mechanism is controlling at low mercury concentrations while diffusion and/or chemical reaction rates are more important at higher mercury levels. Note that a removal limit of 0.003 ug/Nm^3 was reached within 1.2 m of bed at 38°C while a removal limit of 0.02 ug/Nm$_3$ was reached within 1.0 m of bed at 71°C. Maximum column utilization in terms of capacity would be achieved at the higher temperature, however, the effluent mercury concentration would be higher.

Pressure

In the design of adsorbers for LNG plants, there has been some concern that carbon pores would be filled by methane and that the pore volume available for mercury adsorption would decrease with increasing operating pressure. Isotherm data indicates that above 2000 kPa where most LNG plants operate, the amount of methane adsorbed is only slightly dependent on pressure. Changes or fluctuations in operating pressure would not be expected to impact mercury removal performance. Figure 4 demonstrates that a change in pressure from 4240 kPa to 5620 kPa at constant temperature (38°C) and flow velocity (0.25 m/s) does not affect either the removal rate or removal limit of 4x10 mesh HGR carbon. In both cases a removal limit of 0.003 ug/Nm^3 was reached within 1.3 m of bed (or 5.0 s contact time).

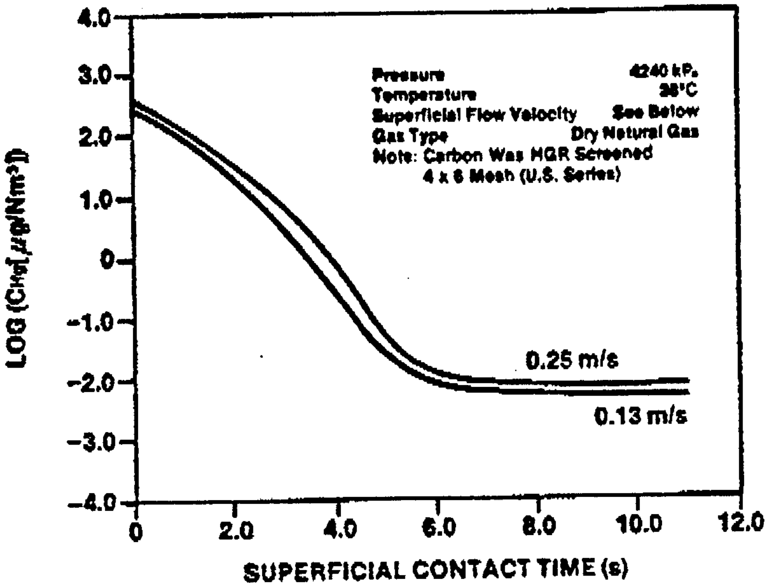
Figure 4
THE IMPACT OF PRESSURE ON THE MERCURY CONCENTRATION PROFILE OF HGR CARBON



Contact Time/Flow Rate

Gas flow rate or superficial velocity impacts on adsorption kinetics. Obviously, the higher the inlet flow to a given adsorber the more gas can be treated in a unit time. To obtain maximum gas throughput one would operate at the highest flow where the MTZ will be contained and pressure drop is not limiting. Pilot data indicates that the MTZ for mercury removal using a 4x6 mesh HGR is directly related to superficial velocity while the removal limit is relatively unchanged. In Figure 5, concentration profiles have been plotted in terms of contact time and bed depth for 4x6 mesh HGR in a dry natural gas stream at 38 °C, 4240 kPa, and two superficial velocities.

Figure 5
IMPACT OF SUPERFICIAL FLOW VELOCITY ON THE MERCURY CONCENTRATION PROFILE OF HGR CARBON



As expected, the MTZ length for the higher velocity is physically about twice the length of that of the lower velocity while the same six second contact time is required to achieve the removal limit. Due to the short transfer zone in relation to adsorber length, the impact on mercury capacity would be slight. With this large mesh size, interparticle or bulk diffusion does not appear to play a primary role in the kinetics. With significantly smaller mesh carbon, one would expect to see an improvement in the kinetics with the result that contact times could be lowered. Pressure drop was related to flow velocity and conformed to values predicted using published correlations for flow through packed beds.

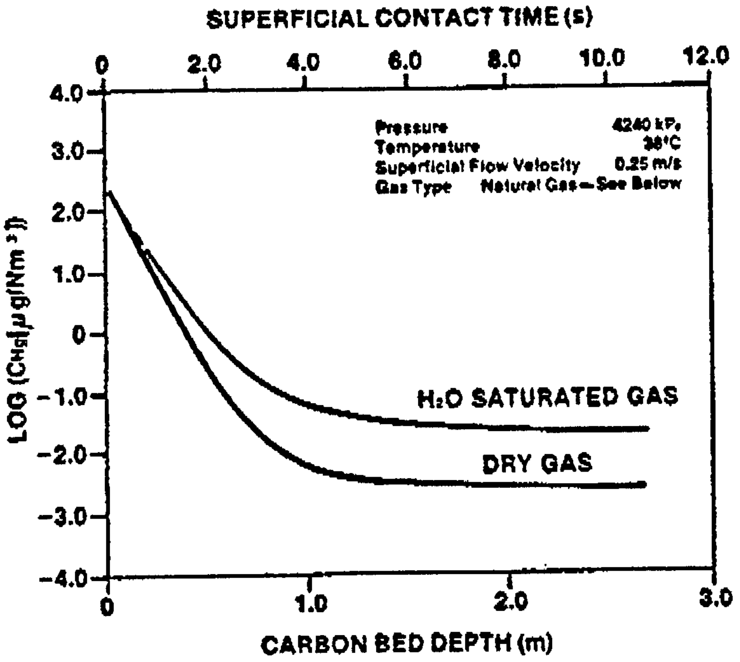
Influent Mercury Concentration

Sulfur impregnated activated carbon has been effective over a very wide range of mercury relative pressures (1 to 10^{-6}). Influent mercury concentration does not affect the removal limit but will impact the MTZ length and bed life. For example, from Figure 3, a factor of ten increase in the mercury vapor influent concentration (from 30 to 300 ug/Nm^3) would require an additional 5-15 cm of bed to contain the MTZ. Since ten (10) times as much mercury enters and is adsorbed on the carbon, the bed life would be reduced. In separate studies, HGR was shown to have a 20 Wt.% capacity for mercury before any movement of the MTZ was observed (equilibrium capacity is > 50 Wt.%). At idealized laboratory conditions, column life would extend for years even at relatively high inlet concentrations. Pilot data also indicates that spikes in mercury concentration to the saturation capacity of the gas are readily contained.

Moisture Level

It is well known that water is adsorbed on activated carbon to varying degrees, depending on the temperature, relative humidity, carbon type, and gas composition. A series of tests were conducted to define the effect of adsorbed moisture on mercury removal performance. It was found that both the removal rate and the removal limit were adversely affected by as little as 3-4 Wt. % on the carbon. Mercury concentration profiles for 4x10 HGR carbon in natural gas at 38°C, 4240 kPa, and a flow velocity of 0.25 m/s are presented in Figure 6.

Figure 6
IMPACT OF MOISTURE ON THE MERCURY CONCENTRATION PROFILE OF HGR CARBON



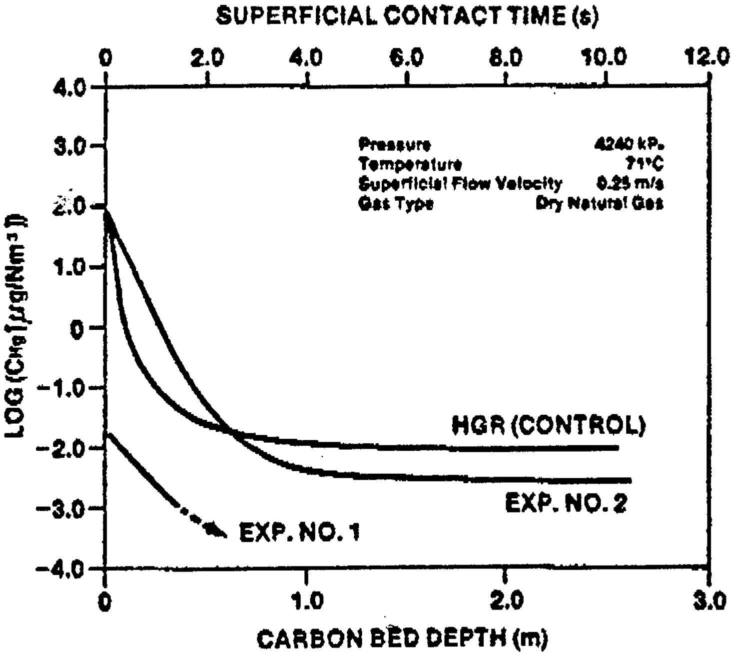
Both saturated and dry conditions were tested. At saturated conditions, the MTZ length was slightly longer: approximately 12% additional bed depth was required to reach the removal limit. In addition, the removal limit increased from 0.003 ug/Nm^3 in dry gas to 0.02 ug/Nm^3 in water-saturated gas. A sample of the test carbon was found to contain approximately 3.0 Wt.% H_2O following the "wet" testing. Apparently, adsorbed water impedes the mercury removal mechanism, either by blocking access pores in the carbon or occupying adsorption sites. The relatively low H_2O saturation capacity of the carbon at these conditions could be a result of competitive adsorption. This effect was observed during other studies to simulate adsorption of heavy hydrocarbons that could be present in natural gas.

Sulfur impregnated carbon was contacted with natural gas that was saturated with both water and hexane. The kinetics and removal limit improved where hexane was present. Hydrocarbons will preferentially adsorb thereby excluding water. These results indicate that strongly adsorbed heavy hydrocarbons (C_{5+}) will exclude H_2O to such a degree that carbon performance actually improves.

Improved Adsorbent

In dry, low temperature natural gas, HGR can easily reduce mercury concentration below the typical performance criterion of 0.01 µg/Nm^3. However, both moisture and higher temperatures decrease removal efficiency. Several experimental carbons were prepared in the laboratory in an effort to improve removal performance at these conditions. Pilot feasibility tests were then conducted to evaluate the mercury removal performance of the two experimental carbons. In both cases, the removal limits of the experimental carbons were superior to an HGR control carbon while the removal rates of the carbons varied. In Figure 7, concentration profiles are present for all three carbons in dry natural gas at 71°C, 4246 kPa, and a flow velocity of 0.25 m/s.

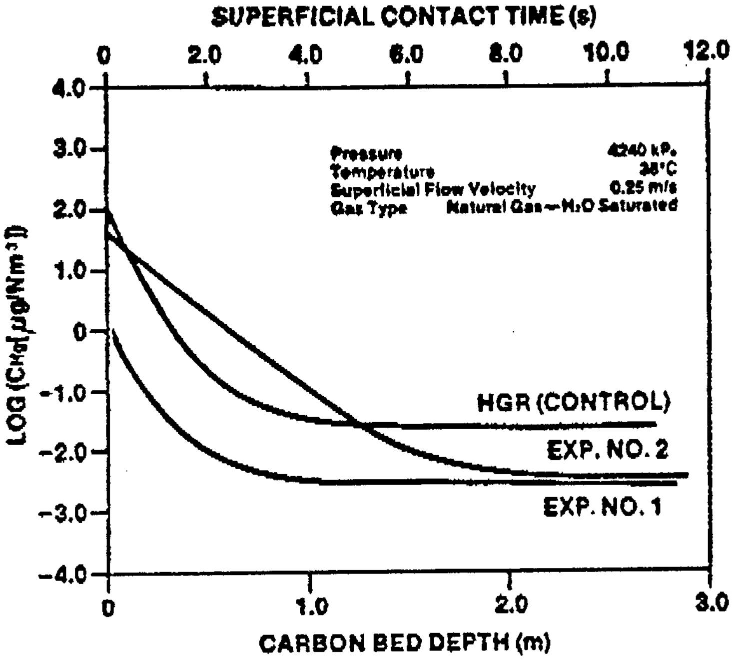
Figure 7
MERCURY CONCENTRATION PROFILES FOR SEVERAL EXPERIMENTAL CARBONS



Note that Experimental carbon #1 was connected in series to the HGR bed effluent stream and was not exposed to a high influent mercury vapor concentration. After approximately 0.4 m of bed, the concentration had been reduced to below detection limits (0.001 µg/Nm^3)

Experimental carbon #2 also showed an improved removal limit (0.003 $\mu g/Nm^3$ vs 0.01 $\mu g/Nm^3$ for HGR) but the MTZ was longer. Profiles for the same carbons in H_2O-saturated gas at 38°C, 4240 kPa, and a flow velocity of 0.25 m/s are presented in Figure 8.

Figure 8
MERCURY CONCENTRATION PROFILES FOR SEVERAL EXPERIMENTAL CARBONS



Again, both experimental carbons had improved removal limits. The removal rate for Experimental carbon #1 was comparable to HGR while Experimental carbon #2 had an inferior rate. These carbons demonstrate improved low concentration removal performance, however, the removal rate (and probably the bed capacity) would not be improved. Note that these carbons are not commercially available but are indicative of the potential to improve the technology.

CONCLUSION

With appropriate adsorber design, sulfur impregnated carbon can tolerate a wide range of process conditions and remove mercury to concentration levels of 0.01 - 0.03 $\mu g/Nm^3$. It has been shown that processing conditions such as lower temperatures and dry gas will permit the existing commercial carbon to attain effluent levels that approach 0.001 $\mu g/Nm_3$. Wellhead natural gas conditions are not ideal and inhibit carbon performance. Gas conditioning or relocation of carbon adsorbers downstream of driers would improve mercury removal but may not be viable alternatives. Another approach is to utilize specialized carbon adsorbents with possible modifications in adsorber configuration. Initial laboratory results are encouraging and indicate that an order of magnitude reduction in mercury levels could typically be obtained.

REFERENCES

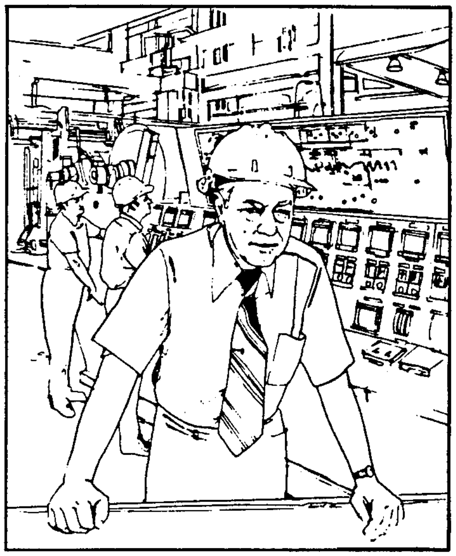
1. Bodle, W.W., Attari, A.,, and Serauskas, R., "Considerations for Mercury in LNG Operations," Pap. - Int. Conf. Liquefied Nat. Gas - 6th Session II, Paper 1, 1-39 (1980).

2. Leeper, J.E., "Mercury Corrosion in Liquefied Natural Gas Plants," Canadian Gas Proc. Assoc. Quart. Meeting (1980) Sept.

3. Jerome Instrument Corporation, P. O. Box 336, Highway 89A, Jerome, Arizona 86331.

Filtration
Technology Inc.

Thin-Mat® Filter Machine



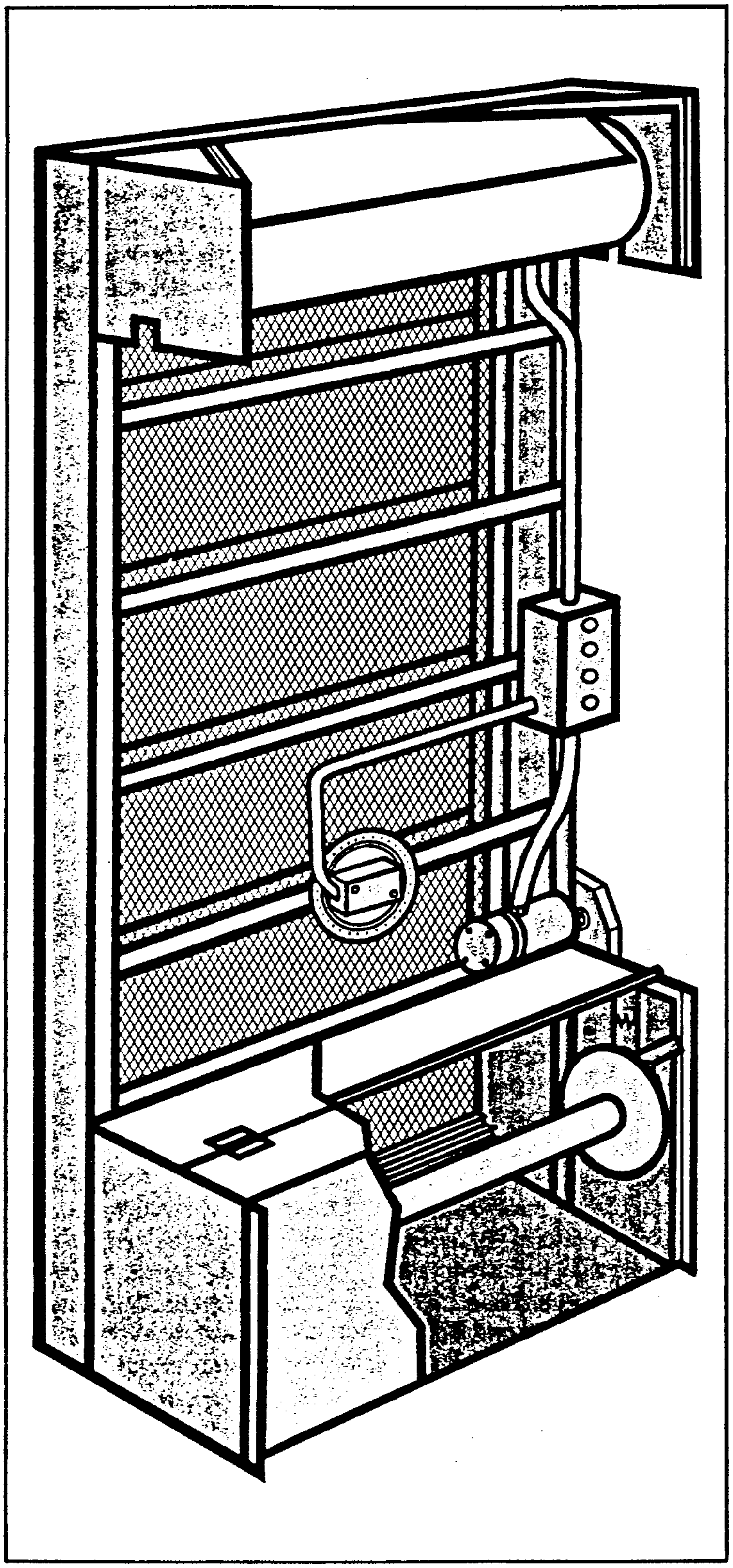
"We have found that
a Healthy environment
is a Productive environment."

Filtration
Technology Inc.

Thin-Mat® is a registered trade mark of
Filtration Technology, Inc.

Filtration
Technology Inc.

Thin-Mat® Filter Machine



End-Use Applications

Due to its unique performance characteristics, the Thin-Mat Filter Machine has been used successfully on the filtration of:

- textile lint and dusts
- oil mist and smoke
- monomer and polymer dusts
- phase changing contaminants
- fine dusts in high concentration
- general ventilation air
- very dirty plant atmospheres
- industrial exhausts for energy conservation
- industrial exhausts for reuse of air
- chicken feathers and animal hair
- paper dust
- tobacco dust
- contaminants too costly for regular filters and too small for dust collectors

End-User Benefits

The Thin-Mat Filter Machine offers:

- better filtration efficiency
- lower initial cost
- lower operating cost
- cleaner air
- longer service life
- high efficiency performance
- high moisture resistance
- easier maintenance/less labor
- equipment space savings
- flexible design for easy adaption to available space
- adjustable speed drive and media indexing control
- manual or automatic drive
- timer and/or pressure switch activated media indexing

Use of the Thin-Mat Filter Machine helps provide its owner:

- better productivity
- lower product reject rate
- cleaner environment
- happier personnel
- better machinery operation
- satisfactory compliance with government criteria

Thin-Mat Dimension and Capacity Chart

44" Standard Unit (special sizes also available)

Width Designator		144	244	344	444	544	644	744	844	944	1044	1144	1244
Width B		3'8"	7'4"	11'0"	14'8"	18'4"	22'0"	25'8"	29'4"	33'0"	36'8"	40'4"	44'0"
Model No.	Height A	CFM Capacities at 500 FPM Net Effective Media Area											
VT60	5'0"	6,625	12,250	19,875	26,500	33,125	39,750	46,375	53,000	59,625	66,250	72,875	79,500
VT65	5'5"	7,250	14,500	21,750	29,000	36,250	43,500	50,750	58,000	65,250	72,500	79,750	87,000
VT70	5'10"	7,875	15,750	23,625	31,500	39,375	47,250	55,125	63,000	70,875	78,750	86,625	94,500
VT75	6'3"	8,500	17,000	25,500	34,000	42,500	51,000	59,500	68,000	76,500	85,000	93,500	102,000
VT80	6'8"	9,125	18,250	27,375	36,500	45,625	54,750	63,875	73,000	82,125	91,250	100,375	109,500
VT85	7'1"	9,750	19,500	29,250	39,000	48,750	58,500	68,250	78,000	87,750	97,500	107,250	117,000
VT90	7'6"	10,375	20,750	31,125	41,500	51,875	62,250	72,625	83,000	93,375	103,750	114,125	124,500
VT95	7'11"	11,000	22,000	33,000	44,000	55,000	66,000	77,000	88,000	99,000	110,000	121,000	132,000
VT100	8'4"	11,625	23,250	34,875	46,500	58,125	69,750	81,375	93,000	104,625	116,250	127,875	139,500
VT105	8'9"	12,250	24,500	36,750	49,000	61,250	73,500	85,750	98,000	110,250	122,500	134,750	147,000
VT110	9'2"	12,875	25,750	38,625	51,500	64,375	77,250	90,125	103,000	115,875	128,750	141,625	154,500
VT115	9'7"	13,500	27,000	40,500	54,000	67,500	81,000	94,500	108,000	121,500	135,000	148.500	162,000
VT120	10'0"	14,125	28,250	42,375	56,500	70,625	84,750	98,875	113,000	127,125	141,250	155,375	169,500
VT125	10'5"	14,750	29,500	44,250	59,000	73,750	88,500	103,250	118,000	132,750	147,500	162,250	177,000
VT130	10'10"	15,375	30,750	46,125	61,500	76,875	92,250	107,625	123,000	138,375	153,750	169,125	184,500
VT135	11'3"	16,000	32,000	48,000	64,000	80,000	96,000	112,000	128,000	144,000	160,000	176,000	192,000
VT140	11'8"	16.625	33,250	49,875	66,500	83,125	99,750	116,375	133,000	149,625	166,250	182,875	199,500
VT145	12'1"	17,250	34,500	51,750	69,000	86,250	103,500	120,750	138,000	155,250	172,500	189,750	207,000
VT150	12'6"	17,875	35,750	53,625	71,500	89,375	107,250	125,125	143,000	160,875	178,750	196,625	214,500
VT155	12'11"	18,500	37,000	55,500	74,000	92,500	111,000	129,500	148,000	166,500	185,000	203,500	222,000
VT160	13'4"	19,125	38,250	57,375	76,500	95,625	114,750	133,875	153,000	172,125	191,250	210,375	229,500
VT165	13'9"	19,750	39,500	59,250	79,000	98,750	118,500	138,250	158,000	177,750	197,500	217,250	237,000
VT170	14'2"	20,375	40,750	61,125	81,500	101,875	122,250	142,625	163,000	183,375	203,750	224,125	244,500
VT175	14'7"	21,000	42,000	63,000	84,000	105,000	126,000	147,000	168,000	189,000	210,000	231,000	252,000
VT180	15'0"	21,625	43,250	64,875	86,500	108,125	129,750	151,375	173,000	194,625	216,250	237,875	259,500
Number of 44" Filter Sections		1	2	3	4	5	6	7	8	9	10	11	12
Number of Drive Sections		1	1	2	2	3	3	4	4	5	5	6	6

Example: Model 544VT120 is a 5-section unit including 3 drive sections, measuring 18'4" wide by 10'0" high. It has a design capacity of 70,625 CFM.

Product Description

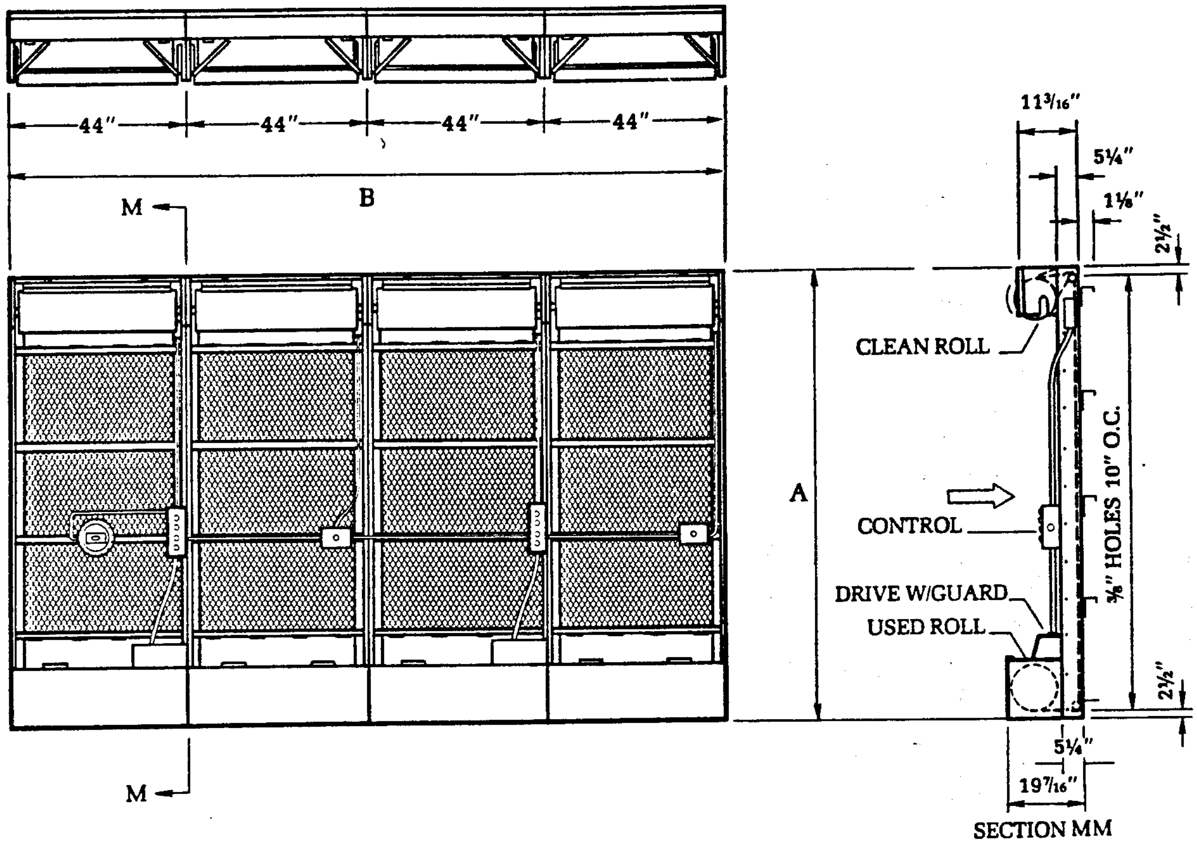
The Thin-Mat Filter Machine is an automatic roll-type unit which uses the inherent strength of a wide choice of specially selected filter media to index this media across an air stream. The filter machine is constructed of U.S.S. 14 gauge galvanized sheet metal. All components are moisture protected.

The unit is designed for use in general ventilation air, in high temperature air (up to 350°F), in high moisture conditions, in high static pressure operation (up to 3" w.g.) and in high velocity conditions (up to 1000 FPM) although 500 FPM is recommended. The unit can also be used as a second-stage filter downstream from dust collectors. It is recommended for applications with dust concentrations too high for regular filters and too light or too fine for dust collectors.

The unit, with its narrow profile in direction of air flow, is factory wired and factory assembled for ease of field installation. The unit can be operated manually or automatically with either pressure control and/or timer control. It can be installed to index media vertically, horizontally, or in any desired plane.

The simplified mechanical drive is by a totally enclosed 1/15 hp gear motor with built-in thermal protection. There is a media run-out automatic cut-off switch on each filter section. The motor and controls can be unit-mounted or remote-mounted as required. The controls contain pressure switch or timer control, media run-out signal, power-on signal, media indexing signal, and if required, high pressure-drop fan cut-off. There is no expensive moving curtain chain required to index the media.

The design versatility of the Thin-Mat Filter Machine allows its use in a wide variety of difficult filtration applications.



Media Choices

The Thin-Mat Filter Machine is normally supplied with a 1000 yard-long roll of .85oz. Cerex® Filter Media. The initial resistance of .85oz. Cerex at 500 FPM face velocity is .4" w.g. The recommended operating pressure is 1.25" - 1.75" w.g. Please see the separate Cerex brochure for detailed performance data.

Other filter media are available for use on specific contaminants. Performance data is available on request.

Case history performance data is also available on specific end-use applications.

Cerex® is a registered trademark of the Monsanto Company.

Suggested Specifications

The filters shall be Thin-Mat Filter Machines as manufactured by Filtration Technology, Inc. of the sizes, capacities and model numbers as listed in plans and/or specifications. All metal parts shall be either galvanized, cadimum plated or aluminum. The units shall be of moisture resistant construction. The sheet metal components shall be U.S.S. 14 gauge. The filter machines shall be factory wired, factory assembled, and factory aligned. The unit shall be (specify pressure switch or timer) controlled and suitable for (specify 115v or 230v) 60HZ, 1 ph electrical service. The unit shall be equipped with a totally enclosed thermally protected motor.

Each assembly shall have a media run-out signal, power-on signal and media indexing signal.

Each section shall have a separate linkage-free direct acting media run-out switch. The drive shall be by heavy duty #40 chain. Each dual section master-slave assembly shall have a common shaft direct drive to individual single piece take-up cores. Each section shall have removable blow-back bars and hinged dirty roll covers.

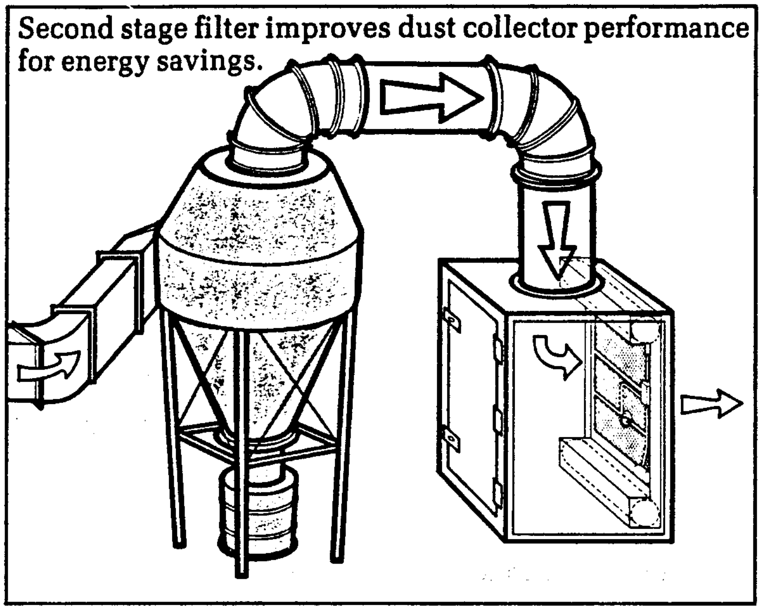
The filter media shall be (specify type) sufficiently strong to index itself thru the airstream and requires no moving curtain support.

Satisfied Users

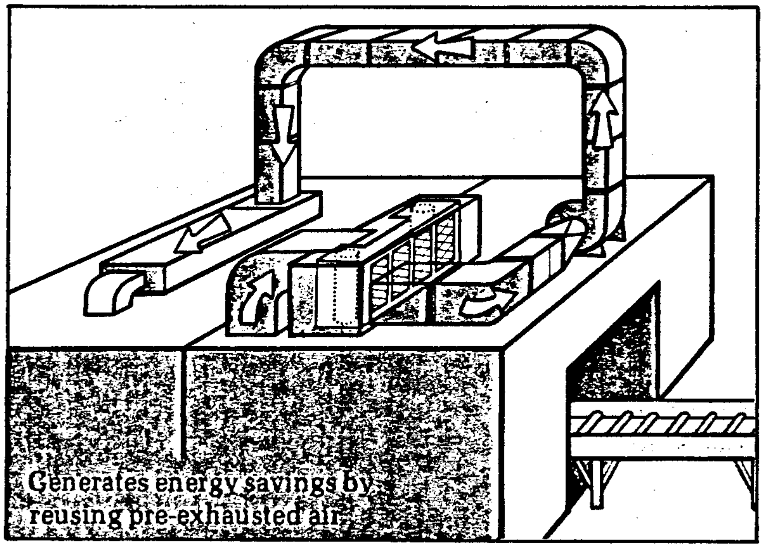
Some of the satisfied users of Thin-Mat Filter Machines are:

Burlington Industries, Inc.
Campbell Soup Company
Coats & Clark, Inc.
Cone Mills Corporation
Duke University Medical Center
Fiber Industries, Inc.
Hanes Corporation
Kendall Company
Levi Strauss & Company
Monsanto Company
Springs Mills, Inc.
E. R. Squibb & Sons, Inc.
J. P. Stevens & Company, Inc.

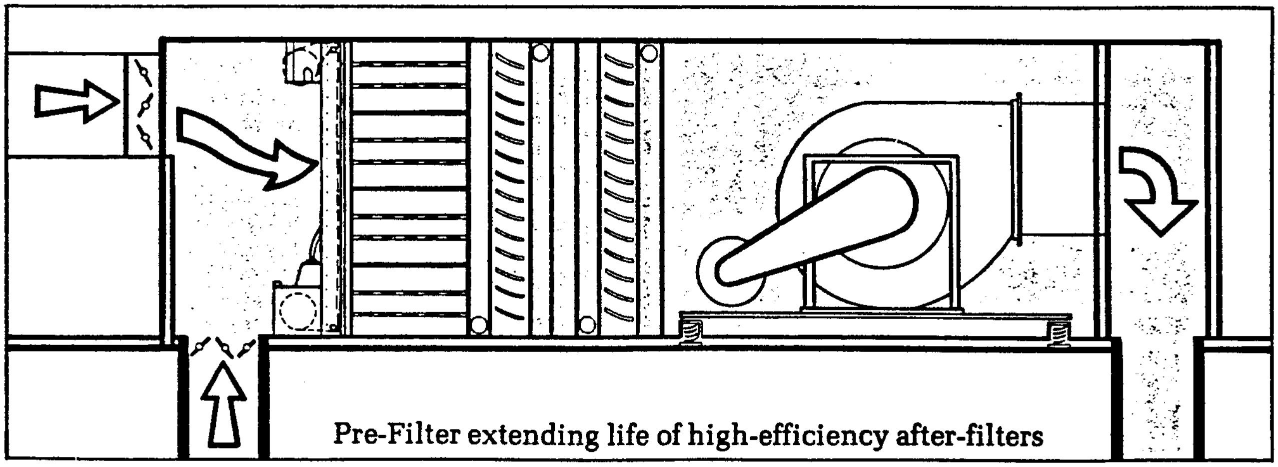
The design flexibility of the Thin-Mat Filter Machine allows for a wide variety of applications.



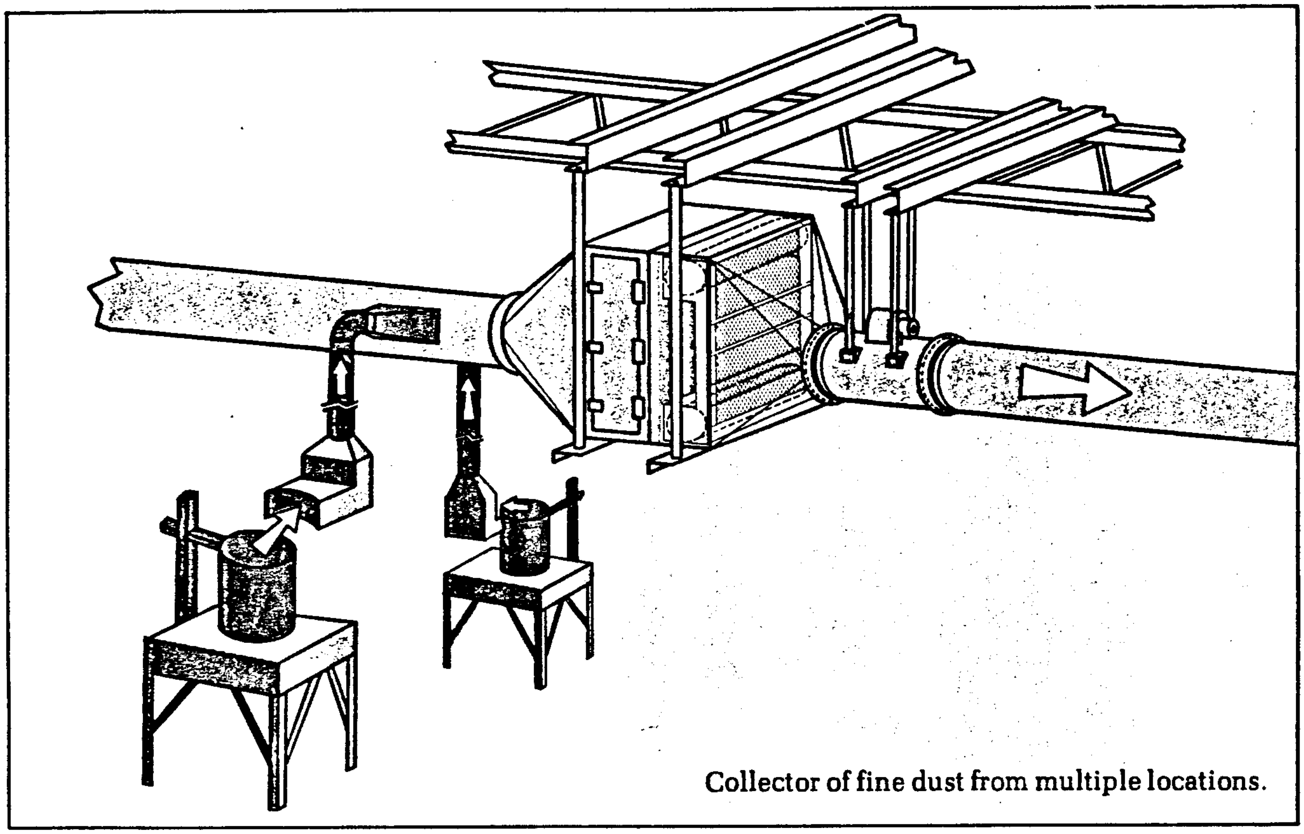
Second stage filter improves dust collector performance for energy savings.



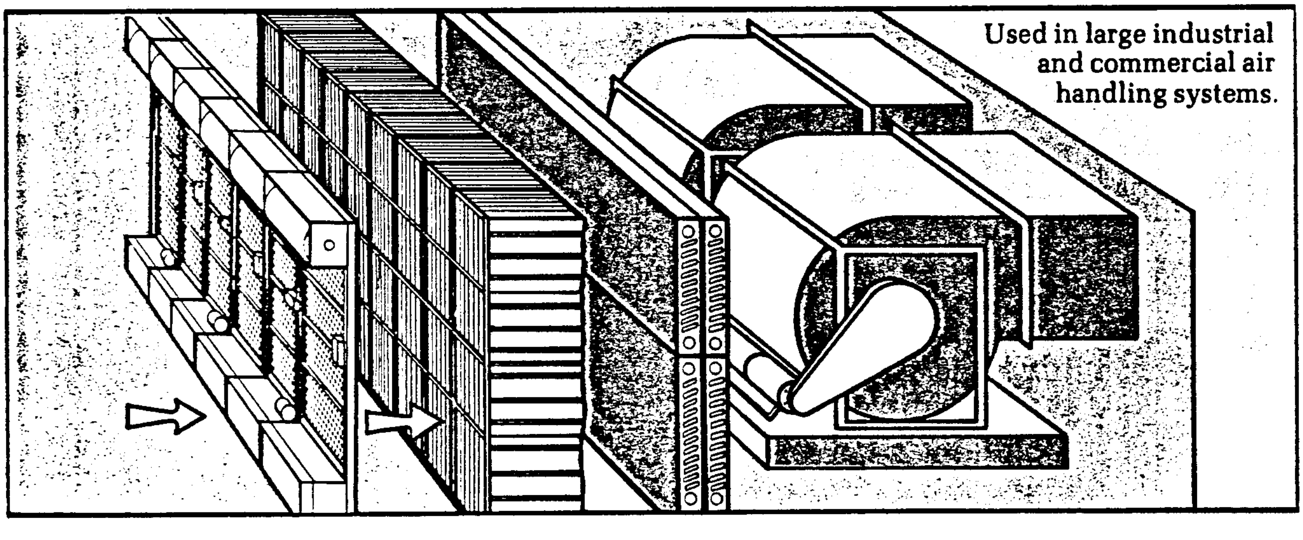
Generates energy savings by reusing pre-exhausted air.



Pre-Filter extending life of high-efficiency after-filters



Collector of fine dust from multiple locations.



Used in large industrial and commercial air handling systems.

Standard Warranty

Filtration Technology, Inc. warrantees its products to perform in accordance with the published data as set forth in its catalogues and bulletins. No warrantees, expressed or implied, other than those set forth herein, shall be binding upon the Corporation, nor shall the Corporation be liable for consequent damage or delays caused by defective material or objectionable performance.

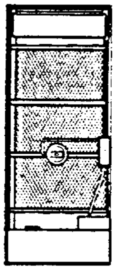
The Corporation guarantees all catalogued products to be free from defects in workmanship and materials for a period of one year from date of shipment. Any parts proving defective will be replaced at our option upon prior approval of authorized Corporation personnel. This guarantee does not apply to products whose useful product life is of necessity less than one year.

Filtration Technology, Inc. reserves the right to change drawings and specifications contained in this catalogue without notice.

Filtration
Technology Inc.

P.O. Box 21442 Columbia, SC 29221
Phone: (803) 772-2231

Thin-Mat®
Filter Machine



"Thin-Mat Filter Machines Solve Problems"

APPENDIX A-3
DESIGN CALCULATIONS

A-3.1 Civil Paving, Grading, Drainage, Fence and Site Planning

A-3.2 Water Supply and Wastewater Disposal

A-3.3 Electrical

A-3.4 In Situ Vitrification (ISV)

APPENDIX A-3.1
CIVIL PAVING, GRADING, DRAINAGE, FENCE AND SITE PLANNING DESIGN CALCULATIONS

Subject M-1 ISV DESIGN (TANK RET. DIKE)

Project No. 89MC114B

By Fy [illegible] Younger

Checked By R.W French

Task No.

File No.

Date 8/19/90

Date 31 AUG 90

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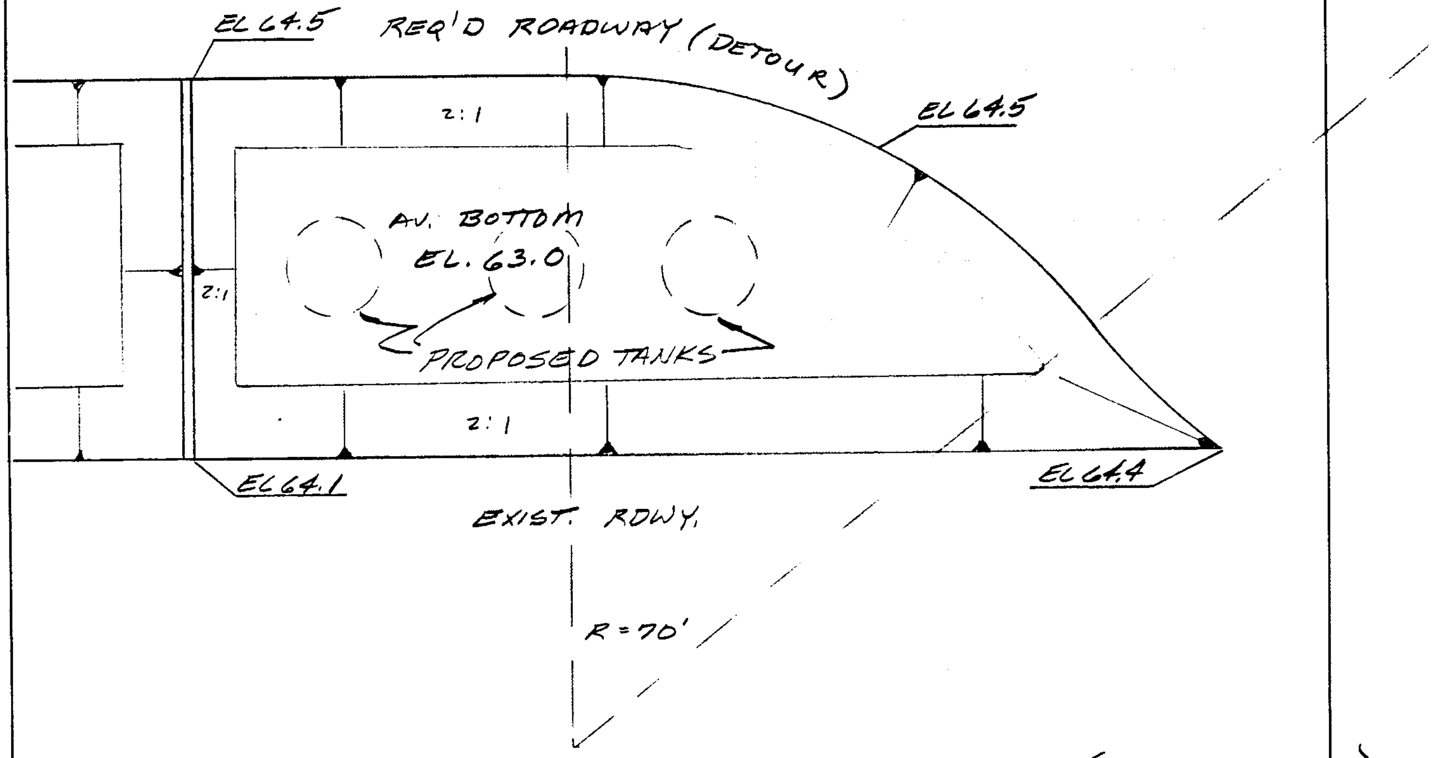

CONTAINMENT AREA: REQ'D 21,000 GAL (3-7000 GAL TKS)

AVERAGE LENGTH 80' (MEASURED @ 1/2 SLOPE)
" WIDTH 35' (" " " ")
" BOTTOM EL 63.0
MIN TOP EL. 64.1

80'L × 35'W × (64.1-63.0) = 3,080 CF × 7.48 GAL/CF =

<u>23,038 GAL CAPACITY</u>
OK 1.09 MIN.

Subject M-1 ISV DESIGN (DETOUR RDWY)

Project No. 89MC114B

Task No.

By

Checked By RLF

File No.

Date 8/19/90

Date 31 AUG 90

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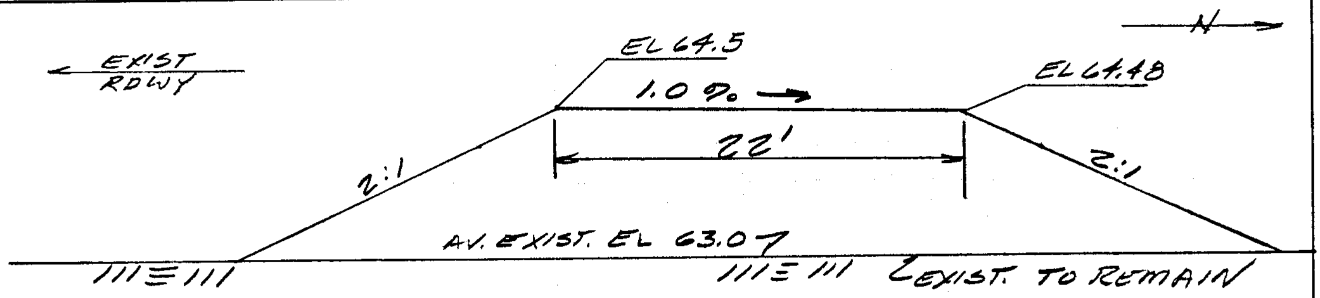


℄ DETOUR LENGTH = 730 LF × 22'W ÷ 9 = 1,784 SY PVMT
6" ASPHALIC CONC.

TOP₁ 64.5
TOP₂ 64.48
2)128.98(64.49 AV TOP EL − 63.0 = 1.49'

1.49' × 2 = (SAY 3') × 2 (EA. SIDE) = 6'

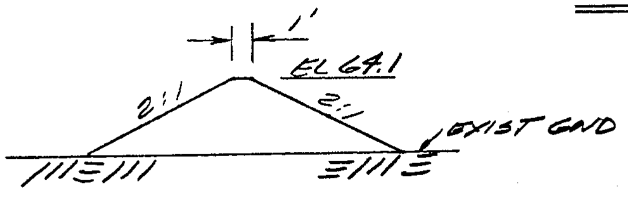
22' TOP WIDTH + 6' SLOPE FALL = 28'

$\frac{\text{28' BOT WIDTH + 22' TOP WIDTH}}{2}$ = 25' AV WIDTH

25' AV W × 1.49' AV H × 730 LF = 27,192.5 CF

÷ 27 = 1007 CU YDS × 1.2 (COMP FACTOR)

1,208 CY EARTHWORK (RDWY)



EXIST. GND EL. 63.5
62.0
64.0
3)189.0(63.0 AV. EL

64.1 − 63.0 = 1.1' × 4 = 4.4 + 1 = 5.4' TOE WIDTH
1.0 TOP "
2)6.4(3.2' AV. WIDTH × 1.1 AV H × 40 L =
140.80 CF ÷ 27 = 5.2 × 1.2 COMP FACTOR
= 6.24 CY EARTHWORK (DIKE)

1,214 C.Y. TOT. EARTHWRK

Subject M-1 ISV DESIGN (EXIST. WELL PROTECTION)

Project No. 89MC114B

By FM

Checked By SLF

Task No.

File No.

Date 8/20/90

Date 31 AUG 90

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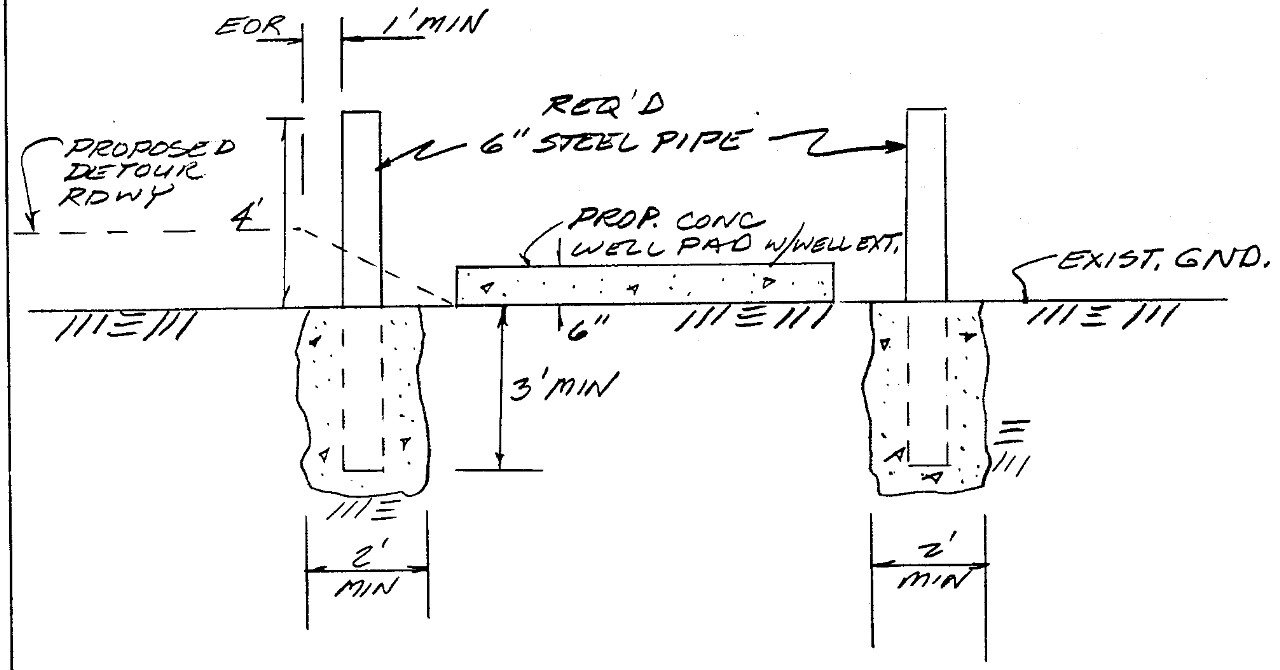

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

Woodward-Clyde Consultants

Subject M-1 DESIGN (SAFETY FENCE)

Project No. 89M2114B

Task No.

By TY

Checked By RLF

File No.

Date 8/19/90

Date 31 AUG 90

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REQ'D CONSTRUCTION FENCE TAKE OFF

2 - 24' DBL SWING CL GATES

60
540
30
45
45
45

765 LF NORTH OF EXIST FENCE

140
585
230

955 LF SOUTH OF EXIST FENCE

REQ'D 1,720 LF FENCE

REMOVE 585 LF FENCE

Subject M-1 ISV DESIGN (DETOUR RDWY. DRAIN)

Project No. 89MC114B

By FY

Checked By RLF

Task No.

File No.

Date 8/20/90

Date 31 AUG 90

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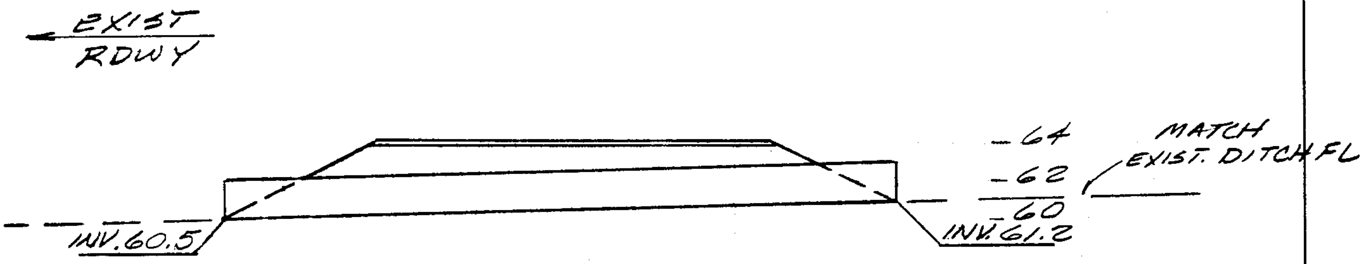

REQ'D 24"x36' RCP @ 1.94%

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

Woodward-Clyde Consultants

Subject

By

Date

Checked By RLF

Date 31 AUG 90

Project No.

Task No.

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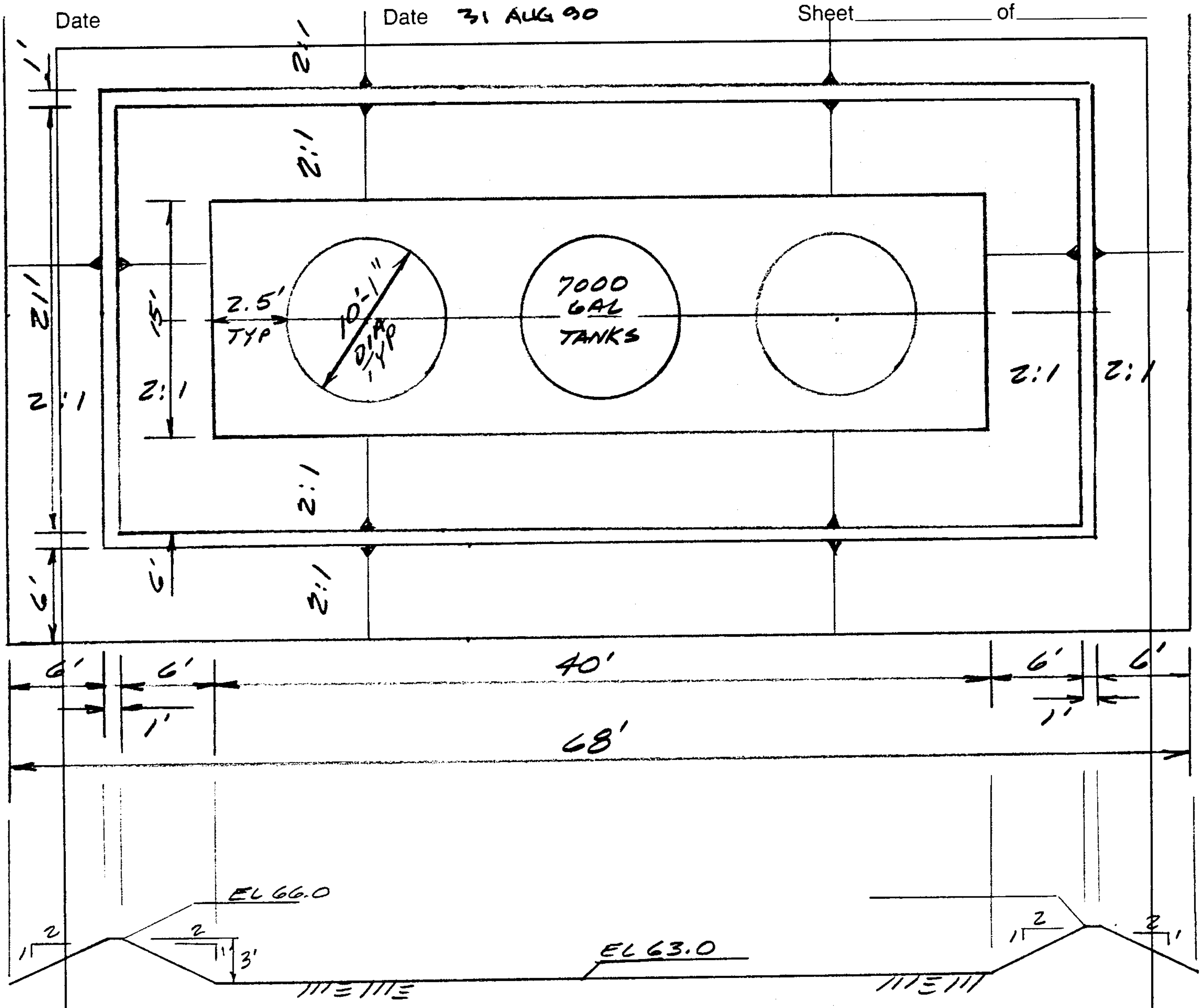


REQ'D CONTAINMENT DIKE FOR 21,000 GAL (3-7000 GAL TKS)
40' x 15' INSIDE TOE + ½ DIKE EL @ 2:1 (3' EA SIDE) x 3' HT.
46' x 21' x 3' x 7.48 GAL/CF = 21,667 gal
1.03 x DESIGN REQ'D

APPENDIX A-3.2
WATER SUPPLY AND WASTEWATER DISPOSAL DESIGN CALCULATIONS

Subject M-1 ISV DESIGN

Project No. 89MC114B

Task No. 302

By RAB

Checked By ESPuch

File No.

Date 8/22/90

Date 8/29/90

Sheet 1 of 2

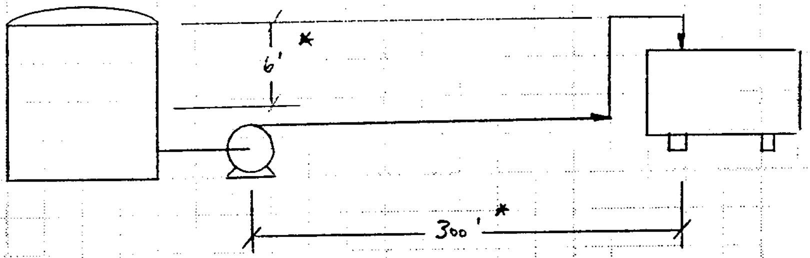
PRELIMINARY SIZING OF MAKE-UP WATER TRANSFER PUMP:

DESIGN BASIS:

ASSUME THE NEED TO TRANSFER 1000 GAL PER 30 MIN

THEREFORE, $Q = \frac{1000 \text{ GAL}}{30 \text{ MIN}} = 33 \text{ GPM}$

SET Q = 35 GPM



* ASSUMED DIMENSIONS

SET A PIPE DIAMETER OF 2"

ASSUME C = 140 FOR PVC PIPE

∴ HAZEN-WILLIAMS SHOWS ΔP_{LOSS} OF 27.5 FT H_2O/1000FT

FOR OUR 300 FT $\Delta P_{LOSS} = 27.5 \times 0.3 = 8.25$ FT H_2O ✓

ASSUME ADD'L 8 FT FOR MISC. LOSSES DUE TO VALVES, FITTINGS, ETC.

∴ TDH = 6' + 8' + 8.25' = 22.25' SAY 24'

CONVERT TO PSI: 24 × 0.432 = 10.4 PSI ✓

$\text{HORSEPOWER} = \frac{\text{GPM}\,(\Delta P)}{1715\,(\epsilon)}$, SET $\epsilon = 0.65$

$= 35(10.4) / 1715(0.65) = 0.33$

SAY HP = 0.5 HP MOTOR

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

Subject M-1 ISV DESIGN

Project No. 89 MC 114B

Task No. 302

By TLAB

Checked By ESP

File No.

Date 8/22/90

Date 8/29/90.

Sheet 2 of 2

∴ ASSUME A 0.5 HP MOTOR 120V, 1ϕ TEFC MOTOR WITH MANUAL ON/OFF CONTROLS IS REQUIRED

PRELIMINARY SIZING OF SPENT SCRUB SOLUTION TRANSFER PUMP:

ASSUME 35 GPM @ 10 psig DISCHARGE PRESSURE

THEN, THE SAME SIZE PUMP SHOULD BE SUFFICIENT.

CONVEYANCE PIPING:

ASSUME APPROXIMATELY 300' OF 2" SCHD 80 PVC FOR EACH CONVEYANCE LINE.

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

APPENDIX A-3.3
ELECTRICAL DESIGN CALCULATIONS

In Situ Vitrification: Project # 89MP114B Task 302
E. Pitchkolan

IN SITU VITRIFICATION
PRELIMINARY ELECTRICAL DESIGN

The attached estimate and calculations have been based on a review of drawings supplied by Geosafe and the Rocky Mountain Arsenal:

Geosafe: System Electrical One Line Diagram # G-1-2841

RMA: General Electrical Map, Area 5 #18-02-01, Sh. 44 of 71

Review of the above drawings show that the required 13.8KV power distribution lines are close enough to the ISV site that no distribution cable routing will be required. The necessary service will be taken directly off of the line to a fused disconnect and routed according to the Geosafe One Line Diagram. The equipment requirements are listed in the estimate.

Subject ISV Power Supply

By E. Pitchkolan

Checked By J. MARTIN

Date 8/20/90

Date 8/20/90

Project No. 89MP114B

Task No. 302

File No.

Sheet 1 of 1

Power Requirements

4.25 MW @ 13.8 KV

From Rocky Mtn. Arsenal Drawing No 18-02-01 Sheet 44 of 71 "General Electrical Map".

There is a size 1/0. 13.8KV Distribution line at the site.

$$\frac{4.25\ MW}{(13.8\ kV)\sqrt{3}} = 177.81 \text{ Amps required}$$

Using Table 310-69 of the 1990 National Electric Code "Ampacities for single copper Conductor in Air" a 1/0 Cable rated for 13.8kW has an ampacity of 260 Amps.

The existing distribution cable has a total capacity of 6.21 MW.

Based on this preliminary review there is sufficient capacity to power the ISV installation. The final design will ensure that existing equipment capacities will not be exceeded.

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

DATE 8-10-90

PROJECT NO. 89MP119B

PAGE NO. 1 OF 1 BY

		MTL	LABOR
A	POLE, WOOD, 40' W/ CROSSARMS & HDW	2915	1915
LF	WIRE, ACRS 15KV, #2/0	9372	1238
LF	WIRE, 15KV, #2/0	2268	310
LF	CONDUIT, 1" PVC	605	1087
LF	" 1" RGS	87	122
EA	LTG FIX, 1000W, FLOOD	4788	677
LF	2/C #10, 600V	2789	1134
LF	#2/0 S.D.B.C. WIRE	64	37
EA	GROUND ROD 3/4" Ø x 10'-0" LG	46	148
EA	CADWELD CONN, 2/0 TO 2/0	24	162
LF	WIRE, ACRS #2	218	101
LF	WIRE, #2, 600V	68	32
EA	DISC. SW, FUSIBLE 15KV, 600A, 3P, WITH 200A FUSES & LIGHTNING ARRESTOR	16,500	620
	TOTAL	39,499	7,763

TOTAL MTL & LABOR 47,207

APPENDIX A-3.4
IN SITU VITRIFICATION (ISV) DESIGN CALCULATIONS

RMA - M1 Pond Site

Zimmerman
7/31/90

M1 Basin Depth

Checked By
8/2/90

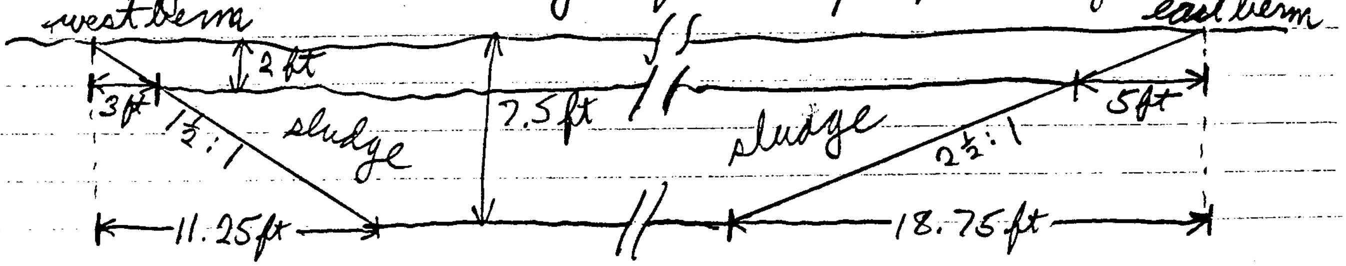
from drwg 7164-2031 dated 1/8/43

west basins 11.25 ft / 1.5 = 7.5 ft deep
east basin 18.75 ft / 2.5 = 7.5 ft deep

plan elev : 5264.3
5256.8
7.5 ft deep

∴ M1 ponds were 7.5 ft deep

Assume current grade level at site is at the top of the berms of the basins. Assume sludge is nominally 2 ft deep from grade.



Sludge encompasses 5.5 ft of depth (if 2 ft deep to top of sludge).

West side : 5.5 ft (1.5) = 11.25 ft
8.25 ft
3.0 ft from west berm edge to sludge

East side : 5.5 ft (2.5) = 18.75 ft
13.75 ft
5.0 ft from east berm edge to sludge

CHK'D - RB 8/2/90

RMA - M1 Pond Site

Timmerman
7/31/90

Initial agreement with the Army was to vitrify to sludge edge, plus 1 ft of buffer zone. Therefore, on the two west basins, the vitrification zone can be moved inward 2 ft on all external sides forming a western vitrification region of 200 × 111 ft. The east basin vitrification region can be moved inward 4 ft on all external sides to form an eastern vitrification region of 99.5 × 107 ft. These two regions are illustrated in the M1 Pond ISV Site figure.

The figure also illustrates two vitrification and hood settings along the north edge of the site where the steam line and fence are located. The hood requires ~20 ft distance from the edge of the vitrification zone to the edge of the hood. The settings show in the figure identify that both the steam line and fence need to be moved to accomodate the hood. All other vitrification edge boundaries appear to have enough access room for the hood, after the tanks and associated piping is moved.

ISV Settings / Arrangement

The computer modeling run attached provides an ISV melt simulation to the projected required depth of 10 ft (3.05 m) including 1 ft of clean cover soil, 8 ft of contaminated sludge material, and 1 ft of lesser contaminated soil beneath the basins. This provides the individual setting information indicated. The melt width of 24.7 ft (7.53 m) will provide the expected number of settings for this site.

3 of

Zimmerman
7/31/90

CHK'D RB
8/2/90

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

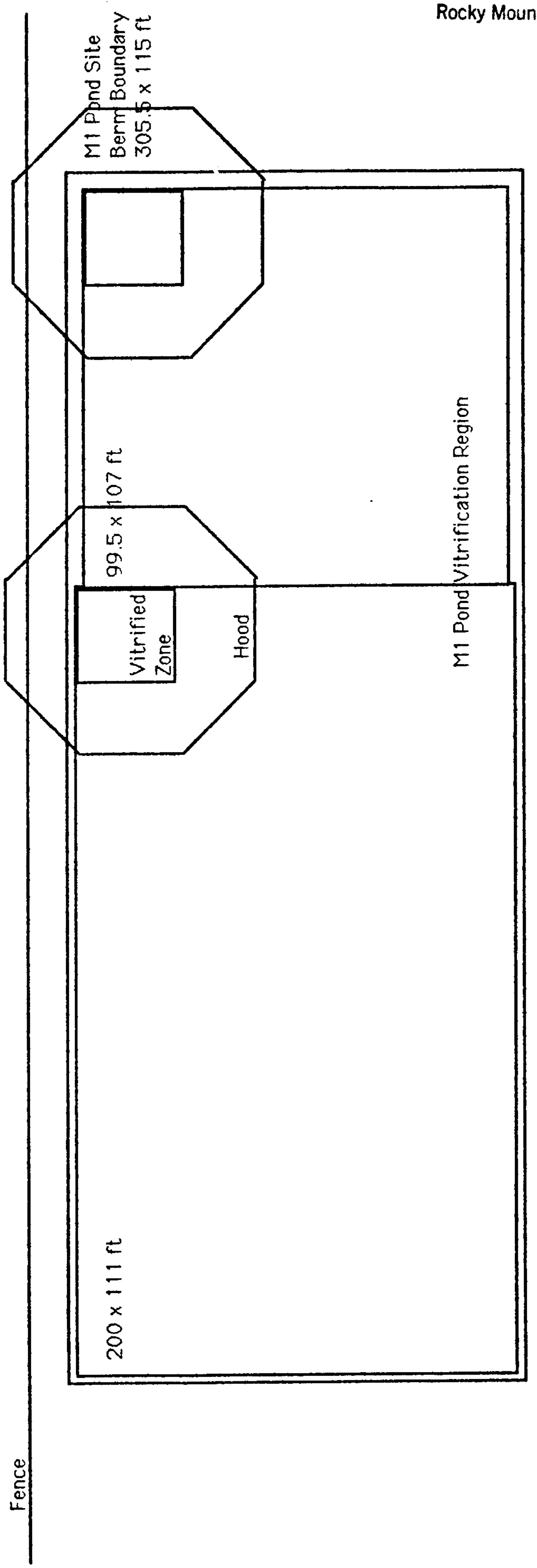


Figure M1 Pond ISV Site

4 of
Timmerman
7/31/90

Chkd. ZB
8/2/90

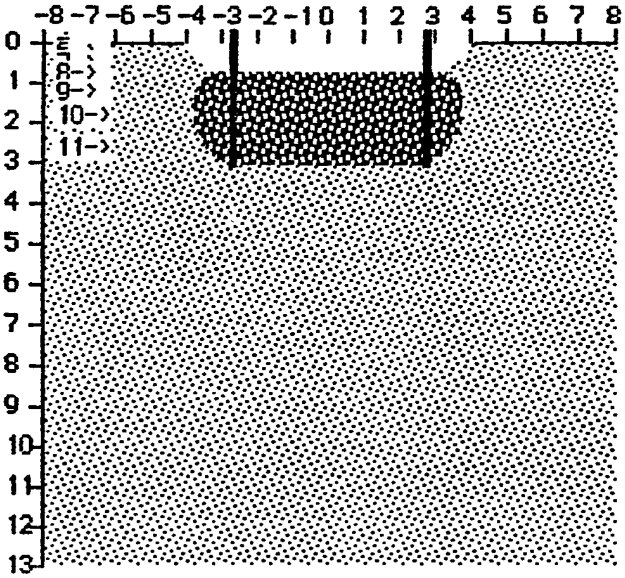
```
******* STATUS *******

Run Time (h)      =  69.4

Melt Depth (m)    =  3.05
Melt Width (m)    =  7.53
Volume (m^3)      =  152.18
Mass (metric ton)=  243.50

Voltage           =  727.6
Amps/Phase        =  2354.5
Power             =  3426.2
Heat Loss (kW)    =  1306.1

Ave Power (kW)    =  3426.2
Energy (MWh)      =  237.78
E/Mass (kWh/kg)   =  0.98
Glass Depth (m)   =  2.318
```



In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colora

```
Press mouse button to abort.

Simulation terminated.
Melt has reached bottom of electrodes.
```

```
** Electrical Parameters **
Power Supply Rating (KW)     =   3750.00
Max. Supply Voltage (V)      =   4160.00
Max. Melt Depth (m)          =   3.05
Electrode Spacing (m)        =   5.50
Number of Voltage Taps       =   16
Ratio Between Taps           =   0.840
Electrode Diameter (m)       =   0.3050
Tap Change Power Loss (%)    =   0.900

** Molten Glass Parameters **
Heat Flux Thru Surface (KW/m) =   32.0
Heat Flux Thru Soil (KW/m)    =   3.20
Average Temperature (Deg C)   =   2000.00
Electrical Resistance (Ohm-m) =   1.20
Glass Heat Cap. (Cal/g-Deg C) =   0.240
Molten Glass Density (g/cc)   =   2.20

** Soil Parameters **
Soil Moisture (%)    =  25.00
Soil Density (g/cc)  =  1.60
Slough Angle (Deg)   =  45.0
```

Note: Run Time is understated due to gradual startup of process during actual field operations.

5 of

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

CHKD - RB 8/2/90

RMA - M1 Pond Site

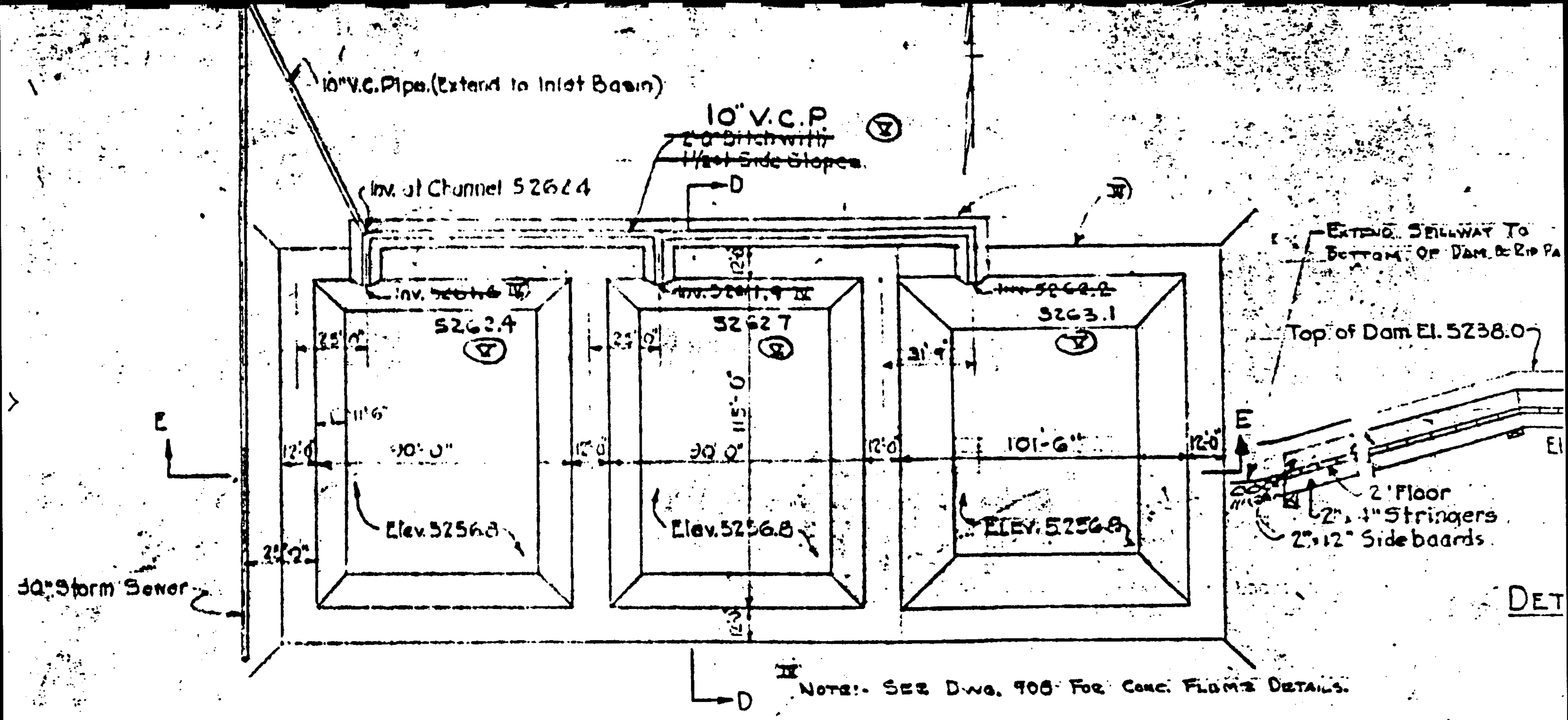
Zimmerman
7/31/90

The ~25 ft melt width coupled with a 10% overlap of adjacent melts, identifies that an ISV setting array of 5 X 14 or 70 settings at a 5.5m (18 ft) electrode separation is required.

We believe the trailers can be positioned and operated along the western boundary of the site, as discussed. Therefore, an electrical line access point of 4.25 MW capacity with 13.8 or 12.47 KV service needs to be provided.

IN ORDER TO REDUCE THE COSTS ASSOCIATED WITH THE 12 INCH OFF-GAS COLLECTION LINE & THE 64 POWER CABLES BETWEEN THE TRANSFORMER AND THE HOOD, THE TRAILERS WILL BE POSITIONED ON DECEMBER 7th AVE & MOVED FROM EAST TO WEST.

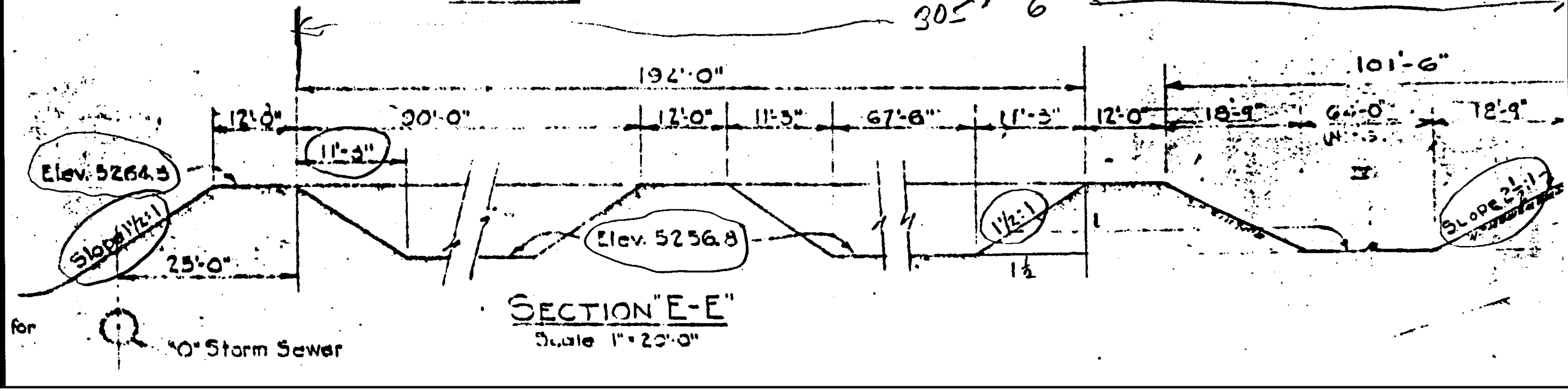
R. BEYAK
8/30/90



Note:- See Dwg. 908 For Conc. Flume Details.

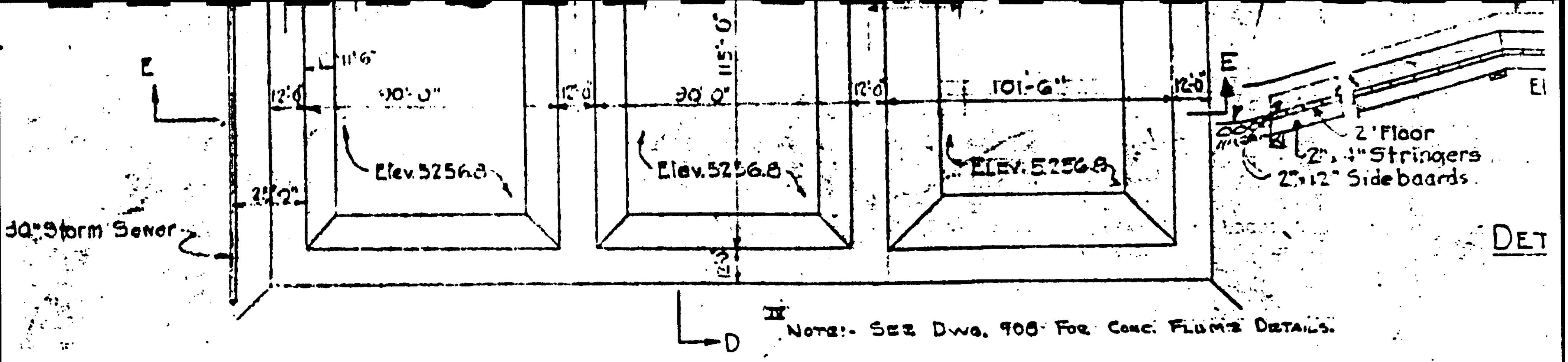
PLAN- M-1 SETTLING BASIN

Scale 1"=50'



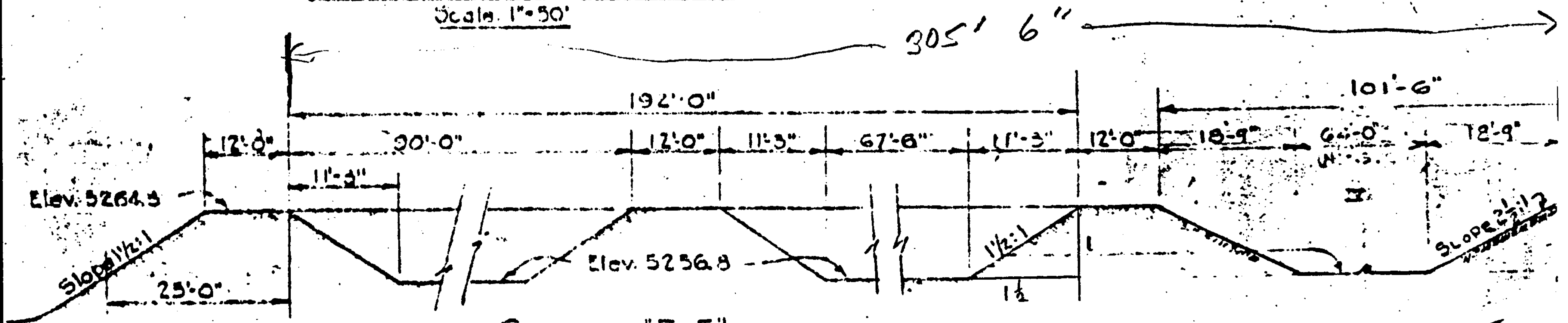
SECTION "E-E"

Scale 1"=20'-0"



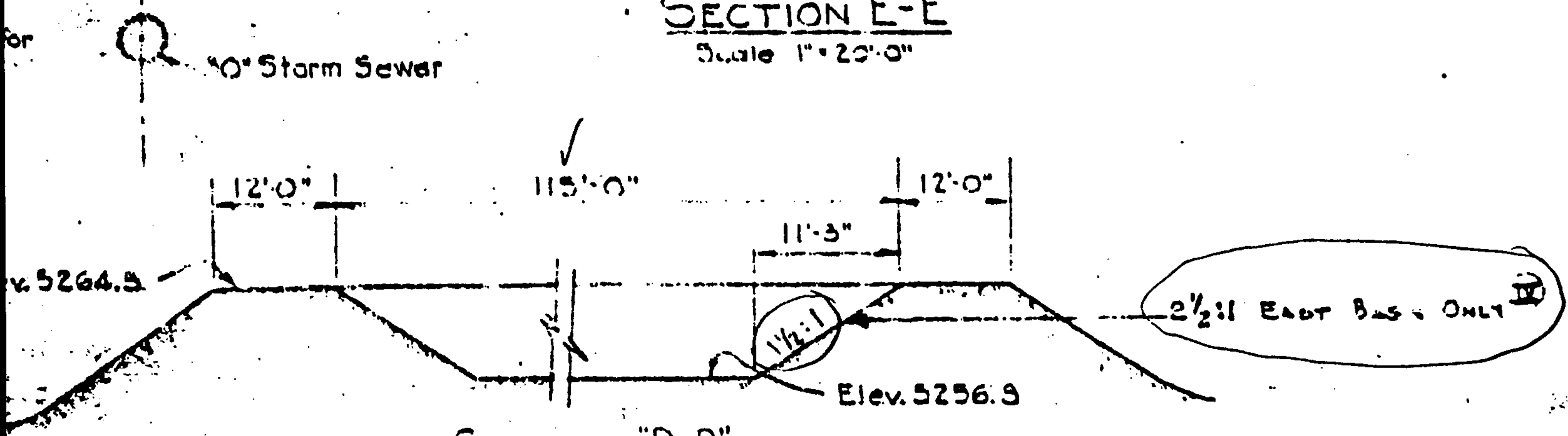
PLAN- M-1 SETTLING BASIN

Scale 1"=50'



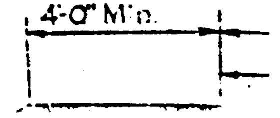
SECTION "E-E"

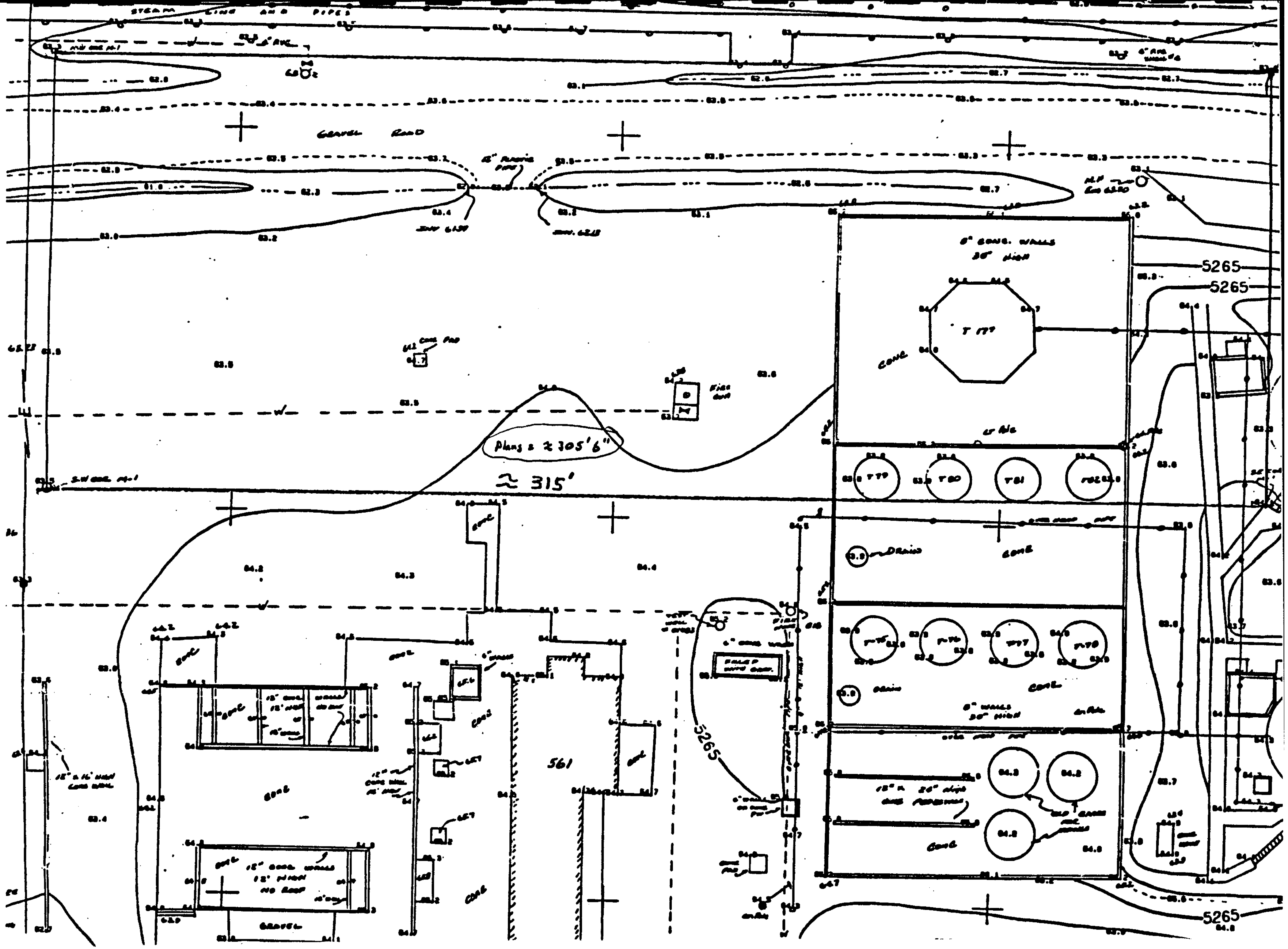
Scale 1"=20'-0"

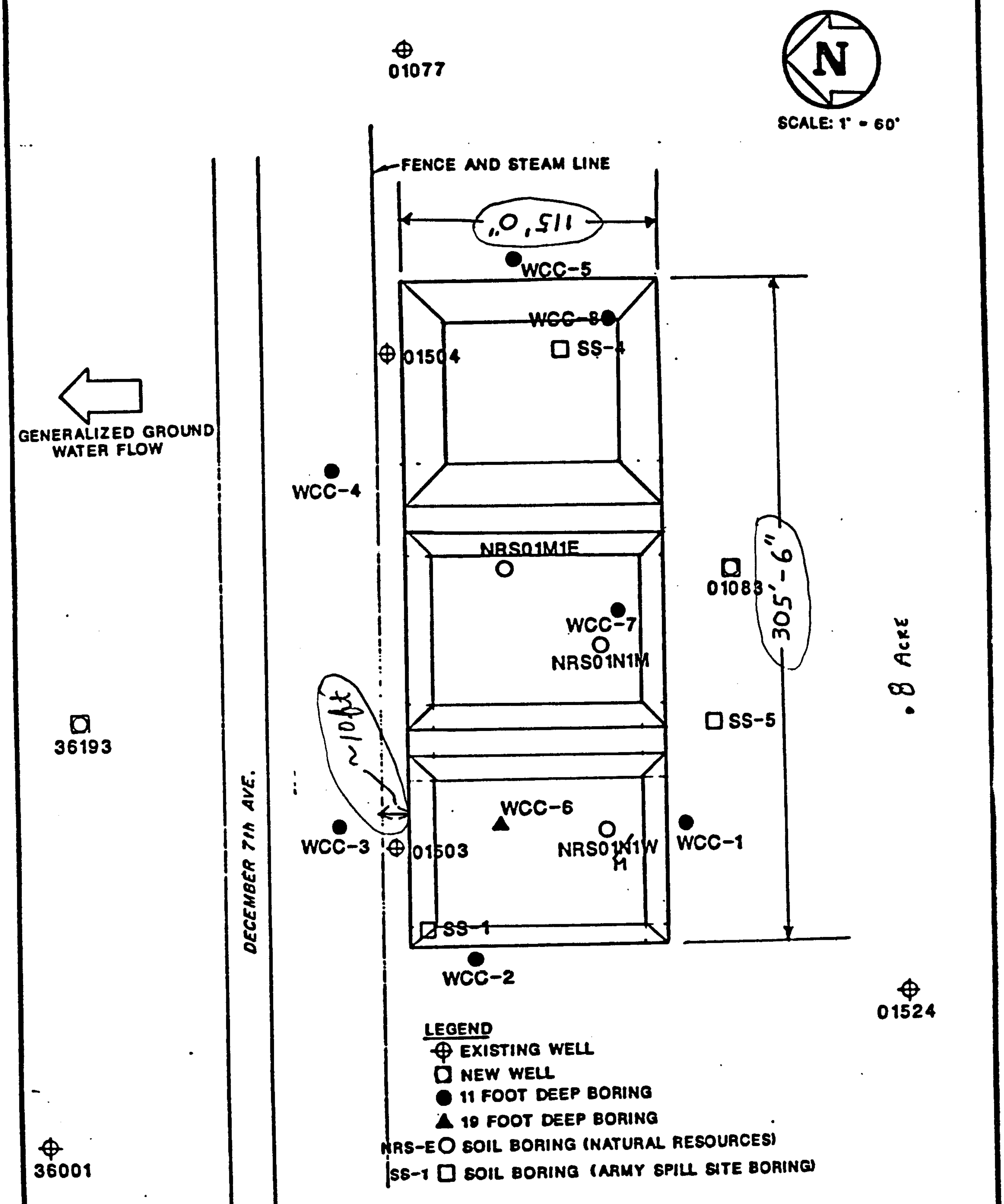


SECTION "D-D"

Scale 1"=20'0"




STEAM LINE AND PIPES
GRAVEL ROAD
18" PLASTIC PIPE
8" CONC. WALLS 30" HIGH
T 177
CONC
5265
5265
5265
5265
Plans ≈ 305'6"
≈ 315'
FIRE
DRAIN
DRAIN
CONC
8" WALLS 30" HIGH
CONC
561
CONC
12" CONC. WALLS 12' HIGH NO ROOF
GRAVEL
CONC
CONC



Job No. : 22238

Prepared by: R.L.C.

Date: 10/19/89

Figure 2-1 M-1 SETTLING BASINS FIELD INVESTIGATIONS

RMA - ISV projected releases

Timmerman
8/13/90

CHECKED BY RICHARD BOFAK
8/14/90

Hg & As releases

RMA sludge conc.

Hg 5,360 mg/Kg (ppm)
As 43,875 mg/Kg

Use sludge density of 1.0 g/cc = 1000 kg/m³

sludge volume per ISV setting = 25 × 25 × 6 ft
= 3750 ft³

mass sludge per setting = (1000 kg/m³)(3750 ft³)(0.02832 m³/ft³)
= 106,200 Kg

Hg = (5.36 g/kg)(106,200 kg) = 569 kg Hg

As = (43.875 g/kg)(106,200 kg) = 4,660 kg As

Component	RF or DF	
	Hg	As
ISV melt	0	80%
scrubber	90%	90%
filter -1	99.9%	99.9%
filter -2	99.9%	99.9%

off-gas flow = 50 m³/min   Run Time/Setting = 70 hr

$$\text{Hg stack release conc} = \left[(569\ \text{kg})(.1)(.001)^2\right] / \left[\left(50\ \tfrac{\text{m}^3}{\text{min}}\right)(70\ \text{hr})\left(\tfrac{60\ \text{min}}{\text{hr}}\right)\right.$$

$$= 2.7E\text{-}4\ \text{mg/m}^3 = 0.27\ \mu\text{g/m}^3$$

Hg - PEL = 0.1 mg/m³   OK by factor 370X

CHKD BY 8/14/90 RB

RMA - ISV projected release (cont)

Timmerman
8/13/90

As stack release conc = $[(4{,}660\,kg)(.2)(.1)(.001)^2] / [(50\,\frac{m^3}{min})(70\,hr)(\frac{60}{hr}$

$= 4.4E-4\ mg/m^3 = 0.44\,\mu g/m^3$

As - PEL $= 10\,\mu g/m^3$ OK by factor of 22.

Organic Releases

RMA org conc.

	soil	sludge	ISV melt DE
dieldrin	890 ppb	4.7 ppb	98.3%
aldrin	113 ppb	non-detect	96.3%

cont soil volume per ISV setting $= 25 \times 25 \times 2$ ft
$= 1250\,ft^3$

cont soil mass $= (1500\,kg/m^3)(1250\,ft^3)(0.02832\,\frac{m^3}{ft^3})$
$= 53{,}100\,kg$

dieldrin $= (890\,ppb)(53{,}100\,kg) + (4.7\,ppb)(106{,}200\,kg)$
$= 47.3\,g + 0.5\,g$
$= 47.8\,g$ per ISV setting

dieldrin ISV melt release conc $= (47.8\,g)(\overset{DE}{.017}) / [(50\,\frac{m^3}{min})(70\,hr)(\frac{60\,min}{hr})]$
$= 0.004\ mg/m^3$

dieldrin - PEL $= 0.25\ mg/m^3$ OK by factor of 64,

∴ ISV melt release concentrations of deildrin are acceptable *exclusive* of an off-gas treatment system, which provides an added 99.9% removal efficiency.

3 of 3

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

CHKD BY RB 8/14/90

RMA - ISV projected releases (cont)

Timmerman
8/13/90

aldrin = (113 ppb)(53,100 kg) + (ND = 0)(106,200 kg)
= 6 g per ISV setting

RB

aldrin ISV melt release conc = $(6g)(\overset{DE}{.0\underset{3}{2}7}) / \left[(50 \frac{m^3}{min})(70 hr)(\frac{60 min}{hr})\right]$
= $0.\underset{2\ ok}{\underline{00}}1\ mg/m^3$

aldrin PEL = $0.25\ mg/m^3$ OK by factor of 32

∴ ISV melt release concentrations of aldrin are acceptable *exclusive* of an off-gas treatment system, which provides an added 99.9% removal efficiency.

Carbon Adsorber Loading

assume 1 bank of 3 carbon adsorber units being used at RM.

mass of activated carbon = 85 lb/unit × 3 units
= 255 lb = 115,770 g

assume organic loading of 10% (conservative) = 11,577 g of organi

RMA org release per ISV setting = 47.8 g (.017) + 6 g (.027)
= 0.813 g + 0.162
= 0.975 g

settings to load adsorber = 11,577 g / 0.975 g
= 11,874 ISV settings

∴ a single bank of activated carbon adsorbers will conservatively last through all 70 ISV settings at the M1 pond site. In addition, the activated carbon will be a sulfur impregnated carbon to capture any residual mercury in the gas stream.

In Situ Vitrification
M-1 Settling Basins
Rocky Mountain Arsenal, Colorado

CHKD. BY Richard Beyer
8/14/90

Timmerman
8/13/90

RMA - ISU Heat Loading

The attached spreadsheet calculates the off-gas hood temperature based on heat release from the melt and any combustibles. The spreadsheet uses the basic energy balance equation:

Off-gas system heat loading = heat of combustion + heat loss from ISV melt − (convective and radiative heat loss from hood)

The specific case performed for the RMA M1 sludge ponds assumes a melt surface area of 18 X 18 ft and allows for a 1% organic loading at a heat combustion rate of 20,000 Btu/lb. These values identify a hood plenum temperature of ~ 350°C and an off-gas system heat loading of 1.2 MBtu/hr as a "worse case" for this site. The off-gas system has a 1.3 MBtu/hr heat removal capacity and therefore can accomodate these conditions.

RMA - ISV Water Balance

As long as the heat loading to the off-gas system is within the operating capabilities of the glycol cooler (1.3 MBtu/hr), as is the case for this site, the off-gas system can be controlled to neither accumulate nor lose water in the scrub solution tanks. Therefore, no water makeup or removal is anticipated during ISV operations. However, water storage and addition capabilities are required between ISV settings.

2 of 2
Timmerman

In Situ Vitrification
M-1 Settling Basins
Off Gas Hood Temp 8/13/90 Rocky Mountain Arsenal, Colorado

CHKD By RB
8/14/90

	A	B	C	D
1		LARGE SCALE		
2				
3	Heat of combustion (kcal/min)	H	6720	1% org
4	Heat loss from ISV melt (kcal/min)	ISV	13932	
5				
6	Hood surface area (ft^2)	Area	2088	Geosafe Hood
7	Off-gas flow (std m^3/min)	Vair	50	
8	Specific heat of air (kcal/kg mole °C)	Cp	7.34	
9				
10	Off-gas temperature (°C)	Tog	351.7	
11	Hood temperature (°C) (°F)	Thc	301.7	575.06
12	Ambient temperature (°C) (°F)	Tac	40	104
13				
14	Heat transfer coefficient (Btu/hr °F ft^2)	hc	1.478	
15	Convective heat transfer (kcal/min)	Qc	6105.8	
16				
17	Stefan Boltzmann constant (Btu/hr ft^2 °R^4)	∂	1.71E-09	
18	Emissivity	E	0.6	
19	Radiative heat transfer(kcal/min)	Qr	9439.0	
20				
21	ΔT off gas to ambient (°C)	meas	311.7	
22	Calculated ΔT off gas to ambient (°C)	calc	311.7	
23				
24	Heat Loading to the Off-Gas Treatment System (kcal/min) (Btu/hr)	Qog	5107.2	1215998
25				
26	Equations and Assumptions:			
27	1) ISV heat loss = melt surface area*(32kW/m^2 or 459kcal/min/m^2 or 43kcal/min/ft^2)			
28	2) Cp = 6.917 + C1*(T) + C2*(T)^2 + C3*(T)^3 (Himmelblau p. 444)			
29	3) hc = .19*(dT)^.3333 (Foust p. 192)			
30	4) Qc = hc * area * hood ΔT			
31	5) Qr = Stefan Boltzmann constant * emissivity * area * (hood temp^4 - amb temp^4)			
32	6) Calculated off-gas ΔT = (H + ISV - Qc - Qr)/(Vair * Cp)			
33	7) Large Scale: hood temp = off-gas temp - 50°C			
34	8) Pilot Scale: hood temp = off-gas temp - 25°C			
35	9) Qog = H + ISV - Qc - Qr			
36				
37				
38	Instructions:			
39	• Input hood area (Row 6) and off-gas flowrate (Row 7) for specific test.			
40	• Adjust ISV melt heat loss (Row 4) as appropriate.			
41	• Calculational Options - 1) hood temperature or 2) combustion rate.			
42	1) Input a test specific heat of combustion rate value into Row 3, then input an off-gas			
43	temperature value into Row 10 until the measured ΔT (Row 21) and the calculated			
44	ΔT (Row 22) agree. This projects the off-gas and hood temperature based upon the			
45	identified combustion rate.			
46	2) Input an off-gas temperature into Row 10, then input a heat of combustion value			
47	into Row 3 until the measured ΔT (Row 21) and the calculated ΔT (Row 22) agree.			
48	This projects the combustion rate based upon a given off-gas/hood temperature.			
49	• Use this program to project maximum hood temperatures based on site specific			
50	combustible loadings or vice versa.			

APPENDIX B
VALUE ENGINEERING STUDY

APPENDIX B
VALUE ENGINEERING STUDY

This appendix contains the Value Engineering Study conducted for the in situ vitrification interim response action at the M-1 Settling Basins, Rocky Mountain Arsenal, Colorado.

Value Engineering Study

M-1 SETTLING BASINS IN-SITU VITRIFICATION

Rocky Mountain Arsenal,
Colorado

AUGUST 1990

STANLEY CONSULTANTS

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- Scope of Value Engineering 1
- Value Engineering Team 1

SECTION 2 - VALUE ENGINEERING STUDY PROCEDURES 3
- VE Workshop 3
  - Information Phase 3
  - Creative Phase 3
  - Evaluation Phase 3
  - Development Phase 4
  - Recommendation Phase 4

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- General 5
- Recommendations 5
- Summary 6

APPENDICES

APPENDIX A - SPECULATION IDEAS
APPENDIX C - RECOMMENDATION COMPUTATIONS

SECTION 1 - INTRODUCTION

General

This report summarizes the Value Engineering (VE) study for the M-1 Settling Basins at Rocky Mountain Arsenal, Colorado. This study was conducted in Muscatine, Iowa, from August 13 thru 17, 1990.

This VE study was performed by Stanley Consultants as part of a contract with Woodward-Clyde. Conceptual Design of the In-Situ Vitrification has been performed by Woodward-Clyde and Geosafe.

Scope of Value Engineering

The purpose of a VE study is to identify areas in the proposed design having high cost, and to develop ideas and alternatives which can bring about cost-effective changes in these areas. The objective of VE is to seek ways to perform the essential function at the lowest acceptable cost. It is important to understand that VE is not necessarily a "cost reduction" program to reduce initial costs if it results in increasing owning and operating costs. To this end, life cycle costing is used as a guard against a degradation of the finished product.

Value Engineering Team

The success of a VE study, as with any other endeavor, is dependent on the quality and technical expertise of those who participate. The members of a VE team are selected for their training and experience as well as personal attributes such as creativity and independence. It is important that they be willing to challenge conformity and not be influenced by peer pressure. The VE team must also be multidisciplined. New and creative ideas many times come from members whose discipline is not directly related to the subject being studied.

The VE team participants and their areas of expertise were as follows:

Jim Hollatz, CVS	Team Leader	Stanley Consultants
Jim Kill	Civil Engineer	Stanley Consultants
Hank Mann	Environmental Engineer	Stanley Consultants
Bob Rusch	Chief Electrical Engineer	Stanley Consultants
Rich Beyak	Process Engineer	Woodward-Clyde
Craig Timmerman	Soil Vitrification	Geosafe

SECTION 2 - VALUE ENGINEERING STUDY PROCEDURES

VE Workshop

During the actual workshop portion of the VE study, the Job Plan is followed. The Job Plan is an organized approach for searching out high-cost areas and developing alternate solutions for consideration. The Job Plan follows five key steps:

A - Information Phase
B - Creative Phase
C - Evaluation Phase
D - Development Phase
E - Recommendation Phase

These five steps are briefly described by the following:

Information Phase - At the beginning of the VE study it is important to understand the background and decision that have influenced the development of the design. Value engineering is not intended to seek out the Designers' "mistakes" or even to be a review of previous design effort, but a process of developing new combinations for review and consideration by the Design Engineers and Owner. During the VE study, the team members must become familiar with the project, concentrate their efforts on high-cost areas, and develop alternate concepts. Being cognizant of the Designers' rational for the development of the design is essential for a clear understanding of the project.

Creative Phase - This step in the VE study involved the listing of creative ideas. A list of 12 ideas were generated in these categories and is shown in the Appendix of this report.

During the Creative Phase, the VE team brainstorms by thinking of as many ways as possible to provide the necessary functions which may reduce cost to the Owner. Judgment of ideas is suspended at this time. The VE team is looking for quantity and association of ideas which will be screened in the next phase of the study.

Evaluation Phase - In this phase of the project, the VE team evaluates ideas resulting from the creative session. The ideas are ranked by the VE team. A matrix comparison technique is used to rank the ideas. Discussion of each idea results in advantages and disadvantages of each idea being listed.

Ideas found to be irrelevant or not worthy of additional study are disregarded. Those ideas that represent the greatest potential for cost savings are developed further. Ideally the VE team would like to develop all ideas, but time constraints usually limit the number that can be evaluated with reasonable accuracy.

Development Phase - The Development Phase of the VE study develops selected ideas into workable solutions. The development consists of a preliminary design and a life-cycle cost comparison. There were no life-cycle cost savings in any of the VE recommendations so the initial cost and life-cycle cost savings are identical.

It is important that the VE team be able to convey the concept for their recommendation to the designers, for if the proposal is not understood it is not likely to be accepted. Therefore, each recommendation is presented with a brief narrative to compare the original design method to the proposed change. Sketches, design calculations, and computations of estimated cost savings are also presented in this part of the study. The VE recommendations are included in Section 4 - VE Results and Recommendations.

Recommendation Phase - The last phase of the VE study is the presentation of recommendations. The recommendations are presented in this report.

SECTION 3 - VE RESULTS AND RECOMMENDATIONS

General

This section of the Value Engineering Report presents the results of development of various ideas created and the recommendations for implementing these ideas. Each recommended idea has been formulated into a workable alternate solution that achieves the same function as the original concept at a lower initial and/or life-cycle cost.

Cost comparisons are included to show projected savings for each recommendation. When possible, unit prices from the original cost estimate were used. To these prices the appropriate subcontractor overhead and profit, prime contractor's mark up, escalation, contingency, and etc., have been added. Where owning and operating costs are involved, savings are computed on a life-cycle cost basis using an interest rate of 8% and a life of 20 years.

Not all ideas that were evaluated are recommended. Unless the idea results in a significant cost savings or, in the opinion of the VE team, improves the accomplishment of the function, recommendation for change is not made. In addition to specific recommendations for change, design suggestions are frequently offered as a possible benefit to the project without regard to cost impact.

Recommendations

The Value Engineering Team recommendations are detailed in the Appendix of this report. Each recommendation has a "VE Recommendation" sheet with the appropriate backup.

Because of the very preliminary nature of the design, it is difficult to determine the "base" design. The VE team assumed a typical design, using conventional practices, as the base case.

Summary

Summarizing recommendations and cost savings resulting from a VE study is difficult since frequently the savings are not cumulative. Acceptance of one item may preclude acceptance of another. A summary of estimated savings is shown in Table 3. It should be emphasized that these figures represent order of magnitude cost and indicate an approximate range of differences to be expected.

Each recommendation should be evaluated on its own merit. There may be a tendency to reject a recommendation because of a small disagreement about one portion of the recommendation. Objective consideration should be given to each recommendation and those portions which can be accepted should be implemented. Many time VE recommendations serve as "building blocks" upon which the design team can build, resulting in further improvement and/or savings.

Prepared by: Jim Hollatz   Date: 8-16-90

Jim Hollatz
CVS 850502

TABLE 3

COST SUMMARY

ITEM	DESCRIPTION	EVALUATION NUMBER	INITIAL COST SAVINGS	LIFE CYCLE COST SAVINGS
1.	Use self-feeding electrode vs. fixed.	8	772,000	772,000
2.	Cut down size area.	9	300,000	300,000
3.	Separate project into two contracts.	9	70,000	70,000
4.	Recycle waste material into next set up.	8	377,000	377,000
5.	Recover mercury.	5	100,000	100,000
6.	Cover area with 1' of earth.	8	390,000	390,000
7.	Reuse electrodes.	7	957,000	957,000

TABLE 3

COST SUMMARY

ITEM	DESCRIPTION	EVALUATION NUMBER	INITIAL COST SAVINGS	LIFE CYCLE COST SAVINGS
8.	Eliminate sheet pile cut-off wall and melt perimeter first.	6	75,000	75,000
9.	Use in-situ slurry system in place of sheet pile.	6	NOT RECOMMENDED	
10.	Use cost plus contract in place of lump sum.	7	375,000	375,000
11.	Use gas turbine.	5	DESIGN SUGGESTION	
12.	Multiple melt units.	6	NOT RECOMMENDED	

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PHASE II CREATIVE

CLIENT:	Study Number	Date
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Idea List

1. USE SELF FEEDING ELECTRODE VS. FIXED.
2. CUT DOWN SIZE OF TREATED AREA.
3. SEPARATE PROJECT INTO TWO CONTRACTS.
4. RECYCLE WASTE MATERIAL INTO NEXT SET UP.
5. RECOVER MERCURY.
6. COVER AREA WITH 1' OF EARTH.
7. REUSE ELECTRODES.

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PHASE II CREATIVE

CLIENT:	Study Number	Date	Idea List
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

8. ELIMINATE SHEET PILE CUT-OFF WALL AND MELT PERIMETER FIRST.
9. USE IN-SITU SLURRY SYSTEM IN PLACE OF SHEET PILE.
10. USE COST PLUS CONTRACT IN PLACE OF LUMP SUM.
11. USE GAS TURBINE.
12. MULTIPLE MELT UNITS.

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PHASE V RECOMMENDATION

CLIENT: OMAHA COE ROCKY MOUNTAIN ARSENAL	**Study Number** 10742	**Date** 8/17/90	**Item** 1
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: USE SELF-FEEDING ELECTRODE VS. FIXED

ORIGINAL DESIGN

The electrode would be inserted into a predrilled hole. Workmen would be required to be suited as the drilling would progress into the hazardous waste.

VE TEAM PROPOSAL

Provide a self-feeding electrode. This would eliminate the need for predrilling into the waste.

ADVANTAGES

Less possibility of contamination on the surface.

DISADVANTAGES

Controls and mechanical systems would need to be added to hood to control feed rate.

INITIAL COST SAVINGS	$ 772,000
LIFE CYCLE COST SAVINGS	$ 772,000

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PHASE IV DEVELOPMENT

CLIENT:	Study Number	Date	Estimate
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	1

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
STATIONARY				
ELECTRODE				
8 ELECTRODES X 70=	560	EA	2,400	1,344,000
ADD				
FEEDING ELECTRODE	560	EA	660	369,600
				974,400
10% CONTINGENCY				97,600
				1,072,000
FEEDING EQUIP.				
MODIFICATIONS				300,000
				772,000

PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	2
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: CUT DOWN SIZE OF TREATED AREA

ORIGINAL DESIGN

Waste was originally deposited in basins with sloped sides. The planned soil vitrification area starts at the top of slope and extends across the trench to the top of the opposite side.

VE TEAM PROPOSAL

Reduce the plan dimensions of vitrification. Extending the melt line only to the midway point on the basin slope. The top edge of the basin will be heated and vitrified because of soil shrinks and will "cave into" the melt.

ADVANTAGES

Lower cost due to fewer melt setups.

DISADVANTAGES

Risk not treating sludge at edge if area reduced too much.

INITIAL COST SAVINGS	$ 300,000
LIFE CYCLE COST SAVINGS	$ 300,000

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PHASE IV DEVELOPMENT

CLIENT:
OMAHA DOE
ROCKY MOUNTAIN ARSENAL

Study Number 10742

Date 8/17/90

Estimate 2

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
SOIL NOT			(1)	
VITRIFIED	857	TONS	$350	299,950
USE				300,000
(1) FROM TREATABILITY				
REPORT				

RECOMMENDATION ITEM 2

Vitrify only the sludge region

Soil from berm edge to vitrification edge that will not be vitrified:

$$\text{Volume} = [2(202 \times 2\ \text{ft}) + (111 \times 2\ \text{ft}) + 2(104 \times 4\ \text{ft}) + (107 \times 4\ \text{ft})]\ (10\ \text{ft})$$

$$= [808 + 222 + 832 + 428\ \text{ft}^2]\ (10\ \text{ft})$$

$$= 22{,}900\ \text{ft}^3$$

Average density = 1.2 g/cc

$$\text{Mass soil } \underline{\text{not vitrified}} = (22{,}900\ \text{ft}^3)(1.2)(62.4\ \text{ft}^2)\left(\frac{1\ \text{ton}}{2{,}000}\right)$$

$$= 857.4\ \text{ton}$$

From treatability report, assume typical remediation cost is ~ $350/ton.

Job No. 10742 Page No.

Computed by Date 8/90

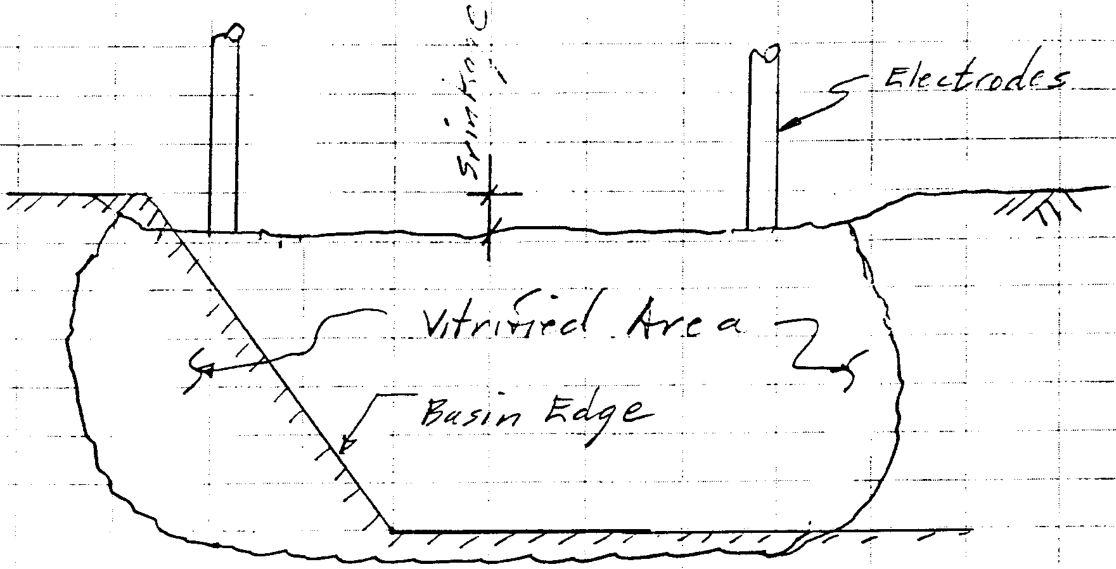
Checked by Date

Reviewed by Date

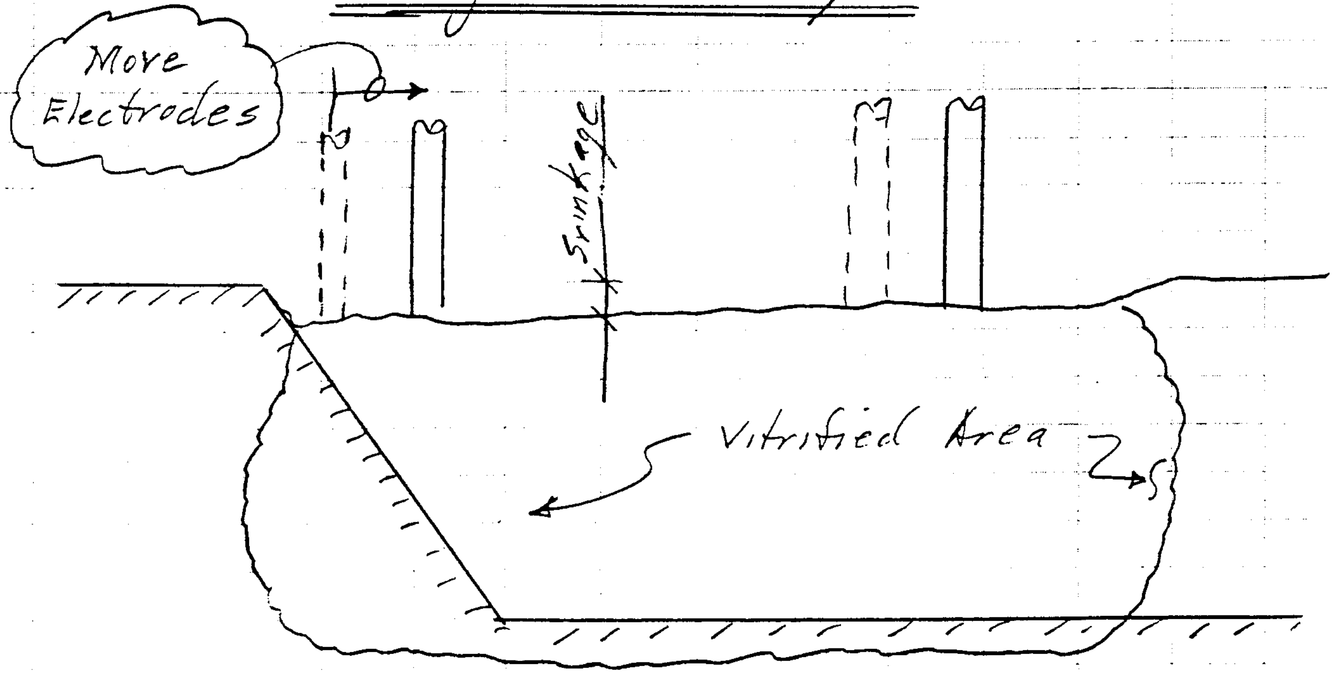
Approved by Date

Subject Z-Cut Down Size Of Treated Area

Sheet No. 4 of 4



Section
Original Design



Section
VE Team Proposal

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PHASE V RECOMMENDATION

CLIENT: OMAHA COE ROCKY MOUNTAIN ARSENAL	**Study Number** 10742	**Date** 8/17/90	**Item** 3
Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS			

TITLE: SEPARATE PROJECT INTO TWO CONTRACTS

ORIGINAL DESIGN

One contract will be let to cover all work for the project. This would include any site preparation, fencing, new utilities, and the vitrification process.

VE TEAM PROPOSAL

Separate project into a site preparation contract and a general contract. The site preparation contract would include any road work, fences, lighting, bringing electrical power to site, and a new substation if required.

ADVANTAGES

Lower cost as prime would subcontract site work out.
Timing of contracts would improve - ISV contractor would not have to be on site early.

DISADVANTAGES

Adds minor contract administration cost.

INITIAL COST SAVINGS	$ 70,000
LIFE CYCLE COST SAVINGS	$ 70,000

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PHASE IV DEVELOPMENT

CLIENT:	Study Number	Date	Estimate
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	3

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
PRIME CONTRACTOR				
MARK UP ON SITE				
WORK SUBCONTRACTOR				
10% OF $700,000				70,000

PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	4

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

TITLE: RECYCLE WASTE MATERIAL INTO NEXT SET UP

ORIGINAL DESIGN

Gases are drawn off the hood and collected in the scrubbing and filtering equipment. Mercury will be drawn off separately. The scrubbing liquid and the filters will pick up various substances from the gases. The liquid and filters will become hazardous waste and must be disposed. Typical disposal would be in a hazardous landfill.

VE TEAM PROPOSAL

Dispose of the waste material from the scrub/filter operation by recycling into the next vitrification area. (See further discussion on the sheet following the cost estimate sheet.)

ADVANTAGES

Save landfill.
Lower cost.

DISADVANTAGES

Increases slightly next vitrification cycle.
Extra energy will be required to boil off the liquid.

INITIAL COST SAVINGS	$ 377,000
LIFE CYCLE COST SAVINGS	$ 377,000

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PHASE IV DEVELOPMENT

CLIENT:	Study Number	Date	Estimate
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	4

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
DISPOSAL OF				
SECONDARY WASTE				
SCRUB SOLUTION				
70 x 1,000 GAL	70,000	GAL	4^{00}	280,000
HEPA FILTERS				
70 x 9 EA =	630	EA	100^{00}	63,000
CONTINGENCY				34,000
				377,000

RECOMMENDATION ITEM 4

Secondary Waste Recycle

Maximum secondary waste generated per ISV setting is estimated at 1,000 gallon scrub solution, 3 - 24 x 24 x 5-7/8" HEPA filters, 3 - 24 x 24 x 11-1/2" HEPA filters, and 3 - 24 x 24 x 11-1/2" activated carbon filters. The scrub solution could be filtered and treated to minimize the volume. This filtrate and all the other loaded filters generated during ISV processing could be recycled into a next vitrification setting exclusive of the secondary wastes generated during the last vitrification setting. This volumetric reduction in secondary waste generation is significant and the cost savings (TBD) for treating the liquids and vitrifying the filters will show benefits, and be the most environmentally conscious method for these byproduct wastes, as opposed to standard landfill disposal.

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PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	5

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

TITLE: RECOVER MERCURY

ORIGINAL DESIGN

Contaminants and materials collected by the off-gas collection and treatment system are recycled back to a subsequent in-situ vitrification process.

VE TEAM PROPOSAL

Recover mercury from the off-gas collection and treatment system.

ADVANTAGES

Approximately 40 tons of mercury is estimated to be in the treatment site. The recovered mercury could be sold.

DISADVANTAGES

Increased manhours and equipment required to reclaim and handle the mercury. Recovered mercury may be considered a hazardous waste.

INITIAL COST SAVINGS	$ 100,000
LIFE CYCLE COST SAVINGS	$ 100,000

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PHASE IV DEVELOPMENT

CLIENT:	Study Number	Date	Estimate
OMAHA DOE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	5

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
RECOVERED VALUE				
OF MERCURY	40	TON	7,500	300,000
ADD				
RECOVERY				
EQUIPMENT				200,000
SAVINGS				100,000

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PHASE V RECOMMENDATION

CLIENT: OMAHA COE ROCKY MOUNTAIN ARSENAL	Study Number	Date	Item
	10742	8/17/90	6
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: COVER AREA WITH 1' OF EARTH

ORIGINAL DESIGN

Existing site has been classified as potential hazardous area requiring Level B personnel protection equipment.

VE TEAM PROPOSAL

Cover entire site with 1' of "clean" compacted soil to reduce the personnel protection equipment to Level D.

ADVANTAGES

Workmen need less protection equipment, work more efficiently, and no decontamination areas required.

DISADVANTAGES

Requires locating, transporting, placing, and compacting of 1,300 cu yds of clean soil.

INITIAL COST SAVINGS	$ 390,000
LIFE CYCLE COST SAVINGS	$ 390,000

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PHASE IV DEVELOPMENT

CLIENT:
OMAHA DOE
ROCKY MOUNTAIN ARSENAL

Study Number
10742

Date
8/17/90

Estimate
6

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
ADDITIONAL COST				
OF LEVEL B				
LABOR OVER LEVEL D				
365 DAY x 48 HR/DAY =	17,520	HRS	25^{00}	438,000
ADD				
EARTH COVER				
325' x 135' x 1'	1,625	CY	30^{00}	48,750
				389,250
USE				390,000

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PHASE V RECOMMENDATION

CLIENT:	**Study Number**	**Date**	**Item**
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	7
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: REUSE ELECTRODE

ORIGINAL DESIGN

Stationary molybdenum graphite electrodes are used in the present hood. Each setting requires two 6' electrode sections.

VE TEAM PROPOSAL

Modify hood to use self-feeding graphite electrodes. Reuse electrodes to reduce electrode cost. Anticipated "best hope" for electrode reuse to be reliably implemented is twice.

ADVANTAGES

Cost savings.

DISADVANTAGES

Electrode reuse has not been proven on large-scale operations.

INITIAL COST SAVINGS	$ 957,000
LIFE CYCLE COST SAVINGS	$ 957,000

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PHASE IV DEVELOPMENT

CLIENT: OMAHA DOE ROCKY MOUNTAIN ARSENAL	Study Number 10742	Date 8/17/90	Estimate 7
Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS			

Item	Quantity	Unit	Labor and Materials	Total
COST SAVINGS				
FROM RECOMMENDED				
ITEM # 1				772,000
~~Add~~ DELETE				
ONE ~~RE~~USE OF				
ELECTRODE	280	EA	660	185,000
				———
				957,000

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PHASE V RECOMMENDATION

CLIENT: OMAHA COE ROCKY MOUNTAIN ARSENAL	Study Number	Date	Item
	10742	8/17/90	8
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: ELIMINATE SHEET PILE CUT-OFF WALL AND MELT PERIMETER FIRST

ORIGINAL DESIGN

Sheet pile will be driven around the melt perimeter. The sheet pile will cut off water infiltration. Resulting reduction in energy costs will occur as excess water will not have to be boiled away.

VE TEAM PROPOSAL

Melt perimeter of site first to form water cutoff to center core.

ADVANTAGES

Eliminates sheet pile operation.

DISADVANTAGES

Increases cost of ducting to trailer filtering equipment.
Since anticipated melt depth is 10' which is approximate water table depth, the perimeter melt is not as effective a water cut-off as sheet pile.

INITIAL COST SAVINGS	$ 75,000
LIFE CYCLE COST SAVINGS	$ 75,000

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PHASE IV DEVELOPMENT

CLIENT: OMAHA DOE ROCKY MOUNTAIN ARSENAL	Study Number 10742	Date 8/17/90	Estimate 8

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
SHEET PILE				
CUT OFF WALL				
	1,000	LF	225	225,000
ADD				
REDUCED EFFICENCY				
DUE TO INCREASED				
WATER DURING				
PERIMETER WORK		LS		150,000
				75,000

PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	9

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

TITLE: USE IN-SITU SLURRY SYSTEM IN PLACE OF SHEET PILE

ORIGINAL DESIGN

Sheet pile is driven as water cutoff wall around perimeter of site.

VE TEAM PROPOSAL

Use an in-situ slurry system instead of sheet pile for perimeter water cutoff.

ADVANTAGES

Better reduction of water flow.

DISADVANTAGES

Disturbs soil.
Higher cost.

INITIAL COST SAVINGS NOT RECOMMENDED

LIFE CYCLE COST SAVINGS NOT RECOMMENDED

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PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	10

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

TITLE: USE COST PLUS CONTRACT IN PLACE OF LUMP SUM

ORIGINAL DESIGN

A lump sum contract is proposed for the soil vitrification.

VE TEAM PROPOSAL

Use a cost plus contract for the project.

ADVANTAGES

Better ultimate price as lump sum contract may be high due to the risks the contractor must take to overcome project unknowns.

DISADVANTAGES

Government must risk the unknowns.
Increases contract management.

INITIAL COST SAVINGS	$ 375,000
LIFE CYCLE COST SAVINGS	$ 375,000

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PHASE IV DEVELOPMENT

CLIENT: OMAHA DOE ROCKY MOUNTAIN ARSENAL	Study Number 10742	Date 8/17/90	Estimate 10

Study Title IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
REDUCE GEOSAFE				
RISK BY 15%,				
THUS REDUCING				
COST OF CONTRACT				
#2.5 M x 15% =				375,000

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PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	11
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: USE GAS TURBINES

ORIGINAL DESIGN

Power will be supplied to the site by tapping into the existing substation and constructing highlines to the site.

VE TEAM PROPOSAL

Bring a natural gas pipe line to the site and have contractor provide a gas turbine for electrical power.

ADVANTAGES

Eliminates possible power spikes or power interruptions into the existing electrical power system.

DISADVANTAGES

Needs gas line.

INITIAL COST SAVINGS	DESIGN SUGGESTION
LIFE CYCLE COST SAVINGS	DESIGN SUGGESTION

Because of the many variables involved, it is impossible for the VE team to evaluate the cost impact of requiring the construction contractor to use gas turbines for electrical power generation. If the cost of electrical power at Rocky Mountain Arsenal is relatively high, it is possible that on-site gas turbine generation may be less costly overall.

In evaluating this recommendation, it is necessary to consider the cost of electrical power vs. natural gas. Initial capital cost considerations would include the cost to make electrical power available vs. depreciation charged to this project by the contractor for the combustion turbine generators.

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PHASE V RECOMMENDATION

CLIENT:	Study Number	Date	Item
OMAHA COE ROCKY MOUNTAIN ARSENAL	10742	8/17/90	12
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

TITLE: MULTIPLE MELT UNITS

ORIGINAL DESIGN

One melt unit makes individual set ups to vitrify small cells until the entire site is done.

VE TEAM PROPOSAL

Build another melt unit and off-gas collection system and operate two units at the same time.

ADVANTAGES

Has earlier completion date.
Reduces total manpower ($) required.

DISADVANTAGES

Doubles electrical demand.
Increases contract cost.

INITIAL COST SAVINGS	NOT RECOMMENDED
LIFE CYCLE COST SAVINGS	NOT RECOMMENDED

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PHASE IV DEVELOPMENT

CLIENT: OMAHA DOE ROCKY MOUNTAIN ARSENAL	Study Number 10742	Date 8/17/90	Estimate 12
Study Title	IN-SITU VITRIFICATION FOR M-1 SETTLING BASINS		

Item	Quantity	Unit	Labor and Materials	Total
DELETE				
CONTRACTOR LABOR				
IS REDUCE BY				
30%				
LABOR				
#2.5M x 30% x 30%				225,000
REDUCTION				
GOVERNMENT				
INSPECTION	6	MO	15,000 =	90,000
ADD				
COST TO PROJECT FOR 2ND				
MELT UNIT			$	1,500,000
NET ADD			$	1,185,000