



## The vehicle-portable analytical system of the Emergencies Science Division of Environment Canada

Ken Li, Mervin F. Fingas, Jacqueline M.R. Bélanger, J.R. Jocelyn Paré\*

*Environment Canada, Emergencies Science Division, Environmental Technology Centre, Ottawa, ON,  
Canada K1A 0H3*

Received 14 February 1995; accepted in revised form 14 March 1995

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### Abstract

The Emergencies Science Division of Environment Canada is equipped with a mobile laboratory (level 3) to perform analytical procedures on-site. A detailed description of this vehicle along with its equipment will be given. Typical procedures such as supercritical fluid extraction for polyaromatic hydrocarbons (PAH) from soil samples, ultrasonic probe extraction of selected chemicals, and microwave-assisted processes (MAP<sup>TM</sup>) for the extraction of contaminated soil will be reported. Analytical results using a GC-MSD will be presented. Experimental procedures and results from an exercise simulating a spill accident will also be presented as well as a post mortem analysis of such operation.

*Keywords:* Vehicle-portable analytical system; Mobile laboratory; Emergency response vehicle; On-site spill response

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### 1. Introduction

Since 1980, the Emergencies Science Division (ESD) has initiated and conducted projects to develop and evaluate systematically various analytical systems for on-site spill response. More recently, research efforts have been focussed on four level of response capabilities defined as follows: level 1, pocket-portable; level 2, person-portable; level 3, vehicle-portable; and level 4 offering mobile analytical capabilities similar to those found in a fixed laboratory facility.

### 2. Description of ESD mobile laboratory

The original instrumentation and apparatus, along with their technical specifications have previously been described in detail [1–8]. The current configuration

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\* Correspondence address: Dr. J. R. Jocelyn Paré Chief, MAP Unit, 3439 River Road, Ottawa, ON, Canada K1A 0H3. Tel.: 613-990-9122. Fax: 613-991-9485.

and modifications are summarized in the appendix and, for the sake of conciseness, only recent modifications and the functions of major modules are highlighted below.

### 2.1. Vehicle

The vehicle is based on a 1986 Ford Econoline cargo van with dual rear wheels, having a net vehicle weight of 9100 lb including all fixed installation and cab body. Total weight with instruments, supplies and two operators is about 10 000 lb. The centre isle layout, with work benches on either side, is well-suited for the use of the vehicle as an analytical centre in an emergency response situation. Access is through two doors in the driver compartment and two wide doors at the back of the cab. The latter provide ease of access for tasks such as the installation of instruments and the changing of gas cylinders.

Heating is provided by a Duotherm propane furnace which is fed by an underslung 30 l tank. Cooling is provided by a roof-mounted Coleman air conditioner which has a 20 000 BTU h<sup>-1</sup> rating and is capable of cooling under the worst conditions (35 °C, all instruments running and 2 operators in the vehicle).

Power is provided by an Onan 6.5 NH-3CR Generator Set with a capacity of 6.5 kW. The generator set is located in an insulated compartment in the right rear corner of the truck and is easily accessible for servicing. Power is conditioned by 2 Sola Portable Micro/Minicomputer Regulator power conditioners (16.7 and 20 A rating). During operation at the home-base, the electrical system can be disconnected from the generator and plugged into a standard 240 VAC, 30 A outlet via a 100 ft cable. To save space, the engine uses gasoline from the same tank as the vehicle. Capacity of the vehicle fuel tank, if required to operate continuously with full instrument load is approximately one-and-a-half day.

For sample workup that requires wet chemistry, a ductless fume hood (Astecair 3000 L) is at the rear right corner with a minimum 0.5 m sec<sup>-1</sup> linear flow and 200 m<sup>3</sup> h<sup>-1</sup> volumetric flow. The unit has a working area of 85 × 61 cm and is equipped with lights and a filter saturation alarm which activates when it is time to change the charcoal filter. An electrostatically charged Filtrete prefilter protects the main filter block by removing dust down to 0.5 µm.

The ventilation system of the van has been heavily modified into a sophisticated air handling system that can be operated in unfiltered (ventilation) mode and filtered (pressurisation) mode. The positive pressurisation unit is situated at the right 'dog-house' storage area of the cabin. A Buffalo 2 VEH variable speed blower, essentially a high-capacity centrifugal pump, draws air from outside through fresh air intakes and passes it through a sectioned filter drawer that can accommodate a variety of loose filter material as well as preformed filters. At present, a combined HEPA and charcoal filter is used to scrub out organic vapours before entry into the vehicle. Given the present blower capacity and normal air leakage, the maximum positive pressure available is 0.25 in of water. Furthermore, extensive sealing to minimize air infiltration is necessary to ensure atmospheric integrity up to about 35 km h<sup>-1</sup> relative wind speed.

## 2.2. Instrumentation

The most important consideration for field analytical methods lies with quick sample turnaround time given a variety of sample types. Ideally, the heart of such 'problem-solving' strategy would have the following attributes:

- field deployable and reasonably short startup time;
- ability to identify qualitatively and quantitatively all the compounds on the target spill list;
- applicable to a variety of sample matrices, i.e. gaseous, liquid and solid;
- has detection limits significantly lower than toxicity level of the compounds of interest;
- fast turnaround time and high sample throughput;
- simple, rugged and easily field repaired;
- commercially available, can be operated without major modification and does not require any special support utility.

Unfortunately, such an idealized field instrument does not exist yet. However, a bench-top gas chromatograph/mass spectrometer system satisfies most of the requirements. Consequently, our mobile laboratory analytical system has been equipped with one fully computerized HP-5890 gas chromatograph interfaced to an HP-5971A mass selective detector (MSD), which was recently upgraded by adding a more sensitive electron multiplier.

This system can uniquely identify most of the organic compounds on the priority list by virtue of chromatographic retention indices and mass spectral information. Gaseous samples collected using tedlar bags or evacuated summa canisters can be injected easily via the split/splitless injector port with a gas-tight syringe. Liquid samples can be partitioned with an appropriate solvent and the organic layer can be injected. Similarly, contaminants in solid samples that can be extracted in a solvent can be concentrated and injected as solution.

The system is equipped with two injectors, namely one split/splitless injector and one cool on-column injector. The system offers dual-channel capabilities where one thermal conductivity detector, chosen for its relative universality in response and the fact that it does not require any auxiliary gas other than helium, complements and offers back-up support to the MSD in case of operational failure of the latter.

The MS ChemStation (DOS series) is used to control data acquisition and data editing. Currently, there are 75 000 spectra in the library on the ChemStation that can be used to identify unknown samples or, at the very least, help in the elucidation of any unknown structure. High sample throughput is ensured with the use of the HP-7673 automated liquid sampler.

## 2.3. Supercritical fluid chromatography (SFE)

To minimize the use of solvent in the field, the use of supercritical fluid extraction (SFE) for the extraction of solid samples was investigated. A Suprex SFE/50 is a free standing integrated system comprised of a pump, control and oven module. SFE

Table 1  
Supercritical fluid extraction of polyaromatic hydrocarbons (PAH) spiked on different matrices (% Recovery (100 µl ISM-2))

Date	Sample/SFE conditions	A	B	C	D
92-06-23	MD-SFE-75/XAD tube & filter, 3 ml cell 0.5 ml methanol eq 150 atm, 50°C, static 10 min, 500 atm, 65°C, static 30 min, 500 atm, 65°C, dynamic	80	70	40	0
92-06-23	MD-SFE-76/XAD tube & filter, 3 ml cell 0.5 ml methanol eq 150 atm, 50°C, static 10 min, 500 atm, 65°C, static 30 min, 500 atm, 65°C, dynamic	70	60	40	10
92-06-23	MD-SFE-77/XAD tube & filter, 3 ml cell 0.5 ml methanol eq 150 atm, 50°C, static 10 min, 500 atm, 65°C, static 30 min, 500 atm, 65°C, dynamic	70	60	30	10
92-03-26	MD-SFE-21/teflon filter eq 150 atm, 50°C, static 20 min, 500 atm, 85°C, static 30 min, 500 atm, 85°C, dynamic	42	36	35	29
92-03-26	MD-SFE-22/glass filter eq 150 atm, 50°C, static 20 min, 500 atm, 85°C, static 30 min, 500 atm, 85°C, dynamic	75	74	73	72
92-03-26	MD-SFE-23/teflon filter 0.5 ml benzene eq 150 atm, 50°C, static 20 min, 500 atm, 85°C, static 30 min, 500 atm, 85°C, dynamic	82	81	77	75

A = d10-acenaphthene, B = d10-phenanthrene, C = d12-benz(a)anthracene, D = d12-perylene.

extraction is usually carried out using SFE grade carbon dioxide on a sample size of 1–2 g in an extraction thimble.

Sample trapping is effected by bubbling the expanded carbon dioxide stream in a calibrated tube containing a few millilitres of an appropriate solvent. Since the solvating power of SF carbon dioxide is a function of density, which is controlled by pressure and temperature, a selective extraction can be carried out in which the easily extractable background material is removed by SF carbon dioxide at a lower density. The pressure is stepped up to effect the extraction of the target analytes, resulting in a solution that is relatively free from interference and ready for analysis.

Typical SFE extraction recovery for polyaromatic hydrocarbons (PAH) in a reference soil sample is illustrated in Table 1, while selective extraction of an alkane

mixture spiked onto glass fibre filter is shown in Fig. 1. Fraction 1 was collected at density of  $0.4 \text{ g ml}^{-1}$ , in which hydrocarbons up to C-26 were completely extracted. Fraction 2 at density of  $0.6 \text{ g ml}^{-1}$  only recovers the higher alkanes (C-36 and C-40).

In addition, the system is equipped with a GC sample transfer kit with independent temperature control that enables on-line SFE. In this extraction mode, the transfer line is simply inserted into the heated injector port of the GC in which the expanded carbon dioxide is allowed to vent through the split vent of the injector. The intervening collection step is thus eliminated. The GC liquid phase is used to trap the analytes. Without additional cryo-focussing, only semi- and non-volatile compounds are amenable to this mode of operation.

#### 2.4. Ultrasonic probe extraction

Small-scale conventional wet chemistry can also be carried out in the van using an ultrasonic probe equipped with micro-tip horn in accordance to EPA methods such as 3550 (publication SW 846). The energy density emitted from the micro-tip is of the order of several hundred  $\text{W/cm}^2$ , compared to several watts from an ultrasonic bath. This results in rapid extraction of soil, vegetation or solid samples.

Typically, 1–2 g samples of soil are extracted with 5–10 ml of an appropriate solvent in 40 ml vials for 1–2 min. The raw extracts are then centrifuged or filtered and made to a known volume. For simplicity, concentration is usually not carried out so the initial solvent volumes, used for extraction, need to be minimized to provide acceptable detection limits for the analyte. A few selected chemicals from the spill list have been spiked onto representative soils and recovery studies carried out (Table 2).

#### 2.5. Extraction using the Microwave Assisted Process (MAP<sup>TM</sup>)

ESD has begun work aimed to adapt the Department of the Environment-owned MAP to the extraction of environmentally significant chemicals from various matrices. The process has shown great promise in the analysis of volatiles from soil or water. By the selective adsorption of microwave energy, the matrix/analyte interaction can be altered to effect the partitioning of the analytes into the air space as in the case of static or dynamic headspace analysis (gas-phase extraction) or into the surrounding solvent as in the case of conventional liquid-phase extraction.

The analysis of volatile and semi-volatile compounds following MAP extraction have been reported in Refs. [9–15]. In emergency response application, the MAP is attractive from the stand point of rapid sample preparation which requires nothing more than a basic microwave applicator and disposable extraction vials.

A generic liquid-phase extraction strategy using MAP illustrates the simplicity of the process: a 0.5–1 g soil or solid sample is weighed into a 40 ml vial into which a 10 ml mixture of hexane and acetone (1:1) is added. This is sealed snugly with a holed cap and Teflon-lined septum and placed in a domestic microwave oven and irradiated with full power (900 W in the unit installed) for 20 s. The vial is allowed to cool and an aliquot of the supernatant (filtered through a nylon syringe filter if necessary) is injected into the GC.

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Operator :  
Acquired : 27 Jun 94 4:29 pm using AcqMethod SIMDIS  
Instrument : 5972 - In  
Sample Name: simdis spiked on filter, HC\_3step.ext,fr1  
Misc Info :  
Vial Number: 3

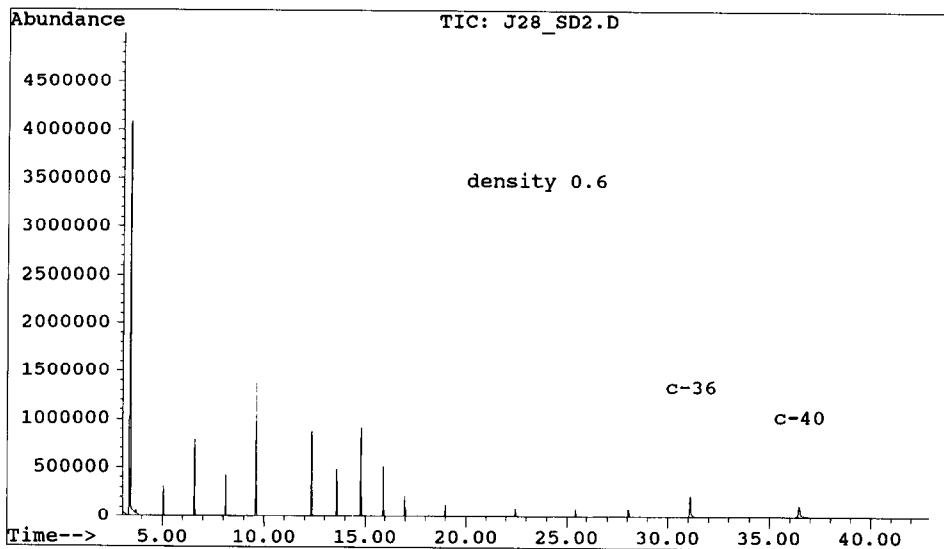
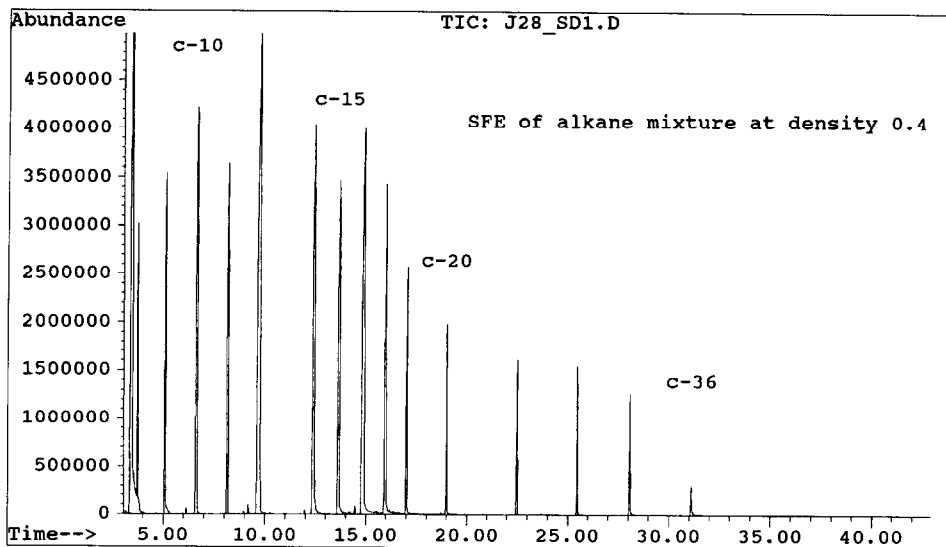


Fig. 1. (a) Chromatogram of selective extraction of total petroleum hydrocarbons using supercritical fluid extraction at a density of  $0.4 \text{ g ml}^{-1}$ . (b) Second extraction at a density of  $0.6 \text{ g ml}^{-1}$ .

Table 2  
Ultrasonic probe extraction of selected chemicals on the spill priority list

Chemical	Sample matrix	Extracting solvent	Extraction time	% Recovery	Comments
PAH	XAD sorbent tube	10 ml MeOH/toluene	5 min, once	78%	$n = 2$
	XAD sorbent tube	10 ml MeOH/toluene	5 min, twice	90%	$n = 3$
	2 g sand	10 ml MeOH/toluene	5 min, twice	60%	$n = 3$
	2 g sand	10 ml ethylacetate	5 min, twice	90%	$n = 3$
	PCB	2 g sand	10 ml hexane	2 min, once	87%
	Glass fibre filter	10 ml hexane	2 min, once	75%	$n = 3$
Malathion/fenitrothion	1 g soil	10 ml acetone	2 min, once	68%	$n = 3$
	1 g sand	10 ml acetone	2 min, once	77%	$n = 3$

Note: (1) PAH spike 100  $\mu$ l surrogate PAH mix at 10  $\text{ng}\mu\text{l}^{-1}$ . (2) PCB spike 100  $\mu$ l PCB window defining mix at 25  $\text{ng}\mu\text{l}^{-1}$ . (3) Malathion/fenitrothion spike 200  $\mu$ l pesticide mix at 50  $\text{ng}\mu\text{l}^{-1}$ .

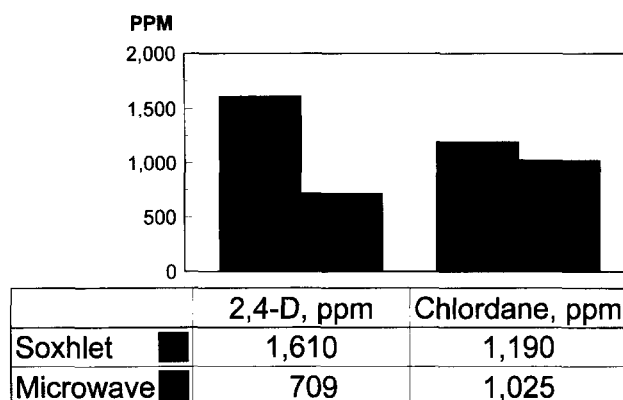


Fig. 2. Comparison of recoveries obtained using soxhlet extraction (8–10 h) versus Microwave-Assisted Process (MAP™) (30 s) for the extraction of pesticides from a chemical fire.

An illustration of rapid MAP extraction of a contaminated soil from an actual chemical fire at Grand Coulee, Saskatchewan, 1991 is shown in Fig. 2. A pink-coloured soil sample (from burst chemical barrels) in the hot zone was extracted by conventional soxhlet extraction and compared to the use of MAP. The first-pass, non-optimized, MAP extraction recovered 44–86% of the soxhlet values by 30 s of microwaving compared to the 8–10 h of soxhlet extraction.

Table 3 shows PAH analysis of reference materials using MAP; again excellent agreement is observed while taking only a fraction of the time needed for conventional soxhlet extractions.

Table 3

Comparison of the Microwave-Assisted Process (MAP) versus soxhlet extractions for polyaromatic hydrocarbons (PAH) from a reference soil contaminated with wood preservative

Compounds	Reference value <sup>a</sup>	MAP <sup>b</sup>	Soxhlet for 16 h
Naphthalene	34.8		
2-Methyl naphthalene	60.4		
Acenaphthylene	6.5 <sup>c</sup>	3.2	3.5
Acenaphthene	627.2	218	244
Dibenzofuran	305.7		
Fluorene	443	207	207
Phenanthrene	1925	1366	1400
Anthracene	431.1	156	150
Fluoranthrene	1426	1038	991
Pyrene	1075	844	814
Benz(a)anthracene	264.4	298	264
Chrysene	316.1	218	194
Benzo(b)fluoranthene	114.7 <sup>c</sup>		
Benzo(k)fluoranthene	63.7 <sup>c</sup>		
Benzo(b + k)fluoranthene	188.6	249	209
Benzo(a)pyrene	96.5	93	75
Pentachlorophenol	1425		
Indeno(1,2,3-cd)pyrene	31.9	27	21
Dibenz(a,h)anthracene	14.2 <sup>c</sup>	8.2	10
Benzo(g,h,i)perylene	25.5 <sup>c</sup>	32	26

<sup>a</sup> Natural matrix certified reference material, US EPA certified (SRS 103-100).

<sup>b</sup> Microwave 10 min at 70 °C in 50 ml hexane/acetone.

<sup>c</sup> Denotes values not certified.

### 3. Actual deployment of the van

The first incident in which the van was deployed was in 1989 during the St. Basile-le-Grand polychlorinated biphenyls (PCB) fire. The vehicle at that time was equipped with a Perkin-Elmer Sigma 2000 GC. Air samples were collected using Gillian personal samplers and filter/XAD cartridges together with wipe and soil samples. Quick extractions were carried out inside the fumehood by ultrasonic extraction and manually injected into the GC. Data output was performed on a Spectra Physics SP 4270 integrator. Further manipulation of the data was performed by downloading the chromatographic data onto an IBM PC. Identification of PCB was carried out by pattern matching to Aroclor mixtures. Without cleanup, the electron capture detector chromatograms were complex and required extensive interpretation work.

#### 3.1. Field exercise

To acquire actual field experience and test out the GC/MSD system which replaced the Perkin-Elmer gas chromatograph in 1990, a mock spill exercise was carried out during the summer of 1994 at a soil remedial site just outside of Ottawa.



In preparation for transit to the site approximately 1 h away, the GC/MSD system was vented and secured to the shock-mounted aluminum pad. Once on site, the MSD was pumped down while preparing the van for on-site analysis. Although high vacuum was established in about half an hour, the MSD was not ready for analysis for another 3–4 h. The ion source and quadrupole analyzer are heated conductively via the transfer line and a 4 h period is recommended by the manufacturer for the system to reach thermal equilibrium.

Once the temperature had stabilized, soil samples collected on site were weighed into 20 ml headspace (HS) vials and enough water added to give a HS volume of 12 ml. The vial was vigorously shaken for 1 min and allowed the volatiles to partition into the HS (about 15 min). A 3 ml disposable syringe with a 24-gauge needle was used to withdraw 200 to 500  $\mu\text{l}$  of HS and injected into the GC/MSD. The analytical conditions were as follows:

*Gas chromatography system:* Oven temperature 40 °C, hold for 2 min, raise temperature to 125 °C at 10°  $\text{min}^{-1}$ ; injector temperature 150 °C, used in splitless mode, purge on after 0.75 min; column used was 30 m DB-5 with 0.25 mm i.d. and 1  $\mu\text{m}$  film thickness; interface at 280 °C.

*Mass selective detector system:* Solvent delay: 1 min; scan: 30–200 Da; automatic tuning at 2000 V.

*Data system:* HPChem (DOS version) on 486-PC.

Calibration was carried out by adding known amounts of BTEX (benzene, toluene, ethylbenzene, xylene) dissolved in methanol to 2 g of soil from the same location that was found to be free from BTEX contamination. A multi-point calibration curve was generated previously and a single-point calibration was performed while on site. Extracted ion chromatograms were quantitated against that of the standard by external standard method.

#### 4. Results and discussion

Of the 12 samples collected from this site, none showed detectable amounts of BTEX. Calibration standards spiked on native soils showed that BTEX response was linear up to 200  $\mu\text{g BTEX g}^{-1}$  of soil. The dynamic range can easily be adjusted by varying the amount of HS volume injected (Fig. 3). However, subsequent spiking studies using different types of soil (clay, loam and sandy) revealed wide variations in recoveries: for loam, recovery is about 40–50%, while that for sandy soil recovery is about 75% using the methodology described above. Fig. 4 shows calibration curves of BTEX made by spiking water against a blank soil sample, the difference in response factor is almost 60%.

To counter the effect of adsorption, soil samples were also extracted by methanol. The raw extract was filtered through a nylon syringe filter and injected into a GC/FID. Results are summarized in Table 4: again the sand matrix shows a higher recovery (>90%) compared to soil (about 60%).

Method detection limit for manual HS BTEX analysis is about 0.1  $\mu\text{g g}^{-1}$  with a precision of about 20%. The method of standard addition may be required to perform the most accurate work because of the adsorption losses due to soil matrices.

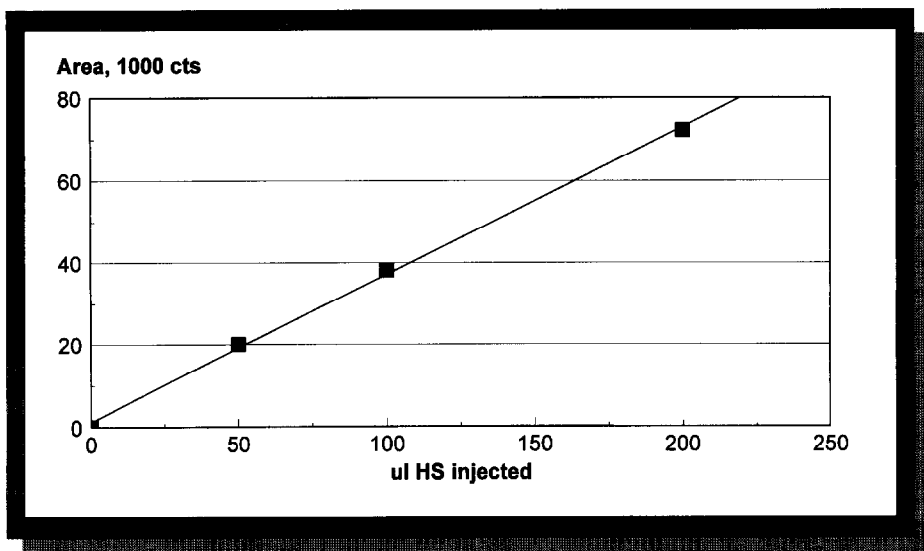


Fig. 3. Manual headspace injection volume of BTEX calibration standards spiked on native soils versus sensitivity (GC-FID).

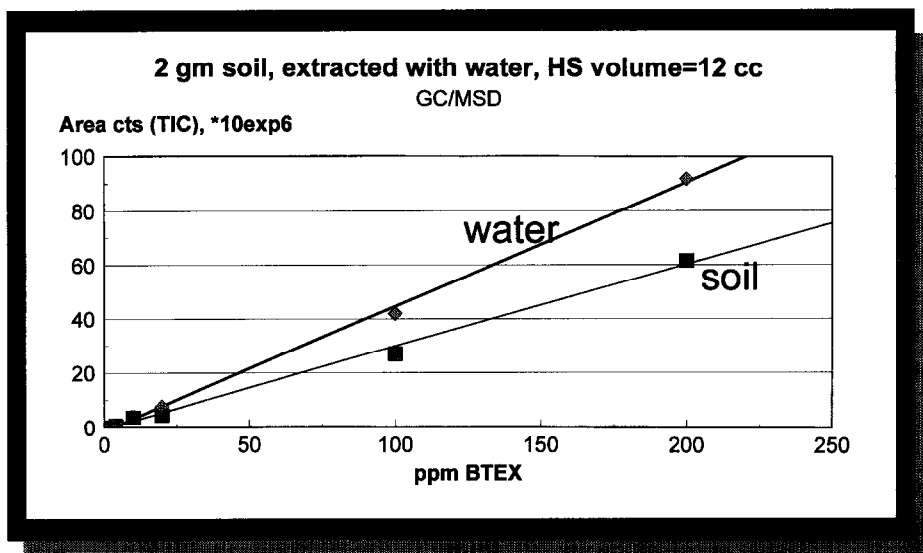


Fig. 4. Recoveries of BTEX from water and soil matrices as determined by headspace.

The following are some points of interest from this field exercise.

1. The outside temperature on that day was about 25 °C. The temperature inside the van, with the air conditioner on maximum, could not be kept below 28 °C. This increased the GC cool down time and reduced the sample throughput.

Table 4  
Methanol extraction of soil spiked with BTEX during a spill exercise at Camp Fortune in August 1994

		% Recovery
1.	Preliminary, vial 1: extract in 20 ml HS vial, 25 ppm soil	69
	Preliminary, vial 2: extract in 7.5 ml HS vial, 25 ppm soil	59
2.	Soil 1, 25 ppm	65
	Soil 2, 25 ppm	66
	Soil 3, 25 ppm	59
3.	Sand 1, 25 ppm	92
	Sand 2, 25 ppm	95
	Sand 3, 25 ppm	98
4.	Control 1, 50 $\mu$ l 1000 $\mu$ g ml <sup>-1</sup> spike into empty vial	87
	Control 2, 50 $\mu$ l 1000 $\mu$ g ml <sup>-1</sup> spike into empty vial	90
	Control 3, 50 $\mu$ l 1000 $\mu$ g ml <sup>-1</sup> spike into 2 g glass bead	88
	Control 4, 50 $\mu$ l 1000 $\mu$ g ml <sup>-1</sup> spike into 2 g glass bead	91
5.	Soil Lo-1, 2.5 ppm	66
	Soil Lo-2, 2.5 ppm	60
	Soil Lo-3, 2.5 ppm	65
6	Soil 1, 25 ppm extract with pentane	50
	Soil 2, 25 ppm extract with pentane	59
	Soil 3, 25 ppm extract with pentane	51

*Method Summary:* (1) 2 g soil spiked with 25  $\mu$ l 2 mg ml<sup>-1</sup> BTEX in 7.5 ml extraction vials. (2) Extract by shaking for 1 min with 5 ml MeOH. (3) Filter through nylon syringe filter. (4) Inject into GC/FID, 1  $\mu$ l splitless by ALS.

2. While on site during system pump down, the hard disk crashed and a new one had to be delivered from the lab. Difficulties had been encountered in the past with this computer system, hence it is impossible to determine whether the failure was related to the actual field conditions or not.

3. To shorten the on-site preparation, the generator could be turned on to maintain the heated zones of the GC and high vacuum of the MSD during transit.

## 5. Conclusions

The level 3 response vehicle is a mobile analytical lab which has a number of innovative support facilities for personnel protection. It is equipped with sophisticated sample preparation and analytical instrumentations which can provide spill responders with fast and comprehensive data on contaminants. Although not equipped to handle large number of samples that requires wet extraction, our system is highly flexible and can handle a variety of sample matrices. We have demonstrated that by using simple sample workup such as SFE, ultrasonic probe and MAP extractions, rapid sample turnaround is possible with more than adequate recoveries for spill response work. At the present state of readiness, a typical response time to deploy the vehicle is about 2 h.

### **Acknowledgements**

The authors acknowledge the technical contribution of M. Bissonnette, M. Goldthorp and A. Hebert during the Field Exercise.

### **Appendix: Summary of ESD level 3 Mobile Laboratory specification**

#### *Vehicle chassis*

1. 1986 Ford Econoline E-350 cube van
2. 10 340 lb. Gross Vehicle Weight
3. Bucket seats driver and passenger
4. In-line V6 Engine 5.7L (460 CID)-gasoline
5. Automatic transmission with transmission oil cooler
6. Rear axle 3.5
7. Tires LT 215/85R-16
8. Heavy duty service package
9. Heavy duty front/rear suspension
10. 100 AMP alternator
11. AM radio

#### *Body: 20 ft custom cube van*

1. Interior dimension (cargo space) L 148 in \* W 80 in \* H 80 in; exterior L 240 in \* W 100 in \* H 112 in (height including light bar and air conditioning unit on roof)
2. Aluminum frame construction
3. Plywood floor with wheel wells
4. Heavy-duty rear step bumper
5. Double rear entry doors with pass through hatch
6. Screen mesh bulkhead behind driver compartment
7. Windows in lab area, two 12"W\*12"H with detachable sun screen
8. Non-slip ribbed rubber mats on floor
9. Additional storage in 'dog-house' above driver compartment for SCBA and sampling equipment

#### *Electrical system*

1. 6.5 kW gasoline-powered Onan Genset (6.5NH-3CR) air-cooled generator mounted in insulated compartment. Remote start/stop inside vehicle and automatic battery charger for vehicle battery
2. Land operation via standard 4-prong line providing 30 AMP/240 VAC
3. Main Disconnect/Circuit breaker box supplying 7-duplex receptacles
4. 12 V interior lighting

5. Two Sola Portable Micro/Minicomputer Regulator power conditioner, rated at 16.7 and 20 AMP hardwired into circuit breaker panel
6. Modular telephone jack receptacles (2)

#### *Laboratory support equipment*

1. Astecair 3000L stand alone fume hood with integral HEPA and charcoal filter, filter saturation warning
2. Gas cylinder rack
3. Eye wash bottle, first aid kit, Halon fire extinguisher
4. Portable Koolatron 34 l (1.2 ft<sup>3</sup>) refrigerator
5. Duotherm propane force air heater, 30 l propane tank.
6. Coleman roof-mounted air conditioner (13500 BTU)
7. Two hardwood-surface lab benches, cabinets and drawers under one bench
8. Positive pressurisation system provided by a Buffalo blower (2 VEH)

#### *Analytical instrumentations*

1. Hewlett-Packard (HP) 5870 Series 2 Gas Chromatograph, direct interface to HP 5971A Mass Selective Detector
2. Main channel: injector (front) split/splitless to MSD
3. Backup channel: injector (back) on-column, to thermal conductivity detector
4. Data system: 486-PC ChemStation (DOS-series) with NBS library of 75 000 compounds
5. Suprex 50 Supercritical Fluid Extractor for extraction without solvent
6. All instruments shocked-mounted on neoprene support

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