METHOD 3571

EXTRACTION OF SOLID AND AQUEOUS SAMPLES FOR CHEMICAL AGENTS

SW-846 is not intended to be an analytical training manual. Therefore, method procedures are written based on the assumption that they will be performed by analysts who are formally trained in at least the basic principles of chemical analysis and in the use of the subject technology.

In addition, SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.0 SCOPE AND APPLICATION

1.1 This method describes the extraction of chemical agents from aqueous and solid samples using a microextraction technique. The method has been applied to concrete, charcoal, wood, water, brine, ash, coral, sand, and soil. The following compounds have been determined by this method:

Compound Name	CAS No.[a]
GB (O-Isopropyl methylphosphonofluoridate)	107-44-8
VX (O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate)	50782-69-9
HD [Bis(2-chloroethyl)sulfide]	505-60-2

[a]Chemical Abstract Service Registry Number

Additionally, this method may be applicable to other chemically similar compounds and chemical agent degradation products.

1.2 Other solvent systems may be employed in place of those described here. For any solvent system used, including those mentioned in the method, one needs to demonstrate adequate performance for the analytes of interest.

1.3 There is a risk to the analyst of exposure to chemical agents. The analyst should pay special attention to the safety information in Section 5.0.

1.4 Prior to employing this method, analysts are advised to consult the base method for each type of procedure that may be employed in the overall analysis (e.g., Methods 3500, 3600, 5000, and 8000) for additional information on quality control procedures, development of QC acceptance criteria, calculations, and general guidance. Analysts also

should consult the disclaimer statement at the front of the manual and the information in Chapter Two for guidance on the intended flexibility in the choice of methods, apparatus, materials, reagents, and supplies, and on the responsibilities of the analyst for demonstrating that the techniques employed are appropriate for the analytes of interest, in the matrix of interest, and at the levels of concern.

In addition, analysts and data users are advised that, except where explicitly specified in a regulation, the use of SW-846 methods is *not* mandatory in response to Federal testing requirements. The information contained in this method is provided by EPA as guidance to be used by the analyst and the regulated community in making judgments necessary to generate results that meet the data quality objectives for the intended application.

1.5 Use of this method is restricted to use by, or under supervision of, personnel appropriately experienced and trained in the handling of chemical agents. Each analyst must demonstrate the ability to generate acceptable results with this method. This method is intended to be a supplement to – but it is NOT intended to be a substitute for – formal training of an analyst in the basic extraction techniques and theory.

> WARNING: The toxicity of these chemical warfare agents presents the worker with hazards unfamiliar to most experienced laboratory personnel. Special techniques and precautions must be used even for the simplest procedures involving these agents. (See Ref. 1 for additional guidance).

2.0 SUMMARY OF THE METHOD

2.1 This method provides the procedures for sample collection and extraction of the referenced compounds from solids and aqueous samples. A separate extract will be required for each agent to be analyzed.

2.2 Materials are subsampled and preservative added, as necessary. Glacial acetic acid is added as a preservative to samples being assayed for GB and glacial acetic acid/NaCl is a preservative for samples assayed for HD. No preservative is added for VX.

2.3 Samples are extracted with 10% IPA in dichloromethane by vortex mixing and filtered, if necessary.

2.4 An optional water wash is included for VX that back-extracts the compound from heavy organics that would interfere with the assay. An optional column cleanup procedure utilizes a Carboprep90 column and a silica column to separate GB from heavy organics, if needed. Suitable solvents are used to elute the extract first through the Carboprep90 column, then the silica column.

3.0 DEFINITIONS

Refer to Chapter One and the manufacturer's instructions for definitions that may be relevant to this procedure.

4.0 INTERFERENCES

4.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in all-glass systems may be necessary. Refer to each method to be used for specific guidance on quality control procedures and to Chapter Four for general guidance on the cleaning of glassware.

4.2 Other phosphorous- and sulfur-containing compounds can interfere with the method performance and affect the result.

4.3 Interferences that can cause the chemical agents to decompose include moisture, light, elevated temperatures, and an improper extraction solvent pH range. The stability of the chemical agents noted in this method is contingent on maintaining the pH ranges designated in Sec. 8.5.

4.4 Samples with high organic loading can mask or elute with the agent analyte.

5.0 SAFETY

WARNING: The toxicity of these chemical warfare agents presents the worker with hazards unfamiliar to most experienced laboratory personnel. Special techniques and precautions must be used even for the simplest procedures involving these agents.

5.1 There are specific requirements for operations with chemical agents. The laboratory should have these included in a Chemical Hygiene Plan prior to conducting operations with agents.

5.2 Personal Protective Equipment (PPE) requirements include safety glasses, lab coat, and protective gloves. The availability of emergency response equipment and support personnel should be as indicated in a laboratory chemical hygiene plan.

5.3 Exposure to chemical agent material is possible from contact. Respiratory exposure can result from spills or improper use of ventilation control.

5.4 Risk is primarily associated with compromise of protective gloves. Compromise is most likely to occur as agent vials are opened.

6.0 EQUIPMENT AND SUPPLIES

6.1 The mention of trade names or commercial products in this manual is for illustrative purposes only and does not constitute a CMA endorsement or exclusive recommendation for use. The products and instrument settings cited in these methods represent those products and settings used during method development or subsequently evaluated by the Agency. Glassware, reagents, supplies, equipment, and settings other than those listed in this manual may be employed provided that method performance appropriate for the intended application has been demonstrated and documented.

6.2 Personal Protective Equipment.

6.3 Vials, 1-, 3-, and 6-dram for sample collection

6.4 Vials, 1-dram for extracts

6.5 Analytical balance, capable of measuring to the nearest mg

6.6 Pasteur pipettes, 5 ¾," Fisherbrand, or equivalent

6.7 Syringes, 10-µl and 50-µl

6.8 Volumetric glassware, 1-, 2-, 5-, and 10-mL

6.9 BD syringe filter (10-mL Luer-Lok)

6.10 Whatman nylon syringe filter, 0.45-µm pore size, or equivalent

6.11 Vortex Mixer, Benchtop, or as noted in Sec. 6.12

6.12 Centrifuge, Benchtop

6.13 Carboprep90 column, or equivalent

6.14 Silica cartridges, Restek PN 24038, or equivalent

6.15 pH test strips

7.0 REAGENTS AND STANDARDS

7.1 Reagent grade chemicals must be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit the use without lessening the accuracy of the determination.

7.2 Dichloromethane (DCM), CH_2Cl_2, optima grade

7.3 2-propanol (IPA), $(CH_3)_2CHOH$, optima grade

7.4 Hexane, C_6H_{14}, optima grade

7.5 1 N Sodium hydroxide, NaOH

7.6 Sodium chloride, NaCl

7.7 Glacial acetic acid, CH_3COOH

7.8 pH4 Buffer (Cole Palmer Oakton® buffer solutions, EW-00654-00), or equivalent

7.9 pH10 Buffer (Cole Palmer Oakton® buffer solutions, EW-00654-08), or equivalent

7.10 Anhydrous sodium sulfate, Na_2SO_4

7.11 Saturated Glacial Acetic Acid/NaCl solution. Dissolve 7 g of NaCl in 35 mL of glacial acetic acid in a 40-mL vial

7.12 Isopropyl methylphosphonofluoridate; Sarin (GB)

7.13 O-ethyl S-(2-diisopropylaminoethyl)methylphosphonothioate (VX)

7.14 Bis(2-chloroethyl)sulfide (HD)

7.15 Diisopropyl fluorophosphonate (DFP), C_6-H_{14}-F-O_3-P

7.16 2-Chloroethyl ethyl sulfide (CEES), C_4-H_9-Cl-S

7.17 Diethyl ethylthiophosphonate (DEETP)

8.0 SAMPLE COLLECTION, PRESERVATION AND STORAGE

8.1 This method is a microextraction technique that requires small volumes of material. Because of this, sample collection plans should consider sufficient replicates. Only gram quantities of material are needed to achieve sensitivity in the low ppb.

8.2 Preservation is utilized for samples that are shipped off-site or otherwise not immediately extracted. A flowchart of preservation requirements is shown in Figure 1.

8.3 Solids Preservation

8.3.1 GB. Add 1 mL of glacial acetic acid for each 1 g of solid sample.

8.3.2 HD. Add 1 mL of glacial acetic acid/NaCl for each 1 g of solid sample.

8.4 Aqueous Preservation

8.4.1 GB. Add 1 mL of glacial acetic acid for each 1 mL of aqueous sample.

8.4.2 HD. Add 1 mL of glacial acetic acid/NaCl for each 1 mL of aqueous sample.

8.4.3 VX. Adjust pH between 7 and 8 using glacial acetic acid or sodium hydroxide.

8.5 Holding Times

8.5.1 It is essential to consider the short holding times associated with these analytes. Preserved samples for GB and HD assay and samples for VX assay

should be extracted within 3 days of collection. Data should be qualified if extracted between 3 and 7 days after collection. Extracts must be analyzed within 14 days of extraction.

8.5.2 When establishing hold time, a daily decrease in analyte recovery was observed. Minimum performance criteria of 50% recovery were used to establish a maximum holding time of 3 days.

8.5.3 GB undergoes rapid hydrolysis to form hydrogen fluoride, isopropyl methyl phosphonic acid and other compounds. Conditions of pH within a range of 3.5 to 5 will slow this decomposition rate. Stability in organic extracts exceeds 28 days.

8.5.4 HD undergoes hydrolysis to form thiodiglycol and other compounds. Conditions of pH within a range of 3.5 to 5 will slow decomposition rate. Chloride ion or EDTA can be added to reduce the effects of metal cations. Stability in organic extracts exceeds 28 days.

8.5.5 VX undergoes very rapid hydrolysis but this rate slows dramatically after a few hours. Optimal pH for VX stability was determined to be within a range of 7 to 8. Stability in organic extracts exceeds 28 days. Partitioning is present with non-polar solvents (hexane).

8.6 Preparation of Sample Vials

8.6.1 For each GB sample, add 5 mL of Glacial acetic acid to a Teflon-lined screw cap vial marked for GB analysis. For every group of twenty or fewer samples, extra vials must be prepared for the blank, laboratory control standard (LCS), matrix spike (MS), matrix spike duplicate (MSD) and a duplicate.

8.6.2 For each HD sample, add 5 mL of Glacial acetic acid and 1 gram of sodium chloride to a Teflon-lined screw cap vial marked for HD analysis. For every group twenty or fewer samples, extra vials must be prepared for the blank, laboratory control standard (LCS), matrix spike (MS), matrix spike duplicate (MSD) and a duplicate.

8.6.3 For both sets of vials (GB and HD), mark the meniscus and the approximate raise in the meniscus (fill line) with the addition of 5 grams of solid material. Note that this is an approximation for field use.

8.6.4 For VX samples, place the sample in the vial and preserve as described in Secs. 8.3 and 8.4. For every group twenty or fewer samples, extra vials must be prepared for the blank, laboratory control standard (LCS), matrix spike (MS), matrix spike duplicate (MSD) and a duplicate.

8.6.5 Identify each vial with a unique number.

8.6.6 Measure and record the weight of the vial and its contents in a controlled laboratory notebook.

8.6.7 The vials are sent to the field sampling crew.

8.7 Sample Collection

8.7.1 The sampling crew collects enough material to bring the liquid/solid material to the fill line indicated on the vial.

8.7.2 The vial identification number is recorded on the chain of custody and the sample label.

8.7.3 The sample label is affixed to a Ziploc bag.

8.7.4 The sample vial is placed in the bag and the bag is sealed. Precautions are taken to ensure that the only change in the weight of the sample is due to the solid sample addition.

8.7.5 Two additional replicates from a single location should be designated as MS and MSD for each group of twenty or fewer samples. One additional replicate from a single location should be designated as a duplicate for each group of twenty or fewer samples. Two empty vials designated as Blank and LCS should be returned for each group of twenty or fewer samples.

9.0 QUALITY CONTROL

9.1 Refer to Chapter One for guidance on quality assurance (QA) and quality control (QC) protocols. When inconsistencies exist between QC guidelines, method-specific QC criteria take precedence over both technique-specific criteria and those criteria given in Chapter One and technique-specific QC criteria take precedence over the criteria in Chapter One. Any effort involving the collection of analytical data should include development of a structured and systematic planning document, such as a Laboratory/Monitoring Quality Assurance Plan (LMQAP) or a Sampling and Analysis Plan (SAP), which translates project objectives and specifications into directions for those that will implement the project and assess the results.

9.2 Before processing any samples, the analyst should demonstrate that all parts of the equipment in contact with the sample and reagents are interference-free. This is accomplished through the analysis of a method blank. Each time samples are extracted, cleaned up, and analyzed, and when there is a change in reagents, a method blank should be prepared and analyzed for the compounds of interest as a safeguard against chronic laboratory contamination.

9.3 Any method blanks, matrix spike samples, or replicate samples should be subjected to the same analytical procedures (Sec. 11.0) as those used on actual samples.

9.4 Also see Method 3500 for QC procedures related to extraction and sample preparation procedures.

9.5 As noted earlier, use of any extraction technique, including solvent extraction, should be supported by data that demonstrate the performance of the specific solvent system and operating conditions for the analytes of interest, at the levels of interest, in the sample matrix.

9.6 All field and QC samples should be spiked with an appropriate mix of surrogate compounds, if available, in order to track extraction efficiency.

9.7 Any reagent blanks, matrix spike, and replicate samples should be subjected to exactly the same analytical procedures as those used on field samples.

10.0 CALIBRATION AND STANDARDIZATION

No calibration is required for this method.

11.0 PROCEDURE

11.1 Extraction of solid preserved samples for GB and HD

With the addition of acid preservative to solid samples, partitioning of these analytes into the aqueous phase will occur and may not be accounted for if the sample is further subdivided. The use of preservatives will require that the entire sample be extracted or that the exact amount of acid added is known for a given sample amount.

For most applications, 20- or 40-mL VOA vials will ease difficulties with field preparation. The entire extraction is carried out within this vial. The preservative, acetic acid, extends the sample hold times for those analytes from minutes to days allowing time for samples to be shipped off-site for extraction and analysis.

11.1.1 Sample Extraction.

It is essential to perform all steps in a timely manner.

11.1.1.1 Weigh out each sample vial and record the weight in a controlled notebook. Calculate the weight of the sample by subtracting the vial tare weight with the preservative.

11.1.1.2 Add approximately 5 grams of agent-free solid material to the appropriate blank and LCS vials.

11.1.1.3 Spike the LCS, MS, or matrix spike duplicate MSD with agent. Record spike amounts into controlled notebook. The recommended GB spike is 100 ng. The recommended HD spike for FPD is 600 ng and for GC/MS is 100 ng.

11.1.1.4 Spike all samples, including the blank, LCS, MS, or MSD with the appropriate surrogate. Record spike amounts into controlled notebook. The recommended DFP surrogate spike for GB is 100 ng. The recommended CEES surrogate spike for FPD is 600 ng and for GC/MS is 100 ng.

11.1.1.5 Add 10.0 mL of 10% IPA in dichloromethane to each sample. Put the lid on the vial. Mix on a vortex mixer for 30 seconds. Centrifuge the sample for 1 minute at 2000 rpm, if necessary. If filtration is necessary, filter the solvent extract into another vial.

11.1.2 Acetic Acid Removal

11.1.2.1 This procedure is used to remove residual acetic acid in the organic extract. When acetic acid is mixed with dichloromethane, a single phase is produced. Addition of water will dissociate the acid from the organic layer and partition in the aqueous layer. This top layer is then removed and discarded. This step is essential for maintaining the analytical column stationary phase.

11.1.2.2 Add laboratory pure water in 1:1 ratio with the extract volume. For example, use 5 mL of laboratory pure water to remove acetic acid from 5 mL of extract. Vortex the samples for 1-2 min. Let settle for 2 min. Remove lower layer (organic layer). (Be careful not to bring water over.) Place organic layer in new vial. Add Na_2SO_4 and shake well. Remove solvent fraction and store in a refrigerator until analysis.

11.2 Extraction of aqueous samples for GB, VX, and HD

The use of preservatives will require that the entire sample be extracted or that the exact preservative volume added is known for a given sample amount.

11.2.1 Mix the sample before pipetting to ensure a representative sample. If multiple phases are present, the analyst should assay each fraction separately.

11.2.2 Check pH of sample with pH paper. Adjust pH using 1N NaOH to within the range of 3 – 6 for GB/HD and within the range of 8 – 10 for VX. It is critical for compound stability and for the most efficient extractions that the recommended pH ranges be maintained at all times.

11.2.3 Pipette 1 mL of the sample into a 3-dram vial with Teflon-lined screw cap. Record sample volume in controlled notebook.

11.2.4 Spike the matrix spike, matrix spike duplicate or laboratory control spike (LCS) with agent. Record spike amounts into controlled notebook. The recommended GB spike is 20 ng. The recommended VX spike is 20 ng. The recommended HD spike for FPD is 120 ng and for GC/MS is 20 ng.

11.2.5 Spike all samples with appropriate surrogates

Recommended 20 ng of DFP for GB samples.

Recommended 20 ng of DEETP for VX samples.

Recommended 120 ng of CEES for HD FPD and 20 ng for GC/MS.

11.2.6 Add 2.0 mL of 10% IPA in dichloromethane to all samples (2 mL solvent is for 1 gm samples; if more sample is used, maintain the 2:1 ratio, e. g., for 3 gm of sample use 6 mL solvent) Check pH with pH paper and if necessary for VX samples, add 100 µL of 1N sodium hydroxide solution to ensure that the extract is basic, taking care not to overshoot desired pH. More sodium hydroxide may be used if needed. The range for VX should be between 8-10.

11.2.7 Mix on a vortex mixer for 30 seconds. Centrifuge the sample for 1 minute at 2000 rpm, if necessary. If filtration is necessary, filter the solvent extract into another vial. Store the extract in a refrigerator until analysis.

11.3 Extraction of unpreserved solid samples for GB, VX, and HD

11.3.1 Weigh out 1 gm of solid into a vial with Teflon-lined screw cap. Record the weight into a controlled notebook. In some cases, it may be prudent to extract more than 1 gram of sample to increase the amount of recovered extract. In such cases, the agent spikes, surrogate spikes and extraction volume should be scaled by the same ratio as the solid weight change.

11.3.2 Spike the MS, MSD, or LCS with agent. Record spike amounts into controlled notebook. Recommended spike for GB and VX is 20 ng. Recommended HD spike for FPD is 120 ng and for GC/MS is 20 ng.

11.3.3 Spike all samples with appropriate surrogates

Recommended 20 ng of DFP for GB samples.

Recommended 20 ng of DEETP for VX samples.

Recommended 120 ng of CEES for HD FPD and 20 ng for GC/MS.

11.3.4 Add 2.0 mL of 10% IPA in dichloromethane for every 1 gm of sample. Volume must be sufficient to ensure that free liquid is present.

11.3.5 For VX samples, add 50 µL of 1N sodium hydroxide solution for every 1.0 mL of solvent to ensure that the extract is basic. More sodium hydroxide may be required to adjust the pH of certain solid matrices to a range between 8 and 10.

11.3.6 Put the lid on the vial. Mix on a vortex mixer for 30 seconds. Centrifuge the sample for 1 minute at 2000 rpm, if necessary. If filtration is necessary, filter the solvent extract into another vial. Store the extract in a refrigerator until analysis.

11.4 Extract Cleanup Techniques.

11.4.1 VX Extract Cleanup via Aqueous Back Extraction (optional).

11.4.1.1 This procedure is used on extracts of VX samples that contain high organic loadings. For this cleanup, 3 mL of sample extract is needed. For Charcoal, increase the sample weight from 1 g to 5 g and the extraction solvent from 2 mL to 10 mL.

11.4.1.2 Place 3 mL of the 10% IPA in dichloromethane filtered extract into a 6-dram vial. Add 12 mL of hexane and mix thoroughly. Add 3 mL of pH 4 buffer and mix for one minute. Remove the organic (top) layer. Add 5 mL of hexane to aqueous solution and mix for one minute. Remove the organic layer. Place 2 mL of the aqueous layer in a 3-dram vial. Add 4.5 mL of pH10 buffer and verify that the pH is greater than 8. Add 2 mL of dichloromethane and mix for one minute. Collect and store the organic layer (bottom) until analysis.

11.4.2 GB Column Cleanup (optional).

This cleanup is applicable to extracts of GB samples that contain high organic loadings.

11.4.2.1 Condition a Carboprep90 or equivalent column as follows. Elute 5 mL of IPA through the column followed by 5 mL of DCM and 10 mL of hexane. Discard these conditioning solvents in an approved manner.

11.4.2.2 Condition silica column by eluting 5 mL of IPA followed by 5 mL of DCM and 10 mL of hexane. Discard these conditioning solvents in an approved manner.

11.4.2.3 Place 1 mL of the 10% IPA in dichloromethane filtered GB extract in a 3-dram vial and add 10 mL of hexane.

11.4.2.4 Elute and collect the hexane diluted extract through the Carboprep90.

11.4.2.5 Elute and collect an additional 3 mL of hexane through the Carboprep90.

11.4.2.6 Elute the collected eluate from the Carboprep90 through the silica column. Elute 2 mL of hexane followed by 1.5 mL of 10% IPA in dichloromethane. The laboratory must verify fraction volumes based upon column conditions. These fraction volumes were observed during development and still must be verified at the point of method use.

11.4.2.7 Elute and collect 3 mL of 10% IPA in dichloromethane. This is the analytical fraction. Store the 3 mL of eluate until analysis.

12.0 DATA ANALYSIS AND CALCULATIONS

Data analysis and calculations will be performed in accordance with the procedures in the determinative methods.

13.0 METHOD PERFORMANCE

13.1 Performance data and related information are provided in CMA methods only as examples and guidance. The data do not represent required performance goals for users of the methods. Instead, performance goals should be developed on a project-specific basis and the laboratory.

13.2 Performance data vary depending on the analytical methodology used. Refer to the determinative methods for indicators of method performance.

14.0 POLLUTION PREVENTION

14.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity and/or toxicity of waste at the point of generation. Numerous opportunities for pollution prevention exist in laboratory operation. The Environmental Protection Agency (EPA) has established a preferred hierarchy of environmental management techniques that places

pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address their waste generation. When wastes cannot be feasibly reduced at the source, the EPA recommends recycling as the next best option.

14.2 For information about pollution prevention that may be applicable to laboratories and research institutions consult *Less is Better: Laboratory Chemical Management for Waste Reduction* available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th St., N.W. Washington, D.C. 20036, http://www.acs.org.

15.0 WASTE MANAGEMENT

The EPA requires that laboratory waste management practices be conducted consistent with all applicable rules and regulations. The Agency urges laboratories to protect the air, water, and land by minimizing and controlling all releases from hoods and bench operations, complying with the letter and spirit of any sewer discharge permits and regulations, and by complying with all solid and hazardous waste regulations, particularly the hazardous waste identification rules and land disposal restrictions. For further information on waste management, consult *The Waste Management Manual for Laboratory Personne*l available from the American Chemical Society at the address listed in Sec. 14.2.

16.0 REFERENCES

1. Applicable documents to support the occupational health program when dealing with chemical agents include AR11-34 (The Army Respiratory Protection Program; AR 40-5 (Preventive Medicine); DA Pam 40-8 (Occupational Health guidelines for the evaluation and Control of Occupational Exposure to Nerve Agents GA, GB, GC, and VX.) and DA Pam 40-173 (Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard Agents H, HD, and HT).

2. Development and Evaluation of an Analytical Method for Determination of GB, VX, and HD in Concrete, SwRI Final Report to PM-ECW, William S. Williamson, Jr. Joseph H. Brewer.

3. Development and Evaluation of an Analytical Method for Determination of GB, VX, and HD in Coral, SwRI Final Report, to PM-ECW William S. Williamson, Jr., Joseph H. Brewer

4. Development and Evaluation of an Analytical Method for Determination of GB, VX, and HD in Charcoal, SwRI Final Report to PM-ECW, Michael G. MacNaughton, Ph.D., P.E., William S. Williamson, Jr., Joseph H. Brewer

5. Development and Evaluation of an Analytical Method for Determination of GB, VX, and HD on Surfaces, SwRI Final Report to PM-ECW, Carter Crigler

6. Laboratory Monitoring and Quality Assurance Plan dated June 2004, Department of Army, Chemical Material Agency.

17.0 TABLES, DIAGRAMS, FLOW CHARTS, AND VALIDATION DATA

The following page contains the figure referenced by this method.

Figure 1

Extraction Flow Diagram