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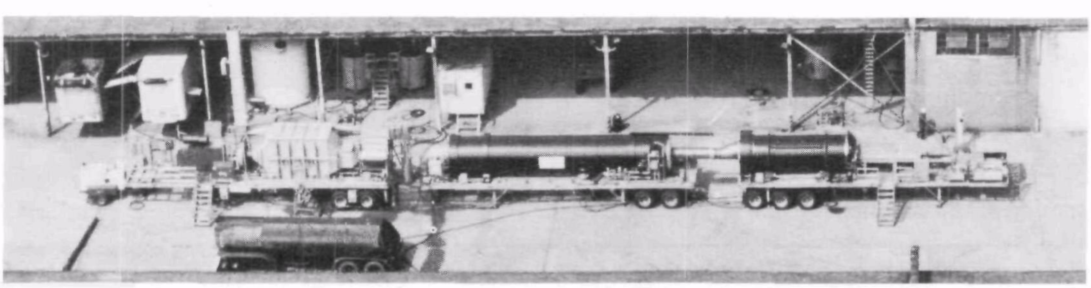
April 1982

Environmental Emergency Response Unit Capability



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Top photo - Mobile Physical-Chemical Treatment Trailer, nicknamed the "Blue Magoo", see page 12 for further information.
Bottom photo - Mobile Incineration System, see page 18 for further information.

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Introduction

The Environmental Emergency Response Unit (EERU) is the U.S. Environmental Protection Agency's (EPA) hazardous material spill response and control organization for situations where the use of complex cleanup equipment and techniques are required. EERU is engaged in the shakedown and field demonstration of prototypical equipment and techniques that have been developed under the direction and sponsorship of EPA's Municipal Environmental Research Laboratory (MERL).

The concept of EERU involves a cooperative effort among spill response research personnel at MERL's Oil and Hazardous Materials Spills Branch in Edison, NJ, EPA's Environmental Response Team and operational personnel (of the Hazardous Response Support Division, Washington, DC), and contractor personnel, to provide the most effective use of the technologies under development. EPA efforts through EERU include the use of government owned equipment during emergency response and hazardous waste site cleanup activities, as well as the operation of a pilot plant facility and a mobile analytical chemical laboratory.

During the past several years, the Environmental Emergency Response Unit has supported EPA Regional and Headquarters personnel at a variety of emergency incidents involving contamination of groundwater, surface waters, and potable water supplies by spills of hazardous materials and oils, as well as at emergency responses to uncontrolled chemical waste sites.

The cooperative effort between EPA and contractor personnel enables EERU to bridge the gap between "research" and "commercially usable" equipment. This effort is intended to inspire enterprising commercial development and application of spill control and cleanup technology.

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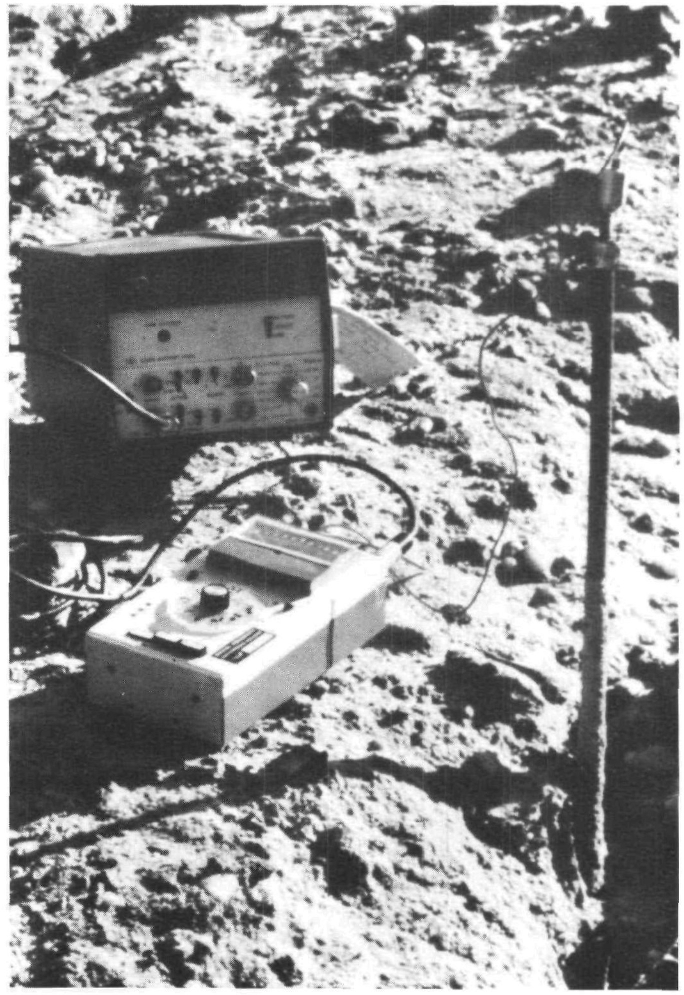
CURRENTLY AVAILABLE EQUIPMENT

Acoustic Emission Monitoring Device



Recently, Federal, state and local government agencies have become concerned by the existence of hundreds of thousands of diked areas containing hazardous materials. Earthen-dam waste ponds in the U.S. can be found at numerous industrial facilities and chemical waste disposal sites. Many of these impoundments are unstable and, with slight over stressing (such as from heavy rains), may collapse and spill their contents into the environment with potentially drastic consequences. In order to prevent such occurrences, simple monitoring/warning techniques are needed to evaluate the stability of earthen dams, locate the site of instability, and detect/locate seepage.

An Acoustic Emission Monitoring Device has been developed to provide early warning of potential failure of earthen dams containing hazardous materials (EPA Grant No. R-802511). The technique is based on the detection of noises that are generated by interparticle movement. The intensity and frequency of these sounds — acoustic emissions — has been correlated with stress level for many soils and, therefore, can be used to indicate stability of dam structures.

The components of the monitoring device include metal wave guides, an accelerometer, an amplifier, and a display system counter. The electronic components are battery operated. Acoustical emissions are transmitted to the surface through waveguides driven into the impoundment walls. These sounds are converted to electrical analogues, amplified, and recorded for analysis. The counter responds to those signals above a preset threshold level and records the rate of signal generation.

The portable, easy-to-use Acoustic Emission Monitoring Device can be operated periodically or continuously. The system is inexpensive and requires little maintenance because only the wave guides must be left at the site for periodic monitoring. Commercially available acoustic emission systems are being used to ascertain and monitor the structural integrity of numerous surface impoundments. On a number of occasions, these monitoring devices have provided adequate warning of earthen dam collapse. Acoustic emission monitoring has been used for industrial waste impoundments and dams that range in size from 1.8 m (6 ft) to 45.7 m (150 ft) high and 6.1 m (20 ft) to 10 km (6 mi) long. Further discussions of acoustic emissions monitoring may be found in an EPA Technology Transfer report, EPA-625/2-79-024.

Carbon Adsorption Pilot Plant

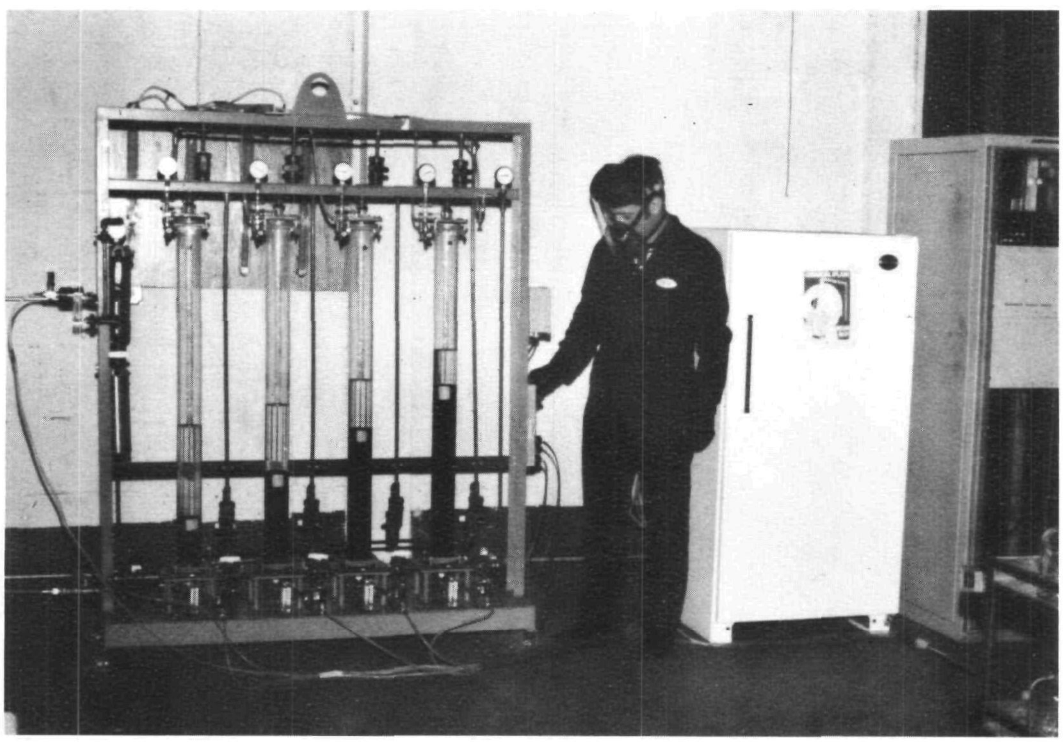
Granular activated carbon (GAC) can be used to remove most organic chemicals from water to generally acceptable levels at a reasonable cost. Prior to initiating full-scale granular carbon treatment in the field, pilot-scale column tests may be performed to evaluate feasibility and cost effectiveness. Pilot-scale tests are also useful for establishing optimum operating conditions in a timely manner.

Several GAC pilot-scale systems and a testing area have been constructed at the Edison facility by EERU; portable as well as fixed based systems are available. Treatability studies are conducted on contaminated samples from spill sites and uncontrolled hazardous waste dumps. During these studies, the following parameters may be evaluated in order to establish specific operating conditions: flow rate, contact time, pressure drop, bed depth, pH, temperature, and backwash requirements.

One pilot-scale unit consists of 4 glass columns (7.62 cm [3 in] i.d., 122 cm [4 ft] high) mounted on a portable rack. Influent and effluent solutions are stored in sealed 2,270 l (600 gal) tanks. Influent flows through a closed system to final disposal. An automatic system is used for unattended sampling for periods as long as 24 hours. Sampling is controlled by a microcomputer, and samples are collected/stored in a nitrogen-blanketed refrigerator. Prior to discharge, all effluent is passed through a 475-cm (15-ft) carbon column.

The pilot-scale test area is constructed to ensure safety of operating personnel. Individual safety equipment—disposable splash-resistant coveralls, rubber boots, gloves, full-face respirators—is used. Fire extinguishers, an emergency shower, and eye-wash equipment are available in the pilot-plant area.

Pilot-scale systems have been used to assess the treatability of chemical waste solutions and contaminated leachate from uncontrolled hazardous dumpsites at Niagara Falls and Oswego, New York. The pilot system has also been used to evaluate full-scale carbon treatment for cleanup of gasoline and mixed chemical spills. In addition, detailed adsorption studies have been conducted on phenol, m-cresol, and quinoline.



Cyclic Colorimeter

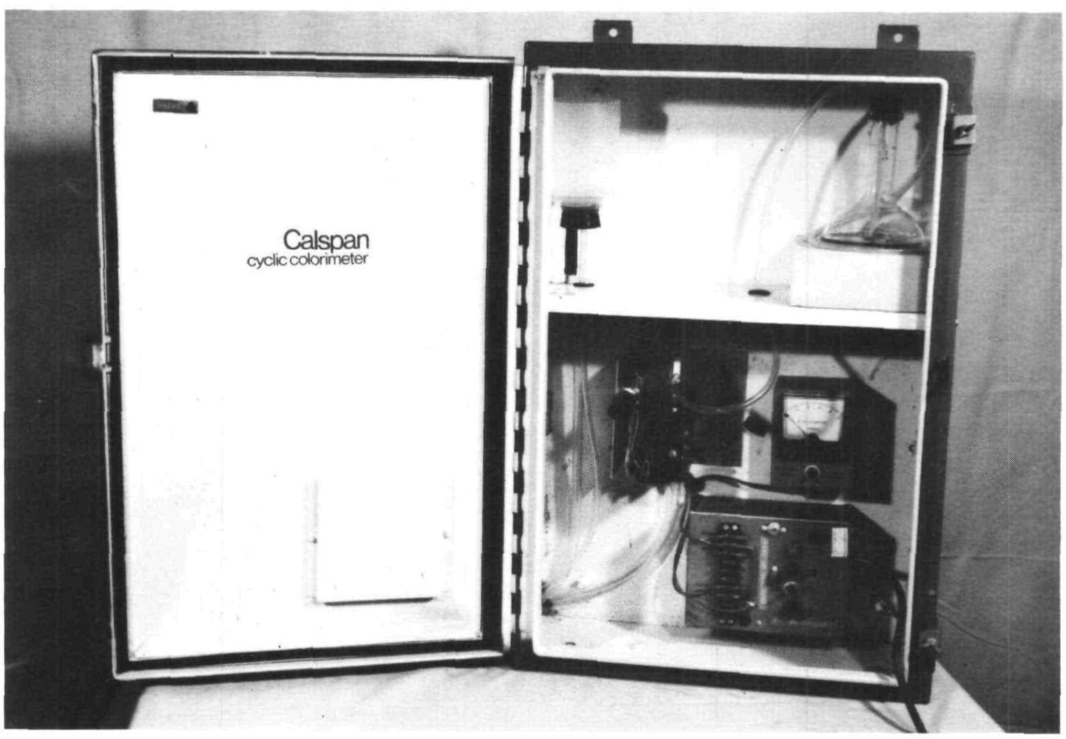
When a spill of hazardous materials occurs, rapid detection and identification of the amount and extent of contamination is imperative. Prompt sensing not only permits cost-effective treatment of concentrated materials, but also enables prompt response to the incident, which reduces the length of exposure of plants and animals, including humans, to spilled hazardous substances.

Often, the reporting of a spill depends on notification either by persons responsible for the situation or by untrained observers who, by chance, notice changes in the environment. In areas with a high probability of spillage, such as harbors and rivers in industrial locations, the use of an automatic spill detection alarm system for heavy metals may be an effective monitoring approach. In order to minimize the costs of the system, it should be capable of reacting to a wide spectrum of heavy metal pollutants. The system should require little maintenance and should be resistant to the variable and hostile environments in which it may be located (e.g., sewers, contaminated waterways). The field monitoring equipment should provide both qualitative and semi-quantitative information about the spilled materials.

The Cyclic Colorimeter (developed under EPA Contract Nos. 68-03-0110 and 68-03-0287) may be useful for field monitoring of heavy metal spills. It incorporates hydraulic, optical, and electronic components that are designed for the automatic detection of most heavy metal pollutants. When an indicator, sodium sulfide, is injected dropwise into a sample stream, the presence of a heavy metal contaminant causes cyclic variations in optical transmittance at the indicator injection frequency. These variations are detected by a lamp and photocell, coupled to an electronic subsystem, which produces either a quantitative indication of the pollutant or an alarm when a threshold level is exceeded.

The Cyclic Colorimeter is capable of detecting low levels of many heavy metals in water of widely varying temperatures. The detector maintains adequate sensitivity for a period of about two weeks without maintenance. Scale buildup and stream turbidity do not affect its performance.

The Cyclic Colorimeter is now commercially available. Instrument design specifications and descriptions of laboratory and field tests are included in the final report, EPA-600/2-79-064.



Foam Dike System

When a spill occurs during the transportation of hazardous substances by land vehicles, the immediate problem is to prevent the materials from entering adjacent land and water systems. Unless spills can be controlled at their source, damage to the water ecosystem may be extensive.

Frequently, spilled hazardous chemicals can be controlled at the site of the accident by the construction of dikes or diversionary barriers until complete cleanup can be accomplished. Although natural barriers and depressions can be used to divert spills, not all surface materials are amenable to the formation of dikes. In the latter case, structures made from synthetic materials can be used to envelop or divert the flow of spilled liquids. Such diking materials should be resistant to chemical attack, nontoxic, disposable, and nonflammable or fire retardant. Under EPA Contract Nos. 68-01-0100 and 68-03-0206, two materials were identified as possessing the aforementioned requirements: polymer foam and foamed inorganic materials.

The polymer Foam Dike System, incorporating polyurethanes and a portable dispensing unit, provides a rapid response method for enveloping or diverting the flow of many spilled hazardous chemicals. The commercially available portable unit weighs less than 18 kg (40 lb) and has two pressurized tanks that can deliver approximately 0.3 m^3 (10 ft^3) of foam (with an expansion of 25:1) at a rate of approximately 0.03 m^3/min (1 cfm). The rigid foam can effectively contain or divert chemical spills, including: water-based liquids except strong acids, nonpolar organics, chlorine, and ammonia. Polyurethane foam is effective on dry hard surfaces (concrete or asphalt), but provides only limited control on dirt, gravel, or vegetated ground.

Larger-sized, commercially available units are capable of generating approximately 2 m^3 (65 ft^3) of foam, which provides sufficient material to construct a barrier 0.3 m (1 ft) high by 0.3 m (1 ft) wide by 6 m (20 ft) in diameter, which would impound approximately 7,600 l (2,000 gal). The foam is also effective in sealing sewer openings and storm drains.

An alternate diking system, utilizing foamed, fast setting (2-3 sec) concrete is available. Mixtures of foamed concrete (approximate density 640 kg/m^3 [40 lb/ft^3]) and sodium silicate can be used to form a gelled structure with sufficient strength to build a dike in excess of 0.6 m (2 ft) high. Barrier strength is a function of water/cement ratio, temperature, and type of cement.

The foamed concrete can be applied over large areas on most surfaces. On-site use of foamed concrete typically requires the following: a mixer for blending a cement-water slurry, a slurry pump, a foam generator, a storage tank, a nozzle, and a sodium silicate solution.

The portable polymer Foam Dike System is frequently used by firefighters and other first-on-scene personnel to control the flow of spilled hazardous substances. Additional information on foam diking systems is contained in the EPA final reports, EPA-R2-73-185 and EPA-600/2-77-162.

Hazardous Materials Detection Kit

Over 3,000 spills of hazardous polluting materials (other than oil) enter the waterways of the United States each year. These spills often result from accidental releases of hazardous materials during in-plant operations and storage, as well as from accidents that occur during transport by barge, tank truck, railway tank car, and pipeline. Additionally, large amounts of pollutants reach rivers, streams, and lakes from agricultural use of chemicals.

Effective response to a spill frequently requires the ability to detect hazardous materials in waterways. In order to facilitate rapid detection, a Hazardous Materials Spills Detection Kit for performing non-specific tests with a broad response to many contaminants has been developed (IAG-D4-0546). The kit is designed for use at spills when the identity of the contaminant is known and the important consideration is tracing the spill plume until countermeasures can be taken.

The Hazardous Materials Detection Kit can be carried by one person and is versatile enough to be modified for special applications. It contains a pH meter, conductivity meter, spectrophotometer, filter assembly, effervescent jar, miniature chromatographic columns, enzyme "tickets", and data sheets. The instrument components are battery-powered for field use, although the spectrophotometer and conductivity meter can be modified for 120- or 240-V a.c. operation using the adapter and cable that are provided. The kit has all the necessary instrumentation, equipment, and reagents that may be needed by a field investigator to detect and trace contaminants in waterways.

Hazardous Materials Detection Kits, which are commercially available, have been used during emergency responses to hazardous materials spills. Additional information about the kits may be found in the EPA report, EPA-600/2-78-055.

Hazardous Materials Identification Kit

During the response to hazardous chemical spills and uncontrolled hazardous waste sites, the identity of contaminants is often unknown. Compact, portable analytical equipment for rapid pollutant identification is critical to effect efficient emergency response activities. However, nearly 300 materials are classified as hazardous substances by EPA (Federal Register, 16 February 1979), and a field kit capable of rapidly and accurately identifying each of these substances would be too unwieldly to be practical. Thus, thirty-six representative hazardous materials (toxic metals, anions, organic compounds) were selected and a field kit was designed to identify these and related substances (IAG-D6-0096).

The identification (ID) kit consists of two major components: (1) an inverter/shortwave UV lamp unit for photochemical and thermal reactions and (2) a package with reagents and auxiliary equipment, including test papers, detector tubes, spray reagents, spot test supplies, and thin-layer chromatography apparatus. Equipment to facilitate the recovery of contaminants from water and soil is also included. The field identification kit contains detailed operating instructions and data cards for each of the 36 representative hazardous substances.

Identification of groups of contaminants, rather than quantification of specific substances, is the intended use of the identification kit. The ID kit can be used in conjunction with the Hazardous Materials Detection Kit, which contains a pH meter, spectrophotometer, conductivity meter, and other analytical equipment. Utilization of both kits can improve identification capability, particularly for inorganic materials. For example, cyanide and fluoride cannot be distinguished by the ID kit alone; however, when the kits are used concurrently, identification becomes possible.

Hazardous Materials Spill Warning System

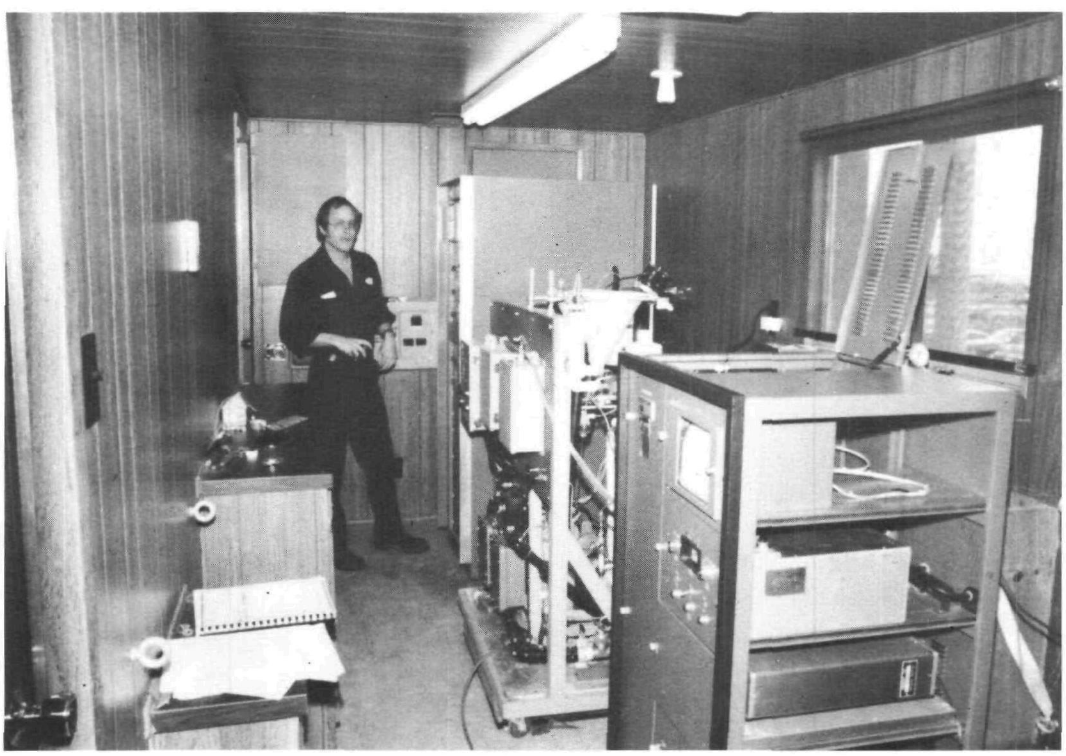
When natural and energy resources are extracted, processed, converted, and used, accidental discharges occur that impact our environment and may threaten the public health and welfare. EPA's OHMS Branch is committed to spill prevention and the development of methods to rapidly detect accidental discharges of hazardous substances in waterways before extensive damage occurs. Rapid detection of spills and immediate notification of response personnel will facilitate initiation of appropriate pollution abatement measures.

An in-stream system capable of detecting a variety of spilled hazardous materials has been developed (EPA Contract No. 68-03-2080). The integrated, operational components of the spill alarm system are housed in an air-conditioned 8.2-m (27-ft) automotive trailer for increased mobility. The system operates continuously at an unattended station, without maintenance, for a period of 14 days. A submersible pump in the watercourse supplies uninterrupted water samples to three instrument consoles in the trailer.

The instrument consoles contain the following: (1) pH, electrical conductivity, and oxidation-reduction potential sensors for the detection of acids and bases, ionic compounds, and oxidizing and reducing substances, respectively, (2) a total organic carbon analyzer with a built-in recorder for the detection of organic compounds, (3) a differential ultraviolet absorptimeter for the detection of aromatic compounds, and (4) a control console with strip chart recorders.

The strip chart recorder channel for each detection component has a built-in alarm circuit, the response level of which can be pre-set. When an alarm condition is detected, several automatic and simultaneous events occur: (1) the chart recorders, which run at a rate of 1.3 cm/h (0.5 in/h) under normal conditions, speed up to 15 cm/h (6 in/h) to record additional detail, (2) a grab sample is collected in a 3.8-l (1-gal) sample bottle, and (3) if the system is in an untended state, a telephone dialer is activated and will transmit a recorded message to any pre-selected telephone station.

The spill warning system has been successfully demonstrated in the laboratory and in the field. Recently, it has been used to monitor discharges from uncontrolled hazardous waste disposal sites.

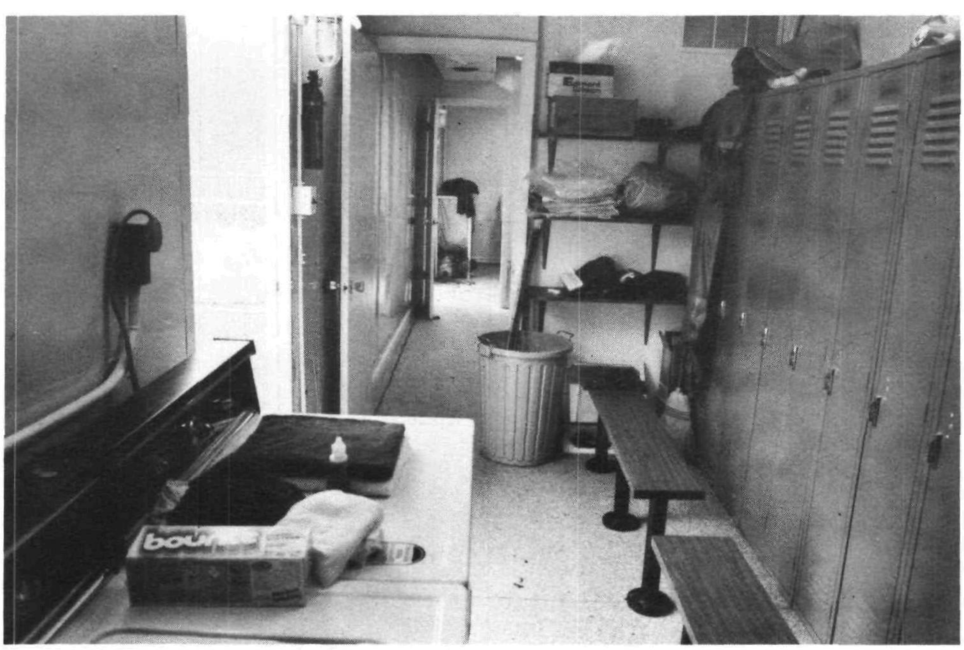


Mobile Decontamination Station For Field Personnel

To prevent undesirable spreading of contamination from hazardous chemical site operations, a mobile decontamination trailer has been developed.

This 12.2-m (40-ft) trailer has been outfitted to provide on-site safety support for emergency response personnel. The unit is placed at the boundary of a cleanup site and all personnel are required to pass through it when entering and leaving the site. The trailer is divided into three compartments: (1) a "clean room" with 12 lockers for street clothing, (2) a 3-stall shower room, and (3) a "dirty room" with 12 lockers for work clothing. The dirty room includes a container for soiled garments, and a clothes washer and dryer.

The decontamination station has an on-board water system, a hot water heater, and a holding tank for used water. Fittings have been provided to enable connection to commercial water and sewer systems. Contaminated water is processed before discharge. Heat, ventilation, lighting, and air conditioning are provided in the mobile station. However, power must be obtained from outside sources.



Mobile Field Office

In accordance with provisions of the National Contingency Plan, a Federal On-Scene Coordinator (OSC) is designated by the U.S. Environmental Protection Agency or U.S. Coast Guard to direct Federal cleanup operations during the response to accidental releases of hazardous materials, as well as oil spills. The OSC has final responsibility for all activities at the site, including: (1) assessing the environmental damage, (2) determining the most suitable cleanup techniques, and (3) ensuring the safety of those living near the impacted areas, as well as of those participating in the cleanup.

The OSC maintains close contact with primary and advisory agencies, local agencies, and elected officials. He issues bulletins on a regular basis to the public through the media and keeps complete records for subsequent evaluation by Federal and state agencies.

In order to carry out these activities, the OSC requires a base of operations convenient to the impacted site. Accordingly, a 10.7-m (35-ft) trailer, which can be transported by either a pickup truck or tractor, has been outfitted by EERU. The mobile office contains communications and support facilities including: telephone, electric power, water lines, running water, sanitary facilities, a shower for emergency decontamination of personnel, heat, air conditioning, and safety equipment.

Mobile Flocculation-Sedimentation System

When contaminated wastewater contains high levels of suspended solids, single stage treatment techniques, such as carbon contact processes, are not practical because the suspended solids may interfere with efficient utilization of the adsorption medium. Therefore, a system that can remove the bulk of the suspended solids should be used to pretreat the wastewater. A physical-chemical treatment system capable of flocculation, sedimentation, and filtration of suspended solids from wastewater prior to the removal of hazardous materials has been developed.

This mobile system is completely enclosed in a 12.2-m (40-ft) long van-type trailer. The major components of the system are a pipe reactor, chemical addition equipment, flocculation chambers, an inclined tube settler, and a tri-media filter. Chemicals, including powdered carbon, lime, aluminum salts, iron salts, clays, polyelectrolytes, acids, and bases can be introduced into the 170-m (560-ft) long, looped pipe reactor at various locations. Adsorbents, coagulants, and polyelectrolytes may be added at the end of the pipe reactor, while pH-adjusting chemicals may be introduced midway in the system. Three positive displacement pumps are provided to feed chemicals into the reactor, and static mixers are located at each chemical addition point to assure rapid and effective mixing.

After the wastewater is chemically treated in the pipe reactor, it flows through gently agitated flocculation chambers. Floc collects in a tube settler and is discharged to a sludge collector. The final treatment phase of the system is the tri-media filter, which insures effective solids removal at the design flow rate of 265 lpm (70 gpm).

The original system, designed as a field demonstration pilot plant, was used to evaluate the efficiency of treating combined sewage and raw municipal wastewater. The system was shown to be highly effective for treating this wastewater. Subsequent controlled field studies demonstrated that the flocculation/sedimentation system is highly effective for pretreating wastewater that is contaminated with hazardous materials. Additional information on the system is contained in the EPA report, EPA-R2-73-149.

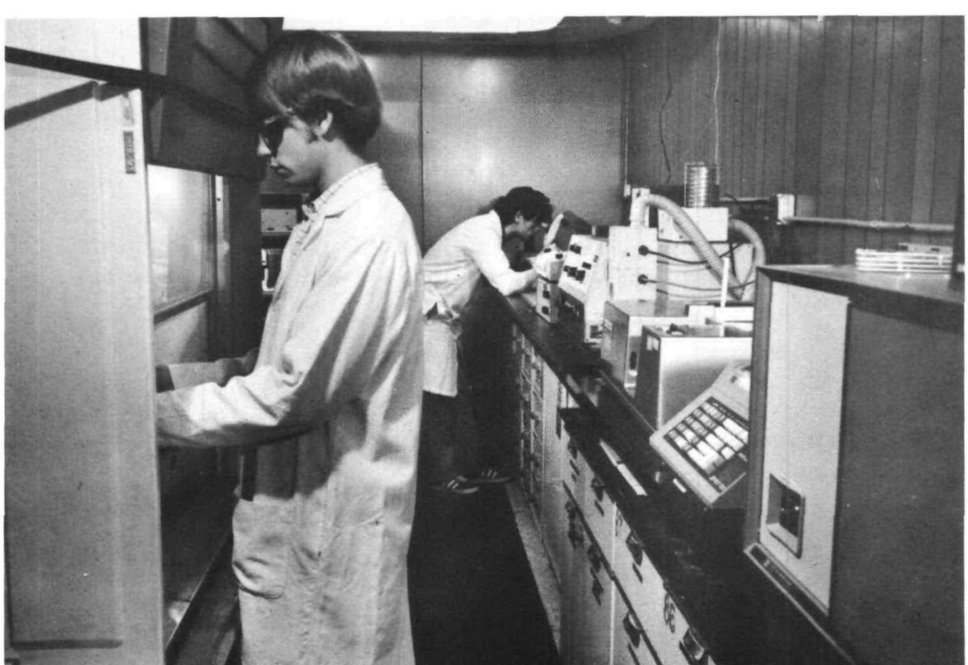
Mobile Laboratory

As part of a continuing effort to provide prompt emergency response to the uncontrolled release of oil and hazardous materials, a Mobile Laboratory has been developed. The Mobile Laboratory was designed to provide analytical services during the cleanup of hazardous materials at spill sites and uncontrolled waste dumpsites. Decisions concernng cleanup efforts are based upon identification of the pollutants, their concentrations, and the physical extent of contamination. Having analytical capability at the site avoids delays inherent in shipping samples to a central laboratory facility.

The Mobile Laboratory is constructed within a 10.7-m (35-ft) semitrailer equipped with a heating, ventilating, and air conditioning system designed for once-through air handling. In order to provide optimum analytical services during environmental emergency response episodes, and to assure an analytical capability for virtually all organic and inorganic hazardous substances (e.g., pesticides, PCB's, heavy metals), the Mobile Laboratory contains a broad range of instruments. These include: a gas chromatograph/mass spectrometer (GS/MS), two gas chromatographs equipped with flame ionization and electron capture detectors, automatic samplers that permit overnight operation, an atomic absorption spectrometer with graphite furnace, infrared and fluorescence spectrometers, an argon-plasma emission spectrometer, and a total organic carbon (TOC) analyzer. In order to permit two-way communication with a central laboratory, the Mobile Laboratory is equipped with an automated telefascimile. Additionally, the laboratory has a 15-kW electric generator, running water, and all necessary glassware, solvents, reagents, and supporting equipment to allow fully independent operation at remote field locations.

For reasons of safety, the laboratory is fitted with a fume hood, vented solvent locker, explosion-proof refrigerator, safety shower, eye wash station, fire alarm, and fire extinguishers. Vented glove boxes are available to permit safe handling of concentrated hazardous waste samples. Protective equipment for personnel includes full face mask respirators, self-contained breathing apparatus, safety goggles, gloves and disposable coveralls. Geiger counters are used to detect the presence of nuclear radiation in samples.

Since August 1977, the Mobile Laboratory has been used to perform several thousand sample analyses in a variety of emergency response situations, including: pentachlorophenol in groundwater and polychlorinated biphenyls, oil, phenol, hexachlorocyclohexane, dichlorobenzene, dichlorotoluene, and various pesticides at uncontrolled hazardous waste disposal sites.



Mobile Physical-Chemical Treatment Trailers

One effective approach to on-site cleanup of hazardous material spills is the highly flexible, Mobile Physical-Chemical Treatment Trailers developed under EPA Contract No. 68-01-0099. Treatment units are provided for flocculation, sedimentation, filtration, and carbon adsorption. Contaminated water is pumped into a settling tank where flocculation and sedimentation occur. The clarified fluid is passed through mixed-media filters before entering the carbon adsorption columns. Sludge is removed from the sedimentation tank and stored for ultimate disposal. Treatment schemes can be varied (i.e., each step in the process may be bypassed) to facilitate the recovery of spilled materials. If required, additional storage tanks are provided for filter backwashing or temporary storage of unprocessed materials.

Two Mobile Physical-Chemical Treatment Trailers are maintained by EERU for operation at hazardous materials spill sites. One system, mounted on a 13.7-m (45-ft) trailer, incorporates three mixed-media filters, three pressure carbon columns (which may be used in parallel or in series), pumps, piping, controls, and a 100-kW diesel generator. A support trailer is equipped with additional pumps, fittings, and several collapsible rubber tanks, which permit the treatment trailer to be located up to 150-m (500-ft) from the spill site. Contaminated water can be processed at flow rates between 380 and 2,270 lpm (100 to 600 gpm).

A smaller unit is equipped with one mixed-media filter and one pressure carbon column. This system is mounted on a small trailer, which is transported by a stake truck. Additional equipment, such as collapsible tanks and gasoline engine pumps, is carried on the truck. Contaminated water can be processed at flow rates of 110 lpm (30 gpm).

The Mobile Physical-Chemical Treatment Trailers have been used by EERU during the past several years. They have facilitated cleanup operations at hazardous materials spill and uncontrolled waste disposal sites. Response to these situations included the treatment of complex mixtures of industrial wastes. Development of the physical-chemical treatment systems is described in the EPA report, EPA-600/2-76-109.

Mobile Stream Diversion System

When small waterways are contaminated by sudden discharges of insoluble sinking hazardous materials, several pollution abatement options exist—dredging, vacuuming, and isolation of the impacted area. Dredging and vacuuming techniques often lead to downstream spread of the contaminant as a result of resuspension of bottom muds and silts. Further, there are significant problems associated with treatment of the water-sediment slurry produced by the dredging.

Isolation is accomplished by damming the stream above the impacted area and bypassing the normal stream flow. This stream diversion technique will permit the spill-impacted segment to dry, thus facilitating cleanup (manually or with mechanical earthmoving equipment). The problems of sediment resuspension and treatment of large volumes of contaminated dredge water are exchanged for the requirements of pumping and piping to achieve the bypass.

The decision to design and develop a Mobile Stream Diversion System (MSDS), EPA Contract No. 68-03-2458, was predicated upon the following: (1) considerable quantities of hazardous materials are often spilled into inland waterbodies, (2) approximately 85% of the stream miles in the U.S. have moderate flow rates (i.e., roughly 0.28-m^3/sec [4,400-gpm]), and (3) nearly one-half of the EPA-designated hazardous substances are either insoluble sinkers or form insoluble precipitates on contact with water.

The MSDS is a completely self-contained, independent system that can maintain flow continuity around an area undergoing decontamination processing. The system was designed to use standardized, readily available/replaceable components and is easily maintained. The major components of the system are booster pumps, submersible pumps, generators, a crane, and aluminum irrigation pipe with ancillary fittings. Over level terrain the system is capable of pumping 0.35-m^3/sec (5,600-gpm) a distance of 0.3-km (1,000-ft) and, if supplemental piping is provided, 0.09-m^3/sec (1,425-gpm) for a distance of approximately 11-km (36,000-ft).

To provide flexibility and reliability, the system has been assembled as two totally independent units mounted on trailers so that spills will be readily accessible via state or interstate highways. Components are fastened on the trailers so they can be quickly unloaded for air shipment to more distant locations. Once on site, the system can be assembled and placed in operation by a crew of five in a matter of hours. The MSDS has been recently used during an emergency response to a spill episode that adversly impacted a public water supply; use of the system insured uninterrupted service to the affected communities.

Additional information about the stream diversion system may be found in the EPA report, EPA-600/2-81-219.

Multipurpose Gelling Agent

Limiting the spread of hazardous liquid materials after a spill is an important countermeasure that can prevent chemical contaminants from further damaging the environment. Immobilization of hazardous liquid materials in order to (1) reduce the size of the affected land area, (2) retard the percolation of toxic materials through the subsoil and into the groundwater, and (3) prevent chemicals from entering adjacent waterways is a critical concern during an emergency spill response.

One method of preventing the spread of spilled hazardous liquid materials is immobilization by means of a gelling agent. Ideally, the gelling agent will transform the liquids into a semi-solid material that can be easily removed by mechanical means.

Multipurpose Gelling Agent (MGA), developed under EPA Contract Nos. 68-01-0110 and 68-01-2093, can immobilize many spilled hazardous liquids within minutes. An optimum formulation—four organic polymers and a fumed silica—requires a minimal amount of gelling agent in order to immobilize a wide variety of hazardous materials.

The system used to distribute the MGA is mounted on a 4-m (13-ft) long utility trailer that can be transported to a spill site. The auger-fed/pneumatic conveyor system is driven by an air-cooled gasoline engine and consists of a hopper that introduces the MGA into a 5-cm (2-in) hose, through which it is transported up to distances of 60 m (200 ft). The MGA then flows through delivery nozzles at a rate of 5.4 kg (12 lb)/min. The nozzles accurately direct the agent an additional 6 m (20 ft). Approximately 1 kg (2 lb) of MGA can gel 10 l (2.6 gal) of spilled liquid.

Additional information about the gelling agent and dispensing system may be found in the EPA final reports, EPA-600/2-78-145 and EPA-600/2-77-151.

Pesticide Detection Apparatus

Spills or discharges of toxic pesticides in waterways pose a serious threat to the aquatic environment and municipal water supplies. With the increased use of organophosphate pesticides, which are toxic at very low levels, precautions are needed to reduce this threat. Because of the stability of toxic organophosphate pesticides under "normal" environmental conditions, it is imperative to rapidly detect these hazardous compounds.

Automatic systems have been developed to monitor water for the presence of organophosphate and carbamate insecticides. The principle used for detecting these cholinesterase-inhibiting toxic substances is based upon: (1) the collection of enzyme inhibitors on immobilized cholinesterase, (2) the chemical reaction of immobilized cholinesterase with a substrate, butyrlthiocholine esterase, in the presence of enzyme inhibitors, and (3) the electrochemical monitoring of substrate hydrolysis products.

CAM-1

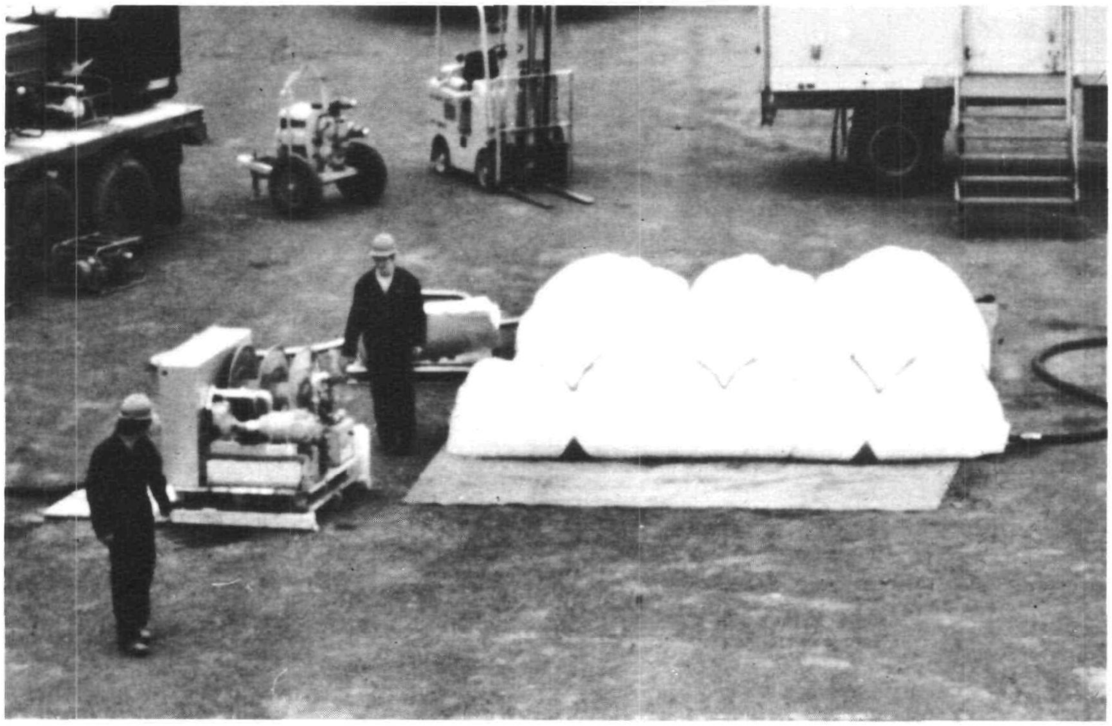
The Cholinesterase Antagonist Monitor (CAM-1), developed under EPA Contract No. 68-01-0038, is an automatic pesticide detection instrument. CAM-1 is intended to be used in a laboratory environment for monitoring potable water supplies and effluents from pesticide manufacturing facilities. An alarm signal is produced when cholinesterase antagonists are detected above a pre-set level.

CAM-4

The Cholinesterase Antagonist Monitor (CAM-4), developed under EPA Contract No. 68-03-0299, is a more rugged instrument that is designed for rapid detection of toxic materials in a river, stream, or pond. The portable apparatus can be used from alongside the banks of a stream or from a boat. An operator is needed to note the presence of enzyme inhibitors when the baseline voltage increases 10 or more millivolts in one sampling cycle, as indicated on the printout of a strip chart recorder. The CAM-4 can operate continuously—with little maintenance—for an 8-hour period when using a 12-V automobile battery or a 110-V a.c. power source.

A complete description of the pesticide detection apparatus, including design specifications as well as results of laboratory and field tests, may be found in the following EPA reports: EPA-R2-72-010, EPA-600/2-77-219, and EPA-600/2-80-033.

Portable Collection Bag System



Frequently, a first step in a hazardous material spill response is containment of the spilled material (e.g., by foam dikes or gelling agents). Emergency collection and temporary storage of spilled hazardous materials is vital for hazardous liquids that are temporarily impounded in a diked area or sumped pool, or are leaking from a damaged transportation vehicle.

A pre-packaged system for collection, containment, and temporary storage of spilled hazardous materials in a group of large, interconnected, flexible plastic bags has been developed (EPA Contract No. 68-03-0206). The system is mounted on a 1.2 - by 1.2-m (4 - by 4-ft) reinforced plastic pallet for transporting by pickup truck or van. Components include: a self-priming centrifugal pump, two 15-m (50-ft) lengths of 5-cm (2-in) hose, and four furled, self deploying plastic bags (a header with three fingers) with a total capacity of 26,500 l (7,000 gal). The collection bags are made of a puncture-resistant plastic material that has sufficient mechanical strength to be minimally affected by most hazardous substances during short-term storage periods.

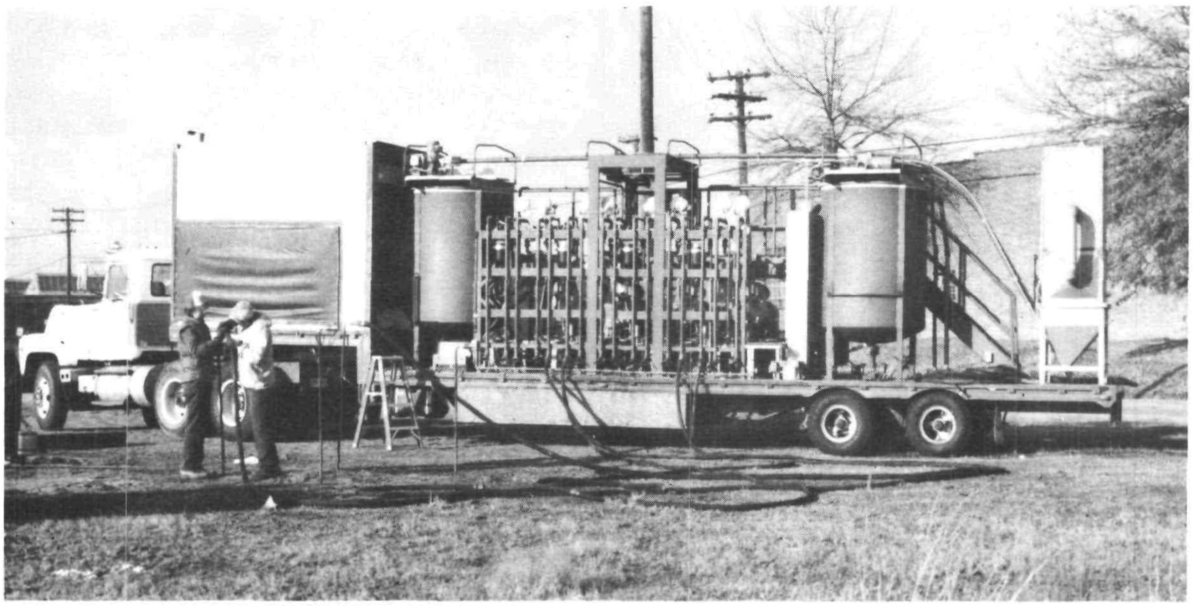
Two models of the Portable Collection Bag System are currently available. One model is powered by an explosion-resistant, gasoline engine and has a nominal pumping rate of 300 lpm (80 gpm). A single tank of fuel provides 2 hours of pumping time, which is generally sufficient to fill the bags. The other model, which is explosion-proof, is battery-powered. It has a nominal pumping rate of 200 lpm (50 gpm) and will operate for 2 to 2½ hours without requiring a battery recharge.

An 8 - by 6-m (25 - by 20-ft) area is needed to assemble the system. The collection bags must be placed on level surfaces, or on inclines no greater than 30°, in order to prevent sliding as they are filled. Where static electricity may build up, as with low conductivity fluids, a cable should be used to ground the pump chassis.

The Portable Collection Bag System has been successfully used to contain materials from leaking tank trucks. Details of the system, including operating manuals for the battery-powered and gasoline-powered models, are contained in EPA-600/2-77-162.

EQUIPMENT UNDER DEVELOPMENT

In-Situ Containment/Treatment System



When spills of hazardous materials contaminate soils and threaten nearby surface water or underlying groundwater, an effective method of preventing percolation through the soil is needed. Excavation and hauling of soil contaminated by hazardous materials to a secure landfill is one solution. However, this approach is not feasible for those spills where a large volume of contaminated soil is involved. An alternate approach is to flush the contaminated soil with water; however, this procedure generally requires large volumes of water, which become contaminated and, subsequently, must be contained and treated. An innovative, alternative method for treating contaminated soils is in-situ detoxification by chemical reaction.

A mobile In-Situ Containment/Treatment System capable of containing a 40-m^3 (10,000-gal) spill has been developed under EPA Contract No. 68-03-2508. The system is mounted on a 13.1-m (43-ft) drop deck trailer and includes: a diesel electric generator, an air compressor, mixing tanks, hoses, a solids feed conveyor, pipe injectors, soil testing apparatus, and accessory items. In-situ containment and treatment is accomplished by direct injection of grouting material into the soil around the contaminated area in order to isolate the spill. The hazardous materials are then treated in place by oxidation/reduction, neutralization, or precipitation. When necessary, contaminated water can be withdrawn from wet wells and treated by other means.

A decision matrix has been prepared to determine if in-situ grouting and chemical injection is the most time and cost effective treatment for a particular land spill. Several critical variables must be considered: type of hazardous materials spilled, interaction with soil, "groutability" of the soil (permeability), void loading, geometry, water table level, volume of contaminated soil, feasibility of an alternate treatment method (such as excavation), and availability of treatment material and equipment. Grouting is limited to the relatively coarsed-grained soils (sand and gravel) through which contaminants can rapidly permeate. Where small-grained soils (silts and clay) preclude the use of grouting techniques, surface treatment of contaminated soil may be effective.

Some chemicals are not amenable to in-place detoxification. For example, long chain organics, many pesticides, and heavy metals are relatively insoluble in water and could not be treated using in-situ, inorganic treatment techniques. However, they may be contained by a grout curtain until alternate pollution abatement measures are initiated.

The mobile In-Situ Containment/Treatment System is currently undergoing shakedown by EERU.

Additional information is contained in the EPA report, EPA-600/2-81-085.

Mobile Incineration System

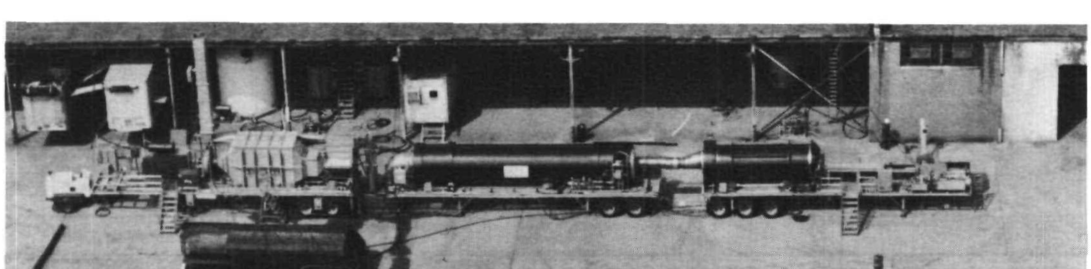
Surveys by Federal, state, and local agencies have revealed the presence of thousands of abandoned or uncontrolled industrial waste dumpsite throughout the country. Some sites contain hazardous chemicals that present a severe threat to public health and safety. Leachates containing toxic chemicals threaten contamination of adjacent water supplies, while noxious vapors released from these sites often comprise the air quality surrounding communities.

Many methods are being investigated to deal with the problem of hazardous wastes. Several include: incineration, deep well injection, solidification, biological degradation, and disposal in secured landfills. The OHMS Branch, of EPA's Municipal Environmental Research Laboratory, is currently evaluating the operating characteristics of a 15 million BTU per hour Mobile Incineration System with fuel oil alone prior to undertaking an exhaustive test plan with specific hazardous substances. The unit will be capable of on-site thermal detoxification of many hazardous materials, such as PCB's, kepone, malathion, and TCDD. The basic system was designed and the major parts fabricated and mounted on three over-the-road trailers under EPA Contract No. 68-03-2515. Under EPA Contract No. 68-03-2647, much of the basic piping and instrumentation was laid out and installed at the OHMS Branch facility. Subsequently, under EPA Contract No. 68-03-3069, the system was shaken down, suitably modified and operated with fuel oil.

The system is mounted on three over-the-road semitrailers. The first trailer carries a refractory-lined rotary kiln incinerator that provides long dwell times, high temperature, and a choice of operating modes (controlled atmosphere and excess air). Solid wastes are fed to the incinerator by a hydraulic ram feed, while pumpable sludges and liquids are injected directly into the incinerator. Residual ash, consisting of inert materials and metal residues, are collected for disposal at an appropriate landfill facility. Exhaust gases carry vaproized and partially combusted toxic components into the excess air secondary combustion chamber (SCC) that is mounted on a second trailer. Off-gases from the SCC are water-quenched in a ground-level venturi scrubber before passing to the third trailer on which are mounted a wetted fiber glass filter to remove residual particulates including phosphorus pentoxide, a caustic sprayed packed mass transfer unit to remove acid gases (HCl and SO_2 for example), a demister, an induced draft fan, a sound attenuator, and the stack. The system is maintained under negative pressure to prevent out-leakage. Sophisticated instrumentation for monitoring temperature, flow, and the levels of process gases and vapors are mounted in a fourth trailer. A complex system of automatic interlocks and alarms is provided to ensure that the system shuts down should it fail to meet permit requirements. Permitting requirements further mandate that detailed analysis of all waste streams—stack gas, processing fluids, and ash—be carried out on a scheduled basis.

Design processing rates, with 20% excess air, are 284-l (75-gal) of contaminated fuel oil per hour, or 4,050-kg (9,000-lb) of contaminated dry sand per hour, or 675-kg (1,500-lb) of water per hour. (An additional 90.8-l [24-gal]) per hour of "clean" fuel is required for the SCC). Nomographs are available for estimating the throughput of mixtures; these depend on fuel value, bulk and gas volume of the combustion products, and inert N_2.

The incineration system will require several support trailers to supply fuel and water, as well as physical-chemical treatment equipment for spent process water. Separate systems are needed for site preparation, feed stock handling, and ash removal. Analytical facilities are essential to identify waste materials, prepare feed stock, and monitor all discharges from the system. Additional trailers provide office space and clothes change/shower facilities. A PCB trial burn of the incinerator by EERU is scheduled during 1982.



Mobile Independent Physical-Chemical (IPC) Wastewater Treatment System

Emergency response personnel at hazardous materials spills and uncontrolled waste-site cleanups are frequently faced with the problem of selecting effective treatment methods for large volumes of complex wastes. When the cleanup is expected to last over an extended time period, wastewater treatment can be both cost and labor intensive. Treatment of the contaminated wastewater in a timely and cost effective manner can be facilitated by a flexible, automated system that is capable of providing several types of treatment (e.g., clarification, filtration, adsorption, neutralization, disinfection).

The Mobile Independent Physical-Chemical (IPC) Wastewater Treatment System utilizes standard equipment and conventional process flow schemes. Wastewater is pumped at a rate of 130 lpm (35 gpm) from the wastewater source to a flash mix tank where coagulant is added. Chemically treated wastewater and recycled sludge (from the clarifier) are then mixed in a flocculation tank and settleable floc is formed. The wastewater then flows to a clarifier, where precipitation and skimming of solids are accomplished. Removal of settled sludge from the clarifier is aided by a slowly rotating rake. A timer-controlled valve regulates the recycling and/or wasting of sludge. Clarified wastewater flows over V-notched weirs to a neutralization mix tank, where it is treated with acid or caustic to adjust the pH. The wastewater then enters a two stage — upflow and downflow — granular carbon contact system for removal of organic materials. Next, the flow enters a pressure sand filter prior to disinfection in a chlorine contact tank.

After the neutralization mix tank, the IPC system is designed to enable flexible treatment schemes. For example, (1) flow can be directed to the sand filter prior to the granular carbon contact system or (2) additional treatment stages can be added between the neutralization mix tank and the chlorine contact tank.

The Mobile Independent Physical-Chemical (IPC) Wastewater Treatment System has been developed and is currently undergoing modification by EERU. This system is ideally suited for long term cleanup activities that may require several months of effort. Once it has been set up, the IPC system requires only minimal operator time for chemical replenishment, sludge disposal, and periodic maintenance.

Mobile Reverse Osmosis Treatment System

Conventional physical-chemical treatment systems (e.g., activated carbon, ion exchange) for hazardous materials can accommodate dilute aqueous solutions (several hundred to several thousand ppm). However, when a solution of hazardous material approaches a concentration range greater than 1%, many of these physical-chemical treatment systems are not as effective. An existing technology that can be used to efficiently separate some constituents of concentrated solutions (> 10,000 ppm) is reverse osmosis.

Osmosis, a natural phenomenon, results when a dilute liquid and a concentrated liquid are separated by a semipermeable, selective membrane. For example, fresh, pure water will diffuse through such a membrane into a salt water solution. When pressure is applied to the salt water, water molecules from the saline solution will be forced through the membrane into the fresh water—reverse osmosis (RO). The "selective" permeability of the membrane will act as a barrier to the passage of salt molecules.

The heart of the reverse osmosis process is the membrane. Although many membrane materials have been studied, cellulose acetate—one of the earliest materials considered—is the most commonly used. Commercially available membranes can hold back all but a few percent of the salt molecules in water. In addition, these membranes have been found to retain other impurities, including various organic materials, high molecular weight substances, bacteria, and viruses. More specifically, experimental work has shown that RO is capable of removing from dilute solution better than 99% of most pesticides and chlorinated hydrocarbons and is also effective for removing relatively low molecular weight, polar organic compounds.

A Mobile Reverse Osmosis Treatment System is currently under construction for EERU. This system, which was originally designed as a pilot plant to test the feasibility of treating acid mine wastewater, is being modified for field use at incidents involving concentrated solutions of hazardous materials (e.g., leachate from uncontrolled hazardous waste sites).

The reverse osmosis treatment process under development will separate the influent waste into two streams: (1) a "purified" stream that can be further treated, if necessary, or directly discharged to the environment, and (2) a concentrated waste stream that will be greatly reduced in volume, thereby facilitating further processing and/or ultimate disposal.

Mobile System For Detoxification/Regeneration of Spent Activated Carbon

A commonly used and generally effective method for removing many dissolved hazardous organic substances from aqueous solutions is adsorption by activated carbon. During the treatment process the activated carbon can become contaminated with relatively high concentrations of hazardous organic material. When the carbon reaches its adsorptive limit, it must be disposed in an approved manner or thermally regenerated. However, in some instances, toxicity of the pollutant is such that transportation of the exhausted carbon to a secure landfill or to a commercial detoxification/regeneration facility is not acceptable.

In order to provide a safe and effective method for handling contaminated carbon, the OHMS Branch has developed a mobile unit for detoxifying/regenerating contaminated carbon at the cleanup site. The mobile detoxification/regeneration system, mounted on a 13.7-m (45-ft) long semitrailer, is equipped with a rotary kiln, a second stage combustion chamber, and a gas scrubber. The unit is self-contained except for fuel and water supplies.

Wet carbon is screw-fed to the direct-fired rotary kiln at a maximum rate of 90.7 kg/h (200 lb/h). During a residence time of approximately 20 minutes, the carbon is heated in a slightly reducing atmosphere to about 1000° C (1800° F). Water is injected at the discharge end of the kiln as a reactivation aid. The carbon is then quenched in water and sized on vibrating screens to remove fines. Once reactivated, 75 percent of the carbon's original adsorptive capacity is restored with a greater than 80 percent bulk recovery of carbon.

When contaminated carbon is heated in the kiln, organic substances are desorbed and volatilized. All vapors and gases from the kiln flow through a duct into the secondary combustion chamber. Temperature and residence time are controlled to assure detoxification of hazardous substances, such as chlorinated hydrocarbons. Off-gases are water-quenched and scrubbed with an alkaline solution before venting to the atmosphere. Stack gases and used process water are monitored.

The detoxification/regeneration system has recently undergone initial shakedown and preliminary testing.

Mobile System For Extracting Spilled Hazardous Materials From Soil

Landborne spills of hazardous materials that percolate through the soil pose a serious threat to groundwater. Effective response to such incidents should include the means for removing the contaminants and restoring the soil to its original condition. Currently practiced techniques, such as excavation with transfer to a landfill or flushing with water in-situ are beset with difficulties — large land area and volume of materials involved. An innovative In-Situ Containment/Treatment System, previously described, has been developed to treat contaminated soils. However, it is not suitable for all soils and/or all chemicals. Another novel treatment system is currently under development (EPA Contract No. 68-03-2696).

A mobile treatment system has been designed for water extracation of a broad range of hazardous materials from spill-contaminated soils. The system will: (1) treat excavated contaminated soils, (2) return the treated soil to the site, (3) separate the extracted hazardous materials from the washing fluid for further processing and/or disposal, and (4) decontaminate process fluids before recirculation, or final disposal. A demonstration model will be developed utilizing conventional equipment for screening, size reduction, washing, and dewatering of the soil. The washing fluid — water — may contain additives, such as acids, alkalies, detergents, and selected organic solvents to enhance soil decontamination. The nominal processing rate will be 3.2-m^3 (4-yd^3) of contaminated soil per hour when the soil particles are primarily less than 2-mm in size and up to 14.4-m^3 (18-yd^3) per hour for soil of larger average particle size.

The soil scrubbing system, currently undergoing laboratory evaluation, is expected to be available in 1982.