

**GAS CYLINDER DISPOSAL PIT REMEDIATION  
WASTE MINIMIZATION AND MANAGEMENT**

Sandia National Laboratories, New Mexico

WM 95 Symposium

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D. Spengler<sup>2</sup>, and T. Rusthoven<sup>3</sup>

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Special waste management, safety, and quality plans were developed and strictly implemented for this project. The project was conceived from a waste management perspective, and waste minimization and management were built into the planning and implementation phases. The site layout was planned to accommodate light and heavy equipment, storage of large quantities of suspect soil, and special areas to stage and treat gases and reactive chemicals removed from the pit, as well as radiation protection areas.

Excavation was a tightly controlled activity using experienced gas cylinder and reactive chemical specialists. Hazardous operations were conducted at night under lights, to allow nearby daytime operations to function unhindered. The quality assurance plan provided specific control of, and documentation for, critical decisions, as well as the record of daily operations. Both hand and heavy equipment excavation techniques were utilized. Hand excavation techniques were utilized. Hand excavation techniques allowed sealed glass containers to be exhumed unharmed.

In the end, several dozen thermal batteries; 5 pounds (2.3 kg) of lithium metal; 6.6 pounds (3.0 kg) of rubidium metal; several kilograms of unknown chemicals; 140 cubic yards (107 cubic meters) of thorium-contaminated soil; 270 cubic yards (205 cubic meters) of chromium-contaminated soil; and 450 gas cylinders, including 97 intact cylinders containing inert, flammable, toxic, corrosive, or oxidizing gases were removed and effectively managed to minimize waste.

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## ACRONYMS

DOE	U. S. Department of Energy
DR	disposal request
EPA	U. S. Environmental Protection Agency
ER	Environmental Restoration (Project)
ES&H	Environmental Safety and Health
GCDP	gas cylinder disposal pit
HE	high explosive
HPCA	high pressure controlled access
HW	hazardous waste
IDW	investigation-derived waste
NMED	New Mexico Environment Department
NRW	nonregulated waste
PCB	polychlorinated biphenyl
PPE	personal protective equipment
psig	pounds per square inch gauge
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RMMA	radioactive materials management area
RW	radioactive waste
SMO	Sample Management Office
SNL/NM	Sandia National Laboratory/New Mexico
SVOC	semivolatile organic compound
SWMU	solid waste management unit
TA	Technical Area
TAL	target analyte list
TCLP	toxicity characteristic leaching procedure
VOC	volatile organic compound
WAC	waste acceptance criteria

## INTRODUCTION

Beginning in 1984, several investigations and assessments, including a Resource Conservation and Recovery Act (RCRA) Facility Assessment (RFA), were conducted at Sandia National Laboratories, New Mexico (SNL/NM) as part of the Department of Energy (DOE) Environmental Restoration (ER) Project. These investigations revealed 172 potential release sites which required investigation and possible corrective action.

One site, known as the Gas Cylinder Disposal Pit (GCDP), was located in the southeast corner of the environmental test range known as Technical Area (TA) III (Figure 1). The dimensions of the excavated pit area were approximately 80 by 180 feet (24 by 55 meters) by 10 feet (3 meters) deep. The pit-bottom configuration and depth suggested that fill material was likely to be less than 6 feet (1.8 meter) thick, and this indicated the volume of the affected soil was no more than 3,200 cubic yards (2,443 cubic meters).

The pit was reportedly dug in 1963, but prior to its excavation, the area in which the site was located may also have been used to dispose of high-explosive (HE) residues by detonation. Following its excavation, the pit was used for the disposal of lithium hydride and other reactive chemicals from various SNL/NM laboratories, and from 1980 to 1984, the pit was used for the disposal of 400 lecture-size [2 by 12 inches (5 by 38 centimeters)] gas cylinders by detonation with shaped-explosive charges. The cylinders reportedly contained a variety of gases, including some toxic materials and unknown materials which could not be shipped off site. This site also had been used occasionally for temporary storage of potentially explosive chemicals, including picric acid. Visual surveys revealed glass shards, bottle remains, and gas cylinder remains. Table 1 lists chemicals thought to have been disposed in the pit. Based on the survey of historic activities, no radioactivity was suspected.

The GCDP site was originally scheduled to be investigated during the course of a RCRA Facility Investigation (RFI) by drilling shallow boreholes into areas likely to have aggregations of gas bottles or chemicals. Because of health and safety concerns during drilling, this type of intrusive characterization was not considered to be the optimal course of action. In addition, hazardous wastes were thought to be present in unstable storage containers that could pose a threat of spontaneous release, resulting in possible explosion and/or potential for exposure to hazardous waste as a result of a container failure.

Two non-intrusive investigations, a walk-over health and safety survey and a surface geophysics survey of the pit, were undertaken to provide more information for the appropriate course of action. The initial walk-over survey was conducted in Level B personal protective equipment (PPE) and served to identify partial and intact lecture bottles, amber glass containers containing unknown solid and liquid materials, and previously unidentified radioactive material. Drilling in the pit was determined to be unacceptable; therefore, complete exhumation and removal of the contents of the pit in association with an accelerated and voluntary corrective action for site cleanup was planned.

## WASTE MANAGEMENT PLAN

SNL/NM is required to practice pollution prevention as part of activities associated with investigation and remediation of sites. Consideration is given to the costs and liabilities associated with management of wastes produced as a result of these activities at the beginning of each planning phase. The remediation of the GCDP was planned from the perspective of waste minimization and waste management, as well as careful attention to aspects of safety, construction, and remediation. The management plan for investigation-derived waste (IDW) was developed with the cooperation of the SNL/NM Generator Interface and Waste Operations Departments, and was formulated to be consistent with existing guidelines of the U. S. Department of Energy (DOE), U. S. Environmental Protection Agency (EPA), and New Mexico Environment Department (NMED).

The excavation operations conformed to specific objectives outlined in the quality assurance project plan prepared for this project. Various field tests and inspections were required during excavation and material segregation. The field inspections typically required a pass/fail decision. These decisions included: 1) identification of pit materials; 2) removal and segregation of clean and suspect soils; 3) removal and segregation of breached and unbreached material containers; and 4) evaluation of cylinder contents. The decision tree for these operations is shown in Figure 2. Following a surface clearance, excavation proceeded from north to south with iterative magnetic surveys.

The majority of waste to be created during pit excavation at the GCDP was believed to be soil and debris, decontamination water, personal protective equipment (PPE), ordinary trash, and gaseous and solid chemicals. Waste to be produced during operations was expected to be contaminated with metals, chemicals, pressurized gases, high explosives (HE) residues, and radioactive soils. Waste was categorized as nonregulated, hazardous, radioactive, and mixed (radioactive with hazardous). The majority of waste by volume was expected to be nonregulated.

Field screening was performed during all soil excavation activities to facilitate segregation. Both real-time instrumentation and field test kits were used to screen for various constituents during the course of the project. Metals in soils were evaluated using X-ray fluorescence (XRF); volatile organic compounds (VOCs) were evaluated using Dräger tubes, photoionization (PID) and flame ionization (FID) detectors; HE was evaluated using EXSPRAY™; and radiological constituents were evaluated using a pancake Geiger-Müller (GM), an alpha scintillometer, and a sodium-iodide (NaI) gamma spectrometer (Table 2). Screening for various gamma-emitting radionuclides was also performed using gamma spectroscopy. Action levels for field screening included mean background plus 2 standard deviations for XRF and radioactivity, and any positive reading for volatile organics and HE. Detection of constituents above the action levels triggered material segregation and resulted in possible additional sampling. Soils and debris were staged in specific engineered locations (Figure 3) until results of laboratory analyses were available and the waste types were determined.

Prior to soil placement in the staging area, a grab sample of up to five aliquots of material collected randomly from the bucket of the front-end loader. These grab samples were combined to form a single composite sample representing the soil contained in the staging area.

Excavated soil was stockpiled onsite in prepared staging areas east of the disposal pit. These areas were bordered by reinforced concrete barriers ("Jersey" barriers) on three sides, an earthen berm on the fourth side, and a lining of very low density polyethylene sheeting. The staging areas were built to accommodate 60 cubic yards of soil each, but could be modified easily to accept more. All soils were covered with fiber-reinforced poly sheeting secured by sandbags for protection against wind and rain. Stained or discolored soils were segregated in separate areas, and sampled to determine possible hazardous or radioactive characteristics. Analysis of the suspect soils included HE (EPA Method 8330), VOCs (EPA Method 8240), SVOCs (EPA Method 8270), TAL metals (EPA Methods 6010 and 7000 series), and isotopic uranium, thorium, and plutonium. Table 2 also provides a list of the laboratory analytical methods used during this project.

Debris (wood, metal scrap including breached cylinders, thermal batteries, glass, and bulk chemicals) from the pit was staged in small engineered staging areas. Pressurized gas cylinders and intact chemical containers recovered from the excavation were staged separately, individually, and away from all other

materials. Before packaging, all debris and scrap removed from the pit was screened for radioactive contamination using a NaI radiation detector, and swiped and counted using a gas proportional counting system.

The section of the pit containing radioactive soil was sectioned into four quadrants approximately 30 by 40 feet (10 by 12 meters). Each quadrant was investigated and excavated separately, in the interest of waste minimization. Every bucket of soil and debris was screened in the field using a NaI radiation detector. Soil having readings greater than background plus 2 standard deviations was considered to be contaminated and was removed. Upon excavation, radioactive soil was segregated and drummed in the pit itself.

All containers and staging areas were marked with appropriate labels. All unknown materials, pending analytical results, were labeled "Investigation-Derived Waste." Materials whose characteristics were known were labeled as nonregulated, hazardous, radioactive, or mixed, as appropriate. Container labels were marked in permanent ink and included waste source, suspected contaminants, results of field screening, contents, the dates accumulation began and ended, associated sample numbers, and the project manager's name and telephone number. Labels were numbered sequentially. All solid waste drums were stored on wooden pallets.

Decontamination water was produced during heavy equipment decontamination. This decontamination was performed at a temporary decontamination pad constructed for the project. Decontamination water was collected in open-topped, lined 55-gallon drums for ease of handling and sampling. Once full, drums were sampled and analyzed for TCLP metals, VOCs, and SVOCs. Personnel decontamination was largely conducted on a dry basis, but contingency for wet decontamination (3-gallon sprayers with soap and water, and 3-gallon sprayers with water only) was available. In addition, a decontamination trailer was installed at the site at the boundary of the controlled area; this facility housed two showers which could be used as a contingency for personnel decontamination. Personnel decontamination water also was collected in open-topped, lined drums, and analyzed for TCLP metals, VOCs, and SVOCs. Liquid waste drums were stored on secondary containment pallets to contain spills or leaks.

All disposable PPE was field screened for radioactive contamination, HE, and organic contamination by PID and FID, and stored as IDW in open-topped, lined, 55-gallon drums upon completion of each day's work. Uncontaminated PPE was segregated from all other wastes. The drums were labeled according to their contents (e.g., "suspect clean as indicated by field screening"). PPE suspected to be radioactive was double-bagged in yellow plastic at least 3 millimeters thick and placed in drums visibly printed with the word "radioactive."

All ordinary trash was stored in plastic household or lawn trash bags upon completion of each day's work. Ordinary trash was considered to be nonregulated and was placed in a commercial dumpster labeled "Nonregulated."

## WASTE MINIMIZATION

Federal and state laws, as well as DOE Orders, require that SNL/NM plan, implement, and document the minimization of all types of waste, including such things as water discharges and air emissions. Therefore, waste minimization practices were incorporated into field activities at the GCDP site to reduce the quantity of waste generated.

The following list includes specific methods of waste minimization implemented during the project.

- Waste management and decontamination procedures were written in order to document activities, provide preplanning and quality control, reduce time in the field, avoid the use of unnecessary equipment, and avoid the generation of excess waste.
- Nonintrusive investigations were completed before intrusive work; no hazardous or radioactive waste was produced during these investigations. These investigations also focused attention and subsequent remediation activities on problem areas which included only 56% of the total pit by surface area.
- Daily activity/health and safety "tailgate" meetings included waste minimization and disposal topics, and described specific tasks which site workers were to perform during that work period. Site workers were encouraged to become a part of the planning team and to identify additional waste minimization opportunities.
- Dry decontamination procedures were used to avoid creating decontamination fluids for personnel decontamination.
- All excavation equipment was kept in the pit during excavation activities, and only when excavation was completed was the equipment removed and decontaminated.
- Only materials that could easily be surface surveyed were used for PPE.
- All PPE and decontamination rags were surveyed for radioactive contamination as part of personnel decontamination. Wherever possible, PPE was reused. Typically Level "A" and "B" suits were sanitized and reused 15 times.
- All debris, scrap, and soil were screened for radioactive contamination, and an aggressive program of field screening was employed for HE, organic and inorganic gases, and metals. Continuous air monitoring was performed for gaseous releases in the controlled-atmosphere of the special operations area to which cylinders of gas removed from the pit were taken. If material screened "positive," it was segregated and containerized with like materials.
- An onsite laboratory for gas analyses, as well as onsite treatment capability for these gases, provided immediate identification and decisionmaking regarding the management of gases, and eliminated the need to ship unknown samples offsite. Only nonregulated treatment-process wastes were ultimately produced.
- Site personnel did not mix waste types or mix soil and decontamination fluids. Daily efforts to prevent cross contamination were practiced. The key to this capability was site setup and preparatory activities which provided a large area for segregated storage.
- Waste was stored in the smallest appropriate containers, often 5-gallon plastic pails for scrap metal and bulk chemicals.



- Aliquots of soil were taken from every loader bucket and composited for waste classification analyses, and the bulk of the material was stored onsite prior to disposal; much of this material was segregated as a result of field screening. This process was time-consuming, but resulted in the minimum amount of regulated waste being sent offsite for disposal. Uncontaminated soils were returned to the pit.
- Investigative geoprobing was used exclusively for subsurface verification sampling. This method removed only the amount of soil necessary to advance the core barrel and eliminated waste cuttings and drilling fluids, and produced little or no dust.

## RESULTS

Excavation was a tightly controlled activity using experienced construction crews and gas cylinder specialists. All field crews had additional specialized training in waste management and waste minimization, as well as Radiological Worker training. Remediation proceeded from north to south in the pit, following the slope contour. A trackhoe excavator was used for coarse excavation during nonhazardous phases of removal. The trackhoe was positioned in the pit itself. Soils were placed 1) in the bucket of a front-end loader positioned out of the pit; 2) directly in drums brought into the pit via the loader; or 3) directly into 40-yard rolloff bins. All soils were passed through a 2-inch mesh screen before removal or containerization. Archaeological-type hand excavation of gas cylinders, reactive chemicals, and thermal batteries was performed by experienced crews using non-sparking shovels after the trackhoe could not continue. Excavation activities were performed in either Level "A" or Level "B" PPE, including work in the trackhoe or backhoe, and during archaeological-type hand excavation. A total of 48 person-hours were spent in Level "A" PPE, 1,728 person-hours in Level "B" PPE, and 612 person-hours in Level "C/D" PPE for support purposes during the excavation phase of the project.

A total of 140 cubic yards (107 cubic meters) of thorium-contaminated soil was drummed directly in the pit and subsequently staged onsite. A total of 270 cubic yards (205 cubic meters) of chromium-contaminated soil (associated with a group of ruptured and intact thermal batteries) was removed from the pit. A total of 1,200 cubic yards (1,096 cubic meters) of suspect soil was removed and staged until waste characterization was made (this soil was to be placed back into the pit).

Several dozen thermal batteries; 5 lb (2.3 kg) of lithium metal; 6.5 lb (3.0 kg) of rubidium metal; several kilograms of unknown chemicals; and 450 gas cylinders, including 97 intact cylinders containing inert, flammable, toxic, corrosive, or oxidizing gases were removed and effectively managed to minimize waste. Thermal batteries were disposed of as hazardous waste. Lithium metal was repackaged and disposed. Rubidium metal was given to the SNL/NM "Metals Reapplication Program." Based on evaluation, no intact cylinder was in condition to be shipped offsite, because of corrosion, nonfunctional valving, dents, or other miscellaneous damage. These cylinders were deemed unstable and unsafe, and the contents had to be rendered safe.

Cylinder evaluation was a multi-step process (Figure 4). Initially, when cylinders were excavated, each underwent an in-field visual inspection; cylinders which were breached were discarded as scrap metal, and those which appeared to be intact were subject to closer inspection in the pit itself. This inspection included a survey using common field-portable direct reading instruments (including a GOW-MAC<sup>®</sup> gas leak detector, and Gastech Model 1314 in the ppm combustibles mode), as well as a soap film solution to determine if leaks were present. Cylinders were stored in the special operations area and visually checked and monitored daily using the PID and FID.

The next phase of cylinder evaluation was similar to the initial evaluation, but was performed under controlled conditions, and cylinder cleaning was included as an initial step. Each container was given a unique identification number. All leak testing was repeated. Each container was examined in detail, and physical measurements including specific defects, wall thickness, color codes, special construction or special metal alloys, and type and construction of the valve were recorded on preprinted forms. All cylinders were photographed using a Polaroid<sup>®</sup> instant camera. Color copies of the pictures together with a copy of all field data were mailed to the ETSC-Schaumburg, Illinois, office for review and consultation on possible courses of action.

Cylinder content analysis was performed in an onsite mobile laboratory containing an Infrared Spectrophotometer and a Mass Spectrometer. Cylinders were connected to the instruments by a vacuum manifold, using either their existing valving, or a new valve installed on the side of the cylinder wall using proprietary "hot tapping" called high pressure container access (HPCA). The HPCA installation is somewhat similar to installing an in-line saddle on an existing conventional plumbing system. Small quantities of gases were allowed to bleed through the system if still

pressurized; alternatively, helium gas was used to purge the cylinder if the pressure in the cylinder was at zero pounds per square in gauge (psig).

The fourth step was management, or on-site stabilization, of gases from cylinders. On-site stabilization of reactive gases from unstable cylinders was performed after registration with the City of Albuquerque Air Quality Division. Either registration or permitting with the City of Albuquerque was required because of the contents of certain cylinders. A permit would be required if the City determined that a significant amount of hazardous air pollutants were being emitted (case-by-case basis, no emission limit set) or the precontrolled emission rate exceeds 10 pounds per hour or 25 tons per year; otherwise registration was required. Registration was the method of choice because of the small quantities of materials found. This course of action was also consistent with SNL/NM's existing agreements regarding permitting of potentially explosive and unstable chemicals. In that agreement, NMED determined that the treatment of potentially explosive and unstable chemicals to render them non-hazardous was exempt from permitting and substantive requirements as outlined in the New Mexico Hazardous Waste Management Regulations. All treatment process residue was disposed through the Permitted Hazardous Waste Management Facility at SNL/NM.

Management of any specific gas from a cylinder depended on the gas identified. A multiple decision pathway on the management and disposition of contents of each group of cylinders was initially compiled. A decision on the "best" option for the management of gas from a particular cylinder was then determined, although contingencies were also retained. In addition, the possibility of making an immediate on site decision to protect human health and the environment if a toxic release, explosion, or fire occurred during handling was retained as an option for all cylinders.

The preferred option for flammable, toxic, corrosive, or oxidizing gases was transfer of the gas to a DOT-shippable container, if the original cylinder contained sufficient quantity of gas (Table 3). The next options for some reactive or toxic gases included neutralization, oxidation, or hydrolysis. For non-toxic or halogenated flammable gases, another option was flaring. Certain very toxic materials required special handling or transfer of contents to a new package without treatment. For inert gases, the preferred option was release to the atmosphere. Descriptions of management methods for pressurized gases are detailed in Table 4.

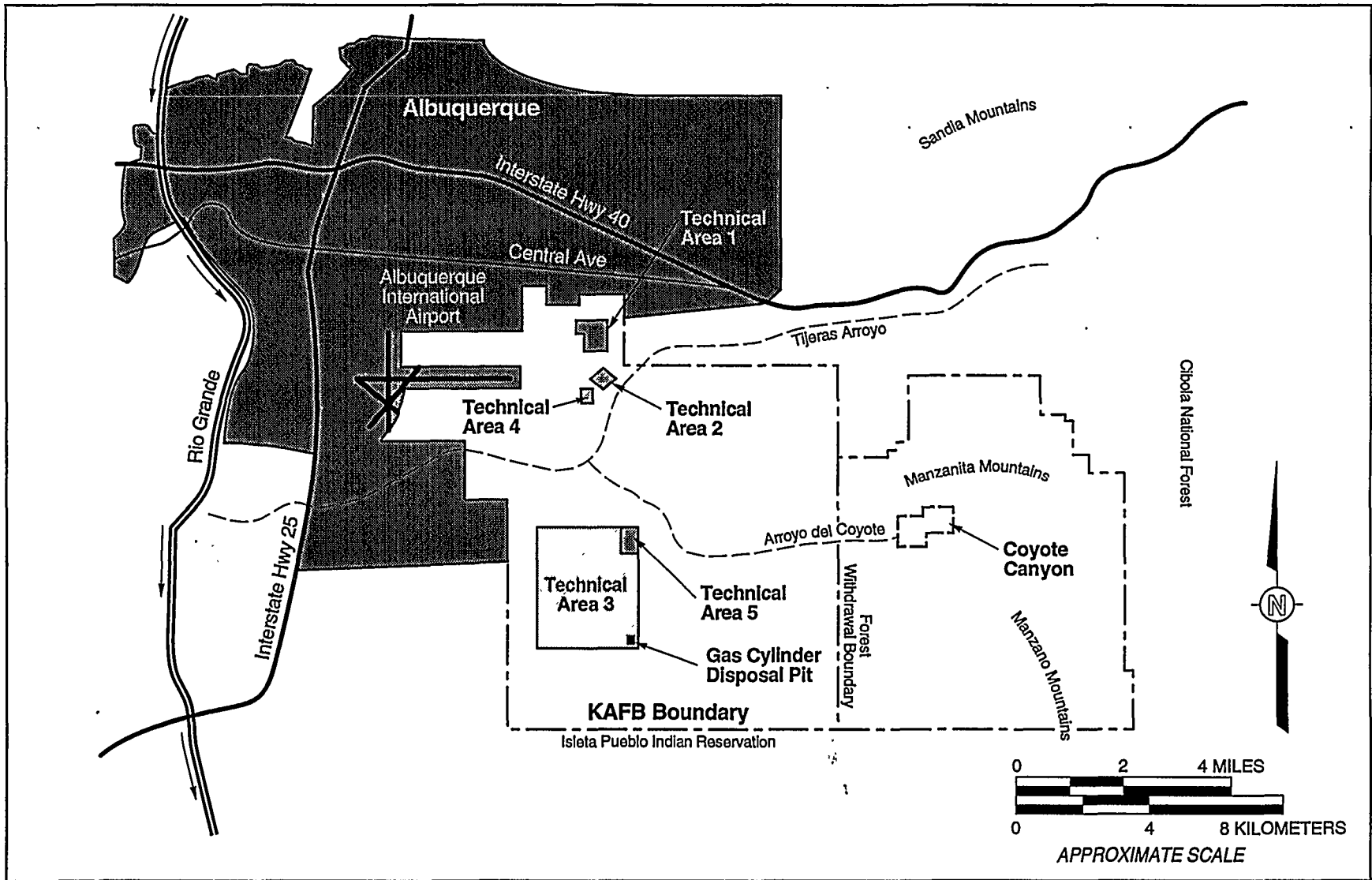
## CONCLUSION

The voluntary corrective action remediation of a Gas Cylinder Disposal Pit at Sandia National Laboratories, New Mexico was recently completed. This facility operated from 1963 to about 1984. The project was planned from a waste management perspective, waste management and waste minimization were built into the planning phases, and were aggressively implemented throughout the course of the project. The original scope of the project was for the removal of 20 intact gas cylinders, and the removal of 3,200 cubic yards (2,443 cubic meters) of contaminated and uncontaminated soil.

A site-specific, written waste management plan was produced at the start of activities. The site layout was planned to accommodate heavy equipment, storage of large quantities of suspect soil, and special areas to treat and dispose of gases in cylinders recovered from the pit during operations. Continuous geophysical investigations and radiological surveys focused the investigation on "hot spots" only and immediately reduced the investigation to 56% of the original estimate. Excavation was tightly controlled and managed, employed both hand digging and heavy equipment to maintain safe operations, and, as a result, further reduce the quantities of waste generated. All debris and soils were field screened before comprehensive laboratory analyses were performed to confirm and quantify contamination. Waste segregation was strictly enforced for all waste streams. Contents of cylinders were determined using an onsite mobile laboratory, and the management of gases, including treatment of hazardous gases, was performed onsite. Steps were also taken to minimize the generation of decontamination fluids and used personal protective equipment.

Several dozen thermal batteries; 5 pounds (2.3 kilograms) of lithium metal; 3.7 pounds (1.7 kilograms) of rubidium metal; several kilograms of unknown chemicals; 140 cubic yards (107 cubic meters) of thorium-contaminated soil; 270 cubic yards (205 cubic meters) of chromium-contaminated soil; and 450 gas cylinders, including 97 intact cylinders containing inert, flammable, toxic, corrosive, or oxidizing gases were removed and effectively managed to minimize waste. These figures amounted to a four-fold increase in the amount of intact cylinders removed from the pit, yet was only 12% of the original estimate of 3,200 cubic yards (2,443 cubic meters) of soil waste generated during the course of the removal. A summary of waste streams and waste quantities is provided in Table 5.

Pre-planning was the key ingredient in a successful recipe for remediation. Efficient site layout allowed ease of operations, generous contingency for the unexpected, adequate temporary storage space, and the facilities to allow treatment of hazardous and toxic gases. Effective and usable waste management documentation provided for smooth and efficient operations, a high level of quality assurance and quality control, and the flexibility to modify operations when needed. Finally, application of the principles of waste minimization showed that remediation could be focused and selective, minimize cost and schedule, and guaranteed that waste volumes were as small as possible. These approaches, or parts of them, could be applied immediately, even to sites which are currently in the process of being remediated, throughout the DOE complex or elsewhere. The cost savings would be significant, quality control would be improved, and disposal volumes decreased.



SNLGasCyl-01/ A44/1-12-95

**Figure 1**  
**SNL/NM-Location of Technical Areas**  
**and the Gas Cylinder Disposal Pit**

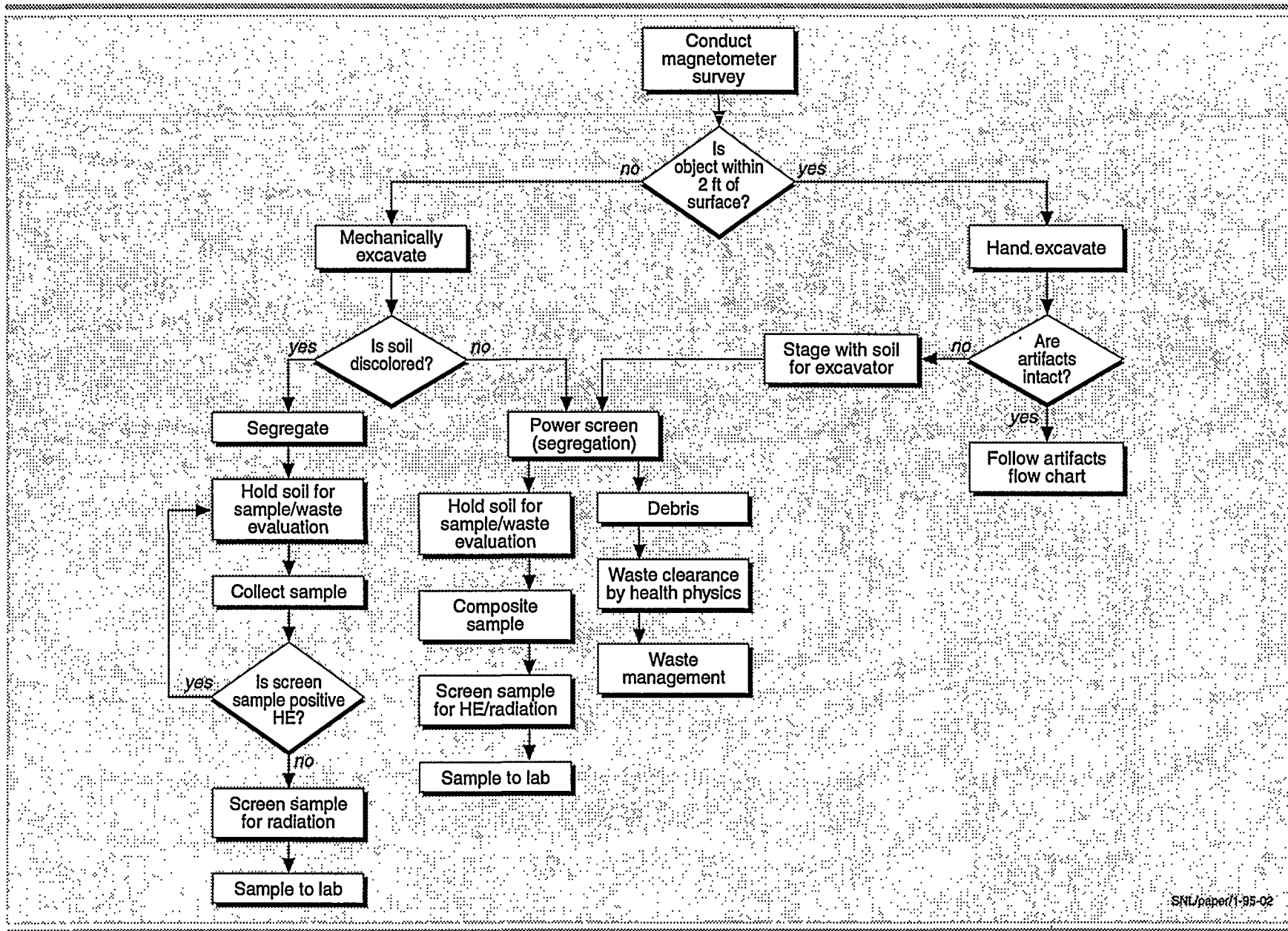
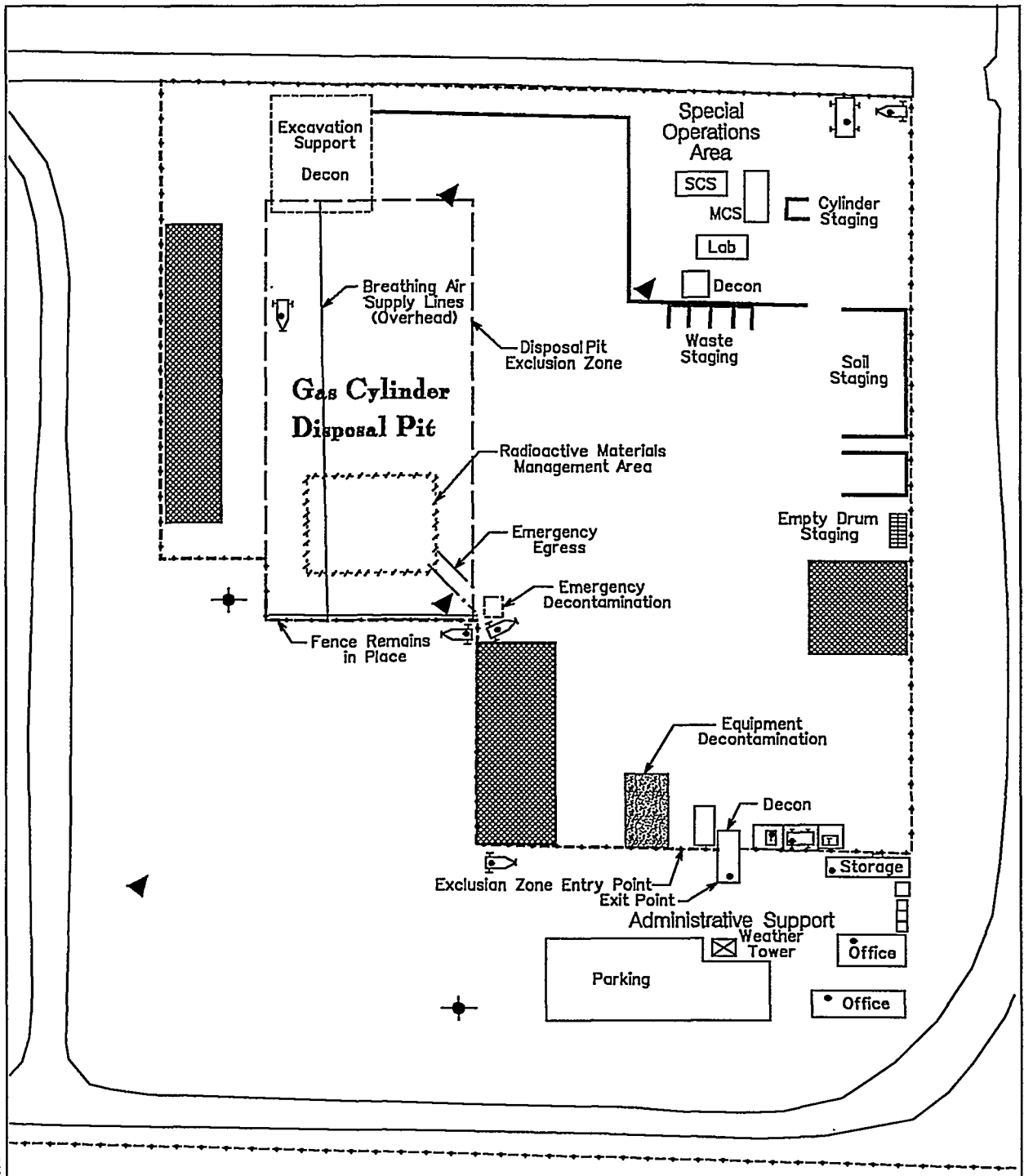


Figure 2. Excavated Materials and Soils Decision Tree.



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		<b>Legend</b>		

Figure 3. Site Layout ER Site 78 Gas Cylinder Disposal Pit Remediation Project.

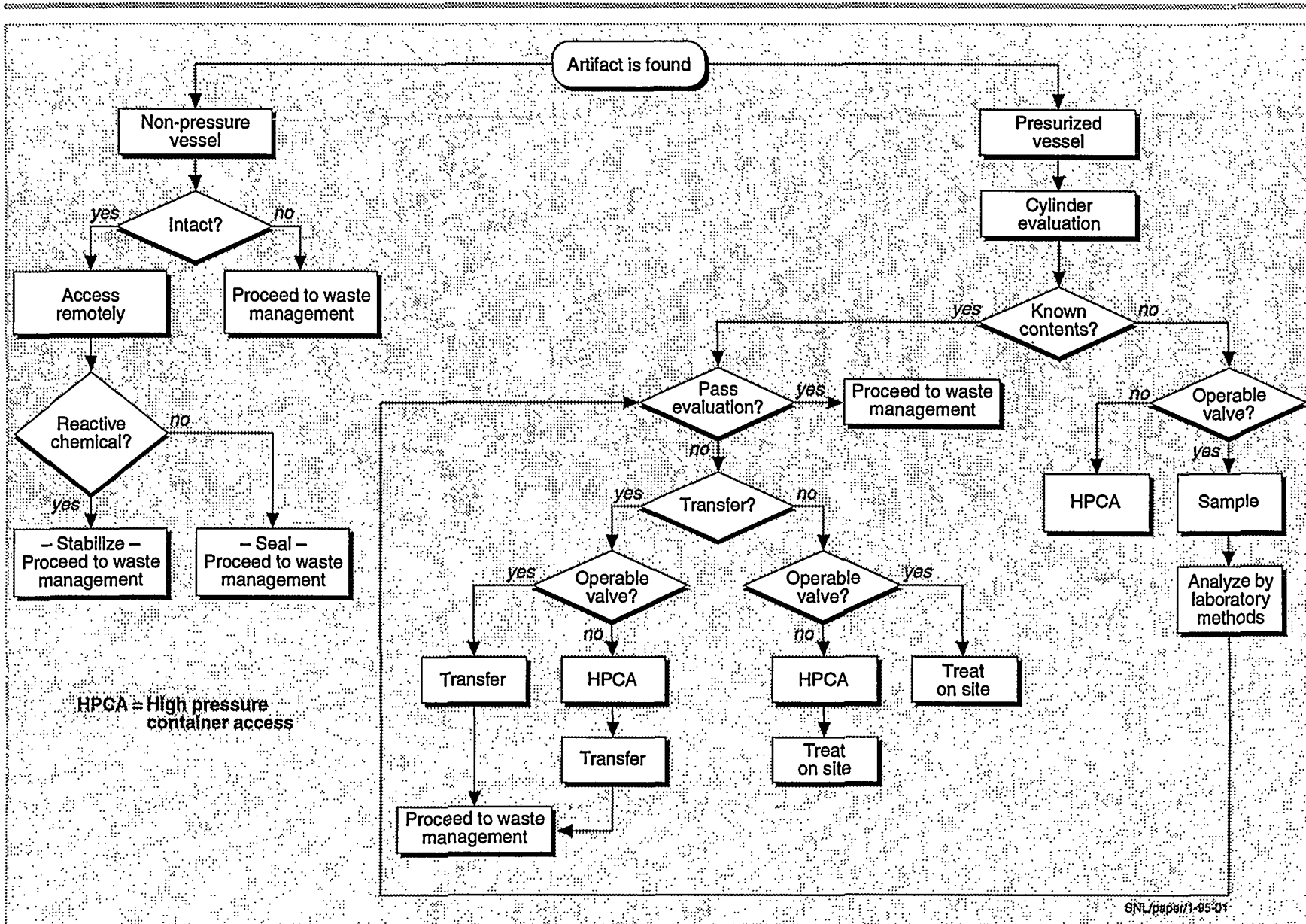


Figure 4. Excavated Container Decision Tree.



Table 1. Chemical Inventory (1983-1984)

Gases	Liquids	Solids
Anhydrous ammonia	Acetone	Halocarbon
Allene	Battery acid	Depleted uranium
Boron trifluoride	Epoxy resin floor sealer	
Butadiene	Freon	
Butene	Freon TMS solvent	
Carbon dioxide	Fluorochemical	
Chlorine	Fluorotrichloromethane	
Chlorotrifluoromethane	Laser scribe protective coating	
Cyclopropane	Nophenol	
Deuterium	Oil	
Dichloroethylene	Photoresist	
Ethane	2-Propanol	
Ethylene	Sulfur compounds	
Fluorotrichloromethane	Ethers	
Helium	Picric acid	
Hexafluoropropylene		
Hexafluoropropene		
Hexafluoroacetone		
Isobutane		
Isobutylene		
Krypton		
Nitric oxide		
Nitrogen dioxide		
Pentafluorobutene		
Propane		
Propylene		
Sulfur dioxide		
Vinyl methyl ether		
Unknown Gases		

**Table 2. Field Screening and Lab Analyses for Constituents of Concern**

<b>Constituent</b>	<b>Field Screening Methods</b>	<b>Lab Analysis Methods</b>
Volatile Organic Constituents	PID, FID, Dräger tubes	8240
Semivolatile Organic Constituents	NA	8270
High Explosives	EXSPRAY™	8030
Target Analyte List Metals	XRF	6010/7000 TCLP
Radionuclides	NaI radiation detector Gamma spectroscopy Beta/gamma pancake G-M detector	Isotopic Uranium (6020), 9310 Isotopic Thorium Isotopic Plutonium Tritium (selected samples)

Table 3. Proposed management of cylinder contents

Compound Identified	Regulatory Status	Number of Containers	Management
Chlorodifluoromethane	Ozone-depleting substance	1	Transfer
Sulfur dioxide	Not regulated by RCRA	2	Neutralization
Nitric oxide	P076	1	Neutralization
Ammonia (anhydrous)	Not regulated by RCRA	1	Neutralization
Carbon dioxide	Not regulated by RCRA	1	Release untreated
Helium	Not regulated by RCRA	1	Release untreated
Argon	Not regulated by RCRA	1	Release untreated
Benzene (liquid under N <sub>2</sub> )	U019	3	Transfer
Hydrogen sulfide	U135	6	Oxidation/neutralization
Ethane	D001	1	Flare
Propanethiol	D001	1	Oxidation/neutralization
Methyl fluoride	D001	1	Transfer
Silicon tetrafluoride	D003	3	Hydrolysis/neutralization
Tetrafluoroethylene	D001; D003	1	Transfer
Ethane/methane (mixture)	D001	3	Flare
Butane	D001	1	Flare
Allene (propadiene)	D001; D003	1	Flare
Nitric/nitrous oxide (mixture)	D003	1	Oxidation/neutralization
Phosphine	P096	1	Oxidation/neutralization
Diborane/pentaborane	D001; D003	1	Oxidation/neutralization
Boron trifluoride	D003	1	Hydrolysis/neutralization
Carbonyl sulfide	D001; D003	2	Oxidation/neutralization
Nitrosyl chloride	D003	1	Hydrolysis/neutralization
Hydrogen chloride	Not regulated by RCRA	1	Neutralization
Dimethyl ether	D001	1	Flare

Compounds are listed in order of identification.

**Table 4. Description of management methods for pressurized gases**

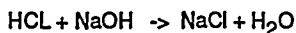
• **FLARE.** The material is mixed with propane and burned in an external flame. Typical susceptible materials are hydrocarbon gases and hydrogen. No material classified as a poison gas or containing halogen is acceptable for flaring. Feed rates are controlled to keep any visible emissions to less than five percent.

Chemistry: example, methane (CH<sub>4</sub>)



• **SIMPLE NEUTRALIZATION.** The material is mixed in a chemical reactor with an aqueous solution of an appropriate neutralization reagent. This type of reaction is normally associated with acid/base chemistry.

Chemistry: example, hydrogen chloride, anhydrous (HCl) and ammonia, anhydrous (NH<sub>3</sub>)



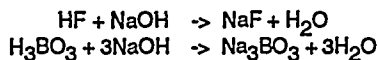
• **HYDROLYSIS/NEUTRALIZATION.** The chemical is first hydrolyzed by water into two or more products. These products are then neutralized by a reagent in the aqueous solution.

Chemistry: example, boron trifluoride (BF<sub>3</sub>)

Hydrolysis step:



Neutralization step:



• **RELEASE UNTREATED.** This is applicable to only a very small group of gases. These are nitrogen, oxygen, nitrous oxide, helium, neon, argon, and xenon. All are non-toxic, non-regulated, and represent no hazard to the surrounding environment.

• **TRANSFER.** The contents are transferred from the unstable/leaking/non-specification container into a new container meeting all of the applicable requirements and specifications for the material. For containers in this size range (less than 5 pounds of net contents), it is not practical to transfer the contents without leaving a significant residue in the old container. The method employed for small containers is based on the physical properties of the individual material. This transfer method requires that the chemical's vapor pressure at -20°C must be less than 380 mm Hg. The transfer is accomplished by connecting both cylinders to a manifold. The manifold and receiver are purged with inert gas and then evacuated to about 1-3 mm Hg pressure. The receiver is cooled to -20°C (the lower limit of artificial cooling for carbon steel containers). The valves are actuated and the product flows from the full container to the empty container. The donor (unstable container) will contain a residue, but will be empty according to RCRA standards.

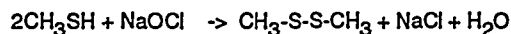
• **CHEMICAL OXIDATION.** This method destroys the chemical by an oxidation reaction. The chemical is mixed into an aqueous solution containing one or more reagents to chemically oxidize the chemical into a less toxic or nontoxic product.

Chemistry: examples, arsine (AsH<sub>3</sub>), methyl mercaptan (CH<sub>3</sub>SH), and nitric oxide (NO)

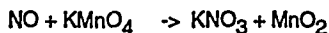
Arsine:



Methyl mercaptan:



Nitric oxide:



• **SPECIAL HANDLING REQUIRED.** Note: No compounds requiring special handling have been identified either administratively or analytically. Each has a different specific method for management. Each method takes into consideration the significant additional hazards associated with the management of that compound.

**Table 5. Summary of waste streams and quantities**

Waste Stream	Quantity	Waste Components	Disposition
Thermal batteries	1,120 pounds (508 kg)	Chromium, explosives	Disposed through SNL/NM hazardous waste facility.
Lithium metal	5 pounds (2.3 kg)	Pure lithium	Disposed through SNL/NM hazardous waste facility.
Rubidium metal	3.7 pounds (1.7 kg)	Pure rubidium	Recycled through SNL/NM "metals reapplication program."
Unknown chemical	100 pounds (45.4 kg)	Unknown	"Haz catted." Disposed through SNL/NM hazardous waste facility.
Scrap metal	8,618 pounds (3,909 kg)	Iron	Disposed through SNL/NM hazardous waste facility.
Thorium-contaminated soil	140 cubic yards (107 cubic meters)	Thorium	Final disposition not determined at present. Still on site.
Chromium-contaminated soil	270 cubic yards (205 cubic meters)	Chromium	Disposed through SNL/NM hazardous waste facility.
Inert gases	100 cubic feet (2.8 cubic meters)	CO <sub>2</sub> , He, Ar	Vented to atmosphere
Hazardous/toxic gases	14 pounds (6.4 kg)	Various materials <sup>1</sup>	Treatment <sup>2</sup>
Used PPE	4,168 pounds (1891 kg)	Used garments, gloves, and cartridges	Disposed through SNL/NM hazardous waste facility.
Decontamination water	15,510 pounds (7,035 kg)	Water	Disposed through SNL/NM hazardous waste facility.
Glass	5 pounds (2.3 kg)	Broken glass	Disposed through SNL/NM hazardous waste facility.
Scrap wood	560 pounds (254 kg)	Pallets, miscellaneous scrap	Disposed through SNL/NM hazardous waste facility.
Visqueen	2203 pounds (999 kg)	Tarps, decon pad	Disposed through SNL/NM hazardous waste facility.
Clean soil	1,200 cubic yards (1,096 cubic meters)	Below proposed RCRA guidelines	Returned to the pit.

<sup>1</sup>Chlorodifluoromethane, sulfur dioxide, nitric oxide, ammonia (anhydrous), benzene (liquid under N<sub>2</sub>), hydrogen sulfide, ethane, propanethiol, methyl fluoride, silicon tetrafluoride, tetrafluoroethylene, ethane/methane (mixture), butane, allene (propadiene), nitric/nitrous oxide (mixture), phosphine, diborane/pentaborane, boron trifluoride, carbonyl sulfide, dimethyl ether, nitrosyl chloride, and hydrogen chloride.

<sup>2</sup>Treatments included flaring, neutralization, oxidation/neutralization, and hydrolysis/neutralization, depending on the material.

## CONCLUSIONS

There is no sign of a critical Mn concentration below which AFM ordering does not occur in CuMn. SDW features occur consistently in neutron scattering studies of CuMn alloys,<sup>1,10,12,15,18,19</sup> with a peak width which is always close to 0.1 RLU, independent of Mn concentration.<sup>20</sup> For SDW antiferromagnetism, this universal width reflects the width of the peak in  $\chi(\mathbf{q})$  at  $q = 2k_F$ . According to the numerical calculations<sup>4</sup> the width of the peak in  $\chi(\mathbf{q})$  is approximately twice the width of the diffraction features. Although neutron count rates have so far prevented significant inelastic studies of samples containing less than 3% Mn, the inelastic features for samples containing 3% to 35% Mn are essentially identical: an excitation with a vertical dispersion relation originates at the SDW peak positions. This behavior is characteristic of an excitation originating at the Fermi surface and is highly reminiscent of the behavior in chromium, a prototype SDW AFM.<sup>21</sup>

As mentioned above, the measurements described here are at the low-concentration limit of the CuMn alloys which can be studied with current neutron sources. However two very interesting alternative directions suggest themselves for x-ray and neutron-scattering studies of CuMn alloys. The first follows the recent report of the coexistence of incommensurate magnetic *and* structural peaks in Ag-Mn alloys.<sup>22</sup> It is important to determine whether such an effect occurs in CuMn. In addition, a careful measurement of the temperature dependence of the structural-peak intensities (in AgMn, or CuMn, if an incommensurate structural feature is found) will determine whether there is any evidence for a spin-density wave to charge-density wave transition. The second line of experiments worth pursuing is a magnetic-field-cooling study of a relatively concentrated ( $\sim 10\%$  Mn) CuMn sample. The aim in this case is to see whether cooling through the Néel temperature with  $H \geq 10$  kG produces an asymmetric population of SDW domains. (In chromium, field cooling is routinely used to prepare single-SDW-domain samples.<sup>21</sup>)

Taken as a whole, the neutron data are consistent in implying that the best description of CuMn is a spin-density-wave antiferromagnet, arising from an instability of the electron gas of copper metal at  $q = 2k_F$ .<sup>23</sup> We expect that with the new experiments described here, the evidence will continue to point in what remains a controversial direction.

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