63039

NON-TRADITIONAL IN SITU VITRIFICATION DEMONSTRATION PLAN FOR THE MDA-V SITE AT THE LOS ALAMOS NATIONAL LABORATORY

Revision 1

by
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2952 George Washington Way
Richland, WA 99352

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I. Introduction

Since its inception in the early 1980s, conventional in situ vitrification (ISV) has been successfully employed to remediate a number of contaminated waste sites in the USA. Typically, these sites have contained radioactive and chemical wastes contained in a soil matrix.

The conventional ISV process employs the use of electrical energy to melt the soil/waste matrix from the top down. The electrical energy is delivered to the soil by means of a set of graphite electrodes emplaced in the upper regions of the target vitrification zone. Soil, by its very nature, is very insulative both electrically and thermally. Therefore, a conductive pathway must be placed between electrodes to promote initial current flow in the system. The circuit between the electrodes is initially formed by means of an array of starter tubes placed on top of the target vitrification zone. These tubes contain a mixture of ground graphite and glass-forming materials. The mixture provides a conductive path to allow current to flow between the electrodes. The flow of current through the pathway generates heat which in turn, melts the soil surrounding the path. As the starter path is consumed the current flow is transferred into the molten soil which is now adequately conductive. This melting process is initiated in the upper region of the waste zone, and is propagated downward through the soil/waste matrix by the action of gravity and continued melting.

ISV generates a very durable, high-quality glassy product. This product has superior leach-rate characteristics and is, therefore, very effective at incorporating radioactive and other non-volatile wastes for geological timeframes. Organic wastes are destroyed during treatment with the process by pyrolysis. Volatile heavy metals (such as mercury) are removed from the treatment volume and routed to the off-gas treatment system for removal via wet scrubbing and filtration.

Geosafe has invented an adaptation to the conventional top-down ISV process for treating wastes that are either containerized, or are surrounded by a relatively impermeable barrier (e.g.: sealed drums, underground storage tanks [UGTs], or confining geologic stratigraphy). In the case of containerized wastes; however, Geosafe has developed, and successfully employed, a preconditioning process in which the integrity of the containers is compromised prior to processing. This allows volatile materials to be effectively pyrolyzed in the case of organics or converted to steam in the case of water without significant pressure buildup during processing. For this approach to be effective, the position, configuration, and strength of the containers must be fairly well defined for successful preconditioning.

This process is termed planar-ISV. In the planar-ISV process, the horizontal array of starter tubes used in conventional ISV is replaced with vertically-oriented planes of starter material. The planes can be positioned at virtually any desired depth and separation between planes. This allows significant control of the initial melt process so that it can be focused for optimal treatment of the waste zone. This approach, although originally invented for treating sealed containers also provides the ability to perform subsurface melt start-ups and to achieve greater depths. The two vertical planes can be sized (both in length and height) to provide complete

conventional top- down ISV (i.e: immobilization of radionuclides and heavy metals, destruction of organics, and removal of volatile heavy metals). Figure I.1 illustrates the basic planar melting technique as applied to waste trench-type application.

Geosafe has demonstrated this type of application numerous times. A series of engineering-scale tests have been performed to determine the basic performance and product characteristics of planar melting. Once the characteristics were established, a series of tests involving buried canisters containing large quantities of water-saturated soil (to simulate sludge) were processed at this scale to further assess and define the efficacy of the process for treating UGTs and containers. Subsequently, the testing was increased in scale to a 2,000-gal. tank (6 ft dia. by 8 ft long) and then a 4,500-gal. tank (8 ft dia. By 12 ft long) with similarly successful results.

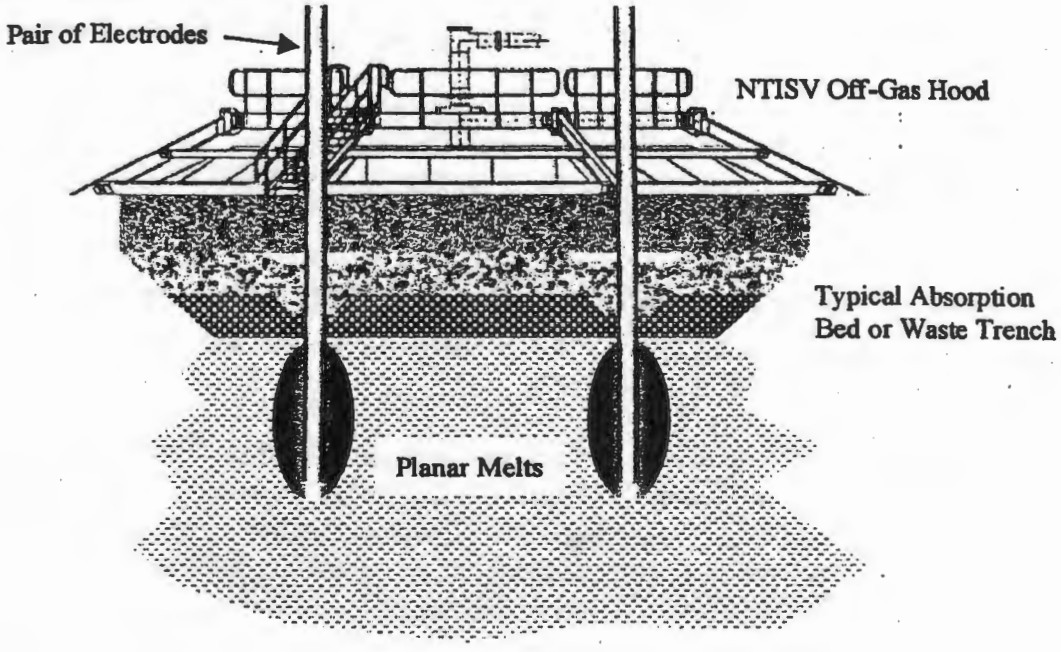

Figure I.1 Illustration of Planar Melting

The overall goal of the NTISV Demonstration Project is to verify the feasibility of using planar-ISV to in situ remediate the wastes present in Absorption Bed 1 at MDA-V, which is the selected site for the "hot" demonstration. In addition, the demonstrations will be designed to demonstrate the technology's capability to treat other waste types and matrices that may be found at LANL and other DOE sites, thereby broadening the DOE's options for cost effective remediation for buried wastes.

This project is oriented into three separate phases:

I. Development of design, demonstration, and regulatory documentation followed by the operational assessment for the cold demonstration;

II. Perform and evaluate the cold demonstration. Prepare design and regulatory documentation for the hot demonstration followed by operational assessment for the hot demonstration, and;

III. Perform and evaluate the hot demonstration and prepare the final project assessment.

The project purpose and objectives will be met by performance of two demonstrations followed by evaluation of performance in the areas of interest noted above. Both demonstrations will be suitably instrumented to promote the safe and successful performance, as well as provide the necessary database for post-demonstration evaluation of the results. All instrumentation and recording practices for these demonstrations will be consistent with the established Data Quality Objectives (DQOs).

Geosafe will perform a cold and a hot demonstration to demonstrate the ability of NTISV to improve significantly upon the current limitations of traditional ISV that remain most important relative to needs with the DOE Complex.

Geosafe will employ its planar melting technology during the NTISV demonstrations. The planar melting technology has been developed through large-scale, and has the ability to operate successfully under the most demanding conditions.

The cold demonstration has been designed to minimize overall project cost while demonstrating the abilities that will be applied to the hot demonstration. A target volume of 10 ft by 15 ft by 18-ft deep (4 to 22-ft bgs) will be treated during the cold demonstration. This volume is half of that planned for the hot demonstration and is sufficient to demonstrate the capabilities of the technology for the larger hot demonstration. A site will be selected for the cold demonstration and will be prepared to resemble the configuration of absorption bed 1 (the site selected for the hot demonstration). Surrogates will be added to the cold demonstration to represent actual radioactive contaminants. Adding surrogates to the waste matrix will allow the evaluation of leach performance, as well as, the determination of surrogate distribution within the vitrified block.

The hot demonstration phase will be initiated after the cold demonstration is performed and fully evaluated. The hot demonstration will involve the treatment of a 20 ft by 30 ft area of absorption bed 1 located in MDA V at the LANL site. As in the cold demonstration, planar ISV will be used to treat the portion of the adsorption bed vertically from 4 ft to 22 ft bgs.

The successful application of NTISV at LANL is expected to provide a useful technology for consideration by the Subsurface Contaminant Focus Area for potential application to DOE sites. In addition, the successful application of NTISV at LANL will help meet the general technology needs of EM-40 (complex-wide) including some specific site remediation needs of LANL.

The cold demonstration objectives include:

- Demonstrate the ability to safely and successfully install planar starter paths within the Bandelier Tuff Formation in the subsurface for application of planar ISV, HOW IF IN FILL ?
- Configure a simulated absorption bed including subsurface conditions that are expected for the hot demonstration,
- Process the materials placed into the simulated absorption bed using NTISV to achieve a vitrified mass depth similar to that anticipated in the hot demonstration,
- Verify the physical dimensions of the vitrified mass by excavating and exposing a portion of it,
- Obtain process performance information necessary to optimize the processing configuration and parameters for the hot demonstration,
- Gather geochemical data by collecting and analyzing samples of the various components that will be processed and compare this data to the anticipated geochemical conditions in the hot demonstration,
- Characterize the vitrified product,
- Obtain costing data to enable estimation of large-scale remediation costs, and to compare costs to the target level of $800/ton or less,
- Generating data that will assist in developing evaluation criteria for the hot demonstration, and
- Provide information that will help refine health and safety, work control, regulatory , NEPA and RCRA requirements for the hot demonstration.

The objectives for the hot demonstration are similar to the objectives for the cold demonstration. These objectives include:

- Taking the information and data gathered from the cold demonstration and applying that knowledge to optimize the performance and technical value of the hot demonstration,
- Evaluate the fate and transport mechanisms that take place and that affect the metals, organics and radionuclides present in the absorption pit. This will include a comprehensive evaluation of off-gas composition, residual components (if any) present in surrounding soil following the demonstration, distribution of contaminants in the vitrified material and an evaluation of the chemical durability of the vitrified material,

- Demonstrate the usefulness of this technology and the ability to apply the knowledge gained from the cold and hot demonstrations to other waste treatment issues at LANL and other DOE installations,
- Assure that the performance of the NTISV system and the results of the hot demonstration will meet or exceed federal, state, and local regulations, H&S goals, and QA goals,
- Process all of the targeted materials in the absorption bed using NTISV to achieve a vitrified mass that exhibits acceptable chemical durability,
- Characterize the vitrified product, and
- Produce costing data to help attain the $800/ton processing cost goal.

In order to address the above mentioned objectives, evaluation of the demonstration results will be performed in relationship to both these demonstrations and prior Geosafe testing and remedial results. The approach will allow the best possible evaluation of NTISV applicability to potential application to DOE sites.

II. ISV Equipment Description

The Geosafe GeoMelt ISV system consists of two major subsystems: 1) the power supply system and 2) the off-gas treatment system. The basic features and capabilities of these subsystems are described in this section.

II.A. Electrical Power Supply System

The heart of the Geosafe GeoMelt ISV power supply system is the Scott-Tee transformer. This transformer converts the three-phase power supply to two single-phase outputs on the secondary side of the transformer. The output from the secondary side of the transformer is applied to the electrode system which, in turn, provides the electrical energy to melt the soil/waste matrix.

The Scott-Tee transformer is designed to accept standard nominal input voltages in the range of 12.47-kV to 13.80-kV. The transformer is rated at 3750 kW and can deliver voltages in the range of 400 to 4160 volts. The corresponding range on secondary side AC current is 4000 to 400 amps.

The melt configuration changes continuously during the ISV process. The increasing size of the melt directly affects the resultant electrical resistance experienced during processing. The net resistance decreases with both increasing melt volume and temperature. The decrease in the melt resistance likewise results in a gradual drop off in power being input to the melt. To compensate for this, the transformer is equipped with sixteen voltage taps that allow adjustment of the voltage and current supplied to the melt to maintain a constant power input. Matching the transformer tap with that appropriate for the system demand helps insure optimal performance of the transformer.

The voltage and current generated on the transformer secondary side is supplied to the electrodes through a set of 1000 MCM electrical cables. Each cable is rated at 1000 amps. Typically, four cables can be connected to each electrode. These four cables can therefore accommodate the peak current draw of 4000 amps.

II.B. Electrode System

The electrode system consists of four graphite electrodes and their associated electrode feeder assemblies. These are illustrated in Figure II.1. The electrodes are indicated in this figure by the four vertical rods projecting above the ISV hood. The output from the Scott-Tee transformer is delivered to the soil/waste matrix through these electrodes. Each phase of the transformer secondary side output is connected to a pair of electrodes. The pair of electrodes connected to each output are configured such that the resulting planes are parallel with each other.

Each individual electrode is composed of three or more electrode segments. Each segment has a diameter of 12 in. and a length of approximately 6 ft. The segments have threaded couplings on each end, which receives a threaded nipple and allows a number of electrode segments to be joined together to form the desired overall length. The electrodes are typically gravity fed into the melt. Therefore, additional electrode segments can be added to each electrode stem to accommodate this feeding process.

The electrodes are held in position by electrode feeders. Each feeder maintains the vertical orientation of the electrode during processing, while also providing the electrical connection between the power supply cables and the electrode. This is achieved by means of a set of copper contactor pads. The pads have mounting plates to accept the lug on each electrical cable, and are spring loaded to insure that contact between the contactor and electrode is maintained during operation.

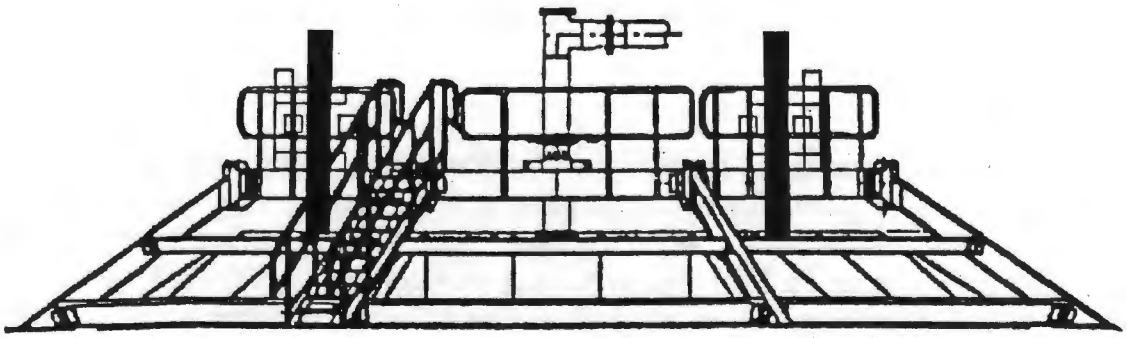

Figure II.1. NTISV Hood and Electrode System

A set of pneumatic grippers is provided on each electrode feeder assembly. These grippers are used to control the insertion depth of the electrode. When the gripper is open, the electrode is allowed to gravity-feed into the developing melt. In this situation, the bottom of the electrode rides on the bottom surface of the melt. Actuating the gripper will arrest the downward progression of the electrode. Raising the electrodes is accomplished with the aid of a crane and lifting bail affixed to the top segment of the electrode (with power off). This method of raising the electrodes is used sparingly, however. Typically, the electrodes are held slightly off the bottom of the melt, and allowed to feed as the melt grows downward and outward using a controlled slip-and-grip technique.

II.C. Off-Gas Treatment System

The off-gas treatment system is composed of two modular subsystems: the off-gas hood and off-gas processing systems. The off-gas hood performs the initial collection and routing of gases. The off gases collected by the hood are then transferred to the off-gas processing system for final treatment. A schematic of the off-gas treatment system is provided in Figure II.2.

II.C.1 Off Gas Hood

An off-gas collection hood is typically staged over the target vitrification zone prior to processing. The hood is composed of a skin of stainless steel panels supported by a steel superstructure. This structure also supports the electrode feeders and associated electrode loads.

During operation, the plenum space beneath the off-gas hood is maintained at a slight vacuum to prevent the release of any gases generated during processing. The off-gas hood collects these gases for subsequent treatment by the off-gas processing system. The vacuum is established by means of a blower in the off-gas processing portion of the system. The blower is capable of pulling 50 std m^3/min of air into the hood and through the off-gas treatment system.

The air and any gases generated during processing are collected by the off-gas hood and routed to the off-gas processing system through a 12-in. diameter stainless steel line.

II.C.2 Off-Gas Processing System

The off-gas processing system is designed to collect and/or destroy any potentially hazardous materials present in the off-gas stream. These can be volatile, semi-volatile, non-volatile, or particulate in nature. The system consists of several stages: a pre-filter, quencher, hydrosonic-scrubber, mist eliminator, heater, and a final high efficiency particulate (HEPA) filter subsystems. As an option, a bank of activated charcoal filters and/or a thermal oxidizer is available for supplementary processing, if desired.

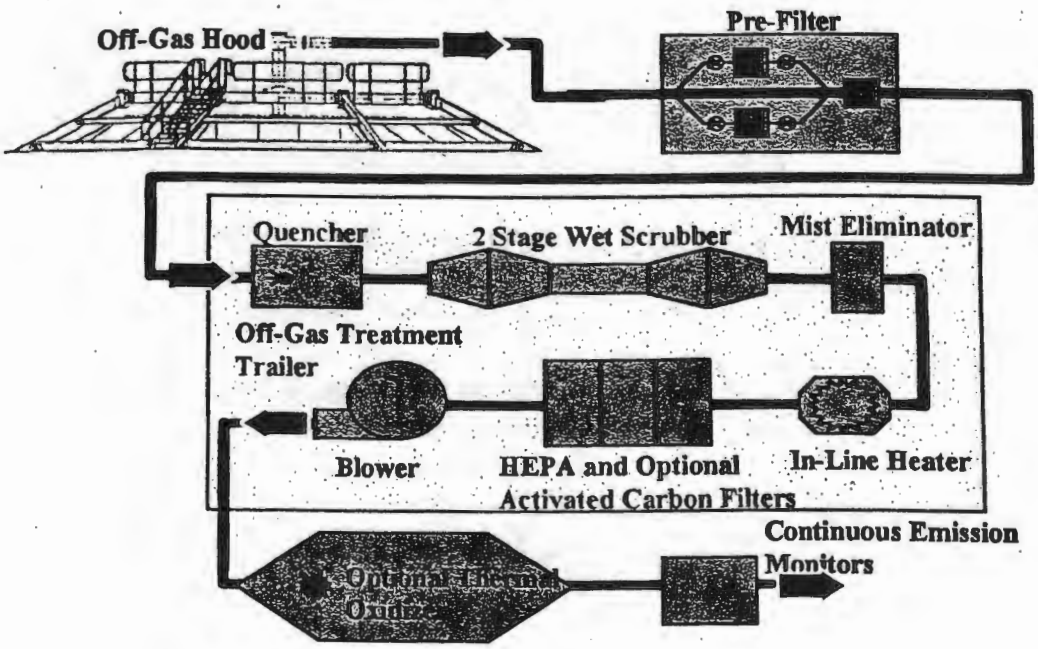

Figure II.2. NTISV Off-Gas Processing System

Flow from the off-gas hood through each of the components of this system is established by means of a high volume blower located near the end of the off-gas treatment system. This blower also develops the slight vacuum needed to insure in-leakage into the off-gas hood. The current system is designed to pull flow from the off-gas hood out the stack at 50 standard m^3/min. A backup blower in the system provides vacuum to the off-gas hood in the event of a failure of the main off-gas blower. The backup blower is designed to provide approximately the same volumetric off-gas flow rate as the main blower. The off-gas passing through this back-up system is processed by a wet scrubber, HEPA filter, and (if included) a thermal oxidizer unit before being exhausted to atmosphere.

The first component of the off-gas processing system that the off-gas enters is a prefilter. The purpose of the prefilter is to remove radionuclide containing particulates prior to them entering the main off-gas processing trailer. The prefilter consists of two parallel HEPA filters and a bypass. Duplicate banks of HEPAs are used to facilitate continuous filtering during periods of filter change-out. To preserve filter life during periods of non-particulate generation, the prefilter is fitted with a bypass to allow routing of off gases around the HEPA filters. HEPA filters posses a removal efficiency of 99.97% for particulates 0.3 micrometers or larger.

The quencher, which is the next off-gas process unit, is contained within Geosafe's off-gas processing trailer. Water spray nozzles inside the quencher cool the incoming off-gas flow. The spray pattern promotes good mixing, condensation, and heat transfer between the spray and off-

gas flow streams. In addition to removing particulates in the off-gas flow, the wet scrubbing nature of the quencher also serves to remove soluble components from the flow stream components (e.g.: fluoride and chloride). Any trace concentrations of semi-volatile materials still present in the off-gas stream are condensed into liquids or particles by the condensing and wet scrubbing action and are consequently also collected at this stage. Condensate from the quencher is further cooled with a water-to-glycol heat exchanger during its transfer to the scrub tanks.

A tandem nozzle hydrosonic scrubber is located just downstream of the quencher. The cooled off gases leaving the quencher enter the first stage of the hydrosonic scrubber system. The mix of off gas and fine mist produced by the scrubber captures and envelops any entrained dust particles at greater than 97% efficiency for particulates in the range of 0.5 micron and larger. A second hydrosonic scrubber is located just downstream of this first stage to further process the off-gas flow. As with the quencher system, the wet scrubbing nature of these venturi scrubbers also serves to remove soluble components from the flow stream (e.g.: fluoride and chloride). Again, any trace concentrations of semivolatile materials still present in the off-gas stream are condensed into liquids or particles by the wet scrubbing action and are consequently also collected at this stage.

Liquids that have been entrained and/or injected into the flow stream to this point must be removed to protect the integrity of the HEPA filter portion of the treatment system. Therefore, a chevron-vane mist eliminator is located downstream of the venturi scrubbers to perform this dewatering function. The resulting condensate is transferred to the scrub tanks for further processing. At the designed off-gas flow rate of 50 standard m3/min, the mist eliminator is designed to remove 99.9% of all water droplets from the off-gas stream.

Two scrub tanks are used to store approximately 1,000 gal each of scrub water. Condensate that is collected in the quencher, scrubbers, and mist eliminator is routed to these scrub tanks. The pH of the scrub water is maintained between 6.0 and 8.0 to neutralize any acid gases (e.g.: HCl) that may form as a result of treating any organic contaminants. A 50 wt% NaOH solution is used to automatically maintain the pH level of the scrub water. The scrub water in these tanks is recirculated to provide the water for the quencher and scrubber spray systems. The scrub tanks are equipped with a transfer pump and line to allow transfer of the scrub solution between tanks during operation.

Following treatment by the mist eliminator, the off-gas is then passed through a heater to raise the temperature of the off gas to above its dewpoint. The power supplied by the heater is automatically controlled to achieve a desired minimum temperature rise in the off-gas flow of 15 °C.

The final treatment stage in the standard off-gas treatment system involves filtering through a series of HEPA filters. The minimum particulate removal efficiency of each filter is 99.97% for particles 0.3 micron and larger.

As Figure II-2 indicates, an additional bank of filter media can be included in the line. This bank can accommodate either a redundant set of HEPA filters, or a bank of activated charcoal filters

Following passage through the HEPA filters, the flow is then drawn through the off-gas blower and exhausted to the atmosphere. If extremely low organic emissions criteria apply or there is the presence of odor causing components such as sulfur, a thermal oxidizer can be included in the off-gas line downstream of the blower to destroy any residual organic vapors and/or gases that have survived to this point. This is effectively a polishing step as the concentrations at this point in the process are extremely low and typically meet air emission criteria.

Monitoring of the treated off gas is performed after the final treatment step. This typically includes monitoring for oxygen, carbon monoxide and dioxide, and total hydrocarbons. In addition, other sampling such as U.S. EPA modified method 5 source sampling or radiation monitoring can be performed depending upon the contaminants present at the site.

III. Phase II (Cold Demonstration)

III.A. Introduction

Phase II of the project will consist of construction of the simulated absorption bed, installation of four melt shape monitoring wells, site preparation activities, mobilizing equipment and personnel to the site, preparation and check-out of the NTISV system, performance of the cold demonstration, analyzing and evaluating the results of the demonstration, and reporting these results. Prior to initiation of the cold demonstration, three on-site activities will occur. First, site personnel under the direction of LANL will construct a simulated absorption bed, which will be the location of the cold demonstration. The simulated pit will be constructed to specifications documented in this demonstration plan and in the site preparation plan. Geosafe and MSE representatives will provide oversight during the simulated absorption bed construction. Geosafe will also assist in the placement of instrumentation that will be used to monitor the progression of the melt during the demonstration. Secondly, Geosafe and its subcontractor will install four 50-ft monitoring wells surrounding the simulated absorption bed. Lastly, Geosafe and its subcontractor will perform the installation of electrodes and starter planes within and below the absorption bed.

The actual melting process will be initiated below the absorption bed, which will cause the material above (including the contents of the absorption bed) to feed into the melt and be incorporated into the vitrified product. Typically, smaller materials (i.e.: soils and gravels) are incorporated directly into the melt due to their smaller size and lower melting temperatures. Some larger materials such as boulders and large cobble will be encapsulated within the vitrified product where they then either melt or if they are of higher melting properties such as granitic materials, then they will slowly go through a dissolution process wherein the outer edge of the boulders is slowly dissolved and incorporated into the melt. This process is slow in occurring such that in smaller melts such as that planned for the cold demonstration it is typical to see some

of these materials remaining within the vitrified product. Although these materials may be somewhat intact within the melt, all of the contaminants that might have been absorbed or adhering to the outside edge are scrubbed off and incorporated into the vitreous product.

Phase II also includes the performance of activities that are required in preparation for the hot demonstration. These activities include document preparation, equipment design and modification, and final reporting of the cold demonstration results.

III.B. Cold Demonstration Strategy and Conceptual Design

The cold demonstration will occur in an uncontaminated location to the northwest of the MDA-V. This location was chosen so that the NTISV system trailers will not have to be relocated in order to perform the hot demonstration and also so that the stratigraphy and chemistry of the area chosen for the cold demonstration will be as representative to that present around and below the actual absorption bed. By planning the demonstrations in this manner, the confidence is increased that the conditions present in the hot demonstration will be the same or similar to that experienced in the cold demonstration and that the data produced will be accurate in identifying the expected waste form quality for the hot demonstration. In addition, the schedule and cost associated with performing the cold and hot demonstrations will both be reduced by the following:

- The off-gas hood will not require disassembly and re-assembly to move to the hot demonstration,
- Relocation of electrical connections and power drops following the cold demonstration will not be necessary,
- Remobilization of the NTISV system following the cold demonstration will not be necessary, and
- Sampling and analysis to establish geochemical conditions will only have to be performed once.

The cold demonstration will be performed in a simulated absorption bed that mimics the actual absorption bed as closely as possible. Historical records, bed as-built drawings, and recent records from characterization efforts performed in MDA-V will be used to aid in the design and construction of a representative simulated absorption bed for the cold demonstration.

To evaluate the product quality of the cold demonstration, two non-hazardous, non-radioactive surrogates will be added to the cobble layer of the absorption bed. The two surrogates have been selected for incorporation into the cold demonstration for their ability to behave similarly to a large population of the radioactive species present within the actual absorption beds. Cesium and cerium have been selected for incorporation in the cold demonstration. Cesium is a semi-volatile metal that has a slightly higher vapor pressure than most metals and thus, is slightly more volatile. However, cesium has been demonstrated at full-scale to remain in the vitrified product at a level of 99.998 % (ORNL 1996). Cerium will be used as it is an excellent representative for

stable species such as plutonium and uranium. Once the demonstration is complete and the vitrified product has sufficiently cooled, samples will obtained of the glass/crystalline product and analyzed. The samples will be submitted for leach testing (TCLP and Product Consistency Testing), Microprobe and direct chemical analysis. These results will be used to compare against established performance criteria for the project.

III.C. Cold Demonstration Cell Configuration

For the cold demonstration, Geosafe specifies that an area 10-ft by 15-ft be excavated to a depth equivalent to the base of the absorption beds (approximately 6-ft deep). This excavation will be used to form the simulated absorption bed to be treated during the "cold" demonstration. Prior to initiating the backfilling process, a trench adjacent to the previously excavated absorption bed area will be excavated from approximately the minus 6 ft from grade depth (the bottom of simulated absorption bed) to a depth of minus 11 ft from grade (see Figures III.1 and III.2). This trench will facilitate the placement of thermocouples (TCs) in the region lateral to and below the absorption bed. The trench shall be constructed to maximize safety and minimize the area that is disturbed by heavy equipment. This is necessary as Geosafe and its contractor will be injecting a starter path directly into the underlying Tuff. To evaluate the injection process accurately for undisturbed soil columns, Geosafe will attempt to design the bed such that the regions where the starter path injection will be performed will not be disturbed during the construction phase. The behavior and thus, the ease at which the starter path material is injected is dramatically different for consolidated versus unconsolidated soils.

During the construction of the simulated absorption bed, TCs will be placed at strategic locations in and around the area to be vitrified to monitor the growth rate of the melt and it's size and shape. The data collected from the TCs will be used to evaluate the melt shape created during processing of the cold demonstration cell and how the absorption bed incorporated into the melt, which will then be used to refine the design of the hot demonstration. For example, the size and shape of the melt might suggest a more optimum configuration for the hot demonstration starter planes. Geosafe's full-scale commercial experience has shown that different soil types exhibit different rates of vertical and lateral melting during the application of ISV. Based upon this experience, Geosafe has proposed what is believed to be the optimum approach to processing the material for the cold demonstration. The Bandelier Tuff possesses a relatively, low, dry density and thus, may exhibit some differences in melting rates compared to previous experience. The cold demonstration will identify the lateral and vertical melting rates and will show how the rock layer in the absorption bed will become incorporated into the melt. In addition to data generated from TCs, the post-demonstration monolith examination will identify if and how the starter planes for the hot demonstration can be configured in a manner that results in optimum processing of the area selected for the hot demonstration. ?

Type K TCs, which can measure continuous temperatures up to approximately 1200°C, will be placed in both vertical and lateral arrays, as well as anchored to select cobble in the absorption

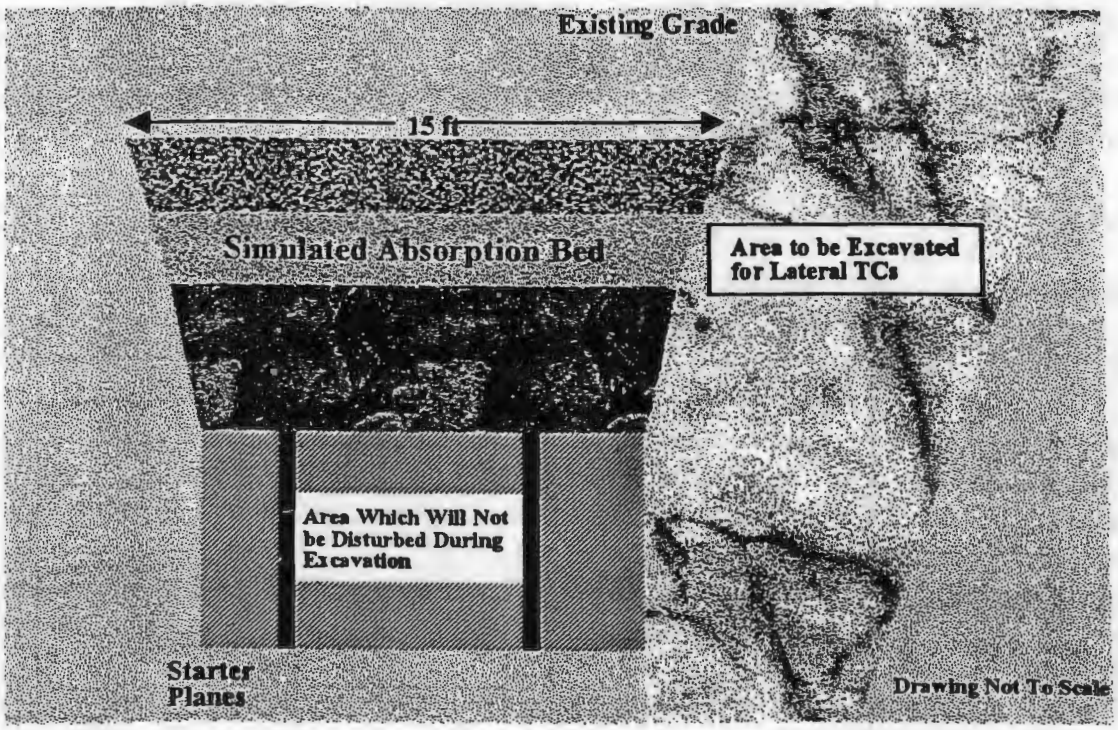

Figure III.1. Construction of Simulated Absorption Bed and Instrument Trenches

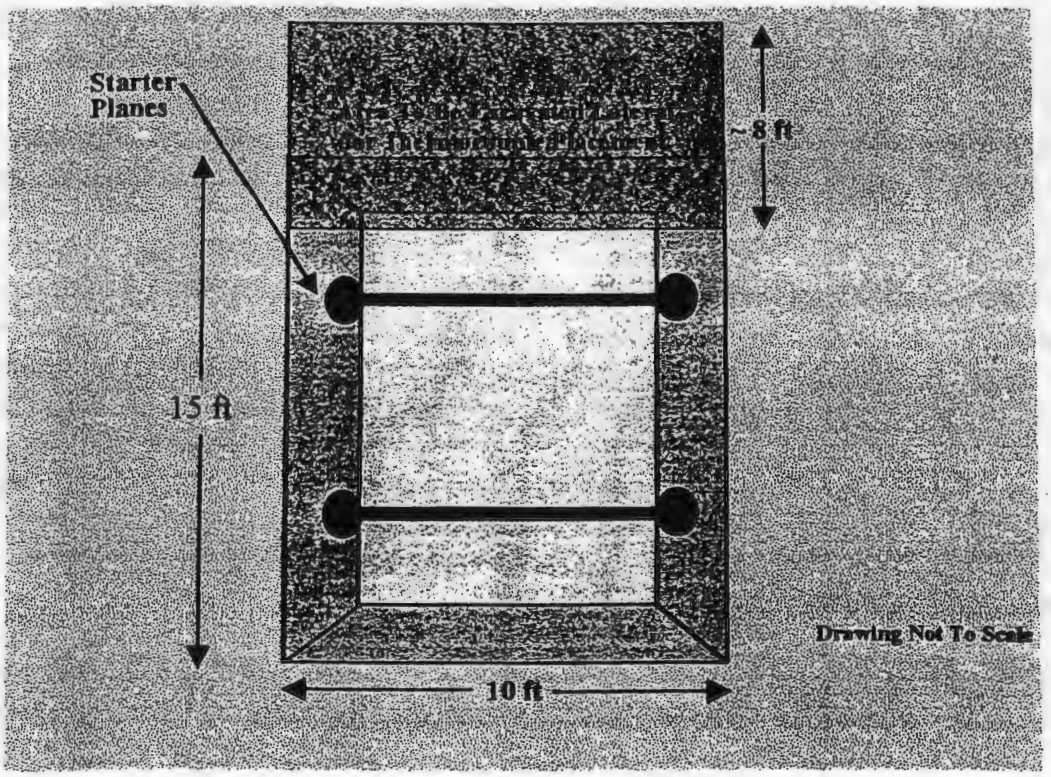

Figure III.2. Plan View of Simulated Absorption Bed Construction

bed. Type K TCs are used predominantly to determine the edge of the melt as their failure temperature coincides closely with the temperature at which the soils begin to melt.

Three vertical arrays of 6 TCs each will be placed to monitor vertical melting within the absorption bed and in the area between the starter planes (see Figures III.3, III.4, and III.5). A vertical bundle will be placed in the center of the absorption bed with the two others being placed 4 ft outward in each direction down the short dimension (10 ft) of the absorption bed. Each bundle will be made of a series of type K TCs separated by a distance of 12 in. The leads

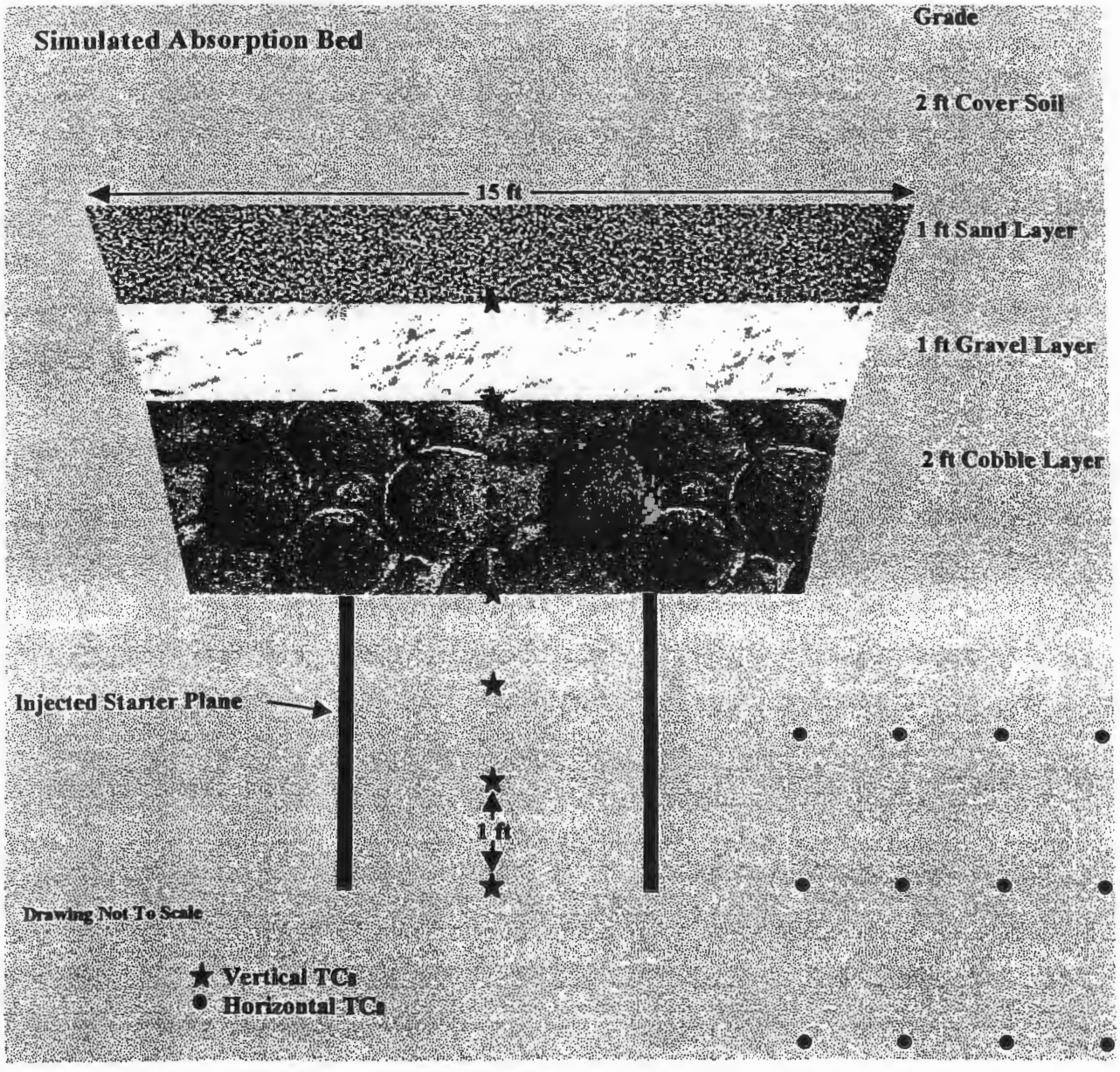

Figure III.3. Thermocouple Layout Plan

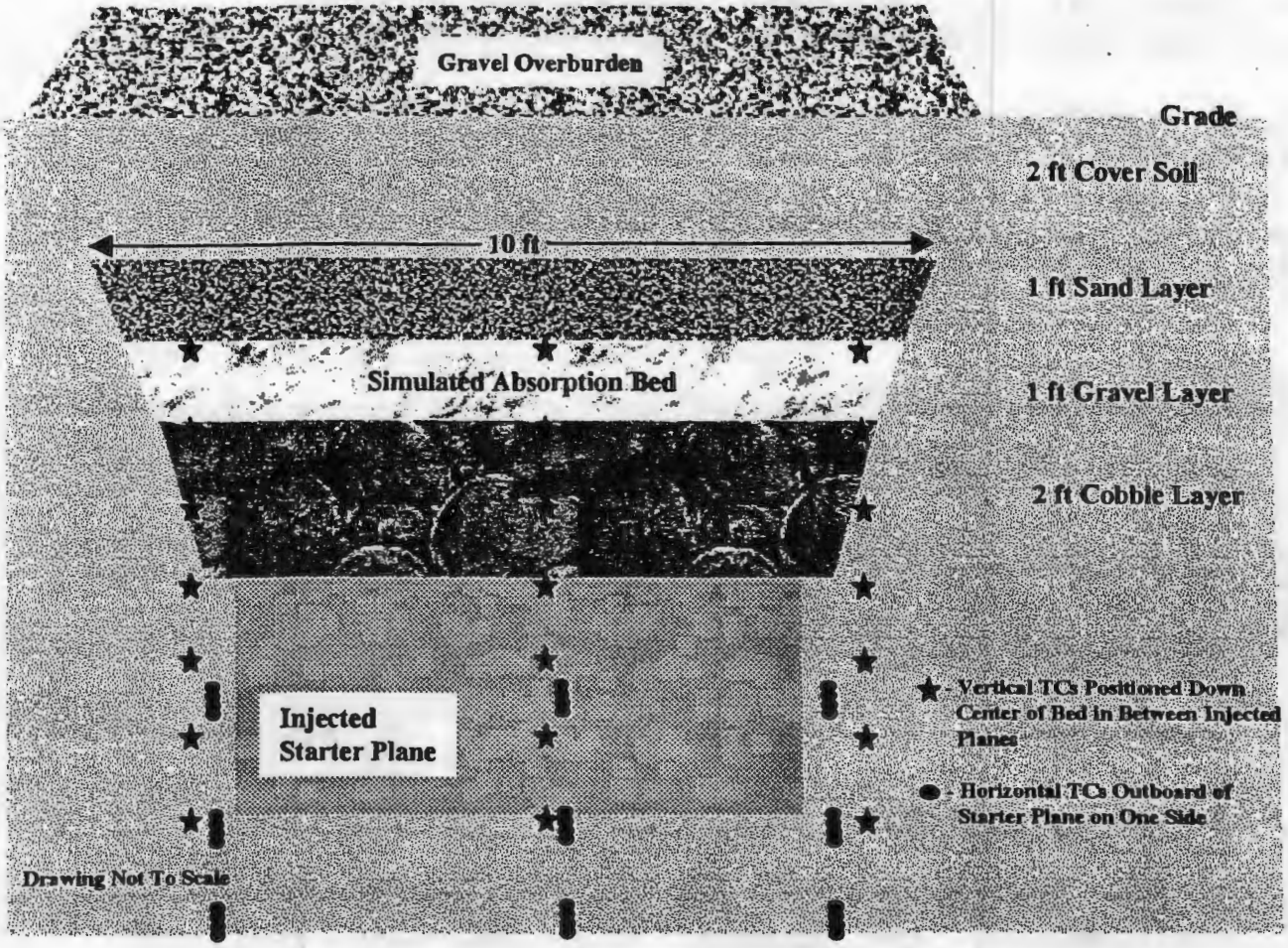

Figure III.4. Cold Demonstration Thermocouple Layout

extending from the TCs will be brought vertically upward between the planes in order to protect the instrument leads from damage due to the high temperatures created during melting.

The lateral bundles will be installed during preconditioning activities performed down the center line between the areas where the starter planes will be injected (see section III.E.). Six lateral TC bundles will be placed on the outer side of one starter plane to monitor the development outward of the melt (see Figures III.3, III.4, and III.5). The nine bundles will be located at three different elevations (i.e., three bundles at a depth equal to 1.5 ft below the bottom of the absorption bed, three additional bundles located at a depth equal to where the bottom of the starter planes will be injected or 3 ft below the bottom of the absorption bed and finally, three more bundles will be placed at a depth of 5 ft below the bottom of the absorption bed. The first TC of each bundle, which is nearest the starter plane in each of these nine bundles will be no closer than 2 ft away to prevent disruption of the tuff. It is important that conditions within the bed and surrounding soils remain as close as possible to that found in the actual absorption beds. Each TC will be interconnected via appropriate instrument cable to a data acquisition system.

The data acquisition system will allow the continuous monitoring and recording of data, as well as facilitating the data transfer into common spreadsheet and graphing software applications.

The placement of the lateral TCs will begin by placing the deepest level first followed by backfilling with native tuff soils up to the next level of lateral TCs. This process will be continued until all of the lateral TCs have been placed. Once the TCs in the region below the absorption bed are placed, the area can be filled to the depth of the bottom of the simulated bed.

Compaction of the tuff material used to refill thetrenches around the TCs will be performed as the area is backfilled filled. The degree of compaction will be determined in the field depending upon several parameters such as nominal particle size, level of natural compaction, availability of equipment, etc,. It is critical that the location and operability of the TCs is not affected by the backfilling or compacting process. The remaining excavation is to be filled with materials similar to that found in the actual absorption beds (i.e., 2-ft layer of cobble with nominal diameter of 3 to 12 in., a 1-ft layer of gravel, and a 1-ft layer of soil/tuff, followed by 2 ft of cover soil). Figures III.1 through III.2 depict the configuration of the cold demonstration cell.

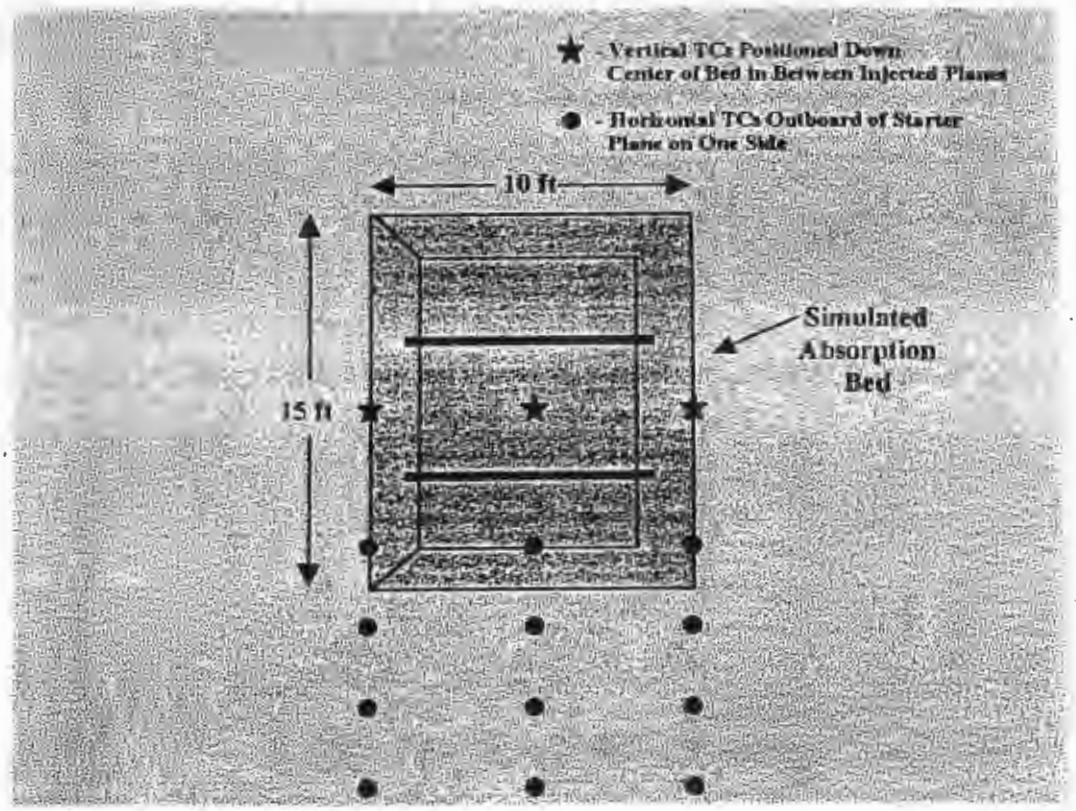

Figure III.5. Cold Demonstration Thermocouple Plan View

Geosafe has been informed that the type of rock in the absorption bed is "granitic" in composition and that LANL knows which quarry it came from. Rock for the demonstration should be obtained from that source. It is critical that the site simulated for the cold demonstration is configured as closely to the actual configuration of the absorption beds.

To confirm that the contents of the simulated absorption bed are incorporated into the melt, six thermocouples will each be securely attached to a large cobble and placed in the simulated absorption bed. These six instrumented cobbles will be distributed in different locations of the simulated bed. As the contents of the absorption bed are fed downward and are incorporated into the melt, the instrumented cobble will move down likewise and be incorporated. This data will indicate the rate at which the absorption bed material is being incorporated into the melt.

The region of the cobble in the simulated absorption bed will contain a quantity of cesium carbonate (Cs_2CO_3) to simulate the presence of the semi-volatile radioactive cesium and cerium oxide (CeO_2) to simulate the presence of uranium and plutonium. The mass of Cs_2CO_3 and CeO_2 to be placed in the simulated absorption bed is typically chosen to be 2 to 100 times the ICP-MS detection limit (DL) for elemental cesium in the vitrified monolith produced in this demonstration (cesium & cerium DL = 0.1 ppm). Due to the fact that the surrogates added to the absorption bed are homogeneously distributed throughout the resultant melt (which will be a large volume than the original absorption bed), it is necessary to place enough surrogate in the absorption bed such that the final melt concentration is significantly above the detection level of the procedure and the background concentration of the native soils.

The amount of Cs_2CO_3 and CeO_2 to be added to the absorption bed will be 6.5 kg and 29.5 kg respectively. The difference in amount of surrogate added is due to the differentbackground level of these naturally occurring material. The background for the cesium was found to be 2.5 ppm whereas for cerium it was 105 ppm. The Bbackground levels of cesium and cerium were determined from samples obtained as a result of previous field activities. In addition actual samples will be collected during preparation of the cold demonstration test area. Details of the sampling can be found in this plan in sections III.L and III.M. The resulting concentration of cesium and cerium in this simulated absorption bed will be significantly greater than the actual concentration of radioactive cesium, plutonium, and uranium present in the actual MDA-V absorption beds.

III.D. Installation of Melt Profile Monitoring Wells

MSE-TA will be performing various melt profile monitoring activities both during and after the cold demonstration. The melt shape monitoring will be performed by using various instrumentation inserted down 50-ft deep boreholes.

Each borehole will be 4 inches in diameter and installed to a depth of 50 feet below ground surface using a method that minimizes bringing drill cuttings to the surface for the methodology used. It is planned that a pneumatic rotary method will be employed. Cuttings will be brought to

WASTE ?

the ground surface during the drilling operation via a vacuum extraction and HEPA filtration system. All cuttings will be containerized in a lined 55-gal drum. Completion of each borehole will consist of flush threaded 2 inch ID PVC well casing sealed at the bottom with a threaded plug and at the top with a plug type cap. The casing will extend from the bottom of the borehole to 1/2 ft bgs and be grouted into the borehole using a cement bentonite grout. Surface completion will consist of a flush mount monitoring well cover set into a cement apron as specified in this scope of work.

MSE-TA will identify all of the borehole locations on site in concert with LANL ER personnel; however, it is expected that the four monitoring wells will be located 360° around the simulated absorption bed. All of the boreholes will be drilled less than 100 feet apart. MSE-TA will provide surveying capabilities from existing surveying monuments located at the site to survey borehole locations and elevations.

III.E. Site Pre-Conditioning

FILL

The Bandelier Tuff is predominantly a cliff-forming formation and is expected to form vertical walls around the melt as the melt experiences subsidence associated with volume reduction. Because of this phenomenon, it is possible that small sections at the edge of the simulated absorption bed would be left untreated if measures are not taken to promote subsidence of the bed edges.

As a result, it will be necessary "break up" the Bandelier Tuff around the edges and below the actual absorption bed to a depth of 10-ft using a vibrating beam prior to placing the electrodes. By breaking up the tuff around the edges of the simulated absorption bed, subsidence of all of the absorption bed walls into the melt will be promoted. Since this approach is the desired method to ensure complete treatment of the hot demonstration absorption bed, this approach will be demonstrated during the cold demonstration. An attempt will be made to disrupt the tuff on three sides of the simulated absorption bed. Disruption around the simulated absorption bed will occur on three sides and down the middle of the bed. The other side of the absorption bed will have already been disturbed as a result of the excavation performed for the thermocouple placement. In addition, vibratory placement of the electrode casings and installation of the starter plane will disturb the remainder of the inner portion both internal to and below the simulated absorption bed. Typical equipment commonly used for this soil preconditioning is either an excavator fitted with a hydraulic hammer and long probe, or a crane supported hydraulic vibrator and steel probe or "H" beam. For this demonstration the latter will be used. Nominally, penetrations every 2 to 4 ft will be made in the area around the simulated bed. This approach will be evaluated after the completion of the cold demonstration. The amount of subsidence and the angle of repose or the degree at which the edge sloughs in will be determined and used in the evaluation for application to the hot demonstration. Figure ~~III.6~~ 4-6 depicts a typical preconditioning pattern.

When preconditioning is occurring directly down the center of the absorption bed as shown in Figure III.6, three vertical bundles of TCs will be placed down the resulting void left by the beam

footprint. Past experience is that each hole will stay open until the adjacent area is preconditioned. During the periods that a hole remains open on each end and in the center of the simulated absorption bed, a bundle of approximately 7 TCs each will be inserted down the hole. As the adjacent preconditionings are done, it is expected that these holes will collapse around the

TC bundles. If one of these holes is the last hole performed then a relatively fine grain material will be used to fill in around the TC bundle.

III.F. Electrode Placement

Four steel electrode casings (16-in. diameter) will be vibrated through the simulated absorption bed to a depth of approximately 4-ft below the bottom of the rock layer. Each casing will be fitted with a nose piece that will prevent soil and other materials from entering the end of the casing. This technique has been demonstrated previously and will be able to penetrate the rock layer in the simulated demonstration areas. Once the steel casings have been placed, the hardened nose piece on the lower end of the steel casings will be knocked out to be left in the subsurface. This process is accomplished by dropping a steel member down the inside of each

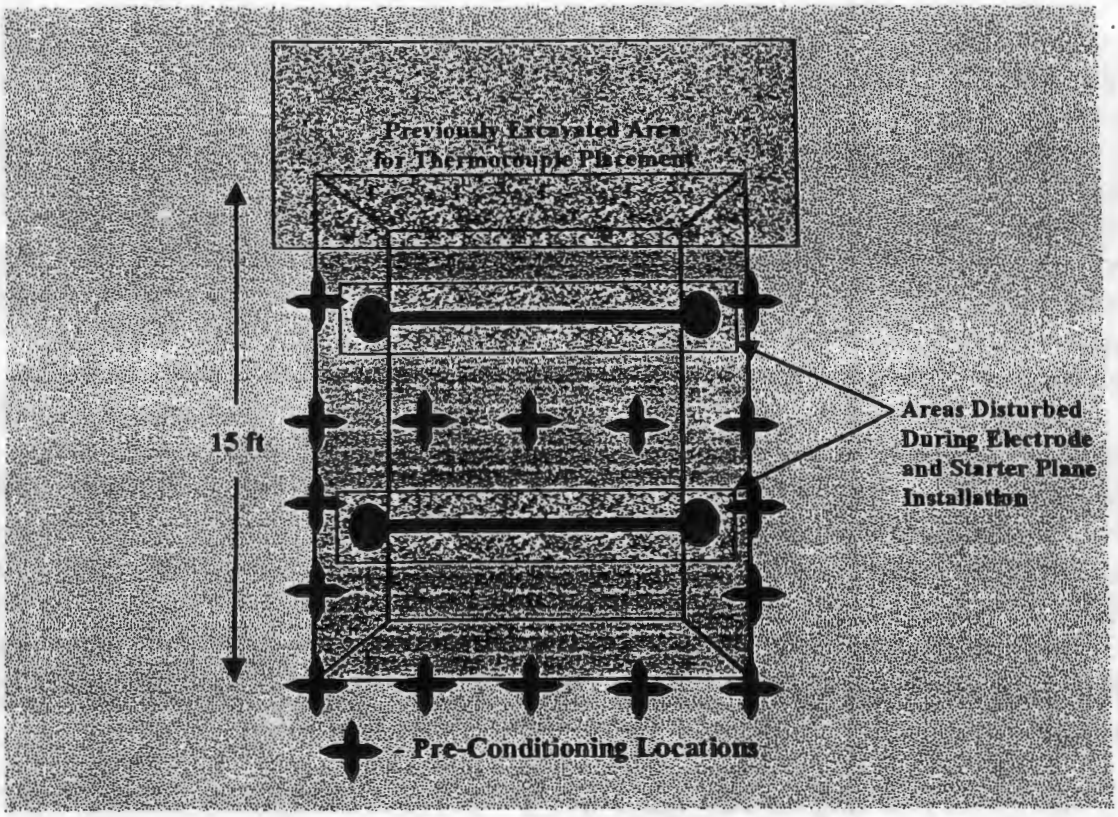

Figure III.6. Typical Preconditioning Pattern Around an Absorption Bed

casing such that it contacts the inside of the nose piece, thus, breaking the spot welds that secure it to the casing. Once this is accomplished, the casings will be with withdrawn slightly to ensure that the nose piece is free. With this confirmed, graphite electrodes will be positioned into and centered within the steel casings. Initially, just two sections of electrodes will be threaded together and placed in the casing. This will allow approximately 2 feet of electrode to stand above grade. Care will be taken to ensure that the electrodes are positioned very close to vertical within the casings. The annular spaces between the electrodes and the casings will then be backfilled with graphite starter material to a depth 3 ft below grade. The casings will then be removed by pulling the casings out vertically over the top of the electrodes. Compaction of the starter material within the casing will be performed periodically as the casing is pulled upward. This is performed to ensure that good contact between the starter material and the electrode is obtained. With the casings removed, visual observations of the annular space should be made by looking down around each electrode. Confirmation will be made that a complete uniform column with a height of approximately 5 ft has been installed 360° around each electrode. The small areas of void near the surface at each electrode will then be filled to grade with native soil/sand.

III.G. Starter Path Injection Parameter Evaluation

Field testing of the injection method will be performed to determine the optimum parameters to achieve proper penetration and placement of the starter material in the soil at the MDA-V. This is not a question of whether or not injection is feasible, as the injection system proposed for the cold and hot demonstrations has been used extensively in a variety of soil conditions. However, the specific performance parameters have not been established for the Bandelier Tuff. Based upon past experience with other soil types, it is anticipated that the efficiency of injecting the starter material will be outstanding. But in order to determine how far the starter material can be injected away from the injection nozzles, a test will be performed prior to performing the injection of the simulated absorption bed. This test will involve injecting starter material into soil in the vicinity of the cold demonstration location and then excavating the injected area to inspect the starter material placement. By establishing the effective distance that starter material can be injected into the soil from a borehole on site, the optimum distance between the casings can be determined. After the injection is complete, the small area will be exhumed to look at penetration distance and homogeneity of the starter material. This inspection will enable determination of the proper spacing and pressures to be used during injection of starter planes in the cold and hot demonstration areas. It is expected the injection test will be performed at the same depth as the actual injection of the starter plane (i.e.: 6 to 9 ft bgs)

The equipment will then be moved to the simulated cold demo adsorption bed and set-up for injection of the starter planes.

III.H. Cold Demonstration Starter Plane Injection

Geosafe has chosen to initiate the NTISV process for the demonstrations by injecting two conductive, vertical starter planes immediately into and below the absorption bed. These planes will be used to initiate the vitrification process. As vitrification progresses, the contents of the absorption beds and the soil below the absorption beds will be treated. The same injection method will be employed to place the starter planes for the hot demonstration. The procedures anticipated for the hot demonstration will be followed to prepare and vitrify the material in the cold demonstration. Demonstration of the NTISV technology on a simulated absorption bed using the same procedures anticipated in the hot demonstration will provide a high level of confidence that the technology can be applied in the hot demonstration over a bed area of 20 by 30-ft.

The conductive starter planes will be injected into the subsurface using a high pressure injection system. This system has the capability to inject a variety of solid materials up to 6-ft from the injection nozzle radially out into soil. The purpose of the starter planes is to establish conductive paths connecting the electrodes. These conductive paths carry the initial electrical current and initiate the joule heating process in the subsurface.

The system to be used to accomplish the starter plane injection includes: (1) a diesel hydraulic track drill with angle drilling capacity, (2) a high pressure liquid and slurry pump, (3) an intermediate pressure liquid and slurry pump, (4) a high pressure and flow air injection compressor, (5) coaxial drilling pipe, (6) a down the hole air or liquid driven drill and drill bit module, (7) jet grout drilling subs, (8) grout continuity instrument probes, (9) bulk handling lift vehicles, and (10) vibratory hammer/extractor.

Generally, the injection is accomplished by first performing vortex colloidal mixing of the bulk components (graphite starter material and sodium silicate carrier solution). This prepares the injection materials for introduction into the soils. Ultra high pressure (up to 10,000 psi) pumping of the resulting slurry is then accomplished with either a triplex diesel mechanical pump or a diesel hydraulic piston pump. The slurry is carried from the pressure pump to injection nozzles via uniaxial or coaxial drilling pipe. Actual injection into the soil column is performed by passing the slurry through a small diameter orifice which induces cutting and displacement of soil/tuff material followed by injection of starter path solution into the void area.

Due to the soil type and stratigraphy of the site, it is a possibility that fractures of the tuff material may be encountered in the vicinity of the injection areas. If fractures are encountered, hardeners will be injected along with the starter material to plug the porous pathways. This situation is not expected to cause a significant problems with the injection process

Once the electrodes are in place, the injection nozzle will be vibrated into the soil vertically to the 9ft bgs depth. The injection nozzle locations will be positioned on approximate to 1-ft centers (depending upon the results of the parameter evaluation) connecting the two pairs of

electrodes parallel to the long axis of the absorption bed. Once the nozzle is vibrated to the appropriate depth, high pressure injection will occur as the nozzle is pulled upward. The nozzle will form a vertical bow tie configuration as it is pulled upward to the 6 ft bgs depth, at which time injecting will be stopped. Each bowtie that is formed between the electrodes will be joined with the previous injection. Confirmation that the pathway is continuous and conductive will be performed by testing the conductivity after each injection. If the conductivity between the electrodes is not adequate to initiate a melt, then additional starter material will be injected until an electrical connection has been established. As each successive casing is used to inject starter material, a conductive plane will be built connecting the two pairs of electrodes.

III.I. Cold Demonstration Setup Completion and Melt Processing

Preparation of the cold demonstration area will include the installation of: 1) the melt monitoring wells, 2) the electrodes, and 3) the starter planes. Once these activities are completed, then a 2 ft layer of 7/8-in. gravel will be placed over the cold demonstration cell. This material will be used as overburden to feed into the subsided area as the underlying bed materials are incorporated into the melt. The overburden helps increase the efficiency of the process by reducing heat loses into the hood environment. The overburden layout can be seen in Figure III.4.

In parallel with the installation of the starter planes, the off-gas hood assembly will begin in a level location adjacent to the cold demo site. Initially, the hood assembly will include interconnection of the superstructure and legs and lifting the hood to its functional height. Once this is completed and the overburden placed, the hood will be aligned over the demonstration area and the hood panels and other equipment such as electrode feeders will be installed. Once the hood assembly is completed, the off-gas piping and electrical and instrument cables will be connected and each component tested for operability. After the entire system has been readied, a complete system check-out coupled with a Geosafe Management walk through will be performed to ensure readiness. Following approval to proceed, the melting process will be initiated. Geosafe employs a graduated power-up schedule that allows the starter planes to heat up and begin melting soil and materials in a controlled fashion. As the melt volume grows with time and power input, the power level is increased to continue the melting process. The power up for the cold demonstration will occur over an estimated 20-hr time period. Table III.1 shows a typical power schedule for this scale of test. The size of the cold demonstration has been scaled down compared to the hot demonstration in order to save costs. As a result, the power levels applied will also be scaled back (anticipated at ~ 2MW total power input.

III.J. Process Monitoring

During the melting process, temperature data from the thermocouples, power level and consumption data and process observations will be recorded. A closed-circuit camera will enable operators to continually observe the conditions inside the off-gas hood. The camera will be

connected to a video tape recorder and recorded for the duration of the melt. A light will be installed the hood to make it possible to see the soil surface.

The off-gas stream which consists primarily of air pulled into and through the hood will be continuously monitored for CO, CO_2, O_2, total hydrocarbons and temperature at the point where it is released to the atmosphere. Off-gas monitoring for contaminants or radionuclides will not be performed during the cold demonstration nor will it be monitored for the surrogate metals.

The thermocouple data taken from within the soil will be recorded by an Advantech Adam 5000 data acquisition system at 5 minute intervals throughout the course of the demonstration.

Electrical data (primary and secondary voltage, current, and power), off-gas system data (pressures, temperatures, scrub water parameters, and stack gas concentrations), and hood data (temperature and vacuum levels) will be electronically recorded by the DataVue data collection system at 10 second intervals throughout the course of the demonstration.

Each of these data will also be recorded manually at one hour intervals for the duration of the demonstration. Electrode depth measurements will also be taken and manually recorded at one hour intervals.

III.K. Cold Demonstration Duration and Shutdown Criteria

The demonstration will be terminated when the electrodes reach a depth of 22 ft below grade. The termination depth will be determined by monitoring the electrode insertion depth. Once the termination depth is reached, power to the melt will be terminated and the system shutdown. The cold demonstration will require up to 192 hours of operation. The off-gas system will be operated for additional 2 hours after turning power off or as specified by the project manager.

III.L. Cold Demonstration Sampling and Data Collection

Samples of soils targeted for melting during the cold demonstration will be collected and subjected to geochemical characterization prior to commencement of the demonstration. In addition, the samples collected for geochemical analysis will be analyzed for the surrogate metals to establish background levels. The chemical composition of the materials to be vitrified affects melt temperature, melt viscosity, mass of off-gas generated from fusion, characteristics of the off-gas (e.g., pH) and electrical conductivity of the melt. These characteristics are all important to establishing proper operational parameters. Details of the planned sampling are provided in the following section (Section III.M. Cold Demonstration Sampling and Analytical Plan).

The constituents examined during the bulk chemistry analyses are typically present in the percent levels. Therefore, the pre-demonstration soil sampling for bulk chemistry will be performed using a shovel or similar tool that has been rinsed clean with water. These samples will be collected during excavation of the cold demonstration area.

Table III.1. Cold Demonstration Power Schedule

Time Schedule (hr)	Power Input Per Phase (kW/phase)	Time Schedule (hr)	Power Input Per Phase (kW/phase)
0.00-0.5	5	15-15.5	355
0.5-1	10	15.5-16	370
1-1.5	20	16-16.5	390
1.5-2	25	16.5-17	420
2-2.5	35	17-17.5	440
2.5-3	45	17.5-18	460
3-3.5	55	18-18.5	480
3.5-4	65	18.5-19	500
4-4.5	75	19-19.5	520
4.5-5	85	19.5-20	540
5-5.5	95	20-20.5	560
5.5-6	105	20.5-21	580
6-6.5	120	21-21.5	600
6.5-7	130	21.5-22	620
7-7.5	145	22-22.5	640
7.5-8	155	22.5-23	660
8-8.5	175	23-23.5	680
8.5-9	180	23.5-24	700
9-9.5	190	24-24.5	720
9.5-10	205	24.5-25	740
10-10.5	220	25-25.5	760
10.5-11	230	25.5-26	780
11-11.5	245	26-26.5	800
11.5-12	260	26.5-27	830
12-12.5	275	27-27.5	860
12.5-13	285	27.5-28	890
13-13.5	300	28-28.5	920
13.5-14	310	28.5-29	950
14-14.5	325	29-29.5	980
14.5-15	340	29.5-30	1010

The results of the analyses of the components to be used in the demonstration will then be used in a geochemical model that numerically mixes the components (cobble, gravel, soil) in the proportions expected in the field and predicts the resultant product composition. This resultant composition will be used to predict melt temperature, viscosity and approximate electrical conductivity. It will also be used to predict approximate crystallization behavior upon cooling.

The sampling locations will be selected at the site in an effort to provide samples that are likely to be representative of the materials to be vitrified during the hot demonstration. The samples will be placed into 9-oz pre-cleaned sample containers and sent to Chemex Laboratories in Sparks, NV for whole rock analysis. A whole rock analysis will be used to quantify the bulk composition of the soil and other materials to be treated.

The samples of vitrified material will be analyzed using various techniques including chemical analysis and leach testing (for the surrogate metals), electron microprobe analysis, and physical characteristics. Approximately one week after the completion of the cold demonstration, the surface of the vitrified mass will be uncovered using excavation equipment to accelerate the cooling process. After approximately two weeks, additional excavation can be performed to expose the edges of the vitrified mass for visual assessment. At this point the size and shape of the monolith can be determined. In addition, an inspection of the degree of overburden incorporation will be performed. This primarily will be a physical inspection wherein the amount of overburden originally present is quantified. The difference between the amount left after the test and what was originally present will be the amount that was incorporated during the demonstration.

Once adequate cool-down time has been reached a long reach excavator will be used to safely uncover a portion of the ISV block to make visual and photographic examination and evaluation of the melt. No personnel will be in close proximity of the hot surfaces or soils during this work. The post-demonstration sampling of the vitrified product will consist of breaking the vitrified product first with heavy equipment and bringing large sections of the vitrified product to grade. Smaller pieces of the large sections will then be created using a hammer or other similar tool. Only pieces of the material that have not touched the tool will be collected as samples. The samples will be collected from various locations in the vitrified monolith. These locations will be selected in the field. Five composite samples will be collected, all of which will be located greater than 1-ft from the edge of the monolith and located greater than 2-ft from any other sampling location. The samples will be placed into 9-oz pre-cleaned sample containers and sent to Chemex Laboratories in Sparks, NV for analyses. This work will employ practices and equipment which will not expose personnel to thermal exposure risk. Table III.2 summarizes the sampling and analytical plan for the cold demonstration.

There will be several techniques employed to assess the mass of the vitrified block produced in this demonstration. These include partial excavation after completion of the demonstration to estimate block dimensions plus the usual estimate provided by the combination of energy usage and electrode depth. The cold demonstration will also employ the use of a non-volatile tracer

material placed in the bottom of the absorption bed. Post-demonstration samples of the block material will be used to, among other things, determine the concentration of these tracer materials. If the assumption of homogeneous mixing is made (and the years of previous testing support this hypothesis), one can use this concentration, together with the known quantity of material staged, to estimate the volume of the block produced. The corresponding block mass can then be estimated assuming an appropriate density for the vitrified material.

The tracer material must have several properties for this technique to be useful. It must be non-volatile, be readily incorporated into the glass matrix, and must be present in very low concentrations in the native soil. The exact tracers to be used will be determined once an elemental analysis of the actual LANL tuff material has been obtained.

III.M. Cold Demonstration Sampling and Analytical Plan

The goal of the sampling and analytical plan is to provide representative and statistically valid data for the evaluation of the NTISV process for treating the absorption beds, as well as other applications within the DOE complex. In order to achieve this goal, adherence to strict protocol is required as provided in this section. Geosafe-generated demonstration and sampling plans follow the quality checks and requirements of EPA SW-846, including provisions for sampling accuracy, precision, representativeness, and completeness. Thorough steps are outlined below in regard to sample acquisition, quality control, field sampling, and handling & sample analysis.

Table III.2. Cold Demonstration Sample Quantities and Analysis Protocol

Samples	No. Of Samples Taken	No. Of Samples Analyzed	Analytical Method
Cesium and Cerium Analyses			
Pre-demo Tuff	10	5	6010
Vitrified Product	5	4	XRF & ICP/MS
Product Volume Determination (X and Y Analyses)			
Pre-demo Tuff	1	1	6010
Vitrified Product	2	2	XRF
Leach Testing			
Vitrified Product	5	5	TCLP & PCT
Whole Rock			
Tuff	5	5	XRF
Cobble	2	2	XRF
Gravel	2	2	XRF
Vitrified Product	5	5	XRF

These methods have been incorporated to ensure that the methodology for collecting and testing representative samples is followed, that the quality control procedures are in place to evaluate the information content of the analytical data, and to determine the necessity or the effect of corrective action procedures.

The sampling and analytical procedure outlined in this plan is primarily targeted at the cesium and cerium tracer materials. Thus, pre-demonstration soil sampling and post-demonstration vitrified product sampling will be performed to determine the disposition within the product, as well as the leachability of the product for the two surrogates used.

All samples generated as a result of this demonstration will be labeled with the operator's initials, date, time, and sample description. The following sections provide sample storage requirements, sample custody protocol, sampling equipment and technique, sampling equipment decontamination procedures, and sample composite procedures to be used during to performance of this demonstration.

III.M.1. Sample Handling Techniques

III.M.1.a. Sample Storage Requirements

The sample storage requirements for samples taken during the demonstration are for all samples to be placed in specially cleaned glass or plastic containers provided by the chosen analytical laboratory and stored in secured ice chests. All samples to be analyzed for chemical characteristics shall be sent via overnight delivery to the laboratory. Additional samples not analyzed will be held from time of collection by the analytical laboratory until data review and issuance of the final report. Metal analyses have allowable holding time of 6 months.

III.M.1.b. Sample Custody Protocol

Sample custody will be the responsibility of Geosafe personnel from the time of sample collection until the samples are shipped to the analytical laboratory. Thereafter, custody will be maintained by the laboratory.

Samples will be kept in appropriate containers and labeled to uniquely identify each sample. A Field Sampling and Collection Form will provide an inventory and field sampling record for each sample collected during demonstration operations. A Chain of Custody Record Form will provide the formal custody record. The Request for Analysis Form documents the required analyses to the sender and the laboratory. Sample Labels and Custody Seals are also used to ensure proper identification and security of the samples as the custody changes during the project. Every sample sent to the laboratory for analysis has a typed analytical result which serves as the final stage of the custody and documentation record for the sample. All process and analytical data and records are considered to be part of the project records as described in

Geosafe's Quality Assurance Procedure (QAP-15), which establishes the methods for storage, maintenance, and retrieval of all project activity records.

Samples will be kept in an ice chest, as appropriate, and will be shipped to the analytical laboratory in a secured chest. Chain of Custody forms will be handled as follows:

- one copy retained by the sampling team
- one copy provided to the Geosafe Project Manager
- original included with the sample shipment
- one copy retained by the analytical laboratory.

The laboratory custodian, after taking inventory of each shipment, will sign and date the original custody form. A note will be made on the custody form of any discrepancy in the samples. A log in which all samples are recorded and described will also be maintained. The samples will be maintained in custody until the final report is submitted and approved.

III.M.2. Sampling Equipment and Technique

III.M.2.a. Stainless Steel Soil Trier

A trier consists of a stainless steel tube cut in half lengthwise with a sharpened tip that allows the sampler to cut into sticky solids and loosen the soil. The trier size must be at least twice the

diameter of the particle size obtained. The following procedure shall be utilized for obtaining soil samples:

1. Clean the trier according to the steps outlined in Section III.M.2.c.
2. Insert the trier into the soil at angle of 0 to 45° from the vertical. Rotate the trier to cut a core of the material. Remove the trier with the concave side up.
3. Transfer the sample to the sample jar using a stainless steel spatula.
4. Clean the trier and spatula label and store the sample.

Alternative Soil Sampling Approach for Excavated Areas

1. Procure sample containers that have been pre-cleaned and certified per EPA protocols.
2. Identify areas to be sampled and using the sample container as a scoop, obtain adequate sample. Alternatively, a cleaned metal scoop or trowel can be used to obtain the sample.
3. Store the sample.

The samples shall be obtained from the sample grid locations as described in SW-846 for obtaining random unbiased samples. It should be noted that multiple triers or other collection devices of the same dimension and construction can be used in order to avoid time consuming

decontamination procedures. However, once a single trier or other collection device is used, it must be decontaminated before obtaining another sample.

III.M.2.b. Vitrified Product Sample Equipment

Sampling of the vitrified product shall be performed once the melt has cooled adequately. Caution should be used in handling the material due to its potential of being thermally hot and possessing very sharp edges that develop as a result of breaking.

1. Spread a 10 x 10-ft plastic sheet on a flat surface, centered on the vitrified block, and secure the area from any personnel.
2. Use heavy equipment to break large pieces of the block off and to lift the pieces up to grade level. If cool enough, place the large pieces on the plastic, otherwise, allow to cool before proceeding.
3. Don protective clothing as specified in the Safety Plan, particularly full faceshield, eye protection, and leather gloves.
4. Use a hammer to break of smaller pieces of the block.
5. Obtain select glass pieces (approximately 2 x 2 x 2-in) and place in glass containers provided by the laboratory per EPA SW-846 protocols. Obtain pieces of glass that have not come in contact with the hammer. Use teflon coated or stainless steel forceps for handling the samples. Alternatively, disposable rubber gloves can be used over leather gloves to select and transfer the samples to the containers. Caution should be used as the samples may be hot and have very sharp edges. Change-out of the rubber gloves should be used for each sample.
6. Seal and label samples accordingly, note approximate locations within the block.

III.M.2.c. Sampling Equipment Decontamination Procedure

All sampling instruments (soil trier, spatula, forceps) will be decontaminated prior to and in between each sample to prevent cross-contamination according to the following steps:

1. Wipe excessive contaminant (dirt, grease, etc.) off with a towel or cloth soaked with soapy water, as appropriate for the contaminant (metals, in this case).
2. Wash with alconox until all visible contaminant has been removed.
3. Rinse three times with deionized or distilled water.
4. Wipe with clean laboratory wipes to remove any excessive water and air dry.

III.M.2.d. Sample Composite Procedure

The following procedure should be followed when compositing of soil samples is required:

1. Obtain a large clean stainless steel mixing bowl.
2. Place equal volume aliquots of all samples required for the composite sample into the mixing bowl. The soil/sample material should be removed from its original sample

container through the use of a disposable wooden tongue depressor. Each sample should have its own tongue depressor in order to prevent cross-contamination between samples.

3. Thoroughly mix the soil/sample material in the bowl using a clean stainless steel spatula.
4. Remove sample from mixing bowl and place in sample jar.
5. Decontaminate mixing bowl and spatula and dispose of tongue depressors prior to compositing next sample.

III.M.2.e. Wipe Sampling Procedure

Wipe sampling equipment consists of wiping a cheesecloth across a desired surface using teflon-coated forceps or clean laytex gloves to handle the cloth. The following procedure shall be used for obtaining every wipe sample:

1. Don clean unused disposable latex sample gloves.
2. Obtain cheese cloth and fold in half three times
3. Obtain clean forceps and grasp cloth with the forceps, approximately 1 cm for and parallel to the triple folded edge.
4. Saturate the cloth with appropriate solvent.
5. Wipe surface sample vertically and horizontally (two swabs each direction).
6. Each swath is 5.5 cm wide, overlapping 0.5 cm (this method of wiping surface areas provides a consistent area of 100 cm^2, if desired, and eliminates cross-contamination of surface areas).
7. After the surface area has been wiped, any torn fragments from the cloth remaining on the sample surface are dabbed off using the cheese cloth to prevent loss of recovery from the sample area.
8. The cloth is then placed in an 8-ounce glass sample container and labeled appropriately. The forceps are held over the mouth of the sample jar and rinsed with hexane, collecting the rinsate in the jar to remove any residual surface contaminant that may have been picked up by the forceps.
9. Prior to obtaining the next sample, the cleaning procedure is repeated and new sample gloves are donned.

III.M.3. Statistical Equations for Representative Sampling

The following equations shall be used to calculate the mean concentration, the standard deviation, and the confidence interval for the samples obtained in the cold and hot demonstrations. The equations given are adopted from the "Test Methods for Evaluating Solid Wastes" (SW-846), 3rd Edition, Volume II, Chapter Nine. The equations are:

<u>Mean Sample Concentration:</u>

$$x = \sum_{i=1}^{n} X_i/n$$

where: X_i = individual sample measurement
n = number of sample measurements.

Standard Deviation:

$$s^2 = \sum_{in=1} X_i^2 - (\sum_{i}^{n=1} X_i)^2]/n]/n-1]$$

$$s = (s^2)^{0.5}$$

$$s_x = s/(n)^{0.5}$$

Confidence Interval:

$$CI = x + t_{20}s$$

where: t_{20} = student t value (for n=4 samples, t = 1.638)

Number of Samples:

$$n = (t^2_{20}s^2)/(RT-x)^2$$

where RT = regulatory threshold value.

III.M.4. Cold Demonstration Sampling

The primary analyses to be performed prior to and after the cold demonstration are for non-radioactive cesium and cerium.. In addition, selected analyses for the materials added to allow determination of the melt volume will be performed. The type, number of samples taken, number of samples analyzed, and the necessary analytical method required for the project are presented in Table II.2. Details regarding the sampling plan for each type of sample are discussed further below.

III.M.4.a. Pre Cold Demonstration Sampling

All of the materials used in this demonstration shall be obtained from uncontaminated sources. Tracer compounds will be used to simulate radioactive cesium and non-volatile radioactive species such a plutonium and uranium and to assist in the determination of the vitrified product volume. Although it is unlikely that these uncontaminated pre-demonstration materials will contain significant amounts of the chosen tracer, the pre-demonstration materials will be sampled for these compounds prior to beginning processing.

III.M.4.a.i. Pre Cold Demonstration Soil Sampling

Samples of the site soils (tuff material) will be collected during the simulated cold absorption bed fabrication and analyzed for the tracers chosen. The soils excavated for the absorption bed will be randomly sampled per the instructions provided in section III.M.2 for obtaining the samples and decontamination of the sampling equipment. The sample results will be used to determine if any of the surrogates are present and if so, to determine baseline values with which to compare post demonstration results.

These samples will be labeled and analyzed as follows:

Sample No.	Parameter	Method	Detection Limit
NTISV-SS-01 through NTISV-SS-8 Plus NTISV-SS-9	metals	6010	0.1 mg/kg

A split sample will be taken of NTISV-SS-01 and will be labeled NTISV-SS-9. Samples NTISV-SS-01 through NTISV-SS-05 and NTISV-SS-9 will be analyzed for cesium and cerium initially. Upon completion and receipt of the analytical results, the sample mean, variance, and 80 percent confidence intervals will be calculated and verified that 5 samples are sufficient to calculate the 80 percent confidence interval for metals; however, no additional samples or analyses are anticipated to be obtained or performed. Section III.M.3 provides the equations for calculating the parameters listed above. Sample NTISV-SS-01 will also be analyzed for the melt volume determination tracers. Sample materials will be archived after analysis, until completion of the project, in the event additional analysis of some samples is required.

After the laboratory results are reviewed, if the statistical variance in the analytical results indicate that a larger sample population size is needed, the required number of additional samples (as archived and available) will be analyzed and a new mean and variance calculated. The procedures provided above will be continued until the 80 percent confidence interval is obtained, as required to meet project objectives or as directed by project management.

III.M.4.a.ii. Natural Oxide Content of Soil (Whole Rock Analyses)

The geochemical properties of materials to be treated by ISV are an important factor to be considered when evaluating ISV applicability. Chemical composition of the materials to be vitrified affects melt temperature, melt viscosity, mass of off-gas generated from fusion, characteristics of the off-gas (e.g., pH) and electrical conductivity of the melt.

A whole rock analysis is used to quantify the bulk composition of the soil. Performing the whole rock analysis also provides the silica, aluminum, iron, and calcium content. Particular attention

is paid to the concentration of glass-forming ions, and ions which serve as fluxing agents in the melt. The monovalent alkali cations (Na^+, Li^+, K^+) provide electrical conductivity in a silicate melt. The conductivity of the melt is generally proportional to the concentration of these ions, but variations occur because of the complexity of multi-component systems such as in soil. Experience in melting various soils has shown that if the sum of the monovalent alkali cations is within the range of 2 to 5 wt%, ISV processing proceeds without electrical difficulty. The presence of cations such as Na^+ and Ca^{+2} also reduces the viscosity of the melt by physically separating the glass-forming cations and reducing the number of glass-forming bonds in the melt. Therefore, the addition of sodium as an electrical flux also reduces melt viscosity and operating melt temperature.

Prior to initiating any vitrification project, the bulk chemistry of each waste component (e.g., soil and other site materials) to be treated is analyzed. These analyses are then used in a geochemical model that numerically mixes the components in the proportions expected in the field and predicts the resultant product composition. This resultant composition can then be used to predict melt temperature, viscosity, and approximate electrical conductivity. It can also be used to predict crystallization behavior during cooling.

The temperature/viscosity prediction is made using the method developed by Shaw (Viscosities of Magmatic Silicate Liquids: An Empirical Method of Prediction, H.R. Shaw, Amer. J. Sci.272:870-893). This method has been found to be accurate to within 50°C of predicting melt operating temperatures for ISV applications provided the composition being evaluated is similar to natural magmatic compositions.

Samples will be obtained from the excavated tuff material, as well as of the cobble and the gravel used in making the simulated absorption bed. These samples will be analyzed using X-ray fluorescence and will be labeled NTISV-TWR-01 through -05 and NTISV-CWR-01 through -05 and NTISV-GWR-01 through -05, respectively.

III.M.4.b. Cold Demonstration Off-Gas Monitoring

Air pulled through the hood and treated via Geosafe's off-gas treatment system will be monitored prior to release to the environment. The air will be sampled during the demonstration for the following parameters:

- carbon monoxide (CO),
- carbon dioxide (CO_2),
- oxygen (O_2), and
- total hydrocarbons

No off-gas sampling will be performed for contaminants or for the surrogate compounds added.

III.M.4.c. Post-Demonstration Sampling

After the ISV melt is complete, samples will be collected from the vitrified block. The analytical protocol listed in Table III.2 defines the number of samples, the analysis parameters and the EPA methods to be used.

All samples should be obtained under the procedures set forth in Section III.M.2 of this Demonstration Plan. The sampling procedure is a random sampling scheme adopted from the Environmental Protection Agency's SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition, Volume II, Chapter Nine. In addition, all statistical calculations will be made in accordance with the guidelines specified in SW 846, Vol. 2, Chapter 9.

III.M.4.c.i. Analyses of Tracers Remaining in Vitrified Product

Once the vitrified product has cooled sufficiently, sampling of the vitrified product will be performed. The block will be sampled by breaking and removing large sections of the vitrified product and then performing the sampling approach outlined in Section III.M.2.b. Glass sample locations will be determined to ensure that all samples are taken no closer to the melt edge than 1-ft and at least 2-ft from any adjacent sample. A total of five samples will be obtained from the vitrified product which will be labeled as follows:

Sample No.	Parameter	Method	Detection Limit
NTISV-GB-01 through NTISV-GB-05 and NTISV-GB-06	metals	XRF & ICP/MS	0.1 mg/kg

Submit samples NTISV-GB-01 through NTISV-GB-05 for metals analyses listed above. In addition, one QC sample will be split into two halves and analyzed for the metal tracer. The blind split QC sample will be labeled NTISV-GB-06. The sample locations will be determined to provide both samples near the center and outward to within one foot of the melt edge.

Samples of the vitrified block will also be collected and analyzed for the melt volume determination. These samples will be labeled NTISV-GB-10 and NTISV-GB-11.

Sample No.	Parameter	Method	Detection Limit
NTISV-GB-10 through NTISV-GB-11	Surrogate metals	XRF & ICP/MS	0.1 mg/kg

III.M.4.c.ii. Product Leach Testing

Samples will also be collected of the vitrified product and submitted for leach testing using the Product Consistency Test (PCT) and Toxic Characteristic Leach Procedure (TCLP). Samples NTISV-LT-01 through NTISV-LT-05 shall be submitted for the following analyses:

Sample No.	Parameter	Method	Detection Limit
NTISV-LT-01 through NTISV-LT-05	metals	PCT & TCLP	0.1 mg/kg

IV. Phase III (Hot Demonstration)

IV.A. Introduction

Phase III of the project primarily consists of mobilizing and performing a hot demonstration in one of the actual absorption beds at MDA-V. Optimization of the approach used during the cold demonstration will be made as a part of the Phase III effort. This will include evaluating the performance, making changes, and then documenting any changes made to the NTISV system. Also, the differences in how the field operations will be implemented when compared to how the work was performed for the cold demonstration will be documented and field preparations will begin. Geosafe will assist LANL in modifying the health and safety and quality assurance plans (if required) and provide assistance in LANL's interface with state and federal regulators in an effort to secure appropriate permits and approvals.

The remainder of Phase III will consist of conducting the hot demonstration, evaluating the results of the demonstration and reporting these results.

Hot Demonstration Objectives

The objectives for the hot demonstration are similar to the objectives for the cold demonstration in some areas and more comprehensive in other areas. These objectives include:

- Taking the information and data gathered from the cold demonstration and applying that knowledge to optimize the performance and technical value of the hot demonstration,

- Evaluate the fate and transport mechanisms that take place and that affect the metals, organics and radionuclides present in the absorption pit. This will include a comprehensive evaluation of off-gas composition and composition relative to discharge regulations, residual components (if any) present in surrounding soil following the demonstration, distribution of contaminants in the vitrified material and an evaluation of the chemical durability of the vitrified material,

- Demonstrate the usefulness of this technology and the ability to apply the knowledge gained from the cold and hot demonstrations to other waste treatment issues at LANL and other DOE installations,

- Assure that the performance of the NTISV system and the results of the hot demonstration will meet or exceed federal, state, and local regulations, H&S goals, and QA goals,

- Process all of the targeted materials in the absorption bed using NTISV to achieve a vitrified mass that exhibits acceptable chemical durability,

- Characterize the vitrified product, and

- Produce costing data to enable evaluation of the $800/ton large-scale remediation processing cost goal.

IV.B. Hot Demonstration Strategy and Conceptual Design

The NTISV will be demonstrated on an actual waste site after review of the cold demonstration results. The site selected for the hot demonstration is an absorption bed located in MDA-V. Specifically, the western most end of absorption bed one will be the target area for the hot demonstration. This absorption bed primarily received process waste from a LANL laundry facility and was active from 1945 to 1978.

The design of the hot demonstration will be significantly guided by the results gained during the cold demonstration. To determine how the approach to the hot demonstration might be changed to optimize results for processing the MDA V absorption bed, including evaluation of the geometry, size and depth of the cold demonstration monolith relative to the targeted treatment volume and the characterization of the vitrified monolith will be evaluated. The size, shape and depth of the cold demonstration monolith is a function of the length, depth and separation of the starter planes. These characteristics are also significantly affected by the chemistry and density of the materials vitrified and by the presence of stratigraphic layers that may exhibit significant physical/chemical differences (e.g., cobble layer).

Sampling will be performed prior to, during, and after the hot NTISV demonstration. Samples will be obtained to determine the effect of the process on the surrounding soils, the composition of the off-gases, the presence of residual concentrations deposited in the off-gas system, and of product quality (leach testing and homogeneity). The details of the sampling effort to be performed during the hot demonstration are presented in the section titled Hot Demonstration Sampling and Analysis Plan (Section IV.G).

The NTISV hot demonstration will be performed late in June, 1999 and will take approximately 10 days to complete. An area 20 ft by 30 ft has been established as the target area. The

treatment depth will consist of processing from the top of the cobble (-4 ft below grade) down to a depth of -22 ft below grade. The area to be treated contains low concentrations of many radionuclides and heavy metals that were distributed within and beneath the absorption bed during its years of active service.

IV.C. Hot Demonstration Cell Configuration

Once the cold demonstration results are evaluated and all criteria are met for proceeding with the hot demonstration, activities needed to prepare for performing the hot demonstration will commence. Primarily, this includes preparing the selected area of absorption bed one, installing the starter planes and electrodes, and preparing and positioning the ISV equipment.

Preparation of the hot demonstration cell will consist initially of removing all vegetation and leveling the area where the hood will sit. Due to the contamination present in and potentially adjacent to the absorption bed, the insertion of thermocouples into the treatment area will not be performed. As in the cold demonstration, disruption of the Bandelier Tuff around the edges and below the actual absorption bed to a depth of 10-ft using a vibrating beam will be performed. By breaking up the tuff around the edges of the absorption bed, subsidence of all of the cobble and gravel into the melt will be promoted. Typical equipment commonly used for this soil preconditioning is either an excavator fitted with a hydraulic hammer and long probe, or a crane supported hydraulic vibrator and steel probe or "H" beam. Nominally, penetrations every 2 to 4 ft should be made in the surrounding soil around the absorption bed. This approach will be evaluated after the completion of the cold demonstration. The amount of subsidence and the angle of repose or the degree at which the edge sloughs in will be determined and used in the evaluation for application to the hot demonstration.

Once the area around the absorption bed has been disrupted, four steel electrode casings (16- in. diameter) will be vibrated through the absorption bed to a depth of approximately 5-ft below the bottom of the rock layer. The installation of the electrode casings will follow identically to the effort performed in preparation for the cold demonstration (see section III.E) with the exception of following procedures for contamination control. It may be necessary to wrap the casings in plastic as they are withdrawn to prevent potential contamination of personnel and surface soils. Only the outer edge of the casings will have been in contact with the contents of the absorption bed. The nose cap installed on the casings will protect the inside walls of the casing from coming in contact with any contaminated material. Experience has shown that any contamination is typically removed from the casings as they are withdrawn, as a result Geosafe expects to find only minimal levels present on the casings after they are removed.

Once the electrodes are in place, the injection nozzle will be vibrated into the soil vertically to the same depth as the electrodes. These casings will be positioned on approximate 1 to 2-ft centers (depending upon the results of the parameter evaluation and the cold demonstration) allowing injection of starter material to connect the two pairs of electrodes parallel to the long axis of the absorption bed. Confirmation that the pathway is continuous and conductive will be

performed by testing the conductivity after each injection. If the conductivity between the electrodes is not adequate to initiate a melt, then additional starter material will be injected until an electrical connection has been established. As each successive casing is used to inject starter material, a conductive plane will be built connecting the two pairs of electrodes.

IV.D. Hot Demonstration Setup Completion and Melt Processing

The process equipment (mobile trailers) can treat melt settings located up to 150 ft radially out in any direction from the trailers, and as a result, the location of the cold and hot demonstrations have been positioned such that the equipment will not have to be moved. Prior to the hot demonstration, Geosafe will mobilize to the site a thermal oxidizer (TO) that is used as a final polishing step in the off-gas treatment system. The TO provides 5 million BTU of thermal energy that provides an additional 99.9% destruction of organics, complete conversion of CO to CO2 and control of any odor emissions (that may arise from the thermal processing of organics released by the laundry into the absorption beds or from naturally occurring compounds such as sulfur). A propane supply system will be set-up on-site to supply fuel to the TO.

Once the off-gas hood is moved into position over the selected area of absorption bed one, the electrodes, off-gas line and electrical and instrument cables will be installed and interconnected and each component tested for operability. After the entire system has been readied, a complete system check-out coupled with a Geosafe Management walk through will be performed to ensure readiness. Following approval to proceed by MSE and LANL project personnel, the melting process will be initiated. Geosafe employs a graduated power-up schedule that allows the starter planes to heat up and begin melting soil and materials in a controlled fashion. As the melt volume grows with time and power input, the power level is increased to continue the melting process. The power up for the hot demonstration will occur over a 60-hr time period. Table IV.1 shows a typical power schedule for this scale of test.

IV.E. Process Monitoring

During the melting process, temperature data from the thermocouples, power level and consumption data and process observations will be recorded. A closed-circuit camera will enable operators to continually observe the conditions inside the off-gas hood. The camera will be connected to a video tape recorder and the view encompassed by the camera will be recorded for the duration of the melt. A light will be installed the hood to make it possible to see the soil surface.

The off-gas stream which consists primarily of air pulled into and through the hood will be continuously monitored for CO, CO_2, O_2, total hydrocarbons and temperature. In addition, off-gas sampling for metals (specifically: Cd, Cr, Cu, Pb, Hg, and Ag) and radionuclides (Am, Cs, Pu and U) will be conducted. Two eight-hour continuous sampling runs will be performed during the hot demonstration. Other sampling such as alpha/beta and tritium will be performed

based upon site and regulatory requirements. Details concerning sampling of the off gases is provided in section IV.G.2. "Sampling During the Hot Demonstration".

Electrical data (primary and secondary voltage, current, and power), off-gas system data (pressures, temperatures, scrub water parameters, TO operating temperature, and stack gas concentrations), and hood data (temperature and vacuum levels) will be electronically recorded by the DataVue data collection system at 10 second intervals throughout the course of the demonstration. Each of these data will also be recorded manually at one hour intervals for the duration of the demonstration. Electrode depth measurements will also be taken and manually recorded at one hour intervals.

IV.F. Hot Demonstration Duration and Shutdown Criteria

The demonstration will be terminated when the electrodes reach a depth of 22 ft below grade and when Geosafe is convinced that the target treatment volume has been treated. It is anticipated that melting will continue for 10 days. Operations will take place continuously, 24 hours per day for the duration of the melt.

The termination depth will be determined by monitoring the electrode insertion depth. Once the termination depth is reached, power to the melt will be terminated and the system shutdown. In addition, the degree of incorporation of the overburden will be monitored to ensure that all the contents of the the absorption bed have been incorporated into the melt. Once all of the data indicates that the demonstration is complete, the melting will be terminated. The off-gas system will be operated for additional 4 hours or as specified by the project manager.

IV.G. Hot Demonstration Sampling and Analysis Plan

The goal of the sampling and analytical plan is to provide representative and statistically valid data for the evaluation of the NTISV process for treating the absorption bed.

The sampling and analytical procedure outlined in this plan is primarily targeted at metals (specifically: Cd, Cr, Cu, Pb, Hg, and Ag) and radionuclides (Am, Cs, Pu and U). Thus, pre-demonstration soil sampling and post-demonstration vitrified product sampling will be performed to determine the disposition within the product, as well as the leachability of the product for the metals and radionuclides. In addition, sampling of adjacent soils will be performed both pre and post demonstration to determine if movement of any of the contaminants of concerns occurred outward into the surrounding soils. Monitoring of off-gases generated during the treatment process will also be performed twice during the hot demonstration. Each off-gas sampling period will consist of an 8-hr collection period.

All samples generated as a result of this demonstration will be labeled with the operator's initials, date, time, and sample description. The following sections provide sample storage requirements, sample custody protocol, sampling equipment and technique, sampling equipment

Table IV.1. Hot Demonstration Power Schedule

Time Schedule (hr)	Power Input Per Phase (kW/phase)	Time Schedule (hr)	Power Input Per Phase (kW/phase)	Time Schedule (hr)	Power Input Per Phase (kW/phase)	Time Schedule (hr)	Power Input Per Phase (kW/phase)
0.00-0.5	10	15-15.5	310	30-30.5	615	45-45.5	1,065
0.5-1	20	15.5-16	320	30.5-31	630	45.5-46	1,080
1-1.5	30	16-16.5	330	31-31.5	645	46-46.5	1,095
1.5-2	40	16.5-17	340	31.5-32	660	46.5-47	1,110
2-2.5	50	17-17.5	350	32-32.5	675	47-47.5	1,125
2.5-3	60	17.5-18	360	32.5-33	690	47.5-48	1,140
3-3.5	70	18-18.5	370	33-33.5	705	48-48.5	1,155
3.5-4	80	18.5-19	380	33.5-34	720	48.5-49	1,170
4-4.5	90	19-19.5	390	34-34.5	735	49-49.5	1,185
4.5-5	100	19.5-20	400	34.5-35	750	49.5-50	1,200
5-5.5	110	20-20.5	410	35-35.5	765	50-50.5	1,215
5.5-6	120	20.5-21	420	35.5-36	780	50.5-51	1,230
6-6.5	130	21-21.5	430	36-36.5	795	51-51.5	1,245
6.5-7	140	21.5-22	440	36.5-37	810	51.5-52	1,260
7-7.5	150	22-22.5	450	37-37.5	825	52-52.5	1,275
7.5-8	160	22.5-23	460	37.5-38	840	52.5-53	1,290
8-8.5	170	23-23.5	470	38-38.5	855	53-53.5	1,305
8.5-9	180	23.5-24	480	38.5-39	870	53.5-54	1,320
9-9.5	190	24-24.5	490	39-39.5	885	54-54.5	1,335
9.5-10	200	24.5-25	500	39.5-40	900	54.5-55	1,350
10-10.5	210	25-25.5	510	40-40.5	915	55-55.5	1,365
10.5-11	220	25.5-26	520	40.5-41	930	55.5-56	1,380
11-11.5	230	26-26.5	530	41-41.5	945	56-56.5	1,395
11.5-12	240	26.5-27	540	41.5-42	960	56.5-57	1,410
12-12.5	250	27-27.5	550	42-42.5	975	57-57.5	1,425
12.5-13	260	27.5-28	560	42.5-43	990	57.5-58	1,440
13-13.5	270	28-28.5	570	43-43.5	1,005	58-58.5	1,455
13.5-14	280	28.5-29	580	43.5-44	1,020	58.5-59	1,470
14-14.5	290	29-29.5	590	44-44.5	1,035	59-59.5	1,485
14.5-15-	300	29.5-30-	600	44.5-45	1,050	59.5-60	1,500

decontamination procedures, and sample composite procedures to be used during to performance of this demonstration.

IV.G.1. Pre-Demonstration Sampling

IV.G.1.a. Pre-Demonstration Surrounding Soil Sampling

One of the goals of the hot demonstration is to evaluate the potential for and prevent contaminant transport from taking place in the subsurface around the boundaries of the material being vitrified. In order to evaluate the potential for subsurface contaminant migration, the concentrations of contaminants at all locations around and beneath the absorption bed would have to be known with a high level of statistical confidence. It is the experience of Geosafe that most unlined waste disposal facilities such as the MDA V absorption beds have widely varying concentrations of contaminants in the soils surrounding and beneath them. Often this variability is controlled by variations in soil stratigraphy and variations in hydraulic conductivity. Consequently, one portion of the immediate edge of the absorption bed might contain little or no contamination while soils in another area might contain high levels of contaminants a significant distance away from the edge of the bed. The contaminant-distribution data in the soils surrounding MDA V does not exhibit a high level of statistical confidence.

To address the subject of contaminant transport in the subsurface, a large number of samples could be collected all around the absorption bed at varying distances in an effort to obtain a profile of the contaminant distribution around the bed. Unfortunately, this type of effort is costly and time consuming. Therefore, to save time and money, Geosafe will select one area beneath and one area adjacent to the absorption bed for detailed contaminant profiling. Three boreholes will be generated in each of these two areas and samples collected at locations immediately adjacent to the edge of the absorption bed and at progressively greater distances from the edge of the bed. The method used for retrieving these samples will be based upon the site conditions and requirements for the particular area being sampled and will be decided upon in concert with site personnel. Figure IV.1 depicts the approximate sampling locations. Cores adjacent to and below the absorption bed will be obtained. Composite samples will be gathered from select portions of each core. For the samples of the adjacent soils, cores from grade down to a depth of 22 ft below grade surface (bgs) will be retrieved. Of this, sections of each core from 6 to 8 ft bgs will be retrieved and composited to make one sample. Likewise, composite samples will be made of the core sections 12 - 14 ft bgs and 18 - 20 ft bgs. A similar approach will be used to sample the selected area underneath the absorption bed. Sampling under the absorption bed will have to be performed at a depth of 22 ft bgs or deeper, as this is the depth to which treatment will be performed. By performing a detailed assessment of two small areas of the edge of the bed, a high level of statistical confidence in the analytical results for that location will be attained without significant impact on the project cost or schedule. These pre-test samples will be archived until after the demonstration is complete.

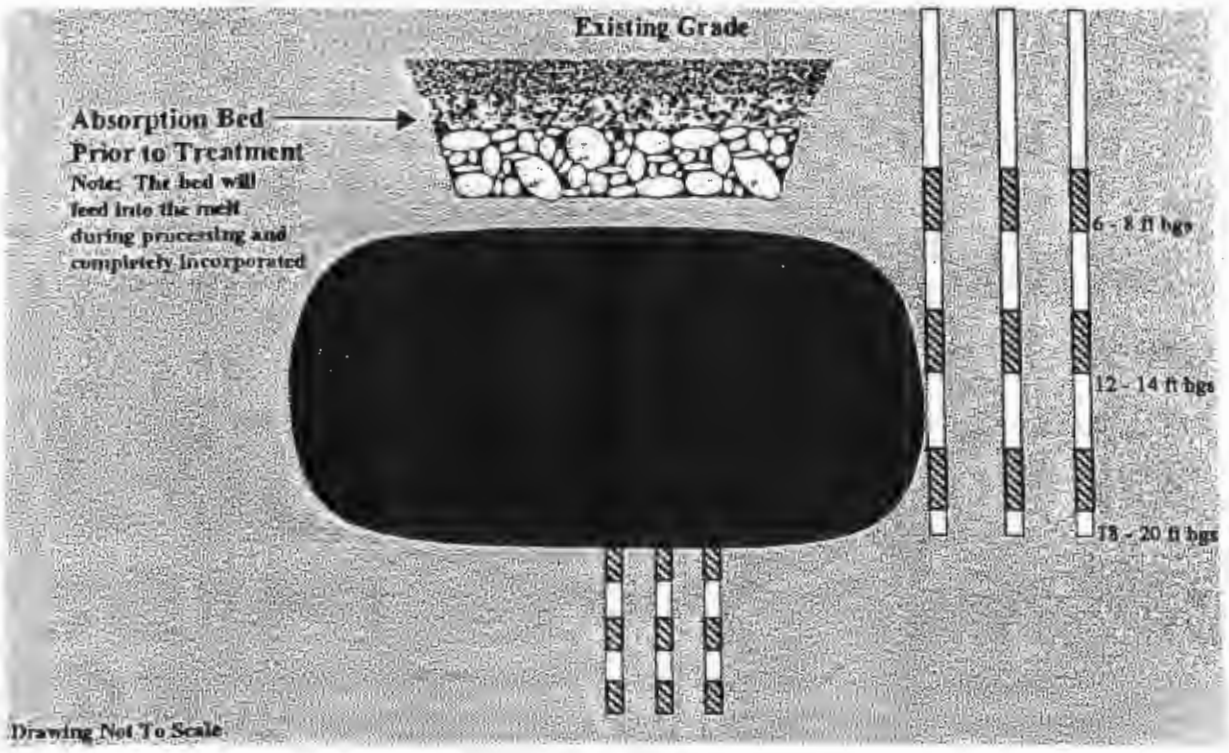

Figure IV.1 Hot Demonstration Soil Sampling Locations

IV.G.1.b. Pre-Demonstration Wipe Sampling

Wipe samples to determine the disposition of contaminants on equipment will be collected prior to the initiation of the hot demonstration. Wipe samples will be taken of the hood panels and off-gas piping to determine the presence of contaminants that may be susceptible to plate-out.

Initially, areas will be selected for sampling that consist of two areas of hood panels and two areas of off-gas piping. These areas will initially be sampled using procedures outlined in section III.M.2.e. These samples will be archived until the post-demonstration sampling is completed and then analyzed if significant levels are reported.

The hood panels to be sampled will consist of an inner roof panel and an outer edge panel. The sample of the inner roof panel will be labeled NTISV-HW-01 and the outer edge panel will be labeled NTISV-HW-02. After the sampling is completed, these areas shall be marked and labeled such that the same area can be sampled after the demonstration is completed. These samples will be archived until the post-demonstration sampling is completed and then analyzed if significant levels are reported.

The off-gas pipe to be sampled shall include a pipe section before and after the pre-filter assembly. The sample of the pipe section connecting the hood and the pre-filter will be labeled NTISV-PW-01 and the sample of the pipe between the pre-filter and the off-gas treatment trailer will be labeled NTISV-PW-02. After the sampling is completed, these areas shall be marked and labeled such that the same area can be sampled after the demonstration is completed. As in the hood panel wipes, these samples will be archived until the post-demonstration sampling is completed and then analyzed if significant levels are reported.

IV.G.2. Sampling During the Hot Demonstration

Off-gas sampling for metals (specifically: Cd, Cr, Cu, Pb, Hg, and Ag) and radionuclides (Am, Cs, Pu, U and tritium) will be conducted. Geosafe will subcontract the off-gas sampling out to a proven and qualified subcontractor. The procedures used by Geosafe's subcontractor for off-gas sample collection are presented in 40 CFR Parts 53-60, Appendix A and in EPA Document: EPA-600/8-88-085 entitled: Guidelines for Stack Testing of Municipal Waste Combustion Facilities. The samples collected will be evaluated using Test Methods for Evaluation solid Waste, SW 846 (for the metals) and appropriate radiochemistry techniques will be used to determine the presence and concentration of the radionuclides. The RFP indicates that organic compounds are not present in the absorption bed at levels that constitute a health risk or regulatory concern. Because of this, it is not anticipated that off-gas testing for organic compounds will be performed.

Two eight hour continuous sampling runs will be performed during the hot demonstration. Methods 1A and 2A are performed to determine the off gas velocity and temperature for calculating the volumetric flow rate. Method 3A is performed to measure the concentration of oxygen and carbon dioxide, which are used to determine an overall molecular weight of the off gas. EPA Method 4 is performed to determine the moisture content of the off gas. EPA Methods 5/29 is used to determine the emission rate of particulate matter and of the metals.

A Modified Method-Five sampling train generates samples which include particulate filters, impinger solutions, front half rinse, and back half rinse. In addition, several blanks will be sent to the analytical laboratory by the sampling contractor including impinger solution and filter media.

All of the samples generated during off-gas sampling will be collected and prepared by the sampling contractor and will be sent to an approved laboratory. The analytical results will be transmitted back to Geosafe and the sampling contractor for use in determining actual stack emission concentrations.

IV.G.3. Post Hot Demonstration Sampling and Analysis

Post demonstration sampling will consist of sampling and analyzing the vitrified product and the soils surrounding the product. In addition, off-gas samples such as HEPA filters and equipment wipes will be analyzed to determine the disposition of the metals and radionuclides of concern.

IV.G.3.a. Sampling and Analyses of the Vitrified Product

Once the vitrified product has cooled sufficiently, sampling of the vitrified product will be performed. All samples should be obtained under the procedures set forth in Section III.M.2.b of this Demonstration Plan. The sampling procedure is a random sampling scheme adopted from the Environmental Protection Agency's SW-846 Test Methods for Evaluating Solid Waste, 3rd Edition, Volume II, Chapter Nine. In addition, all statistical calculations will be made in accordance with the guidelines specified in SW 846, Vol. 2, Chapter 9.

The results of the analytical work on the vitrified product developed during the cold demonstration are expected to demonstrate that the surrogate metals have been uniformly mixed throughout the vitrified product. Uniform distribution of metals and radionuclides (even when placed as a point source surrogate) is typical during ISV and NTISV processing. This has been shown during demonstrations for the Maralinga Nuclear Test Range using U and Pu and during the planar melt demonstration for INEEL using non-radioactive Cs. Thus, sampling only one corner of the hot demonstration monolith is expected to provide samples that are representative of the entire monolith. It is expected that a rotary drilling with a diamond impregnated bit and water cooling will be required depending upon the temperature of the vitrified product. Coring will proceed into the block but not through it, which could allow a pathway for drilling spoils and cooling water to pass through it. By not penetrating through the bottom of the melt, all spoils and cooling water will be contained either in the boring or returned to the surface where they can be controlled and collected. Glass sample locations will be determined to ensure that all samples are taken no closer to the melt edge than 1-ft. A total of five samples will be obtained from the vitrified product which will be labeled as followed:

Sample No.	Parameter	Method	Detection Limit
NTISV-GB-12 through NTISV-GB-16 and NTISV-GB-17 (split of sample 12)	metals & radionuclides	XRF & ICP/MS	0.1 mg/kg

Samples NTISV-GB-12 through NTISV-GB-16 will be submitted for metals and radionuclides analyses listed above. In addition, one QC sample will be split into two halves and analyzed for the metal tracer. The blind split QC sample will be labeled INEEL-GB-17. The sample

locations will be determined to provide both cores near the center and outward to within one foot of the melt edge.

The bulk chemistry of the melt will also be determined via whole rock analyses. The whole rock will enable a comparison of the predicted melt chemistry with that of the actual melt as well as quantifying the concentrations of hazardous metals contained within the product. Samples collected of the vitrified product will be analyzed using X-ray fluorescence and will be labeled NTISV-HDWR-01 through -05. One sample of the vitrified block will be submitted for electron microprobe analysis, which will determine if nucleation and/or crystallization has taken place upon cooling and it can identify the mineral species present in the vitrified mass. It is expected that some crystallization will occur due to slow cooling of the monolith.

IV.G.3.b. Vitrified Product Leach Testing

Samples will also be collected from the above mentioned vitrified product composites and submitted for leach testing using the Product Consistency Test (PCT) and Toxic Characteristic Leach Procedures (TCLP). Samples NTISV-LT-06 through NTISV-LT-10 shall be submitted for the following analyses:

Sample No.	Parameter	Method	Detection Limit
NTISV-LT-06 through NTISV-LT-10	metals & radionuclides	PCT & TCLP	0.1 mg/kg

IV.G.3.c. Wipe Sample Analyses of the NTISV Equipment

Samples to determine the disposition of contaminants on equipment will be collected and analyzed. Wipe samples will be taken of the hood panels and off-gas piping to determine the presence of contaminants that may be susceptible to plate-out. Wipe sampling of the same locations that were previously sampled during the pre-demonstration sampling should be performed after the demonstration has been completed. Procedures outlined in section III.M.2.e should be followed for these samples.

The first two wipe samples will be obtained from the off-gas hood and will be labeled NTISV-HW-03 and -04. The first wipe sample (NTISV-HW-03) will be obtained from inside of the center portion of the hood (directly over the melt center). The second wipe sample (NTISV-HW-04) will be obtained from the inside of one of the side hood panels. The locations of these sample areas was identified during the pre-demonstration wipe sampling (see section IV.G.1.b).

The third and fourth wipes will be performed on the inside of the off-gas line. The sections of off-gas pipe previously sampled during the pre-demonstration wipe sampling will be located after the equipment is dismantled. These samples will be labeled NTISV-PW-03 and -04. All of the post-demonstration wipe samples will be analyzed for metals and radionuclides.

IV.G.3.d. HEPA Filter Sampling and Analyses

Upon completion of vitrification, the HEPA filter will be removed from the pre-filter housing and the final HEPA housing and will be representatively sampled. Two inch sections of the filter media will be removed and composited. One sample will be collected from the pre-filters and

the final filters and submitted for metals and radionuclide analyses. The sample will be labeled as follows:

Sample No.	Parameter	Method	Detection Limit
NTISV-HF-01 and NTISV-HF-02	metals & radionuclides	6010	0.1 mg/kg

NTISV-HF-01 will be the sample of the pre-filter HEPA and NTISV-HF-02 will be the final HEPA filter.

IV.G.3.e. Surrounding Soil Sampling and Analyses

Post demonstration soil samples will be collected at the same locations where the pre-demonstration contaminant profile samples were collected. Because of the high temperature of the monolith, samples of the soils adjacent to the vitrified monolith can be collected in approximately one to two months. The sampling locations beneath the vitrified monolith cannot be obtained until at least 6 months following the demonstration. If drilling is attempted before adequate cooling has progressed, coring tools will be destroyed and samples will not be obtained. The samples obtained adjacent to the vitrified monolith will be analyzed for the target contaminants. If contaminants are detected in these samples at levels that are significant to MSE, LANL or regulators, then the previously-archived pre-demonstration samples will be analyzed to determine if contaminants were present in the soil at this location prior to the demonstration. If contaminants are not detected or if concentrations are too low to raise concern, then the archived pre-demonstration samples will not be analyzed.

Only the post-demonstration soil samples collected at locations where pre-demonstration soil samples were collected will be used to assess subsurface contaminant migration (see Section IV.G.1.a). If post-demonstration soil samples collected at other locations exhibit contaminant concentrations that are of concern to MSE, LANL or the regulators, it will be assumed that these contaminants were present at these locations prior to processing with the NTISV system.

The samples of soil and vitrified material will be analyzed using various techniques including chemical and radiochemical analysis, leach testing, electron microprobe analysis and physical characteristics. Geosafe assumes that samples of the soils and the vitrified material can be removed from the site for analytical procedures. All sample preparation waste and residual sample material will be returned to the site for proper disposal by LANL.

IV.G.3.f. Scrub Water Sampling and Analysis

Samples of the scrub water will be collected to determine the presence of contaminants and to also assist in the characterization of the scrub water for disposal and or treatment. Samples of any condensate water that forms either in the off-gas pipe or within the off-gas treatment trailer shall be collected and submitted for analyses. These samples will be labeled either NTISV-Cond-01 and -02 for condensate or NTISV-SW-01 and -02 for scrub water.

Table IV.2 presents a summary of sample types, quantities and analysis protocols for the hot demonstration.

Table IV.2. Sample Quantities and Analysis Protocols for Hot Demonstration

Sample Point Surrounding Soils	Number of Samples Analyzed[a]	Analyzed For
Pre-demo Surrounding Soil	10	Metals & Radionuclides
Post-demo Surrounding Soil	10	Metals & Radionuclides
Off Gas Sampling Method 5 Sampling	12	Metals & Radionuclides
Scrub water and condensate sampling	4	Metals & Radionuclides
Equipment Wipe sampling	4	Metals & Radionuclides
HEPA Filter	2	Metals & Radionuclides
Vitrified Product Leach Testing	5	TCLP and PCT
Homogeneity Testing	5	Metals & Radionuclides
Whole Rock Site Soil	5	XRF

(a) The values noted are the minimum expected number of analyses; additional analyses of demo samples may be required depending upon initial analytical results.

V. Demobilization

Demobilization of project equipment and personnel will take place upon completion of field activities. Rented equipment and subcontractors with equipment on site will demobilize immediately upon completing their respective tasks and following decontamination procedures (if required). Demobilization of Geosafe equipment will involve dismantling and decontaminating the off-gas hood, off-gas piping system, radiological survey of equipment that may have come into contact with radio-isotopes (e.g., inside surfaces of hood panels). Once dismantled and decontaminated, the ISV equipment will be mobilized off the site. Final demobilization activities will include disconnection and termination of utilities, decontamination

and removal of any administrative support equipment, site cleanup and removal of debris from the work area.

Decontamination refers to the process, means, and controls applied to prevent contaminants from leaving a controlled area. LANL will provide the equipment and supplies needed for appropriate decontamination of equipment that may have come into contact with contaminated material. Geosafe personnel will perform decontamination procedures on it's own equipment. Geosafe's Corporate Health and Safety Plan provides a detailed description of equipment and personnel decontamination procedures that are practiced by Geosafe. If LANL requires decontamination procedures that are peculiar to this site, then LANL will provide Geosafe personnel with training on these special procedures.

VI. Site Restoration

Site restoration for the cold demonstration area includes leveling, erosion control and eventual revegetation. The heat that is slowly released from the subsurface monolith keeps the surface soil dry (but not hot) for a period of 4 to 6 months following the vitrification process. Therefore, it is necessary for the area recently treated to cool to the point where the surface soils can maintain adequate moisture to support plant life. At that time, revegetation of the demonstration area can be performed. Typically, the area to be revegetated can be seeded with a local grass or ground cover.