FINAL

FIELD SAMPLING AND SURVEY RESULTS REPORT

FOLLOW-UP PASSIVE SOIL GAS INVESTIGATION
CONSTRUCTION DEBRIS LANDFILL SITE

NASA WALLOPS FLIGHT FACILITY
Accomack County, VA

Prepared By

United States Army Corps of Engineers
Norfolk District
803 Front Street
Norfolk, VA 23510

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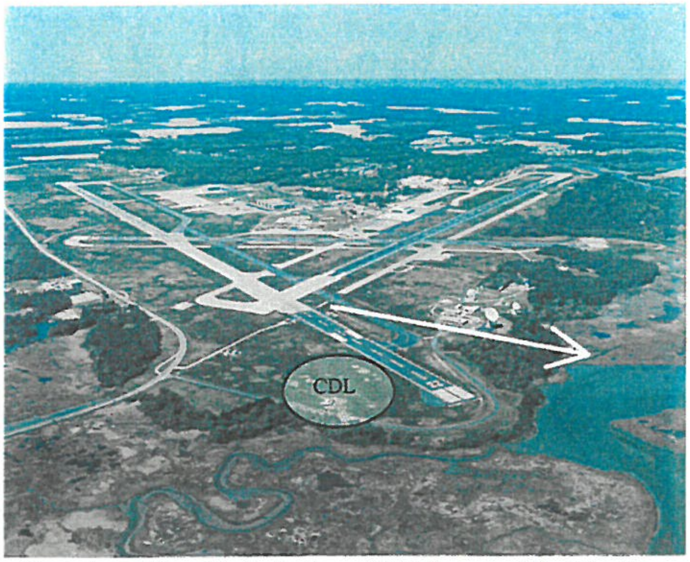
I. FIELD SAMPLING AND SURVEY RESULTS REPORT

1. PROJECT DESCRIPTION.

The GeoEnvironmental Engineering (GeoE) Section of the Engineering Branch of the Norfolk District U.S. Army Corps of Engineers (USACE) recently performed a Follow-up Field Investigation at the Former Construction Debris Landfill (CDL) at the NASA Wallops Flight Facility (WFF). The purpose of the investigation was to obtain additional contaminant information to assist in developing future investigations at this location. WFF is located on Virginia's Eastern Shore, south of the Maryland border (Figure 1, Figures Section at end of this report). This work is being performed under the Formerly Used Defense Site (FUDS) Program.

In August 2002, three GeoProbe borings were collected in an area of WFF referred to as the Former Construction Debris Landfill, located at the northeast corner of WFF and just east of the approach end of NASA Wallop's Runway 22. The boring locations were selected using a U.S. Army Topographic Engineering Center produced historical analysis report of area ground scars, disturbances, channels and other anthroprogenic activities at WFF dating back to pre-U.S. involvement in World War II (*Wallops Flight Facility–Main Base–Ground Features; GIS Based Historical Photographic Analysis 1938-1980,* USATEC, November 2000). Significantly, aerial photographs revealed a series of ground disturbances in areas at the northeast corner of WFF, clearly visible in 1949, 1954, 1959, and 1963 aerial photographs (Figures 2a–2e of this report from the U.S. Army Topographic Engineering Center (USATEC, pp. 21, 22, 24, 27, 28). By 1963, some of these features are no longer visible and, by 1974, none of them remained visible (USATEC, pp. 29, 30). One of these features was a Suspected Excavation that would now be located inside the runway area fence. East of this location and the present-day fence were several features that were referred to (listed in order from northeast to east) as Disturbed Ground in 1949, but Excavation in 1954; Mounds of Material in 1954, changing to Excavation in 1959; Disturbed Ground/Probable Burning Dump (a 1950 Site Map confirms a "Burning Dump" in this area); and two Man-Made Channels (ibid). Figure 2 shows most of these areas and the locations of the three GeoProbe borings collected during the 2002 Limited Site Investigation (LSI) fieldwork (LSI, Figure 5.4-1, SAIC, 2003). The aerial photo below indicates the general location of the former CDL area.



WFF: Former Construction Debris Landfill Area with North arrow (white)

A portion of the August 2002 LSI field effort was dedicated to collecting several soil and groundwater samples at locations around the CDL area that might be expected to hold some evidence of past activities if contaminants had been introduced into any of these past areas of disturbance. In Figure 2, the location of soil boring SB-CDL-01 is shown to the northeast of the feature labeled "Construction Debris Landfill/ Possible Burning Dump" and directly east and downgradient of the feature labeled "Mounds of Material/ Possible Dump Site" (LSI Report, SAIC, May 2003, p. 5.4-2 and Figure 5.4-1). However, the entire area of disturbances was collectively evaluated as the former Construction Debris Landfill as outlined using a red border on Figure 2. Another boring (SB-CDL-02) was located adjacent to the landward end of the northern man-made channel and a third boring (SB-CDL-03) was located adjacent to the southern man-made channel (ibid). While the significant analytical results from the sampling at these locations will be summarized in Section 2 of this report, and the details provided in tables in Appendix A, significant visual and analytical levels of contamination were found only at the SB-CDL-01 boring location (Appendix B). Beyond indicating that the contaminating material was hydrocarbon-based, the analytical results from the LSI were insufficient to help identify potential hydrocarbon sources or to help determine whether the contamination was a result of historical dumping, was related to an aircraft or a ship incident, or was related to a leak(s) from any of potentially dozens of fuel locations that have been located in the northern end of WFF. The 2002 LSI fieldwork did establish the presence of one location of contamination in the CDL area; however, a single point provides little basis upon which to design future investigations. Thus, this follow-on investigation was based on two premises. The first of these was that collecting an additional sample of the contaminated material would permit Norfolk District to obtain specialized forensic fuel identification tests to augment the contaminant information collected through the initial EPA methods employed during the original LSI. Secondly, performing a soil gas survey would help investigators define the area(s) of impact and help focus future investigative resources where needed. While this intermediate investigation was not designed to delineate the area of contamination, it was able to identify specific areas of impact, eliminate others, and provide evidence that this contamination is migrating to the east and into the mudflats and estuary bordering Mosquito Creek. With this new information, future investigations should be able to minimize impacts on the vegetative buffer separating WFF from the estuary leading out to Mosquito Creek and beyond to Simonaeston Bay and the Chincoteague Channel (Figure 3).

2. FIELD ACTIVITIES

2.1. 7 August 2002 LSI Sampling at Construction Debris Landfill

During the August 2002 LSI field work, two soil samples and one groundwater sample were collected using a GeoProbe from each of the three boring locations, described above, at the former CDL site. The LSI work plan called for taking 12-foot borings at each boring location and collecting a surface soil sample and a subsurface sample from just above the water table. As each GeoProbe push produces a four-foot core of soil within an acetate sleeve, assuming no compression or loss of material, the LSI work plan called for three, four-foot GeoProbe pushes at each location. However, the LSI field team modified this objective in the field at the request of Norfolk District in order to collect an additional four-foot interval when a prominent layer of contaminated soil was encountered at a depth of 7.5 feet below ground surface bgs at the first boring location (SB-CDL-01) that continued through to the intended 12-foot depth bgs (photos provided in Appendix B). At this point, the contractor was requested to extend the depth of this boring an additional four feet to see if the base of the contamination could be identified, and to collect another subsurface soil sample from well within the contaminated zone. The surface soil sample at this location was deleted to achieve this added sample. When the additional GeoProbe push from 12 feet bgs to 16 feet bgs failed to identify a base of the contamination, further coring efforts were discontinued and the available sections of core material were logged.

The first soil sample at the SB-CDL-01 boring site was collected at a depth of 6.5 feet bgs, just above the water table. This sample location should have identified any analytical transition occurring above the visible jet-black sheen of the contaminated soil that showed up at the 7.5 foot depth bgs point of the 4 to 8 foot core depth interval. The soil above the contamination was described as "reddish-brown, fine silty sand, dry (85-15-0)", with the numbers in parentheses indicating the estimated fractions of sand, silt and clay-sized material, respectively, in the sampled soil. The photoionization detector (PID) used to screen the borings alarmed out (exceeded 1,000 parts per million [ppm]) on the actual contamination and registered 62 ppm when held over the open boring hole at the foot of the GeoProbe (field logbook entry). The second soil sample from the SB-CDL-01 boring was collected at a depth of 9 feet bgs, placing it below the water table and well within the contaminated material. A GeoProbe Hydropunch groundwater sample was also collected at this location. All samples were analyzed for mercury and TAL metals (Methods 7471 and 6010, respectively), semi-volatile organic compounds (SVOCs) by Method 8270, and volatile organic compounds (VOCs) by Method 8260. All of the August 2002 sampling results were published in the LSI report (May 2003, SAIC); however, those results pertaining to the CDL area are included in this report as Appendix A and the VOC and SVOC results are summarized in Section 3 of this report for reference in comparing these sampling results to the information acquired during the March and April 2004 follow-on investigation sampling. While the original LSI analytical methods were appropriate for determining the presence or absence of a wide range of possible contaminants, the analytical results were of little value in identifying the possible sources of the contaminants that were identified.

2.2. March/April 2004 Follow-up Investigation.

2.2.1 Soil Sampling

On Tuesday morning, March 23, 2004, George Mears, Chris Turner and Tim Thompson of USACE, Norfolk District, arrived at the NASA Wallops' Security Gate at 0900 to pick up security access badges that had been arranged by the WFF Environmental Office. The field team members met with various WFF personnel and were provided with a hand-held radio to use in coordinating with Wallops Tower and our project Dig Permit (Utilities Clearance) from the WFF Environmental Office before commencing work at the CDL boring location where the contamination was originally discovered (Appendix C).

Mr. Tim Thompson, an archeologist, was added to the field team after it was discovered during a February 27, 2004 visit to WFF that the CDL area fell within a portion of WFF that had recently been identified as an Historic Area of High Sensitivity due to being considered as a "Possible Location of Revolutionary War Fort" in a recent Cultural Resources report (Figure 4, from URS and EG&G, November 2003, Figure 17). Mr. Thompson was able to prevent a potentially lengthy delay in this fieldwork by coordinating with the Virginia Department of Historical

Records (VDHR) to comply with the applicable portions of Section 106 regulations, 36 CFR Part 800 ("Protection of Historic Properties"), of the National Historic Preservation Act. Mr. Thompson was able to convince VDHR to render an expedited decision to allow this fieldwork to occur on schedule based on an acknowledgement that the placement of the passive gas array was not sufficiently intrusive to constitute an effect on any archaeological resources. The other consideration was that the single proposed auger boring was to be collected at the same location as the previous, much deeper, LSI boring collected several months before the subject report was produced. However, the brokered arrangement with VDHR included Mr. Thompson's willingness to accompany the field team and monitor all activities. A copy of the after-action memorandum Mr. Thompson submitted to Sue Smead of VDHR, Shari Silbert of WFF and others is included as Appendix D.

In accordance with the Field Sampling Plan (FSP), Norfolk District field personnel used a properly decontaminated hand auger to collect a sample of the contaminated soil at a location within a couple of feet of the original August 7, 2002 SB-CDL-001 LSI boring in which the contamination was discovered. The LSI SB-CDL-001 boring field notes were available which showed that the earlier boring at this location produced no visible or field screening (PID) evidence of contamination to a depth below 6.5 feet bgs. Based on this, the Field Sampling Plan called for close monitoring and screening of the soil down to this level and for setting aside the material recovered on plastic sheeting. This monitoring and screening demonstrated no evidence of contamination allowing this clean soil to be segregated and later replaced into the boring hole after the soil sample was collected from a deeper depth. In this case, prior knowledge of the site and close monitoring allowed the field team to minimize the amount of investigative derived waste (IDW) generated to an amount that could fit into a few small containers. The excess contaminated soil and field gloves were placed into two one-quart plastic wide-mouthed containers, and the decontamination (decon) water into a 1.5-gallon sealable hard-plastic container. These containers were labeled, transported back to Norfolk and delivered to Industrial Marine Services, Inc. (IMS), a hazardous waste contractor, on March 26, 2004. Two bills of lading were prepared to document the transfer of this material to IMS, #20762 for the decon water and S11876 for 4 pounds of soil and PPE (Appendix E).

The layer of contamination was again identified at a depth of just below 7.0 feet bgs and the sample was collected from auger material collected from the 7.0 to 7.5 foot depth interval in three EnCore samplers and one 8-ounce clear wide-mouth (CWM) glass soil jar. The sample (ID **04 SGI-CDL-SB01-07)** was collected at 1130 on March 23, 2004. Analyses requested included EPA Method 8015 for Gas Chromatograph (GC) Fingerprinting, Massachusetts Department of Environmental Protection Method for Volatile Petroleum Hydrocarbons (MADEP VPH), and MADEP Method for Extractable Petroleum Hydrocarbons (MADEP EPH) (Chain of Custody, Appendix F). Since standard EPA Methods 8260 and 8270 had already been used to evaluate the soil and groundwater samples collected from this location during the previous LSI, the MADEP VPH/EPH methods were selected to supplement those results with additional information. The labels were properly filled out and affixed to the sample containers as per the FSP and the sample jar was wrapped in bubble wrap. All sample containers were placed in a small cooler that had been pre-filled with ice. At this time, the Chain of Custody was filled out and the cooler was placed in the field team's Corps vehicle until it was delivered to the FEDEX office in Salisbury, MD later in the afternoon for shipping to the Accutest Laboratories facility in Dayton, NJ.

2.2.2. Passive Soil Gas (Gore-Sorber®) Module Array Installation

The passive soil gas array deployed at WFF is what W.L. Gore & Associates, Inc. refers to as a Gore-sorber® Screening Survey. Such a survey is designed to screen areas for the presence of subsurface volatile and semi-volatile hydrocarbons, including polycyclic aromatic hydrocarbons (PAHs). The manufacturer offers three varieties of passive soil gas collection modules: A9A modules for the detection of Total Petroleum Hydrocarbon (TPH) compounds, A1 modules for standard VOC and SVOC compounds (petroleum mix), and A4 modules for VOCs, SVOCs and Heavy PAHs (Full compound sweep). The array initially designed by Norfolk District employed a mix of the A1 and A4 modules; however, W.L. Gore offered to provide all A4 modules at the same cost to ensure that detections at any individual module could be related to those at neighboring modules without having to correct for differences in detection capability or sensitivity. The plan was then changed to use all A4 modules. The sample modules used in this survey were capable of detecting the following 29 target VOC, SVOC, and PAH compounds:

- 1,1,1-Trichloroethane
- 1,1-Dichloroethane
- 1,2-Dichloroethane; Trichloroethene
- 1,3,5-Trimethylbenzene; 1,2,4-Trimethylbenzene
- 1,4-Dichlorobenzene
- 2-Methyl naphthalene
- Acenaphthene
- Anthracene
- Benzene
- Carbon tetrachloride
- Chlorobenzene
- Chloroform
- cis-1,2-Dichloroethene
- Ethylbenzene
- Fluoranthene
- Fluorene
- m,p-Xylene
- Methyl t-butyl ether
- Naphthalene
- Octane
- o-Xylene
- Pentadecane; Acenaphthylene
- Phenanthrene
- Pyrene
- Tetrachloroethene
- Toluene
- Trans-1,2-Dichloroethene
- Tridecane
- Undecane

Each Gore collector (sorber) module is able to collect data from vapor, soil-adsorbed, separate and dissolved phases of target constituents. This ability to detect contaminants correctly in both vadose and saturated environments was critical to the WFF application because the location of the known contamination (the array origin) was within yards of partially to fully saturated estuary and mudflat environments. The two-week period of data collection specified in the FSP allowed for passive collection of soil vapors over an extended period. The March 24 to April 7th module deployment window included some periods of cooler weather than anticipated, tending to reduce soil gas movement and volatility. However, this collection period provided sufficient periods of warming conditions to satisfy the soil gas movement needs for module exposure.

The investigation involved deploying 47 GORE-SORBER® A-4 Modules in an array anchored at the location of the initial contamination detection (CDL-SB-001) and extending out approximately 400 to 450 feet upgradient and up to 50 feet seaward and into the mudflats bordering Mosquito Creek. The resulting array encompassed approximately 13 acres and covered 150 degrees of compass arc from 350° magnetic to the north, westerly (counterclockwise) to 200° magnetic to the south (Figure 7). As per the FSP, the array was reproduced in the field using a hand-held Garmin V GPS unit to locate intermediate and outermost points along each axis of the array. The actual module locations were selected and marked using a combination of GPS positioning and a 300-foot measuring tape to determine the proper distances from the origin, and visual cues back along the previously marked locations to ensure the waypoints lined up properly on the proper axis. Due to the amount of thick and thorny vines and overgrowth, laying out and confirming the proper array points for module placement between the airfield fence and out into the mudflats along Mosquito Creek took the remaining daylight hours on Tuesday, March 23rd, the first day of this field effort.

Field team members commenced survey array layout activities inside the NASA Wallops airfield fence on the morning of March 24th after checking in with NASA Wallops Tower personnel. The team established hand-held radio communication with the Tower, which provided travel directions to reach the project area within the airport fence via airport taxiways and off-road paths. These precautions were pre-planned and allowed Tower personnel to contact field team members when changes were made to the duty runway or when team members needed to back away from the active runway due to an approaching aircraft. This also ensured that the Tower personnel would be immediately available in the event of any emergency to coordinate a response. An additional benefit was that the Tower was able to contact security personnel to open up nearby gates when work within the fence was completed, allowing immediate access to the other portions of the project area beyond the fence line without having to travel back through the entire base to continue work on the other side of the fence.

Since all the array axes were well established, with module points laid out from the array origin to the airfield fence line during the previous day, the work within the airfield fence went rapidly. Passive soil gas modules were installed as per the FSP and Appendix G procedures (Figure 6). The outermost points were identified by GPS and visually adjusted by a couple of feet to line up along the established axes, and distances and the intermediate module location points were measured off using a tape measure and confirmed by GPS (Figure 7). Module installation commenced with those inside the airfield fence area to enable the field team members to complete all work within the fence line as soon as possible.

The module insertion holes were created using a manual, 7/8" diameter x 33" long, Open-Ended, T-handled Soil Probe. At most locations, the probe could be forced down to depth in 6" to 8" increments with brute force. Incremental steps were required while working the probe down to the desired target depth of from 2' to 2.5' bgs to allow removal of sections of soil within the open-ended section of the probe prior to "packing" the soil into the closed portion of the probe. This greatly reduced the level of effort needed to decontaminate the probe before moving to the next module installation location. At a number of locations, the efforts of two individuals were required to reach the proper depth. Similarly, pipe wrenches were needed to extract the probe from some locations. The Gore-sorber modules were placed within the holes as per the FSP and in accordance with the manufacturer's instructions and, once in place, corks—provided by W.L. Gore—were used to seal each hole (Appendix G).

Sturdy 30-inch wood stakes were used to mark each location within the airfield fence to facilitate relocating the modules when it was time to retrieve them a couple of weeks later. While wire survey flags were appropriate for most locations outside of the fence, wooden stakes were selected for use within the airport area. Wooden stakes could be driven in deeper, preventing premature removal, and the absence of plastic flags would preclude such material from becoming loose material in an airport environment, presenting a potential FOD (Foreign Object Damage) problem to aircraft engines. Norfolk District had coordinated the dates for passive soil gas array installation and removal with both the WFF Environmental Office and the NASA Wallops Tower personnel so that area grass cutting could be scheduled to occur prior to array installation so that it would not be needed again until after module retrieval. All fieldwork within the fence was completed by noon on Wednesday and the field team moved beyond the fence where all module locations had been marked the previous day. Most of the module locations outside the airfield fence were marked using wire survey flags; however, stakes were still used out in the mudflats since these locations would be subject to fluctuating tides, exposed to area storms, or potentially disturbed by animals (rodents, foxes, marsh crabs, birds). Any of these factors could have resulted in the displacement of the small wire survey flags and the potential loss of the passive soil gas module they were deployed to help relocate. The time and identifying serial number of each module installed in the CDL area array was recorded in the Gore-Sorber Screening Survey Installation and Retrieval Log, a copy of which is included in Appendix H.

2.2.3. Passive Soil Gas (Gore-Sorber®) Module Retrieval and Processing

Marc Gutterman and George Mears, both from the GeoEngineering Section of Norfolk District, returned to WFF on Wednesday, April 7, 2004 to retrieve and containerize the Gore-Sorber modules, remove the marking stakes/flags and fill in holes, and repackage the modules for shipping to the W.L. Gore and Associates, Inc. Screening Modules Laboratory in Elkton, MD. The time that each module was removed and returned to its glass vial was recorded on the Gore-Sorber Screening Survey Installation and Retrieval Log that accompanied the samples when shipped to the Gore laboratory. A copy of this completed log is included in the Final Report submitted to Norfolk District from W.L. Gore & Associates, Inc. (Appendix H). Note that, as per the FSP and manufacturer's instructions, once the modules were properly collected and individually resealed within their original glass vials, they were under no holding time or preservation requirements. This allowed the field team to bring the modules back to Norfolk for final packaging and shipping on the following day. A copy of the Chain of Custody documentation for the passive soil gas survey modules is also included in the Gore Final Report (Appendix H).

2.2.4. Quality Control

The EPA previously evaluated the W.L. Gore & Associates, Inc. Gore-Sorber Screening Survey system under its Superfund Innovative Technology Evaluation Program. EPA found that, unlike active soil gas sampling, passive soil gas sampling—relying on diffusion and adsorption—can be used successfully for VOCs and SVOCs, depending on the adsorbent selected and the diffusion membrane used (EPA/600/R-98/095, August 1998). Specifically, the Gore module sorbers consist of several granular adsorbent materials housed in a chemically inert, hydrophobic, microporous Gore-Tex® expanded polytetrafluoroethene (ePTFE) membrane. The EPA verification document reported that the microporous structure of ePTFE allowed vapors to move freely across the membrane and onto the sorbent material while preventing water and soil particles from entering the sampler (EPA, 1998. p. 5).

In accordance with the FSP, no separate quality control (QC) or quality assurance (QA) soil samples were collected; however, three EnCore samplers and additional soil were collected to provide the primary laboratory with adequate amounts of sample material to run Matrix Spike and Duplicate analyses for GC Volatiles (Appendix I, Section 4) and GC Semi-volatiles (Appendix I, Section 5). Internal laboratory quality control procedures included Method Blank, Blank Spike and Surrogate Recovery analyses. Analytical summaries of all these procedures are included in Appendix I.

QC procedures for the passive soil gas portion of this investigation included trip blanks and duplicate sorbers built into each passive gas collection module. Each module consists of a Gore-tex® membrane container surrounding sorbers made up of proprietary sorbent material. Each passive soil gas module contained four sorbers, providing duplicates within every array module. W.L. Gore provided four more modules than required for the designed array to serve as trip blanks. These trip blanks were shipped with and kept with the 47 primary array modules until the array modules were installed in the field at WFF. During the data collection period the trip blanks were stored at Norfolk District. Two weeks later, they were carried back out to WFF where they were again combined with the recovered modules, packaged with them and shipped to the Gore laboratory for analysis. At the laboratory, sorbers from all modules were processed identically. As no target compounds were detected on the trip blanks and/or the method blanks, target analyted levels reported for the field-installed modules that exceed trip and method blank levels, and the analyte method detection limit, should represent detections from project area sources (Gore Final Report, Appendix H, p. 5 of 6). Specific Gore QC laboratory procedures are discussed in the Gore Final Report (Appendix H, p. 4 of 6).

3. ANALYTICAL RESULTS.

3.1 7 August 2002 LSI Soil and Groundwater Sampling

3.1.1. LSI Soil Sample Analytical Results in CDL Area

Each soil and groundwater sample collected during the LSI fieldwork in the CDL area was analyzed for mercury and TAL metals (Methods 7471 and 6010, respectively), semi-volatile organic compounds (SVOCs) by Method 8270, and volatile organic compounds (VOCs) by Method 8260. The LSI results are summarized below and included in Table 1, along with comparisons to current (April 2004) EPA Region III RBC table screening values, several of which have changed since the LSI report was finalized.

The metals analysis of these samples revealed that the two other borings had higher soil levels of most metals than at SB-CDL-01, except for Arsenic and Barium, which appeared to be roughly equivalent in the samples from the three CDL boring locations. However, the groundwater sample collected from the SB-CDL-01 location revealed elevated levels of both Iron and Manganese, both of which, at 28,600 and 791 ug/L, respectively, exceeded the corresponding Region III Tapwater RBC screening values for these inorganics, 11,000 and 730 ug/L, respectively.

SVOC analytical results for the SB-CDL-01 6.5-foot depth sample revealed a variety of semi-volatile organic compounds (SVOCs) by Method 8270, predominantly PAHs, at estimated (J-coded) levels that were below the 330 ug/kg reporting limit. These included Acenaphthene, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b) fluoranthene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Carbazole, Chrysene, Dibenzofuran, Indeno(1,2,3-cd)pyrene, and Naphthalene at 72, 150, 270, 220, 260, 150, 94, 79, 210, 44, 110, and 55 ug/kg, respectively. Additionally, three SVOCs were detected at measured (not estimated) levels above reporting limits: Fluoranthene at 430 ug/kg, Phenanthrene at 530ug/kg, and Pyrene at 510 ug/kg. No volatile organic compounds were detected in this 6.5-foot depth (top of interval) soil sample using the EPA Method 8260 analysis.

The SVOC analysis of the 9' (bgs) soil sample collected from within the contaminated layer at SB-CDL-01 shows levels of Fluorene and Phenanthrene at estimated (J-coded) values of 95 and 63 ug/kg, and 2-Methylnaphthalene and Naphthalene at above reporting limit measured values of 2500 and 830 ug/kg, respectively. While the number of reported SVOC constituents and values (measured or estimated) in the deeper sample drops significantly, the reporting limit for the deeper sample also increased from 330 ug/kg to 400 ug/kg. Thus, given the low levels of detection in both samples and the change in reporting limits between the two samples, little significance is attributed to differences in SVOCs reported in the two soil samples from this location. The SVOC analysis of the samples from the other CDL boring locations revealed no similar detections at either of the sample elevations.

However, the VOC detections in the 9-foot (bgs) sample from the SB-CDL-01 boring increased over the number detected in the 6.5-foot (bgs) sample at this location, or in any other CDL-area boring sample. The following estimated (J-coded) levels were reported from the VOC analysis of the 9-foot (bgs) soil sample at SB-CDL-01: 1,2-Dichloropropane at 2,000, Ethylbenzene at 12,000, m-and/or p-Xylene at 9,600 and Tetrachloroethene (PCE) at 1,100 micrograms per kilogram (ug/kg), respectively. There were no similar VOC detections in any of the other samples at the other CDL boring locations.

Table 1: August 2002 LSI Sampling Results at SB-CDL-01 Screened Against April 2004 EPA Region III RBC Table Criteria

Contaminant	SB-CDL-01	SB-CDL-01	EPA Region III RBC (Apr 2004)	HP-CDL-01	EPA Region III RBC (Apr 2004)
	6.5' bgs soil sample	9.0' bgs soil sample	Residential Soil	groundwater sample	Tapwater
VOCs	(ug/kg)	(ug/kg)	(ug/kg)	(ug/L)	(ug/L)
Chloromethane	U	U	NA	0.7 J	190
cis-1-2-Dichloroethene (DCE)	U	U	NA	12 J	61
1,2-Dichloropropane(C)	U	2,000 J	9,400	U	NA
Ethylbenzene	U	12,000 J	7,800,000	920 J	1,300
m-and/or p-Xylene	U	9,600 J	16,000,000	**3700 J**	210
o-Xylene	U	U	NA	**1700 J**	210
Styrene	U	U	NA	22 J	1,600
Tetrachloroethene (PCE)	U	1,100 J	1,200	**12 J**	0.10
Toluene	U	U	NA	**12,000**	750
Trichloroethene (TCE) (C)	U	U	NA	**1.1**	0.026
SVOCs					
Acenaphthene	72 J	U	4,700,000	U	NA
Anthracene	150 J	U	23,000,000	U	NA
Benzo(a)anthracene (C)	270 J	U	870	U	NA
Benzo(a)pyrene (C)	**220 J**	U	87	U	NA
Benzo(b)fluoranthene(C)	260 J	U	870	U	NA
Benzo(g,h,i)perylene	150 J	U	no RBC	U	NA
Benzo(k)fluoranthene	94 J	U	8700	U	NA
Carbazole (C)	79 J	U	32000	U	NA
Chrysene (C)	210 J	U	87000	U	NA
Dibenzofuran	44 J	U	160000	U	NA
2,4-Dimethylphenol	U	U	NA	10.4 J	730
Fluoranthene	430	U	3,100,000	U	NA
Fluorene	78 J	95 J	3,100,000	U	NA
Indeno(1,2,3-cd)pyrene (C)	110 J	U	870	U	NA
2-Methylnaphthalene	U	2500 J	310,000	**49**	24
2-Methylphenol	U	U	NA	27	1,800
4-Methylphenol	U	U	NA	46	180
Naphthalene	55 J	830 J	1,600,000	**120**	6.5
Phenanthrene	530	63 J	no RBC	U	U
Pyrene	510	U	2,300,000	U	U

Footnotes:

J – Value is estimated

U – Compound was analyzed for but not detected

NA – Not Applicable

Of all soil samples collected in the CDL area as part of the 2002 LSI, only the SB-CDL-01 soil samples revealed non-metal constituents at levels above screening criteria. The benzo(a)pyrene value was 220 J ug/kg in the soil sample collected above the water table. This was the only contaminant that exceeded a Region III Residential Soil RBC screening value (Table 1, above).

This contaminant also exceeded the Migration to Groundwater Dilution Attenuation Factor 1 (DAF 1) screening level of 190 ug/L. All other soil contaminant levels exceeding RBC screening criteria also involved the very conservative Soil to Groundwater Migration (DAF 1) Site Screening Level (SSL) criteria shown in the right hand column of Table 2. Using the most recent RBC table (April 2004), these constituents included 1,2-Dichloropropane (at 2,000 J ug/kg), Ethylbenzene (at 12,000 J ug/kg), m-and/or p-Xylene (at 9,600 J ug/kg), Benzo(a)pyrene (at 220 J ug/kg), 2-Methylnaphthalene (at 2,500 J ug/kg), Naphthalene (at 830 J ug/kg) and Tetrachloroethene (at 1,100 J ug/kg) (SAIC, 2003, p. 5.4-21, updated with April 2004 EPA Region III RBC tables). A review of the 2002 results revealed that, at a detected soil level of 2.5 mg/kg, 2-methylnaphthalene was well below the Residential Soil RBC value of 1,600 mg/kg. Since 2002, this Residential Soil screening level has dropped to 310 mg/kg. The level of 2-methylnaphthalene exceeded the DAF 1 Migration to Groundwater SSL value in 2002 (1.1 mg/kg) and that screening value has since been lowered to 0.22 mg/kg, increasing the magnitude of exceedance.

3.1.2. 2002 LSI Groundwater Sample Analytical Results

Analysis of the groundwater samples revealed that, at HP-CDL-01 (the 2002 LSI Hydropunch sample collected from the SB-CDL-01 boring location), Trichloroethene was the only non-J-coded volatile organic compound detected. At 1.1 ug/L, this exceeded the Region III RBC screening value of 0.026 ug/L for Tapwater. Other VOC constituents were detected at estimated (J-coded) values in this groundwater sample. These VOCs and their corresponding estimated values (all in ug/L) include: Chloromethane at 0.7, cis-1-2-Dichloroethene (DCE) at 12, Ethylbenzene at 920, m- and/or p-xylene at 3700, o-xylene at 1700, styrene at 22, Tetrachloroethene (PCE) at 12 and Toluene at 12000 ug/L, respectively.

Four SVOC compounds were detected in the 2002 LSI groundwater sample collected at the SB-CDL-01 boring location, all at measured (not estimated) values. None were detected in the other CDL area groundwater samples. 2-Methylnaphthalene was detected at a level of 49 ug/L, 2-Methylphenol at 27 ug/L, 4-Methylphenol at 46 ug/L and Naphthalene at 120 ug/L. The level of 2-methylnaphthalene in the groundwater sample (49 ug/L) was well below the 2002 RBC Tapwater screening value of 120 ug/L, but this screening value has since been lowered significantly to 24 ug/L, resulting in another exceedence that needs to be evaluated.

Only two VOC compounds were discovered in the groundwater samples collected from the other two boring locations in the CDL area. In the HP-CDL-02 sample collected at the SB-CDL-02 boring location, Benzene was detected at an estimated (J) value of 0.54 ug/L, exceeding the Region III RBC Tapwater screening value for benzene of 0.34 ug/L. Toluene was also detected in the HP-CDL-02 sample at an estimated value of 1.1 ug/L, far below the 750 ug/L Tapwater RBC screening value.

Tetrachloroethene and Trichloroethene both exceeded the existing Tapwater RBC screening values in 2002 and the screening value for Tetrachloroethene was lowered from 0.63 ug/L to 0.10 ug/L between 2002 and 2004. The levels of Napthalene, Tetrachloroethene and Toluene in the 2002 LSI HP-CDL-01 groundwater sample also exceeded Federal Maximum Contaminant Levels (MCLs).

3.2. March/April 2004 Soil Gas Investigation Soil Sampling and Passive Soil Gas Array Results.

3.2.1. Primary Soil Sampling Results

The single soil sample (04 SGI-CDL-SB01-07) collected from the contaminated layer was analyzed for MADEP VPH and EPH and EPA 8015 GC Fingerprinting as discussed in Section 2.2.1. of this report.

3.2.1.1. Results of EPA Method 8015 GC Fingerprinting

EPA Method 8015 Gas Chromatograph fingerprinting analysis of the contaminated soil sample material (Laboratory ID N62849-1) (Appendix J) produced a chromatogram that, while clearly in the distillate hydrocarbon range, failed to satisfactorily match one of the Petroleum Chromatogram Standards (Appendix K). Mr. David Speis, Accutest Laboratories Director of Corporate Quality Assurance, provided his best judgment that the sample material was most likely weathered JP-5 aviation fuel with a significant number of the lower boiling point hydrocarbons missing (included in Appendix K). JP-5 is a high flashpoint (low volatility) kerosene fuel developed for the Navy in 1952. Due to its combination of high specific performance and exceptional flash resistance, it has been used continuously and heavily since being introduced and it remains the only jet fuel used aboard aircraft carriers today. Significantly, the lack of heavy-range hydrocarbons identified in the material chromatogram eliminates the sample contaminant mixture from some categories of hydrocarbon contaminants that are typically associated with far greater persistence in the environment and potential environmental risk, such as creosote type materials and long chain heavy maritime bulk fuel oils. The MADEP VPH and EPH method results, discussed below, support this interpretation.

3.2.1.2. Results of MADEP VPH Analysis.

As discussed in the associated Field Sampling Plan, the Massachusetts Department of Environmental Quality (MADEP) Method for Volatile Petroleum Hydrocarbon (VPH) analysis is designed to measure the collective concentrations of volatile aliphatic and aromatic petroleum hydrocarbons in both water and soil by Gas Chromatography (GC), Purge & Trap, and in-series Photoionization and Flame Ionization Detectors (PID/FID). As noted previously, MADEP VPH is not designed to replace other standard EPA Methods such as 8260 or 8270, both of which had already been used to evaluate the soil and groundwater samples collected from this location during the previous LSI, but to supplement these results with additional information.

Specifically the VPH analysis uses purge-and-trap and gas chromatography (GC) to quantify volatile aliphatic hydrocarbons within two ranges: C_5 through C_8, and C_9 through C_{12} (Appendix L, MADEP-VPH-98-1, p. 1). Note that the subscript numbers refer to the number of carbon atoms in the hydrocarbon compound chain with higher numbers indicating longer, and presumably more persistent, chain compounds. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range of approximately 36°C to 220°C (ibid). This range allows the VPH method to be used to evaluate gasoline, mineral spirits and certain petroleum naphthas. Note that the MADEP EPH method (discussed in subsection 3.2.1.3.) was used to evaluate the sample material for the presence of kerosene, jet fuel, heating oils, lubricating oils and other petroleum products containing a significant percentage of hydrocarbons heavier than C_{12}. The

VPH method is also able to measure individual concentrations of the VPH Target Analytes, including benzene, toluene, ethylbenzene, xylenes (BTEX), naphthalene, and methyl-tert-butyl-ether (MTBE), in water and soil. Typically, the Reporting Limit (RL) of this method for each of the collective aliphatic and aromatic fractional ranges is approximately 2-18 mg/kg in soil (note: ppm but data presented in tables below is in ug/kg, or ppb). The RL of this method for Target Analytes is compound-specific, and ranges between 0.1 to 0.2 mg/kg in soil (ibid). As with other GC procedures, this method is subject to a "false positive" bias in reporting of Target Analytes. The method literature explains that this is due to non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window causing a false identification and/or quantification as a Target Analyte. Where this is suspected, or where the level reported exceeds an applicable reporting or cleanup standard, confirmatory analysis by a GC/MS procedure is recommended. See Appendix L for a more thorough discussion of VPH method particulars.

For ease in comparison, the analytical results for the 9' (bgs) sample collected in 2002 are included in column 3 of Table 2 (below), next to the results acquired from analysis of the 7.5' (bgs) sample at the same location in 2004, analyzed by the MADEP Methods (combined VPH and EPH), in column 2. The complete primary lab report on the 04 SGI-CDL-SB01-07 soil sample analyses is included as Appendix I. The proportions of hydrocarbons as detected during the VPH analysis are provided in Table 3 (from Appendix I).

Table 2: March 2004 (04 SGI-CDL-SB01-07) Soil Sample MADEP VPH and EPH Analytical Results Compared to Aug 2002 LSI Results by Methods 8260 and 8270

Contaminant	**04 SGI-CDL-SB01-07**	**LSI SB-CDL-01**	**Apr 2004 EPA Region III RBC**	**Apr 2004 EPA Region III RBC**
	7 –7.5' bgs	**9' bgs**	**Residential Soil**	**Migration to Groundwater (DAF 1)**
VOCs	**VPH/EPH (ug/kg)**	**8260/8270 (ug/kg)**	**(ug/kg)**	**(ug/kg)**
cis-1-2-Dichloroethene	NA	U	NA	17
1,2-Dichloropropane(C)	NA	2,000 J	9,400	.1
m-and/or p-Xylene	14,100	9,600 J	16,000,000	**150**
o-Xylene	U	U	NA	150
Ethylbenzene	26,500	12,000 J	7,800,000	**750**
Toluene	5200	U	NA	**440**
Trichloroethene ©	NA	U	NA	.01
SVOCs	**VPH/EPH (ug/kg)**	**8260/8270 (ug/kg)**	**(ug/kg)**	**(ug/kg)**
Acenaphthene	U	U	4,700,000	5,200
Anthracene	U	U	23,000,000	23,000
Benzo(a)anthracene (C)	U	U	870	730
Benzo(a)pyrene (C)	U	U	87	190
Benzo(b)fluoranthene(C)	U	U	870	230
Benzo(g,h,i)perylene	U	U	no RBC	no RBC

Contaminant	04 SGI-CDL-SB01-07	LSI SB-CDL-01	Apr 2004 EPA Region III RBC	Apr 2004 EPA Region III RBC
	7 –7.5' bgs	9' bgs	Residential Soil	Migration to Groundwater (DAF 1)
SVOCs (continued)	**VPH/EPH (ug/kg)**	**8260/8270 (ug/kg)**	**(ug/kg)**	**(ug/kg)**
Benzo(k)fluoranthene	U	U	8700	2,300
Carbazole (C)	NA	U	32000	230
Chrysene (C)	U	U	87000	7,300
Dibenzofuran	NA	U	160000	190
2,4-Dimethylphenol	NA	U	NA	--
Fluoranthene	U	U	3,100,000	310,000
Fluorene	U	95 J	3,100,000	6,800
Indeno(1,2,3-cd)pyrene (C)	U	U	870	640
2-Methyl-naphthalene	10,600	2500 J	310,000	**220**
2-Methylphenol	NA	U	NA	--
4-Methylphenol	NA	U	NA	--
Naphthalene	3,800/4,800	830 J	1,600,000	**7.7**
Phenanthrene	U	63 J	no RBC	no RBC
Pyrene	U	U	2,300,000	340

Footnotes:
J – Value is estimated
U – Compound was analyzed for but not detected
NA – Not Applicable

Table 3: Carbon Polymer Distribution Range by MADEP VPH Analysis

Carbon Range	**RL (ug/kg)**	**Result (ug/kg)**
$C_5 - C_8$ Aliphatics (Unadjusted)	3200	1,480,000
$C_9 - C_{12}$ Aliphatics (Unadjusted)	3200	1,440,000
$C_5 - C_8$ Aliphatics	3200	1,470,000
$C_9 - C_{12}$ Aliphatics	3200	1,030,000
$C_9 - C_{10}$ Aromatics	3200	374,000

3.2.1.3. Results of EPH Analysis.

The MADEP EPH Method uses solvent extraction, a silica gel solid-phase extraction/fractionation process (SPE), and Gas Chromatography (GC) analysis using a flame ionization detector (FID) to measure the collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons in water and soil. Extractable aliphatic hydrocarbons are collectively quantified within two ranges: C_9 through C_{18}, and C_{19} through C_{36}. Extractable aromatic hydrocarbons are collectively quantitated within the C_{11} through C_{22} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 150°C and 500°C. This method can also measure the individual concentrations of Target Polynuclear Aromatic Hydrocarbons (PAH) Analytes, including Diesel PAH Analytes in both water and soil. The RL of this method for each of the collective aliphatic and aromatic fractional ranges is approximately 2-10 mg/kg in soil. The RL for this method for TPH is approximately 10 mg/kg in soil. The RL of this method for the Target PAH Analytes is compound-specific, and ranges from approximately 0.5 to 1.0 mg/kg in soil. Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target PAH Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantitated as a Target or Diesel PAH Analyte.

As with the results of both the EPA 8015 GC and the MADEP VPH methods, the EPH method analyses results also support an interpretation that the unknown contaminant material is a distallate fuel. The large proportion of the material is in the C_{19} to C_{22} hydrocarbon range, noticeably lacking in the lower weight hydrocarbons. Even more distinctive is the complete lack of aliphatics in the over-C_{22} (C_{19} – C_{36} aliphatics) weight range. Laboratory analysts also advise that the relatively low amount of Ethylbenzene argues against the presence of creosote. The proportions of hydrocarbons as detected during the EPH analysis are provided in Table 4, below (from Appendix I).

Table 4: Carbon Polymer Distribution Range by MADEP EPH Analysis

Carbon Range	RL (ug/kg)	Result (ug/kg)
C_{11}-C_{22} Aromatics (unadjusted)	57,000	860,000
C_9 – C_{18} Aliphatics	57,000	1,980,000
C_{11}-C_{22} Aromatics	57,000	845,000
C_{19} – C_{36} Aliphatics	57,000	ND

3.2.2. Passive Soil Gas Survey Results.

Using a modified (proprietary) EPA method 8260/8270, the W.L. Gore Screening Modules Laboratory processed all fifty-one (51) passive soil gas survey modules shipped to the lab by overnight FEDEX on April 8, 2004. Four of these survey modules were trip blanks. Analytical results are provided in the Gore Final Report (Appendix H). No target compounds were detected in any of the trip and method blanks, suggesting that the target analyte levels reported for the field-installed modules resulted from exposure to on-site (CDL area) sources. As discussed in the FSP, positive identification of the target compounds listed in the FSP was determined by the presence of target ions, at least two secondary ions, consideration of retention time versus reference standard, and the laboratory analyst's judgment. All analytical data is reported as a mass of analyte in micrograms per sample and, thus, has little correlation to soil mass/kg values reported in traditional analytical results for soil analyses.

At the completion of module processing by the Screening Modules Laboratory, the W.L. Gore & Associates Project Manager faxed Norfolk District a copy of the table with the detection results so that Norfolk District could determine which contaminant plots to be included in the final laboratory report. The data table sent to Norfolk District is included as the 8-page table "Gore Expanded Target VOCs/SVOCs (A4); NASA Wallops Flight Facility, Accomack County, VA, Production Order #11787295" included in Appendix H. Plots for Benzene, Toluene, BTEX and a combined plot of PCE, TCE and DCE were requested and provided in Appendix H. The contaminant values used are included in the 8-page data table referred to above.

Gore analysts provided four plots of various contaminants or combination of contaminants. These include plots for Benzene, BTEX, Toluene and a combined plot of PCE, TCE, and cis- & trans-1,2-DCE (PCE and daughter products of PCE biodegradation as shown in a graphic in Section 5.2 of this report).

4. DISCUSSION POINTS

1. As recorded on the Gore-Sorber Screening Survey Installation and Retrieval Log, two of the 47 survey modules were found on the ground next to their insertion holes during the retrieval process. One of these modules was found next to Array Waypoint #6 (serial # 444424). The other was found next to Array Waypoint #42 (serial # 444456). There was no evidence suggesting what may have taken place at Waypoint #6 and, as this module location was in the relative open, tampering can not be ruled out. However, the Waypoint #42 module was deep in the woods and the condition of both the hole and the cork used to plug the hole after the module was inserted made it obvious that an animal had clawed around the hole until the cork could be removed and the module pulled out at this second location. There appeared to be no damage to either sampler other than being pulled out of its respective hole. There was no evidence of chewing on the Gore-Tex ® outer casing of the sample module itself. However, neither is there any way to determine how long either module had remained in place prior to being prematurely removed from its hole. It should be noted that, upon analysis, both of these modules revealed detections of possible target analytes. The Waypoint #6 module revealed chloroform at 0.03 ug, but this constituent is a relatively common lab contaminant. The module from array Waypoint #42 revealed low levels (0.01 ug) of both TMBs ("combined masses of 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene") and 1,2,4-trimethylbenzene, alone. As all of these constituents were reported at low levels in several other survey modules, it suggests that these modules probably remained in the ground long enough to adsorb some soil gas. No other waypoint modules were disturbed prior to module retrieval.

2. A review of the Gore Final Report and accompanying contaminant plots reveals that the area of coverage for the passive soil gas array successfully bounded any evidence of contaminant sources that could potentially be contributing to plumes discovered in the CDL area from the north and west; however, plume and source delineation is incomplete to both the southeast and east. In view of this, W.L. Gore & Associates project personnel have suggested that additional survey modules could be deployed in these area and that any additional data acquired could be included with the existing project data allowing the plots to be updated. However, the most northerly survey array axis (oriented 350° magnetic) is as far east as modules could physically be installed and successfully be retrieved. It does appear possible that one additional line of modules could have been successfully installed along the 185° magnetic axis from the origin. Similarly, it appears that an additional module could have been added to each of the three axes to the east of the origin (060°, 090° and 120° magnetic, respectively) to extend the range of these axes. However, these efforts would only have added up to seven additional data points—at a significantly increased level of effort. Also, the maximum that the eastern axes could be extended would be under 50 feet. Thus, it appears very unlikely that this additional effort, if undertaken, would fully define the easternmost side of the BTEX plume that appears to intensify seaward of the survey array (BTEX plot, Appendix H), or successfully define the full extent of the PCE, TCE and cis- & trans-1,2-DCE plume, based on the size and shape that was defined by the survey performed.

5. CONCLUSIONS AND RECOMMENDATIONS

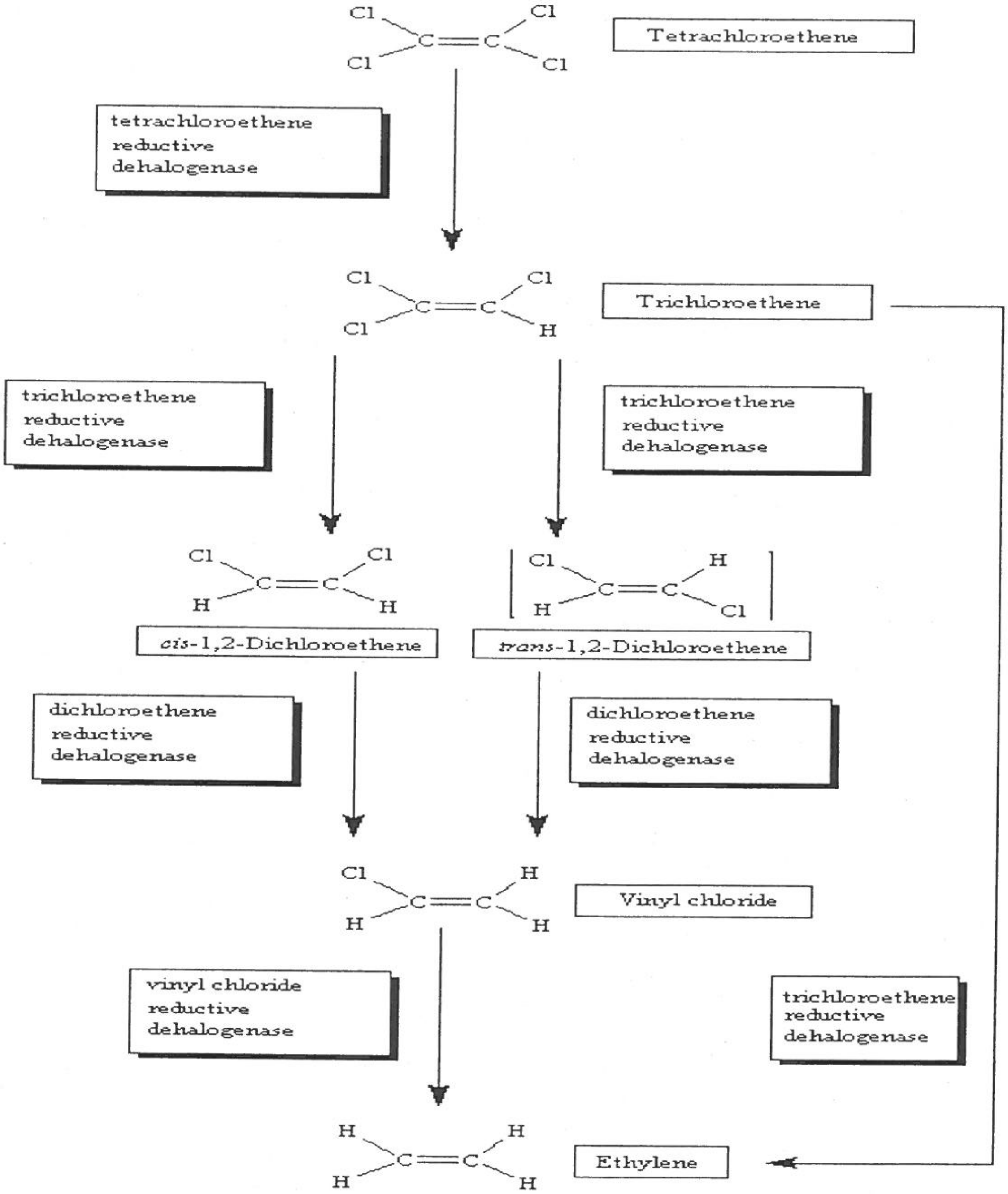
5.1. Soil Sample Interpretation

This follow-on investigation generated sufficient information to suggest that a significant portion of the source material is a distillate fuel and, probably, weathered JP-5 aviation fuel mixed with solvents. The MADEP VPH/EPH methods identified several target analytes at significantly higher levels than the EPA 8260/8270 methods used during the previous LSI work in this area. Such constituents included the following target analytes: ethylbenzene, m-and/or p-xylene, toluene, 2-methylnaphthalene, and naphthalene. Based only on the physical appearance and the readings of the field screening instrument (PID) during the LSI, the analytical values reported from those samples were lower than expected. In any case, the MADEP methods confirmed earlier detections and provided the carbon polymer data that proved useful when the EPA 8015 GC fingerprinting failed to match a known petroleum standard.

5.2 Passive Soil Gas Survey Interpretation

The passive soil gas survey produced enough data to produce definitive plots of several significant contaminants, none of which appear to be coming into the area from elsewhere on the WFF. As such, it is very likely that the contaminants discovered and plotted were the result of historic dumping of fuel and solvents related to aircraft operations and maintenance. While the plots support an interpretation of dumping, additional information will need to be acquired before any conclusions can be reached as to whether removable contamination sources, such as drums, are present in the area. This will probably take exploratory work that could involve excavation and/or geophysical investigation. The presence of the CDL within a potential Historic Area of High Sensitivity (Figure 5) will have to be considered as future investigations are being planned.

Specifically, the most mobile of the contaminants, BTEX and Benzene, appear to have migrated downgradient and offshore from the probable location of the original dumping—either the CDL or the former excavation area to the north of it. This migration of the plumes has occurred in the direction of groundwater flow. Given the measured levels of tetrachloroethene (PCE) and associated daughter (decay) products at locations very close to the center of the current plumes, the fact that these plumes are close to the mudflats and moving offshore and through an area where no wells or homes are located or envisioned, the current contaminant levels are probably low enough not to be considered a significant human health risk. This preliminary conclusion does not consider potential bioaccumulation and food chain impacts associated with the offshore estuary environment, but it does reflect consideration of the measured contaminant values generated during the earlier LSI sampling in this area, including sampling for VOCs, SVOCs, pesticides, explosives, and metals. It is also significant to note that, even though the levels of the solvent related contamination are low, the presence of the daughter products (see degradation graphic, below) suggests the possibility that this solvent has been in the environment long enough for some degradation to take place. Additionally, the presence of these compounds provides some evidence that the environment may be conducive to at least some level of in-situ decay contributing to natural attenuation of some of the source material. As the time of exposure of the fuel and solvent to the environment is unknown, no estimates can be made regarding the rate of biodegradation or the efficiency of natural processes. The data from this investigation, however, does suggest that some level of degradation may be taking place, as shown in the following graphic.



5.3 Conclusions

This follow-on investigation of the Former CDL area has produced enough information to help direct future planning efforts in that probable source materials have been identified, excluding many WFF sources that previously had to be considered as potential candidates for the contamination. However, this investigation also demonstrated that contamination is moving offshore to the east of WFF and the level of impact to the east now has to be considered and evaluated. The levels of BTEX compounds require additional investigation to determine whether human health and ecologic impacts exist. Any continuing impact to low levels of solvent-related compounds is likely to be only ecologic in nature. Given the combination of data collected during both the previous LSI and this follow-on investigation, Norfolk District believes the knowledge of this Area of Concern is sufficient to move on to a Remedial Investigation as the next step in the investigative process.

6. REFERENCES

Accutest Laboratories: *Technical Report to USACE-Norfolk District: NASA Wallops FF – Passive Soil Gas Investigation, Accomack City (sic), VA*. April 22, 2004.

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W.L. Gore & Associates, Inc. Survey Products Group, *Gore Survey for Site Assessment Final Report, NASA Wallops Flight Facility, Accomack County, VA*. April 19, 2004.

FIGURES

APPENDICES

Appendix A.	Soil and Groundwater Analytical Results for Samples Collected in the CDL Area during the August 2002 LSI Sampling Event.
Appendix B.	Photographs of Contamination Discovered at SB-CDL-01 Location.
Appendix C.	Dig Permit issued by WFF for Soil Gas Investigation.
Appendix D.	Thompson, Tim. Memo: *Preliminary Archaeological Reconnaissance of Mosquito Point, NASA Wallops Island, VA*, March 26, 2004.
Appendix E.	Chain-of-Custody Documentation for the IDW generated during the collection of the March 23, 2004 Soil Sample
Appendix F.	Chain-of-Custody Documentation for the March 23, 2004 Soil Sample.
Appendix G.	Passive Soil Gas Module Installation /Retrieval Procedures.
Appendix H.	Gore$^{\text{TM}}$ Survey for Site Assessment; Final Report, April 19, 2004, NASA Wallops Flight Facility, Accomack County, VA.W.L. Gore Report.
Appendix I.	Accutest Laboratories Technical Report to USACE-Norfolk District; NASA Wallops FF – Passive Soil Gas Investigation, 22 April 2004, Accomack County, VA. Accutest Job Number: N62849; Sampling Date: 03/23/04.
Appendix J.	Accutest Laboratories: 8015 GC Chromatogram (06 April 2004 Quantitation Report) for Laboratory ID# N62849-1 (04SGI-CDL-SB01-07 soil sample) and interpretation provided by Mr. David Speis.
Appendix K.	Petroleum GC Standards. Accutest Laboratories File: C:\HPCHEM\1\ DATA\ GCFING~1\YZ3*. The JP-5 Chromatogram is C:\HPCHEM\ 1\ DATA\ GCFING~1\yz32070.D.
Appendix L.	MADEP EPH and VPH Method Descriptions.

FIGURES

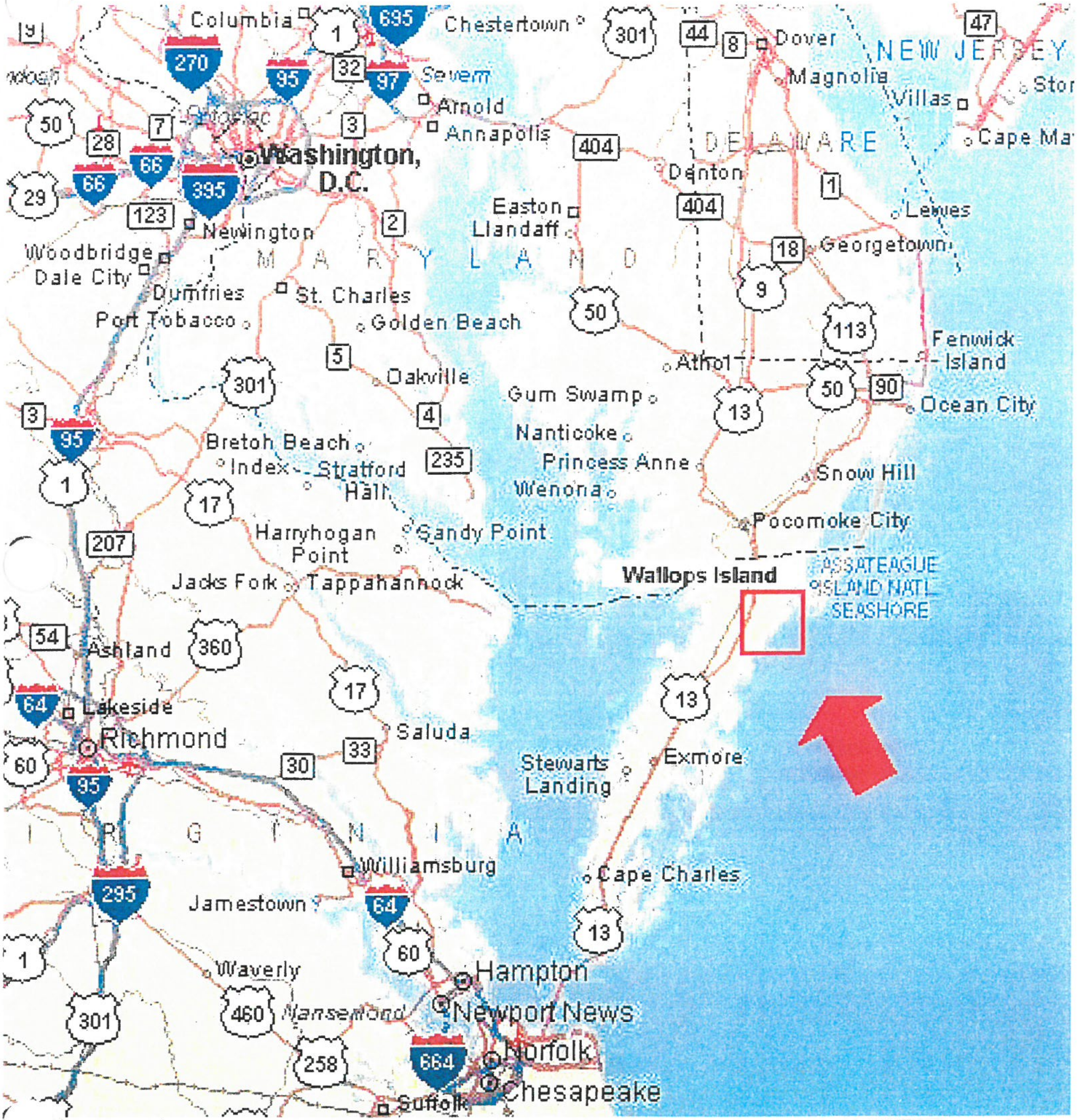

Figure 1: Location of NASA Wallops Flight Facility (WFF) on Virginia's Eastern Shore

Notes: NAD 1983 UTM Zone 18N
Aerial Photo taken 10/5/1959

US Army Corps of Engineers.

SAIC. An Employee-Owned Company

CONSTRUCTION DEBRIS LANDFILL
SITE LOCATION MAP

WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA

PROJECT: \GIS_DATA\Wallops\Projects\General\Wallops_CDL_Location_Map.mxd

FIGURE: 5.4-1 DATE: 11/06/02

Figure 2a: 1949 Ground Features in Vicinity of Approach End of WFF Runway 22

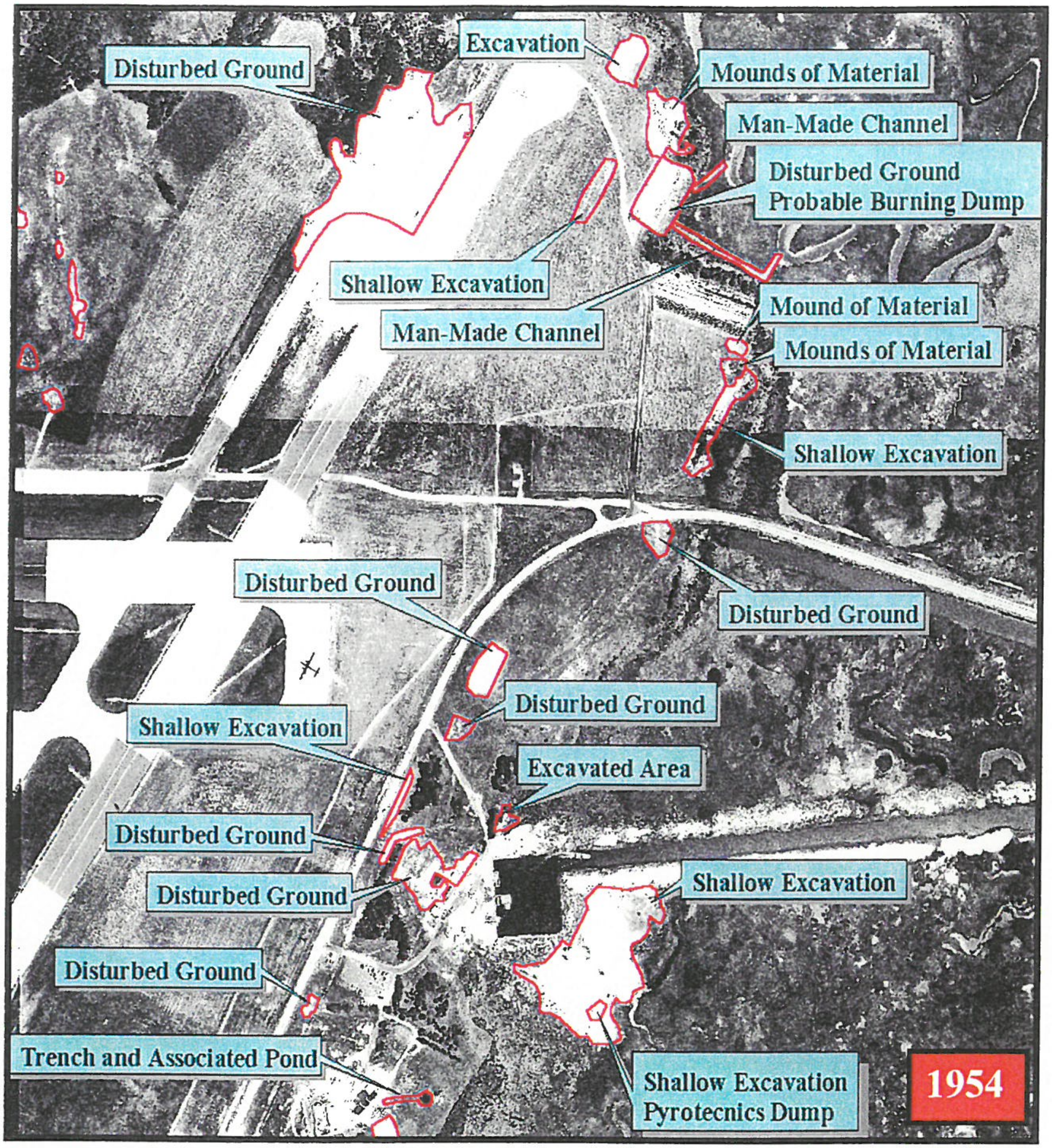

Figure 2b: Identified Ground Features in 1954 Aerial of WFF Runway 22 Area.

Figure 2c: Identified Ground Features in 1959 Aerial of WFF Runway 22 Area.

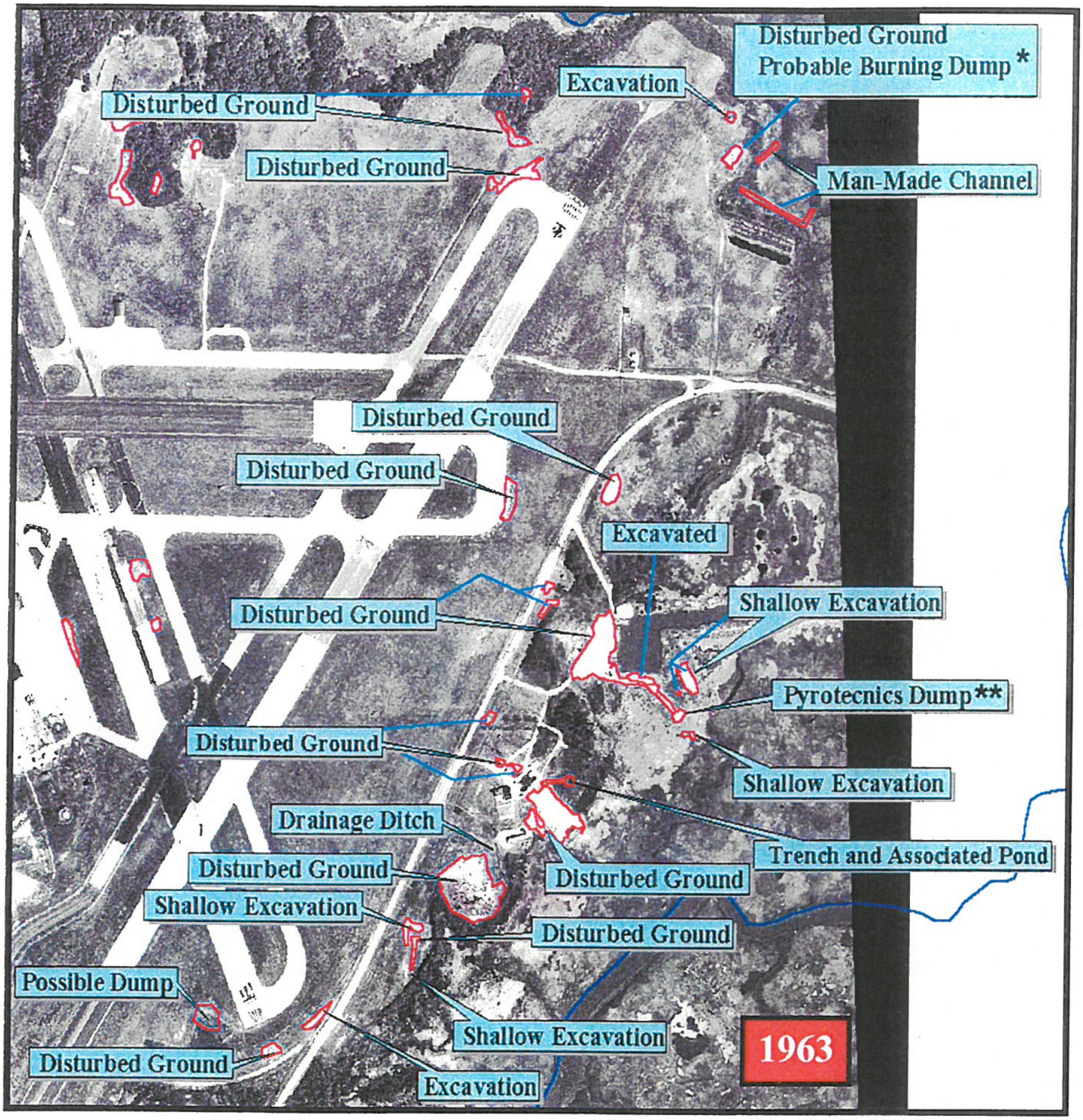

Figure 2d: Identified Ground Features in 1963 Aerial of WFF Runway 22 Area.

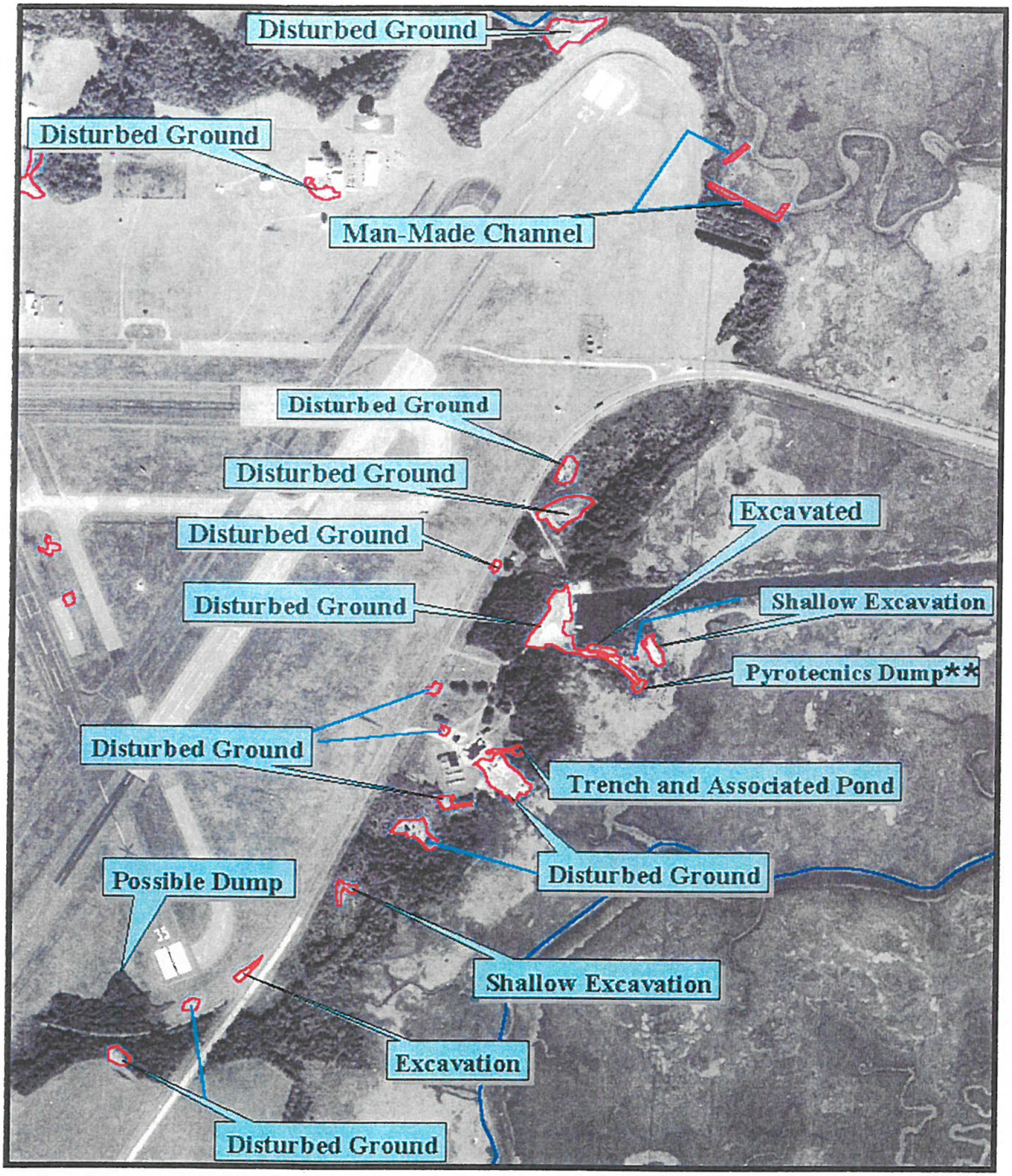

Figure 2e: 1974 Aerial of WFF Showing Little Evidence of Former Ground Disturbances in Areas to the East of the Approach End of Runway 22.

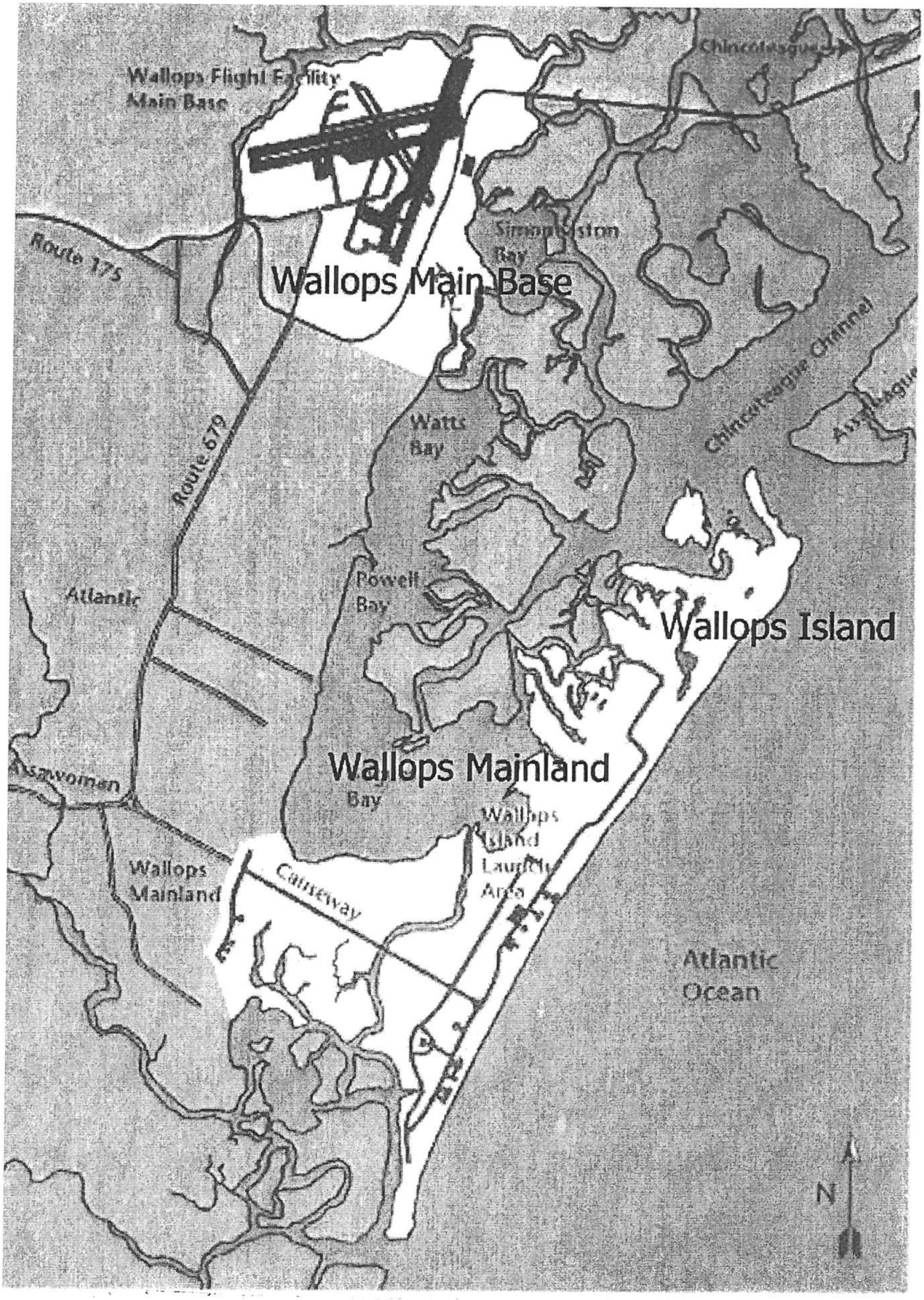

Figure 3: Water Bodies Surrounding WFF.

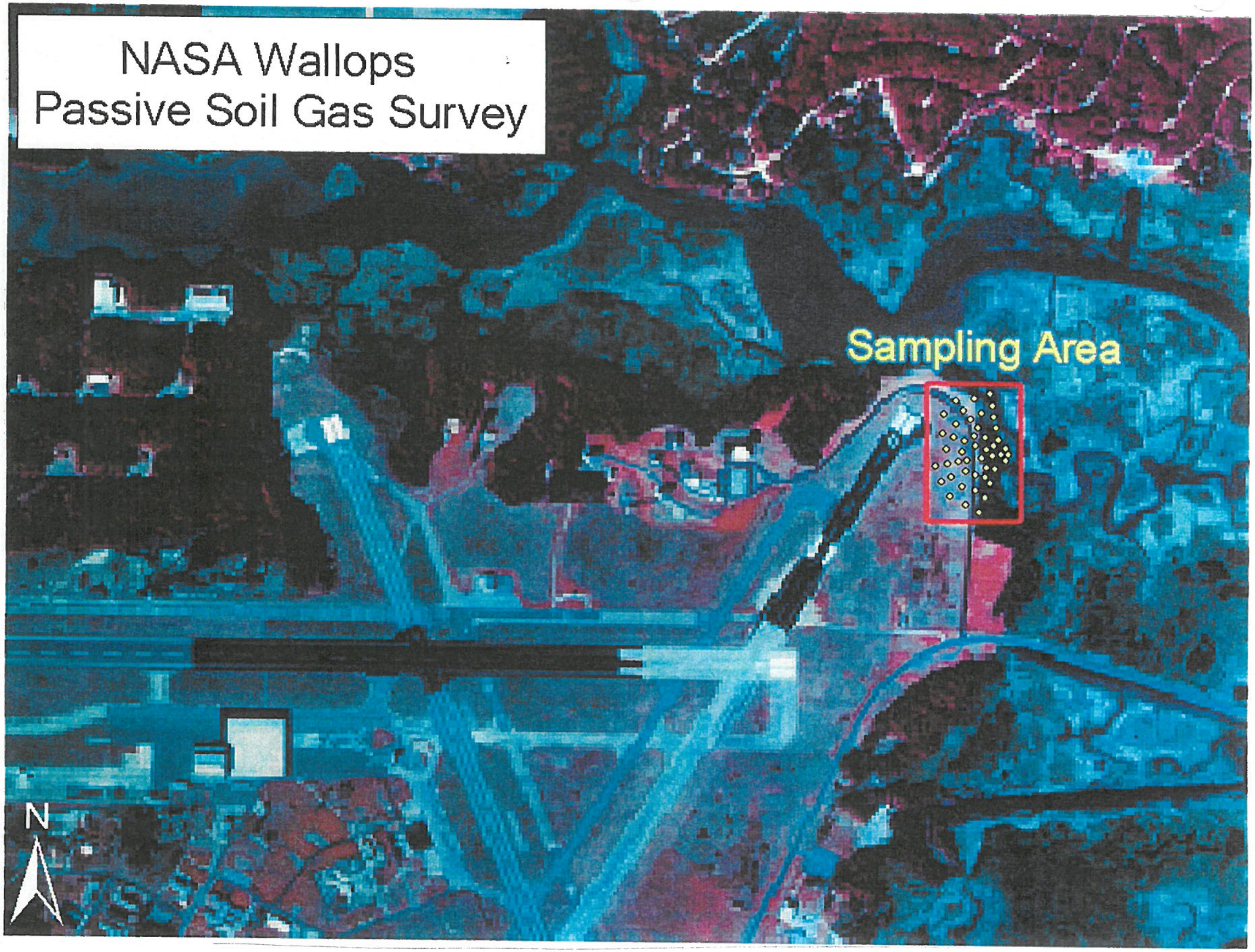

Figure 4: Construction Debris Landfill Site Location Diagram

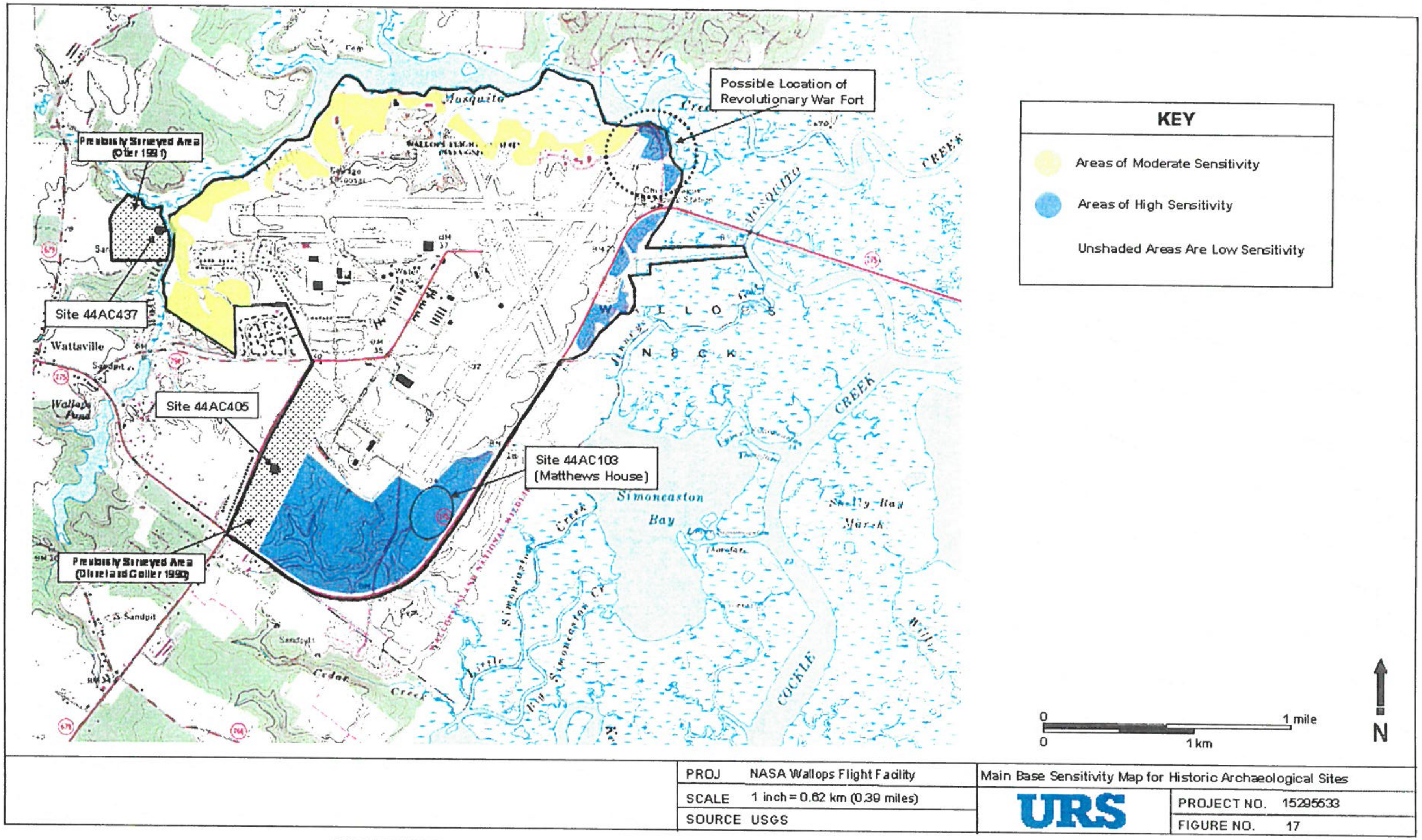

Figure 5: Figure 17, Cultural Resources Assessment report, November 2003, URS Group

GORE-SORBER® Module Installation Schematic

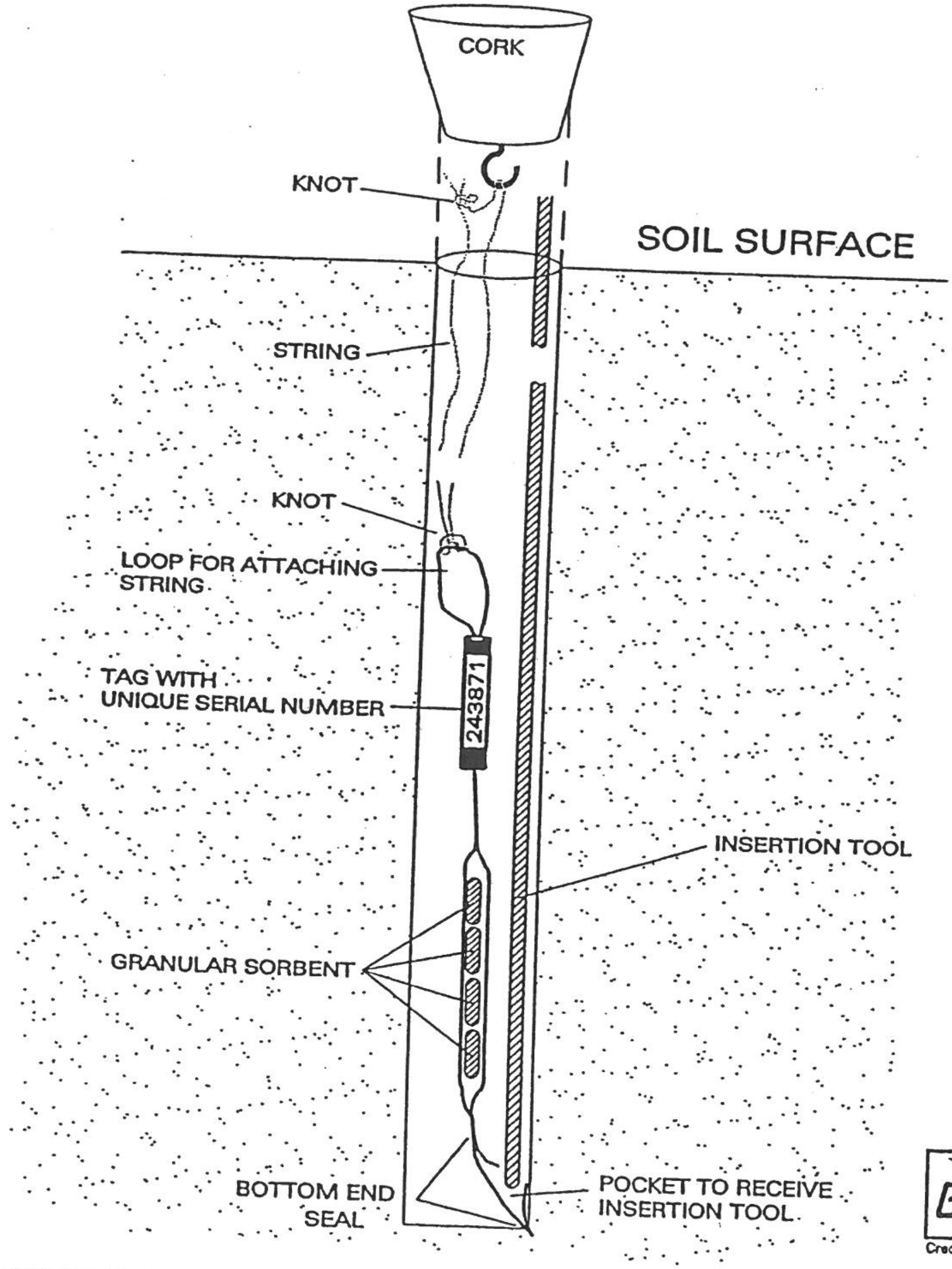

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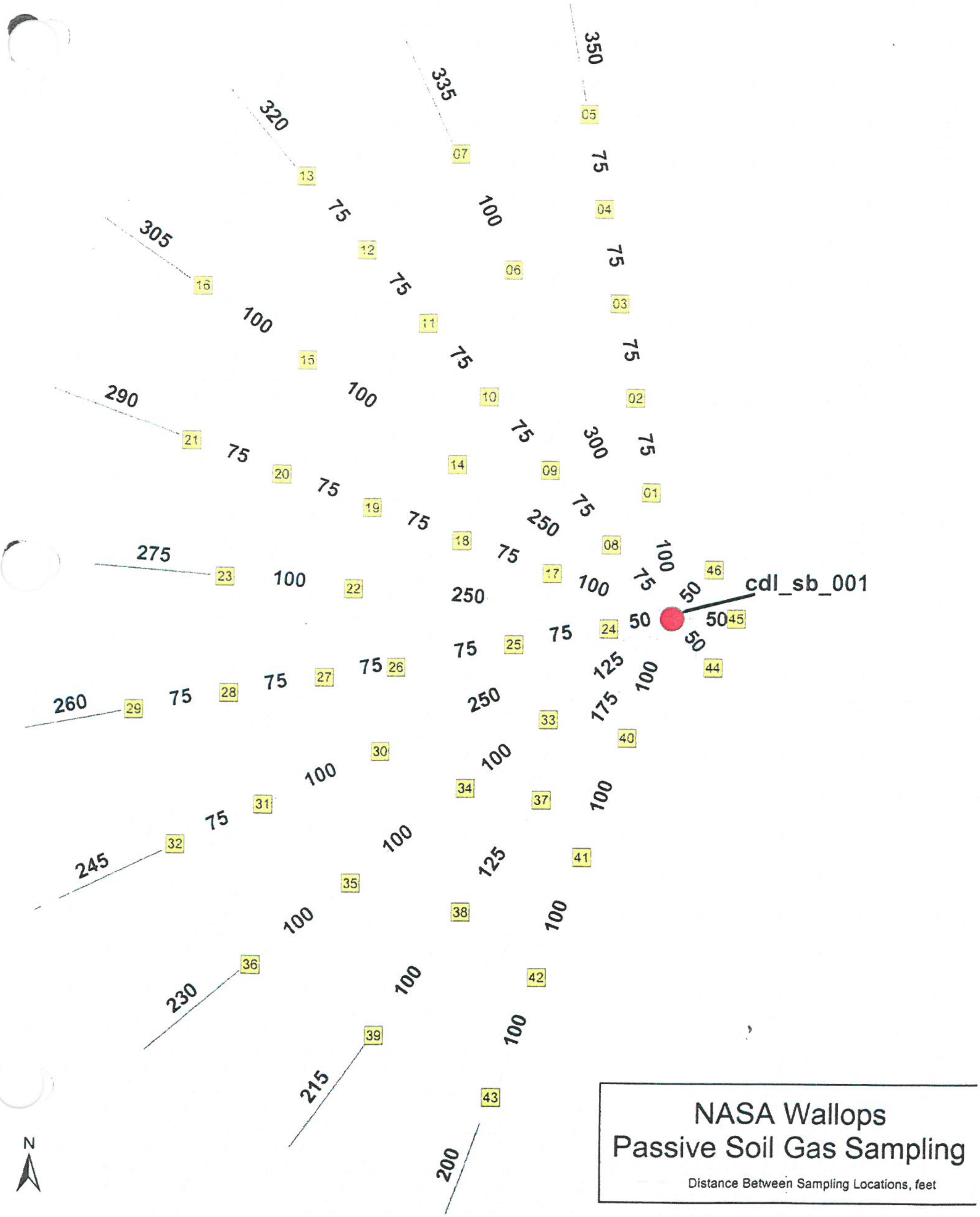
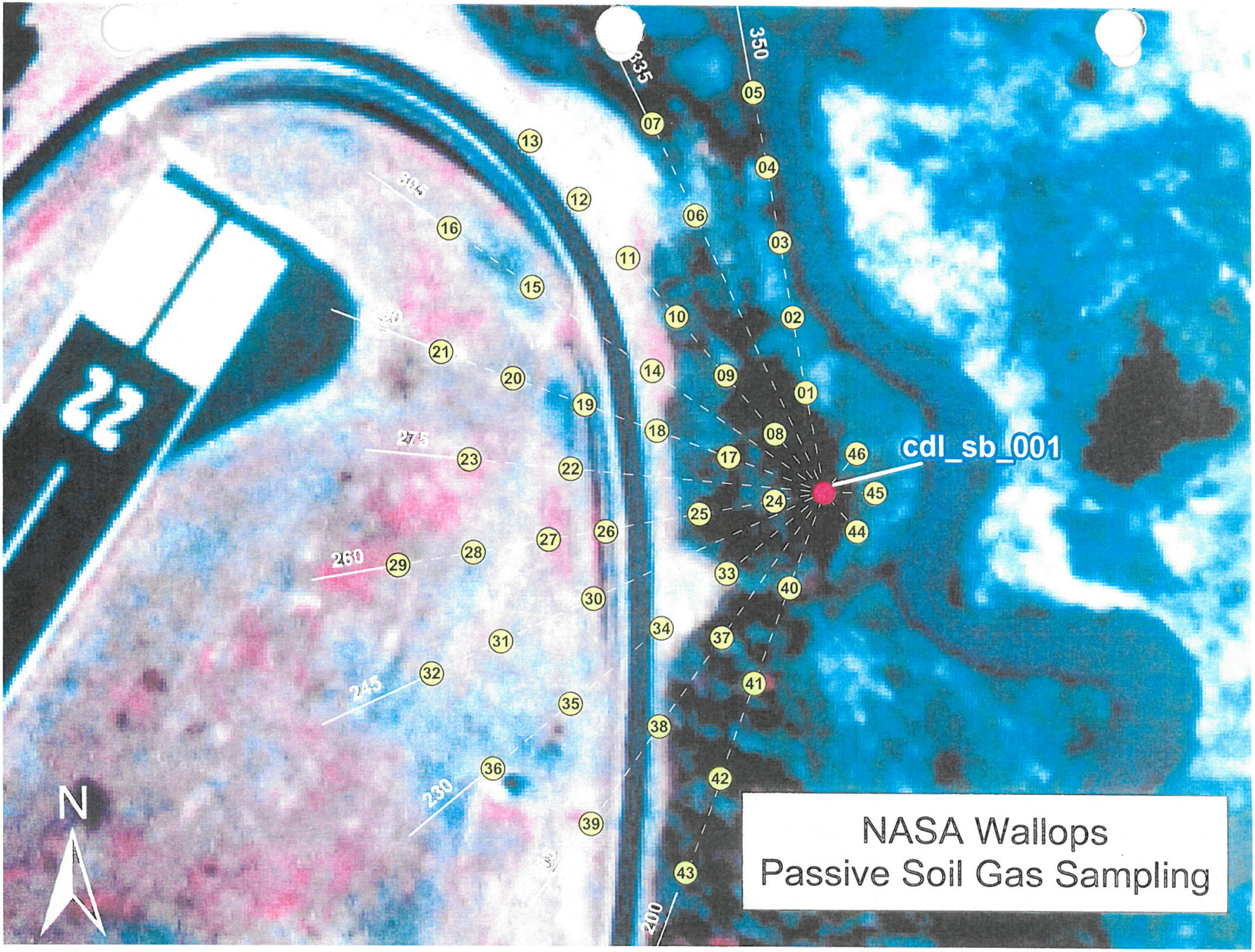
Figure 6: Gore-Sorber® Module Installation Schematic

Figure 7: Module Layout (Azimuth and Distances from Origin) Diagram





NASA Wallops
Passive Soil Gas Sampling

APPENDICES

Appendix A.	**Soil and Groundwater Analytical Results for Samples Collected in the CDL Area during the August 2002 LSI Sampling Event.**
Appendix B.	**Photographs of Contamination Discovered at SB-CDL-01 Location.**
Appendix C.	**Dig Permit issued by WFF for Soil Gas Investigation.**
Appendix D.	**Thompson, Tim. Memo: *Preliminary Archaeological Reconnaissance of Mosquito Point, NASA Wallops Island, VA*, March 26, 2004.**
Appendix E.	**Chain-of-Custody Documentation for the IDW generated during the collection of the March 23, 2004 Soil Sample**
Appendix F.	**Chain-of-Custody Documentation for the March 23, 2004 Soil Sample.**
Appendix G.	**Passive Soil Gas Module Installation /Retrieval Procedures.**
Appendix H.	**Gore^{TM} Survey for Site Assessment; Final Report, April 19, 2004, NASA Wallops Flight Facility, Accomack County, VA.W.L. Gore Report.**
Appendix I.	**Accutest Laboratories Technical Report to USACE-Norfolk District; NASA Wallops FF – Passive Soil Gas Investigation, 22 April 2004, Accomack County, VA. Accutest Job Number: N62849; Sampling Date: 03/23/04.**
Appendix J.	**Accutest Laboratories: 8015 GC Chromatogram (06 April 2004 Quantitation Report) for Laboratory ID# N62849-1 (04SGI-CDL-SB01-07 soil sample) and interpretation provided by Mr. David Speis.**
Appendix K.	**Petroleum GC Standards. Accutest Laboratories File: C:\HPCHEM\1\ DATA\ GCFING~1\YZ3*. The JP-5 Chromatogram is C:\HPCHEM\ 1\ DATA\ GCFING~1\yz32070.D.**
Appendix L.	**MADEP EPH and VPH Method Descriptions.**

Table 5.4-5. Data Summary: Soil Boring Results, Construction Debris Landfill
Wallops Flight Facility, Accomack County, Virginia

Site ID			SB-CDL-01	SB-CDL-01	SB-CDL-02	SB-CDL-02	SB-CDL-02	SB-CDL-03	SB-CDL-03
Field Sample Number			SAIC01	SAIC02	SAIC01	SAIC01D	SAIC02	SAIC01	SAIC02
Site Type			BORE	BORE	BORE	BORE	BORE	BORE	BORE
Collection Date			08/07/02	08/07/02	08/07/02	08/07/02	08/07/02	08/07/02	08/07/02
Depth (ft)			6.50	9.00	0.00	0.00	7.00	0.00	4.00
METALS(6010)									
Parameter	Units	RL							
Aluminum	MG/KG	20	7170	4140	29100	31200	6770	44400	11000
Antimony	MG/KG	0.6	0.21 UJ	0.22 UJ	1.2 UJ	1.7 UJ	0.24 UJ	23.5 J	3.4 UJ
Arsenic	MG/KG	1	1.6	0.54 B	6 B	6.9 B	1.9	5.3 B	6.9
Barium	MG/KG	20	15.9	6.2	371	325	30.6	240	55.3
Beryllium	MG/KG	0.5	0.17	0.15	0.41 B	0.4 B	0.34	0.4 B	0.28
Cadmium	MG/KG	0.5	0.03 B	0.02 U	25.9	29.7	0.04 B	23.9	4.9
Calcium	MG/KG	100	3480	546	2940	2710	626	1750	871
Chromium	MG/KG	1	7.6	3.7	26.8	29.7	6.7	53	19.7
Cobalt	MG/KG	5	1.3	1.2	3	3.8	1.6	3.6	4.3
Copper	MG/KG	1	3.5	1.5 U	1110	1240	2.5	2660	155
Iron	MG/KG	10	3740	2100	7740	34300	4420	10700	39200
Lead	MG/KG	0.3	9.8	12.4	266	253	4	947	141
Magnesium	MG/KG	100	288	134	1450	1390	660	1950	843
Manganese	MG/KG	1.5	30.8	6.7	407	642	45.3	387	185
Nickel	MG/KG	1	4.2 J	2.2 J	10.8 J	12.7 J	3.9 J	110 U	15.4 J
Potassium	MG/KG	100	179	99	565	518	255	389	387
Selenium	MG/KG	0.5	0.23 B	0.22 U	1.2 U	1.3 B	0.37 B	2 B	1 B
Silver	MG/KG	1	0.05 U	0.05 U	0.29 U	0.33 B	0.06 U	16.8	1.6
Sodium	MG/KG	100	73.5 UJ	62.4 UJ	163 UJ	113 UJ	76.4 UJ	150 UJ	39.6 UJ
Thallium	MG/KG	1	0.47 U	0.49 U	2.8 U	2.8 U	0.53 U	2.7 U	1.4 B
Vanadium	MG/KG	5	7.5	3.9	14.1	14.7	9.7	13.2	15.6
Zinc	MG/KG	2	14.5	3.2	1400	1420	15.9	1030	258
METALS(7471)									
Parameter	Units	RL							
Mercury	MG/KG	0.1	0.04	0.02 U	0.33	0.08	0.02 B	0.32	0.04
SEMIVOLATILE ORGANIC COMPOUNDS(8270)									
Parameter	Units	RL							
2-Methylnaphthalene	ug/kg	330	370 U	2500	360 U	360 U	400 U	380 U	410 U
Acenaphthene	ug/kg	330	72 J	400 U	360 U	360 U	400 U	380 U	410 U
Anthracene	ug/kg	330	150 J	400 U	360 U	360 U	400 U	380 U	410 U
Benzo(a)anthracene	ug/kg	330	270 J	400 U	360 U	360 U	400 U	380 U	410 U
Benzo(a)pyrene	ug/kg	330	220 J	400 U	360 U	360 U	400 U	37 J	410 U
Benzo(b)fluoranthene	ug/kg	330	260 J	400 U	360 U	360 U	400 U	380 U	410 U
Benzo(g,h,i)perylene	ug/kg	330	150 J	400 U	360 U	360 U	400 U	380 U	410 U
Benzo(k)fluoranthene	ug/kg	330	94 J	400 U	360 U	360 U	400 U	380 U	410 U
bis(2-Ethylhexyl)phthalate	ug/kg	330	370 U	400 U	360 U	25 J	400 U	65 J	410 U
Carbazole	ug/kg	330	79 J	400 U	360 U	360 U	400 U	380 U	410 U
Chrysene	ug/kg	330	210 J	400 U	360 U	360 U	400 U	380 U	410 U
Dibenzofuran	ug/kg	330	44 J	400 U	360 U	360 U	400 U	380 U	410 U
Di-n-butyl phthalate	ug/kg	330	370 U	400 U	360 U	360 U	400 U	380 U	410 U
Fluoranthene	ug/kg	330	430	400 U	360 U	360 U	400 U	380 U	410 U
Fluorene	ug/kg	330	78 J	95 J	360 U	360 U	400 U	380 U	410 U
Indeno(1,2,3-cd)pyrene	ug/kg	330	110 J	400 U	360 U	360 U	400 U	380 U	410 U
Naphthalene	ug/kg	330	55 J	830	360 U	360 U	400 U	380 U	410 U

Table 5.4-5. Data Summary: Soil Boring Results, Construction Debris Landfill Wallops Flight Facility, Accomack County, Virginia (continued)

Site ID			SB-CDL-01	SB-CDL-01	SB-CDL-02	SB-CDL-02	SB-CDL-02	SB-CDL-03	SB-CDL-03
Field Sample Number			SAIC01	SAIC02	SAIC01	SAIC01D	SAIC02	SAIC01	SAIC02
Site Type			BORE	BORE	BORE	BORE	BORE	BORE	BORE
Collection Date			08/07/02	08/07/02	08/07/02	08/07/02	08/07/02	08/07/02	08/07/02
Depth (ft)			6.50	9.00	0.00	0.00	7.00	0.00	4.00
Phenanthrene	ug/kg	330	**530**	**63** J	360 U	360 U	400 U	380 U	410 U
Pyrene	ug/kg	330	**510**	400 U	360 U	360 U	400 U	380 U	410 U
VOLATILE ORGANIC COMPOUNDS(8260)									
Parameter	Units	RL							
1,2-Dichloropropane	ug/kg	5	5.5 U	**2000** J	6 U	6.4 U	4.8 U	9.5 U	5.7 U
Acetone	ug/kg	10	12 U	**4100** UJ	36 U	55 U	9.5 U	55 U	15 U
Carbon disulfide	ug/kg	5	5.5 U	2100 U	6 U	6.4 U	4.8 U	9.5 U	5.7 U
Chloromethane	ug/kg	5	5.5 U	2100 U	6 U	6.4 U	4.8 U	**87**	5.7 U
Ethylbenzene	ug/kg	5	5.5 U	**12000** J	6 U	6.4 U	4.8 U	9.5 U	5.7 U
m-and/or p-Xylene	ug/kg	5	5.5 U	**9600** J	6 U	6.4 U	4.8 U	9.5 U	5.7 U
Methylene Chloride	ug/kg	5	5.6 U	2200 U	6 U	6.4 U	4.8 U	9.7 UJ	5.7 U
Tetrachloroethene	ug/kg	5	5.5 U	**1100** J	6 U	6.4 U	4.8 U	9.5 U	5.7 U
Trichloroethene	ug/kg	5	5.5 U	2100 U	6 U	6.4 U	4.8 U	9.5 U	5.7 U

Table 5.4-5. Data Summary: Soil Boring Results, Construction Debris Landfill Wallops Flight Facility, Accomack County, Virginia (continued)

Footnotes:

B – Metals: Reported value was less than the contract required detection limit but greater than or equal to the instrument detection limit.
B – Organics: Analyte was found in the associated method blank. Validation of the data did not result in this compound being qualified as nondetect due to blank contamination. Therefore this result is considered to be site related.
D - The value for the target analyte was calculated from a dilution.
E - Metals: The reported value is estimated because of the presence of interferents.
E - Organics: Concentration range exceeded for this analyte.
J – Value is estimated.
N - Metals: Spiked sample recovery not within control limits.
N - Organics: Tentatively identified compound based on mass spectral library search.
P - There is greater than 25% difference for detected concentrations between the two GC columns for the associated pesticide/PCB target analyte.
R – Value is rejected.
U – Compound was analyzed for but not detected.
UJ - Compound was analyzed for but not detected and is considered an estimate.
X - The mass spectrum does not meet EPA CLP criteria for confirmation, but compound presence is strongly suspected.
* - Duplicate analysis not within control limits.
N/A – Compound not analyzed for.
NF – Data not found.
RL – Reporting Limit for each method. For SW846 methods, the samples are reported down to the method detection limits (MDL). For metals, the samples are reported down to the instrument detection limit (IDL).
MDL – Method Detection Limit.
SAICXXR – An SAIC field sample number followed by an "R" designates a recollected sample.

Table 5.4-6. Data Summary: Groundwater Results, Construction Debris Landfill Wallops Flight Facility, Accomack County, Virginia

Site ID			HP-CDL-01		HP-CDL-02		HP-CDL-03	
Field Sample Number			SAIC01		SAIC01		SAIC01	
Site Type			PNCH		PNCH		PNCH	
Collection Date			08/07/02		08/07/02		08/07/02	
Depth (ft)			10.00		8.00		4.00	
METALS(6010)								
Parameter	Units	RL						
Arsenic	ug/L	10	12.7	U	3.4	U	3.4	U
Barium	ug/L	200	**28**		**18.7**		**316**	
Cadmium	ug/L	5	**0.35**	B	0.3	U	0.3	U
Calcium	ug/L	1000	**17000**		**33600**		**54000**	
Chromium	ug/L	10	1.3	U	1.3	U	**3.4**	B
Copper	ug/L	10	2.2	U	5.6	U	3	U
Iron	ug/L	100	**28600**		24.3	U	**359**	
Lead	ug/L	3	**13.6**		1.6	U	1.6	U
Magnesium	ug/L	1000	**1110**		**8500**		**6210**	
Manganese	ug/L	15	**791**		**105**		**451**	
Nickel	ug/L	10	1.1	U	1.1	U	**14.3**	
Potassium	ug/L	1000	**2220**		**2360**		**4300**	
Sodium	ug/L	1000	**9040**		**9670**		**9530**	
Vanadium	ug/L	50	**3.1**	B	**0.79**	B	0.7	U
Zinc	ug/L	20	9.3	U	4.5	U	**87.4**	
SEMIVOLATILE ORGANIC COMPOUNDS(8270)								
Parameter	Units	RL						
2,4-Dimethylphenol	ug/L	10	**10.4**	J	14	U	13	U
2-Methylnaphthalene	ug/L	10	**49**		14	U	13	U
2-Methylphenol	ug/L	10	**27**		14	U	13	U
4-Methylphenol	ug/L	10	**46**		14	U	13	U
Naphthalene	ug/L	10	**120**		14	U	13	U
VOLATILE ORGANIC COMPOUNDS(8260)								
Parameter	Units	RL						
Acetone	ug/L	5	5	UJ	**5.2**		5	UJ
Benzene	ug/L	1	500	UJ	**0.54**	J	1	UJ
Chloromethane	ug/L	1	**0.7**	J	1	U	1	UJ
cis-1,2-Dichloroethene	ug/L	1	**12**	J	1	U	**2.3**	J
Ethylbenzene	ug/L	1	**920**	J	1	U	1	UJ
m-and/or p-Xylene	ug/L	1	**3700**	J	1	U	1	UJ
Methylene Chloride	ug/L	1	1	UJ	2.2	UJ	2	UJ
o-xylene	ug/L	1	**1700**	J	1	U	1	UJ
Styrene	ug/L	1	**22**	J	1	U	1	UJ
Tetrachloroethene	ug/L	1	**12**	J	1	U	1	UJ
Toluene	ug/L	1	**12000**	J	**1.1**		1	UJ
Trichloroethene	ug/L	1	**1.1**	J	1	U	1	UJ

Created on 5/27/2003

Table 5.4-6. Data Summary: Groundwater Results, Construction Debris Landfill Wallops Flight Facility, Accomack County, Virginia (continued)

Footnotes:

B – Metals: Reported value was less than the contract required detection limit but greater than or equal to the instrument detection limit.
B – Organics: Analyte was found in the associated method blank. Validation of the data did not result in this compound being qualified as nondetect due to blank contamination. Therefore this result is considered to be site related.
D - The value for the target analyte was calculated from a dilution.
E - Metals: The reported value is estimated because of the presence of interferents.
E - Organics: Concentration range exceeded for this analyte.
J – Value is estimated.
N - Metals: Spiked sample recovery not within control limits.
N - Organics: Tentatively identified compound based on mass spectral library search.
P - There is greater than 25% difference for detected concentrations between the two GC columns for the associated pesticide/PCB target analyte.
R – Value is rejected.
U – Compound was analyzed for but not detected.
UJ - Compound was analyzed for but not detected and is considered an estimate.
X - The mass spectrum does not meet EPA CLP criteria for confirmation, but compound presence is strongly suspected.
* - Duplicate analysis not within control limits.
N/A – Compound not analyzed for.
NF – Data not found.
RL – Reporting Limit for each method. For SW846 methods, the samples are reported down to the method detection limits (MDL). For metals, the samples are reported down to the instrument detection limit (IDL).
MDL – Method Detection Limit.
SAICXXR – An SAIC field sample number followed by an "R" designates a recollected sample.
1,2-Dichlorobenzene; 1,3-Dichlorobenzene; 1,4-Dichlorobenzene; and 1,2,4-Trichlorobenzene - For samples analyzed prior to February 2000, these four compounds are reported as part of the semivolatile organic compound list. For samples analyzed after February 2000, these four compounds are reported as part of the volatile organic compound list.
1,2-Dichloroethene (total); Cis-1,2-Dichloroethene and Trans-1,2-Dichloroethene – For samples analyzed prior to February 2000, cis-1,2-dichloroethene and trans-1,2-dichloroethene (not 1,2-dichloroethene [total]) are reported as part of the volatile organic compound list. For samples analyzed after February 2000, 1,2-dichloroethene (total) (not cis-1,2-dichloroethene and trans-1,2-dichloroethene) is reported as part of the volatile organic compound list.

APPENDIX B: Photographs of LSI Investigation SB-CDL-01 Location

WFF: Photograph looking North with the NASA Wallops runway fence shown on left. Pathway to SB-CDL-01 boring location cut into vegetative buffer to right of white van.

View from SB-CDL-01 looking East through undergrowth. Mosquito Creek just visible (center) through opening. Land elevation drops off to mudflats about 5 yards to east of this view.

GeoProbe Soil Boring SB-CDL-01 with transition from reddish brown silty sand to contaminated black material at approximately 7.5 foot depth in 4' to 8' boring interval shown to the left. The 8' to 12' boring interval is shown to the right. The water table is within 0.5' of the visual transition—in the upper most portion of the core interval shown to the right of the photograph.

APPENDIX G: Passive Soil Gas Module (Gore A-4 Survey Module) Installation and Retrieval Procedures

MODULE INSTALLATION

To facilitate the installation of the modules, it is recommended that the cord and corks be prepared prior to going to the field. For the installation of each module, cut a piece of the supplied polypropylene cord to a length of approximately 7.0 feet or 2.25 meters. Tie the ends of the cord together using a non-slip knot (square knot is suggested - see below). This loop should be long enough to allow for an installation of three feet (one meter) into the subsurface. Pass the looped cord through the eyelet in the cork and pull it back through itself. This will attach the cord to the cork. Wrap the remainder of the cord around the cork and secure the cord/cork combination with a rubber band. The cork and cord are now ready to attach to the module after the pilot hole is created at the installation location.

Square knot instructions (see figure 1)

1. Take an end of the cord in each hand.
2. Pass the left-hand cord over the right-hand cord and wrap it around the right-hand cord.
3. Take the cord end that is now in your right hand, place it over the cord end in your left hand and wrap it around that cord.
4. Pull the cord carefully to tighten the knot.

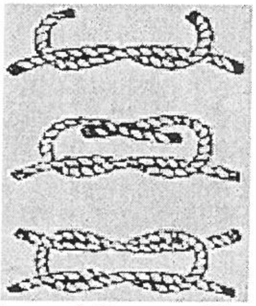


Figure 1.Square Knot

- Always obtain utility clearance before digging or probing.
- We do not recommend installation of modules within 15 feet of monitoring wells, utility trenches or other conduits, which may act as a preferential pathway for soil vapor migration.
- Drive/drill narrow pilot hole at desired pre-marked location. In sandy soils, occasionally the pilot hole will collapse after the drill or tile probe is removed. Adding deionized water to the sandy soil will temporarily compact the soil and keep the hole open for module insertion.
- Wearing clean surgical gloves, remove module from numbered container and re-seal the jar (this numbered container should correspond to the numbered module ID tag - please verify this).
- Attach the cord and cork to the module by passing the looped cord through the loop on the module and pull the cord/cork back through itself.
- Place insertion rod into the pre-cut pocket at the base of the module and lower it into the hole. If you encounter resistance, remove the module, ream the hole, and re-insert the module.

- Once deployed to the desired depth, press the insertion rod against the side of the hole and twist slightly to release the module. Remove the rod, push any excess cord into the pilot hole, and plug it with the cork. See Figure 2 for schematic of completed module installation.
- Indicate the module number, date and time of installation and any pertinent comments on the installation/retrieval log (Attachment A). Write the module serial number on the site map adjacent to the appropriate map location.
- To minimize sample location errors, it is preferable to record the GORE-SORBER Module location on the field map. However, if another sample numbering system is used, information relating the sample number system to the GORE-SORBER Module serial numbers must be provided either on the Installation and Retrieval Log, or in a separate table.
- Clean the tile probe or drill bit and the insertion rod prior to use at the next location. Replace the surgical gloves as necessary before handling any modules.
- Following module installation, the modules selected as trip blanks should be kept in the sample box provided and stored as described above in "STORAGE" until sample retrieval.

MODULE RETRIEVAL

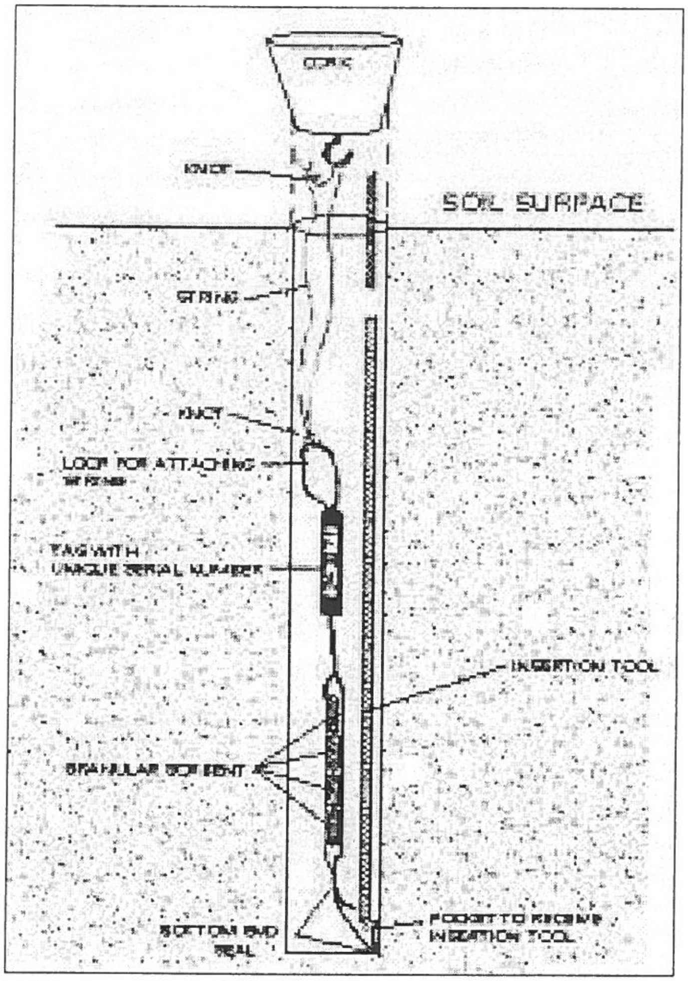
- Following the module exposure period (usually 10 - 14 days) identify and check each module location in the field using the site map.
- Remove the cork with a penknife or corkscrew. Grasp the cord and pull the module from the ground; verify the module ID number. Cut off and discard the cork and cord. Place the entire module in its labeled container and tightly secure the lid.
- Use caution when screwing down the lid on the sample jars. Be sure the seal is tight and that no part of the module or any dirt/ debris is pinched in the jar threads. Over-tightening may cause breakage.
- Replace the sample container in the box. Where possible, please attempt to keep modules in numbered sequence to expedite sample check-in and processing.
- Complete the module retrieval date/time on the installation/retrieval log.
- Do not use Styrofoam "peanuts" as packing material. Bubble packing is acceptable but no ice or cooling of samples is required or desired according to the manufacturer (Gore).
- Return the samples with insertion rod and paperwork (preferably by overnight courier) to:

Screening Modules Laboratory
W.L. Gore & Associates, Inc.
100 Chesapeake Blvd.
Elkton, MD 21921
Phone: (410) 392-7600

Attn: NOTIFY LAB IMMEDIATELY UPON SHIPPING !!

IMPORTANT: Samples should not be shipped for weekend or holiday delivery at GORE.

Figure 2. GORE-SORBER Module Installation



ACCUTEST Laboratories

CHAIN CUSTODY

2235 Rou , Dayton NJ 08810
TEL. 732-329-0200 FAX: 732-329-3499/3480
www.accutest.com

FED-EX Tracking # 824200593760	Bottle Order Control # MV - 3/17/2004 - 18
Accutest Quote #	Accutest Job #

Client / Reporting Information

Company Name: USACE - Norfolk District
Address: 803 Front Street
City: Norfolk State: VA Zip: 23510
Project Contact: George Mears E-mail:
Phone #: 757-441-7267
Sampler's Name: George Mears

Project Information

Project Name: NASA Wallops FF - Passive Soil Gas Investigation
Street:
City: Accomack Cty. State: VA
Project #: NASA Wallops F.F. Passive Gas Survey
Fax #:
Client Purchase Order #:

Accutest Sample #	Field ID / Point of Collection	SUMMA # MEOH Vial #	Collection Date	Collection Time	Collection Sampled By	Matrix	# of bottles	HCl	NaOH	HNO3	H2SO4	NONE	NaHSO4	MEOH	ENCORE	8260 ☐ 624 ☐ 8021 ☐ 602 ☐ PAUG ☐ BTEX ☐ MTBE ☐ TBA ☐ NAP ☐ PALG ☐	8260 ☐ 624 ☐ TCL ☐ PPL ☐ STARS ☐ MTBE ☐ TBA ☐ NAP ☐ +10 ☐ +15 ☐	8270 ☐ 625 ☐ TCL ☐ PPL ☐ STARS ☐ ABN ☐ BN ☐ PAH ☐ PADF ☐ +TICs ☐	MADEP VPH	MADEP EPH + GC Fingerprint Soils							LAB USE ONLY
	04 SGI - CDL - SB01 - 07'		3/23/04	1130	GM	SO	1													1							
	04 SGI - CDL - SB01 - 07'		3/23/04	1130	GM	SO	3												3								

Matrix Codes
- DW - Drinking Water
- GW - Ground Water
- WW - Water
- SW - Surface Water
- SO - Soil
- SL - Sludge
- OI - Oil
- LIQ - Other Liquid
- AIR - Air
- SOL - Other Solid
- WP - Wipe

Turnaround Time (Business Days)

☐ Std. 15 Business Days
☐ 10 Day *RUSH*
☐ 5 Day *RUSH*
☐ 3 Day *EMERGENCY*
☐ 2 Day *EMERGENCY*
☐ 1 Day *EMERGENCY*
☐ Other

Approved By: / Date:

Emergency & Rush T/A data available VIA LabLink

Data Deliverable Information

☐ Commercial "A"
☐ Commercial "B"
☐ NJ Reduced
☐ NJ Full
☐ Other _______

☐ FULL CLP
☐ NYASP Category A
☐ NYASP Category B
☐ State Forms
☐ EDD Format _______

Commercial "A" = Results Only

Comments / Remarks

Sample Custody must be documented below each time samples change possession, including courier delivery.

Relinquished by Sampler: 1 George H.	Date Time: 3/23/04 1700	Received by: 1	Relinquished by: 2	Date Time:	Received by: 2
Relinquished by: 3	Date Time:	Received by: 3	Relinquished by: 4	Date Time:	Received by: 4
Relinquished by: 5	Date Time:	Received by: 5	Custody Seal #	Preserved where applicable ☐	On Ice ☐ Cooler Temp.

DISTRIBUTION: BLUE AND YELLOW COPIES TO YARD FOREMAN - WHITE COPY TO CUSTOMER - MANILA - DRIVERS BOOK

INDUSTRIAL MARINE SERVICES, INC. FORM #102 SOLID
1301 MARSH STREET • P.O. BOX 1779
Norfolk, Virginia 23501 **S** 11876

EMERGENCY 24 HOUR telephone (757) 543-5718

DATE	TIME-IN	TIME OUT
1. 3/26/04	1300	1315

NON-NEGOTIABLE TRUCK LOADING TICKET AND BILL OF LADING

This carrier certifies that the container(s) supplied for this shipment is a proper container for the transportation of the commodity as described below.

The Shipper certifies the product is properly identified and labeled as indicated below in accordance with 49 CFR 172.101 and is not a hazardous waste according to 40 CFR 261 and VR672.10.1 (if cargo is HAZARDOUS WASTE contact HAZMAT Mgr. for Proper Manifest.)

2. JOB NUMBER	JOB NAME	JOB SUPERVISOR	WASTE CATEGORY
	Wallops Island		

3. CONSIGNED TO: Bob Real, IMS

4. CONSIGNEE G. Mears ADDRESS ACOE STATE

5. CARRIER NAME:

(*) Provide Technical Name for n.o.s. Materials

6. PRODUCT	HM	QUANTITY	PRODUCT	HM	QUANTITY
Petroleum oil, 3 NA 1270 PG III Sludge			Liquid mixed with Combustible Sorbents 3 UN 1993 PG III if Req.		
Petroleum oil, 3 NA 1270 PG III Sand			Debris		
Soil X		4lbs	Other PPE		24oz

7. RECEIVED BY DATE 3/26 TIME 1315 A.M. P.M.

8. REMARKS

9. ACCOUNTING

10. SHIPPER REPRESENTATIVE	DRIVER
George Mears (Print Name)	(Print Name)
Per (Signature)	Per (Signature)

DISTRIBUTION: WHITE AND YELLOW COPIES TO TANK FARM FOREMAN - BLUE COPY TO CUSTOMER - MANILA - DRIVERS BOOK

INDUSTRIAL MARINE SERVICES, INC. FORM #102 LIQUID
1301 MARSH STREET • P.O. BOX 1779
Norfolk, Virginia 23501 20762**L**

EMERGENCY 24 HOUR telephone (757) 543-5718

DATE	TIME-IN	TIME OUT
1. 3/26/04	1300	1315

NON-NEGOTIABLE TRUCK LOADING TICKET AND BILL OF LADING

This carrier certifies that the cargo tank supplied for this shipment is a proper container for the transportation of the commodity as described below.

The Shipper certifies the product is properly identified and labeled as indicated below in accordance with 49 CFR 172.101 and is not a hazardous waste according to 40 CFR 261 and VR672.10.1 (if cargo is HAZARDOUS WASTE contact HAZMAT Mgr. for Proper Manifest.)

2. JOB NUMBER	JOB NAME	JOB SUPERVISOR	TANK NO.
	Wallops Island		

3. CONSIGNED TO: Bob Real, IMS

4. CONSIGNEE George Mears ADDRESS ACOE STATE

5. CARRIER NAME:

(*) Provide Technical Name for n.o.s. Materials

6. PRODUCT	HM	GALLONS	PRODUCT	HM	GALLONS
Petroleum oil, n.o.s. 3 NA 1270 PG III (Flammable Liquid)(*)			Gasoline 3 UN 1203 PG II		
Petroleum oil, n.o.s. 3 NA 1270 PG III (Combustible Liquid)			Fuel oil (or) Flammable liq. n.o.s. 3 UN 1993 PG III (Flammable Liquid) (*)		
Decon water		1.5	Fuel oil (or) Combustible liq. n.o.s. 3 NA 1993 PG III (Combustible Liquid)		

7. RECEIVED BY DATE 3/26/04 TIME 1315 A.M. P.M.

8. THIS SALE NUMBER	GALLON READING FINISH	10Ths
V	V	
Λ	Λ	
THIS SALE NUMBER	GALLON READING FINISH	10Ths

9. METERED GALLONS

10. SHIPPER REPRESENTATIVE	DRIVER
George Mears (Print Name)	(Print Name)
Per (Signature)	Per (Signature)

If further investigations are indicated by the results of the gas sensors, I will need to review these, and depending on the extent of soil intrusion may need to monitor that work. Please advise me if any such activity is planned in the future and I will evaluate the situation further at that time.

Tim Thompson
Archaeologist

Memo

26 Mar 2004

From: Tim Thompson
To: File
CC: John Regan,George Mears, Shari Silbert, Sue Smead
Subject: Preliminary Archaeological Reconnaissance of Mosquito Point, NASA Wallops Island, Virginia

This provides a report of an examination of the Mosquito Point Location at the NASA Wallops Flight Facility, Virginia, by Tim Thompson, Archaeologist, Norfolk District, U.S. Army Corps of Engineers. The field visit took place on 23 and 24 March, 2004 and was done in conjunction with the placement of an array of Passive Soil Gas Sensors at the subject location. The field examination was accomplished by Thompson while assisting in the placement of an auger hole and the array of gas sensors.

This location was of particular interest because a previous environmental survey had detected the presence of contaminated soil in this area, at a depth of at least nine feet. The placement of the passive gas array was not sufficiently intrusive to constitute an effect on any archaeological resources that might be present, but the location had been identified as a location of high probability for prehistoric archaeological resources and the possible location of a Revolutionary War fortification in a Cultural Resources Assessment prepared by NASA (Cultural Resources Assessment, NASA Wallops Flight Facility, Accomack County, Virginia, November, 2003, by URS, Gaithersburg, Maryland). If further, intrusive, environmental testing or remediation were necessary, compliance measures for Section 106, National Historic Preservation Act would be necessary, and the preliminary field evaluation for archaeological resources was a prudent step in anticipation of this possibility.

The location of concern included the marshy area along the margins of Mosquito Creek, the adjacent shoreline area, which was covered with secondary natural vegetation and the graded area surrounding the end of runway 22. Although the topography suggested that the ground at the center of the array might be the remnant of an older landform -- possibly an ancient dune line -- it was clear that the entire area had been subject to extensive grading in connection with the construction of runway 22. From the shoreline of Mosquito Creek (approximately sea level) the elevation rose rapidly to the west to the elevation of the surface of the runway at 34' amsl, within the horizontal distance of approximately 100 meters. The soil profile in the auger test suggested that the entire area had been filled starting within a few feet of the shoreline, with the depth of the fill increasing dramatically to the west up to the level of the runway.

Because the soil intrusion for the placement of the gas sensors was so limited, no indications of archaeological resources could be observed. In addition, no surface indications were observed that either confirmed or disconfirmed the possible presence of a Revolutionary War fort or other archaeological resources.

*Outside fence / Noaa side first
Construction Debris Landfill Site

Location / Project ~~E10 / B129~~ Permit No. 1046-04
Monitoring Wells Request No. 7302

Excavation Permit

In accordance with the attached request, I verify that the area to be excavated is clear of underground utilities except those field marked or shown on the excavation permit drawings.

☒ Approved for digging on the following dates, 3/22 – 3/26, in accordance with the excavation procedures listed below.

Special Requirements, ________.

Robert Reynolds / 228
Jerry Wall / 228 / Alternate

☐ Not approved for digging for the following reason:

____

____

Robert Reynolds / 228
Jerry Wall / 228 / Alternate

Excavation Procedures:

1 This permit must be kept available at the excavation site for review by NASA inspectors.

2 The requester must ensure that excavators hand-dig and physically locate any underground utilities identified on the permit drawings or field located in the area of the excavation prior to starting machine excavation. Hand digging for the purpose of locating shall be perpendicular to the field marks and shall extend 24 inches on either side of the field mark. Further digging for utility locating purposes may be required by the contract COTR.

3 When appropriate, arrangements should be made with FMB to de-energize direct buried power cables.

4 The requester is responsible for ensuring that any field marks designating utilities are maintained after the excavation date stated on the excavation request.

5 Any underground utilities identified on the excavation permit sketches or in the field which are damaged through negligence by an excavation contractor are to be repaired at no cost to NASA.

Contact: Glenn Tindle x2462

Jim
Rad

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Creative Technologies Worldwide

W. L. GORE & ASSOCIATES, INC.

100 CHESAPEAKE BLVD., P.O. BOX 10 • ELKTON, MARYLAND 21922-0010 • PHONE: 410/392-7600
FAX: 410/506-4780

GORE-SORBER® EXPLORATION SURVEY
GORE-SORBER® SCREENING SURVEY

1 of 6

GORE^{TM} Survey for Site Assessment
Final Report

NASA Wallops Flight Facility
Accomack County, VA

April 19, 2004

Prepared For:
US Army Corps of Engineers, Norfolk District
803 Front Street
Norfolk, VA 23510-1096

W.L. Gore & Associates, Inc.

Written/Submitted by:
Jay W. Hodny, Ph.D., Project Specialist
Jay W. Hodny

Reviewed/Approved by:
Jim E. Whetzel, Project Manager
Jim Whetzel

Analytical Data Reviewed by:
Jim E. Whetzel, Chemist
Jim Whetzel

S:\Environmental\GORE Surveys\Projects in Progress\11787295\040419R.DOC

GORE™ Surveys for Site Assessment
Final Report

REPORT DATE: April 19, 2004 **AUTHOR:** JWH

SITE INFORMATION

Site Reference: NASA Wallops Flight Facility, Accomack County, VA
Customer Purchase Order Number: DACA65-03P-0068
Gore Production Order Number: 11787295 **Gore Site Code:** CQS

FIELD PROCEDURES

 # Modules shipped: 51
Installation Date(s): 3/24/2004 **# Modules Installed:** 47
Field work performed by: US Army Corps of Engineers, Norfolk District

Retrieval date(s): 4/7/2004 **Exposure Time:** 14 **[days]**
 # Modules Retrieved: 47 **# Trip Blanks Returned:** 4
 # Modules Lost in Field: 0 **# Unused Modules Returned:** 0

Date/Time Received by Gore: 4/12/2004 @ 12:08 PM **By:** DY
Chain of Custody Form attached: √
Chain of Custody discrepancies: None
Comments:
Modules #444420, -432, -414, and 426 were identified as trip blanks.
Module #444424 was noted as laying exposed on the Installation Log.
Module #444456 was noted as pulled from hole on the Installation Log.

GORE™ Surveys for Site Assessment Final Report

ANALYTICAL PROCEDURES

W.L. Gore & Associates′ Screening Module Laboratory operates under the guidelines of its Quality Assurance Manual, Operating Procedures and Methods. The quality assurance program is consistent with Good Laboratory Practices (GLP) and ISO Guide 25, "General Requirements for the Competence of Calibration and Testing Laboratories", third edition, 1990.

Instrumentation consists of state of the art gas chromatographs equipped with mass selective detectors, coupled with automated thermal desorption units. Sample preparation simply involves cutting the tip off the bottom of the sample module and transferring one or more exposed sorbent containers (sorbers, each containing 40mg of a suitable granular adsorbent) to a thermal desorption tube for analysis. Sorbers remain clean and protected from dirt, soil, and ground water by the insertion/retrieval cord, and require no further sample preparation.

Analytical Method Quality Assurance:
The analytical method employed is a modified EPA method 8260/8270. Before each run sequence, two instrument blanks, a sorber containing 5µg BFB (Bromofluorobenzene), and a method blank are analyzed. The BFB mass spectra must meet the criteria set forth in the method before samples can be analyzed. A method blank and a sorber containing BFB is also analyzed after every 30 samples and/or trip blanks. Standards containing the selected target compounds at three calibration levels of 5, 20, and 50µg are analyzed at the beginning of each run. The criterion for each target compound is less than 35% RSD (relative standard deviation). If this criterion is not met for any target compound, the analyst has the option of generating second- or third-order standard curves, as appropriate. A second-source reference standard, at a level of 10µg per target compound, is analyzed after every ten samples and/or trip blanks, and at the end of the run sequence. Positive identification of target compounds is determined by 1) the presence of the target ion and at least two secondary ions; 2) retention time versus reference standard; and, 3) the analyst's judgment.

NOTE: All data have been archived. Any replicate sorbers not used in the initial analysis will be discarded fifteen (15) days from the date of analysis.

Laboratory analysis: thermal desorption, gas chromatography, mass selective detection
Instrument ID: # 5 **Chemist:** KH
Compounds/mixtures requested: A4
Deviations from Standard Method: None
Comments: Soil vapor analytes and abbreviations are tabulated in the Data Table Key (page 6). Phenanthrene, anthracene, fluoranthene, and pyrene were quantified using responses from fluorene.

GORE^{TM} Surveys for Site Assessment
Final Report

DATA TABULATION

 # CONTOUR MAPS ENCLOSED: Three (3) B-sized color contour maps

LIST OF MAPS ENCLOSED:

- Benzene, Toluene, Ethylbenzene, and total Xylenes (BTEX)
- Toluene
- Tetrachloroethene, Trichloroethene, and cis- & trans-1,2-Dichloroethene (PCE, TCE, & cis- & trans-1,2-DCE)

NOTE: All data values presented in Appendix A represent masses of compound(s) desorbed from the GORE^{TM} Modules received and analyzed by W.L. Gore & Associates, Inc., as identified in the Chain of Custody (Appendix A). The measurement traceability and instrument performance are reproducible and accurate for the measurement process documented. Semi-quantitation of the compound mass is based on either a single-level (QA Level 1) or three-level (QA Level 2) standard calibration.

General Comments:

- This survey reports soil gas mass levels present in the vapor phase. Vapors are subject to a variety of attenuation factors during migration away from the source concentration to the module. Thus, mass levels reported from the module will often be less than concentrations reported in soil and groundwater matrix data. In most instances, the soil gas masses reported on the modules compare favorably with concentrations reported in the soil or groundwater (e.g., where soil gas levels are reported at greater levels relative to other sampled locations on the site, matrix data should reveal the same pattern, and vice versa). However, due to a variety of factors, a perfect comparison between matrix data and soil gas levels can rarely be achieved.
- Soil gas signals reported by this method cannot be identified specifically to soil adsorbed, groundwater, and/or free-product contamination. The soil gas signal reported from each module can evolve from all of these sources. Differentiation between soil and groundwater contamination can only be achieved with prior knowledge of the site history (i.e., the site is known to have groundwater contamination only).
- QA/QC trip blank modules were provided to document potential exposures that were not part of the soil gas signal of interest (i.e., impact during module shipment, installation and retrieval, and storage). The trip blanks are identically manufactured and packaged soil gas modules to those modules placed in the subsurface. However, the trip blanks remain unopened during all phases of the soil gas survey. Levels reported on the trip blanks may indicate potential impact to modules other than the contaminant source of interest.

- Unresolved peak envelopes (UPEs) are represented as a series of compound peaks clustered together around a central gas chromatograph elution time in the total ion chromatogram. Typically, UPEs are indicative of complex fluid mixtures that are present in the subsurface. UPEs observed early in the chromatogram are considered to indicate the presence of more volatile fluids, while UPEs observed later in the chromatogram may indicate the presence of less volatile fluids. Multiple UPEs may indicate the presence of multiple complex fluids.
- Stacked total ion chromatograms (TICs) are included in Appendix A. The six-digit serial number of each module is incorporated into the TIC identification (e.g.: <u>123456</u>S.D represents module #<u>123456</u>).

Project Specific Comments:

- The minimum (gray) contour level, for each mapped analyte or group of analytes, was set at the maximum blank level observed or the method detection limit, whichever was greater. When target compounds are summed together (i.e., BTEX), the contour minimum is arbitrarily set at 0.02 μg or the maximum blank level, whichever is greater. The maximum contour level was set at the maximum value observed.
- No target compounds were detected on the trip blanks and/or the method blanks. Thus, target analyte levels reported for the field-installed modules that exceed trip and method blank levels, and the analyte method detection limit, are more likely to have originated from on-site sources.
- Elevated levels of benzene and PCE were observed. The mapped spatial patterns indicated isolated "hot spots" for the compounds selected for mapping. A fairly well-defined soil gas plume was observed when the chlorinated compounds were summed together and contoured (PCE, TCE, and c,t-1,2-DCE).
- If the objective of the soil gas survey was to delineate the nature and extent of the contamination, then additional soil gas sampling is recommended in those areas where the color contours appear to extend into unsampled areas. Subsequent sampling events can be combined with the data from this event and mapped together to provide greater coverage.

GORE^{TM} Surveys for Site Assessment
Final Report

KEY TO DATA TABLE
NASA Wallops Flight Facility, Accomack County, VA

UNITS	
µg	micrograms (per sorber), reported for compounds
MDL	method detection limit
bdl	below detection limit
nd	non-detect
ANALYTES	
BTEX	combined masses of benzene, toluene, ethylbenzene and total xylenes (Gasoline Range Aromatics)
BENZ	benzene
TOL	toluene
EtBENZ	ethylbenzene
mpXYL	m-, p-xylene
oXYL	o-xylene
C11,C13&C15	combined masses of undecane, tridecane, and pentadecane (C11+C13+C15) (Diesel Range Alkanes)
UNDEC	undecane
TRIDEC	tridecane
PENTADEC	pentadecane
TMBs	combined masses of 1,3,5-trimethylbenzene and 1,2,4-trimethylbenzene
135TMB	1,3,5-trimethylbenzene
124TMB	1,2,4-trimethylbenzene
ct12DCE	cis- & trans-1,2-dichloroethene
t12DCE	trans-1,2-dichloroethene
c12DCE	cis-1,2-dichloroethene
NAPH&2-MN	combined masses of naphthalene and 2-methyl naphthalene
Combined PAHs	combined masses of naphthalene, 2-methyl naphthalene, acenaphthene, acenaphthylene, fluorene, phenanthrene, anthracene, fluoranthene, and pyrene.
NAPH	naphthalene
2MeNAPH	2-methyl naphthalene
MTBE	methyl t-butyl ether
PHEN	phenanthrene
11DCA	1,1-dichloroethane
$CHCl_3$	chloroform
111TCA	1,1,1-trichloroethane
12DCA	1,2-dichloroethane
CCl_4	carbon tetrachloride
TCE	trichloroethene
OCT	octane
PCE	tetrachloroethene
ClBENZ	chlorobenzene
14DCB	1,4-dichlorobenzene
BLANKS	
TBn	unexposed trip blanks, travels with the exposed modules
method blank	QA/QC module, documents analytical conditions during analysis

APPENDIX A:

1. CHAIN OF CUSTODY
2. DATA TABLE
3. STACKED TOTAL ION CHROMATOGRAMS
4. COLOR CONTOUR MAPS

GORE-SORBER® Screening Survey Chain of Custody

For W.L. Gore & Associates use only
Production Order # 11787295

GORE
Creative Technologies Worldwide

W. L. Gore & Associates, Inc., Survey Products Group
100 Chesapeake Boulevard • Elkton, Maryland 21921 • Tel: (410) 392-7600 • Fax (410) 506-4780

Instructions: Customer must complete ALL shaded cells

Customer Name: US ARMY CORPS OF ENGINEERS
Address: FINANCECENTER (ATT: ACCOUNTS PAYABLE)
5720 INTEGRITY DRIVE
MILLINGTON TN 38054 U.S.A.
Phone: (757) 441-7267
FAX: (757) 441-7478

Site Name: 2ALLOPS DCL
Site Address: WALLOPS ISLAND VA
Project Manager: GEORGE MEARS
Customer Project No.: 11987230
Customer P.O. #:
Quote #: 217165

Serial # of Modules Shipped			
# 444409	- # 444459	#	- #
#	- #	#	- #
#	- #	#	- #
#	- #	#	- #
#	- #	#	- #
	- #	#	- #
	- #	#	- #
#	- #	#	- #
#	- #	#	- #
#	- #	#	- #

\# of Modules for Installation 47 # of Trip Blanks 4
Total Modules Shipped: 51 Pieces
Total Modules Received: 51 Pieces
Total Modules Installed: 47 Pieces

Serial # of Trip Blanks (*Client Decides*)		#
# 444420	#	#
# 444432	#	#
# 444414	#	#
# 444426	#	#
#	#	#
#	#	#
#	#	#
#	#	#

Prepared By: Marlene Yellowdy
Verified By:

Installation Performed By:
Name (*please print*): GEORGE MEARS / CHRIS TURNER
Company/Affiliation: US Army Corps of Engineers

Installation Method(s) (*circle those that apply*):
Slide Hammer Hammer Drill Auger
Other: Soil Coring Tool

Installation Start Date and Time: 3 / 24 / 2004 9 : 51 [✓ AM] PM
Installation Complete Date and Time: 3 / 24 / 2004 5 : 20 AM [✓ PM]

Retrieval Performed By:
Name (*please print*): GEORGE MEARS / Marc GUTTERMAN
Company/Affiliation:1 US Army Corps of Engineers

Total Modules Retrieved: 47 Pieces
Total Modules Lost in Field: 0 Pieces
Total Unused Modules Returned: 0 Pieces

Retrieval Start Date and Time: 4 / 7 / 2004 9 : 57 [✓ AM] PM
Retrieval Complete Date and Time: 4 / 7 / 2004 1 : 17 AM [✓ PM]

	Date	Time		Date	Time
Relinquished By Marlene Yellowdy Affiliation: W.L. Gore & Associates, Inc.	3/16/04	10:00 AM	Received By: Affiliation: US Army Corps of Engineer	3/18/04	1522
Relinquished By ffiliation: U.S Army Corps of Engineers	4/9/04	1215	Received By: Affiliation:		
linquished By Affiliation			Received By: Marlene Yellowdy Affiliation: W.L. Gore & Associates, Inc.	4/12/04	12:08 pm

QUOTE # 217165

GORE-SORBER® Screening Survey Installation and Retrieval Log

Page 1 of 2

SITE NAME & LOCATION

NASA WALLOPS FLIGHT FACILITY (GORE: WALLOPS DC)
ACCOMACK COUNTY, VA
CONSTRUCTION DEBRIS LANDFILL PASSIVE SOIL GAS INVESTIGATI

LINE # (WP#)	MODULE #	INSTALLATION DATE/TIME	RETRIEVAL DATE/TIME	EVIDENCE OF LIQUID HYDROCARBONS (LPH) or HYDROCARBON ODOR (Check as appropriate)			MODULE IN WATER (check one)		COMMENTS
				LPH	ODOR	NONE	YES	NO	
1.	444417	3/24/04 / 1424	4/7/04 1129			✓	✓		MUD FLAT
2.	444423	3/24/04 / 1416	4/7/04 1132			✓	✓		MUD FLAT
3.	444429	3/24/04 / 1406	4/7/04 1136			✓	✓		MUD/BELOW WL
4.	444435	3/24/04 / 1354	4/7/04 1119			✓	✓		MUD/BELOW WL
5.	444441	3/24/04 / 1346	4/7/04 1212			✓	✓		MUD/BELOW WL
6.	444424	3/24/04 / 1523	4/7/04 1116			✓			laying exposed
7.	444447	3/24/04 / 1340	4/7/04 1215			✓	✓		MUD FLAT
8.	444442	3/24/04 / 1505	4/7/04 1108			✓		✓	MOVED, FOR CONCRETE RUBBLE 8' WEST
9.	444436	3/24/04 / 1511	4/7/04 1110			✓		✓	
10.	444430	3/24/04 / 1515	4/7/04 1112			✓		✓	
11.	444416	3/24/04 / 1313	4/7/04 1206			✓		✓	
12.	444410	3/24/04 / 1318	4/7/04 1204			✓		✓	
13.	444453	3/24/04 / 1324	4/7/04 1202			✓		✓	
14.	444418	3/24/04 / 1536	4/7/04 1105			✓	✓		wet
5.	444457	3/24/04 / 1008	4/7/04 1003			✓		✓	
.	444459	3/24/04 / 0951	4/7/04 0957			✓		✓	
17.	444419	3/24/04 / 1555	4/7/04 123[illegible]			✓		✓	
18.	444412	3/24/04 / 1542	4/7/04 1103			✓		✓	
19.	444422	3/24/04 / 1209	4/7/04 1043			✓		✓	
20.	444409	3/24/04 / 1013	4/7/04 1006			✓		✓	
21.	444458	3/24/04 / 0957	4/7/04 1000			✓		✓	
22.	444428	3/24/04 / 1155	4/7/04 1039			✓		✓	
23.	444415	3/24/04 / 1020	4/7/04 1011			✓		✓	
24.	444425	3/24/04 / 1605	4/7/04 123[illegible]			✓		✓	
25.	444413	3/24/04 / 1552	4/7/04 1238			✓		✓	
26.	444440	3/24/04 / 1143	4/7/04 1036			✓		✓	
27.	444446	3/24/04 / 1129	4/7/04 1034			✓		✓	
28.	444452	3/24/04 / 1117	4/7/04 1029			✓		✓	
29.	444421	3/24/04 / 1032	4/7/04 1013			✓		✓	
30.	444434	3/24/04 / 1137	4/7/04 1031			✓		✓	
31.	444451	3/24/04 / 1111	4/7/04 1026			✓		✓	
32.	444427	3/24/04 / 1042	4/7/04 1017			✓		✓	
33.	444438	3/24/04 / 1700	4/7/04 1253			✓		✓	
34.	444455	3/24/04 / 1641	4/7/04 1243			✓		✓	
35.	444445	3/24/04 / 1106	4/7/04 1024			✓		✓	
36.	444433	3/24/04 / 1049	4/7/04 1018			✓		✓	
7.	444449	3/24/04 / 1633	4/7/03 1240			✓		✓	
3.	444444	3/24/04 / 1656	4/7/03 1245			✓		✓	
39.	444439	3/24/04 / 1059	4/7/04 1021			✓		✓	
40.	444437	3/24/04 / 1622	4/7/04 1235			✓		✓	
41.	444443	3/24/04 / 1628	4/7/04 1242			✓			

GORE-SORBER ® Screening Survey is a registered service mark of W.L. Gore & Associates. Inc.

FORM 8R.3
7/23/97

Quote # 217165

GORE-SORBER® Screening Survey Installation and Retrieval Log

Page 2 of 2

SITE NAME & LOCATION

NASA Wallops Flight Facility (GORE: WALLOPS DC

Accomack County, VA

Construction Debris Landfill Passive Soil Gas Investigation

LINE # (WP#)	MODULE #	INSTALLATION DATE/TIME	RETRIEVAL DATE/TIME	EVIDENCE OF LIQUID HYDROCARBONS (LPH) or HYDROCARBON ODOR (Check as appropriate)			MODULE IN WATER (check one)		COMMENTS
				LPH	ODOR	NONE	YES	NO	
~~1.~~ 42	444456	3/24/04 / 1646	4/7/04 1248			✓		✓	pulled out hole
~~2.~~ 43	444450	3/24/04 / 1650	4/7/04 1257			✓		✓	
~~3.~~ 44	444411	3/24/04 / 1434	4/7/04 1138			✓	✓		
~~4.~~ 45	444454	3/24/04 / 1440	4/7/04 1140			✓	✓		
~~5.~~ 46	444448	3/24/04 / 1444	4/7/04 1147			✓	✓		
~~6.~~ 47	444431	3/24/04 / 1610	4/7/04 1235			✓		✓	
~~7.~~ 48	444420	~~3/24/04 1705~~	~~4/7/04 1303~~			✓		✓	(TRIP BLANK)
~~8.~~ 49	444432	~~3/24/04 1710~~	~~4/7/04 1308~~			✓		✓	(TRIP BLANK)
~~9.~~ 50	444414	~~3/24/04 1715~~	~~4/7/04 1312~~			✓		✓	(TRIP BLANK)
~~10.~~ 51	444426	~~3/24/04 1720~~	~~4/7/04 1317~~			✓		✓	(TRIP BLANK)
11.									
12.									
13.									
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NOTE: LINE ITEM NUMBERS CORRESPOND TO ARRAY (WAYPOINT) LOCATIONS. WP# 47 corresponds to ARRAY ORIGIN (CDL-SB-001 Location). LINE ITEMS 48-51 are TRIP BLANKS.

GORE(TM) SURVEYS FOR ENVIRONM ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

DATE ANALYZED	SAMPLE NAME	BTEX, ug	BENZ, ug	TOL, ug	EtBENZ, ug	mpXYL, ug	oXYL, ug	C11, C13, &C15, ug	UNDEC, ug	TRIDEC, ug	PENTADEC, ug
	MDL=		0.05	0.03	0.02	0.03	0.03		0.03	0.02	0.02
4/13/2004	444409	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444410	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444411	11.86	2.91	0.05	0.12	4.35	4.43	nd	nd	nd	nd
4/13/2004	444412	nd	nd	nd	nd	nd	nd	0.00	bdl	nd	nd
4/13/2004	444413	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444415	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444416	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444417	0.19	0.19	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444418	0.23	nd	0.23	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444419	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444421	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444422	0.04	nd	0.04	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444423	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444424	0.00	bdl	bdl	nd	nd	nd	0.00	bdl	nd	nd
4/13/2004	444425	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444427	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444428	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444429	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444430	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444431	0.26	nd	0.26	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444433	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444434	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444435	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444436	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444437	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444438	0.13	nd	0.13	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444439	0.12	nd	0.12	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444440	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444441	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444442	nd	nd	nd	nd	nd	nd	0.00	bdl	nd	nd
4/14/2004	444443	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444444	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444445	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444446	0.15	nd	0.15	nd	nd	nd	0.00	bdl	nd	nd

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONMI L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

DATE ANALYZED	SAMPLE NAME	BTEX, ug	BENZ, ug	TOL, ug	EtBENZ, ug	mpXYL, ug	oXYL, ug	C11, C13, &C15, ug	UNDEC, ug	TRIDEC, ug	PENTADEC, ug
	MDL=		0.05	0.03	0.02	0.03	0.03		0.03	0.02	0.02
4/14/2004	444447	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444448	0.95	nd	0.16	0.17	0.32	0.31	0.00	bdl	nd	nd
4/14/2004	444449	nd	nd	nd	nd	nd	nd	0.00	bdl	nd	nd
4/14/2004	444450	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444451	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444452	0.03	nd	0.03	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444453	0.03	nd	nd	0.03	bdl	bdl	nd	nd	nd	nd
4/14/2004	444454	22.94	22.28	nd	0.15	0.19	0.33	nd	nd	nd	nd
4/14/2004	444455	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444456	0.00	nd	nd	nd	bdl	nd	0.00	bdl	bdl	nd
4/14/2004	444457	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444458	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444459	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444414	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444420	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	444426	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	444432	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/13/2004	method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
4/14/2004	method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
	Maximum	22.94	22.28	0.26	0.17	4.35	4.43	0.00	0.02	0.00	0.00
	Standard Dev.	3.73	3.27	0.06	0.04	0.64	0.65	0.00	0.00	0.00	0.00
	Mean	0.79	0.54	0.03	0.01	0.10	0.11	0.00	0.00	0.00	0.00

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONME . ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

SAMPLE NAME	TMBs, ug	124TMB, ug	135TMB, ug	ct12DCE, ug	t12DCE, ug	c12DCE, ug	Combined PAHs, ug	NAPH&2-MN, ug	NAPH, ug	2MeNAPH, ug
MDL=		0.01	0.01		0.05	0.05			0.01	0.01
444409	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444410	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444411	0.05	0.05	bdl	nd	nd	nd	nd	nd	nd	nd
444412	0.00	nd	bdl	nd	nd	nd	nd	nd	nd	nd
444413	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444415	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444416	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444417	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444418	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444419	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444421	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444422	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444423	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444424	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444425	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444427	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444428	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444429	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444430	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444431	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444433	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444434	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444435	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444436	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444437	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444438	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444439	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444440	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444441	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444442	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444443	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444444	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444445	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444446	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONMI L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

SAMPLE NAME	TMBs, ug	124TMB, ug	135TMB, ug	ct12DCE, ug	t12DCE, ug	c12DCE, ug	Combined PAHs, ug	NAPH&2-MN, ug	NAPH, ug	2MeNAPH, ug
MDL=		0.01	0.01		0.05	0.05			0.01	0.01
444447	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444448	0.03	0.02	0.01	0.40	nd	0.40	nd	nd	nd	nd
444449	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444450	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444451	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444452	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444453	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444454	nd	nd	nd	0.05	nd	0.05	nd	nd	nd	nd
444455	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444456	0.01	0.01	nd	nd	nd	nd	nd	nd	nd	nd
444457	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444458	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444459	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444414	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444420	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444426	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444432	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Maximum	0.05	0.05	0.01	0.40	0.00	0.40	0.00	0.00	0.00	0.00
Standard Dev.	0.01	0.01	0.00	0.06	0.00	0.06	0.00	0.00	0.00	0.00
Mean	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONM L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

SAMPLE NAME	MTBE, ug	11DCA, ug	111TCA, ug	12DCA, ug	TCE, ug	OCT, ug	PCE, ug	14DCB, ug	Acenaphthene, ug	Acenaphthylene, ug	Fluorene, ug
MDL=	0.04	0.05	0.03	0.04	0.03	0.04	0.03	0.02	0.01	0.02	0.02
444409	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444410	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444411	bdl	nd	nd	nd	nd	0.16	nd	nd	nd	nd	nd
444412	nd	nd	nd	nd	nd	nd	0.16	nd	nd	nd	nd
444413	nd	nd	nd	nd	nd	nd	bdl	nd	nd	nd	nd
444415	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444416	bdl	nd	nd	nd	nd	nd	0.04	nd	nd	nd	nd
444417	bdl	nd	nd	nd	nd	0.10	nd	nd	nd	nd	nd
444418	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444419	bdl	nd	nd	nd	nd	nd	0.29	nd	nd	nd	nd
444421	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444422	bdl	nd	nd	nd	nd	nd	0.06	nd	nd	nd	nd
444423	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444424	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444425	bdl	nd	nd	nd	nd	nd	11.24	nd	nd	nd	nd
444427	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444428	nd	nd	nd	nd	nd	nd	bdl	nd	nd	nd	nd
444429	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444430	nd	nd	nd	nd	nd	nd	0.03	nd	nd	nd	nd
444431	nd	nd	nd	nd	nd	nd	0.62	nd	nd	nd	nd
444433	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444434	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444435	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444436	nd	nd	nd	nd	nd	nd	bdl	nd	nd	nd	nd
444437	nd	nd	nd	nd	nd	nd	0.13	nd	nd	nd	nd
444438	bdl	nd	nd	nd	nd	nd	2.93	nd	nd	nd	nd
444439	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444440	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444441	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444442	nd	nd	nd	nd	nd	nd	0.06	nd	nd	nd	nd
444443	bdl	nd	nd	nd	0.14	nd	5.12	nd	nd	nd	nd
444444	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444445	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444446	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONM L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

SAMPLE NAME	MTBE, ug	11DCA, ug	111TCA, ug	12DCA, ug	TCE, ug	OCT, ug	PCE, ug	14DCB, ug	Acenaphthene, ug	Acenaphthylene, ug	Fluorene, ug
MDL=	0.04	0.05	0.03	0.04	0.03	0.04	0.03	0.02	0.01	0.02	0.02
444447	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444448	bdl	nd	nd	nd	nd	1.63	nd	nd	nd	nd	nd
444449	bdl	nd	nd	nd	0.04	0.11	6.61	nd	nd	nd	nd
444450	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444451	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444452	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444453	nd	nd	nd	nd	nd	bdl	nd	nd	nd	nd	nd
444454	bdl	nd	nd	nd	nd	0.60	nd	nd	nd	nd	nd
444455	nd	nd	nd	nd	nd	nd	0.03	nd	nd	nd	nd
444456	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444457	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444458	bdl	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444459	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444414	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444420	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444426	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
444432	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Maximum	0.03	0.00	0.00	0.00	0.14	1.63	11.24	0.00	0.00	0.00	0.00
Standard Dev.	0.01	0.00	0.00	0.00	0.02	0.25	2.03	0.00	0.00	0.00	0.00
Mean	0.00	0.00	0.00	0.00	0.00	0.06	0.58	0.00	0.00	0.00	0.00

No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

GORE(TM) SURVEYS FOR ENVIRONM[illegible]L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

SAMPLE NAME	PHEN, ug	Anthracene, ug	Fluoranthene, ug	Pyrene, ug	CHCl3, ug	CCl4, ug	ClBENZ, ug
MDL=	0.02	0.02	0.02	0.02	0.02	0.03	0.02
444409	nd	nd	nd	nd	nd	nd	nd
444410	nd	nd	nd	nd	nd	nd	nd
444411	nd	nd	nd	nd	nd	nd	nd
444412	nd	nd	nd	nd	nd	nd	nd
444413	nd	nd	nd	nd	nd	nd	nd
444415	nd	nd	nd	nd	nd	nd	nd
444416	nd	nd	nd	nd	nd	nd	nd
444417	nd	nd	nd	nd	nd	nd	nd
444418	nd	nd	nd	nd	nd	nd	nd
444419	nd	nd	nd	nd	nd	nd	nd
444421	nd	nd	nd	nd	nd	nd	nd
444422	nd	nd	nd	nd	nd	nd	nd
444423	nd	nd	nd	nd	nd	nd	nd
444424	nd	nd	nd	nd	0.03	nd	nd
444425	nd	nd	nd	nd	nd	nd	nd
444427	nd	nd	nd	nd	0.03	nd	nd
444428	nd	nd	nd	nd	nd	nd	nd
444429	nd	nd	nd	nd	nd	nd	nd
444430	nd	nd	nd	nd	nd	nd	nd
444431	nd	nd	nd	nd	nd	nd	nd
444433	nd	nd	nd	nd	nd	nd	nd
444434	nd	nd	nd	nd	0.02	nd	nd
444435	nd	nd	nd	nd	nd	nd	nd
444436	nd	nd	nd	nd	nd	nd	nd
444437	nd	nd	nd	nd	nd	nd	nd
444438	nd	nd	nd	nd	nd	nd	nd
444439	nd	nd	nd	nd	nd	nd	nd
444440	nd	nd	nd	nd	nd	nd	nd
444441	nd	nd	nd	nd	nd	nd	nd
444442	nd	nd	nd	nd	nd	nd	nd
444443	nd	nd	nd	nd	nd	nd	nd
444444	nd	nd	nd	nd	nd	nd	nd
444445	nd	nd	nd	nd	nd	nd	nd
444446	nd	nd	nd	nd	nd	nd	nd

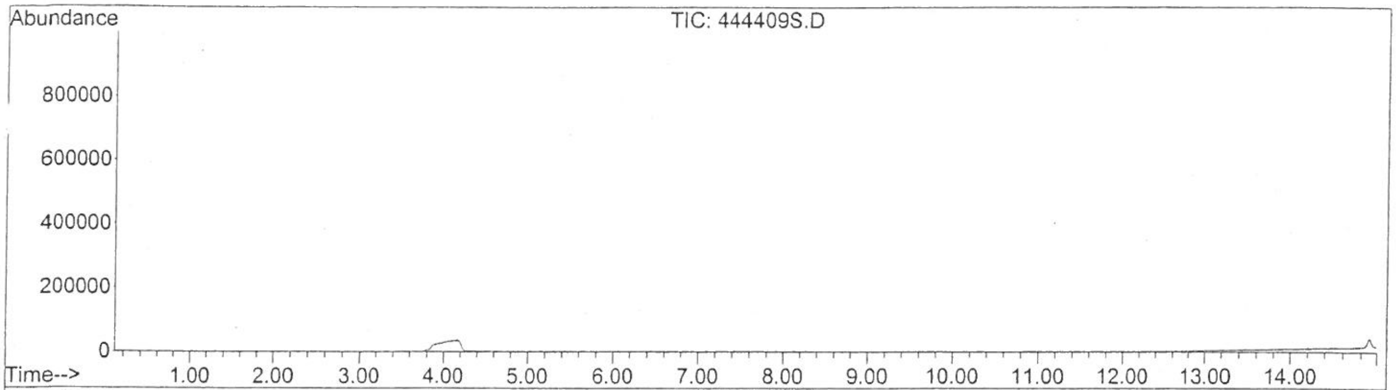
No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

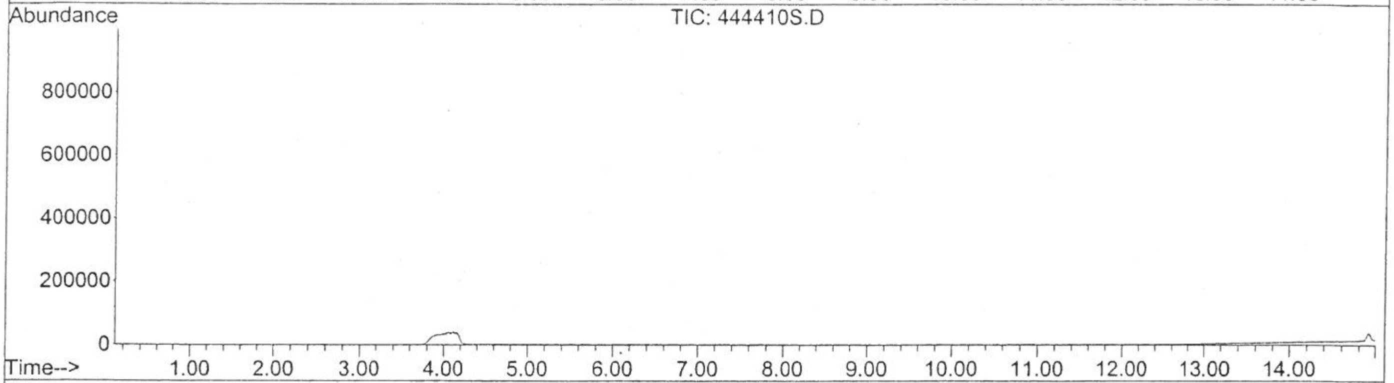
GORE(TM) SURVEYS FOR ENVIRONME L ASSESSMENT ANALYTICAL RESULTS
US ARMY CORPS OF ENGINNERS, NORFOLK, VA
GORE EXPANDED TARGET VOCs/SVOCs (A4)
NASA WALLOPS FLIGHT FACILITY, ACCOMACK COUNTY, VA
PRODUCTION ORDER #11787295

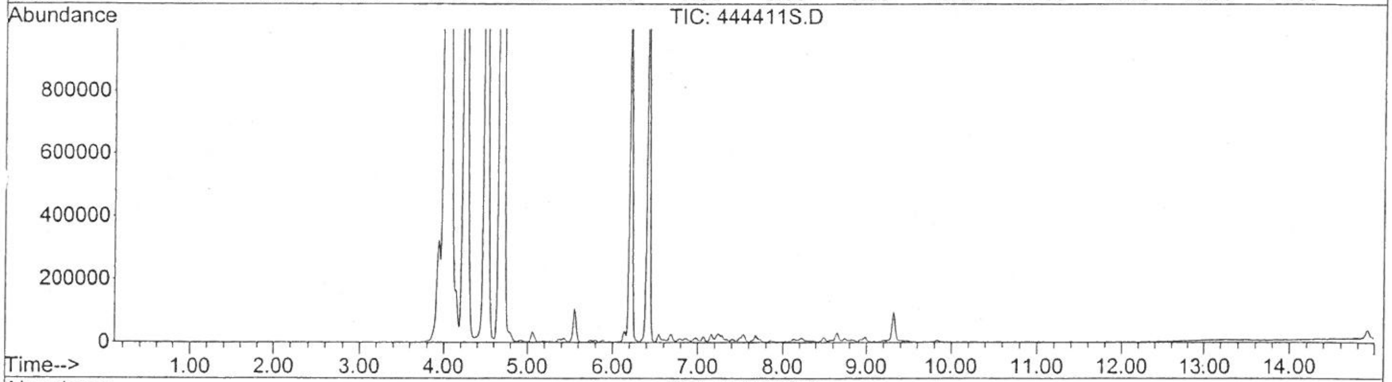
SAMPLE NAME	PHEN, ug	Anthracene, ug	Fluoranthene, ug	Pyrene, ug	CHCl3, ug	CCl4, ug	ClBENZ, ug
MDL=	0.02	0.02	0.02	0.02	0.02	0.03	0.02
444447	nd	nd	nd	nd	nd	nd	nd
444448	nd	nd	nd	nd	nd	nd	nd
444449	nd	nd	nd	nd	nd	nd	nd
444450	nd	nd	nd	nd	nd	nd	nd
444451	nd	nd	nd	nd	nd	nd	nd
444452	nd	nd	nd	nd	nd	nd	nd
444453	nd	nd	nd	nd	nd	nd	bdl
444454	nd	nd	nd	nd	nd	nd	nd
444455	nd	nd	nd	nd	nd	nd	nd
444456	nd	nd	nd	nd	nd	nd	nd
444457	nd	nd	nd	nd	nd	nd	nd
444458	nd	nd	nd	nd	nd	nd	nd
444459	nd	nd	nd	nd	nd	nd	nd
444414	nd	nd	nd	nd	nd	nd	nd
444420	nd	nd	nd	nd	nd	nd	nd
444426	nd	nd	nd	nd	nd	nd	nd
444432	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd
method blank	nd	nd	nd	nd	nd	nd	nd
Maximum	0.00	0.00	0.00	0.00	0.03	0.00	0.02
Standard Dev.	0.00	0.00	0.00	0.00	0.01	0.00	0.00
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00

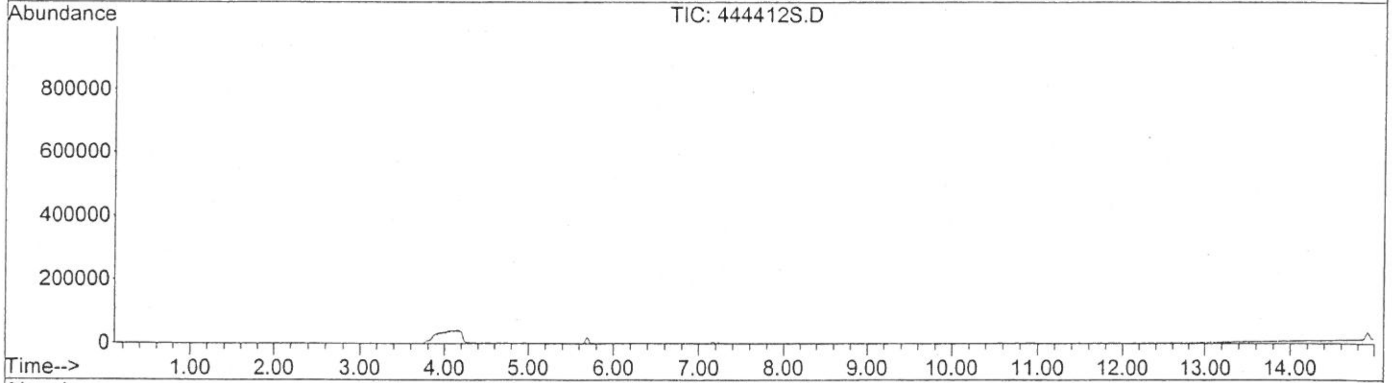
No mdl is available for summed combinations of analytes. In summed columns (eg., BTEX), the reported values should be considered ESTIMATED if any of the individual compounds were reported as bdl.

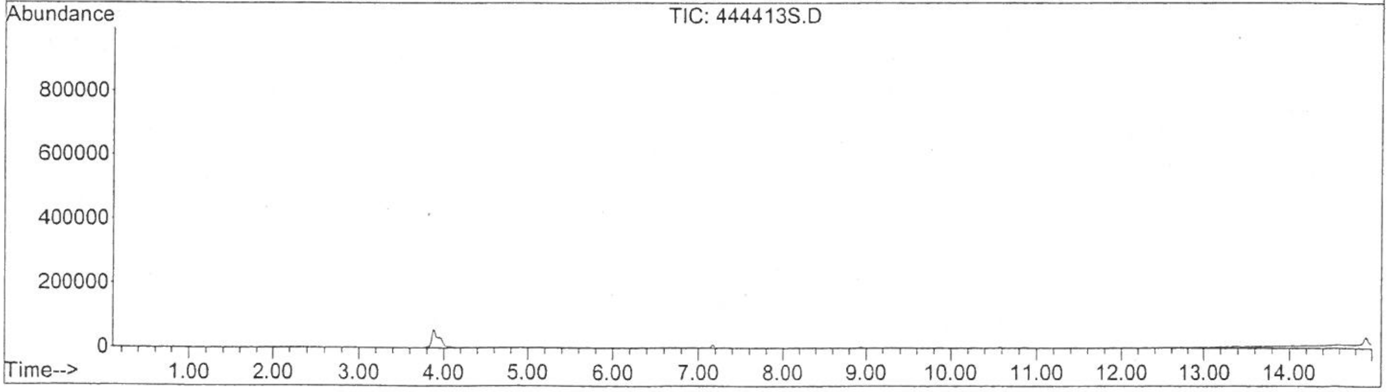
TIC - SITE CQS - PRODUCTION ORDER #11787295
In Numerical Order











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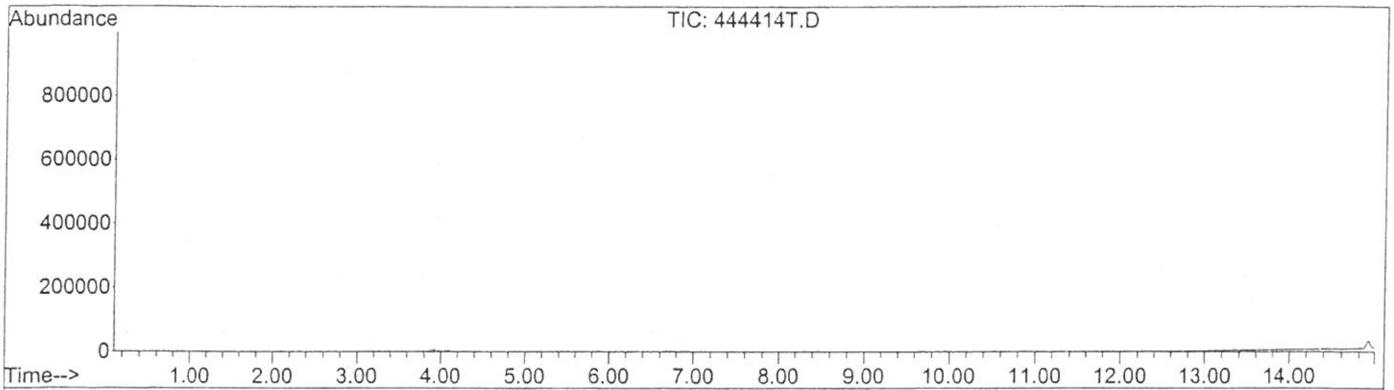
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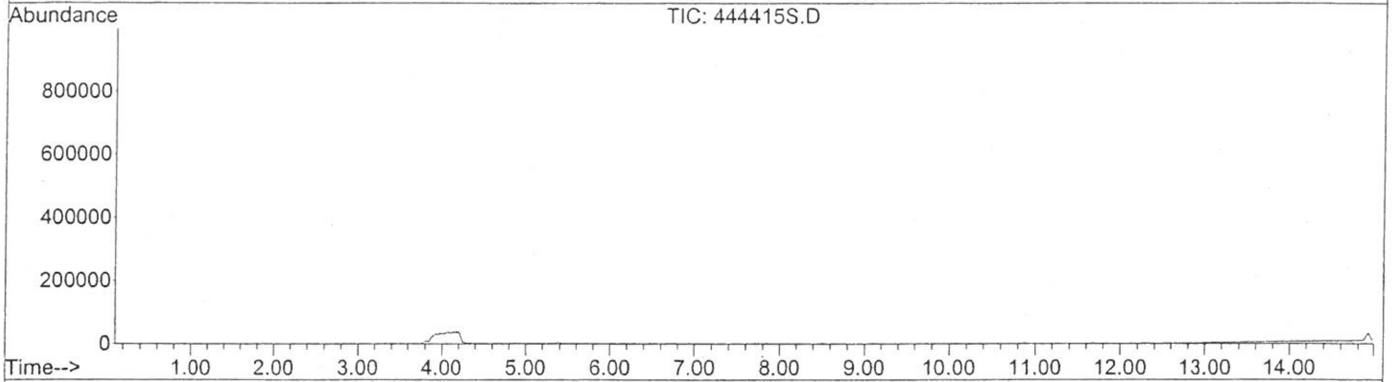
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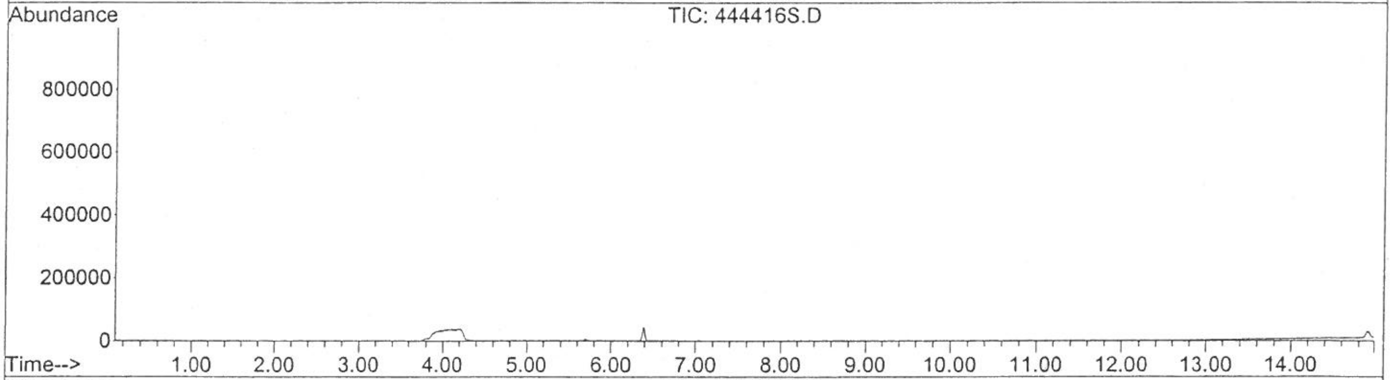
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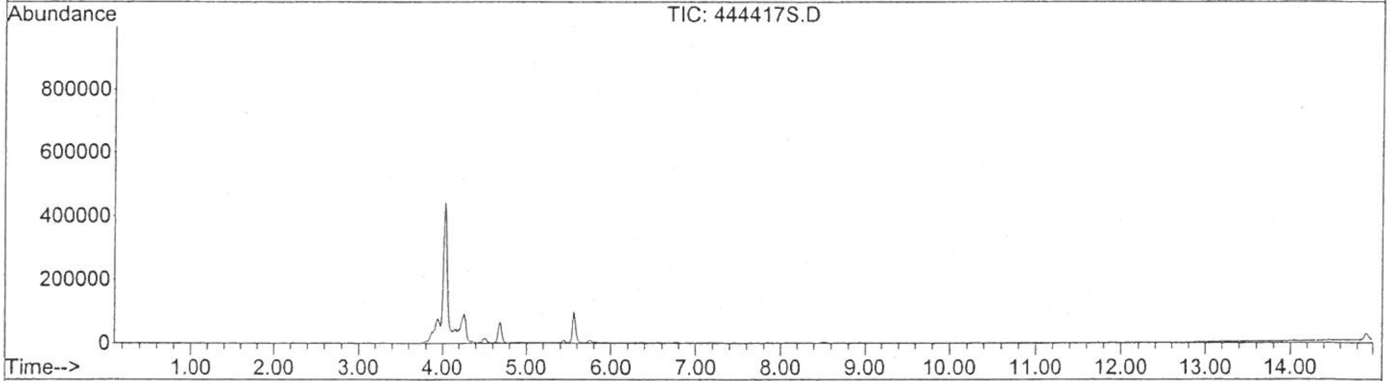
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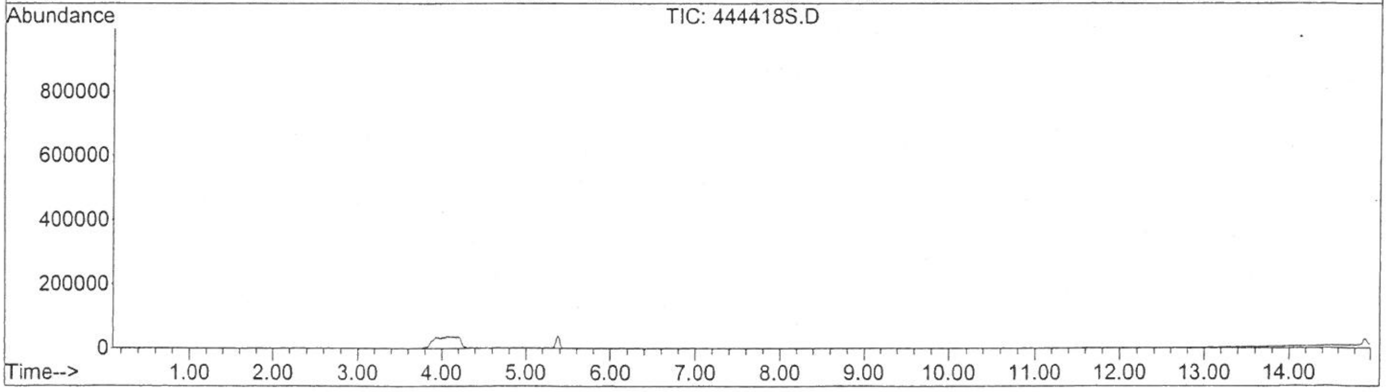
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TIC - SITE CQS - PRODUCTION ORDER #11787295
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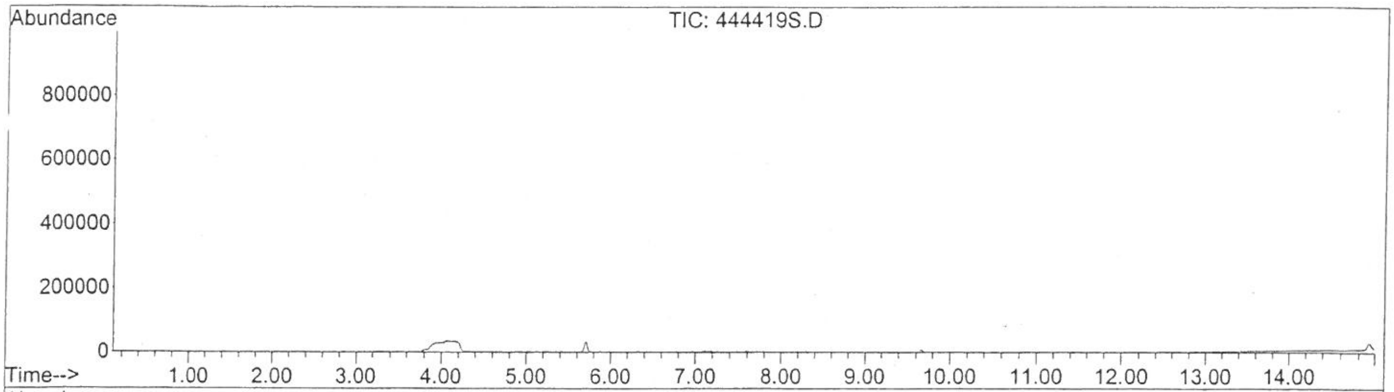

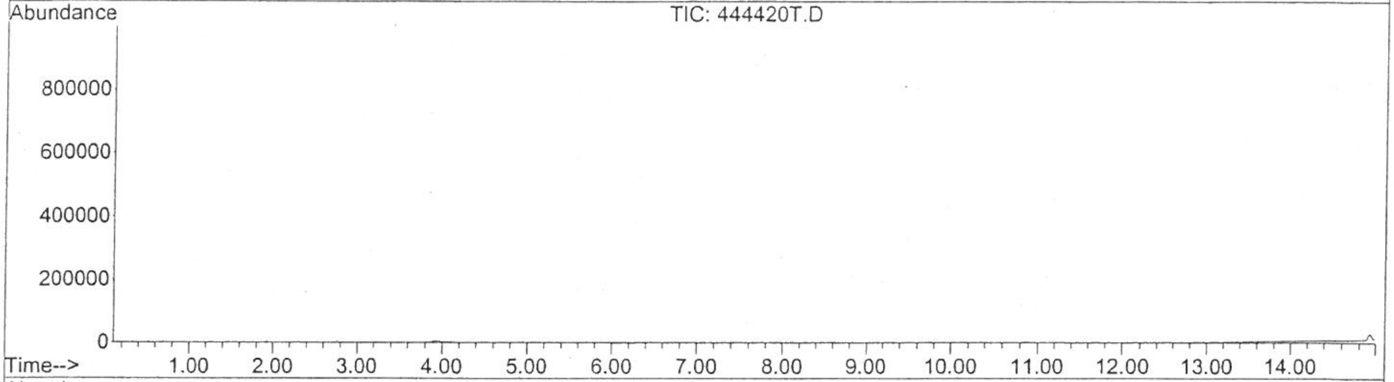

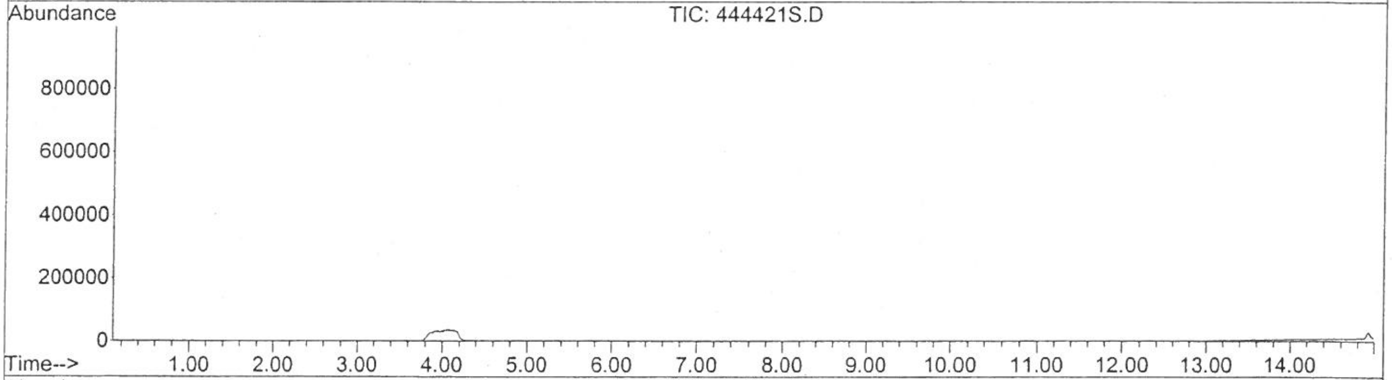

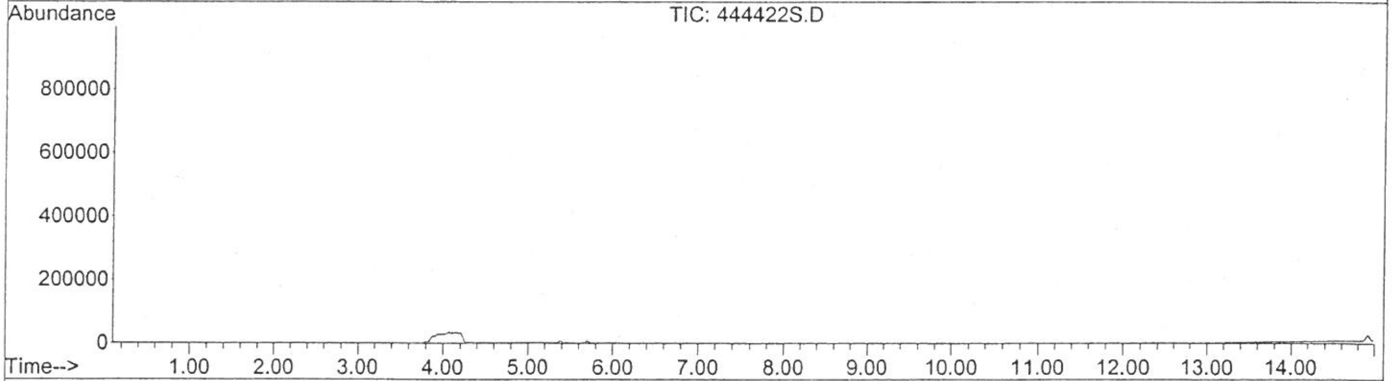

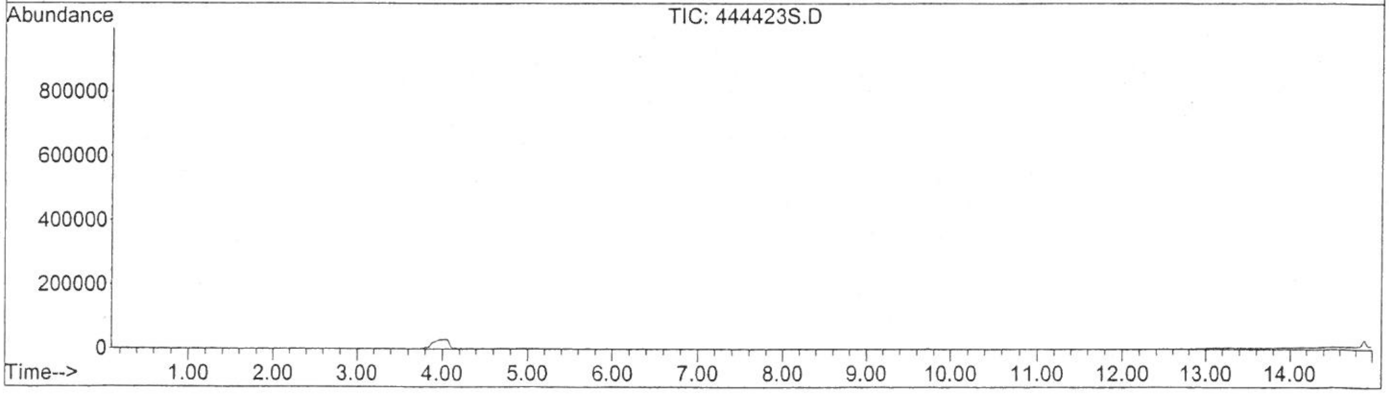

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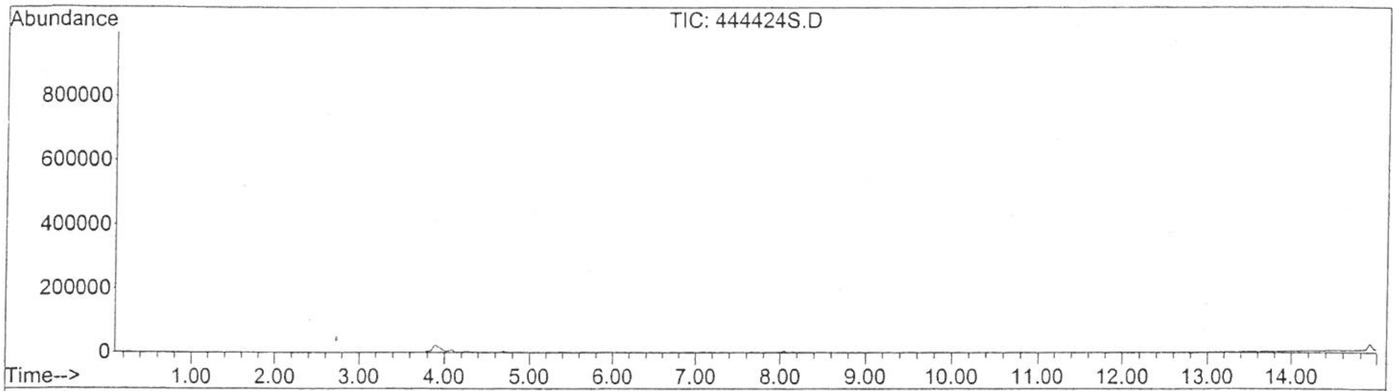

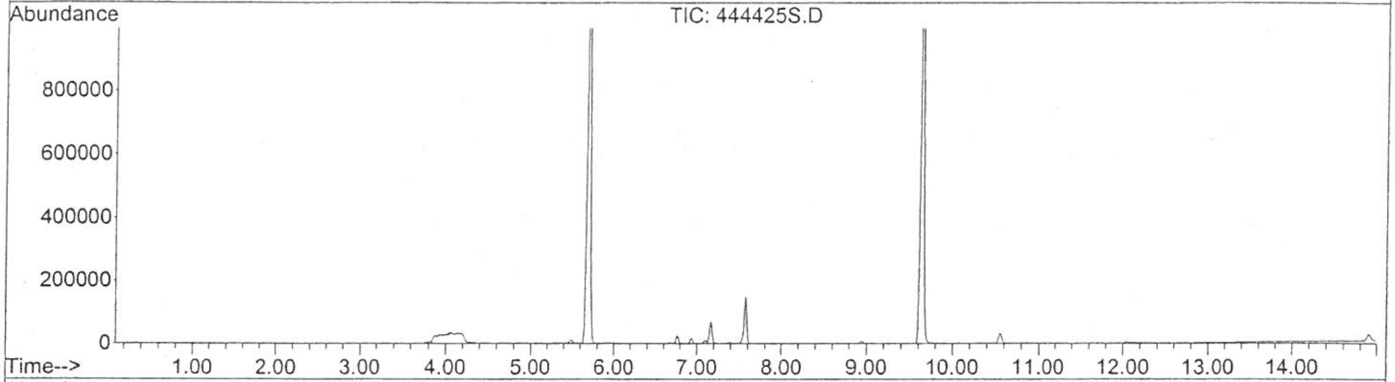

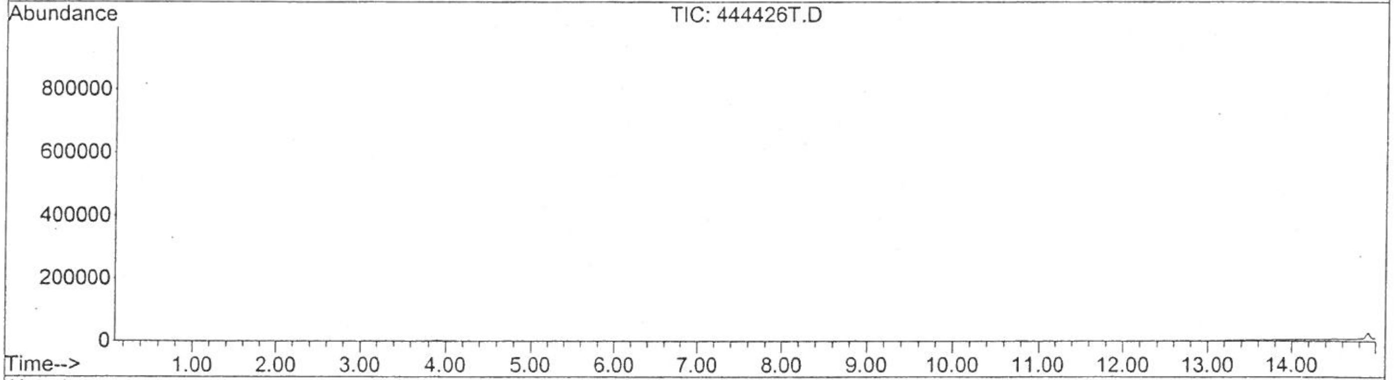

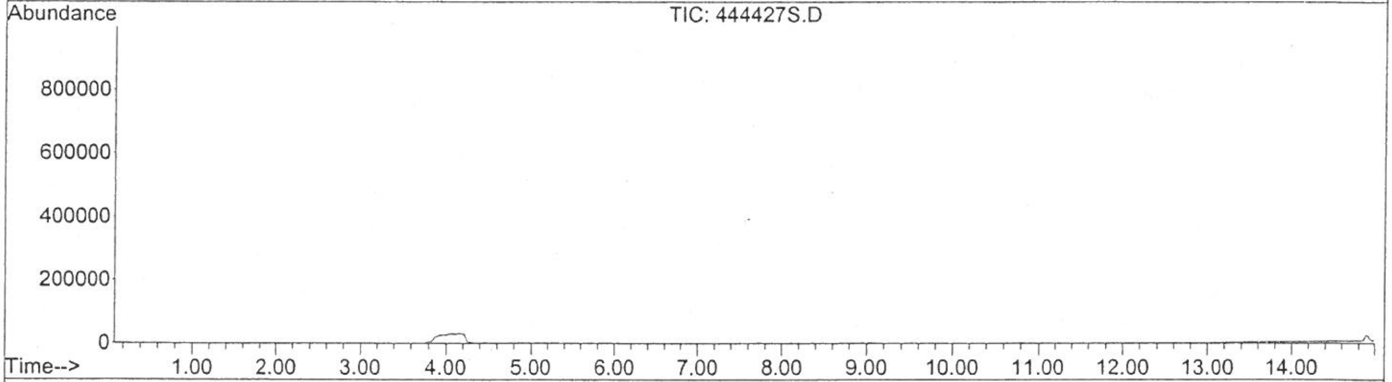

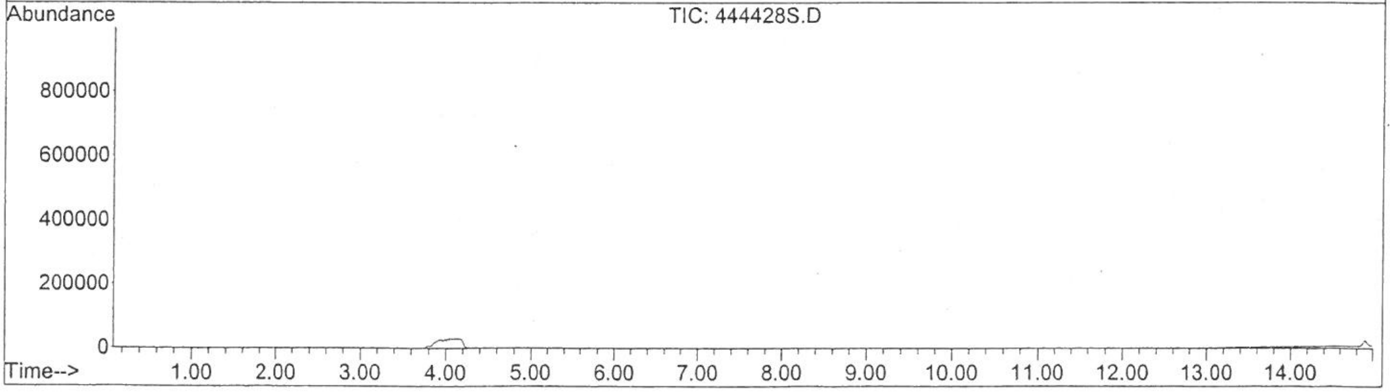

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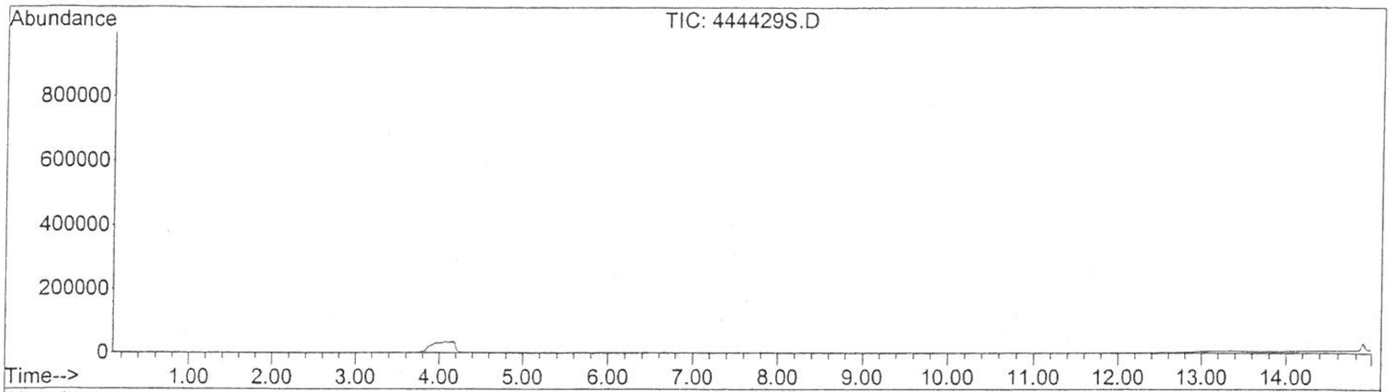

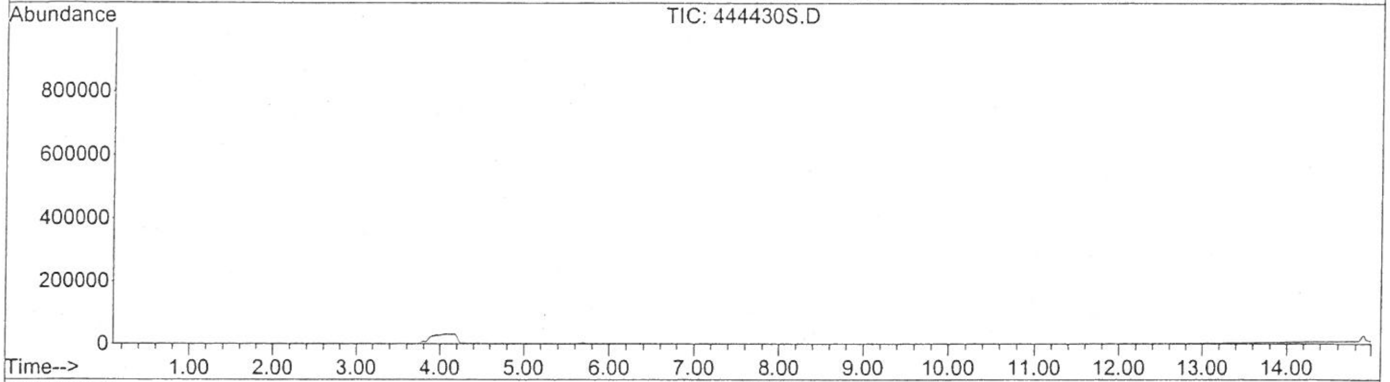

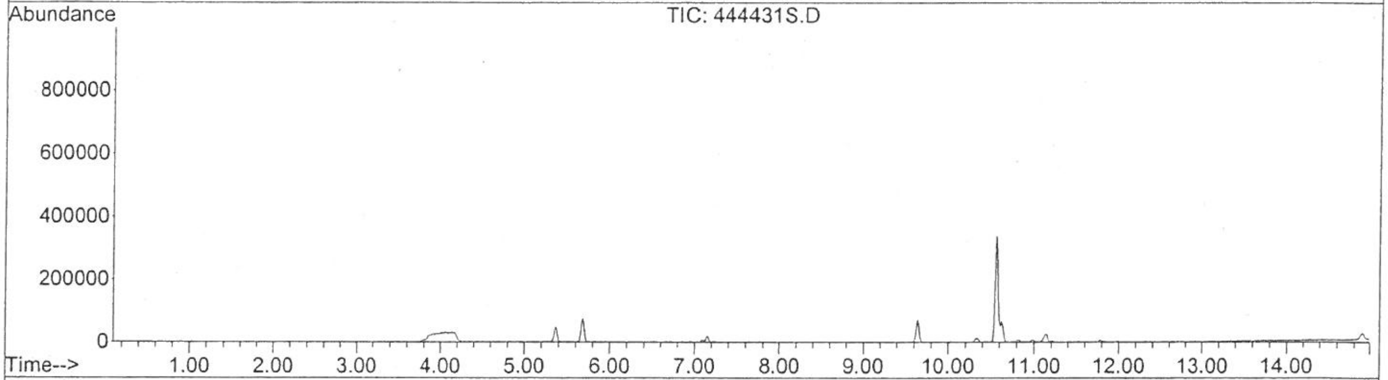

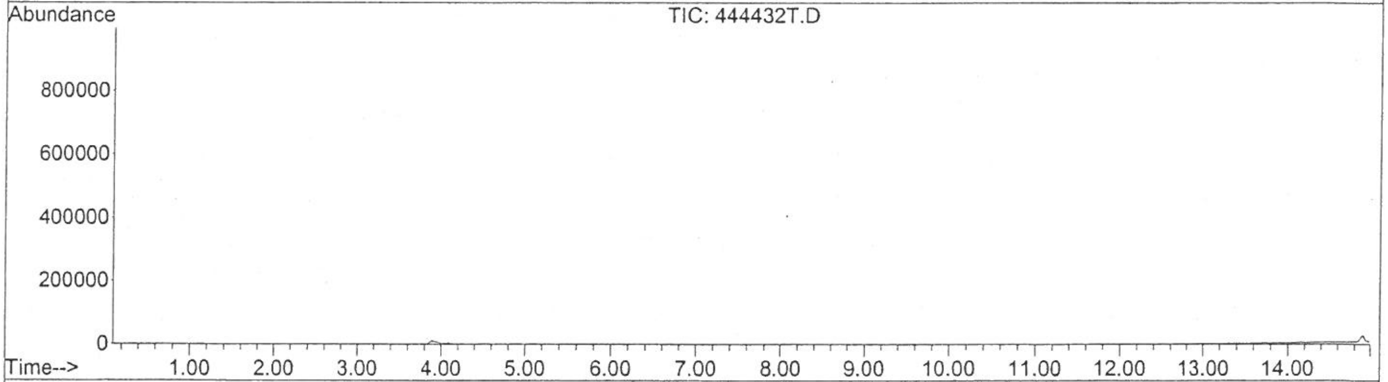

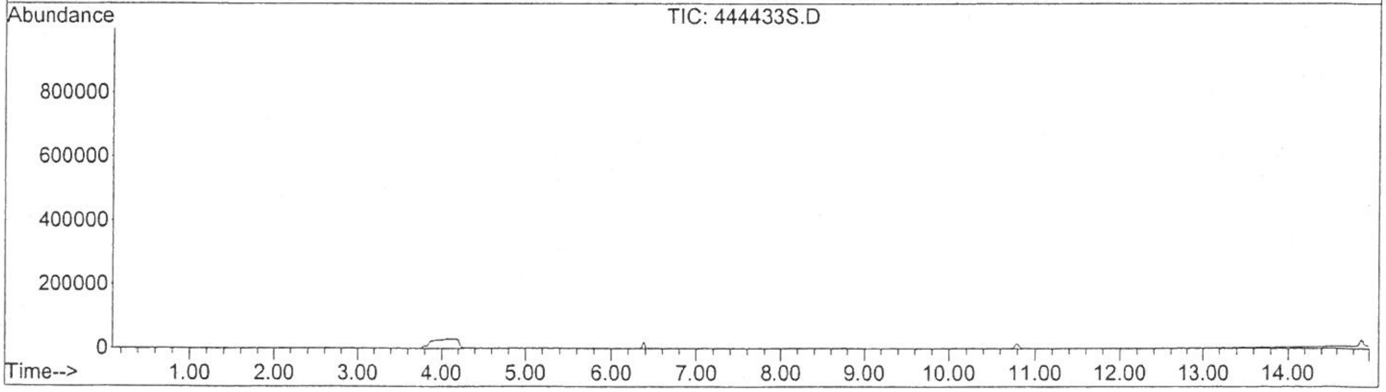

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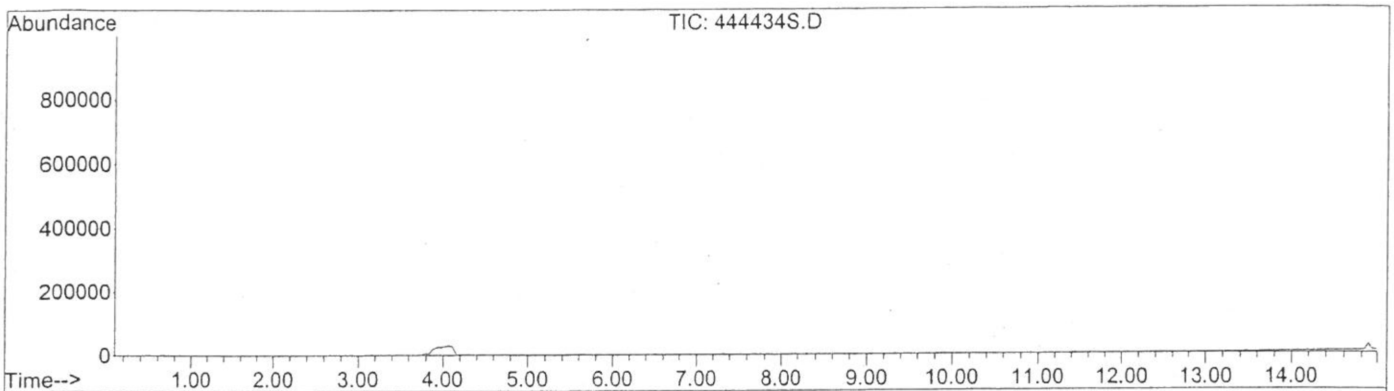

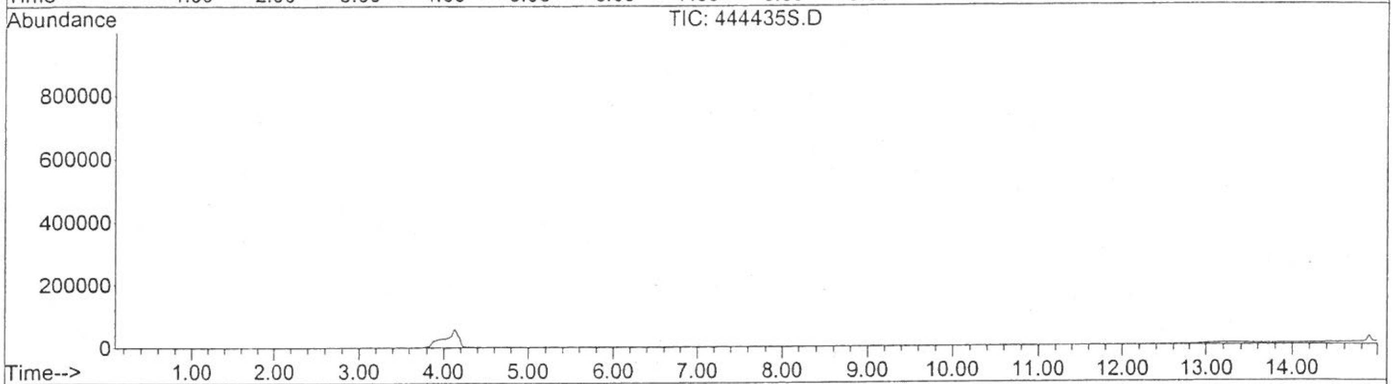

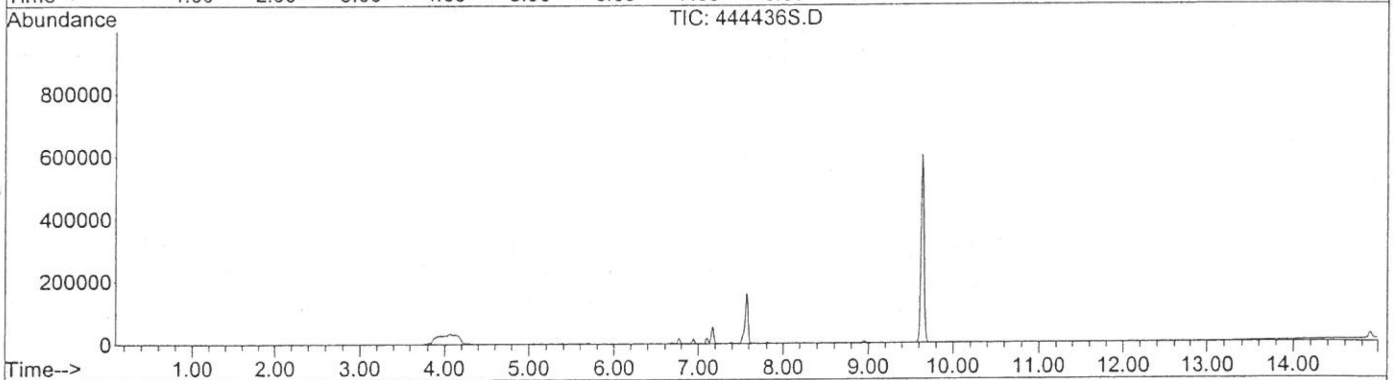

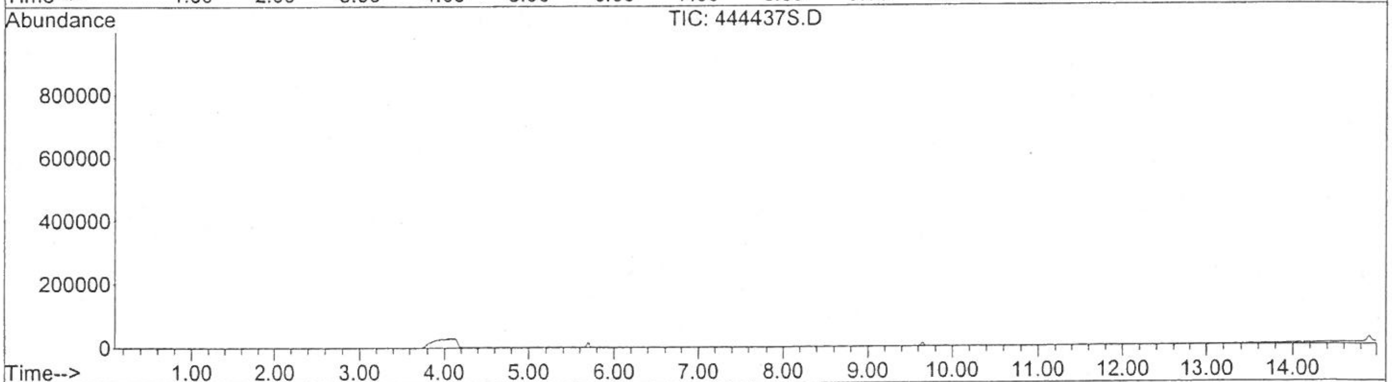

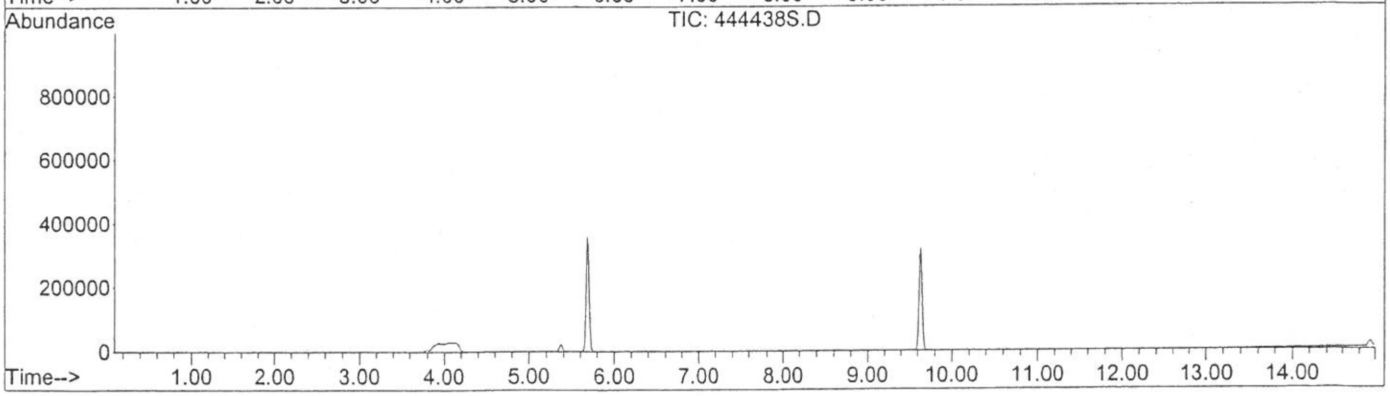

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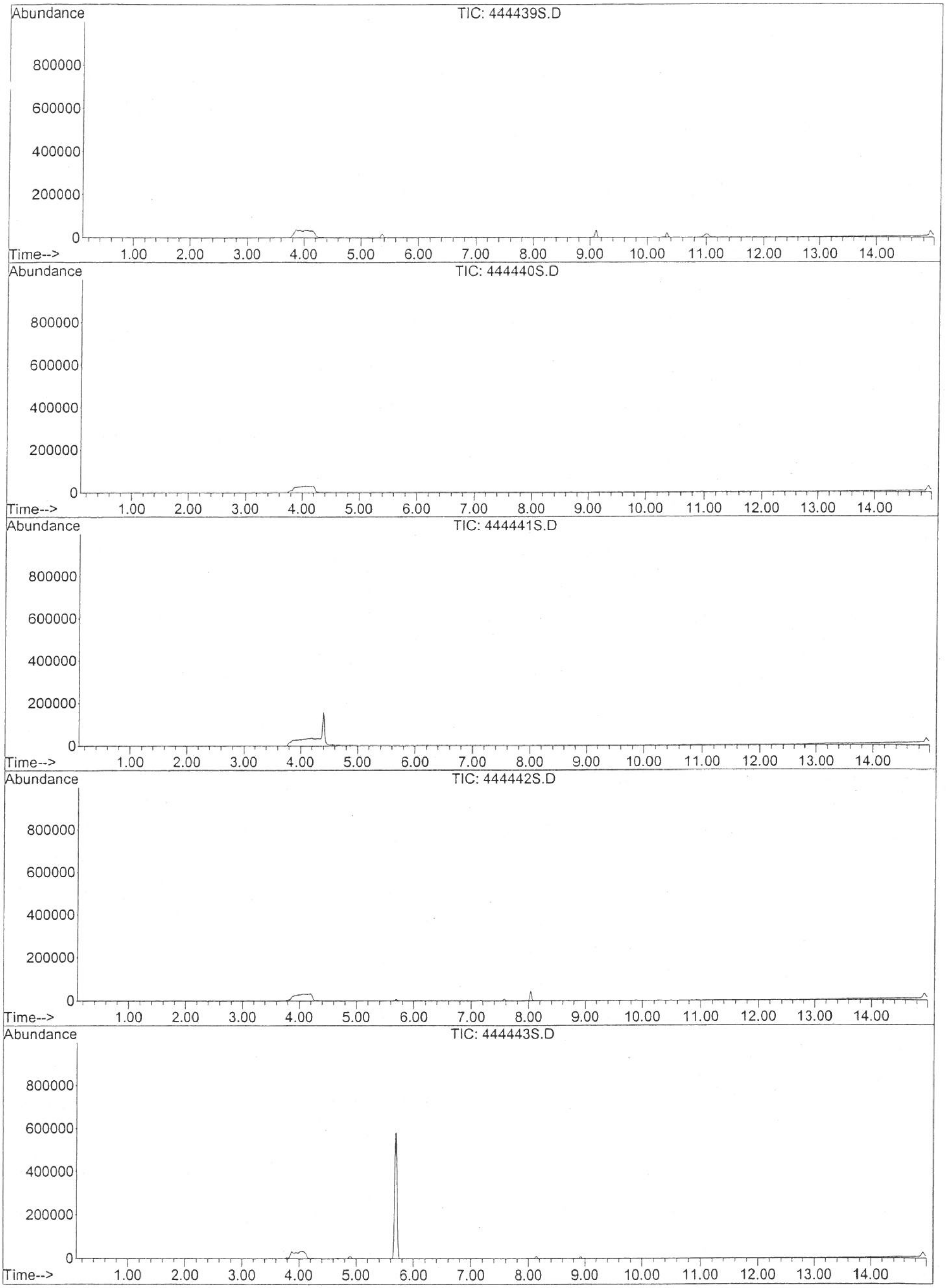

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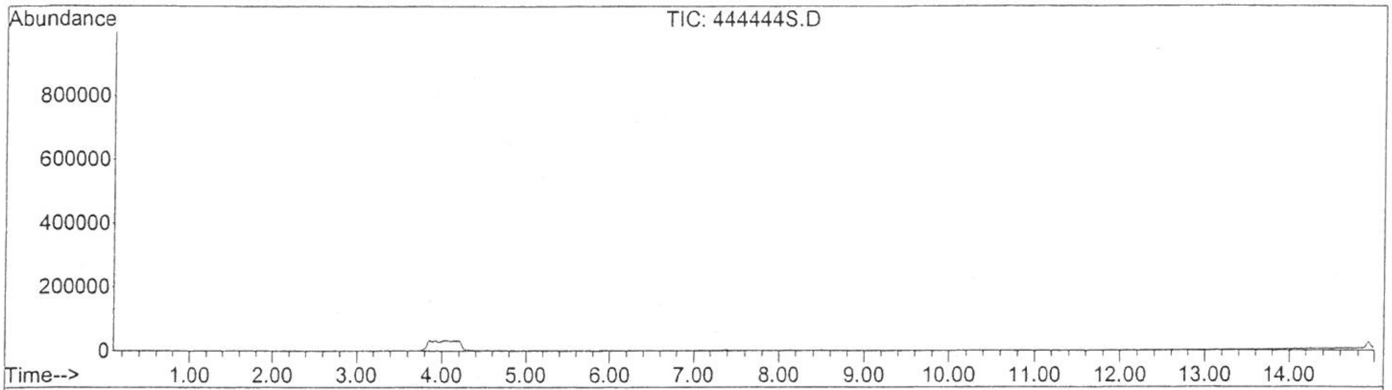

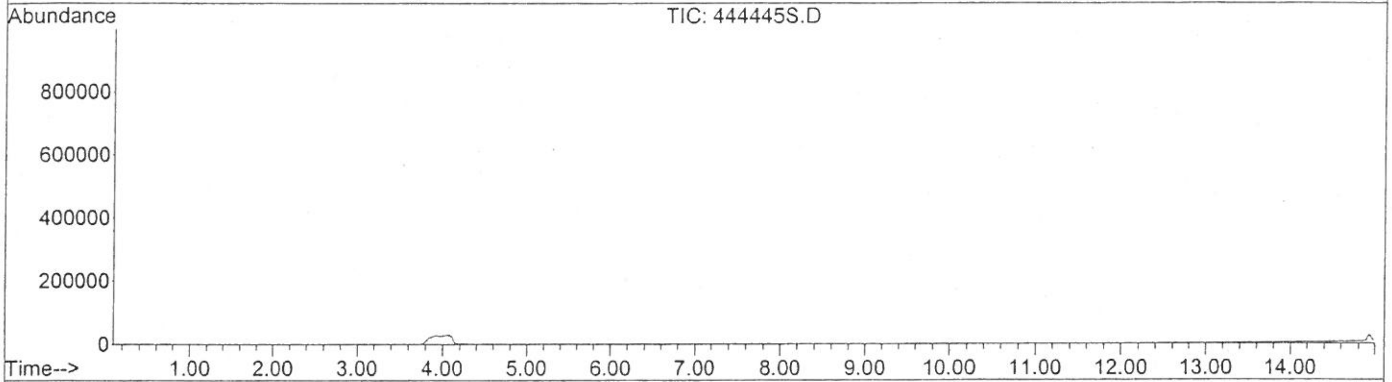

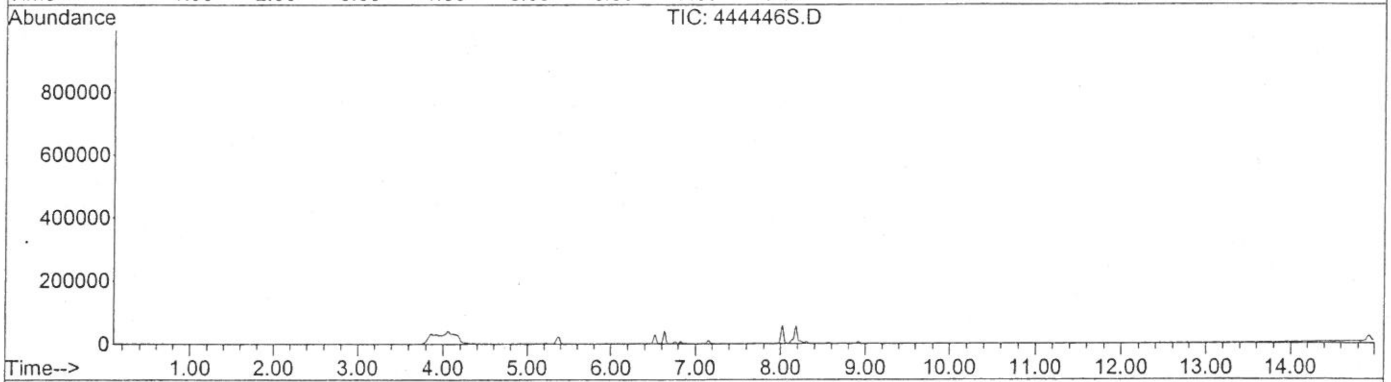

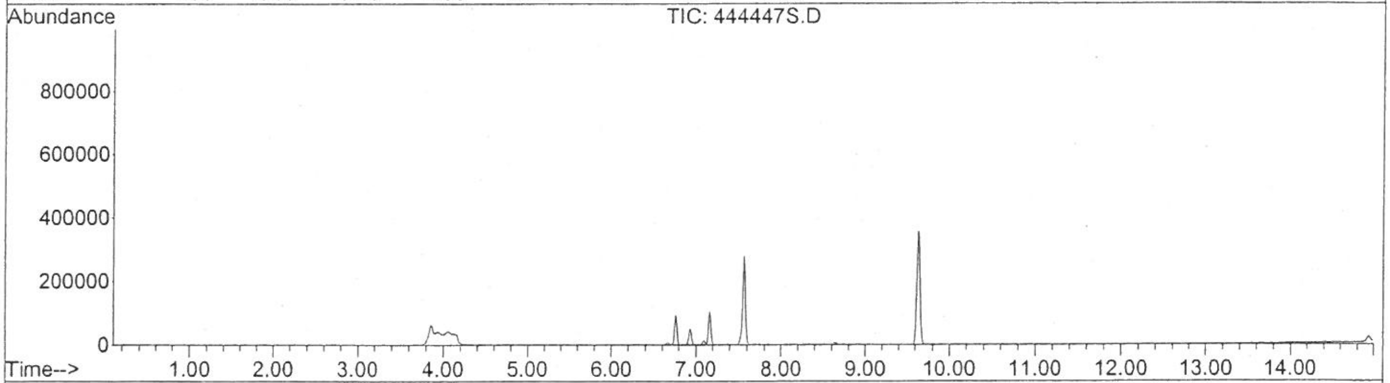

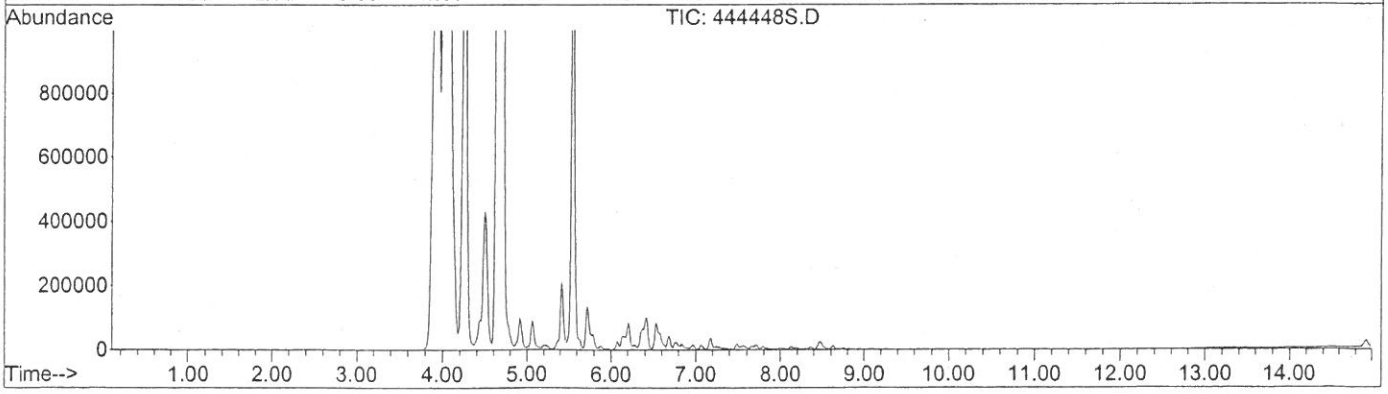

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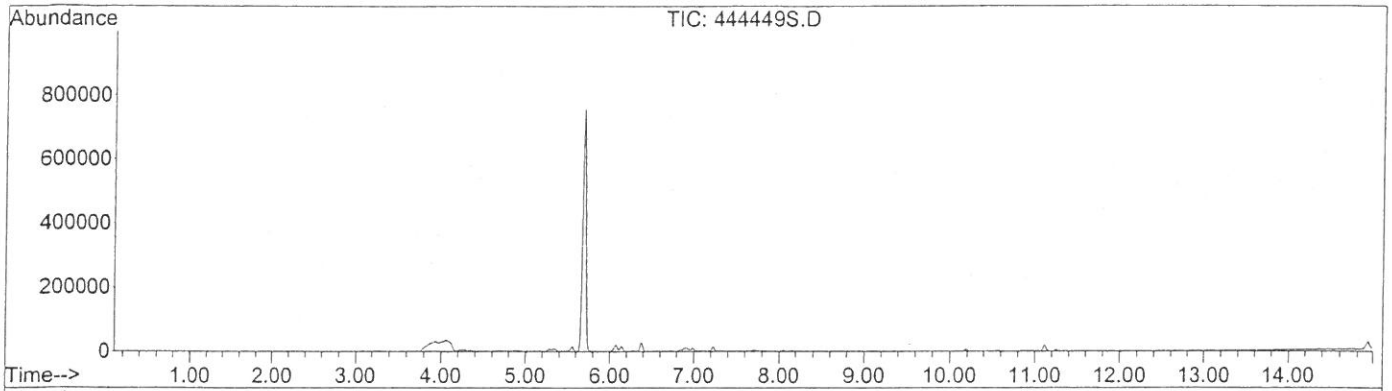

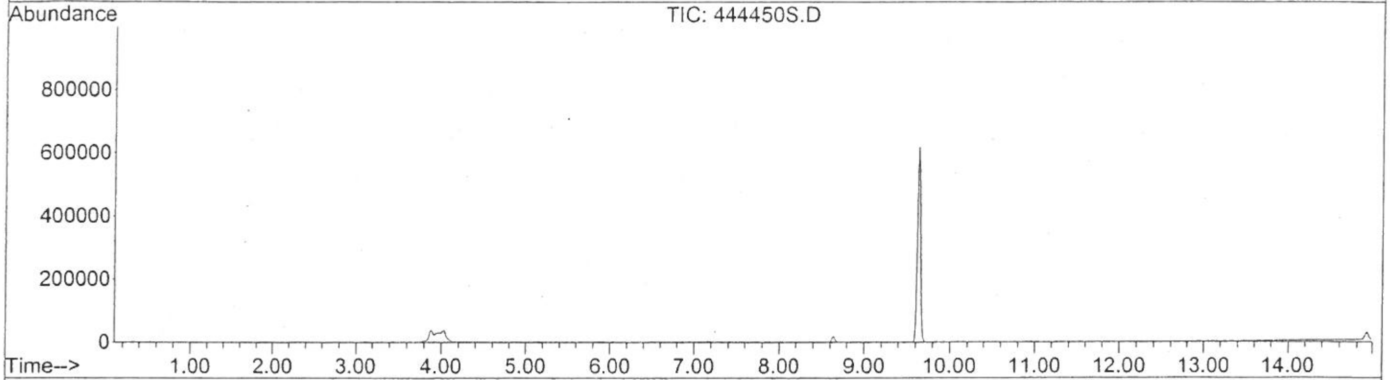

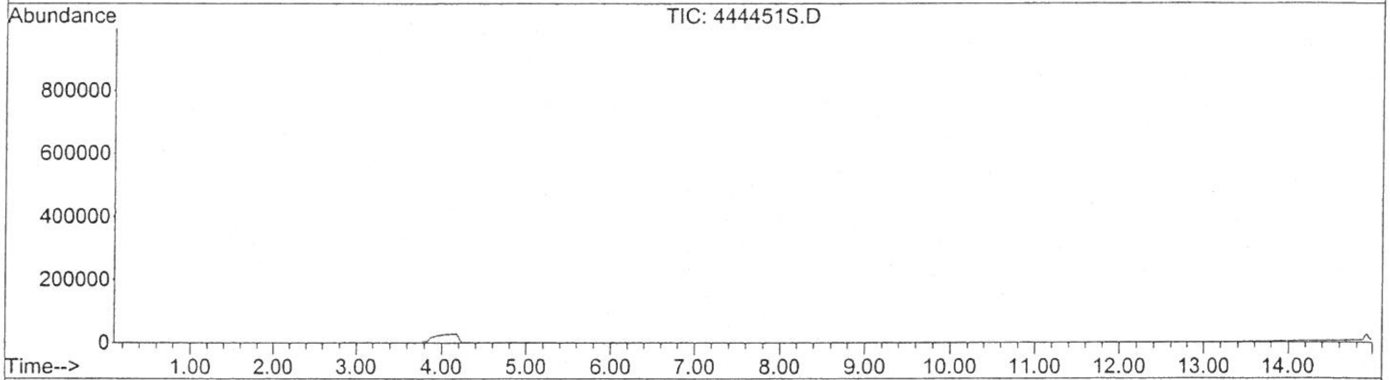

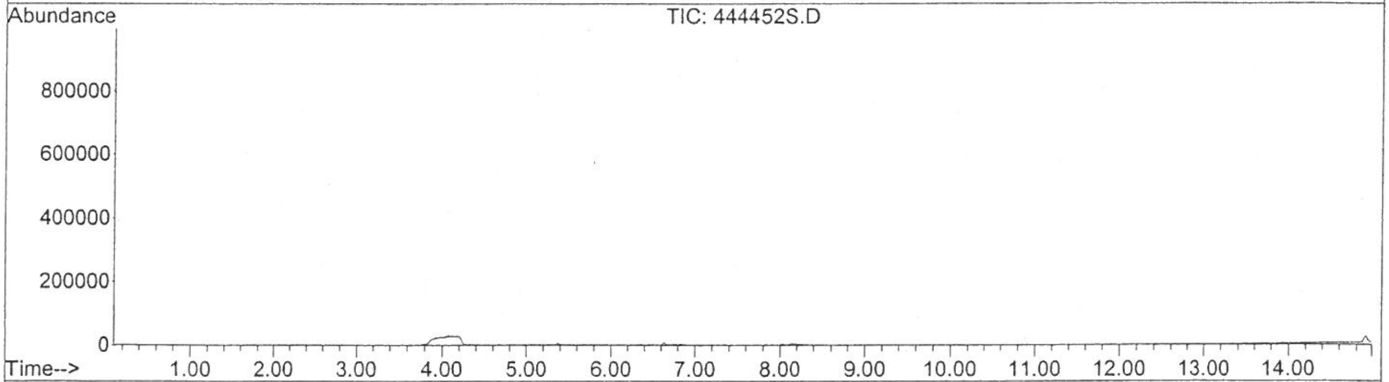

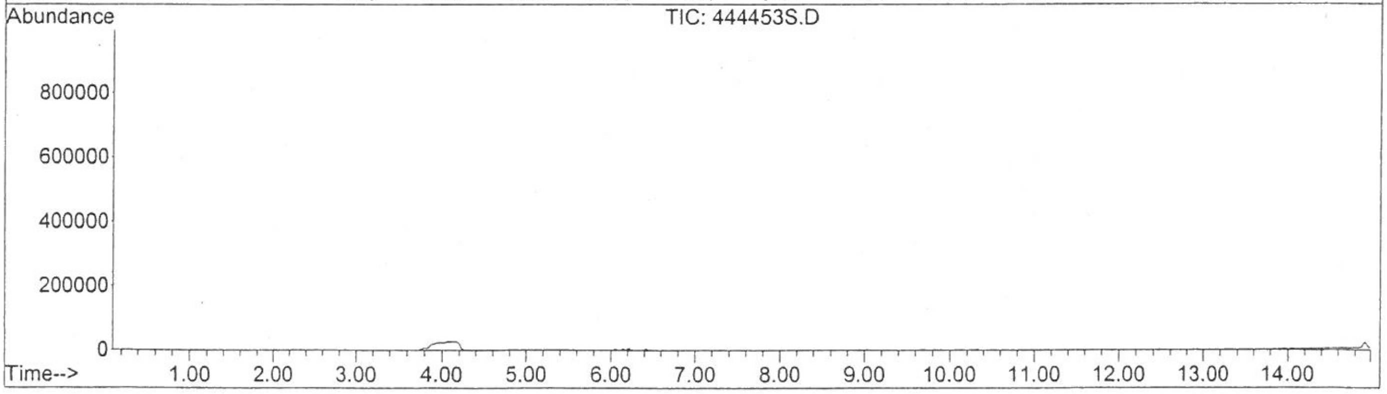

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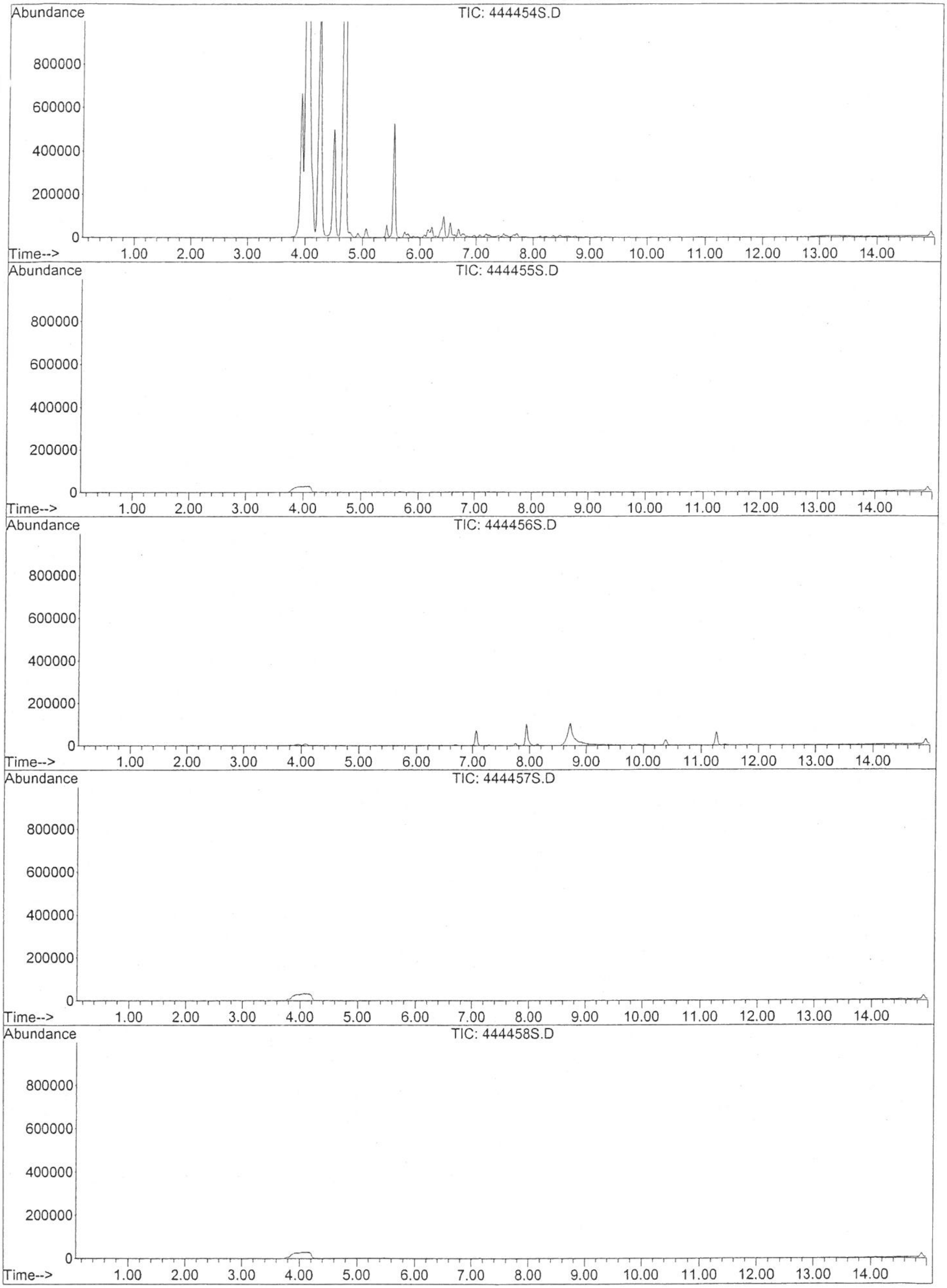

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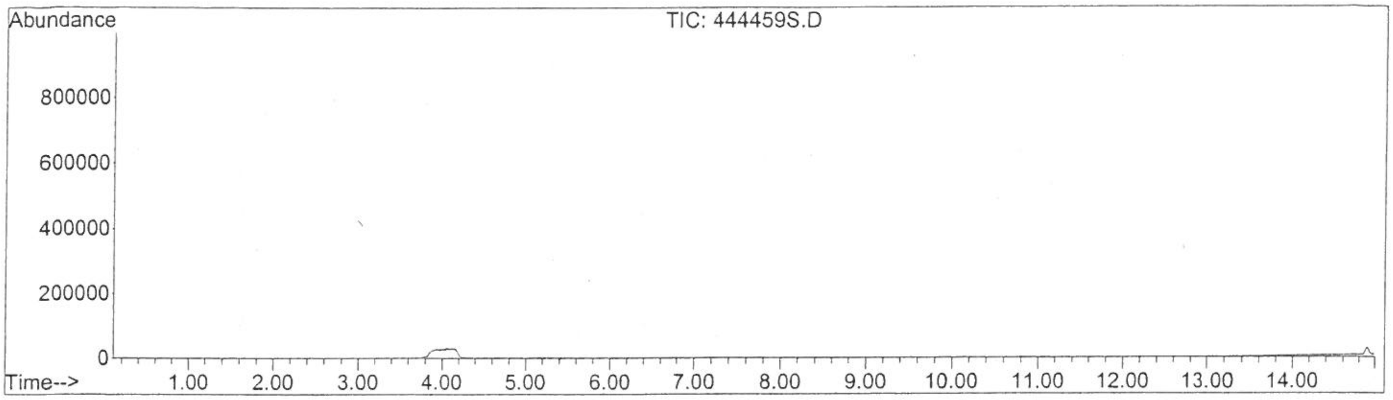

Scale 1:420

25 0 25 50 75

meters

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ELKTON, MD, USA 21921
USA
(410) 392-7600

GORE
Creative Technologies Worldwide

US Army Corps of Engineers, Norfolk, VA
NASA Wallops Flight Facility, Accomack County, VA
PCE, TCE, & cis- & trans-1,2-DCE

DATE DRAWN: 19 April 2004	DRAWN BY: JH	ORIG. CAD: NASA Wallops...dwg	SITE CODE: CQS
REV. DATE:	REV. #:	PROJECT NUMBER: 11787295	

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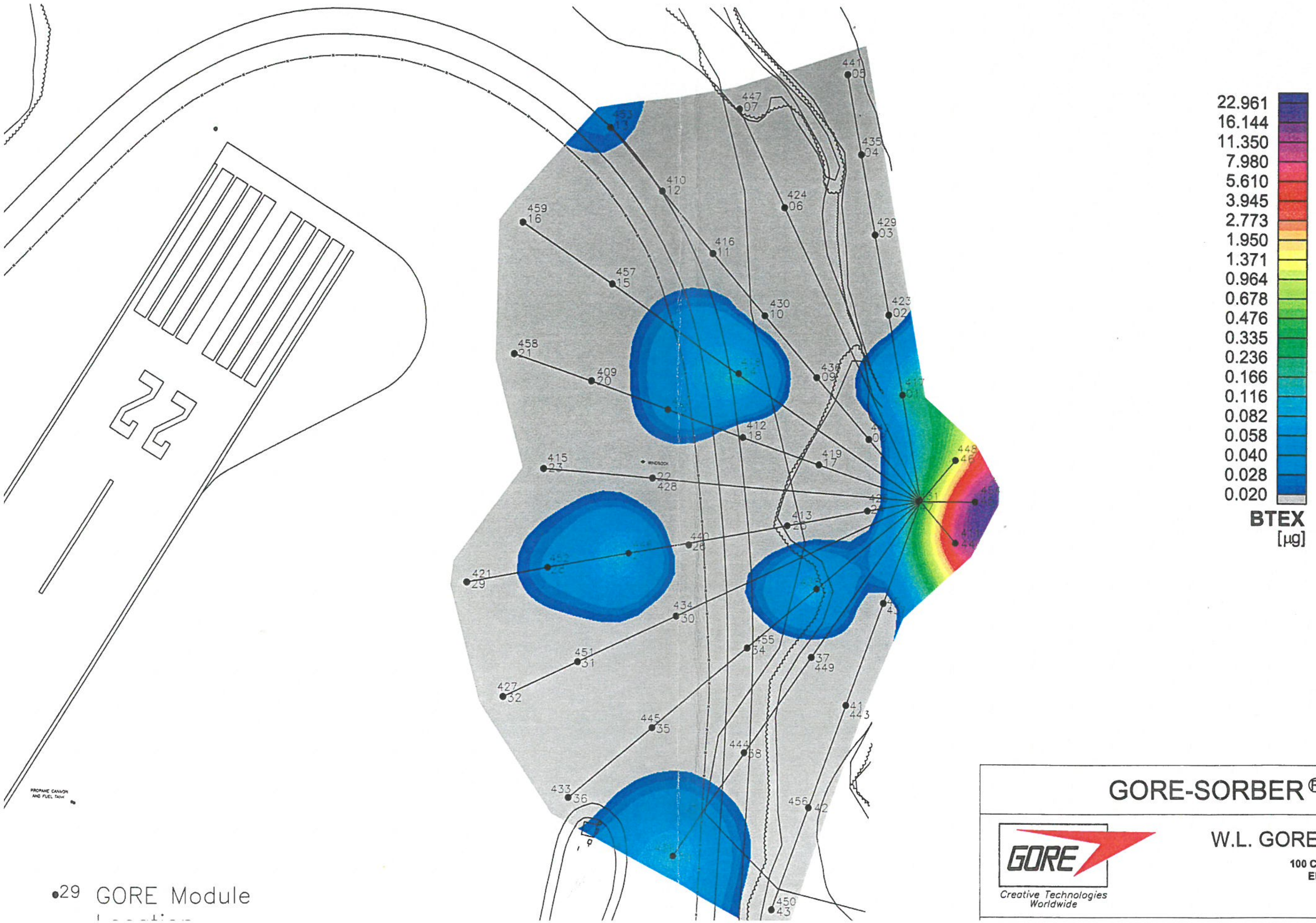

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Scale 1:420

25 0 25 50 75

meters

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USA
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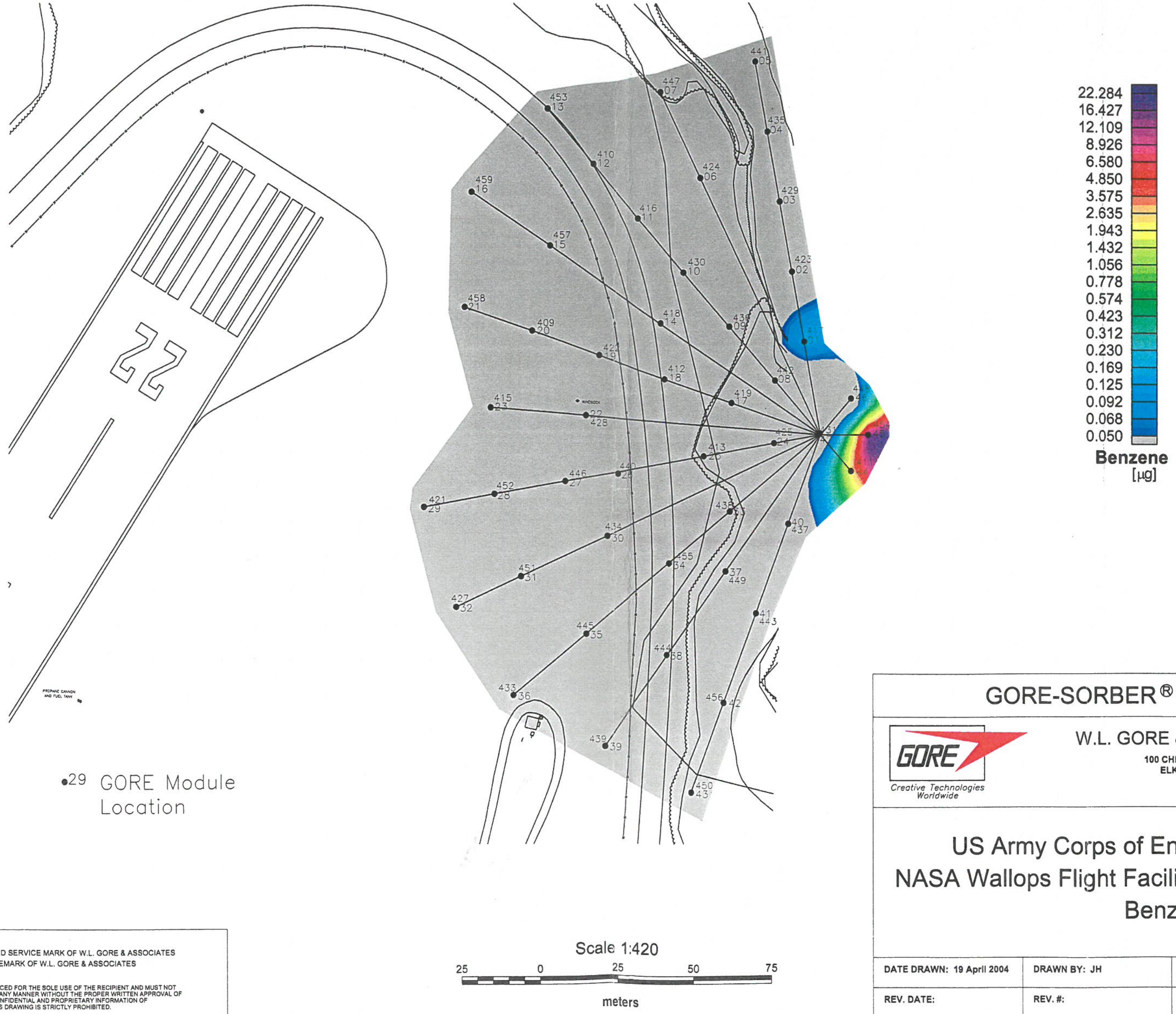
US Army Corps of Engineers, Norfolk, VA
NASA Wallops Flight Facility, Accomack County, VA
Toluene

DATE DRAWN: 19 April 2004	DRAWN BY: JH	ORIG. CAD: NASA Wallops...dwg	SITE CODE: CQS
REV. DATE:	REV. #:	PROJECT NUMBER: 11787295	



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US Army Corps of Engineers, Norfolk, VA
NASA Wallops Flight Facility, Accomack County, VA
Benzene

DATE DRAWN: 19 April 2004	DRAWN BY: JH	ORIG. CAD: NASA Wallops Project	SITE CODE: CQS
REV. DATE:	REV. #:	PROJECT NUMBER: 11787295	

New Jersey
ACCUTEST.
Laboratories

04/22/04

Technical Report for

USACE-Norfolk District

NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Accutest Job Number: N62849

Sampling Date: 03/23/04

Report to:

USACE-Norfolk District
803 Front Street
Norfolk, VA 23510

ATTN: George Mears

Total number of pages in report: **20**

ACCREDITED IN ACCORDANCE WITH nelac

Test results contained within this data package meet the requirements of the National Environmental Laboratory Accreditation Conference and/or state specific certification programs as applicable.

Vincent J. Pugliese
President

Certifications: NJ(12129), NY(10983), CA, CT, DE, FL, MA, MD, NC, PA, RI, SC, VA

Sample Summary

USACE-Norfolk District

NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Job No: N62849

Sample Number	Collected Date	Time	By	Received	Matrix Code	Type	Client Sample ID
N62849-1	03/23/04	11:30		03/24/04	SO	Soil	04 SGI-CDL-SB01-07

Soil samples reported on a dry weight basis unless otherwise indicated on result page.

Report of Analysis

Client Sample ID:	04 SGI-CDL-SB01-07		
Lab Sample ID:	N62849-1	Date Sampled:	03/23/04
Matrix:	SO - Soil	Date Received:	03/24/04
Method:	MADEP-EPH-98-1 SW846 3550B	Percent Solids:	87.8
Project:	NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA		

	File ID	DF	Analyzed	By	Prep Date	Prep Batch	Analytical Batch
Run #1	2Y420.D	5	04/13/04	CEG	03/24/04	OP16432	G2Y8
Run #2							

	Initial Weight	Final Volume
Run #1	10.0 g	2.0 ml
Run #2		

MAEPH List

CAS No.	Compound	Result	RL	MDL	Units	Q
83-32-9	Acenaphthene	ND	2300	370	ug/kg	
208-96-8	Acenaphthylene	ND	2300	320	ug/kg	
120-12-7	Anthracene	ND	2300	350	ug/kg	
56-55-3	Benzo(a)anthracene	ND	2300	340	ug/kg	
50-32-8	Benzo(a)pyrene	ND	2300	350	ug/kg	
205-99-2	Benzo(b)fluoranthene	ND	2300	330	ug/kg	
191-24-2	Benzo(g,h,i)perylene	ND	2300	360	ug/kg	
207-08-9	Benzo(k)fluoranthene	ND	2300	360	ug/kg	
218-01-9	Chrysene	ND	2300	520	ug/kg	
53-70-3	Dibenzo(a,h)anthracene	ND	2300	300	ug/kg	
206-44-0	Fluoranthene	ND	2300	1100	ug/kg	
86-73-7	Fluorene	ND	2300	260	ug/kg	
193-39-5	Indeno(1,2,3-cd)pyrene	ND	2300	210	ug/kg	
91-57-6	2-Methylnaphthalene	10600	2300	360	ug/kg	
91-20-3	Naphthalene	4880	2300	390	ug/kg	
85-01-8	Phenanthrene	ND	2300	330	ug/kg	
129-00-0	Pyrene	ND	2300	320	ug/kg	
	C11-C22 Aromatics (Unadj.)	860000	57000		ug/kg	
	C9-C18 Aliphatics	1980000	57000		ug/kg	
	C11-C22 Aromatics	845000	57000		ug/kg	
	C19-C36 Aliphatics	ND	57000		ug/kg	

CAS No.	Surrogate Recoveries	Run# 1	Run# 2	Limits
3386-33-2	1-Chlorooctadecane	46%		40-140%
580-13-2	2-Bromonaphthalene	240% [a]		40-140%
84-15-1	o-Terphenyl	104%		40-140%
321-60-8	2-Fluorobiphenyl	99%		40-140%

(a) Outside control limits due to matrix interference.

ND = Not detected
MDL - Method Detection Limit
RL = Reporting Limit
E = Indicates value exceeds calibration range
J = Indicates an estimated value
B = Indicates analyte found in associated method blank
N = Indicates presumptive evidence of a compound

Misc. Forms

Custody Documents and Other Forms

Includes the following where applicable:

- Chain of Custody

GC Volatiles

QC Data Summaries

Includes the following where applicable:

- Method Blank Summaries
- Blank Spike Summaries
- Matrix Spike and Duplicate Summaries
- Surrogate Recovery Summaries

Blank Spike Summary

Job Number: N62849
Account: USACEVAN USACE-Norfolk District
Project: NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Sample	File ID	DF	Analyzed	By	Prep Date	Prep Batch	Analytical Batch
GPF505-BS	PF12772.D	1	04/06/04	XPL	n/a	n/a	GPF505

The QC reported here applies to the following samples:

Method: MADEP VPH 98-1

N62849-1

CAS No.	Compound	Spike ug/kg	BSP ug/kg	BSP %	Limits
71-43-2	Benzene	1250	1150	92	70-130
100-41-4	Ethylbenzene	1250	1120	90	70-130
1634-04-4	Methyl Tert Butyl Ether	3750	3410	91	70-130
91-20-3	Naphthalene	2500	1890	76	70-130
108-88-3	Toluene	3750	3500	93	70-130
	m,p-Xylene	5000	4610	92	70-130
95-47-6	o-Xylene	2500	2350	94	70-130

CAS No.	Surrogate Recoveries	BSP	Limits
615-59-8	2,5-Dibromotoluene	118%	70-130%
615-59-8	2,5-Dibromotoluene	106%	70-130%

Duplicate Summary

Job Number: N62849
Account: USACEVAN USACE-Norfolk District
Project: NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Sample	File ID	DF	Analyzed	By	Prep Date	Prep Batch	Analytical Batch
N62959-5DUP	PF12777.D	1	04/06/04	XPL	n/a	n/a	GPF505
N62959-5	PF12774.D	1	04/06/04	XPL	n/a	n/a	GPF505

The QC reported here applies to the following samples:

Method: MADEP VPH 98-1

N62849-1

CAS No.	Compound	N62959-5 ug/kg	Q	DUP ug/kg	Q	RPD	Limits
71-43-2	Benzene	ND		ND		nc	
100-41-4	Ethylbenzene	ND		ND		nc	
1634-04-4	Methyl Tert Butyl Ether	ND		ND		nc	
91-20-3	Naphthalene	ND		ND		nc	
108-88-3	Toluene	ND		ND		nc	
	m,p-Xylene	ND		ND		nc	
95-47-6	o-Xylene	ND		ND		nc	
	C5- C8 Aliphatics (Unadj.)	ND		ND		nc	
	C9- C12 Aliphatics (Unadj.)	ND		ND		nc	
	C5- C8 Aliphatics	ND		ND		nc	
	C9- C12 Aliphatics	ND		ND		nc	
	C9- C10 Aromatics	ND		ND		nc	

CAS No.	Surrogate Recoveries	DUP	N62959-5	Limits
615-59-8	2,5-Dibromotoluene	139%* [a]	122%	70-130%
615-59-8	2,5-Dibromotoluene	124%	109%	70-130%

(a) Outside in house QC limits.

GC Semi-volatiles

QC Data Summaries

Includes the following where applicable:

- Method Blank Summaries
- Blank Spike Summaries
- Matrix Spike and Duplicate Summaries
- Surrogate Recovery Summaries

Method Blank Summary

Job Number: N62849
Account: USACEVAN USACE-Norfolk District
Project: NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Sample	File ID	DF	Analyzed	By	Prep Date	Prep Batch	Analytical Batch
OP16433-MB1	YZ33419.D	1	04/01/04	CEG	03/24/04	OP16433	GYZ939

The QC reported here applies to the following samples:

Method: SW846-8015

N62849-1

CAS No.	Compound	Result	RL	Units	Q
	Gasoline (C4-C12)	NO MATCH			
	Turpentine (C9-C11)	NO MATCH			
	Mineral Spirits (C9-C12)	NO MATCH			
	Kerosene (C9-C18)	NO MATCH			
	Diesel /Fuel oil #2 (C9-C22)	NO MATCH			
	Fuel Oil #4 (C11-C24)	NO MATCH			
	Fuel Oil #6 (C11-C26)	NO MATCH			
	Other Patterns	NO MATCH			

Matrix Spike/Matrix Spike Duplicate Summary

Job Number: N62849
Account: USACEVAN USACE-Norfolk District
Project: NASA Wallops FF - Passive Soil Gas Investigation, Accomack City, VA

Sample	File ID	DF	Analyzed	By	Prep Date	Prep Batch	Analytical Batch
OP16432-MS	2Y387.D	1	04/10/04	CEG	03/24/04	OP16432	G2Y8
OP16432-MSD	2Y388.D	1	04/10/04	CEG	03/24/04	OP16432	G2Y8
N62849-1	2Y420.D	5	04/13/04	CEG	03/24/04	OP16432	G2Y8

The QC reported here applies to the following samples:

Method: MADEP-EPH-98-1

N62849-1

CAS No.	Compound	N62849-1 ug/kg	Q	Spike ug/kg	MS ug/kg	MS %	MSD ug/kg	MSD %	RPD	Limits Rec/RPD
83-32-9	Acenaphthene	ND		5690	4180	73	4590	81	9	40-140/50
208-96-8	Acenaphthylene	ND		5690	6240	110	6440	113	3	40-140/50
120-12-7	Anthracene	ND		5690	3880	68	3970	70	2	40-140/50
56-55-3	Benzo(a)anthracene	ND		5690	5850	103	6020	106	3	40-140/50
50-32-8	Benzo(a)pyrene	ND		5690	5820	102	5880	103	1	40-140/50
205-99-2	Benzo(b)fluoranthene	ND		5690	6950	122	6320	111	9	40-140/50
191-24-2	Benzo(g,h,i)perylene	ND		5690	5820	102	5860	103	1	40-140/50
207-08-9	Benzo(k)fluoranthene	ND		5690	6130	108	6730	118	9	40-140/50
218-01-9	Chrysene	ND		5690	6230	109	6430	113	3	40-140/50
53-70-3	Dibenzo(a,h)anthracene	ND		5690	6370	112	6420	113	1	40-140/50
206-44-0	Fluoranthene	ND		5690	5750	101	5940	104	3	40-140/50
86-73-7	Fluorene	ND		5690	6960	122	6140	108	13	40-140/50
193-39-5	Indeno(1,2,3-cd)pyrene	ND		5690	6250	110	6280	110	0	40-140/50
91-57-6	2-Methylnaphthalene	10600		5690	9240	0*[a]	9060	0*[a]	2	40-140/50
91-20-3	Naphthalene	4880		5690	5600	13*[a]	5750	15*[a]	3	40-140/50
85-01-8	Phenanthrene	ND		5690	6130	108	6280	110	2	40-140/50
129-00-0	Pyrene	ND		5690	5630	99	5790	102	3	40-140/50
	C11-C22 Aromatics (Unadj.)	860000		96800	205000	0*[b]	172000	0*[b]	18	50-150/30[c]
	C9-C18 Aliphatics	1980000		34200	362000	0*[b]	268000	0*[b]	30	40-140/50
	C11-C22 Aromatics	845000		96800	102000	0*[b]	68400	0*[b]	39*[b]	50-150/30[c]
	C19-C36 Aliphatics	ND		45600	46600	102	44600	98	4	40-140/50

CAS No.	Surrogate Recoveries	MS	MSD	N62849-1	Limits
3386-33-2	1-Chlorooctadecane	52%	50%	46%	40-140%
580-13-2	2-Bromonaphthalene	145%*[a]	142%*[a]	240%*[a]	40-140%
84-15-1	o-Terphenyl	107%	108%	104%	40-140%
321-60-8	2-Fluorobiphenyl	78%	86%	99%	40-140%

(a) Outside control limits due to matrix interference.
(b) Outside control limits due to high level in sample relative to spike amount.
(c) Advisory control limits.

```
                        Quantitation Report    (QT Reviewed)

     Signal #1 : C:\MSDCHEM\1\DATA\PF12780.D\FID1A.CH        Vial: 15
     Signal #2 : C:\MSDCHEM\1\DATA\PF12780.D\ELC2B.CH
     Acq On    : 06 Apr 2004   8:35 pm                     Operator: XULIU
     Sample    : N62849-1                                  Inst    : GCPF
     Misc      : GC19170,GPF505,4.4,,100,5,1               Multiplr: 1.00
     IntFile Signal #1: autoint1.e     IntFile Signal #2: autoint2.e
     Quant Time: Apr 06 21:10:18 2004  Quant Results File: MPF465.RES

     Quant Method : C:\MSDCHEM\1\METHODS\MPF465.M (Chemstation Integrator)
     Title        : VPH
     Last Update  : Mon Jan 12 14:33:32 2004
     Response via : Initial Calibration
     DataAcq Meth : MPF465.M

     Volume Inj.      : N/A
     Signal #1 Phase : crossbond phenylm Signal #2 Phase:
     Signal #1 Info  : RTX-502.2 105 m.X Signal #2 Info : RTX-502.2

        Compound                            R.T.      Response    Conc Units
   -----------------------------------------------------------------------

   System Monitoring Compounds
15) S   2,5-DIBROMOTOLUENE              30.23       16304485   46.224 ppb  m
Spiked Amount   40.000                     Recovery      =  115.56%
27) S   2,5-DIBROMOTOLUENE #2           30.23      100999172   39.565 ppb
Spiked Amount   40.000                     Recovery      =   98.91%

   Target Compounds
 6) M   TOLUENE                         20.65      686351472  334.784 ppb  m
 7) M   ETHYLBENZENE                    23.37f    1758412587  934.413 ppb
 8) M   m,p-XYLENE                      23.54      871184099  428.087 ppb
 9) H   C5- C8 ALIPHATIC (UNADJ.)       18.00    33658009581 22872.707 ppb
13) M   NAPHTHALENE                     29.07      128900658   96.880 ppb
    H   C9- C12 ALIPHATIC (UNADJ.)      24.12    28326143753 22282.536 ppb
    M   TOLUENE #2                      20.65      457596758   80.422 ppb
21) M   ETHYLBENZENE #2                 23.40f    2080147213  408.751 ppb
22) M   m,p-XYLENE #2                   23.54     1285160921  217.708 ppb
25) M   NAPHTHALENE #2                  29.07      288475711   58.651 ppb
26) H   C9- C10 AROMATIC (UNADJ.)       27.12    30358483106 5778.179 ppb
```

GX 4/7

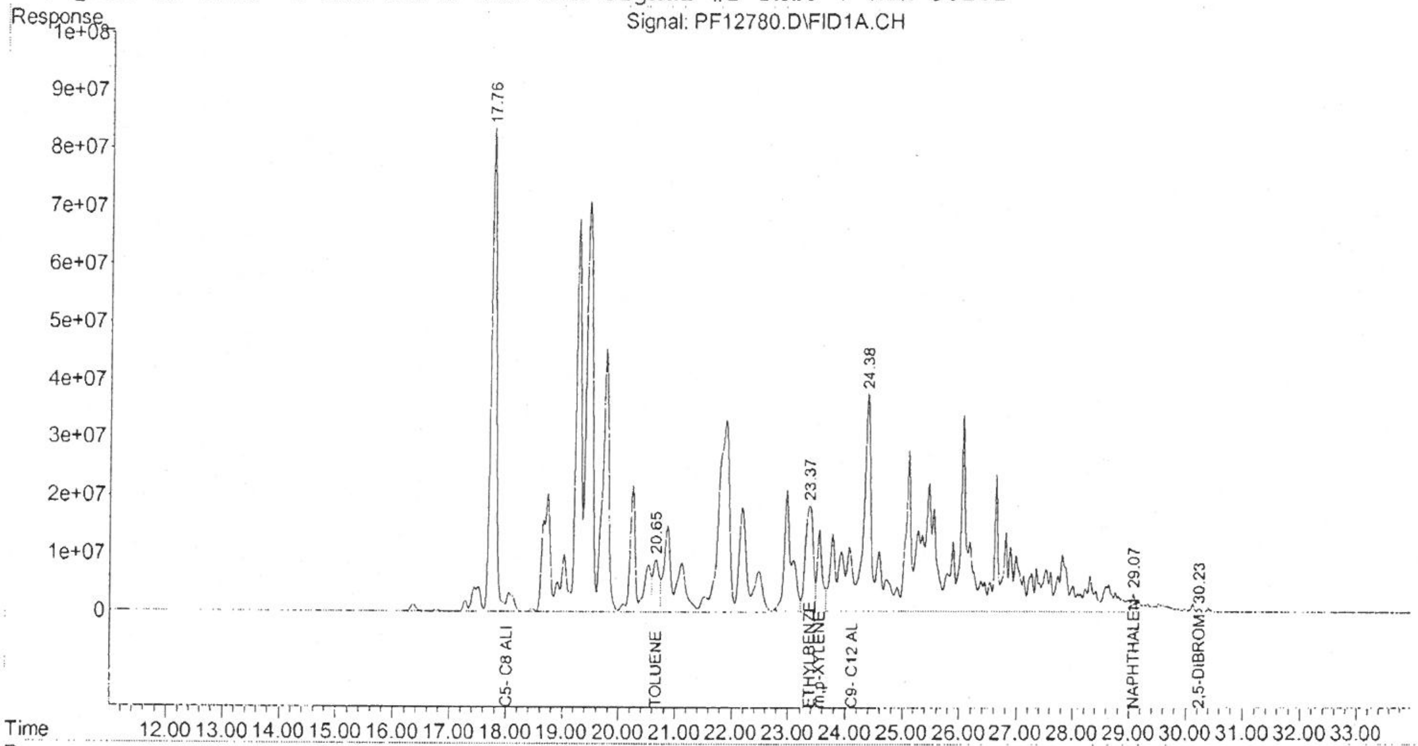
```
-----------------------------------------------------------------------
```

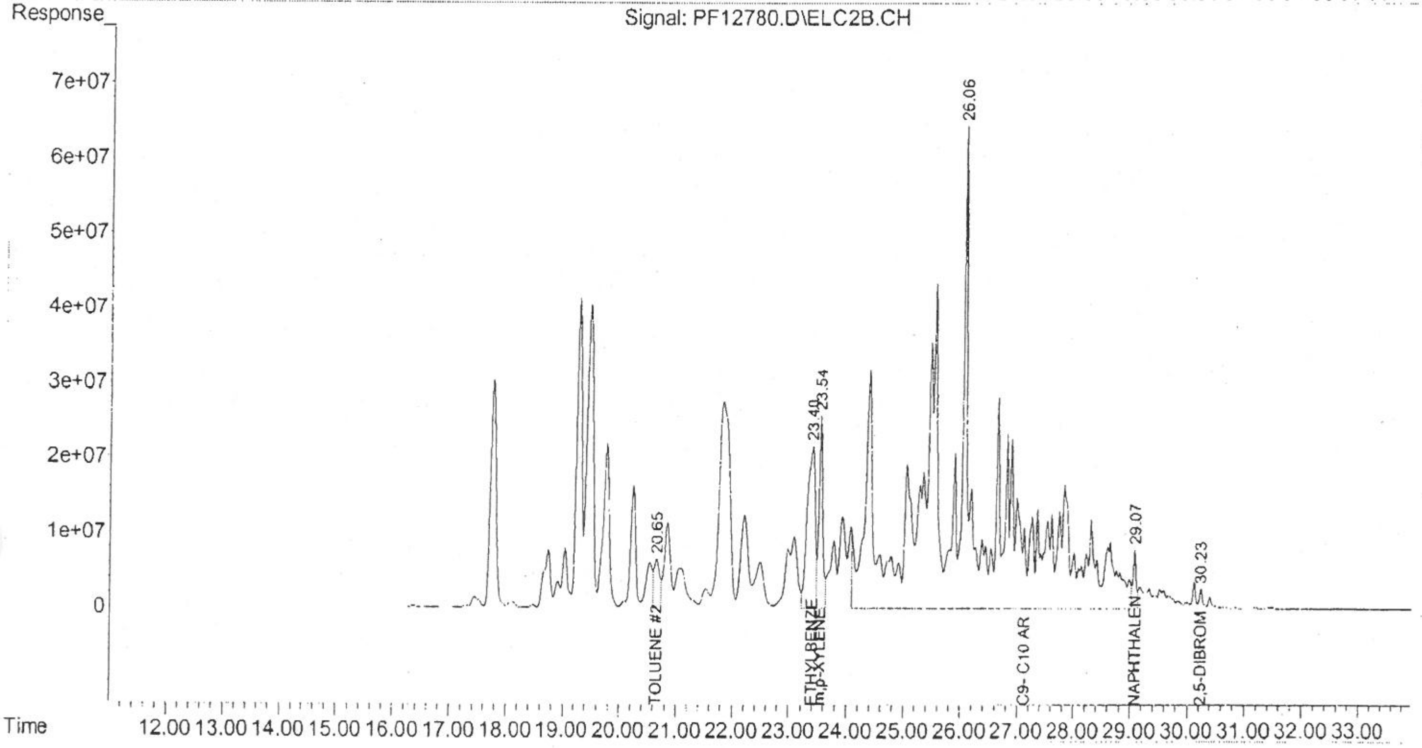
```
                        Quantitation Report     (QT Reviewed)

Signal #1 : C:\MSDCHEM\1\DATA\PF12780.D\FID1A.CH         Vial: 15
Signal #2 : C:\MSDCHEM\1\DATA\PF12780.D\ELC2B.CH
Acq On    : 06 Apr 2004   8:35 pm                    Operator: XULIU
Sample    : N62849-1                                 Inst    : GCPF
Misc      : GC19170,GPF505,4.4,,100,5,1              Multiplr: 1.00
IntFile Signal #1: autoint1.e     IntFile Signal #2: autoint2.e
Quant Time: Apr  7 10:04 2004  Quant Results File: MPF465.RES

Quant Method : C:\MSDCHEM\1\METHODS\MPF465.M (Chemstation Integrator)
Title        : VPH
Last Update  : Mon Jan 12 14:33:32 2004
Response via : Single Level Calibration
DataAcq Meth : MPF465.M

Volume Inj.       : N/A
Signal #1 Phase : crossbond phenylm Signal #2 Phase:
Signal #1 Info  : RTX-502.2 105 m.X Signal #2 Info : RTX-502.2
```

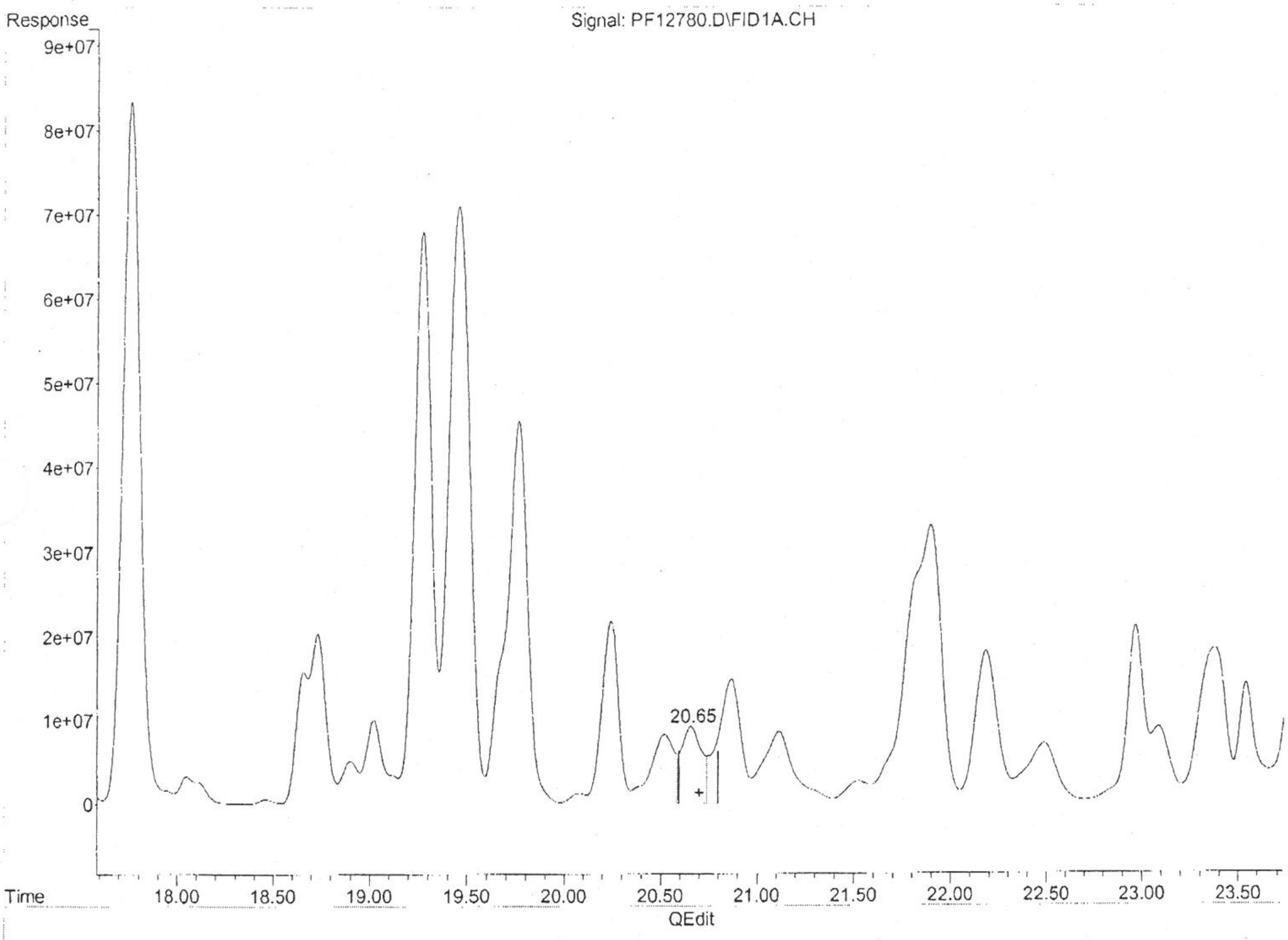

Signal: PF12780.D\FID1A.CH


Signal: PF12780.D\ELC2B.CH

```
                              Quantitation Report (Qedit)

Signal #1 : C:\MSDCHEM\1\DATA\PF12780.D\FID1A.CH          Vial: 15
Signal #2 : C:\MSDCHEM\1\DATA\PF12780.D\ELC2B.CH
Acq On    : 06 Apr 2004   8:35 pm                     Operator: XULIU
Sample    : N62849-1                                  Inst    : GCPF
   c      : GC19170,GPF505,4.4,,100,5,1               Multiplr: 1.00
   File Signal #1: autoint1.e     IntFile Signal #2: autoint2.e
Quant Time: Apr  7  8:20 2004  Quant Results File: MPF465.RES


Method       : C:\MSDCHEM\1\METHODS\MPF465.M (Chemstation Integrator)
Title        : VPH
Last Update  : Mon Jan 12 14:33:32 2004
Response via : Multiple Level Calibration
```



(6) TOLUENE (M)

20.65min 334.784ppb m

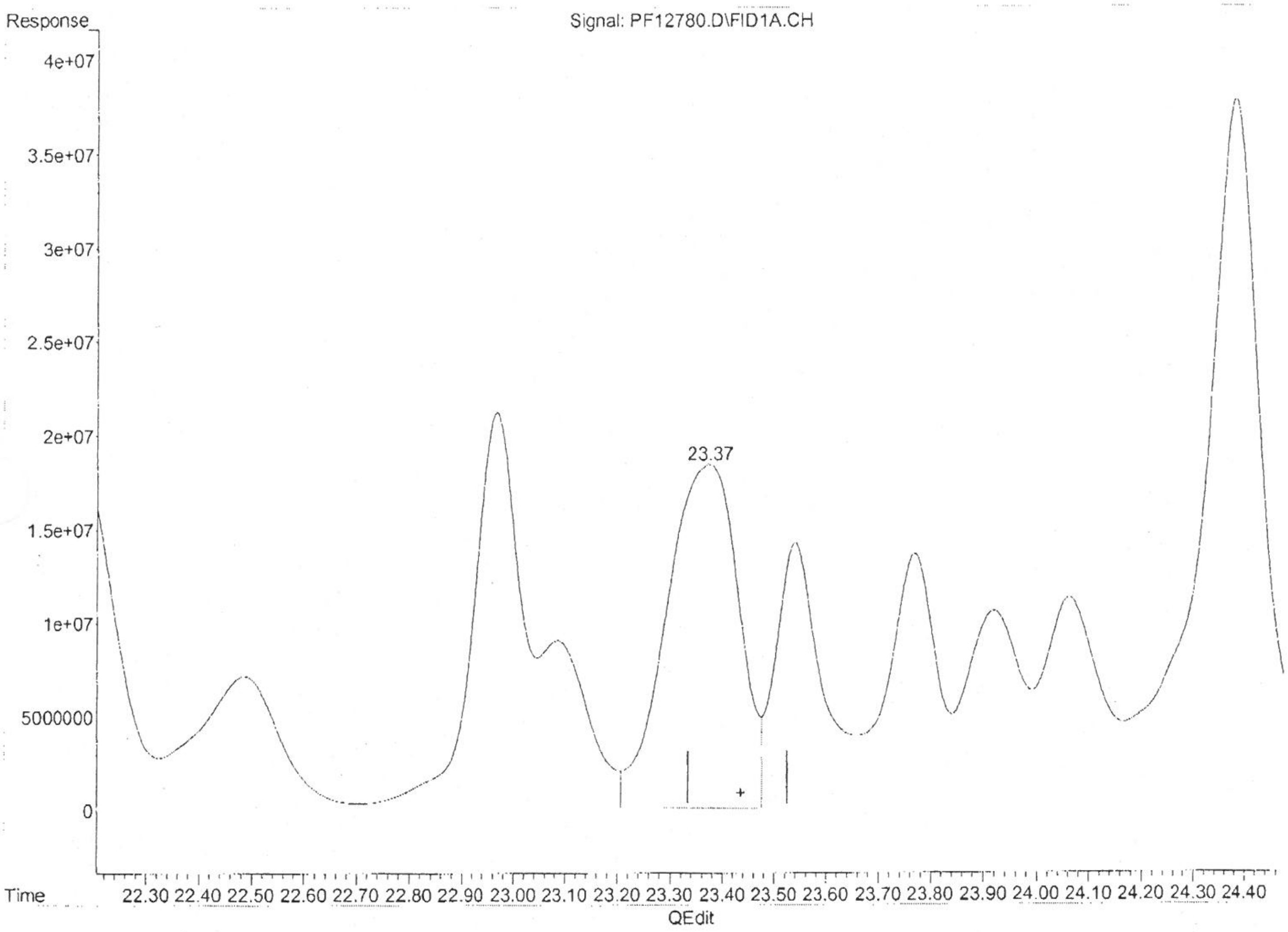
response 686351472

(+) = Expected Retention Time

Quantitation Report (Qedit)

```
Signal #1 : C:\MSDCHEM\1\DATA\PF12780.D\FID1A.CH        Vial: 15
Signal #2 : C:\MSDCHEM\1\DATA\PF12780.D\ELC2B.CH
Acq On    : 06 Apr 2004   8:35 pm                    Operator: XULIU
Sample    : N62849-1                                 Inst    : GCPF
          : GC19170,GPF505,4.4,,100,5,1              Multiplr: 1.00
  File Signal #1: autoint1.e     IntFile Signal #2: autoint2.e
Quant Time: Apr  7 10:04 2004  Quant Results File: MPF465.RES


Method       : C:\MSDCHEM\1\METHODS\MPF465.M (Chemstation Integrator)
Title        : VPH
Last Update  : Mon Jan 12 14:33:32 2004
Response via : Multiple Level Calibration
```



(7) ETHYLBENZENE (M)

23.37min 934.413ppb

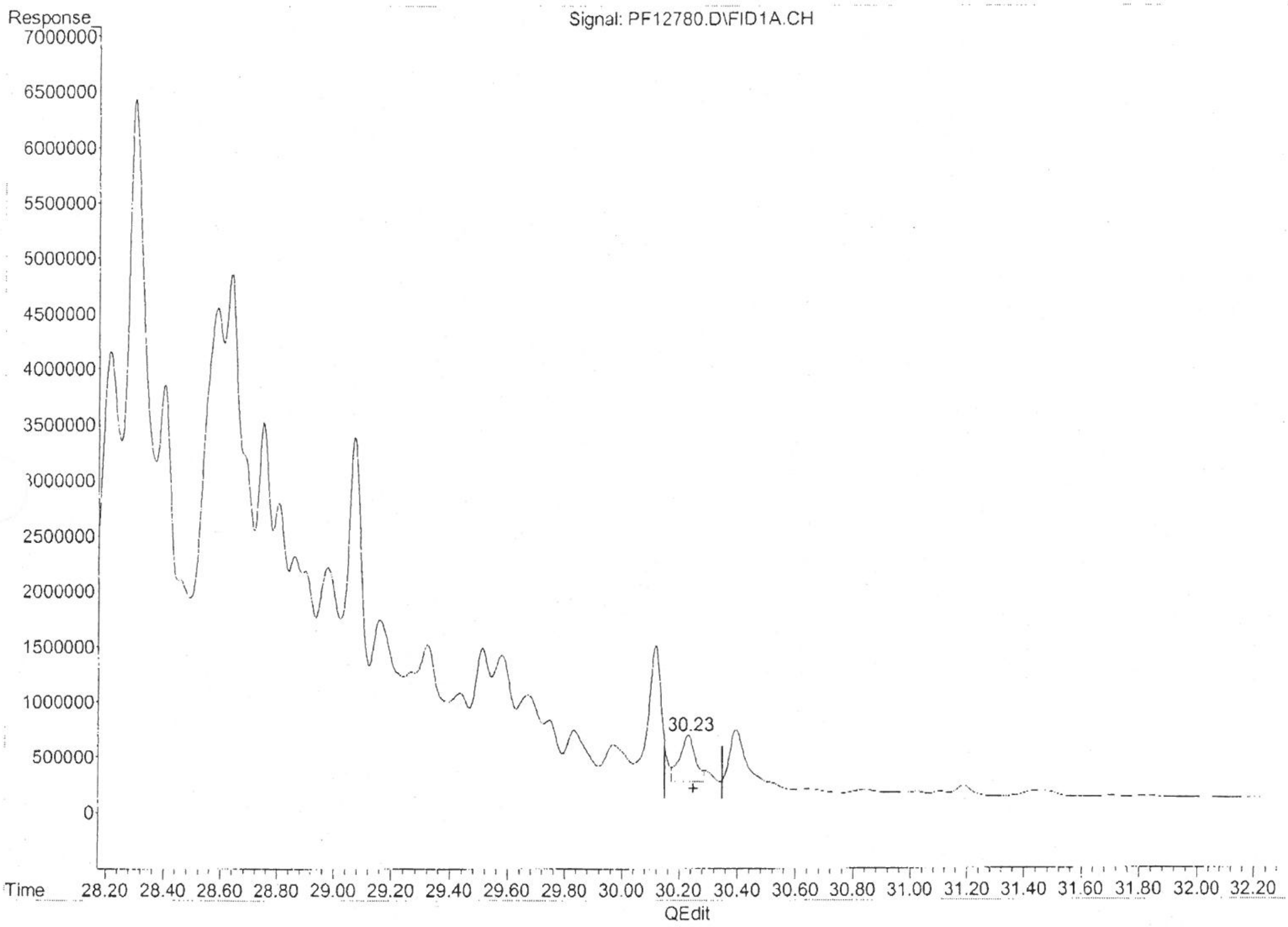
response 1758412587

(+) = Expected Retention Time

Quantitation Report (Qedit)

```
Signal #1 : C:\MSDCHEM\1\DATA\PF12780.D\FID1A.CH         Vial: 15
Signal #2 : C:\MSDCHEM\1\DATA\PF12780.D\ELC2B.CH
Acq On    : 06 Apr 2004   8:35 pm                     Operator: XULIU
Sample    : N62849-1                                  Inst    : GCPF
   c      : GC19170,GPF505,4.4,,100,5,1               Multiplr: 1.00
  File Signal #1: autoint1.e     IntFile Signal #2: autoint2.e
Quant Time: Apr  7  8:20 2004  Quant Results File: MPF465.RES


Method        : C:\MSDCHEM\1\METHODS\MPF465.M (Chemstation Integrator)
Title         : VPH
Last Update   : Mon Jan 12 14:33:32 2004
Response via  : Multiple Level Calibration
```



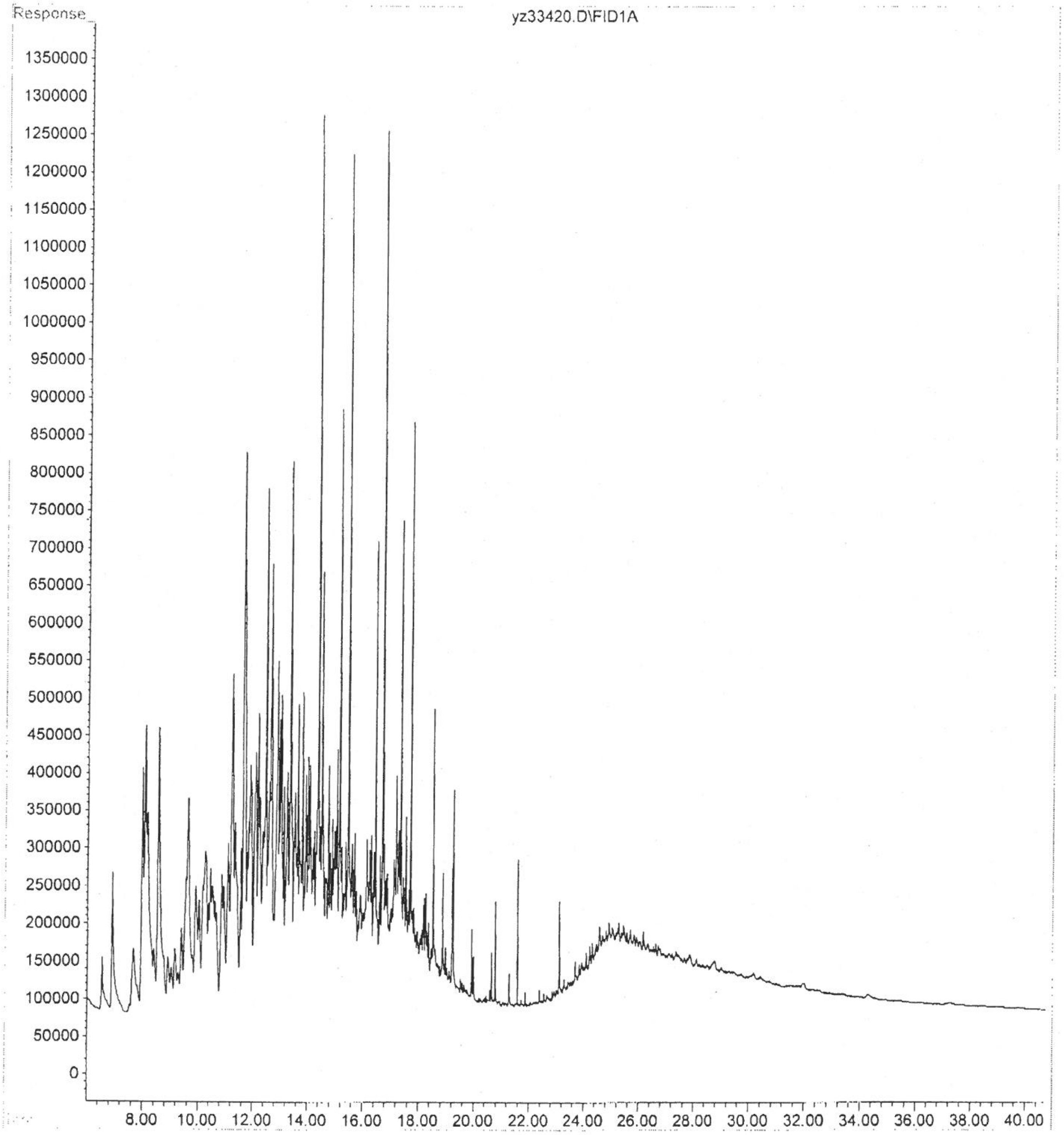
(15) 2,5-DIBROMOTOLUENE (S)

30.23min 46.224ppb m

response 16304485

(+) = Expected Retention Time

```
File         : C:\HPCHEM\2\DATA\yz33420.D
Operator     : CEMILEG
Acquired     : 4-1-04 7:02:49 PM using AcqMethod DRO905.M
Instrument :   GCYZ
Sample Name: N62849-1
Misc Info    : OP16433,GYZ939,30.0,,,1,50
Vial Number: 8
```



```
                       Quantitation Report    (QT Reviewed)

    Data File : C:\HPCHEM\2\DATA\yz33420.D                    Vial: 8
    Acq On    : 4-1-04 7:02:49 PM                         Operator: CEMILEG
    Sample    : N62849-1                                  Inst    : GCYZ
    Misc      : OP16433,GYZ939,30.0,,,1,50                Multiplr: 1.00
    IntFile   : autoint1.e
    Quant Time: Apr  7 15:07 2004  Quant Results File: DRO905.RES

    Quant Method : C:\HPCHEM\1\METHODS\DRO905.M (Chemstation Integrator)
    Title        : GCTPHS
    Last Update  : Wed Apr 07 15:05:49 2004
    Response via : Initial Calibration
    DataAcq Meth : DRO905.M

    Volume Inj.  : 1 ul
    Signal Phase : DB-5
    Signal Info  : .32 mm ID

       Compound                         R.T.      Response   Conc Units
   ------------------------------------------------------------------------

   System Monitoring Compounds
  2) S   o-TERPHENYL                   20.76      1819661    3.400 PPB  m
 Spiked Amount   50.000                    Recovery     =    6.80%
  3) S   5a-ANDROSTANE                 21.57      1968650    4.016 PPB
 Spiked Amount   50.000                    Recovery     =    8.03%
  4) S   TETRACOSANE-d50               23.10      1658306    4.150 PPB
 Spiked Amount   50.000                    Recovery     =    8.30%

   Target Compounds
  1) H   TPH-DRO                       18.25    897867988 1896.968 PPB
```

EG
04/07/04

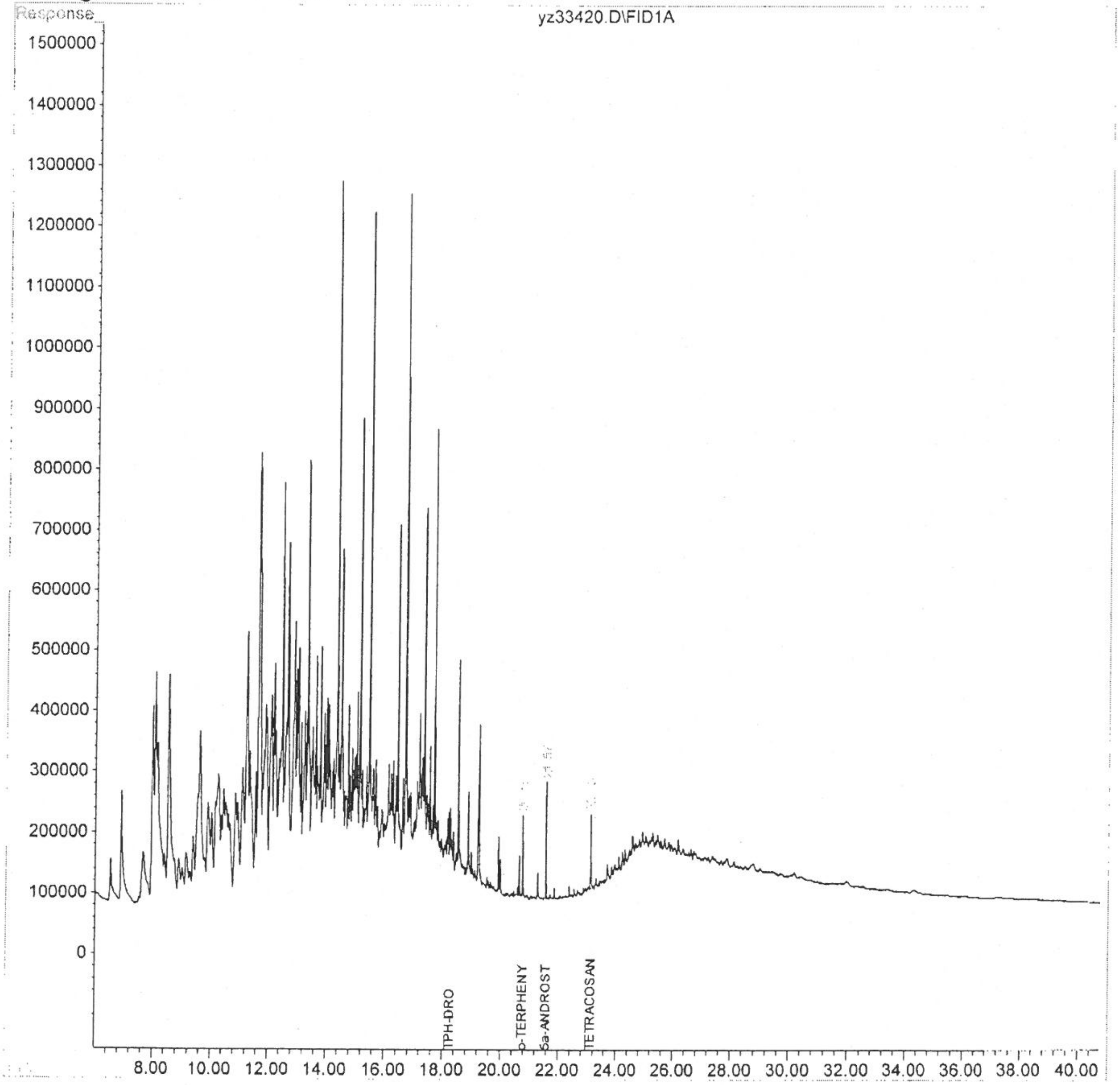
```
--------------------------------------------------------------------------
(f)=RT Delta > 1/2 Window                            (m)=manual int.
```

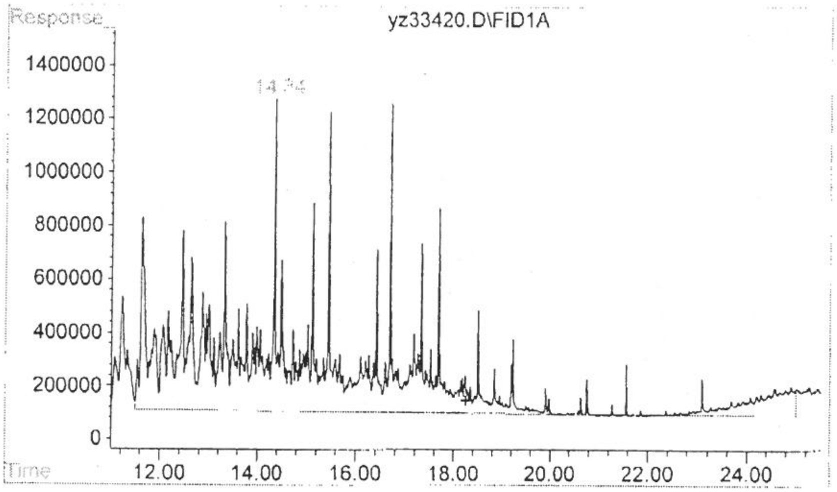
Quantitation Report

```
Data File : C:\HPCHEM\2\DATA\yz33420.D                          Vial: 8
Acq On    : 4-1-04 7:02:49 PM                               Operator: CEMILEG
Sample    : N62849-1                                        Inst     : GCYZ
Misc      : OP16433,GYZ939,30.0,,,1,50                      Multiplr: 1.00
IntFile   : autoint1.e
Quant Time: Apr  7 15:07 2004  Quant Results File: DRO905.RES

Quant Method : C:\HPCHEM\1\METHODS\DRO905.M (Chemstation Integrator)
Title        : GCTPHS
Last Update  : Wed Apr 07 15:05:49 2004
Response via : Multiple Level Calibration
DataAcq Meth : DRO905.M

Volume Inj.  : 1 ul
Signal Phase : DB-5
Signal Info  : .32 mm ID
```





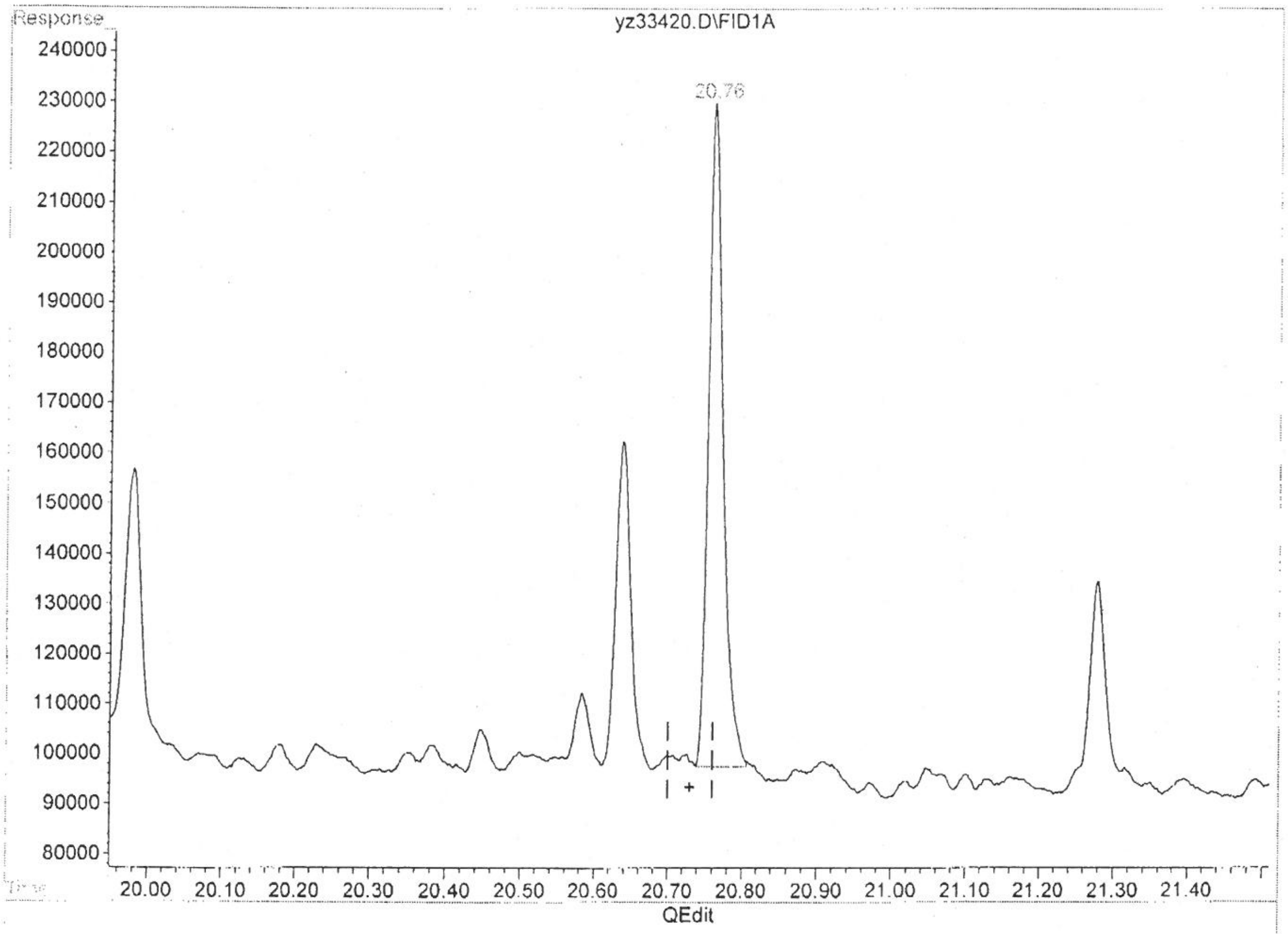
```
#1  TPH-DRO

      R.T.:  18.250 min
Delta R.T.:   0.000 min
  Response: 897867988
      Conc: 1896.97 PPB m
```

Quantitation Report

```
Data File : C:\HPCHEM\2\DATA\yz33420.D                      Vial: 8
Acq On    : 4-1-04 7:02:49 PM                           Operator: CEMILEG
Sample    : N62849-1                                    Inst    : GCYZ
Misc      : OP16433,GYZ939,30.0,,,1,50                  Multiplr: 1.00
IntFile   : autoint1.e
Quant Time: Apr  7 15:07 2004  Quant Results File: DRO905.RES

Method         : C:\HPCHEM\1\METHODS\DRO905.M (Chemstation Integrator)
Title          : GCTPHS
Last Update    : Tue Feb 10 08:18:32 2004
Response via   : Multiple Level Calibration
```



(2) o-TERPHENYL (S)

20.76min 3.400PPB m

response 1819661

(+) = Expected Retention Time

Petroleum Product Fingerprinting

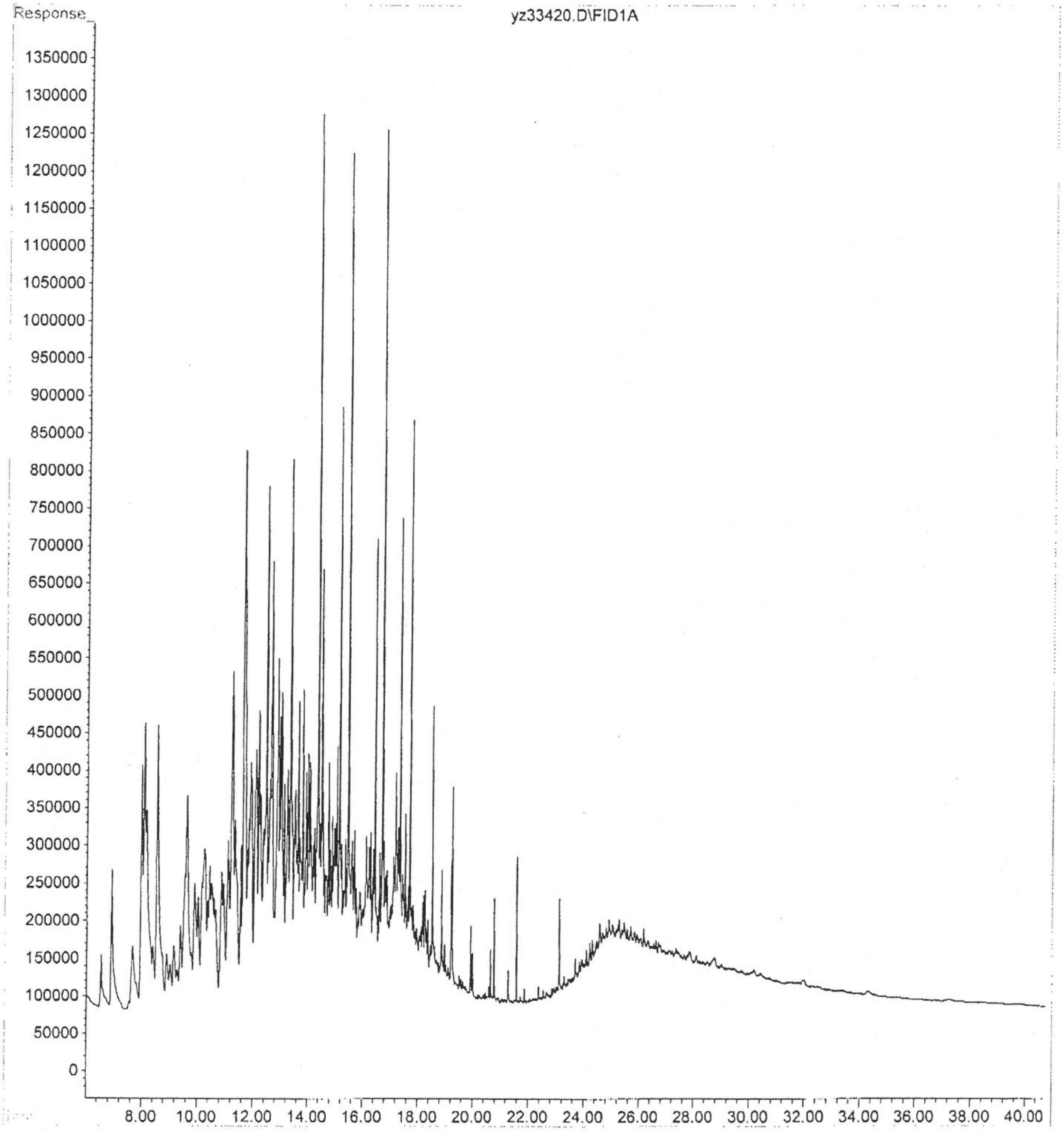
Petroleum Product Fingerprinting analysis is performed to determine the identity of a suspected petroleum products detected in environmental samples. The analysis is performed using gas chromatography with flame ionization detection (GC/FID).

The unknown product is analyzed by GC/FID using instrument conditions that separate the mixture of hydrocarbons present in the sample. Standard petroleum product samples are analyzed by GC/FID under identical chromatographic conditions. The chromatograms of the sample and the standard products are compared to determine the most likely product of the field sample.

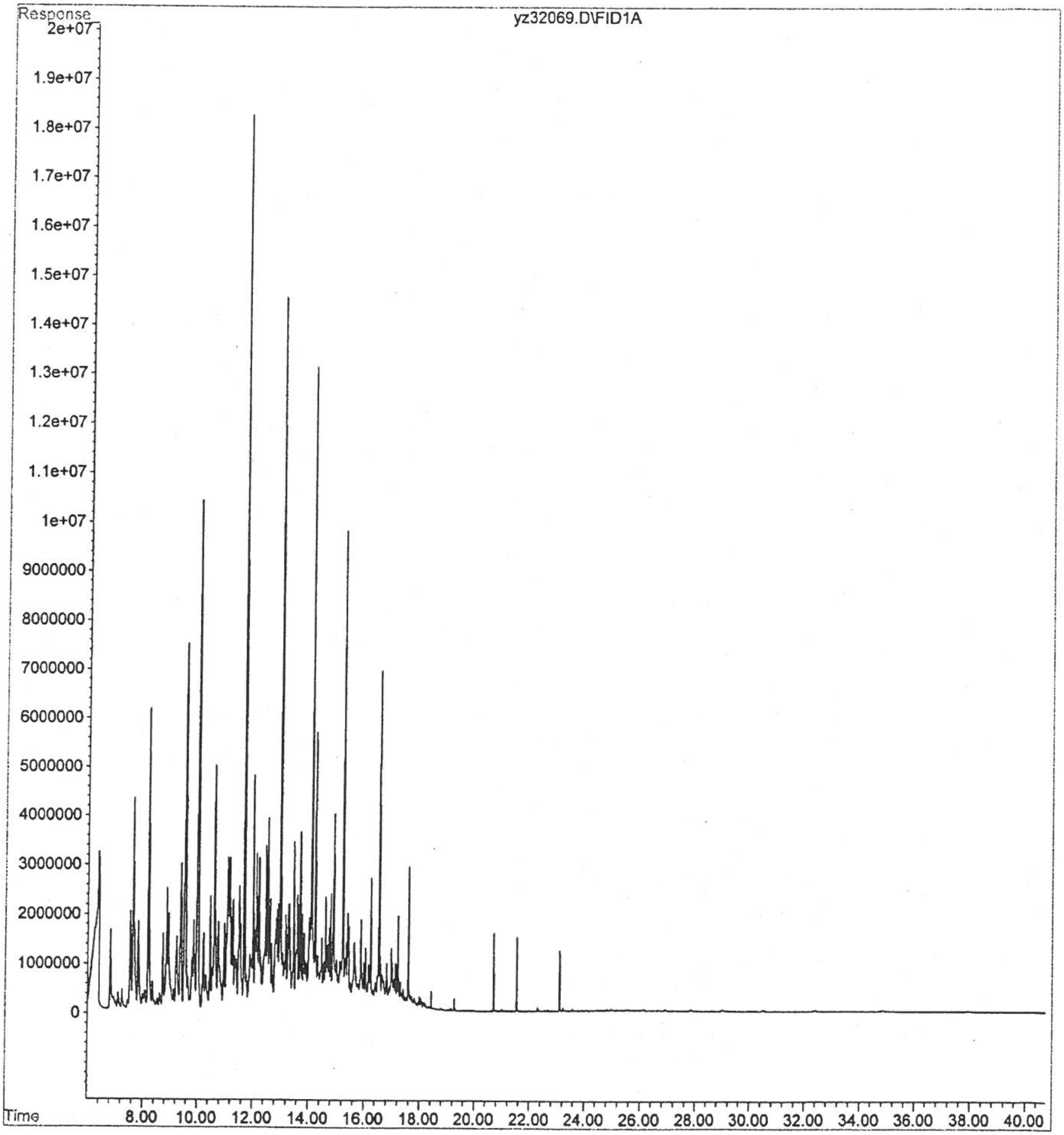
The chromatogram of sample N62849-1 was compared to the chromatograms of standard petroleum products to determine if a matching product could be identified. An exact match could not be determined in this case. However, the sample chromatograph appeared to be similar to a weathered JP-5. The sample contained a hydrocarbon range similar to a JP-5. The lower molecular weight (lower boiling) hydrocarbons in the sample were substantially different from the JP-5. It is possible that the differences between the sample and product standard may have been caused by an extended period of weathering that heavily affected the lighter compounds in the sample.

David N. Speis
Director, Corporate Quality Assurance
Accutest Laboratories,
2235 Route 130
Dayton, New Jersey 08810
732.329.0200 ex. 242

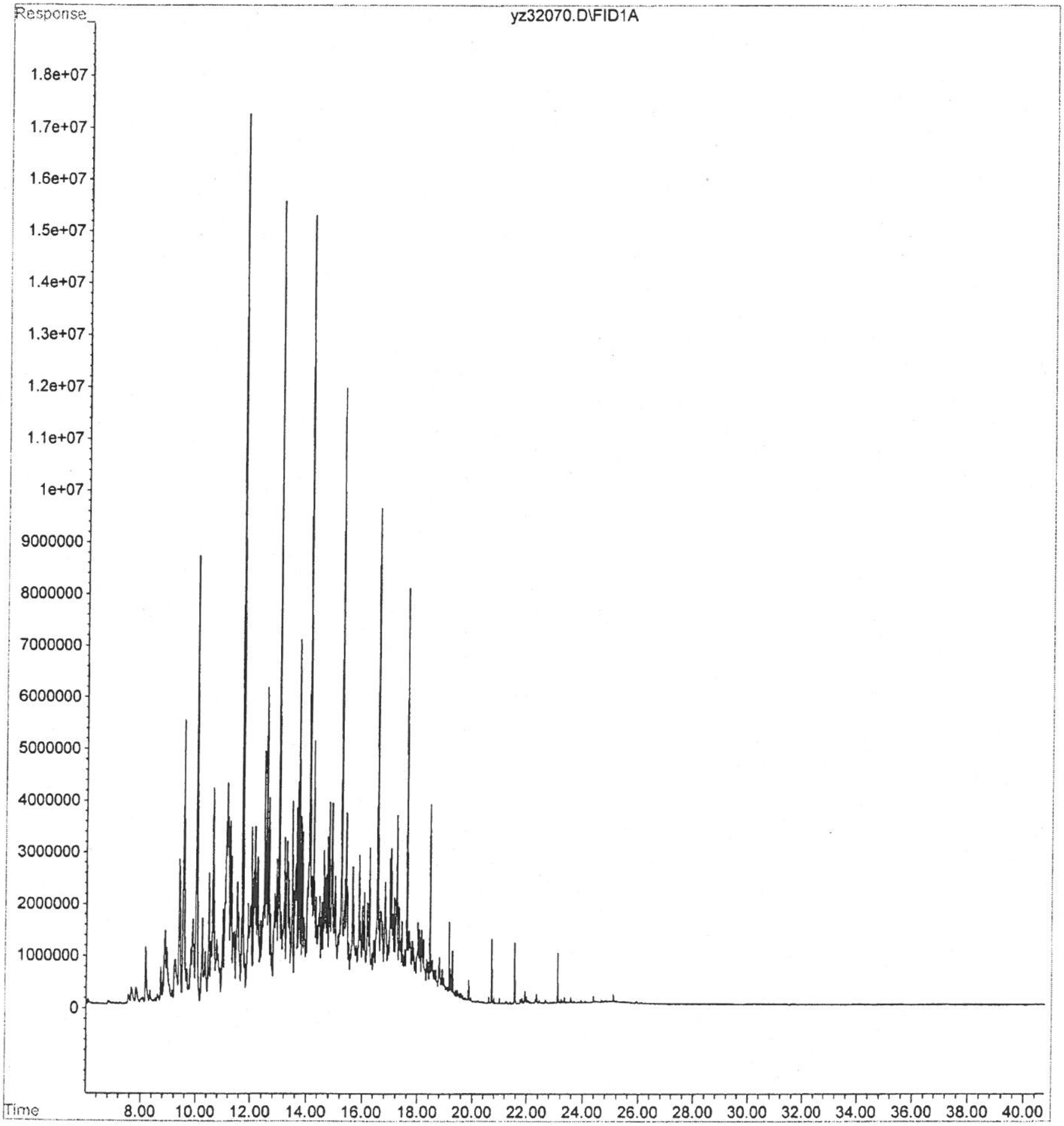
```
File        : C:\HPCHEM\2\DATA\yz33420.D
Operator    : CEMILEG
Acquired    : 4-1-04 7:02:49 PM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: N62849-1
Misc Info   : OP16433,GYZ939,30.0,,,1,50
Vial Number: 8
```



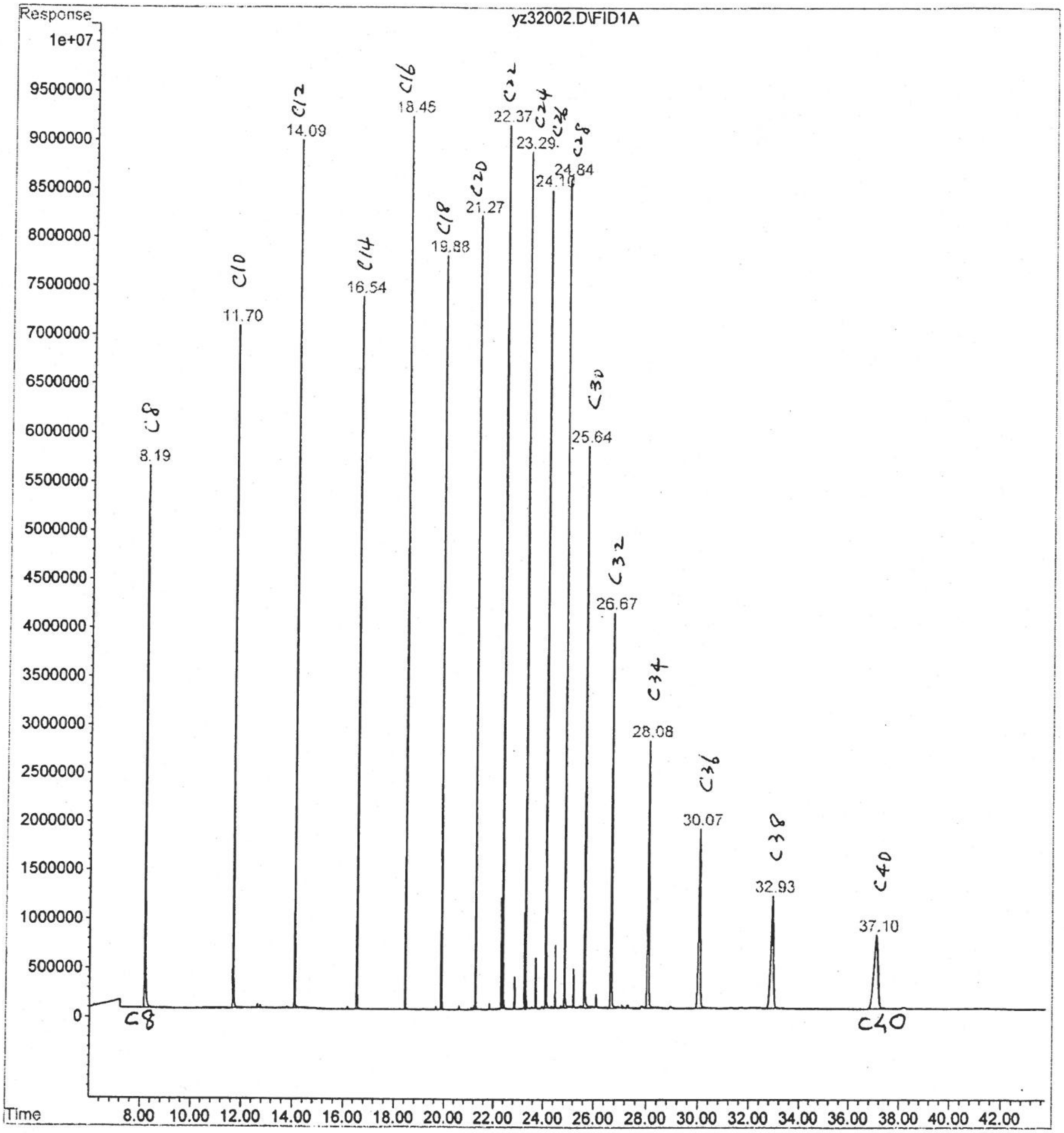
```
File          : C:\HPCHEM\1\DATA\GCFING~1\yz32069.D
Operator      : cemileg
Acquired      : 2-11-04 4:20:25 PM using AcqMethod DRO905.M
Instrument :    GCYZ
Sample Name: JP-4 JET FUEL
Misc Info     : OP15761,GYZ905,1000,,,1,1
Vial Number: 9
```



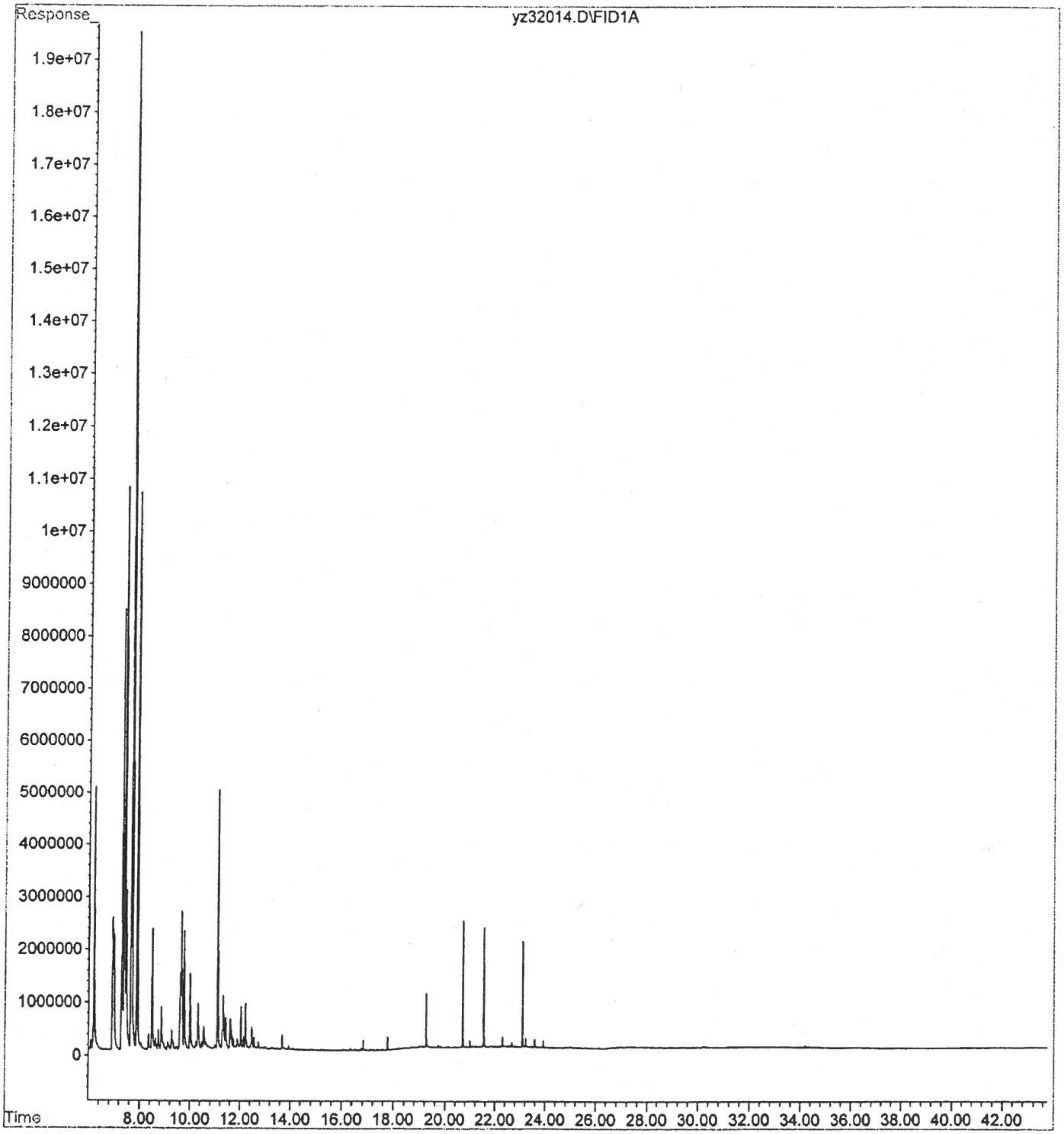
```
File        : C:\HPCHEM\1\DATA\GCFING~1\yz32070.D
Operator    : cemileg
Acquired    : 2-11-04 5:09:11 PM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: JP-5 JET FUEL
Misc Info   : OP15761,GYZ905,1000,,,1,1
Vial Number: 10
```



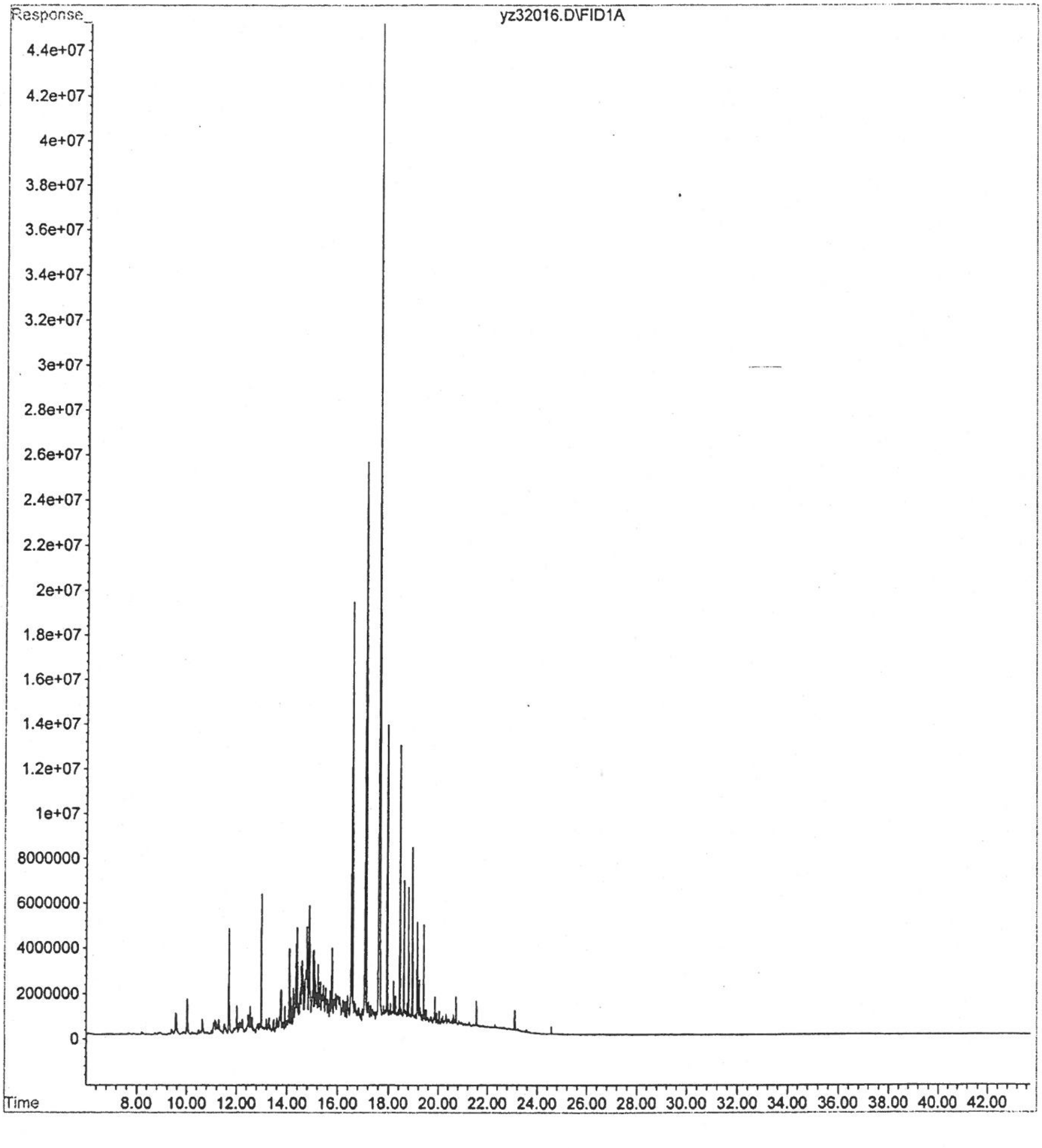
```
File        : C:\HPCHEM\1\DATA\GCFING~1\yz32002.D
Operator    : cemileg
Acquired    : 2-9-04 6:34:25 PM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: FLORIDA OIL
Misc Info   : OP14684,GYZ905,30.0,,,1,
Vial Number: 2
```



```
File        : C:\HPCHEM\1\DATA\GCFING~1\yz32014.D
Operator    : cemileg
Acquired    : 2-10-04 5:07:29 AM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: AVIATION FUEL
Misc Info   : OP14684,GYZ905,30.0,,,1,
Vial Number: 11
```



```
File        : C:\HPCHEM\1\DATA\GCFING~1\yz32016.D
Operator    : cemileg
Acquired    : 2-10-04 6:53:10 AM using AcqMethod DRO905.M
Instrument :   GCYZ
Sample Name: #2 DIESEL FUEL
Misc Info   : OP14684,GYZ905,30.0,,,1,
Vial Number: 13
```



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Operator     : cemileg
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Sample Name: #2 DIESEL FUEL 50 W
Misc Info  : OP14684,GYZ905,30.0,,,1,
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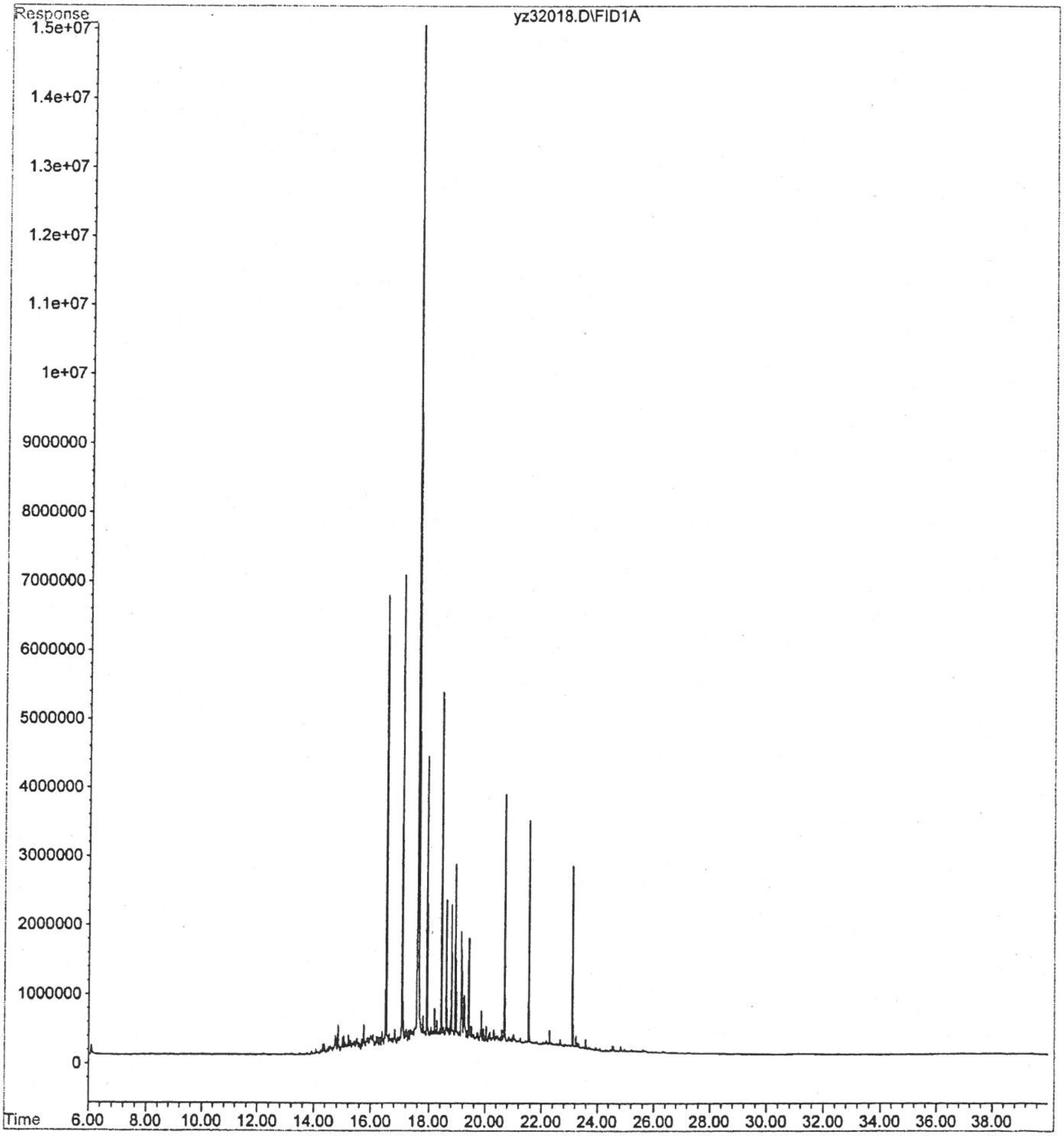

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Operator     : cemileg
Acquired     : 2-11-04 1:04:48 PM using AcqMethod DRO905.M
Instrument :    GCYZ
Sample Name: GASOLINE REGULAR UNLEADED
Misc Info    : OP15761,GYZ905,1000,,,1,1
Vial Number: 5
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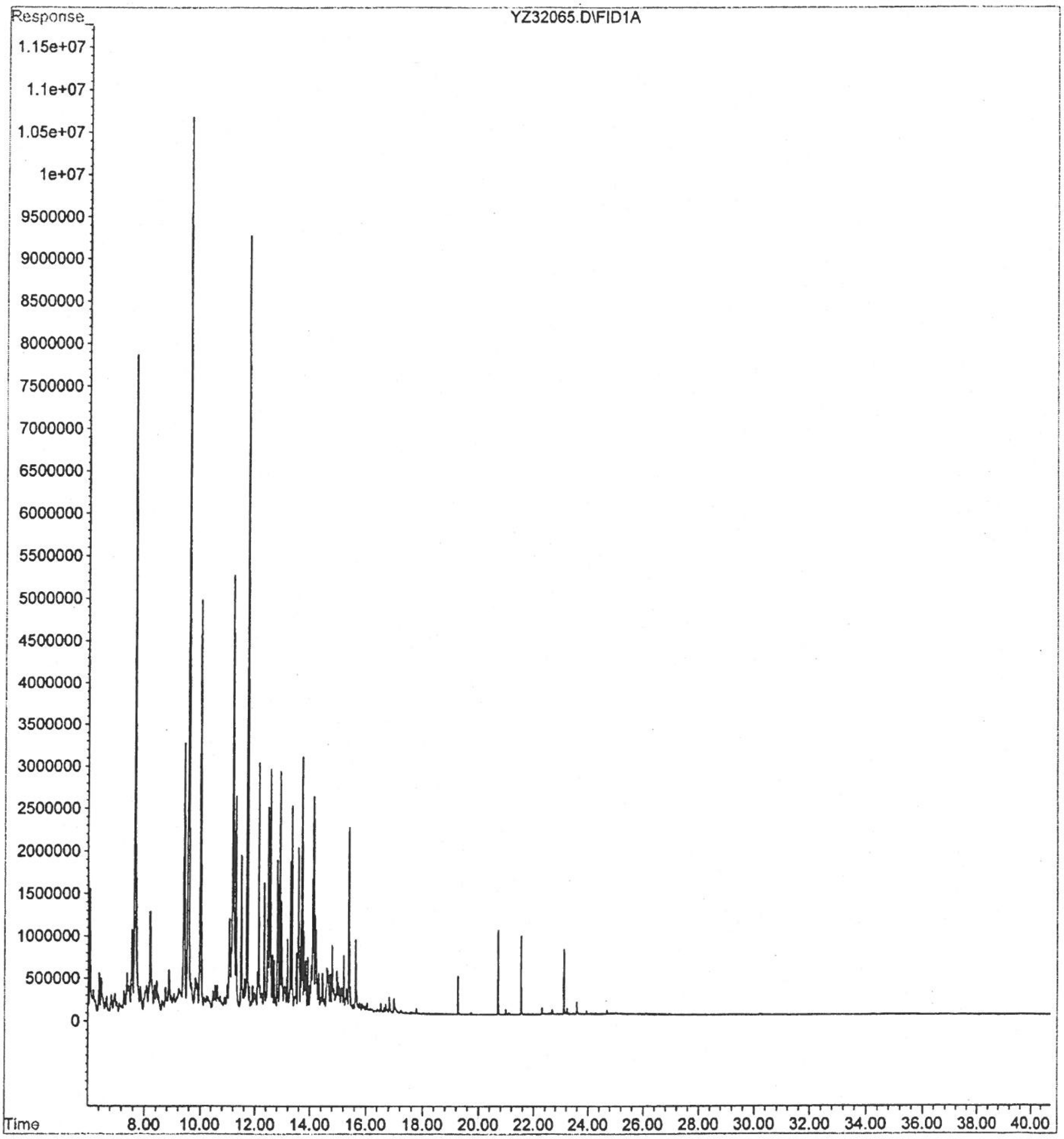

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Operator    : cemileg
Acquired    : 2-11-04 2:42:57 PM using AcqMethod DRO905.M
Instrument :   GCYZ
Sample Name: GASOLINE  UNLEADED 50 W
Misc Info   : OP15761,GYZ905,1000,,,1,1
Vial Number: 7
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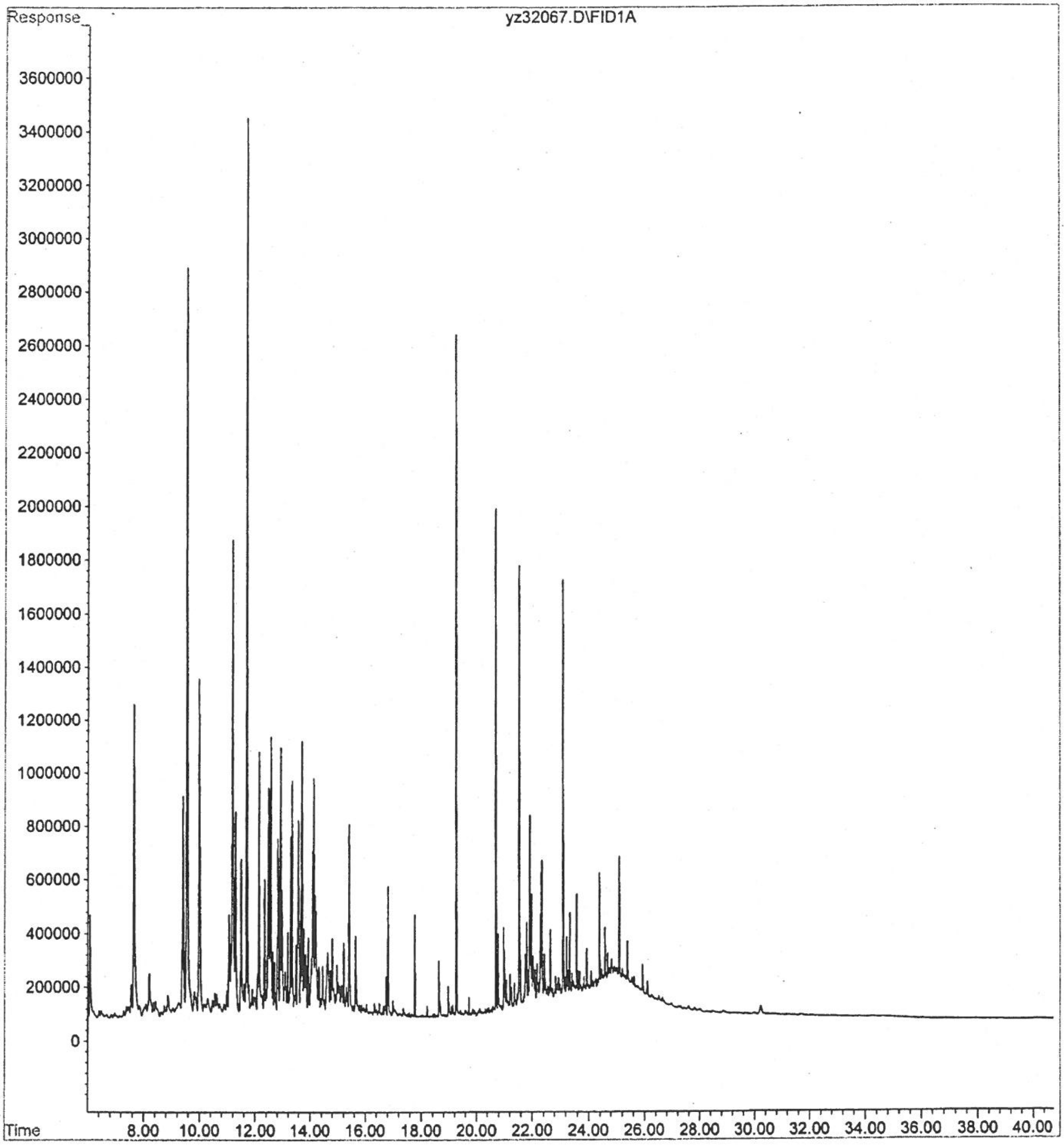

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Operator      : cemileg
Acquired      : 2-11-04 5:58:08 PM using AcqMethod DRO905.M
Instrument :    GCYZ
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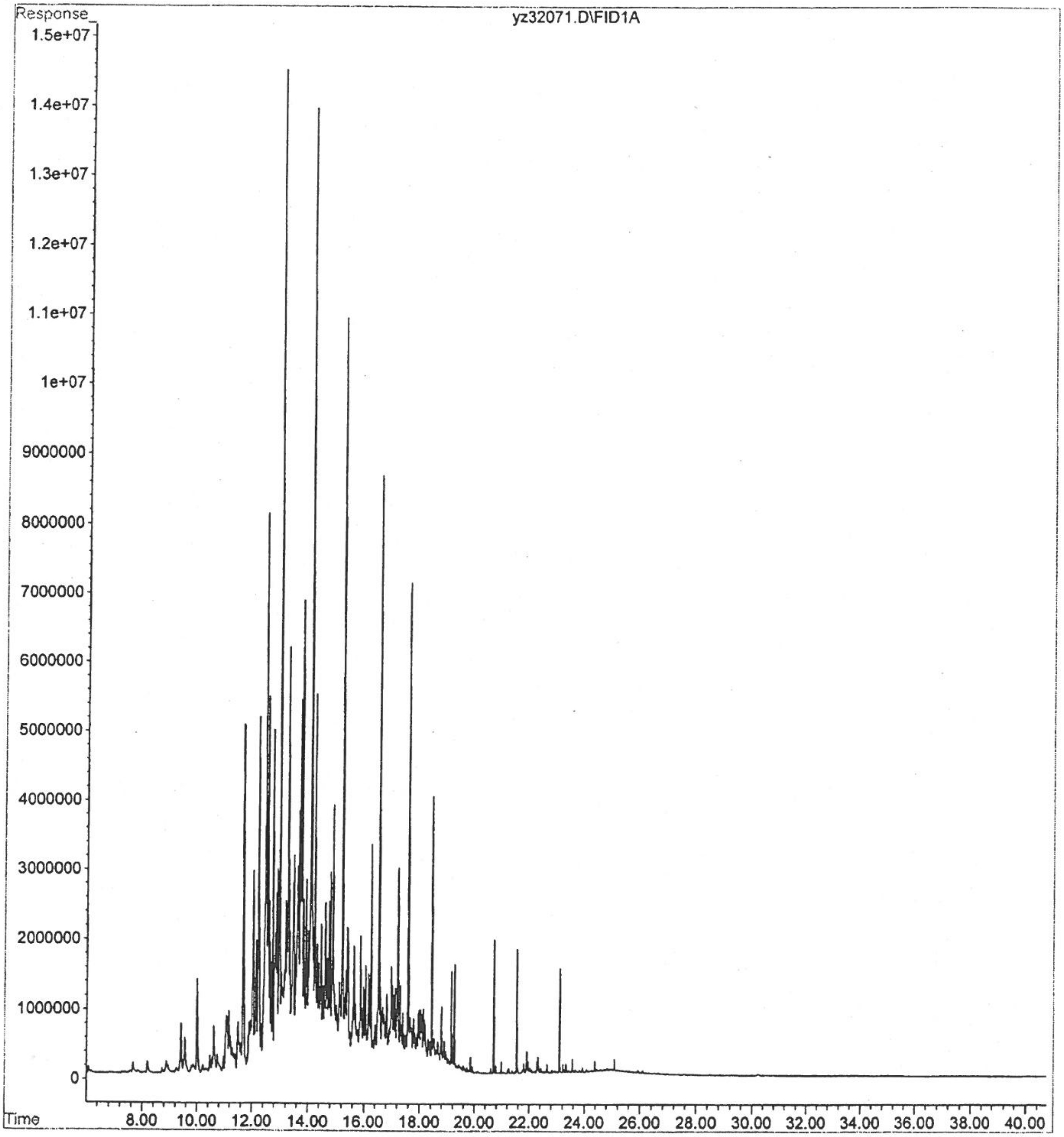

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Operator    : cemileg
Acquired    : 2-11-04 10:03:16 PM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: SAE 30 W
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 14
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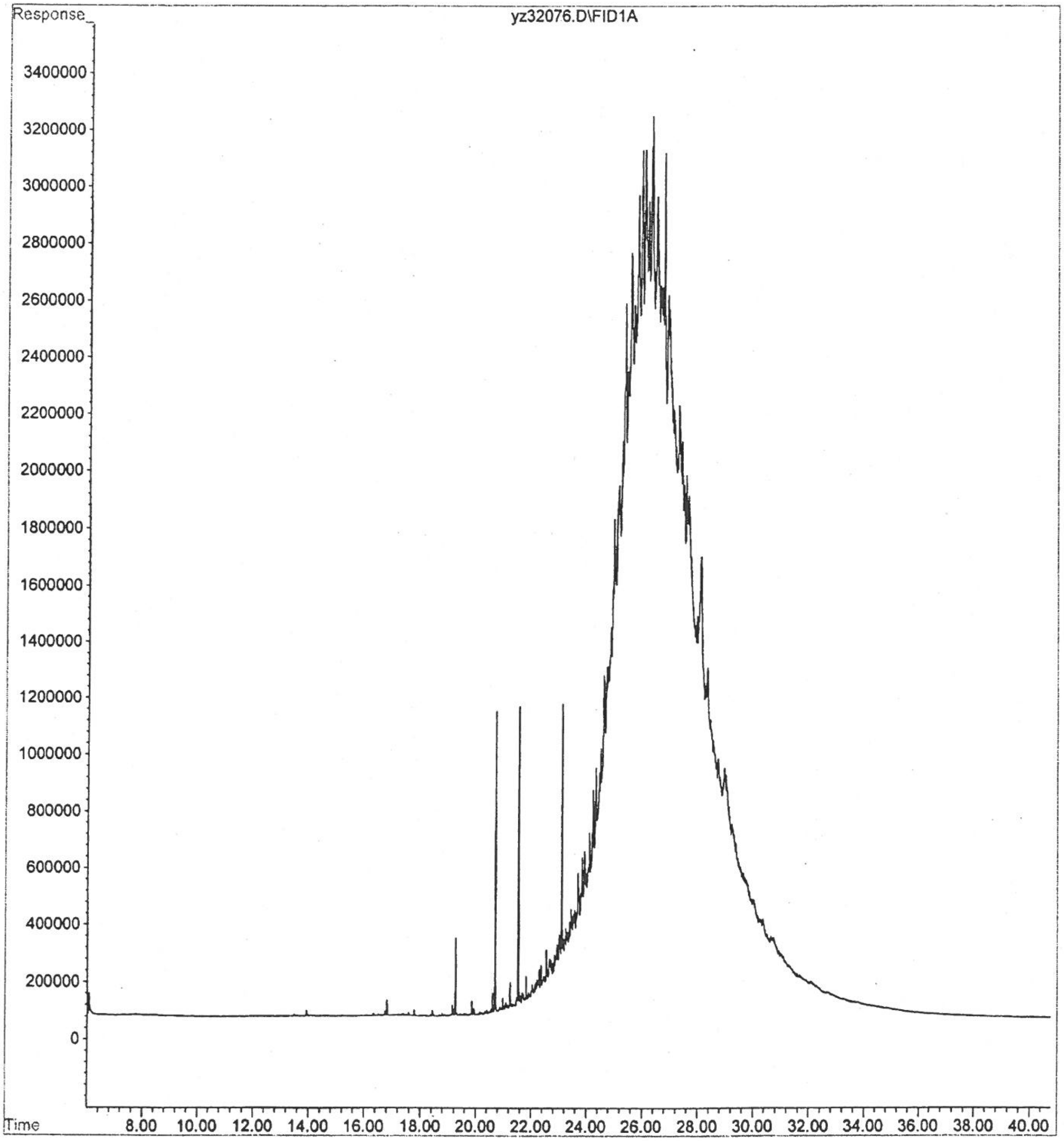

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Operator    : cemileg
Acquired    : 2-11-04 11:41:57 PM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: SAE 50 W
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Vial Number: 16
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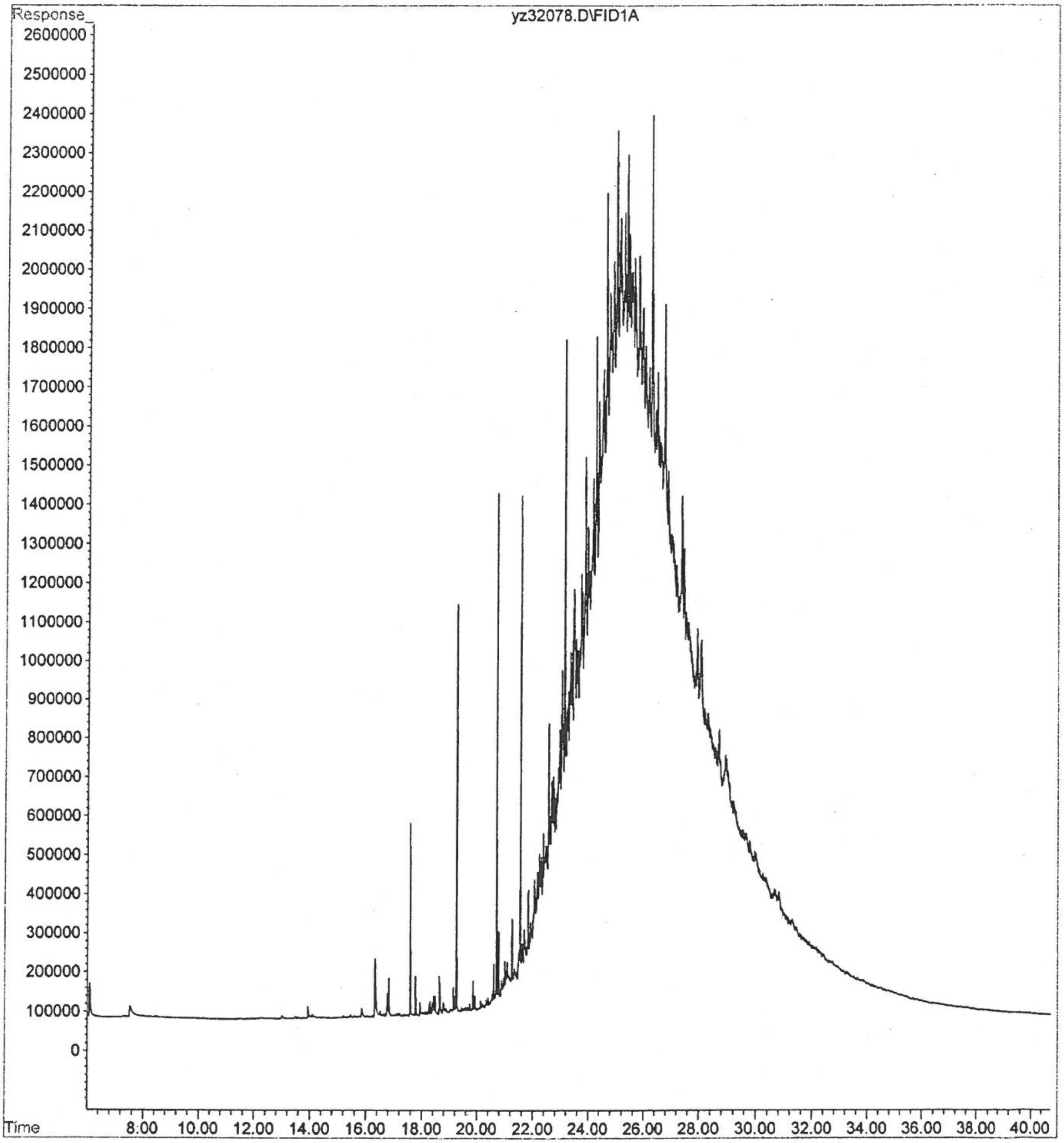

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Operator   : cemileg
Acquired   : 2-12-04 1:20:41 AM using AcqMethod DRO905.M
Instrument :   GCYZ
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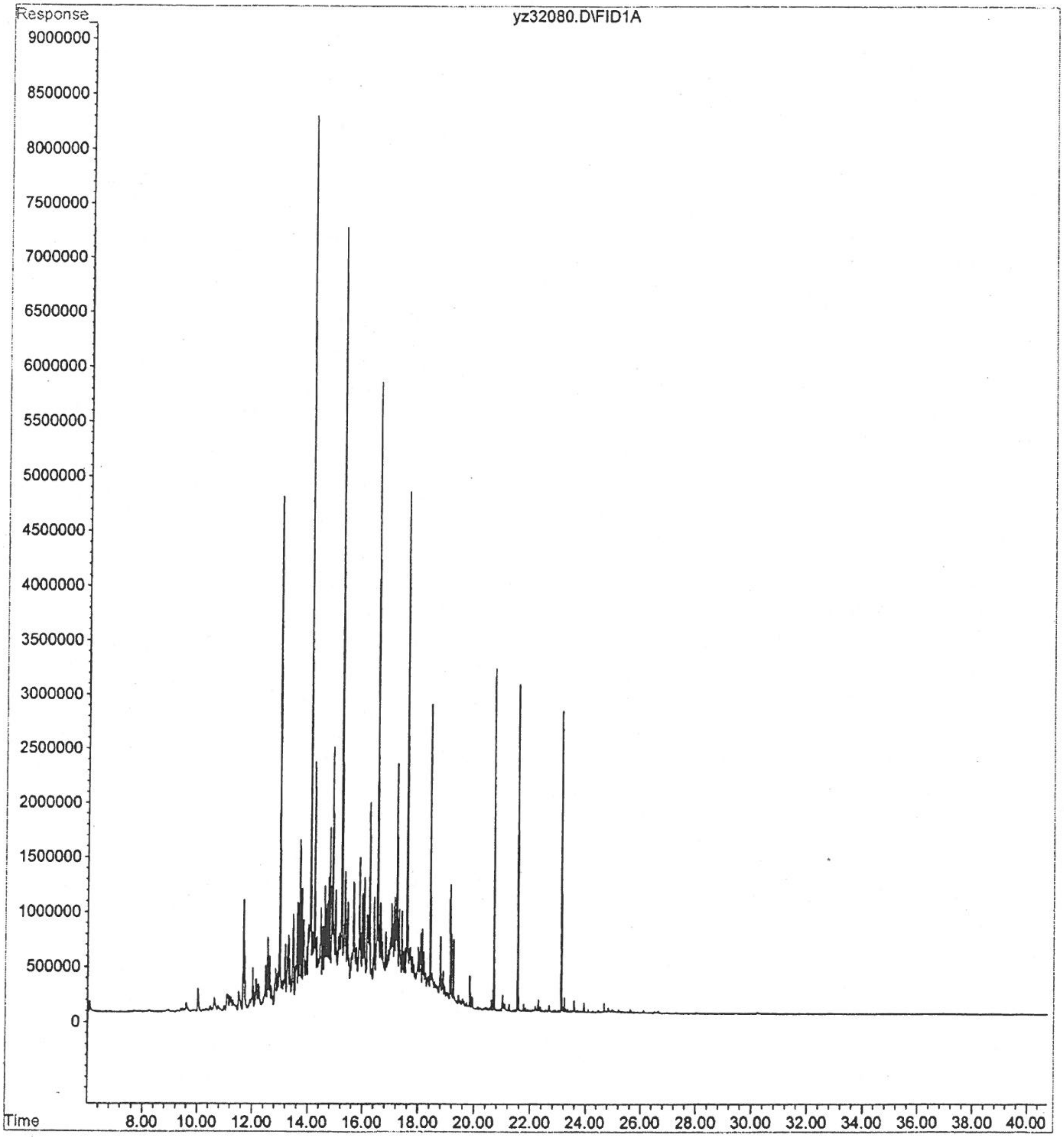
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 18



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Operator    : cemileg
Acquired    : 2-12-04 2:59:10 AM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: KEROSENE 75 W
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 20
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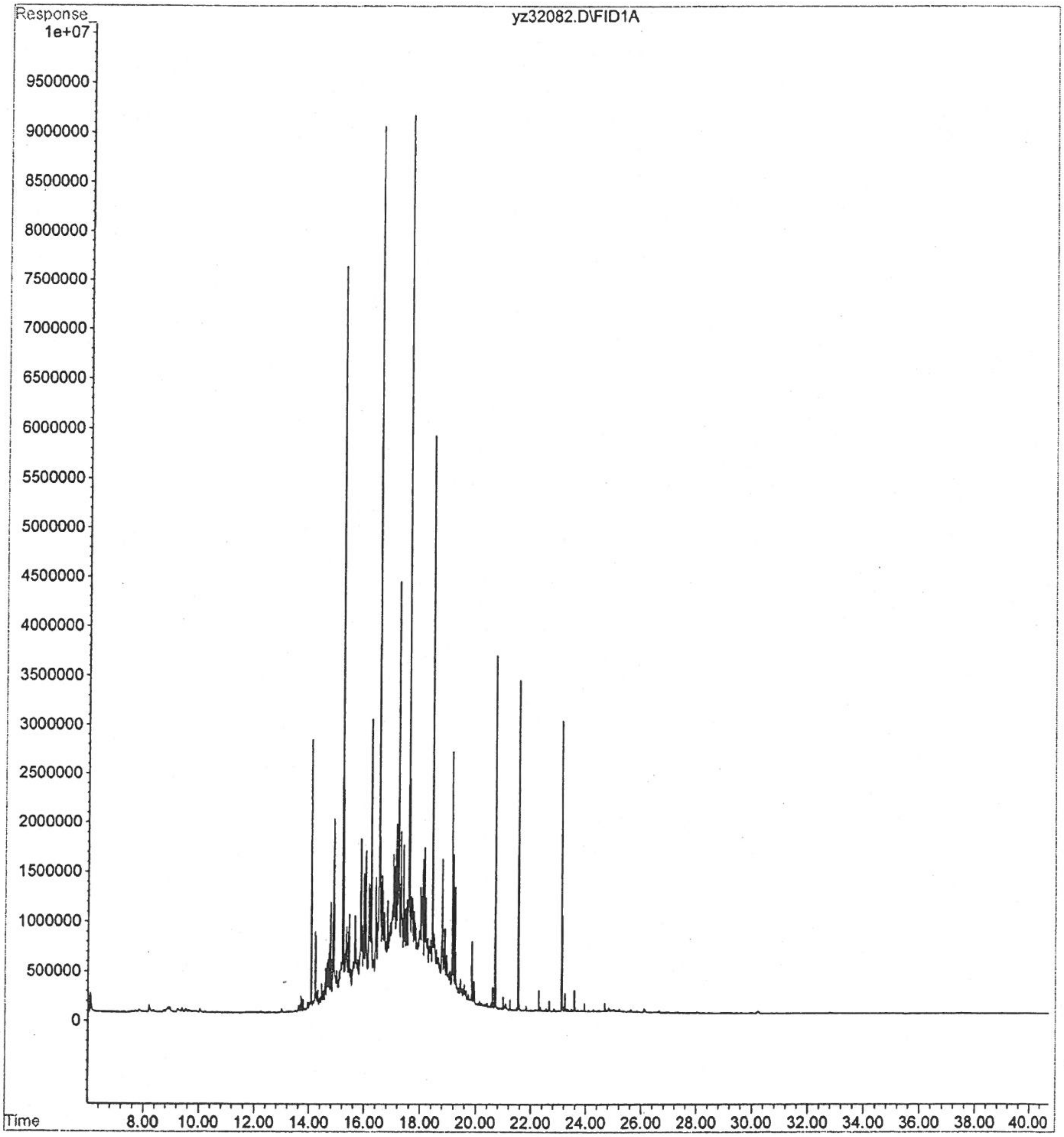

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Operator    : cemileg
Acquired    : 2-12-04 7:05:16 AM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: GASOLINE PREMIUM  UNLEADED
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 22
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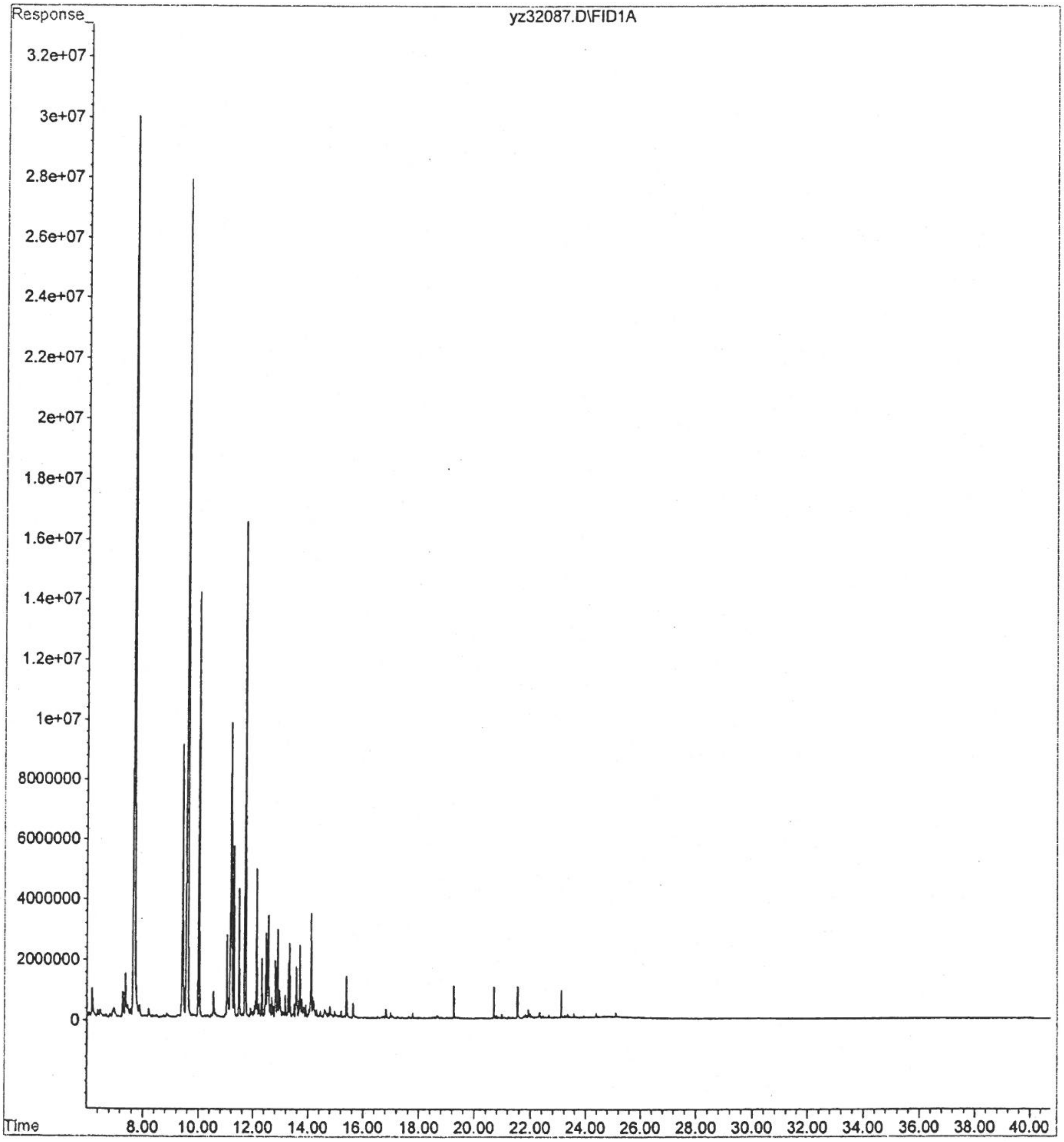

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Operator    : cemileg
Acquired    : 2-12-04 8:43:39 AM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: #4 FUEL OIL
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 24
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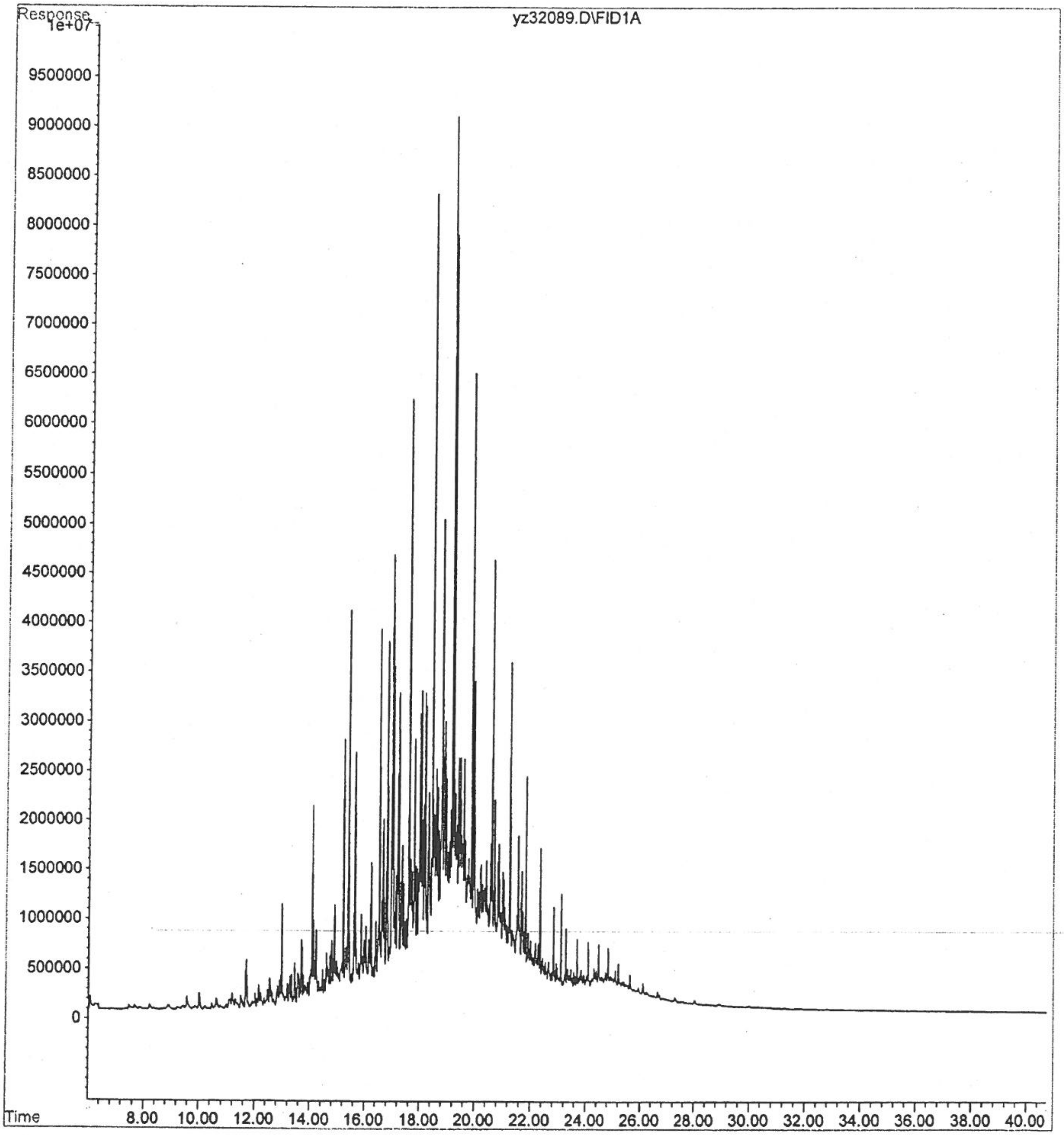

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Operator    : cemileg
Acquired    : 2-12-04 10:22:29 AM using AcqMethod DRO905.M
Instrument  :   GCYZ
Sample Name: MINERAL SPIRITS
Misc Info   : OP16035,GYZ905,1.0,,,1,1
Vial Number: 26
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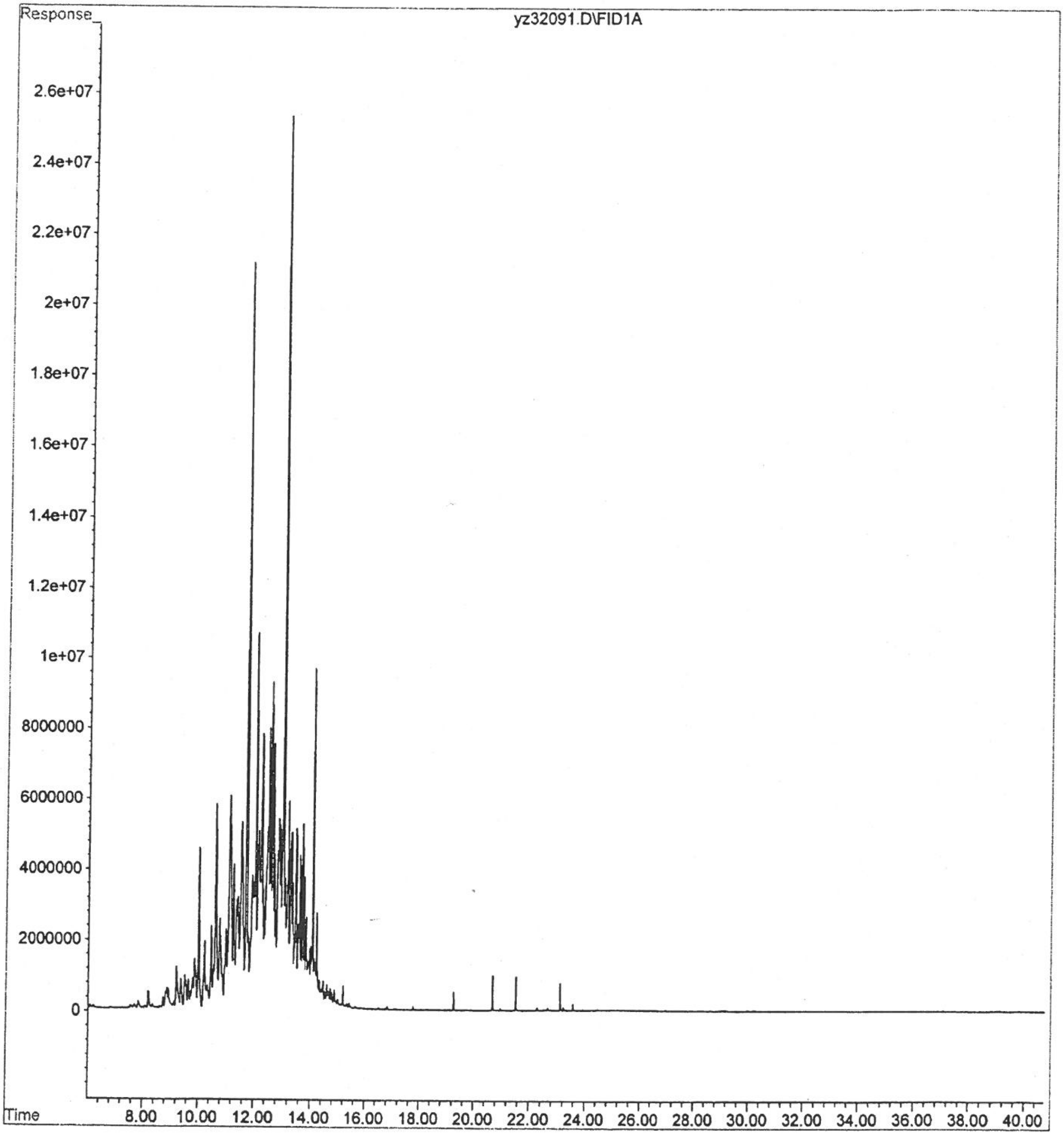

Collecting and Preserving VPH Soil Samples

OPTION 1: In-Field Methanol Preservation Technique

PERFORMANCE STANDARD: **Obtain undisturbed soil sample and preserved with methanol at a ratio of 1 mL methanol per 1 gram soil.**

Step 1: Choose appropriate sampling container:

60 mL wide mouth packer bottle; or
60 mL straight sided wide mouth bottle; or
60 mL VOA vial; or
40 mL VOA vial

All sampling containers should have an open-top screw cap with Teflon-coated silicone rubber septa or equivalent.

Step 2: Label each container with a unique alpha/numerical designation. Obtain and record tare (empty) weight of each container to nearest 0.1 gram. *This information must be available to the laboratory performing the analyses.*

Step 3: Add 25 mLs of purge and trap grade methanol to 60 mL containers, or 15 mL to 40 mL containers. *It is essential that the methanol be purge and trap grade or equivalent quality*. Immediately cap the container. Make a mark on the 60 mL containers approximately 15 mL above the level of methanol, or a mark on the 40 mL container approximately 10 mL above the level of methanol. The objective is to obtain 25 grams of soil in the 60 mL container, or 15 grams of soil in the 40 mL container, which is approximately 15 and 10 mL of soil volume, respectively, depending upon soil type and moisture content. Store at 4°C. *The use of a methanol trip blank prepared in this manner is recommended.*

Step 4: In the field, carefully add soil to the sample container, until the level of methanol in the vial reaches the designated volumetric mark. For wet soil, add slightly beyond the mark. IN NO CASE, HOWEVER, MAY THE LEVEL OF SOIL IN THE CONTAINER RISE ABOVE THE LEVEL OF METHANOL. The use of a 10-30 mL disposable syringe with the end cut off is recommended to obtain an undisturbed soil sample from freshly exposed soils. In such cases, obtain and extrude the soil into sample container, avoiding splashing methanol out of the container.

Optional: use a field electronic balance to ensure addition of desired mass of soil (25 grams to 60 mL containers, 15 grams to 40 mL containers).

Step 5: Use a clean brush or paper towel to remove soil particles from the threads of the sample container and screw cap. Tightly apply and secure screw cap. Gently swirl sample to break up soil aggregate, if necessary, until soil is covered with methanol. DO NOT SHAKE. Duplicate samples obtained in this manner are recommended. A split-sample must also be obtained for a determination of soil moisture content. This sample must NOT be preserved in methanol. HINT: fill this container 1/2 full, to allow screening of the sample headspace by the field investigator or the laboratory.

Step 6: Immediately place containers in cooler for storage in an upright position. Sample containers can be placed in separate zip-lock bags to protect containers in case of leakage during transport. Transport to analytical laboratory using appropriate chain-of-custody procedures and forms.

OPTION 2: Use of a Sealed-Tube Sampling/Storage Device

PERFORMANCE STANDARD:	**Obtain undisturbed soil sample and immediately seal in air-tight container, for shipment to laboratory and immersion in methanol within 48 hours.**

Step 1:	Obtain pre-cleaned and/or disposable samplers/containers that allow the collection and air-tight storage of at least 15 grams of soil.
Step 2:	In the field, obtain an undisturbed sample from a freshly exposed soil. Immediately seal container, and place in a cooler. Obtain a duplicate sample to enable the determination of soil moisture content (this does not need to be in a sealed sampler/container). Transport to analytical laboratory using appropriate chain-of-custody procedures and forms.
Step 3:	Samples must be extruded and immersed in purge and trap (or equivalent) grade methanol at the laboratory within 48 hours of sampling, at a ratio of 1 mL methanol to 1 gram soil. In no case, however, shall the level of soil in the laboratory container exceed the level of methanol (i.e., the soil must be completely immersed in methanol).

NOTE: Documentation MUST be provided/available on the ability of the sampler/container to provide an air-tight seal in a manner that results in no statistically significant loss of volatile hydrocarbons for at least 48 hours. To date, only one commercially available product, the En Core Sampler, has provided this level of demonstration.

OPTION 3: Use of Alternative Collection/Storage/Preservation Techniques

PERFORMANCE STANDARD: **Obtain and store an undisturbed soil sample in a manner that ensures the chemical integrity of the sample by (1) preventing the volatilization of petroleum hydrocarbons heavier than C5, and (2) preventing the biological degradation of petroleum hydrocarbons.**

NOTE: The onus is on the user of such techniques to demonstrate the validity of the procedures used, via reference to published literature and/or other pertinent data .

SAFETY

Methanol is a toxic and flammable liquid, and must be handled with appropriate care. Use in a well-vented area, and avoid inhaling methanol vapors. The use of protective gloves is recommended when handling or transferring methanol. Vials of methanol should always be stored in a cooler with ice at all times, away from sources of ignition such as extreme heat or open flames.

Shipping of Hazardous Materials

Methanol is considered a hazardous material by the US Department of Transportation (DOT) and the International Air Transport Association (IATA). Shipments of methanol between the field and the laboratory must conform to the rules established in Title 49 of the Code of Federal Regulations (49 CFR parts 171 to 179), and the most current edition of the IATA Dangerous Goods Regulations. Consult these documents or your shipping company for complete details.

Small Quantity Exemption

The volumes of methanol recommended in the VPH method fall under the small quantity exemption of 49 CFR section 173.4. To qualify for this exemption, all of the following must be met:

- the maximum volume of methanol in each sample container must not exceed 30 mL
- the sample container must not be full of methanol
- the sample container must be securely packed and cushioned in an upright position, and be surrounded by a sorbent material capable of absorbing spills from leaks or breakage of sample containers
- the package weight must not exceed 64 pounds
- the volume of methanol per shipping container must not exceed 500 mL
- the packaging and shipping container must be strong enough to hold up to the intended use
- the package must not be opened or altered while in transit
- the shipper must mark the shipping container in accordance with shipping dangerous goods in acceptable quantities, and provide the statement:

> *"This package conforms to conditions and limitations specified in 49 CFR 173.4"*

Shipping Papers

All shipments must be accompanied by shipping papers which include the following:

Proper Shipping Name: Methyl Alcohol
Hazardous Class: Flammable Liquid
Identification Number: UN1230
Total Quantity: *(mL methanol/container x the number of containers)*
Emergency Response Info: Methanol MSDS attached
Emergency Response Phone: *provide appropriate number*
Shipping Exemption: DOT-E 173.118, Limited Quantity

Labeling & Placarding

Labeling and placarding is not required for valid small quantity exemptions (per 173.118)

METHOD FOR THE DETERMINATION OF VOLATILE PETROLEUM HYDROCARBONS

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

1.0 SCOPE & APPLICATION

1.1 This method is designed to measure the collective concentrations of volatile aliphatic and aromatic petroleum hydrocarbons in water and soil. Volatile aliphatic hydrocarbons are collectively quantitated within two ranges: C_5 through C_8, and C_9 through C_{12}. Volatile aromatic hydrocarbons are collectively quantitated within the C_9 to C_{10} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 36°C and 220°C.

1.2 This method is based on a purge-and-trap, gas chromatography (GC) procedure using in-series Photoionization and Flame Ionization Detectors (PID/FID). This method should be used by, or under the supervision of, analysts experienced in the use of purge-and-trap systems and gas chromatographs. The analysts should be skilled in the interpretation of gas chromatograms and their use as a quantitative tool.

1.3 This method is designed to complement and support the toxicological approach developed by the Massachusetts Department of Environmental Protection to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MADEP, 1994). It is intended to generate data in a format suitable for evaluation by that approach, and generate data that may be compared to reporting and cleanup standards promulgated in the Massachusetts Contingency Plan (310 CMR 40.0000).

1.4 This method is also able to measure the individual concentrations of the VPH Target Analytes benzene, toluene, ethylbenzene, xylenes (BTEX), naphthalene, and methyl-tert-butylether (MTBE) in water and soil. Use of this method to identify and quantitate these Target Analytes is optional.

1.5 Petroleum products suitable for evaluation by this method include gasoline, mineral spirits, and certain petroleum naphthas. This method, in and of itself, is not suitable for the evaluation of kerosene, jet fuel, heating oils, lubricating oils, and/or other petroleum products which contain a significant percentage of hydrocarbons heavier than C_{12}.

1.6 The Reporting Limit (RL) of this method for each of the collective aliphatic and aromatic fractional ranges is approximately 2-10 mg/kg in soil, and approximately 50-100 µg/L in water. The RL of this method for Target Analytes is compound-specific, and ranges from approximately 0.1 to 0.2 mg/kg in soil, and 1 to 10 µg/L in water.

1.7 This method includes a series of data manipulation steps to determine the concentrations of aliphatic and aromatic ranges of interest. These steps may be taken by the laboratory or by the data user.

1.8 Data generated using this method must be reported using the form/format provided.

1.9 Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantitated as a Target Analyte. Confirmatory analysis by a GC/MS procedure or other suitable method is recommended in cases where a Target Analyte reported by this method exceeds an applicable reporting or cleanup standard, and/or where co-elution of a non-targeted hydrocarbon compound is suspected.

1.10 The first draft of this method was evaluated by two interlaboratory "Round Robin" testing programs. In the final evaluation effort, participating laboratories were provided (single-blind) sand samples spiked with gasoline, and a "real world" groundwater sample contaminated by gasoline. Laboratory proficiency was evaluated using a Z-score approach. Data received from 21 laboratories performing this method without significant modifications are summarized below:

Matrix	# Labs Proficient	% Labs Proficient	Data from Proficient Laboratories		
			Fraction	**%RSD**	**% labs within +/- 30% mean value**
soil	**20**	**95**	**C5-C8 Aliphatics**	**28**	**80**
			C9-C12 Aliphatics	**52**	**50**
			Total GC/FID	**31**	**70**
			C9-C10 Aromatics	**24**	**80**
water	**17**	**81**	**C5-C8 Aliphatics**	**31**	**71**
			C9-C12 Aliphatics	**44**	**47**
			Total GC/FID	**24**	**76**
			C9-C10 Aromatics	**20**	**82**

Laboratory and method performance were believed to have been adversely impacted by the use of multiple chromatographic columns, which may have significantly altered the placement of aliphatic hydrocarbons into either the C_5 - C_8 or C_9 - C_{12} Aliphatic Hydrocarbon fractions. Better performance was noted for the aromatic fraction and Total GC/FID data. Improvements incorporated into this final method are expected to significantly improve overall method performance.

1.11 This is a performance-based method. Modifications to this method are permissible, provided that adequate documentation exists, or has been developed, to demonstrate an equivalent or superior level of performance. MADEP encourages methodological innovations which (a) better achieve method and/or data quality objectives, (b) increase analytical precision and accuracy, (c) reduce analytical uncertainties and expenses, and/or (d) reduce the use of toxic solvents and generation of hazardous wastes. Laboratories that modify this method must achieve all required performance and acceptance standards, and must have on file a Standard Operating Procedure which thoroughly describes the revised or alternative method, and documentation which demonstrates an equivalent or superior level of performance. All significant modifications to the method must be disclosed and described on the data report form, as detailed in Section 11.3.

1.12 Additional information and details on the MADEP VPH/EPH approach, and on the results of interlaboratory "Round Robin" evaluations of this method, are available on the World Wide Web at http://www.magnet.state.ma.us/dep/bwsc/pubs.htm.

2.0 SUMMARY OF METHOD

2.1 Samples are analyzed using purge-and-trap sample concentration. The gas chromatograph is temperature programmed to facilitate separation of organic compounds. Detection is achieved by a photoionization detector (PID) and flame ionization detector (FID) in series. Quantitation is based on comparing the PID and FID detector response of a sample to a standard comprised of aromatic and aliphatic hydrocarbons. The PID chromatogram is used to determine the individual concentrations of Target Analytes (BTEX/MTBE/naphthalene) and collective concentration of aromatic hydrocarbons within the C_9 through C_{10} range. The FID chromatogram is used to determine the collective concentration of aliphatic hydrocarbons within the C_5 through C_8 and C_9 through C_{12} ranges.

2.2 This method is suitable for the analysis of waters, soils, and sediments. Water samples may be analyzed directly for volatile petroleum hydrocarbons by purge-and-trap concentration and gas chromatography. Soil samples are dispersed in methanol to dissolve the volatile organic constituents. A portion of the methanolic solution is then analyzed by purge-and-trap GC.

2.3 This method is based on (1) USEPA Methods 5030, 8000, 8020, and 8015, SW-846, "Test Methods for Evaluating Solid Wastes", 3rd Edition, 1986; (2) Draft "Method for Determination of Gasoline Range Organics", EPA UST Workgroup, November, 1990; and (3) "Method for Determining Gasoline Range Organics", Wisconsin Department of Natural Resources, PUBL-SW-140, 1992.

3.0 DEFINITIONS

3.1 **Analytical Batch** is defined as a group of field samples with similar matrices which are processed as a unit. For Quality Control purposes, if the number of samples in such a group is greater than 20, then each group of 20 samples or less are defined as separate analytical batches.

3.2 **Calibration Check Standard** is defined as a calibration standard used to periodically check the calibration state of an instrument. The calibration check standard is prepared from the same stock solution as calibration standards, and is generally one of the mid-level range calibration standard dilutions.

3.3 **Calibration Standards** are defined as a series of standard solutions prepared from dilutions of a stock standard solution, containing known concentrations of each analyte and surrogate compound of interest.

3.4 **C_5 through C_8 Aliphatic Hydrocarbons** are defined as all aliphatic hydrocarbon compounds which elute on the FID chromatogram from n-pentane (C_5) to just before n-nonane (C_9).

3.5 **C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all aliphatic hydrocarbon compounds which elute on the FID chromatogram from n-nonane (C_9) to just before naphthalene.

3.6 **C_9 through C_{10} Aromatic Hydrocarbons** are defined as all aromatic hydrocarbon compounds which elute on the PID chromatogram from just after o-xylene to just before naphthalene. Although it is an aromatic compound with 10 carbon atoms, naphthalene is excluded from this range because it is evaluated as a separate (Target) analyte.

3.7 **Field Duplicates** are defined as two separate samples collected at the same time and place under identical circumstances and managed the same throughout field and laboratory procedures. Analyses of field duplicates give a measure of the precision associated with sample collection, preservation, and storage, as well as laboratory procedures.

3.8 **Laboratory Fortified Blank (LFB)** is defined as a reagent water blank or clean sand blank fortified with a matrix spiking solution.

3.9 **Laboratory Duplicates** are defined as split samples taken from the same sampling container and analyzed separately with identical procedures. The analysis of laboratory duplicates give a measure of the precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.10 **Laboratory Fortified Matrix (LFM) Sample** is defined as an environmental sample which has been spiked with a matrix spiking solution containing known concentrations of method analytes. The LFM sample is treated and analyzed exactly as a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined through the separate analyses of a laboratory or field duplicate, and the measured values in the LFM sample corrected for background concentrations.

3.11 **Laboratory Method Blank (LMB)** is defined as an aliquot of reagent water or clean sand spiked with a surrogate standard. The laboratory method blank is treated exactly as a sample, exposed to all glassware, solvents, reagents, and equipment. A laboratory method blank is analyzed with every batch of samples, to determine if method analytes or other interferences are present in the laboratory environment, reagents, or equipment.

3.12 **Matrix Spiking Solution** is defined as a solution prepared independently from the calibration standards, containing known concentrations of method analytes.

3.13 **System Solvent Blank** is defined as an aliquot of method solvent (e.g., methanol) that is directly purged into the GC system. The purpose of the Solvent Blank is to determine the level of noise and baseline rise attributable solely to the GC system, in the absence of any other analytes or contaminants.

3.14 **Target VPH Analytes** are defined as benzene, toluene, ethylbenzene, m-xylene, p-xylene, o-xylene, naphthalene, and methyl-tert-butylether.

3.15 **Unadjusted C_5 through C_8 Aliphatic Hydrocarbons** are defined as all hydrocarbon compounds which elute on the FID chromatogram from n-pentane (C_5) to just before n-nonane (C_9).

3.16 **Unadjusted C_9 through C_{12} Aliphatic Hydrocarbons** are defined as all hydrocarbon compounds which elute on the FID chromatogram from n-nonane (C_9) to just before naphthalene.

3.17 **Volatile Petroleum Hydrocarbons (VPH)** are defined as collective fractions of hydrocarbon compounds eluting from n-pentane to naphthalene, excluding Target VPH Analytes. VPH is comprised of C_5 through C_8 Aliphatic Hydrocarbons, C_9 through C_{12} Aliphatic Hydrocarbons, and C_9 through C_{10} Aromatic Hydrocarbons.

3.18 **Volatile Petroleum Hydrocarbon (VPH) Component Standard** is defined as a 13 component mixture of the aliphatic and aromatic compounds listed in Table 1. The compounds comprising the VPH Component Standard are used to (a) define the individual retention times and chromatographic response factors for each of the Target VPH Analytes, (b) define and establish the windows for the collective aliphatic and aromatic hydrocarbon ranges of interest, and (c) determine average chromatographic response factors that can in turn be used to calculate the collective concentration of hydrocarbons within these ranges.

3.19 All other terms are as defined in SW-846, "Test Method for Evaluating Solid Waste", USEPA, September, 1986, and as amended and updated.

4.0 INTERFERENCES

4.1 Samples can become contaminated by diffusion of volatile organics through the sample container septum during shipment and storage or by dissolution of volatiles into the methanol used for preservation. Trip blanks prepared from both reagent water and methanol should be carried through sampling and subsequent storage and handling to serve as a check on such contamination.

4.2 Contamination by carryover can occur whenever high-level and low-level samples are sequentially analyzed. To reduce carryover, the sample syringe and/or purging device must be rinsed between samples with reagent water or solvent. For volatile samples containing high concentrations of water-soluble materials, suspended solids, high boiling-point compounds or organohalides, it may be necessary to wash the syringe or purging device with a detergent solution, rinse with distilled water, and then dry in an oven at 105°C between analyses. The trap and other parts of the system are also subject to contamination, therefore, frequent bake-out and purging of the entire system may be required. A screening step is recommended to protect analytical instrumentation. Whenever an unusually concentrated sample is encountered, it must be followed by the analysis of a system solvent blank or laboratory method blank to check for cross-contamination.

Table 1. Volatile Petroleum Hydrocarbon (VPH) Component Standard

Compound	**Retention Time (minutes)**[1]		**MDL**[2]			
	PID	**FID**	**Water (µg/L)**		**Soil (µg/g)**	
			PID	**FID**	**PID**	**FID**
n-Pentane	N/A	7.00		1.1		0.28
2-Methylpentane	N/A	8.65		2.2		0.47
Methyl-tert-butylether	9.18	9.18	0.47		0.39	
2,2,4-Trimethylpentane	N/A	13.42		1.5		0.22
Benzene	14.25	14.25	0.21		0.14	
Toluene	20.11	20.11	0.55		0.42	
n-Nonane	N/A	24.11		0.44		0.25
Ethylbenzene	24.46	24.46	0.16		0.16	
m- & p- Xylene	24.66	24.66	0.62		0.51	
o-Xylene	25.75	25.75	0.81		0.28	
1,2,4-Trimethylbenzene	28.64	28.64	0.34		0.25	
Naphthalene	33.05	33.05	1.57		0.15	
2,5-Dibromotoluene (surrogate)	35.21	35.21			0.68	

[1] Results obtained using an RTX-1 column and chromatographic conditions described in Sections 6.3 and 9.2, respectively

[2] Single laboratory MDL study; see Appendix 1 for more details

4.3 Certain organic compounds not associated with releases of petroleum products, including chlorinated solvents, ketones, and ethers, will be quantitated as Volatile Petroleum Hydrocarbons. If necessary and/or desirable, additional sample cleanup and/or analytical procedures may be employed to minimize or document the presence of such compounds.

METHOD FOR THE DETERMINATION OF EXTRACTABLE PETROLEUM HYDROCARBONS

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION

1.0 SCOPE & APPLICATION

1.1 This method is designed to measure the collective concentrations of extractable aliphatic and aromatic petroleum hydrocarbons in water and soil. Extractable aliphatic hydrocarbons are collectively quantitated within two ranges: C_9 through C_{18}, and C_{19} through C_{36}. Extractable aromatic hydrocarbons are collectively quantitated within the C_{11} through C_{22} range. These aliphatic and aromatic hydrocarbon ranges correspond to a boiling point range between approximately 150 °C and 500 °C.

1.2 This method is based on a solvent extraction, silica gel solid-phase extraction/fractionation process (SPE), and gas chromatography (GC) analysis using a flame ionization detector (FID). This procedure should be used by, or under the supervision of, analysts experienced in extractable organics analysis. Analysts should be skilled in the interpretation of gas chromatograms and their use as a quantitative tool.

1.3 This method is designed to complement and support the toxicological approach developed by the Massachusetts Department of Environmental Protection to evaluate human health hazards that may result from exposure to petroleum hydrocarbons (MADEP, 1994). It is intended to generate data in a format suitable for evaluation by that approach, and generate data that may be compared to reporting and cleanup standards promulgated in the Massachusetts Contingency Plan (310 CMR 40.0000).

1.4 This method is also able to measure the individual concentrations of Target Polynuclear Aromatic Hydrocarbons (PAH) Analytes, including Diesel PAH Analytes, in water and soil. The use of this method to quantitate these analytes is optional, and the Method Detection Limits for some of these PAH compounds in water are greater than the notification and/or cleanup standards specified in the Massachusetts Contingency Plan for sites located in drinking water resources areas. In cases where it is necessary to demonstrate compliance with these standards, the use of a GC/MS method in the SIM mode and/or HPLC methodology may be necessary.

1.5 The fractionation step described in this method may be eliminated to allow for the determination of a Total Petroleum Hydrocarbon (TPH) value, and/or obtain qualitative "fingerprinting" information. While TPH provides little information on the chemistry, toxicity, or environmental fate of petroleum mixtures, it may be a cost-effective screening tool in cases where relatively low concentrations of contamination is suspected.

1.6 Petroleum products suitable for evaluation by this method include kerosene, fuel oil #2, fuel oil #4, fuel oil #6, diesel fuel, jet fuel, and certain lubricating oils. This method, in and of itself, is not suitable for the evaluation of gasoline, mineral spirits, petroleum naphthas, or other petroleum products which contain a significant percentage of hydrocarbons lighter than C_9. This method, in and of itself, is also not suitable for the evaluation of petroleum products which contain a significant percentage of hydrocarbons heavier than C_{36}.

1.7 The Reporting Limit (RL) of this method for each of the collective aliphatic and aromatic fractional ranges is approximately 2-10 mg/kg in soil, and approximately 50-100 µg/L in water. The RL of this method for TPH is approximately 10 mg/kg in soil and approximately 100 µg/L in water. The RL of this method for the Target PAH Analytes is compound-specific, and ranges from approximately 0.5 to 1.0 mg/kg in soil, and 1 to 5 µg/L in water.

1.8 This method includes a data adjustment step to subtract the concentration of Target Analytes from the concentration of C_{11} through C_{22} Aromatic Hydrocarbons. This step may be taken by the laboratory or the data user.

1.9 Data generated using this method must be reported using the form/format provided.

1.10 Like all GC procedures, this method is subject to a "false positive" bias in the reporting of Target PAH Analytes, in that non-targeted hydrocarbon compounds eluting or co-eluting within a specified retention time window may be falsely identified and/or quantitated as a Target or Diesel PAH Analyte. While cleanup procedures specified in this method to segregate aliphatic and aromatic fractions will serve to mitigate this concern, confirmatory analysis by dissimilar columns, gas chromatography/mass spectrometry (GC/MS) analysis, or other suitable technique is recommended in cases where a target PAH analyte reported by this method exceeds an applicable reporting or cleanup standard, and/or where coelution of a non-targeted hydrocarbon compound is suspected.

1.11 The first draft of this method was evaluated by two interlaboratory "Round Robin" testing programs. In the final evaluation effort, participating laboratories were provided (single-blind) sand samples spiked with a #2 fuel oil, and a "real world" groundwater sample contaminated by a highly weathered fuel oil. Laboratory proficiency was evaluated using a Z-score approach. Data received from 23 laboratories performing the method without significant modifications are summarized below:

Matrix	# Labs Proficient	% Labs Proficient	Data from Proficient Laboratories		
			Fraction	**%RSD**	**% Labs within +/- 40% mean value**
soil	**19**	**83**	**C9-C18 Aliphatics**	**23**	**95**
			C19-C36 Aliphatics	**30**	**89**
			C11-C22 Aromatics	**19**	**100**
			Total All Fractions (TPH)	**17**	**100**
water	**20**	**87**	**C9-C18 Aliphatics**	**84**	**22**
			C19-C36 Aliphatics	**192**	**94**
			C11-C22 Aromatics	**47**	**72**
			Total All Fractions (TPH)	**35**	**83**

Laboratory and method performance on the water sample were adversely impacted by the relatively low concentrations of the aliphatic fractions (due to the low solubilities of these hydrocarbons in real world samples), and by leaching of naphthalenes into the aliphatic extract during fractionation. Improvements incorporated into this final method are expected to mitigate problems of this nature and significantly improve overall method performance.

1.12 This is a performance-based method. Modifications to this method are permissible, provided that adequate documentation exists, or has been developed, to demonstrate an equivalent or superior level of performance. MADEP encourages methodological innovations which (a) better achieve method and/or data quality objectives, (b) increase analytical precision and accuracy, (c) reduce analytical uncertainties and expenses, and/or (d) reduce the use of toxic solvents and generation of hazardous wastes. Laboratories that modify this method must achieve all required performance and acceptance standards, and must have on file a Standard Operating Procedure which thoroughly describes the revised or alternative method, and documentation which demonstrates an equivalent or superior level of performance. All significant modifications to the method must be disclosed and described on the data report form, as detailed in Section 11.3.

1.13 Additional information and details on the MADEP VPH/EPH approach, and the results of interlaboratory "Round Robin" evaluations of this method, are available on the World Wide Web at http://www.magnet.state.ma.us/dep/bwsc/pubs.htm.

2.0 SUMMARY OF METHOD

2.1 A sample submitted for EPH analysis is extracted with methylene chloride, dried over sodium sulfate, solvent exchanged into hexane, and concentrated in a Kuderna-Danish apparatus. Sample cleanup and separation into aliphatic and aromatic fractions is conducted using commercially available silica gel cartridges or self-packed silica gel columns. The two extracts produced are then re-concentrated to final volumes of 1 mL each (i.e., an aliphatic extract and an aromatic extract). The extracts are then separately analyzed by a capillary column gas chromatograph equipped with a flame ionization detector. The resultant chromatogram of aliphatic compounds is collectively integrated within the C_9 through C_{18} and C_{19} through C_{36} ranges. The resultant chromatogram of aromatic compounds is collectively integrated within the C_{11} through C_{22} range, and is (optionally) used to identify and quantitate individual concentrations of Target PAH Analytes.

2.2 Average calibration factors or response factors determined using an aliphatic hydrocarbon standard mixture are used to calculate the collective concentrations of C_9 through C_{18} and C_{19} through C_{36} aliphatic hydrocarbons. An average calibration factor or response factor determined using a PAH standard mixture is used to calculate a collective C_{11} through C_{22} aromatic hydrocarbon concentration. Calibration factors or response factors determined for individual components of the PAH standard mixture are also used to calculate individual concentrations of Target PAH Analytes.

2.3 This method is suitable for the analysis of waters, soils, and sediments.

2.4 This method is based on (1) USEPA Methods 8000, 8100, and 3630, SW-846, "Test Methods for Evaluating Solid Waste", 3rd Edition, 1986; (2) Draft "Method for Determination of Diesel Range Organics", EPA UST Workgroup, November, 1990; and (3) "Method for Determining Diesel Range Organics", Wisconsin Department of Natural Resources, PUBL-SW-141, 1992.

3.0 DEFINITIONS

3.1 **Aliphatic Hydrocarbon Standard** is defined as a 14 component mixture of the normal alkanes listed in Table 1. The compounds comprising the Aliphatic Hydrocarbon Standard are used to (a) define and establish windows for the two aliphatic hydrocarbons ranges, and (b) determine average chromatographic response factors that can in turn be used to calculate the collective concentration of aliphatic hydrocarbons in environmental samples within those hydrocarbon ranges.

3.2 **Analytical Batch** is defined as a group of field samples with similar matrices which are processed as a unit. For Quality Control purposes, if the number of samples in such a group is greater than 20, then each group of 20 samples or less are defined as separate analytical batches.

3.3 **Aromatic Hydrocarbon Standard** is defined as a 17 component mixture of the polynuclear aromatic hydrocarbons (PAHs) listed in Table 2. The compounds comprising the Aromatic Hydrocarbon Standard are used to (a) define the individual retention times and chromatographic response factors for each of the PAH analytes listed in Table 2, (b) define and establish the window for the C_{11} through C_{22} Aromatic Hydrocarbon range, and (c) determine an average chromatographic response factor that can in turn be used to calculate the collective concentration of aromatic hydrocarbons in environmental samples within the C_{11} through C_{22} hydrocarbon range.

3.4 **C_9 through C_{18} Aliphatic Hydrocarbons** are defined as all aliphatic hydrocarbon compounds eluting from n-nonane (n-C_9) to just before n-nonadecane (n-C_{19}).

Table 1. Aliphatic Hydrocarbon Standard

Carbon Number	Compound	Retention Time (min.)[1]
9	n-Nonane	3.14
10	n-Decane	4.55
12	n-Dodecane	7.86
14	n-Tetradecane	11.10
16	n-Hexadecane	14.05
18	n-Octadecane	16.71
19	n-Nonadecane	17.95
20	n-Eicosane	19.14
1-Chloro-octadecane (surrogate)		20.13
22	n-Docosane	21.35
24	n-Tetracosane	23.40
26	n-Hexacosane	25.29
28	n-Octacosane	27.04
30	n-Triacontane	28.69
36	n-Hexatriacontane	34.82

[1] Results obtained using the column and chromatographic conditions described in Sections 6.4 and 9.2, respectively.

3.5 **C_{19} through C_{36} Aliphatic Hydrocarbons** are defined as all aliphatic hydrocarbon compounds eluting from n-nonadecane (n-C_{19}) through n-hexatriacontane (n-C_{36}).

3.6 **C_{11} through C_{22} Aromatic Hydrocarbons** are defined as all aromatic hydrocarbon compounds eluting from naphthalene through Benzo(g,h,i)Perylene, excluding Target PAH Analytes.

3.7 **Calibration Check Standard** is defined as a calibration standard used to periodically check the calibration state of an instrument. The calibration check standard is prepared from the same stock standard solution as calibration standards, and is generally one of the mid-level range calibration standard dilutions.

3.8 **Calibration Standards** are defined as a series of standard solutions prepared from dilutions of a stock standard solution, containing known concentrations of each analyte and surrogate compound of interest.

3.9 **Diesel PAH Analytes** are defined as naphthalene, 2-methylnaphthalene, phenanthrene, and acenaphthene, and are a subset of Target PAH Analytes. For most sites contaminated by a release of (only) diesel or #2 fuel oil, Diesel PAH Analytes will be the only Target PAH Analytes of interest.

Table 2. Aromatic Hydrocarbon Standard/Target PAH Analytes

Compound	Retention Time (min.)[1]	MDL[2]	
		Water (µg/L)	Soil (mg/kg)
Naphthalene	7.66	0.14	0.09
2-Methylnaphthalene	9.49	0.18	0.09
Acenaphthylene	11.93	0.14	0.09
Acenaphthene	12.46	0.16	0.09
Fluorene	13.89	0.25	0.09
Phenanthrene	16.54	0.31	0.16
Anthracene	16.66	0.30	0.16
Ortho-Terphenyl (surrogate)	17.95	0.31	0.13
Fluoranthene	19.92	0.47	0.16
Pyrene	20.51	0.47	0.16
Benzo(a)Anthracene	24.08	0.60	0.19
Chrysene	24.21	0.60	0.19
Benzo(b)Fluoranthene	26.94	0.60	0.19
Benzo(k)Fluoranthene	27.02	0.66	0.16
Benzo(a)Pyrene	27.66	0.50	0.16
Indeno(1,2,3-cd)Pyrene	30.25	0.41	0.13
Dibenzo(a,h)Anthracene	30.36	0.44	0.13
Benzo(g,h,i)Perylene	30.76	0.57	0.13

[1] Results obtained using the column and chromatographic conditions described in Sections 6.4 and 9.2, respectively.

[2] Single laboratory MDL study; see Appendix 1 for more details.

3.10 **Extractable Petroleum Hydrocarbons (EPH)** are defined as collective fractions of hydrocarbon compounds eluting from n-nonane to n-hexatriacontane, excluding Target PAH Analytes. EPH is comprised of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and C_{11} through C_{22} Aromatic Hydrocarbons.

3.11 **Field Duplicates** are defined as two separate samples collected at the same time and location under identical circumstances and managed the same throughout field and laboratory procedures. Analyses of field duplicates give a measure of the precision associated with sample collection, preservation and storage, as well as laboratory procedures.

3.12 **Fractionation Surrogate Standards** are compounds that are spiked into the sample extract immediately prior to fractionation, in order to determine if significant quantities of naphthalene or substituted naphthalenes are being stripped into the aliphatic extract.

3.13 **Laboratory Fortified Blank** is defined as a reagent water blank or clean sand blank fortified with a matrix spiking solution.

3.14 **Laboratory Duplicates** are defined as split samples taken from the same sampling container and analyzed separately with identical procedures. The analysis of laboratory duplicates give a measure of the precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.15 **Laboratory Fortified Matrix (LFM) Sample** is defined as an environmental sample which has been spiked with a matrix spiking solution containing known concentrations of method analytes. The LFM sample is treated and analyzed exactly as other samples, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentration of analytes in the sample matrix must be determined through the separate analyses of a laboratory or field duplicate, and the measured values in the LFM sample corrected for background concentrations.

3.16 **Laboratory Method Blank** is defined as an aliquot of reagent water or clean sand spiked with a surrogate standard. The laboratory method blank is treated exactly as a sample, exposed to all glassware, solvents, reagents, and equipment. A laboratory method blank is analyzed with every batch of samples, to determine if method analytes or other interferences are present in the laboratory environment, reagents, or equipment.

3.17 **Matrix Spiking Solution** is defined as a solution prepared independently from the calibration standards, containing known concentrations of method analytes.

3.18 **System Solvent Blank** is defined as an aliquot of a method solvent (e.g., hexane or methylene chloride, pesticide grade or better) that is directly injected into the GC system. The purpose of the System Solvent Blank is to determine the level of noise and baseline rise attributable solely to the GC system, in the absence of any other analytes or system contaminants.

3.19 **Surrogate Standards** are compounds spiked into all samples, blanks, and matrix spikes to monitor the efficacy of sample extraction, chromatographic, and calibration systems.

3.20 **Target PAH Analytes** are defined as the 17 polynuclear aromatic hydrocarbon (PAH) compounds listed in Table 2.

3.21 **Total Petroleum Hydrocarbons (TPH)** are defined as the collective concentration of all hydrocarbon compounds eluting from n-nonane to n-hexatriacontane, excluding Target PAH Analytes. TPH is equivalent to the summation of C_9 through C_{18} Aliphatic Hydrocarbons, C_{19} through C_{36} Aliphatic Hydrocarbons, and C_{11} through C_{22} Aromatic Hydrocarbons.

3.22 **Unadjusted C_{11} through C_{22} Aromatic Hydrocarbons** are defined as all aromatic hydrocarbon compounds eluting from naphthalene through Benzo(g,h,i)Perylene.

3.23 **Unadjusted TPH** is defined as the collective concentration of all hydrocarbon compounds eluting from n-nonane to n-hexatriacontane.

6.0 APPARATUS AND MATERIALS

6.1 The following glassware is used for this method:

- 6.1.1 1-L amber glass bottles
- 6.1.2 4 oz. (120 mL) amber glass wide-mouth jars
- 6.1.3 Vials:
  - 6.1.3.1 auto sampler: 2-mL glass vials with Teflon-lined rubber crimp caps
  - 6.1.3.2 10-mL vials with Teflon-lined caps
- 6.1.4 Glass funnels
- 6.1.5 2-L Separatory funnels with Teflon stopcock
- 6.1.6 Kuderna-Danish apparatus including 10-mL graduated concentrator tube, 500-mL Evaporative flask, & 3-ball Snyder column
- 6.1.7 250-mL Erlenmeyer flasks
- 6.1.8 Disposable pipets: Pasteur
- 6.1.9 25-mL graduated cylinder
- 6.1.10 1-Liter graduated cylinder
- 6.1.11 100-mL beakers
- 6.1.12 Class "A" volumetric flasks: 10, 25, 50 and 100-mL
- 6.1.13 Class "A" volumetric pipets: 1, 5 or 10-mL

6.2 Analytical balance: An analytical balance capable of accurately weighing 0.0001 g must be used for weighing standards. A top-loading balance capable of weighing to the nearest 0.1 g must be used for weighing soil samples.

6.3 An air or nitrogen blowdown apparatus, or equivalent sample concentration apparatus, is required to concentrate extracts.

6.4 **Gas Chromatography**

6.4.1 Gas Chromatograph: An analytical system complete with temperature programmable gas chromatograph for use with capillary columns is required. The data station must be capable of storing and reintegrating chromatographic data and must be capable of determining peak areas using a forced baseline projection.

6.4.2 Recommended Column: 30-m long x 0.32-mm I.D., 0.25-µm film RTX5 column (Restek Corp.) or equivalent. This column will allow for the adequate resolution of alkanes from n-C_9 to n-C_{36}. This column will also resolve the Target PAH Analytes listed in Table 2.

6.4.3 Detector: A Flame Ionization Detector (FID) is required.

7.6 **Matrix Spike Standard**

7.6.1 Five or more analytes from each analyte group (i.e., aromatic and aliphatic hydrocarbons) are selected for use in a matrix spiking solution, which is prepared independently from the calibration standards.

7.6.2 The recommended spiking solution, consisting of C_9, C_{14}, C_{19}, C_{20}, and C_{28} normal alkanes and naphthalene, acenaphthene, anthracene, pyrene and chrysene, is prepared in acetone at concentrations of 50 ng/µL.

7.6.3 The samples selected as the matrix spike are fortified with 1.0 mL of the matrix spiking solution.

7.7 **Fractionation Check Solution**

7.7.1 The Fractionation Check Solution is used to monitor the fractionation efficiency of the silica gel cartridge/column, and establish the optimum volume of hexane needed to sufficiently elute aliphatic hydrocarbons, but not strip aromatic hydrocarbons.

7.7.2 Prepare a Fractionation Check Solution in hexane containing 200 ng/µL of the Aliphatic Hydrocarbon standard (C_9-C_{36} alkanes) and 200 ng/µL of the Aromatic Hydrocarbon standard (targeted PAH analytes). The final solution will contain 14 alkanes and 17 PAHs at concentrations of 200 ng/µL each. Alternative concentrations are permissible.

8.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

8.1 Aqueous samples are collected in 1 liter amber glass bottles with Teflon-lined screw caps.

8.2 Soil and sediment samples are collected in 4 oz. (120 mL) amber wide-mouth glass jars with Teflon-lined screw caps.

8.3 Aqueous samples must be preserved at the time of sampling by the addition of a suitable acid to reduce the pH of the sample to less than 2.0. This may be accomplished by the addition of 5 mL of 1:1 HCl to a 1 liter sample. The use of alternative acids are permissible. Following collection and addition of acid, the sample must be cooled to 4°C.

8.4 Soil and sediment samples must be cooled to 4°C immediately after collection.

8.5 A chain of custody form must accompany all aqueous, soil and sediment samples, documenting the time and date of sampling and any preservative additions.

8.6 Aqueous samples must be extracted within 14 days of collection, and analyzed within 40 days of extraction.

8.7 Soil and sediment samples must be extracted within 7 days of collection, and analyzed within 40 days of extraction.

8.8 A summary of sample collection, preservation, and holding times is provided in Table 3.

Table 3. Holding Times and Preservatives for EPH Samples

Matrix	Container	Preservation	Holding Time
Aqueous Samples	1-Liter amber glass bottle with Teflon-lined screw cap	Add 5 mL of 1:1 HCl; cool to 4°C	Samples must be extracted within 14 days and extracts analyzed within 40 days
Soil/Sediments Samples	4-oz. (120 mL) widemouth amber glass jar with Teflon-lined screw cap	Cool to 4°C	Samples must be extracted within 7 days and extracts analyzed within 40 days

9.0 PROCEDURE

9.1 Sample Preparation

Samples are extracted using methylene chloride, and solvent-exchanged into hexane. The recommended extraction procedure for water samples is a separatory funnel liquid-liquid extraction technique based upon SW-846 Method 3510A. For soil or sediment samples, use of a Soxhlet or Soxtec technique is recommended. Alternative extraction procedures are acceptable, provided that the laboratory can document acceptable performance. During the Round Robin evaluations conducted on this method, the use of a sonication extraction procedure appeared to provide acceptable performance for freshly-spiked sand samples.

9.1.1 Water Extraction

9.1.1.1 Mark the meniscus on the 1 liter sample bottle (for later volume determination) and transfer it to a 2-liter separatory funnel. For blanks and quality control samples, pour 1 liter of reagent water into the separatory funnel. Add 1.0 mL of the surrogate spiking solution to all samples, blanks and matrix spikes. For samples selected for spiking, add 1.0 mL of the matrix spiking solution.

9.1.1.2 Check the pH of the sample with wide-range pH paper. Note the pH in the laboratory notebook. The pH of the sample need not be adjusted.

9.1.1.3 Add 60 mL methylene chloride to the sample bottle to rinse the inner walls of the container, then add this solvent to the separatory funnel.

9.1.1.4 Seal and shake the separatory funnel vigorously for 1 to 2 minutes with periodic venting to release excess pressure.

NOTE: Methylene chloride creates excessive pressure very rapidly; therefore, venting should be done immediately after the separatory funnel has been sealed and shaken once.

9.1.1.5 Allow the organic layer to separate from the water phase for a minimum of 5 minutes. If the emulsion interface between layers is more than one-third the size of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample and may include stirring, filtration of the emulsion through glass wool, centrifugation, or other physical methods. Collect the solvent extract in an Erlenmeyer flask.

9.1.1.6 Repeat the extraction two more times using additional 60 mL portions of solvent. Combine the three solvent extracts in a 250-mL Erlenmeyer flask. (Steps 9.1.1.3 to 9.1.1.5)

9.1.1.7 For sample volume determination add water to the sample bottle to the level of the meniscus previously marked then transfer this water to a graduated cylinder.

9.1.1.8 Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporation flask.

9.1.1.9 Dry the extract by passing it through a glass powder funnel containing anhydrous sodium sulfate. Collect the dried extract in a K-D concentrator. Rinse the Erlenmeyer flask, which contained the solvent extract, with 20 to 30 mL of methylene chloride and add it to the funnel to complete the quantitative transfer.

9.1.1.10 Add one or two clean boiling chips to the K-D flask and attach a three ball Snyder column. Pre-wet the Snyder column by adding about 1 mL of methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 10 to 20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

9.1.1.11 Exchange the methylene chloride with hexane by adding 50 mL of hexane to the top of the Snyder column. Concentrate the extract to less than 10 mL, as described in Paragraph 9.1.1.10, raising the temperature of the water bath, if necessary, to maintain proper distillation.

9.1.1.12 Remove the Snyder column and evaporation flask from the 10-mL concentrator tube. Place the concentrator tube containing the hexane extract onto an air blowdown apparatus. Adjust the extract volume to 1 mL under a gentle stream of nitrogen or air. If the extract is highly colored, forms a precipitate, or stops evaporating, the final volume should be higher.

9.1.1.13 Add 1 mL of the fractionation surrogate spiking solution to the 1 mL hexane extract. Alternatively, add 20-50 ng each of the fractionation surrogate standards using a microliter syringe and concentrated spiking solution.

9.1.1.14 Record the sample preparation information for the extraction and concentration steps. At a minimum, record the date, sample laboratory number, sample volume, volume and concentration of added surrogates, fractionation surrogates, and matrix spike solutions, and any deviations or problems associated with the extraction of the samples.

9.1.1.15 The 2 mL extract is now ready to be cleaned and fractionated by silica gel SPE. If cleanup will not be performed immediately, transfer the extract to a Teflon-lined screw-cap vial, label, and refrigerate. If a TPH analysis is to be conducted, without fractionation, proceed to Section 9.1.5

9.1.1.16 For cleanup and fractionation, refer to Section 9.1.4.

9.1.2 Soil/Sediment Extraction using Soxtec Extraction

9.1.2.1 Blend 10 g of the solid sample with 10 g anhydrous sodium sulfate and place in an extraction thimble. The extraction thimble must drain freely for the duration of the extraction period. Add 1.0 mL of the surrogate spiking solution onto the sample. For samples selected for spiking, add 1.0 mL of the matrix spiking standard.

9.1.2.2 Place 70 mL of methylene chloride into a 100-mL Soxtec beaker containing 1 or 2 boiling chips. Attach the beaker to the Soxtec extractor and extract the sample for 4 hours.

9.1.2.3 Allow the extract to cool after the extraction is complete.

9.1.2.4 Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporation flask. Alternatively, sample concentration may be accomplished in the Soxtec extractor.

9.1.2.5 Dry the extract by passing it through a glass powder funnel containing anhydrous sodium sulfate. Collect the dried extract in the K-D concentrator. Wash the Soxtec cup and sodium sulfate column with 100 to 125 mL of methylene chloride to complete the quantitative transfer.

9.1.2.6 Add one or two clean boiling chips to the flask and attach a three-ball Snyder column. Pre-wet the Snyder column by adding about 1 mL of methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature, as required, to complete the concentration in 10 to 20 min. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

9.1.2.7 Exchange the methylene chloride with hexane by adding 50 mL of hexane to the top of the Snyder column. Concentrate the extract as described in Paragraph 9.1.2.6, raising the temperature of the water bath, if necessary, to maintain proper distillation.

9.1.2.8 Remove the Snyder column and evaporation flask from the 10-mL concentrator tube. Place the concentrator tube containing the hexane extract onto an air blowdown apparatus. Adjust the extract volume to 1 mL under a gentle stream of nitrogen or air. If the extract is highly colored, forms a precipitate, or stops evaporating, the final volume should be higher.

9.1.2.9 Add 1 mL of the fractionation surrogate spiking solution to the 1 mL hexane extract. Alternatively, add 20-50 ng each of the fractionation surrogate standards using a microliter syringe and concentrated spiking solution.

9.1.2.10 Record the sample preparation information for the extraction and concentration steps. At a minimum, record the date, sample laboratory number, sample volume, volume and concentration of added surrogates, fractionation surrogates, and matrix spike solutions, and any deviations or problems associated with the extraction of the samples.

9.1.2.11 The 2 mL extract is now ready to be cleaned and fractionated by silica gel SPE. If cleanup will not be performed immediately, transfer the extract to a Teflon-lined screw-cap vial, label, and refrigerate. If a TPH analysis is to be conducted, without fractionation, proceed to Section 9.1.5

9.1.2.12 For cleanup and fractionation, refer to Section 9.1.4.

9.1.3 Soil/Sediment Extraction by Soxhlet Extraction

9.1.3.1 Blend 10 g of the solid sample with 10 g anhydrous sodium sulfate and place in an extraction thimble. The extraction thimble must drain freely for the duration of the extraction period. Add 1.0 mL of the surrogate spiking solution onto the sample. For samples selected for matrix spiking, add 1.0 mL of the matrix spiking solution.

9.1.3.2 Place 300 mL of methylene chloride into a 500-mL round-bottom flask containing one or two clean boiling chips. Attach the flask to the extractor and extract the sample for 16-24 hr.

9.1.3.3 Allow the extract to cool after the extraction is completed.

9.1.3.4 Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10-mL concentrator tube to a 500-mL evaporation flask.

9.1.3.5 Dry the extract by passing it through a glass powder funnel containing anhydrous sodium sulfate. Collect the dried extract in the K-D concentrator. Wash the extractor flask and sodium sulfate column with 100 to 125 mL of methylene chloride to complete the quantitative transfer.

9.1.3.6 Add one or two clean boiling chips to the flask and attach a three-ball Snyder column. Pre-wet the Snyder column by adding about 1 mL of methylene chloride to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature, as required, to complete the concentration in 10 to 20 min. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 1 mL, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

9.1.3.7 Exchange the methylene chloride with hexane by adding 50 mL of hexane to the top of the Snyder column. Concentrate the extract as described in Paragraph 9.1.3.6, raising the temperature of the water bath, if necessary, to maintain proper distillation.

Table 1-1. **Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Alkanes Spiked Into Reag ent Water and Analyzed by the EPH Method**

Compound[a]	Compound Conc. Measured (µg/L)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (µg/L)
	Mean	Std. Dev.			
C_9	1.79	0.13	72	7.3	0.41
C_{10}	2.65	0.02	106	0.7	0.06
C_{12}	2.46	0.03	98	1.2	0.09
C_{14}	2.51	0.05	100	1.9	0.15
C_{16}	2.54	0.05	102	1.8	0.14
C_{18}	2.53	0.05	101	2.1	0.17
C_{19}	2.52	0.05	101	2.0	0.16
C_{20}	2.50	0.06	100	2.4	0.19
COD	2.39	0.06	96	2.3	0.18
C_{22}	2.45	0.08	98	3.2	0.25
C_{24}	2.41	0.10	96	4.0	0.30
C_{26}	2.40	0.13	96	5.4	0.41
C_{28}	2.43	0.16	97	6.6	0.50
C_{30}	2.46	0.16	98	6.5	0.50
C_{36}	2.63	0.46	105	17.5	1.44

[a] Compounds were spiked into 7 samples at a concentration of 2.5 µg/L.

[b] Recovery (%) of spiked concentration.

[c] RSD = relative standard deviation (%) of mean concentration measured.

Table 1-3. **Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Alkanes Spiked Into EPH-Free Sand and Analyzed by the EPH Method**

Compound[a]	Compound Conc. Measured (mg/Kg)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (mg/Kg)
	Mean	Std. Dev.			
C_9	0.49	0.02	98	3.7	0.06
C_{10}	0.46	0.02	92	3.9	0.06
C_{12}	0.44	0.02	88	4.5	0.06
C_{14}	0.46	0.03	92	6.5	0.09
C_{16}	0.48	0.03	96	6.2	0.09
C_{18}	0.51	0.03	102	5.8	0.09
C_{19}	0.52	0.03	104	5.8	0.09
C_{20}	0.53	0.03	106	5.7	0.09
COD	0.53	0.03	106	5.7	0.09
C_{22}	0.55	0.03	110	5.5	0.09
C_{24}	0.56	0.04	112	7.1	0.13
C_{26}	0.57	0.05	114	8.8	0.16
C_{28}	0.57	0.06	114	10.5	0.19
C_{30}	0.58	0.07	116	12.1	0.22
C_{36}	0.62	0.02	124	3.2	0.06

[a] Compounds were spiked into 7 samples at a concentration of 0.5 mg/Kg.

[b] Recovery (%) of spiked concentration.

[c] RSD = relative standard deviation (%) of mean concentration measured.

Table 1-4. Single Laboratory Accuracy, Precision, and Method Detection Limits (MDLs) for Polynuclear Aromatic Hydrocarbons (PAHs) Spiked Into EPH-Free Sand and Analyzed by the EPH Method

Compound[a]	Compound Conc. Measured (mg/Kg)		Mean Accuracy (Mean % Recovery[b])	Method Precision (RSD[c] - %)	MDL (mg/Kg)
	Mean	Std. Dev.			
Naphthalene	0.48	0.03	96	6.3	0.09
2-Methylnaphthalene	0.48	0.03	96	6.3	0.09
Acenaphthylene	0.50	0.03	100	6.0	0.09
Acenaphthene	0.51	0.03	102	5.9	0.09
Fluorene	0.51	0.03	102	5.9	0.09
Phenanthrene	0.53	0.05	106	9.4	0.16
Anthracene	0.52	0/05	104	9.6	0.16
OTP	0.54	0.04	108	7.4	0.13
Fluoranthene	0.55	0.05	110	9.1	0.16
Pyrene	0.55	0.05	110	9.1	0.16
Benzo(a)Anthracene	0.59	0.06	118	10.2	0.19
Chrysene	0.59	0.06	118	10.2	0.19
Benzo(b)Fluoranthene	0.64	0.06	128	9.3	0.19
Benzo(k)Fluoranthene	0.63	0.05	126	7.9	0.16
Benzo(a)Pyrene	0.62	0.05	124	8.0	0.16
Indeno(123 cd)Pyrene	0.59	0.04	118	6.7	0.13
Dibenzo(ah)Anthracene	0.55	0.04	110	7.3	0.13
Benzo(ghi)Perylene	0.58	0.04	116	6.9	0.13

[a] Compounds were spiked into 7 samples at a concentration of 0.5 mg/Kg.
[b] Recovery (%) of spiked concentration.
[c] RSD = relative standard deviation (%) of mean concentration measured.

APPENDIX 2

CHROMATOGRAMS