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TREATABILITY TEST REPORT FOR APPLICATION OF IN SITU VITRIFICATION TECHNOLOGY TO PESTICIDE ARSENIC AND MERCURY CONTAMINATED SOILS FROM THE M-1 PONDS SITE OF ROCKY MOUNTAIN ARSENAL, COLORADO

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13. ABSTRACT (Maximum 200 words)

THE M-1 SETTLING BASINS CONTAIN APPROXIMATELY 16,000 CUBIC YARDS OF CONTAMINATED SOILS AND SLUDGES THAT ARE BEING STUDIED TO IDENTIFY AN EFFECTIVE TREATMENT TECHNOLOGY. THIS REPORT DOCUMENTS AN ENGINEERING SCALE TREATABILITY TEST TO DEMONSTRATE THE APPLICABILITY OF THE IN-SITU VITRIFICATION (ISV) PROCESS TO THE SITE.

THE REPORT PROVIDES THE FOLLOWING INFORMATION:

1. SUMMARY AND ANALYSIS OF THE SIGNIFICANT TEST RESULTS
2. DESCRIPTION OF THE ISV PROCESS AND DISCUSSION OF THE THEORETICAL BASIS OF ITS OPERATION
3. DESCRIPTION OF THE TREATABILITY TEST SETUP, OPERATION, AND RESULTS
4. ASSESSMENT FOR APPLICATION OF THE ISV PROCESS TO THE M-1 BASINS.

RESULTS FROM THE TESTS DEMONSTRATED THE FEASIBILITY OF USING ISV TO PROCESS THE CONTAMINATED SLUDGE INTO AN ENVIRONMENTALLY STABLE AND COMPACT GLASS PRODUCT.

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GSC 1904
August 31, 1989

**Treatability Test Report for Application
of In Situ Vitrification Technology to
Pesticide-, Arsenic-, and Mercury-Contaminated
Soils from the M-1 Ponds Site of
Rocky Mountain Arsenal, Colorado**

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September 1, 1989

Mr. Jeff McCleary
Woodward Clyde Consultants
Stanford Place 3, Suite 1000
4582 South Ulster Street Parkway
Denver, Colorado 80237

Dear Mr. McCleary:

Geosafe Corporation is pleased to submit the enclosed report: Treatability Test Report for Application of In Situ Vittrification Technology to Pesticide-, Arsenic-, and Mercury-Contaminated Siols from the M-1 Ponds Site of Rocky Mountain Arsenal, Colorado. This report presents data and the results from the second treatability test that was performed on the waste. In addition, a comprehensive discussion which compares the results of the first and second test is presented along with their signif cance relative to application of ISV in the field.

The results show that the destruction and removal efficiency for pesticides will exceed RCRA standards. The results also show that arsenic and mercury went into solution in the melt and/or removed by and routed to the off gas system resulting in decontamination of the treated soils to regulatory cleanup levels. We conclude that full-scale application of ISV at the M-1 Ponds Site is technically feasible.

The time constraints necessary for preparation of this report prevented evaluation of the chemical form of the particulates recovered in the off-gas system and the exact amount of arsenic retained in the glass. Geosafe archived samples of the particulates and glass so that these data gaps can be quantified at the leaisure of Woodward Clyde. For your information, X-ray diffraction will identify the compounds or elements present in the off-gas particulates and energy dispersive analysis (EDS) will quantify the amount of arsenic present in the glass. The cost for these analyses is approximately \$600. These analyses are not necessary to evaluate the effectiveness of ISV in field applications. The data presented in the report clearly indicate that adequate decontamination of the waste can be accomplished by ISV. However, the above described analyses will help identify appropriate scrub solution treatment and disposition of secondary waste and are recommended prior to initiation of field-scale operations.

Mr. Jeff McCleary
September 1, 1989
Page two

We at Geosafe appreciate the opportunity of working with Woodward Clyde on this interesting project. We look forward to working with you again in the near future.

Sincerely,

GEOSAFE CORPORATION

A handwritten signature in cursive script, reading "Dale Timmons".

Dale M. Timmons
Senior Geologist/Corporate Marketing

Enclosure



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October 27, 1989

Mr. Jeff McCleary
Woodward Clyde Consultants
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SUBJECT: Addendum to: Treatability Test Report for Application
of In Situ Vittrification Technology to Pesticide-,
Arsenic-, and Mercury-Contaminated Soils from the M-1
Ponds Site of Rocky Mountain Arsenal, Colorado.

Dear Mr. McCleary:

Pursuant to our recent telephone conversation, this letter serves
as an addendum to the above referenced project report dated
August 31, 1989.

On pages 39 and 40 of the above referenced report, there is a
discussion of the retention of arsenic in the glass product
resulting from ISV and a discussion of the analytical methods
used to quantify the concentration of arsenic in the glass. It
is apparent that the analytical methods used for determining the
concentration of arsenic in the glass were not appropriate and
produced incorrect data.

Since the report was submitted, Geosafe subjected additional
glass and metallic nodule samples to neutron activation analysis
(NAA) to more accurately quantify the concentration of arsenic in
the glass. A glass sample from the second test and a nodule from
the first test were submitted for analysis. The analytical
results are presented below:

Arsenic Concentrations From NAA

<u>Sample</u>	<u>Conc. in Report</u>	<u>Conc. From NAA</u>
Glass: Second Test	146 ppm	1345 ppm $\pm$ 5%
Glass: First Test	0.04 ppm	506 ppm $\pm$ 5%
Nodule: First Test	Est. 1-3 wt%	37 ppm $\pm$ 5%

By using the new concentration of arsenic in the glass and
ignoring the arsenic contained in the nodules (this was also
ignored in the report) the amount of arsenic retained in the
glass is 94,823 mg. This confirms a minimum retention factor of
arsenic in the glass of 46.4% and reduces the amount of arsenic
unaccounted for to 77,852 mg from 158,406 mg. These data
indicate that 37% of the arsenic is still unaccounted for.

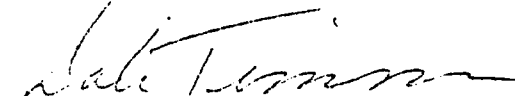
However, this percent is now low enough that it can be realistically reconciled through errors in density assumptions, statistical deviations, and the possibility that arsenic may not have been evenly distributed in the glass or nodules. To substantiate this possibility, I have included: An In Situ Vitrification Pilot-Scale Radioactive Test, a report prepared by Battelle for the U.S. Department of Energy, Document# PNL-5240. The section: "Product Characterization" on page 39 discusses the variation of various radioactive elements in the resultant glass from the test. You can see from this report that concentrations of elements can vary by as much as a factor of 4. This indicates that the arsenic not reconciled in the mass balance for the RMA treatability test is most likely in the glass and not anywhere else.

Attached is the analytical report from Dr. Marvin Beeson, Professor of Geology at Portland State University, Portland, Oregon.

I hope this information is useful to you and timely for your report submission to the Army, If you have any questions, please call.

Sincerely,

GEOSAFE CORPORATION



Dale M. Timmons
Senior Geologist/Corporate Marketing

File: addendum.rpt

Portland State University

October 25, 1989

P O. Box 751, Portland, OR 97207-0751

Dale M. Timmons
Geosafe Corporation
Kirkland Parkplace
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Kirkland, WA 98033

Dear Dale:

Michael Pollock and I have finished analyzing your three samples for arsenic. We encountered no problem at all with Instrumental Neutron Activation Analysis (INAA) of these samples and are confident of the results which are as follows:

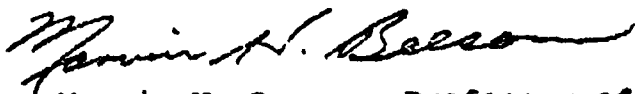
RMA-M1	506 ppm
RMA-M1-A	1345 ppm
RMA-M1-N	37 ppm

These numbers should be accurate to within 5%, based on the counting statistics.

The samples were first crushed to a fine sand size for purposes of weighing into small vials for irradiation. Approximately 0.5 to 0.7 grams of each sample were sealed in polyvials and irradiated for 10 minutes at 100 kW power in the rotary specimen rack of the TRIGA Mark II research nuclear reactor at Reed College in Portland, Oregon. A sample of coal fly ash (NBS standard #1633a), containing 145 ppm of As, was irradiated along with your samples for comparison. After approximately 20 hours the samples and standard were counted with a high-resolution gamma-ray spectrometer for 10 minutes each sample and 150 minutes for the coal fly ash standard. The concentrations of As were then calculated by comparison of the gamma spectra from samples and standard. We encountered no problems of interference that would affect the results. No antimony was detected in any of these samples.

INAA seems to be an ideal method of analyzing for As in this kind of sample. We thank you for the opportunity of helping you with this problem and hope that we can be of service again in the future.

Sincerely,



Marvin H. Beeson, Professor of Geology

TREATABILITY TEST REPORT FOR APPLICATION
OF IN SITU VITRIFICATION TECHNOLOGY TO
PESTICIDE, ARSENIC, AND MERCURY-CONTAMINATED SOILS
FROM THE M-1 PONDS SITE OF ROCKY MOUNTAIN ARSENAL

Job Number 309001

Submitted To:

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Stanford Place 3, Suite 1000
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Prepared By:

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303 Parkplace, Suite 126
Kirkland, WA 98027

August 31, 1989

NOTICE

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TREATABILITY TEST REPORT FOR APPLICATION
OF IN SITU VITRIFICATION TECHNOLOGY TO
PESTICIDE, ARSENIC, AND MERCURY-CONTAMINATED SOILS
FROM THE M-1 PONDS SITE OF ROCKY MOUNTAIN ARSENAL

APPROVALS

Prepared By: Stephen C. Lichstein 8/31/89
Applications Engineer Date

Approved By: [Signature] 8/31/89
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I. INTRODUCTION

The M-1 Ponds site at Rocky Mountain Arsenal [RMA] consists of three lime settling ponds that have been filled with soil and calcium sludge containing elevated levels of arsenic [As], mercury [Hg], and organochlorine pesticides. Characterization data indicate the highest concentrations of contaminants are present in the calcium sludges. The soils above and below the sludges contain lesser levels of arsenic and mercury, and elevated levels of pesticides, as well as minor amounts of volatile organic compounds [VOCs].

The M-1 Ponds site contains approximately 16,000 cubic yards of contaminated soils and sludges that are currently being studied to identify an effective treatment technology. Woodward Clyde Consultants is evaluating Geosafe Corporation's in situ vitrification (ISV) technology as a candidate for both interim stabilization and long-term remediation of the contaminated soil and sludge. To evaluate the potential of the ISV process, Woodward Clyde Consultants contracted with Geosafe to provide an engineering-scale treatability test to demonstrate the applicability of the ISV process to this site.

Two treatability tests were conducted in accordance with the approved Test Plan [Appendix A] and were witnessed by representatives from Woodward Clyde Consultants. Results from the first test were inconclusive prompting the performance of a second test. Results of the second test are presented in this report and a relevant discussion of the comparison of both tests is presented in Section VIII. The primary objectives of the treatability test were to determine: 1] the hazardous material destruction removal efficiency; 2] the leaching characteristics of the residual product; 3] the processing characteristics of the soil and sludge, and 4] the response of the adjacent soil to the treatment. Attainment of these objectives was accomplished by: 1] measurement of the contaminants initially present in the soil and sludge, 2] measurement of the contaminants released to the off-gas system during processing, and 3] measurement of the disposition of contaminants in untreated soil after the test. The processing data obtained during the treatability test also provided some of the information required to predict operational behavior for field operations.

This report provides: 1] a summary and analysis of the significant test results, 2] a description of the ISV process and discussion of the theoretical basis of its operation, 3] a description of the treatability test setup, operation, and test results, and 4] an assessment for application of the ISV process to the M-1 Ponds site.

II. SUMMARY AND CONCLUSIONS

The ISV treatability test was successfully performed on soil and sludge from the M-1 Ponds of the Rocky Mountain Arsenal located in Commerce City, Colorado. Geosafe has evaluated the test data and presents the following conclusions.

- Processing results from the treatability test demonstrated the feasibility of using ISV to process the subject contaminated soil/sludge into an environmentally stable and compact glass product. The ISV treatment process and the final glass product conformed to the three requirements of the Superfund Amendment and Reauthorization Act (SARA): 1] reduced toxicity, 2] reduced volume, and 3] reduced mobility of wastes. In addition, the waste can be treated in situ, which eliminates transportation liabilities and health and safety risks associated with excavation.

- Destruction efficiencies (DE) were 98.3% for dieldrin and 96.6% for aldrin. The small amount of these materials released to the off-gas treatment system can be effectively removed (scrubbed and adsorbed) by the off-gas treatment scrub system contained within Geosafe's large-scale ISV system. The combination of the pesticide DE with the minimum expected removal efficiency (RE) of the off-gas system (99.9% minimum) yields an expected destruction and removal efficiency (DRE) of 99.998% for dieldrin and 99.996% for aldrin.

- The leach testing results for the glass product per the Toxic Characteristic Leach Procedure (TCLP) indicated that the 0.91mg/L arsenic and the 0.0001 mg/L mercury results would allow the final vitrified product to pass the TCLP. This indicates that the arsenic and mercury is immobilized or removed to a level that should allow the treated volume to be delisted (i.e., declared as nonhazardous material according to regulatory criteria) after ISV treatment.

- Post-test soil sampling data indicates that the clean soil adjacent to the melt and the clean soil beneath the glass product illustrated at or near the same concentrations as pre-test levels.

- The stack gas concentration was 20.9% oxygen, 0.1% carbon dioxide, and non-detectable carbon monoxide. In addition, gas samples taken during the test indicated that the arsine gas concentration ranged from non-detectable to less than 0.05 ppm arsine. The maximum threshold limit value (TLV) time weighted average (TWA) for arsine gas is 0.05 ppm, indicating that ISV treatment is within the acceptable range, especially since the sample was taken prior to off-gas treatment.

· Occupational exposure data obtained during the three phases of ISV treatment (pre-test soil placement, vitrification, and post-test sampling and decontamination) were non-detectable for mercury.

· Vitrification of the soil/sludge resulted in a volume reduction of 28% and a weight reduction 44%. The reductions are attributed to the high moisture content and low density of the sludge.

· Large-scale application of ISV to the M-1 Ponds site is considered both economically and technically feasible. The estimated cost for large-scale vitrification of the site range from \$345/ton to \$395/ton depending upon several variables. The variables are specified in the cost estimate summary of Section X.

III. PROCESS DESCRIPTION

ISV is a process that electrically melts inorganic materials [e.g., soil] for the purpose of thermochemically treating free and/or containerized contaminants present within the treatment volume. Most ISV applications involve the melting of natural soils; however process residuals [e.g., sludges, tailings, sediments] may also be treated. The unique feature of the ISV process is that the process simultaneously destroys and/or removes organic contaminants and chemically incorporates [immobilizes] inorganic contaminants into a chemically inert, stable glass and crystalline residual product.

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

Continued application of electrical energy causes the molten volume to grow downward and outward encompassing the desired treatment volume. Individual settings [the melt involved with a single placement of the electrodes] may grow to encompass a total melt mass of over 1,000 tons and a maximum width of ~30 feet. Depths up to 30 feet are considered practical with the existing large scale ISV equipment. Several methods, utilizing geophysical, optical and thermal principals, may be used to determine the extent of melting for control purposes. Figure 2 illustrates how adjacent settings are positioned to fuse to each other and to completely process the desired volume at a site involving more than one placement of the electrodes.

The molten soil mass is typically in the 1,600 to 2,000°C temperature range; specific temperatures are dependant on the overall chemistry of the melt and the composition of the soil being melted. Within the melt, a vigorous, chemically reducing environment is typical [Buel et al 1987]. Because soil typically has low thermal conductivity, a very steep thermal gradient of 150-250°C per inch precedes the advancing melt surface. Typically, the 100°C isotherm is less than one foot away from the molten mass.

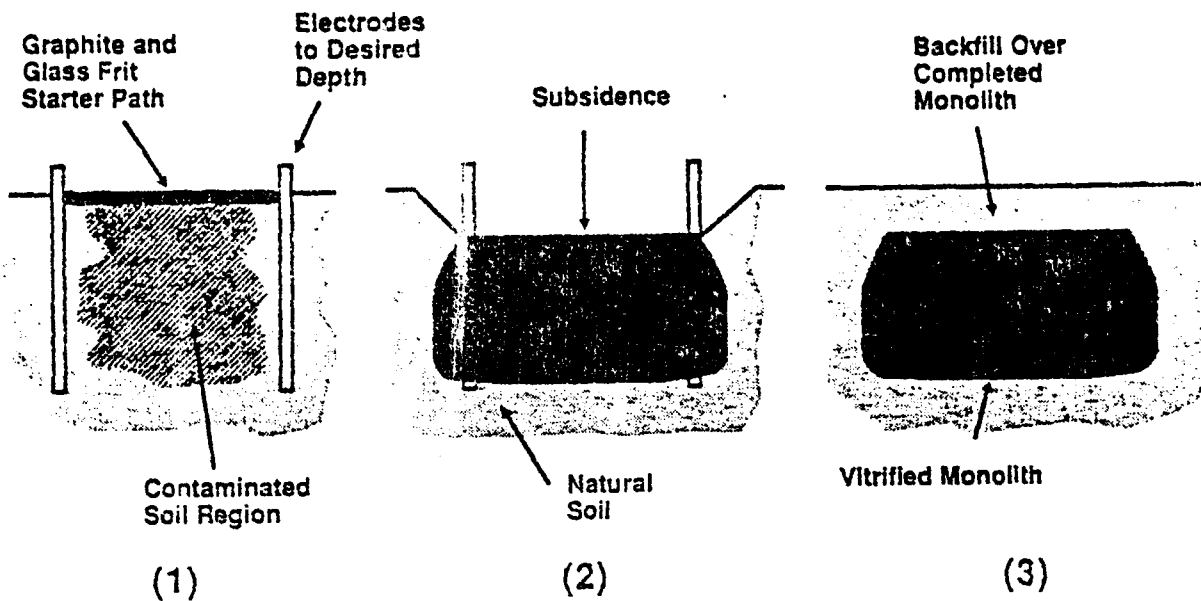


Figure 1. Stages of ISV Processing

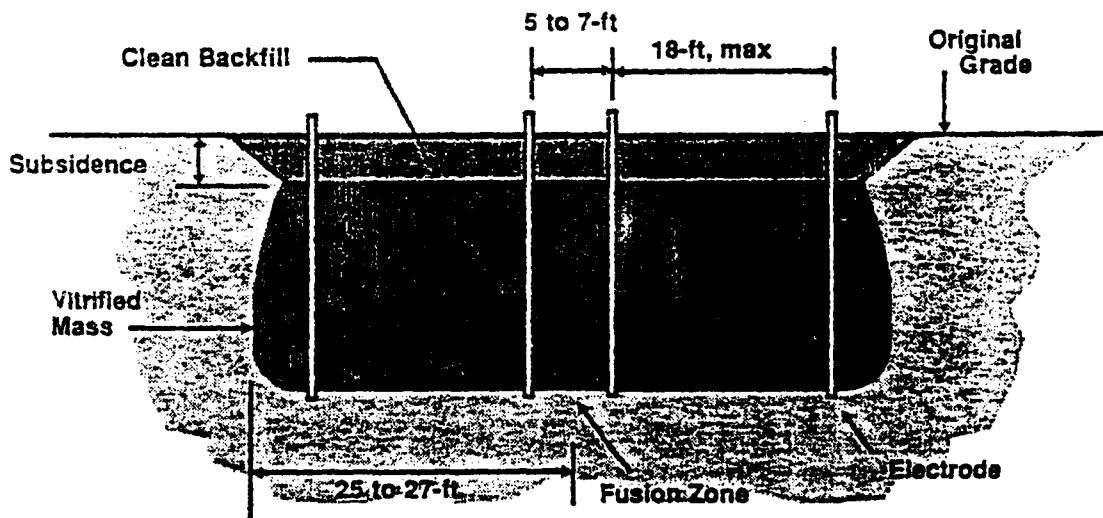


Figure 2. Relationship of Adjacent Settings

The large-scale ISV system melts soil at a rate of 4 to 6 tons per hour. Accordingly, the rate of the melt advance is in the 1 to 2 inches per hour range. As the thermal gradient advances on solid or liquid organic materials, they first vaporize and then pyrolyze [decompose in the absence of oxygen] into elemental components. Organic pyrolysis products are typically gaseous; the gases move slowly through the melt toward the upper melt surface. The rate of movement through the melt is controlled by the viscosity of the molten glass, which is typically about 100 poise [the viscosity of water is 0.01 poise]. Some of the gases dissolve in the molten glass; the remainder move to the surface where those that are combustible oxidize in the presence of the air in the hood. Typical pyrolysis products are carbon dioxide and water, with traces of acid gas. Pyrolysis and combustion products are collected in an off-gas collection hood and are subsequently treated to ensure process air emissions meet regulatory requirements. Because of the high temperature of the melt, no residual organic contamination remains in its original compound form within the vitrified product.

The behavior of inorganic material upon exposure to the advancing thermal gradient is similar to that of organics. Inorganic compounds may thermally decompose or otherwise enter into reactions with the molten glass. Nitrates and sulphates yield gaseous decomposition products which pass upward through the melt and into the off-gas treatment system. The nitrates decompose into the diatomic gases and the sulphates are reduced to sulfur dioxide, which is easily scrubbed out in the off-gas treatment system. Halogens such as chlorides and flourides are soluble in molten glass and are incorporated into the vitrified product to their limits of solubility. Typically, the heavy and transition metals are incorporated into the glass product and become a portion of the actual glass matrix, and are therefore intimately bound in the vitrified product. The more volatile heavy metals (e.g., Hg and As) may be all or partially removed from the melt; major variables impacting the degree of retention include melt chemistry, depth of treatment, solubility of the contaminant in glass, and vapor pressure.

Since the void volume present in the particulate materials is removed during ISV processing, a corresponding volume reduction of 20 to 40% occurs. Further volume reduction occurs because of the removal of bound and free water, the decomposition of humus and organics, and the decomposition of inorganic compounds such as carbonates [lime]. The volume reduction creates a subsidence volume above the melt and an angle of repose in the soil adjacent to the melt. This subsidence volume is filled with clean backfill, raising the final surface to original grade level.

As the melt grows in size, its electrical resistance decreases, making it necessary to periodically adjust the ratio between the

voltage and the current to maintain operation at the desired power level. When power is shut off, the extent of melting is limited to the point achieved at that moment, and the melt starts to cool. Within a few hours, gaseous emissions from the melt cease. After that time has passed, the off-gas hood may be removed and the subsidence volume filled with clean backfill. No attempts are made to force cool the melt; slow cooling reduces the internal stresses which result from differential thermal contraction, thus limiting cracking and improving compressional and tensile strength. The resulting product possesses excellent leach resistant and structural properties. The vitrified product is monolithic in nature and assuming contiguous settings at a site, a single large monolith will be produced, as shown in Figure 2.

The process utilizes an equipment system as illustrated in simplified form in Figure 3 and in a site layout configuration in Figure 4. Electric power is usually taken from a utility distribution system at typical transmission voltages of 12,400 and 13,800 volts. Alternately, the power may be generated on-site using diesel generators. Two trailer mounted transformers are utilized to provide power to the ISV process equipment by interfacing with the utility distribution system. Power for operation of the off gas treatment system is regulated through a standard air cooled 3-phase 480 volt step down transformer. The 3-phase power from the distribution system is also supplied to a special multiple-tap transformer [Scott Tee] that converts the power to 2-phases and transforms it to the voltage levels needed for supplying conditioned power to the electrodes. The electrical supply system for the electrodes utilizes an isolated ground circuit which provides appropriate operational safety.

Electric power is supplied to the array of electrodes through flexible conductors. The electrodes are placed into processing position using casings, and the casings are withdrawn prior to setting the hood and energizing the electrodes. The casing can be placed using a variety of techniques that range from standard well drilling and casing techniques to pile driving and staging. The maximum spacing between electrodes in the large-scale system is about 18 feet, which allows formation of a maximum melt width of ≈ 30 feet. The processing area is covered by an octagonal shaped hood with a maximum dimension across the flats of 55 feet. The large distance between the edge of the hood and the melt ensures off-gas containment even under the worst case angle of repose (from subsidence) conditions.

Flow of air through the hood is controlled to maintain a negative pressure of ≈ 1.0 inch of water with respect to atmospheric pressure. An ample supply of air [flow rate of $\approx 1,750$ cfm] provides excess oxygen for combustion of pyrolysis products and any organic vapors. The off-gases, combustion

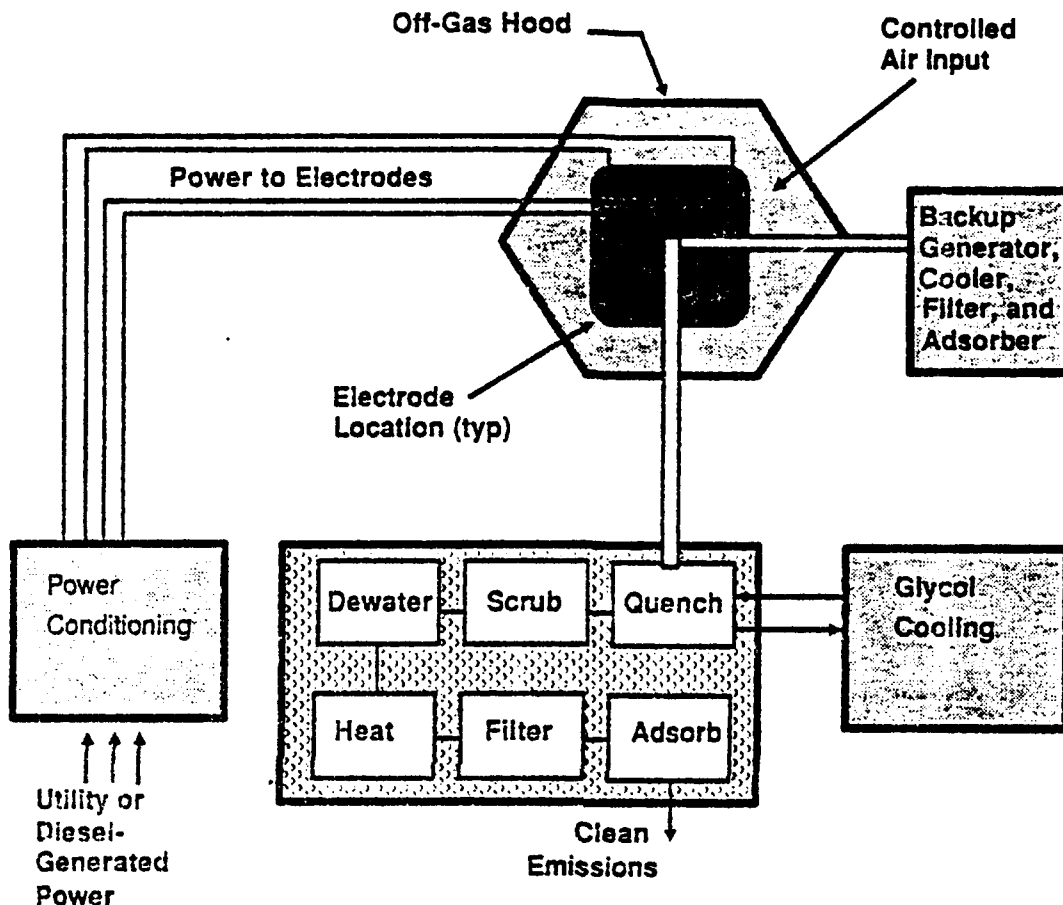


Figure 3. ISV Equipment System

products, and air are drawn from the hood by the induced draft blower into the off-gas treatment system which utilizes the following unit processes to ensure compliant air emissions: 1] quenching, 2] pH controlled scrubbing, 3] moisture removal [mist elimination], 4] reheating the gas to above the dew point, 5] particulate filtration and 6] activated carbon adsorption. A self-contained glycol cooling system is utilized to cool the quenching and scrubbing solution, avoiding the need for a constant on-site water supply. The amount of moisture present in the exhaust air stream is controlled to equal the moisture that is removed from the treatment volume during processing.

Typically, the volume of gases evolving from the melt represents less than 1 volume % of the total volume of air processed by the off-gas treatment system. Typically there is very little, if any, hazardous material that evolves from the melt during the processing. Some small quantity of particulates may be present in the off-gases, in addition to the pyrolysis and combustion

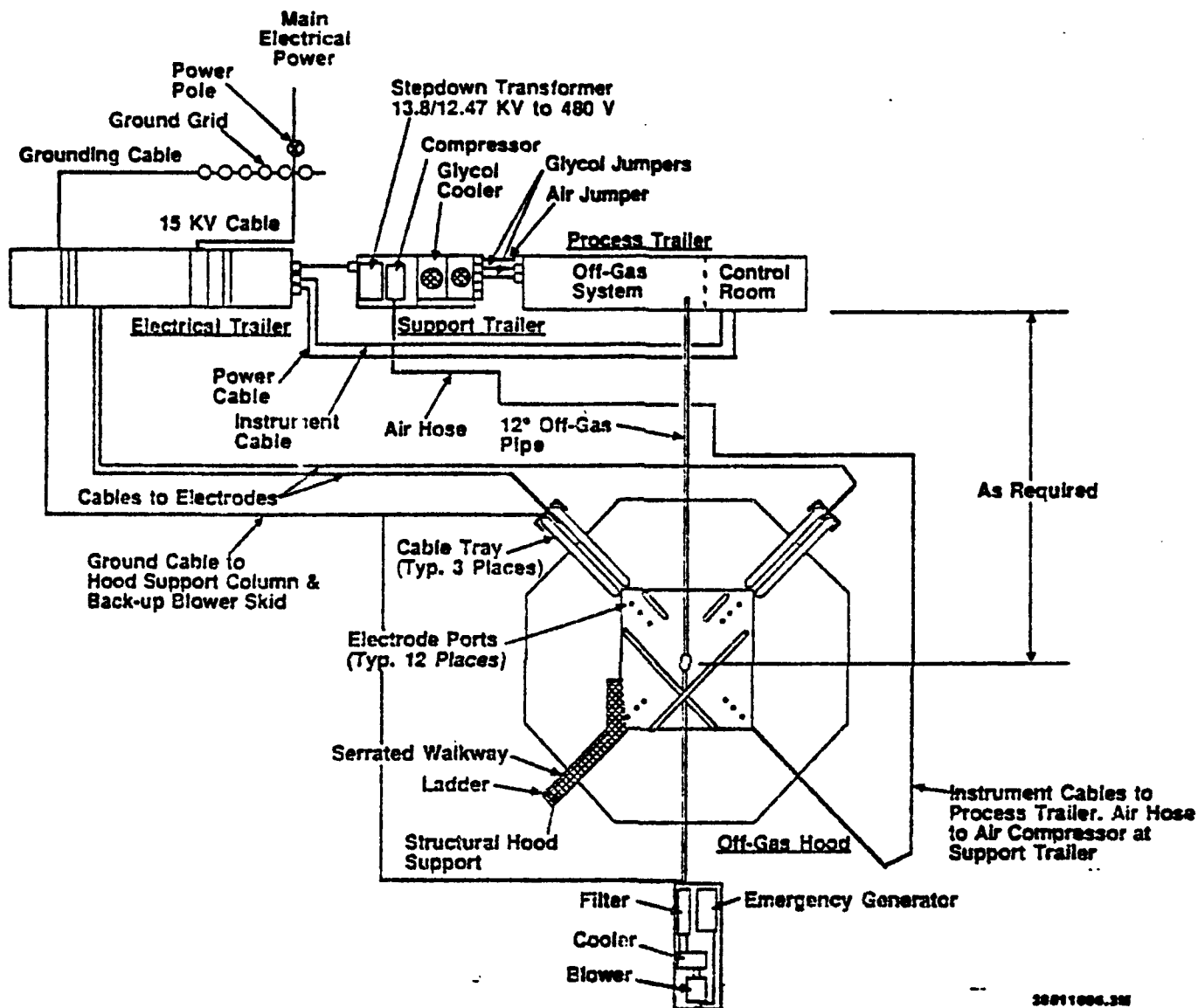


Figure 4. ISV Equipment Site Layout

products. Substantially all of the off-gas contaminants are removed from the off-gas stream at the quenching and scrubbing stages. The filters and carbon adsorption columns are utilized as polishing or secondary stages to ensure safe air emissions. After processing a series of melts, the filters and scrub solution and activated carbon may contain sufficient contaminants to warrant treatment or disposal. Typical treatment includes passing the scrubber water through diatomaceous earth [filter aid] and activated carbon, followed by reuse of the water or discharge to a sanitary or chemical sewer, and placement of the activated carbon and filters in a subsequent

ISV setting for disposal. In this way the destruction/chemical incorporation of contaminants collected in the off-gas treatment system is maximized, and the only secondary waste resulting from the ISV processing is that which is contained in the off-gas treatment system after the last setting at a site.

In addition to the primary off-gas treatment system, the ISV process system employs a backup off-gas treatment system for use in the event of a power failure. The backup system employs a diesel powered generator, blower, mist cooler, filter and activated carbon column. The backup system is capable of removing and treating the off-gases for the period of time that a melt may release off-gases after the power to the electrodes has been terminated, or for the time required for the melt surface to solidify.

The overall ISV process is monitored and controlled by a distributed microprocessor system. The process equipment system utilizes a large number of safety methods and devices to ensure safety of operations. The process is monitored and controlled by two qualified operators at all times. The process operates around the clock with about 16 hours of downtime between settings. Support personnel perform advance preparatory work [e.g., electrode assembly and placement] during operation of the system to minimize the downtime associated with moving the system.

IV. THEORETICAL BASIS OF PROCESS OPERATIONS

The behavior of hazardous wastes during ISV processing is controlled by several interrelated mechanisms as they affect the overall measured effects of destruction, removal and incorporation of hazardous materials into the molten glass. These mechanisms include: 1] diffusion along a concentration gradient [Fick's Law]; 2] capillary or wicking action; 3] reduced flow resistance in the dry zone adjacent to the melt; 4] carrier gas transport; 5] pyrolysis; and 6] solubility in the molten glass. The first four mechanisms effect the movement of water and organic liquids and vapors in the soil column. As mechanisms affecting the movement of materials, they can enhance the destruction of organics by causing organics to move to the pyrolysis isotherm where they are destroyed; they can also enhance removal from the treated volume by assisting in the movement of the material to the surface through the dry zone adjacent to the melt. And, they can enhance the incorporation into the molten glass by causing soluble inorganic materials to move toward [not move away from] the advancing melt front. The fifth mechanism directly affects the thermal destruction of organics and the sixth mechanism affects the incorporation of inorganic contaminants [generally metals] into the vitrified product.

Solubility of inorganics varies widely, with most metals being soluble to the extent of their concentration in the soil column [e.g., mercury is the notable exception with little or no solubility]. The retention of metals in the melt is a complex function of their solubility and vapor pressure. While small quantities of metals can be evolved from the melt, the material is captured in the hood, and routed to the off-gas treatment system.

Anions exhibit a wide variety of behavior. Halogen solubility is moderate to high with solubility increasing with decreasing atomic radii. The solubility of sulfur compounds is essentially zero, however, they are easily scrubbed out in the off-gas treatment system. Nitrates are thermally destroyed, creating gases, so these compounds have no solubility considerations. Carbonates are reduced to carbon dioxide and calcium oxide. The carbon dioxide gas is released from the melt and the calcium oxide goes into solution into the molten glass.

The relative importance of each of the mechanisms on destruction, removal and incorporation into the melt have been identified; their relationship is illustrated in Figure 5. While the relative affects have been identified, they have not been empirically quantified. However, the data base from ISV operations to date provides bounding values for the relationships

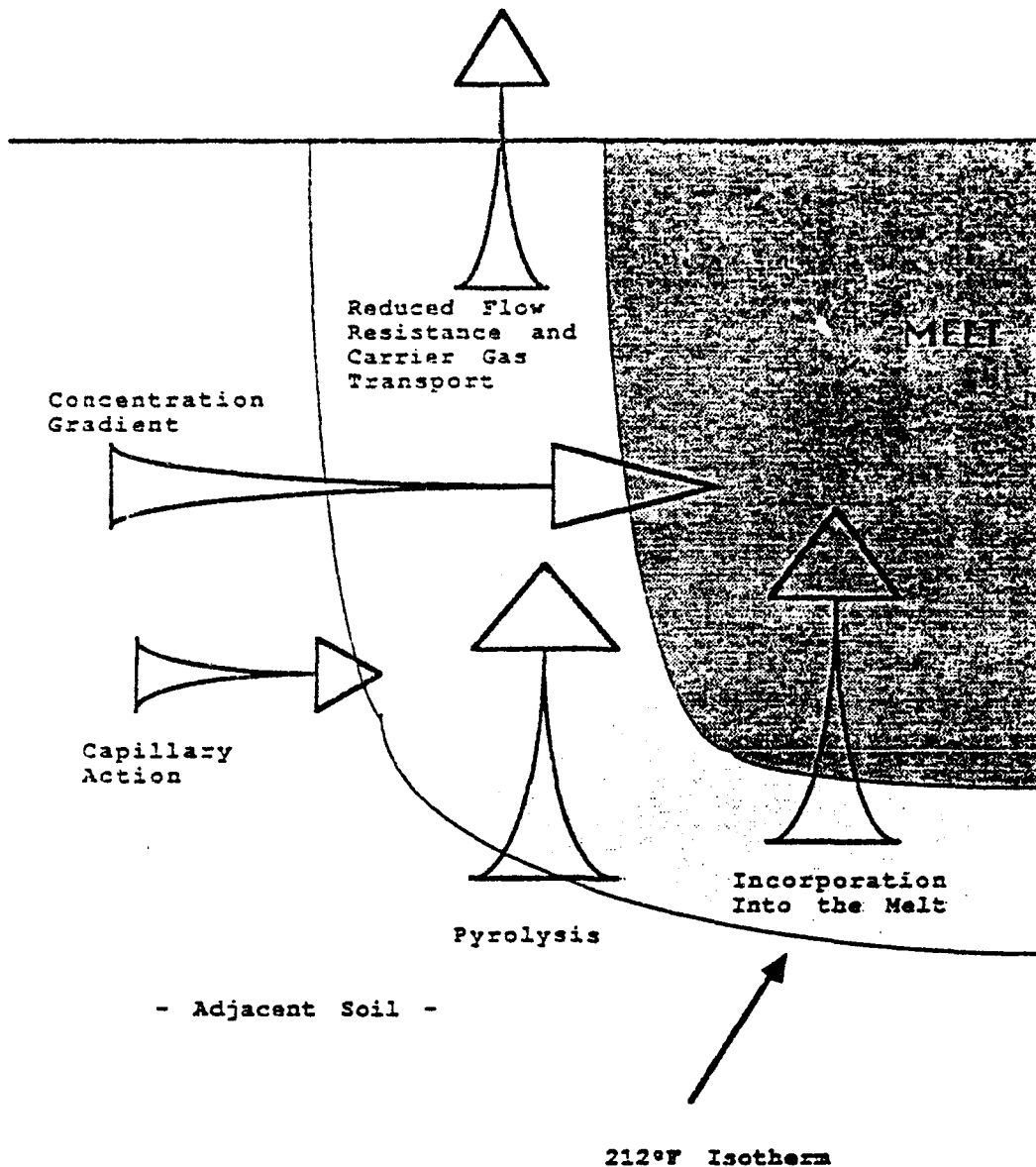


Figure 5. Factors That Effect Destruction, Removal, and Incorporation of Hazardous Wastes
(Size of arrow indicates relative importance)

of destruction and removal of organics and for removal and incorporation of inorganics.

It is important to understand the effect of each mechanism, how the mechanisms interrelate and the scientific validity of each mechanism to understand the effectiveness of the ISV process. It is not uncommon, when first encountering the ISV process to think

that organics may be driven outward by the heating process, into the surrounding or ambient soil. However, experimental data and observations during the development and demonstration of the ISV process dispel this concept and support the validity of the aforementioned mechanisms. Experimental data consistently demonstrate that organics are destroyed and removed from the contaminated soil. A destruction efficiency in the soil of >99.9% is typically observed for a spectrum of organics with the balance being released to the off-gas treatment system. An attendant removal efficiency for the off-gas treatment system of >99.9% yields and overall process DRE [destruction/removal efficiency] of >99.9999%.

Similarly, semi-volatile and non-volatile heavy metals have retention efficiencies in the molten glass of >99.9% and volatile metals (e.g. lead and cadmium) have a retention efficiency of about 99%. The off gas treatment system has a scrubbing efficiency of 99%, combined with a filter efficiency of at least 99.9% for particulates containing these metals. Overall retention/removal efficiencies for metals range from 99.9999% for the volatile metals to upward to 99.999999% for the non-volatile metals. Arsenic, while quite volatile, may have a relatively high retention efficiency (e.g. 75 to 95%) for large scale operations. Bauer reports arsenic concentrations in commercial glasses range from 0.1 to 0.9 wt.%, with a maximum observed concentration of 5 wt.%. This corresponds to arsenic retentions of 70 to 99% with a weighted average of approximately 91%. Mercury, which is classified as a very volatile metal, is postulated to behave more like an organic, without an accompanying destruction efficiency. Very little data are available for the behavior of mercury in glass.

Independent scientific corroboration of the validity of the mechanisms governing vapor behavior during the ISV process was provided in a recent paper presented at Superfund 38 [Dev et al 1988]. The paper describes the results of a radio-frequency heating field test, sponsored by the U. S. Air Force, at a site contaminated with unburned jet fuel. The contaminants were volatile aromatics and aliphatics and semi-volatile aliphatics. While the processing temperature for the radio-frequency heating test was well below the pyrolysis temperature for the compounds and the temperature gradients were not as great as those in the ISV process, the research determined that the organics moved from outside the heated region into the heated region, and from the heated region up to the ground surface. These observations are consistent with the behavior of vapors under exposure to the ISV process.

During the test, the movement of organics was assessed by injection of tracers in the soil adjacent to the heated zone. Halon, a mobile tracer injected four feet outside the heated zone at a depth of six feet, was detected in the off-gas stream

being collected from the heated zone, thus demonstrating the movement of organics toward the heated zone. This movement was independently confirmed by the post-test measurements indicating a net reduction of 70 to 76% in the concentration of organics originally present in the area immediately adjacent to the heated zone.

A recent paper [Buelte and Bonner 1989] documented the complete recovery of the water in the treatment zone during ISV processing. The behavior of water, with the exception that it does not pyrolyze during ISV processing, is quite similar to the behavior of liquid organics. This provides additional validation of the mechanisms controlling the behavior of materials during ISV processing.

Prior to discussing the relationship between the mechanisms that effect the behavior of material during ISV processing, it is valuable to review the physical relationship between the molten soil and the surrounding soil. During ISV processing there is a very steep thermal gradient in the soil adjacent to the molten soil. Typically, the temperature gradient in the adjacent soil is 150 to 300°C per inch. With a processing temperature of 1,600 to 2,000°C, the 100°C isotherm is usually within 6 to 9 inches of the melt. The soil outside the 100°C isotherm is referred to as ambient soil. The isotherm for pyrolysis of an organic is usually found between the 100°C isotherm and the melt, and usually within an inch or two of the melt (e.g., the 400°C isotherm is only 2 to 3 inches from the molten glass). The temperature gradient also creates a dry zone in the soil adjacent to the melt because the soil moisture between the soil particles has been volatilized and removed. This lowers the pressure drop for the passage of liquids and gases, creating a preferred flow path of lower resistance compared to the soil further from the melt.

It is also important to remember, that the quantity of water in soils is usually much greater than the quantity of organics present. Water in the ambient soil that is drawn toward the dry zone by capillary action effectively plugs up the soil pores adjacent to the dry zone, inhibiting the movement of organics away from the melt.

The analogy of a burning candle is useful in explaining the relationship of the mechanisms, as they affect the destruction of organics. First the candle, the solid wax [an organic] is melted by thermal energy from the flame. The molten wax is drawn up the wick toward the heat of the flame by capillary forces, to replace wax vaporized at the top of the flame. Similarly, in the ISV process, water and liquid organics are drawn by capillary forces toward a region near the melting soil that is being dried by the evaporation of water.

Second, in the candle, vaporized wax is swept into the flame by convection of air along the wick. Similarly, in the ISV process, soil moisture is converted to steam and the attendant pressurization forces steam into the melt, or upward along the boundary of the melt, as is evident from the virtually complete recovery of soil moisture in the ISV off-gas treatment system. The steam flow can also act as a carrier gas [similar to steam stripping or chromatographic operations], sweeping organics along the same path, either into the melt or along side the molten region to the off-gas collection system.

Finally in the candle, some vaporized wax condenses back on the wick, since the wick is much cooler than the flame. Once an organic [such as wax] is volatilized the gas molecules move randomly, unless acted on by other forces; so lacking other influences, the degree of condensation would be proportional to the molecules on a "newtonian random walk" contacting a single plane. However, consumption of the wax by pyrolysis in the base of the flame creates a concentration gradient that "pulls" the vapor into the flame by diffusion. Similarly, in the ISV process, the very high temperature of the molten soil causes the organics to be consumed by pyrolysis, creating a concentration gradient between the melt and the region where organics are volatilized. This concentration gradient pulls the vapor toward the melt by Fick's Law of gaseous diffusion. Vapors also diffuse away from the molten soil and condense when they reach their vapor point isotherm; however, the evaporation and transport of organics to a region of condensation is reversible; especially since the molten material is moving toward the condensation isotherm, and water moving toward the dry zone plugs the soil pores in the region of condensation.

In summary, in the course of ISV processing, pyrolysis is the predominant destruction mechanism and carrier gas transport is the predominant removal mechanism for organic contaminants. Based on the destruction efficiency of >99.9% typically observed, it appears that pyrolysis is dominant over the carrier gas removal mechanism; however, pyrolysis may be enhanced by the carrier gas mechanism. The heat from processing creates a dry zone adjacent to the processing area, providing an area of reduced pressure drop, enhancing movement of vaporized water and organics and promoting a steam stripping action. Capillary forces cause the moisture adjacent to the dry zone to move into the dry zone where they can be volatilized. Also, capillary forces cause the movement of water toward the dry zone, filling the pores and preventing the movement of other materials away from the melt. The volatilized gases are drawn toward the melt because of the concentration gradient created by pyrolysis. These effects are shown graphically in Figure 6.

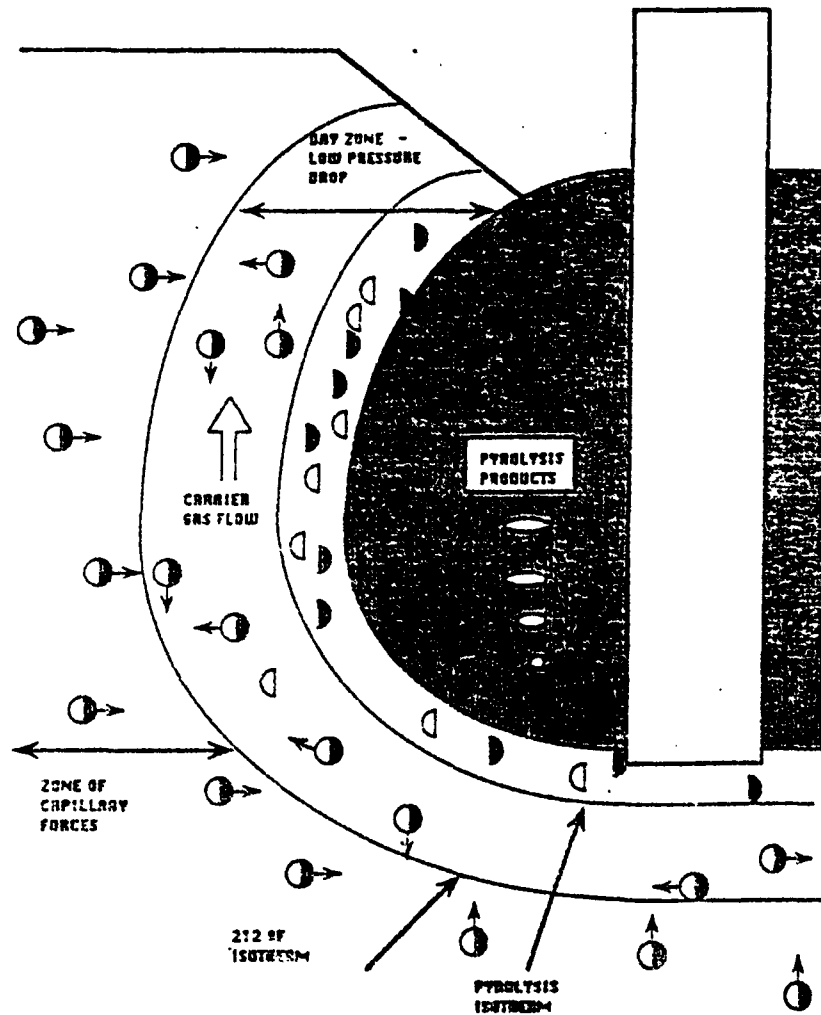


Figure 6. Behavior of Organics During ISV Processing

V. TEST DESCRIPTION

This section describes the engineering scale test equipment, the test array, the off-gas sampling system and the specific test set up operations. The soil chemistry of the samples received for the test are also described.

A. Soil/Sludge Characterization

Prior to beginning the vitrification operations, soil/sludge characterization was performed to determine metal oxide content, which allowed prediction of the melt viscosity, and the moisture content of the soil and sludge. The monovalent alkali earth metals (Na, Li, & K) affect the electrical conductivity of the molten mass. In order for ISV to have a suitable current carrying capacity, the sum of the monovalent earth metals must be in the range of 2 to 5 percent. The oxide analysis also provides the silica, aluminum, iron, and calcium content. The silica and aluminum oxides are glass formers; this data allows estimation of whether there are enough natural glass forming elements in the soil to make a suitable glass product. The calcium content is related to the viscosity and electrical conductivity within the vitreous zone.

The normalized oxide analyses content of the RMA soil, sludge, and cover soil are presented in Table 1, and detailed evaluation of the data is presented in Appendix C. The major oxide analysis was conducted using both the standard inductively-coupled plasma spectroscopy (ICP) technique, to obtain accurate analysis of the trace elements, and by potassium fusion and ICP, to obtain a more accurate indication of the sodium and silica content. Sufficient monovalent alkali earths were present to provide adequate electrical conductivity, and sufficient glass formers were available to make a high quality glass product.

The oxide analyses were evaluated using the Geothermal Program Package [GPP], from the Center for Volcanology, University of Oregon, to predict the melt viscosities over a range of temperatures for the various melt compositions expected with this waste. These results are presented in Appendix C.

Arsenic contamination levels averaged 150 ppm in the RMA soil and 44,000 ppm in the sludge. The clean soil covering and surrounding the contaminated RMA soils had a natural arsenic concentration average of 9.9 ppm. Mercury contamination levels averaged 38 ppm in the RMA soil and 5,400 in the sludge, and 0 ppm in the surrounding soil. Pesticide levels ranged from 100 ppb to 900 ppb in the RMA soil for Aldrin and Dieldrin respectively. The concentration of Dieldrin in the sludge was 5 ppb and Aldrin was below the detection limit. There were no pesticides in the surrounding clean soils. The mean concentrations of the contaminants and the respective confidence

intervals are presented in Table 2.

TABLE 1 SOIL OXIDE ANALYSIS

<u>ELEMENT</u>	<u>RMA SLUDGE</u>	<u>RMA SOIL</u>	<u>HANFORD SOIL</u>
SiO ₂	3.48	70.34	55.87
TiO ₂	0.05	0.35	1.49
Al ₂ O ₃	1.77	14.09	14.19
Fe ₂ O ₃	0.52	2.39	8.34
MnO ₃	---	0.06	0.02
MgO	0.28	1.27	4.88
CaO	92.53	2.97	7.03
Na ₂ O	---	3.29	5.86
K ₂ O	1.36	5.24	1.93
P ₂ O ₅	---	---	0.38
TOTAL	100.00	100.00	100.00

TABLE 2 ARSENIC, MERCURY AND PESTICIDE CONCENTRATIONS

<u>CONTAMINANT</u>	<u>RMA SOIL</u>	<u>RMA SLUDGE</u>
Mercury	37.3 +/- 6.4 mg/kg	5,360 +/-215 mg/kg
Arsenic	150 +/-29.3 mg/kg	43,875 +/-1,764mg/kg
Dieldrin	890 +/-514 µg/kg	4.7 +/-1.8 µg/kg
Aldrin	113 +/-37.7 µg/kg	Below Detection

The sludge separated into solid and a liquid phases in the drum containing the test sample. Similar behavior was observed with the sludge in the sample bottles. The liquid phase was analyzed separately; the level of arsenic and mercury in the liquid was <2 ppm, and pesticide contamination was <0.2 ppb. The quantity of contaminants in the liquid phase was not considered significant and therefore, no attempt was made to homogenize the sludge sample. The moisture content of the RMA soil was estimated to be 12 % and the moisture content of the sludge was estimated to be 50 %. The dry density of the RMA soil was estimated to be 1.5 to 1.6 g/cc as received, and the density of the sludge was estimated to be 1.1 to 1.2 g/cc.

B. Test Equipment and Setup

The engineering scale ISV unit illustrated in Figure 7 was used to conduct the engineering-scale treatability test. The power system consists of a 30 kW capacity Scott-Tee transformer. The transformer is equipped with 12 voltage taps and two silicon controlled rectifiers (SCRs) for controlling the power input to

the melt. The transformer is equipped with metering on the secondary side [output to the electrodes] for power, voltage, and amperage.

The RMA test utilized two of the three available sampling ports for off-gas sampling. The first port was connected to a Multi-Metals sampling train for arsenic and mercury sampling. The second port was capped off and not utilized. The third port

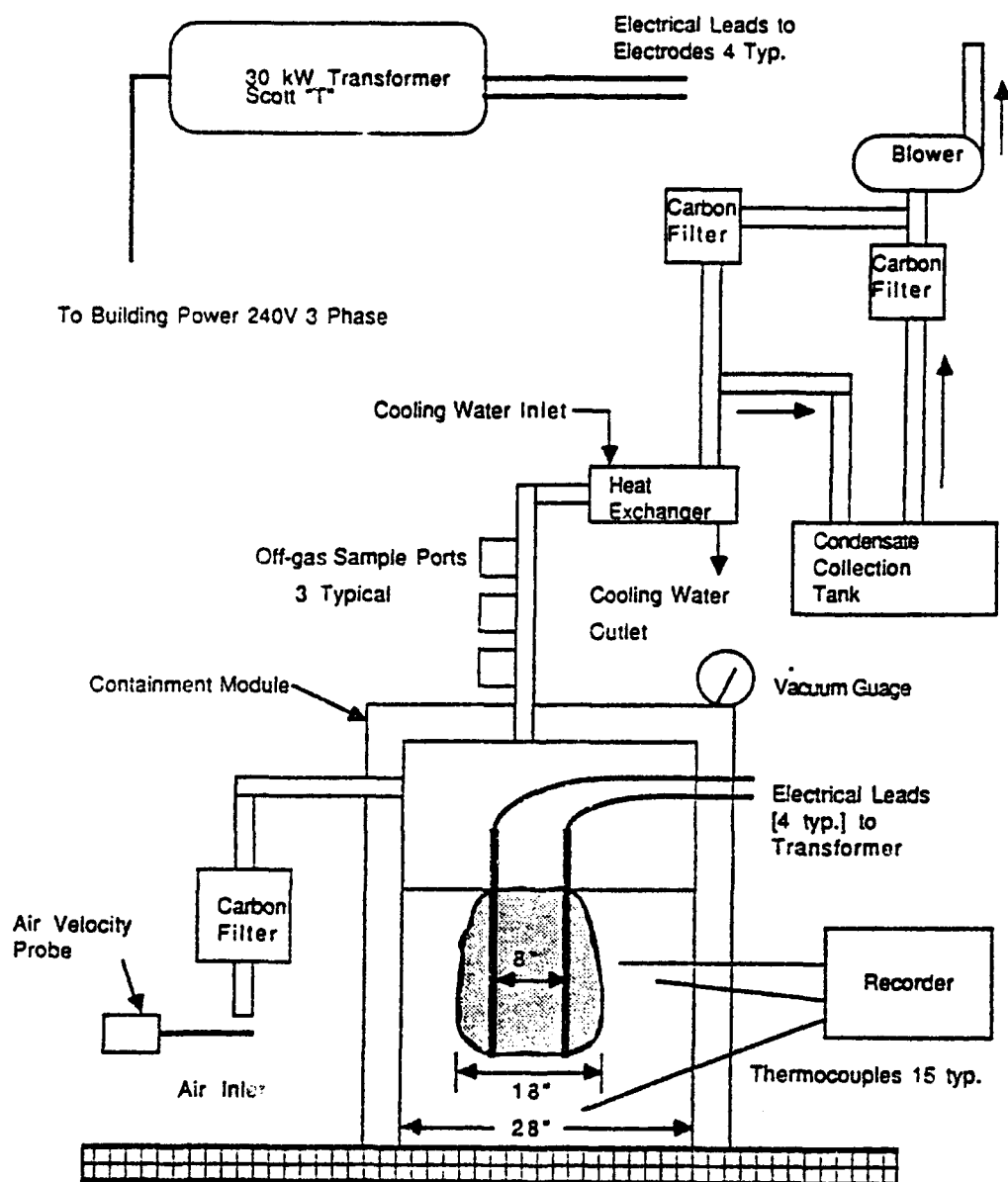


Figure 7. Engineering-Scale ISV System

was connected to a semi-VOST sampling train for collection of pesticides. Each train had Methods 1 and 2 performed to determine the sample gas velocity, temperature, and volumetric flow rate. The velocity and volume of the stack gas was also determined. Methods 3 and 3A were performed to determine the molecular weight of the stack gas using the following instrumental analyzers. An Infrared Industries Model 2200 oxygen analyzer was used to measure the percent oxygen (O_2). An Infrared Industries Model 702D non-dispersive infrared analyzer (NDIR) was used to measure the percent carbon dioxide (CO_2). An Automated Customs Systems (ACS) Model 3300 NDIR analyzer was used to measure the ppm carbon monoxide (CO). These analyzers meet 40 CFR 60, Appendix B, Performance specification 3 and 4 criteria. Method 4 was performed to determine the moisture content of the stack gas. Arsine gas samples were also collected by pumping the stack gas into tedlar bags and then pumping the contents of the bag through Drager tubes for possible detection of arsine. Appendix D contains a copy of the AmTest Inc. Source Emission Evaluation Report, which provides the sampling details and describes the methodologies used for air sampling.

Downstream of the sampling ports, the off-gases from vitrification operations were cooled to approximately 30°C by a single pass shell and tube heat exchanger. The condensate removed from the off-gas by the heat exchanger was collected in a water condensate collection tank. The gaseous phase continued through a filter system containing drierite dessicant to remove any additional moisture carryover and activated vapor phase carbon to remove the particulate and gaseous organic emissions from the melt.

Figure 8 illustrates the soil placement, thermocouple locations, and electrode orientation for the treatability test. Three inches of clean soil was placed as the top layer so test operations could reach an equilibrium level and background readings could be obtained prior to melting the RMA soil. The relationship between the thickness of the RMA soil and the RMA sludge was selected to simulate the stratigraphy of the M-1 Ponds site. The soil surrounding the vitrification zone was non-contaminated in order to assess the possibility for disposition of contaminants from the waste into adjacent outlying areas. The ISV zone was covered with a 3-inch kaowool insulation blanket, leaving small gaps around the electrodes for venting. The insulation promotes subsidence of the molten zone and improves the melting efficiency of the operation; this technique is also used in large-scale operations.

The test was conducted in an 85 gallon drum placed inside a steel box for double containment and safety purposes. The four 0.5 inch diameter by 24 inch long molybdenum electrodes were sheathed by 1.5 inch diameter by 20 inch long graphite collars to

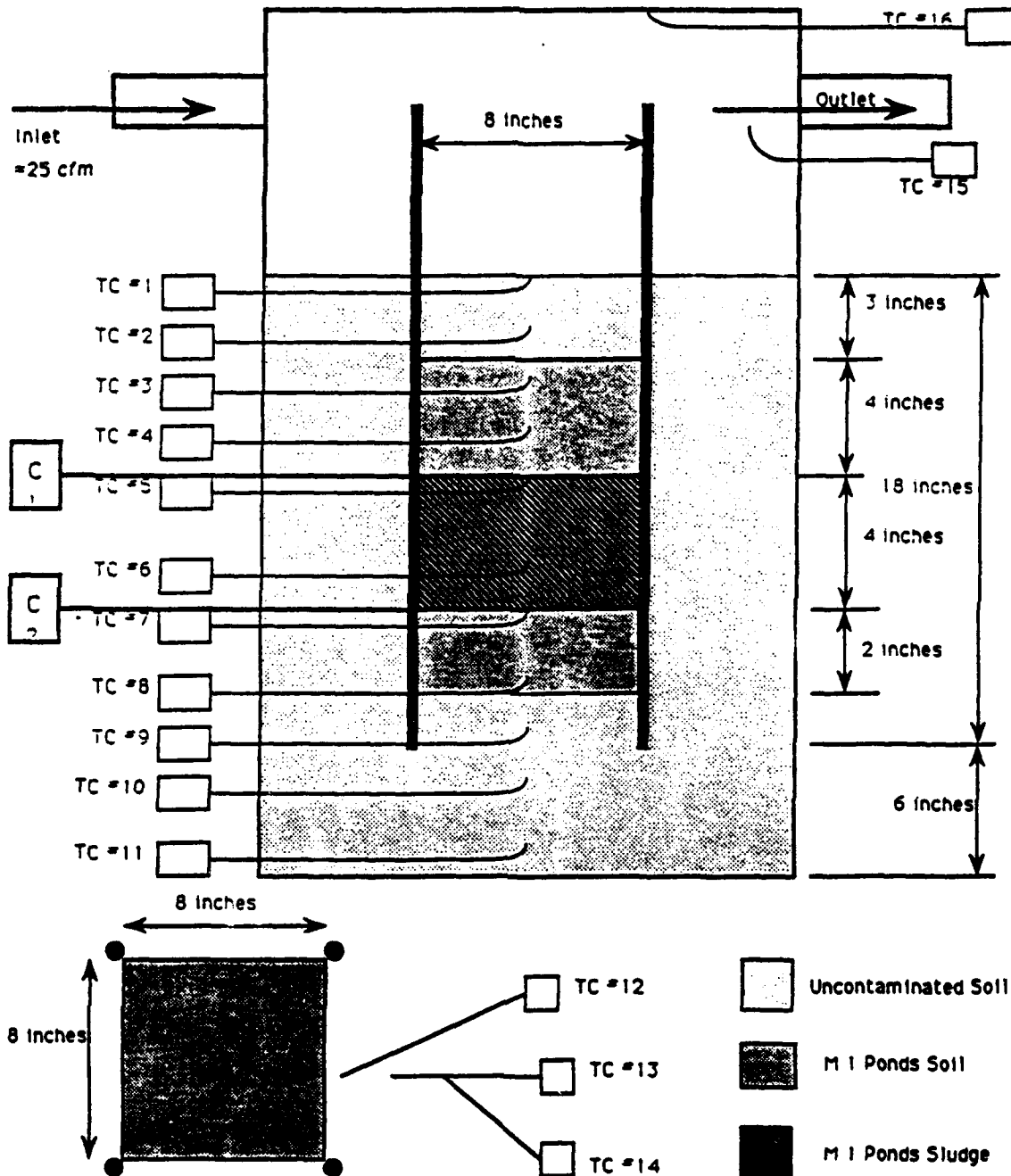


Figure 8. Placement of Test Soils

help prevent oxidation of the molybdenum and promote subsidence of the melt zone. The electrodes were placed in the soil to a depth of 18 inches. The electrode assemblies had a center to center spacing of 8 inches in a square array. A mixture of flaked graphite and glass frit was placed in a 1 in. x 1 in. path laid in an "x" and square pattern on the surface of the soil to provide a conductive path between the electrodes.

Type K thermocouples were placed at selected intervals located in the center of the test drum to monitor the melt depth during processing. The thermocouples were placed from the surface down to the bottom of the drum, at 2-inch intervals. In addition, three type K thermocouples were installed on a horizontal axis at a depth 10 inches below the surface grade. The horizontal thermocouples were also spaced at 2 inch intervals and were used to measure the horizontal melt dimensions and the temperature of the isotherms in the surrounding melt. The relationship of the thermocouples is shown in Figure 8.

VI. TEST OPERATIONS

The engineering scale treatability test was conducted on August 2, 1989. Power to the electrodes was initiated at 0835 hours. Power build up was normal and a stable melt was achieved about two hours into the test. The vitrification treatment proceeded to the target depth of 18 inches before power to the electrodes was terminated. This depth corresponds to a burn-out temperature reading on thermocouple #9, and a temperature reading of 432°C on thermocouple 10 [see Figure 8]. The total test time was 7 hours 5 minutes.

The data readings for power level are presented in Table 3 and plotted in Figure 9. Power to the electrodes was controlled based on transformer meter readings to provide an accurate scale-down of power density for the large-scale system. Power density is defined as $PD = P/A$; where PD equals power density, [kW/ft²], P = power level [kW], and A equals surface area [ft²] of the vitrification zone after startup material is consumed. The maximum power density of the large scale system is 26 kW/ft², which is based on a 3,750 kW power supply and a minimum area between the electrodes of 144 ft². During the latter portion of the test an average power level of ≈15 kW was maintained, assuming the surface area of the melt was between 70 and 80 square inches, yielding a power density of 27.0 to 30.9 kW/ft².

The melt temperature of the vitreous zone was measured using a type C thermocouple located 10 inches below the surface of the soil at the center of the melt and at the upper interface of the RMA soil and sludge. The peak melt temperature observed was 1,740°C. This temperature was measured after the melt had just began processing the sludge. The incorporation of calcium into the melt lowered the melt temperature several hundred degrees from the maximum melt temperature attained during processing the RMA soil [see Appendix C for the pretest predictions of the melt temperatures]. The RMA soil, which contained 70% silican dioxide and 14% aluminum oxide, should have had an average melt temperature of ≈1,800°C. A second Type C thermocouple was placed at the bottom interface between the sludge and the RMA soil so additional readings could be obtained, however, this thermocouple failed and additional temperatures were unattainable.

Calcium forms a eutectic with silica resulting in lower melting and operating temperatures and lower viscosities. Once the sludge was completely vitrified, the equilibrium temperature would be expected to rise to melt the soil below the sludge. This behavior means that the sludge will be preferentially melted during full-scale operations. This will maximize the operating efficiency of the ISV process and is consistent with observations from the treatability test for the Crystal Chemical Superfund Site, which is also an arsenic and pesticide site, with high

RMA ENGINEERING SCALE POWER READINGS

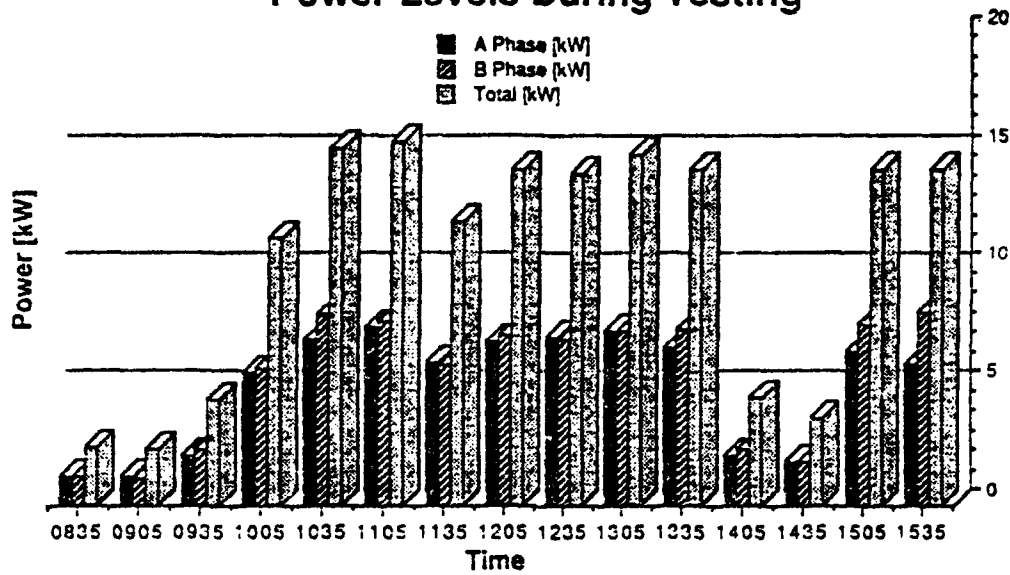
(TRANSFORMER READINGS)

TIME	A-Phase			B-PHASE		
	VOLTS	AMPS	KILOWATTS	VOLTS	AMPS	KILOWATTS
8:35	99	11	1.23	100	8	1.26
9:05	57	19	1.23	66	12	1.15
9:35	57	35	2.13	82	20	2.38
10:05	157	35	5.6	165	23	5.8
10:35	183	38	7.05	180	29	8.1
11:05	182	41	7.55	173	29	7.86
11:35	198	30	6.04	184	22	6.03
12:05	173	40	7	158	30	7.24
12:35	160	43	7.11	149	31	7.02
13:05	133	55	7.42	126	39	7.43
13:35	100	66	6.73	102	49	7.53
14:05	71	29	2.13	73	22	2.41
14:35	80	22	1.86	78	16	1.88
15:05	99	65	6.56	100	51	7.67
15:35	88	68	6.02	89	61	8.23
TOTAL			75.66			81.99

TOTAL A PHASE AND B PHASE = 75.66+81.99 = 157.65 KW

Table 3. Test Power Levels

Power Levels During Testing



Power Level During Test - A & B Phase

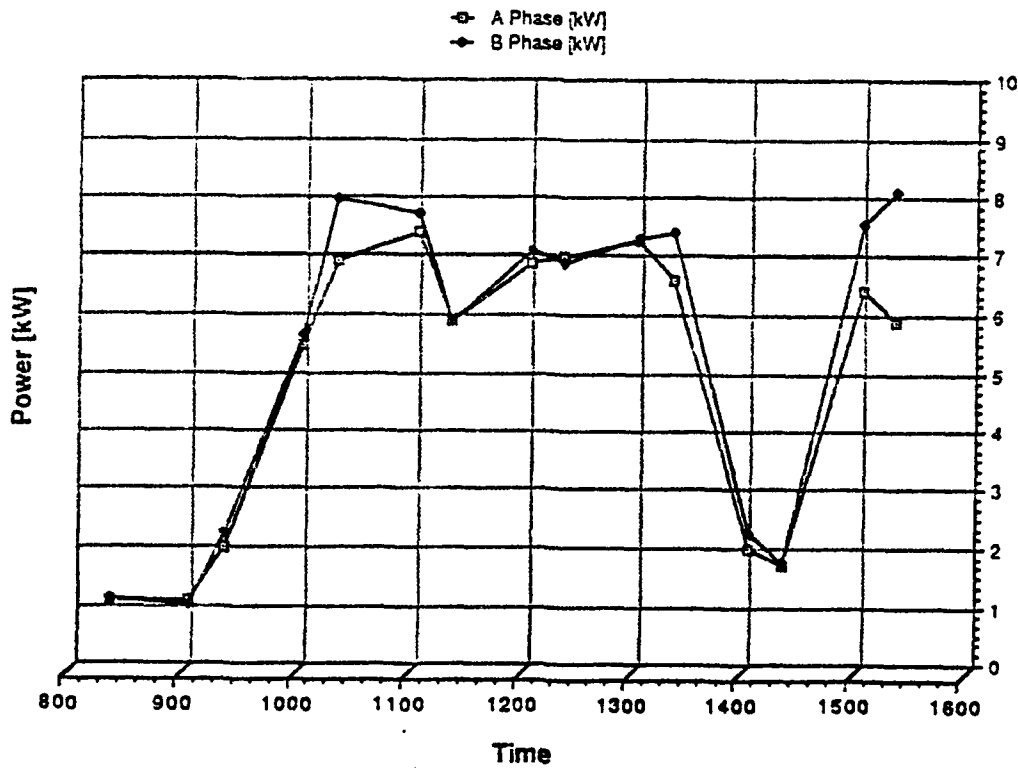


Figure 9. Power Level Curves

concentrations of calcium from prior neutralization operations.

A major amount of foaming was observed as the calcium sludge was consumed by the melt. This was most likely caused by the presence of high concentrations of calcium and arsenic in the sludge. Arsenic is used as a fining [degassing] agent in the commercial glass industry. Fining is accomplished with oxygen. Arsenic tri and pentoxide release oxygen and are reduced to a lower valence state. The foaming could have been enhanced by the decomposition of calcium carbonate, releasing CO₂. When the melt had been "degassed" or clarified, the foaming action ceased. The fining process was also assisted by the decreasing viscosity as the calcium concentration in the melt increased. No additional foaming was observed once the melt proceeded into the soil beneath the sludge.

Gas samples were drawn through the multi-metals and semi-Vost trains from 1018 to 1348. The starting time corresponds to when the number 3 thermocouple at the Hanford/RMA soil interface rose to a temperature of $\approx 300^{\circ}\text{C}$. The ending time is coincident with the burnout of the number 8 thermocouple, which was located at the bottom of the test zone, at the RMA/Hanford soil interface. See Figure 8 for the locations of the thermocouples. After thermocouple number 8 burned out, the power level was lowered, the sampling trains removed, and a second metal sampling train attached to the sampling port. The sampling train was set up specifically for measuring Arsenic. The purpose for this second train was to measure Arsenic emanation from the melt during the final portion of the test. When the second train was in place, the power level was raised, and operations continued until thermocouple 9 was burned out. Thermocouple 9 was located at the bottom of the electrodes (≈ 18 inches below the initial grade).

The vitrified block generated during the test weighed 155 pounds, including the material fused to the block. This represents a weight loss of approximately 92 pounds or 37% excluding the water, or 122 pounds or 44% including the water. A subsidence void approximately 5 inches in depth was observed beneath the formation of a thin cold cap of glass. The cold cap was less than 1/2-inch thick. The volume reduction of 28% resulted from a combination of elimination of pore volume plus volume reduction associated with the decomposition of CaCO₃ in the sludge. A schematic cross section of the vitrified block is shown in Figure 10.

In summary, operations during the test were extremely smooth. Power was applied to the electrodes at 0835. A stable melt was achieved within two hours. Power control was at or near the target level of 15 kW, except during the period sample trains were being changed, when the power level was intentionally reduced. All off-gas sampling was performed in accordance with standard EPA protocols, using calibrated equipment traceable to

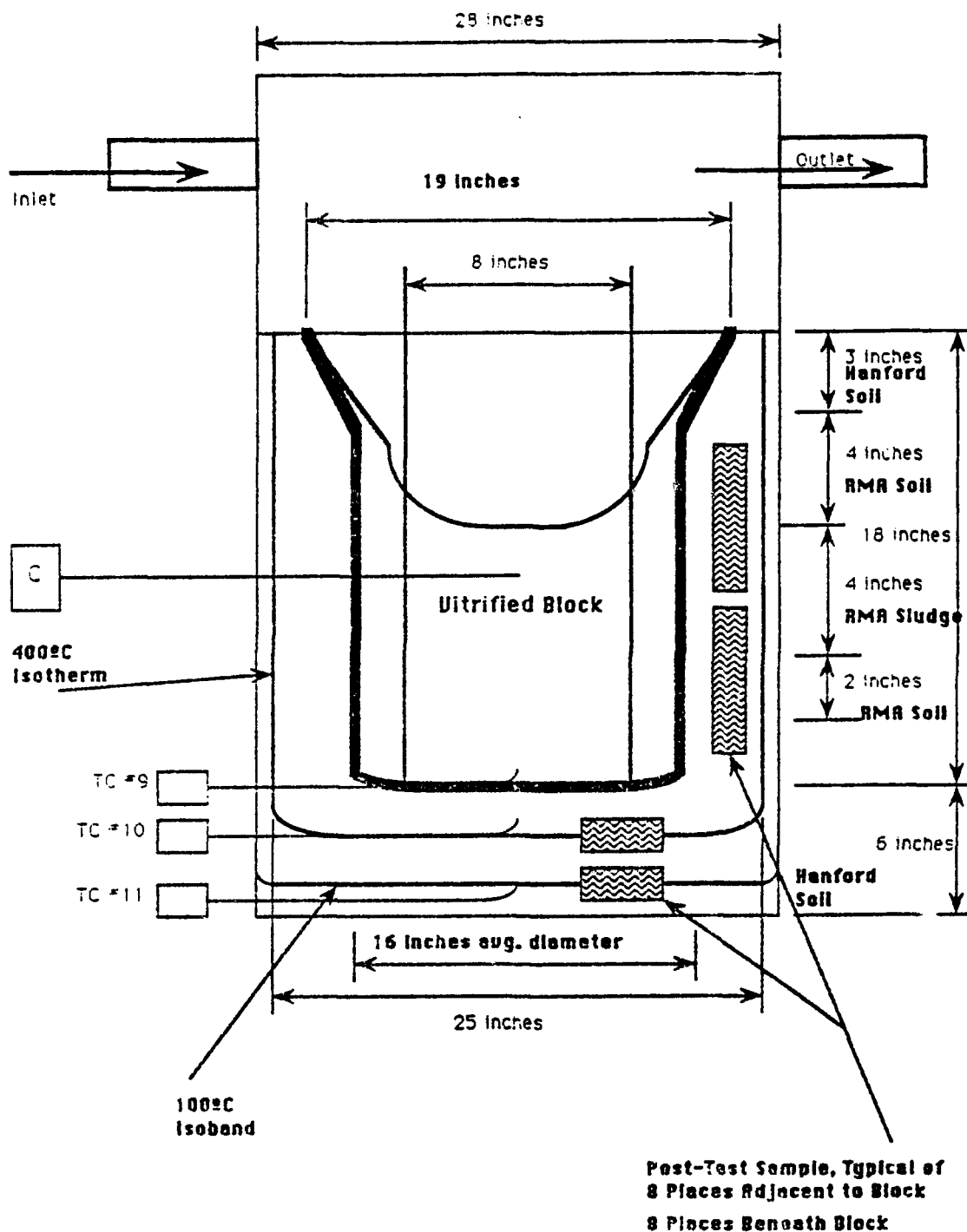


Figure 10. Schematic Cross Section of Vitrified Block

National Bureau of Standards calibration data. The test was terminated at 1540, shortly after the number 9 thermocouple (at the bottom of the electrodes) had burned out. Cool down was accomplished overnight, with full off-gas flow and vacuum on the test chamber, and cooling water flow through the condenser.

At the time power to the electrodes was shut off, the target depth of 18 inches had been reached, and thermocouples 1 - 9 in the vertical array had burned out. Thermocouples 10 and 11 were both indicating temperatures of about 100°C. Thermocouples 12 and 13 in the horizontal array had burned out, and thermocouple 14 was indicating a temperature of about 340°C.

Off-gas system flow was terminated at 1005 on 8/3/89. At that time, thermocouple 10 was indicating a temperature of 150°C. Thermocouple 11 was indicating a temperature of 96°C and thermocouple 14 was indicating a temperature of 180°C. During the thermal surge after power to the electrodes was shut off, thermocouple 10 reached a peak temperature of 432°C and thermocouple 14 reached a peak temperature of 480°C. Both peaks were observed at 1810, 150 minutes after power to the electrodes was turned off. Cooling rates during the cooling time until off-gas system flow was terminated were nearly linear at a rate of $\approx 18^\circ\text{C/hr}$. Figures 11 through 16 provide photographs of the various stages of the treatability test.



Figure 11. View of ISV Process



Figure 12. View of Vitrified Block in Test Chamber

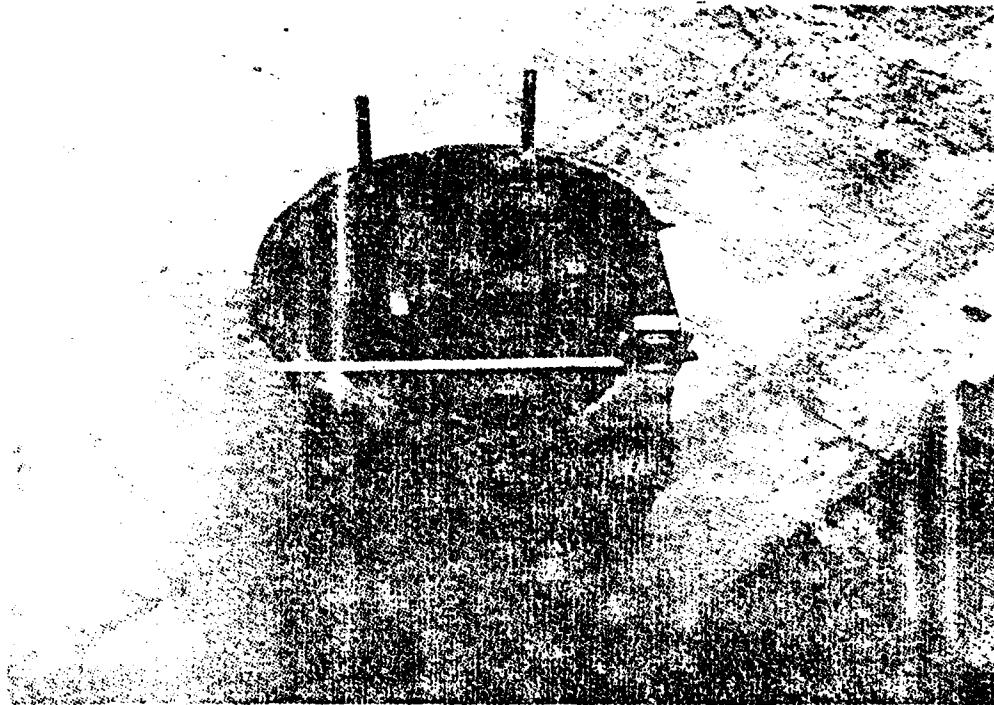


Figure 13. Vitrified Block (Top View)

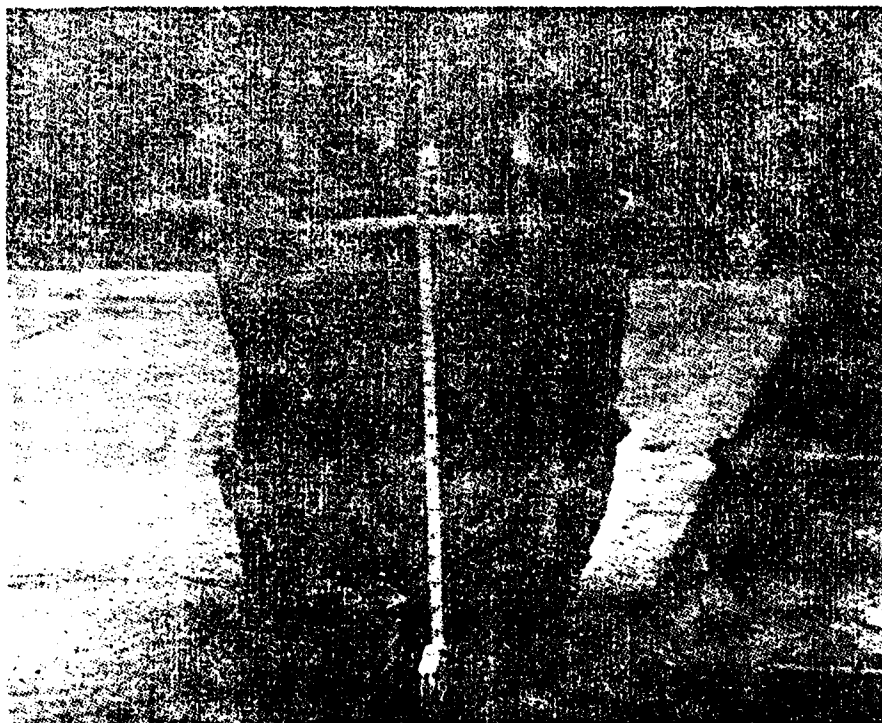


Figure 14. Vitrified Block (Side View)

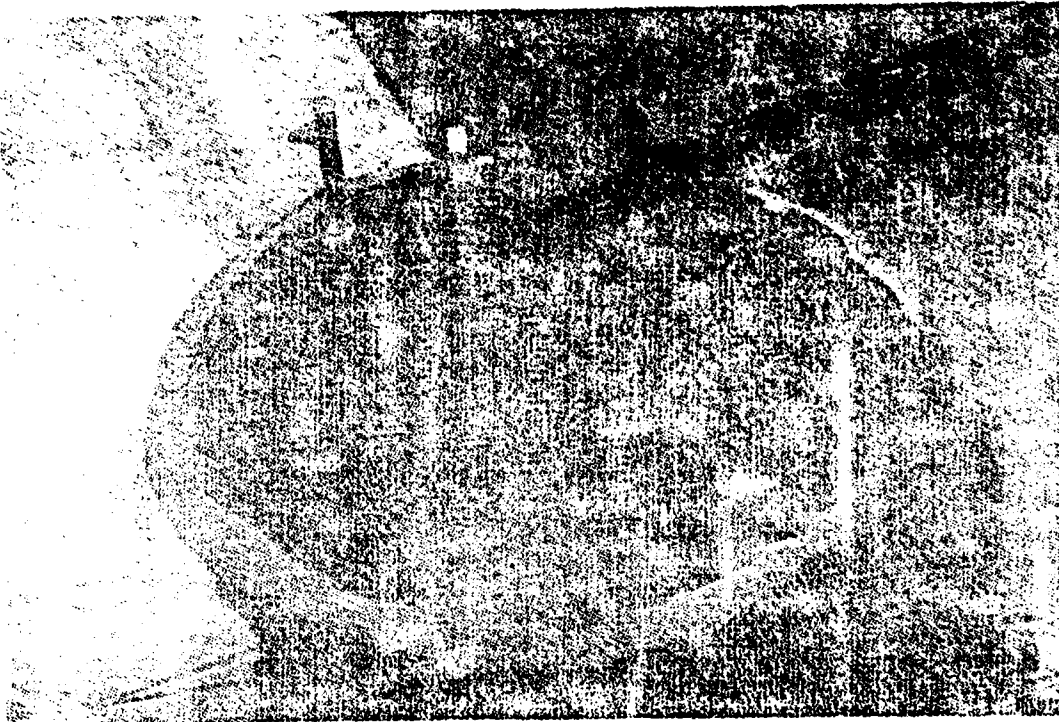


Figure 15. View of ISV Block Subsidence

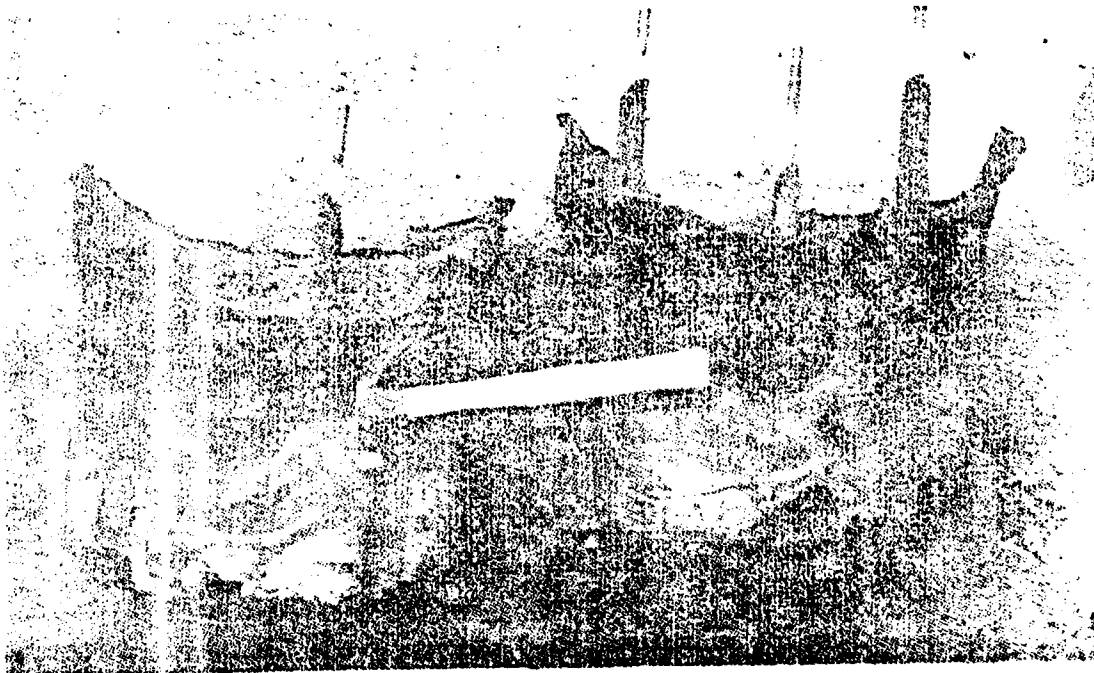


Figure 16. View of Cross Section of ISV Glass Block

VII. TEST RESULTS

The presentation of the test results are divided into three major sections: A] pre and post test measurements of the contaminants in the soil, off-gas, and glass; B] analysis of the data, e.g., calculation of the destruction and removal efficiencies and mass balances; and, C] discussion of the results.

A. Pre and Post Test Measurements

A-1. Pre-Test Soil Results

The following concentrations and quantities of contaminants are based on dry densities of 1.6 g/cc for the RMA and clean soil and 1.1 g/cc for the RMA sludge.

Pesticides

The average pre-test concentration of dieldrin was 890 ppb in the soil and 4.7 ppb in the sludge resulting in 8,933 ug dieldrin present in the test chamber. The average pre-test concentration of aldrin was 113 ppb in the soil and non-detectable in the sludge resulting in 1,138 ug aldrin present in the test chamber.

Arsenic

The average pre-test concentration of arsenic was 150 ppm in the RMA soil, 43,875 ppm in the RMA sludge, and 9.9 ppm in the clean [Hanford] soil adjacent to the melt. This amounts to a total of 207,691 mg arsenic present in the test chamber.

Mercury

The average pre-test concentration of mercury was 37.3 ppm in the RMA soil, 5,360 ppm in the RMA sludge, and assumed to be non-detectable in the clean soil adjacent to the melt. This amounts to a total of 24,736 mg mercury present in the test chamber.

A-2. Post-Test Soil Results

After completion of the melt, soils were collected adjacent to and beneath the glass block (see Figure 10) in accordance with the Test Plan (see Appendix A).

Pesticides

There was no dieldrin detected in the soils adjacent to the block. The average concentration of dieldrin beneath the block was 1.6 ppb for a total dieldrin quantity of 52 ug remaining in

the drum after vitrification. This assumes that a circular volume, of uniform concentration, 14-inches in diameter and 8-inches deep is present directly beneath the ISV glass block. Analyses on post-test soil samples adjacent to and beneath the glass block were non-detectable for aldrin.

Arsenic

Post test analyses on the soil adjacent to and beneath the block showed an average arsenic concentration of 12.7 ppm +/- 2 ppm. The pre-test concentration of arsenic in the clean soil was 10 ppm +/- 2 ppm. This yields a total of 3,400 mc arsenic remaining in the surrounding soil after vitrification, with no significant movement of arsenic from the contaminated to clean soil areas.

Mercury

Post test analyses on the soil adjacent to and beneath the block showed an average mercury concentration of 4.8 ppm +/- 2 ppm. The pre-test concentration of mercury in the clean soil was assumed to be non-detectable. This yields a total of 953 mg mercury remaining in the test chamber after vitrification.

A-3. Off-Gas Results

A slip stream off-gas sample was continuously drawn off through a semi-VOST sampling train for collection of the pesticides. The sample collection time for the semi-Vost train was 208 minutes, the sample volume was 71.4 dry standard cubic feet (dscf), and the off-gas flow rate was 44.5 dry standard cubic feet per minute (dscfm). The total test time was 425 minutes. Actual sampling times are presented in the Test Operations Section and Appendix D.

Two independent sampling trains were utilized for sampling the metals. The first train operated from the time the melt entered the contaminated zone through completion of the contaminated soil. The second train (Arsenic only) operated for the duration of the test. A slip stream off-gas sample was also continuously drawn off through the multi-metals sampling trains for the collection of arsenic and mercury. The sample collection time for the multi-metal train was 165 minutes, the sample volume was 69.5 dscf, and the off-gas flow rate was 44.5 dscfm. The second train operated for 67 minutes and the total sample volume was 44.2 dscf. The total test time was 425 minutes. Actual sampling times are presented in the Test Operations Section and Appendix D.

Pesticides

The total quantity of dieldrin collected during the 208 minutes of off-gas sampling was 1.2 ug. Multiplication of the mass

emission rate of 0.012 ug/sec, for a sample duration of 208 minutes yields a total of 0.150 mg dieldrin released to off-gas.

The total quantity of aldrin collected for the 208 minute sampling time was 0.3 ug. Multiplication of the emission rate of 0.0031 ug/sec, for a test duration of 208 minutes yields a total of 0.038 mg aldrin released to off-gas.

Arsenic

The total quantity of arsenic collected during the 165 minutes of off-gas sampling was 79,500 ug. Multiplication of the mass emission rate of 895 ug/sec, for a test duration of 358 minutes yields a total of 19,225 mg arsenic released to off-gas. This emission rate was applied to the entire first portion of the test because of the presence of arsenic in the Hanford soils, that may have been released prior to the start of sampling and to account for the arsenic not measured during the time the sampler was not operating while RMA sludge was being processed. The second off-gas sampling train, operated for 67 minutes, after the melt had processed the RMA soils. This train collected 27,120 ug of arsenic. Multiplication of the emission rate of 598 ug/sec for a test duration of 67 minutes yields a total of 2,404 mg arsenic released to the off-gas system. The two release numbers indicate a overall test release of 21,629 mg arsenic.

Mercury

The total quantity of mercury collected during the 165 minutes of off-gas sampling was 36,469 ug. Multiplication of the mass emission rate of 410.3 ug/sec, for a test duration of 425 minutes yields a total of 10,455 mg mercury released to off-gas. This emission rate was applied to the entire test period to account for the mercury released during sludge processing and while the sampler was not operating and to account for the mercury released during the thermal stage at the completion of the test.

A-4. Glass Product and TCLP Results

Pesticides

It was assumed that there were no pesticides present in the glass product. This assumption is based upon prior RMA test results.

Arsenic

The average residual arsenic concentration within the glass was 146 ppm. Multiplying by the mass of the block (155 lbs/70.5 kg) yields a total of 10,278 mg arsenic remaining in the glass product. A toxic characteristic leach procedure (TCLP) test was performed on a section of glass immediately adjacent to the electrode (worst case scenario) using the grind and sieve method

rather than the monolith method. The concentration of the leachate was 0.91 mg/L arsenic. Based on these results, the vitrified product would pass the TCLP. The TCLP was selected because it is a more stringent delisting protocol than the EP Tox test.

Mercury

The average residual mercury concentration within the glass was below the limits of detection. A toxic characteristic leach procedure (TCLP) test was performed on a section of glass immediately adjacent to the electrode (worst case scenario) using the grind and sieve method rather than the monolith method. The concentration of the leachate was 0.0001 mg/L mercury. Based on these results, the vitrified product would pass the TCLP. The TCLP was selected because it is a more stringent delisting protocol than the EP Tox test.

A-5. Other Analytical Results

Pesticides

There was no dieldrin or aldrin detected in the wipe samples after vitrification was complete. It was assumed that there was no pesticides present in the kaowool insulation blanket covering the melt. This assumption was based on prior RMA test results.

Arsenic

The kaowool insulation blanket was analyzed for arsenic. The results of this analysis showed an arsenic concentration of 2,680 ppm for a total quantity of 1,767 mg arsenic in the entire insulation blanket. Final wipe samples of the vitrification drum, the containment box, and the off-gas line yielded a concentration of 5,470 mg arsenic. The off-gas line was then washed with a dilute solution of nitric acid followed by a water rinse. The two solutions were analyzed for arsenic with 1,302 mg contained in the acid wash and 1,448 mg in the water rinse.

There were two separate water condensation collection tanks utilized during the test. The first tank was used during the time contaminated soil was being melted. The second tank began collecting water after vitrification was through the contaminated material through post-test cool-down. The quantity of arsenic collected in the first condensation collection tank was 18,410 mg, primarily in dissolved form. In addition, two wipe samples were obtained from the condensation collection tank which yielded an additional 337 mg arsenic. The second condensation collection tank collected 6,810 mg arsenic, primarily in the dissolved form and a total of 63.1 mg arsenic in the wipes.

Mercury

The kaowool insulation blanket was analyzed for mercury. The results of this analysis showed an mercury concentration of 7.7 ppm for a total quantity of 5.1 mg mercury in the entire insulation blanket.

Final wipe samples of the vitrification drum, the containment box, and the off-gas line yielded a concentration of 101 mg mercury. The off-gas line was then washed with a dilute solution of nitric acid followed by a water rinse. The two solutions were analyzed for mercury with 58 mg contained in the acid wash and 40.6 mg in the water rinse.

As previously indicated, there were two separate water condensation collection tanks utilized during the test. The first tank was used during the time contaminated soil was being melted. The second tank began collecting water after vitrification was through the contaminated material through post-test cool-down. The quantity of mercury collected in the first condensation collection tank was 34 mg, primarily in solid form. In addition, two wipe samples were obtained from the knockout pot which yielded an additional 7 mg mercury. The condensation collection tank pot collected 2.3 mg mercury, primarily in solid form and a total of 0 mg mercury in the wipes.

The results discussed above are summarized in Table 4.

B. Analysis of the Data

Pesticides

The off-gas flow rate was 60 actual cubic feet per minute (acfm) or 44.5 dscfm. The corresponding minimum destruction efficiency (DE) for dieldrin at this flow rate was 98.3% for dieldrin. Combining the DE with the expected removal efficiency (RE) of >99.9% for the large-scale ISV off-gas treatment system yields a minimum expected DRE of 99.998% for dieldrin. The mass balance off-gas quantity released to the off-gas system during the treatability test was 155 ug dieldrin.

The corresponding minimum DE for aldrin at the flow rate of 44.5 dscfm was 96.6% for aldrin. Combining the DE with the expected RE of >99.9% for the large-scale ISV off-gas treatment system yields a minimum expected DRE of 99.996% for aldrin. The mass balance off-gas quantity released to the off-gas system during the treatability test was 38.8 ug aldrin.

	Dieldrin (mg)	Aldrin (mg)	Arsenic (mg)	Mercury (mg)
Pre-Test - Test Chamber	8.983	1.138	207,691	25,112
Post-Test - Test Chamber	0.14	0	3,400	953
Off-Gas - Measured Release	0.155	0.038	21,629	10,455
Kaowool Retention	0	0	1,767	5
Post-Test Wipes	0	0	5,470	101
Post-Test HNO3 Rinse	0	0	1,302	58
Post-Test H2O Rinse	0	0	1,448	41
Cond. Coll. Tank 1	0	0	18,410	34
Cond. Coll. Tank 1 Wipes	0	0	337	7
Cond. Coll. Tank 2	0	0	6,810	0
Cond. Coll. Tank 2 Wipes	0	0	63	2
Glass - Measured	0	0	10,278	0
Sum of Post-Test Measurements			49,285	11,613
Material Unaccounted For			158,406	13,499

Table 4. Analytical Summary

Arsenic

A total quantity of 207,691 mg of arsenic was present at the beginning of the test. A total of 21,629 mg of arsenic was released to the off-gas system and 10,278 mg retained within the glass product. When combined with the rest of the arsenic sample results (wipes, kaowool, condensation collection tanks, rinses, remaining arsenic in soil) this leaves an un-accounted quantity of 135,456 mg arsenic.

Mercury

A total quantity of 25,112 mg of mercury was present at the beginning of the test. A total of 10,455 mg of mercury was released to the off-gas system and was non-detectable in the glass product. When combined with the rest of the mercury sample results (wipes, kaowool, condensation collection tanks, rinses, remaining mercury in soil) this leaves an un-accounted quantity of 13,456 mg mercury.

Water Collection

A total of 1.25 gallons of water were collected in the water condensation collection tanks. The first tank, which contained 0.5 gallons of water, collected water from the time the melt began until the vitrification depth processed through the second layer of RMA soil (see Figure 8). The second condensation collection tank, which contained 0.75 gallons, collected water from the bottom of the second RMA soil layer through the end of

the test and through the cool-down period.

Arsine Gas

Measurement for Arsine gas (AsH_3) were periodically taken during the melt using Drager detector tubes. Grab samples of the off-gas were drawn into Tedlar bags using a pump, and subsamples of the gas were drawn from the bag using the detector tube pump. A total of 7 grab samples were collected between 09:17 to 11:15 (just entering the sludge layer). Those samples did not indicate any traces of arsine. At 11:15, 11:25, and 11:34 the samples which were collected measured about 0.05 ppm arsine, using multiple pump strokes; indicating an arsine concentration less than 0.05 ppm. Samples collected after 11:47 did not indicate any traces of arsine. It should be emphasized that this methodology was intended as an indicator technique only, therefore, quantification is not appropriate. Further, the threshold limit value (TLV), time weighted average (TWA) for Arsine is 0.05 ppm, indicating the quantity is within acceptable ranges, especially since the sample was taken prior to off-gas treatment.

EPA Method 1 through 4 Sample Results

In addition to the off-gas sampling results presented above, EPA off-gas sample Methods 1 through 4 were performed for each sample train. Methods 1 and 2 were used to determine the stack gas velocity which was 2,749 ft/min, the stack temperature which was 218 °F (103 °C), and the volumetric flow rate which was 60 acfm and 44.5 dscfm. Methods 3 and 3A were performed to determine the molecular weight of the stack gas. The results indicate that 0.1% of the gas was carbon dioxide, 20.9% of the gas was oxygen, and 0 ppm carbon monoxide. Method 4 was performed to determine the moisture content of the stack gas. The moisture content was 3.28%.

Occupational Exposure Data

Occupational exposure data was gathered for mercury during pre-test soil placement, vitrification operations, and during post-test sampling and decontamination. All three exposure samples were non-detectable for mercury. The detection limit was 0.0001 mg/sample. The OSHA permissible exposure limit (PEL) for mercury is 0.1 mg/m³. The analytical results are presented in Appendix G.

C. Discussion of Test Results

Pesticides

The destruction efficiency [DE] for dieldrin was 98.3% and the DE for aldrin was 96.3%. Combined with a removal efficiency of at least 99.9% for the off-gas treatment system yields an overall process destruction/removal efficiency [DRE] of >99.99% for both aldrin and dieldrin. A DRE of 99.99% would satisfy RCRA requirements. The DRE observed in the engineering-scale test is be expected to increase during field applications. The destruction of organics and the retention of metals increases with increasing scale of application. Observations during prior ISV operations indicates the DRE is expected to increase by about an order of magnitude [Buel et. al. 1987]. The small quantity of dieldrin observed below the block is expected to be below regulatory significance, if in fact some remained after field operations. With the increased scale of operations a corresponding decrease in residuals is expected.

Arsenic

During the test, 39,007 mg of arsenic [approximately 19%] were volatilized. This calculation is based on the material collected in the condensation collection tanks plus the sum of the post-test wipes and rinses and material retained in the Kaowool and assumes the arsenic which is unaccounted for in the mass balance was retained in the glass. Observations from the Crystal Chemical Superfund Site test indicated 23% of the arsenic was volatilized [Buel 1989]. This is a reasonable agreement between the two tests and it is consistent with glass melter data. During field-scale operations the Kaowool blanket would be expected to collapse into the melt and be incorporated into the melt, recycling the arsenic that would otherwise be retained in the blanket. The quantity of arsenic collected in the condensate collection tanks [25,620 mg] agrees quite well with the measurement of the arsenic in the off-gas stream [21,629 mg]. The presence of additional material in the tanks is reasonable, since some additional arsenic would be evolved after the power to the electrodes was shut off prior to the time the surface froze [≈3 hours]. Off-gas sampling was terminated when power to the electrodes was shut off. The chemical form of the arsenic in the tanks has yet not been determined, however, 95% of the arsenic in both tanks was soluble. Samples of the condensate solution and sludge were archived for future analysis to determine the chemical form and to provide a basis for determining how to purify the scrub solution for the field-scale system.

The quantity of arsenic measured in the glass was 10,278 mg, corresponding to a concentration of 146 ppm. The glass matrix was crushed and dissolved using hydrofluoric acid. Discussions with the laboratory indicate there is a very large uncertainty associated with the dissolution procedure, as there are no standards for comparison of extraction efficiency. In addition the refluxing operation was conducted in a heated beaker, covered with a watch glass. It is quite possible, even likely, that a

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VIII. COMPARISON OF TEST RESULTS

The objective of this section is to compare the results obtained during the first and second tests of the RMA soils and sludges and to draw any conclusions that may be relevant to the applications assessment. There were two main differences between the first and the second test: first, the type of soil and contamination levels in the soils adjacent to the test array; and second, the methods used for sampling the off-gas stream.

Difference between adjacent soils in the first and second test.

In the first test, the soils adjacent to the test array were RMA soil, contaminated to the same level as the material in the test array. The RMA soils also contained two distinct phases, which included a sandy, silty phase and clay balls which were presumably produced during the mixing operation at the site. The clay balls were much larger; on the order of one-half to four inches in diameter. It should be noted that neither of these particle sizes are representative of the undisturbed soil matrix at the RMA site. Based upon observation of the sample, it appears that the silt soil consists of a stratified sequence of silty sand and clay.

After the completion of the first test, levels of arsenic in soils adjacent to the block were slightly reduced from the original concentration, however the mercury levels were considerably elevated. Soils beneath the block showed slight elevations in the arsenic concentration over the original concentration, with a considerable decrease in the mercury concentration. It was not until additional samples were analyzed that it was shown there was a correlation between the mercury level in the soils adjacent to the block and the soil medium. In the soils adjacent to the block the clay balls [1 to 4 inch] had mercury concentrations of one tenth to one twentieth of the mercury concentration for the silty sand. These balls could not be sampled using a trier as originally intended in the Test Plan.

It was mutually agreed not to open the soil drums until just before the test, in case it was decided to sample for VOC prior to and during the test. This prevented any observation and potential for discussion of the difference in particle sizes until the day before the test when the soils were being placed in the test chamber.

In the soils beneath the block, the difference in mercury concentration was smaller. However, there was an observable and statistically significant difference in the mercury concentration between the clay balls and the silty sand in the post test soils. Larger concentrations of mercury were measured in small particles and the lower concentrations were measured in large particles. Re-analysis of the pre test samples showed

there was no significant difference in the concentration between the clay balls and the silty sand, confirming the homogeneity of the pre-test materials. These additional data are presented in Appendix I. A working hypothesis was developed that could explain the observations, however, it was not possible to prove or demonstrate the hypothesis without conducting an additional test.

The hypothesis is based on the observed thermal surge [increase in temperature observed after the power is turned off] and cooling curves from operational acceptance tests of the engineering-scale system. During the test, mercury was mobilized by vaporizing in the clay balls adjacent to and beneath the block, and released to the off-gas system. When power to the electrodes is turned off, there is a thermal surge in the soil adjacent to the melt that corresponds to the cooling of the block. The thermal surge beside the block is usually about one half of the thermal surge below the block, and the cooling time below the block is much longer than beside the block. This leads to a situation where heating below the block lasts longer than beside the block. It also allows for the volatilization of materials below the block if their boiling point is below 500°C, with the potential for recondensation adjacent to the block where temperatures are cooler sooner.

With a peak post test temperature in the range of 400°C, it is quite possible to mobilize or volatilize the mercury, without significantly affecting the arsenic. It appears reasonable to postulate that the mercury vapor condensing on soils adjacent to the block would condense uniformly on the available surfaces within the media containing higher gas permeability. Uniform surface deposition combined with significant differences between particle sizes [therefore much different surface area to volume ratios] could lead to much higher apparent concentrations in the smaller particles. In addition, the low gas permeability of the clay balls would prevent vapor diffusion into the clay. This hypothesis is consistent with the analytical data and the observed post test heating and cooling cycles beside and beneath the block.

In the second test, the soils adjacent to the test array were Hanford soils, with no mercury or pesticides and a natural arsenic level of 10 ppm as compared to 150 ppm in the first test. The Hanford soils also had a more uniform texture and particle size, with a clay content of $\approx 10\%$. Post test analysis showed there were small increases in the pesticide and mercury levels below the block, with no measurable increase in the soils adjacent to the block. The arsenic levels showed a slight increase in the soils adjacent to and beneath the block. It is believed that these data, combined with the data presented above show that the presence of the contaminants in the soils adjacent to the test array, combined with the thermal surge during cooling

and the different sized particles produced the results observed in the first test, and the second test demonstrates that the movement of the contaminants during processing into adjacent soils is quite nominal. Extrapolated to field conditions, the levels of residuals should be below regulatory concern, as the soils adjacent to the block should easily pass either a EP Tox or a TCLP test.

Difference between methods used for sampling the off-gas stream

There were two principle differences between the off-gas sample collection techniques between the first and the second test. In the first test NIOSH collection techniques, more suitable for personnel dosimetry were used. In the second test, all off-gas sampling was accomplished using proven EPA protocols. Further, the addition of the condensate collection tank allows a secondary assessment of the material passing through the off gas system. The changes employed in the second test should lead to a higher confidence level in the off-gas sampling data.

Other observations

Destruction efficiencies [DE] observed in the first test for pesticides were 99.09 to 99.82% for Aldrin, vs. the 96.3% observed for Aldrin in the second test. Similarly, the DE observed for Dieldrin in the first test ranged from 99.95 to 99.91% vs. 98.3% for the second test. While the correlation between the test results is reasonably close, given the increased confidence in the sample collection methodology in the second test, the data from the second test are what should be considered. With the removal efficiency for the off-gas treatment system, the overall process destruction/removal efficiency [DRE] will be >99.99%, which should be sufficient to satisfy RCRA requirements. During the development of the ISV process, it has been shown that destruction efficiency for organics and retention efficiency for metals increases with increasing scale. Generally, there is at least an order of magnitude improvement when scaling up from engineering-scale to field-scale operations. With a non-quantifiable error in the off-gas sampling for metals in the first test, it is not appropriate to make rigorous comparisons between the off-gas sampling data from the first and second test. However, the overall results from both tests are similar, and tend to support each other.

Upon examination of the glass following the first test, spherical nodules (microscopic to 0.5 cm in diameter) were observed adjacent to the electrodes and near the base of the monolith (see Figure 17). These nodules were analyzed using scanning electron microscopy and energy dispersive analysis (SEM/EDS). SEM techniques included backscattered electron imaging (BEI) and secondary electron imaging (SEI). A



Figure 17. Metallic Nodule In Glass

Photo shows sample of Vitrified Product with reduced metallic nodule consisting of ferrosilicates and sulphides of iron, titanium and arsenic.

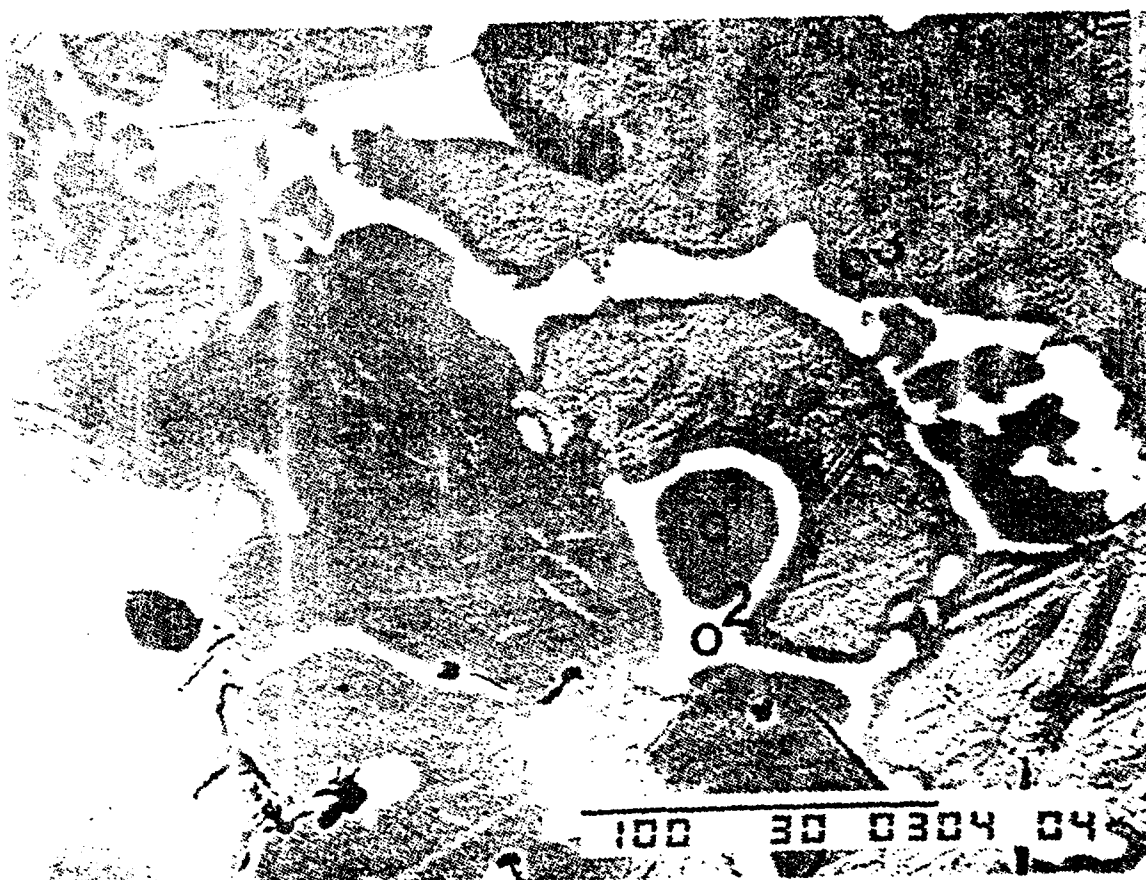


Figure 18. BEI Photograph

Backscattered electron image of metallic nodule. EDS spectra for designated locations appear in Appendix H.

1. Ferrosilicate/Suessite
2. Ferrosilicate/Iron and Arsenic Sulphides
3. Same as #2, slightly higher arsenic
5. Same as #1

photograph of the BEI image is shown in Figure 18. The lighter colored zones in these image represents the more dense material (which, incidently, contains the arsenic). EDS spectra were acquired at locations indicated in Figure 18 and are presented in Appendix H. These locations represent different phases present in the nodule.

A qualitative analysis of the EDS spectra indicates that 5 to 10 wt% of the light-colored material is arsenic. It is estimated that 50% of the nodules are light colored material (this includes the solid white and the white portion of the mottled materials) indicating that the nodules probably consist of 3 to 5 wt% arsenic. At this concentration, 1.5 to 2 lbs. of nodules would be necessary to contain all of the arsenic present in the treatment volume. By counting the number of nodules observed around a section of electrode and weighing what appeared to be an average size nodule, the total mass of nodules was estimated at 120 grams. Assuming that 3 wt% of the nodules consists of arsenic, there appears to be less than 5 g of arsenic in the nodules.

In addition to the aforementioned analyses, a nodule from the second test was submitted for ICP and X-ray diffraction (XRD) analysis. The results of these analyses are presented in Appendix H. Since the only elements found in the nodules from the first test included Fe, Si, Ti, As, and P, these elements and mercury were the elements chosen for analysis. The results show that As and Hg were not detected in the nodules sent in for analysis. It was found that Fe and Si make up about 88% of the mass of the nodules. The missing 12 wt% is sulphur and was detected by the XRD analysis in the form of FeS and TiS. The sulphur was not detected in the ICP analysis because it was not part of the analytical protocol.

The XRD analysis show that there were five crystalline phases in the nodule analyzed. These phases include: 1) elemental Fe, 2) iron silicide/suessite (Fe_3Si), 3) iron sulfide/triolite (FeS), 4) titanium sulphide (Ti_{77}S), and 5) elemental Ti. The XRD analysis is only capable of estimating the percentages crystalline phases present with an uncertainty of 5 to 10 wt%. The elemental Fe represents 55-65%, the FeS, Ti, and TiS represent 15 to 25%, and the Fe_3Si represents 1-5% of the mass of the nodule.

The maximum retention (assuming the unaccounted arsenic was incorporated in the glass) for Arsenic was 86% during the first test and 81% during the second test. There are several factors which contributed to the higher As retention in the glass (Appendix F) and nodules (Appendix H) from the first test compared to the glass and nodules from the second test. These factors are related to the chemistry of the two melts. More sludge was processed in the first test than the second test.

This resulted in higher SiO_2 and lower Ca in the second melt than in the first melt. These two conditions raised the melt temperature thus lowering the melt viscosity. The higher temperature (substantiated by temperature readings from the type C thermocouples) in the second melt tended to promote increased volatilization of the As. The reduction of arsenic and corresponding release of oxygen happened quickly which promoted entrainment of arsenic with the evolved gases. In addition the lower viscosity resulted in a very short period of time for the As entrained with the oxygen to be in contact with the melt. The short residence time was clearly evident from observation. Some of the gas bubbles rising through the melt were very large (as can be seen from the photograph of the vitrified block in Figure 16) and appeared to have a residence time of less than one second. Entrainment, resulting in higher release of metals has been observed previously, especially associated with gas generating events such as decomposition reactions and pyrolysis (Buel, 1987).

These data show that the high temperatures and low viscosity of the melt in the second test promoted the release of the arsenic by entrainment with the gasses evolved from fining. The short residence times prevented absorption of arsenic into the melt. On the other hand, the higher viscosity and lower temperatures that would be encountered in field conditions combined with the greater depth of the melt would allow additional time for some of the arsenic to be absorbed into the melt. Therefore, because of the long period of time in which the arsenic and the melt will be in contact during large-scale operations, the arsenic retention factor is expected to be higher than observed in the engineering-scale test.

Reduction of the arsenic into metallic nodules was observed in the first test. The nodules are silicate and sulphide in nature and are partially or fully encapsulated in the glass. The nodules examined in the second test did not contain arsenic. This difference can be explained by the higher concentration of iron in the second test (four times as much, see Table 1) due to the higher iron concentration in the surrounding soils (Hanford soils) when compared to the RMA soils. There was simply four times as much iron competing for the same reduction sites. Arsenic may have been present in the nodules from the second test but was below detection levels. In conclusion, large-scale operations should result in high retention factors for arsenic (due to high retention times) and low leachability characteristics of the glass product (due to chemical incorporation of As in the glass and nodules and encapsulation of nodules).

The physical characteristics between the two ISV melts were very similar. The mass of the ISV glass block from test 1 was 145 pounds and the mass of the block from test 2 was 155 pounds. A

post-test volume reduction of 50% was achieved for test 1 and 28% for test 2. The subsidence void from test 1 was 8-inches and test 2 was 5-inches. The larger subsidence and greater volume reduction for test 1 was due to the extra 1-inch of sludge volume processed and the extra volume of water contained within that sludge. In addition, the moisture content of the surrounding soil for test 1 was greater than for test 2, which also contributed to the greater volume reduction. The glass block dimensions for test 1 were 16-inches wide at the top, 14-inches wide at the bottom, and 18-inches tall. The glass block dimensions for test 2 were 18-inches wide at the top, 14-inches wide at the bottom, and 18-inches tall. A total power consumption of 198 kW was required for test 1 and 158 kW for test 2. The maximum melt temperature observed from test 1 was 1,470 °C compared to 1,740 °C for test 2. The difference in maximum melting temperatures was due to the placement of the type C thermocouple. The thermocouple was placed in the middle of the sludge layer for test 1 and at the sludge soil interface for test 2. Therefore, due to the lower melting temperature of the calcium sludge layer compared to the RMA soil layer a difference was observed in the maximum melt temperature. The total test time was 7 hours 30 minutes for test 1 and 7 hours 5 minutes for test 2.

IX. APPLICATIONS ASSESSMENT

The ISV treatability test performed on the M-1 Ponds waste provided data which enabled Geosafe to assess the technical and economic applicability of using ISV for full-scale remediation of the site. Three processing scenarios (specified by Woodward Clyde) were selected to be evaluated for applicability assessment. The ponds can be treated as a single unit (including berms) with regard to remedial action. The total surface area of the ponds is approximately 36,800 ft² (115 ft. X 320 ft.). Three processing depths were selected for evaluation including 10, 12 and 14 feet. Processing waste in the M-1 Ponds at these depths corresponds to approximate waste volumes of 13,630 yd³, 16,360 yd³ and 19,080 yd³ respectively.

The stratigraphy of the M-1 Ponds site has been described by Woodward Clyde as consisting of three layers. The top layer consists of 2 ft of soil with approximately 10 wt% moisture. The middle layer consists of 4 ft of lime sludge with a moisture content of 50 wt%. The bottom layer consists of soil, the thickness of which will vary between 6 ft and 10 ft depending upon the total depth of processing. It is assumed that the bottom layer will be dewatered by others prior to processing to achieve 20 wt% moisture with negligible recharge into the processing zone.

Assuming these processing scenarios, the Geosafe Process Simulation Model was used to estimate physical characteristics and economics of full-scale operations. For the 10 and 12 foot depth scenarios, 71 and 67 respective melt settings will be required to process the given volume of waste. When processing to 14 feet the melt width will be larger allowing for fewer melts. Therefore, only 62 melts are required for the 14 foot processing depth scenario. The melt specifications for each of the processing scenarios are given in Table 5 below:

Table 5. Processing Scenario Details

Depth <u>ft.</u>	Width <u>ft.</u>	Rate <u>t/hr</u>	Duration <u>days</u>	Number of <u>settings</u>	Volume <u>Yd³</u>
10 ft.	24.5	3.8	230	71	13,630
12 ft.	25.7	3.8	260	67	16,360
14 ft.	27.1	3.8	310	62	19,080

These figures include scheduled down-time and assume 5% melt overlap to assure complete vitrification of all waste present.

Analytical data resulting from the treatability test show that a destruction efficiency (DE) of 96.6% for aldrin and 98.3% for

dieldrin was achieved during the test. Combining the DE with the expected off-gas treatment removal efficiency of 99.9%, the DRE expected in the large-scale operations is 99.996% for aldrin and 99.998% for dieldrin. Therefore, because processing results improve with scale-up, full-scale ISV remediation of the site should result in a DRE for pesticides equal to or greater than that achieved in the treatability test. The remaining pesticides released to the off-gas treatment system will be removed by the large-scale off-gas system. Carbon loading calculations indicate that replacement of the carbon filters will be required every sixth melt setting. When replaced, the carbon will be placed in the next melt setting to be reprocessed. Thus, the only spent carbon left over at the conclusion of the process will be that left from the last melt setting.

The treatability tests indicate that, given sufficient time, the arsenic at the M-1 Ponds will be reduced to arsenopyrite (FeAsS) or dissolve in the silicate melt having the chemistry of that expected during large-scale vitrification. Arsenic retention is expected to be high. Therefore, particulates recovered in the large-scale off-gas system should be primarily mercury with smaller amounts of arsenic and silicate dust.

There is approximately 500,000 lbs. of arsenic in the M-1 Ponds. Assuming an 80% retention factor of the arsenic in the melt, approximately 100,000 lbs. of arsenic may be evolved to the off-gas system. The current market price of arsenic in its metallic form is about \$1.00/lb. The arsenic released to the off-gas system during large-scale operations will be particulate in nature and will be scrubbed out in the quencher and in the tandem nozzle scrubber in the off-gas treatment system.

Because of the higher off-gas flow rates and smaller relative surface areas upon which mercury can collect in the large-scale off-gas equipment, mercury recovery is expected to be nearly 100%. Rough estimates of mercury and arsenic recovery indicate that approximately 70,000 lbs. of mercury will be accumulated by the scrubber system along with smaller amounts of arsenic soil particles. It is expected that the mercury will settle quickly in the scrubber tank. The sludge in the scrubber tank will have considerable commercial value, especially with respect to mercury. As of April 1989, the commercial value of mercury was \$325/flask. A flask weighs 76 lbs. which places a value of the mercury at about \$300,000. Combining this with the value of the recovered arsenic (\$100,000), there is potential for significant cost recovery. The low vapor point of mercury makes it easy to purify via distillation. Geosafe has not evaluated the details of options available for separation of the mercury or arsenic into a commercial-quality product. In addition, Geosafe is not proposing to perform purification or further treatment of the recovered mercury. However, there is an Asarco ore purchasing station in Denver, CO where the sludge might be sold as an ore.

In addition, Geosafe has retained the recovered sludge if further analysis is requested. The costs and benefits for recovery of the mercury and arsenic are not included in the cost estimates.

Cost estimates for each of the processing scenarios have been prepared and appear in Section X. These cost estimates state the assumptions which were made while preparing the estimates and incorporate the data collected during the treatability test. Assuming the assumptions stated are correct, the cost figures are accurate within $\pm 20\%$. The costs which are not covered by these estimates are also stated in Section X.

X. GEOSAFE CORPORATION ISV COST ESTIMATE

DEFINITION: Cost estimate for ISV of Rocky Mountain Arsenal M-1 Ponds Site (3 Scenarios)

Date: 7/5/89

Site Name: Rocky Mountain Arsenal M1 Ponds

Site Location: Commerce City, Colorado

Estimate Prepared For: Woodward Clyde Consultants

ASSUMPTIONS:

<u>Contaminants/Concentrations:</u>	See Appendix B
<u>Soil Type/Composition:</u>	See Appendix C
<u>Soil Fusion Temperature:</u>	See Appendix C
<u>Soil Moisture Content:</u>	Scenario 1: 30 wt% (average) Scenario 2: 28 wt% (average) Scenario 3: 27 wt% (average)
<u>Volume to be Treated:</u>	Scenario 1: 13,630 yd ³ Scenario 2: 16,360 yd ³ Scenario 3: 19,080 yd ³
<u>Dry Density:</u>	Sludge: 1.1 g/cm ³ Soil: 1.6 g/cm ³
<u>Depth of Processing:</u>	Scenario 1: 10 ft. Scenario 2: 12 ft. Scenario 3: 14 ft.
<u>Tonnage to be Treated:</u>	Scenario 1: 16,100 tons Scenario 2: 19,300 tons Scenario 3: 23,500 tons
<u>Presence of Inclusions:</u>	None anticipated
<u>Price of Electricity:</u>	\$0.05/kwh
<u>Cost of Electrical Service:</u>	Not Provided, assume zero
<u>Volume Treated/Setting:</u>	Scenario 1: 192 yd ³

Scenario 2: 245 yd³
 Scenario 3: 310 yd³

Tonnage Treated/Setting:

Scenario 1: 226 tons
 Scenario 2: 289 tons
 Scenario 3: 382 tons

Expected Melt Dimensions:

Scenario 1: 25 X 25 X 10
 feet
 Scenario 2: 26 X 26 X 12
 feet
 Scenario 3: 27 X 27 X 14
 feet

TIME AND COST ESTIMATES BY CATEGORY:

Mobilization/Demobilization: (including transport of equipment, onsite erection, readiness testing, post-project decontamination, disassembly, and transport to base location)

\$110,000

This is a worst-case estimate. In reality, Geosafe will probably demobilize the ISV unit to another site. The costs associated with transportation to another site may result in a reduced overall cost or be paid by a third party.

Pre- and Post-Operational Technical Support (including support of site characterization, site preparation, application engineering for remedial design, permitting/ARARs compliance activities, support of site restoration, post-project sampling/monitoring, and delisting activities:

The costs for items will vary from site to site depending upon the size of the site, it's complexity, the type of contaminants and the regulating authority. Therefore, these costs are charged on a time and material basis at \$70/hr. Total costs for these services is estimated to be \$100,000.

Vitrification Operations: (including all costs of operations ... burdened labor, materials, electric power, off-gas treatment, movement between settings, equipment maintenance)

Scenario 1: \$395.00/ton X 16,100 tons = \$6,359,500
 Scenario 2: \$370.00/ton X 19,300 tons = \$7,141,000
 Scenario 3: \$345.00/ton X 23,500 tons = \$8,107,500

Total Project: Scenario 1: \$ 6,569,500
 Scenario 2: \$ 7,351,000
 Scenario 3: \$ 8,317,500

COSTS NOT INCLUDED: Site characterization, site preparation, permitting/regulatory compliance, excavation and staging of materials for processing (if any), site restoration, delisting, secondary waste disposal, any other non-ISV related costs.

SENSITIVITY: The above estimates are believed to be accurate within $\pm 20\%$. These costs are sensitive to variations in the assumed moisture contents for the various waste strata, the cost of power and the depth of processing. The non-linear relationship between the tonnage to be treated and the depth is a result of the stratified nature of the waste. The waste has a dry density of 1.1 g/cm^3 while the soil has a dry density of 1.6 g/cm^3 . The waste also has a much higher moisture content as does the lower soil layer and all of the soil has a much higher melting temperature than the waste. Therefore, as more soil is treated (with increasing depth from Scenarios 1 to 3), a larger percentage of water must be processed and the power requirements for maintenance of a melt increase (due to the increase in silica). In addition, the average density increases with depth which simply means that more mass per unit volume must be melted with an increase in depth.

IX. REFERENCES

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A-1

APPENDIX A

TEST PLAN

Geosafe

Corporation

Kirkland Parkplace
303 Parkplace, Suite 126
Kirkland, Washington 98033
(206) 822-4000
Fax: (206) 827-6608

July 17, 1989

Jeff McCleary
Woodward Clyde Consultants
Stanford Place 3, Suite 1000
4532 South Ulster Street Parkway
Denver, Colorado 80237

Dear Jeff:

Attached for your review and approval is the new Test Plan for the forthcoming retest of the Rocky Mountain Arsenal Soils and Sludges. You will note we have made several system modifications to deal with the water evolution during testing and we have incorporated standard EPA off-gas sampling protocols into the sampling plan. We are also planning to measure arsine during the test. We have elected to place a clean soil around the Rocky Mountain Arsenal Soils and Sludges. This, combined with improved off-gas measurement techniques should allow a more complete calculation of the material balance for arsenic and mercury.

We plan to conduct the test on August 2, 1989, and we anticipate attendance by Woodward Clyde. Let us know who is planning to attend test and their arrival time and we will make reservations for you at the Greenwood Hotel.

If you have questions or comments, please call me.

Sincerely,

GEOSAFE CORPORATION



Vincent FitzPatrick
Director of Engineering

STANDARD TEST PLAN
ENGINEERING-SCALE TEST OF IN SITU VITRIFICATION
For WOODWARD CLYDE CONSULTANTS
JOB NUMBER 30900 - REV.

Geosafe Corporation
Kirkland, WA

July, 1989

STANDARD TEST PLAN
ENGINEERING-SCALE TEST OF IN SITU VITRIFICATION

PREPARED BY: Stephen C. Liskala 7/17/89
Applications Engineer Date

APPROVED BY:  7/17/89
Dir. of Engineering & Technology Date

Patricia A. Murray For BWS 7/19/89
Dir. of Regulatory Affairs Date

Woodward Clyde Consultants

Date

STANDARD TEST PLAN
ENGINEERING-SCALE TEST OF IN SITU VITRIFICATION

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and [s]

Appendix E - List of Acutely Hazardous Wastes

STANDARD TEST PLAN ENGINEERING-SCALE TEST OF IN SITU VITRIFICATION

I. INTRODUCTION/SCOPE

During the initial test of the Rocky Mountain Soil and sludge, conditions where such that the results from the mercury and arsenic post-test analysis were not quantifiable and a material balance for the those compounds could not be performed. In order to assist the sponsor, GenSafe has decided to rerun the test using extra soil and sludge left from the initial test. Lessons learned from the first test are incorporated into this test plan. To facilitate review by the client, the sections, sentences or words that have been changed from the original test plan are underlined. Omissions are handled by deletion. Results from the initial and second test will be combined into the final report.

This project will specifically test the applicability of ISV to the M-1 Ponds of the Rocky Mountain Arsenal site located in Denver, Colorado. Soil samples before and after; glass samples after; and process off-gas samples during the test will be obtained to determine:

- Final Product Quality;
- Destruction and Removal Efficiency of Organic Contaminants;
- Incorporation of Inorganic Contaminants;
- Disposition of Contaminants and secondary wastes; and,
- Ability to Comply With Applicable or Relevant and Appropriate Requirements (ARARs).

In addition to evaluating the samples for performance data, the engineering scale melt provides data for assessing full-scale remediation operating conditions, specifies health and safety factors, aids in the development of a community relations program, and provides insights for performing an estimate of the cost for full-scale remediation.

There are five additional documents provided in Appendices A through E which give specific direction for conducting the engineering scale test. The documents are:

- Appendix A - Standard Operating Procedure

- Appendix B - Test Specific Health and Safety Plan
- Appendix C - Quality Assurance Project Plan
- Appendix D - Washington Administrative Code 173-303-071 [r] and [s]
- Appendix E - List of Acutely Hazardous Wastes.

These documents are intended to be utilized with this test plan and are written in accordance with Geosafe's corporate Health and Safety Plan and Quality Assurance Policy, Program Guidelines, and Procedures Manuals.

The test will be performed in More Hall at the University of Washington, located in Seattle, Washington. The results from the initial and this engineering scale melt will be submitted in a report which evaluates the potential for performing full-scale ISV remediation at the site.

II. SHIPPING REQUIREMENTS

Geosafe Corporation requires approximately 50 to 60 pounds of contaminated soil and 400 to 450 pounds of clean soil to perform the engineering scale melt. The soil samples shall be shipped in properly labeled Department of Transportation (DOT) approved 55 gallon drums. In addition, the shipment shall comply with the requirements of Washington Administrative Code (WAC) 173-303-071 Sections [r] and [s] as outlined below. The drums shall have Chain of Custody Report Forms attached to ensure that the clean soil is not mixed with or confused with the contaminated soil. The shipments shall be sent to:

University of Washington Civil Engineering Department
More Hall
Stevens Way
Seattle, Washington 98195
Attention: Geosafe Corporation and Professor R. D. Holtz

Geosafe requires five (5) days notification for sample shipment and the approximate arrival date and method of shipping in order to coordinate sample arrival with the University of Washington. Geosafe will not accept samples from any client until a signed contract is in place.

The generator or sample collector shall use no more than the following quantities of waste in accordance with WAC 173-303-071 (r) (ii) (A):

- 1000 kg of any dangerous waste, or
- 1 kg of acutely hazardous waste, or
- 250 kg of soils, water, or debris contaminated with acutely hazardous waste for each generated waste stream parameter.

In accordance with WAC 173-303-071 (r) (ii) (c), the samples shall be packaged such that:

- They will not leak
- They will not spill
- They will not vaporize from its packaging during shipment
- Transportation of samples complies with U.S. Department of Transportation (DOT), U.S. Postal, or other applicable shipping requirements;

or if DOT/USPS/Other shipping requirements do not apply to the shipment, the following information must accompany the sample:

- Name, mailing address, and telephone number of originator of sample
- Name, address, and telephone number of laboratory that will perform the test
- Quantity of the sample
- Date of shipment; and
- Description of sample, including its dangerous waste number.

Regardless of choice of shipping method, within 90 days of being generated or collected the sample must be shipped to Geosafe.

The client must maintain the following records for a period of three (3) years after Geosafe completes the treatability study:

- Copies of the shipping documents
- Copy of the contract with Geosafe
- Documentation of quantity of waste shipped
- Documentation of Geosafe Corporation as the test sample receiver
- Documentation of the name, address, and EPA/State identification number of Geosafe
- Documentation of the date the shipment was made; and

- Documentation stating whether or not the samples and residues were returned to the generator.

Both Geosafe and the client will record the above information and Geosafe will present it in an annual report to the State of Washington. The records will be maintained in the corporate files for a minimum of three (3) years after completing the project.

In the event that any of the above requirements are violated, particularly the shipping requirements, Geosafe shall not accept the shipment and will notify the client and return the shipment unopened.

III. TEST EQUIPMENT

The engineering scale ISV unit, illustrated in Figure III-1, will be used to conduct the engineering scale treatability test. The Standard Operating Procedure (SOP) located in Appendix A, provides the operational details for the power supply, the electrical control system, and the sign-off procedure to be used for the engineering scale ISV system. The off-gas stream from the test unit is equipped with a knock out pot for the collection of water and particulates released from the melt. This pot simulates the performance of the quencher and scrub tank in the Geosafe large scale system. In addition, the system contains disposable activated vapor phase carbon sorption columns to remove any particulate or gaseous emissions from the melt.

Off-gases generated from the melt will be sampled continuously during the test. Methods 1 and 2 will be performed to determine the stack gas velocity, temperature and volumetric flow rate. Method 3 and 3A will be performed to determine the molecular weight of the stack gas using instrumental analyzers. An Infrared Industries Model 2200 oxygen analyzer will be used to measure the percent oxygen. An Infrared Industries Model 702D non-dispersive infrared analyzer (NDIR) will be used to measure the percent carbon dioxide. An Automated Custom Systems (ACS) Model 3300 NDIR will be used to measure the parts per million carbon monoxide. These analyzers meet 40 CFR 60 Appendix B, Performance Specifications 3 and 4 criteria. Method 4 will be performed to determine the moisture content of the stack gas.

Method 5 techniques will be employed to collect samples of the arsenic and mercury. One train will be used for each compound. Arsine gas will be measured using indicating detector tubes. A sample to be analyzed for pesticides will be collected using a semi-volatile organic train (semi-VOST), also referred to as Modified Method 5 (MM5).

All samples will be labeled with the operators initials, date, time, test number, and sample description. Sections IV-A, B, C, D, and E. Sample Storage Requirements, Sample Custody Protocol, Sampling Equipment and Technique, Sampling Equipment Decontamination Procedures, and Sample Composite procedures provide the sample handling techniques required for the test.

Figure III-2 illustrates the proposed soil placement, thermocouple location, and electrode orientation for the treatability test. The test will be conducted in an 85 gallon drum (placed inside a steel containment box for safety purposes). The four 0.5 inch diameter by 24 inch long molybdenum electrodes will be sheathed by 1.5 inch diameter by 20 inch long graphite collars to prevent oxidation of the molybdenum and induce subsidence of the melt zone. The molybdenum and graphite electrodes will be placed in the soil to a depth of 20 inches. The electrode assemblies will have a center to center spacing of 8 inches in a square array. A flaked graphite/glass frit mixture is placed in a 1 in. x 1 in. path laid in an "x" and square pattern on the surface of the soil to provide a direct electrical conductive path between the electrodes. This is consistent with full-scale remediation operations.

The contaminated soil/sludge will be buried in an 10-inch deep square zone between the electrodes and will consist of a layered approach to simulate the M-1 ponds. The first three inches will be clean virgin soil. The following 4 inches will consist of RMA soil (designated by sample notation A and B). Directly beneath the RMA soil will be a 4 inch layer of RMA sludge (sample notation W). The final layer will consist of 2 additional inches of RMA soil. The clean soil is added to ensure that a full vitreous zone is established prior to encountering any contaminants. The ISV boundaries are surrounded by clean soil and will be analyzed after testing to determine the disposition of the original chemical constituents.

In order to monitor processing depth, type K thermocouples will be installed in the center of the test drum extending from 2.5 inches below the surface down to the bottom of the drum (32 inches). In addition, three type K thermocouples will be installed on a horizontal axis, 10 inches below the surface grade at 2.5 inch intervals to measure horizontal melt dimensions and the temperature isotherms in the surrounding uncontaminated soil. Geosafe will continue to vitrify soil until the thermocouple located at the 18 inch depth reaches the 1200 °C (2192 °F) temperature. This is expected to take approximately 5 hours.

The melt temperature of the vitreous zone will be monitored using one or more type C thermocouples. If only one Type C thermocouple is used, the type C thermocouple located 10 inches below the surface at the center of the melt.

The power system consists of a 30 kW capacity Scott-Tee transformer. The transformer is equipped with 12 voltage taps and two saturable core reactors for controlling the power input to the

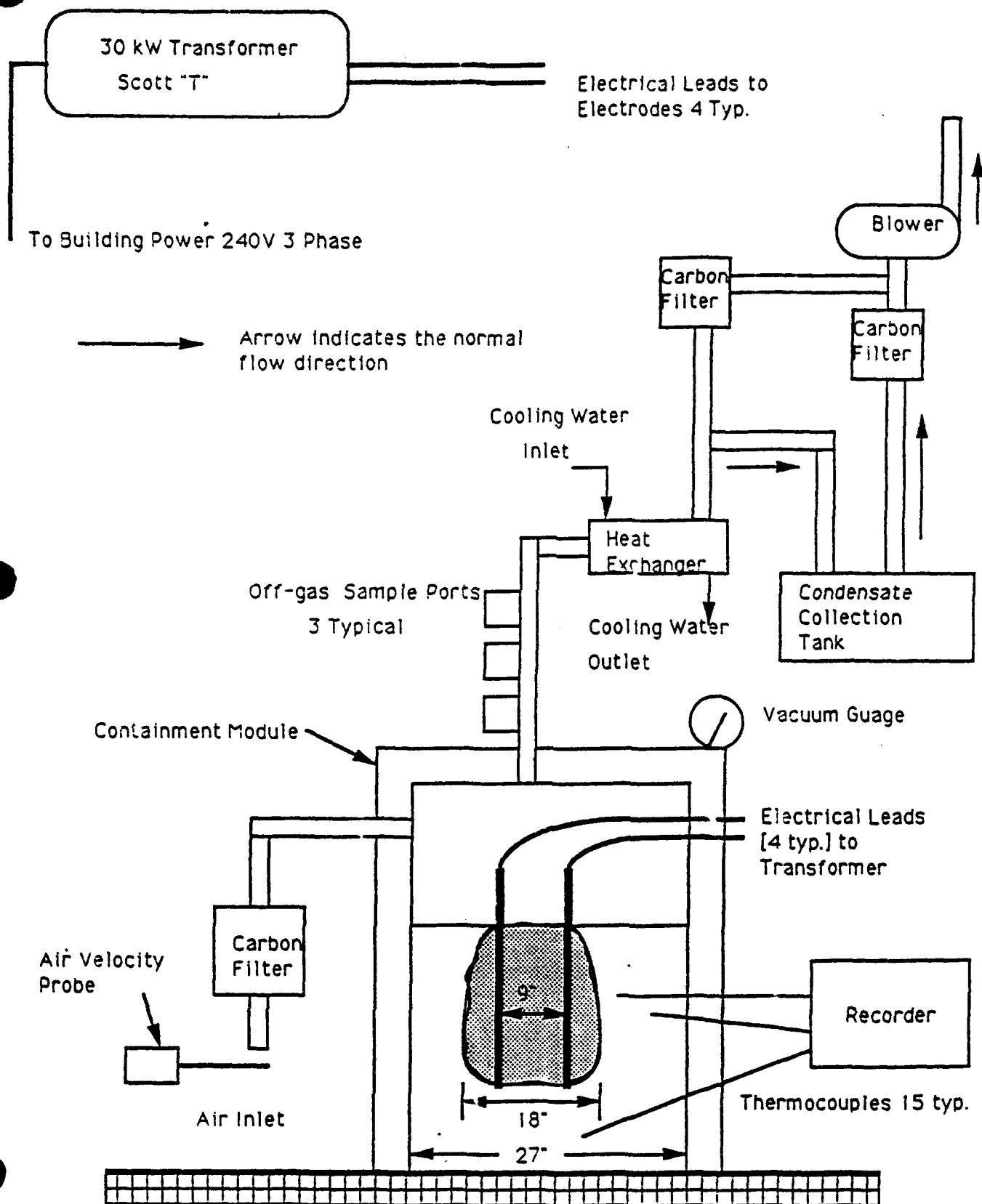


FIGURE III-1. Engineering-Scale Treatability System

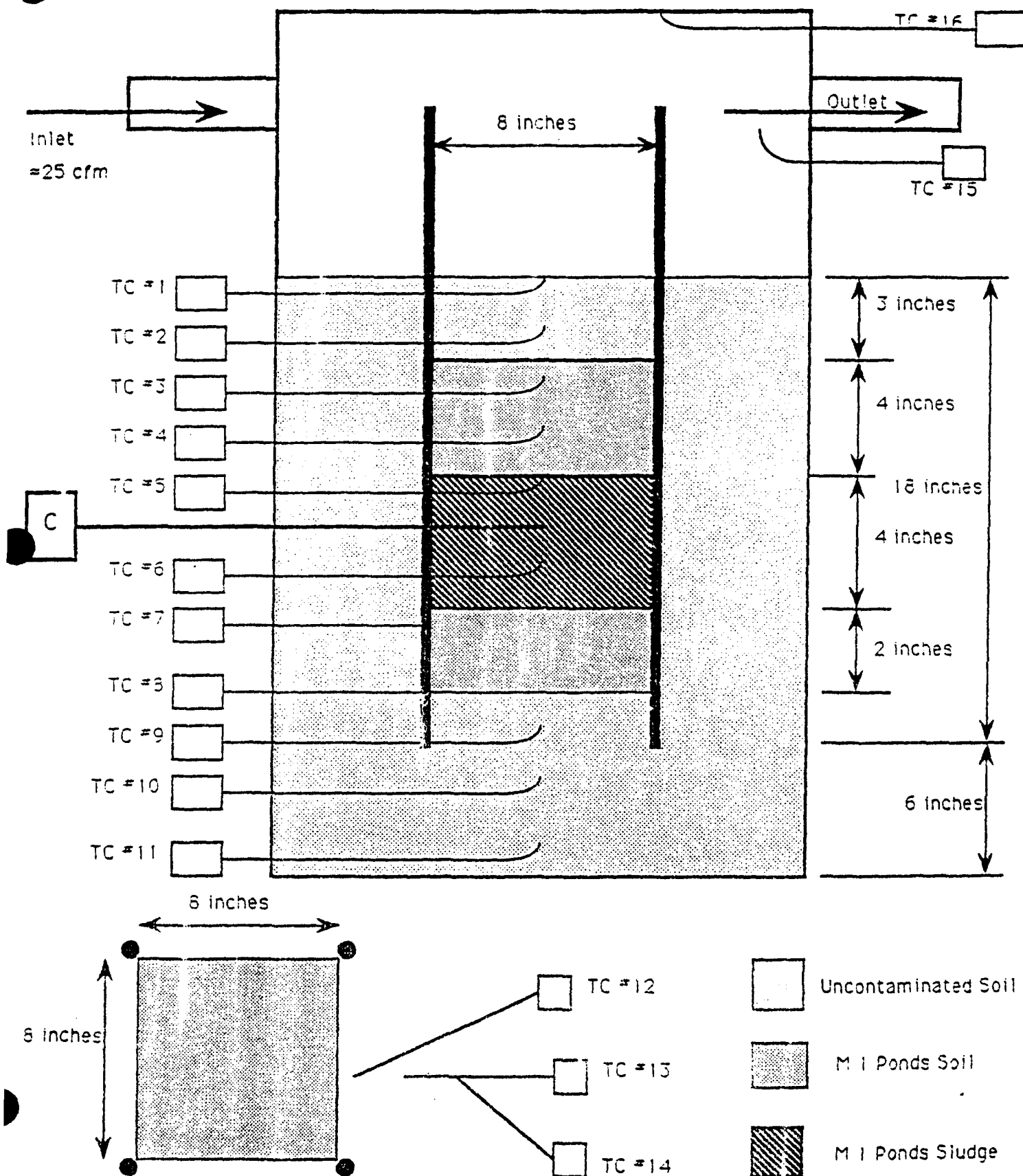


FIGURE III-2. Soil Placement
for Treatability Test

melt. The test will be run at a target control power input of 15 kW to closely simulate full-scale operations (power density). The transformer is equipped with metering on the secondary side (output to the electrodes) for power, voltage, and amperage. Electrical and thermocouple data will be recorded at 0.5 hour intervals.

During ISV testing, the vitrification zone will be covered with a 3-inch kaowool insulation blanket, leaving a small gap around the electrodes for venting. The insulation helps promote subsidence of the molten surface and improves the melting efficiency of the operation. This technique is consistent with full-scale operations.

The area immediately surrounding the ISV engineering scale unit will be restricted to authorized personnel only. In addition, "Danger High Voltage" and "Danger Hot" signs will be posted on all four sides of the test unit during test operations and the cool down period. Appendix B, the Test Specific Health and Safety Plan provides all the relevant details associated with the safety of the ISV operation.

IV. SAMPLE HANDLING TECHNIQUES

A. Sample Storage Requirements

The sample storage requirements for all samples taken during the engineering scale test are for all samples to be placed in specially cleaned glass containers provided by the chosen analytical laboratory and stored in secured ice chests at 4 °C. Additional samples not analyzed will be held from time of collection by the analytical laboratory until data review and acceptance of the final report (See Section VIII).

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. An example Field Sampling and Collection Form, (Figure IV-1), will provide an inventory and field sampling record for each sample collected during test operations. Figure IV-2 is a Chain

of Custody Record Form, which will provide the formal custody record. Figure IV-2 is a Request for Analysis Form. 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. Those samples returned by the laboratory or not analyzed by Geosafe will be returned to the client (see section VIII).

Samples will be kept on ice as appropriate in an ice chest 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 sent 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. He will make a note on the custody form of any discrepancy in the samples and will also maintain a log in which all samples are recorded and described. The samples will be maintained in custody until the final report is submitted and approved.

C. Sampling Equipment and Technique

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 every soil sample:

1. Clean the trier according to the steps outlined in Section IV-D.
2. Insert the trier into the soil at angle of 0 to 45° from the horizontal. 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 (Section D) label and store the sample (Section A).

The samples shall be obtained from the sample grid locations illustrated in Figures V-1 and VII-1. It should be noted that multiple triers of the same dimension and construction can be used in

order to avoid timely decontamination procedures. However, once a single trier is used, it must be decontaminated before obtaining another sample.

Wipe Sample Equipment - Wipe sampling equipment consists of wiping a filter paper across a desired surface using teflon coated forceps to handle the paper. The following procedure shall be used for obtaining every wipe sample:

1. Don clean unused disposable latex sample gloves.
2. Obtain 1-11cm Whatman GF/A filter paper and fold in half three times.
3. Obtain clean (see Section D) forceps and grasp filter paper with the forceps, approximately 1 cm from and parallel to the triple folded edge.
4. Saturate filter paper with hexane.
5. Wipe surface sample ten times vertically and ten times horizontally (two swaths each direction).
6. Each swath is 5.5 cm wide, overlapping 0.5 cm and approximately 9.5 cm long (this method of wiping surface areas provides a consistent area of 100 cm², and eliminates cross-contamination of surface areas).
7. After the surface area has been wiped, any torn fragments from the filter remaining on the sample surface are dabbed off using the filter to prevent loss of recovery from the sample area.
8. The filter is then placed in an 8-ounce glass sample container and labeled appropriately (Section V and VII). 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.

The samples shall be obtained from the sample locations illustrated in Figure III-1.

Glass Sample Equipment - Glass sampling consists of breaking the vitrified block and selecting pieces of glass to be sent to the laboratory. For obtaining a glass sample the following procedure should be utilized:

1. Spread a 10 x10 foot plastic sheet on a flat surface and place vitrified block in center of plastic and secure the area from any personnel.
2. Don protective clothing as specified in the Safety Plan, particularly full faceshield, eye protection, and leather gloves.
3. Use sledge hammer and wedge to break block open.
4. Obtain select glass pieces (approximately 2 x 2 x 2 inches) and place in glass containers provided by the laboratory. Use teflon coated or stainless steel forceps for handling the samples. The forceps should be decontaminated prior to and in between each sample according to the procedure in Section D.
5. Seal and label samples accordingly note approximate locations within the block.
6. Fold remaining vitrified block product into plastic and prepare for return shipment to client.

D. 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, hexane, or acetone, which ever is appropriate for the contaminant.
2. Wash with soapy water until all visible contaminant has been removed.
3. Rinse three times with deionized or distilled water.
4. Rinse two times with pesticide grade hexane.
5. Rinse two times with pesticide grade acetone.
6. Wipe with clean laboratory wipes to remove any excessive acetone and air dry or burn off any residual solvent with a propane torch.

NOTE: If material is sampled for heavy metals, three rinses of a 10 percent nitric acid (reagent grade) must be inserted between steps 2 and 3 above.

As a Geosafe Corporation general rule all decontamination solutions will be collected, containerized separately, and placed in the original sample shipment

drum for subsequent storage, and returned to the client at the completion of the test. In some cases (contaminant specific), it may be permissible to dispose of the decontamination wash water down the drain. The discretion is left up to the Test Engineer in these cases. As a matter of corporate policy, Geosafe will not take possession of any decontamination wash waters or any hazardous waste after the completion of the test.

E. Sample Composite Procedure

The following procedure should be followed when sample compositing of soils is required:

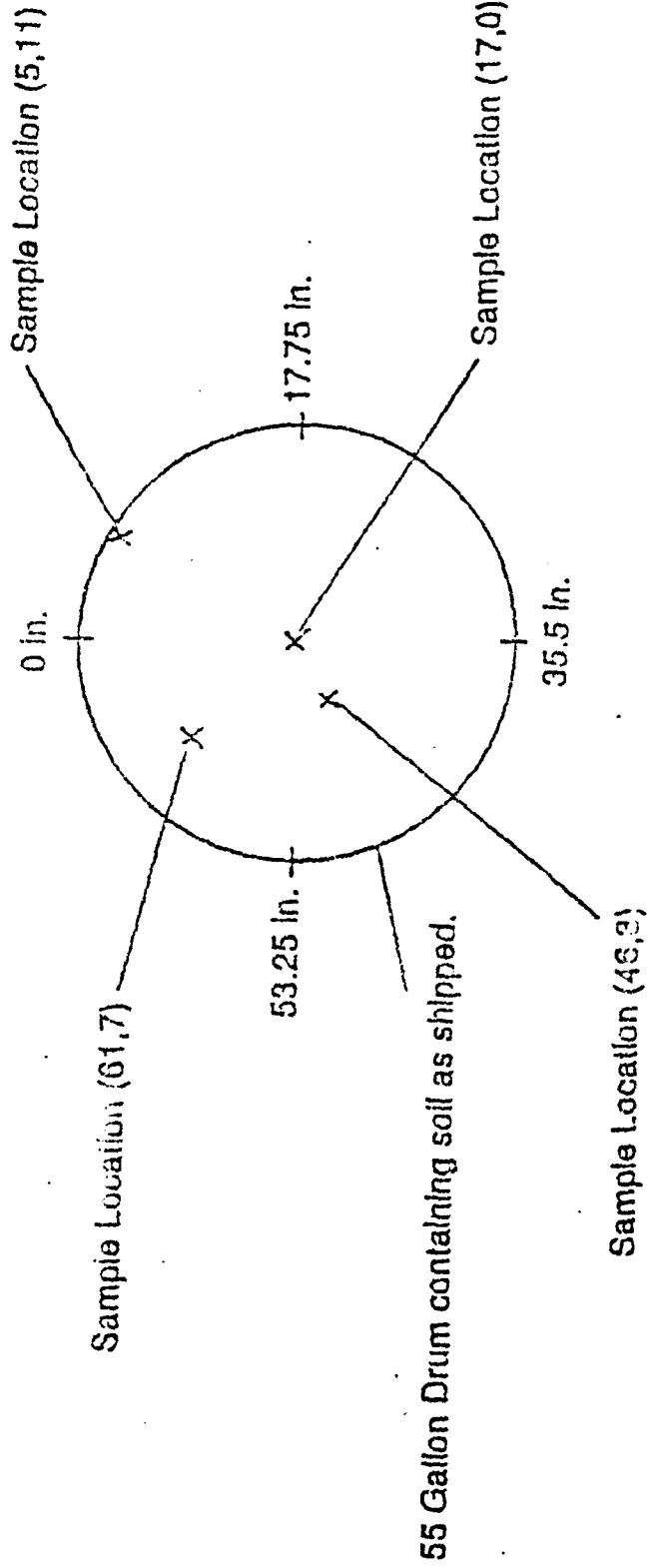
1. Obtain a large clean stainless steel mixing bowl.
2. Place equal volume aliquots of all samples required for the composite sample into the mixing bowl. The soil should be removed from its original sample container through the use of a disposable wooden tongue depressor. Each sample should have its own tongue depressor in order to prevent cross-contamination between samples.
3. Thoroughly mix the soil 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.

F. 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 Sections V and VII. The equations given are adopted from the "Test Methods for Evaluating Solid Wastes" (SW-846), 3rd Edition, Volume II, Chapter Nine. The equations are:

Mean Sample Concentration:

Top View



ISV Engineering Scale Test

SCALE: 1" = 8.65"	APPROVED BY: <i>[Signature]</i>	DRAWN BY: <i>g. L. L. L.</i>
DATE: April 1989		REVISED

Clean and Contaminated Soil Sample Locations

DRAWING NUMBER
Figure V-1

Sample Locations Correspond to Samples Cln and Cnt.

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

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

Standard Deviation:

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

$$s = \sqrt{s^2}$$

$$s_x = s / \sqrt{n}$$

Confidence Interval:

$$CI = \bar{x} \pm t_{.20} s$$

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

V. PRE-TEST SOIL SAMPLING

All samples should be obtained under the procedures set forth in Section IV of this Test 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.

The sampling plan set forth in the following sections is generic and intended to be applicable to all ISV engineering scale tests.

A. Clean Soil Analysis

Verification of Receipt of Clean Soil. Geosafe Corporation requires the verification of the receipt of clean soil shipped by the client through an independent laboratory analysis. The

samples are obtained through the use of a stainless steel soil trier which is decontaminated between each sample to prevent cross contamination. Section IV-C and D provides the instructions for obtaining the samples and decontamination of the trier. The label Cln- stands for clean.

Establish the following grid system (see Figure V-1) for the 85 gallon drum which has a circumference of 85 inches and a radius of 13.5 inches:

1. Establish a zero point on the circumference and locate 1-inch increments around the entire circumference (85 total points).
2. Establish a 13.5 inch radius consisting of 1-inch increments (13 total points).
3. Obtain approximately 500 grams of soil using the trier from the following locations:

<u>Sample #</u>	<u>Depth</u>	<u>Circumference</u>	<u>Radius</u>
Cln-01	0-12"	17 in. point	0 inch
Cln-02	12-24"	17 in. point	0 inch
Cln-03	0-12"	5 in. point	11 inch
Cln-04	12-24"	5 in. point	11 inch
Cln-05	0-12"	46 in. point	3 inch
Cln-06	12-24"	46 in. point	3 inch
Cln-07	0-12"	61 in. point	7 inch
Cln-08	12-24"	61 in. point	7 inch

Composite equal aliquots (see Section IV-E) of samples Cln-01 and Cln-02 for a total sample volume of 500 grams and label the new sample as Cln-09. Composite equal aliquots of samples Cln-03 and Cln-04 for a total sample volume of 500 grams and label the new composite sample as Cln-10. Composite equal aliquots of samples Cln-05 and Cln-06 and label the new sample Cln-11. Composite equal aliquots of samples Cln-07 and Cln-08 and label the new sample Cln-12. Submit samples Cln-09 through Cln-12 for analysis. Archive samples Cln-01 through Cln-08 until the engineering scale test is completed and the data has been accepted. The composite samples (Cln-09 through Cln-12) should be analyzed for:

<u>Sample #Cln</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
09-12	Pesticides	8080	= 1 ug/L
09-12	Mercury	7471	0.0002 mg/L

09-12

Arsenic

7060

1 ug/L

Upon completion of the analyses of Cln-09 through Cln-12, calculate the mean concentration, the standard deviation, and the confidence interval for the composites to ensure that an 80 percent confidence level is achieved. The calculation equations for these parameters are illustrated in the Section IV-F

Physical Characteristics of Soil In addition to analyzing the sample for contaminants, Geosafe requires the following physical characteristics to be determined:

- Fusion Temperature
- 100 poise Temperature (T100P)
- Electrical Conductivity at the 100 poise Temperature
- Melting Temperature
- Soil Moisture Content
- Soil Dry Density

This analysis confirms whether or not fluxants are needed to make an acceptable ISV product and is mandatory for providing accurate cost estimates for full scale vitrification of the entire site.

Obtain a surface grab sample from the drum of clean soil using a clean stainless steel spatula. Label the sample PC-01 and analyze for the above parameters. The notation PC- represents physical characteristics.

Natural Oxide Content of Soil The mono-valent alkali earth metals (Na, Li, & K) are the elements that conduct the electricity in the molten soil. In order for ISV processing to be effective, the sum of the mono-valent earth metals must be in the range of 2 to 5 percent. These metals are analyzed in the form of their oxides. If the sum of the metals is less than 2 percent then a fluxant such as sodium carbonate must be added to the melt. Performing the oxide analysis also provides the silica, aluminum, iron, and calcium content. The silica and aluminum data is required to ensure that there are enough natural glass formers in the soil for ISV processing, the calcium content is related to the viscosity and conductivity of the molten soil.

Obtain a surface grab sample of 500 grams of clean soil using a clean stainless steel spatula. Label the sample NOC-01 and analyze using Inductively Coupled Plasma Spectroscopy (ICP) according to Test Methods for Solid Waste (SW-846) Method 6010. The notation NOC means natural oxide content.

Wipe Sample Analysis of ISV Equipment Geosafe will obtain wipe samples of the ISV equipment (drum cover and off-gas line) prior to beginning the ISV melt. The wipe samples will only be analyzed if the post-test wipe samples show unusual quantities of contaminants. The analysis will correspond to the contaminants that have displayed elevated levels in Section VII-E. In this manner, significant cost savings can be obtained by avoiding un-needed analyses.

Obtain two wipe samples from the locations illustrated in Figure III-1. Label the first sample from the drum cover W-01 and the second sample from the off-gas line W-02. Archive samples unless otherwise specified by the test engineer and hold until test completion and data review. The sample notation W- represents wipe.

B. Contaminated Soil Analysis

Verification of Contaminant Spectrum and Concentration Geosafe will obtain four composite samples of the 50 pounds of contaminated soil and analyze for the following contaminants. The samples are obtained through the use of a stainless steel soil trier which is decontaminated between each sample to prevent cross contamination. Section IV-C and D provides the instructions for obtaining the samples and decontamination of the trier.

Establish the following grid system (see Figure V-1) for the 85 gallon drum which has a circumference of 85 inches and a radius of 13.5 inches:

1. Establish a zero point on the circumference and locate 1-inch increments around the entire circumference (85 total points).
2. Establish a 13 inch radius consisting of 1-inch increments (13 total points).
3. Obtain approximately 500 grams of soil using the trier from the following locations:

<u>Sample #</u>	<u>Depth</u>	<u>Circumference</u>	<u>Radius</u>
Cnt-01	0-4"	17 in. point	0 inch
Cnt-02	4-8"	17 in. point	0 inch
Cnt-03	0-4"	5 in. point	11 inch
Cnt-04	4-8"	5 in. point	11 inch
Cnt-05	0-4"	46 in. point	3 inch
Cnt-06	4-8"	46 in. point	3 inch
Cnt-07	0-4"	61 in. point	7 inch
Cnt-08	4-8"	61 in. point	7 inch.

Composite equal aliquots (see Section IV-E) of samples Cnt-01 and Cnt-02 for a total sample volume of 500 grams and label the new sample as Cnt-09. Composite equal aliquot of samples Cnt-03 and Cnt-04 for a total sample volume of 500 grams and label the new composite sample as Cnt-10. Composite equal aliquots of samples Cnt-05 and Cnt-06 for a total sample volume of 500 grams and label the new sample as Cnt-11. Composite equal aliquots of samples Cnt-07 and Cnt-08 for a total sample volume of 500 grams and label the new sample as Cnt-12. Submit samples Cnt-09 through Cnt-12 for analysis. Archive samples Cnt-01 through Cnt-08 until the engineering scale test is completed and the data has been accepted.

The composite samples (Cnt-09 through Cnt-12) should be analyzed for:

<u>Sample #Cnt</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
09-12	Pesticides	8080	= 1 ug/L
09-12	Mercury	7471	0.0002 mg/L
09-12	Arsenic	7060	1 ug/L

Upon completion of the analyses of Cnt-09 through Cnt-12, calculate the mean concentration, standard deviation, and confidence interval to ensure that an 80 percent confidence interval is achieved. The calculation equations for these parameters are illustrated in the Section IV-F. The label Cnt- stands for contaminated.

VI. VITRIFICATION OPERATIONS

Prior to beginning any vitrification operations Geosafe ISV operators are required to have:

- 40 hour OSHA approved hazardous waste training
- A health physical within the last 12 months
- ISV training
- CPR training
- Read and signed the Test Specific Health and Safety Plan, the Quality Assurance Plan, and the Standard Operating Procedure.

A. Pre-Startup Operations

Pre-startup operations will commence upon receipt and acceptance of all analytical data by

the project manager. Pre-startup includes, but is not limited to, placement of soil, electrode connection, placement of starter path, set-up of sampling trains, and sealing of the test drum. The Standard Operating Procedure (SOP) located in Appendix A provides the step by-step sign off procedure for all the pre-test requirements.

E. Operations

ISV operations will commence only after all the steps in the Pre-Startup Operations have been signed and approved by the test engineer. After completing the pre-startup, operations will commence. Vitrification operations include, but are not limited to, energizing the transformer and supplying power to the electrodes, sampling the off-gases, recording temperature and power requirements, recording visual observations, and de-energizing power to the electrodes at test completion. The Standard Operating Procedure located in Appendix A provides the step-by-step sign off procedure for all the operating requirements.

C. Post-Test Operations

ISV post test operations will commence immediately after de-energizing the transformer. The post test operations include, but are not limited to, continued off-gas sampling and treatment, final air sampling collection, preservation, and storage, entry into test drum after cool-down period, and all post test sampling requirements. The Standard Operating Procedure located in Appendix A provides the step-by-step sign off procedure for all the post-test operating requirements.

VII. POST-TEST SAMPLING

All samples should be obtained under the procedures set forth in Section IV of this Test 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.

The off-gas samples (Section A) will be analyzed along with the soil adjacent to the vitrified block (Section B), the vitrified product (Section C), and the wipe samples of the ISV

equipment (Section D) to provide a material balance for the total destruction and removal efficiency (DRE) of the ISV treatment system. Specifically, the off-gas analysis determines the destruction efficiency (DE) of ISV. The analyses of soil adjacent to the block, the vitrified product, and the wipe samples are summed together with the pre-test analysis of the contaminated soil to provide the mass balance of ISV. The removal efficiency, using standard values, is summed with the destruction efficiency (DE) to provide the DRE of ISV.

A. Off-Gas Sample Analyses

Upon completing the ISV engineering scale test. The off-gas samples collected will be analyzed for the following parameters:

<u>Sample #</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
OG-1	Pesticides	8080	≈ 1 ug/L
OG-2	Mercury	7471	0.0002 mg/L
OG-3	Arsenic	7060	1 ug/L

All off-gas samples should be labeled with OG before the sample number.

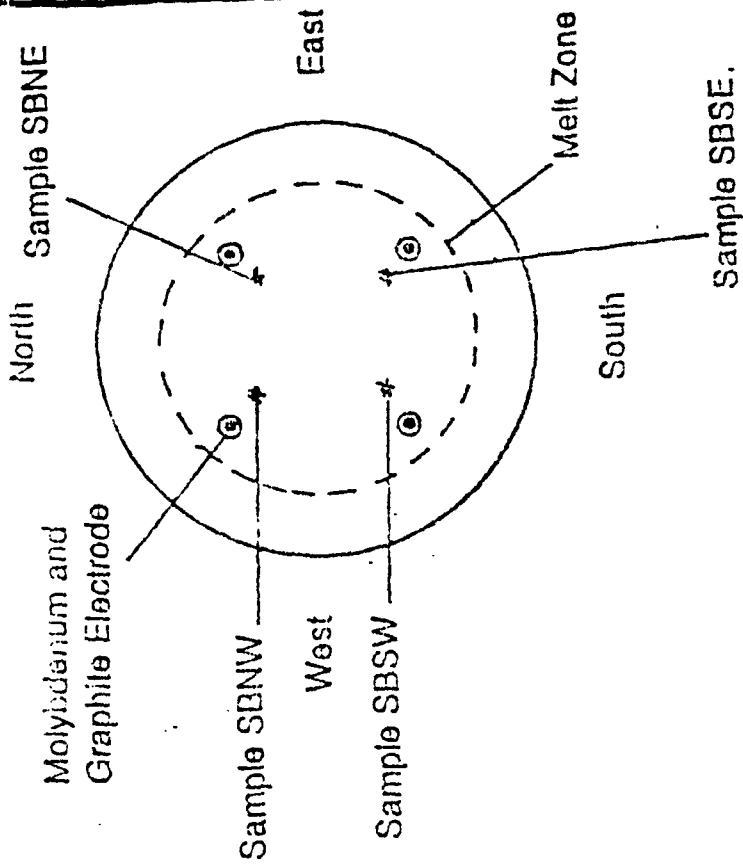
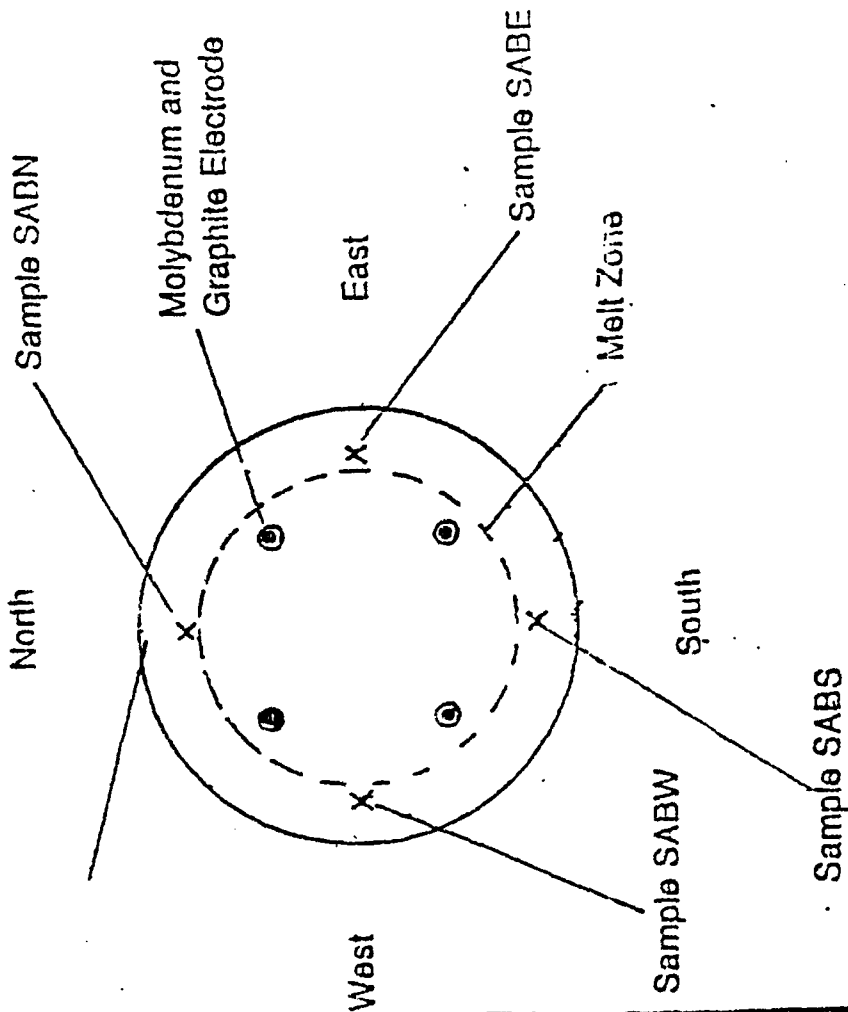
B. Analysis of Soil Adjacent to Vitrified Product

Based on the results of the initial test, the 400°C isotherm will be at or nearly at the boundary of the 85 gallon drum at the completion of the test. This means that sampling beyond the 400°C isotherm will not be possible in the lateral direction. Therefore, samples adjacent to the block will be limited to between the 400°C isotherm and the edge of the vitrified block.

Soil Between Melt Edge and the 85 Gallon Drum - Upon completing the ISV engineering scale melt, 2 composite samples of soil adjacent to the glass product will be analyzed. The samples are obtained through the use of a stainless steel soil trier which is decontaminated between each sample to prevent cross contamination. Section IV-C and D provides the instructions for obtaining the samples and decontamination of the trier.

Establish the following grid system (see Figure VII-1) for the 85 gallon vitrification drum:

TOP VIEW



KEY

- X - Denotes SAB Sample Location
- SAB - Denotes Soil Adjacent Block
- * - Denotes SOI Sample Location
- # - Denotes SB Sample Location
- SB - Denotes Soil Beneath Vitrified Glass

ISV Engineering Scale Test

SCALE: 1" = 8.65"	APPROVED BY: <i>[Signature]</i>	DRAWN BY: J. J. J. J.
DATE: April 1989		REVISED: 7/17/89

Soil Sample Locations

DRAWING NUMBER
Figure VII-1

1. Establish the north/south and east/west orientation of the drum.
2. Locate the midpoint between each set of electrodes.
3. Extend laterally outward towards the drum wall to the ± 400 °C isotherm from the midpoint of the electrodes established in step 2. Obtain the following samples in the soil between the ISV outer block edge and the ± 400 °C isotherm :

<u>Sample #</u>	<u>Depth</u>	<u>Electrode Location</u>	<u>Isotherm</u>
SABN-01	0-8"	North	$>\pm 400$ °C
SABN-02	8-16"	North	$>\pm 400$ °C
SABE-03	0-8"	East	$>\pm 400$ °C
SABE-04	8-16"	East	$>\pm 400$ °C
SABS-05	0-8"	South	$>\pm 400$ °C
SABS-06	8-16"	South	$>\pm 400$ °C
SABW-07	0-8"	West	$>\pm 400$ °C
SABW-08	8-16"	West	$>\pm 400$ °C

Composite equal aliquots (see Section IV-E) of samples SAB-01 through SAB-04 for a total sample volume of 500 grams and label the new sample as SAB-09. Composite equal aliquots of samples SAB-05 through SAB-08 for a total sample volume of 500 grams and label the new sample SAB-10. Submit samples SAB-09 and SAB-10 for analysis. Archive samples SAB-01 through SAB-08 until the engineering scale test is completed and the data has been accepted. The composite samples SAB-09 and SAB-10 should be analyzed for:

<u>Sample #SAB</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
09-10	Pesticides	8080	≈ 1 ug/L
09-10	Mercury	7471	0.0002 mg/L
09-10	Arsenic	7060	1 ug/L

Upon completion of the analyses of SAB-09 and SAB-10, calculate, with the results from SAB-05 and SAB-06, the mean concentration, standard deviation, and confidence interval, to ensure that an 80 percent confidence level is achieved. The calculation equations for these parameters are illustrated in the Section IV-F. In addition, upon completion of the analysis and review of the data report, if any contamination is found above pre-test background levels the test engineer and the project manager will determine if the individual composite samples should be analyzed. The label SAB- stands for soil adjacent block.

It is not anticipated that any contaminants will be detected above background levels. In the event that contamination is present, it will be addressed at that time in accordance with Geosafe Quality Assurance requirements.

Soil Beneath the Block Between the Melt Edge and the 100 °C Isotherm - Similar to the analysis of soil adjacent to the vitrified block, additional samples will be obtained and analyzed beneath the vitrified block between the melt edge and the 100 °C isotherm. Upon completing the ISV engineering scale melt, 2 composite samples will be analyzed from beneath the vitrified block. The samples are obtained through the use of a stainless steel soil trier which is decontaminated between each sample to prevent cross contamination. Section IV-C and D provides the instructions for obtaining the samples and decontamination of the trier. Note: because of the depth below the electrodes, the 100°C isotherm will be several inches above the bottom of the 85 gallon drum at the completion of the test, therefore it will be possible to sample out to the 100°C isotherm for the soils beneath the block.

Utilize the same grid system (see Figure VII-1) for the 85 gallon vitrification drum used for the soil adjacent block analysis:

1. Establish the north/south and east/west orientation of the drum.
2. Locate the four electrodes.
3. Extend diagonally inwards from the electrode location towards the center point of the melt a distance of two inches. Obtain the following samples in the soil between the ISV outer block edge and the 100 °C isotherm:

<u>Sample #</u>	<u>Depth</u>	<u>Electrode Location</u>	<u>Isotherm</u>
SBNW-01	0-4"	Northwest	>100 °C
SBNE-02	0-4"	Northeast	>100 °C
SBSW-03	0-4"	Southwest	>100 °C
SBSE-04	0-4"	Southeast	>100 °C

Composite equal aliquots (see Section IV-E) of samples SBNW-01 and SBNE-02 for a total sample volume of 500 grams and label the new sample as SB-05. Composite equal aliquots of samples SBSW-03 and SBSE-04 for a total sample volume of 500 grams and label the new sample

SB-06. Submit samples SB-05 and SB-06 for analysis. Archive samples SB-01 through SB-04 until the engineering scale test is completed and the data has been accepted. The composite samples SB-05 and SB-06 should be analyzed for:

<u>Sample #SB</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
05-06	Pesticides	8080	= 1 ug/L
05-06	Mercury	7471	0.0002 mg/L
05-06	Arsenic	7060	1 ug/L

Upon completion of the analyses of SB-05 and SB-06, calculate, with the results from SAB-09 and SAB-10, the mean concentration, standard deviation, and confidence interval, to ensure that an 80 percent confidence interval is achieved. The calculation equations for these parameters are illustrated in the Section IV-F. In addition, upon completion of the analysis and review of the data report, if any contamination is found above pre-test background levels the test engineer and the project manager will determine if the individual composite samples should be analyzed. The label SB- stands for soil beneath block.

Soil Beneath the Block Outside the 100 °C Isotherm - In addition to obtaining samples beneath and adjacent to the melt, several samples will be taken outside the 100 °C isotherm beneath the block to provide a safety analyses of the soil beyond the area affected by the temperature variation. The samples are obtained through the use of a stainless steel soil trier which is decontaminated between each sample to prevent cross contamination. Section IV-C and D provides the instructions for obtaining the samples and decontamination of the trier.

Utilize the same grid system (see Figure VII-1) for the 85 gallon vitrification drum used for the soil adjacent block analysis:

1. Establish the north/south and east/west orientation of the drum.
2. Locate the four electrodes.
3. Extend diagonally inwards from the electrode location towards the center point of the melt a distance of two inches. Obtain the following samples in the soil between the bottom of the drum and the 100 °C isotherm:

<u>Sample #</u>	<u>Depth</u>	<u>Electrode Location</u>	<u>Isotherm</u>
SBNW-07	4-12"	Northwest	<100 °C

SBNE-08	4-12"	Northeast	<100 °C
SBSW-09	4-12"	Southwest	<100 °C
SBSE-10	4-12"	Southeast	<100 °C.

Archive samples SB-07 through SB-10 until the analysis of the soil beneath and adjacent to the block between the melt edge and the 100 °C isotherm is complete. In the event that no contamination above pre-test background levels is found in the soil adjacent block analysis, the soil outside the 100 °C isotherm (samples SB-07 through SB-10) will not be analyzed. If contamination is found, the test engineer and the project manager will determine the compositing plan and analyses for the soil outside the 100 °C isotherm. The label SB- stands for soil beneath isotherm.

C. Analyses of Contaminants Remaining in Vitrified Product

The vitrified glass product will have two samples analyzed for remaining contaminants. The contaminants to be tested for are:

<u>Sample #VP</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
01-02	Pesticides	8080	= 1 ug/L
01-02	Mercury	7471	0.0002 mg/L
01-02	Arsenic	7060	1 ug/L

The DRE of the test is specifically applied to organic contaminants in the soil. When metal and radioactive compounds are vitrified the remaining product in the block is a meaningless analysis, unless a leach test procedure is performed. Section E provides the analysis for Toxic Characteristic Leach Procedure (TCLP) for the ISV test.

D. Wipe Sample Analysis of ISV Equipment

A total of two wipe sample analysis of the ISV equipment (drum cover and off-gas line) will be performed at the conclusion of the ISV melt. The wipe samples will be analyzed for the following parameters:

<u>Sample #W</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
03-04	Pesticides	8080	= 1 ug/L
03-04	Mercury	7471	0.0002 mg/L
03-04	Arsenic	7060	1 ug/L

In the event that an unusual amount of contamination is obtained from the wipe samples, then the wipe samples taken prior to performing the melt will be submitted for analysis to determine if residual contamination existed from a previous test. If residual contamination is found, it will be addressed at that time in accordance with Geosafe Quality Assurance requirements.

E TCLP Analysis on the Vitrified Product

A toxic characteristic leach procedure test (TCLP) analysis will be performed on the final vitrification glass product to determine if any of the remaining contaminants within the glass exist in a leachable form. The monolith method will be utilized and the following parameters will be analyzed:

<u>Sample # VP</u>	<u>Parameter</u>	<u>Method</u>	<u>Detection Limit</u>
03-04	Pesticides	8080	= 1 ug/L
03-04	Mercury	7471	0.0002 mg/L
03-04	Arsenic	7060	1 ug/L

The TCLP test analyses is performed to evaluate leaching characteristics of the vitrified block. Contaminants of inorganic nature are not destroyed by ISV but are encapsulated in the final glass product. The TCLP analysis ensures that the contaminants remaining are not leachable.

VIII. MATERIAL RETURN TO CLIENT

After completing the ISV melt all material used for the test will be returned to the client for subsequent disposal. This material includes:

- disposable vapor phase carbon cartridges
- electrode cable
- all safety equipment and protective clothing, respirator cartridges, etc.
- samples archived, but not analyzed
- the ISV glass block
- unused soil.

The material will be returned to the client under the requirements of Section II, Shipping Requirements, upon receipt of the final report by the client.

IX. FINAL REPORT

After completing the ISV melt, Geosafe will issue a final report which will summarize all analytical and operational results for this and the initial engineering scale test. The report will evaluate the technology's capability to vitrify the waste and soil type and provide recommendations for full-scale remedial operations. If requested, a detailed or updated cost proposal will be sent with the final report.

B-1

APPENDIX B

PRE-TEST SOIL ANALYSES



RECEIVED

JUN 19 1989

GEOSAFE CORP.

**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, Wa 98109-5187
(206) 621-6490

15 June 1989

Mr. Steve Liikala
Geosafe Corporation
303 Parkplace, Suite #126
Kirkland, WA 98033

Dear Steve:

RE: ARI Job #02953

Please find the enclosed results for the above referenced project.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC.

David R. Mitchell

David R. Mitchell
Project Manager

DRM/bv

Enclosures

cc: file#02953



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

EXPLANATIONS OF INORGANIC DATA REPORT CODES

THE COLUMNS LABELED 'PREP', 'C', AND 'M' CONTAIN IMPORTANT INFORMATION ABOUT YOUR ANALYSES. THE CODES ARE DEFINED BELOW.

333 Ninth Ave. North
Seattle, Wa 98109-5187
(206)621-6490

PREP CODES

THE 3-LETTER CODES IN THIS COLUMN ARE USED TO DESCRIBE THE METHOD USED TO PREPARE THE SAMPLE FOR ANALYSIS.

THE FIRST LETTER OF THE CODE STANDS FOR THE MATRIX TYPE OR THE FRACTION OF THE SAMPLE THAT IS BEING ANALYZED:

- A = AN AIR FILTER SAMPLE.
- C = A CLAY OR EARTHENWARE SAMPLE.
- D = THE DISSOLVED FRACTION OF A SAMPLE (FILTERED THROUGH A 0.45 μ MEMBRANE FILTER.)
- E = THE EP TOXICITY FRACTION OF A SAMPLE.
- F = A PROCEDURE FOR DIGESTING FISH, OR OTHER TISSUE.
- K = A COPRECIPITATION PROCEDURE
- M = A DIGESTION FOR MISCELLANEOUS SAMPLES NOT FITTING IN NORMAL CATEGORIES
- O = A DIGESTION OF AN OIL, GREASE, OR TAR.
- P = A WIPE SAMPLE.
- R = A WATER SAMPLE PREPARED BY A 'TOTAL RECOVERABLE' DIGESTION.
- S = A DIGESTION OF A SOIL OR SEDIMENT SAMPLE.
- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- U = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- S = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

THE MIDDLE LETTER OF THE CODE RELATES TO THE SOURCE OF THE PROCEDURE.

- A = THE CURRENT AOAC MANUAL.
- C = THE USEPA CLP PROGRAM STATEMENT OF WORK.
- E = THE USEPA 1979 WATER AND WASTEWATER MANUAL.
- H = A METHOD DEVELOPED BY ARI.
- M = A COMMON PROCEDURE FOUND IN A MANY SOURCES.
- P = THE PUGET SOUND ESTUARY PROTOCOLS.
- S = STANDARD METHODS.
- U = THE USEPA SW-846 SOLID WASTE MANUAL.

THE LAST LETTER OF THE PREPARATION CODE REFERS EITHER TO THE FINAL MATRIX OF THE PREPARED SAMPLE OR TO A SPECIALIZED USE OF THE PROCEDURE.

- A = A PROCEDURE FOR ARSENIC AND SELENIUM ANALYSIS ONLY.
- C = A HYDROCHLORIC ACID MATRIX.
- F = A HYDROFLUORIC ACID DIGESTION.
- H = A PROCEDURE FOR MERCURY ANALYSIS ONLY.
- N = A NITRIC ACID MATRIX.
- P = A PERCHLORIC ACID DIGESTION.
- Q = AN AQUA REGIA DIGESTION
- R = A SPECIAL 'SCIT' DIGESTION OF A SOLID.
- S = A METHOD FOR MEASURING HEXAVALENT CHROMIUM

C CODES

THESE CODES ARE USED TO QUALIFY THE REPORTED CONCENTRATIONS. A CODE OF 'L' MEANS NO ANALYTE WAS DETECTED AT THE REPORTED CONCENTRATION LEVEL.

M CODES

THESE CODES SIGNIFY THE TYPE OF INSTRUMENTAL TECHNIQUE USED WHEN ANALYZING THE SAMPLES. THE CODES ARE DEFINED BELOW:

- CVA = COLD VAPOR AAS
- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:20:57

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A1
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: A

Released by: MAJ

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7429-90-5	Aluminum	15900 mg/kg-dry		SWC	ICP
7440-36-0	Antimony	5.4 mg/kg-dry	L	SWC	ICP
7440-33-2	Arsenic	128 mg/kg-dry		SWC	ICP
7440-39-3	Barium	176 mg/kg-dry		SWC	ICP
7440-41-7	Beryllium	0.59 mg/kg-dry		SWC	ICP
7440-42-6	Boron	3.26 mg/kg-dry		SWC	ICP
7440-43-9	Cadmium	0.49 mg/kg-dry		SWC	ICP
7440-70-2	Calcium	11700 mg/kg-dry		SWC	ICP
7440-47-3	Chromium	14.6 mg/kg-dry		SWC	ICP
7440-43-4	Cobalt	6.45 mg/kg-dry		SWC	ICP
7440-50-8	Copper	13.4 mg/kg-dry		SWC	ICP
7439-89-6	Iron	17900 mg/kg-dry		SWC	ICP
7439-92-1	Lead	10.0 mg/kg-dry		SWC	ICP
7439-95-4	Magnesium	3590 mg/kg-dry		SWC	ICP
7439-96-5	Manganese	522 mg/kg-dry		SWC	ICP
7439-97-6	Mercury	NOT ANALYZED		SCM	CVA
7439-98-7	Molybdenum	0.86 mg/kg-dry		SWC	ICP
7440-02-0	Nickel	20.0 mg/kg-dry		SWC	ICP
7440-09-7	Potassium	3060 mg/kg-dry		SWC	ICP
7782-49-2	Selenium	5.4 mg/kg-dry	L	SWC	ICP
	Silica	1910 mg/kg-dry		SWC	ICP
7440-22-4	Silver	0.33 mg/kg-dry	L	SWC	ICP
7440-23-5	Sodium	620 mg/kg-dry		SWC	ICP
7440-28-0	Thallium	5.4 mg/kg-dry	L	SWC	ICP
7440-62-2	Vanadium	34.4 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
PAGE 2

Client: GEOSAFE ARI job number: 2953
Contact: V. FITZPATRICK ARI sample number: A
Project: 309100
ID number: A1
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

CAS Number	Analyte	Concentration	C	Prep	M
7440-66-6	Zinc	51.4 mg/kg-dry		SWC	ICP

Hg > 4.6 mg/kg-dry

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:21:37

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A1
Description: LABORATORY DUPLICATE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: ADUP

Released by: 112W

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7429-90-5	Aluminum	16400 mg/kg-dry		SWC	ICP
7440-36-0	Antimony	3.9 mg/kg-dry	L	SWC	ICP
7440-38-2	Arsenic	120 mg/kg-dry		SWC	ICP
7440-39-3	Barium	173 mg/kg-dry		SWC	ICP
7440-41-7	Beryllium	0.58 mg/kg-dry		SWC	ICP
7440-42-8	Boron	0.84 mg/kg-dry		SWC	ICP
7440-43-9	Cadmium	0.37 mg/kg-dry		SWC	ICP
7440-70-2	Calcium	11400 mg/kg-dry		SWC	ICP
7440-47-3	Chromium	14.8 mg/kg-dry		SWC	ICP
7440-48-4	Cobalt	6.52 mg/kg-dry		SWC	ICP
7440-50-8	Copper	13.2 mg/kg-dry		SWC	ICP
7439-89-6	Iron	17500 mg/kg-dry		SWC	ICP
7439-92-1	Lead	9.8 mg/kg-dry		SWC	ICP
7439-95-4	Magnesium	3680 mg/kg-dry		SWC	ICP
7439-96-5	Manganese	442 mg/kg-dry		SWC	ICP
7439-97-6	Mercury	NOT ANALYZED		SCM	CVA
7439-98-7	Molybdenum	0.59 mg/kg-dry		SWC	ICP
7440-02-0	Nickel	19.5 mg/kg-dry		SWC	ICP
7440-09-7	Potassium	3070 mg/kg-dry		SWC	ICP
7782-49-2	Selenium	3.9 mg/kg-dry	L	SWC	ICP
	Silica	1500 mg/kg-dry		SWC	ICP
7440-22-4	Silver	0.23 mg/kg-dry	L	SWC	ICP
7440-23-5	Sodium	623 mg/kg-dry		SWC	ICP
7440-28-0	Thallium	3.9 mg/kg-dry	L	SWC	ICP
7440-62-2	Vanadium	33.6 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
PAGE 2

Client: GEOSAFE ARI job number: 2953
Contact: V. FITZPATRICK ARI sample number: ADUP
Project: 309100
ID number: A1
Description: LABORATORY DUPLICATE
Sampled: / /
Matrix: SEDIMENT

CAS Number	Analyte	Concentration	C	Prep	M
7440-66-6	Zinc	51.1 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
PAGE 2

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A1
Description: MATRIX SPIKE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: ASPK

CAS Number	Analyte	Concentration	C	Prep	M
7440-66-6	Zinc	108 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:22:56

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A2
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: B

Released by: RAW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	123 mg/kg-dry		SWN	ICP
7439-97-6	Mercury	29 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:23:01

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A3
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: C

Released by: MAW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	201 mg/kg-dry		SWN	ICP
7439-97-6	Mercury	41 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:23:12

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: A4
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: D

Released by: HPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	149 mg/kg-dry		SWN	ICP
7439-97-6	Mercury	42 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:23:19

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: W1
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: I

Released by: 11/12/89

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7429-90-5	Aluminum	4500 mg/kg-dry		SWC	ICP
7440-36-0	Antimony	27.0 mg/kg-dry		SWC	ICP
7440-38-2	Arsenic	46900 mg/kg-dry		SWC	ICP
7440-39-3	Barium	40.2 mg/kg-dry		SWC	ICP
7440-41-7	Beryllium	0.66 mg/kg-dry		SWC	ICP
7440-42-8	Boron	12.0 mg/kg-dry		SWC	ICP
7440-43-9	Cadmium	36.3 mg/kg-dry		SWC	ICP
7440-70-2	Calcium	402000 mg/kg-dry		SWC	ICP
7440-47-3	Chromium	8.43 mg/kg-dry		SWC	ICP
7440-48-4	Cobalt	1.13 mg/kg-dry		SWC	ICP
7440-50-8	Copper	13.1 mg/kg-dry		SWC	ICP
7439-89-6	Iron	2860 mg/kg-dry		SWC	ICP
7439-92-1	Lead	24.3 mg/kg-dry		SWC	ICP
7439-95-4	Magnesium	785 mg/kg-dry		SWC	ICP
7439-96-5	Manganese	20.3 mg/kg-dry		SWC	ICP
7439-97-6	Mercury	5200 mg/kg-dry		SCM	CVA
7439-98-7	Molybdenum	0.63 mg/kg-dry	L	SWC	ICP
7440-02-0	Nickel	2.6 mg/kg-dry		SWC	ICP
7440-09-7	Potassium	38 mg/kg-dry	L	SWC	ICP
7782-49-2	Selenium	32 mg/kg-dry	L	SWC	ICP
	Silica	1460 mg/kg-dry		SWC	ICP
7440-22-4	Silver	3.03 mg/kg-dry		SWC	ICP
7440-23-5	Sodium	375 mg/kg-dry		SWC	ICP
7440-28-0	Thallium	6.3 mg/kg-dry	L	SWC	ICP
7440-62-2	Vanadium	5.61 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
PAGE 2

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: W1
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number; 2953
ARI sample number: I

CAS Number	Analyte	Concentration	C	Prep	M
7440-66-6	Zinc	15.1 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report

06/12/89

14:24:04

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: W3
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: K

Released by: RAW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	43400 mg/kg-dry		SWN	ICP
7439-97-6	Mercury	NOT ANALYZED		SCM	CVA

Hg > 7.6 mg/kg-dry

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:24:15

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: W4
Description: COMPOSITE
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: L

Released by: MAW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	41800 mg/kg-dry		SWN	ICP
7439-97-6	Mercury	5580 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:35:41

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: W2
Description: LIQUID FRACTION
Sampled: / /
Matrix: WATER

ARI job number: 2953
ARI sample number: N

Released by: HRW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	1.07 mg/L		WMN	ICP
7439-97-6	Mercury	1.8 mg/L		TMM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
06/12/89
14:24:23

Client: GEOSAFE
Contact: V. FITZPATRICK
Project: 309100
ID number: METHOD BLANK
Description:
Sampled: / /
Matrix: SEDIMENT

ARI job number: 2953
ARI sample number: MB

Released by: MBW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7429-90-5	Aluminum	3 mg/kg-dry		SWC	ICP
7440-36-0	Antimony	5 mg/kg-dry	L	SWC	ICP
7440-38-2	Arsenic	5 mg/kg-dry	L	SWN	ICP
7440-39-3	Barium	0.1 mg/kg-dry	L	SWC	ICP
7440-41-7	Beryllium	0.1 mg/kg-dry	L	SWC	ICP
7440-42-8	Boron	3.2 mg/kg-dry		SWC	ICP
7440-43-9	Cadmium	0.2 mg/kg-dry	L	SWC	ICP
7440-70-2	Calcium	5 mg/kg-dry		SWC	ICP
7440-47-3	Chromium	0.5 mg/kg-dry	L	SWC	ICP
7440-48-4	Cobalt	0.3 mg/kg-dry	L	SWC	ICP
7440-50-8	Copper	0.2 mg/kg-dry	L	SWC	ICP
7439-89-6	Iron	1.2 mg/kg-dry		SWC	ICP
7439-92-1	Lead	3 mg/kg-dry	L	SWC	ICP
7439-95-4	Magnesium	1 mg/kg-dry		SWC	ICP
7439-96-5	Manganese	0.1 mg/kg-dry	L	SWC	ICP
7439-97-6	Mercury	0.05 mg/kg-dry	L	SCM	CVA
7439-98-7	Molybdenum	0.5 mg/kg-dry	L	SWC	ICP
7440-02-0	Nickel	1 mg/kg-dry	L	SWC	ICP
7440-09-7	Potassium	30 mg/kg-dry	L	SWC	ICP
7782-49-2	Selenium	5 mg/kg-dry	L	SWC	ICP
	Silica	26 mg/kg-dry		SWC	ICP
7440-22-4	Silver	0.3 mg/kg-dry	L	SWC	ICP
7440-23-5	Sodium	6 mg/kg-dry		SWC	ICP
7440-28-0	Thallium	5 mg/kg-dry	L	SWC	ICP
7440-62-2	Vanadium	-0.2 mg/kg-dry		SWC	ICP

ANALYTICAL RESOURCES, INC.

Results of Quality Control Duplicate Analysis

Client: GEOSAFE

Sample Identification: 2953 A

Units: mg/kg-dry

ANALYTE	ORIGINAL SAMPLE	C	DUPLICATE ANALYSIS	C	RELATIVE PERCENT DIFFERENCE
Aluminum	15900		16400		3.1
Antimony	5.4	L	3.9	L	
Arsenic	128		120		6.5
Barium	176		173		1.7
Beryllium	0.59		0.58		1.7
Boron	3.26		0.84		113.0
Cadmium	0.49		0.37		27.9
Calcium	11700		11400		2.6
Chromium	14.6		14.8		1.4
Cobalt	6.45		6.52		1.1
Copper	13.4		13.2		1.5
Iron	17900		17500		2.3
Lead	10		9.8		2.0
Magnesium	3590		3680		2.5
Manganese	522		442		16.6
Molybdenum	0.86		0.59		37.2
Nickel	20		19.5		2.5
Potassium	3060		3070		0.3
Selenium	5.4	L	3.9	L	
Silicon	1910		1500		24.0
Silver	0.33	L	0.23	L	
Sodium	620		623		0.5

Thallium:	5.4	L	3.9	L	
Vanadium:	34.4		33.6		2.4
Zinc	51.4		51.1		0.6

ANALYTICAL RESOURCES, INC.

Results of Quality Control Matrix Spike Analysis

Client: GEOSAFE

Sample Identification: 2953 A

Units: mg/kg-dry

ANALYTE	ORIGINAL SAMPLE	C	SPIKED SAMPLE	C	AMOUNT ADDED	PERCENT RECOVERY
Aluminum	15900		20800		218.8	
Antimony	0		18		54.7	32.9
Arsenic	128		311		218.8	83.6
Barium	176		384		218.8	95.1
Beryllium	0.59		5.62		5.47	92.0
Boron	3.26		504		547	91.5
Cadmium	0.49		6.1		5.47	102.6
Calcium	11700		11700		1094	
Chromium	14.6		38.8		21.88	110.6
Cobalt	6.45		106		109.4	91.0
Copper	10.4		40.8		27.35	100.2
Iron	17900		18600		109.4	
Lead	10		63.7		54.7	98.2
Magnesium	3590		5170		1094	144.4
Manganese	522		482		54.7	
Molybdenum	0.86		82.7		109.4	74.8
Nickel	20		78.4		54.7	106.8
Potassium	3060		4710		1094	150.8
Selenium	0		205		218.8	93.7
Silicon	1910		1990		547	14.6
Silver	0		5.3		5.47	96.9
Sodium	620		1780		1094	106.0

Thallium	0	197	218.8	90.0
Vanadium	34.4	142	109.4	98.4
Zinc	51.4	108	54.7	103.5



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333 Ninth Ave. North
Seattle, Wa 98109-5187
(206) 621-6490

**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: Method Blank

Lab ID: 2953MBW
Matrix: Water

GC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Pete M. Kurler*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 06/01/89

Amount Analyzed: 40 ml
Conc/Dil Factor: 1 to 1
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/L	CAS Number		µg/L
319-84-6	Alpha-BHC	0.1 U	72-54-8	4,4'-DDD	0.3 U
319-85-7	Beta-BHC	0.1 U	1031-07-8	Endosulfan Sulfate	0.5 U
319-86-8	Delta-BHC	0.1 U	50-29-3	4,4'-DDT	0.3 U
58-89-9	Gamma-BHC (Lindane)	0.1 U	72-43-5	Methoxychlor	0.4 U
76-44-8	Heptachlor	0.1 U	53494-70-5	Endrin Ketone	0.3 U
309-00-2	Aldrin	0.1 U	5103-74-2	Gamma-Chlordane	0.2 U
1024-57-3	Heptachlor Epoxide	0.1 U	5103-71-9	Alpha-Chlordane	0.2 U
959-98-3	Endosulfan I	0.1 U	8001-35-2	Toxaphene	15 U
60-57-1	Dieldrin	0.2 U	-	Aroclor-1242/1016	20 U
72-55-9	4,4'-DDE	0.2 U	12672-29-6	Aroclor-1248	20 U
72-20-8	Endrin	0.2 U	11097-69-1	Aroclor-1254	20 U
33212-65-9	Endosulfan II	0.2 U	11096-82-5	Aroclor-1260	20 U

Pesticide Surrogate Recovery

Dibutylchlorodane	95%
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Data Reporting Qualifiers

- | | | | |
|----|--|---|---|
| U | Indicates compound was analyzed for but not detected at the given detection limit. | Y | Indicates a hit above the linear range of the detector. Dilution is required. |
| J | Indicates a hit below the calculated detection limit but considered real by the analyst. | Z | Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required. |
| NR | Indicates not reported due to the dilution factor or matrix interference. | | |



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Seattle, Wa 98109-3187
(206) 621-6490

**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: Method Blank

Lcb ID: 2953MBS
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *[Signature]*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/30/89

Dry Weight Analyzed: 30.0 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	20U	72-54-8	1,4'-DDD	6.0U
319-85-7	Beta-BHC	20U	1031-07-3	Endosulfan Sulfate	10U
319-86-3	Delta-BHC	20U	50-29-3	4,4'-DDT	6.0U
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	8.0U
76-44-8	Heptachlor	20U	53494-70-5	Endrin Ketone	6.0U
309-00-2	Aldrin	20U	5103-74-2	Gamma-Chlordane	3.0U
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	3.0U
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	40U	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	40U	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	40U	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodane	79%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: A1

Lab ID: 2953A
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Pete M. Kuylen*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 28.59 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	26U
319-85-7	Beta-BHC	20U	1031-07-8	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	28U	50-29-3	4,4'-DDT	19
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	80U
76-44-3	Heptachlor	54	53494-70-5	Endrin Ketone	87
309-00-2	Aldrin	180	5103-74-2	Gamma-Chlordane	30
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	15
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	Z	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	14	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	90	11097-69-1	Aroclor-1254	130
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodane	NR
-------------------	----

Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
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333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-3490

**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: A1
Recanalysis

Lab ID: 2953AD
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *[Signature]*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 28.59 g
Conc/Dil Factor: 1 to 1000
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	100U	72-54-8	4,4'-DDD	300U
319-85-7	Beta-BHC	100U	1031-07-3	Endosulfan Sulfate	500U
319-86-8	Delta-BHC	100U	50-29-3	4,4'-DDT	300U
55-39-9	Gamma-BHC (Lindane)	100U	72-43-5	Methoxychlor	400U
76-44-8	Heptachlor	100U	53494-70-5	Endrin Ketone	73J
309-00-2	Aldrin	170	5103-74-2	Gamma-Chlordane	28J
314-57-3	Heptachlor Epoxide	100U	5103-71-9	Alpha-Chlordane	150U
959-98-8	Endosulfan I	100U	8001-35-2	Toxaphene	15000U
60-57-1	Dieldrin	740	-	Aroclor-1242/1016	2000U
72-55-9	4,4'-DDE	200U	12672-29-6	Aroclor-1248	2000U
72-20-8	Endrin	66J	11097-69-1	Aroclor-1254	2000U
33212-65-9	Endosulfan II	200U	11096-82-5	Aroclor-1260	2000U

Pesticide Surrogate Recovery

Dibutylchlorodate	NR
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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Sample No: A2

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Dry Weight Analyzed: 30.28 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

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A2
leanalysis

2953-Geosafe
309100
05/11/89

30.28 g
1 to 1000
NO
YES

$\mu\text{g/Kg}$	CAS Number		$\mu\text{g/Kg}$
20U	72-54-8	4,4'-DDD	19U
20U	1031-07-8	Endosulfan Sulfate	10U
23U	50-29-3	4,4'-DDT	24
20U	72-43-5	Methoxychlor	8.0U
2.6	53494-70-5	Endrin Ketone	55
68	5103-74-2	Gamma-Chlordane	12
20U	5103-71-9	Alpha-Chlordane	5.1
20U	8001-35-2	Toxaphene	300U
330 Y	-	Aroclor-1242/1016	40U
6.9	12672-29-6	Aroclor-1248	40U
42	11097-69-1	Aroclor-1254	40U
40U	11096-82-5	Aroclor-1260	40U

	$\mu\text{g/Kg}$
4,4'-DDD	300U
Endosulfan Sulfate	500U
4,4'-DDT	300U
Methoxychlor	400U
Endrin Ketone	43J
Gamma-Chlordane	150U
Alpha-Chlordane	150U
Toxaphene	15000U
Aroclor-1242/1016	2000U
Aroclor-1248	2000U
Aroclor-1254	2000U
Aroclor-1260	2000U

NR

Data Reporting Qualifiers

was analyzed
at the given

Y

Indicates a hit above the linear
range of the detector. Dilution
is required.

the calculated
considered real

Z

Indicates a tentative hit above
the working range of the
detector. A value is unavailable
and dilution is required.

Qualifiers

Indicates a hit above the linear
range of the detector. Dilution
is required.

Indicates a tentative hit above
the working range of the
detector. A value is unavailable
and dilution is required.



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCP**

Sample No: A3

Lcb ID: 2953C
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Pete M. Kaplan*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 31.34 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-34-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	26U
319-35-7	Beta-BHC	20U	1031-07-3	Endosulfan Sulfate	10U
319-36-8	Delta-BHC	3.2U	50-29-3	4,4'-DDT	17
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	8.0U
76-44-8	Heptachlor	3.4	53494-70-5	Endrin Ketone	96
309-00-2	Aldrin	85	5103-74-2	Gamma-Chlordane	15
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlorocane	6.4
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	2	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	6.1	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	87	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodane	NR
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: A3
Reanalysis

Lcb ID: 295300
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Date Release Authorized: Peter M. Kuylen
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 31.34 g
Conc/Dil Factor: 1 to 1000
- GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	100U	72-54-8	4,4'-DDD	300U
319-85-7	Beta-BHC	100U	1031-07-8	Endosulfan Sulfate	500U
319-86-6	Delta-BHC	100U	50-29-3	4,4'-DDT	300U
58-89-9	Gamma-BHC (Lincane)	100U	72-43-5	Methoxychlor	400U
76-44-8	Heptachlor	100U	53494-70-5	Endrin Ketone	80J
309-00-2	Aldrin	86J	5103-74-2	Gamma-Chlordane	150U
1024-57-3	Heptachlor Epoxide	100U	5103-71-9	Alpha-Chlordane	150U
959-98-8	Endosulfan I	100U	8001-35-2	Toxaphene	15000U
60-57-1	Dieldrin	1800	-	Aroclor-1242/1016	2000U
72-55-9	4,4'-DDE	200U	12672-29-6	Aroclor-1248	2000U
72-20-3	Endrin	77J	11097-69-1	Aroclor-1254	2000U
33212-65-9	Endosulfan II	200U	11096-82-5	Aroclor-1260	2000U

Pesticide Surrogate Recovery

Dibutylchloroendate	NR
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: A4

Lab ID: 2953D
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Peter M. Kasper*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 31.32 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDC	60U
319-85-7	Beta-BHC	20U	1031-07-8	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	35U	50-29-3	4,4'-DDT	39
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	80U
76-44-3	Heptachlor	45	53494-70-5	Endrin Ketone	98
309-00-2	Aldrin	130	5103-74-2	Gamma-Chlordane	22
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	11U
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	2	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	15	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	86	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchloroendate	NR
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

**Sample No: A4
Reanalysis**

Lab ID: 2953DD
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *John M. Kyle*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 31.82 g
Conc/Dil Factor: 1 to 1000
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	100U	72-54-8	4,4'-DDD	300U
319-85-7	Beta-BHC	100U	1031-07-8	Endosulfan Sulfate	500U
319-86-8	Delta-BHC	100U	50-29-3	4,4'-DDT	300U
58-89-9	Gamma-BHC (Lincane)	100U	72-43-5	Methoxychlor	400U
76-44-8	Heptachlor	100U	53494-70-5	Endrin Ketone	75J
309-00-2	Aldrin	120	5103-74-2	Gamma-Chloroane	150U
1024-57-3	Heptachlor Epoxide	100U	5103-71-9	Alpha-Chloroane	150U
959-98-8	Endosulfan I	100U	8001-35-2	Toxaphene	15000U
60-57-1	Dieldrin	660	-	Aroclor-1242/1016	2000U
72-35-9	4,4'-DDE	200U	12672-29-6	Aroclor-1248	2000U
72-20-8	Endrin	63J	11097-69-1	Aroclor-1254	2000U
33212-65-9	Endosulfan II	200U	11096-82-5	Aroclor-1260	2000U

Pesticide Surrogate Recovery

Dibutylchloroate	NR
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Data Reporting Qualifiers

U Indicates compound was analyzed for but not detected at the given detection limit.

J Indicates a hit below the calculated detection limit but considered real by the analyst.

NR Indicates not reported due to the dilution factor or matrix interference.

Y Indicates a hit above the linear range of the detector. Dilution is required.

Z Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: W 1

Lab ID: 29531
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *[Signature]*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 19.38 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	6.0U
319-85-7	Beta-BHC	20U	1031-07-8	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	20U	50-29-3	4,4'-DDT	6.0U
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	8.0U
76-44-8	Heptachlor	20U	53494-70-5	Endrin Ketone	6.0U
309-00-2	Aldrin	20U	5103-74-2	Gamma-Chlordane	3.0U
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	3.0U
959-98-3	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	4.1	-	Arcclor-1242/1216	40U
72-55-9	4,4'-DDE	4.0U	12672-29-6	Arcclor-1248	40U
72-20-8	Endrin	1.6J	11097-69-1	Arcclor-1254	40U
33212-65-9	Endosulfan II	4.0U	11096-82-5	Arcclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodane	133%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: W 2

Lab ID: 2953J
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: Peter M. Kaplan
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89

Date Analyzed: 05/31/89

Dry Weight Analyzed: 18.82 g

Conc/Dil Factor: 1 to 10

GPC Cleanup: NO

Alumina Cleanup: YES

CAS Number		$\mu\text{g/Kg}$	CAS Number		$\mu\text{g/Kg}$
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	60U
319-85-7	Beta-BHC	20U	1031-07-3	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	20U	50-29-3	4,4'-DDT	60U
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	80U
76-44-8	Heptachlor	20U	53494-70-5	Endrin Ketone	60U
309-00-2	Aldrin	20U	5103-74-2	Gamma-Chlordane	30U
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	30U
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	53	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	40U	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	13J	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodate	113%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: W 3

Lab ID: 2953K
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Peter M. Kozlowski*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 05/31/89

Dry Weight Analyzed: 19.03 g
Conc/Dil Factor: 1 to 10
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/Kg	CAS Number		µg/Kg
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	6.0U
319-35-7	Beta-BHC	20U	1031-07-8	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	20U	50-29-3	4,4'-DDT	6.0U
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Methoxychlor	8.0U
76-44-3	Heptachlor	20U	53494-70-5	Endrin Ketone	6.0U
309-00-2	Alann	20U	5103-74-2	Gamma-Chloracne	3.0U
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chloracne	3.0U
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	29J	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	40U	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	0.9J	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	40U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodate	107%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: W 4

Lab ID: 2953L
Matrix: Soil/Sediment

QC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Pete M. Lytle*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89

Date Analyzed: 05/31/89

Dry Weight Analyzed: 20.02 g

Conc/Dil Factor: 1 to 10

GPC Cleanup: NO

Alumina Cleanup: YES

CAS Number		$\mu\text{g/Kg}$	CAS Number		$\mu\text{g/Kg}$
319-84-6	Alpha-BHC	20U	72-54-8	4,4'-DDD	6.0U
319-85-7	Beta-BHC	20U	1031-07-8	Endosulfan Sulfate	10U
319-86-8	Delta-BHC	20U	50-29-3	4,4'-DDT	6.0U
58-89-9	Gamma-BHC (Lindane)	20U	72-43-5	Merthoxychlor	8.0U
76-44-8	Heptachlor	20U	53494-70-5	Endrin Ketone	6.0U
309-00-2	Aldrin	20U	5103-74-2	Gamma-Chlordane	3.0U
1024-57-3	Heptachlor Epoxide	20U	5103-71-9	Alpha-Chlordane	3.0U
959-98-8	Endosulfan I	20U	8001-35-2	Toxaphene	300U
60-57-1	Dieldrin	28J	-	Aroclor-1242/1016	40U
72-55-9	4,4'-DDE	4.0U	12672-29-6	Aroclor-1248	40U
72-20-8	Endrin	0.7J	11097-69-1	Aroclor-1254	40U
33212-65-9	Endosulfan II	4.0U	11096-82-5	Aroclor-1260	40U

Pesticide Surrogate Recovery

Dibutylchlorodane	106%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



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**ORGANICS ANALYSIS DATA SHEET
PESTICIDE/PCB**

Sample No: W 2

Lab ID: 2953N
Matrix: Water

GC Report No: 2953-Geosafe
Project: 309100

Date Received: 05/11/89

Data Release Authorized: *Peter M. Kelle*
Report Prepared 06/02/89 - MAC:E

Date Extracted: 05/22/89
Date Analyzed: 06/01/89

Amount Analyzed: 40 ml
Conc/Dil Factor: 1 to 1
GPC Cleanup: NO
Alumina Cleanup: YES

CAS Number		µg/L	CAS Number		µg/L
319-24-6	Alpha-BHC	0.1 U	72-54-8	4,4'-DDD	0.3 U
319-25-7	Beta-BHC	0.1 U	1031-07-8	Endosulfan Sulfate	0.5 U
319-36-8	Delta-BHC	0.1 U	50-29-3	4,4'-DDT	0.3 U
58-59-9	Gamma-BHC (Lindane)	0.1 U	72-43-5	Methoxychlor	0.4 U
76-44-8	Heptachlor	0.1 U	534-470-5	Endrin Ketone	0.3 U
309-00-2	Alar	0.1 U	510-74-2	Gamma-Chlordane	0.2 U
1024-57-3	Heptachlor Epoxide	0.1 U	5103-71-9	Alpha-Chlordane	0.2 U
959-98-8	Endosulfan I	0.1 U	8001-35-2	Toxaphene	15 U
60-57-1	Dieldrin	0.2 U	-	Aroclor-1242/1016	2.0 U
72-55-9	4,4'-DDE	0.2 U	12672-29-6	Aroclor-1248	2.0 U
72-20-8	Endrin	0.2 U	11097-69-1	Aroclor-1254	2.0 U
33212-65-9	Endosulfan II	0.2 U	11096-82-5	Aroclor-1260	2.0 U

Pesticide Surrogate Recovery

Dibutylchlorodane	87%
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Data Reporting Qualifiers

U	Indicates compound was analyzed for but not detected at the given detection limit.	Y	Indicates a hit above the linear range of the detector. Dilution is required.
J	Indicates a hit below the calculated detection limit but considered real by the analyst.	Z	Indicates a tentative hit above the working range of the detector. A value is unavailable and dilution is required.
NR	Indicates not reported due to the dilution factor or matrix interference.		



RECEIVED

AUG - 7 1989

GEOSAFE CORP.

**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, WA 98109-5137
(206) 621-6490
(206) 621-7523 (FAX)

4 August 1989

Mr. Steve Liikala
Geosafe Corporation
303 Parkolace, Suite #126
Kirkland, WA 98033

RE: Geosafe Project: RMA; ARI Job #3240

Dear Steve:

Please find the enclosed Metals results for the above referenced project.

The pesticides analyses was cancelled per your request.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC.

David R. Mitchell
Project Manager

DRM/bv

Enclosures

cc: file#3240



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

300 Ninth Ave. North
Seattle, Wa 98109-5187
(206)621-6490

EXPLANATIONS OF INORGANIC DATA REPORT CODES

THE COLUMNS LABELED 'PREP', 'C', AND 'M' CONTAIN IMPORTANT INFORMATION ABOUT YOUR ANALYSES. THE CODES ARE DEFINED BELOW.

PREP CODES

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THE FIRST LETTER OF THE CODE STANDS FOR THE MATRIX TYPE OR THE FRACTION OF THE SAMPLE THAT IS BEING ANALYZED:

- A = A) AIR FILTER SAMPLE.
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- L = THE TCLP EXTRACT OF A SAMPLE
- M = A DIGESTION FOR MISCELLANEOUS SAMPLES NOT FITTING IN NORMAL CATEGORIES
- O = A DIGESTION OF AN OIL, GREASE, OR TAR.
- P = Wipe Sample.
- R = WATER SAMPLE PREPARED BY A 'TOTAL RECOVERABLE' DIGESTION.
- S = A DIGESTION OF A SOIL OR SEDIMENT SAMPLE.
- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- U = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- V = A NON-STANDARD WATER EXTRACTION
- W = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

MIDDLE LETTER OF THE CODE RELATES TO THE SOURCE OF THE PROCEDURE.

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- P = THE PUGET SOUND ESTUARY PROTOCOLS.
- S = STANDARD METHODS.
- W = THE USEPA SW-846 SOLID WASTE MANUAL.

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- P = A PERCHLORIC ACID DIGESTION.
- Q = AN AQUA REGIA DIGESTION
- R = A SPECIAL 'SOFT' DIGESTION OF A SOLID.
- 6 = A METHOD FOR MEASURING HEXAVALENT CHROMIUM

C CODES

THESE CODES ARE USED TO QUALIFY THE REPORTED CONCENTRATIONS. A CODE OF 'L' MEANS NO ANALYTE WAS DETECTED AT THE REPORTED CONCENTRATION LEVEL.

M CODES

THESE CODES SIGNIFY THE TYPE OF INSTRUMENTAL TECHNIQUE USED WHEN ANALYZING THE SAMPLES. THE CODES ARE DEFINED BELOW:

- CVA = COLD VAPOR AAS
- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report

08/03/89

07:45:40

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SOIL B-1
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: A

Released by: MEW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	29 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:45:45

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SOIL B-2
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: B

Released by: MRW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	32 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:45:49

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SOIL B-2
Description: LABORATORY DUPLICATE
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: BDUP

Released by: MRW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	32 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:45:53

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SOIL B-3
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 1240
ARI sample number: 0

Released by: MPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration		Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	23 mg/kg-dry		SCM	CVA

CHAIN-OF-CUSTODY RECORD

No. 1023

Geosale Corporation
303 Parkplace, Suite 128
Kirkland, WA 98033
(208) 822-4000

Receiving Entity Analytical Resources
Entity Contact Dave Hillman
Entity Phone # 621-6444

Geosale Site Phone 822-4000
Geosale Project Mgr. VINCE ELLERMAN
Geosale Shift Eng. STEVE LAYMAN

Project	Client	Project Number
ROVA	Woodward Clyde	309100

Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check
1	B1-B4	glass, 1 pint	Pre Test B soils (4) TOTAL COMPLICATES TO BE ANALYZED	1 2 3 4 5 6
2	SAB --OS Large	glass, 1 pint	Re-test Soil Adjacent Block Large Particles	✓
3	SUB --OS	glass, 1 pint	Re-test Soil Beneath Block	✓
4	SAB --OS Fine	glass, 1 pint	Re-test Soil Adjacent Block Fine Particles	✓

Person Responsible for Sample		Affiliation	Date
STEVE LAYMAN		Geosale	6/30/89
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)			
All three elements for TWH Hg			
7000 As			
20000 Pb/Zn			
(All other)			
Transfer Number	Item Number	Transfer Requested By:	
1	1	J. Hillman	
		Accepted By:	Date
		<u>Steve Layman</u>	6/30/89
		Time	13:00

Send Analytical Results to:

Name STEVE LAYMAN
Address 303 Parkplace, Suite 128
City Kirkland
State/Zip WA 98033
Verbal Results Yes No

Phone to: STEVE LAYMAN Phone #: 822-4000

WHITE COPY--LABORATORY

PINK COPY--SHIPPING

YELLOW COPY--QA COORDINATOR

BLUE COPY--SAMPLER

25 August 1989



RECEIVED
AUG 28 1989
GEOSAFE CORP.

**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-6450
(206) 621-7523 (FAX)

Mr. Steve Liikala
Geosafe Corporation
303 Parkplace, Suite #126
Kirkland, WA 98033

RE: Geosafe Project: RMA #2 - 30900

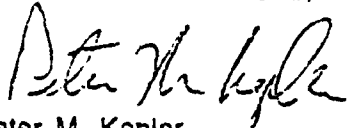
Dear Steve:

Please find the enclosed Metals & Pesticides results for the above referenced project.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC.


Peter M. Kepler
Project Coordinator.

PMK/bv

Enclosures

cc: file#3406



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
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Consultants

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333 Ninth Ave. North
Seattle, Wa 98109-5187
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- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- W = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- X = A NON-STANDARD WATER EXTRACTION
- 5 = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

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- M = A COMMON PROCEDURE FOUND IN A MANY SOURCES.
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- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/22/89
09:32:43

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA #2 30900
ID number: SOIL - AB
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3406
ARI sample number: F

Released by: MAW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	9.2 mg/kg-dry		SWN	ICP

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/22/89
09:32:50

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA #2 30900
ID number: SOIL - BB
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3406
ARI sample number: G

Released by: MPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	10.6 mg/kg-dry		SWN	ICP

CHAIN-OF-CUSTODY RECORD

No. 11111

Geosale Corporation
303 Parkside, Suite 126
Kirkland, WA 98033
(208) 822-4000

Receiving Entity Analytical Resources Geosale Site Phone 822-4000
Entity Contact DAVE MILLER Geosale Project Mgr. 11111111
Entity Phone # 822-4000 Geosale Shift Eng. 11111111

Project	Client	Project Number
<u>R01H #2</u>	<u>Washco, Inc.</u>	<u>30700</u>

Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check
1	Glass 1	Plastic Bag	ISV Glass	1 2 3 4 5 6
2	Soil AB	125ml Plastic	Pre Test Soil Abnormal Black	✓
3	Soil BB	125ml Plastic	Pre Test Soil Normal Black	✓
4	Kan used	125ml Plastic	Kan used Insulation 5" x 1" x 1"	✓
5	Drum Liquid	125ml Plastic	Waste Drum Liquid	✓
6	Drum Liquid	125ml Plastic	Waste Drum Liquid	✓

Person Responsible for Sample	Affiliation	Date
<u>Slove Liikala</u>	<u>Geosale</u>	<u>8-3-89</u>
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)		
<u>Item 1 - Yeast Substrate to be provided.</u>		
<u>2,3</u>	<u>As only</u>	
<u>4</u>	<u>As only</u>	
<u>5</u>	<u>As only</u>	
<u>6</u>	<u>KOAO Testosterone</u>	

Send Analytical Results to:

Name Slove Liikala
Address 303 Parkside, Suite 126
City Kirkland
State/Zip WA 98033
Verbal Results Yes No
Phone for Slove Liikala Phone #: 822-4000

Transfer Number	Item Number	Transfer Reinitiated By	Accepted By	Date	Time
	1				

C-1

APPENDIX C

PREDICTIONS OF MELT CHARACTERISTICS

Major element is 48 in sample percentage 1.24 48%

WATER 1.24 48% 1.24 48% 1.24 48% 1.24 48% 1.24 48% 1.24 48% 1.24 48%

101	0.43	20.04	55.57	54.94	55.00	40.94	45.06
117	0.00	0.00	1.43	0.75	0.00	0.00	0.00
120	1.77	14.04	14.19	14.10	11.13	9.30	10.82
213	0.50	2.04	5.34	4.60	3.61	3.01	2.91
50							
55		0.00	0.00	0.00	0.00	0.00	0.00
56	0.11	1.07	3.22	3.61	0.04	1.70	1.89
57	42.50	2.97	1.00	4.48	15.06	32.82	15.95
58		0.00	5.35	4.25	0.21	2.59	2.78
59	1.00	5.14	1.90	4.01	3.75	2.95	5.50
60+							
60-							
100			0.35	0.15	0.10	0.05	0.05
100+	100.00	100.00	100.00	100.00	100.00	100.00	100.00
1			1.08	0.42	0.50	0.25	0.15
2		0.15	0.05	0.00	0.11	0.05	0.11
3		15.40	3.15	15.20	15.27		17.21
4		15.03	15.15	15.15	15.54		15.15
5	0.00	13.40	15.14	14.08	11.01	2.00	10.00
6	0.10		0.00	0.00	0.00	0.00	0.00
7		1.12	5.35	5.11		0.00	0.00
8						0.00	0.00
9		35.00	15.90	32.00	0.00		
10	3.54					11.13	
11	0.40	0.04	11.35	15.30	5.00	4.15	0.00
12		0.00	4.60	1.40	1.91		
13	0.15					1.00	1.45
14		0.14					
15	0.00				41.35	37.01	44.37
16	54.41					23.79	
total	100.00	100.00	99.48	99.21	99.24	99.87	99.92
	52.61	55.95	22.05	38.41	39.01	39.59	44.75
	9.40	6.35	15.25	12.62	12.45	12.31	11.15
	37.73	34.67	51.15	48.97	48.54	48.10	44.07
	55.13	55.85	53.02	57.24	48.20	47.99	48.59
	1.25	4.22	17.59	9.17	30.23	30.25	31.73
	42.59	36.94	25.90	33.50	20.97	21.15	19.68

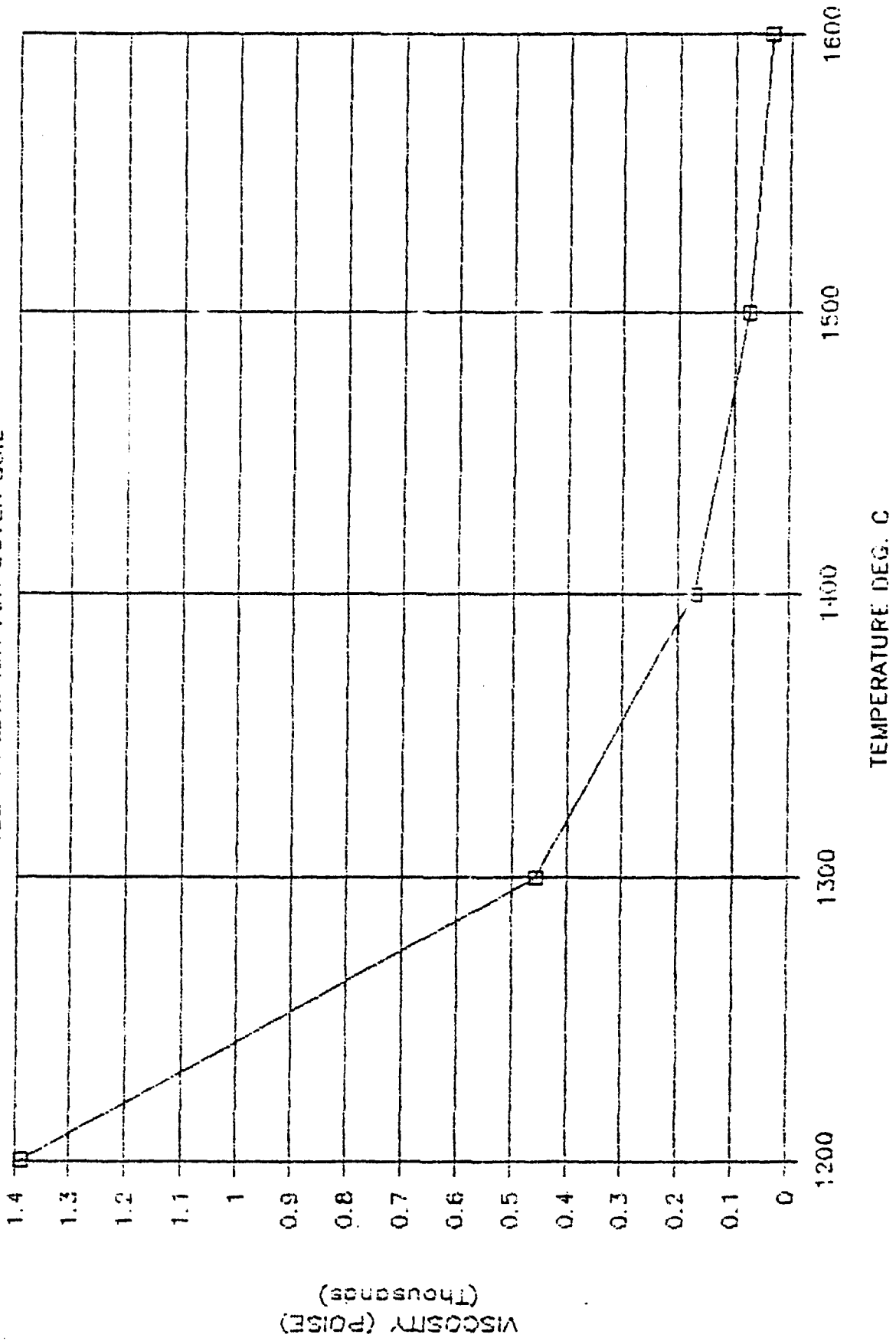
ROCKY MOUNTAIN ARSENAL TEST PREDICTIONS

VISCOSITIES

TEMPERATURE SAMPLED		8 INCHES	10.5 INCHES	13 INCHES	16 INCHES
=====					
900			20184	784	14859
1000	11727		4288	321	3071
1100	4977	188484	6130	78	278
1200	1090	34995	393	30	154
1300	487	8831	132	14	106
1400	171	2830	54	7	45
1500	72	899	26	4	21
1600	53	544	12	2	10

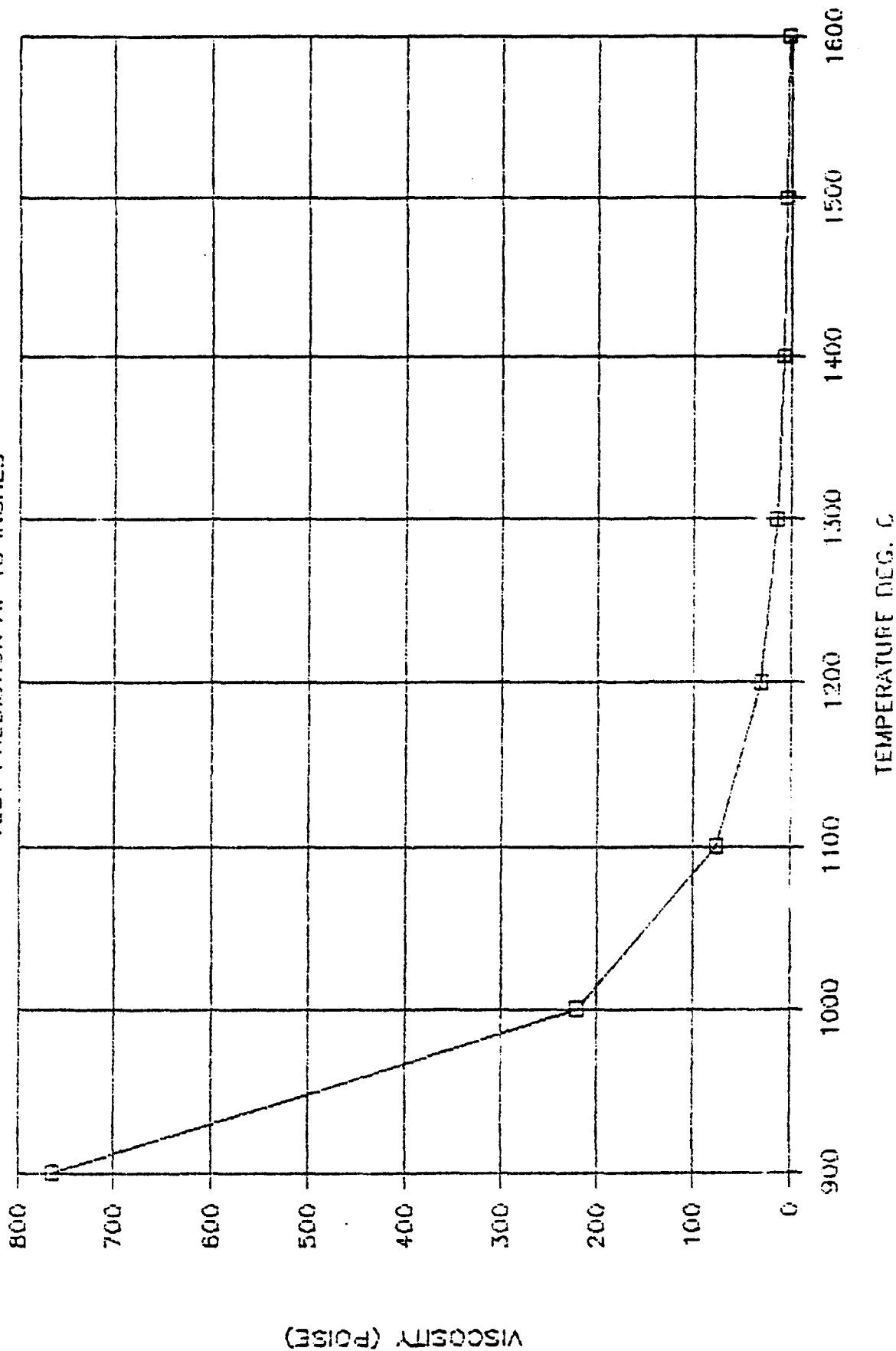
RMA TEMPERATURE VS VISCOSITY

TEST PREDICTION FOR COVER SOIL



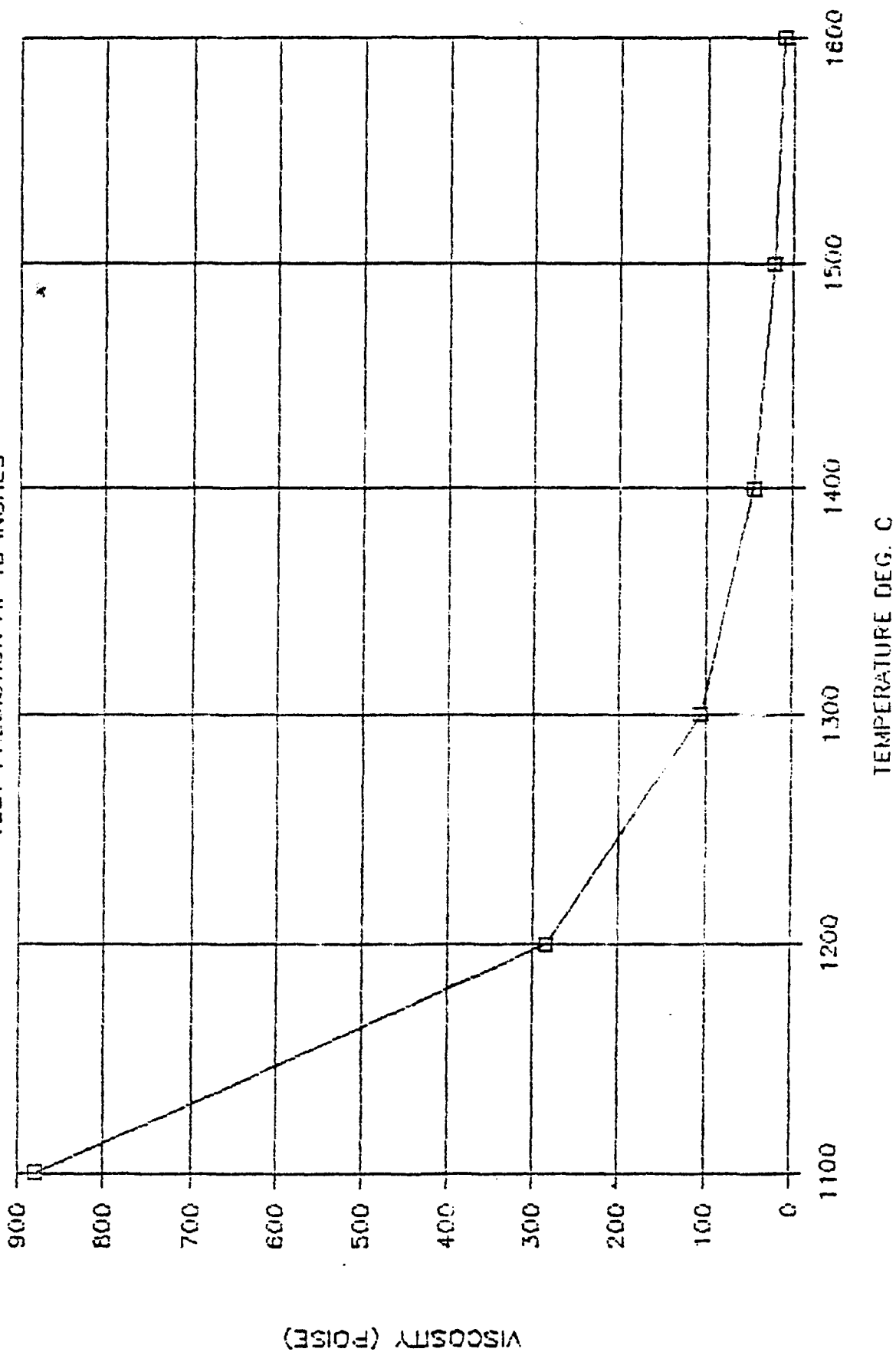
RMA TEMPERATURE VS VISCOSITY

TEST PREDICTION AT 13 INCHES



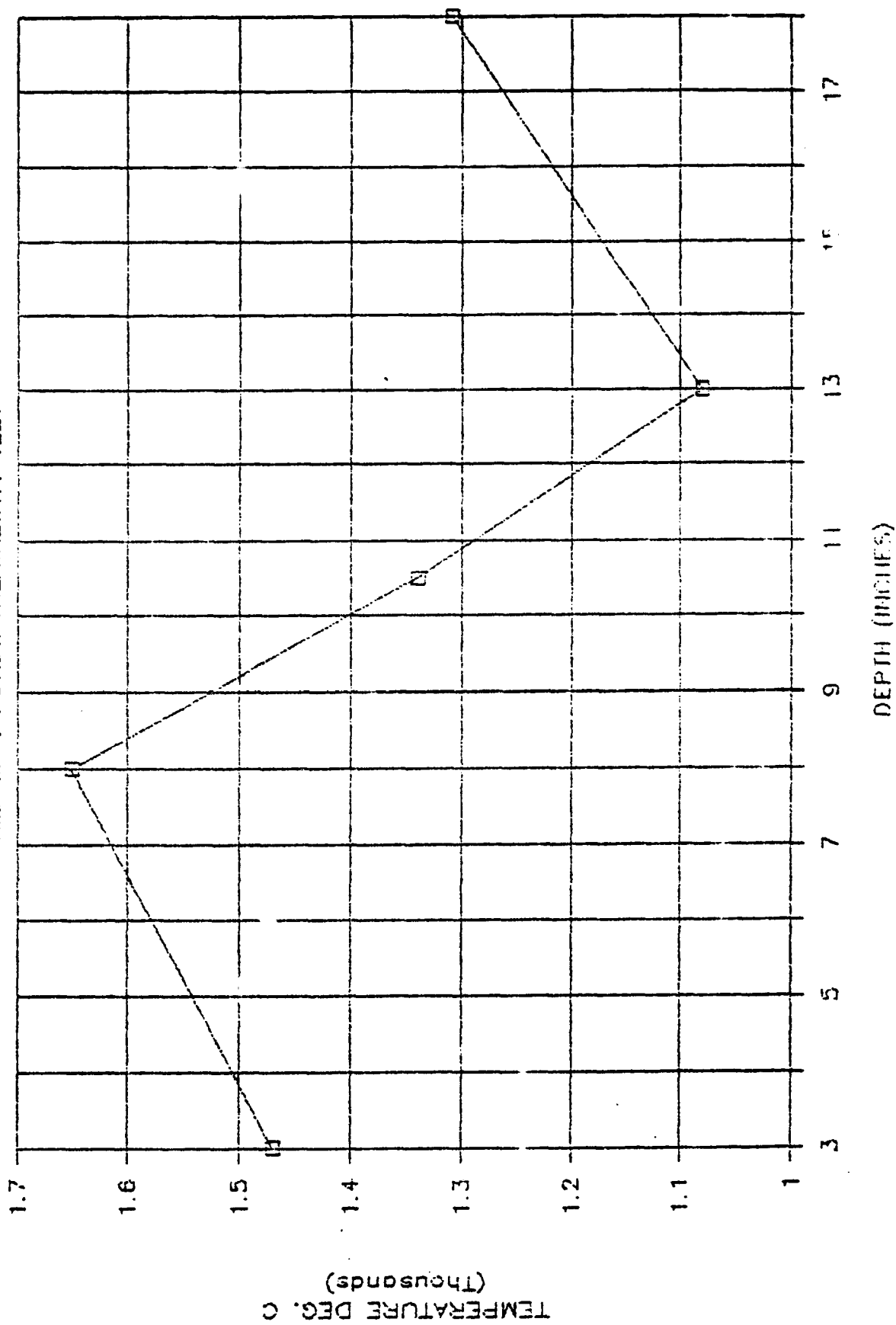
RMA TEMPERATURE VS VISCOSITY

TEST PREDICTION AT 18 INCHES



PREDICTED TEMP. VS DEPTH AT 100 POISE

RMA M-1 POUNDS TREATABILITY TEST



D-1

APPENDIX D
OFF-GAS ANALYTICAL RESULTS

**SOURCE
EMISSION
EVALUATION
REPORT**

AUGUST 21, 1989

Prepared For:

**GEOSAFE CORPORATION
ENGINEERING SCALE
IN-SITU VITRIFICATION TEST
RMA 30000
UNIVERSITY OF WASHINGTON LAB
AUGUST 2, 1989**

Submitted by:


**KRIS A. HANSEN
DIRECTOR
AIR QUALITY DIVISION**


**ANGELA F. BLAISDELL
TECHNICAL WRITER**

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INTRODUCTION

The purpose of this source emission evaluation was to quantify levels of arsenic, arsine, mercury, and pesticides during an engineering-scale test of In Situ Vittrification (ISV) for Woodward-Clyde Consultants. Geosafe Corporation contracted Am Test, Inc.'s Air Quality Division to perform measurements of the off-gases from the test melt. The samples were drawn from a two-inch (2") inside diameter duct at the outlet of the ISV containment box. Am Test, Inc.'s Trace Metals Division analyzed the arsenic and mercury samples. Twin City Testing Corporation, an analytical laboratory based in St. Paul, Minnesota, analyzed the pesticide samples.

During this engineering scale melt, the stack gases were measured to quantify the velocity, temperature, airflow, combustion gas composition, moisture, arsine gas, metals (including arsenic and mercury), and organochlorine pesticides in the gas stream exhausting from the ISV containment box. A summary of the methodology which was used is included on page 2.

This sampling project was performed by the Air Quality Division of Am Test, Inc. of Redmond, Washington. Mr. Kris A. Hansen was the Project Manager for Am Test. Mr. Hansen and Ms. Angela F. Blaisdell of Am Test performed the field sampling, data reduction and report preparation. Ms. Kathy Fugiel of Am Test performed the metals analyses. Ms. Barbara Larka coordinated the semi-VOST analysis for Twin City Testing Corporation. Mr. Steve Liikala coordinated this project for Geosafe Corporation.

SUMMARY OF TESTING METHODOLOGY

Methodology

Information Obtained

EPA Method 1, 2

Velocity measured with a digital velometer.
Temperature measured with type K thermocouples.

EPA Method 3A
Gas Composition

Gas composition (percent carbon dioxide, percent oxygen and ppm carbon monoxide).

EPA Method 4
Moisture

A gas sample was extracted from the source and moisture was condensed from the gas stream and measured gravimetrically.

EPA Method 103
Arsenic

Particulate and gaseous arsenic emissions were withdrawn from the source and collected in 2 impingers containing Type II DI water. The impingers were rinsed with 0.1 N sodium hydroxide solution after sampling. The samples were analyzed using EPA Method 200.7 which utilizes inductively coupled plasma (ICP) spectroscopy.

EPA Method 101A
Mercury

Particulate and gaseous mercury was withdrawn from the source and collected in DI water and acidified potassium permanganate solution. The permanganate impingers were rinsed with 8 N hydrochloric acid solution. The high level mercury samples were analyzed using EPA Method 200.7 which utilizes ICP. The lower level mercury samples were analyzed using EPA Method 245.1 which utilizes cold vapor atomic absorption spectroscopy.

EPA Method 0010
Semi-Volatile Organic
Sample Train

Particulate and gaseous pollutants were withdrawn from the source and collected in a multicomponent sampling train. The components include a quartz-fiber filter and a packed bed of porous polymeric adsorbent resin. The components were rinsed and extracted with methylene chloride. The samples were analyzed for organochlorine pesticides using EPA Method 8080 which utilizes a gas chromatograph equipped with an electron capture detector (GC-ECD).

SUMMARY OF RESULTS

EPA METHODS 1 AND 2 - AIRFLOW DETERMINATION

The velocity and temperature of the gas passing through the duct was measured during the semi-VOST sample period. The average temperature in the duct during the 208-minute test period was 218° F. The velocity of the gas was measured using a KURZ velometer which is NBS traceable. The velocity averaged 2749 ft/minute. The airflow through the duct averaged 60.0 actual cubic feet per minute (acfm), or 44.4 dry standard cubic feet per minute (dscf/min).

ARSINE GAS MEASUREMENTS

Arsine gas (AsH_3) was measured periodically during the melt using Drager detector tubes. Grab samples of the off-gas were drawn into Tedlar bags using a pump, and subsamples of the gas were drawn from the bag using the detector tube pump. The first arsine sample was collected at 09:17. A total of 7 grab samples were collected between 09:17 to 11:15. Those samples did not indicate any traces of arsine. At 11:15, 11:25, and 11:34 the samples which were collected measured approximately 0.05 ppm arsine. Samples collected after 11:47 did not indicate any traces of arsine. It should be emphasized that this methodology was intended as an indicator technique only, therefore, quantification is not appropriate.

EPA METHOD 4 - MOISTURE

The percent moisture in the gas stream was quantified during each test period by weighing the impingers in the condenser section of each semi-VOST and multiple metals sample train to 0.1 grams before and after each run on a digital top-loading balance. The average moisture content of the gas stream during the melt was 3.4%.

EPA 600/8-88-085, SECTION 4.4 MULTIPLE METALS SCREEN

One (1) EPA Method 108 and Method 101A sample was collected during the melt by conducting a "multiple metals screen" sample for a total of 165 minutes. The recommended procedure is outlined in the Northeast States for Coordinated Air Use Management (NESCAUM) document titled "Guidelines for Stack Testing of Municipal Waste Combustion Facilities", document number EPA-600/8-88-085. Particulate and gaseous arsenic and mercury emissions were withdrawn isokinetically from the source and passed through a series of two (2) impingers containing Type II deionized water followed by a third and fourth impinger contained acidified potassium permanganate (KMnO_4) solution. A schematic of the multiple metals screen sample train is included on page 6. All rinses of the probe and the first 2 impingers were made with 0.1 N sodium hydroxide solution and combined with the water impinger catch. The permanganate impingers were rinsed with 8 N hydrochloric acid (HCl) solution and combined with the permanganate impinger catch. The samples were analyzed for arsenic and mercury using EPA Method 200.7 which utilizes Inductively Coupled Plasma (ICP) spectroscopy. The lower level mercury samples were analyzed using EPA Method 245.1 which utilizes cold vapor atomic absorption spectroscopy (CVAA). The metals results from the laboratory were presented in units of total micrograms per sample. The laboratory results were converted to emission concentration units of milligrams per cubic meter (mg/m^3) and parts per million (ppm) for each sample. The concentration results are presented on page 7. The results were also converted to mass emission rate units of micrograms per second ($\mu\text{g}/\text{sec}$) and pounds per hour (lb/hr). The mass emission rate results are presented on page 8. Supporting data (sample times, volumes, temperature, airflow, etc.) collected during run 1 (multiple metals screen) are presented on a computer printout titled "Method 1-4 and Multiple Metals Screen Results" on page 9. A second test was conducted over a 67 minute period to collect

arsenic only (no mercury) during the final stages of the melt. The results from run 2 are presented on page 10. The analytical results for metals provided by Am Test, Inc.'s Trace Metals Division are included on page 11-12. Field data collected during the metals tests are included on pages 13-14. Example calculations of the derivation of the arsine and mercury results are included on pages 15-19.

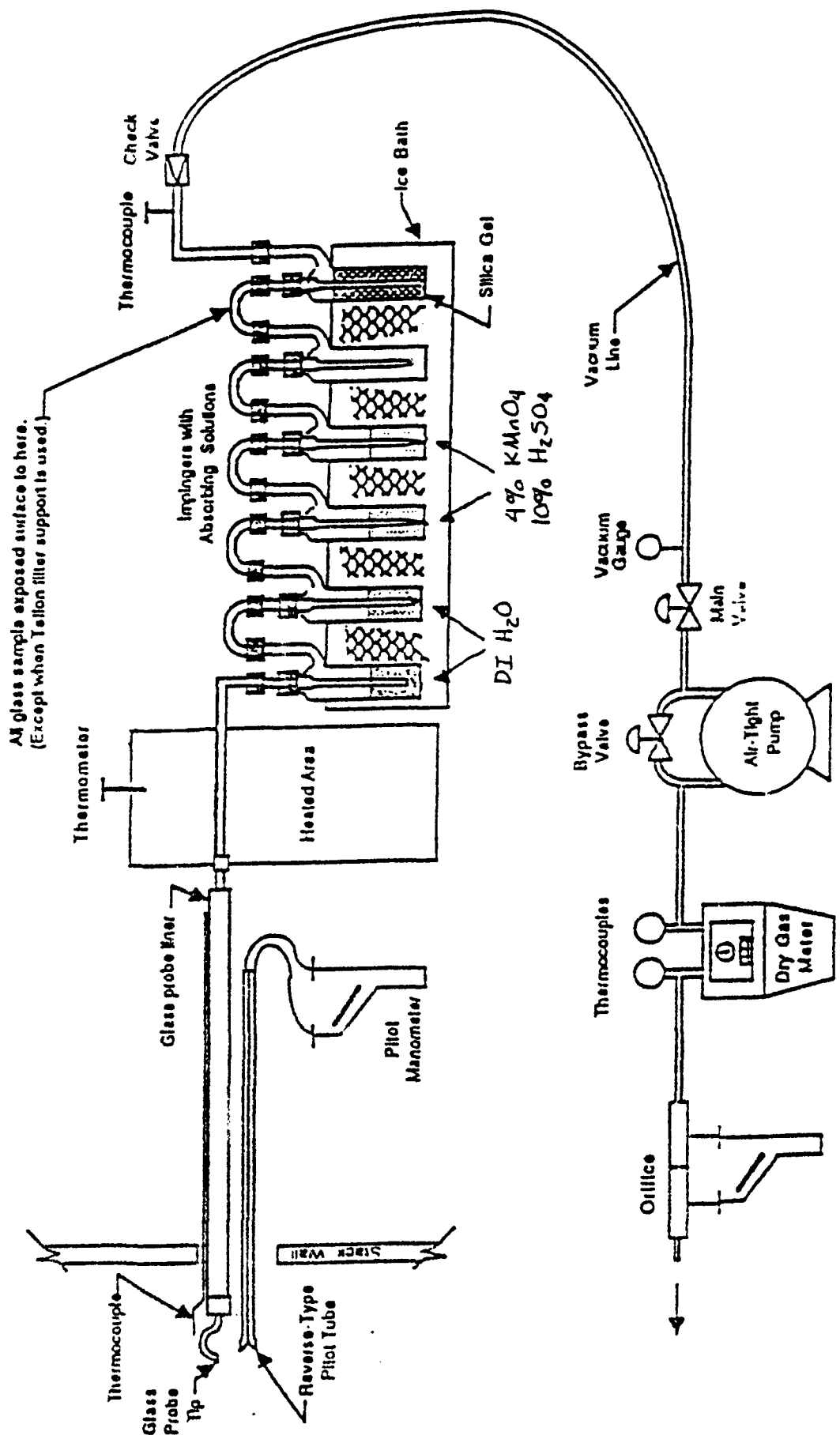


Figure 1. Multiple Metals Sample Train

METALS IN AIR
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME: M-MET-C
 CLIENT: GEOSAFE CORPORATION
 LOCATION: U of W LAB
 SAMPLE LOCATION: ISV CONTAINMENT BOX OUTLET
 RUN NUMBER: 1-MULTIPLE METALS
 SAMPLE DATE: AUGUST 2, 1989
 SAMPLE TIMES: 10:18-13:48
 VOLUME SAMPLED: 1.867 DSCM

		RUN 1 CONCENTRATION		
		Imp. 1 & 2 H2O mg/m3	Imp. 3 & 4 KMnO4 mg/m3	Total mg/m3
COMPOUND				
Arsenic	As	42.58	NR	42.58
Mercury	Hg	0.27	19.27	19.53

		RUN 1 CONCENTRATION		
		Imp. 1 & 2 H2O ppm	Imp. 3 & 4 KMnO4 ppm	Total ppm
COMPOUND				
Arsenic	As	13.67	NR	13.67
Mercury	Hg	0.03	2.31	2.34

mg/m3 = milligrams of metal per cubic meter of gas
 sampled (dry @ standard conditions)

ppm = parts per million

NR = Not Reported (or analyzed)

METALS IN AIR
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME: M-MET-R
 CLIENT: GEOSAFE CORPORATION
 LOCATION: U of W LAB
 SAMPLE LOCATION: ISV CONTAINMENT BOX OUTLET
 RUN NUMBER: 1-MULTIPLE METALS
 SAMPLE DATE: AUGUST 2, 1989
 SAMPLE TIMES: 10:18-13:48
 VOLUME SAMPLED: 65.916 DSCF
 AIRFLOW: 44.5 DSCF/MIN

		RUN 1 MASS EMISSION RATE		
		Imp. 1 & 2 H2O ug/sec	Imp. 3 & 4 KMnO4 ug/sec	Total ug/sec
COMPOUND				
Arsenic	As	894.5	NR	894.5
Mercury	Hg	5.61	404.7	410.3

		RUN 1 MASS EMISSION RATE		
		Imp. 1 & 2 H2O lb/hr	Imp. 3 & 4 KMnO4 lb/hr	Total lb/hr
COMPOUND				
Arsenic	As	0.0071	NR	0.0071
Mercury	Hg	0.00004	0.0032	0.0033

ug/sec = micrograms of metal emitted per second

lb/hr = pounds of compound emitted per hour

NR = Not Reported (or analyzed)

METHOD 1-4 AND MULTIPLE METALS SCREEN RESULTS
AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME:	GEO-MM1	START TIME:	10:18 O'CLOCK
CLIENT:	GEOSAFE CORPORATION	STOP TIME:	13:48 O'CLOCK
LOCATION:	U OF W LAB	SAMPLE TIME:	165.0 MINUTES
SAMPLE SITE:	ISV CONTAINMENT BOX OUTLET		
SAMPLE DATE:	AUGUST 2, 1989		
RUN #:	1-MULTIPLE METALS		
OPERATORS:	HANSEN/BLAISDELL		
CONTACT:	LIKALA/FITZPATRICK		

FINAL WT.	INIT. WT.	NET WT.	PITOT Cp:	0.82
OF H2O G.	OF H2O G.	OF H2O G.	NOZZLE DIA INCHES:	NA
			NOZZLE AREA FT^2:	NA
893.2	859.5	33.7	STACK DIA. INCHES:	2.0
875.1	887.1	-12.0	STACK AREA FT^2:	0.022
331.8	323.4	8.4	METER TEMP. DEG F:	84.2
769.5	752.1	17.4	BAROM. PRES. "HG:	30.05
TOTAL H2O GAIN:	47.5		STATIC PRES. "H2O:	-7.6
TOTAL VOLUME (SCF)	2.24		STACK PRES. "HG:	29.49
PERCENT MOISTURE:	3.28		ORIFICE PRES "H2O:	0.560
Bws:	0.0328		METER PRES. "HG:	30.09

INIT. METER VOL.:	325.123	AVERAGE % CO2:	0.1
FINAL METER VOL.:	392.552	AVERAGE % O2:	20.9
VOLUME SAMPLED:	67.429	AVERAGE ppm CO:	0
STD VOLUME (DSCF):	65.916	STACK GAS MW. DRY:	28.85
STD VOLUME (DSCM):	1.867	STACK GAS MW. WET:	28.50
Y FACTOR:	1.002		

SAMPLE POINT	VELOCITY FT/MIN	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY FT/MIN	TEMPERATURE DEGREES F.
POINT OF	3210	176	POINT OF	3100	217
AVERAGE	3290	199	AVERAGE	3110	213
VELOCITY	3200	214	VELOCITY	3120	206
	3170	230		1750	204
	3020	263		1690	210
	3220	272		1730	206
	3150	241		1720	201

STACK TEMPERATURE:	218.0 DEG. F.	678.0 DEG. R.
STACK GAS VELOCITY:		2748.6 FT/MIN.
STACK GAS AIR FLOW:	60.0 ACF/MIN.	44.5 DSCF/MIN.

RELATION 1-4 AND METHOD 108 (ARSENIC) RESULTS AM TEST, INC. - AIR QUALITY DIVISION

FILE NAME: GEO-AS2
CLIENT: GEOSAFE CORPORATION
LOCATION: U OF W LAB
SAMPLE SITE: ISV CONTAINMENT
BOX OUTLET
SAMPLE DATE: AUGUST 2, 1989
RUN #: 2-ARSENIC
OPERATORS: HANSEN/BLAISDELL
CONTACT: LITKALA/FITZPATRICK

START TIME: 14:35 O'CLOCK
STOP TIME: 15:42 O'CLOCK
SAMPLE TIME: 67.0 MINUTES

FINAL WT. INIT. WT. MET. WT.
409.0 381.9 27.1
489.6 483.6 6.0
323.6 322.7 0.9
783.6 769.5 14.1
TOTAL H₂O GAIN: 48.1
TOTAL VOLUME (SCF) 2.27
PERCENT MOISTURE: 4.87
BWS: 0.0487

PITOT CP: 0.82
NOZZLE DIA. INCHES: NA
NOZZLE AREA FT²: NA
STACK DIA. INCHES: 2.0
STACK AREA FT²: 0.022
METER TEMP. DEG F: 126.8
BAROM. PRES. "HG: 30.04
STATIC PRES. "H₂O: -1.8
STACK PRES. "HG: 29.91
ORIFICE PRES. "H₂O: 1.650
METER PRES. "HG: 30.16

AVERAGE % CO₂: 0.1
AVERAGE % O₂: 20.9
AVERAGE DPM CO: 0
STACK GAS MW. DRY: 28.65
STACK GAS MJ. WET: 28.32

INIT. METER VOL.: 619.955
FINAL METER VOL.: 668.749
VOLUME SAMPLED: 48.794
STD VOLUME (DSCF): 44.214
STD VOLUME (DSCF): 1.253
Y FACTOR: 0.999

SAMPLE POINT	VELOCITY FT/MIN	TEMPERATURE DEGREES F.	SAMPLE POINT	VELOCITY FT/MIN	TEMPERATURE DEGREES F.
POINT OF 3100	131	128	POINT OF 3000	3000	128
AVERAGE 3100	129	128	AVERAGE 3000	3000	128
VELOCITY 3100	128	129	VELOCITY 3270	3270	129

STACK TEMPERATURE: 128.8 DEG. F. 588.8 DEG. R.
STACK GAS VELOCITY: 67.7 ACF/MIN. 3101.7 FT/MIN.
STACK GAS AIR FLOW: 57.7 DSCF/MIN.

ARSENIC ANALYSIS RESULTS

ARSENIC CONC. IN SOLUTION (micrograms): 27120
ARSENIC CONCENTRATION IN AIR (mg/dscm): 21.65
ARSENIC CONCENTRATION IN AIR (ppm): 6.922
ARSENIC EMISSION RATE (ug/sec): 589.8
ARSENIC EMISSION RATE (lb/hr): 0.005

ANALYSIS REPORT

CLIENT: Air Quality Division

DATE RECEIVED: 7/26/89

REPORT TO: Kris Hansen

DATE REPORTED: 8/22/89

PROJECT: Geo Safe

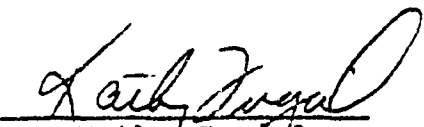
Laboratory Sample No.	Client Identification	Mercury (ug)	Arsenic (ug)	Volume (ml)
913333	Run 1 (KMNO ₄ /HCl)	35,790.*	-	645.
913334	Blank (KMNO ₄)	0.156**	-	780.
913335	Run 1 (H ₂ O & 0.1N NaOH)	499.**	79,500.*	530.
913336	Run 2	-	27,120.*	452.
913337	Blank NaOH	-	15.5*	141.

*EPA Method 200.7

**EPA Method 245.1

KF/ja

REPORTED BY:


Kathy Fugiel

cc: Micro _____
 T.O. _____
 WChem WCK
 TMetals ✓
 Ind _____

 AM TEST LABORATORY
 SAMPLE SHEET

Client Name:

Air Quality

Date Sample Rec'd:

8-3-89

AM Test

Log Number(s)

Client

Identification

Analyses Requested

913333Geosafe - Run 1 - Metalsmercury in $KMnO_4/HCl$ 913334Blank $KMnO_4$ Mercury in $KMnO_4$ 913335Run 1 - metalsBoth Hg, As in $H_2O \pm$
0.1 N Na913336Run 2Arsenic913337Blank NaOHArsenic in 0.1 N NaOH

please measure & report volume
of liquid in each container

Date results requested:

ASAP

From:

Name

Dept.

Date results given:

To:

Name

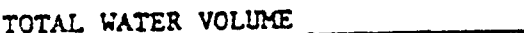
Dept.

Page 1 of

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Aug 11 H.
-7.6

Page 1 of 1

Thermocouple @ °F

Reference ΔP _____

ΔΗ Τ

SAMPLE CALCULATION SHEET METHODS 1-5

CLIENT: GEOSAFEDATE OF TEST: 8-2-89LOCATION: U of WRUN #: 1 - multiple metals
screenParticulate Matter Emission Concentration - Equation 5-1

$$V_{m_{std}} = 17.647 * \underline{6.1429} \text{ ft}^3 * \underline{1.002} * (\underline{30.345} \text{ mmHg} - (\underline{0.560} \text{ mmHg}_0 / 13.6)) / (460 + \underline{84.2}^\circ \text{F})$$

$$= \underline{65.916} \text{ dscf}$$

$$\text{dscm} = \underline{65.916} \text{ dscf} / 35.3 \text{ ft}^3/\text{m}^3$$

$$= \underline{1.867} \text{ dscm}$$

Substitution of Equation 5-4 into 5-5

$$W_1 = \underline{\hspace{1cm}} \text{ mg} * \underline{\hspace{1cm}} \text{ ml} / \underline{\hspace{1cm}} \text{ ml}$$

$$= \underline{\hspace{1cm}} \text{ mg}$$

$$M_n = (\text{net weight filter catch}) + (\text{net weight "B" section}) - W_a + \text{Back-half}$$

$$= \underline{\hspace{1cm}} \text{ mg} = \underline{\hspace{1cm}} \text{ mg} + \underline{\hspace{1cm}} \text{ mg} - \underline{\hspace{1cm}} \text{ mg} + \underline{\hspace{1cm}} \text{ mg}$$

$$C_s = (0.001 \text{ g/mg}) * (15.43 \text{ grains/gram}) * \underline{\hspace{1cm}} \text{ mg} / \underline{\hspace{1cm}} \text{ dscf}$$

$$= \underline{\hspace{1cm}} \text{ gr/dscf (Equation 5-6)}$$

$$\text{gr/dscf @ 7\% O}_2 = \underline{\hspace{1cm}} \text{ gr/dscf} * (20.9\% - 7\% \text{O}_2) / (20.9\% - \underline{\hspace{1cm}} \text{O}_2)$$

$$= \underline{\hspace{1cm}} \text{ gr/dscf @ 7\% O}_2$$

$$\text{gr/dscf @ 12\% CO}_2 = \underline{\hspace{1cm}} \text{ gr/dscf} * 12\% / \underline{\hspace{1cm}} \text{CO}_2$$

$$= \underline{\hspace{1cm}} \text{ gr/dscf @ 12\% CO}_2$$

$$\text{mg/dscm} = \underline{\hspace{1cm}} \text{ mg} / \underline{\hspace{1cm}} \text{ dscm}$$

$$= \underline{\hspace{1cm}} \text{ mg/dscm}$$

Particulate Matter Emission Rate

$$\text{pounds/hour} = \underline{\hspace{1cm}} \text{ gr/dscf} * \underline{\hspace{1cm}} \text{ dscf/min} * 60 \text{ min/hr} * 1 \text{ lb}/7000 \text{ grains}$$

$$= \underline{\hspace{1cm}} \text{ lb/hr}$$

Moisture - Equation 5-2 and 5-3

$$V_{w_{std}} = (0.04707 * \underline{30.1} \text{ grams of H}_2\text{O condensed}) +$$

$$(0.04715 * \underline{17.4} \text{ grams of H}_2\text{O in silica gel})$$

$$= \underline{2.24} \text{ scf}$$

SAMPLE CALCULATION SHEET (continued)
METHODS 1-5

16

$$B_{ws} = (\underline{2.24} \text{ scf}) / (\underline{2.24} \text{ scf} + \underline{65.916} \text{ dscf})$$

$$= \underline{0.0328}$$

$$\% \text{Moisture} = \underline{0.0328} * 100$$

$$= \underline{3.28} \%$$

Molecular weight - Equation 3-2

$$M_1 = 0.440 * (\underline{0.1} \% \text{CO}_2) + 0.320 * (\underline{20.9} \% \text{O}_2) + 0.280 * (\underline{79.0} \% \text{CO} + \% \text{N}_2)$$

$$M_1 = \underline{28.85} \text{ g/g-mole (dry)}$$

$$M_2 = \underline{28.85} \text{ g/g-mole} * (1 - \underline{.0328}) + 18.0 * \underline{.0328}$$

$$3 \quad M_3 = \underline{28.50} \text{ g/g-mole (wet)}$$

Stack gas velocity and volumetric flow rate - Equation 2-9 and 2-10

$$V_s = 85.49 * \underline{\quad} * \underline{\quad} * \sqrt{\underline{\quad}^{\circ} \text{R} / \underline{\quad} \text{g/g-mole} / \underline{\quad} \text{"Hg}}$$

$$V_s = \underline{\quad} \text{ ft/sec (std)}$$

$$Q_{sd} = 3600 * (1 - \underline{\quad}) * \underline{\quad} \text{ ft/sec} * \underline{\quad} \text{ ft}^2 * (\underline{\quad}^{\circ} \text{R} / \underline{\quad}^{\circ} \text{R}) *$$

$$(\underline{\quad} \text{"Hg} / \underline{\quad} \text{"Hg})$$

$$= \underline{\quad} \text{ dscf/hr} / 60 \text{ min/hr}$$

$$= \underline{\quad} \text{ dscf/min (dry standard cubic feet per minute)}$$

$$\text{acfm} = \underline{\quad} \text{ ft/sec} * \underline{\quad} \text{ ft}^2 * 60 \text{ sec/min}$$

$$= \underline{\quad} \text{ acfm (actual cubic feet per minute)}$$

Isokinetic variation - Equation 5-8

$$I = 0.09450 * \underline{\quad} \text{ dscf} * \underline{\quad}^{\circ} \text{R} / (\underline{\quad} \text{"Hg} * \underline{\quad} \text{ ft/sec} * \underline{\quad} \text{ min} * \underline{\quad} \text{ ft}^2 * (1 - \underline{\quad}))$$

$$I = \underline{\quad} \%$$

All of the above numbered equations are from the 40 CFR 60 and assume English units.

Example Calculation of Airflow - multi metals

Velocity measured using KURZ velometer - average

2748.6 ft/min

To calculate actual cubic feet per minute:

$$2748.6 \text{ ft/min} * \frac{\text{area of 2" duct}}{(2^2 * \pi / 4 / 144)} = \underline{\underline{60.0 \text{ acfm}}}$$

0.022 ft²

To calculate dry standard cubic feet per minute

$$60.0 \frac{\text{ft}^3}{\text{min}} * \frac{528^\circ \text{R (std temp)}}{678^\circ \text{R (gas temp)}} * \frac{29.49 \text{ "Hg (P}_g\text{)}}{29.72 \text{ "Hg (P}_{\text{std}}\text{)}} * \frac{(1 - B_{ws})}{.0328}$$

44.5 dscf/min

Example Calculation

Arsenic Emission Concentration

Run 1 - Multiple Metals Screen

Laboratory results presented in units of micrograms per sample:

79500 μg in Impinger 1:2 solution

To calculate Emission Concentration...

$$\frac{79500 \mu\text{g}}{1.867 \text{ dscm}} \times \frac{1 \text{ mg}}{1000 \mu\text{g}} = \underline{\underline{42.58 \text{ mg/dscm}}}$$

or

$$42.58 \frac{\text{mg}}{\text{dscm}} \times \frac{22.414 \text{ l/g-mole}}{74.9216 \text{ g/g-mole}} \times \frac{293.15^\circ\text{K}}{273.15^\circ\text{K}} \times \frac{1 \text{ m}^3}{10^3 \text{ l}} \times \frac{1 \text{ g}}{10^3 \text{ mg}} \times 10^6$$

(molecular weight of arsenic)

$$= \underline{\underline{13.67 \text{ ppm Arsenic}}}$$

To calculate Mass Emission Rate...

$$\frac{79500 \mu\text{g}}{65.916 \text{ dscf}} \times \frac{44.5 \text{ dscf}}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} \times \frac{1 \text{ g}}{10^6 \mu\text{g}} = \underline{\underline{0.0071 \text{ lb/hr}}}$$

or

$$\frac{79500 \mu\text{g}}{65.916 \text{ dscf}} \times \frac{44.5 \text{ dscf}}{\text{min}} \times \frac{1 \text{ min}}{60 \text{ sec.}} = \underline{\underline{894.5 \mu\text{g/sec}}}$$

Example Calculation

Mercury Emission Concentration

Run 1 - Multiple metals Screen

Laboratory Results presented in units of micrograms per sample in 2 types of solution (H_2O & $KMnO_4$)

To Calculate Emission Concentration...

- In Impingers 1 & 2

$$\frac{499 \mu g}{1.867 dscm} \times \frac{1 mg}{1000 \mu g} = \underline{\underline{0.27 mg/dscm}}$$

- In Impingers 3 & 4

$$\frac{35970 \mu g}{1.867 dscm} \times \frac{1 mg}{1000 \mu g} = \underline{\underline{19.27 mg/dscm}}$$

Total
19.53 $\frac{mg}{dscm}$

or

$$0.27 mg/dscm \times \frac{22.414 \text{ l/g-mole}}{200.59 \text{ g/m-mole}} \times \frac{293.15^\circ K}{273.15^\circ C} \times \frac{1 m^3}{10^3 l} \times \frac{1 g}{10^3 mg} \times 10$$

(molecular wt. of mercury)

$$= \underline{\underline{0.03 ppm}} \text{ in Impingers 1 \& 2}$$

$$19.27 mg/dscm \times \frac{22.414}{200.59} \times \frac{293.15}{273.15} = \underline{\underline{2.31 ppm}} \text{ in Impingers 3 \& 4}$$

$$0.03 + 2.31 = \underline{\underline{2.34 ppm total Hg}}$$

EPA METHOD 0010 - SEMI-VOLATILE ORGANIC SAMPLE TRAIN

One (1) EPA Method 0010 sample was collected during the melt over a 208-minute period. Particulate phase semivolatile organic compounds (SOCs) were collected in a borosilicate glass probe and on a quartz-fiber filter, and vapor phase SOCs were collected in a sorbent module packed with XAD-2 resin. Aqueous phase SOCs were collected in a condensate knockout trap downstream of the filter and sorbent module. A schematic of the semi-volatile organic sample train is included on page 21. Each portion of the train was recovered and extracted, then the extracts were combined and concentrated for organochlorine pesticide analysis. The sample extracts were analyzed using EPA Method 8080 which utilizes a gas chromatograph equipped with an electron capture detector (GC-ECD).

The pesticide results from the laboratory were presented in units of total micrograms per sample. The analysis for pesticides detected Aldrin and Dieldrin. The emission concentration of Aldrin was 0.15 micrograms per dry standard cubic meter ($\mu\text{g}/\text{dscm}$) and of Dieldrin was 0.59 $\mu\text{g}/\text{dscm}$. No conversion of units from micrograms per sample was necessary for the remaining compounds which were not detected. The pesticide results from Twin City Testing are included on page 22-23. Supporting data (sample times, volumes, temperature, airflow, etc.) collected during the semi-VOST test are presented on a computer printout titled "Method 1-4 and Semi-Volatile Organic Sample Train Results" on page 24. The field data sheet for this run is included on page 25.

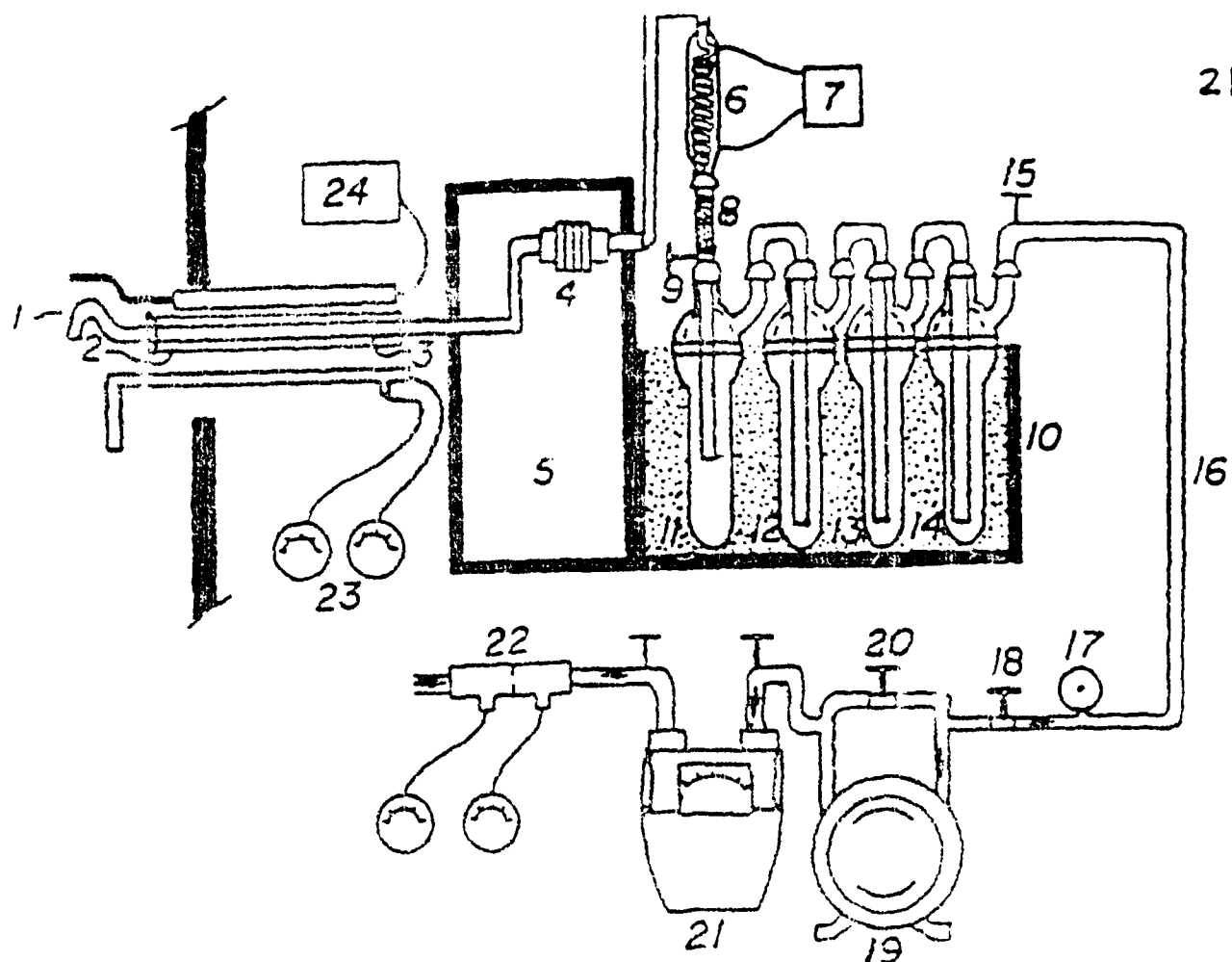


Figure 2. Semi-Volatile Organic Sample Train.

1. Sampling nozzle
2. Sampling probe sheath
3. Heated sample probe line
4. Out of stack filter assembly
5. Heated filter compartment maintained at $248^{\circ}\text{F} \pm 25^{\circ}\text{F}$
(or temperature specified in 40 CFR subpart)
6. Ice water cooled coil condenser
7. Recirculating pump
8. Sorbent module containing XAD-2 resin
9. Sorbent module exit gas temperature sensor
10. Impinger case - contains ice during sampling
11. First impinger w/ short stem - empty
12. Modified Greenburg-Smith impinger containing 1.0 M H_2O
13. Third impinger - empty
14. Fourth impinger containing indicating silica gel desiccant
15. Impinger exit gas temperature sensor
16. Umbilical cord - vacuum line
17. Vacuum gauge
18. Coarse adjustment valve
19. Leak free pump
20. Bypass valve
21. Dry gas meter with inlet and outlet temperature sensors
22. Coffee meter with magnetic gauges
23. F or S-type pilot tube with magnetic gauges
24. Fluks multi-channel digital thermocouple indicator



twin city testing
corporation

662 CROMWELL AVENUE
ST. PAUL, MN 55114
PHONE 612/545-3601

AUG 28 1989

22

REPORT OF: CHEMICAL ANALYSIS

PROJECT: GeoSafe Corporation Pesticide

DATE: August 22, 1989

ISSUED TO: AmTest Incorporated
Attr: Kris Hansen
145603 NE 87th Street
Redmond, Washington 98052

LABORATORY NO. 4410 89-6440

INTRODUCTION

This report summarizes the results of the analyses performed on air sampler components submitted by AmTest Incorporated. The samples were analyzed for pesticides.

PESTICIDE ANALYSIS

The pesticides were determined by a modified version of EPA Method 608. The extracts were analyzed using a 30M J & W DB-608 megabore column in a Hewlett-Packard Model 5890A gas chromatograph equipped with an electron capture detector. Pesticides were identified by column retention time and quantified by peak area comparisons to those of known standards using a VG laboratory data system. Compounds detected on the DB-608 column were confirmed by reanalysis on a HP-5 megabore column.

RESULTS

The results of the analysis are summarized in Table 1. A copy of the chain of custody is attached.

TWIN CITY TESTING CORPORATION

Charles Sueper
Charles Sueper
Mass Spectrometrists

Barbara A. Larka
Barbara Larka, Supervisor
Mass Spectrometry Section

TABLE 1
AM TEST
Results of Pesticide Analyses
GeoSafe Project

Parameter	TCT ID: Client ID:	141182 Run 1	141183 Field Blank	141184 Trip Blank	141185 Lab Blank	MDL
Aldrin		0.3	ND	ND	ND	0.1
A - EHC		ND	ND	ND	ND	0.8
B - EHC		ND	ND	ND	ND	0.4
C - EHC		ND	ND	ND	ND	0.8
Chlordane		ND	ND	ND	ND	1.0
4,4' DDD		ND	ND	ND	ND	0.3
4,4' DDE		ND	ND	ND	ND	0.3
4,4' DDT		ND	ND	ND	ND	0.3
Dieldrin		1.2	ND	ND	ND	0.3
Endosulfan I		ND	ND	ND	ND	1.0
Endosulfan II		ND	ND	ND	ND	1.0
Endosulfan Sulfate		ND	ND	ND	ND	1.0
Endrin		ND	ND	ND	ND	1.0
Endrin Aldehyde		ND	ND	ND	ND	0.2
Heptachlor		ND	ND	ND	ND	0.1
Heptachlor Epoxide		ND	ND	ND	ND	0.3
Lindane (G-EHC)		ND	ND	ND	ND	0.1
Toxaphene		ND	ND	ND	ND	1.0
Methoxychlor		NT	ND	ND	ND	0.2
DEC Recovery *		83%	76%	78%	75%	

Concentrations and detection limits are expressed as ug/sample
*Measured recovery of the surrogate standard dibutylchloroendate



25

Page 1 of 1

[illegible]

$CO_2 = 0.1\%$
$O_2 = 20.9\%$
$CO = 0 \text{ ppm}$

$$\frac{0.496}{\Delta H} \quad \frac{124.9}{T_m}$$

v

 $(\sqrt{\Delta P})^2$

DE

1



CHAIN OF CLODDY RECORD

[illegible]

Distribution: Original Accompanies Shipment; Copy to Coordinator/ Field Files

E-1

APPENDIX E

ADJACENT SOIL, TCLP, AND WIPE ANALYTICAL RESULTS

25 August 1989



RECEIVED
AUG 28 1989
GEOSAFE CORP.

**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-6490
(206) 621-7523 (FAX)

Mr. Steve Liikala
Geosafe Corporation
303 Parkplace, Suite #126
Kirkland, WA 98033

RE: Geosafe Project: RMA #2 - 30900

Dear Steve:

Please find the enclosed Metals & Pesticides results for the above referenced project.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC

Peter M. Kepler
Project Coordinator

PMK/bv

Enclosures

cc: file#3406



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Chemists &
Consultants

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Seattle, WA 98109-5187
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(206) 621-7523 (FAX)

ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PCB

Lab Sample ID: 0809MB
Matrix: Soil
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10
Dry Weight: 30.00 g.

Sample No.: Method Blank
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Date: Release Authorized: *Pete M. Hughes*

DATA PREPARED: MAC:C C.G. (08/16/89)

CAS Number		ug/kg
319-84-6	Alpha-BHC	0.6 U
319-85-7	Beta-BHC	0.6 U
319-86-8	Delta-BHC	1.0 U
58-89-9	Gamma-BHC (Lindane)	0.6 U
76-44-8	Heptachlor	0.6 U
309-00-2	Aldrin	0.6 U
1024-57-3	Heptachlor Epoxide	0.6 U
959-98-8	Endosulfan I	0.6 U
60-57-1	Dieldrin	1.2 U
72-55-9	4,4'-DDE	1.2 U
72-20-8	Endrin	1.2 U
33212-65-9	Endosulfan II	1.2 U
72-54-8	4,4'-DDD	1.8 U
1031-07-8	Endosulfan Sulfate	2.5 U
50-29-3	4,4'-DDT	1.8 U
72-43-5	Methoxychlor	2.5 U
53494-70-5	Endrin Ketone	1.8 U
5103-74-2	Gamma-Chlordane	1.0 U
5103-71-9	Alpha-Chlordane	1.0 U
8001-35-2	Toxaphene	90 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	99%
-------------------	-----

Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.



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ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PCB

Lab Sample ID: 3406 A
Matrix: Soil
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10
Dry Weight: 31.80 g.

Sample No.: SAB-10
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Data Release Authorized: *Peter H. Kaplan*

DATA PREPARED: MAC:C C.G. (06/16/89)

CAS Number		ug/kg
319-84-6	Alpha-BHC	0.6 U
319-85-7	Beta-BHC	0.6 U
319-86-8	Delta-BHC	1.0 U
58-89-9	Gamma-BHC (Lindane)	0.6 U
76-44-8	Heptachlor	0.6 U
309-00-2	Aldrin	0.6 U
1024-57-3	Heptachlor Epoxide	0.6 U
959-98-8	Endosulfan I	0.6 U
61-57-1	Dieldrin	0.4 J
72-55-9	4,4'-DDE	1.2 U
72-20-8	Endrin	1.2 U
33212-65-9	Endosulfan II	1.2 U
72-54-8	4,4'-DDD	1.8 U
1031-07-8	Endosulfan Sulfate	2.5 U
50-29-3	4,4'-DDT	1.8 U
72-43-5	Methoxychlor	2.5 U
53494-70-5	Endrin Ketone	1.8 U
5103-74-2	Gamma-Chlordane	1.0 U
5103-71-9	Alpha-Chlordane	1.0 U
8001-35-2	Toxaphene	90 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	95%
-------------------	-----

Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.



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ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PCB

Lab Sample ID: 3406 B
Matrix: Soil
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10
Dry Weight: 30.20 g.

Sample No.: SBB-10
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Data Release Authorized: *Peter W. Lytle*

DATA PREPARED: MAC:C C.G. (08/16/89)

CAS Number		ug/kg
319-84-6	Alpha-BHC	0.6 U
319-85-7	Beta-BHC	0.6 U
319-86-8	Delta-BHC	1.0 U
58-89-9	Gamma-BHC (Lindane)	0.6 U
76-44-8	Heptachlor	0.6 U
309-00-2	Aldrin	0.6 U
1024-57-3	Heptachlor Epoxide	0.6 U
959-98-8	Endosulfan I	0.6 U
60-57-1	Dieldrin	1.7
72-55-9	4,4'-DDE	1.2 U
72-20-8	Endrin	1.2 U
33212-65-9	Endosulfan II	1.2 U
72-54-8	4,4'-DDD	1.8 U
1031-07-3	Endosulfan Sulfate	2.5 U
50-29-3	4,4'-DDT	1.8 U
72-43-5	Methoxychlor	2.5 U
53494-70-5	Endrin Ketone	1.8 U
5103-74-2	Gamma-Chlordane	1.0 U
5103-71-9	Alpha-Chlordane	1.0 U
8001-35-2	Toxaphene	90 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	85%
-------------------	-----

Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.



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(206) 621-7523 (FAX)

ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PCB

Lab Sample ID: 3406 C
Matrix: Soil
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10
Dry Weight: 37.11 g.

Sample No.: SAB-5
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Data Release Authorized: *Peter H. Kelle*

DATA PREPARED: MAC:C C.G. (08/16/89)

CAS Number		ug/kg
319-84-6	Alpha-BHC	0.6 U
319-85-7	Beta-BHC	0.6 U
319-86-8	Delta-BHC	1.0 U
58-89-9	Gamma-BHC (Lindane)	0.6 U
76-44-8	Heptachlor	0.6 U
309-00-2	Aldrin	0.6 U
1024-57-3	Heptachlor Epoxide	0.6 U
959-98-8	Endosulfan I	0.6 U
60-57-1	Dieldrin	1.2 U
72-55-9	4,4'-DDE	1.2 U
72-20-8	Endrin	1.2 U
33212-65-9	Endosulfan II	1.2 U
72-54-8	4,4'-DDD	1.8 U
1031-07-8	Endosulfan Sulfate	2.5 U
50-29-3	4,4'-DDT	1.8 U
72-43-5	Methoxychlor	2.5 U
53494-70-5	Endrin Ketone	1.8 U
5103-74-2	Gamma-Chlordane	1.0 U
5103-71-9	Alpha-Chlordane	1.0 U
8001-35-2	Toxaphene	90 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	95%
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Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.



**ANALYTICAL
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(206) 621-6490
(206) 621-7523 (FAX)

ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PC3

Lab Sample ID: 3406 D
Matrix: Soil
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10
Dry Weight: 32.70 g.

Sample No.: SBB-5
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Data Release Authorized: *[Signature]*
DATA PREPARED: MAC: C.C.G. (08/16/89)

CAS Number		ug/kg
19-84-6	Alpha-BHC	0.6 U
19-85-7	Beta-BHC	0.6 U
19-86-8	Delta-BHC	1.0 U
8-89-9	Gamma-BHC (Lindane)	0.6 U
6-44-8	Heptachlor	0.6 U
309-00-2	Aldrin	0.6 U
1024-57-3	Heptachlor Epoxide	0.6 U
959-98-8	Endosulfan I	0.6 U
60-57-1	Dieldrin	1.5
72-55-9	4,4'-DDE	1.2 U
72-20-8	Endrin	1.2 U
33212-65-9	Endosulfan II	1.2 U
72-54-8	4,4'-DDD	1.8 U
1031-07-8	Endosulfan Sulfate	2.5 U
50-29-3	4,4'-DDT	1.8 U
72-43-5	Methoxychlor	2.5 U
53494-70-5	Endrin Ketone	1.8 U
5103-74-2	Gamma-Chlordane	1.0 U
5103-71-9	Alpha-Chlordane	1.0 U
8001-35-2	Toxaphene	90 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	96%
-------------------	-----

Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.



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ORGANICS ANALYSIS DATA SHEET - PESTICIDE/PCB

Lab Sample ID: 3406 J
Matrix: Wipe
VTSR: 08/04/89

Date Extracted: 08/09/89
Date Analyzed: 08/14/89
Conc/Dil Factor: 1:10

Dry Weight: NA

Sample No.: Wipe 02
QC Report No.: 3406 - Geosafe Corp.
Project: RMA#2 - 30900

GPC Cleanup: No
Alumina Cleanup: Yes
Sulfur Cleanup: No

Data Release Authorized: *Peter W. Kasper*

DATA PREPARED: MAC/C.C.G. (08/16/89)

Reported In Total μ g

CAS Number

319-84-6	Alpha-BHC	0.03 U
319-85-7	Beta-BHC	0.03 U
319-86-3	Delta-BHC	0.05 U
58-89-9	Gamma-BHC (Lindane)	0.03 U
76-44-8	Heptachlor	0.03 U
309-00-2	Aldrin	0.03 U
1024-57-3	Heptachlor Epoxide	0.03 U
959-98-8	Endosulfan I	0.03 U
60-57-1	Dieldrin	0.06 U
72-55-9	4,4'-DDE	0.06 U
72-20-8	Endrin	0.06 U
33212-65-9	Endosulfan II	0.06 U
72-54-8	4,4'-DDD	0.09 U
1031-07-8	Endosulfan Sulfate	0.15 U
50-29-3	4,4'-DDT	0.09 U
72-43-5	Methoxychlor	0.12 U
53494-70-5	Endrin Ketone	0.09 U
5103-74-2	Gamma-Chlordane	0.05 U
5103-71-9	Alpha-Chlordane	0.05 U
8001-35-2	Toxaphene	4.5 U
-	Aroclor-1242/1016	NA
12672-29-6	Aroclor-1248	NA
11097-69-1	Aroclor-1254	NA
11096-82-5	Aroclor-1260	NA

*** Pesticide Surrogate Recovery**

Dibutylchlorodate	88%
-------------------	-----

Data Qualifiers

- U Indicates compound was analyzed for but not detected at the given detection limit.
- J Indicates an estimated value when the result is less than the calculated detection limit.
- NA Indicates not analyzed.

CHAIN-OF-CUSTODY RECORD

No. 1013

Geosale Corporation
303 Parkplace, Suite 120
Kirkland, WA 98033
(206) 822-4000

Receiving Entity Alaska Pipeline Geosale Site Phone 822-4000
Entity Contact Robert M. Munk Geosale Project Mgr. W. J. Munk
Entity Phone # 822-4000 Geosale Shift Eng. W. J. Munk

Project		Client		Project Number					
1011 #2		Woodward Clyde		30700					
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check					
1	SAB-10	12.5 gal Plastic	Composite of SAB-08 thru 09 8 to 16" core adjacent track	1	2	3	4	5	6
2	SAB-10	802 gal tank	" " " "	✓					
3	SAB-10	12.5 gal Plastic	Composite of SAB-08 thru 09 4" to 8" core beneath 100 block	✓					
4	SAB-10	802 gal tank	" " " "	✓					

Person Responsible for Sample		Attestation	Date
Steve Munk		Geosale	8-2-89
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)			
Item 1 : 3 : A : 11			
Item 2 : 1 : 2 : 1 : N. 100			

Send Analytical Results to:

Name Steve Munk
Address 303 Parkplace, Suite 120
City Kirkland
State/Zip WA 98033
Verbal Results Yes No
Phone to: 822-4000 Phone #: 822-4000

Transfer Number	Item Number	Transfer Relinquished By:	Accepted By:	Date	Time
1	1-1	Steve Munk		8/2/89	1:00

WHITE COPY--LABORATORY

PINK COPY--SHIPPING

YELLOW COPY--QA COORDINATOR

BLUE COPY--SAMPLER

CHAIN-OF-CUSTODY RECORD

No. 1010

Geosale Corporation
303 Rainplace, Suite 128
Richland WA 99353
(206) 822-4000

Receiving Entity Analytical
Entity Contact Steve Linkala
Entity Phone # 822-4000

Geosale Site Phone 822-4000
Geosale Project Mgr. Steve Linkala
Geosale Shift Day

Project		Client		Project Number		
KAM 42		Weather 1 Sample		30900		
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check		
1	Wipe-01	125ml Plastic	Pre Test Brown Wipe	1	2	3
2	Wipe-02	4oz Glass	Pre Test Brown Wipe	4	5	6
3	Wipe-03	125ml Plastic	Pre Test Glass Hot Barrel	7	8	9
4	Wipe-04	4oz Glass	Pre Test Glass Hot Barrel	10	11	12
5	Wipe-05	4oz Glass	Post Test Brown Wipe	13	14	15
6	Wipe-06	125ml Plastic	Post Test Brown Wipe	16	17	18
7	Wipe-07	4oz Glass	Post Test Glass Hot Barrel	19	20	21
8	Wipe-08	125ml Plastic	Post Test Glass Hot Barrel	22	23	24
9	Wipe-09	125ml Plastic	Travel Blank	25	26	27
10	Wipe-10	4oz Glass	Travel Blank	28	29	30

Person Responsible for Sample: Steve Linkala

Attestation: Geosale

Date: 10-3-89

Analytical and Preservation Instructions (Use Back of First Chain if Necessary)

Wipe-01, 03, 06, 08, 09 / As, Hg

Wipe-02, 04, 05, 07, 10 / 8080 Testosterone (Nortest)

Send Analytical Results to:

Name: Steve Linkala

Address: 303 Rainplace, Suite 128

City: Richland

State/Zip: WA 99353

Verbal Results: Yes No

Phone for: Steve Linkala Phone #: 822-4000

Transfer Number	Item Number	Transfer Relinquished By:	Accepted By:	Date	Time
1	1	Steve Linkala			

CHAIN-OF-CUSTODY RECORD

No. 1011

Geosafe Corporation
303 Parkplace, Suite 128
Kirkland, WA 98033
(206) 822-4000

Receiving Entity Geosafe Corporation Geosafe Site Phone 822-4000
Entity Contact Steve Lilkala Geosafe Project Mgr. Steve Lilkala
Entity Phone # 822-4000 Geosafe Shift Eng. Steve Lilkala

Project		Client		Project Number					
R011 #2		Wolverine Cycle		30900					
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check					
				1	2	3	4	5	6
1	Glass 1	Plastic Bag	ISV Glass	✓					
2	Soil AB	125ml Plastic	Pie Test Soil Almond Black	✓					
3	Soil BB	125ml Plastic	Pie Test Soil Pecan Black	✓					
4	Known	125ml Plastic	Known Transition 5" x 1" x 1"	✓					
5	Known Liquid	125ml Plastic	Waste Brown Liquid	✓					
6	Known Liquid	4oz Glass	Waste Brown Liquid	✓					

Person Responsible for Sample		Affiliation	Date
Steve Lilkala		Geosafe	8-3-89
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)			
Item 1 Verbal Instructions to be provided.			
2,3	As only		
4	As, Hg		
5	As, Hg		
6	8030 Petroleum w/ Pb		

Send Analytical Results to:

Name Steve Lilkala
Address 303 Parkplace, Suite 128
City Kirkland
State/Zip WA 98033
Verbal Results Yes No
Phone for: Steve Lilkala 822-4000

Transfer Number	Item Number	Transfer Relinquished By:	Accepted By:	Date	Time
	1				

WHITE COPY--LABORATORY

PINK COPY--SHIPPING

YELLOW COPY--QA COORDINATOR

BLUE COPY--SAMPLER



RECEIVED
AUG 30 1989
GEOSAFE CORP.

ANALYTICAL
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Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-6490
(206) 621-7523 (FAX)

29 August 1989

Mr. Steve Likala
Geosafe Corporation
303 Parkplace, Suite #126
Kirkland, WA 98033

RE: Geosafe Project: RMA #2-30900

Dear Steve:

Please find the enclosed Metals results for the above referenced project.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC.

N. Rocky Wells
Laboratory Manager

NRW/bv

Enclosures

cc: file#3523



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, Wa 98109-5187
(206)621-6490

EXPLANATIONS OF INORGANIC DATA REPORT CODES

THE COLUMNS LABELED 'PREP', 'C', AND 'M' CONTAIN IMPORTANT INFORMATION ABOUT YOUR ANALYSES. THE CODES ARE DEFINED BELOW.

PREP CODES

THE 3-LETTER CODES IN THIS COLUMN ARE USED TO DESCRIBE THE METHOD USED TO PREPARE THE SAMPLE FOR ANALYSIS.

THE FIRST LETTER OF THE CODE STANDS FOR THE MATRIX TYPE OR THE FRACTION OF THE SAMPLE THAT IS BEING ANALYZED:

- A = AN AIR FILTER SAMPLE.
- C = A CLAY OR EARTHENWARE SAMPLE.
- D = THE DISSOLVED FRACTION OF A SAMPLE (FILTERED THROUGH A 0.45 μ MEMBRANE FILTER.)
- E = THE EP TOXICITY FRACTION OF A SAMPLE.
- F = A PROCEDURE FOR DIGESTING FISH, OR OTHER TISSUE.
- K = A COPRECIPITATION PROCEDURE
- L = THE TCLP EXTRACT OF A SAMPLE
- M = A DIGESTION FOR MISCELLANEOUS SAMPLES NOT FITTING IN NORMAL CATEGORIES
- O = A DIGESTION OF AN OIL, GREASE, OR TAR.
- P = A WIPE SAMPLE.
- R = A WATER SAMPLE PREPARED BY A 'TOTAL RECOVERABLE' DIGESTION.
- S = A DIGESTION OF A SOIL OR SEDIMENT SAMPLE.
- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- W = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- X = A NON-STANDARD WATER EXTRACTION
- Y = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

THE MIDDLE LETTER OF THE CODE RELATES TO THE SOURCE OF THE PROCEDURE.

- A = THE CURRENT AOAC MANUAL.
- C = THE USEPA CLP PROGRAM STATEMENT OF WORK.
- E = THE USEPA 1979 WATER AND WASTEWATER MANUAL.
- H = A METHOD DEVELOPED BY ARI.
- M = A COMMON PROCEDURE FOUND IN A MANY SOURCES.
- P = THE PUGET SOUND ESTUARY PROTOCOLS.
- S = STANDARD METHODS.
- W = THE USEPA SW-846 SOLID WASTE MANUAL.

THE LAST LETTER OF THE PREPARATION CODE REFERS EITHER TO THE FINAL MATRIX OF THE PREPARED SAMPLE OR TO A SPECIALIZED USE OF THE PROCEDURE.

- A = A PROCEDURE FOR ARSENIC AND SELENIUM ANALYSIS ONLY.
- C = A HYDROCHLORIC ACID MATRIX.
- F = A HYDROFLUORIC ACID DIGESTION.
- M = A PROCEDURE FOR MERCURY ANALYSIS ONLY.
- N = A NITRIC ACID MATRIX.
- P = A PERCHLORIC ACID DIGESTION.
- Q = AN AQUA REGIA DIGESTION
- R = A SPECIAL 'SOFT' DIGESTION OF A SOLID.
- 6 = A METHOD FOR MEASURING HEXAVALENT CHROMIUM

C CODES

THESE CODES ARE USED TO QUALIFY THE REPORTED CONCENTRATIONS. A CODE OF 'L' MEANS NO ANALYTE WAS DETECTED AT THE REPORTED CONCENTRATION LEVEL.

M CODES

THESE CODES SIGNIFY THE TYPE OF INSTRUMENTAL TECHNIQUE USED WHEN ANALYZING THE SAMPLES. THE CODES ARE DEFINED BELOW:

- CVA = COLD VAPOR AAS
- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/28/89
14:44:36

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA# 2-30900
ID number: TOTAL DECON WIPE
Description:
Sampled: 08/24/89
Matrix: WIPE

ARI job number: 3523
ARI sample number: A

Released by: 11/21

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	5470 mg/wipe		PHN	ICP
7439-97-6	Mercury	101 mg/wipe		PHM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/28/89
14:44:51

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA# 2-30900
ID number: METHOD BLANK
Description:
Sampled: / /
Matrix: WIPE

ARI job number: 3523
ARI sample number: MB1

Released by: MDW

A N A L Y T I C A L R E S U L T ;

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	0.03 mg/wipe	L	PHN	ICP
7439-97-6	Mercury	0.0001 mg/wipe	L	PHM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/28/89
14:44:59

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA# 2-30900
ID number: METHOD BLANK
Description:
Sampled: / /
Matrix: WATER

ARI job number: 3523
ARI sample number: ME2

Released by: M. Du

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	0.05 mg/L	L	TWC	ICP
7439-97-6	Mercury	0.0001 mg/L	L	TMM	CVA

F-1

APPENDIX F

VITRIFIED SOIL ANALYTICAL RESULTS



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, Wa 98109-5187
(206)621-6490

EXPLANATIONS OF INORGANIC DATA REPORT CODES

THE COLUMNS LABELED 'PREP', 'C', AND 'M' CONTAIN IMPORTANT INFORMATION ABOUT YOUR ANALYSES. THE CODES ARE DEFINED BELOW.

PREP CODES

THE 3-LETTER CODES IN THIS COLUMN ARE USED TO DESCRIBE THE METHOD USED TO PREPARE THE SAMPLE FOR ANALYSIS.

THE FIRST LETTER OF THE CODE STANDS FOR THE MATRIX TYPE OR THE FRACTION OF THE SAMPLE THAT IS BEING ANALYZED:

- A = AN AIR FILTER SAMPLE.
- C = A CLAY OR EARTHENWARE SAMPLE.
- D = THE DISSOLVED FRACTION OF A SAMPLE (FILTERED THROUGH A 0.45 μ MEMBRANE FILTER.)
- E = THE EP TOXICITY FRACTION OF A SAMPLE.
- F = A PROCEDURE FOR DIGESTING FISH, OR OTHER TISSUE.
- K = A COPRECIPITATION PROCEDURE
- L = THE TCLP EXTRACT OF A SAMPLE
- M = A DIGESTION FOR MISCELLANEOUS SAMPLES NOT FITTING IN NORMAL CATEGORIES
- O = A DIGESTION OF AN OIL, GREASE, OR TAR.
- P = A WIPE SAMPLE.
- R = A WATER SAMPLE PREPARED BY A 'TOTAL RECOVERABLE' DIGESTION.
- S = A DIGESTION OF A SOIL OR SEDIMENT SAMPLE.
- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- W = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- X = A NON-STANDARD WATER EXTRACTION
- 5 = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

THE MIDDLE LETTER OF THE CODE RELATES TO THE SOURCE OF THE PROCEDURE.

- A = THE CURRENT AOAC MANUAL.
- C = THE USEPA CLP PROGRAM STATEMENT OF WORK.
- E = THE USEPA 1979 WATER AND WASTEWATER MANUAL.
- H = A METHOD DEVELOPED BY ARI.
- M = A COMMON PROCEDURE FOUND IN A MANY SOURCES.
- P = THE PUGET SOUND ESTUARY PROTOCOLS.
- S = STANDARD METHODS.
- W = THE USEPA SW-846 SOLID WASTE MANUAL.

THE LAST LETTER OF THE PREPARATION CODE REFERS EITHER TO THE FINAL MATRIX OF THE PREPARED SAMPLE OR TO A SPECIALIZED USE OF THE PROCEDURE.

- A = A PROCEDURE FOR ARSENIC AND SELENIUM ANALYSIS ONLY.
- C = A HYDROCHLORIC ACID MATRIX.
- F = A HYDROFLUORIC ACID DIGESTION.
- H = A PROCEDURE FOR MERCURY ANALYSIS ONLY.
- N = A NITRIC ACID MATRIX.
- P = A PERCHLORIC ACID DIGESTION.
- Q = AN AQUA REGIA DIGESTION
- R = A SPECIAL 'SOFT' DIGESTION OF A SOLID.
- 6 = A METHOD FOR MEASURING HEXAVALENT CHROMIUM

C CODES

THESE CODES ARE USED TO QUALIFY THE REPORTED CONCENTRATIONS. A CODE OF 'L' MEANS NO ANALYTE WAS DETECTED AT THE REPORTED CONCENTRATION LEVEL.

M CODES

THESE CODES SIGNIFY THE TYPE OF INSTRUMENTAL TECHNIQUE USED WHEN ANALYZING THE SAMPLES. THE CODES ARE DEFINED BELOW:

- CVA = COLD VAPOR AAS
- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/22/89
09:32:35

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA #2 30900
ID number: GLASS-1
Description:
Sampled: / /
Matrix: GLASS

ARI job number: 3406
ARI sample number: E

Released by: MRW

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-33-2	Arsenic	0.91 mg/L		LEN	ICP
7439-97-6	Mercury	0.0001 mg/L	L	LEM	CVA
7439-97-6	Mercury	NOT ANALYZED		SHF	CVA

303 Parkplace, Suite 128
Kirkland, WA 98033
(206) 822-4000

Receiving Entity	Entity Contact	Entity Phone #

Application No.

66-11100-10000

Geosafe Site Phone
Geosafe Project Mgr.
Geosafe Shift Eng.

0-177

Geosafe Project Mgr.
Geosafe Shift Eng.

Project

2112

Clan

Washed cloth

Project Number

30710

Item Number	Sample Container	Container Size and Type	Sample Description	Transfer Number and Check
				1 2 3 4 5 6
1	Glass 1	Plastic Bag	TSV glass	✓
2	Soil AB	125ml Plastic	Pre Test Soil adjacent Block	✓
3	Soil BB	125ml Plastic	Pre Test Soil Perched Block	✓
4	Known 1	125ml Plastic	Known Trenches 5' x 1' x 1'	✓
5	Drain Liquid	125ml Plastic	Waste Drain Liquid	✓
6	Drain Liquid	4oz Glass	Waste Drain Liquid	✓

Person Responsible for Sample

Steve Likich

Affiliation

Geniale

11

68-2-8

[illegible]

Item 1: Verbal instructions to be presented,

2:3 1:5 wily

As, I,

45

8080 test case 2. 100

Transfer Number	Item Number
-----------------	-------------

—

Transfer Relinquished By:

1703

Accepted by:

ପ୍ରାଣ

But

Grand Analytical Results to:

Name Srey Likela

Address 305 Park Place Sub 121

1970-1971

Verbal

Yes No

phone to: Sleer L.V.V. phone #:

WHITE COPY - LABORATORY

PINK COPY—SHIPPING

YELLOW COPY--QA COORDINATOR

BLUE COPY--SAMPLER

SAMPLE IDENTIFICATION

Class 1 RNA Test #1

DATE COLLECTED

not specified

TYPE OF ANALYSIS

Aluminum	140
Arsenic	17.0
Calcium	320
Iron (Total)	1000
Mercury	20.04
Potassium	36
Magnesium	107
Manganese	29
Sodium	136
Phosphorus	30
Silicon	307100
Titanium	17

uq/atom

Class 2 RNA Test #2

not specified

Aluminum	140
Arsenic	17.0
Calcium	320
Iron (Total)	1000
Mercury	20.04
Potassium	36
Magnesium	107
Manganese	29
Sodium	136
Phosphorus	30
Silicon	307100
Titanium	17

REPORT GEOSAFE CORPORATION
TO 301 Park Plaza, Suite 126
Kirkland, WA 98033

Environmental Controls for Environmental
Pollution, Inc.
1925 Rosina Street
Santa Fe, NM 87507

ATTN: Steve Likala
CLIENT: GEOSAFE CORP. SAMPLES: 2
COMPANY: GEOSAFE CORPORATION
FACILITY: PROJECT: RMA #2 #30900

ALLEN
PHONE: (505) 389-7891
CONTACT: GAIL

Regulation of sample(s) for routine analysis will be disposed
of three weeks from final report date. Sample(s) for bacteria
analysis will be disposed of one day after final report.
This is not applicable if other arrangements have been made.

WORK ID: Water Quality
TAKEN:
TRANS: Federal Express
TYPE: Glass
P.O. #
INVOICE under separate cover

SAMPLE IDENTIFICATION
GEP, Inc. TEST CODES and NAMES used on this report

01 Glass 1 RMA Test #1
02 Glass 2 RMA Test #2

AL S	Aluminum
AS S	Arsenic
CA S	Calcium
FE T S	Iron (Total)
HG S	Mercury
K S	Potassium
MG S	Magnesium
MN S	Manganese
NA S	Sodium
PHOS S	Phosphorus
SI S	Silicon
Ti S	Titanium

SAMPLE IDENTIFICATION

Netal Module-VE-AB Module

DATE COLLECTED

not specified

TYPE OF ANALYSIS

- Aluminum
- Iron
- Mercury
- Phosphorus
- Silicon
- Titanium

04/02/00

0113/00
20.04
510
02800
51.0

PAGE

RECEIVED: 08/09/89

REPORT GEOSAFE CORPORATION
TO 303 Park Plaza, Suite 126
Kirkland, WA 98033

ATTEN Steve Lihala

CLIENT GEOSAFE CORP SAMPLES 2
COMPANY GEOSAFE CORPORATION
FACILITY PROJECT RMA #2 #30900

WORK ID Water Quality

TAKEN

TRANS Federal Express

TYPE glass

P.O. #

INV. # 435482

SAMPLE IDENTIFICATION

Q1 Glass 1 RMA Test #1
Q2 Glass 2 RMA Test #2

CEP, Inc

REPORT

08/30/89 16:38:15

PREPARED Controls for Environmental

BY Pollution, Inc.

1222 Romana Street

Santa Fe, NM 87502

ATTEN

PHONE (505) 902-2841

CONTACT GAIL

Remainder of sample(s) for routine analysis will be disposed
of three weeks from final report date. Sample(s) for bacteri-
analysis only will be disposed of one day after final report
This is not applicable if other arrangements have been made

* Prepared by hydrofluoric acid digestion

CEP, Inc. TEST CODES and NAMES used on this report

AL S	Aluminum
AS 1	Arsenic
AS S	Arsenic
CA S	Calcium
FE T S	Iron (total)
HQ S	Mercury
K S	Potassium
HQ S	Manganese
MN S	Manganese
NA S	Sodium
PHOS S	Phosphorus
SI S	Silicon
TI S	Titanium

SAMPLE IDENTIFICATION

Class 1 RMA Test #1

DATE COLLECTED

not specified

TYPE OF ANALYSIS

Aluminum
 Arsenic
 Arsenic
 Calcium
 Iron (total)
 Mercury
 Potassium
 Magnesium
 Manganese
 Sodium
 Phosphorus
 Silicon
 Titanium

Class 2 RMA Test #2

not specified

Aluminum
 Arsenic
 Arsenic
 Calcium
 Iron (total)
 Mercury
 Potassium
 Magnesium
 Manganese
 Sodium
 Phosphorus
 Silicon
 Titanium

UQ/ATM

140
 580 *
 19.0
 560
 3700
 <0.04
 35
 107
 27
 136
 20
 77100 *
 12
 150
 146 *
 5.2
 320
 5310
 <0.04
 44
 87
 26
 127
 20
 275200 *
 20

Geosale Corporation
303 Parkplace, Suite 128
Kirkland, WA 98033
(206) 822-4000

CHAIN-OF-CUSTODY RECORD

Receiving Entity: CEP
Entity Contact: SEE FILE
Entity Phone #: (509) 772-1641

Geosale Site Phone: 1000 811 1111
Geosale Project Mgr.: V. [unclear]
Geosale Shift Eng.: [unclear]

Project		Client		Project Number						
RMA v2		Woodward Clyde		20100						
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check						
1	Glass 1	Plastic Bag	ISV Glass Round Test 1	✓	1	2	3	4	5	6
2	Glass 2	Plastic Bag	ISV Glass Round Test 2	✓						
3	Metal Nube	Plastic Bag	ISV Iron Arsenic Nucleide	✓						
Person Responsible for Sample		Affiliation		Date						

Person Responsible for Sample		Allocation	Date
Steve Liikala		Geosale	8/8/81
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)			
Test 1: <u>Woods Hole Analytical</u> <u>Iron, S, Ti, Al, Mn, P, Mg, Pb, Cu, Na, K, F, As, Hg</u> <u>Iron, S, Ti, Al, Mn, P, Mg</u>			
Transfer Number	Item Number	Transfer Relinquished By:	
1	1	<u>Steve Liikala</u>	

Send Analytical Results to:

Name: Steve Liikala
Address: 500 Parkplace, Suite 128
City: Kirkland
State/Zip: WA 98033
Verbal Results: Yes No
Phone to: Steve Liikala Phone #: 206-822-4000

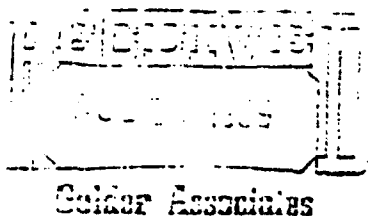
Accepted By:	Date	Time

G-1

APPENDIX G
OCCUPATIONAL EXPOSURE RESULTS



HAGER
LABORATORIES, INC.



Box 4012
Golden, Colorado 80401-4012
(303) 278-3400 (800) 282-1835
FAX # (303) 278-2121

REPORT ON SERVICE NUMBER 433851H
August 10, 1989

Customer Project Code:

To: Mr. Bill Hagar
Golder Associates Inc.
4104 149th NE
Redmond, WA 98052

Analysis: The following samples were submitted for analysis:
Three badge samples for mercury.

Method: MERCURY (Badge)
The mercury content of each badge was determined by dissolving the sorbent capsule in an acid mixture. The dissolved mercury in the diluted acid solutions was reduced to the vapor state and analyzed with flameless atomic absorption spectroscopy. A sampling rate of 20 cc/min was used in concentration calculations.

Results: The results are found on Table 1.

Discussion: The OSHA permissible exposure limit (PEL) for mercury is 0.1 mg/M³.

LT() indicates "less than" with the lower limit of quantification shown in parentheses.

Hager Laboratories, Inc., has been AIHA accredited since 1977.

The results contained in this report are expressed strictly in terms of the concentration per sample volume and are computed based upon data provided by the client. These values are not necessarily comparable to any specific permissible exposure limit (PEL), nor have they been corrected for variation in temperature, altitude or atmospheric pressure. PEL's for the reported substances are listed for your convenience.

Laboratory data are filed and available upon request.

If you have any questions, please contact Steve Andrews, of our Technical Services Department, at (303)278-3400 or toll free at (800)282-1835.

Submitted by: James M. Shuman, Jr.
Maria Mleynikov
Supervisor

MA/agg

SN 13085IH
August 10, 1989

TABLE 1

Compound: mercury

Sample Number	Total (mg)	Sample Time (minutes)	Air Concentration
W1-1 "Soil Placement"	LT(0.0001)	995.	LT(0.006) mg/cu.M.
W1-2 "Background"	LT(0.0001)	995.	LT(0.006) mg/cu.M.
W1-3 "Post Test"	LT(0.0001)	305.	LT(0.02) mg/cu.M.

● SKC Mercury Vapor Dosimeter - For analysis.

Geology test run.

UW 1-1 Sil Placement.

10:55 6/20/89 → 15:30 6/21/89

16 hrs / 35 min sample time.

UW 1-2 Background

● 10:55 6/20/89 → 15:30 6/21/89

16 hrs / 35 min sample time.

UW 1-3 Post Test

6/22/89 13:05 - 18:10

5 hrs, 5 min sample time.

● Original PO # 9310.

Bill to Golden Associates Inc
4104 148th NW

att. Bill Hager

Chemical Analysis

[illegible]

1: Please list under Other Comments, any other substance(s) not normally found in the air, that may have been present.

2: Hydrocarbon mixtures, i.e. petroleum distillates, oil mix, etc., require a client supplied 2-3 ml. bulk standard. Please ship this bulk standard separately to avoid sample contamination.

3: When using POVMs, we need only time exposed.

H-1

APPENDIX H

SEM/EDS AND X-RAY DIFFRACTION RESULTS

GEOSAFE CORPORATION
ANALYSIS OF TWO BULK SAMPLES
NVEC NO.: 89-0300-05



Westinghouse
Environmental Services

Northwest Environmental Center

1234 Columbia Dr SE
Richland Washington 99352
(509) 735 3211

August 17, 1989

Dale Timmons
Geosafe Corporation
303 Park Place
Suite 126
Kirkland, Washington 98033

Dear Mr. Timmons:

Enclosed is the final report describing the analytical results performed for Geosafe Corporation under NWECC Job Number: 89-0300-CS. The results of this project are considered confidential and will not be released outside Westinghouse Environmental Services without your written approval.

Please sign and return the enclosed report transmittal form at your earliest convenience. If you have any questions concerning these results, please contact Nancy Uziemblo or me at (509) 735-3211.

Sincerely,

Larry L. Lockrem
Laboratory Director

LLL:sra

enclosure

ANALYTICAL REPORT

Westinghouse
Northwest Environmental Center

TABLE OF CONTENTS

SECTION 1 - Analytical Report

SECTION 2 - Chain of Custody

SECTION 3 - XRD Data Sheets

SECTION 4 - SEM Photographs

**X-RAY DIFFRACTION AND
SCANNING ELECTRON MICROSCOPY ANALYSIS
NVEC NO. 89-0300-05**

Westinghouse Northwest Environmental Center was contracted by you to analyze two bulk samples. One sample was analyzed by X-Ray Diffraction (XRD) and the other sample by Scanning Electron Microscopy (SEM). The samples were received August 10, 1989. Preliminary results were discussed with you on August 16, 1989.

A final report is attached along with photographs, diffractograms and peak listings. The samples will be returned to you under separate cover.

X-RAY DIFFRACTION ANALYSIS

One of the metallic nodules was crushed and then ground in an agate mortar and pestle before scanning. The primary phases are listed in the following table. Arsenic and phosphorus are probably present in crystalline structures in trace amounts. Additional analysis is needed in order to identify these phases.

NVEC NO.	MAJOR 55-65%	MINOR 15-25%	TRACE 1-5%
89300-2B	Iron	Iron Sulfide Titanium/ Titanium Sulfide	Iron Silicide

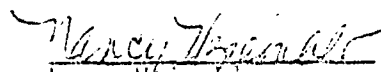
SCANNING ELECTRON MICROSCOPY ANALYSIS

The area of the epoxy plug represented in the overexposed SEM positive has been rephotographed with a JEOL JSM-T300 scanning electron microscope. The positive and negative photographs are enclosed. All photographs were taken at 350X.

The slight variation in the detail, contrast, and brightness between the original and enclosed photographs is presumably due to set microscope conditions. Run parameters of these photographs are listed below.

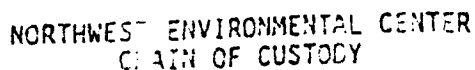
Sample #	Run conditions	
	<u>Imaging*</u>	<u>kV</u>
04	BEI	30
05	BEI	30
06	SEI	30
07	SEI	30
08	SEI	20

*Imaging: Backscattered electron imaging (BEI)
Secondary electron imaging (SEI)


Nancy Uziemblo
Senior Scientist


Larry L. Lockrem
Laboratory Director

CHAIN OF CUSTODY



JOB NUMBER: 87-0300-05

DATE/TIME RESULTS PHONED: 5/16/67

ADDRESS: 303 Park Lane Suite 126

CITY: Long Beach STATE: CA ZIP: 90803

FACILITY: _____

POINT OF CONTACT: D. [unclear] 4045 PHONE: (213) 877-4000 FAX: (213) 877-4608

SAMPLE INFORMATION

[illegible]

PACKAGING: ACCEPT: ☒ REJECT: ☐ TEM: ☐ AHERA: ☐ YAMATE LEVEL II: ☐

COMMENTS:

Please Print and Sign Your Name

RECEIVED FROM: FBI Ex

RECEIVED BY: SR Sharma Ctr SR Sharma / or

DATE: 8-10-89

RECEIVED BY: _____

DATE:

ARCHIVED BY: _____

DATE: _____

DISPOSED BY: _____

DATE: _____

See Reverse for Terms and Conditions

NORTHWEST ENVIRONMENTAL CENTER 1234 COLUMBIA DRIVE SE RICHLAND, WASHINGTON

XRD DATA SHEETS

PEAKFINDER RESULTS FOR SAMPLE :

83-0300-05

IN FILES : 89300-28

WAVELENGTH IN USE : 1.54059

AVERAGE BACKGROUND NOISE (CPM) = 503

#	2THETA	D	CPM	ESD	#	2THETA	D	I	APPR. AREA
1.	7.490	11.7933	963	0	14.	44.626	2.0289	100	6703.
2.	7.940	11.1259	791	0	12.	43.204	2.0923	37	3375.
3.	9.753	9.0523	995	0	9.	39.619	2.2730	33	3023.
4.	12.140	7.2346	1020	174	8.	38.383	2.3433	29	1949.
5.	29.846	2.9912	1728	383	15.	45.443	1.9943	15	1201.
6.	33.650	2.6612	2296	352	17.	53.105	1.7232	10	977.
7.	35.120	2.5531	1891	384	13.	43.689	2.0702	9	325.
8.	38.383	2.3433	8483	756	16.	51.839	1.7623	8	701.
9.	39.619	2.2730	9870	883	26.	82.636	1.1667	8	798.
10.	39.920	2.2565	1561	268	18.	53.420	1.7138	7	705.
11.	42.139	2.1398	1308	255	6.	33.650	2.6612	7	527.
12.	43.204	2.0923	11019	895	19.	53.538	1.7103	7	636.
13.	43.689	2.0702	2833	478	7.	35.120	2.5531	6	144.
14.	44.626	2.0289	29171	1469	21.	65.110	1.4313	6	504.
15.	45.443	1.9943	4482	583	23.	77.507	1.2306	6	425.
16.	51.839	1.7623	2517	431	5.	29.846	2.9912	5	397.
17.	53.105	1.7232	3188	537	10.	39.920	2.2565	5	358.
18.	53.420	1.7138	2304	343	25.	82.400	1.1694	5	470.
19.	53.538	1.7103	2274	367	27.	82.970	1.1628	5	455.
20.	63.380	1.4663	1162	256	24.	77.981	1.2243	4	321.
21.	65.110	1.4315	1823	357	11.	42.139	2.1398	4	200.
22.	65.514	1.4236	1297	301	22.	65.514	1.4236	4	394.
23.	77.507	1.2306	1848	411	20.	63.380	1.4663	3	266.
24.	77.981	1.2243	1400	308	4.	12.140	7.2846	3	234.
25.	82.400	1.1694	1536	277	3.	9.753	9.0523	3	228.
26.	82.636	1.1667	2605	454	1.	7.490	11.7933	3	221.
27.	82.970	1.1628	1487	292	2.	7.940	11.1259	2	181.

ALL SAMPLES RUN

ENTER COMMAND (INPUT OR CR, RUN, EDIT, BYE)

FN:8903-28.NI
DATE: 8/14/89

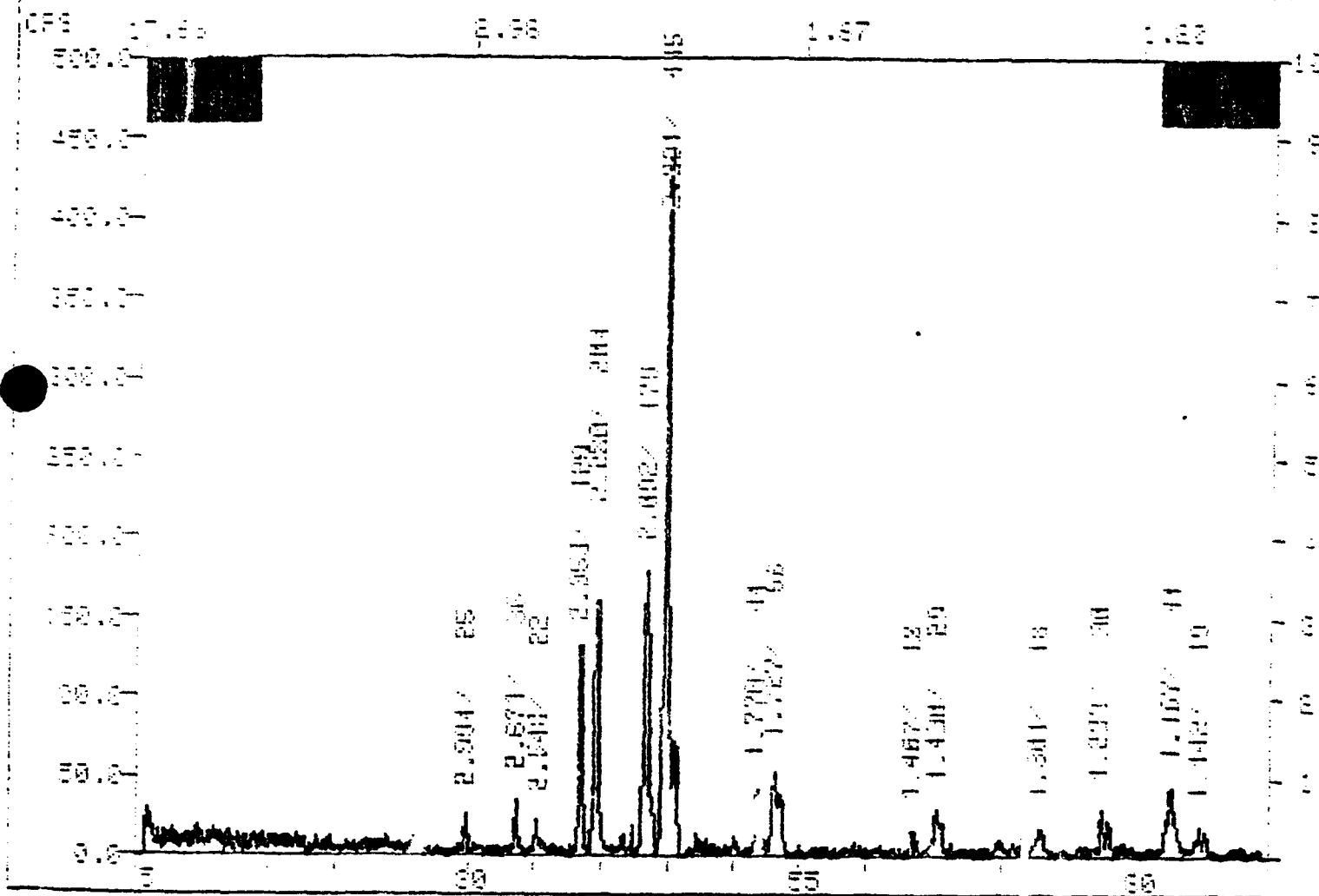
ID:89-0300-05
TIME: 8:18

PT: 0.900

STEP:0 030

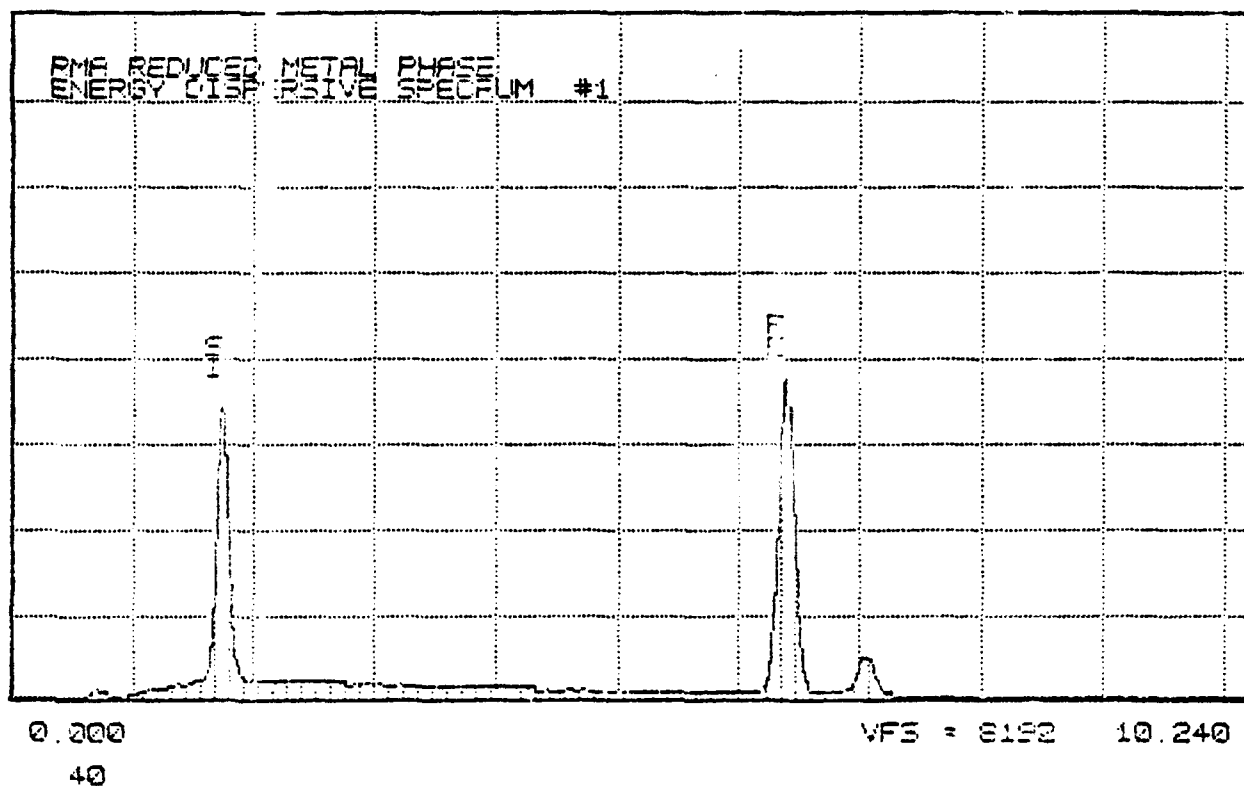
SCINTAG/USA
WL:1.54059

FULL COPY: POPY PAGE TITLE: CYCLE 0 ANGLE: END OVER: REPDS: CURSOR: LABEL:

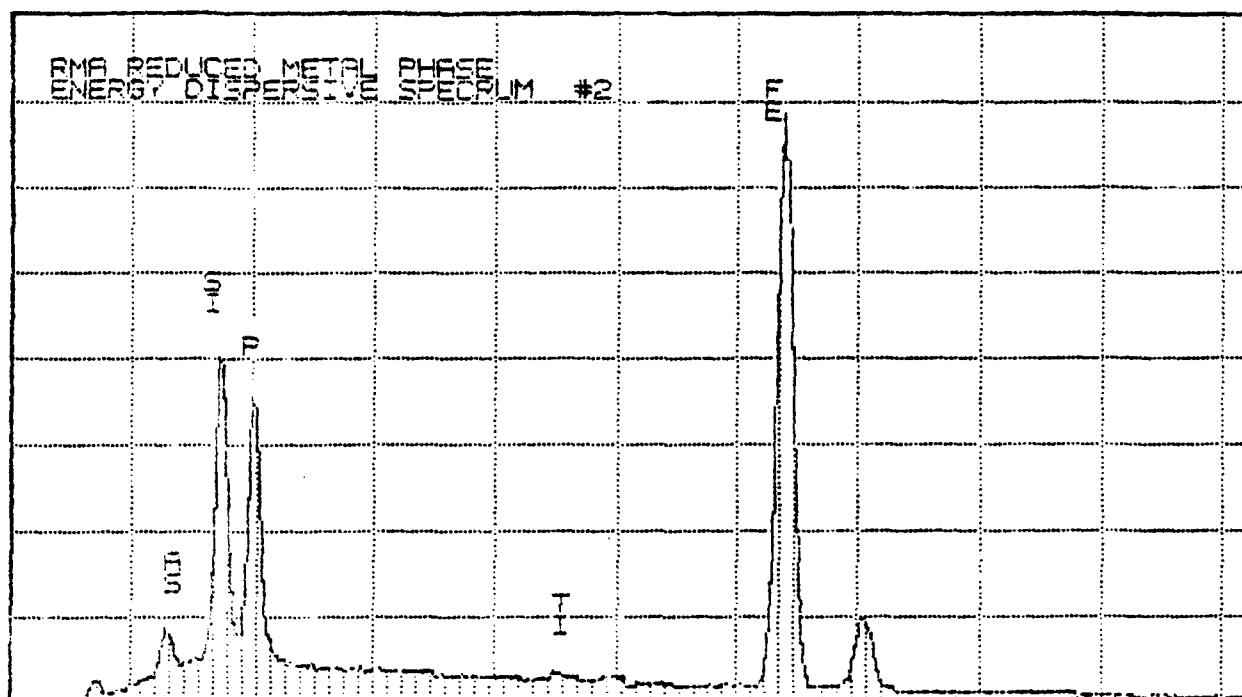


TN-5500 University of Washington / JEOL WED 19-JUL-89 10:15

Cursor: 0.000 eV = 0 ROI (0) 0.000: 0.000



TN-5500 University of Washington / JEOL WED 19-JUL-89 10:20
Cursor: 0.000keV = 0 ROI (0) 0.000: 0.000

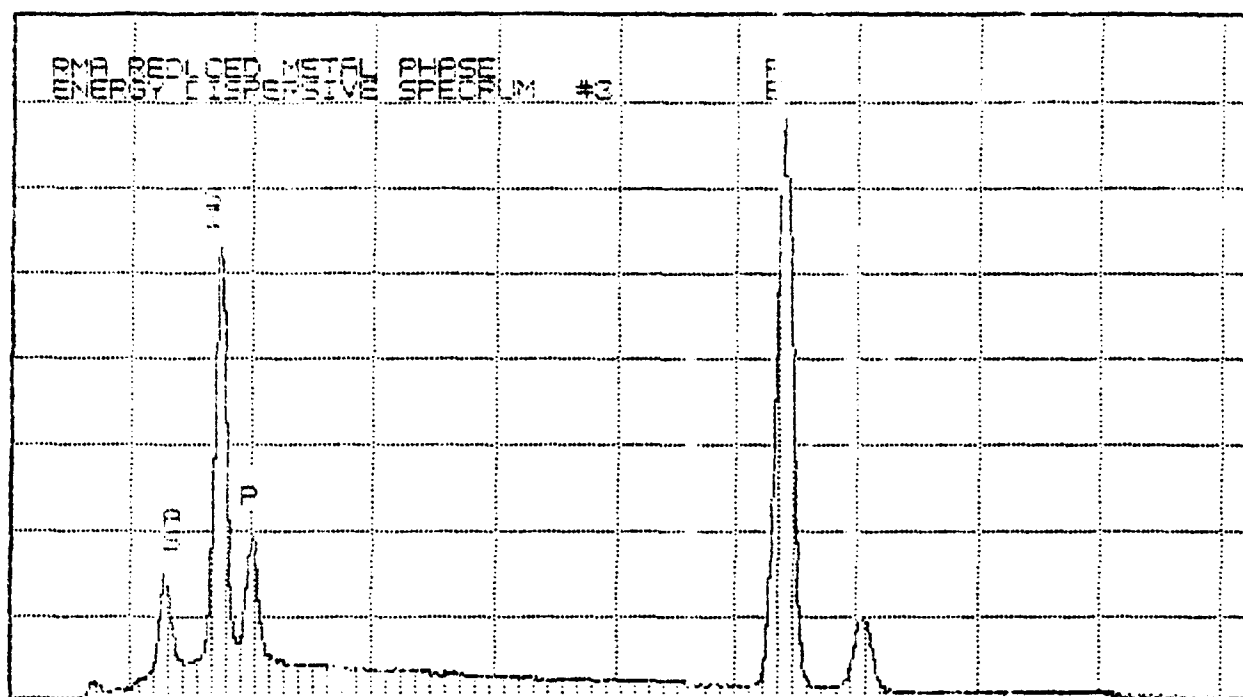


0.000

40

VFS = 4096 10.240

TN-5500 University of Washington / JEOL WED 19-JUL-89 10:34
Cursor: 0.000keV = 0 ROI (0) 0.000: 0.000



0.000

VFS = 4096 10.240

40

EDS 0 10 10

EDS 0 10 10

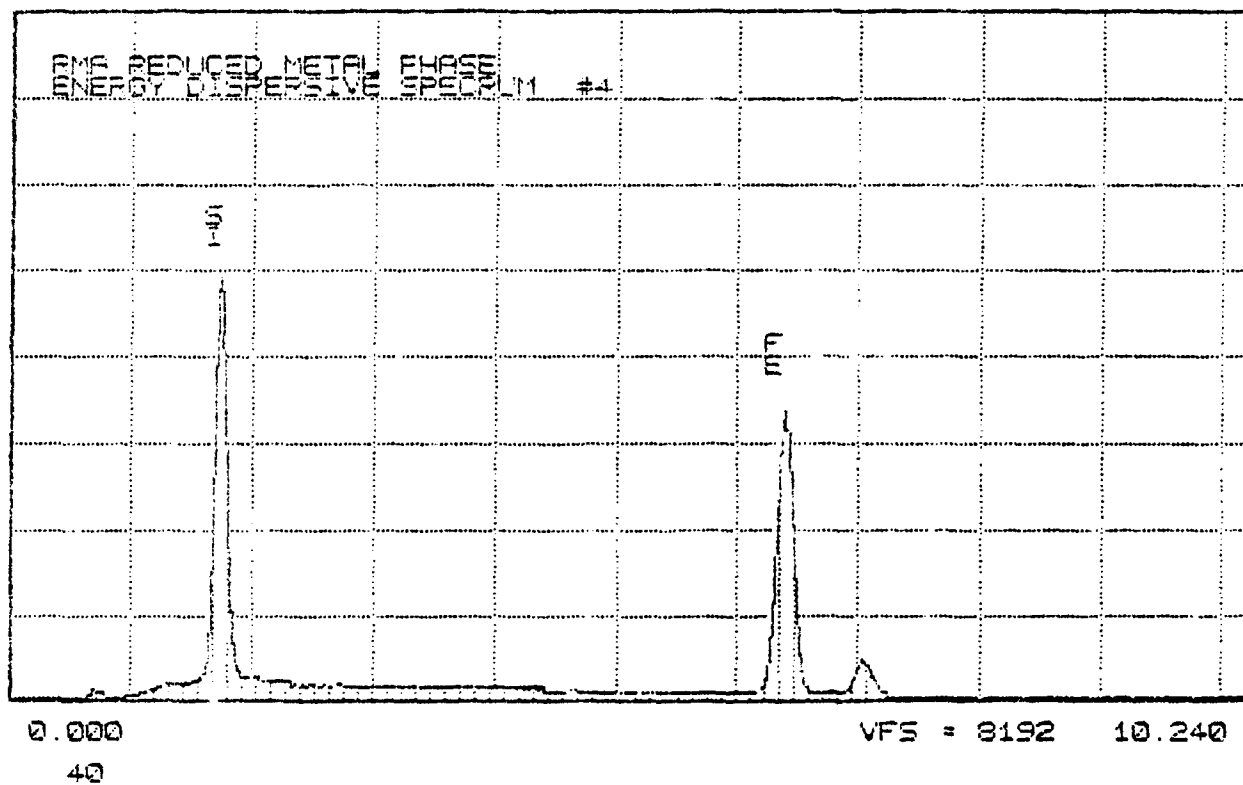
EDS 0 10 10

EDS 0 10 10

EDS 0 10 10

EDS

TN-5500 University of Washington / JEOL WED 19-JUL-89 11:01
Cursor: 0.000keV = 0 ROI (0) 0.000: 0.000



I-1

APPENDIX I

CONTAMINANT PARTICLE SIZE RESULTS



RECEIVED

AUG - 7 1989

GEOSAFE CORP.

ANALYTICAL
RESOURCES
INCORPORATED

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, WA 98109-5187
(206) 621-6490
(206) 621-7523 (FAX)

4 August 1989

Mr. Steve Liikala
Geosafe Corporation
303 Parkplace, Suite #126
Kirkland, WA 98033

RE: Geosafe Project: RMA; ARI Job #3240

Dear Steve:

Please find the enclosed Metals results for the above referenced project.

The pesticides analyses was cancelled per your request.

If you have any questions or need any further information, please feel free to call any time.

Sincerely,

ANALYTICAL RESOURCES, INC.

David R. Mitchell
Project Manager

DRM/bv

Enclosures

cc: file#3240



**ANALYTICAL
RESOURCES
INCORPORATED**

Analytical
Chemists &
Consultants

333 Ninth Ave. North
Seattle, Wa 98109-5187
(206)621-2490

EXPLANATIONS OF INORGANIC DATA REPORT CODES

THE COLUMNS LABELED 'PREP', 'C', AND 'M' CONTAIN IMPORTANT INFORMATION ABOUT YOUR ANALYSES. THE CODES ARE DEFINED BELOW.

PREP CODES

THE 3-LETTER CODES IN THIS COLUMN ARE USED TO DESCRIBE THE METHOD USED TO PREPARE THE SAMPLE FOR ANALYSIS.

THE FIRST LETTER OF THE CODE STANDS FOR THE MATRIX TYPE OR THE FRACTION OF THE SAMPLE THAT IS BEING ANALYZED:

- A = AN AIR FILTER SAMPLE.
- C = A CLAY OR EARTHENWARE SAMPLE.
- D = THE DISSOLVED FRACTION OF A SAMPLE (FILTERED THROUGH A 0.45 μ MEMBRANE FILTER.)
- E = THE EP TOXICITY FRACTION OF A SAMPLE.
- F = A PROCEDURE FOR DIGESTING FISH, OR OTHER TISSUE.
- K = A COPRECIPITATION PROCEDURE
- L = THE TCLP EXTRACT OF A SAMPLE
- M = A DIGESTION FOR MISCELLANEOUS SAMPLES NOT FITTING IN NORMAL CATEGORIES
- O = A DIGESTION OF AN OIL, GREASE, OR TAR.
- P = A PIPE SAMPLE.
- R = A WATER SAMPLE PREPARED BY A 'TOTAL RECOVERABLE' DIGESTION.
- S = A DIGESTION OF A SOIL OR SEDIMENT SAMPLE.
- T = A WATER SAMPLE PREPARED BY A 'TOTAL' DIGESTION.
- W = A SAMPLE ANALYZED WITHOUT ANY PREPARATION.
- X = A NON-STANDARD WATER EXTRACTION
- 5 = A SAMPLE FILTERED THROUGH A 5.0 μ FILTER

MIDDLE LETTER OF THE CODE RELATES TO THE SOURCE OF THE PROCEDURE.

- A = THE CURRENT AOAC MANUAL.
- C = THE USEPA CLP PROGRAM STATEMENT OF WORK.
- E = THE USEPA 1979 WATER AND WASTEWATER MANUAL.
- H = A METHOD DEVELOPED BY ARI.
- M = A COMMON PROCEDURE FOUND IN A MANY SOURCES.
- P = THE PUGET SOUND ESTUARY PROTOCOLS.
- S = STANDARD METHODS.
- W = THE USEPA SW-846 SOLID WASTE MANUAL.

THE LAST LETTER OF THE PREPARATION CODE REFERS EITHER TO THE FINAL MATRIX OF THE PREPARED SAMPLE OR TO A SPECIALIZED USE OF THE PROCEDURE.

- A = A PROCEDURE FOR ARSENIC AND SELENIUM ANALYSIS ONLY.
- C = A HYDROCHLORIC ACID MATRIX.
- F = A HYDROFLUORIC ACID DIGESTION.
- M = A PROCEDURE FOR MERCURY ANALYSIS ONLY.
- N = A NITRIC ACID MATRIX.
- P = A PERCHLORIC ACID DIGESTION.
- R = AN AQUA REGIA DIGESTION
- S = A SPECIAL 'SOFT' DIGESTION OF A SOLID.
- 6 = A METHOD FOR MEASURING HEXAVALENT CHROMIUM

C CODES

THESE CODES ARE USED TO QUALIFY THE REPORTED CONCENTRATIONS. A CODE OF 'L' MEANS NO ANALYTE WAS DETECTED AT THE REPORTED CONCENTRATION LEVEL.

M CODES

THESE CODES SIGNIFY THE TYPE OF INSTRUMENTAL TECHNIQUE USED WHEN ANALYZING THE SAMPLES. THE CODES ARE DEFINED BELOW:

- CVA = COLD VAPOR AAS
- FLA = FLAME AAS
- GFA = GRAPHITE FURNACE AAS
- ICP = ICP-AES

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:10

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SAB-05
Description:
Sampled: / /
Matrix: SCIL

ARI job number: 3240
ARI sample number: E

Released by: MPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	65 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:17

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SBB-05
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: F

Released by: MPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
74-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	96 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:24

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: SAB-06
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: G

Released by: MPW

A N A L Y T I C A L R E S U L T S

CPS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	394 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:39

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: 13056 L
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: I

Released by: mw

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	26 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:46

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: WIPE 05
Description:
Sampled: / /
Matrix: WIPE

ARI job number: 3240
ARI sample number: J

Released by: MAW

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	0.11 mg/wipe		PHN	ICP
7439-97-6	Mercury	4.2 mg/wipe		FHM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:46:54

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: WIPE 06
Description:
Sampled: / /
Matrix: WIPE

ARI job number: 3240
ARI sample number: K

Released by: MPW

A N A L Y T I C A L F E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	0.001 mg/wipe	L	PHN	GFA
7439-97-6	Mercury	0.0002 mg/wipe	L	PHM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:47:01

Client: GECSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: 13057 FINE
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: L

Released by: MPW

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	22 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:47:08

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: 13056 FINE
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: M

Released by: MPW

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	30 mg/kg-dry		SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:47:16

Client: GEOSAFE
Contact: STEVE LINKALA
Project: RMA
ID number: METHOD BLANK
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: MB1

Released by: MPW

ANALYTICAL RESULTS

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsen c	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	0.05 mg/kg-dry	L	SCM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:52:33

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: PMA
ID number: METHOD BLANK
Description:
Sampled: / /
Matrix: SOIL

ARI job number: 3240
ARI sample number: MB2

Released by: MBJ

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	0.0002 mg/wipe	I	PHN	GFA
7439-97-6	Mercury	0.00002 mg/wipe	L	PHM	CVA

ANALYTICAL RESOURCES, INC.
Inorganic Laboratory Data Report
08/03/89
07:47:31

Client: GEOSAFE
Contact: STEVE LIIKALA
Project: RMA
ID number: NBS 2704
Description: BUFFALO RIVER SED
Sampled: / /
Matrix: SEDIMENT

ARI job number: 3240
ARI sample number: REF

Released by: M. W.

A N A L Y T I C A L R E S U L T S

CAS Number	Analyte	Concentration	C	Prep	M
7440-38-2	Arsenic	NOT ANALYZED		SWN	GFA
7439-97-6	Mercury	1.32 mg/kg-dry		SCM	CVA

Results of Quality Control Duplicate Analysis

Client: GIOSAFE

Sample Identification: 3240 B

Units: mg/kg-dry

ANALYTE	ORIGINAL SAMPLE	C	DUPLICATE ANALYSIS	C	RELATIVE PERCENT DIFFERENCE
Mercury	32		32		0.0

Results of NBS 2704 Buffalo River Sediment Analysis

Client: GEOSAFE

ARI Sample number: 3240 REF

Units: mg/kg-dry

ANALYTE	FOUND	CERTIFIED	ALUE	RECOVERY
Mercury	1.32	1.44	= 0.07	91.7

RECOVERY = Percent Recovery

CHAIN-OF-CUSTODY RECORD

No. 1023

Geosafe Corporation
303 Parkplace, Suite 128
Kirkland, WA 98033
(208) 822-4000

Receiving Entity Analytical Resources
Entity Contact DAVE MILLER
Entity Phone # 621-6444

Geosafe Site Phone 822-4000
Geosafe Project Mgr. VINCE FILLERICK
Geosafe Billi Eng. STEVE LUKKILA

Project		Client		Project Number	
RMA		Woodward Clyde		309100	
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check	
1	BA-B1	glass, 1 pint	Pre Test B soils (TOTAL COMBUSTIBLES TO BE ANALYZED)	1	✓
2	SAB -05 Large	glass, 1 pint	Re-test Soil Adjacent Block Large Particles	2	✓
3	SBB -05	glass, 1 pint	Re-test Soil Beneath Block ^{gravel}	3	✓
4	SAB -06 Fine	glass, 1 pint	Re-test Soil Adjacent Block Fine Particles	4	✓

Person Responsible for Sample
STEVE LUKKILA
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)
Composite per Request for Analysis

Allocation
Geosafe
6/30/89

Send Analytical Results to:

Name STEVE LUKKILA
Address 303 Parkplace, Suite 128
City Kirkland
State/Zip WA 98033
Verbal Results Yes No
Phone for STEVE LUKKILA Phone # 822-4000

Analyze All three Items for 7471 fly
7000 As
8085 Particles
(No PCBs)

Transfer Number	Item Number	Transfer Relinquished By	Accepted by	Date	Time
1	1	DAVE MILLER	STEVE LUKKILA	6/30/89	13:00

WHITE COPY-LABORATORY

PINK COPY-SHIPPING

YELLOW COPY-OA COORDINATOR

BLUE COPY-SAMPLER

CHAIN-OF-CUSTODY RECORD

Geosale Corporation
303 Parkplace, Suite 128
Kirkland, WA 98033
(208) 822-4000

Receiving Entity Analytical Resources
Entity Contact Steve Linkham
Entity Phone # 621-6440

Geosale Site Phone 822-4000
Geosale Project Mgr. Steve Linkham
Geosale Shift Eng. Steve Linkham

No. 1022

Project		Client		Project Number					
RMA		Woodward Clyde		309/00					
Item Number	Sample Number	Container Size and Type	Sample Description	Transfer Number and Check					
1	13057 Recess	1 pint glass	Recess Virgin 13057	1	2	3	4	5	6
2	13058 Recess	1 pint glass	Recess Virgin 13058	✓					
3	13059 Wipe	5" x 5" square wipe	Wipe adjacent to off-gas	✓					
4	13060 Wipe	1 pint glass	Trace Blank	✓					
5	13061 Fine	" "	Virgin 13057 drum soil (Fine)	✓					
6	13062 Fine	" "	Virgin 13056 drum soil (Fine)	✓					

Person Responsible for Sample		Affiliation		Date	
Steve Linkham		Geosale		6-30-81	
Analytical and Preservation Instructions (Use Back of First Sheet if Necessary)					
Thurs 1 and 2: Method		7471 11g		7060 AS	
Thurs 3 and 4: Method		7471 11g		7060 AS	

Send Analytical Results to:

Name STEVE LINKHAM
Address 303 PARKPLACE, SUITE 128
City KIRKLAND
State/Zip WA 98033
Verbal Results Yes No
Phone to: STEVE LINKHAM Phone #: 822-4000

Transfer		Item		Transfer Relinquished By:	
1	13057	1	13057	Steve Linkham	6/30/81
2	13058	2	13058	Steve Linkham	6/30/81
3	13059	3	13059	Steve Linkham	6/30/81
4	13060	4	13060	Steve Linkham	6/30/81
5	13061	5	13061	Steve Linkham	6/30/81
6	13062	6	13062	Steve Linkham	6/30/81

WHITE COPY-LABORATORY

PINK COPY-SHIPPING

YELLOW COPY-QA COORDINATOR

BLUE COPY-SAMPLER