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Hazardous Waste Minimization Assessment: Fort Campbell, KY

by
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On November 8, 1984, the U.S. Congress signed into public law the Hazardous and Solid Waste Amendments (HSWA) act establishing a national policy on waste minimization. Regulations created to support the HSWA require hazardous waste generators to develop and follow a hazardous waste minimization program. Moreover, the Department of Defense has established a goal of 50 percent reduction in hazardous waste generation by 1992 (compared to 1985 generation data).

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FOREWORD

This work was performed for Headquarters, U.S. Army Forces Command (HQFORSCOM), under Interagency Reimbursable Order (IAO) 3788, dated 25 July 1988. The FORSCOM technical monitor was Mr. Rudy Stine.

The work was done by the Environmental Engineering Team of the Environmental Division (EN), U.S. Army Construction Engineering Research Laboratory (USACERL). Dr. Edward W. Novak is the Acting Chief of EN. The technical editor was Gloria J. Wienke, USACERL Information Management Office.

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COL Everett R. Thomas is Commander and Director of USACERL, and Dr. L.R. Shaffer is Technical Director.

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HAZARDOUS WASTE MINIMIZATION ASSESSMENT:
FORT CAMPBELL, KY

1 INTRODUCTION

Background

Waste minimization is the process of reducing the net outflow of hazardous solid, liquid, and gaseous effluents from a given source or generating process. It involves reducing air emissions, contamination of surface and ground water, and land disposal by means of source reduction, recycling processes, and treatment leading to complete destruction. Transferring pollutants from one medium to another (e.g., from water to air) by treatment processes is not waste minimization.

On November 8, 1984, the U.S. Congress signed into public law[1] the Hazardous and Solid Waste Amendments (HSWA) act establishing a national policy on waste minimization. HSWA required the U.S. Environmental Protection Agency (USEPA) to issue regulations that began the process of implementing the 1984 amendments to the Resource Conservation and Recovery Act (RCRA).[2] Among the Federal regulations is a requirement that every generator of hazardous wastes (HW) producing in excess of 2205 pounds (lb)[*] per month certify, when hazardous wastes are manifested (listed on a tracking document), that a hazardous waste minimization program is in operation.[3] Generators are required to submit biennial reports to the USEPA that describe efforts taken to reduce the volume and toxicity of waste generated during the year. Federal regulations issued in October 1986 clarify the status of small quantity (220 to 2205 lb/month) generators (SQG) of hazardous waste.[4] SQGs are required to make a "good faith" effort to minimize hazardous waste generation and implement the best available treatment, storage, or disposal alternative economically feasible.

The more restrictive regulations, high treatment/disposal expenses, and increased liability costs prompted private industry and several government agencies to critically examine means that will lead to prevention of pollution as opposed to end-of-pipe treatment methods. Waste minimization is economically beneficial to Army installations. Some of the cost savings realized by minimizing wastes result from: reduced transportation and disposal costs for offsite disposal; reduced compliance costs for permits, monitoring, and enforcement; reduced onsite treatment costs; reduced onsite storage and handling costs; lower risk of spills, accidents, and emergencies; lower long term liability and insurance costs; reduced raw materials costs; reduced waste generation fees; reduced effluent costs and assessments from local sewage treatment plants; reduced production costs through better management and efficiency; and, reduced operation and maintenance costs.

In fiscal year (FY) 1987, the Army directly paid (through a centrally funded process) the Defense Logistics Agency (DLA) $17.5 million for disposal of only 15 percent of the total wastes generated

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[1] Public Law 98-616, *Hazardous and Solid Waste Amendments* (1984).
[2] Public Law 94-580, *Resource Conservation and Recovery Act* (1976).
[*] Regardless of the units of measure used in source documents, all measurements have been converted to English units. Metric conversions are on p 220.
[3] 40 CFR 261, *Identification and Listing of Hazardous Waste*, and 40 CFR 262, *Standards Applicable to Generators of Hazardous Wastes* (1985).
[4] Federal Register, Vol 51, No. 190 (October 1986), pp 35190-35194.

by Army installations.[5] The DLA, through its Defense Reutilization and Marketing Offices (DRMOs) located in several regions, was responsible for disposal of most categories of hazardous waste generated by the installations. The installations do not have a separate funding account for waste disposal and therefore do not realize the responsibility for waste generation and the cost of disposal. Beginning in FY 1990, the accounting process for waste disposal will be decentralized to provide a strong economic incentive to reduce waste generation.[6] The installations will have to pay the waste disposal costs from their operation and maintenance budget.

In December 1985, the Joint Logistics Commanders (JLC) established the following Department of Defense (DOD) policy:[7]

> The generation of hazardous waste (HW) at Department of Defense activities is a short- and long-term liability in terms of cost, environmental damage, and mission performance. A HW minimization program shall be developed by each service and shall contain the basic concepts in this directive.

Recognizing the liabilities of improper disposal and the advantages of waste minimization, JLC set a DOD-wide goal of 50 percent reduction in hazardous waste generation by 1992, based on the baseline generation in 1985. The Department of the Army is following this DOD goal and has established a policy[8] applicable to all Active Army, Reserve, and National Guard installations.

Army installations are like small cities with a variety of activities that generate pollution within their boundaries. Unlike civilian cities, where there are many SQGs, each installation as a whole (and its Commander) is a generator held responsible for complying with regulations and reducing pollution from all the activities within its boundaries. Environmental protection must be made a primary concern of every employee on an installation. Everyone must make an effort to protect air, water, and land from industrial and chemical contaminants. Pollution prevention pays not only in terms of complying with regulations, saving in disposal/treatment costs, reducing liability and improving public image, but also in maintaining the good health and welfare of all people.

Each installation is responsible for implementing a hazardous waste minimization (HAZMIN) plan and each employee, military and civilian, is responsible for following the plan. To comply with both the letter and the spirit of the law, the U.S. Army Forces Command (FORSCOM) contracted the U.S. Army Construction Engineering Research laboratory (USACERL) to prepare HAZMIN plans for five FORSCOM installations. This report is the first of the plans and provides a framework for surveying similar installations and developing their HAZMIN plan.

Objective

The objective of this research was to develop a hazardous waste minimization plan for Fort Campbell, KY, to include the actions necessary to accomplish reduction in volume and toxicity of hazardous wastes generated.

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[5] V.J. Ciccone and Associates, Inc., *Program Status Report: Department of the Army Hazardous Waste Minimization*, (U.S. Army Environmental Office, August 1988), p 43.

[6] Office of the Assistant Chief of Engineers, "Hazardous Waste Disposal Funding," DAEN-ZCP-B Memorandum (Department of the Army, 28 October 1988).

[7] Joint Logistics Commanders, "Hazardous Waste Minimization Program," Memorandum to the Deputy Secretary of Defense (12 December 1985).

[8] *Hazardous Waste Minimization (HAZMIN) Policy* (Department of the Army, 1989).

Approach

The following approach was used to develop the plan:

1. Prepare a study strategy that included development of a protocol for conducting a HW inspection/survey. The inspection/survey protocol was developed from literature reviews and previous HW surveys performed by the U.S. Army Environmental Hygiene Agency (USAEHA), and USACERL.

2. Conduct a survey of all possible waste generated at Fort Campbell from 7 through 17 August 1989.

3. Compile data on hazardous materials procurement by different users on the installation.

4. Compile data on hazardous waste generation for each possible generator on the installation.

5. Compile information on each waste stream including: waste characterization; waste source; baseline generation; current method of treatment, storage, and disposal and the associated costs; and past/present minimization efforts and associated costs.

6. Prioritize waste streams by criteria such as: composition, quantity, degree of hazard, method and cost of disposal, compliance status, liability, and potential to minimize.

7. Identify and prioritize minimization options for major waste streams.

8. Conduct feasibility and economic analyses of minimization options.

9. Prepare the final plan.

Scope

A mass balance comparison between the quantity of hazardous materials procured by different activities on Fort Campbell and the corresponding quantity of hazardous wastes generated was performed to ascertain where and for what waste streams minimization efforts should be concentrated. When based on complete and accurate data, such a comparison provides a rough indication of the operational efficiency of different processes and forms a basis for evaluating the costs and benefits of implementing any changes. Unfortunately this methodology was only marginally successful on Fort Campbell because of the great variability in scale of operations and paucity of accurate waste generation data for individual activities.

Tabular portions of Chapter 4 that present material usage and waste generation rates for different activities contain blanks. These are not meant to imply zero consumption nor waste generation, but rather that accurate data were not available from the corresponding activity. As inventory control and waste tracking procedures are developed and implemented on Fort Campbell, improvement in availability and accuracy of such data should result and subsequently be used to update the existing inventories.

Mode of Technology Transfer

The HAZMIN plan (Appendix A) will be presented to Fort Campbell for implementation. The recommendations that have been made should be incorporated in the installation policies and regulations.

2 HAZARDOUS WASTE MINIMIZATION

The HSWA requires generators of hazardous wastes to certify that they have a waste minimization program. Every waste shipment manifest (or tracking document) is accompanied by the following declaration, in compliance with Section 3002(b) of HSWA:

> The generator of the hazardous waste has a program in place to reduce the volume and toxicity of such waste to the degree determined by the generator to be economically practicable; . .

HSWA Section 3002(a) requires the generators of hazardous wastes to submit a biennial report, including their efforts to reduce the volume and toxicity of wastes generated. HSWA Section 3005(h) requires facilities that treat, store, or dispose of hazardous wastes to submit annual reports accompanied by similar declarations on waste minimization.

The HSWA also established a national land disposal restriction program by developing a schedule for banning all hazardous wastes from land disposal by May 1990. In November 1986, USEPA issued the first set of restrictions regarding land disposal of hazardous wastes.[9] These restrictions prohibited land disposal of untreated and concentrated spent solvents. Deadlines for banning land disposal were extended for other solvent wastes because it was felt that sufficient nationwide capacity for treatment did not then exist. It may well be that in a few years commercial land disposal will be available only to hazardous waste residues from treatment processes. In addition, generators must realize that they may be held liable for environmental contamination. Therefore, alternatives to land disposal are necessary.

Minimization includes any reduction in hazardous waste generation and any activities that result in either a reduction in the total volume or quantity of hazardous wastes, or a reduction in the toxicity of hazardous wastes produced, or both. as long as the activities are consistent with the national goal minimizing present and future threats to the environment.[10] By this definition, treatment options such as incineration are considered HAZMIN techniques. HAZMIN, therefore, can be achieved by:

1. Source Reduction: reducing or eliminating waste generation at the source, usually within a process or by an action taken to reduce the amount of waste leaving a process,

2. Recycling Onsite/Offsite: using a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in a process. Recycling also implies reclaiming useful constituent fractions from a waste or removing contaminants, allowing the waste to be reused, or

3. Treatment: eliminating the hazardous characteristics of a waste to make it nonhazardous to human health and the environment.

The hierarchy that should be used in a waste minimization process is shown in Figure 1.* The small amount of residue (e.g., ash) from the process will require "ultimate" disposal (e.g., landfill burial). Various waste minimization techniques, discussed in detail below, are shown in Figure 2. Although attempts are made to clearly divide these techniques into three HAZMIN categories, there

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[9] Federal Register, Vol 51, No. 190.

[10] *Minimization of Hazardous Waste. Executive Summary and Fact Sheet*, EPA/530/SW-86/033A (U.S. Environmental Protection Agency [USEPA], 1986).

*Figures and tables are located at the end of each chapter.

may be overlap for certain specific techniques. Maximum waste reduction is usually achieved by using the best combination of suitable techniques from all three categories.

Source Reduction

Source reduction is at the top of the hierarchy and is the "ideal" solution to the problem of hazardous wastes. All wastes have some potential to be minimized by using better operating practices, product/material substitution, and process changes. Source reduction eliminates the need for storage, transportation, treatment, and residue disposal, and the associated liabilities.

Better Operating Practices

Better operating practices include the simplest source reduction measures such as reducing spillage and leaks, inventory control, employee education/training and control, and better materials/wastes handling practices (e.g., segregation). Experience has shown that education and training programs in safety and hazardous materials/wastes management can be very effective. One approach to good housekeeping is to automate or computerize continuous processes, thereby decreasing human involvement and errors. Waste segregation is an extremely important housekeeping practice that should be incorporated into the work standard. For example, mixing a minute quantity of hazardous waste with a large quantity of nonhazardous waste generates a large quantity of hazardous waste that has to be reported and properly disposed of. Therefore, wastes should never be mixed (e.g., solvents and oils, trash and solvents/oils, gasoline and solvents, etc.). Also, the purity of the waste determines its recyclability (discussed below). Combining dissimilar wastes reduces the chance of recovering either one of them. By using waste segregation and improved handling, most generators could considerably reduce the quantities of wastes generated.

Inventory control is perhaps the most critical and effective better operating practice for HAZMIN. It is a low-cost and easily implementable method that is popularly used in many industries.[11] The quantities of wastes generated can be minimized by reducing the amount of excess material in stock and the amount used in any process or operation. Controlling the purchase of raw materials is the first step in inventory control. Standard operating procedures that allow local or Federal supply system purchase of only approved materials should be established. New materials must be approved before purchase. A tracking system should be established to ensure that all the materials purchased are used properly. Such a materials "manifest" system is a tool that is useful not only in minimizing waste generation but also in complying with the Community "Right-To-Know" law.[12]

Product/Material Substitution

Product/material substitution is a major category of source reduction. Most hazardous wastes are so categorized because they result from processes that use hazardous materials as input or in an intermediate step. Product substitutions are necessary to minimize the environmental impacts of some products (e.g., pesticides such as DDT, 2,4,5-T, etc.) and associated wastes. Use of nonhazardous or less hazardous products as substitutes is therefore recommended. An example of product substitution is replacing cadmium plated products with zinc or aluminum plated products in metal finishing operations.

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[11] G.E. Hunt and R.N. Schecter, "Minimization of Hazardous-Waste Generation," in ***Standard Handbook of Hazardous Waste Treatment and Disposal***, H.M. Freeman, Ed. (McGraw Hill, New York, NY, 1989), pp 5.3-5.27; D. Huisingh, ***Profits of Pollution Prevention: A Compendium of North Carolina Case Studies*** (North Carolina Board of Science and Technology, Raleigh, NC, 1985).

[12] Public Law 99-499 Title III, ***Superfund Amendments and Reauthorization Act*** (1986).

Material substitution can also be viewed as a change in a process that involves using nonhazardous or less hazardous input or raw material, or a material with few impurities. Less hazardous materials with fewer impurities can reduce the likelihood of generating high volumes of hazardous wastes. Some examples of material substitution are:[13] replacing chlorinated solvents (e.g., trichloroethylene [TCE], 1,1,1-trichloroethane etc.) with hot caustic solutions or detergents in degreasing operations; using noncadmium pigments in ink manufacture; and replacing cyanide formulations with noncyanide formulations in cadmium electroplating baths.

One major form of product/material substitution is "aqueous" substitution; the use of water-based materials as inputs or products in a process. Many aqueous alternatives have been developed by the chemical industries. Some examples of aqueous substitution are:[14] replacing organic liquids (e.g., TCE, Stoddard solvent, xylene, toluene, etc.) with water-based products (e.g., Citrikleen, Histoclear, etc.) in metal cleaning and degreasing operations; replacing petroleum-based fluids with water-based fluids in metalworking and machining operations; substituting solvent-based ink with water-based ink in the printing processes; and using a water-based developing system instead of a solvent-based system in the manufacture of printed circuit boards.

Process Changes

Some generators will have to consider either improvements in the manufacturing process or even major changes in the technological processes to achieve waste reduction. Process change is a category of source reduction and includes source control. Source control implies examination and reevaluation of the processes that generate hazardous waste. Process optimization and increased efficiency were terms commonly used in source control projects to obtain the best quality product. Not much attention was paid to the waste. The concept of source control, therefore, is not new. Optimizing a process or increasing its efficiency also reduces the quantities of wastes generated. Process change or source control can further be divided into: process/equipment modifications, improved controls, and energy/ water conservation.

Process/equipment modifications will require that operating/manufacturing processes and equipment used for waste minimization be redesigned. Some examples of process modifications are:[15] using dry plastic media blasting instead of wet chemical stripping (with methylene chloride, hot caustics, etc.) to remove paint from metallic substrates, replacing cocurrent rinsing with countercurrent rinsing in metal plating and surface finishing operations, and retrofitting the existing chrome-plating processes with equipment that reduces the discharge of rinsewater to almost zero.

Improved controls could also be included under "better operating practices." It implies proper control of processes or equipment to reduce emissions and waste generation. Conserving energy/water by controlling the heat input and reducing the amount of rinse/process water used can reduce emissions, solid wastes, and wastewater.

Recycling Onsite/Offsite

After all source reduction techniques have been examined for a particular waste stream, recycling options, both onsite and offsite, should be considered. Three types of onsite recycling operations are

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[13] *Alternative Technology for Recycling and Treatment of Hazardous Wastes*, Third Biennial Report (California Department of Health Services, Alternative Technology and Policy Development Section, 1986).
[14] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[15] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*

available:[16] (1) reuse of waste in the same process (e.g., continuous recycling of rinsewaters in plating/finishing operations, recycling of tetrachloroethylene in dry cleaning operations), (2) use of the waste in a different process (e.g., using waste battery acid as a neutralizing agent in an industrial wastewater treatment plant), and (3) processing the waste to produce a reusable product (e.g., distilling solvents, burning used oil for heat content, etc.). Offsite recycling includes methods used to process the waste to produce a usable product (e.g., re-refining waste oil, reclaiming lead from lead-acid batteries, recovering silver from fixing bath solutions, incinerating hazardous wastes for heat content, etc.).

Recycling of hazardous wastes is encouraged by the Federal and State governments. Hazardous waste generators must explore all recycling opportunities for wastes whether or not the generation is reduced. Industrial recyclers are available for a number of wastes. Recyclable wastes include:[17] unused commercial chemical products, halogenated solvents, oxygenated solvents, hydrocarbon solvents, petroleum products (including oils and hydraulic fluids), pickling liquor, unspent acids and alkalis, and selected empty containers. Some offsite programs recycle batteries, mercury, and drums. Offsite recycling is also a major part of the program called "solvent leasing." In this program, a generator will lease process equipment. The equipment owner provides clean solvent and is responsible for removing and recycling used solvent.

An offsite recycling method that needs to be evaluated by DLA and DRMOs is the use of waste exchanges to recycle wastes. Waste exchanges are operations that engage or assist in transferring wastes and information concerning wastes. They help generators develop effective waste minimization programs and comply with legislative and regulatory requirements. A list of waste exchanges operating in North America is provided in Table 1. Some of these organizations are waste information "clearinghouses" and others are waste material exchanges. The information exchanges are usually nonprofit organizations that provide information about the availability and demand of waste materials. Material exchanges act as agents or brokers, and usually take the waste materials, process them, and market them for profit.

Treatment

Treatment of hazardous wastes should be the last minimization choice; after source reduction and recycling, but before "ultimate" disposal. Treatment alternatives must be considered only if source reduction and recycling are not feasible or economically practical. A treatment process: (1) destroys or detoxifies a hazardous waste to a material safe for disposal, (2) concentrates or reduces the volume of wastes for safer handling and disposal, or (3) immobilizes the hazardous components to keep them from the environment. Generators of large amounts of hazardous wastes usually treat the wastes onsite; generators of small amounts of hazardous wastes use offsite treatment facilities. With the increased availability of commercially packaged treatment units, generators may opt to treat wastes onsite. A hazardous residue requiring "ultimate" disposal may still be generated. Treatment processes include neutralization, filtration, evaporation, incineration, and precipitation. Acids, bases, and plating wastes are some of the waste streams that can be treated readily.

Four broad categories of treatment technologies (physical, chemical, biological, and thermal) are applicable to all waste streams. Physical treatment techniques, generally involving phase separation (e.g., solids from liquids), include:[18] separation techniques such as centrifugation, clarification,

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[16] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[17] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[18] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*

coagulation, decantation, encapsulation, filtration, flocculation, flotation, foaming, sedimentation, thickening, and ultrafiltration; and specific component removal techniques such as adsorption, blending, catalysis, crystallization, dialysis, distillation, electrodialysis, evaporation, magnetic separation, leaching, ion exchange, liquid-liquid extraction, reverse osmosis, stripping, and sand filtration. Some of the physical treatment techniques can be readily used as pretreatment steps (e.g., filtration, sedimentation, etc.) before onsite recycling of wastes and also as a part of better housekeeping practices.

Chemical treatment techniques that use the differences in chemical properties of substances, include:[19] mound adsorption, fixation, oxidation, precipitation, reduction, chlorination, chlorinolysis, cyanide destruction, degradation, detoxification, ion exchange, neutralization, ozonation, and photolysis. Biological treatment techniques include:[20] activated sludge digestion, aerobic processes, composting, trickling filtration, and waste stabilization. Biological treatment processes rely on microorganisms (bacteria, fungi, etc.) to decompose and/or bioaccumulate the contaminants in wastes.

As a HAZMIN technique, treatment, unlike source reduction or recycling, has legal (or RCRA) implications. A permit has to be obtained for treatment of hazardous wastes. Only elementary neutralization (e.g., laboratory acids/bases neutralization) and "enclosed" wastewater and other treatment units are exempt from permitting requirements.[21]

HAZMIN Assessment

The HAZMIN assessment procedure and development of the plan (Appendix A) was based on the methods described in *EPA (Environmental Protection Agency) Manual for Waste Minimization Opportunity Assessments*,[22] and other references.[23] The assessment protocol and survey forms are attached in Appendix B.

Development of a successful HAZMIN program contains four critical phases: planning and organization, assessment, feasibility analysis, and implementation (see Figure 3). Figure 4 indicates the two phases that USACERL was involved in. FORSCOM did the initial planning and organization for Fort Campbell.

The first task in the assessment phase is to gather all the available information pertaining to hazardous materials procurement, waste generation, and operating procedures. Second, the waste streams are prioritized and selected for assessment. Team members are selected and a survey agenda is organized. The next step is the actual survey that includes: interviewing supervisors, foremen, and operators; observing housekeeping practices; inquiring about standard operating procedures; and gathering information about levels of administrative controls. Waste minimization options are then evaluated. The most promising options are selected for detailed evaluation.

In the feasibility analysis phase, the technical and economic feasibility of selected minimization options is evaluated. This phase includes the airfield information (Chapter 3) and data gathered

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[19] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[20] *Alternative Technology for Recycling and Treatment of Hazardous Wastes.*
[21] 40 CFR 260, *Hazardous Waste Management System: General* (1985).
[22] *EPA (Environmental Protection Agency) Manual for Waste Minimization Opportunity Assessments*, EPA/600/2-88-025 (USEPA, Hazardous Waste Engineering Research Laboratory, 1988).
[23] R.H. Hemstreet, "How to Conduct your Waste Minimization Audit," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 61-75; M.E. Resch, "Hazardous Waste Minimization Audits using a Two-Tiered Approach," *Environmental Progress*, Vol 7 (1988), pp 162-166; M. Drabkin, C. Fromm, and H. M. Freeman, "Development of Options for Minimizing Hazardous Waste Generation," *Environmental Progress*, Vol 7 (1988), pp 167-173.

(Chapter 4), waste minimization techniques for the various types of sources and wastes (Chapters 5 to 11), and economic analysis of minimization options for select waste streams (Chapter 12).

Fort Campbell should implement the HAZMIN plan according to methodology presented in Chapter 13. Successful implementation of the plan will require command support and commitment. Continuance of the HAZMIN program in the future will require constant evaluation of the goals, reassessment of generators, and developing newer/better procedures for minimizing wastes.

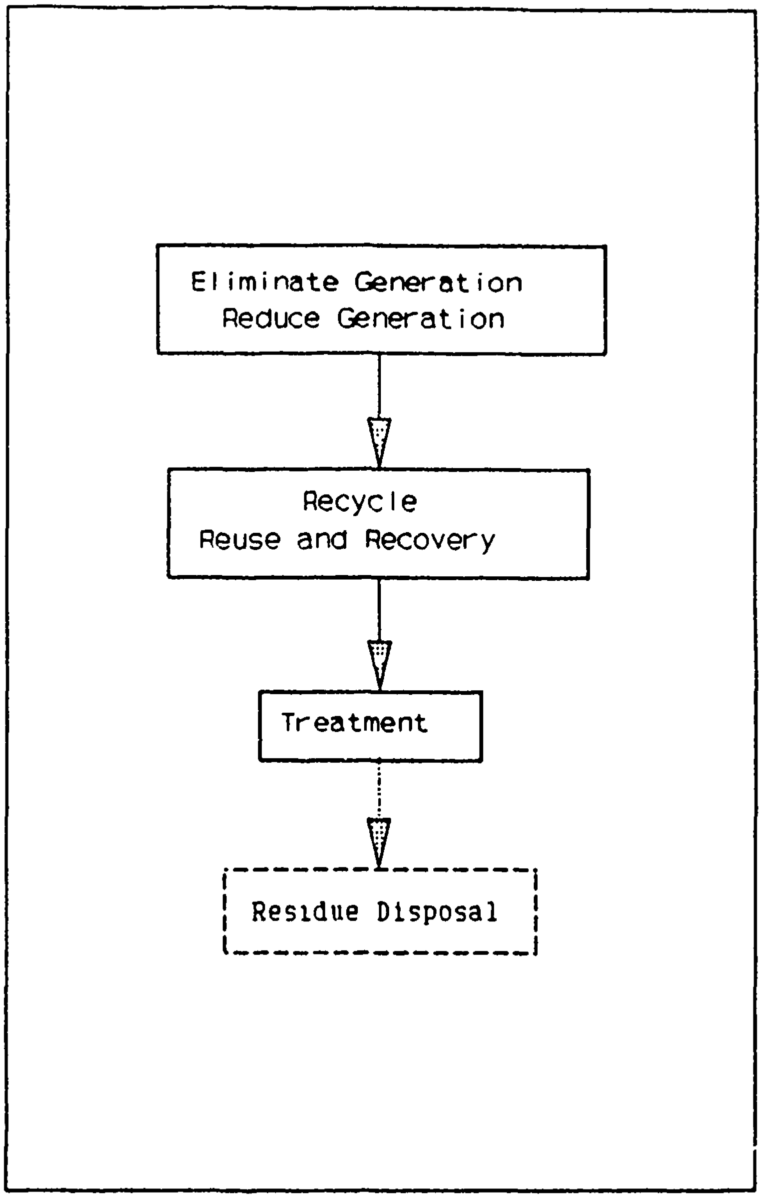

Figure 1. Waste minimization hierarchy.

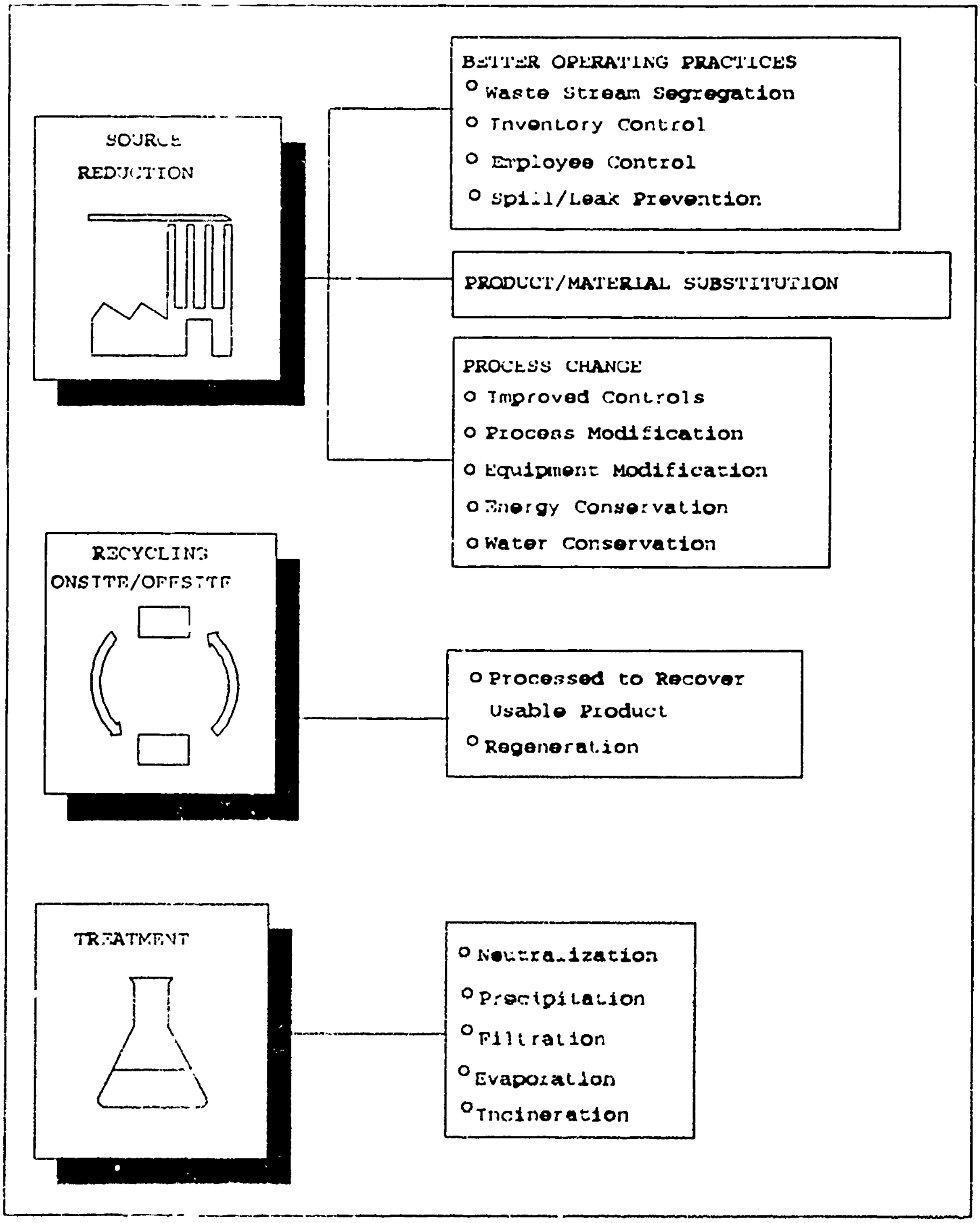

Figure 2. Waste minimization techniques.

Table 1

List of Waste Exchanges*

Alberta Waste Materials Exchange
4th Floor Terrace Plaza
4445 Calgary Trail South
Edmonton, Alberta
CANADA T6H 5R7
(403) 450-5461

California Waste Exchange
Department of Health Services
Toxic Substances Control Division
714 P Street
Sacramento, CA 95814
(916) 324-1807

Canadian Inventory Exchange**
900 Blondin
Ste-Adele, Quebec
CANADA J0R 1L0
(514) 229-6511

Canadian Waste Materials Exchange
Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario
CANADA L5K 1B3
(416) 822-4111

Enkarn Research Corporation**
P.O. Box 590
Albany, NY 12202
(518) 436-9684

Georgia Waste Exchange**
c/o America Resource Recovery
P.O. Box 7178, Station A
Marietta, GA 30065
(404) 363-3022

Great Lakes Regional Waste Exchange
470 Market Street, S.W.
Suite 100-A
Grand Rapids, MI 49503
(616) 451-8992

Indiana Waste Exchange
P.O. Box 1220
Indianapolis, IN 46206
(317) 634-2142

Industrial Materials Exchange Service
2200 Churchill Road
IUSEPA/SLPC-24
Springfield, IL 62706
(217) 782-0450

Industrial Waste Information Exchange
New Jersey Chamber of Commerce
5 Commerce Street
Newark, NJ 07102
(201) 623-7070

Manitoba Waste Exchange
c/o Biomass Energy Institute, Inc.,
1329 Niakwa Road
Winnipeg, Manitoba
CANADA R2J 3T4
(204) 257-3891

Montana Industrial Waste Exchange
Montana Chamber of Commerce
P.O. Box 1730
Helena, MT 59624
(406) 442-2405

Northeast Industrial Waste Exchange
90 Presidential Plaza, Suite 122
Syracuse, NY 13202
(315) 422-2405

Resource Recovery of America***
P.O. Box 75283
Tampa, FL 33675-0283
(813) 248-9000

South Waste Exchange
Urban Institute
UNCC Station
Charlotte, NC 28223
(704) 547-2307

Southern Waste Information Exchange
P.O. Box 6487
Tallahassee, FL 32313
(904) 644-5516

Tennessee Waste Exchange
Tennessee Manufacturers and Taxpayers Association
226 Capitol Blvd., Suite 800
Nashville, TN 37219
(615) 256-5141

Wastelink, Division of Tenecon Associates**
P.O. Box 12
Cincinnati, OH 45174
(513) 248-0012

Western Waste Exchange
ASU Center for Environmental Studies
Krause Hall
Tempe, AZ 85287
(602) 965-1858

Zero Waste Systems***
2928 Poplar Street
Oakland, CA 94608
(415) 893-8261

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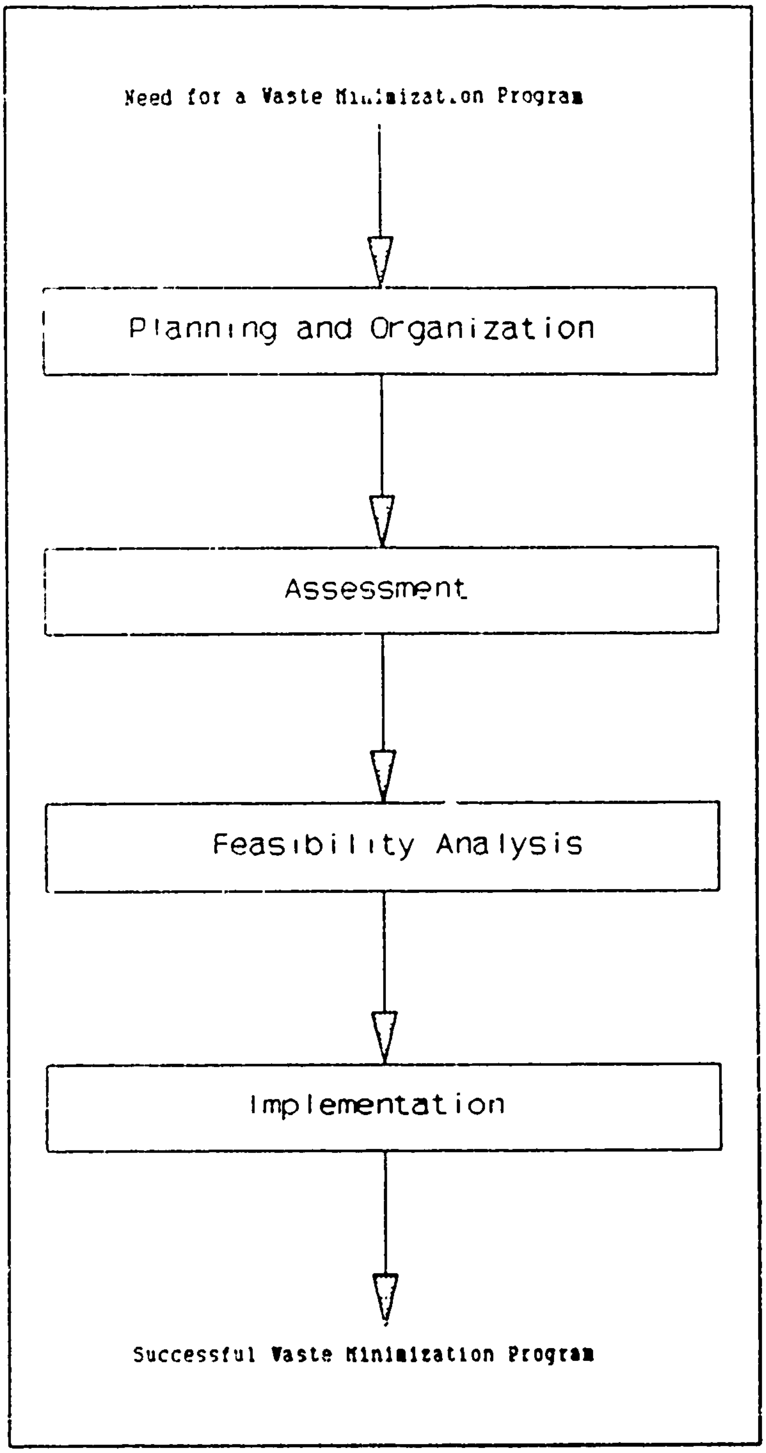
*Source: E.B. Jones, W. Banning, and R.C. Herndon, "Waste Exchanges and Waste Minimization and Reclamation Efforts," in *Waste Minimization Manual* (Government Institutes, Inc., Rockville, MD, 1987), pp 78-85.
**For-profit information exchange
***Material waste exchange.



Figur 3. Hazardous waste minimization program development procedure.

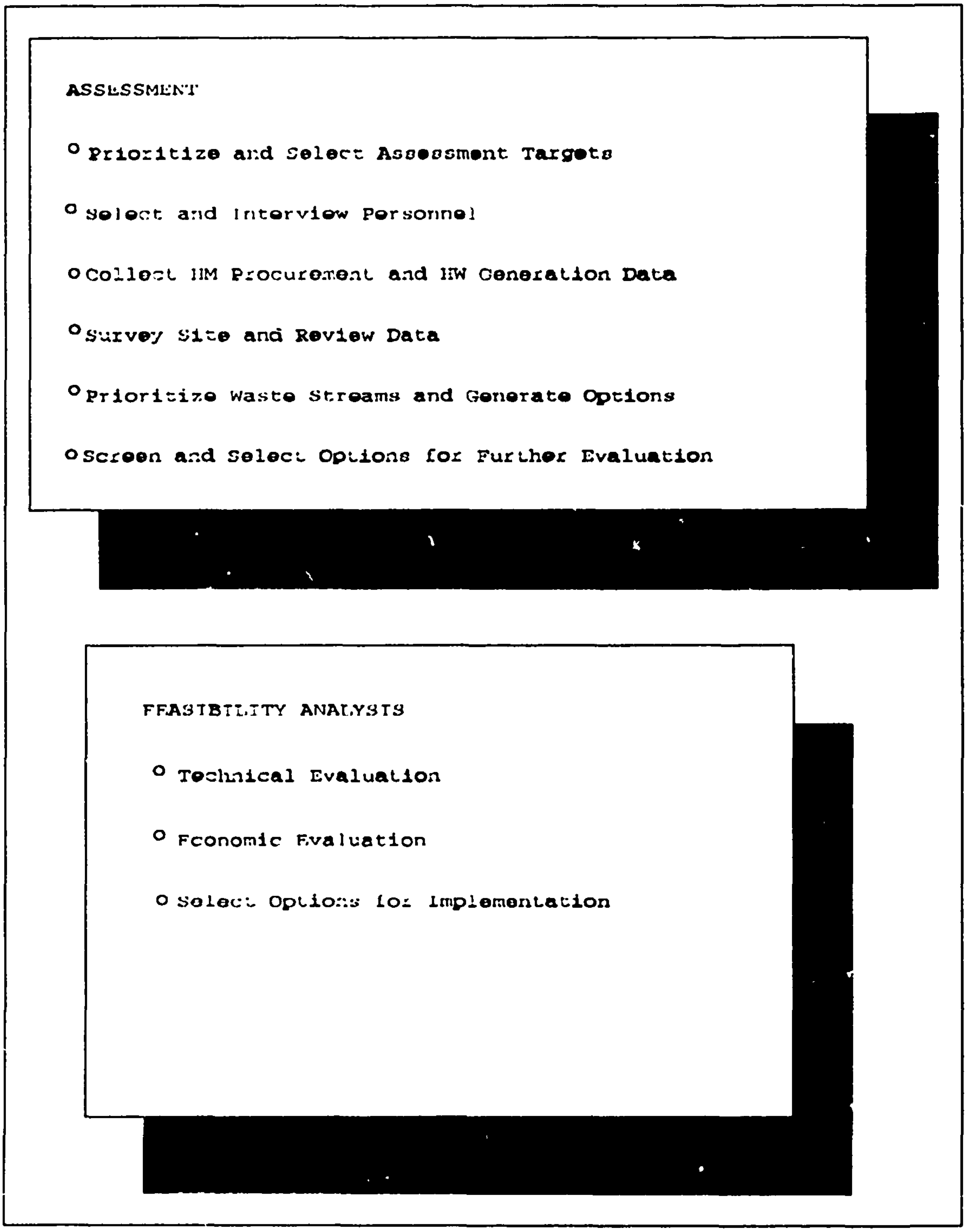


Figure 4. Hazardous waste minimization assessment and feasibility analysis procedure.

3 FORT CAMPBELL

History/Geography

Fort Campbell is located on the border of Tennessee and Kentucky. Its neighboring towns are Hopkinsville, KY and Clarksville, TN. Fort Campbell is located in four counties: Montgomery and Stewart Counties in Tennessee and Christian and Trigg Counties in Kentucky. It is approximately 50 miles northwest of Nashville, the Tennessee State capitol.

Fort Campbell covers about 105,350 acres; approximately two-thirds of the total land area is located in Tennessee. Geologically, Fort Campbell is located on the western portion of the Highland Rim Plateau and is underlain by nearly flat-lying limestone bedrock of Mississippian Age that dips gently toward the north-northeast. Sink holes and subterranean caves typical of Karst type topography are common within the reservation boundaries, but are not completely mapped. Mapped surficial deposits include well-rounded, unconsolidated gravels of the Tuscaloosa Formation (typical of hilltops and backslopes west and north of the impact area), stream alluvium deposited along perennial drainage channels, and a heavy (clayey) red residuum derived from the weathering of cherty limestone material. Fort Campbell is located within three low order drainage networks (Ringgold, Saline, and Casey Creeks) all of which are part of the Cumberland River watershed. The main cantonment area is located along the eastern boundary of the reservation.

Camp Campbell was established in 1942 and was named after William Bowen Campbell, a Congressman, Governor of Tennessee, and veteran of the Creek and Seminole Indian Wars and the Mexican War. It was procured by direct purchase, through condemnation proceedings, and by direct transfer from the Farm Security Administration. It was commissioned as a major armor training and mobilization center during WWII and served as a prisoner of war (POW) detention center for 4,000 German soldiers between mid-1943 and April 1946. In June 1948, the existing Campbell Army Airfield, operated at that time by the U.S. Air Force, became a Strategic Air Command installation.

In May 1949, Camp Campbell was changed from an armored post to an airborne post with the return of the 11th Airborne Division from Japan. The 11th Airborne Division established a jump school, cleared drop zones, and expanded airbase facilities. On April 14, 1950, Camp Campbell was redesignated as Fort Campbell and became a permanent post. During the Korean conflict, Fort Campbell served as a testing ground for many new military innovations, including electronic pop-up targets and the T-10 parachute. During this time, the fort was greatly expanded.

In January 1956, the 11th Airborne Division was replaced by the 101st Airborne Division, commonly known as the "Screaming Eagles" and one of the two oldest airborne divisions in the Army. Between 1956 and 1966, Fort Campbell experienced a resurgence in construction activity. In January 1959, the airfield was transferred from the USAF to the Army, and became the largest Army airfield.

When the 11th Airborne Division was transferred to Fort Benning, GA in 1962, a Basic Combat Training Center was established at Fort Campbell. Between 1966 and 1971, 50,000 men were trained annually at the Center for participation in the Vietnam conflict. In December 1967, the last members of the 101st Airborne were airlifted to Vietnam, to be replaced by the 6th Infantry Division (STRAC). In 1971, the 101st returned to Fort Campbell to replace the 6th Infantry Division. April 1974 marked the end of the 101st airborne capability as a result of losing its parachute jump status. Soon after, Fort Campbell adopted "Air Assault" status which it is presently under.

Tenants

Support and training of the 101st Airborne (Air Assault) is the primary mission of Fort Campbell. It supports a working population of approximately 35,000. The tenants that use the facilities available and/or provide support necessary to accomplish the mission are[24]:

1. Defense Reutilization and Marketing Office (DRMO)
2. Federal Aviation Administration (FAA)
3. 3rd Region, U.S. Army Criminal Investigation Command
4. Region III, U.S. Army Trial Defense Service
5. Resident Agency, Defense Investigative Service (DIS), Department of Defense (DOD)
6. HQ FORSCOM, DCS Resource Management, FORSCOM Manpower Staffing Standards Systems Activity (FORMSA), Field Measurement Team 1, (MS-3)
7. U.S. Army Area Test, Measuring, and Diagnostic Equipment (TMDE) Support Operations
8. U.S. Army Commissary
9. U.S. Army Corp of Engineers, Fort Campbell Area Office
10. U.S. Army Information Systems Command (USAISC)
11. U.S. Army Judiciary, First Judicial Circuit
12. U.S. Army Logistic Assistance Office
13. U.S. Army Medical Department Activity (MEDDAC)
14. U.S. Army Dental Activity (DENTAC)
15. Detachment 1, 5th Weather Squadron (MAC)
16. 2/31st Field Artillery
17. 95th Service Company (TMDE) Detachment - 101, ATST #101 TMDE Support Team #7
18. 101st Finance Support Unit
19. 101st Personnel Service Company
20. 114th Engineer Detachment (Fire Truck)
21. 17th Ordnance Detachment
22. Detachment 1, 436th Military Airlift Wing, Military Airlift Command (MAC), U.S. Air Force
23. Detachment 5, 507th Tactical Air Control Wing
24. 887th Engineer Company
25. Resident Office, 902d Military Intelligence Group
26. Army Air Force Exchange Service (AAFES)
27. A Company 1st Battalion 58th Aviation Regiment
28. U.S. Post Office
29. U.S. Army Corps of Engineers Area Office
30. 2101 Communications Squadron
31. 529th Engineer Detachment
32. American Red Cross

Fort Campbell provides facilities and training support for USAR and National Guard Units.

Environmental Programs

The following paragraphs discuss environmental quality as affected by the various generation sources at Fort Campbell. Because Fort Campbell is an installation that generates, treats, and stores

[24] *Manual of Organization, Mission, and Functions*, Regulation No. 10-8 (Department of the Army Headquarters, 101st Airborne Division (Air Assault) and Fort Campbell, Kentucky, May 14, 1987).

hazardous wastes and hazardous materials, it is regulated by Federal and State environmental laws, including the RCRA, the Clean Water Act, and the Clean Air Act.

Air Pollution

Because Fort Campbell is in two states, it is governed by two Air Quality Control Regions (AQCRs): the Paducah-Cairo Interstate AQCR in Kentucky and the Middle Tennessee Intrastate AQCR in Tennessee. Fort Campbell has approximately 900 permitted air pollution sources in Tennessee and approximately 100 in Kentucky. The two AQCRs in which Fort Campbell is located have attained the ambient air quality standards including total suspended particulates (TSP), sulfur dioxide (SO_2), carbon monoxide (CO_2), photochemical oxidants (O_x), and nitrogen dioxide (NO_2).

The Kentucky air programs are managed by the Division of Air Quality (DAQ) which keeps copies of regulations, helps solve local problems, and manages all federal permit programs. Kentucky's ambient air quality standards include limits on hydrogen sulfide, gaseous fluorides, and total fluorides[25]. Similarly, the Tennessee air programs are managed by the Division of Air Pollution Control.

Five major heating plants and a hospital incinerator are the primary stationary sources of air pollution emissions. Other sources include 12 paint spray booths; two carpentry shops; a laundry and dry cleaning facility with solvent storage tanks and two boilers; sanitary landfills; a construction waste landfill site; liquid fuel tanks (vapor emissions associated with fuel transfer to and from the tanks); open burning/open detonation sites; and unsurfaced roads and parking lots (fugitive dust). Mobile sources of air pollution include vehicle and aircraft emissions.

The heating plants currently use natural gas and No. 2 heating oil. They are in compliance with Tennessee and Kentucky regulations. All coal-fired boilers previously used were taken out of service. Fifteen of them were modified to use No. 2 heating oil; final compliance was achieved by July 1, 1979. The boilers in the hospital and Bldg 7008 currently use natural gas, but can be converted to No. 5 fuel oil.

Dust emissions from the carpenter shops on the post, most of the paint spray booths and the landfill sites is minimal and there have been no violations.

Fort Campbell has no inspection system for vehicle exhaust emission because there is no state requirement to do so.

Fort Campbell has a number of noise sources, including fixed-wing aircraft, rotary-wing aircraft, weapons firing, motor vehicles, railroad activities, and construction activities. Most of the aircraft noise complaints come from areas adjacent to helicopter corridors, and most blast complaints originate in small communities adjacent to the western boundary of the installation.

Water Pollution Control

All water quality programs including use, energy-related, and waste management activities in Kentucky are regulated, managed, and permitted via the Clean Water Act and the Division of Water. In Tennessee, water quality programs are regulated under three divisions: (1) the Division of Water Supply, (2) the Division of Construction Grants and Loans, and (3) the Division of Ground Water Protection. These three divisions are coordinated via the Office of Water Management.

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[25] D.H. Jessup, *Guide to State Environmental Programs* (Bureau of National Affairs Inc., Washington, D.C., 1988).

Fort Campbell receives most of its water from the Boiling Spring aquifer located near the Little West Fork Creek, just west of the main cantonment area. During the summer months the fort also gets water from the Red River which is about 13 km southeast of the installation boundary. Water treatment includes aeration, chemical addition and rapid mixing, coagulation and sedimentation, post chlorination, filtration, and final chemical addition. Gaseous chlorine is used for prechemical addition. Alum and lime are also added as needed to remove excess turbidity when the Red River water is used or after long periods of rainfall.

The DEH and Preventive Medicine (PVNTMED) Activity monitor the chemical composition of the water. USAEHA has also monitored the water for trihalomethanes, which are well below the maximum contaminant level.

Fort Campbell has one secondary treatment for sanitary sewage. The treated effluent is discharged to the Little West Fork Creek. The plant achieves 95 percent removal of Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS). The plant operators report no problems with plant operations other than infiltration during rainy weather.

Storm sewers and open swales and ditches make up the stormwater drainage system. Drainage infiltrates into the subsurface water through seep wells and sink holes. The major areas of concern include a northeast area contaminated by JP-4 where fueling and defueling operations take place, the motor pool in the south-central part of the installation, and two housing areas.

Solid Waste Management

In its recent history Fort Campbell has used a number of landfills, both on and offpost, for disposing of construction, natural, or residential related solid wastes. Depending on the disposal location, the solid waste management program on Fort Campbell has strived to remain in compliance with regulations promulgated by either the Commonwealth of Kentucky or the State of Tennessee. Traditionally, however, problems involving the illegal dumping or deliberate concealment of hazardous or otherwise prohibited wastes at the landfills have plagued Fort Campbell. The reported incidence of these problems seems accentuated when individual trop units undertake the responsibility of transporting garbage and trash collected from their respective facilities to the landfill without proper guidance or authority from their commanding officers. Currently all sanitary and construction related waste are taken to the primary landfill located on Fort Campbell. Prior to their covering and closure, problems noted at these sites included: (1) refuse being placed in eroded draws and ravines which increased leaching potential; (2) the presence of badly corroded cans containing unknown quantities of DS-2, Diazinon, and aircraft washing compound; (3) the discovery of a 55-gallon drum containing approximately 14 gallons of a corrosion removing compound; (4) the frequent uncontrolled blowing of trash and other light debris resulting from poor covering and compaction procedures; and (5) repeated instances of malicious dumping and unauthorized scavenging.

One landfill that was closed in 1967 was a low-level radioactive waste burial site containing filter elements, gloves, wipe samples, and twenty-three 55-gal drums of animal tissue waste. A USAEHA survey of this site found no significant radioactive contamination.

Hazardous Materials and Waste Management

Several Fort Campbell activities use toxic and hazardous chemicals and generate hazardous wastes in support of specific mission assignments. These activities include: (1) vehicle and aircraft maintenance, (2) printing, painting, and photographic processing, (3) laboratory and treatment procedures of the post potable water and sewage treatment plants, (4) medical, dental, and veterinary laboratories, (5) building and grounds pest control, (6) utilities maintenance, and (7) combat training exercises for specific troop units. The maintenance of ground vehicles and aircraft is the most significant waste generating activity. Small quantities of reagents used at the sewage treatment plant and medical laboratories are often neutralized and discharged to the sanitary sewer system. Photographic and medical laboratories generate large volumes of fixative from X-ray and other film processing from which silver is recovered as part of a precious metals recovery program. Fixative from which silver has been recovered is discharged to the sanitary sewer system.

Fort Campbell currently has no hazardous waste conforming storage facility. It is working with the DRMO to obtain a Part B permit for such a facility. The Part B permit application must be approved by the State of Tennessee and the EPA before construction of such a facility can begin. Tentative approval for construction has been received.

The electrolyte from spent lead acid batteries is drained, drummed, and disposed of through DRMO as a corrosive hazardous waste. Until August 1989, battery acid was neutralized and discharged to the sanitary sewer system without screening for heavy metal contaminants.

Materials containing asbestos are used for steam pipe insulation in some of the older buildings. Protective measures need to be taken to minimize asbestos contact. The post has begun an asbestos removal program. In May 1989, the State of Tennessee initiated legal action which would force FTC to pay fines for the non-notification by a contractor concerning asbestos removal.

Radiological materials are stored and handled by two tenant activities: the 95th Service Company and the Civilian Calibration Team. These activities provide calibration for radiological monitoring devices. The calibrators contain sealed sources of radioactive material and are stored in lead-lined boxes. The storage area is monitored monthly.

Other radiation sources are used in weapons systems and compasses. Several hundred of these items are used and stored at Fort Campbell. If one is damaged, it is turned into the Installation Supply Service Office of the Directorate if Industrial Operations.

Aviation fuel (JP-4) motor fuels (MOGAS and diesel fuel), and motor lubricating oils constitute the major portion of Petroleum, Oils, and Lubricants (POL) procured on Fort Campbell. The daily testing of JP-4 for water contamination within helicopter fuel systems and at bulk storage tanks at Campbell Army Airfield and Sabre Army Heliport generates a sizable quantity of a relatively homogeneous waste stream that is easily disposed via Auburn University at little cost to Fort Campbell. The regular changing of crankcase and other lubricating oils from ground vehicles generates a large volume of used oil which is also accepted by Auburn if proven to be nonhazardous. Heating fuels (Numbers 2 and 5) comprise the next largest category of POL usage, but normally does not result in corresponding waste generation. Underground storage tanks used throughout Fort Campbell for POL products or wastes are pressure tested annually and monitored daily to detect anomalous fluctuations that could indicate a leaking tank or unauthorized dumping. These procedures are consistent with the installation's Spill Prevention Control and Countermeasures Plan (SPCCP) per RCRA regulation. The SPCCP also requires secondary containment structures for all aboveground storage tank systems that exceed 500 gallons or for aggregate drum storage facilities that exceed 1350 gallons in total capacity. Improved efforts must be made on the behalf of activities that use these facilities to properly construct and maintain containment structures according to instructions disseminated from the Energy, Environment, and Natural Resources Division (EENR) in order to avoid issues of regulatory non-compliance and site contamination.

Polychlorinated biphenyls (PCBs) exist on Fort Campbell in older electrical transformers and light ballast equipment only and are not generated as part of any ongoing processes. All online transformers on Fort Campbell have been sampled and analyzed for possible PCB contamination and properly identified in accordance with Federal regulations. The data collected from this survey are being organized into a computerized database by EENR. When removed from service, PCB contaminated (>50 ppm) equipment is immediately taken to a storage building (Building 5121), which was construction in June 1990, that conforms to all Federal regulations. PCB contaminated fluids (i.e., dielectric fluids and insulating oils) are drained only from leaking or damaged equipment and stored in properly labeled drums. Disposal of PCB contaminated waste is accomplished on private contract through the auspices of DRMO.

The open burning and open demolition (OB/OD) of unexploded ordnance and other pyrotechnics are conducted by the 17th EOD in the Demo-11 Area. Demolition is performed in unlined earthen pits or trenches which are subsequently covered with soil. As a result of these activities, Fort Campbell maintains a Part A RCRA permit with the USEPA Region IV Administrator as an owner/operator of a thermal treatment facility. A 90-day extension for completing a Part B application has recently been submitted to allow the incorporation of procedural improvements pursuant to a recent investigation concerning activities at the Demo-11 Area conducted by U.S. Army Toxic and Hazardous Materials Agency (USATHAMA).

A number of small industrial operations on Fort Campbell produce small quantities of assorted industrial wastes; no single, large waste-producing industrial operations exist. Industrial wastes include oils and solvents, paint waste, and acidic wastes. Since the quantities of industrial wastes plus waste explosives generated exceed the 1,000 kg/mo limit of Hazardous Waste Management System (HWMS), Fort Campbell is classified as a large generator of hazardous waste.

The regular maintenance of ground vehicles and other motorized equipment generates used lubricating oils; hydraulic, brake, and transmission fluids; degreasing solvents; spent antifreeze solution; and unserviceable lead-acid batteries. Used oil, hydraulic, brake, and transmission fluids are collected in 55-gal drums or 400- to 600-gal pods near the generation site until arrangements can be made through EENR to transfer it to underground storage tanks (USTs) located throughout the post. Clor-D-Tect screening kits were once used at individual accumulation sites before the phase of onpost transfer and consolidation. Use of the kits as regular procedure has since been discontinued because of their reported unreliability. The USTs are owned by Fort Campbell but are maintained by DRMO and range in capacity from 4,000 to 12,000 gallons. Complete laboratory analyses are performed on representative samples from the USTs to assess the presence of hazardous contaminants which render the oil off-specification for recycling or energy recovery. Nonhazardous, or on-specification, used oil is transferred to Auburn University at no cost. Hazardous, or off-specification, used oil is also contracted through DRMO, but at substantial cost to Fort Campbell. Although at one time spent degreasing solvents (primarily PD680 Types I and II) and small quantities of contaminated fuels were routinely mixed with used oil at individual motor pools, tightened control of waste segregation procedures, the implementation of a closed-loop solvent recycling program with Safety Kleen, and improved guidance from EENR has markedly improved its recyclability and lowered the incidence of hazardous waste oil generation on Fort Campbell. Additional improvements in used oil management could be obtained by prohibiting the commingling of hydraulic and brake fluids which contain synthetic bases and hinder its reuse as an industrial boiler fuel.

Motor vehicle painting generates waste paints, thinners, and residues. Most large scale painting is performed at special paint booths although some touch-up or spot vehicle painting is performed in motor pools or parking areas. The camouflage paint used may contain lead, and the thinner used to clean the spray guns has a xylene or toluene base. Solidified paint waste is collected and disposed of in the landfill with other solid wastes. These wastes are not tested for EP toxicity and/or ignitability to determine if they are hazardous. Liquified paint wastes (residue of chemical agent resistant coating and thinner) are disposed of as HW.

Helicopter maintenance wastes include contaminated fuels, used oil, used solvents, and paint waste. Contaminated fuel and used oils are collected and disposed of by DRMO or sold to recyclers. Paint waste from helicopter operations include toluene based solvents and infrared (IR) paint of unknown composition. These wastes are drummed and transferred to DRMO for disposal.

Wastes from the various aviation maintenance shops include used lubricating and hydraulic oils, halogenated and nonhalogenated cleaning solvents, methyl ethyl ketone (MEK), and Nickel-Cadmium (NICAD) batteries. These are also drummed and transferred to DRMO for disposal.

The DOL weapons shop generates waste 1,1,1-trichloroethane, nonhalogenated degreasing solvents (PD-680), and used oils. Waste 1,1,1-trichloroethane is drummed and sent to DRMO for HW disposal.

Solid waste from the furniture shop is disposed of in the landfill, since the paint used in the furniture operation contains no lead.

The rubber drum repair facility generates waste fuel, since the drums must be emptied before repair. Waste fuels are stored onsite until arrangements can be made for its disposal.

Solid waste (dry cleaning solvent sludge) generated by the post laundry is classified as hazardous based on ignitability criteria and is disposed of in special drums as HW. The solvent used at this facility is PD680-I.

Most of the newer motorpools on Fort Campbell have vehicle wash racks connected to oil-water separators to prevent the inadvertent discharge of oily waste waters to the sanitary sewer system. Although such facilities are permitted under the National Pollutant Discharge Elimination System (NPDES), the operational efficiency of many of these systems has been hampered from excessive accumulations of mud and grit which enter the separators from washing heavily soiled vehicles returning from the field. Once clogged, the racks backfill with addition influxes of sediment, become stagnant, and continue to accumulate larger debris such as trash and leaves. Vehicles returning from the field should be cleansed of heavy mud accumulations outside the cantonment area at the central wash facility before entering the motorpools. Greater control over the use of the motorpool wash racks should be exercised by Battalion maintenance supervisor to ensure the operational efficiency of the oil-water separators. Older motorpools typically lack modern vehicle wash facilities and use compacted gravel pads with supplied water outlets. Both privately owned and military vehicles were observed in these areas during the site visit. No oil-water separators exist at these facilities which discharge directly into nearby drainage ditches or adjacent inlets to the sanitary sewer system. Similar problems of excessive mud accumulation and poor quality control were noted at these facilities. Privately owned vehicles should be prohibited from such areas.

Pesticides/Pest Management

Insecticides, rodenticides, herbicides, and fungicides are stored and/or used by the Entomology Section, Buildings and Grounds, the Golf Course Activity, and Supply and Services Division. Most of these facilities do not conform to USAEHA guidelines that require curbed, impervious floors for storage of pesticides. Some of them lack proper signage and security. Empty pesticide containers are rinsed and disposed of at the post sanitary landfill; the wastewaters are either sprayed over the treated area or are used as diluents for subsequent formulations.

4 SOURCES OF WASTE GENERATION AND TYPES OF WASTES

FORSCOM installations are generally administrative, hospital/medical, or active troop installations. Various quantities of hazardous wastes are generated depending on their respective installation mission. Table 2 shows the quantities of hazardous waste generated at 22 installations.[26]

Fort Campbell generated 181.1, 42.3, and 83.7 metric tons in 1985, 1986, and 1987 respectively, as reported in their annual Defense Environmental Status Reports and survey forms completed for V.J. Ciccone and Associates, Inc. These are wastes that were turned in to the Defense Reutilization and Marketing Service for proper disposal. These numbers do not reflect quantities of: waste oil that is being recycled for heat recovery; acid drained and neutralized from lead-acid batteries; diesel or aviation fuels burned in fire training exercises; unexploded ammunition and explosives detonated at OB/OD pits; contaminated water treated at the wastewater treatment plant; hazardous air emissions; etc.

The data presented in this chapter were obtained from a survey of the various generators, offsite shipping manifests, and waste generation data kept on file at the EENR Office of the DEH. An analysis of the data indicates that the average waste generation rate (excluding PCB-contaminated equipment) is 2,212,124 lb/yr. Approximately 180,887 lb/yr of this total are disposed as RCRA regulated hazardous wastes.

Source Types

Many different source types generate hazardous wastes. It is necessary to understand each of the source types and the wastes generated before attempting to minimize the total quantities generated.

Fort Campbell is an active troop installation and Headquarters of the 101st Airborne Division and the U.S. Army Air Assault School. The majority of hazardous and potentially hazardous waste generated is attributable to the maintenance and repair of motorized ground vehicles and aircraft necessary to accomplish the mission of the 101st Airborne and the installation. As such, there are few major waste streams, such as contaminated fuels, used oil, drained lead-acid batteries, and several minor types of miscellaneous wastes that require quantitative characterization. The development of the HAZMIN plan for Fort Campbell involved individual assessment of each generator and included a survey of the types and quantity of waste produced. The first step was to identify and prioritize all the generators on the installation. Next, each generator was examined in order of decreasing importance for characterization of waste streams generated. The most important waste streams were then studied to determine alternative minimization management options and the economic and technical feasibility of their implementation.

Three different criteria were used to determine the ranking of the different types of sources. The first is the number of such sources on an installation, which can vary depending on the installation's mission. The second is the numbers and quantities of waste streams generated at each type of source, which is generally known or can be estimated. And the third is the minimization potential (including provision for cost of managing wastes) for the wastes for each type of source, which is important in developing a feasible waste minimization plan. Based on the above criteria, each source type was scored on a scale of 1 to 5. The ranking of sources, shown in Table 3, is in decreasing order of the total scores. Each source type is discussed in the same order below.

[26] V.J. Ciccone and Associates, Inc., p C-4.

Motor Pools and Vehicle Maintenance Facilities (MPVM)

FORSCOM installations typically have a variety of motor pools and vehicle maintenance facilities for tactical and nontactical vehicles. Nontactical vehicle motor pools are used to service and maintain all the administrative vehicles (e.g., cars, vans, trucks, etc.), engineering maintenance vehicles (e.g., trucks, bulldozers, forklifts, etc.) and grounds maintenance vehicles (e.g., tractors, mowers, etc.) on the installation. Servicing and maintenance of tactical vehicles is performed at various troop and tactical vehicle motor pools. Tactical vehicles can be divided into track-laying vehicles (e.g., self-propelled howitzers, guns, mortars, armored personnel carriers, etc.) and wheeled vehicles (e.g., cargo trucks, ambulances, truck tractors, wreckers, etc.). Fort Campbell has a number of motor pools and vehicle maintenance (MPVM) facilities as shown in Table 4.

Various levels of services are performed on the vehicles at each of the motor pools and vehicle maintenance facilities. Included in the services are: periodic maintenance (e.g., fluids change, tuneup, etc.), transmission maintenance, engine repair, brake servicing, battery repair/servicing, front-end alignment, and unique repairs (as required, for different tactical vehicles). The typical repair operations that use hazardous materials and generate hazardous wastes are: oil and grease removal, engine parts and equipment cleaning, solution replacement, and paint stripping and painting (discussed later under *Paint Shops*). Among the equipment commonly used at motor pools and vehicle maintenance facilities are: solvent sinks (parts cleaning), hot tanks (for engine and radiator cleaning), and spray equipment.

Some general categories of hazardous materials used at motor pools and vehicle maintenance facilities are: batteries, oils, petroleum distillates, mineral spirits, varsol, halogenated solvents, aromatic hydrocarbons, oxygenated hydrocarbons, mixtures, acids, and alkalis. A variety of nonhazardous materials (e.g., sorbent, rags, etc.) are used in conjunction with these hazardous materials and also generate hazardous wastes.

Each motor pool generates different quantities of wastes (Table 5). For comparison, some of the hazardous and nonhazardous materials used that lead to the generation of wastes are listed in Table 6. The blanks in these tables (and similar tables throughout this report) do not represent zero generation, but rather that the data was not available.

MPVM #49 [801st MNT BN-Heavy Support Section, Building 5717] is the largest waste generator (297,775 lb/yr) of the MPVMs on Fort Campbell. As a heavy equipment repair and support shop for several other units on post, MPVM #49 generates large quantities of used engine oil (75,000 lb/yr), contaminated brake and transmission fluid (65,250 lb/yr combined), and spent antifreeze solution (45,000 lb/yr). Delta Company of the 801st MNT BN also staffs one of the primary lead-acid battery exchange points on Fort Campbell. It is located in an adjacent facility (Building 5712). Nonserviceable batteries generated by units within the maintenance and support mission of DISCOM are brought to Building 5712 for direct exchange through the TSO (Technical Supply Office). Preparing new batteries for issue and use is also accomplished in Building 5712. Until recently, the electrolyte from nonserviceable vehicle batteries was drained into plastic tubs, neutralized with sodium bicarbonate, and discharged to the sanitary sewer. Generally, the procedure was poorly controlled, from both worker safety and environmental compliance perspectives, as witnessed during the site visit and evidenced by the heavily corroded floor drain leading to the sewer system. Draining and neutralization was purportedly necessary due to the lack of heated storage space at DRMO and the risk of batteries cracking during freezing temperatures of the winter months. With the recent completion of a heated storage facility at DRMO specifically for nonserviceable batteries, the draining and neutralizing of battery acid has been discontinued post-wide. Batteries are now accepted with their acid for transfer to the Department of Energy (DOE) by a licensed hauler. Acid is drained only from leaking or badly damaged batteries and turned in to DRMO for disposal as a hazardous waste. This change in practice has eliminated a source of tremendous liability for Fort Campbell, decreased the quantity of corrosive hazardous waste generated by the installation, and improved working conditions for battery shop personnel. Because MPVM #49 is one of the largest handlers of hazardous materials and the largest reported generator of hazardous wastes, the unit needs a modern facility and an increased awareness of the necessity and incentives of proper material and waste storage procedures.

MPVM #33 [541st TRANS CO, Building 5813], is the second largest waste generator (179,780 lb/yr) of the MPVMs at Fort Campbell and represents approximately 8 percent of the total waste generation reported by the base. The most significant waste stream reported for disposal through DRMO is contaminated JP-4 (157,125 lb/yr). The 541st provides bulk distribution of JP-4 and other aviation fuels to rapid refueling points operated by the 102nd Quartermaster Company and to other units during field training exercises. The unit is one of several subordinate support elements of the Eagle Support Brigade (ESB) whose primary mission is to support and ensure combat readiness of the 101st Airborne Division (Air Assault) and the installation. The 541st is also responsible for providing equipment and personnel to move refrigerated vans during field training. The unit uses over fifty 5-ton tractors, several 2 1/2-ton trucks, and other transportation and general purpose equipment which they also maintain and service. Other significant wastes generated include used oil (1350 lb/yr), spent degreasing solvent (600 lb/yr), and nonserviceable lead-acid batteries (19,500 lb/yr) which are exchanged through the 584th MNT CO DSU.

MPVM #52 [DOL SUPPLY & SERVICE DIV - Vehicle and Equipment Unit, Building 5346] is the third largest reported generator of wastes (68,875 lb/yr) of which nonserviceable lead-acid batteries (25,000 lb/yr), contaminated mogas and diesel fuels (21,000 lb/yr), spent antifreeze solution (9000 lb/yr), sulfuric acid (7500 lb/yr), and used motor oil (6375 lb/yr) are the primary waste streams. Wastes reported from MPVM #52 account for approximately 3 percent of Fort Campbell's total and are generated from the maintenance of ISSD Material Handling Equipment (MHE) and the activities of the Operational Cannibalization Point for the installation. Wastes generated at this facility are segregated into appropriate receptacles and disposed through DRMO. Nonserviceable lead-acid batteries are drained onsite and filled with sodium bicarbonate prior to being turned in to DRMO. The drained electrolyte is containerized in plastic disposal drums and turned in to DRMO.

MPVM #35 [584th MNT CO DSU, Building 6535] is the fourth largest generator of wastes among the MPVMs (55,976 lb/yr) and is a relatively new facility located on the Kentucky side of the main cantonment area. The facility has several large maintenance bays, which are organized into specific shop repair sections; a large paved compound for storing equipment scheduled for repair; a sheltered, secure hazardous materials storage area; underground waste oil storage tanks; and a grated drainage system with an oil/water separator to catch and treat wash from the paved parking compound. Specific shop operations within MPVM #35 include automotive fuel and electronics systems repair; armament, glass, and radiator repair; and general and heavy engineering equipment repair. Smaller waste generating activities include a communications and electronics equipment repair section and ORF (Operational Readiness Float) maintenance. The local mission of the 584th MNT CO DSU is to provide direct support maintenance and repair, parts support to assigned and attached ESB Headquarters Command units and other elements of the 101st Airborne (Air Assault). This mission includes the responsibility of managing the receipt and neutralization of nonserviceable lead-acid batteries and the preparation and delivery of new batteries in exchange. Battery draining, neutralization of the acid with sodium bicarbonate, decanting of fresh acid into new batteries, and battery charging are performed in a small building adjacent to the larger maintenance bays. Drained lead-acid battery casings are the largest waste stream from this MPVM although no accurate quantitative data could be derived by either personnel in the battery shop or the Company Executive Officer. Equipment assigned to the 584th MNT CO DSU to perform its intended mission include large MHE (Material Handling Equipment, i.e., cranes, forklifts), general and heavy engineering equipment (bucket loaders, bulldozers), 2 1/2-ton, 5-ton, and 10-ton tractor trucks, and several pieces of smaller general purpose equipment. Wastes generated from the repair and maintenance of this equipment, as well as equipment scheduled from assigned units includes used oil (20,250 lb/yr), contaminated hydraulic fluid (3750 lb/yr), spent degreasing solvent (3150 lb/yr), and spent antifreeze solution (2700 lb/yr). The wastes generated at MPVM #35 represent less than 3 percent of the total reported generation rate for Fort Campbell.

MPVM #41 [426th SUPPLY & TRANS CO, Building 6874] is a recently constructed (January 1988), consolidated maintenance facility located on the Tennessee side of the cantonment area. The facility supports the operations of five subordinate companies of the 426th SUPPLY & TRANS CO (HSC, A, B, C, D) and two attached units (53rd QM DET and the 63rd CHEM CO). Waste data reported in Table 5 are reflective of the combined maintenance and operational activities of these units. Wash racks, inspection/grease racks, material and waste storage areas, and maintenance bays are shared, although forward support companies of the 426th (A, B, and C) are the dominant waste generating units. MPVM #41 ranks fifth in total waste generation among the MPVMs and accounts for approximately 2 percent (50,880 lb/yr) of all wastes reported. The 426th S & T BN is one of four primary battalions or regiments within the logistical and material support mission of DISCOM. Authorized equipment includes: seventy-five 5-ton tractors; twenty 2 1/2-ton trucks; forty forklifts ranging in size class from 4000 to 10,000 lb; twenty-two 3-30 kW field generators; and several smaller general purpose vehicles. Contaminated JP-4 (37,500 lb/yr) is the largest waste stream attributable to MPVM #41 followed by nonserviceable lead-acid batteries (3900 lb/yr) which are exchanged one-for-one with new batteries through Delta Company of the 801st MNT BN, contaminated water (1700 lb/yr), contaminated transmission fluid (1500 lb/yr), contaminated diesel fuel (1125 lb/yr), and spent degreasing solvent (1125 lb/yr). The facility has several maintenance bays, sheltered inspection/grease racks, and a wash pit used to remove heavy accumulations of clay and mud from vehicles before their repair. The compound is concrete paved and equipped with a drainage system that leads to an oil/water seperator attached to an underground storage tank (UST). USTs located near the inspection/grease racks may be accessed directly from funneled receptacles inside the maintenance bays or from sliding drip pans affixed to the grease rack. The exact locations of the USTs and their volumes was not immediately available although it was disclosed that the majority of liquid wastes generated from the maintenance bays are mixed into these tanks. Although MPVM #41 is a new maintenance facility with several conveniences the other MPVMs lack, poor supervisory control of maintenance actions and procedures has rendered the wash pit and drains of the wash racks inoperative due to excessive accumulation of trash and other debris, and has impaired the operational efficiency of the oil/water seperator due to the unscreened dumping of drain pans from the maintenance bay. Additional problems associated with worker negligence include the removal of plastic seals and threaded bung covers from several 55-gal drums of unused fog oil stored near the rear of the compound. Removal of these items has resulted in excessive leaking of fog oil and extensive contamination of the gravel pad on which they are stored. In one area, the continually leaking fog oil has begun to seep beneath the compound fence and into a nearby erosional gulley. Efforts to rectify the problem of unauthorized removal of bung covers or seals or to reduce the rate of leakage and ground contamination were not evident during the visit.

MPVM #34 [584th MNT CO, Building 5610] is an organizational level maintenance facility responsible for the regular servicing and maintenance of vehicles and equipment assigned to the Company. Equipment issued to the unit include: 43 field generators ranging in power output from 1.5 kW to 60 kW; twenty-eight 5-ton tractors; twenty-five 2 1/2-ton trucks; forklifts; wreckers; and smaller general purpose vehicles. Principle waste streams from this MPVM are contaminated fuels (13,500 lb/yr diesel and mogas), contaminated transmission and hydraulic fluids (9900 lb/yr combined), nonserviceable lead-acid batteries (9360 lb/yr), used motor oil (6750 lb/yr), and spent degreasing solvent (2700 lb/yr). Total waste generation from this MPVM (49,000 lb/yr) represents approximately 2 percent of the reported total for Fort Campbell. The facility is one of several older buildings within a maintenance compound located on the Tennessee side of the cantonment area which supports the organizational maintenance activities of other elements of the 561st S & S BN within the ESB.

MPVM facilities account for approximately 60 percent of all hazardous wastes generated on Fort Campbell and are the primary sources of used oil (403,666 lb/yr), contaminated fuels (306,011 lb/yr), nonserviceable lead-acid batteries (187,230 lb/yr), spent antifreeze solution (156,717 lb/yr), and spent degreasing solvent (50,604 lb/yr).

Industrial Maintenance, Small Arms Shops (IMSS)

The DOL and DEH are usually responsible for the major IMSS on a FORSCOM installation. The DOL and DEH industrial operations shops repair and maintain everything from office machines and furniture to small arms and nuclear weapons. Tenant units may also have industrial operations shops conducting maintenance and repair on a small scale. Table 7 lists all the IMSS located at Fort Campbell.

Industrial shops typically use vapor degreasers for degreasing operations, caustic dip tanks for cleaning iron and aluminum parts, battery recharging equipment and electrolyte neutralization tanks for battery repair/ replacement, painting and paint-stripping equipment (see *Paint Shops* section), and phosphoric/chromic acid tanks for small arms refinishing. These operations use hazardous materials and generate hazardous wastes. Table 8 shows a list of wastes that may be generated from the industrial shops.

Many different kinds of hazardous materials are used at these IMSSs, including halogenated solvents (TCE, 1,1,1-trichloroethane), paint thinners (xylene, toluene, etc.), corrosive chemicals (alkalis, acids, etc.), and radioactive materials. Most of the hazardous and nonhazardous materials used are listed in Table 9.

The principal IMSS hazardous waste generators on Fort Campbell are organized under the Shop Operations Branch of DOLs Maintenance Division. The Maintenance Division provides technical assistance and material maintenance support to general and direct support units of the 101st Airborne (Air Assault) and satellite organizations such as the U.S. Army Reserve (USAR) and the National Guard. Sections within the Shop Operations Branch engage in specific maintenance responsibilities that generate a variety of hazardous wastes which are characterized below.

IMSS #4 [DOL MNT DIV-Shop Operations Branch-Motorized/Heavy Equipment Repair and Powered Systems Support Sections, Building 754] is the largest reported waste generator (22,712 lb/yr) of the IMSS on Fort Campbell. Operations include repairing and overhauling heavy engineering, material handling, and grounds maintenance equipment, and portable power generating systems. Specific repair items include tractors, cranes, forklifts, fire fighting equipment, chassis components of military combat vehicles, field generators, and portable refrigeration/heating equipment. Resultant waste streams include used oil (15,000 lb/yr), nonserviceable lead-acid batteries (1950 lb/yr), contaminated transmission fluid (1875 lb/yr), spent degreasing solvent (1500 lb/yr), and spent antifreeze solution (900 lb/yr).

IMSS #1 [DOL MNT DIV-Shop Operations Branch-Oil Analysis Laboratory Section, Building 7137] is the second largest waste generator (18,741 lb/yr). This section is responsible for testing to determine physical characteristics of used oil and other petroleum based fluids used in major component assemblies of motorized equipment. The test results pertaining to the concentration of microscopic wear metals, viscosity, or water content of submitted samples determine the frequency of fluid changes in major equipment and serve as a diagnostic aid in determining the internal condition of engines, gearboxes, transmission and transfer cases, and hydraulic systems. Participation in the testing program, which involves sampling petroleum fluids from various equipment at prescribed intervals and performance of maintenance recommendations made by the laboratory, is applicable to all commands, units (including the USAR and National Guard), and activities that operate or provide maintenance support to equipment on Fort Campbell. Benefits of this testing program include an accurate means for assessing when fluids and lubricants should be changed, which conserves material resources, and the early detection of possible mechanical failures, which improves equipment reliability and lowers support costs by reducing the incidence of catastrophic failures. Used oil (11,250 lb/yr) is the largest waste stream reported by IMSS #1, followed by contaminated JP-4 (6000 lb/yr), empty sample bottles (720 lb/yr), and contaminated grease (600 lb/yr). Spent halogenated degreasing solvents (1,1,1-trichloroethane and freon) are smaller volume waste streams (80 lb/yr) generated by cleaning laboratory equipment and are properly managed through segregation and disposal through DRMO.

IMSS #2 [DOL MNT DIV-Shop Operations Branch-Automotive End Item Repair Section, Building 752] is the third largest waste generator (11,703 lb/yr) and engages in the organizational and direct support maintenance on passenger motor vehicles, trucks, trailers, and tankers of both civilian and military design. Principle waste streams from this section include used oil (3750 lb/yr), nonserviceable lead-acid batteries (2000 lb/yr) spent antifreeze solution (1575 lb/yr), and spent degreasing solvent (1575 lb/yr). Battery acid is drained and neutralized onsite.

IMSS #3 [DOL MNT DIV-Shop Operations Branch-Automotive Component Rebuild Section, Building 753] is the next significant waste generator (6990 lb/yr) and performs general support testing and rebuilding of major component assemblies of governmental motorcycles, automobiles, and trucks. Used oil (1500 lb/yr) and spent degreasing solvent (1500 lb/yr) are the significant waste streams generated by this section, followed by spent antifreeze solution (900 lb/yr).

IMSS #8 [DOL TRANS DIV-Movements Branch-Rail and Yard Section Engine House, Building 837] is the fifth largest IMSS waste generator (5091 lb/yr) of which spent antifreeze solution is the largest waste stream (3240 lb/yr), followed by used engine oil (690 lb/yr) and nonserviceable lead-acid batteries which are brought to the Automotive End Item Repair Shop for neutralization. This shop maintains one 40-ton diesel/electric locomotive crane, and two 100-ton EMD locomotives. Oil is changed from this equipment based on the recommendations of the oil laboratory. Wastes generated at this facility are well managed through segregated storage and are secured in a locked area before disposal through DRMO. Hazardous and nonhazardous materials used in this maintenance section are stored in a seperate, well posted building adjacent to the rail house.

The five sections discussed above represent approximately 87 percent of the total waste generation reported by IMSS. Other IMSS activities within DOL and under the mission responsibilities of DISCOM and the AVN BDE, that use hazardous materials and generate hazardous wastes are listed in Table 7. Waste streams from these facilities are listed in Table 8 and are typically smaller in volume or quantity of generation and greater in diversity and hazardous potential. For comparison, some of the hazardous and nonhazardous materials used that lead to the generation of wastes are listed in Table 9.

Total waste generation from IMSS (73,836 lb/yr) is approximately 3 percent of the reported total for Fort Campbell (2,212,124 lb/yr). IMSS activities are considered the second most significant source of hazardous wastes on Fort Campbell.

Aviation Maintenance Facilities (AMF)

Most FORSCOM installations have aviation maintenance facilities for helicopters and airplanes. Various levels of services are performed on the aircraft at each of the facilities. Included in the services are: periodic maintenance (e.g., fluids change, tuneup, etc.), engine repair, brake servicing, battery repair/servicing, and unique repairs (if required, for different aircraft). There are 14 AMFs at Fort Campbell as shown in Table 10.

The typical repair operations that use hazardous materials and generate hazardous wastes are: oil and grease removal, engine parts and equipment cleaning, solution replacement, paint stripping, and painting (discussed later under *Paint Shops*). AMF commonly use: solvent sinks (parts cleaning), hot tanks (for engine cleaning), and spraying equipment. Table 11 lists the wastes generated at the AMF. Some general categories of hazardous materials used are: batteries, oils, petroleum distillates, mineral spirits, varsol, halogenated solvents, aromatic hydrocarbons, oxygenated hydrocarbons, mixtures, acids, and alkalis. A variety of nonhazardous materials (e.g., sorbent, rags, etc.) are used in conjunction with hazardous materials and also generate hazardous wastes. The hazardous and nonhazardous materials used at the AMF are listed in Table 12.

AMF are the third significant source of hazardous and nonhazardous wastes on Fort Campbell. Records on total waste generation (240,850 lb/yr) allocated to these activities indicate contaminated JP-4 (198,389 lb/yr), used aircraft engine oil (10,852 lb/yr), and nonserviceable NICAD battery cells as the principle waste streams. These wastes are generated from the scheduled maintenance and repair of combat attack and support helicopters and a few fixed winged aircraft assigned to the 101st Airborne Division (Air Assault). AMF outside the organization of the AVN BDE include units within DISCOM and the 160th SOAG (ABN), and maintenance and support operations of a civilian contractor (Crawford Technological Service, CTS). A second civilian contract has been awarded to Dynalelectron Corporation which operates a major painting facility in coordination with H Company 159th AVN, a tenant activity within DISCOM. AMF are located near one of the installation's two airfields (Sabre Army Heliport, SAH, and Campbell Army Airfield, CAAF). Although specific maintenance and repair responsibilities are performed at Company or Troop levels, storage of unused materials and generated wastes is frequently accomplished at the Battalion level within a given facility. The commingling and consolidation of the waste streams of several activities into a few waste storage areas (Battalion USTs and 500-gal pods) and the absence of accurate material consumption/waste generation data, created difficulties in assessing quantities and types of wastes generated within the AVN BDE. As a result, data provided in Tables 10 and 11 for elements of this BDE are incomplete; the total waste generation derived for AMF may be lower than expected.

With the exception of AMF #10 and #11 [1st and 3rd BN 101st AVN REGT, Building 6638] and AMF #8 [2nd SQDRN 17th CAV, Building 6628] the only source of quantitative waste generation data for the AVN BDE was obtained by reviewing disposal records on file at EENR. This data indicate that AMF #13 [7th BN 101st AVN REGT, Building 7920] is the largest generator of wastes (82,125 lb/yr) almost entirely composed of contaminated JP-4. AMF #12 [6th BN 101st AVN REGT, Building 6911] and AMF #14 [160th SOAG (ABN), CAAF] rank second and third based solely on their annual rate of contaminated JP-4 generation; 36,875 lb/yr and 33,000 lb/yr respectively.

AMFs #10 and #11 are the fourth and fifth largest generators, respectively. They operate from the same hangar at SAH and engage in repair and maintenance procedures of similar scope and scale. Completed survey forms from these facilities indicate that contaminated JP-4, spent sorbent, contaminated water, and used aircraft engine oil are the principle waste streams. The only effort toward segregation of different waste streams at this facility was the separation of used oil, hydraulic fluid, and solvent from contaminated JP-4, both of which are stored in USTs. Operations within these AMF are oriented toward maintenance and repair of approximately 35 helicopters (AH-1 Cobras, AH-60 Apaches, and OH-58 Scouts). Contaminated hydraulic fluid, spent degreasing solvent, and spent MEK are also significant waste streams generated from these facilities.

AMF #8 [2nd SQDRN 17th CAV, Building 6628] is the next significant generator of wastes and operates from a large maintenance hangar at SAH. Responsibilities of this Squadron are organized into six subordinate Troops (HSC, A, B, C, D, E) and entail the organizational level maintenance of approximately 50 helicopters (AH-1 Cobras, UH-60 Blackhawks, and OH-58 Scouts). Wastes from this facility are consolidated into a single 500-gal storage pod located on the flight ramp some distance from the maintenance hangar and adjacent to a MOGAS refueling point. During the visit, the pod was leaking badly from a faulty drain cock on its underneath side and several gallons of the commingled waste mixture had accumulated within the confines of the bermed concrete pad on which the pod was located. Hazardous and potentially hazardous materials observed in storage and in use for which no corresponding waste streams were reported include carbon removing compound, aircraft coating thinner, technical grade acetone, anti-icing compound, turbine engine gas path cleaner, and smaller volumes of miscellaneous materials such as paints, adhesives, and sealants. These materials were well organized and segregated in storage based on their inherent hazards (i.e., flammable, corrosive) and secure from the effects of weather and access by unauthorized personnel. Use of MEK at this facility has been discontinued and all material stocks have been turned in to DRMO. Supervisory personnel at this AMF should upgrade methods and procedures associated with the segregation and storage of hazardous wastes.

AMFs #1 and #2 [CTS- Transient Alert/POL Facility and Fixed Wing Aircraft Maintenance Shop, Buildings 7265 and 7161] are civilian operated activities located at CAAF. The two waste streams reported from AMF #1, contaminated JP-4 (13,500 lb/yr) and spent sorbent (1000 lb/yr), are derived from the daily testing of JP-4 stored in several, large USTs used to refuel transient aircraft and to clean up small spills associated with fuel transfer. Samples drawn daily from the USTs are examined for moisture or other sources of contamination and are temporarily stored onsite as flammable waste before being transferred to a larger waste storage tank located in the main cantonment area. Disposal of the contaminated fuel is arranged through DRMO on a regular basis. AMF #2 is a maintenance hangar used to house and repair two fixed wing aircraft (U-21 and C-12) assigned to CAAF for the transportation needs of the Commanding General and his immediate staff. Waste streams of significance from this shop include floorwash solution (468 lb/yr), used aircraft engine oil (180 lb/yr), spent MEK (150 lb/yr), and spent degreasing solvent (150 lb/yr). These wastes are containerized as they are generated and are transported to a hazardous waste storage area adjacent to the Contractor's MPVM (MPVM #50, Table 4). At this location, efforts are made to properly segregate and safely store hazardous wastes before disposal through DRMO.

Total reported waste generation from AMF on Fort Campbell (240,850 lb/yr) represents approximately 11 percent of the reported total for the installation (2,212,124 lb/yr). Approximately 82 percent of this waste volume is contaminated JP-4 and other aviation fuels (198,389 lb/yr) generated from storage, transfer, and testing before use. AMF are considered the third significant source type of hazardous and nonhazardous waste on Fort Campbell.

Paint Shops (PS)

A FORSCOM installation has painting operations ranging from painting with aerosol cans and brushes to painting large vehicles or aircraft with spray guns in large paint booths. Specific painting and protective coating maintenance responsibilities are delegated to different units on post respective to local mission assignments and to maximize the availability of necessary equipment and trained personnel. DEH paint shops are usually responsible for the exterior and interior painting of buildings, painting signs, road markings, utility equipment (i.e., light posts, fire hydrants, etc.), and grounds maintenance equipment. DOL paint shops typically use enclosed paint booths and handle work orders for large civilian and military equipment. Smaller scale painting operations are also common at auto crafts, art, and woodworking shops within DPCA, and TSC graphics and device sections of DPTM. The only potential hazardous waste associated with painting from aerosol cans, which is quite prevalent throughout Fort Campbell, is the empty paint can with wet/dried paint residue. Paint thinners used in large painting operations result in the generation of large quantities of ignitable hazardous waste.

There are nine painting facilities located on Fort Campbell, as listed in Table 13, that maintain operating permits with either Kentucky or Tennessee. Most of these shops are located on the

Tennessee side of the cantonment area and use paint booths with dry filtration systems for air intake and exhaust. The only wet filtration system on Fort Campbell is a water curtain located at PS #10. Shops that paint military vehicles and aircraft handle a heavy work load and generate most of the wastes reported in Table 14. The type and quantity of materials used at these shops are listed in Table 15.

PS #1 [DOL MNT DIV-Shop Operations Branch-Allied Trades Section, Buildings 756, 6490] is the largest generator of wastes (11,134 lb/yr) among the PS. Principal waste streams from this section are contaminated aircraft coating thinner (3375 lb/yr), liquid CARC residue (2884 lb/yr), empty cans that previously contained hazardous materials (1855 lb/yr), contaminated laquer thinner from cleaning spray equipment (1125 lb/yr), and contaminated xylene (1125 lb/yr). Three seperate paint booths are used at these two buildings, each reserved for specific coating procedures. The application of CARC compounds constitutes a large portion of this section's workload and materials contaminated by CARC comprise a large percentage of toal wastes reported. Building 756 has two paint booths; one for CARC application associated with smaller military vehicles submitted from organizational units, and the other for non-CARC work orders pertinent to civilian equipment. Larger military equipment is painted at Building 6490 which is reserved exclusively for application of CARC. Work orders handled at this building are derived primarily from direct support units such as the 801st MNT BN and 584th MNT CO. Spent air intake and exhaust filters from this paint booth are changed weekly by a private contractor and disposed of with dried paint residues in the sanitary landfill. Abrasive surface preparation procedures, such as grinding, sanding, and blasting are accomplished only at Building 756. Recovered abrasive residues are also disposed of in the sanitary landfill. The use of CARC compounds (which contain a toxic hexamethylene diisocyanate [HDI] monomer) and certain epoxy enamels which contain lead and hexavlent chromium, creates additional health hazards to those already associated with the application of xylene and toluene based thinners. The use of protective clothing, gloves, and respiratory equipment is mandatory. PS #1 is the largest generator of liquid CARC residue (approximately 40 to 60 percent CARC plus thinner and trash), which requires costly disposal as a hazardous waste. A reduction in the volume of this waste stream could be achieved easily by implementing more strict segregation procedures (i.e., separation of hazardous thinner and CARC from nonhazardous trash and empty paint cans). Segregation would improve the possibility of recycling and reusing the contaminated thinner through distillation. The quantity of hazardous waste req , costly disposal would be limited to still bottoms and raw material costs could be reduced b sing the reclaimed product.

PS #2 [H Company 159th AVN REGT, Building 7156] is the second significant generator of wastes (9617 lbs /yr) of which contaminated aircraft coating thinner (4950 lb/yr), contaminated paint and primer (1650 lb/yr), and spent paint stripper (1238 lb/yr) are the primary waste streams. H Company is a tenant operation assigned to the 8th BN 101st AVN REGT of DISCOM. One large (60 x 25 x 20ft) paint booth is used at this PS for painting helicopters assigned to the 101st Airborne Division (Air Assault). All painting procedures involving CARC or alkyd type coatings are accomplished by personnel employed by a civilian contractor (Dyn-Cort Corporation, Fort Worth, TX). The contractor does an excellent job of implementing and enforcing recommended safety procedures and exercises good management of generated wastes through proper containerization and segregative storage. Other significant waste streams from this PS include paint rags (600 lb/yr), spent plastic blasting media contaminated with various paint residues (560 lb/yr), and spent exhaust filters (206 lb/yr) from the paint booths; all are disposed through DRMO.

PS #4 [DPCA CMTY REC DIV-Skills Development Branch-Auto Crafts Shop, Building 5611] is the third significant waste generator (4732 lb/yr) and has one enclosed paint booth for painting personal vehicles belonging to military and civilian personnel. The paint booth is medium sized and uses fiberglass filter elements for air intake only. Overspray emissions are vented directly to the atmosphere through a large exhaust flue on the rear of the booth. As many as three cars per week are painted at this facility and patrons are responsible for providing their own materials (i.e., paint, primer, thinner). Equipment is provided by the shop which also manages the disposal of generated wastes through DRMO. Shop personnel displayed little concern for recommended waste storage and segregative procedures as was evident from the absence of labeled and accessible disposal containers and the accumulation of 55-gal drums of commingled waste mixtures behind the facility whose contents had spilled from influxes of rain and sloppy handling procedures. Waste streams derived from the mechanical maintenance of vehicles at this shop are summarized under MPVM (Table 5, MPVM #57). Wastes generated from the paint booth include contaminated paint thinners of various types (mineral spirits, laquer thinner, enamel reducer, and acetone) used to mix paint and clean equipment, empty paint cans and partially full cans of spoiled paint left at the facility by patrons upon completion of their work, and spent air intake filters from the walls of the paint booth.

Total wastes reported from PS represent approximately 1 percent (26,496 lb/yr) of the total generation rate for Fort Campbell and are comprised primarily of contaminated paint thinners (10,798 lb/yr) and other paint related wastes (8974 lb/yr) such as spoiled paint, contaminated protective clothing, spent paint booth filters, spent blasting media, and paint sludge mixtures. PS are considered the fourth significant source type of hazardous wastes on Fort Campbell.

Photography, Printing, and Arts/Crafts Shops (PPAS)

FORSCOM installations have photography and print shops that conduct a wide range of printing operations including standard forms, brochures, pamphlets, newsletters, and circulars. The shops perform image and plate processing. Image processing is a method for preparing artwork that includes typesetting and photoprocessing. The photographic process produces a negative with the light portions of the photographed object filled with large deposits of silver. Among the steps involved in a photographic process are: developing, fixing, washing, and reducing/intensifying. Wastes produced by the photographic processes include: chemical wastes, bath dumps, and wastewaters containing photoprocessing chemicals, silver, etc.

The printing process requires an image carrier (manual, mechanical, electrostatic, or photomechanical) that takes the ink from a roller and transfers it to a rubber blanket. The image is then transferred from the rubber blanket to a paper. Wastes produced from the printing process include: waste inks, trash, used plates, used ink containers, damaged or worn rubber blankets, waste press oils (lubricating oils), cleanup solvents, and rags.

There are seven PPAS on Fort Campbell (Table 16). Two of the facilities are under the Directorate of Plans, Training, and Mobilization (DPTM) and associated with the mission responsibilities of the Training Support Center (TSC). Material use and waste generation data were not obtained from these sections although the scope of work performed, equipment used, and to a degree the type of hazardous wastes generated may be generalized from experience in similar shops on other FORSCOM installations. These shops are included in the corresponding tables of this section with a brief discussion of their known waste generating procedures. Types and quantities of wastes generated from PPAS source types and materials use are listed in Tables 17 and 18, respectively.

PPAS #1 [DPTM TSC-Graphics and Device Shops, Building 847] is responsible for the design, production, and maintenance of informational and material support training aids. Graphics sections typically employ a variety of printing, painting, silk screening, duplicating, and diazo film developing equipment to produce visual training aids such as posters, catalogs, informational bulletins, and blue prints. Generated wastes include small quantities of spoiled ink, paint, and adhesives; spent paint thinners and halogenated plate cleaning chemicals; empty canisters and aerosol cans; spent photographic processing chemicals; and used anhydrous ammonia. Spent photographic chemicals containing silver are processed and discharged to the sanitary sewer. Waste inks may be recovered and remixed in the formulation of darker inks. Spoiled paints, empty aerosol cans, and contaminated rags may be landfilled providing they contain no liquid residues. Used anhydrous ammonia may be given to other users on post with less stringent material specifications. Device sections design and fabricate plastic, wooden, and metallic replicas of weapons, explosives, and other military hardware to exact size and weight specifications for training troops in the field. Other responsibilities entail constructing scale models to depict battle situations and painting of designed training aids. Wastes typically generated from device shops include small quantities of spoiled paint, mineral spirits, denatured alcohol, laquer thinner, waste plastics and resins, and empty containers or aerosol cans.

PPAS #2 [DPTM TSC-Photographic Shop, Building 832] designs, develops, and distributes both black and white and color photographic products for all civilian and military activities or units. Typical equipment used at photographic sections include processing machines for color or black and white film, prints, and slide negatives. Large quantities of processing chemicals (developers, fixers, toners, stabilizers, bleaches, replenishers, and rinse solutions) are generated from the use of this equipment and may be disposed of through various methods depending on the presence and concentration of hazardous constituents or recoverable silver. Silver is recovered as part of a precious metals recovery program from all contaminated photographic solutions before they are truned in to DRMO for disposal or discharge to the sanitary sewer system. Spent photo fixer (ammonium triosulfate, acetic acid solution) generated from processing black and white slide and print film contains the highest concentration of recoverable silver. Spent fixer solution is commonly transferred manually to in-house recovery units where it is gravimetrically passed through a two-stage bucket filter or electrostatic separator. Contained silver is concentrated into an aqueous sludge and removed periodically by in-house or post personnel. Most of the waste solutions generated at photographic shops do not contain silver or high concentrations of hazardous compounds and may be discharged directly to the sanitary sewer when diluted with copious quantities of water.

PPAS #6 [MEDDAC-BACH-Department of Radiology-X Ray Processing Section, Building 650B], is the largest reported generator of spent photographic fixer (48,246 lb/yr) and photographic developer (31,212 lb/yr). These wastes are derived from processing x-ray film at the main hospital and affiliated medical, dental, and veterinary clinics throughout the installation. These solutions are collected from the many facilities and brought to a central processing point for silver recovery. Effluent from the silver recovering unit is discharged to the sanitary sewer.

PPAS #3 [DPCA CMTY REC DIV-Skills Development Branch-Guenette Arts and Crafts Shop, Building 89] is a multicrafts shop that provides a variety of equipment for recreational use by military employees and members of their families. Hobby interests supported by this shop include photography, ceramics, lithography, painting, and silk screening, among others. The facility is a minor generator of hazardous and potentially hazardous wastes (2260 lb/yr) and, as a nonappropriated fund (NRF) facility, must finance many of its own activity interests. A fee charged to all patrons for use of equipment and provided supplies helps maintain the facility and provides funds to purchase new materials and to dispose of generated hazardous wastes. Hazardous wastes, such as spent mineral spirits, denatured alcohol, laquer thinner, acetone, and spoiled paints and inks are segregated and turned in to DRMO. In many instances, materials turned in by troop units because they do not meet military specifications are purchased at low cost by DPCA for use at PPAS #3 or other DPCA recreational facilities (i.e., Auto Crafts Shop). Local reuse of these materials, which include tools, camping equipment, cleaning solvent, paint thinner, etc., helps to lower material operating costs and decreases the quantity and cost of waste disposal.

PPAS #4 [DPCA SERV DIV-Publicity and Marketing Branch, Building 2157] is responsible for the design and production of advertisements and other marketing materials distributed to community and family activities on Fort Campbell. The reported waste total (730 lb/yr) from this facility is derived primarily from operating and cleaning the offset printing and platemaking equipment and is disposed of as nonhazardous waste in the sanitary landfill or discharged to the sanitary sewer system.

Hi-Speed blanket wash solution is the largest waste stream (384 lb/yr), followed by Copyrapid offset fixer (72 lb/yr), developer (60 lb/yr), and offset plate cleaner (56 lb/yr) that contains phosphoric acid and petroleum distallates. Many hazardous materials used at this shop are entirely consumed in the process and do not result in the generation of hazardous waste. Examples include 2-way surface cleaner (1,1,1-trichloroethane) and acrylic and flourescent spray paints (xylol and toluol based constituents) which result only in the generation of empty containers or aerosol cans. Wastes generated from the shelf-life expiration of materials or from incomplete use and spoilage due to poor closure or storage practices is not prevalent because materials are procurred on an "as needed" basis and their rate of consumption is closely monitored. PPAS #4 is the third significant generator of hazardous and potentially hazardous waste surveyed within this source type as characterized in Table 17.

Total wastes reported from PPAS source types (83,587 lb/yr) represents approximately 4 percent of the total generation rate for Fort Campbell and consists almost entirely of spent photographic solutions (82,712 lb/yr) that are diluted and discharged to the sanitary sewer. PPAS are the third largest generators of spent halogenated solvents (783 lb/yr), primarily from cleaning printing equipment, which are properly segregated from other waste streams and disposed of through DRMO. Overall, PPAS are considered the fifth significant source type of hazardous waste on Fort Campbell.

Hospitals, Clinics, and Laboratories (HCL)

A typical FORSCOM installation has at least one hospital (or medical center) providing full medical and dental services for active duty and retired military personnel and dependents on the installation. Each hospital has many clinics supporting different medical departments (anesthesiology, dermatology, internal medicine, obstetrics and gynecology, pathology, radiology, surgery, urology, etc.). Each department has laboratories that use hazardous materials and generate hazardous wastes. An installation may have other teaching facilities and laboratories for training personnel belonging to medical activities in the military services. Other dental and veterinary clinics and facilities may also be located on the installation. Table 19 lists the HCL on Fort Campbell that responded to circulated survey forms.

The preventive medicine department of the hospital is primarily responsible for the safety and security of medical staff and patients that may be exposed to hazardous materials/wastes and emissions. Many hazardous and radioactive materials are used in HCL that result in the generation of a variety of hazardous and potentially hazardous waste. The wastes generated and materials used are listed in Tables 20 and 21, respectively.

Colonel Florence A. Blanchfield Army Community Hospital (BACH) is a large, modern medical complex that functions as the primary health care facility for Fort Campbell. BACH and its affiliated laboratories and clinics are professionally staffed and operated by MEDDAC which also provides complete administrative and logistical support to dental activities (DENTAC). BACH and MEDDAC are part of the administrative organization of the Office of the Commander that serves as the Directorate of Health Services (DHS). MEDDAC is responsible for the overall development, implementation, and enforcement of regulations governing the use of hazardous materials and generation of hazardous wastes within DHS. The authority of enforcement and responsibility of compliance assurance has been appointed to the MEDDAC Safety Officer who coordinates specific management programs with individual Divisions, Services, and Activities. The Chief, Logistics Division, BACH, is responsible for the receipt, inspection, and temporary storage of hazardous wastes generated by HCL supported by MEDDAC and for coordinating with EENR for final disposition through DRMO. Regulations applicable to all users of hazardous materials or generators of hazardous waste include the maintenance of annual consumption/generation inventories, the provision and accessibility of toxic and hazardous chemical MSDSs, the development and implementation of approved emergency procedures pertaining to fire and accidental substance release, and the assurance that all hazardous materials and generated wastes are properly labeled, containerized, and securely stored.

HCL #1 [MEDDAC-BACH-Department of Pathology and Affiliated Laboratories, Building 650] is the largest generator of wastes (19,167 lb/yr) reported in Table 20. Medical infectious wastes (body fluids, contaminated clothing and protective equipment, gauze, plastic materials, broken glass exposed to infectious biological agents, and metallic sharps) comprise the largest waste stream (7250 lb/yr) generated from this department. These items are segregated from each other (i.e., sharps from fluids and clothing) and from noninfectious trash into designated containers or red colored bags and transported to the hospital incinerator or Pathology Department autoclaves for destruction or sterilization. Ash from the incinerator and encapsuled autoclave bags are disposed of in the sanitary landfill. Efforts are consistently made by departmental staff to reduce the quantity of medical infectious waste generated through careful segregation procedures and source reduction. Spent alcohols comprise the largest percentage of generated hazardous wastes (3650 lb/yr), followed by spent acids and bases (1737 lb/yr), nonhalogenated cleaning solvents (1440 lb/yr), and contaminated formaldehyde (640 lb/yr). These wastes and materials are properly managed through segregative storage and quality operating procedures strictly enforced within the department. Contaminated xylene (1125 lb/yr) represents a large percentage of the volume of spent cleaning solvents generated from HCL #1. Xylene is used exclusively within the Histology laboratory as a fixative in the preparation of tissue specimens and also as a cleaning solvent to remove mounting agents (paraffin) from microscope slides, micro media culture plates, and other glassware. Stringent product purity standards imposed in the laboratory environment necessitate a high grade solvent, one with high solvation capabilities that leaves no residues upon evaporation. The technical grade xylene used in the Histology laboratory has great potential to be recycled and reused in-house with the use of benchtop batch distillation equipment. The usefullness of this equipment could be extended to other volatile solvents used in volume in the laboratory, such as contaminated alcohols, with the purchase of a fractioning column. An economic analysis specific to the volume of xylene and ethyl alcohol use and waste generation at BACH is presented in Chapter 12. Pathological wastes (tissue specimens and body parts) comprise the third significant waste stream generated from HCL #1 that requires special handling, storage, and disposal procedures. Pathological wastes are transported to the hospital incinerator for thermal destruction as they are generated.

HCL #2 [MEDDAC-BACH-Logistics Division Executive Housekeeper/Contract Officer Representative, Building 650 B] is responsible for the collecting, transporting, and disposing of all medical infectious wastes generated from BACH, troop, dental, and veterinary clinics. Presently, medical infectious wastes are segregated into red bags or sharp keepers and destroyed at the newly installed (December 1989) hospital incinerator. A quantitative inventory of medical infectious wastes has been kept since March 1988. Based on these data, Fort Campbell treats approximately 10,448 pounds of medical infectious wastes each month (125,256 lb/yr). Also monitored are the number of hospital admissions and outpatients, number of surgical cases, and number of births each month. Monitoring the level of activity within medical infectious waste generating departments and the quantity of this type of waste requiring treatment and disposal each month provides a crude index for assessing the efficiency of material use and proficiency of waste segregation procedures of each department.

HCL #3 [MEDDAC-BACH-Pharmacy Service, Building 650] provides storage, preparation, and distribution of general prescription drugs, chemotherapeutics, antineoplastics, and other medical treatments issued to outpatients or requested for use by hospital research/medical staff. Typical waste streams generated from this service include shelf-life expired items, spent reagents and analytes, protective clothing, and contaminated handling and dispensing equipment. RCRA regulated wastes, listed or characteristic, are segregated, properly containerized, and physically disposed of through DRMO. Antineoplastics are incinerated as permitted by the state of Tennessee. DRMO is not authorized to assume custody for condemned drugs, or biologicals requiring special handling and storage. Disposition of these items must be accomplished by the generator or host facility through a licensed medical waste hauler.

HCL #4 [DPCA-DRUG CNTR DIV-Education and Training Branch-Biochemical/Urinalysis Laboratory, Building 2537] is the largest generator of medical infectious wastes (707 lb/yr) outside the organization of MEDDAC and BACH. These wastes, which consist of contaminated sample cups, blood viles, disposable sharps, protective equipment, and gauze, are accumulated and transported to BACH for required treatment and disposal procedures. Blood, urine, and other bodily fluids are discharged to the sanitary sewer.

Collectively, wastes reported from HCL represent approximately 7 percent (145,680 lb/yr) of the total waste generation for Fort Campbell. Medical infectious wastes account for the greatest percentage of this total (127,546 lb/yr), most of which are incinerated. Hazardous wastes account for the next largest percentage of this total and consist primarily of contaminated alcohols, nonhalogenated solvents, and spent acids and bases. Pathological and pharmaceutical wastes require special disposal considerations independent of the services provided by DRMO, but account for a small percentage of the total waste generation reported. HCL are considered the sixth significant source type of hazardous waste on Fort Campbell.

Other Source Types

Other source types at a typical FORSCOM installation are: heating and cooling plants, laundry and drycleaning facilities, sanitary landfills, wastewater treatment plants, troop units, industrial wastewater treatment plants, fire departments, hazardous waste storage facilities, POL storage yards, golf courses, grounds maintenance/garden shops, entomology shops, electrical maintenance shops, other storage warehouses, water treatment plants, and miscellaneous sources (unique to each installation).

Table 22 lists Troop Units on Fort Campbell that generate unusable decontamination agents, chemical detection kits, spent power packs used in communications and electronics equipment, and other miscellaneous wastes. Data presented in this table were derived from the review of a hazardous waste disposal data base maintained by EENR and, as a result, no corresponding hazardous/nonhazardous materials consumption table could be produced. Of the total wastes (100,045 lb/yr) presented in Table 23, unserviceable lead-acid batteries (65,277 lb/yr) and spent lithium cartridges (11,702 lb/yr) comprise the largest percentage. Spent magnesium oxide batteries (8196 lb/yr) is the second largest waste stream, followed by spent NICAD battery cells (4854 lb/yr). These waste items are generated from the operation of communications and other electronic equipment by individual troop units while in the field, during training maneuvers offbase, or from the natural discharge of the equipments' power packs while in storage. The listed quantity of lead-acid batteries was unattributable to a specific generator. With the exception of spent magnesium batteries, in quantities under 500 pounds, these items are considered hazardous by RCRA reactivity (lithium batteries) and EP toxicity (mercury batteries) characteristic criteria. The largest percentages of all three types of these batteries were traceable to Troop Unit #1 [1st BDE and Organizational Battalions]. These wastes are overpacked in drums and turned in to DRMO for disposal. Waste DS-2 (decontamination solution-2) is the fourth largest waste stream from Troop Units (4496 lb/yr). DS-2 is seldom used while in garrison or during training missions and is turned in for disposal primarily because of expiration of its dated shelf-life or from corrosive damage to its metallic container. DS-2 is centrally stored and distributed to individual Troop Units by Division Chemical for use in the event of chemical warfare. Waste DS-2 is turned in to DRMO for disposal as a corrosive hazardous waste. Other significant waste streams attributable to Troop Units listed in Table 22 include: spent protective mask filters (1157 lb/yr), waste Supertropical Bleach, STB, (495 lb/yr); and waste insecticides (483 lb/yr).

Table 24 lists grounds and utilities maintenance operations that responded to circulated HAZMIN survey forms but reported no generation of hazardous waste. The six activities listed are either DEH- or DPCA-affiliated and staffed by civilian personnel. They include: DPCA-Army Travel Camp; DPCA-Golf Course Grounds Maintenance Section; DEH-Exterior Electrical Maintenance Section (PCB contaminated transformers, capacitors); DEH-Boiler Plant Section; DEH-Entomology Section (insecticides, rodenticides, herbicides, fertilizers); and DEH-Roads and Grounds Maintenance Section.

Table 27 lists miscellaneous waste generators that do not fall within the source type operations previously discussed in this chapter. MISC #1 [DOL PLANS & OPN DIV- Laundry and Dry Cleaning Facility, Building 860] generates spent drycleaning fluid filters, drycleaning fluid sludge, and caustic laundry detergent that is flushed into the sanitary sewer. The spent filters contain diatomaceous earth, darco carbon, lint, and possibly residual quantities of drycleaning fluid (PD680-II). Currently, the spent filters are managed as ignitable hazardous wastes. Filters require replacement for approximately every 18,000 pounds of clothes drycleaned and are disposed of through DRMO. If the spent filters were tested and shown not to contain ignitable solvent residue, they could be disposed of as ordinary refuse in the sanitary landfill.

Wastes Selected for Technical/Economic Analysis

Specific waste streams chosen for technical/economic analysis were selected based on criteria of magnitude of generation, the availability of specific minimization management alternatives, and the feasibility of implementing such alternatives at Fort Campbell. Table 30 summarizes the data presented in the previous section that were obtained during the HAZMIN survey. Also included in this summary table are waste disposal data obtained from the EENR Office. In some instances, it was difficult to allocate EENR waste disposal information to a specific generator. However, this source of information proved useful in tracking infrequently generated or small volume waste streams to general source types (Organizational Troop Units), and as comparative data source for information collected from the circulation of HAZMIN survey forms. There are thirteen different waste categories considered in Table 30; they are listed on its last page. Categorical totals represent the cumulative total of respective waste stream units. Waste generation data were collected and summarized at the waste stream unit level. Table 31 presents the total wastes generation rate for Fort Campbell according to each of the waste categories and the generator source type. PCB-contaminated equipment have not been included in the above summaries.

As listed in Table 31, MPVM facilities generate the largest quantity (1,323,263 lb/yr) of wastes consisting primarily of used oil (403,666 lb/yr), nonserviceable lead-acid battery casings (187,230 lb/yr), spent antifreeze solution (156,717 lb/yr), spent battery electrolyte (80,430 lb/yr), and spent nonhalogenated degreasing solvent (50,604 lb/yr). AMF are ranked second in total generation (240,850 lb/yr) and generate waste streams similar to those reported from MPVM. They are: contaminated fuels (198,389 lb/yr); miscellaneous wastes (27,732 lb/yr); used oil from aircraft turbine engines (10,852 lb/yr); and spent nonhalogenated degreasing solvent (2554 lb/yr). HCL are the third largest generators of waste (145,680 lb/yr). Most of the waste consists of medical infectious wastes that are incinerated. Organizational Troop Units are ranked fourth (100,045 lb/yr) and are the largest generators of spent batteries from communications and electronics equipment and waste decontamination chemicals. IMSS facilities generate the next significant quantity of wastes (73,836 lb/yr), which includes used motor oil (38,054 lb/yr), spent nonhalogenated degreasing solvent (7090 lb/yr), contaminated fuels (7088 lb/yr), and spent antifreeze solution (6615 lb/yr). Other significant waste streams from IMSS include nonserviceable lead-acid batteries (4340 lb/yr) and spent halogenated degreasing solvents (1800 lb/yr) resulting from the solvent vapor-tank degreasing operations within DOL. PPAS are the sixth largest generators of wastes (83,578 lb/yr); most of the waste is nonhazardous and may be disposed of in the sanitary landfill or discharged to the sanitary sewer. PS are the seventh largest generators of waste

(26,496 lb/yr). A large percentage of the waste is managed as RCRA regulated hazardous wastes. Spent paint thinner (10,798 lb/yr) is the largest waste stream from this source type which is the primary source of this waste stream on Fort Campbell.

Other generators (i.e., DPCA Golf Course, the Post Fire Department, Water Treatment Facility, and DOL Laundry and Drycleaners) are the smallest reported source types of hazardous and potentially hazardous wastes on Fort Campbell. Heating and hot water facilities operated and maintained by DEH Utilities Branch are potentially large sources of waste (caustic boiler blowdown, contaminated heating fuel, spent boiler cleaning chemicals, etc.) as demonstrated at previously visited FORSCOM installations. No conclusive waste generation rates could be derived for these facilities on Fort Campbell.

Contaminated fuels comprise the largest category of wastes generated (511,488 lb/yr-23 percent of total), followed by used oils (452,761 lb/yr-20 percent), nonserviceable lead-acid batteries (285,080 lb/yr-13 percent), spent antifreeze solution (164,135 lb/y--7 percent), spent acids and bases (83,564 lb/yr-4 percent), spent photographic solutions (82,712 lb/yr-4 percent), spent nonhalogenated degreasing solvent (63,428 lb/yr-3 percent), and contaminated paint thinner (11,023 lb/yr-0.5 percent).

Waste streams or waste generating processes selected for technical and economic analysis are used engine oil, contaminated JP-4, nonserviceable lead-acid vehicle batteries and battery acid, spent antifreeze solution, spent nonhalogenated degreasing solvent, spent paint thinner, contaminated xylene and ethyl alcohol specific to BACH, spent halogenated degreasing solvent specific to 1,1,1-trichloroethane use at the DOL-Maintenance Division, and wet to dry filter type paint booth conversion applicable to the water curtain also used at DOL.

Table 2

Hazardous Waste Generation at FORSCOM Installations

	Quantity of Waste Generated (metric tons)			Quantity of Waste Generated Onsite (metric tons)			Quantity of Waste Generated Offsite (metric tons)		
	1985	1986	1987	1985	1986	1987	1985	1986	1987
Ft. A.P. Hill	n/a	0.6	810.7	n/a	0.6	810.7	0.0	0.0	0.0
Ft. Bragg	94.5	246.9	258.2	94.5	236.3	242.3	0.0	10.6	15.9
Ft. Buchanan	-	-	-	-	-	-	-	-	-
Ft. Campbell	181.1	42.3	83.7	181.1	42.3	83.7	0.0	0.0	0.0
Ft. Carson	37.5	29.1	28.9	37.5	29.1	28.9	0.0	0.0	0.0
Ft. Devens	1142.6	359.4	412.4	1142.6	359.4	412.4	0.0	0.0	0.0
Ft. Drum	18.4	89.0	0.7	18.4	89.0	0.7	0.0	0.0	0.0
Ft. Hood	46.5	238.5	129.8	46.5	223.0	129.6	0.0	15.5	0.3
Ft. Irwin	2090.4	1019.6	1224.1	2090.4	1019.6	1224.1	0.0	0.0	0.0
Ft. Lewis	n/a	214.3	668.3	n/a	187.3	649.3	n/a	27.0	19.0
Ft. McCoy	62.6	35.1	64.0	23.9	23.5	26.2	38.7	11.6	37.8
Ft. McPhearson	0.1	2.4	n/a	0.1	2.4	n/a	0.0	0.0	n/a
Ft. Meade	n/a	3.1	3.5	n/a	3.1	3.5	n/a	0.0	0.0
Ft. Ord	190.9	293.9	n/a	190.9	290.8	n/a	0.0	3.1	n/a
Ft. Polk	0.1	20.7	11.5	0.1	20.7	11.5	0.0	0.0	0.0
Presidio, SF	-	-	-	-	-	-	-	-	-
Ft. Richardson	21.1	16.4	4.8	21.1	16.4	4.8	0.0	0.0	0.0
Ft. Riley	18.6	18.6	18.6	18.6	18.6	18.6	0.0	0.0	0.0
Ft. Sam Houston	34.7	33.4	19.8	34.7	32.7	18.5	0.0	0.7	1.3
Ft. Sheridan	4.9	4.9	4.9	4.9	4.9	4.9	0.0	0.0	0.0
Ft. Stewart Hunter	7.7	302.4	445.8	7.7	302.4	445.8	0.0	0.0	0.0
Ft. Wainright	27.2	16.9	63.6	19.4	16.1	29.3	7.8	0.7	34.3
Total	3978.7	2987.5	4253.2	3932.2	2918.4	4144.7	46.4	69.1	111.5

Table 3

List of Sources Ranked in Order of Importance

Rank	Source Types	Numbers	Numbers and Quantities of Waste Streams	Minimization Potential	Total
I.	Motor pools & vehicle maintenance facilities	5	5	5	15
II.	Industrial maintenance, small arms shops, etc.	4	5	5	14
III.	Aviation maintenance facilities	4	5	4	13
IV.	Paint shops	4	4	4	12
V.	Photography, printing & arts/crafts shops	3	4	4	11
VI.	Hospitals, clinics, & laboratories	2	4	4	10
VII.	Troop NBC/COMMO	5	2	2	9
VIII.	Grounds maintenance and entomology shops	2	3	3	8
IX.	Miscellaneous	2	3	2	7

Table 4

Motor Pools and Vehicle Maintenance (MPVM) Facilities

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1. 1st BDE - Headquarters and Headquarters Company Motorpool - Building 6318
2. 1 - 327th INF BN - Battalion Motorpool - Building 6316
3. 2 - 327th INF BN - Battalion Motorpool - Building 6314
4. 3 - 327th INF BN - Battalion Motorpool - Building 6312
5. 2nd BDE - Headquarters and Headquarters Company Motorpool - Building 6518
6. 1 - 502nd INF BN - Battalion Motorpool - Building 6556
7. 2 - 502nd INF BN - Battalion Motorpool - Building 6504
8. 3 - 502nd INF BN - Battalion Motorpool - Building 6518
9. 3rd BGE - Headquarters and Headquarter Company Motorpool - Building 6783
10. 1 - 187th INF BN - Battalion Motorpool - Building 6850
11. 2 - 187th INF BN - Battalion Motorpool - Building 6847
12. 3 - 187th INF BN - Battalion Motorpool - Building 6849
13. DIVARTY - Headquarters and Headquarters Battery Motorpool - Building 7049
14. 1 - 320th FA BN - Battalion Motorpool - Building 7042
15. 2 - 320th FA BN - Battalion Motorpool - Building 7050
16. 3 - 320th FA BN - Battalion Motorpool - Building 7043
17. 2 - 44th ADA BN - Battalion Motorpool - Buildings 6512 and 6514
18. 106th SOAG (ABN) - Headquarters ad Service Company Motorpool - Building 5848
19. 5th SF GP (ABN) - Support Battalion - Battalion Motorpool - Building 3211
20. 311th MI BN - Battalion Motorpool - Building 6316
21. 501st SIG BN Battalion Motorpool - Building 5510
22. Law Enforcement Command - 101st MP CO. - Company Motorpool - Building 6808
23. 101st ABN Div - Headquarters and Headquarters Company Motorpool - Building 6843
24. 326th ENGR BN - Battalion Motorpool - Building 7062
25. 887th Light Equipment Company - Company Motorpool - Building 7062
26. 20th ENGR BN - Battalion Motorpool - Building J-6120
27. 29th TRANS BN - 372nd Transportation Company Motorpool - Building 6426
28. 29th TRANS BN - 494th Transportation Company Motorpool - Building 5918
29. 29th TRANS BN - 594 Transportation Company Motorpool - Buildings 5913 and 5908
30. 86th EVAC HOSP BN - Battalion Motorpool - Building 64_
31. 561st SUPPLY & SERVICE BN - 102nd Quarter Master (POL) Company Motorpool - Building 5819
32. 561st SUPPLY & SERVICE BN - 227th General Supply Company Motorpool - Building 5711
33. 561st SUPPLY & SERVICE BN - 541st Transportation Company Motorpool - Building 5813
34. 561st SUPPLY & SERVICE BN - 584th Maintenance Company Motorpool - Building 5610
35. 561st SUPPLY & SERVICE BN - 584th Maintenance Company Support Section - Buildings 6533 and 6535
36. DISCOM - Headquarters and Headquarters Company Motorpool - Building 6804
37. 8th BN 101st AVN REG - Headquarters and Headquarters Company Motorpool - Building 7134
38. 8th BN 101st AVN REG - A Company Motorpool - Building 7152
39. 3th BN 101st AVN REG - B Company Motorpool - Building 7210
40. 326th MED BN - Battalion motorpool - Building 5644
41. 426th SUPPLY & TRANS BN - Battalion Motorpool - Building 6784
42. 801st MNT BN - Headquarters and Light Maintenance Company Motorpool - Building 5725
43. 801st MNT BN - A Company Motorpool - Building T-5422
44. 801st MNT BN - A Company Forward Support Section - Building 5415
45. 801st MNT BN - B Company Motorpool - Building 5419
46. 801st MNT BN Company Forward Support Section - Building 5413
47. 801st MNT BN - C Company Motorpool - Building 5725
48. 801st MNT BN - C Company Forward Support Section - Building 5724
49. 801st MNT BN - D Company Heavy Maintenance Support Section - Buildings 5717 and 5712
50. CAAF - Departure/Arrival Control Group - Contractor Vehicle Maintenance Section - Building P7181
51. USAF - DET 1 436th MAW - Motorpool - Buildings 7170 and 7173
52. DOL - SUPPLY & SERVICE DIV - Vehicle and Equipment Maintenance Unit - Building 5346
53. DOL - TRANS DIV - Transportation Motorpool - Buildings 602 and 603
54. DEH - OPN & MNT DIV - Roads and Grounds Branch Vehicle Maintenance - Building 5123
55. DPCA - Community Recreation Division - Outdoor Recreation Branch Vehicle Maintenance - Buildings 5658 and F6621
56. DPCA - Community Recreation Division - Outdoor Rec. Branch Riding Stables Vehicle Maintenance Shop - Bldg. 6603
57. DPCA - Community Recreation Division - Skill Development Branch - Auto Crafts Shops - Buildings 5611 and 5670
58. DPCA - Education Division - Austin Peay St. University Automotive Technology Program - Building 5511
59. DPCA - Community Operations Division - Golf Course Vehicle Maintenance - Building 1568
60. AVN BDE - 3rd BN 101st AVN REGT - Battalion Motorpool - Building 6917

Table 5

Quantities of Wastes Generated at MPVM Facilities*

Type of Waste	1	2	3	4	5	6	7	8	9	10	11	12
Degreasing Solvent Nonhologenated	150	450	450	450	188	375	375	375	450	825	825	1125
Degreasing Solvent Hologenated	**											
Used Motor Oil	563	1650	1650	1650	1313	1875	1875	1875	1088	6750	675	4500
Fog Oil												
Antifreeze	585	1800	1800	1800	270	900	900	900	360	2250	1800	22500
Lead-Acid Batteries	2080	4680	4680	4680					650	2600		
Battery Acid												
Aqueous/Caustic Detergent										360		
Oily Grit/Sludge	20	30	30	30	20	50	50	50		10		60
Contaminated Soil												
Contaminated Water												
Spent Sorbent	400	1200	1200	1200	75	250	250	250	300	1500	1200	9600
MOGAS					375	1500	1500	1500	413	188	450	113
DF-2	38	150	150	150	1125	750	750	750	300	750	750	563
JP-4												
Dirty Rags	200	600	600	600	50	100	100	100	60	200	300	100
Transmission Fluid	600	1800	1800	1800	150	638	638	638	450	1125	1200	1725
Hydraulic Fluid												
Brake Fluid	15	38	38	38	38	113	113	113	450	188	300	38
Mixed Wastes					400	800	800	800				
Spoiled Paint												
Paint Thinner												
Xylene												
Contaminated Filters												
Methanol									75			
Contaminated Cases									5			10
Hazardous Faulty Parts					50	100	100	100	10	25	60	10
Floor Wash Detergent	170	510	510	510					298	850		
Empty Cans									5			10

*Quantities are reported in pounds per year.

**A blank in this and similar tables does not mean zero generation. Where data is unavailable, Fort Campbell should make every effort to locate the data and update the tables. Proper inventory control will generate data for future use in helping meet HAZMIN goals.

Table 5 (Cont'd)

Type of Waste	13	14	15	16	17	18	19	20	21	22	23	24	25
Degreasing Solvent Nonhologenated	150	225	675	225	1800	750		900	3000	225	750	4500	75
Degreasing Solvent Hologenated													
Used Motor Oil	1088	2625	2625	2438	5948	3750	3150	1800	12000	750	2363	11250	938
Fog Oil													
Antifreeze	360	270	540	450	900	900	900	540	630	495	1980	2160	90
Lead-Acid Batteries	1560	6500	6500	4875	7800				1625	3900	3770		
Battery Acid													
Aqueous/Caustic Detergent													
Oily Grit/Sludge	50			50	30	50			5				
Contaminated Soil													
Contaminated Water									850				
Spent Sorbent	40	1000	1000	1200	5000	180			400	500	300	300	20
MOGAS		188			188	75			300	15	75	375	
DF 2		563			375	300			75	60	338	1875	38
JP-4													
Dirty Rags		100			480		1200						100
Transmission Fluid	1125	263	225	225	1613	338		900	2325	338	300		188
Hydraulic Fluid					225		225						
Brake Fluid	38	188	38	113	225	38		900	225	38	38		38
Mixed Wastes					1350	100					225		100
Spoiled Paint													
Paint Thinner							75						
Xylene													
Contaminated Filters													
Methanol													
Contaminated Cases					380				35		21		
Hazardous Faulty Parts	400				36	20			25	50	30		25
Floor Wash Detergent	408				510	850			170		850	1632	43
Empty Cans					238		10		30				

Table 5 (Cont'd)

Type of Waste	26	27	28	29	30	31	32	33	34	35	36	37
Degreasing Solvent Nonhologenated	2850	750	750	750	375	1800	900	600	2700	3150	1500	750
Degreasing Solvent Hologenated												
Used Motor Oil	8108	750	2625	3565	750	1800	3150	1350	6750	20250	1500	225
Fog Oil												
Antifreeze	1890	4050	1575	1800	225	3240	720	180	2160	2700	450	675
Lead-Acid Batteries		2600		11700	975	7800	7800	19500	9360	180000		390
Battery Acid		10	200	10	10					20000		
Aqueous/Caustic Detergent					180	180						
Oily Grit/Sludge	50	40			10		30	50	100	1000	400	
Contaminated Soil												
Contaminated Water												
Spent Sorbent	1100	200	175	200	700		500	600		3000	275	800
MOGAS	375				375	1500			4500		38	38
DF-2	1500				750	7500			9000		525	338
JP-4												
Dirty Rags	1020	200	200	200	400	240	200	300	480		150	400
Transmission Fluid	2100	2175	1500	375	38	900	600	75	4950	338	1131	75
Hydraulic Fluid					150				4950	3750		
Brake Fluid	225	75	23	30	188	900	38		2250	38	38	38
Mixed Wastes		75				400					2500	
Spoiled Paint												
Paint Thinner					15							
Xylene												
Contaminated Filters												
Methanol												
Contaminated Cases	100						300		1800			
Hazardous Faulty Parts	250	30			25					50	15	30
Floor Wash Detergent	638	425								1700	8500	
Empty Cans	110	20			6							

Table 5 (Cont'd)

Type of Waste	38	39	40	41	42	43	44	45	46	47	48	49	50
Degreasing Solvent Nonhologenated	750	450	600	1125	113	750	150		1500	375	825	3150	450
Degreasing Solvent Hologenated							24						
Used Motor Oil	2063	1425	1500	450	1875	1500	900	3000	4500	1500	11250	75000	2250
Fog Oil													
Antifreeze	360		540	450	2250	450	1080	2250	2700	3150	18000	45000	450
Lead-Acid Batteries	650		3510	3900	1625	1300	390	2925	3250	2600	650	978750	1300
Battery Acid	50			100	10					20	20	50000	500
Aqueous/Coustic Detergent	180			450			198					900	180
Oily Grit/Sludge	20		20	35			550		20	5	25	2000	
Contaminated Soil												1000	
Contaminated Water	213		213	1700	85				425	170	213	2550	
Spent Sorvent	200	250	200	230	400	300	200	300	150	100	400	5000	700
MOGAS	38	150	75	375	75			225	113		188	11250	
DF-2	113	38	188	1125	150			750	638		75	26250	
JP-4													
Dirty Rags	300	60	100	200	240	200	125	200	200	100	300	5000	
Transmission Fluid	60	585	450	1500	225	750	413	150	2250	750	3600	63750	563
Hydraulic Fluid													1125
Brake Fluid	15	75	68	375	150	375	188	38	113	75	75	1500	8
Mixed Wastes													
Spoiled Paint													
Paint Thinner													
Xylene													
Contaminated Fluids													
Methanol													
Contaminated Cases	200		20	500	20	5	500		30	10	28	5000	100
Hazardous Faulty Parts			100	15	20	50	2000	10	20	15	50		
Floor Wash Detergent		255	85	850	978		94	1275	850	213	260	425	
Empty Cans			50	30	15		25		20	20	200		

Table 5 (Cont'd)

Type of Waste	51	52	53	54	55	56	57	58	59	60
Degreasing Solvent Nonhologenated	375		225	300	240	75	2250	563		150
Degreasing Solvent Hologenated			72	24				48	24	
Used Motor Oil	2250	6375	7313	11250	255	113	1500	1500	2475	450
Fcg Oil										
Antifreeze	900	9000	900	1800	711	36		450	270	135
Lead-Acid Batteries	260		4875	10000	780	130	3250		2210	2600
Battery Acid		7500		2000						
Aqueous/Caustic Detergent	1875			45	18					
Oily Grit/Sludge	10		50	25			40	20		
Contaminated Soil				100						
Contaminated Water										
Spent Sorbent	200		350	1000			2000	1000	250	400
MOGAS	375	9000	38	375		900				38
DF-2	1875	12000	75	1125	75					150
JP-4										
Dirty Rags			15600	500	10		2000	100	250	60
Transmission Fluid			1313	150	75			375	413	
Hydraulic Fluid	188								825	1875
Brake Fluid			188	38	15	8		10	23	75
Mixed Wastes				50	50					
Spoiled Paint										
Paint Thinner										
Xylene										
Contaminated Filters										
Methanol										
Contaminated Cases								20	360	
Hazardous Faulty Parts	10		200				200	10		30
Floor Wash Detergent							425			170
Empty Cans	70									

Table 6

Quantities of Hazardous/Nonhazardous Materials Used at MPVM Facilities*

Type of Materials	MPVM#	1	2	3	4	5	6	7	8	9	10	11	12
Degreasing Solvent, Nonhalogenated		188	563	563	563	225	375	375	375	450	825	938	1200
Degreasing Solvent, Halogenated													
Motor Oil		600	1688	1688	1688	1313	2250	2250	2250	1088	6750	750	4875
Antifreeze		585	1800	1800	1800	450	900	900	900	360	2250	1800	22500
Lead-Acid Batteries		2080	4680	4680	4680					650	2600		
Battery Acid													
Aqueous/Caustic Engine Detergent										360			
Floor Wash		170	510	510	510					298	850		
Methanol										75		38	188
Ether													
MOGAS										3750	1500	6750	7500
DF-2										18750	15000	162000	76500
JP-4													
Transmission Fluid		600	1800	1800	1800	150	638	638	638	450	1125	1313	3563
Hydraulic Fluid													
Brake Fluid		15	38	38	38	38	113	113	113	450	188	375	75
Paint, Latex										50			2500
Paint, Alkyd													
Paint Thinner										8			
Xylene													
Paint Filters													
Fluid Filters													
GAA Grease													375
Break Free													
Sorbent		400	1200	1200	1200	100	250	250	250	300	1500	1200	900
Rags		200	600	600	600	50	200	200	200	60	200	300	100
Hazardous Replacement Parts													
Paint, Aerosol													

*Quantities are reported in pounds per year.

Table 6 (Cont'd)

Type of Materials	MPVM#	13	14	15	16	17	18	19	20	21	22	23	24
Degreasing Solvent, Nonhalogenated		150	260	776	260	1800	750		900	3000	225	825	5175
Degreasing Solvent, Halogenated													
Motor Oil		1125	2625	2625	2438	7560	3750	3150	1800	12188	750	1838	11250
Antifreeze		540	135	270	225	1350	900	990	540	900	495	990	1080
Lead-Acid Batteries		1300	6500	6500	4875	7800				1625	3900	3770	
Battery Acid													
Aqueous/Caustic Engine Detergent													
Floor Wash		340				510	850			170		850	1632
Mehtanol										38			
Ether													
MOGAS		6000				30030		15000		525000		18750	
DF-2		15000				225000		23445		315000		33750	180000
JP-4													
Transmission Fluid		1200	263	225	225	1770	338		900	2325	338	300	
Hydraulic Fluid						225							
Brake Fluid		75	188	38	113	720	38	225	900	225	38	38	
Paint, Latex						2380		100		100			
Paint, Alkyd													
Paint Thinner								75					
Xylene													
Paint Filters													
Fluid Filters													
GAA Grease						1400						42	
Break Free												15	
Sorbent		40	1000	1000	1200	5000	180		400	400	500	300	300
Rags			100			480		1200				120	
Hazardous Replacement Parts						36				25	50	30	
Paint, Aerosol											200		

Table 6 (Cont'd)

Type of Materials	MPVM#	25	26	27	28	29	30	31	32	33	34	35	36
Degreasing Solvent, Nonhalogenated		86	2850	1500	825	825	750	4500	1650	690	6300	3150	1650
Degreasing Solvent, Halogenated													
Motor Oil		938	13650	3000	2625	3750	1500	9000	7125	1350	6750	15000	1875
Antifreeze		45	4212	4050	1800	1980	270	3240	990	180	1080	2250	900
Lead Acid Batteries				2600		11700	975	7800	7800	19500	9360	180000	
Battery Acid					400	50						18000	
Aqueous/Caustic Engine Detergent							180						
Floor Wash		43	638	340				1530			2040	1700	1020
Methanol				150			75						
Ether							12		40				
MOGAS				2250	188	375	11250	15000					1500
DF-2				15000	36000	45000	150000	75000					11250
JP-4													
Transmission Fluid		188		2250	1800	450	150		1200	75	4950	338	150
Hydraulic Fluid							188				4950	3750	
Brake Fluid		38		188	23	23	225		75			38	75
Paint, Latex			800	50			100						
Paint, Alkyd							200						
Paint Thinner							75						
Xylene													
Paint Filters													
Fluid Filters													
GAA Grease									1500		1800		
Break Free													
Sorbent		20	1100	400	200	210	700		500	600		3000	275
Rags		100	1020	200	225	210	400	600	200	300	480		150
Hazardous Replacement Parts			250	30								50	15
Paint, Aerosol				300									

Table 6 (Cont'd)

Type of Materials	MPVM#	37	38	39	40	41	42	43	44	45	46	47	48
Degreasing Solvent, Nonhalogenated		750	1125	825	600	1650	75	750	188		1875	563	750
Degreasing Solvent, Halogenated			4						24				
Motor Oil		225	2063	1838	1583	450	2063	1500	900	3000	4500	1875	5250
Antifreeze		675	585		900	720	2880	450	1080	2250	2700	2250	7200
Lead-Acid Batteries		390	650		3510	3900	1625	1300	390	2925	3250	3250	1560
Battery Acid			50									50	
Aqueous/Caustic Engine Detergent			225			450			198				
Floor Wash				225	85	750	1020		94	1275	850	255	1275
Methanol					188						375	188	
Ether													
MOGAS		5250	1875	2875	450	750	6000	7500		3750	3750		3750
DF-2		36000	16500	22163		30000	12000	15000		22500	15000		11250
JP-4													
Transmission Fluid		75	60	675	450	1500	600	750	413	150	3000	1125	3375
Hydraulic Fluid													
Brake Fluid		38	15	75	68	375	300	375	188	38		113	75
Paint, Latex						300	50				50	230	500
Paint, Alkyd					250								
Paint Thinner											75		
Xylene													
Paint Filters													
Fluid Filters													
GAA Grease													1500
Break Free													
Sorbent		800	300	250	200	400	400	300	200	300	500	100	360
Rags		400	300	180	100	200	250	200	125	200	300	125	260
Hazardous Replacement Parts		30	15		100		20	50	200	10	20	15	
Paint, Aerosol						100							

Table 6 (Cont'd)

Type of Materials	MPVM#	49	50	51	52	53	54	55	56	57	58	59	60
Degreasing Solvent, Nonhalogenated		3750	525	375		720	563	255	86	3750	600	60	188
Degreasing Solvent, Halogenated						72	24				48	24	
Motor Oil		75000	2438	1500		33750	15000	165	113		1500	1650	750
Antifreeze		45000	495	375		2700	4500	711	18		450	135	180
Lead-Acid Batteries		978750	1300	260		4875	10000	585	130			2210	2600
Battery Acid		50000	500				3500						
Aqueous/Caustic Engine Detergent		4500	180	1575			225	90				884	
Floor Wash		4250					340	85		442			170
Methanol													
Ether													
MOGAS				27000		1950000						72000	7500
DF-2				75000		150000		75				9900	33750
JP-4													
Transmission Fluid		63750	600			1313	150	38			375	413	
Hydraulic Fluid			1275	188								825	2250
Brake Fluid		11250	8			188	38	15	8		10	23	75
Paint, Latex				1000									
Paint, Alkyd													
Paint Thinner													
Xylene													
Paint Filter													
Fluid Filter													
GAA Grease		5000	110									360	
Break Free													
Solvent		5000	725	200		350	1000			2000	1000	250	400
Rags		5000				15600	500			2000	100		60
Hazardous Replacement Parts				10		1200					10		30
Paint, Aerosol													

Table 7

Industrial Maintenance and Small Arms Shops (IMSS)

1. DOL - MNT DIV - Shop Operations Branch - Petroleum Analysis Lab - Building 7137
2. DOL - MNT DIV - Shop Operations Branch - Auto End Item Repair Section - Building 752
3. DOL - MNT DIV - Shop Operations Branch - Auto Component Rebuild Section - Building 753
4. DOL - MNT DIV - Shop Operations Branch - Tactical and Heavy Equipment - Repair Section - Building 754
5. DOL - MNT DIV - Shop Operations Branch - Communication & Electronics/Office Machine Repair Section - Building 755
6. DOL - MNT DIV - Shop Operations Branch - Weapons Repair/Drum Repair Section - Buildings 7811 and 7820
7. DOL - MNT DIV - Shop Operations Branch - Machine Shop/Furniture Wood and Metal Repair/Heavy Canvas Section - Buildings 751, 755, and 758
8. DOL - TRANS DIV - Unit Movement/Rail Section Engine House - Building 837
9. DEH - OPN & MNT DIV - Maintenance and Repair Branch - Electric Motor Repair Shop - Building 868
10. Area TMDE Support Team 101 - 95th MNT CO - Production Control - Building 2912
11. DISCOM - 8th BN 101st AVN REGT - Headquarters and Headquarters Service Company Arms Room - Building 7150
12. DISCOM - 8th BN 101st AVN REGT - A Company Allied Trades Section - Building 7152
13. DISCOM - 8th BN 101st AVN REGT - B Company Maintenance Section - Building 7210
14. 160th SOAG (ABN) - B Company Armament Shop - Hangar 12
15. 160th SOAG (ABN) - C/D Company Armament Shop - Hangar 12
16. 160th SOAG (ABN) - F Company (Victor Section) Maintenance Shop - Hangar 12
17. 160th SOAG (ABN) - F Company (Tango Section) Armament Shop - Hangar 12

Table 8

Quantities of Wastes Generated at IMSS*

Type of Waste	IMSS# 1	2	3	4	5	6	7	8	9	10	11	12	13
Degreasing Solvent, Nonhalogenated		1575	1500	1500	225							75	
Degreasing Solvent, Halogenated, NOS.		240			34		96						
Trichloroethylene												12	
1,1,1-trichloroethane	80												
Freon													
Surface Cleaner, MEK						38						16	
Toluene								23					
Carbon Remover			150										
Used Motor Oil	11250	3750	1500	15000	90	75		690				38	
Cutting/Penetrating Oil							87						
Hydraulic Fluid						75							788
Transmission Fluid		300		1875									
Brake Fluid				75									
Antifreeze		1575	900	900				3240					
Caustic Radiator Wash													
Caustic/Aqueous Detergent							72						
Lead-Acid Vehicle Batteries		2000		1950				390					
NICAD Batteries													
Battery Electryte Sulfuric Acid		500		200				200					
Battery Electryte, Potassium Hydroxide							72						
Corrosive, Phosphuric Acid													
Corrosive, NOS	16											8	
Spoiled Paint												3	
Paint Thinner							15						
Adhesives												40	
Sealants												11	
Paint Filters													
Paint Remover							1000						
Paint Sludge													
Solvent Tank Bottoms			100	5								20	
Contaminated Soil			200										
Spent Sorbent		800	150	400	50			300					
Hazardous, Faulty Parts		20	50	20									
Oily Rags		75		20				200					
Hazardous Empty Cans, Bottles	720			457			278						
Mixed Wastes			2000	10									
Contaminated Grease	600		15					48					
Contaminated MOGAS		375		150									
DF-2	75	338		150									
JP-4	6000												
Spent Oil Fuel Filters		155											
Floor Wash			425				34						

*Quantities are reported in pounds per year.

Table 8 (Cont'd)

Type of Waste	14	15	16	17
Degreasing Solvent, Nonhalogenated	750	553		225
Degreasing Solvent, Halogenated, NOS.				
Trichloroethylene			80	
1,1,1-trichloroethane				
Freon				
Surface Cleaner, MEK			150	
Toluene				
Carbon Remover				
Used Motor Oil			1500	368
Cutting/Penetrating Oil	188			
Hydraulic Fluid			180	
Transmission Fluid				
Brake Fluid				
Antifreeze				
Caustic Radiator Wash				
Caustic/Aqueous Detergent				
Lead-Acid Vehicle Batteries				
NICAD Batteries				
Battery Electryte Sulfuric Acid				
Battery Electryte, Potassium Hydroxide				
Corrosive, Phosphuric Acid				
Corrosive, NOS				
Spoiled Paint				
Paint Thinner				
Adhesives				
Sealants				
Paint Filters				
Paint Remover				
Paint Sludge				
Solvent Tank Bottoms				
Contaminated Soil				
Spent Sorbent			100	
Hazardous, Faulty Parts				
Oily Rags				
Hazardous Empty Cans, Bottles	25			
Mixed Wastes				
Contaminated Grease		5		
Contaminated MOGAS				
DF-2				
JP-4				
Spent Oil, Fuel Filters				
Floor Wash				

Table 9

Quantities of Hazardous/Nonhazardous Materials Used at IMSS*

Type of Material IMSS#	1	2	3	4	5	6	7	8	9	10	11	12
Degreasing Solvent, Nonhalogenated		1875	1500	1875	338				38			180
Degreasing Solvent, Halogenated, NOS188	320			38			96		19			
Trichloroethylene						880						120
1,1,1-trichloroethane												
Freon												
MEK												15
Toluene								24				
Carbon Remover			150									
Motor/Lube Oil		4125	1125	7500	113			690				
Cutting/Penetrating Oil						75	87					38
Hydraulic Fluid						150						
Transmission Fluid				3000								
Brake Fluid				225								
Antifreeze		1800	900	3600				3240				
Caustic Radiator Wash												
Caustic/Aqueous Detergent							178					
Lead-Acid Vehicle Batteries		3500		3250				390				
Battery Electrolyte, Sulfuric Acid		800		2000				200				
Corrosive Phosphoric Acid												
Corrosive, NOS	16					298						8
Paint, Latex				200								
Paint, Aerosol					63		19					
Paint Thinner												
Adheasives							25					100
Sealants												10
Paint Filters												
Paint Remover						38						
Acetone						11						
Methanol				188								
Denatured Alcohol				188								
Break Free							23		25		90	
GAA Grease				100				48				
Sorbent		800	150	400	50			300				
Rags		75	25	220				200				
MOGAS			7500	3000								
DF-2				1500				16028				
JP-4												
Fluid Fil[illegible]ers		155										
Floor W[illegible]n			425									
Hazar[illegible] Parts		20	50	20								
Paint, A[illegible]d												
Corrosion Preventative												

*Quantities are reported in pounds per year.

Table 9 (Cont'd)

Type of Material	13	14	15	16	17
Degreasing Solvent, Nonhalogenated		900	975	200	263
Degreasing Solvent, Halogenated, NOS					
Trichloroethylene					
1,1,1-trichloroethane					
Freon					
MEK				150	
Toluene					
Carbon Remover					
Motor/Lube Oil			122	2250	420
Cutting/Penetrating Oil		45			
Hydraulic Fluid	200			225	
Transmission Fluid					
Brake Fluid					
Antifreeze					
Caustic Radiator Wash					
Caustic/Aqueous Detergent					
Lead-Acid Vehicle Batteries					
Battery Electrolyte, Sulfuric Acid					
Corrosive Phosphoric Acid					
Corrosive, NOS					
Paint, Latex					
Paint, Aerosol	48				
Paint Thinner					
Adheasives					
Sealants					
Paint Filters					
Paint Remover					
Acetone					
Methanol					
Denatured Alcohol					
Break Free			38		
GAA Grease			5		
Sorbent				100	
Rags					
MOGAS					
DF-2					
JP-4					
Fluid Filters					
Floor Wash					
Hazardous Parts					
Paint, Alkyd					
Corrosion Preventative		60			

Table 10

Aviation Maintenance Facilities (AMF)

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1. CAAF - CTS - Transient Alert/POL Facilities - Building 7265
2. CAAF - Fixed Winged Maintenance Detachment - Building 7161
3. DISCOM - 8th BN 101st AVN REGT - A Company Aircraft Maintenance Section - Building 7152
4. DISCOM - 8th BN 101st AVN REGT - B Company Aircraft Maintenance Section - Building 7210
5. DISCOM - H CO 159th AVN (Attached) - Aircraft Maintenance Shop - Building 7156
6. DISCOM - 326th MED BN - D Company Aircraft Maintenance/Direct Support Shop - Building 7156
7. 5th SF GP (ABN) - Service Company Aviation Maintenance Platoon - Hangar 11
8. AVN BDE - 17th CAV 2nd SQDN - Squadron Aviation Maintenance Section - Building 6628
9. AVN BDE - 1st BN 101st AVN REGT - Battalion Aviation Maintenance - Building 6638
10. AVN BDE - 3rd BN 101st AVN REGT - Battalion Aviation Maintenance - Building 6638
11. AVN BDE - 4th BN 101st AVN REGT - Battalion Aviation Maintenance Section - Building 7249
12. AVN BDE - 6th BN 101st AVN REGT - D Company Aviation Maintenance - Building 6911
13. AVN BDE - 7th BN 101st AVN REGT - Battalion Aviation Maintenance - Building 7920
14. 160th SOAG (ABN) - Aviation Maintenance Hangars - CAAF

Table 11

Quantities of Wastes Generated at AMF*

Type of Waste	AMF# 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Degreasing Solvent, PD-680, Naptha		150	750	8	188	75	150		188	188				
Degreasing Solvent, MEK		150	263	98	113	75	8		75	75				
Degreasing Solvent, Halogenated, NOS														
Carbon Remover														
Used Aircraft Engine Oil		180	938		150	375	188	3301	1875	1875				
Used Hydraulic Fluid					788			432	375	375				
Calibration Fluid														
Gas Path Cleaner							450							
Deicer Solution			38		15				375	375				
Aqueous/Caustic Detergents		43	135		45	900			630	630				
Floorwash Solution		468				425			170	170				
Contaminated Water			4250	85					2250	2250				
Contaminated Soil/Oily Grit						100								
Contaminated Grease			113											
Solvent Sludge			50						50	50				
Oily Rags			500			50			50	50				
Spent Sorbent	1000	100	300		100	200			6000	6000				
Contaminated Avgas (JP-4, etc.)	13500		150	1950	538	750		11213	3863	11250	3375	36875	82125	33000
NICAD Batteries			25	75	85									
NICAD Electrolyte Potassium Hydroxide			250	50	27									
Spoiled Paint														
Paint Stripper														
Paint Thinner			8											
Empty Paint Cans			30	24		50			7	7				

*Quantities are reported in pounds per year.

Table 12

Quantities of Hazardous/Nonhazardous Materials Used at AMF*

Type of Material	AMF# 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Degreasing Solvent, PD-680, Naptha		150	975	38	263	188	173		263	263				
Degreasing Solvent, MEK		150	450	225	188	188	1		113	113				
Degreasing Solvent, Halogenated, NOS														
Carbon Remover														
Aircraft Engine Oil	94	180	1238		300	525	188	3301	2250	2250				
Hydraulic Fluid					1350			432	413	413				
Calibration Fluid														
Gas Path Cleaner							450							
Deicer Solution	19800		38		30				375	375				
Aqueous/Caustic Detergent		45	180		90	900			525	525				
Floorwash Solution		468				425			170	170				
GAA Grease			150											
Rags			500			50			50	50				
Sorbent	1000	100	500		125	200			6000	6000				
Avgas (JP-4, etc.)	11250000		90000		20250									
NICAD Batteries			1500	100	85									
NICAD Electrolyte, Potassium Hydroxide			900	135	45									
Paint, Aerosol														
Paint, Carc														
Paint, Latex														
Paint Stripper		40												
Paint Thinner			15											
Paint, NOS				360										

*Quantities are reported in pounds per year.

Table 13

Paint Shops (PS)

1. DOL - MNT DIV - Shop Operations Branch - Allied Trades Section - Paint Booths and Body Shops Buildings 756 and 6490
2. DEH - OPN & MNT DIV - Roads and Grounds Equipment Paint Shop - Building 5125
3. DEH - OPN & MNT DIV - Construction Branch - Paint and Sign Shop - Building 877
4. DPCA - CMTY REC DIV - Skill Development Branch - Auto Crafts Shop Paint Booth - Building 5611
5. DPCA - CMTY REC DIV - Skill Development Branch - Woodcraft Shop - Building 5613
6. DPTM - TSC - Devices Section Paint Booth - Building 847
7. DISCOM - 8^{th} BN 101^{st} AVN REGT - H Company 159^{th} Aviation Regiment - Civilian Contractor (Dynalectron Corporation) - Building 7156
8. DISCOM - 6^{th} BN 101^{st} AVN REGT - A Company Painting Operations
9. ESB - 86^{th} EVAC HOSP - Medical Company - R & U Section Paint Operations - Building 168
10. DOL - MNT DIV - Shop Operations Branch - Weapons Repair Shop - Building 7811

Table 14

Quantities of Wastes Generated at PS*

Type of Waste	PS# 1	2	3	4	5	6	7	8	9	10
Old/Used Paint Cans	1855	50		260			413	110	100	
Old/Used Paint, Primer		50					1650	12		
Paint Thinner, NOS		38	180						5	
Aircraft Thinner	3375						4950			
Lacquer Thinner	1125									
Shellac Thinner										
Denatured Alcohol										
Enamel Reducer										
Acetone										
Paint Stripper		16					1238			
Xylene	1125									
Mineral Spirits										
CARC Liquid Residue	2884									
Surface Preparation Residue							560			
Paint Sludge (Non-Carc)										
Spent Paint Filters	770	12		30			206			
Contaminated Clothing, Rags		200		2000			600			
Aqueous/Caustic Detergents		10								
Floorwash Solution				442						
Spent Sorbent		200		2000						
Oily Grit/Dirt		25								
Contaminated Water										
Mixed Wastes										5

*Quantities are reported in pounds per year.

Table 15

Quantities of Hazardous/Nonhazardous Materials Used at PS*

Type of Material	PS# 1	2	3	4	5	6	7	8	9	10
Paint, CARC	10000						2700			
Paint, Enamel	3000			1560				50		40
Paint, Latex								500	1000	50
Paint, Primer				1040			650			
Paint, Lacquer									30	25
Varnish										180
Adhesives										516
Sealants										
Paint Thinner, NOS		188		1170	450					225
Mineral Spirits			180						15	
Denatured Alcohol	38		90							
Aircraft Thinner	3750						4500			
Lacquer Thinner	2250									
Xylene	1125									
Acetone										
Paint Stripper		40					960			200
Caustic/Aqueous Detergent		50								
Floor Wash		85		442						
Sorbent		200		2000						
Rags		200		2000			240			
Paint Filters	385	5		25			48			
Blasting Media							1120			

*Quantities are reported in pounds per year.

Table 16

Photograhpy, Printing, Arts/Crafts Shops (PPAS)

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1. DPTM - TSC - Graphics Section - Building 847
2. DPTM - TSC - Photographic Section - Building 832
3. DPCA - CMTY REC DIV - Skill Development Branch - Photo Shop - Building 89
4. DPCA - SERV DIV - Publicity and Marketing Branch - Print Shop - Building 2157
5. USAISC/DOIM - OPN SYS INTEG DIV - Reproduction Section - Building 2615
6. MEDDAC - BACH - Department of Radiology - X-Ray Processing Section (MEDDAC, DENTAC) - Building 650B
7. ESB - 86th EVAC HOSP - X-Ray Section - Building 6424

Table 17

Quantities of Wastes Generated at PPAS*

Type of Waste	PPAS# 1	2	3	4	5	6	7
Ink/Paint Solvent				17			
Surface Cleaner				12			
Blanket Wash				384	240		
Blanket Fix				1			
Plate Cleaner				56			
Deglazing Compound				16	40		
Degreaser, NOS				15			
Oil Base Ink							
Rubber Base Ink							
Offset Fixer				72	128		
Offset Developer				60	255		
Preserving Gum				10			
Dry Toner				53			
Mineral Spirits							
Acetone							
Paint Thinner							
Photo Developer			884		50	31212	213
Photo Fixer			884			48246	213
Photo Stabilizer							
Photo Toner							
Photo Bleach			442				
Waste Paint			50				
Fountain Solution				34			

*Quantities are reported in pounds per year.

Table 18

Quantities of Hazardous/Nonhazardous Materials Used at PPAS*

Type of Material	PPAS# 1	2	3	4	5	6	7
Denatured Alcohol				17			
Surface Cleaner				12			
Blanket Wash				384	800		
Blanket Fix				1			
Plate Cleaner				56			
Deglazing Compound				16	400		
Degreaser, NOS				17	15		
Oil Base Ink				41	100		
Rubber Base Ink				24	200		
Offset Fixer				72	128		
Offset Developer				60	305		
Preserving Gum				10			
Dry Toner				53			
Mineral Spirits							
Acetone							
Paint Thinner, NOS							
Photo Developer			884		100	31212	213
Photo Fixer			884			48246	213
Photo Stabilizer							
Photo Toner					200		
Photo Bleach			442				
Paint, Latex				15			
Paint, Enamel							
Paint, Aerosol							
Acrylic Leaner				4			
Fountain Solution				34	213		
Etching Compound					119		

*Quantities are reported in pounds per year.

Table 19

Hospitals, Clinics, and Laboratories (HCL)

1. MEDDAC-BACH-Department of Pathology (Blood Bank, Chemistry, Histology/Cytology) Laboratories Building 650
2. MEDDAC-BACH-Logistics, Executive Housekeeper/Contract Officer Representative-Medical Waste Collection Service (MEDDAC, DENTAC) - Building 650B
3. MEDDAC-BACH-Pharmacy Service-Building 650
4. DPCA-DRUG CNTR DIV-Education/Training Branch - Biochemical/Urinalysis Lab - Building 2537
5. ESB - 86th EVAC HOSP - Pharmacy Service - Building 160
6. ESB - 86th EVAC HOSP - EMT Section - Building 142
7. ESB - 86th EVAC HOSP - Medical Laboratory - Building 122

Table 20

Quantities of Wastes Generated at HCL*

Type of Waste	HCL# 1	2	3	4	5	6	7
Pathological Waste, Body Parts	500			707			
Medical Infectious, Body Fluids	5000						
Medical Infectious, Dressing, gauze	750	125256				5	
Medical Infectious, Metallic Sharps	1500				10	10	
Medical Infectious, Plastics				10		5	
Formaldehyde	640						
Formalin							1
Phenol	38						
Methanol	1500						1
Ethyl Alcohol	1725						
Isopropyl Alcohol	338					15	2
Alpha Naphthol	4						
Acetone	300						1
Xylene	1125						
Toluene	15						
Pharmaceutical Wastes, Drugs							
Acetic Acid	425						1
Boric Acid	10						
Formic Acid	43						
Nitric Acid	9						
Hydrochloric Acid	85						
Oxalic Acid	9						
Picric Acid	43						
Sulfuric Acid	26						
Tannic Acid	4						
Tungstic Acid	4						
Hydrogen Peroxide					26	4	
Sodium Hydroxide	5						
Ammonium Hydroxide	11						
Sodium Hypochlorite	1063			9			
Mercury							
Miscellaneous Chemicals	1020			425		23	
Crystal Violet	1275						1
Wright Stain	1700						1

*Quantities are reported in pounds per year.

Table 21

Quantities of Hazardous/Nonhazardous Materials Used at HCL*

Type of Material	HCL# 1	2	3	4	5	6	7
Gauze, Bandages	750					5	
Metallic Sharps	1500				10	10	
IV Tubing						5	
Formaldehyde	600						1
Phenol	38						
Methanol	1350						1
Ethyl Alcohol	1275						
Isopropyl Alcohol	300					15	2
Alpha Nopthol	4						
Acetone	300						1
Xylene	1125						
Toluene	15						
Acetic Acid	425						1
Boric Acid	10						
Formic Acid	43						
Nitric Acid	9						
Hydrochloric Acid	85						
Oxalic Acid	9						
Picric Acid	43						
Sulfuric Acid	26						
Tannic Acid	4						
Tungstic Acid	4						
Hydrogen Peroxide					51	17	
Sodium Hydroxide	5						
Ammonium Hydroxide	11						
Sodium Hypochlorite	1063						
Mercury							
Pipets				4			
Curvets				4			
Plastic Containers				2			
Crystal Violet	1275						1
Wright Stain	1700						1
Sodium Bicarbonate	5						
Iodine						43	

*Quantities are reported in pounds per year.

Table 22

Troop Units

1. 1st BDE - HHC, 1-327th INF BN, 2-327th INF BN, 3-327th INF BN
2. 2nd BDE - HHC, 1-502nd INF BN, 3-502nd INF BN,
3. 3rd BBDE - HHC, 1-187th INF BN, 2-187th INF BN, 3-187th INF BN
4. 106th SOAG (ABN) - Headquarters Service Company
5. 5th SF GP (ABN) - 1st BN, Support BN
6. 311th MI BN - Service Support Company, Headquarters and Headquarters Operation Company - Buildings 6927 and 6928
7. 501st SIG BN
8. 101st AVN DIV
9. 326th ENGR BN
10. 2 - 44th ADA BN
11. DISCOM - 326th ENGR BN
12. DIVARTY - 2nd BN 31st FA
13. ESB - 20th ENGR BN, 86th EVAC HOSP
14. USAF Tenant - DET 5 507th TAIRCW - Support Section - Radio Maintenance - Building 5513
15. NCO Academy - 108 Reed Road
16. AVN BDE - 17th CAV 2nd SQDN - Squadron Commo. - Building 7572
17. Unattributable to a specific generator

Table 23

Quantities of Wastes Generated by Troop Units*

Type of Waste	1	2	3	4	5	6	7	8	9	10	11	12
Lithium Batteries	2905	743	667	691	681	1026	1613		58	241	550	355
Mercury Batteries	1189	382	1070	41	68	60				32	100	
Magnesium Batteries	3501	243	1768		269	194				285	208	52
Carbon/Alk. Batteries			20		76	66						
NICAD Batteries		357		2008	305						53	
DS-2	880		397					180	117		160	340
STB											100	
Chemical Detection Kits											25	
Skin Decontamination											25	
Protective Mask Filters											400	757
Heat Tabs						10						
Smoke Grenades												
Fog Oil												
Acetone												
Methyl Alcohol												
Isopropanol												
Denatured Alcohol												
Insecticides						17						
Rodenticides												
Herbicides												
Lead-Acid Batteries												

*Quantities are reported in pounds per year.

Table 23 (Cont'd)

Type of Waste	13	14	15	16	17
Lithium Batteries	21	138	3	362	1648
Mercury Batteries		1		191	
Magnesium Batteries		454	325	411	486
Carbon/Alk. Batteries					
NICAD Batteries			102		2029
DS-2	336			135	351
STB	395				
Chemical Detection Kits					
Skin Decontamination					
Protective Mask Filters					
Heat Tabs					
Smoke Grenades					
Fog Oil					
Acetone					
Methyl Alcohol					
Isopropanol					
Denatured Alcohol					
Insecticides	466				
Rodenticides	20				
Herbicides	9				
Lead-Acid Batteries					65277

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Table 24

Grounds and Utilities Maintenance Operations

1. DPCA - CMTY REC DIV - Outdoor Recreation Branch - Army Travel Camp Grounds Maintenance Building 6621
2. DPCA - CMTY OPN DIV - Golf Course Grounds Maintenance - Buildings 7606 and 1568
3. DEH - OPN & MNT DIV - Maintenance and Repair Branch - Exterior Electrical Shop - Building 865
4. DEH - OPN & MNT DIV - Maintenance and Repair Branch - Boiler Plant Section - Building 893
5. DEH - OPN & MNT DIV - Maintenance and Repair Branch - Entomology Section - Building 7606
6. DEH - OPN & MNT DIV - Roads and Grounds Branch - Grounds Maintenance Section - Buildings 5148 and 7607

Table 25

Quantities of Wastes Generated by Grounds and Utilities Maintenance Operations*

Waste Stream	1	2	3	4	5	6
Fungicides						
Insecticides						
Nemacides						
Herbicides						
Rodenticides						
Growth Regulators						
Wetting Agents						
Defoamers						
Colorants/Dyes						
Fertilizers						
Hazardous Empty Cans, Bags.	5					

Table 26

Quantities of Hazardous/Nonhazardous Materials Used by Grounds and Utilities Maintenance Operations**

Type of Material	1	2	3	4	5	6
Fungicides		255				
Insecticides		1616				
Nemacides		46000				
Herbicides	43	21887				
Rodenticides						
Growth Regulator		94				
Wetting Agents		413				
Defoamers		60				
Colorant/Dye		40925				
Miscellaneous Chemicals		577				

*Quantities are reported in pounds per year.
**Quantities are reported in pounds per year.

Table 27

Miscellaneous Generators

1. DOL - PLANS & OPN DIV - Laundry and Drycleaning Facility - Building 860
2. DOL - PLANS & OPN DIV - Quality Assurance Branch - Building 749
3. DPCA - SERV DIV - Maintenance Branch - Building 5345
4. CAAF - Air Traffic Control - Radar Facilities maintenance - Building 7146
5. 311^{th} MI BN - Headquarters and Headquarters Operation Company, A Company (Collection and Jamming), B Company (Ground Serveillance Radar) - Buildings 6428 and 6927
6. ESB - 86^{th} EVAC HOSP - Medical Maintenance Company - Building 168
7. ESB - 20^{th} REPL DET - Special Project Detachment - Building 2744

Table 28

Quantities of Wastes Generated by Miscellaneous Generators*

Type of Waste	1	2	3	4	5	6	7
Degreasing Solvents, NOS		150			12		
PD-680-I							
Surface Cleaner					1712		
Acetone						2	
Isopropyl Alcohol			15				
Freon							
Motor Oil		225			8		
Lube/Cutting Oil					15		
Pine Oil					113		
High Voltage Insulation Oil				38			
Caustic Detergent		180			250		
Coil Cleaner, Corrosive			34				
Bleach					9	17	
Glass Cleaner					51		
Spoiled Paint					25		
Paint Thinner, NOS					91	15	
Mineral Spirits			4				
Solvent Sludge	3325						
Contaminated Soil							
Contaminated Water					212500		
Empty Cans			30	5	20	5	50
Moth Balls					1		
Spent Sorbent		100					
Oily Rags		150					
Break Free					15		

*Quantities are reported in pounds per year.

Table 29

Quantities of Hazardous/Nonhazardous Materials Used by Miscellaneous Generators*

Type of Materials	1	2	3	4	5	6	7
Degreasing Solvent, NOS			150			12	
PD-680-I		26250					
Surface Cleaner						1724	
Acetone							2
Isopropyl Alcohol				15			
Freon				150	15		
Motor Oil			150			8	
Lube/Cutting Oil						15	
Pine Oil						113	
Insulation Oil					38		
Caustic Detergent		27600	180			250	34
Coil Cleaner, Corrosive				34			
Bleach						9	17
Glass Cleaner						51	
Paint, Latex				50		150	500
Paint, Enamel							50
Paint Thinner, NOS						91	15
Mineral Spirits				8			
Equipment Filters							
Moth Balls						1	
Sorbent			100				
Rags			150				
Break Free						15	

*Quantities are reported in pounds per year.

Table 30

Waste Generation Summary

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Motor Pools and Vehicle Maintenance Facilities	1	50604	50604	PD-680, Neptha, Varsol
	2	192	192	Carburetor Cleaner, Methylene Chloride
	3	403666		
			259704	Motor Oil
			8000	Motor Oil, Halogenated
			10616	Brake Fluid
			112033	Transmission Fluid
			13313	Hydraulic Fluid
	4	156717	156717	Ethylene Glycol
	5	75	75	Methanol
	6	80430	80430	Sulfuric Acid
	7	90	90	Paint Thinner, NOS
	10	187230	187230	Lead-Acid Batteries
	11	306011	37296	MOGAS
			74090	DF-2
			194625	JP-4
	13	138248	4086	Caustic Engine Detergent
			24454	Floor Wash Detergent
			9434	Contaminated Grease
			1100	Contaminated Soil/Sand
			6419	Contaminated Water
			39815	Spent Sorbent
			5035	Solvent Tank Bottoms
			34225	Oily Rags
			5171	Hazardous Faulty Parts
			859	Hazardous Empty Containers
			7650	Mixed Wastes
Industrial Maintenance and Small Arms Shops	1	7090	6863	PD-680, Naptha, Varsol
			204	Methyl Ethyl Ketone
			23	Toluene
	2	1800	80	1, 1, 1-trichloroethane
			200	Trichloroethylene
			150	Methylene Chloride
			1000	Paint Stripper, NOS

Table 30 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Industrial Maintenance and Small Arms Shops (continued)			370	Halogenated Cleaning Solvent, NOS
	3	38054	34486	Motor Oil
			275	Cutting/Penetrating Oil, Fluid
			75	Brake Fluid
			2175	Transmission Fluid
			1043	Hydraulic Fluid
	4	6615	6615	Ethylene Glycol
	6	996	900	Sulfuric Acid
			72	Potassium Hydroxide
			24	Corrosive, NOS
	7	15	15	Paint Thinner, NOS
	8	54	3	Paints
			40	Adhesives
			11	Sealants
	10	4340	4340	Lead-Acid Batteries
	11	7088	525	MOGAS
			563	DF-2
			6000	JP-4
	13	7784	252	Caustic Engine Detergent
			459	Floor Wash Detergent
			668	Contaminated Grease
			200	Contaminated Soil/Sand
			1900	Spent Sorbent
			125	Solvent Tank Bottoms
			445	Oily Rags
			90	Hazardous Faulty Parts
			155	Spent Fluid, Fuel Filters
			1480	Hazardous Empty Containers
			2010	Mixed Wastes
Aircraft Maintenance Facilities	1	2554	1697	PD-680, Naptha, Varsol
			857	Methyl Ethyl Ketone
	3	10852	8882	Aircraft Engine Oil
			1970	Hydraulic Fluid
	4	803	803	Deicer Solution
	6	327	327	Potassium Hydroxide
	7	8	8	Paint Thinner, NOS

Table 30 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Aircraft Maintenance Facilities (continued)	10	185	185	NICAD Batteries
	11	198389	198389	JP-4
	13	27752	2383	Caustic Engine Detergent
			1233	Floor Wash Detergent
			450	Turbine Engine Gas Path Cleaner
			113	Contaminated Grease
			100	Contaminated Soil/Sand
			8835	Contaminated Water
			13700	Spent Sorbent
			150	Solvent Tank Bottoms
			650	Oily Rags
			118	Hazardous Empty Containers
Paint Shops	2	1254	1254	Paint Stripper
	7	10798	223	Paint Thinner, NOS
			8325	Aircraft Thinner
			1125	Laquer Thinner
			1125	Xylene
	8	8974	1712	Paint, Primer
			2884	CARC Sludge (>60%)
			560	Blasting Media
			1018	Paint Filters
			2800	Contaminated Clothing
	13	5470	10	Caustic Detergent
			442	Floorwash Detergent
			25	Contaminated Soil/Sand
			2200	Spent Sorbent
			2788	Hazardous Empty Containers
			5	Mixed Wastes
Print, Photography, and Arts/Crafts Shops	1	15	15	Degreasing Solvent, NOS
	2	783	12	Surface Cleaner (1,1,1-trichloroethane)
			624	Blanket Wash Solution
			1	Blanket Fix Solution
			56	Offset Plate Cleaner
			56	Deglazing Compounds
			34	Fountain Solution
	5	17	17	Denatured Alcohol

Table 30 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Print, Photography, and Arts/Crafts Shops (continued)	8	60	50	Paint
			10	Preserving Gum
	9	82712	32359	Photographic Developer
			49343	Photographic Fixer
			442	Photographic Bleach
			53	Dry Toner
			200	Offset Fixer
			315	Offset Developer
Hospitals, Clinics, and Laboratories	1	1441	301	Acetone
			15	Toluene
			1125	Xylene
	2	641	640	Formaldehyde
			1	Formalin
	5	3623	4	Alpha Napthol
			1725	Ethyl Alcohol
			355	Isopropyl Alcohol
			1501	Methanol
			38	Phenol
	6	1777	426	Acetic Acid
			10	Boric Acid
			43	Formic Acid
			9	Nitric Acid
			85	Hydrochloric Acid
			9	Oxalic Acid
			43	Picric Acid
			26	Sulfuric Acid
			4	Tannic Acid
			4	Tungstic Acid
			30	Hydrogen Peroxide
			5	Sodium Hydroxide
			11	Ammonium Hydroxide
			1072	Sodium Hypochlorite
	13	138198	5707	Pathological Waste, Body Fluids
			500	Pathological Waste, Body Parts
			126011	Infectious Dressings, Guaze
			1520	Infectious Metallic Sharps

Table 30 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Hospitals, Clinics, and Laboratories (continued)			15	Infectious Plastic Containers
			1276	Crystal Violet
			1701	Wright Stain
			1468	Miscellaneous Chemicals
Troop Units	10	93325	11702	Lithium Batteries
			3134	Mercury Batteries
			8196	Magnesium Batteries
			162	Carbon/Allcaline Batteries
			4854	NICAD Batteries
			65277	Lead-Acid Batteries
	12	5041	4496	DS-2
			495	STB
			25	Chemical Detection Kits
			25	Skin Decontamination Kits
	13	1679	1157	Protective Mask Filters
			10	Heat Tabs
			483	Insecticides
			9	Herbicides
			20	Rodenticides
	13	5	5	Hazardous Empty Containers
Grounds and Utilities Maintenance Operations	1	1724	12	Degreasing Solvent, NOS
			1712	Surface Cleaner, NOS
	3	189	8	Motor Oil
			15	Lube/Cutting Oil
			113	Pine Oil
			38	High Voltage Insulation Oil
			15	Break Free
	5	15	15	Isopropyl Alcohol
	6	34	34	Corrosive Coil Cleaner
	7	112	106	Paint Thinner, NOS
			4	Mineral Spirits
			2	Acetone
	8	25	25	Paint
	13	216263	250	Caustic Detergent
			26	Bleach
			51	Glass Cleaner

Table 30 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Grounds and Utilities Maintenance Operations (continued)			212500	Contaminated Water
			3325	Solvent Tank Bottoms
			1	Moth Balls
			110	Hazardous Empty Containers

Table 31

Total Waste Generation Rates Sorted By Waste Categories*

Generator	Total	1	2	3	4	5	6	7	8	9	10	11	12	13
MPVM	1323263	50604	192	403666	156717	75	80430	90			187230	306011		138248
IMSS	73836	7090	1800	38054	6615		996	15	54		4340	7088		7784
AMF	240850	2554		10852	803		327	8			185	198389		27732
PS	26496		1254					10798	8974					5470
PPAS	83587	15	783			17			60	82712				
HCL	145680	1441	641			3623	1777							138198
Troop Units	100045										93325		5041	1679
Grounds	5													5
Miscellaneous	218362	1724		189		15	34	112	25					216263
TOTAL	2212124	63428	4670	452761	164135	3730	83564	11023	9113	82712	285080	511488	5041	535379

*Quantities are in pounds per year.

Waste Categories

1. Spent Cleaning Solvents (Nonhalogenated)
2. Spent Cleaning Solvents (Halogenated)
3. Used Oils, Lubricating Fluids
4. Spent Antifreezes
5. Used Alcohols
6. Spent Acids or Bases
7. Spent Paint Thinners
8. Waste Paint Related Materials
9. Spent Photo or Print Chemicals
10. Waste Batteries
11. Contaminated Fuels
12. Waste Decontamination Chemicals, Materials
13. Miscellaneous Chemicals or Materials

5 WASTE MINIMIZATION FOR MOTOR POOLS AND VEHICLE MAINTENANCE FACILITIES AND AVIATION MAINTENANCE FACILITIES

The typical maintenance and repair operations conducted in a vehicle or aviation maintenance facility are: oil and grease removal; engine, parts, and equipment cleaning; and solution replacement. Table 32 lists the operations, the corresponding materials used, and the wastes generated. Table 33 lists the process descriptions and the corresponding waste descriptions according to hazardous waste codes and Department of Transportation (DOT) classifications. These waste descriptions are used when shipping the wastes offsite. Most of the wastes generated at MPVM are: parts cleaning solutions and miscellaneous detergent solutions, oil and grease from engine cleaning, spent automotive fluids, and lead-acid batteries. AMF generated most of the above wastes (except automotive fluids and lead-acid batteries) and nickel-cadmium batteries. Paint removal and painting operations may also occur at both MPVM and AMF. The minimization of wastes from such activities is discussed in Chapter 7.

Some of the equipment used, primarily in parts cleaning operations, are solvent sinks, hot tanks, and jet spray washers. Proper operation of this equipment minimizes material use and waste generation. The solvent in the sinks is recirculated continuously from a tank to the parts wash tray. The solvent (e.g., PD680-II) is replaced periodically. Hot tanks contain aqueous detergent or caustic solutions for immersion cleaning. These tanks are equipped with air or mechanical agitation devices and electrical heating devices to heat the solution to 356 °F. The jet spray washers consist of nozzles that emit rotating water jets to clean parts immersed in an aqueous wash solution. The contaminated liquid and sludge from both the hot tanks and jet sprays are removed periodically.

Most of the minimization options discussed below have been obtained from *Waste Audit Study - Automotive Repairs*,[27] and other references.[28]

Source Reduction

All Wastes - Better Operating Practices

Better housekeeping practices are necessary to minimize the quantity and toxicity of wastes or emissions generated. Some of the methods include: closing the lids of containers (e.g., solvent sinks) containing volatile substances (e.g., Stoddard solvent); conveniently locating cleaning equipment near service bays; increasing employee awareness of proper waste handling and disposal procedures; labeling hazardous waste containers properly; segregating wastes in separate containers; and separating trash/solids before waste collection for recycling or treatment.[29] Draining wastes to a sewer is not a good practice and may be illegal in many states. Inadvertent losses (spills) can also be minimized by using good housekeeping practices.

[27] W.M. Toy, *Waste Audit Study - Automotive Repairs* (Prepared for the California Department of Health Services, Sacramento, CA, 1987).

[28] *Hazardous Waste Reduction Checklist - Automotive Repair Shops* (California Department of Health Services, Toxic Substances Control Division, 1988), *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops* (California Department of Health Services, Toxic Substances Control Division, 1988).

[29] W.M. Toy, pp 27-28.

All Wastes - Better Operating Practices - Segregation

Segregation of waste streams is a very good practice that minimizes hazardous waste generation and also increases the recyclability of wastes. It is extremely important not to mix solvents and oils. Mixing results in a liquid with very little recycle value and increases the costs of disposal.[30] Minimizing the quantity of contaminants in solvents improves the purity of reclaimed solvent (in onsite recycling) and its market value (in offsite recycling). Used oils, after being drained from engines are known to be contaminated with parts cleaning solvent, carburetor cleaner, fuels, rags, water, trash, etc.[31] These contaminants may make the used oil a hazardous waste due to ignitability, corrosivity, or toxicity, thereby reducing the possibility of energy recovery by burning it in boilers or reducing its market value (for offsite reclamation).

All Wastes - Better Operating Practices - Periodic Maintenance and Cleanup of Equipment

All the equipment, including solvent sinks, hot tanks, and spray washers, must be properly maintained. The tank bottoms must be cleaned frequently to reduce sludge accumulation and contamination of replacement solutions.

Solvent (PD680-I) - Material Substitution - PD680-II

Petroleum distillate Type I (PD680-I) is a flammable substance with a flash point of 102 °F, which is below the USEPA's flammability hazard limit of 140 °F. It must be substituted with petroleum distillate Type II (PD680-II) that has a flash point of 140 °F or above. Changes must be made in the local and centralized procurement processes to prevent users from obtaining PD680-I. When ordering solvent, the user must specify that substitution is not acceptable.

Solvent (PD680-II) - Better Operating Practices

A parts cleaning solvent, such as PD680-II, must not be used to clean floors or hands. It is expensive and must be dedicated to the intended purpose of parts cleaning only. Immersion and removal of parts from the solvent sinks must be done slowly to minimize splashes and rapid evaporation of solvent.

Solvent (PD680-II) - Better Operating Practices - Emissions Minimization

Among the good housekeeping practices, efforts to reduce air emissions are probably the most significant in terms of reducing hazardous wastes released to the environment. Using covers on solvent sinks (or cold cleaning tanks) can result in a 24 to 50 percent reduction in solvent losses.[32] Several standard methods are available for minimizing emissions from immersion cleaning, wipe cleaning, and spray cleaning operations.[33]

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[30] R H. Salvesan Associates, *Used Oil and Solvent Recycling Guide*, Final Report (Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1985).

[31] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, *Reuse of Waste Oil at Army Installations*, Technical Report N-135/ADA123097 (USACERL, September, 1982).

[32] ICF Associates, Inc., *Guide to Solvent Waste Reduction Alternatives: Final Report* (Prepared for the California Department of Health Services, October 1986), pp 4-11 through 4-13.

[33] ASTM Standard D3640-80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (American Society of Testing and Materials [ASTM], 1988).

Solvent (PD680-II) - Process Change

If dip tanks or dunk buckets full of solvent are used for parts cleaning, the process must be modified. Solvent sinks clean parts more effectively and are easy to use. Spillage and evaporation is less from solvent sinks than from dip tanks or buckets. Equipment leasing services (see Table 34) lease solvent sinks. The equipment, raw materials, maintenance, and waste removal are part of the contract and are included in the service price (see Table 35). Testing of solvents (discussed below) before changing must be included in the contract.

If a leasing service is not desirable economically, a solvent sink must be purchased and the waste solvent recycled. Table 36 lists the sizes and the approximate costs of solvent parts washers. Local vendors must be contacted for exact information.

Solvent (PD680-II) - Process Change - Testing

Solvents are normally replaced periodically, based on the operator's perception of "dirtiness." Simple tests to estimate the "solvation power" of the spent solvent can be used to extend the life of the solvent before disposal. The physicochemical tests most useful for used solvent testing are: absorbence, specific gravity, viscosity, and electrical conductivity.[34] Testing instruments (optical probe colorimeter, electronic specific gravity meter, Ostwald viscometer, and electrical conductivity meter) are commercially available. By obtaining a measure of these properties, the usefulness of the solvent can be determined based on Table 37. If the total score (sum of the ratings for all the properties) is less than 6, the solvent is not "spent." If the score is greater than 6, the solvent should be recycled. The criteria provided in Table 37 are only recommendations; they must be revised based on site-specific use and testing. Using solvent testing will reduce raw material and waste disposal costs and minimize the wastes generated.

Solvent (PD680-II) - Process Change - Solvent Sinks (Equipment) Modifications

Solvent losses can be minimized by adding drip trays and lids to existing solvent sinks. About 25 to 40 percent of the solvent is lost because of spillage and about 20 percent because of evaporation.[35] Racks or baskets may be designed and fitted to the solvent sinks to drain parts after cleaning. Minimizing solvent losses results in cost savings for the raw material and waste handling/disposal.

Carburetor Cleaner - Product Substitution

Carburetor cleaners typically contain methylene chloride (< 47 percent), 1,1,1-trichloroethane (< 5 percent), cresylic acid (< 27 percent), and wetting agents. The automobile industry has reformulated them to exclude the use of 1,1,1-trichloroethane.[36] Substitute cleaners must be used.

Used Oil - Better Operating Practices - Selective Segregation

Segregation of used oils and related products is not a source reduction alternative in the strictest sense of the term, yet selective segregation of used oil products may ultimately reduce the large volumes of hazardous wastes[37] that could be produced by mixing used oils with radiator drainings

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[34] B.A. Donahue, et al., *Used Solvent Testing and Reclamation, Volume I: Cold-Cleaning Solvents*, Technical Report N-89/03/ADA182452, Vol I (USACERL, December 1988).
[35] W.M. Toy, pp A-1 - A-23.
[36] W.M. Toy, p 20.
[37] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, *Management of Used Lubricating Oil at Department of Defense Installations: A Guide*, NIPER B06711-2 (National Institute for Petroleum and Energy Research, 198[illegible]), p 26.

(containing oxylates, phenols, ketones, and acids) and used solvents. Product segregation is cost-intensive initially, but many factors favor selective segregation of used oils. These factors include but are not limited to: the increasing costs of hazardous waste disposal, particularly for mixed waste disposal; the fact that the British thermal unit (Btu) value of used oil for burning as a fuel is lowered by the presence of solvents; and under USEPA regulations, hazardous wastes cannot be burned except in boilers with air pollution controls and secondary burners. These factors effectively prohibit blending used oil with boiler fuel if the used oil is listed as a hazardous waste.

Used Oil - Process Change - Fast Lube Oil Change System (FLOCS)

The Fast Lube Oil Change System (FLOCS) is a quick and efficient method of draining crankcase oil from vehicles. The model 30A FLOCS oil evacuation unit is designed to evacuate oil from crankcases under a vacuum. The engines must be fitted with quick-connect couplings to provide easy access to the oil drain, eliminating the need for lifts or pits. Because the oil is evacuated under vacuum pressure, sludge buildup in the oil pans is reduced. Spills are virtually eliminated and a substantial savings in time, labor costs, and equipment can be realized. All FLOCS units are designed to accommodate manual draining of the oil pan when necessary.

A single FLOCS unit was tested at Peterson Air Force Base (AFB), CO, from February 1982 to April 1983 to determine if FLOCS afford sufficient advantages over the normal lube oil change methods to warrant its adoption in the Air Force. Savings during 1 year of operation totaled $1,176.00 for 25 vehicles. A total savings of $7,526.40 was expected based on a conservative 8-year life expectancy for the unit. A payback of 1.6 years was projected. The economic success of the FLOCS unit, along with the elimination of spills that could result in accidents to shop personnel, prompted recommendations that the FLOCS evacuation unit be adopted for Air Force use.[34]

Caustic Wastes - Product Substitution

Caustic cleaning compounds are used in hot tanks and jet spray washers. Substitution of detergent compounds minimizes the amount of hazardous (corrosive) wastes produced. Caustic compounds are necessary for cleaning engines made of iron or iron alloys. With the rapid change to manufacturing engine blocks of aluminum, the use of detergent solutions for cleaning is also increasing.

Caustic Wastes - Process Change - Hot Tank (Equipment) Modifications

A major waste from hot tank operations is the tank bottom sludge containing heavy metals, oil, grease, etc. A typical practice is to dislodge the sludge from the bottom of the tank and dump it into a sump. Installing a collection tray with an overflow to the sump will allow for proper capture and disposal of the sludge. Hot tanks must also be equipped with drip trays and pans for collecting solution that drips off the parts after cleaning. The solution in the trays or pans must then be emptied back into the hot tank.

Aqueous or Caustic Wastes - Process Change - Dry Ovens

Hot tanks or spray washers are typically used for engines/parts washing. If the parts are small enough, ovens could be used to burn off the grease, oil, and particles. The dry ash can then be removed from the parts using shot blasters (preferably with plastic beads) and disposed of in a landfill. The ash must be tested for toxicity before assigning a disposal method. Testing the oven stack

[34] *Management/Equipment Evaluation Program*, Report H82-1B (1st Space Support Group, U.S. Air Force, Peterson Air Force Base, CO, 1983).

emissions for air pollutants may be required. However, using a dry oven will eliminate hazardous (corrosive and toxic) wastes that contain caustics, heavy metals, and oily dirt.

Aqueous Wastes - Process Change - Two-Stage Cleaning in Jet Spray Operations

Most of the parts covered with oil, grease, and heavy dirt residues are cleaned using jet spray operations. If many parts need to be cleaned, a two-stage cleaning operation might provide cleaner parts in a shorter time. Two washers can be connected in series with the first removing most of the heavier residue and the second providing the final rinse. The cleaning solution from the second tank is transferred to the first tank (countercurrent processing).

Antifreeze Solution - Better Operating Practice - No Draining

On many Army installations it is common practice to dispose of spent antifreeze solution from vehicle radiators through discharge to the sanitary or industrial sewer system. Although the solution contains primarily ethylene glycol (which is poisonous), it is biodegradable and is neither carcinogenic nor mutagenic. Therefore, disposal in a sewer system should not present a problem.[39] However, the U.S. Army Mobility Equipment Research and Development Command has documented the presence of phenols, ketones, acids, oxylates, and aldehydes in radiator drainings formed during the use of ethylene glycol as a coolant.[40] Antifreeze wastes are considered hazardous wastes in some states (e.g., California) because ethylene glycol's oral human lethal dose (LD_{50}) is 1400 mg/kg, which is far below the state of California toxicity limit of 5000 mg/kg. As other state and local regulations lower the levels of phenols permitted in drinking water and sewage treatment plant effluents, antifreeze waste may have to be disposed of as a hazardous waste.

Antifreeze Solution - Product Substitution

Biological treatment of the ethylene glycol waste stream is difficult and the chlorination processes (commonly used in a waste treatment plant) generate other toxic chlorinated hydrocarbons. Substituting propylene glycol for ethylene glycol in antifreeze formulas will reduce the toxicity of the waste stream. Propylene glycol is a nontoxic compound commonly used as a food additive.[41]

Antifreeze Solution - Process Change - Testing

Testing the antifreeze solution, which may currently be drained into the sanitary sewers, before draining and disposal can help minimize the amount of wastes generated. Standard methodologies available for testing engine coolants in cars and light trucks[42] may be adapted for other types of vehicles. Electrochemical tests based on the measurement of galvanic currents have proven useful for measuring the levels of corrosion inhibitors and corrosivity of the antifreeze solution in a radiator (or any other heat transfer device).[43] Such test methods allow continuous monitoring of the solution to

[39] Union Carbide Corporation, *Ecological Aspects of UCAR Deicing Fluids and Ethylene Gylcol* (Hazardous Materials Technical Center, Rockville, MD, 1984).

[40] J.H. Conley and R.G. Jamison, *Reclaiming Used Antifreeze*, Report 2168/ADA027100 (U.S. Army Mobility Equipment Research and Development Command [USAMERDC], Fort Belvoir, VA, 1976).

[41] F.E. Mark and W. Jetten, "Propylene Glycol, A New Base Fluid for Automotive Coolants," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (American Society of Testing and Materials [ASTM], 1986), pp 61-77.

[42] ASTM Standard D2847-85, "Standard Practice for Testing Engine Coolants in Car and Light Truck Service," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (ASTM, 1988).

[43] R.L. Chance, M.S. Walker, and L.C. Rowe, "Evaluation of Engine Coolants by Electrochemical Methods," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 99-102; C. Fiaud, et al., "Testing of Engine Coolant Inhibitors by an Electrochemical Method in the Laboratory and in Vehicles," in *Engine Coolant Testing. Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 162-175.

determine the exact time of change (rather than change on a periodic basis, such as 6 months, or when the mechanic thinks it is "dirty").

Antifreeze Solution - Process Change - Extend Life

A Military Specification, MIL-A-53009[44], developed by the U.S. Army Research and Development Center, Fort Belvoir, VA, allows the use of antifreeze (MIL-A-46153[45]) whose inhibitor system has reached a marginal condition.[46] The military additive can extend the life of the antifreeze by more than 1 year. It was originally developed for use if new antifreeze was in short supply. During 1987 and 1988, ethylene glycol was in short supply because of the unavailability of ethylene (base stock) and the retail price doubled. In addition to environmental incentives, economic incentives to minimize the quantities of ethylene glycol wastes generated also exist.

Brake Shoes (Asbestos Waste) - Better Operating Practices

Asbestos dust derived from brake shoes and pads on some vehicles is a toxic material and may be released into the working environment during their replacement or servicing. Friable (crushed under hand pressure) asbestos is easily dispersed in air and must be carefully collected and handled by responsible personnel to minimize the potential health threat to others in the work area. When properly bagged and labeled, asbestos dust and asbestos bearing materials may be disposed in restricted portions of some sanitary landfills. Private vendors of asbestos collection equipment and removal services are available and sometimes economically viable to implement as part of a prudent management program.

Recycling Onsite/Offsite

Solvent (PD680-II) - Onsite Recycling - Distillation

If large quantities of solvents are used (i.e., over 4000 gal/yr) they can be recycled onsite using distillation stills. These units offer a quick investment payback (i.e., less than 3 years).[47] In the distillation process, the solvent is boiled and the vapors are condensed and collected in a separate container. Substances with a higher boiling point than the solvent (e.g., oils, metal residues, etc.) remain in the bottom of the still. A smaller amount of contaminants will result in a higher purity for the reclaimed solvent. Therefore, it is very important to segregate solvent wastes from oils and other contaminants in the service bays. Table 35 lists some of the major suppliers of solvent distillation equipment. Detailed comparisons of the economics of distillation and solvent management options discussed in this chapter are available elsewhere.[48]

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[44] Military Specification MIL-A-53009, *Additive, Antifreeze Extender, Liquid Cooling System* (Department of Defense [DOD] 6 August 1982).

[45] Military Specification MIL-A-46153, *Antifreeze, Ethylene Glycol, Inhibited, Heavy Duty, Single Package* (DOD, 31 July 1979).

[46] J.H. Conley and R.G. Jamison, "Additive Package for Used Antifreeze," in *Engine Coolant Testing: Second Symposium*, R.E. Beal, Ed., ASTM STP 887 (ASTM, 1986), pp 78-85.

[47] R.H. Salvesan Associates, pp 35-36.

[48] B.A. Donahue and M.B. Carmer, *Solvent "Cradle-To-Grave" Management Guidelines for Use at Army Installations*, Technical Report N-168/ADA137063 (USACERL, December 1983); *Economic Analysis of Solvent Management Options*, Technical Note 86-1 (Department of the Army, May 1986).

Solvent (PD680-II) - Offsite Recycling - Contract/Leased Recycling

Solvent sinks for parts cleaning can be owned or leased. In a lease arrangement, the contractor (e.g., Safety Kleen) replaces fresh solvent periodically (specified in the contract) and takes the spent solvent for recycling. Wastes can thus be better contained and the solvent recycled rather than disposed of. Contract recycling has been accepted as a good practice by the automobile industry.[49] Table 31 lists some of the equipment leasing and service companies.

Solvent and Carburetor Cleaner - Offsite Recycling

Solvent and carburetor cleaner wastes can also be sent to a solvent contractor/recycler for offsite recycling. A number of companies (Table 34) provide this service.

Carburetor Cleaner - Offsite Recycling - Contract/Leased Recycling

Some companies distill spent carburetor cleaners and return the cleaner to the user. Equipment similar to solvent sinks are available for lease or purchase. The contract fees include the cost of periodic pickup and disposal of sink bottoms. Companies that provide equipment leasing services for carburetor cleaners are listed in Table 34.

Used Oil - Onsite Recycling - Gravity Separation/Blending

A state-of-the-art RACOR™ oil-to-fuel blending system that will help avoid the problem of disposing of used oils has been developed. The RACOR system is typically used in conjunction with a fuel reservoir or tank. The system blends waste diesel crankcase oil with diesel fuel. It also filters/recycles and transfers diesel fuel from the fuel holding tank. The system comes with a waste holding tank and oil injection system. Used oil from the system's holding tank is blended into diesel fuel (not to exceed 5 percent) and cycled through a three-stage filter to remove water and solid contaminants, resulting in a fuel that is 99.5 percent free of emulsified water and solid particulates. Use of a closed-loop system such as the RACOR system may satisfy all technical requirements and military specifications for oil/fuel blends[50] and should be tested.

Used Oil - Offsite Recycling - Closed-Loop Contract

A closed-loop re-refining contract stipulates that the re-refiner agrees to process the used oil furnished by the generator, returning it to original quality for a contracted price per gallon. The re-refiner does not take ownership of the used oil but merely assumes custody of the oil until it is returned to the generator.

Among the possible disadvantages of a closed-loop contract is that installations may wish to offer used oil, solvents, and synthetic lubricants as a package. Of more immediate and important concern, is that before re-refined oil can be used in government vehicles and engines, it requires approval for the Qualified Products List. Approval is a costly procedure but ensures that the product meets specifications. With estimates of $50,000 for an engine sequence test (1982 dollars) to qualify used oil to meet Army requirements,[51] many re-refiners are reluctant to enter into a contractual agreement

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[49] W.M. Toy, pp 29-30.

[50] D.W. Brinkman, W.F. Marshall, and M.L. Whisman, *Waste Minimization Through Enhanced Waste Oil Management*, NIPER B06803-1 (National Institute for Petroleum and Energy Research, 1987); T.C. Bowen, Personal Communication, U.S. Army, Belvoir R&D Center, Materials, Fuels, and Lubricants Laboratory, Fort Belvoir, VA, 1987.

[51] Military Specification Mil-L-46152, *Lubricating Oil, Internal Combustion Engine, Administrative Service, Metric* (DOD, 1 August 1988).

unless the cost of such tests can be included in the closed-loop contract.[52] More recent studies have placed the cost of such a qualification procedure at $75,000.[53]

Used Oil - Offsite Recycling - Sale to Recyclers

Sale of used lubricating oils may be the most economical answer for an installation. Although burning and closed-loop recycling agreements offer increased economic rewards, constraints may limit the options available to an installation and make selling used oil the only feasible alternative. The cost of selling or disposing of used oil includes sampling and testing the oil, storage before the sale, 55-gal drums for sale/disposal, inventorying expenses, advertising for bid solicitations, bid evaluation, bid letting, and accounting. Draft USEPA regulations, when finalized, could increase the workload of sales personnel slightly by requiring the selling installation (or DRMO/DRMS) to notify the USEPA of the intent to market used lubricating oil and obtain an identification number. Certified analyses on each batch of used oil will also be required, and if the oil is classified as a hazardous waste, it must be manifested and transported by a licensed hazardous waste hauler and may be distributed only to an industrial user.

Antifreeze Solutions - Onsite Recycling

In addition to reducing the quantity of waste produced, there is a major economic incentive for recycling and reusing antifreeze solutions. Because of the shortage of ethylene, the price of antifreeze has more than doubled in the past 2 years ($3 to $8/gal) and it is in short supply. A simple recycling method is available.[54] This method includes mechanical filtration that removes large particles before the solution is pumped into a large tank. An antifreeze extender is added to the tank based on the measured pH. The extender neutralizes the acidic byproducts in used antifreeze. The whole recycling system is available as a skid-mounted, 100-gal batch unit.

Lead-Acid Batteries - Offsite Recycling

Because of their weight, lead-acid batteries are the largest quantity of waste generated from vehicle maintenance facilities. Battery recyclers pay between $1.00 and $1.50 per battery (or $0.20 to $0.40 per pound, wet or dry). The batteries are rebuilt or processed to recover lead. Approximately 20 percent of the batteries can be rebuilt. Table 34 lists processors and smelters of lead-acid batteries. Installation logistics personnel can transport "intact" lead-acid batteries to a recycling facility if one is located nearby. A bill of lading is required if more than 10 batteries are transported at any time. Use of a registered hazardous waste hauler is not required and the waste does not have to be manifested. However, cracked or broken batteries must be transported as hazardous waste by registered haulers.

Aqueous or Caustic Wastes - Equipment Leasing

Hot tanks and spray washers are also available from equipment leasing companies (Table 35). The leasing service fee is site-specific and usually includes the raw materials, equipment maintenance, and waste disposal costs.

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[52] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, pp 16-19.
[53] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, p S-3.
[54] *GLYCLEAN - Anti-freeze Recycling System*, brochure (FPPF Chemical Co., Inc., 117 W. Tupper St., Buffalo, NY 14201, 1988).

Dirty Rags/Uniforms - Onsite/Offsite Recycling - Laundry Service

Rags used to wipe up spills or clean off grease must not be disposed of as trash in a solid waste container. They must be collected and sent with dirty uniforms to a laundry for cleaning.

Treatment

Used Oil - Onsite Pretreatment - Filtration

A number of filtration devices are available for removing solids from used oil. Simple screen filters must be used when draining oil into containers to prevent entry of large objects (e.g., rags, cans, trash, etc.). Other filter media ranging from sand to fibrous material are available in filtration units for removing solids and even water.

Used Oil - Onsite Pretreatment - Gravity Separation

Gravity separation units are composed of a series of tanks used to contain oil and allow for gradual sedimentation of solids and water because of gravitational force and buoyancy. These units usually include skimmers and pumps to remove the water and solids. Some of the units use heat to enhance separation. Gravity separators are effective on used oils that do not contain emulsions and when a sufficient residence time can be provided for settling to occur.[55]

Used Oil - Onsite Treatment - Blending/Burning

Used oil exceeding any of the specification levels for toxic metals, flash point, or total halogen content is termed "off specification used oil" and is subject to regulatory controls. Furthermore, an installation without an industrially classified boiler and whose used oil has hazardous characteristics (heavy metals, halogens, toxics) must blend the oil to meet burning specifications. Regulations regarding used oil for burning can be found in a DOD Memorandum.[56]

Classification as an industrial boiler requires that energy from the boiler be used in manufacturing operations. The manufacture of steam or heat does not satisfy this criteria.[57] The amount of used oil to be blended with the fuel is not likely to have short-term impacts on the combustion efficiency of a boiler, but long-term use will likely present a problem in repeated clogging of pipes and nozzles, accelerated corrosion of pipes and tanks, and a reduction of heat transfer efficiency.[58] Current Navy regulations limit the amount of used oil in fuel oil blends to 1 percent.[59] Mixtures up to 5 percent oil, however, appear to have no appreciable impact on the Btu value of the fuel oil mixture and result in only minor additional maintenance costs, although long-term impacts of blending/mixing on operating parameters of boilers are unknown.

Before blending and burning, used oils must be filtered to remove any large impurities. Other important characteristics of used oils as a boiler fuel are API gravity and viscosity. Viscosity will

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[55] R.H. Salvesan Associates, pp 54-57.

[56] DOD Memorandum for Deputy of Environment, Safety and Occupational Health, OASA (I&L); Deputy Director for Environment, OASN (S&L); Deputy for Environment and Safety and Occupational Health (SAF/MIQ); Director, Defense Logistics Agency (DLA-S); 28 January 1986, subject: Regulation of Used Oil for Burning.

[57] D.W. Brinkman, M.L. Whisman, and C.J. Thompson, p 34.

[58] L.C. Chicoine, G.L. Gerdes, and B.A. Donahue, pp 33-43.

[59] C.W. Anderson, *Cost-Effectiveness Analysis of Luoricant Reclamation by the Navy*, Technical Note 1481 (Naval Civil Engineering Research Laboratory [NCEL], Port Hueneme, CA, 1977).

impact the flow rate of the fuel and the spray pattern from the nozzle as the fuel is introduced to the boiler. The API gravity of an oil is a function of the specific gravity and is related to the heat of the burning oil. Firing temperatures for a given viscosity and discussions of the relationships between specific gravity, API gravity, and heating value can be found in literature.[60]

Aqueous Wastes - Onsite Pretreatment - Filtration

Installing filters on aqueous waste streams to collect grit and heavy residue increases the life of the wash solution. In one case,[61] providing a pump-around loop through a 25-micron filter bag (on a slipstream from jet spray washer) extended the solution life by 2 weeks, thus minimizing the quantity requiring subsequent treatment or disposal.

Aqueous Wastes - Onsite Treatment - Evaporation

Aqueous wastes consist primarily of water with various amounts of contaminants. Evaporating the water minimizes the amount of waste requiring disposal. In an evaporation device, the water is heated away (using an electric or natural gas heating device) leaving behind a semisolid or solid residue requiring disposal. Oil, if present in the waste, could inhibit boiling. Solid residue accumulated on the inner surface of the evaporator could inhibit heat transfer and, therefore, it may have to be cleaned frequently. Table 39 is a list of suppliers of aqueous waste volume reduction equipment.

Aqueous Wastes - Onsite Treatment - Waste Treatment

Onsite batch treatment devices that neutralize and precipitate heavy metals from aqueous wastes are available.[62] A pretreatment system is included to separate oil and grease. Sulfuric acid is added to reduce the pH to between 2 and 3 to reduce any hexavalent chrome to a trivalent state. Adding sulfites leads to precipitation of trivalent chrome. Sodium hydroxide is then added to raise the pH and precipitate the remaining metallic species. The precipitates settle to the bottom as a sludge and the water decanted from the top may be reused in cleaning processes. A filter press is included to reduce the water content of the sludge produced, thus also minimizing the volume to be disposed of.

Carburetor Cleaner - Offsite Treatment

Some solvent recyclers (e.g., Safety Kleen, Safe-Way Chemical) send spent carburetor cleaners to another company (e.g., Solvent Services) for treatment. This treatment process produces a lacquer wash from the spent carburetor cleaner.[63] Lacquer wash can be recycled and used in paint stripping processes.

Antifreeze Solution - Offsite Treatment

If large quantities of spent antifreeze solutions are generated at vehicle maintenance operations, the solutions can be treated at an approved treatment facility (Table 34) for recovery of ethylene glycol that may be used as waste fuel.

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[60] T.T. Fu and R.S. Chapler, *Utilization of Navy-Generated Waste Oils as Boiler Fuel - Economic Analysis and Laboratory Tests*, Technical Note N-1570 (U.S. Navy Construction Battalion Center, 1980), pp 14-44.
[61] W.M. Toy, p 27.
[62] W.M. Toy, p 25-27.
[63] W.M. Toy, pp 31-32.

Lead-Acid Battery Electrolyte - Treatment

Lead-acid batteries must not be drained. These batteries are not a hazardous waste if they are sold to a recycler. Draining the batteries creates two types of wastes: lead dross, and spent sulfuric acid contaminated with lead. The electrolyte, if drained, must be neutralized and tested for lead and lead salts and neutralized before draining into the sewer.

NICAD Battery Electrolyte - Treatment

NICAD battery cells contain a caustic potassium hydroxide solution (31 percent by weight). This electrolyte is corrosive. The electrolyte also contains cadmium and cadmium salts that are listed by the USEPA as hazardous wastes. The electrolyte must therefore be tested for cadmium and neutralized before disposal in the sewer.

Table 32

Typical MPVM and AMF Operations With Materials Used and Wastes Generated*

Process/ operation	Materials used	Ingredients	Wastes generated
Oil and grease removal	degreasers - (gunk), carburetor cleaners, engine cleaners, varsol, solvents, acids/alkalis	petroleum distillates, aromatic hydrocarbons, mineral spirits	ignitable wastes, spent solvents, combustible solids, waste acid/alkaline solutions
Engine, parts, and equipment cleaning	degreasers - (gunk), carburetor cleaners, engine cleaners, solvents, acids/alkalis cleaning fluids	petroleum distillates, aromatic hydrocarbons, mineral spirits, benzene, toluene, petroleum naptha	ignitable wastes, spent solvents, combustible solids, waste acid/alkaline solutions
Rust removal	naval jelly, strong acids	phosphoric acid, hydrochloric acid, hydrofluoric acid, sodium hydroxide	waste acids, waste alkalis
Solution replacement	antifreeze solution, petroleum oil	ethylene glycol, petroleum distillates	hazardous liquid, combustible liquid
Lead-acid batteries; recharging, repair, draining	automobile, truck, tracked vehicle, and other equipment batteries	lead dross, less than 3 percent free acids	used lead-acid batteries, strong acid
NICAD batteries; repair, draining	helicopter and airplane batteries	Battery cells containing KOH	used NICAD battery cells, strong alkali

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986).

Table 33

Waste Classification for MPVM and AMF*

Process Description		Waste Description			
Typical process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Vehicle oil changes	Used crankcase oil (not manifested)	None	Waste petroleum oil, NOS	Combustible liquid	NA1270
Oil/grease removal and equipment cleaning	Acids	D002	Depends on type of acid	Corrosive material	Varies
	Potash	D002	Waste potassium hydroxide	Corrosive material	UN1814
	Caustic soda	D002	Waste sodium hydroxide solution	Corrosive material	UN1824
	Carburetor cleaners	F002/F004	Waste solvent NOS	ORM-A	UN1591/3
	Chlorinated solvents	F001	Waste (main ingredient)	ORM-A	Varies
	Ignitable (flammable) degreasers	D001	Waste flammable liquid NOS	Flammable liquid	UN1268
	Mineral spirit solvents	D001	Waste naptha	Flammable liquid	UN2553
	Petroleum naptha	D001	Waste naptha	Flammable liquid	UN1255
	Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
	1,1,1-trichloroethane	F001	Waste 1,1,1-trichloroethane	ORM-A	UN2831
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
	"MEK"	F005	Waste Methylethylketone	Flammable liquid	UN1193
Rust removal	Acids	D002	Depends on type of acid	Corrosive material	Varies
	Naval jelly	D002	Waste phosphoric acid	Corrosive material	UN1805
Solution replacement	Ethylene glycol	None	Waste hazardous liquid	ORM-E	UN9189
Used lead-acid batteries	Sulfuric acid	D002	Waste sulfuric acid	Corrosive material	UN1830
	Lead dross/scrap	D008	Hazardous waste solid NOS	ORM-C	NA9189
Used NICAD batteries	Potassium hydroxide	D002	Waste potassium hydroxide	Corrosive material	UN1814
	Battery cells	D002/D006	Hazardous waste solid NOS	ORM-C	NA9189

*_**Vehicle Maintenance/Equipment Repair**_, Hazardous Waste Fact Sheet (Small Quantity Generators Activities Group, Minnesota Technical Assistance Program, 1986).

Table 34

Partial Listing of Waste Recyclers, Haulers, Equipment Leasing Companies, and Equipment Manufacturers*

Company and address	Telephone and services	Solvent waste	Caustic waste	Waste oil	Used antifreeze	Used batteries
Acto-Kleen P.O. Box 278 Pico Rivera, CA 90660	(213) 723-5111 (714) 944-3330 Hauler, seller	X				
American Labs 5701 Compton Avenue Los Angeles, CA 90011	(213) 588-7161 Hauler, transfer facility, and recycler	X	X			
Antifreeze Environmental Svc. Corp. 2081 Bay Rd., P.O. Box 50757 Palo Alto, CA 94303	(415) 325-2666 Recycler					X
Antifreeze Environmental Svc. Corp. 16031 E. Arrow Hwy, Unit H Irwindale, CA 91706	(818) 337-3877 Recycler				X	
Appropriate Technologies II 1700 Maxwell Road Chula Vista, CA 92011	(619) 421-1175 Processor	X	X			
Baron Blakeslee, Inc 3596 California Street San Diego, CA 92101	(619) 295-0041 Hauler, processor, seller	X				
Baron Blakeslee, Inc 8333 Enterprise Drive Newark, CA 94560	(415) 794-6511 Hauler, processor, seller	X				
Battery Exchange 2195 Story Road San Jose, CA 95122	(408) 251-3493 Lead acid battery processor, 7,000 lb/month processed					X
Bayday Chemical 2096-B Walsh Avenue Santa Clara, CA 95050	(408) 727-8634 Hauler, processor	X				
Bud's Oil Service, Inc. 1330 West Lincoln Street Phoenix, AZ 85007	(602) 258-6155 Processor			X		
California Oil Recyclers, Inc. 977 Bransten Road San Carlos, CA 94070	(415) 795-4410 Processor			X	X	
Chem-Tech Systems 3650 East 26th Street Los Angeles, CA 90023	(213) 268-5056 Processor			X		

*Source: *Hazardous Waste Reduction Checklist - Automotive Repair Shops*, pp 17-20.
Note: Names of other companies specific to each area can be obtained from trade publications, associations, and local telephone directories.

Table 34 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
Chem-Tak 1719-B Marshall Court Los Altos, CA 94022	(415) 968-1861 Equipment leasing and service company		X			
Demenno/Kerdoon 2000 North Alameda Street Compton, CA 90222	(213) 537-7100 Processor			X		
Detrex Chemical Industries 3027 Fruitland Avenue Los Angeles, CA 90058	(213) 588-9214 Hauler, processor	X				
Environmental Pacific Corp. 5258 SW Meadows Rd, Suite 120 Lake Oswego, OR 97035	(916) 989-5130, (503) 226-7331 Processor, recycler All lead batteries					X
Equipment Manufacturing Corp. 1433 Lidcombe Avenue South El Monte, CA 91733	(818) 575-1644 Hot tank and jet spray washer manufacturer		X			
Evergreen Oil 6880 Smith Avenue Newark, CA 94560	(415) 795-4400 Recycler			X		
EKOTEC 27833 Industrial Pk, Bldg 1, Unit 1 Valencia, CA 91355	(805) 257-9390 Processor, recycler			X		
Fuel Processors, Inc. P.O. Box 1407 Woodland, WA 98674	(503) 286-8352 Rerefiner			X		
Gibson Oil & Refining Co. 3121 Standard Street Bakersfield, CA 93308	(805) 327-0413 Processor			X		
GNB, Inc. - Metals Division 2700 South Indiana Street Los Angeles, CA 90023	(213) 262-1101, Lead-acid battery processor, 9,000 lbs. min, non-metallic cases					X
Hedrick Distributors, Inc. 210 Encinal Street Santa Cruz, CA 95060	(408) 427-3773 Hauler, storage			X		
Holchem/Service Chemical 1341 East Maywood Santa Ana, CA 92706	(714) 546-5890 (714) 538-4554 Processor	X				
Hot Tank Supply 3733 E. Clinton Avenue Fresno, CA 93703	(209) 229-3565 Equipment leasing and service		X			
Industrial Oils, Inc. P.O. Box 1221 Klamath Falls, OR 97601	(503) 884-4685 Rerefiner			X		
IT Corp/Vine Hill Facility 4575 Pacheco Blvd. Martinez, CA 94553	(415) 372-9100 Hauler, Processor	X	X			

Table 34 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
JJS Warehouse, Inc. 1076 Park Avenue San Jose, CA	(408) 294-9717 Solvent parts washer manufacturer	X				
Kinsbursky Bros Supply North Lemon Street Anaheim, CA 92801	(714) 738-8516 Recycler, Spent batteries					X
Lubrication Co of America 4212 East Pacific Way Los Angeles, CA 90223	(213) 264-1091 Hauler, processor			X		
McKesson Chemical Co 5353 Jillson Street Commerce, CA 90040	(213) 269-9531 Hauler, Seller	X				
Nelco Oil Refining Corp 600 West 12th Street National City, CA 92050	(619) 474-7511 Processor					
Oil and Solvent Process Co 1704 West First Street Azusa, CA 91702	(818) 334-5117 Hauler, processor, seller	X				
Omega Chemical Company 12504 W Whittier Blvd Whittier, CA 90602	(213) 698-0991 Hauler, processor, seller	X				
Orange County Chemical Co. 425 Ancleason Drive Escondido, CA 92025	(619) 489-0798 Hauler, seller	X				
Orange County Chemical Co 1230 E Saint Gertrude Place Santa Ana, CA 92707	(714) 546-9901 Hauler, seller, processor	X				
Pacific Treatment Corp 2190 Main Street San Diego, CA 92113	(619) 233-0863 Processor		X	X		
Pepper Oil Company, Inc 2300 Tidelands Avenue National City, CA 92050	(619) 477-9336 Processor			X	X	
Petroleum Recycling Corp. 1835 East 29th Street Signal Hill, CA 90806	(213) 595-4731 Processor			X		
Plastic Materials, Inc 3033 West Mission Road Alhambra, CA 91083	(818) 289-7979 Hauler, seller, processor	X				
Rho-Chem Corporation 425 Iris Avenue Inglewood, CA 90301	(213) 776-6233 Hauler, processor	X				
Romic Chemical Corp 2081 Bay Road East Palo Alto, CA 94303	(415) 324 1638 Hauler, processor	X				

Table 34 (Cont'd)

Company and address	Telephone and services	Solvent waste	Caustic oil	Waste oil	Used antifreeze	Used batteries
RSR Quemetco, Inc. 720 South 7th Avenue City of Industry, CA 91746	(800) 527-9452 Lead acid battery processor					X
Safety Kleen Corporation 777 Big Timber Rd Elgin, IL 60120	(800) 323-5740 Equipment leasing & service from locations throughout CA	X				
Safe-Way Chemical 909 Stockton Avenue San Jose, CA 95110	(408) 292-9289 Equipment leasing and service company	X	X			
SDI Company P.O. Box 835 Upland, CA 91785	(714) 982-0553 Solvent parts washer manufacturer	X				
Solvent Services 1021 Berryessa Road San Jose, CA 95113	(408) 286-6446 Hauler, processor	X				
Tanks-A-Lot 220 W. Santa Ana Anaheim, CA 92805	(714) 778-5155 Radiator flush booth manufacturer				X	
Triad Marine & Industrial Cleaning 1668 National Avenue San Diego, CA 92113	(619) 239-2024 Processor			X	X	
Van Waters and Rogers 2256 Junction Avenue San Jose, CA 95131	(408) 435-8700 Hauler, seller	X				
Van Waters and Rogers 1363 S. Bonny Beach Place Los Angeles, CA 90023	(213) 265-8123 Hauler, seller	X				

Table 35

Equipment Leasing Costs*

Equipment	Size	Approximate cost (November 1986 prices)
Solvent Sink Includes monthly leasing of solvent sink with recirculation pump, monthly maintenance service, removal of spent solvent, and replacement with fresh solvent.	11 gal of solvent with 22-gal barrel	$38/mon
	10 gal of solvent with 16-gal barrel	$33.75/mon
	10 gal of solvent with 16-gal barrel	$36.75/mon
Hot Tank Includes monthly hot tank leasing, monthly maintenance service, removal of 10 gal of solution and sludge, and recharge of solution with caustic detergent and water.	60 gal	$93/mon
Jet Spray Washer Includes monthly jet spray washer leasing, monthly maintenance service, removal of 10 gal of solution and sludge, and recharge with caustic detergent and water.	90 gal	$242/mon

*Source: *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops*, p 20.

Table 36

Parts Cleaning Equipment Purchase Costs*

Equipment	Size	Approximate cost (November 1986 prices)
Solvents parts washer	Small: fill/capacity = 11/22 gal or 10/16 gal	$200 - $300
	Large: fill/capacity = 15/30 gal or 20/30 gal	$250 - $400
Jet spray washer	45 gal	$3,400
	85 gal	$3,800
	100 gal	$4,500
Hot tank	60 gal	$300

*Source: *Hazardous Waste Reduction Assessment Handbook - Automotive Repair Shops*, p 20.

Table 37

Test Criteria for Used Cleaning Solvent (PD680-II)

Rating	Absorbence (500 nm)	Specific Gravity (17°C)	Viscosity cp (18°C)	Conductivity nmho (23°C)
0	< 0.6	< 0.773	< 1.35	< 22.5
1	0.6 - 0.8	0.773 - 0.779	1.35 - 1.85	> 22.5
2	0.8 - 1.0	0.779 - 0.785	> 1.85	
3	1.0 - 1.2	> 0.785		
4	> 1.2			

Table 38

Solvent Recovery Equipment

Supplier	Model	Capacity	Temperature limits	Approximate cost*
Acra Electric Corp 3801 N. 25th Avenue Schiller Park, IL 60176 (solvent: TCE, 1,1,1-TCE,PCE,etc.)	SD-15	5 gal	--	$750
Artisan Industries 73 Pond Street Waltham, MA 02154	--	5-1440 gal/h	--	$4,000 to $1.4 million
Baron Blakesless, Inc. 2001 N. Janice Avenue Melrose Park, IL 60160 (solvents: TCE, 1,1,1-TCE, PCE)	NRS-60 HRS-60	45-60 gal/h 45-60 gal/h	-- --	-- --
Branson Cleaning Equipment Co. Parrot Drive, P.O. Box 768 Shelton, CT 06484 (solvents: 1,1,1-TCE, Freon TF)	S111W S121W	9-15 gal/h 21-31 gal/h	-- --	-- --
Crest Ultrasonics Corporation Scotch Road Mercer County Airport Trenton, NJ 08628 (solvents: TCE, 1,1,1-TCE, PCE)	CRS-10H CRS-10U CRS-20H CRS-20U	10 gal/h 10 gal/h 20 gal/h 20 gal/h	-- -- -- --	-- -- -- --
DCI Corporation 5752 W. 79th Street Indianapolis, IN 46268 (solvents: chlorinated, aliphatic, aromatic fluorocarbons)	D1-DG-15	15 gal/h	--	--
Detrex Chemical Industries, Inc. P.O. Box 501 Detroit, MI 48232 (solvents: TCE, 1,1,1-TCE, Freon TF)	FC-6-EW FC-6-ER	7-25 gal/h 7-25 gal/h	-- --	-- --

Table 38 (Cont'd)

Supplier	Model	Capacity	Temperature limits	Approximate cost
Finish Engineering Company	LS-Jr.	3-5 gal/8h	<320 °F	$2,995
921 Greengarden Road	LS-15	15 gal/8h	<320 °F	$5,895
Erie, PA 16501	LS-15V	15 gal/8h	<320 °F	$9,390
(814)455-4478, (415)821-4154				
(Hazardous waste solvents)				
Garden Machinery Corp.	#50	50-60 gal/h	--	$4,950
700 N. Summit Avenue				
Charlotte, NC 28233				
(Petroleum solvents and oils)				
Hoyt Corporation	EP8	4-8 gal/h	<330 °F	$14,500
Westport, MA 02790	EP20	<20 gal/h	<330 °F	$26,945
Hazardous waste solvents)				
Interel Corporation	--	7.5 gal/h	--	$8,950
P.O. Box 4676	--	15 gal/h	--	$11,850
Englewood, CO 80155				
(solvents: chlorinated,				
Petroleum)				
Kontes Scientific	K-547100	0.8 gallons	--	$1,961
Glassware/Instruments	K-547700	2.5 gallons	--	$2,723
Spruce Street, P.O. Box 729				
Vineland, NJ 08360				
O-I/Shott Process Systems, Inc.	--	13.2 gallons	--	--
1640 SW Blvd., P.O. Box T	--	26.4 gallons	--	--
Vineland, NJ 08360				
Phillips Manufacturing Co.	RS-1	2-5 gal/h	--	--
7343 N. Clark Street	RS-3	4-10 gal/h	--	--
Chicago, IL 60626	RS-5	6-12 gal/h	--	--
	RS-15	13-28 gal/h	--	--
	RS-20	17-37 gal/h	--	--
Progressive Recovery, Inc.	SC-Jr.	1-2 gal/h	<400 °F	$4,795
P.O. Box 521	SC-25	2-4 gal/h	--	$6,495
Trumbull, CT 06611				
(solvents: MEK, toluene,				
xylene, TCE, Freon, etc.)				
Recyclene Product, Inc.	R-2	5 gal/4h	<375 °F	$2,495
405 Eccles Ave.	RS-20	5-7 gal/h (1)	<375 °F	$11,000
South San Francisco, CA 94080	RS-35AF	6-8 gal/h (2)	<375 °F	$21,000
(415)589-9600	RX-35AF	12-16 gal/h (2)	<375 °F	$25,850
Unique Industries, Inc.	1100-10W	12 gal/h	--	
11544 Sheldon Street	1100-10RW	12 gal/h	--	$5,270
Sun Valley, CA 91353	1100-10RA	12 gal/h	--	$8,250
(solvents: chlorinated and				$8,600
fluorinated)				

Table 39

Aqueous Waste Volume Reduction Equipment Suppliers*

Supplier	Model	Capacity	Approximate Cost
EMC Manufacturing	EVAP-85E 1433 Lidcombe Ave. El Monte, CA 91733 (818) 575-1644	85 gallons	$ 1,995
Nordale Fluid Eliminator	FE-150 990 Xylite Ave., N.E. Minneapolis, MN 55434 (603) 668-7111 (714) 885-0691	150 gallons	$ 8,000 - $13,000
Wastewater Treatment	BM-50 Systems 440 N. Central Ave. Campbell, CA 95008 (408) 374-3030	50 gallons	$15,000 - $18,000

*Source: *Hazardous Waste Reduction Asessment Handbook - Automotive Repair Shops*, p 22.

6 WASTE MINIMIZATION FOR INDUSTRIAL MAINTENANCE, SMALL ARMS SHOPS

Most of the hazardous wastes generated from IMSS operations can be categorized as corrosive wastes (acids and alkalis), spent solvents, paint stripping wastes, and wastes containing toxic metals. The operations that generate these wastes include: equipment and vehicle repair, metal cleaning, surface preparation, and metal finishing. A summary of processes, wastes generated, and DOT classifications are listed in Table 40. The minimization options for vehicle maintenance repair wastes are discussed in Chapter 5.

Chlorinated or nonchlorinated solvents are commonly used to clean or degrease parts before repair, rebuilding, or finishing. Nonchlorinated solvents (e.g., petroleum distillates) are normally used in cold cleaning operations using solvent sinks or dip tanks. Chlorinated solvents such as TCE, 1,1,1-trichloroethane, methylene chloride (MC), and perchloroethane (PC), are used in vapor degreasers, where condensing solvent vapors remove the grease, oil, or wax from the dirty parts. 1,1,1-trichloroethane is the safest of these four solvents and is the most commonly used. Of the several different vapor degreasers commercially available, the open top vapor degreasers are the most common at Army installations. In such a vapor degreaser, the heater coils at the bottom of a tank boil nonflammable solvent. The solvent vapors that are denser than air, displace the air and form a vapor zone. A condensing coil at the top of the tank prevents the vapors from escaping from the open top. The parts are lowered into the vapor zone and pure solvent vapors condense on them and solubilize the soil and grease. The solvent drips off or evaporates as the parts are removed after they are cleaned. The soil accumulates at the bottom of the tank. This contaminates the solvent which has to be changed periodically. Also, because the solvent evaporates, fresh solvent must be added frequently.

Cleaning with caustic compounds or detergents also occurs at IMSS operations. Cleaning is usually followed by surface preparation such as painting or scale stripping. Sand, glass, or shot blasting are common methods of removing paint or scale. In some cases, paint stripping is accomplished with solvent (MC) or caustic strippers.

Metal finishing operations, such as surface finishing of small arms, and metalworking, such as cutting and threading are also common at IMSS. A small arms shop conducts weapons rebuilding on many types of small arms. Chemicals such as chromic acid, phosphoric acid, etc., are used. Manganese phosphate coatings are the most common surface finishing treatments used on small arms components. The phosphate coating is dull black and provides wear resistance to the cast iron/steel surfaces. The first step in the process is to clean the parts. The methods include: vapor degreasing or alkali cleaning, blasting with sand/walnut shells, self-emulsified solvent treatment, and phosphoric acid-solvent-detergent cleaning. The parts are then rinsed in water and coated with phosphate. The parts are rinsed in water immediately after the phosphate coating. The next step is to use a hot oil conditioning rinse and then dry the coated and rinsed surfaces. Any supplementary coatings are then applied.[64] The typical coating time is 15 to 40 minutes. The phosphate immersion coating bath is maintained between 200 and 210 °F. The phosphate tank and heating elements are usually made of acid-resistant material. Some of the equipment used in the immersion coating process include: conveying equipment, if necessary; work-supporting equipment such as hooks, racks, baskets, and tumbling barrels; tanks associated with water and heat (steam or electricity); a drain to the sewer line; ventilation equipment; and drying equipment such as ovens, air heaters, fans, and compressors.[65] The

[64] A. Douty and E.A. Stockbower, "Surface Protection and Finishing Treatments - A. Phosphate Coating Processes," revised by W.C. Jones, in *Electroplating Engineering Handbook*, Fourth Edition, L.J. Durney, Ed. (Van Nostrand Reinhold Co., 1984), pp 366-390.

[65] A. Douty and E.A. Stockbower.

operator of the small arms shop must account for all materials used in the process. The potential for severe environmental hazards exists in the operation of a small arms shop.

The metalworking operations in IMSS use petroleum and synthetic oils and small quantities of solvents in cleaning, cutting, and threading metallic pipes and other surfaces. Used oil and waste solvents are commonly generated. Painting vehicles, equipment, and parts is also conducted by IMSS. The minimization options for painting and surface coating are discussed in Chapter 7.

The five major categories of processes conducted at Fort Campbell that are discussed in this chapter are: solvent cleaning, alkaline cleaning, dry media blasting, and cutting and threading.

Source Reduction - Solvent Cleaning

PC/MC/TCE - Product Substitution

If PC, MC, or TCE are still being used in vapor degreasing, 1,1,1-trichloroethane should be substituted. The hazards associated with it are much less than those with PC, MC, or TCE. It also has a higher threshold limit value (TLV, 350 ppm), in terms of worker safety, than PC (100 ppm) and TCE (100 ppm). Although MC has a higher TLV (500 ppm), it is a known carcinogen.[66]

TCE/PC/1,1,1-Trichloroethane - Better Operating Practices - Testing

Solvents are replaced in a vapor degreasing tank based on the operator's perception of its contamination or "dirtiness." A more scientific methodology must be used to determine a solvent's "solvation" power and cleaning efficiency. Chlorinated solvents have physicochemical and electrical properties that can be used to determine this capacity.[67]

A combination of tests including visible absorbence, viscosity, conductivity, and acid acceptance value (AAV), must be used to determine if a solvent is spent based on recommended scores listed in Tables 41, 42, and 43. If the solvent has a score of six or more, it is ready for reclamation disposal. Among all the tests, AAV is the most important because it determines the concentration of amine and alpha epoxide inhibitors left in the solvent. A standard titration procedure,[68] reacting the solution with excess hydrochloric acid which in turn is neutralized with sodium hydroxide, is used to measure the total AAV. Direct measurement instruments (UV/visible Spectrophotometer, Ostwald viscometer, and Conductivity meter) are available for the other tests. Eventually solvent test kits will be available for use at Army installations.[69] With continued use of the testing procedures, more accurate scores can be developed and substituted for those suggested in Tables 41, 42, and 43.

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[66] Technical Note 86-2, *Solvent Minimization and Substitution Guidelines* (Department of the Army, Office of the Chief of Engineers, 1986), 18 pp.

[67] B.A. Donahue, et al., *Used Solvent Testing and Reclamation, Volume II: Vapor Degreasing and Precision Cleaning Solvents*, Technical Report N-89/03/ADA204732 (U.S. Army Corps of Engineers, Construction Engineering Research Laboratory, 1988).

[68] ASTM Standard D 2942-86, "Standard Test Method for Total Acid Acceptance for Halogenated Organic Solvents (Nonreflux Methods)," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (1988).

[69] A.R. Tarrer, Personal Communication (Auburn University Department of Chemical Engineering, Auburn, Alabama).

1,1,1-Trichloroethane - Better Operating Practices - Aluminum Scratch Test

A standard method[70] is available to qualitatively determine the amount of inhibitor present in 1,1,1-trichloroethane to prevent its degradation in the presence of aluminum or aluminum alloys. This test determines the stability of the solvent being used in a degreaser and also that of recycled material.

In this test, a cleaned/degreased aluminum coupon is immersed in inhibited 1,1,1-trichloroethane and scratched. Allowing sufficient time to elapse for a reaction to occur, the formation of dark resinous ("blood"-like) material, bubbling, and discoloration is noted. If the solvent is sufficiently inhibited, no reaction takes place. The reaction can be categorized into four groups: (1) no reaction; (2) bleeds but heals, no solvent discoloration; (3) bleeds but heals, solvent discoloration; and (4) bleeds with no healing. By continued use of this test method over a period of time, a site-specific semiqualitative procedure can be developed for determining when 1,1,1-trichloroethane is "spent" and should be recycled or disposed of.

1,1,1-Trichloroethane - Better Operating Practices - Emissions Minimization

Reducing air emissions is probably the most significant good operating practice in terms of reducing hazardous wastes released to the environment. Proper covers should be installed and used for both cold cleaning and vapor degreasing operations. The use of covers on vapor degreasing vats has been shown to result in a 24 to 50 percent reduction in solvent losses.[71] Boiling of solvent increases emissions by 81 percent as compared to covered-top vapor degreasers.[72] Standard guidelines[73] must be established to help minimize emissions from vapor degreasers that will reduce the hazards to workers, optimize system performance, and conserve material.

Other methods of reducing emissions from vapor degreasers include: increasing freeboard height (0.75 times or greater than the degreaser width); limiting hoist system speed to less than 11 ft/min; limiting the load's cross-sectional area to less than 0.5 times that of the degreaser width; installing a freeboard chiller with a minimum capacity of 100 Btu/hour/feet of perimeter coil; removing the load only when the liquid runoff has stopped; and protecting the degreaser from drafts, air currents, and excessively high velocity exhaust ducts.[74]

1,1,1-Trichloroethane - Better Operating Practices - Material Conservation

Proper handling is required for empty containers that contain residual quantities of 1,1,1-trichloroethane. They must be triple rinsed before disposal or use. The rinsing process generates a large quantity waste stream that requires proper treatment before drainage to a treatment plant. Purchasing 1,1,1 trichloroethane in minibulk (e.g., 55-gal drums) rather than large containers (e.g., tankers) is a good practice. After purchase it must be stored in containers of 230 gallons or less. Material transfer carts specifically designed for transfer from storage tanks to vapor degreasers must be dedicated for that use only. Cross-contamination may thus be prevented.

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[70] ASTM Standard D 2943-86, "Standard Method of Aluminum Scratch Test for 1,1,1-Trichloroethane," *Annual Book of American Society of Testing and Materials Standards*, Vol. 15.05 (ASTM, 1988).

[71] ICF Consulting Associates, Inc., *Guide to Solvent Waste Reduction Alternatives*, Final Report (Prepared for the California Department of Health Services, October 1986), pp 4-8 - 4-9.

[72] Technical Note 86-2.

[73] ASTM Standard D 3640-80, "Standard Guidelines for Emission Control in Solvent Metal-Cleaning Systems," *Annual Book of American Society of Testing and Materials Standards*, Vol 15.05 (1988).

[74] ASTM Standard D 3640-80.

1,1,1-Trichloroethane - Better Operating Practices - Material Transfer and Storage

Sometimes stored new products may be cross-contaminated, making them unusable. This contamination is caused by using transfer equipment such as solvent pumps on drums containing several different products.

Degradable hazardous materials must not be stored in areas that are overheated. Also, contamination from the other materials present must be avoided. Hazardous material handlers must be trained in proper handling and storage of hazardous materials.

1,1,1-Trichloroethane - Better Operating Practices - Chemical Purchase

The purchase of new solvents must be controlled by proper inventory management. Overstocking must be avoided. The material safety data sheets that accompany new products must be reviewed to ensure worker safety and minimize environmental pollution.

1,1,1-Trichloroethane - Better Operating Practices - Operator Handling

The operators must be trained in the proper use of degreasers. The training must include not only the health and safety aspects, but also efficient use and proper waste handling/disposal. Training the operators in process control, proper equipment use, and handling, increases the performance efficiency and minimizes the wastes generated. Standard operating procedures must be written to include the above considerations.

1,1,1-Trichloroethane - Product Substitution - Aqueous Cleaners

Aqueous cleaners that are possible substitutes for chlorinated solvents are commercially available.[75] The advantages of substituting aqueous cleaners for solvents include minimizing the exposure of workers to solvent vapors, and reduced liability and disposal costs. Since aqueous cleaners are usually biodegradable, the wastewaters produced can be discharged directly to a wastewater treatment plant for further treatment--no disposal of used solvents is required. Substituting aqueous cleaners for solvents will require additional cleaning steps and equipment to achieve the same cleaning performance. Some of the aqueous solvents, that have been determined to be possible substitutes for chlorinated solvents, are listed in Table 44.

One disadvantage of aqueous cleaners is that they are generally more corrosive. Tanks liners must be installed to prevent excessive corrosion. This may present a problem for open top vapor degreasers with baffles and heating coils. Noncorrosive cleaners typically do not possess the necessary cleaning power required. Aqueous cleaners also require agitation to work properly; installation of a circulating pump or ultrasonic agitator is often required. Furthermore, aqueous cleaners leave metals wet after cleaning. Parts must be blow dried to guard against rust. Particular problems have been noted in cleaning galvanized metal which corroded appreciably when aqueous cleaning solutions were used. Finally, oil removed from parts during cleaning will typically float on top of aqueous cleaning solutions and must be skimmed by an internally floating oil skimming pump or a small external pump and hydrocyclone which continuously cleans the aqueous cleaner and returns it to the tank.[76]

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[75] J.M. Beller, et al., *Biodegradable Solvent Substitution - A Quick Look Report* (U.S. Air Force Logistics Command, 1988).
[76] ICF Consulting Associates, Inc.

1,1,1-Trichloroethane - Process Change - Ultrasonic Cleaning

Using an ultrasonic cleaning process instead of vapor degreasing will eliminate the problems associated with wastes management. Ultrasonic cleaners use high frequency sound to discharge fine particles attached to surfaces. Further treatment of the aqueous waste stream may be required, depending on the concentration of toxic contaminants in solution. Additional information about ultrasonic equipment can be obtained from manufacturers (e.g., Crest Ultrasonics Corporation, (609) 883-4000).

1,1,1-Trichloroethane - Process Change - Process Controls

Unnecessary changes of solvents from degreaser tanks must be avoided. A method of determining the need to change the solvent is to measure the vapor boiling temperature of the contaminated solvent. Solvent suppliers provide information about the boiling temperature range for all solvents. When a high temperature is reached, the cleaning efficiency of the solvent is minimum and a change is recommended. Other testing methodologies were mentioned above.

Controlling movement of parts in and out of the vapor degreaser (to less than 11 ft/min) can also be viewed as a process control technique that minimizes solvent dragout and emissions.[77] Speed control equipment (governors) must be used to allow for adequate draining time, and cooling and condesation of solvent in the chilling zone.

Vapor degreasers must not be used as drying chambers for parts that have been cleaned and rinsed with water. The wet parts introduce water into the solvent decreasing its useful life. The water may also react with 1,1,1-trichloroethane to form hydrochloric acid that corrodes equipment and contaminates the solvent. Use of water separators can extend the life of the solvent.

Recycling Onsite/Offsite - Solvent Cleaning

1,1,1-Trichloroethane - Onsite Recycling - Closed-Loop Distillation

A closed-loop distillation system must be designed and used to recover 1,1,1-trichloroethane from vapor degreasers. Solution from the vapor degreasing tank is pumped into a distillation still and the pure 1,1,1-trichloroethane is pumped back into the tank after the recovery process. Adding inhibitors will be required. The still bottoms from the distillation process have to be disposed of as a hazardous waste. A list of manufacturers of distillation equipment is provided in Table 38. In addition to recycling of solvent, this process also segregates 1,1,1-trichloroethane from other wastes, thus preventing cross-contamination with other cleaning wastes.

1,1,1-Trichloroethane - Onsite Recycling - Degreaser

In small degreasing operations, the vapor degreaser can be used part time for distillation. This is accomplished by diverting the vapor-return-to-sump line to a separate holding tank. The level of the "spent" solvent to be distilled must always exceed the level of heating coils. Usually this operation is undertaken during periods of slow workload or during off-hours.

[77] ASTM Standard D 3640-80.

Treatment - Solvent Cleaning

1,1,1-Trichloroethane - Onsite Treatment - Filtration

Filtration devices, when used in a vapor degreasing operation, remove particles and thus extend the life of the solvent and reduce cleaning frequency. Equipment suppliers (e.g., Motor Guard Corporation, 415/569-9766) must be contacted to obtain additional information about filtration equipment.

1,1,1-Trichloroethane - Onsite Treatment - Freeze Crystallization

Freeze crystallization is a treatment process that selectively crystallizes certain components from waste solvent. The crystals can then be filtered and disposed of separately. A flow rate of 0.25 gal/min is required[78] for continuous operation of freeze crystallization equipment (e.g., Heist Engineering Corporation, 415/283-8121). Dissimilar metals may thus be removed from waste solvent. This treatment process must be designed on a case-by-case basis.

1,1,1-Trichloroethane - Offsite Treatment

Methods that solvent recyclers use for recovery of solvents include: distillation, solvent extraction, and ultrafiltration. A list of solvent recyclers is provided in Table 29. Thermal destruction of contaminated solvent in a hazardous waste incinerator for energy recovery is also a common treatment technique.

Treatment - Alkaline Cleaning

Caustic Wastes - Onsite Treatment

Cleaning of metal substrate using alkaline cleaners generates a corrosive waste that must be neutralized. In addition to neutralization, removing grease and heavy metals may also be necessary. Batch treatment units are commercially available. A precipitation/neutralization system can also be designed for onsite use. Sludge collected on the bottom of the treatment tank must be tested for hazard characteristics and disposed of properly.

Source Reduction - Dry Media Blasting

Dry Wastes - Product Substitution - Plastic Media Blasting

Plastic media blasting (PMB) is a relatively new method to remove paint and rust from a variety of metallic and alloy substrates such as aluminum, steel, titanium, copper, and zinc. It is a good substitute for organic chemical stripping (using mixtures of MC and other toxic compounds) and abrasive blasting with sand, glass beads, or agricultural media (walnut shells, rice hulls, corn cobs, etc.).

Agricultural media blasting has several drawbacks such as high explosion potential, poor paint/rust removal, high contamination, low recycle rate, and generation of large quantities of wastes. Comparatively, sand and glass beads are better for blast cleaning because of good performance and low

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[78] Fred C. Hart Associates, *Aerospace Waste Minimization Report* (Prepared for the California Department of Health Services and Northrop Corporation, CA, 1987).

explosion potential, however they also have a very low recycle rate. Some of the advantages of PMB are: (1) it is aggressive and requires less operating time (compared to agricultural media only); (2) the plastic maintains its size and hardness; (3) the plastic does not break up and thus can be recycled 10 to 20 times,[79] resulting in lower replacement and disposal costs; and (4) overall, the method is economically favorable.

PMB is slower than sand or glass bead blasting, however it produces a better quality finish. Also, the amount of waste produced in PMB is greatly reduced because most of the media can be recycled many times. Assuming a labor rate of $15/h and a media recycle rate of 90 percent, the costs of sand blasting and PMB are $0.62 and $0.36/sq ft, respectively.[80]

Suppliers of plastic media including: Aerolyte Systems, 1657 Rollins Rd., Burlingame, CA 94010, (415) 570-6000; E.I. du Pont de Nemours & Co., Inc., Fabricated Products Dept., Wilmington, DE 19898, (800) 441-7515; and U.S. Blast Cleaning Media, 328 Kennedy Drive, Putnam, CT 06260. The price of plastic media (available on a GSA contract, 1988 prices) ranges from $1.75 to $2.50 per pound.

Dry Wastes - Process Change - Plastic Media Blasting

Existing abrasive blasting machines can be replaced with more efficient plastic media blasting machines. A number of companies manufacture PMB machines; however, design consultants must be retained to design specific applications. Two types of PMB machines are available: cabinets and open blast systems. Cabinet systems are very similar to the conventional abrasive blasting machines. The most commonly used cabinet has an opening that measures about 5 ft by 4 ft. Small open blast systems are portable and self-contained.

Source Reduction - Cutting and Threading

Cooling/Cutting Oils - Better Operating Practices - Material Conservation

The application of cooling/cutting oils in metalworking must be limited to the area that has to be cooled without using it in excess. Efficient applicators or directional delivery systems, if used, can reduce the amount of coolant delivered to a surface. This efficient use extends the life of oils and minimizes the amount of oil purchased and wastes generated.

Cooling/Cutting Oils - Better Operating Practices - Proper Concentration Maintenance

The coolant performance depends on maintaining the proper coolant to water ratio. Accurate measurements of the concentrations can be obtained by using refractometers. Also, coolant proportioning devices are available to ensure accurate mixing. Specific information on coolant maintenance must be obtained from the manufacturer; the recommendations must be followed.

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[79] J. Gardner, *Dry Paint Stripping Utilizing Plastic Media. A New Solution to an Old Problem*, Technical Bulletin (Clemco Industries, 1987).

[80] C.H. Darvin and R.C. Wilmoth, *Technical, Environmental, and Economic Evaluation of Plastic Media Blasting for Paint Stripping*, EPA/600/D-87/028 (U.S. Environmental Protection Agency [USEPA], Water Engineering Research Laboratory, 1987); J.B. Mount, et al., *Economic Analysis of Hazardous Waste Minimization Alternatives*, Draft Technical Report (USACERL, 1989).

Cooling/Cutting Oils - Better Operating Practices - Proper Storage

Water soluble oils can be stored easily. Proper storage avoids deterioration by biodegradation. The manufacturer's storage recommendations must be followed.

Cooling/Cutting Oils - Better Operating Practices - Operator Handling/Segregation

The operators of metalworking equipment must be cautioned about minimal use of coolant. They should also be trained about the hazards of mixing oils and chlorinated/nonchlorinated solvents and the associated disposal problems.

Cooling/Cutting Oils - Better Operating Practices - Chemical Purchase

When purchasing oils, screen them for undesirable hazardous components. If such information is not available in the manufacturers' Material Safety Data Sheets (MSDSs), testing may be required.

Cooling/Cutting Oils - Better Operating Practices - Metal Chips Removal

Metal chips that accumulate in a coolant must be removed frequently. They interfere with the machine's performance and serve as a site for bacterial growth. Filter screens, when placed at the entrance to the sump and at the exit from the holding trays, can prevent chips from entering the sump. The chips can then be vacuumed from the screens.

Cooling/Cutting Oils - Product Substitution

Several different brands of water soluble oils are available. Some of them contain small amounts of hazardous materials such as cresol (< 1 percent). Only those oils that do not contain hazardous materials can be purchased.

Cooling/Cutting Oils - Process Change - Equipment Modifications

Worn equipment must be repaired or replaced to optimize performance and minimize waste generation (e.g., leaks). Older models should be replaced with automated equipment.

Adding skimmers (belts or disks) to remove "tramp" petroleum oil from the cooling/cutting oils can minimize the quantities of mixed wastes produced. These skimmers must be placed near the sump containing the coolant. Timers are also available to control equipment operation and to ensure that the quantities of coolant removed with the oil are minimal.[81]

Cooling/Cutting Oils - Process Change - Process Controls

The loss of cooling/cutting oils during metalworking operations must be minimized. Adding splash guards or drip trays allows the excess oils to be collected and possibly recycled/reused. Splash guards and drip trays can also be used to contain spills in the machining areas, thus reducing the use of adsorbent material (e.g., DRY-SWEEP) and wastes generated.

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[81] *Prolonging Machine Coolant Life*, Fact Sheet (Minnesota Technical Assistance Program Minneapolis, MN, 1988).

Cooling/Cutting Oils - Process Change - Control Bacterial Growth

Bacterial growth in coolants can be controlled by. cleaning the sump whenever the coolant is replaced, using biocides, adjusting the pH, and adequately circulating the coolant.[82] The sump must be cleaned with steam or chemicals. In some cases, its design may have to be modified to provide sufficient access for cleaning tools.

When using biocides to control bacterial growth, it is important to realize the "ultimate" treatment or fate of the coolant. Bacterial test kits must be used to determine the exact amount of biocide to be added. The use of biocides can be minimized by proper pH control. Bacterial growth decreases the pH of the coolant. Measuring the pH (with a pH meter or litmus paper) and adjusting it (with caustic soda) to the manufacturer's recommended level can control bacterial growth. It is also necessary to maintain proper circulation of the coolant to ensure an oxygen enriched environment in the sump. A mixer or an agitator can be used for this.

Treatment - Cutting and Threading

Cooling/Cutting Oils - Onsite Treatment

Fine particles in oils, such as metal cuttings, can be removed in a pretreatment step by using a centrifuge. Batch centrifuges are available for small metalworking equipment. Large continuous centrifuges are available for removing particles from oils generated continuously in large volumes.

Mobile treatment services are provided by some companies to generators that produce large quantities of water soluble oils. The cost for such a service depends on the volume of oil and the concentration of contaminants.

Another physical treatment technique is ultrafiltration to remove fine particles. About 90 percent of the water fraction can be extracted and discharged directly to the sewer system.[83] The oil recovered is high quality and can be recycled.

Epsom salts (magnesium sulfate) can be used to reduce volume by precipitation and separation before disposal. However, this method is less efficient than other volume reduction techniques available.

To reuse water soluble oils, it is necessary to treat them by pasteurization followed by filtration. The biological contamination accumulated during use can thus be removed. The blend ratio of recycled oil to new oil is determined before use with a refractometer.

Cooling/Cutting Oils - Offsite Treatment

Several offsite treatment and recovery techniques are available for cutting/cooling oils, including ultrafiltration, evaporation, and thermal destruction by incineration. The choice of a method depends on the volume of wastes and their physical/chemical state.

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[82] *Prolonging Machine Coolant Life.*

[83] Fred C. Hart Associates, *Aerospace Waste Minimization Report* (California Department of Health Services, 1987).

Table 40

Waste Classification for IMSS

Process Description		Waste Description			
Process/operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Degreasing metal surfaces/parts and other metal surface preparation	Caustic soda	D002	Waste sodium Hydroxide solution	Corrosive material	UN1824
	Chlorinated solvents	F001	Waste (main ingredient)	ORM-A	Varies
	Freon	F001	Hazardous waste liquid, NOS	ORM-A	UN9189
	Ignitable (flammable) degreasers	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	MEK	F005	Waste methylethylketone	Flammable liquid	UN1193
	Methylene chloride	F001	Waste methylene chloride	ORM-A	UN1593
	Mineral spirits solvents	D001	Waste naptha	Flammable liquid	UN2553
	Petroleum naptha	D001	Waste naptha	Flammable liquid	UN1255
	Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
	1,1,1-trichloroethane	F001	Waste 1,1,1-trichloroethane	ORM-A	UN2831
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
Metal finishing (including etching)	Spent acid solutions	D002	Waste chromic acid solution	Corrosive material	UN1755
	Chromic solutions	D002	Waste hydrochloric acid	Corrosive material	NA1789
	Hydrochloric solutions	D002	Waste nitric acid > 40%	Oxidizer	UN2031
	Nitric stripping solutions	D002	Waste nitric acid < 40%	Corrosive material	NA1760
	Phosphoric solutions	D002	Waste phosphoric acid	Corrosive material	UN1805
	Sulfuric solutions	D002	Waste sulfuric acid	Corrosive material	UN1832
Surface preparation	Acetone	F003	Waste acetone	Flammable liquid	UN1090
	Alcohols	D001	Waste alcohol, NOS	Flammable liquid	UN1987
	Caustic paint stripper	D002	Waste paint related material	Corrosive material	NA1760
	Methylene chloride stripper	F002	Waste methylene chloride	ORM-A	UN1593
	Mineral spirits	D001	Waste naptha	Flammable liquid	UN2553
				Flammable liquid	UN1263
Metalworking	Used oils (not manifested)	None	Waste petroleum oil, NOS	Combustible liquid	NA1270
	Spent solvents		Varies	Varies	Varies

* Source: ***Metal Manufacturing and Finishing***, Hazardous Waste Fact Sheet (Small Quantity Generators Activity Group, Minnesota Technical Assistance Program, Minneapolis, MN, 1987).

Table 41

Test Criteria for Trichloroethylene

Rating	Acid Acceptance Value (wt percent NaOH)	Absorbence (450 nm)	Viscosity (cp)	Conductivity (nanomho/cm)
0	>0.06	<0.50	0.57	> 27.0
1	--	0.50-0.67	0.571-0.590	27.0-24.0
2	--	0.68-0.84	0.591-0.600	23.9-20.0
3	--	0.85-1.00	>0.600	<20.0
4	0.06-0.03	>1.00	--	--
6	<0.03	--	--	--

Table 42

Test Criteria for Perchloroethylene

Rating	Acid Acceptance Value (wt percent NaOH)	Absorbence (500 nm)	Viscosity (cp)	Conductivity (nanomho/cm)
0	>0.06	<0.18	0.75	>29.4
1	--	0.18-0.42	0.76-0.77	29.4-26.7
2	--	0.43-0.66	0.78-0.80	26.6-24.0
3	--	0.67-0.90	>0.80	<24.0
4	0.06-0.03	>0.90	--	--
6	<0.03	--	--	--

Table 43

Test Criteria for 1,1,1-Trichloroethane

Rating	Acid Acceptance Value (wt percent NaOH)	Absorbence (400 nm)	Conductivity (nanomho/cm)
0	>0.06	<0.98	>22.7
1	--	0.980-0.986	22.7-21.1
2	--	0.987-0.994	21.0-19.5
3	--	0.995-1.00	<19.5
4	0.06-0.03	>1.00	--
6	<0.03	--	--

Table 44

Aqueous Solvents and Suppliers

Solvent	Supplier
Safety Solvent Degreaser	Bio-Tek Inc.
Exxate 1000, Exxate 1300, Exxate 600, Exxate 700, Exxate 800, Exxate 900	Exxon Chemical Co.
Desolve-It	Orange-Sol Inc.

7 WASTE MINIMIZATION FOR PAINT SHOPS

Paints are applied to metal or other surfaces (e.g., wood) for waterproofing, flameproofing, rustproofing, insulating, etc. There are three different categories of paints: architectural, original equipment manufacture (OEM), and special purpose. Architectural paints are used on buildings. OEM paints are used in industries that manufacture automobiles, appliances, and furniture.[84] Special purpose paints such as chemical agent resistant coating are used in maintenance operations in some industries, the armed services, and highways' maintenance. Forty-four percent of the special purpose coatings are used on automobiles, 18 percent in industrial maintenance, and the remaining distributed between aerosols, traffic paints, and other categories.[85]

The painting process involves: paint stripping and surface preparation, application of the paint, and curing. Paint stripping (using wet or dry techniques) and surface preparation are necessary to clean the substrate and prepare it for adhesion of the paint. Paint is then applied to the surface. The method used depends on the size, shape, complexity, and number of items. After painting, the items are placed in a curing oven to remove excess solvent and make the coating uniform. Some of the common painting techniques are: dip painting, flow painting, roll painting, curtain painting, spray painting, and bulk painting. Spray painting is the most commonly used technique and can be manual or automatic. Spray painting techniques (including conventional pressure/air atomized, and electrostatic centrifugal/air atomized) have transfer efficiencies that range from 30 to 95 percent. The overspray from the paint application process can be as high as 50 to 70 percent, and is in most cases collected and disposed of. The method of painting may sometimes be dictated by the type of paint formulation (e.g., water-based enamels cannot be sprayed).

Most paint formulations use solvents as carriers for binders such as pigments, powders, and adhesives. The solvent content can vary from 1 to 85 percent. Typical solvents include: acetone, n-butanol, o-dichlorobenzene, diethyl ether, ethyl acetate, butanol, MEK, methyl isobutyl ketone, MC, 1,1,1-trichloroethane, trichlorofluoro-methane, tetrahydrofuran, cyclohexanone, and petroleum derivatives such as naptha, xylene, toluene, or hexane. Powder or water-based paints do not contain solvents. Solvent-based paints (e.g., acrylic lacquers) have the advantage of durability, fast drying time, low corrosivity to substrate, and high gloss finish.[86] Some of the disadvantages include: emission control problems; worker exposure hazards; fire hazards; and waste management, disposal, and liability problems. The criteria used in choosing a solvent depends on the type of paint required, drying speed, the nature of the substrate, and the properties of the solvent.

In addition to the wastes from the painting process, a large quantity of solvent wastes are generated during equipment cleaning. Table 45 describes the wastes generated from the painting process and lists the corresponding DOT classifications.

Source Reduction

Solvent-Based Paints - Product Substitution - Powder Coatings

Powder coating is an effective alternative to solvent-based paints. In a powder coating process, the paint powder is applied to a substrate with an electrostatic spray gun. The carrier is pressurized air, rather than solvents. The powder coating adheres to the surface because of electrostatic forces. Excess powder that does not cling to the surface can be recycled. Heating in the curing oven ensures

[84]ICF Consulting Associates, Inc.
[85]P.L. Layman, "Paints and Coatings: the Global Challenge," *Chemical and Engineering News* (September 30, 1985), pp 27-68.
[86]ICF Consulting Associates, Inc.

that the powder fuses to the surface. Powder coatings can also be applied using a fluidized bed process where the heated objects are immersed in the fluidized bed.

Because powder coatings contain no solvents, emissions of volatile organic compounds and the related air pollution problems are eliminated. Fire hazard and insurance rates are reduced and better neighborhood relations develop as the odor associated with solvent-based application are eliminated. Preliminary toxicological studies indicate that many of the commercial powder formulations are nontoxic. Since the overspray powder can be recycled, material use is high and solid waste generation is minimal. Waste disposal and liability problems are reduced. The process also has a high transfer efficiency, resulting in a lower reject ratio of parts. Coating quality is claimed to be better than with solvent-based coating. The messy cleanup operations associated with liquid based paints are avoided. Powder coating is easier to apply and it is easier to train people to use it. The operators' attitudes improve. The operation is less labor intensive. Maintenance is easier and the overall operating costs are lower. Powder costs are minimally affected by petroleum prices and the operation is more flexible to changing coating requirements.

However, powder application equipment is more expensive to install than solvent-based or high solids coating equipment. Another disadvantage is that powder coating must be done at elevated temperatures. It is not usable on heat sensitive substrates such as plastics, wood, and assemblies containing nonmetal parts. Formulations with lower cure temperatures (275 °F) are being developed.[87]

Solvent-Based Paints - Product Substitution - Water-Based Formulations

Water-based formulations reduce the amount of solvents used and emitted in the coating process. Solvent-based paint equipment can easily be modified to apply water-based paints/coatings. The paint overspray can easily be collected with water in the spray booth and recycled. Though this can also be done in a solvent-based process, a difficult-to-treat aqueous waste stream may result due to direct contact with the solvent. Disposal and liability issues associated with wastes from the solvent-based formulation are reduced and the fire and explosion hazards present with the solvent-based process are eliminated. Concerns about worker exposure to solvents are also eliminated. Energy savings can be achieved by recirculating hot air in the ovens used to cure the paint. Similar recirculation is not possible in a solvent-based operation as the solvent levels in the recirculated air may reach explosive levels. The installed capital cost of water-based units is lower than that for high solids or powder coating.[88]

A number of private companies and a naval installation (Naval Air Rework Facility, Pensacola, Florida) have successfully converted from solvent-based painting to a water-based painting operation.[89] Based on their experience, the annual cost to coat using water-based coating was higher compared to conventional solvent, high solids, or powder coating. The applied coating cost per square foot for a water-based unit is also higher and the coating may be inferior. The quality of water-based coatings varies with ambient conditions such as room temperature and humidity. The drying time is longer and could be a bottleneck in the production line. It may necessitate installating a drying unit. Surface treatment procedures may need extensive modification to convert to a water-based coating method.[90]

One company that unsuccessfully tried to convert to water-based painting reported that the increased drying time led to production scheduling problems. The new system took several hours for drying, compared to the 30 minutes required for the solvent based process. It required an increased amount of surface cleaning before the water-based coating could be applied. The time and cost

[87]ICF Consulting Associates, Inc.
[88]ICF Consulting Associates, Inc.
[89]ICF Consulting Associates, Inc.
[90]ICF Consulting Associates, Inc.

involved in the extra cleaning were prohibitive. The water coating did not have the same hardness, durability, or gloss and the quality of the water-based paint varied with room temperature and humidity. The company also reported that the water environment was corrosive to galvanized steel. The existing equipment made of galvanized steel needed to be replaced with stainless steel, which involved considerable expense.[91]

Solvent-Based Paints - Product Substitution - Two-Component Catalyzed Coatings

Two-component catalyzed coatings are comprised of isocyanates (highly toxic compounds) and hydroxyl compounds. These compounds polymerize on a surface to form a polyurethane coating. Their use has been extensively investigated by the automobile industry.[92] Substituting two-component catalyzed coatings for solvent-based formulations is not justified because of the toxicity of the components.

Solvent-Based Paints - Product Substitution - Radiation-Curable Coatings

Radiation-curable coatings do not contain solvents and therefore could be good substitutes. A liquid prepolymer is allowed to react with a thinner under ultraviolet light to form a coating. These coatings have been found to be effective on a number of surfaces.[93]

Paint Wastes - Better Operating Practices - Segregation

The current practice for disposing of residual paint left in cans is to pour it into drums containing thinner wastes. However, segregating paints from thinner wastes maintains the purity of the thinner and improves its recyclability. Thinners can be recycled onsite or offsite and reused in painting and cleaning processes.

Excess paints should be given to customers for touchup use, thus reducing the improper disposal of cans containing liquid paint with other nonhazardous wastes. (Cans containing dried paint residue can be thrown out.)

Solvent Wastes - Better Operating Practices - Adopt Good Manual Spraying Techniques

When manual spraying practices are used, the amount of waste produced can be reduced by: using a 50 percent overlap in the spray pattern, maintaining a 6- to 8-in. distance between the spray gun and the surface, maintaining a gun speed of 250 ft/min, holding the gun perpendicular to the surface, and triggering at the beginning and end of each pass.[94] In addition to reducing the amount of waste produced, an increase in the production rate and a decrease in rejection rate can be realized.

Solvent Wastes - Better Operating Practices - Avoid Adding Excess Thinner

The tendency to use excess thinners should be avoided. If the paint is difficult to apply, adding thinner may make it easy. However, adding excess thinner affects the film thickness, density, and durability.[95]

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[91]ICF Consulting Associates, Inc.

[92] M.E. Campbell and W.M. Glenn, *Profit from Pollution Prevention - A Guide to Industrial Waste Reduction and Recycling* (The Pollution Probe Foundation, Toronto, Canada, 1982).

[93]M.E. Campbell and W.M. Glenn.

[94] J. Kohl, P. Moses, and B. Triplett, *Managing and Recycling Solvents: North Carolina Practices, Facilities, and Regulations* (North Carolina State University, Raleigh, NC, 1984).

[95]L.J. Durney, "How to Improve Your Paint Stripping," *Product Finishing* (December 1982), pp 52-53.

Solvent Wastes - Better Operating Practices - Avoid Excessive Air Pressures for Atomization

Using excessive air pressure to atomize paint particles leads to increased emissions and overspray, and must be avoided. By adjusting the air pressure, a 30 percent decrease in overspray and therefore a savings in raw material costs could be realized.[96]

Solvent Wastes - Better Operating Practices - Maintain Equipment Properly

Proper equipment maintenance is critical to reducing the number of reject products and improving productivity.[97] Proper maintenance also reduces the quantity of waste produced from paint stripping and repainting operations.

Solvent Wastes - Better Operating Practices - Lay Out Equipment Properly

Proper layout of equipment in a work area can also reduce emissions and improve the quality of the finished products. Solvent tanks must be kept away from heat sources such as curing ovens. This will help minimize evaporation of the solvents and will also prevent the solvent vapors from entering the curing oven and affecting the curing rate or decreasing the quality of the finish.[98]

Solvent Wastes - Better Operating Practices - Isolate Solvent-Based Spray Units From Water-Based Spray Units

Isolation of solvent-based spray units from water-based spray units is a good segregation practice. The oversprays from these operations should not be allowed to mix; the mixture could be classified as a hazardous waste. If the units are segregated, the filters from the water-based paint spray booths are not classified as hazardous waste.

Solvent Wastes - Better Operating Practices - Close Floor Drains in Production Area

Closing the floor drains will reduce the amount of water used to clean up spills. This practice promotes the use of rags that must be drycleaned. Thus the generation of large quantities of rinse water containing solvents can be minimized.[99]

Solvent Wastes - Better Operating Practices - Purchase Proper Quantities of Paints

Buying paint in large containers is preferable to buying the same quantity in smaller containers. The amount of residual materials can thus be reduced. Large containers can be returned to manufacturers for cleaning and reuse. Ordering extra paint for any given job should also be avoided. The exact amount of paint required must be calculated to reduce the number of small cans containing residues for disposal.

Solvent Wastes - Better Operating Practices - Segregate Wastes

Segregating wastes is extremely important to reducing the amount of hazardous wastes generated and to improve the recyclability of solvents. If many solvents are used, they should be segregated. Some solvents can be directly reused in equipment cleaning operations.

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[96]ICF Consulting Associates, Inc.
[97]ICF Consulting Associates, Inc.
[98]ICF Consulting Associates, Inc.
[99]L.J. Durney.

Proper labels must be attached to containers. Hazardous wastes must be segregated from nonhazardous wastes and handled and disposed of properly. Labeling a container containing non-hazardous waste as "hazardous" can result in an unnecessary increase in disposal costs.

Solvent Wastes - Better Operating Practices - Standardize Solvent Use

Standardizing solvent use will reduce the numbers of different types of thinners and solvents used in coating formulations. If fewer solvents are stocked, the possibility of mixing of the wastes is reduced. Only one type of thinner or solvent corresponding to each type of paint should be purchased.

Solvent Wastes - Product Substitution - Use High-Solids Formulations

High-solids formulations contain a reduced quantity of solvent. Using high-solids formulations will therefore reduce the amounts of wastes and emissions generated from the painting operations.

Solvent Wastes - Process Change - Choose Proper Coating Equipment

The proper choice of coating equipment can reduce the quantity of wastes produced and result in raw material savings. Overspray from painting operations generates the most waste. Equipment with high transfer efficiencies must be chosen.

Solvent Wastes - Process Change - Replace Conventional Spray Units With Electrostatic Units

Electrostatic units (either centrifugally- or air-atomized spray) have high transfer efficiencies. Converting from conventional equipment to electrostatic equipment may lead to a 40 percent reduction in overspray and considerable savings.[100] The overspray collects on the spray booth walls that are electrically grounded. Thus, the amount of residues in the rest of the work area is reduced. However, the complete conversion requires a lot of time and work in testing, visiting other plants, engineering, and maintenance.

Solvent Wastes - Process Change - Replace Air-Spray Guns With Pressure Atomized Spray Guns

Replacing air-spray guns with air-less spray guns increases the transfer efficiencies. A 23 percent reduction in raw material costs has been reported.[101] Also, the cleaning frequency is increased from once every 3 weeks to once a week.

Aqueous Wastes - Process Change - Dry Paint Booths

Large volumes of wastewater are generated from "water curtain" paint booths. The water curtain is used to remove the paint overspray particulates from the exhaust system. A significant concentration of paint, solvents, and flocculating/coagulating agents accumulates in the wastewater. This wastewater must be treated to remove hazardous contaminants and the sludge must be disposed of as a hazardous waste.

Converting from a wet to a dry paint booth eliminates the problem of wastewater generation. In a dry booth, the contaminated air (laden with paint particles) is drawn through fibrous filters which must then be disposed of as hazardous waste. A much smaller volume of waste is generated. Results

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[100] L.J. Durney.
[101] J. Kohl, P. Moses, and B. Triplett.

of a Navy study[102] indicate that converting to dry operation is technically feasible and cost effective (payback 8 months to 2 years) for small, medium, and large painting facilities.

Recycling Onsite/Offsite

Paint Wastes - Onsite Recycling - Recycle Paint Overspray/Sludge

In water curtain spray booths, the overspray impinges on a water curtain. The paint/water mixture is then pumped to a separator. If the paints used are immiscible in water, they can be separated out and recycled. Also, the water can be recycled back into the water curtain. Recycling of the water and paint reduces the amount of wastes produced and results in a savings in raw materials costs.

Solvent Wastes - Onsite Recycling - Ultrafiltration, Distillation, or Evaporation

In ultrafiltration, the sludge containing solvents is filtered using membranes with pore sizes of 0.01 microns. Paint particles, usually larger than 1 micron, collect on the membranes and are removed continuously. A series of membranes filter the waste to produce a pure solvent that can be recycled.[103]

Distillation stills can be used to recover solvents. The solvent is indirectly heated and the vapors are condensed and collected. Purities of 90 to 99 percent can be obtained by this process. Table 38 lists manufacturers of distillation stills and associated costs. The concentrated still bottoms containing paint sludge must be shipped for proper disposal as a hazardous waste. Another possibility is to ship the still bottoms to a cement kiln for use as a supplemental fuel through a waste exchange program.

Evaporation, using drum-dryers or thin-film evaporators, is effective on solvents that are heat-sensitive. Large scale equipment is necessary for evaporation and, therefore, is cost effective only for large quantities of solvents. Many commercial solvent recyclers use agitated thin-film evaporators.

Solvent Wastes - Offsite Recycling - Closed-Loop Contract

Wastes consisting primarily of thinners, paint sludge, and paint can be reclaimed at an offsite facility. This closed-loop service is provided by many paint and thinner suppliers. Usually the purchase price includes delivery, waste hauling, recycling, and disposal. Such a service removes the wastes when it delivers the new product. The waste is processed at a licensed treatment, storage, and disposal (TSD) facility. Processes used for recycling thinners are well-established and widely used.[104] Commercial recyclers have the versatility and have developed technologies for recycling large varieties of waste solvents. Between 70 and 80 percent of spent thinners can be recycled into a useful product.

Treatment

Solvent Waste - Onsite Pretreatment - Gravity Separation

Gravity separation is a relatively inexpensive option that is easy to implement. In this treatment process, the thinner and paint sludge mixture is allowed to separate by the force of gravity without

[102] Acurex Corporation, *Navy Paint Booth Conversion Feasibility Study*, CR 89.004 (Prepared for the Naval Civil Engineering Laboratory [NCEL], Port Hueneme, CA, 1989).

[103] Y. Isooka, Y. Imamura, and Y. Sakamoto, "Recovery and Reuse of Organic Solvent Solutions," *Metal Finishing* (June 1984), pp 113-118; W.H. Reay, "Solvent Recovery in the Paint Industry," *Paints & Resins* (March/April 1982), pp 41-44.

[104] SCS Engineers, Inc., *Waste Audit Study - Automotive Paint Shops* (California Department of Health Services, January, 1987).

external disturbance or agitation. The heavier paint sludge particles settle to the bottom of the container and the supernatant can be decanted off. The decanted thinner can be used as a "wash thinner" for cleaning equipment or for thinning primer and base coatings.[105]

Paint/Solvent/Aqueous Wastes - Offsite Treatment

Although most waste associated with paint can be treated using a number of different physical, chemical, and biological techniques, these techniques are not feasible for most Army installations that generate small quantities. However, licensed TSD facilities can use a number of processes such as activated carbon adsorption, chemical oxidation, solvent extraction, solid/liquid separation, stabilization/solidification, thermal destruction, volume reduction, and biological treatment. The applicability of each technique will not be discussed here.

Table 45

Waste Classification for Paint Removal, Painting, and Brush Cleaning

		Waste Description		
Materials used/ wastes produced	**HW code**	**DOT shipping name**	**Hazard class**	**Number**
Acetone	F003	Waste acetone	Flammable liquid	UN1090
Alcohols	D001	Waste alcohol, NOS	Flammable liquid	UN1987
Caustic paint stripper	D002	Waste paint related material	Corrosive material	NA1760
Chlorobenzene	F002	Waste chlorobenzene	Flammable liquid	UN1134
Enamel liquids	D001	Waste enamel	Combustible liquid	UN1263
Ethylene dichloride		Waste ethylene dichloride	Flammable liquid	UN1184
MEK	F005	Waste methylethylketone	Flammable liquid	UN1193
Methylene chloride stripper	F002	Waste methylene chloride	ORM-A	UN1593
Mineral spirits	D001	Waste naptha	Flammable liquid	UN2553
Paint dryer	None	Waste paint dryer, liquid	Combustible liquid	UN1263
Paint liquids	D001	Waste paint	Flammable liquid	UN1263
Paint solids (toxic)	Varies	Hazardous waste (solid), NOS	ORM-E (if solid)	UN9189
Paint thinners, lacquers	D001	Waste paint related material	Flammable liquid	NA1263
Paint waste with heavy metals	Varies	Hazardous waste liquid, NOS	ORM-E	NA9189
		Hazardous waste solid, NOS	ORM-E	NA9189
Petroleum distillates	D001	Waste petroleum distillate	Flammable liquid	UN1268
Toluene (Toluol)	F005	Waste toluene	Flammable liquid	UN1294
VM&P naphtha	D001	Compound, paint removing liquid	Flammable liquid	NA1142
Xylene (Xylol)	F003	Waste xylene	Flammable liquid	UN1307

[105] SCS Engineers, Inc.

8 WASTE MINIMIZATION FOR PHOTOGRAPHY, PRINTING, AND ARTS/CRAFTS SHOPS

Photography and photoprocessing are common operations at Army installations. Among the source types that use photography are: training and audiovisual centers, hospitals, dental clinics, and research laboratories (as discussed in Chapter 4). Printing operations are limited to training and audiovisual centers. The materials used in producing a photograph are paper, plastic film, or a sheet of glass containing light-sensitive photographic emulsion. The emulsion is a gelatineous substance containing silver halides (chloride, bromide, and iodide). Some photographic films may be made of cellulose acetate. However, most are made of polyester. In photography, a negative containing different shadings is produced. The dark portions on a negative contain heavy deposits of silver. The processing that follows the exposure of a film or emulsion consists of developing, fixing, and washing. Wastewater containing photoprocessing chemicals and silver is the primary wastestream of concern.

A printing process usually follows image processing, including typesetting and the photographic processing step discussed above. However, an intermediate step to prepare plates to carry the image to paper is necessary. A roller transfers ink onto a plate or a cylinder. The image on the plate or cylinder is transferred to a rubber blanket which in turn transfers it to paper. There are four different types of image carriers: manual - in screen printing; mechanical - for relief printing; electrostatic - in offset duplicating, and photomechanical - most common method of platemaking.[106] Preparation of plates is followed by the actual printing. Two common types of printing presses used are: sheet-fed presses that can print up to 3 impressions per second and web presses that operate at the rate of 1000 to 1600 feet per minute.[107]

In the printing process, the plate (a thin aluminum sheet) is first attached to the plate cylinder of the press. Each unit of a printing press then prints a single color. Four units (red, blue, yellow, and black) are required for a full color illustration. The raw materials typically used in a printing operation are ink, paper or other print substrate, and fountain solution. Wastes generated from a printing process include waste inks, used ink containers, used plates, damaged or worn rubber image transfer blankets, waste press oils, cleanup solvents, rags, and trash.[108]

The arts and crafts shops are educational and vocational shops that provide training in automobile maintenance/repair, metalworking, graphic arts, and woodworking. Only the minimization of wastes from the photography and printing section of arts and crafts shops is considered in this chapter. Minimization of wastes from automobile maintenance/repair and metalworking are discussed in Chapters 5 and 6, respectively. A summary of processes, corresponding waste streams, and DOT classifications is provided in Tables 46 and 47.

Most of the waste minimization options discussed in this chapter have been extracted from *Waste Audit Study - Commercial Printing Industry*.[109]

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[106] Jacobs Engineering Group, Inc., *Waste Audit Study - Commercial Printing Industry* (California Department of Health Services, Sacramento, CA, May 1988).
[107] Jacobs Engineering Group, Inc.
[108] Jacobs Engineering Group, Inc.
[109] Jacobs Engineering Group, Inc.

Source Reduction - Photography and Printing Operations

All Wastes - Better Operating Practices - Proper Material Handling and Storage

Raw materials may become obsolete and get spoiled due to improper storage and handling. Therefore, proper storage and handling is a good operating practice that will reduce the amount of waste generated and result in savings in raw materials costs.

Photographic and printing chemicals require proper storage, which is usually indicated on the containers. They are sensitive to light and temperature. Proper storage under recommended conditions increases their shelf life and results in savings in raw materials costs and disposal costs.

The storage area must be kept clean. One way to keep the storage area clean is to prohibit through traffic and restrict entry to only a few persons. Traffic increases the amount of dirt and the possibility of contamination. It is easier to contain spills if the entry is restricted to only a few persons.

Proper inventory control is necessary to decrease the possibility of the material's shelf life expiring before the materials are used The materials should be arranged and labeled on shelves so that those that were purchased first must be used first. Computerized inventory control and materials tracking will help manage the inventory.

Material with an expired shelf life should not be discarded. Tests must be used to determine the effectiveness and usability. Waste disposal may thus be minimized. Excess material should be recycled through a manufacturer or a waste exchange.

Ordering excess material should be avoided. Material ordering should be based on use. Small printing operations should purchase inks in small containers to limit the possibility of the ink spoiling in large containers that may not be properly sealed. Large printing operations should order materials in large containers that can be returned to manufacturers for cleaning and reuse.

Raw materials should be inspected when they arrive and before use. Unacceptable and/or damaged items must be returned to manufacturers to avoid disposal problems and to avoid creating defective products.

Source Reduction - Photographic Operations

Photographic Chemicals - Better Operating Practices - Proper Chemical Storage

Many of the photographic chemicals degrade in the presence of air. Small photographic operations store chemicals in plastic containers. Adding glass beads to the containers to bring the liquid level up to the brim has been found to be useful.[110] The life of the chemicals can thus be extended.

Photographic Films - Material Substitution - Nonsilver Films

Substituting films containing silver with those containing nonhazardous chemicals reduces hazardous waste generation. The silver from silver films makes the photographic wastes (e.g., fixing

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[110] Jacobs Engineering Group, Inc.

bath solutions, rinse water, etc.) hazardous. Only very low silver concentrations are allowed in wastewaters treated at wastewater treatment plants operated by county sanitation districts.

Some substitutes to silver halide films include vesicular (diazo), photopolymeric, and electrostatic films.[111] However the disadvantage of these films is that they are slower than silver films. Vesicular films consist of a honeycomb structure and are constructed from a polyester base coated with a thermoplastic resin. These films are also coated with a light-sensitive diazonium salt. Photopolymeric films use carbon black instead of silver. A weak alkaline solution is used to process these films. The spent bath solution is a nonhazardous waste that can be neutralized before disposal. An electrostatic charge makes electrostatic film light sensitive. The speed of this nonsilver film is comparable to silver films and it has a high resolution.

Other Photographic Wastes - Material Substitution

Other photographic wastes such as intensifiers and reducers also contain hazardous compounds (e.g., mercury, cyanide salts, etc.). Use of available nonhazardous substitutes will reduce the amount of hazardous wastes generated.

Fixing Bath Solutions - Process Change - Extend Bath Life

The life of fixing baths can be extended to reduce the quantities of wastes generated from photographic operations. Some of techniques that could be used include:[112]

1. Adding ammonium thiosulfate which increases the bath life by doubling the allowable silver concentration,

2. Using an acidic stop-bath before the fixing bath,

3. Adding acetic acid to the fixing bath to keep the pH low.

Photographic Wastewater - Process Change - Reduction in Water Use

Parallel rinsing is commonly used in photographic processing operations. Converting to countercurrent rinsing reduces the amount of wastewater generated. In countercurrent rinsing, the water flows in a direction that is opposite to the film movement. Thus, fresh water in the final tank is used in the final film washing stage after most of the contamination has been rinsed off. The most contaminated water is in the very first washing stage. A countercurrent system, however, requires more equipment and space.

Sponges or squeegees must be used in nonautomated operations to remove excess water from the films. Thus the dragout of chemicals from one tank to another can be reduced by almost 50 percent.[113] Minimizing contamination of processing baths has many advantages including: increasing the recyclability of solutions, extending solution life, and reducing the quantities of raw materials (replenishments) required.

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[111]Jacobs Engineering Group, Inc.
[112]Jacobs Engineering Group, Inc.
[113]Jacobs Engineering Group, Inc.

Another method of reducing waste chemicals is to add accurate amounts of replenishment chemicals and properly monitor the chemical concentrations of baths. Exposing the process baths to air must be minimized to prevent oxidation reactions.

All Photographic Wastes - Process Change

With the recent advances in desk top publishing systems and the use of personal computers, "electronic prepress photographic systems" are gaining widespread popularity. In such a system, the graphics, photographs, and layouts are scanned into the computer. Editing is accomplished on the monitor rather than on paper. Only the final version is printed on paper. Use of electronic sytems will greatly reduce the quantities of wastes generated from photographic operations conducted at printing facilities.

Source Reduction - Printing Operations

Metal Etching/Plating Wastes - Process Change

If printing operations still include metal etching and plating, alternative processes (e.g., lithographic plate, hot metal, flexographic, etc.) must be examined as substitutes. These alternative processes do not present the problems associated with treatment and disposal of hazardous wastes.

Metal Etching and Plating Wastewater - Process Change - Reducing Water Use

The wastewater produced from metal etching and plating is a hazardous waste. Efforts must be made to reduce the toxicity of wastewater by reducing the dragout from process tanks and by using countercurrent rinsing. Dragout reduction can be achieved by: (1) positioning parts on racks so they drain properly, (2) using drip bars and drain boards to collect the dragged-out chemicals and returning them to the process tanks, and (3) increasing the process tank temperature to reduce surface tension of the solution thereby minimizing its tendency to cling to parts.

Countercurrent rinsing reduces the amount of wastewater leaving an operation. However, it does not reduce the hazardous material content in wastewater.

Lithographic Plate Processing Chemicals - Better Operating Practices - Reduced Chemical Use

The use of plate processing chemicals must be reduced. One way to reduce chemical consumption is to frequently monitor the pH, temperature, and chemical concentration of the bath. Bath life can thus be extended and changing of solutions can be reduced to only a few times a year. Using automatic plate processors facilitates precise monitoring of bath conditions.

Lithographic Plate Processing Plates - Better Operating Practices - Proper Storage/Recycling

Proper storing of plates reduces the possibility of them getting spoiled and maintains their effectiveness. Used plates are not a hazardous waste and must be collected and sold to an aluminum recycler.

Lithographic Plate Processing Plates - Material Substitution

Alternative "presensitized plates" are available that can be processed with water. Other plates available include "Hydrolith" plates manufactured by 3M Corporation.[114] 3M has also developed a platemaking system that eliminates the need for photoprocessing, and has been found to be economical for large plating operations.[115]

Web Press Wastes - Process Change - Break Detectors

Using break detectors in web presses prevents severe damage to the presses and also reduces the quantities of wastes from spillage of inks, fountain solutions, and lubricating oil. Web break detectors detect tears in a web as it passes through a high speed press. Broken webs tend to wrap around rollers and force them out of their bearings.

Waste Inks/Cleaning Solvents/Rags - Better Operating Practices

Rags dampened with cleaning solvents are used to clean presses. The amount of solvent and number of rags used can be minimized by reducing the cleaning frequency and by properly scheduling cleaning. Ink fountains must be cleaned only when a different color ink is used or if the ink has dried out. Overnight drying of ink may be reduced by using compounds that are dispensed as aerosol sprays.[116] Thus, the amount of waste ink, solvents, and rags is reduced.

Waste Inks - Better Operating Practices

The amount of waste ink generated can be reduced by implementing better operating practices. Only the required amount of ink must be put in an ink fountain before starting a print job. Resealing the ink containers after use is a good practice that prevents contamination by dust/dirt, formation of a "skin" on the ink surface, loss of solvents, and hardening. As much of the ink as possible must be scraped from the container for use.

Automatic ink levelers, when used in large presses, improve the print quality and reduce the amount of trash and the likelihood of accidental spills.

Waste (Flexographic) Inks - Product Substitution - Water-Based Inks

Substituting water-based inks for solvent-based inks in flexographic printing reduces the quantity of hazardous wastes generated. Use of water-based inks also eliminates the problems encountered with volatilization of solvents. Some of the disadvantages of water-based inks include: limited range of colors, higher energy requirement for drying because of high heat of vaporization, higher equipment operating costs, lower capacity, lower speed, and difficult cleaning requirements.[117] Water-based inks are not available for lithographic printing operations.

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[114]M.E. Campbell and W.M. Glenn.
[115]M.E. Campbell and W.M. Glenn.
[116]Jacobs Engineering Group, Inc.
[117]Jacobs Engineering Group, Inc.

Waste Inks - Product Substitution - UV Inks

Ultraviolet (UV) inks are those that dry when exposed to UV light. UV inks contain: monomers, photosynthesizers, and pigments rather than solvents. Because they do not dry in fountains, the need for cleaning is reduced. The advantages of UV inks include:[118]

1. UV inks eliminate "set-off" -- the unintentional transfer of ink from one sheet to the back of the preceding sheet after the sheets have been stacked, which occurs when the ink has not completely dried.

2. UV inks eliminate the need for anti-offset sprays that prevent set-off.

3. UV inks eliminate the need for ventilated storage of sheets when using oxidative drying processes.

Disadvantages of UV inks include:[119]

1. The cost is 75 to 100 percent higher than conventional heat-set inks.

2. UV light is a hazard to plant personnel.

3. The interaction of UV light and atmospheric oxygen forms ozone.

4. Conventional paper recycling procedures will not deink paper printed by this process. This creates a waste source from an otherwise recyclable material.

5. Some of the chemicals in the inks are toxic.

Waste Inks - Product Substitution - EB Inks

Electron beam (EB) inks are those that are dried by electron beams and are similar to UV inks in operational concept. They have the same advantages as UV inks. However, operator protection from X-rays is necessary and these inks degrade the paper.

Waste Inks - Product Substitution - Heat Reactive Inks (Web Presses)

Heat reactive inks contain a prepolymer, a cross-linking resin, and a catalyst. At 350 °F, the inks are activated to polymerize and set. These inks contain much less solvent than the conventional heat-set inks.

Cleaning Solvents - Good Operating Practices - Pour Cleaning

Whenever possible "pour" cleaning with solvent followed by "wipe" cleaning with a rag could be used to clean presses. The drained solvent must be collected and recycled. Although more solvent is used in this process, less ink ends up on the rags. Cross-contamination of inks must be avoided. The used solvent can be used to clean rollers and blankets, thus reducing the amount of fresh solvent used.

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[118] Jacobs Engineering Group, Inc.
[119] Jacobs Engineering Group, Inc.

Use of wipe cleaning with rags may be preferable to pour cleaning in some cases because the quantity of solvent wastes is considerably reduced.

Cleaning Solvents - Good Operating Practices

Detergents or soap solutions rather than solvents should be used for general cleaning. Use of solvents should be limited to removing inks and oils.

Cleaning Solvents - Product Substitution - Nonhazardous Formulations

Hazardous materials such as benzene, carbon tetrachloride, TCE, and methanol were previously used as cleaning solvents. Several "blanket washes" containing glycol ethers and other heavy hydrocarbons that are less toxic and flammable are now available. Using nonhazardous blanket washes is recommended for all cleaning requirements in a printing operation.

Fountain Solutions - Product Substitution

Conventional fountain solutions contain water, isopropyl alcohol, gum arabic, and phosphoric acid. These compounds are transferred to the printing paper or they evaporate causing volatile organic compounds to be released. Substitute formulations must be used to reduce the emissions.

Waste Paper - Good Operating Practices - Reduce Use

Printing operations generate a large quantity of waste paper. Although paper is not a hazardous waste, reducing paper consumption and thus the purchase of new paper is a good operating practice.

Recycling Onsite/Offsite - Photographic Operations

Spent Fixing Bath Solution - Onsite Recycling - Silver Recovery

Spent fixing bath solutions contain silver that can be recovered. Following recovery, the bath can be reused or discharged to a sewer. Some of the reasons for recovering silver from the solution include:[120] reducing the amount of hazardous silver compounds in wastewaters, extending the useful life of fixing baths, and redeeming the precious metal value of silver.

Electrolytic deposition is the most common method of recovering silver. The electrolytic recovery units have carbon anodes and steel cathodes. Applying a low voltage results in the plating of metallic silver on the cathode. The fixing bath solution, after silver removal, can be mixed with fresh solution and reused in the photographic development process.

A second method of silver recovery is the use of steel wool cartridges to replace silver in an oxidation-reduction reaction. In this process, the spent fixing bath solution is pumped through the steel wool cartridge and iron replaces silver in the solution. Silver sludge settles to the bottom of the cartridge.

A detailed discussion of methods and procedures for silver recovery including: general procedures for hypo collection and recovery, procedures for removing silver from recovery units, recommended recovery procedures for use with automatic film processors, and procedures for using the metallic

[120] Jacobs Engineering Group, Inc.

replacement recovery cartridges are outlined in the Defense Logistics Agency's *Defense Utilization and Disposal Manual.*[121]

Photographic Films - Offsite Recycling - Silver Recovery

Photographic laboratories and many other facilities that use X-ray films generate used photographic films that contain 1 percent (0.15 troy ounces) of silver.[122] These films must be sold to recyclers for silver recovery.

Recycling Onsite/Offsite - Printing Operations

Metal Etching and Plating Wastewater/Sludge - Onsite/Offsite Recycling - Material Recovery

The wastewater from metal etching and plating operations contains heavy metals and various quantities of process chemicals. Material recovery processes can be implemented to recover some of the process chemicals and thus reduce raw material costs.

Used Metal Wastes - Offsite Recycling

Linotype operations used for letterpress printing generate used metal wastes. The process uses an alloy with a low melting point to create the letters in lines of text. The metal must be melted in the linotype machines and/or recycled. The manufacturer or metal supplier may be willing to buy the used metal and recycle it.

Waste Inks - Onsite Recycling

A simple recycling technique is to blend all the waste inks together to form black ink. It may be necessary to add small amounts of color and toner to obtain an acceptable black color. The reformulated black ink is similar in quality to new newspaper ink. Most newspaper printing presses use recycled black ink.[123]

Waste Inks - Offsite Recycling

Contract recycling of waste inks can be used to produce black ink. This black ink can be used to print newspapers or flyers. In such a contract, waste inks are bottled and shipped to the recycler (or manufacturer) and the reformulated black ink is shipped back. The costs of buying new black inks and disposing of waste inks can thus be reduced.

Cleaning Solvents - Onsite Recycling - Distillation

Small distillation units are available for recycling solvent used in pour cleaning. Proper segregation of solvents and trash is necessary. Still bottoms have to be disposed of as hazardous waste.

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[121] *Defense Utilization and Disposal Manual*, DOD 41620.21-M (Defense Logistics Agency, Office of the Assistant Secretary of Defense, Alexandria, VA, September 1982), pp VI-42 and XVII-A-5 through XVII-A-10.
[122] *Defense Utilization and Disposal Manual.*
[123] C. Woodhouse, *Waste Ink Reclamation Project* (California Department of Health Services, Toxic Substances Control Division, August 1984).

Waste Paper - Offsite Recycling

Waste paper must be collected and recycled. Manufacturers or paper recyclers remove the ink and repulp the paper. Pulp from recycled paper adds strength and durability to many other paper products.

Treatment - Printing Operations

Wastewater from metal etching and plating operations is classified as hazardous and must be treated before discharge to a municipal sewer. If not treated, it must be put in drums and disposed of as hazardous waste. Packaged treatment units that neutralize and precipitate the heavy metals are available. The sludge generated from treatment is also a hazardous waste and is banned from land disposal.

Table 46

Typical PPAS Operations With Materials Used and Wastes Generated*

Process/ Operation	Materials Used	Ingredients on Labels	Wastes Generated
Apply light sensitive coating	resins, binders, emulsion, photosensitizers, gelatin, photoinitiators	PVA/ammonium dichromate, polyvinyl cinnamate, fish glue/albumin, silver halide/gelatin emulsion, gum arabic/ammonium dichromate	photographic waste
Develop plates	developer	lactic acid, zinc chloride, magnesium chloride	photographic waste
Wash/clean plates	alcohols, solvents	ethyl alcohol, isopropyl alcohol, methyl ethyl ketone, trichloroethylene, perchloroethylene	spent solvents
Apply lacquer	resins, solvents, vinyl lacquer	PVC, PVA, maleic acid, methyl ethyl ketone	spent solvents
Counter-etch to remove oxide	phosphoric acid	phosphoric acid	acid/alkaline wastes
Deep-etch coating of plates	deep etch bath	ammonium dichromate, ammonium hydroxide	acid/alkaline waste, heavy metal solutions, waste etch bath
Etch baths	etch bath for plates	ferric chloride (copper), aluminum chloride/zinc chloride/hydrochloric acid (chromium), nitric acid (zinc, magnesium)	waste etch bath, acid/alkaline waste, heavy metal solutions
Printing (Ink)	pigments, dyes, varnish, drier, extender, modifier	titanium oxide, iron blues, molybdated chrome orange, phthalocyanine pigments, oils, hydrocarbon solvents, waxes, cobalt/zinc, magneze oleates, plasticizers	waste ink with solvents/heavy metal, ink sludge with chromium/lead
Making gravure cylinders	acid plating bath	copper hydrochloric acid	spent plating waste

*Source: H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), pp 146-147.

Table 47

Waste Classification for PPAS

Process Description		Waste Description			
Process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Photographic processing	Carbon tetrachloride	F001	Waste carbon tetrachloride	ORM-A	UN1846
	Waste solutions with heavy metals (Cd, Cr, Pb, etc.)	Varies	Hazardous waste solution, NOS	ORM-E	NA9189
Washing, cleaning plates; press cleanup	Ethyl alcohol	D001	Waste ethyl alcohol	Flammable liquid	UN1170
	Isopropyl alcohol	D001	Waste isopropyl alcohol	Flammable liquid	UN1219
	Methylethylketone	F005	Waste methylethylketone	Flammable liquid	UN1193
	Naptha	D001	Waste naptha	Flammable liquid	UN2553
	Perchloroethylene	F002	Waste perchloroethylene	ORM-A	UN1897
	Petroleum distillates	D001	Waste petroleum distillates	Flammable liquid	UN1268
	Press wash	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
	Xylene	D001	Waste xylene	Flammable liquid	UN1307
Etching, plating	Ammonium hydroxide	D002	Waste ammonium hydroxide	Corrosive material	NA2672
	Hydrochloric acid (Cr)	D002	Waste hydrochloric acid	Corrosive material	NA1789
	Nitric acid (Zn, Mg)	D002	Waste nitric acid	Corrosive material	NA1760
	Phosphoric acid	D002	Waste phosphoric acid	Corrosive material	UN1805
Printing	Waste ink (containing various solvents and heavy metals)	D002	Waste ink	Combustible liquid Flammable liquid	UN2867 UN1210
	Ink sludge (heavy metals - Cr or Pb)	D002	Hazardous waste liquid, NOS Hazardous waste solid, NOS	ORM-E ORM-E	NA9189 NA9189

9 WASTE MINIMIZATION FOR HOSPITALS, CLINICS, AND LABORATORIES

Army hospitals, veterinary clinics, dental clinics, and other laboratories are usually tenants located on an installation. The types of wastes generated by these activities can be divided into infectious wastes (IW), pathological wastes (PW), sharps, pharmaceutical wastes (PhW), radioactive wastes (RW), laboratory wastes (LW), chemotherapy wastes (CW), infectious linen (IL), and general wastes (GW). Only the LW and CW are hazardous wastes by the RCRA and HSWA definition.

For this discussion, some of the definitions for hospital wastes are extracted from Army Regulation (AR) 40-5.[124] Detailed definitions and classifications of infectious wastes can be obtained from USEPA's *Guide to Infectious Waste Management*.[125]

IW is from patients in strict or respiratory isolation, or with wound and skin precautions; wastes from microbiological laboratories; and surgical waste (at the discretion of the operating room supervisor). PW includes anatomical parts, excluding human corpses and animal carcasses. Sharps include discarded hypodermic needles, syringes, pipettes, broken glass, and scalpel blades that pose infection and physical injury hazards through cuts or puncture wounds. GW is all the waste not classified as infectious, pathological, or hazardous, for example: refuse generated from general patient units, emergency rooms, dental areas, surgical suites, administrative areas, and supply areas. PhW consists primarily of outdated medicines (drugs, vaccines, and physiological solutions). RW wastes emit ionizing radiation (such as alpha, beta, gamma, or X-rays).

The activities that generate most of the highly infectious wastes are: general surgery/recovery, vascular surgery, plastic surgery, pathology, blood bank, microbiology laboratory, labor and delivery rooms, obstetrics, emergency room isolation, and the morgue. Among the wastes generated are: (1) significant laboratory waste, including all tissue or blood elements, excreta, and secretions obtained from patients or laboratory animals and disposable fomites (items that may harbor or transmit pathogenic organisms); (2) surgical specimens and attendant disposable fomites; (3) disposable materials from outpatient areas and emergency departments; (4) equipment, instruments, utensils, and fomites of a disposable nature from isolation rooms; (5) animal feces, animal bedding, supplies, and fomites resulting from and/or exposed to infectious animal care and laboratory procedures; and (6) all disposable needles and syringes.[126]

Radioactive wastes are usually generated by the radiology ward, nuclear medicine, clinical pathology, and laboratories that use radionuclides. Some of the radionuclides administered to patients during treatment include: $^{99\text{-M}}$Technetium, ^{51}Chromium, ^{32}Phosphorus, and ^{131}Iodine.[127] Most of the radioactive wastes that require special handling and disposal are generated by the use of radionuclides such as ^{14}Carbon, ^{4}Hydrogen, and ^{131}Iodine, in clinical laboratories.

A number of different types of hazardous wastes are generated in HCL, although in small quantities. Table 48 lists processes and operations that generate wastes, and the corresponding DOT classifications. LW is mostly chemical wastes, including ignitable/chlorinated solvents and miscellaneous used chemicals (e.g., xylene, formalin, mercury, etc.) generated in analytical and clinical laboratories. These wastes may also be generated in maintenance, pharmacy, and nursing areas.

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[124] Army Regulation (AR) 40-5, *Preventive Medicine* (HQDA, 30 August 1986).
[125] *Guide to Infectious Waste Management*, EPA/530-SW-86-014 (USEPA, Washington, D.C., 1986).
[126] D. Kraybill, T. Mullen, and B.A. Donahue, *Hazardous Waste Surveys of Two Army Installations and an Army Hospital*, Technical Report N-90/ADA088260 (USACERL, August 1980), pp 46-48.
[127] D. Kraybill, T. Mullen, and B.A. Donahue.

Photographic films and chemicals are used in radiology. Other toxics and corrosives are used throughout the hospitals.

CW is a large quantity HW generated by the use of antineoplastic, or cytotoxic agents in chemotherapy solutions administered to patients. The chemicals themselves are only a small volume of the waste; most of it consists of protective clothing and gauze pads that are lightly contaminated.

Most of the guidance on proper management and minimization of wastes discussed in this chapter has been obtained from *Protocol Health Care Facility Waste Management Surveys*,[128] and *Waste Audit Study - General Medical and Surgical Hospitals*.[129] The minimization of photographic wastes is discussed in Chapter 8.

Regulations

On October 21, 1988, the U.S. Congress passed the Medical Waste Sanctions Act (MWSA) which requires strict control on generation and disposal of medical wastes, and prohibits anyone from dumping the wastes in oceans and large water bodies (such as the Great Lakes).[130] MWSA was initiated as an amendment to the original Marine Protection, Research and Sanctuaries Act (MPRSA) of 1972. MPRSA and MWSA define "medical waste" to include "isolation wastes; infectious agents; human blood and blood products; pathological wastes; sharps; body parts; contaminated bedding; surgical wastes and potentially contaminated laboratory wastes; dialysis wastes; and other equipment and material that the Administrator of the USEPA determines may pose a risk to public health, welfare, or the marine or Great Lakes environment." Of the 160 million tons of waste generated in the United States each year, 3.2 million tons of them are medical wastes from hospitals.[131] These medical wastes do not include refuse from doctors' offices, laboratories, home health care, veterinary clinics, and blood banks. Of the 3.2 million tons of medical wastes, USEPA estimates that 10 to 15 percent are infectious.

MWSA was passed because medical wastes could be regulated under the RCRA and HSWA but are not under the USEPA rules. MWSA requires USEPA to develop rules and regulations for a cradle-to-grave manifest system to track the medical wastes from generation to disposal, and for record-keeping, reporting, and proper segregation (from ordinary refuse) and disposal requirements. The States have been given the authority to enforce MSWA more stringently than the USEPA requirements. Therefore, States such as Delaware, Louisiana, Maryland, Minnesota, New York, and Pennsylvania, have passed stricter laws for tracking and disposing of medical wastes.

In the private sector, research and testing laboratories such as those located in Army hospitals and associated research facilities would be regulated as small quantity generators of hazardous laboratory waste. All the rules of RCRA and HSWA would apply and cradle-to-grave management and development of minimization strategies would be necessary.

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[128] *Protocol Health Care Facility Waste Management Surveys* (USAEHA, 1987).

[129] Ecology and Environment, Inc., *Waste Audit Study - General Medical and Surgical Hospitals* (California Department of Health Services, Sacramento, CA, 1988).

[130] *Medical Waste Sanctions Act of 1988*, Report 100-1102 (House of Representatives, 100th Congress, October 1988).

[131] *Medical Waste Sanctions Act of 1988*.

Source Reduction - All Wastes

IW/PW/GW/Sharps - Better Operating Practices - Segregation

IW and PW must be segregated from GW and sharps. GW such as surgical glove wrappers should not be placed in IW containers (e.g., red bags in rigid containers). Sharps must be placed in separate containers (e.g., rigid plastic boxes) in every room where they are used. Separate containers (e.g., yellow or white bags) must be used for general wastes including paper and trash.

Source Reduction - Infectious and Pathological Wastes

IW/PW - Better Operating Practices - Segregation/Labeling

All the containers must be rigid and must be lined with impervious, tear resistant, and distinctively colored bags (e.g., red bags for infectious wastes only). The same type and color bags must be used at all waste generation points and marked/labeled with the universal biohazard symbol. Standardized procedures (labeling, color, etc.) reduce confusion among personnel and improve waste management, thus, minimizing quantities of wastes generated.

IW/PW - Better Operating Practices - Collection/Transportation

Sufficient numbers of IW/PW containers must be provided and conveniently located in all rooms where the wastes are generated. They should also be located in such a way as to minimize patients/personnel exposure to the wastes. The containers must be cleaned and disinfected every time they are emptied. All the containers should have tight-fitting lids and the lids should be in place when the containers are not in use. To minimize exposure for patients and staff, IW/PW must be collected frequently from all the generation points by trained personnel only. The transport containers must have tight-fitting lids and should be used exclusively for IW/PW. The interior of the transport containers must be cleaned and disinfected regularly.

IW/PW - Better Operating Practices - Storage

All IW/PW storage areas (including access doors, containers, freezers, refrigerators, etc.) must be labeled and marked with the universal biohazard symbol.

Treatment - Infectious and Pathological Wastes

IW/PW - Treatment/Better Operating Practices - Incineration

Incineration is one of the options used to treat infectious wastes. The manufacturer's operating instructions and standard operating procedures must be posted on the incinerator. A State or local air quality permit must be obtained and the incinerator must be operated in compliance by following the manufacturer's recommended temperature to reduce emissions and opacity problems.

The incinerator ash could be a hazardous waste. It should be tested annually for hazardous characteristics. Testing of incinerator ash at Army installations[132] has revealed that it is Extraction Procedure (EP) toxic fc heavy metals.

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[132] *Protocol Health Care Facility Waste Management Surveys.*

The red bags used to contain IW/PW burned in incinerators are made of chlorinated plastics (PVC). Burning these red bag wastes generates a number of air pollutants of concern including: hydrochloric acid, dioxins, furans, and particles. These toxic stack emissions are a significant hazard to the community. As public concern increases (and regulations change) proper flue-gas cleanup will be required. Some of the air emission control devices that could be installed include: dry impingement separators, dry cyclonic separators, venturi scrubbers, electrostatic precipitators, fabric filters, wet acid gas scrubbing devices, and dry scrubbing systems.

IW/PW - Treatment/Better Operating Practices - Autoclaves/Retorts

Autoclaves or retorts are used in several hospitals to disinfect IW/PW before landfill disposal. All the operators should be trained in proper equipment use. The bags used in autoclaves should allow sufficient steam penetration and yet contain the wastes. Compaction of wastes must always follow the autoclaving process. Spore strips should be used to check the effectiveness of the operation.

Source Reduction - Sharps

Clipping needles after use is prohibited by AR 40-5 to prevent generation of pathogen-containing aerosols. Used syringes must be placed only in rigid impervious containers marked with the universal biohazard symbol. Adequate containers must be provided and managed by trained personnel.

Source Reduction - Hazardous Wastes

HW - Better Operating Practices - Inventory

A current and comprehensive inventory must be developed for all the hazardous materials used and hazardous wastes generated. The inventory must contain the following for each HW: a description; hazard code; USEPA (or State) number; physical form; rate of generation; method of treatment, storage, and disposal; and an indication if the waste is infectious. All HW on the inventory must be reviewed annually and reported to the installation environmental office.

Infectious hazardous wastes could be generated at the histology (waste xylene), parasitology (hazardous fluids), and radiology (waste barium) laboratories. A proper inventory must be developed for these wastes. The procedures for handling these wastes are outlined in *Infectious Hazardous Waste Handling and Disposal.*[133]

HW - Better Operating Practices - Proper Storage

Proper containers must be used to store hazardous wastes; they must be properly labeled. They must contain liners compatible with the wastes. Upon exceeding the 55-gal (or 1 qt for acute HW) storage limit in the satellite accumulation areas, the 90-day temporary storage requirements[134] have to be complied with and the wastes must be turned in to the installation's hazardous wastes storage building.

[133] *Infectious Hazardous Waste Handling and Disposal*, Technical Guide Number 147 (USAEHA, 1986).
[134] 40 CFR 262.34, *Onsite Accumulation Requirements.*

HW (solvents) - Better Operating Practices - Segregation

Solvent wastes must be segregated according to the recycling or treatment processes used for their recovery or disposal. The greater the purity of the waste solvent, the higher is its recyclability. Some of the criteria useful for segregation are:[135] flash point, Btu value, viscosity, halogen content (e.g., chlorine), and water content. Segregating wastes as individual chemicals (with minimal contamination) simplifies waste management.

HW (solvents) - Product Substitution

Nonhalogenated solvents must be substituted for halogenated solvents (e.g., TCE, 1,1,1-trichloroethane, MC, etc.). Simple alcohols and ketones are good substitutes for petroleum hydrocarbons (e.g., toluene, xylene, etc.). Aqueous reagents must be used whenever possible. The feasible substitutions have to be determined by laboratory managers on a case-by-case basis.

Xylene is commonly used as a tissue clearing agent at hospitals. Use of a nonhazardous substitute (such as Histoclear™) must be examined to determine its effectiveness.

HW (solvents) - Process Change

Cleaning processes that use alcohol-based disinfectants must be modified to use ultrasonic or steam cleaning methods. Premixed containerized test kits must be used for solvent fixation (making slides). Calibrated solvent dispensers must be used for routine tests. Minimizing the sizes of cultures or specimens in the pathology, histology, and other laboratories, minimizes the quantities of solvent wastes produced.

Modifying laboratory methodologies to use modern technologies (e.g., monoclonal antibodies, radioisotope labeled immunoassays, and ultrasensitive analytical devices) minimizes or even eliminates the need for extractions and fixation with solvents. Sensitive analytical equipment can reduce analyte volume requirements.

LW - Better Operating Practices - Disposal

All the laboratory hazardous wastes that may be discharged into the sanitary sewer must be identified. Approval must also be obtained from local authorities. According to USEPA requirements [40 CFR 261.3(a)(2)(iv)(E)] the following conditions must be met:

1. Only low toxic hazard, and biodegradable wastes may be discharged,

2. The annualized average flow rate of laboratory wastewater must not exceed 1 percent of the total wastewater flow into the inflow of the wastewater treatment plant,

3. The combined annualized average concentration must not exceed one part per million (ppm) of the inflow to the wastewater treatment plant.

Proper standard operating procedures must be developed and used for disposal of chemicals in the sanitary sewer system.[136] Approval must also be obtained from local authorities. Disposal actions

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[135] Ecology and Environment, Inc., pp 5-1 -- 5-3.
[136] National Research Council, *Prudent Practices for Disposal of Chemicals from Laboratories* (National Academy Press, Washington, DC, 1983).

must be coordinated with the installation's environmental office. Sewer disposal is an environmentally unsound practice and must be avoided. However, controlled disposal is allowed by law.

HW (mercury) - Better Operating Practices

Waste mercury can be recycled and must be recovered from spills and from crevices of broken devices. All the residual mercury contained in broken thermometers, blood pressure reservoirs, or other devices should be drained. However, proper spill cleanup and handling operations have to be designed to protect the employees. Special mercury vacuums and spill absorbing kits are available.

HW (mercury) - Process Change

Many hospitals in the United States are using electronic piezometric sensing devices instead of mercury-based thermometers and blood pressure instruments. Such a substitution eliminates both the hazards and cleanup costs associated with broken glass and spilled mercury.

HW (formaldehyde) - Better Operating Practices

Reducing both the cleaning frequency of hemodialysis and reverse osmosis (RO) water supply equipment and the solution strength will minimize the quantities of waste formaldehyde generated. The membranes used in RO units have to occasionally be flushed with formalin. A laboratory standard for formalin solutions should be developed based on microbial culture studies that compare microbial residue with variations in strength, cleaning frequency, and water supply systems.[137]

HW (formaldehyde) - Process Change

The dialysis equipment used in the hospital can be used to capture and concentrate waste formalin (containing 4 percent formaldehyde, 1 percent methanol, and 95 percent water).[138] Formaldehyde extracted and concentrated with the used dialysis membranes can then be sent for proper disposal (e.g., incineration) thus minimizing the waste and associated costs.

CW - Better Operating Practices - Collection/Disposal

Special dedicated containers must be used to collect antineoplastics, cytotoxins (cancer treatment agents), and other controlled drugs. Many of these drugs are listed hazardous wastes and must be managed using proper turn-in procedures.

CW - Better Operating Practices

Segregation of CW from other wastes is an effective minimization practice. Personnel must be properly trained and separate containers (with distinct labels) must be placed in all the drug handling areas.

The cleaning frequency for hoods used for compounding drugs should be reduced. According to OSHA recommendations, hoods should be wiped down daily with 70 percent acohol and decontaminated weekly with an alkaline solution.[139] However, the actual cleaning frequency must be determined based on the use and amount of spillage in the hood.

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[137]Ecology and Environment, Inc.
[138]Ecology and Environment, Inc.
[139]Ecology and Environment, Inc.

Spill cleanup kits, for small and large spills, must be readily available in the drug compounding and use areas. The garments, except gloves, worn by employees should be disposed of with non-hazardous refuse if no spills occurred.

The location of compounding and administration areas should be centralized to minimize spillage and exposure hazards. Drug purchases must be controlled such that only the appropriate container sizes are procured and no residue is left for disposal. Outdated drugs should be returned to the manufacturer.

CW - Product Substitution

Antineoplastics and cytotoxic agents are highly toxic and environmentally persistent. They must be substituted with biodegradable drugs. In some cases, the shelf life can be used as an indicator of environmental persistence. Doctors and pharmacists must be encouraged to choose less environmentally hazardous drugs of equal effectiveness.

RW - Product Substitution

A knowledge of the properties of radionuclides is required for the minimization of RW. A stable radionuclide with a short half-life, low energy, nontoxic decay product, and minimal extraneous radiation emissions must be chosen. Extraneous radiation is the radiation generated that is not required in a test or procedure. If a beta emitter is required, a radionuclide with minimal gamma emissions must be chosen. Containment of gamma rays is difficult.

A radiation safety committee should be established to advise researchers about alternative isotopes that are less environmentally hazardous than those currently in use.

RW (^{226}Radium) - Product Substitution

^{226}Radium is the most hazardous radionuclide used for cancer treatment in hospitals. It has a very long half-life and its decay products are unstable. ^{192}Iridium or ^{137}Cesium needles have been found to be good substitutes for ^{226}Radium needles.[140]

Recycling Onsite/Offsite - Hazardous Wastes

HW (xylene, other solvents) - Recycle Onsite - Distillation

Xylene wastes generated at the hospitals are contaminated with paraffin and tissue samples, and must be accumulated in proper segregated containers. The recyclability is greater if the contamination is minimal. Small distillation stills can be used to distill pure xylene for reuse. The still bottoms must be properly disposed of as HW. Once purchased, the still can be used for recycling a variety of other solvents (e.g., ethanol).

Table 38 lists manufacturers of industrial distillation equipment. For laboratories, stills made of glassware (process-spinning band distillation[141]) may be more suitable. Appropriate manufacturers

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[140] Ecology and Environment, Inc.

[141] L.M. Gibbs, "Recovery of Waste Organic Solvents in a Health Care Institution," *American Clinical Products Review* (November/December 1983).

(e.g., B/R Instrument Corporation, P.O. Box 7, Pasadena, MD 21122; (301) 647-2894) must be contacted for information on technical feasibility and costs.

HW (solvents) - Offsite Recycling

A number of commercial recyclers process solvents for reuse. Table 34 lists some of them.

HW (mercury) - Offsite Recycling

If more than 10 lb of liquid mercury is accumulated, it can be sold to a commercial reprocessor.[142] Large quantities can be sent in standard (76-lb) flasks supplied by the reprocessor. These reprocessors are willing to purchase from institutions rather than individuals. Therefore, DRMO must pursue this option for Army installation generators such as hospitals, laboratories, etc.

HW (formaldehyde) - Onsite Recycling - Reuse

Direct reuse of formaldehyde solutions in autopsy and pathology laboratories is possible, depending on the type of specimen. Reuse is possible because the specimen holding times are short and formalin solutions retain their properties for a long time. Additionally, the desired preservative properties may be more effective at lower concentrations than the 10 percent formaldehyde solutions commonly used in pathology laboratories.[143] Minimum effective strength of formalin solutions should be determined based on microbial culture studies.

HW (photographic chemicals) - Recycle Onsite/Offsite - Silver Recovery

Silver recovery methods such as those described in Chapter 8 must be used.

Treatment - Hazardous Wastes

HW (solvents) - Onsite Treatment - Incineration

If recovery by distillation is not a feasible option, onsite incineration should be considered. A permit is needed to operate an incinerator to burn solvents. Therefore, onsite incineration may not be a practical option for most Army hospitals. However, with the increase in offsite incineration costs and the ban on land disposal of liquid wastes and long-term liabilities, onsite incineration may become a feasible treatment method in the future.

Waste designated for incineration must have a high Btu content, a high flash point, low specific gravity, and a low solids content. The incinerator must be designed to achieve complete destruction while generating negligible quantities of air pollutants. Both technical and institutional problems have to be addressed before acquiring an incinerator to burn small amounts of a wide variety of chemical wastes.[144]

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[142]National Research Council, pp 44-55.
[143]National Research Council, Chapter 4.
[144]National Research Council, Chapter 9, pp 111-125.

HW (solvents) - Offsite Treatment - Incineration

Use of offsite facilities to incinerate solvent wastes may be a feasible option for most laboratories. Commercial incineration facilities require generators to segregate wastes and arrange for transportation.

LW (acids/alkalis) - Treatment - Neutralization

Elementary neutralization of corrosive liquids is exempt from treatment permit requirements. Acids (pH < 2) and alkalis (pH > 12.5) must be neutralized before they are allowed to flow into the drain.

Table 48

Waste Classification for HCL

Process Description		Waste Description			
Typical process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Analytical/clinical	Nonhalogenated solvents:				
laboratories,	Acetone	F003	Waste acetone	Flammable liquid	UN1090
Pathology,	Acetonitrile	D001	Waste acetonitrile	Flammable liquid	UN1648
Histology,	Ethanol	F003	Waste ethyl alcohol	Flammable liquid	UN1170
Embalming,	Ethyl acetate	F003	Waste ethyl acetate	Flammable liquid	UN1173
Sterile processing,	Isopropanol	D001	Waste isopropyl acohol	Flammable liquid	UN1219
Facilities	Methanol	F003	Waste methanol	Flammable liquid	UN1230
maintenance,	Toluene	F005	Waste toluene	Flammable liquid	UN1294
Laundry	Xylene	F003	Waste xylene	Flammable liquid	UN1307
	Halogenated solvents:				
	Chloroform		Waste chloroform	ORM-A	UN1888
	Freon	F001	Hazardous waste liquid, NOS	ORM-A	UN9189
	Methylene chloride	F001	Waste methylene chloride	ORM-A	UN1593
	1,1,1-trichloroethane	F001	Waste 1,1,1-trichioroethane	ORM-A	UN2831
	Trichloroethylene	F001	Waste trichloroethylene	ORM-A	UN1710
	Acids/bases:				
	Acetic acid	D002	Waste acetic acid (solution)	Corrosive material	UN2790
	Hydrochloric acid	D002	Waste hydrochloric acid	Corrosive material	UN1789
	Nitric acid	D002	Waste nitric acid, > 40%	Oxidizer	UN2031
		D002	Waste Nitric Acid, ≤ 40%	Corrosive material	NA1760
	Sulfuric acid	D002	Waste sulfuric acid	Corrosive material	UN1830
		D002	Waste sulfuric acid, spent	Corrosive material	NA1831
	Ammonium hydroxide	D002	Waste ammonium hydroxide, < 12%	ORM-A	NA2672
		D002	Waste ammonium hydroxide, ≥ 12% < 44%	Corrosive material	NA2672
	Potassium hydroxide	D002	Waste potassium hydroxide, solid	Corrosive material	UN1813
		D002	Waste potassium hydroxide, liquid	Corrosive material	UN1814
	Sodium hydroxide	D002	Waste sodium hydroxide, solid	Corrosive material	UN1823
		D002	Waste sodium hydroxide, liquid	Corrosive material	UN1824
	Others:				
	Mercury	D009	Waste mercury	ORM-A	UN2809
	Oxidizers		Waste oxidizer, NOS	Oxidizer	UN1479
			Waste oxidizer, corrosive, liquid, NOS	Oxidizer	NA9193
			Waste oxidizer, corrosive, solid, NOS	Oxidizer	NA9194
	Poisons		Waste poison B, liquid, NOS	Poison B	UN2810
			Waste poison B, solid, NOS	Poison B	UN2811
			Waste corrosive liquid, poisonous, NOS	Corrosive material	UN2922
	Poisonous, oxidizers		Waste poisonous solid, corrosive, NOS	Poison B	UN2928
	Nonspecific hazardous Wastes		Waste oxidizer, poisonous, liquid, NOS	Oxidizer	NA9199
			Waste oxidizer, poisonous, solid, NOS	Oxidizer	NA9200
			Hazardous waste liquid, NOS	ORM-E	NA9189
				ORM-E	NA9189

Table 48 (Cont'd)

Process Description		Waste Description			
Typical process/ operation	Materials used/ wastes produced	HW code	DOT shipping name	Hazard class	Number
Chemotherapy, pharmacy, clinics	Antineoplastics Cytotoxic drugs		Hazardous waste solid, NOS		UN2209
					UN1198
Radiology	Photographic chemicals: Fixer Developer			ORM-A ORM-A	
Hemodialysis, Pathology, Autopsy, Embalming, Nursing	Formaldehyde		Waste formaldehyde solution, flash point > 141 °F Waste formaldehyde solution, flash point ≤ 141 °F		
Clinical Testing	Radioisotopes				

10 WASTE MINIMIZATION FOR OTHER SOURCE TYPES

Heating and Cooling Plants

Army installations have a number of heating and cooling plants that generate power and steam. Hazardous wastes are generated by using various combustible (e.g., cyclohexylamine) and corrosive (e.g., caustic soda, caustic potash, hydrochloric acid) chemicals to adjust pH, prevent scaling or corrosion, clean the interior of the boiler, and to test feedwater. In addition, boiler blowdown liquid mixed with water is a hazardous waste generated periodically. Waste oil blended with virgin fuel oil is burned in boilers at some installations. The waste oil may be a hazardous waste, depending on the content, and should be burned only in permitted facilities.

A number of efficiency related boiler maintenance procedures can be used to minimize environmental pollution, while correcting malfunctions in boiler operation and preventing performance degradation. Component malfunction or performance degradation can cause increases in: stack gas temperature; excess air requirements; carbon monoxide, smoke, or unburned carbon in ash; convection or radiation losses from the boiler exterior, ductwork, and piping; blowdown above that required to maintain permissible water concentrations, and auxiliary power consumption by fans, pumps, or pulverizers. In addition to the normal maintenance recommended by manufacturers, efficiency-related maintenance procedures must be performed to extend equipment life and for personnel safety. These procedures include:[145] efficiency spotchecks of combustion conditions, establishing best achievable performance goals, monitoring performance (boiler log) to document deviations, periodic equipment inspection, and troubleshooting. Boiler tuneups also improve efficiency and fuel conservation.

Some modifications to the boiler operating practices improve boiler efficiency, save fuel, and reduce continuous blowdowns. These practices include: reducing boiler steam pressures, controlling the water quality by continuous blowdowns instead of infrequent blowdowns, and proper load management. Efficient boiler operation also minimizes the amounts of air pollutants (particulates, carbon monoxide, nitrogen oxides, sulfur dioxide, hydrocarbons, and oxidants) released to the atmosphere.

Inventory management of chemicals and reducing their use in water treatment and scale removal minimizes the amounts of wastes produced. Nonhazardous substitutes must be developed and used instead of the combustible and corrosive chemicals normally found at heating and cooling plants.

Used Oil Burning

Used lubricating oil generated by vehicle maintenance activities can be recycled as a fuel and blended and burned in boilers. Before burning, however, it is necessary to determine if the oil meets fuel specifications (Table 49). Used oil that meets the specifications can be burned in any burner

[145] *Efficient Boiler Operations Sourcebook*, F.W. Payne, Ed. (The Fairmont Press, Inc., Atlanta, GA, 1986), pp 79-106.

(space heater, nonindustrial boiler, industrial boiler, utility boilers, and industrial furnaces),[146] whereas other waste oils can only be burned in high-efficiency industrial boilers, industrial process furnaces, or boilers that have demonstrated compliance with performance standards set for hazardous waste incinerators. Nonspecification used oils can be blended with virgin oil to meet specifications and burned in an industrial or nonindustrial boiler.

It is necessary to test the used oil for halogen and heavy metal content before burning. Other treatment techniques such as filtration, oil-water separation, etc. (discussed in Chapter 5), must be used to improve the quality of the oil and its heating value.

Laundry and Drycleaning Facilities

Laundry and drycleaning facilities on a Army installation are the responsibility of the DOL. Caustic soda and other corrosive chemicals are used in the laundry. Perchloroethylene (PERC) is the most common drycleaning solvent used. The two other solvents used are Valclene™ (fluorocarbon 113 or tetrachloroethylene), and petroleum solvent (Stoddard). Use of solvents and corrosive chemicals in these processes results in the generation of contaminated wastewater and dry wastes (Table 50). Table 51 lists the wastes generated and the corresponding DOT classifications.

PERC drycleaning plants generate: (1) still residues from solvent distillation (entire weight), (2) spent filter cartridges (total weight of cartridge and solvent remaining after draining), and (3) cooked filter residue (the total weight of drained powder residue from diatomaceous or other powder filter systems after heating to remove excess solvent). Valclene plants generate still residues and spent filter cartridges. Petroleum solvent plants generate still residues only. Proper disposal is required for all the hazardous wastes generated at laundry and drycleaning facilities. Among the acceptable options are recycling, incineration, or disposal in an authorized hazardous waste landfill. However, source reduction by material substitution seems to be the most effective minimization technique for drycleaning operations. The possibility of replacing PERC or Valclene with Stoddard (PD680-II) or petroleum naptha must be explored. As is obvious from Table 50, using Stoddard produces the smallest amount of hazardous waste. If the petroleum solvent has a flash point greater than 140 °F, the wastes are not considered hazardous and are exempt from reporting requirements. Drycleaning plants generally have stills for continuous distillation of solvents, which are constantly recycled. However, the still bottoms must be disposed of properly.

Woodworking and Preserving

Table 52 lists the woodworking and preserving operations and corresponding waste classifications. Some of the wastes are generated by carpentry shops that manufacture or refinish wooden cabinets, softwood and hardwood veneer and plywood, household or office furniture, and other furniture (including reupholstery and repair). Typical wood preserving operations used to condition wood

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[146] Industrial boilers are defined as utility or power boilers used to supply heated or cooled air or steam for a manufacturing process, and are usually rated at greater than 25 x 10^6 Btu/hour. In addition to being located at a manufacturing facility, it must be a device using controlled flame combustion and have the following characteristics: (1) a combustion chamber and primary energy recovery section of integral design, (2) thermal energy recovery efficiency of at least 60 percent, and (3) at least 75 percent of recovered energy must be exported.
Utility boilers are boilers not located at a manufacturing facility and have the above listed characteristics. They must be used to generate electric power, steam, heated or cooled air, or other gases or fluids for sale.
Nonindustrial boilers are those that do not fall in the above two categories. They are subject to prohibition.

include: steaming, boultonizing, kiln or air drying (under pressure or vacuum), and applying agents such as creasote, pentachlorophenol (PCP), and other arsenical compounds.

Inventory control and management is an effective technique for minimizing hazardous wastes associated with woodworking and preserving. Proper disposal practices must also be used.

Pesticide Users

Army installations have a number of pesticide users including the entomology shop (pest control services), the garden shop (lawn, garden, and tree services), and the golf courses. Table 53 lists a variety of pesticides used and their waste classifications. Use of pesticides in activities ranging from protecting food and structures to pest and disease control results in generation of hazardous rinsewater, empty containers with pesticide residue, unused pesticides, and possibly contaminated soil.

Very dilute rinsewaters or soil contaminated with very low concentrations may not be hazardous. However, chemical analysis is necessary to verify the concentrations. Pesticide containers are not a hazardous waste if they are triple rinsed. The rinsewater, however, is a hazardous waste. Some pesticides that contain flammable solvents or ignitable material are also hazardous wastes when discarded. A number of pesticides exhibit acute toxicity characteristics. Therefore, all the discarded and off-specification products, containers, and spill residues containing acute toxic species are listed as "P" hazardous wastes [40 CFR 261.33(e)]. All the hazardous material/wastes related to pesticides must be managed carefully to prevent environmental problems and to protect the health and safety of personnel.

The amounts of pesticide rinsewaters generated can be minimized by using multiple rinse tanks, installing drain boards and drip tanks, and recycling and reusing the water for rinsing.[147] Treatment methods include destruction with chlorine or lime, incineration, and carbon adsorption.[148] Minimization of empty containers and contaminated soil wastes is discussed in Chapter 11.

Open Burning/Open Detonation

Open burning/open detonation (OB/OD) is one option used to demilitarize ordnance containing propellants, explosives, and pyrotechnics (PEP). Other methods are washout/steamout/meltout and deactivation in a furnace. Ingredients of some common explosive compounds are listed in Table 54. OB/OD is the simplest and has been the primary method of demilitarization used at Army installations.[149] Active and inactive sites of OB/OD are commonly found. The environmental contaminants generated from OB/OD activity include gases and particles (carbon, soot, etc.) released into the atmosphere and as residues in soils. The soil residues are comprised mainly of undetonated PEP materials and combustion/detonation products. Table 55 lists the elements found in soils, including some that are regulated under RCRA and HSWA. Soils at all the active and inactive sites must be analyzed to determine the chemical content and proper disposal.

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[147] Ventura County Environmental Health, *Hazardous Waste Reduction Guidelines for Environmental Health Programs* (California Department of Health Services, Sacramento, CA, 1987).

[148] *Standard Handbook of Hazardous Waste Treatment and Disposal*, H.M. Freeman, Ed. (McGraw Hill, New York, NY, 1989).

[149] D.W. Layton, et al., *Demilitarization of Conventional Ordnance. Priorities of Data-Base Assessments of Environmental Contaminants*, UCRL-15902 (U.S. Army Medical Research and Development Command [USAMRDC], Fort Detrick, MD, 1986).

Some of the materials in the demilitarization inventories at installations may have a recovery value in excess of the cost of the original item because of the increase in material and manufacturing costs.[150] Recovery and reuse of such materials before burning will reduce raw material costs and production requirements, and, thereby, minimize wastes generated. A number of processes (e.g., resolvation of ground propellants, selective solvent extraction, disposal of scrap propellant, solution-pelletization, etc.) are available for recovery and reuse of propellants or their ingredients. Processing propellants by such reclamation techniques[151] minimizes environmental discharges, conserves strategic materials, and provides cost savings.

Under USEPA and State regulations, OB/OD is considered a treatment technique for hazardous wastes (ordnance). Therefore, installations are required to obtain a Part B permit. The generation of contaminated soil residues from OB/OD activity can be minimized by conducting the activity on steel "burn-pans" instead of on open ground. Incineration must also be explored as a possible minimization alternative. Controlled incineration allows for better control of air pollutants. However, proper disposal is required for residues generated in any of the operations.

Firefighting and Training

Aqueous film forming foam (AFFF) is considered a hazardous material in a number of states. Firefighting operations that use AFFF must be replaced with nonhazardous substitutes. All other wastes generated by maintenance of fire trucks and other equipment can be minimized by methods discussed in Chapters 5 and 6.

Another waste generated from fire training activities is contaminated soils in the training pits. Typically, contaminated fuel (e.g., JP-4, gasoline) is used to generate a fire in the pits for training exercises. The soil from the pits must be analyzed for chemical contaminants and properly disposed of.

Underground Storage Tanks (USTs)

Discovery of a number of leaking USTs throughout the United States prompted Congress to add Subtitle I to RCRA in 1984. Subtitle I requires the USEPA to develop regulations for leaking USTs to safeguard human health and environment. In September 1988, USEPA finalized the UST rules and regulations[152] that cover the technical requirements for designing, installing, testing, and monitoring USTs, and the requirements for cleanup following releases from leaking USTs. Many USTs are located on each Army installation. They must all be tested for leaks and any leaking tanks must be managed according to the rules. Proper management of USTs will minimize the quantities of vapor emissions, soil contamination, and potential groundwater contamination.

A data base of information of Army-owned USTs was developed at USACERL.[153] Many of the Army's USTs are more than 30 years old, greater than 10,000 gal, may contain hazardous substances, are made of steel, and have a high potential for leakage. A leak potential index (LPI)

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[150] D.W. Layton, et al.

[151] F.W. Nester and L.L. Smith, *Propellant Reuse Technology Assessment*, AMXTH-TE-CR-86076 (USATHAMA, Aberdeen Proving Ground, MD, 1986).

[152] 40 CFR Parts 280-281, *Underground Storage Tanks: Technical Requirements and State Program Approval; Final Rule*, pp 37081 - 37247.

[153] B.A. Donahue, T.J. Hoctor, and K. Piskin, *Managing Underground Storage Tank Data Using dBase III Plus*, Technical Report N-87/21/ADA182452 (USACERL, June 1987).

associated with the data base has been devised to indicate the likelihood of individual tank leakage.[154] The LPI is a tool that enables tank managers to group tanks based on the likelihood of leaks. This information indicates which tanks should be monitored more closely, which should be tested, and which should be considered for replacement.

The HAZMIN technique of inventory control is very effective in detecting tank leaks. This method requires regular measurement of the level of substances in the tanks. Records must also be maintained concerning addition and withdrawl of products. Comparison of inflow, outflow, and the inventory indicates product loss. Other leak detection methods can be grouped into volumetric methods, nonvolumetric methods, and leak effects monitoring.[155] Volumetric methods measure the change in volume with time and are the most fully developed and popular. Site-specific decisions have to be made regarding the use of the most appropriate leak detection method. Nonvolumetric methods measure changes in a variable, such as a tracer gas or acoustic signal, to determine changes in the level of the tank contents. Leak effects monitoring refers to methods used to determine leaks in the surrounding environment (e.g., soil vapor analysis).

Table 49

Used Oil Fuel Specifications*

Constituent or Property	Allowable Level
Arsenic	5 mg/kg maximum
Cadmium	2 mg/kg maximum
Chromium	10 mg/kg maximum
Lead	100 mg/kg maximum
Total Halogens	4,000 mg/kg maximum**
Flashpoint	37.7 °C (100 °F) minimum

[154] S. Dharmavaram, et al., "A Profile and Management of the U.S. Army's Underground Storage Tanks," *Environmental Management*, Vol 13 (1989), pp 333-338.
[155] J. Makwinski and P.N. Cheremisinoff, "Special Report: Underground Storage Tanks," *Pollution Engineering*, Vol 20 (1988), pp 60-69.
* Source: Federal Register, Vol 50, No. 23, pp 49,164 - 49,249.
** Used oil containing more than 1000 mg/kg total halogens must be shown not to have been mixed with hazardous waste. This is called the "rebuttable presumption."

Table 50

Amounts of Typical Hazardous Wastes Generated from Drycleaning Operations*

	Cleaning Solvent**		
Waste Type	PERC	Valclene	Stoddard
Still Residues	25	10	20
Spent Cartridge Filters			
Standard (carbon core)	20	15	***
Adsorptive (split)	30	20	***
Cooked Powder Residue	40	n/a	n/a
Drained Filter Muck	n/a	n/a	***

* Source: H. Winslow, *Hazardous Waste SQG Workbook* (Int^reg Group, Inc., Chicago, IL, 1986), p 144.
** In pounds per 1000 pounds of clothes cleaned.
*** Well-drained filter cartridges and filter muck are solids that do not meet the criteria for classification as an ignitable solid, and are therefore not considered hazardous wastes.

Table 51

Drycleaning and Laundry Operations and Wastes Classification*

			Waste Description		
Process/ operation	Materials used	HW code	DOT shipping name	Hazard class	Number
Drycleaning	PERC	F002	Waste perchloroethylene or waste tetrachlore 'hylene	ORM-A	UN1897
	Valclene	F002	Hazardous waste liquid or solid, NOS	ORM-E	UN9189
	Petroleum solvents	D001	Waste petroleum distillate	Combustible liquid	UN1268
			Waste petroleum naptha	Combustible liquid	UN1255
Laundering	Caustic soda	D002	Waste sodium hydroxide	Corrosive material	UN1824
	Cleaning compound	D001	Hazardous waste liquid, NOS	Flammable liquid	UN9189

*Source: *Drycleaning and Laundry Plants*, Hazardous Waste Fact Sheet (Small Quantity Generators Activity Group, Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Table 52

Wastes Classification: Woodworking and Preserving Operations*

Process/ operation	Materials used	Waste Description			
		HW code	DOT shipping name	Hazard class	Number
Wood cleaning and wax removal	Petroleum distillates	D001	Waste flammable liquid	Flammable liquid	UN1993
	White spirits	D001	Waste naptha	Combustible liquid	UN2553
			Waste naptha solvent	Flammable liquid	UN2553
			Waste naptha solvent	Combustible liquid	UN1256
				Flammable liquid	UN1256
Refinishing/ stripping, brush cleaning and spray gun cleaning	Paint strippers (containing methylene chloride)	F002	Hazardous waste liquid or waste methylene chloride	ORM-E ORM-A	UN2553 UN1593
	Paint removers (containing disullates, acetone, toluene)	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Paint removers (containing caustic)	D002	Corrosive liquid	Corrosive material	NA1760
Staining	Stains (mineral spirits, alcohols, pigments)	D001	Waste flammable liquid	Flammable liquid	UN1993
Painting	Paints (enamels, lacquers, epoxy, alkyds, acrylics)	D001	Waste paint or enamel liquid	Flammable liquid	UN1263
Finishing	Varnish, shellac, lacquer	D001	Waste flammable liquid, NOS	Flammable liquid	UN1993
Preserving	Creosote	K001	Hazardous waste liquid or solid, NOS	ORM-E	NA9189
	Pentachlorophenol	K001	Waste pentachlorophenol, liquid or solid	ORM-E	NA2020
	Chromated copper arsenate	D004/ D007	Waste arsenical compounds, liquids	Poison B	UN1557
	Ammoniacal copper arsenate	D004	Waste arsenical compounds, solids	Poison B	UN1556
			Waste arsenical compounds, liquids	Poison B	UN1557
			Waste arsenical compounds, solids	Poison B	UN1556
	Other wood preservatives	Varies	Hazardous waste liquid or solid, NOS	ORM-E	NA9189

*Source: H Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL, 1986), pp 146-147.

Table 53

Waste Classification: Pesticides*

Process/operation	Materials used	Waste Description		
		DOT shipping name	Hazard class	Number
Pesticides Containing Arsenic:				
Arsenic pentoxide	Arsenic acid anhydride	Waste arsenic pentoxide, solid	Poison B	UN1559
	Arsenic (V) oxide			
Arsenic trioxide	Arsenic sesquioxide	Waste arsenic trioxide, solid	Poison B	UN1561
	Arsenic (III) oxide			
	Arsenous acid (anhydride)			
	White arsenic			
Cacodylic acid	Hydroxydimethylarsine oxide	Waste arsenical pesticide, solid, NOS[3]	Poison B	UN2759
	Dimethylarsinic acid	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Phytar	Waste arsenical pesticide, liquid, NOS	Flammable liquid	UN2760
Monosodium Methanearsonate	MSMA	Waste arsenical pesticide, solid, NOS	Poison B	UN2759
	Ansar 170 H.C. and 529 H.C.			
	Arsanote liquid	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Bueno 6			
	Daconate 6	Waste arsenical pesticide, liquid, NOS	Flammable liquid	UN2760
	Dal-E-Rad			
	Herb-All			
	Merge 823			
	Mesamate			
	Monate			
	Trans-Vert			
	Weed-E-Rad			
	Weed-Hoe			
Disodium Monomethanearsonate	DSMA	Waste arsenical pesticide, solid, NOS	Poison B	UN2759
	Ansar 8100	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Arrhenal	Waste arsenical pesticide, liquid, NOS	Poison B	UN2759
	Arsinyl			
	Dinate			
	Di Tac			
	DMA			
	Methar 30			
	Sodar			
	Versar DSMA-LQ			
	Weed-E-Rad			

*Source. H. Winslow, *Hazardous Waste SQG Workbook* (Intereg Group, Inc., Chicago, IL 1986), pp 150-161.

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Pesticides Containing Carbomates:				
Temik	Aldicarb	Waste carbamate pesticide, solid, NOS	Poison B	UN2757
	OMS 771	Waste carbamate pesticide, liquid, NOS	Poison B	UN2757
	UC 21149	Waste carbamate pesticide, liquid, NOS	Flammable liquid	UN2758
Pesticides Containing Mercury				
2-Methoxyethyl-mercuric Chloride	MEMC Agallol Cekusil Universal-C Ceresan-Universal-Nassbeize Emisan 6	Waste mercury based pesticide, solid, NOS Waste mercury based pesticide, liquid, NOS Waste mercury based pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2777 UN2777 UN2778
Phenylmercurie acetate	PMA PMAS Agrosan Cekusil Celmer Gallotox Hong Nien Liquidphene Mersolite Pamisan Phix Seedtox Shimmer-ex Tag HL 331	Waste mercury based pesticide, solid, NOS Waste mercury based pesticide, liquid, NOS Waste mercury based pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2777 UN2777
Pesticides Containing Substituted Nitrophenols:				
Dinitrocresol	DNC DNOC Chemset Detal Elgetol 30 Nitrador Selinon Sinox Trifocide Trifrina	Waste substituted nitrophenol pesticide, solid, NOS Waste substituted nitrophenol pesticide, liquid, NOS Waste substituted nitrophenol pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2779 UN2779 UN2780
Dinoseb	DNBP Basanite Caldon Chemox general Chemox PE Dinitro Dinitro general Dynamite Elgetol 318 Gebutox	Waste substituted nitrophenol pesticide, solid, NOS Waste substituted nitrophenol pesticide, liquid, NOS Waste substituted nitrophenol pesticide, liquid, NOS	Poison B Poison B Flammable liquid	UN2779 UN7890 UN2780

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Dinoseb (Cont'd)	Hel-Fire			
	Nitropone C			
	Premerge 3			
	Sinox general			
	Subitex			
	Vertac general weed killer			
	Vertac selective weed killer			
Organophosphate pesticides:				
Dimethoate	AC-12880	Waste organophosphorous pesticide,	Poison B	UN2783
	Bi 58 EC	solid, NOS		
	Cekuthoate	Waste organophosphorous pesticide,		
	Cygon	liquid, NOS	Poison B	UN2783
	Daphene	Waste organophosphorous pesticide,		
	De-Fend	liquid, NOS	Flammable liquid	UN2784
	Demos-L40			
	Devigon			
	Dimet			
	Dimethogen			
	Perfekthion			
	Rebelate			
	Rogdial			
	Rogor			
	Roxion			
	Trimetion			
Disulfoton	Bay 19639 and S276	Waste disolfoton	Poison B	NA2783
	Dithiodemeton	Waste disulfoton mixture, dry	Poison B	NA2783
	Dithiosystox	Waste disulfoton mixture, liquid	Poison B	NA2783
	Di-Syston	Waste organophosphorous pesticide,	Flammable liquid	UN2784
	Ethylthiodemeton	liquid, NOS		
	Frumin AL			
	M-74			
	Solvirex			
	Thiodemeton			
Famphur	Bash	Waste organophosphorous pesticide,	Poison B	UN2783
	Bo-Ana	solid, NOS		
	Dovip	Waste organophosphorous pesticide,	Poison B	UN2783
	Famfos	liquid, NOS		
	Warbex	Waste organophosphorous pesticide,	Flammable liquid	UN2784
		liquid, NOS		
Methylparathion	Cekumethion	Waste methyl parathion, liquid	Poison B	NA2783
	E-601	Waste methyl parathion mixture, dry	Poison B	NA2783
	Devithion	Waste methyl parathion mixture,	Poison B	NA2783
	Folidon M	liquid, (containing 25% or less		
	Fosferno M50	methylparathion)		
	Gearphos	Waste methyl parathion mixture,	Poison B	NA2783
	Methacide	liquid, (containing more than 25%		
	Metaphos	methylparation)		
	Nitrox 80	Waste organophosphorous pesticide,	Flammable liquid	UN2784
	Parataf	liquid, NOS		
	Paratox			
	Partron M			

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Methylparathion (Cont'd)	Penncap-M			
	Wofatox			
Parathion	AC-3422	Waste parathion, liquid	Poison B	NA2783
	Alkron	Waste parathion mixture, dry	Poison B	NA2783
	Alleron	Waste parathion mixture, liquid	Poison B	NA2783
	Aphamite	Waste organophosphorous pesticide, liquid, NOS	Flammable liquid	UN2784
	Bladan			
	Corothion			
	E-605			
	ENT 15108			
	Ethyl parathion			
	Etilon			
	Folidol E-605			
	Fosterno 50			
	Niran			
	Orthophos			
	Panthion			
	Paramar			
	Paraphos			
	Parathene			
	Parawet			
	Phoskil			
	Rhodiatox			
	Soprathion			
	Stathion			
	Thiophos			
Strychnine Pesticides:				
Strychnine	Strychnine salts	Waste strychnine, solid	Poison B	UN1692
		Waste strychnine salt, solid	Poison B	UN1692
Thallium Sulfate Pesticides:				
Thallium sulfate	Thallous sulfate	Waste thallium sulfate, solid	Poison B	NA1707
	Ratox	Waste flammable liquid, poisonous, NOS	Flammable liquid	UN1992
	Zelio			
Triazine Pesticides:				
Amitrole	Amerol	Waste triazine pesticide, solid, NOS	Poison B	UN2763
	Amino triazol weedkiller 90	Waste triazine pesticide, liquid, NOS	Poison B	UN2763
	Amizol	Waste triazine pesticide, liquid, NOS	Flammable liquid	UN2764
	AT-90			
	AT liquid			
	Azolan			
	Azole			
	Cytrol			
	Diurol			
	Farmco			
	Herbizole			
	Simazol			
	Weedazol			
	Weedazol TL			

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Flammable Solvents Used in Pesticides:				
Methyl alcohol	Methanol	Waste methyl alcohol	Flammable liquid	UN1230
Ethyl alcohol	Ethanol Alcohol	Waste ethyl alcohol	Flammable liquid	UN1170
Isopropyl alcohol	Isopropanol	Waste isopropanol	Flammable liquid	UN1219
Toluene	Methyl benzene Toluol	Waste toluene (tuluol)	Flammable liquid	UN1294
Xylene	Dimethyl benzene Xylol	Waste xylene (xylol)	Flammable liquid	UN1307
Solvent mixtures		Waste combustible liquid, NOS Waste flammable liquid, NOS	Combustible liquid Flammable liquid	NA1993 UN1993
Phenoxy Pesticides:				
2,4-D	Amoxone Brush Killer Brush-Rhap Chloroxone Crop Rider D50 DMA 4 Dacamine Ded-Weed Desormone Dinoxol Emulsamine BK and E3 Envert DT and 171 Hedonal Miracle Pennamine D Rhodia Salvo Super-D Weedone Verton Visko-Rhap Weed Tox Weed-B-Gone Weed-Rhap Weedar Weedone Weedtrol	Waste 2,4-dichlorophenoxyacetic acid Waste 2,4-dichlorophenoxyacetic acid ester Waste phenoxy pesticide, liquid, NOS	ORM-A ORM-E Flammable liquid	NA2765 NA2765 UN2766
2,4,5-T	Brush-Rhap Dacamine Ded-Weedon Esteron Farmco Fence Rider Forron Inverton 245 Line Rider	Waste 2,4,5-trichlorophenoxyacetic acid Waste 2,4,5-trichlorophenoxyacetic acid (amine, ester, or salt) Waste phenoxy pesticide, liquid, NOS	ORM-A ORM-E Flammable liquid	NA2765 NA2765 UN2766

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
2,4,5-T (Cont'd)	Super D Weedone Tormona Transamine U 46 Veon 245 Weedar Weedone			
Silvex	2,4,5-TP Fenoprop	Waste 2-(2,4,5-trichlorophenoxy) propionic acid	ORMA-A	NA2765
	AquaVex Double Strength	Waste 2-(2,4,5-trichlorophenoxy) propionic acid ester	ORM-E	NA2765
	Fruitone T Kuron Kurosal Silver-Rhap Weed-B-Gone	Waste phenoxy pesticide, liquid, NOS	Flammable liquid	UN2766
Organochlorine Pesticides:				
Aldrin	HHDN Aldrex 30	Waste aldrin	Poison B	NA2761
	Aldrite Aldrosol	Waste aldrin mixture, dry (with more than 65% aldrin)	Poison B	NA2761
	Altox Drinox	Waste aldrin mixture, liquid (with or less aldrin)	ORM-A	NA2761
	Octalene Seedrin liquid	Waste aldrin mixture, liquid (with more than 60% aldrin)	Poison B	NA2762
		Waste aldrin mixture, liquid (with 60% or less aldrin)	ORM-A	NA2762
		Waste organchlorine pesticide, liquid, NOS	Flammable liquid	UN2762
Chlordan	Belt Chlordan	Waste chlordane, liquid	Flammable liquid	NA2762
	ChlorKil Chlortox Corodane Gold Crest C-100 Kypchlor Vesicol 1068 Topiclor 20 Niran Octachlor Octa-Klor Ortho-Klor Synklor Termi-Ded	Waste chlordane, liquid	Combustible liquid	NA2762
DDT	Dedelo Didimac	Waste DDT	ORM-A	NA2761
	Digmar Genitox Gyron Gildit Kopsol Neocid	Waste organochlorine pesticide, liquid, NOS	Flammable liquid	UN2762

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
DDT (Cont'd)	Pentachlorin Rukseam Zerdand			
Dichloropropene	1,3-dichloropropene Telone II Soil Fumigant	Waste dichloropropene	Flammable liquid	UN2047
Dieldrin	Dieldrex Dieldrite Octalox Panoram D-31	Waste dieldrin Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable Liquid	NA2761 UN2762
Endrin	Endrex Hexadrin	Waste Endrin Waste Endrin mixture, liquid Waste organochlorine pesticide, liquid, NOS	Poison B Poison B Flammable liquid	NA2761 NA2761 UN2762
Endosulfan	Beosit Chlorthiepin Crisulfan Cyclodan Endocel EnSure FMC 5462 Hildan Hoc 2671 Malix Thifor Thimul Thiodan Thiofor Thionex Tiovel	Waste Endosulfan Waste Endosulfan mixture, liquid Waste organochlorine pesticide, liquid, NOS	Poison B Poison B Flammable liquid	NA2761 NA2761 UN2762
Heptachlor	Gold Crest H-60 Drinox H-34 Heptamul Heptox Chlordecone	Waste Heptachlor Waste organochlorine pesticide, liquid NOS	ORM-E Flammable liquid	NA2761 UN2762
Kepone	Exagama Forlin	Waste Kepone Waste organochlorine pesticide, liquid, NOS	ORM-E Flammable liquid	NA2761 UN2762
Lindane	Gallogama Gamaphex Gammex Inexn Isotox Lindafor Lindagam Lindagrain Lindagranox Lindalo Lindamul Lindapoudre	Waste Lindane Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable liquid	NA2761 UN2762

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description: DOT shipping name	Hazard class	Number
Lindane (Cont'd)	Lindaterra Novigam Silvanol			
Methoxychlor	Flo Pro McSeed Protectant Marlate	Waste Methoxychlor Waste organochlorine pesticide, solid, NOS Waste organochlorine pesticide, liquid, NOS Waste organochlorine pesticide, liquid, NOS	ORM-E Poison B Poison B Flammable liquid	NA2761 UN2761 UN2761 UN2762
Propylene Dichloride	1.2-dichloropropane	Waste propylene dichloride	Flammable liquid	UN1279
Toxaphene	Attac 4-2, 4-4, 6, 6-3, 8 Camphochlor Motox Phenacide Phenatox Strobane T-90 Toxakil Toxon	Waste toxaphene Waste organochlorine pesticide, liquid, NOS	ORM-A Flammable liquid	NA2761 UN2762
Other Pesticides:				
Thiram	TMTD AAtack Arasan Aules Evershield T Seed Protectant Fermide 850 Fernasan Flo Pro T Seed Protectant Hexathir Mercuram Nomersan Pomarsolforte Polyram-Ultra Spotrete-F Tetrapom Thimer Thionock Thiotex Thiramad Thiuramin Tirampa Trametan Tripomol Thylate Tudas Vancide TM	Waste Thiram Waste flammable liquid, poisonous, NOS	ORM-A Flammable liquid	NA2771 UN1992
Warfarin	Co-Rax Cov-R-Tox Kypfarin Liqua-Tox	Hazardous waste solid, NOS Hazardous waste liquid, NOS	ORM-E ORM-E	NA9189 NA9189

Table 53 (Cont'd)

Process/operation	Materials used	Waste Description		
		DOT shipping name	Hazard class	Number
	RAX	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Rodex			
	Rodex Blax	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Tox Hid			
Pentachlorophenol	PCP	Waste pentachlorophenol	ORM-E	NA2020
	Penta			
	Penchlorol	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Pentacon			
	Penwar	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Sinitudo			
	Santophen			
Pentachloronitrobenzene	PNCB	Hazardous waste, solid	ORM-E	NA9189
	Avicol			
	Botrilex	Hazardous waste, liquid	ORM-E	NA9189
	Brassicol			
	Earthcide	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Folosan			
	Kobu	Waste combustible liquid, NOS	Combustible liquid	NA1993
	Pentagen			
	Saniclor 30			
	Terraclor			
	Tilcarex			
	Tritesan			
Hexachlorobenzene	Perchlorobenzene	Hazardous waste, solid	ORM-E	NA9189
	Anticarie			
	Ceku C.B.	Hazardous waste, liquid	ORM-E	NA9189
	HCB			
	No Bunt	Waste flammable liquid, NOS	Flammable liquid	UN1993
	DBCP	Waste combustible liquid, NOS	Combustible liquid	NA1993
1,2-Dibromo 3 Chloropropane	Nemafume	Hazardous waste, solid, NOS	ORM-E	NA9189
	Nemanox	Hazardous waste, liquid, NOS	ORM-E	NA9189
	Nemaset	Waste flammable liquid, NOS	Flammable liquid	UN1993
	Nematocide	Waste combustible liquid, NOS	Combustible liquid	NA1993

Table 54

Ingredients Contained in Propellants, Explosives, and Pyrotechnics

Compound	Type
2,4,6-Trinitrotoluene (TNT)	EX*
Cyclotrimethylenetrinitramine (RDX)	EX
Pentaerythritol Tetranitrate (PETN)	EX
2,4,6-Trinitrophenylmethylnitramine (Tetryl)	EX
Ammonium Picrate (Explosive D)	EX
Cyclotetramethylenetetranitramine (HMX)	EX
2,4-Dinitrotoluene (DNT)	PP
Nitroglycerin (NG)	PP
Nitroguanidine (NQ)	PP
Dibutyl phthalate	PP
Diethyl phthalate	PP
Diphenylamine	PP
Benzene	EX
Toluene	EX
Sodium Nitrate	PY
Barium Nitrate	PY
Magnesium Nitrate	PY
Strontium Peroxide	PY
Strontium Oxalate	PY
Calcium Resinate	PY

*EX = explosives; PP = propellants; PY = pyrotechnics.

Table 55

Common Elements Found in PEP and OB/OD Soil Residue

Element	OB	OD
	% of samples greater than EP toxic limits	
Strontium		
Cadmium	2.5	1.3
Arsenic	0.3	0.0
Antimony		
Lead	6.0	0.7
Mercury	0.6	0.0
Barium		

*Source: D.W. Layton, p 29.

11 WASTE MINIMIZATION FOR MISCELLANEOUS WASTES

Polychlorinated Biphenyls (PCBs)

PCBs are chlorinated organic compounds with a wide range of physical properties. There are 209 possible PCBs of which tri-, tetra-, penta-, and hexachloro biphenyls are the most important. They were commonly used in coolants and insulation fluids in transformers. Some of the older products that may contain PCBs or oils with PCBs include: heat-transfer fluids, lubricants, paints, plastics, air conditioners, fluorescent lights, and televisions. PCBs were most widely used in capacitors and transformers because of their low conductivity and thermal stability.

In several cases of poisoning in Japan and Taiwan, PCBs and their secondary products such as polychlorinated dibenzofurans were found to be the major contaminants in bran oil used to cook rice. Since then, PCBs have been linked to severe health problems (e.g., gastric disorders, skin lesions, swollen limbs, cancers, tumors, eye problems, liver disorders, menstrual irregularities, etc.) and birth defects (e.g., reproductive failures, mutations, etc.). Compounding the problem of PCBs' toxicity is their bioaccumulation in cells and fatty tissues of micro-organisms and animals, which are then consumed by other animals higher in the food chain.

PCBs are regulated by the Toxic Substances Control Act (TSCA) passed in 1976. Manufacture of PCBs was banned under TSCA and deadlines were provided for removing capacitors and transformers containing PCBs. One year was allowed for storage before disposal. If regulatory agencies determine that the use of PCB transformers poses no risk, the use will be allowed to continue. All capacitors were to have been removed by October 1988, and transformers of certain size in or near commercial buildings should be removed by October 1990.

If the concentration of PCBs in a product is greater than 50 parts per million (ppm), the product is regulated as hazardous under TSCA. Some States have set limits that are stricter than Federal limits (e.g., California, 5 ppm).

PCBs in Transformers

In the United States, there are 150,000 askarel (nonflammable electrical fluid) transformers, each of which contains thousands of pounds of PCBs with a wide range of concentrations. Many of these tranformers develop leaks.

The transformers are generally classified as: PCB transformers (greater than 500 ppm), PCB-contaminated transformers (50 to 500 ppm), and Non-PCB transformers (less than 50 ppm). PCB transformers must be inspected quarterly for leaks; detailed records must be kept. No maintenance work involving removal of the coil or casing is allowed. PCB-contaminated transformers must be inspected annually. Their requirements for maintenance and recordkeeping are less restrictive than for PCB transformers. Non-PCB transformers are exempt from regulation.

The importance of analyzing all transformers for PCBs must be stressed. All the transformers on an installation must be inventoried and tested for PCBs. If the PCB levels are greater than 50 ppm, appropriate actions must be taken.

PCB Wastes Management

There are no minimization options available for PCB wastes. Recycling of PCBs is illegal. Nevertheless, containers and oils contaminated with PCBs may be recycled if the PCBs are removed.

Federal regulations require that PCBs be destroyed in approved high-temperature incinerators. Oils containing 50 to 500 ppm PCBs can be burned in high-efficiency boilers. Alternate technologies capable of operating at the high incinerator efficiencies, such as the molten salt processes or UV/Ozonation may also be considered for "ultimate" treatment/disposal. In addition to incineration, which is the most common, chemical dechlorination technologies have also been successful. Table 56 lists the names and addresses of incineration facilities and available chemical dechlorination services.

The most common practice at Army installations is to retain PCB transformers in service until the end of their useful life or they leak. They are then replaced with non-PCB transformers. The other possible options that may be available are decontaminating and/or retrofilling the transformers. Table 57 lists the names and addresses of companies that provide retrofilling services.

USACERL's PCB Transformer System

A computer-aided, fate-decision analysis tool was developed at USACERL to help users make decisions about transformers containing PCB levels greater than 50 ppm. The computer model is available to Army users through the Environmental Technical Information System (ETIS) on the mainframe computer at USACERL. A PC-based model is also available.*

The model provides users with information about PCBs and appropriate regulations, and allows them to input information for risk assessment, fate-decision analysis, and life cycle cost analysis. The options considered in the final economic analysis are: retaining, retrofilling, decontaminating, and replacing transformers.

Onsite Mobile Treatment Units

Mobile incineration and chemical dechlorination units can decontaminate insulating oils from transformers. One dechlorination process, the "PCBX" process developed by ENSR, is a self-contained continuous-flow unit. It is designed and equipped to destroy PCBs (up to 2600 ppm) from transformer oil without moving the transformer. The operating capacity of the unit is up to 600 gallons per hour. Exceltech, Inc., based in California, also markets mobile dechlorination units for removing PCBs from transformers.

Lithium Batteries

Lithium batteries are discarded from troop equipment that uses batteries as a reserve power source. Six types of primary lithium batteries are commonly used: Li-CuO, Li-nnO2, Li-(CFx)n, Lithium Sulfur dioxide (Li-SO2), Li-SO2C12, and Lithium thionyl chloride (Li-SOC12).

The U.S. Navy has proposed the development of a center of excellence to develop a fully permitted state-of-the-art, portable disposal technology for world-wide utilization.[156] A study conducted by USAEHA to evaluate the disposal of lithium batteries under RCRA regulations[157] noted that fully charged and duty-cycle discharge batteries were hazardous because of reactivity and/or ignitability characteristics and must be discharged through DRMO. Fully discharged batteries are not hazardous

* For information, contact Bernard Donahue or Keturah Reinbold at USACERL-EN, P.O. Box 4005, Champaign, IL 61824-4005, or telephone 800-USACERL (outside Illinois) 800-252-7122 (within Illinois).

[156] Comarco, Inc., *U.S. Navy Lithium Battery Disposal*, Report No. CESD-88-179 (Prepared for the Naval Weapons Support Center, High Energy Battery Systems Branch, Crane, IN, January 1989).

[157] *Evaluation of Lithium Sulfur Dioxide Batteries, US Army Communications - Electronics Command and US Electronics Research and Development Command, Fort Monmouth, New Jersey*, USAEHA-37-26-0427-85 (USAEHA, Aberdeen Proving Ground, MD, 1985).

and could be disposed of in a permitted landfill. Assurances must be sought that the batteries have reached their fully discharged state. Manual discharging methods such as soaking in an aqueous solution are not practical and alternative approaches must be explored.

A recent review presents general information regarding lithium batteries.[158] It includes information about battery technology, safety aspects, purchasing, packaging, transport, storage, and disposal

Ordnance

A number of hazardous ordnance materials are used on Army installations. Ingredients contained in some of them were listed in Table 54. Further details are available in Technical Manual (TM) 9-1300-214.[159] Army directives prohibit burial of ordnance materials or dumping them in waste places, pits, wells, marshes, shallow streams, rivers, inland waterways, or at sea. All existing locations of buried explosives must be identified and marked accordingly. The only means of disposal available is destruction by burning and detonation (discussed in Chapter 10). Proper operating procedures for disposal of discarded ordnance materials should be developed and updated frequently to comply with Federal, State, and local regulations.

Contaminated Soil

Contaminated soil is generated because of leaks or spills of hazardous materials. Some effective source reduction techniques include: installing splash guards and dry boards on equipment, preventing tank overflow, using bellow sealed valves, installing spill basins, using seal-less pumps, secondary containment, plant maintenance, and personnel training to develop good operating practices.

A number of nonthermal and thermal treatment techniques are available for decontamination of soil.[160] Nonthermal techniques include: aeration, biodegradation, carbon adsorption, chemical dechlorination, solvent extraction, stabilization/fixation, and ultraviolet photolysis. Thermal treatment techniques include: stationary rotary-kiln incineration, mobile rotary-kiln incineration, liquid injection incineration, fluidized bed incineration, high-temperature fluid-wall destruction, infrared incineration, supercritical-water oxidation, plasma-arc pyrolysis, and in situ vitrification.

Empty Containers

Containers with residual hazardous materials/wastes must also be treated as hazardous wastes. Under HSWA, if a container with hazardous residue is found in a cleanup (Superfund) site or other landfill, the generator (Army) is liable and has to pay for part of the cost of cleanup. Even "triple rinsed" containers could contain some residue. Scrap dealers and landfills are becoming reluctant to accept "clean" empty 55-gal drums or other containers.

The problem of disposing of empty drums and containers can be minimized by giving careful consideration to the kinds and sizes of containers in which materials are originally received. When purchasing materials in bulk, the suppliers must be asked to send them in rinsable and/or recyclable containers. A number of commercial recyclers (listed in Regional Waste Exchange bulletins/newslet-

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[158] W.N. Garrard, *Introduction to Lithium Batteries*, MRL-GD 0018, DODA-AR-005-652 (Materials Research Laboratory, Ascot Vale, Australia, 1988).
[159] Technical Manual (TM) 9-1300-214, *Military Explosives* (Headquarters Department of the Army, 20 September 1984).
[160] *Standard Handbook of Hazardous Waste Treatment and Disposal.*

ters or directories) accept containers less than 30 gal.[161] Treating empty containers by triple rinsing is a good waste minimization technique. However, the rinsate, if hazardous, must be properly managed.

Some of the other options to consider when procuring materials, and in the ultimate disposal of containers, are:[162] returning drums to suppliers, contracting with a drum conditioner, contracting with a scrap dealer, and, lastly, disposal in an approved landfill.

Returning Drums to Suppliers

When buying material, a purchase agreement must be established to include the option of returning empty containers to the suppliers. Cash deposits may be required and drums should be maintained in good condition. All the accessories, such as bungs, rings, and closures, must also be kept and returned with the drums.

Contracting With a Reconditioner

If the suppliers do not sell chemicals in returnable drums, ask them to send materials in heavy steel (18 to 20 gauge) drums that can be reconditioned when "empty." A typical 55-gal heavy drum should have a 20-gauge side and 18-gauge ends. A good market exists for these drums and they can be sent to reconditioning contractors for minimal or no cost. Empty heavy drums must be treated as a valuable asset and personnel should be trained in their proper handling (including keeping the bungs, rings, etc.). Another good practice is to avoid accumulating the drums for long periods of time, thus, preventing deterioration.

Contracting With a Scrap Dealer or Disposal in a Landfill

Scrap dealers and landfill operators usually require certain conditions to be met before they accept drums or other containers. Generators have to drain the drums or containers thoroughly, remove the residues by triple rinsing, certify that they do not contain hazardous materials, remove both the ends, crush them before transporting, and pay for disposal.

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[161] Ventura County Environmental Health, *Hazardous Waste Reduction Guidelines for Environmental Health Programs* (California Department of Health Services, Sacramento, CA, 1987), p 3-2.

[162] *Managing Empty Containers*, Fact Sheet (Minnesota Technical Assistance Program, University of Minnesota, Minneapolis, MN, 1988).

Table 56

PCB Replacement/Treatment/Disposal Services

Company	Address
ENSCO	P.O. Box 1975, El Dorado, AR 71730, (501) 863-7173
ENSR (formerly SunOhio)	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 452-0837
USEPA Mobile Incinerator	Woodbridge Ave., Raritan Depot Bldg. 10, Edison, NJ 08837, (201) 321-6635
GSX Chemical Services	121 Executive Center Dr., Congaree Bldg. # 100, Columbia, SC 29221, (800) 845-1019
Rollins	P.O. Box 609, Deer Park, TX 77536, (713) 479-6001
General Electric	One River Road/Bldg 2-111B, Schenectady, NY 12345, (518) 385-9763
SCA Chemical Services	1000 E. 111th St., 10th Fl., Chicago, IL 60628, (312) 660-7200

Table 57

PCB Transformer Retrofilling Services

Company	Address
DOW Corning Corp	P.O. Box 0994, Midland, MI 48686-0994, (517) 496-4000
ENSR (formerly SunOhio)	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 452-0837
General Electric	One River Road/Bldg 2-111B, Schenectady, NY 12345, (518) 385-9763
Hoyt Corporation	251 Forge Rd., Westport, MA 02790-0217, (800) 343-9411
Retrotex	1700 Gateway Blvd. SE, Canton, OH 44707, (216) 453-4677
Transformer Service Inc.	78 Regional Dr., P.O. Box 1077, Concord, NH 03301-9990, (603) 224-4006
Unison Transformer Services	1338 Hundred Oaks Dr., Charlotte, NC 28210, (800) 544-0030
Westinghouse/Industry Services	875 Greentree #8-MS 804, Pittsburgh, PA 15220, (800) 441-3134

HSWA requires generators of hazardous wastes to develop a waste minimization program that is economically practicable. Therefore, once the alternatives for minimization are identified, their economic feasibility must also be studied. A major source for funding for hazardous waste minimization projects has been through the Defense Environmental Restoration Account (DERA). If the payback from a project is expected to be 1 year or less, funding is also available from the Defense Productivity Enhancing Capital Investment (PECI) program. In many instances, minimization is a cost-effective means of conducting business. In such instances, any account may be used to finance minimization and benefit from the resultant savings. However, with the multiplicity of alternative treatment technologies available to treat various hazardous waste streams, it is imperative that installation environmental personnel use a standard methodology to evaluate hazardous waste minimization options.

In 1984, DOD initiated a Used Solvent Elimination (USE) program. In conjunction with the USE program, USACERL developed a model for performing an economic analysis on various alternatives for recycling or disposing of used solvents. Based on this earlier model, a microcomputer model has been developed for economic analysis of minimization options. (Refer to USACERL Technical Report N-89/XX[163] for a detailed discussion of the process of economic analysis and use of the model.) A part of the model related to nonspecific or "general" waste types is used to determine the life cycle costs and comparison of alternatives for waste streams in this report. Many other publications on economic analysis are available.

The caveat of an "economically practicable" level of waste minimization, as defined in HSWA, is very important. It is not necessary (and is impossible in most cases) to completely eliminate generation of wastes. An economic analysis provides a reasonable methodology for choosing between options for waste minimization. The typical costs considered for any option are initial capital costs and operating costs such as labor, materials, transportation, and waste disposal. Benefits achieved from a waste minimization option (e.g., reduced liability) can also be quantified and given dollar values.

The costs are summed to obtain life cycle costs over the assumed economic life for each option. Net present value (NPV) of the total life cycle costs can be calculated for each option. Comparing the NPVs provides a basis for selecting a minimization technique Results of detailed economic analysis for the selected waste streams are provided in the sections below.

Waste Oil

A large quantity of used oil, primarily engine lubricating oil, is generated on Army installations. Fort Campbell generates 60,368 gal/yr of used oil. Lubricating oil is drained from wheeled and tracked vehicles by the traditional drip-pan method and collected in 55-gal drums or larger storage tanks. Some of the contaminants found in used oil are trash/rags, solvents, hydraulic fluids, and wear metals. Oil is normally changed from larger vehicles (2 1/2 ton size class and above) based on the AOAP test. Smaller vehicles (Humm-Vs, Cutt-Vs, etc.) follow a regular service interval of 6 months or 6,000 miles.

A source reduction method for minimizing waste oil generation is a change in the process of draining the oil. A FLOC system can be implemented to replace the gravity-drain (drip-pan) method. A description of the technique is provided in Chapter 5. Adapters have to be purchased for all the

[163] J.B. Mount, et al.

different types of Army vehicles. The major savings is in the labor costs. The amount of extraneous contaminants in the used oil is considerably reduced if the procedure is implemented.

A comparison of the life cycle (10-yr) costs for the two techniques was performed for fleets ranging from 50 to 5000 vehicles. Some of the assumptions made were:

- The average crankcase oil per vehicle is 3.25 gal.

- The average number of oil changes per year is 2.

- Liability due to spills, including labor costs for cleanup, is $177 for the gravity drain system.

- The time required for an oil change using the gravity drain system is 15 minutes.

- The time required for an oil change using the FLOC system is 4.5 minutes.

- A labor time of 0.7 hours is assumed for removal of an accumulation of up to 50 gal in a 55-gal drum.

- The cost of a small FLOC unit is $2,260 (site preparation, etc. = $1,530 and personnel training = $1,235). Costs of larger units vary with size.

- The system is used 260 working days per year.

- The utility cost for each FLOC unit is $75/yr/unit.

- Costs do not escalate.

- Repair and maintenance is $50/yr/unit.

- One FLOC unit can handle approximately 35 to 40 vehicles per day. If more than 10,000 oil changes are conducted annually, two or more units will be required.

Table 58 lists the savings to investment ratios (SIR) and discounted payback period (DPP) for numbers of vehicles ranging from 100 to 5000. The SIR is 0.39 (not economical) in almost every case and the DPP is greater than the assumed economic life of 10 years. Varying the number of oil changes from 2 to 6 per year, a comparison can be made of the SIR and DPP, as shown in Table 59 for 1000 vehicles. Only when more than six oil changes per year, per vehicle are conducted does the FLOC system become cost-effective and a payback of less than 10 years is achieved.

Other management options analyzed for used oil include: (1) segregation and offsite disposal (status quo); (2) segregation and offsite sale as a nonhazardous waste; (3) minimal processing, blending, and burning, and (4) comprehensive processing, blending, and burning. Proper segregation of used oil from other waste streams and additional testing are prerequisites for management options 3 and 4. Cost estimates used in option 2 for the sale of used oil were obtained from Midwest Oil Refining Company, St Louis, MO.

The present management practice for used oils is commingled storage (engine lubricating oil mixed with hydraulic fluids, brake fluid, transmission fluid, and diesel fuel) into 55-gal drums or 500-gal mobile storage tanks (buffalos) located throughout the base. A used oil recovery truck is dispatched from DEH upon request of the generating unit to collect and transport nonhazardous used oil to one of seven UST located on base. Before oil is transferred to the DEH recovery truck, a simple Clor-D-Tect (Clor-D-Tect is a trademark of the Dexsil Corporation, Hamden, CT) test is performed to determine the presence and relative concentration of chlorinated contaminants. If the results demonstrate the existence of high levels of chlorides (>1000 ppm), a comprehensive laboratory analysis is required to determine its flash point, PCB, and heavy metal concentrations (lead, chromium, arsenic, cadmium, and chloride). If the results from the laboratory analysis are positive for any of these parameters, the used oil is considered a hazardous waste and disposed as such through DRMO. If the results of the Chlor-D-Tect test are negative, the used oil is considered nonhazardous and transferred via the DEH recovery truck to the large underground storage tanks. These tanks range in size from 4000 to 12,000 gal, are owned by Fort Campbell and managed by DRMO. Of the 60,368 gal of used oil generated on base last year, approximately 8000 gal were classified as hazardous waste which was disposed of at $4.00/gal. The remainder of the used oil was classified as nonhazardous and transferred to Auburn University at no cost. Auburn University reprocesses used oil for resale to other users.

A 10-year economic life and mid-year discounting at a rate of 10 percent are assumed for the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260, and
- Annual logistics and procurement - 1.6 percent of other O&M costs.

The major assumptions made in the analysis were:

- Nonsegregated oil may be considered hazardous depending on the concentration of halogens and heavy metals.
- Hazardous oil, when burned in a boiler without permits, is subject to fines. Operating without permits or in violation of permits will cause the facility to be shut down by the regulating agency.

- Disposal cost for hazardous halogenated oil is $4.00/gal (FY 90 price list);

- Transportation cost for onsite transfer and consolidation of hazardous and nonhazardous used oil and oily sludge generated fron processing activities is $0.10/gal.

- Sampling and testing costs incurred before the offsite transfer of used oil in all options is $0.1153/gal (this was calculated from the number and cost of tests performed in the previous year - approximately 480 tests at $6/each and approximately 34 laboratory analyses at $120/each).

- Labor requirements for the onsite transfer of used oil from points of generation to DRMO or to underground storage tanks are 0.005 h/gal.

- Liability costs for onsite transportation and transfer of hazardous waste oil, nonhazardous waste oil, and processing sludge to DRMO or to underground storage tanks are $0.002/gal. Liability costs associated with all offsite transportation are $0.008/gal.

- Labor requirements associated with options 3 and 4 are: onsite transfer of waste oil and processing sludge to DRMO or to underground storage tanks for disposal - 0.01 h/gal; onsite transfer of nonhazardous oil to the boiler facility - 0.0008 h/gal; minimum processing at the boiler facility - 0.0016 h/gal; drumming of processing sludge and upkeep of minimal processing equipment - 0.002 h/gal; and comprehensive processing at the boiler facility - 0.0016 h/gal.

- Managerial labor is assumed to accrue at a rate of 1 h/5000 gal of used oil burned, disposed of, or sold.

- Fifty-five-gal disposal drums required in options 3 and 4 for shaker sludge produced from minimal processing are $20.00 each.

- Maintenance and repair costs for minimal processing and comprehensive processing equipment are $0.001/gal and $0.006/gal, respectively. Maintenance costs associated with boiler equipment for blending and burning options are $0.11/gal with minimal processing and $0.03/gal with comprehensive processing.

- Utility costs for minimal and comprehensive processing equipment are based on the default values provided in the economic analysis model. For minimal processing of used oil, a cost of $0.005/gal is assumed; for comprehensive processing it is $0.01325/gal plus an additional $0.0003/gal for waste water treatment.

- Sale of nonhazardous used oil kept in underground storage tanks yields $0.05/gal for option 2 (estimate given by Midwest Oil Refining Company, MO).

- There is no disposal cost for nonhazardous used oil accumulated in underground storage tanks in option 1.

- For the status quo option, 86.75 percent of the used oil waste stream is classified as nonhazardous and 13.25 percent is classified as hazardous.

- In options 3 and 4, 2 percent of the nonhazardous waste oil is disposed of as shaker sludge at $4.00/gal.

- Investment costs for minimal and comprehensive processing equipment (options 3 and 4) are $10,000 and $30,000, respectively.

- No investment costs for retrofitting the boiler facility for blending and burning (options 3 and 4) are considered, as necessary equipment is presumed to be already in place.

- Escalation rates for the above costs are as follows: transportation-4 percent; liability-4 percent; disposal-8 percent; sampling and testing-4 percent; other materials and supplies (disposal drums)-4 percent; and maintenance and repair-4 percent.

Figure 5 shows the comparison between the NPV total of the life cycle (10-yr) costs for used oil generation rates between 10,000 and 100,000 gal/yr for the four management options examined in this section. Option 1 (status quo) is the second least expensive alternative at all generation rates. At the current generation rate (60,368 gal/yr), the NPV of O&M costs for this option amount to $425,168 ($42,517/yr). This may be compared to options 2, 3, and 4 which result in NPV operating costs of $401,847 ($40,185/yr), $523,695 ($52,370/yr), and $484,681 ($48,468/yr), respectively. Neither of the two blending and burning options (3 and 4) offer an attractive SIR or DPP over the given generation range. Minimal processing (option 3) requires an NPV investment of $12,833 while comprehensive processing (option 4) requires an NPV investment of $38,501. Both are more expensive than options 1 and 2 at all generation rates. Therefore, it is recommended that Fort Campbell continue with the present practice of transfer to Auburn University while increasing emphasis on the necessity for source reduction and controlled segregation and storage at the generator level. Ultimately, eliminating the practice of commingling waste streams at the generator level could make used oil generated on Fort Campbell suitable for sale.

Contaminated JP-4

Approximately 53,000 gal of waste JP-4 are reported in Table 31. Source types that generate waste JP-4 include AMF (from the daily testing bulk fuel supplies kept at CAAF and SAH and from the screening of helicopter fuel tanks, fuel lines, and fuel pumps for the presence of water contamination), MPVM (from accidental spills during the transfer of JP-4 at refueling depots and the repair and cleaning of portable fuel drums or tanker trucks), and the Army Oil Analysis Laboratory (from the screening of fuel to be purchased from commercial vendors or testing of onsite supplies). The majority of the waste JP-4 contains only a small percentage of water, in excess of the 10 ppm usability threshold etablished by the Army for aviation fuels, and can be given to Auburn University at no disposal cost. Auburn University refines and sells the JP-4 as an industrial boiler fuel. JP-4 taken by Auburn is usually contaminated with less than 15 percent water and does not require manifesting as a hazardous waste. As much as 3000 gal of the total JP-4 waste stream may be heavily contaminated with oils, solvents, or excessive water and require disposal as hazardous waste through DRMO. Although the current management practice for waste JP-4 provides considerable benefits to both Auburn and Fort Campbell, other management alternatives such as onsite recycling and reuse, or disposal through a private recycler, were examined for their economic and technical feasibility should disposal through Auburn be discontinued. Specific management alternatives examined in this analysis are: (1) disposal of 96 percent of the waste stream through Auburn University at no cost with the remaining 4 percent (approximately 3000 gal) requiring disposal through DRMO as a hazardous waste (status quo); (2) disposal of 100 percent of the waste stream through DRMO as hazardous waste; (3) onsite recycling and reuse with the purchase and implementation of a filter separator; and (4) disposal of 96 percent of the waste stream through a commercial recycler (Consolidated Recycling, Troy, IN) with 4 percent requiring disposal through DRMO because of excessive contamination.

A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for options requiring an investment in new equipment. The economic model's default values retained for this analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - \$16.00/h,
- Labor rate (laborer) - \$11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260, and
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Other important assumptions of this analysis are:

- Disposal cost for heavily contaminated JP-4 through DRMO as a hazardous waste is \$4.50/gal.
- Disposal cost for waste JP-4 through a private disposal contractor (Consolidated Recycling, Troy, IN) is \$0.25/gal.
- Cost of laboratory waste characterization testing required before disposal through DRMO is \$0.12/gal of contaminated JP-4.
- Cost of waste characterization testing required by the private disposal contractor is \$0.02/gal of waste JP-4.
- Cost of transportation for the onsite transfer of JP-4 from points of generation to either DRMO or centralized USTs before offsite disposal is estimated at \$0.1(gal.
- Labor requirement to transfer JP 4 from points of generation to temporary onsite storage areas is estimated at 1 h/100 gal.
- Managerial Labor costs are assumed to accrue at a rate of 1 h/5000 gal of JP-4.

- The three-stage, two-component, water coalescer/filter separator system is designed to process waste JP-4 at a rate of 50 gal/min.

- Total cost for the filtration system (including pumps, connecting lines. a single stage water coalescer, a two-stage filter separator, and filter elements) is $11,238.

- The filtration system is designed to effectively handle JP-4 with as much as 15 percent water contamination by volume and will provide clean, recycled fuel with water concentrations <10 ppm.

- The technical specifications and procurement costs of equipment examined in this analysis are available from Gelber Industries, Lincolnwood, IL (pump manufacturer) and Becker and Associates, Inc., Lombard, IL (distributor of the water coalescer and filter separator).

- The cost of shipping the entire filtration system to Fort Campbell is $675.00.

- The total cost of replacing coalescing cartridges and filter elements is estimated at $281/yr based on processing a waste volume of approximately 50,000 gal.

- The cost of electricity associated with operation of the filtration system is approximately $0.02/gal of processed JP-4.

- Wastewater treatment plant charges incurred are $35/year.

- The estimated value of processed JP-4 as a reuseable helicopter fuel is $0.61/gal.

- Since the proposed filtration system is completely automated, labor associated with operation and maintenance are considered negligible;

- The cost of repair and maintenance of the filtration system is estimated to be less than $40/yr.

- The cost of screening processed JP-4 for purity and useability, via Aqua-Glow moisture sensitive pads (Type GTP-25) is estimated at $125/yr for approximately 40,000 gal.

- The liability cost associated with disposal through DRMO is $0.08/gal, liability associated with disposal through Auburn University, the private disposal contractor, or processing with the filtration system is $0.03/gal.

- Escalation rates applied to various O&M costs associated with the above management options are as follows: transportation-4 percent, liability-4 percent, sampling and testing-4 percent, maintenance and repair-4 percent, replacement materials-4 percent, disposal through Auburn University or the private contractor-6 percent, and hazardous waste disposal through DRMO-8 percent.

Figure 6 shows a comparison of the NPV total of the life cycle (10-yr) costs for each of the waste JP-4 management options outlined above at generation rates between 35,000 and 70,000 gal per year. Option 2, 100 percent disposal through DRMO, represents the worst case management scenerio where a high degree of contamination of the entire waste stream would necessitate disposal as hazardous waste. Option 4, disposal through a private contractor, is considerably less expensive than disposal through DRMO, but provides no savings over the current management practice. Option 3, processing with filtration equipment for reuse, is the only management alternative that provides incentives over the current practice at the estimated generation rate. A NPV investment of $15,288 for new filtration equipment, plus an additional NPV O&M of $70,588, would provide a NPV savings of $122,140 over the current disposal procedure with Auburn University. The computed SIR and DPP for this management alternative are 7.98 and 1.92 years, respectively. Despite the attractive economics of this alternative, it is recommended that Fort Campbell continue with its current management practice while striving to reduce the quantity of heavily contaminated JP-4 that must be disposed through DRMO. The current procedure allows Fort Campbell to dispose of waste JP-4 as a recyclable fuel, without manifesting as hazardous waste, and at no cost.

Although the filtration system examined in this analysis has been used extensively by both commercial airlines and major oil companies with great success, performance ratings pertinent to military applications are lacking. Should the price of virgin JP-4 drastically increase or disposal arrangements with Auburn University ever be disrupted, the purchase of a filtration system and implementation of an onsite recycling program for waste JP-4 could become a valuable alternative.

Lead-Acid Batteries/Battery Acid

An estimated 5137 lead-acid vehicle batteries were used and processed for transfer to the Department of Energy from Fort Campbell in FY 88. Until September 1989, the acid from most of these batteries was drained and neutralized onsite with sodium bicarbonate. Neutralization is considered elementary waste treatment under RCRA and is permitted only if the treated effluent is tested and shown to not contain heavy metal contaminants. Past neutralization procedures did not include testing before sump discharge to the sanitary sewer. Currently, nonserviceable batteries are still drained, but the acid is drummed and turned in to DRMO for disposal as corrosive hazardous waste. Approximately nineteen, 55-gal drums (950 gal) of sulfuric acid have been generated for disposal through DRMO since the change in disposal practice. Empty battery casings are still palletized and turned over to the Department of Energy, Idaho Falls, ID, for lead recovery. This section presents results of an economic analysis pertinent to four management alternatives: (1) draining batteries and neutralizing the acid; (2) draining batteries and drumming and disposing of the acid through DRMO as hazardous waste (status quo); (3) no draining, sale of batteries with their acid to a private recycler (assuming 20 percent of the batteries are cracked and require draining of their acid to be disposed through DRMO); and (4) no draining, sale of batteries to a private recycler (assuming no cracked batteries).

The model's default values retained for this analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,

- Adjustments for leave -18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Transportation of hazardous waste - $0.04/lb, and
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other assumptions used in the calculations are:

- Weight of a typical lead-acid vehicle battery without electrolyte is 50 lb.
- Volume of electrolyte per battery is 1.5 gal (at 9.99 lb/gal).
- Weight of electrolyte per battery is 15 lb (density, 10 lb/gal).
- Cost of disposal of drummed electrolyte is $4.50/gal.
- Cost escalation factors: disposal-8 percent, liability-4 percent, raw materials-4 percent, other materials/supplies-4 percent, sampling/testing-4 percent, maintenance & repair-4 percent, and IWTP costs-4 percent.
- Transportation and storage cost is $0.07/battery and $0.11/gal of spent electrolyte.
- Transportation cost of neutralization sump sludge to DRMO is $0.02/gal of treated electrolyte.
- Liability costs for: disposal - $0.013 and transport - $0.002/lb of casings, and: draining - $0.001, disposal - $0.013, transport - $0.002, and precipitation - $0.001/lb of electrolyte.
- Cost of sodium bicarbonate used is $0.13/gal of electrolyte neutralized.
- Quantity of neutralized sludge produced is 0.05 lb/lb of electrolyte;
- Neutralized sludge disposal cost (including labor) is $0.05/lb.
- Wastewater treatment cost is $3.10/1000 gal.
- Labor hours in bringing batteries to DRMO is 1 h/150 units.
- Labor hours for bringing drummed electrolyte to DRMO is 0.5 h/55-gal drum.
- Purchase price for 55-gal disposal drums is $20.00/drum.

- Labor hours for draining and drumming of electrolyte is 0.04 h/gal.

- Labor hours for monthly neutralization sump maintenance (cleaning, drum and transport to DRMO) is assumed to be 2 hours

- Costs associated with neutralization sump and pH meter upkeep are $10.00/1000 gal of electrolyte treated ($0.01 per gal).

- Labor hours required for neutralization is 0.02 h/gal of electrolyte.

- Labor hours for manager (for bid preparation, etc.) is 1 h/500 batteries.

- Batteries sold to the private recycler (Electro-Lite Battery Mfg. Co., Chattanooga, TN) brings $0.03/lb ($1.95/65-lb battery, with electrolyte, and $1.50/50-lb battery, without electrolyte).

- Sampling and testing costs required for characterization of neutralization sump sludge were estimated at $50.00/yr for each neutralization shop, at least three neutralization shops were once operating at Fort Campbell.

Figure 7 shows the comparison of the total life cycle (10-yr) costs of the four options. Option 2 is the most costly over the generation range (3500 to 5000 batteries/yr). Option 1, formerly the status quo, is less expensive but liability associated with neutralization, in terms of environmental damage and worker safety, compounded by the costs of increased shop maintenance, provides no incentives for this option over wet recycling. In option 4, recycling nonserviceable lead-acid vehicle batteries with electrolyte will result in a NPV savings of $180,366 (or $18,037/yr) and additional revenues of $66,204 over 10 years (or $6620/yr). Assuming that 20 percent of the batteries are cracked, option 3 (wet recycling of uncracked batteries and disposal of drained acid) would result in a net savings of $93,672 (or $9367/yr) over the current practice. Revenues gained from the sale of batteries in this option would not offset annual O&M costs. From both legal and waste minimization perspectives, sale of nonserviceable lead-acid batteries with their acid to a private recycler is the best management alternative for Fort Campbell and is strongly recommended for immediate implementation.

Antifreeze Solution

MPVM generate the largest percentage of spent antifreeze solution reported from Fort Campbell followed by IMSS. Spent antifreeze is generated from the regular servicing and maintenance of vehicle cooling systems and from the overhaul or replacement of vehicle radiators. Since spent antifreeze solution may not be considered a hazardous waste in some states, on many Army installations it may be diluted with water and discharged to the sewage treatment plant. In many instances, spent antifreeze can be reconditioned and reused in the same vehicle from which it came, providing savings in raw material purchase costs. Recycling used antifreeze is considered a minimization option and the results of the economic analysis are presented in this section. Management options considered in this analysis are: (1) discharge of 95 percent of the waste stream to the IWTP and disposal of the remaining 5 percent through DRMO (status quo), (2) disposal of the entire waste stream through DRMO, (3) recycling and reuse with two Glyclean machines, and (4) recycling and reuse with five Glyclean machines.

Investment costs for the antifreeze recycling systems are assumed to be all incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for all the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Annual logistics and procurement - 1.6 percent of other O&M costs, and
- Costs of sampling and testing.

Some of the other assumptions made in the economic analysis are:

- Disposal cost of spent antifreeze through DRMO is $4.50/gal (FY90 price list).
- Labor hours for: manager (bids, etc.) - 1 h/1000 gal; and laborers (drumming and transport) - 1 h/100 gal.
- Cost of one Glyclean recycling system is $2368.
- Two Glyclean systems are required when waste generation rates exceed 10,000 gal/yr.
- Cost of one, 55-gal drum of Glyclean chemical additives is $26.65/gal.
- The quantity of additives needed is 0.03 gal/1 gal of antifreeze recycled.
- The time required to recycle 100 gal of used antifreeze is 0.5 h.
- The purchase price of new antifreeze is $8.45/gal (on GSA schedule).

- Recycled antifreeze from the Glyclean system is equivalent to a mixture of 40 percent fresh antifreeze and 60 percent water.

- Fresh antifreeze (10 percent of the recycled volume) must be added to the recycled Glyclean product to obtain desired coolant protection levels.

- Utility cost associated with Glyclean machine operation is $0.02/gal of waste.

- Repair and maintenance costs associated with onsite recycling systems is $0.006/gal.

- Liability for both disposal and reuse is $0.01/gal.

- Escalation is 8 percent for disposal and 4 percent for others.

- Onsite transport cost from point of waste generation to recycling facility and back or to DRMO for disposal is $2.00/100 gal.

Figure 8 shows a comparison between the total life cycle (10-yr) costs of the status quo option to those of offsite disposal through DRMO and onsite recycling with two and five Glyclean recycling systems. Onsite recycling of antifreeze solution results in a considerable savings at any generation rates at Fort Campbell compared to IWTP discharge or disposal through DRMO (options 1 and 2).

Fort Campbell generates approximately 18,148 gal/yr of spent antifreeze solution. The NPV of current O&M costs amounts to $621,638 per 10 years (or $62,164/yr). Purchasing two Glyclean recycling systems would require an NPV investment of $78,419. The resultant NPV savings would be $346,968 (or $34,697/yr). The SIR and DPP for the conversion are 4.30 and 3.02 years, respectively. Conversion from the current disposal method to recycling of antifreeze with Glyclean machines is recommended.

Cleaning Solvent Waste

Cold cleaning solvents such as petroleum distillates (PD680-I and PD680-II), petroleum naphtha, varsol, etc., are used in parts cleaning operations as discussed in Chapter 5. At Fort Campbell, spent cleaning solvents are disposed through DRMO as hazardous waste. Alternative management options exist for spent cleaning solvents, such as recycling and reuse, that provide favorable economic returns over offsite disposal through waste minimization and reduced raw material dependency. Implementation of a solvent recycling program, through either an offsite, closed-loop recycler such as Safety Kleen, or through the purchase of distillation equipment for use onsite, reduces the quantity of solvent related wastes requiring disposal as well as the liability associated with hazardous waste disposal. The feasibility of implementing a specific recycling program dependends on the type and volume of spent solvent generated. Fort Campbell generates approximately 7870 gal/yr of spent PD680-I and PD680-II.

An economic analysis was performed to compare the practice of purchasing fresh solvent periodically and offsite disposal of waste with recycling solvent by onsite distillation and offsite recycling by contract. Investment costs for onsite distillation are assumed to be all incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for all the options. The model's default values retained for analysis include:

- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs, and
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Some of the other major assumptions applied in the calculations are:

- An annual escalation rate of 4 percent was applied to raw materials and replacement materials, maintenance and repair, other materials and supplies, utilities, sampling and testing, and liability.
- Escalation rates of 8 percent and 6 percent were used for recurring disposal and contractual costs, respectively.
- The liability costs were assumed as follows: onsite distillation and reuse - $0.03/gal; offsite disposal/sale - $0.03/gal; and contract recycling - $0.01/gal.
- Twenty percent of the solvents are assumed lost because of open lids (evaporation) and other bad operating practices such as carry-off and spillage.
- Volume of the still bottoms is assumed to be 10 percent of the waste volume.
- Fresh solvent makeup is expected to be 30 percent of the waste volume to be purchased every year.
- Repair and maintenance costs are calculated to be 5.75 percent of the original cost of the equipment (in dollars per year) and based upon 2080 hours of operation per year. Should the equipment be used only a fraction of this time, the costs are adjusted accordingly.
- Laboratory analytical costs are assumed to be $75.00/yr for onsite distillation options.
- Transporting and warehousing costs are based on the volume of wastes generated at $2.00/100 gal.

- Cost of electricity is $0.05 per kWh.

- Costs for disposal of still bottoms (assumed hazardous) and spent solvent through DRMO are $4.50/gal (using FY90 price of $0.10/gal for spent solvent and $4.00/lb for the container, 55-gal drums).

- Cost of new solvents PD680-I (Safety Kleen - flash point 105 °F, boiling point 310 to 400 °F) is $1.60/gal, and PD680-II (NSN 6850-00-285-8011) is $2.24/gal.

- Equal portions of PD680-I and PD680-II are presently used on the post.

- Because the boiling point of solvent is above 325 to 350 °F (PD680-II - boiling point > 350 °F), a vacuum attachment must be used in the distillation process.

- Labor cost for loading and unloading the still will be less than 2 hours. According to manufacturers, the loading and unloading of a 55-gal still varies from 1/4 to 1/2 hour per shift.

- Utility costs are often provided by still manufacturers and typically range from $0.06 to $0.12/gal of solvent distilled ($0.10/gal was used for the 15- and 55-gal stills).

- Labor associated with the transport of spent solvent to the distillation site is 1 h/100 gal.

- Labor for 15- and 55-gal still operation are assumed to be 0.75 and 1.5 hours per batch, respectively.

- Three different size (10-, 20- and 30-gal) parts washers are used in calculations for contract recycle options.

- A one time installation charge of $30.00 is associated with each 30-gal capacity washer in option 3 and is considered an investment cost.

- The still prices on GSA schedule (quoted by Finish Engineering, presented in Table 60) were used in this analysis (Recyclene and Progressive Recovery, Inc., do not have GSA contracts), and do not include shipping costs. The purchase price for 15- and 55-gal stills, with vacuum attachments, is $13,361 and $24,609, respectively.

- For onsite distillation options, 70 percent of the initial purchase of raw materials is included as an investment cost, the remaining 30 percent is included as an annual O&M cost.

- The same generation (accounting for frequency of change) is assumed for owned equipment and disposal and contract recycling at 12.5 changes (services)/yr.

Figure 9 shows the comparison of net present values (NPV) of the total life cycle (10-yr) costs for the following options: (1) purchase of fresh cleaning solvent and offsite disposal of waste through DRMO (status quo), (2) onsite distillation and reuse with a 55-gal still, (3) contract recycling offsite with leased parts washing equipment (LE), (4) contract recycling offsite with owned parts washing equipment (OE), and (5) onsite distillation and reuse with a 15-gal still. Options 2 through 5 employ the high flash point (140 °F) solvent, PD680-II, since it is the safer of the two. The NPV of 10-yr costs were calculated for each of the above options at waste generation rates between 1000 and 10,000 gal/yr.

Safety Kleen is a typical contract recycling firm (on GSA schedule through June 1991). They offer two types of contracts. In one, the solvent is supplied and the user leases equipment (recommended option). In the other contract, only the solvent is supplied and recycled by the company and the user purchases equipment. The cleaning solvent supplied is equivalent to PD680-II (flash point 140 °F). In option 4, the necessary parts washing equipment is considered to have already been purchased and put in place. Maintenance and repair of this equipment is the responsibility of the user.

Onsite distillation with a 55-gal still (option 2) is the most economical option at waste generation rates greater than 3000 gal/yr. An NPV investment of $43,352 results in NPV savings of $300,453 (or $30,045/yr) at the actual generation rate for Fort Campbell (7870 gal/yr) when compared to the current practice of offsite disposal (option 1). The NPV of O&M costs associated with the current practice is $396,883 ($39,688/yr). The resultant SIR and DPP from the purchase and use of a 55-gal still are 6.93 and 2.31 years, respectively. Although onsite distillation is an economical option, the change in procurement, storage, and disposal procedures that would result could cause logistical and other problems for personnel involved in degreasing operations. Despite these considerations, recycling and reuse of spent solvent with a 55-gal still is recommended for Fort Campbell.

Paint Thinner Waste

Paint thinner waste is generated from the cleaning of painting equipment as discussed in Chapter 7. Onsite distillation (with 15- and 55-gal batch stills) and closed-loop recycling through the services of a commercial vendor were the options examined and compared to the current practice. The purchase of fresh thinners and offsite disposal of generated wastes (1470 gal/yr) defines the status quo.

Investment costs for onsite distillation are assumed to be all incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for all the options. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,

- Average maintenance - 5.75 percent of equipment costs, and
- Annual logistics and procurement - 1.6 percent other O&M costs.

Some of the other assumptions made in this economic analysis are given below.

- An escalation of 4 percent was applied to raw materials and replacement materials, maintenance and repair, other materials and supplies, liability, sampling and testing, and utilities.
- An escalation rate of 8 percent was used for offsite disposal costs.
- Liability costs were as follows: onsite distillation and reuse - $0.03/gal, and offsite disposal -$0.08/gal.
- In the recycling process, it is assumed that 20 percent of the waste stream must be replaced with new material in each cycle, 10 percent of the original material is assumed to evaporate and 10 percent is disposed of with residue. Residue and thinner make up 20 percent of the original volume for disposal purposes.
- Repair and maintenance is an annual cost which is 5.75 percent of the original cost of the equipment and is based on a continual usage of 2080 h/yr. If the equipment is not used for the total time the costs are adjusted accordingly.
- Laboratory analytical costs are estimated to be a certain percentage of labor costs, although the minimum laboratory cost per sample may be substantially higher than the computed value for wastes generated in small volumes. A minimum of $50.00 is assumed.
- Transportation and warehousing costs are dependent upon the volume of waste handled and the distance between points of waste generation and distillation. For recycling/reuse options (2 and 3) an estimate of $0.02/gal was used.
- Transportation costs for bringing waste thinner to DRMO for disposal are $10/100 gal.
- Cooling water and electrical utility costs were based on model default values of $0.70/1000 gal and $0.05 per kWh, respectively.
- Disposal cost of thinner waste with container is $4.50/gal (FY90 price list - DRMO).
- Distillation stills are available with or without vacuum attachments. If the boiling point of the solvent is below 300 or 350 °F, a still with vacuum attachment is considered. For recovery of solvents with boiling points between 300 and 500 °F, a vacuum attachment should not be necessary.
- Most paint thinners have a boiling point of less than 300 °F. Although vacuum attachments may not be required on distillation equipment, they were considered in this analysis.
- The GSA price for 5 gal size of paint thinner is $3.65/gal. If available in a 55-gal drum, the price could be even lower. For this analysis, a price of $3.65/gal is used.

- Labor costs for loading and unloading of the still, especially for a batch 15-or 55-gal sizes, will be less than 2 hours (default value in the model). The labor requirements for operating 15- and 55-gal stills are 3/4 and 1 hour per batch, respectively.

- Labor costs for drumming and transporting waste thinner to DRMO were estimated to be 1 h/100 gal of waste. Managerial labor was estimated to accrue at a rate of 1/2 h/100 gal.

- Utility costs (electricity and water) for still operation can be obtained from the power input to the still and the rate of cooling water used. At present, it is estimated that the cost of power per gal of solvent distilled is $0.10/gal.

- Equipment manufacturers such as Finish Engineering, Recyclene, and Progressive Recovery, Inc., were contacted for the price of distillation equipment; the price of one manufacturer was competitive with the price of similar equipment of another manufacturer. Since Finish Engineering currently has a GSA contract, the corresponding GSA prices (15-gal, $13,361; 55-gal, $24,609) for stills with vacuum attachments were used.

- Eighty percent of the initial raw material purchase cost is included with the initial cost of equipment. The remaining 20 percent was included as an annual O&M cost.

With the above assumptions, life cycle costs were calculated for: (1) offsite disposal and purchase of fresh thinner (status quo or current practice), (2) onsite distillation with a 55-gal still, (3) onsite distillation with a 15-gal still, and (4) closed-loop recycling through a commercial vendor. Net present values of total 10-yr costs were calculated for the above options for a number of annual generation rates ranging from 500 to 2000 gal/yr. Figure 10 shows the comparison between the NPVs for all the options.

There are no investment costs associated with option 1. The purchase prices of the stills are shown in Table 60 (Finish Engineering Prices). The purchase and use of a 55-gal still (option 2) is cost effective beyond a waste generation rate of approximately 700 gal/yr compared to the current method of contract disposal through DRMO. Purchase and use of a 15-gal still (option 3) is the least cost management option throughout the entire waste generation range (500 to 2000 gal/yr) portrayed in this analysis.

Fort Campbell generates approximately 1470 gal/yr of paint thinner waste, which is disposed of through DRMO. The NPV O&M cost for the current practice is $104,735 ($10,474/yr). Investing $32,011 for a 55-gal still will result in an annual savings of $6206. The SIR and DPP are 2.03 and 5.68 years, respectively. Although purchase and use of a 15-gal still shows a greater economic incentive for the installation over the 55-gal still, from a logistical perspective, possible limitations of batch capacity and operator time involvement could render the equipment less effective in meeting the diverse and unexpected recycling needs of the installation. The purchase of a 55-gal still is therefore recommended. In addition to minimizing wastes, a payback can be expected in less than 6 years.

Spent Xylene and Alcohol Wastes

Each year laboratory activities of the Pathology Department in the Hospital generate approximately 150 gal of spent xylene and 230 gal of contaminated ethyl alcohol, ignitable hazardous wastes that require costly offsite disposal. The majority of these two waste streams are generated from the Histology and Cytology laboratories where xylene and ethyl alcohol are used for cleaning procedures and to fix and preserve tissue specimens. Unlike the xylene used at MPVM facilities, IMMS, or PS for paint thinning or cleaning of spray equipment, xylene used at the Hospital is not entirely consumed in the process and must consistently conform to strict product purity standards. Waste xylene generated is primarily contaminated with paraffin, and smaller quantities of tissue and is temporarily stored in 5- to 10-gal drums before its disposal through DRMO. An economic analysis is presented in this section to compare the costs of the procurement/disposal procedure for xylene and alcohols currently practiced to those associated with recycling/reuse through the purchase and use of a spinning band distillation unit. The proposed recycling equipment is manufactured by BR Instrument Corporation, Pasadena, MD, and is available in 6- or 12-liter batch capacity (1.6 or 3.2 gal). Use of such equipment would reduce the volume of hazardous xylene and alcohol related wastes and consistently provide laboratory staff with a high grade solvent for tissue processing with minimal investment of time, space, and energy.

Investment costs for onsite distillation are assumed to be all incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for this option. The model's default values retained for this analysis include:

- Site preparation and equipment installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment purchase costs, and
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Other major assumptions made in this analysis are given below.

- An escalation factor of 4 percent was applied to raw material and replacement material purchases, maintenance and repair, other materials and supplies, liability, sampling and testing, transportation and warehouse storage, and utilities.
- An escalation rate of 8 percent was used for offsite disposal costs.
- Liability costs were as follows: onsite distillation and reuse - $0.03/gal; and offsite disposal - $0.08/gal.
- In the recycling process, it is assumed that 10 percent of the waste stream is replaced with new material in each cycle. Five percent of the material is assumed to be lost through evaporation and 5 percent disposed of with the generated still bottoms

- Repair and maintenance is an annual cost that is 5.75 percent of the original cost of the equipment and is based on a continual usage of 2080 h/yr. If the equipment is not used for the total time, the costs are adjusted accordingly.

- Laboratory analytical costs are estimated to be a certain percentage of labor costs. However, the minimum laboratory cost per sample may be considerably higher than the computed value for wastes generated in small volumes. A minimum of $50.00 is assumed.

- Transportation and warehouse storage costs are dependent upon the volume of waste handled and the distance between points of material storage, waste generation, and waste disposal. For option 1 (offsite disposal through DRMO) a cost of $10.00/10 gal of spent xylene waste transported is used. For option 2 (onsite recycling), a minimal cost of $1.00/gal was used to cover the expense of transporting hazardous still bottoms to DRMO.

- Costs of cooling water and electricity are assumed to be $0.70/1000 gal and $0.05 per kWh, respectively. The cost of operating the proposed distillation unit is estimated to be $0.10/gal of recycled material.

- Disposal costs for spent xylene and alcohol and contaminated still bottom residues are $4.00/gal (FY90 price list-DRMO).

- The GSA listed price for fresh xylene, ACS grade (NSN 6810-00-138-8414) is $6.50/gal.

- Purchase prices for 6- and 12-liter spinning band distillation units (BR Instruments Corporation, Models 8300 and 8400) without vacuum attachments are $7400 and $11,300, respectively.

- Labor costs for drumming and transporting wastes to DRMO for offsite disposal are estimated at 1 h/20 gal of waste and 1/2 h/20 gal of waste for managerial labor.

- Ninety percent of the cost of initial raw material purchase is included as an investment in the onsite recycling option as a startup expense. The remaining 10 percent is accounted for as a recurring O&M cost.

With the above assumptions, life cycle costs were calculated for (1) offsite disposal and purchase of fresh materials (status quo), (2) onsite distillation with a 12-liter batch still, and (3) onsite distillation with a 6-liter batch still. Net present values of total 10 yr costs were calculated for the above options for annual waste generation rates applicable solely to spent xylene (150 gal/yr) and for the combined volume of xylene and ethyl alcohol (380 gal/yr). Figure 11 shows the comparison between the NPVs for the three options. NPV O&M costs for the status quo option at the current rate of spent xylene generation (150 gal/yr) are approximately $16,991 (or $1699/yr) and for xylene and ethyl alcohol (380 gal/yr) $45,310 ($4531/yr). Investing $9095 in a 6-liter distillation unit for recycling xylene only would result in an annual savings of $820. The computed SIR and DPP for this option are 0.90 and approximately 10 years respectively. Investing $14,842 in a 12-liter still to handle both xylene and alcohol waste streams would result in an annual savings of $3193 and produce SIR and DPP values of 2.15 and 5.34 years, respectively.

There are no investment costs associated with option 1 (status quo). Use of the 12-liter batch still is cost effective at waste generation volumes above 220 gal/yr. For waste volumes between 150 and 220 gal/yr, the 6-liter still is applicable. The purchase of a 12-liter distillation unit and the development and implementation of an in-house solvent recycling program is recommended for the Pathology Department.

Spent 1,1,1-Trichloroethane/Degreaser Tank Bottoms

A small capacity (75 gal), vapor-spray degreasing tank is located and used at the Weapons Repair Shop of DOL. The equipment is used to clean howitzer and small arms components of grease, wax, or other oily grime during their repair or overhaul and before the bluing process. The long practiced use of Trichloroethylene as a solvent in this equipment, since the equipment's installation in 1974, has recently been discontinued and replaced by the use of less toxic 1,1,1-trichloroethane. The tank requires cleaning at least once each year and involves the complete draining and drumming of spent solvent, the removal of bottom sludges and accumulated trash, and fresh solvent replacement. Additional volumes of fresh solvent are added to the tank periodically to replenish losses incurred during use through evaporation and equipment carry-off. To reduce the quantity of hazardous waste generated from the DOL facility and to improve the quality of the working environment for personnel involved in degreasing operations, discontinuing the use of 1,1,1-trichloroethane as a degreasing solvent should be considered. Implementation of HAZMIN technologies, such as a hot water jet washer that uses biodegradable detergents, could eliminate the need for DOL personnel to purchase, store, or handle toxic 1,1,1-trichloroethane and the liability associated with the handling and disposal of the spent solvent waste and degreaser tank bottoms.

All investment costs for the purchase of new equipment are assumed to be incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for the three alternatives. The model's default values retained for this analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 260,
- Average maintenance - 5.75 percent of equipment costs,
- Transportation of hazardous waste - $0.04/lb, and,
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Other assumptions made in this economic analysis are given below.

- An escalation rate of 4 percent was applied to the recurring costs of raw materials and replacement materials, liability, utilities, other materials and supplies, maintenance and repair, and sampling and testing.

- An escalation rate of 8 percent was used for offsite disposal costs.

- Liability costs were as follows: vapor degreaser operation - $0.01/gal, and offsite disposal - $0.08/gal.

- Solvent loss due to evaporation during the operation of the vapor degreaser was estimated at 98 gal over 65 hours use.

- Repair and maintenance costs for major equipment was based on use rates and 5.75 percent of the original purchase price, if equipment was to be used less than 2080 h/yr (continual use), costs were adjusted accordingly.

- The disposal cost for spent 1,1,1-trichloroethane and tank bottoms with container is $4.50/gal (FY90-price list).

- The volume of waste solvent generated for disposal is based on the equipment's maintenance interval and the working capacity of the degreasing equipment (75 gal).

- The purchase cost for fresh 1,1,1-trichloroethane is $6.75/gal.

- Cooling water and electrical utility costs were based on model default values of $0.70/1000 gal and $0.05/kWh, respectively.

- Labor associated with vapor degreaser cleaning, maintenance, and solvent replenishment was estimated to be a minimum of 8 man hours/yr.

- Managerial labor costs were assumed to accrue in a supervisory capacity at a rate of 1 hour for every 8 laborer hours.

- Labor costs associated with the maintenance and cleaning of the jet washers were assumed to be a minimum of 4 h/yr.

- The purchase price for one Model-60 Jet Washer manufactured by Better Engineering,Mfg., Baltimore, MD, is $10,290 (including shipping and installation).

- The purchase price for one 5-gal batch distillation unit is approximately $2770.

- The purchase price for one, Model DS-20 (20 gal/h) continuous recovery still manufactured by Delta Industries, Santa Fe Springs, CA, is $9328.

With the above assumptions, life cycle (10-yr) costs were calculated for options: (1) offsite disposal and purchase of fresh solvent, the status quo, (2) purchase and use of a hot water jet washer, (3) onsite distillation with a 5-gal batch still, and (4) onsite distillation with a 20-gal/h continuous recovery still. Figure 12 shows a comparison of the current management practice and three alternatives at waste generation rates ranging from 25 to 150 gal/yr. The NPV O&M cost for option 1 at the estimated generation rate within this shop is $39,030 ($3903/yr). Investing $11,483 in new jet washer equipment would result in an annual savings of $1011. The SIR and DPP are 0.88 and approximately 10 years, respectively. The results of this analysis indicate that the purchase of a hot water jet washer to replace the existing vapor degreaser and using 1,1,1-trichloroethane is economically sound at or above waste generation rates of 75 gal/yr. To further minimize hazardous waste generation and to produce savings in annual operation and maintenance costs, the purchase of a hot water jet washer is recommended.

Aqueous Paint Sludge Waste

Aqueous paint sludges are generated from the use of wet-wall (or waterfall type) paint booths that use water as a filtration media for booth emissions. Although very high overspray removal efficiencies are achieved with these systems, they require greater maintenance and generate more waste than booths of similar size that use dry filtration systems. The only operational waterfall type paint booth on Fort Campbell is located in Building 7811 and used by DOL-Weapons Repair Shop personnel. A second wet-walled booth is located at Building 7833 but is reportedly nonoperational. Building 7833 was originally used by the DOL-Furniture Repair Section but is currently assigned to the 5th SF GP (ABN). An economic analysis is presented in this section to compare the costs of converting one small wet-booth to a dry filter operation. Such a conversion would completely eliminate the generation of aqueous paint sludge wastes.

All investment costs for wet to dry paint booth conversion are assumed to be incurred in the first year. A 10-yr economic life, and midyear discounting at a rate of 10 percent is assumed for this option. The model's default values retained for analysis include:

- Site preparation and installation - 15 percent of total equipment costs,
- Logistics and procurement - 7 percent of installed equipment costs,
- Contingencies - 10 percent of installed equipment costs,
- Labor rate (manager) - $16.00/h,
- Labor rate (laborer) - $11.00/h,
- Adjustments for leave - 18 percent of total man hours,
- Adjustments for fringe benefits - 36.2 percent of adjusted base labor cost,
- Number of work days in a year - 247,
- Average maintenance - 5 percent of equipment costs,

- Transportation of hazardous waste - $0.04/lb, and,
- Annual logistics and procurement - 1.6 percent of other O&M costs.

Other assumptions made in this economic analysis are:

- A small paint booth is approximately 6 ft wide, 9 ft deep, and 9 ft high.
- Solids content of the paints used is 40 percent.
- Transfer efficiency is 35 percent.
- Sump capacity is 280 gal.
- Water from the sump is drained and filtered at 4-week intervals.
- Eighty percent of the solids deposited in the sump (during various painting operations) is collected as sludge.
- The sludge contains 25 percent solids and 75 percent liquid (mostly water).
- Sludge removed from the collection sump is drummed and shipped offbase as a hazardous waste.
- Liquid is discharged to the wasteweater treatment plant.
- The capacity of the airduct fan is 3 hp.
- The curtain size is 6 ft wide and 6 ft high.
- The capacity of the water pump is 5 hp.
- The frequency of use is 1/2 a working shift/day/5-day work week.
- The volume of paint used is 5 gal/day.
- The volume of replacement water for the sump is 3500 gal.
- The volume of wastewater is 3500 gal.
- The volume of sludge generated is 26 gal in 4 weeks: (solids deposited in sump per day = 0.4 gal; recovery at 80 percent in 4 weeks = 8 x 0.8 = 6.4 gal, volume of sludge (containing 25 percent solids) = 6.4 x 4 = 26 gal in 4 weeks).
- A fiberglass cartridge dry filter system is used for replacement.

- The cost to install the fiberglass filter system is $280/linear ft.
- The filter capacity is 0.02 gal of paint/sq ft.
- Filter replacement cost is $0.20/sq ft.
- The linear flow rate after conversion is 125 ft/min: (volumetric flow rate = cross sectional area of booth x 125 = 6 x 9 x 125 = 6750 sq ft).
- The air flow rate through a clean fiberglass filter is 150 ft/min.
- The area of the cartridge is 45 sq ft [i.e., 6750/150 = 45].
- To ensure a sufficiently low pressure drop, a surface area of 50 sq ft is considered, therefore, cost of (5 ft x 50 ft) filter face = 5 ft x $280/ft = $1400.
- The quantity of solids to be collected on the filter is 1 gal.
- The overspray rate is 0.39 gal of solids/day.
- Filter replacement frequency is 2 times/week.
- The fan in the airduct may be downsized from 3 to 2 hp (considered an even exchange, no additional investment).
- Labor required for filter replacement is 1 h/week.
- Labor for sump draining, cleaning, and drumming of sludge is 52 h/yr.
- The cost of electricity is $0.05/kWh.
- The cost of sludge disposal is $300/55-gal drum: (number of drums of sludge per year = (52 x 26) / (4 x 55) = 6; disposal cost = $1800/yr).
- The cost of disposal drums is $20 each.
- The cost of water used is $3.00/1000 gal.
- Electricity used by one wet paint booth over the course of 1 year is 6214 kWh.
- Escalation rates for: disposal - 8 percent; and others - 4 percent.
- Fiberglass filter replacement costs are $1040/yr.
- Disposal costs for spent dry filters is negligible.

- Electricity used by one dry paint booth over the course of 1 year is 1552 kWh.

Table 61 lists the life cycle (10-yr) costs of one small-sized wet and dry paint booth. The table also provides the results of the detailed comparison for conversion in terms of SIR and DPP.

The NPV O&M costs for one small wet-booth are $25,036 ($2504/yr) . Compared to the NPV O&M costs for one similar sized dry-booth, $14,970 ($1497/yr), conversion of the wet paint booth operation at DOL-Weapons Repair Shop to a dry filter operation would result in an estimated NPV savings of $10,537 (or $1054/yr). An investment of $1562 at this facility provides a SIR of 6.74 and a DPP of 2.45 years. In addition to the complete elimination of aqueous paint sludge wastes, a considerable savings and quick payback can be realized. Conversion of the existing wet paint booth at DOL-Weapons Repair Shop on Fort Campbell to use dry filters is recommended.

Table 58

SIR and DPP From a Comparison of the Costs of Gravity Drain with FLOCS

Number of Vehicles	SIR	DPP
100	0.38	> 10
250	0.39	> 10
500	0.39	> 10
1000	0.39	> 10
5000	0.39	> 10

Table 59

SIR and DPP From a Comparison of the Costs of Gravity Drain
With FLOCS for 1000 Vehicles

Number of Oil Changes	SIR	DPP
2	0.39	> 10
4	0.79	> 10
5	0.98	> 10
6	1.17	9.99

Table 60

Purchase Cost of Distillation Stills

Manufacturer	Model	Capacity (gal)	Price ($) no vacuum attachment	Price ($) vacuum attachment
Finish Engineering	LS-Jr	5	$ 2770	$ 4338
	LS-15IID	15	$ 10,128	$ 13,361
	LS-55IID	55	$ 20,123	$ 24,609
Recyclene	R-2	5	$ 2995	
	RS-20	20-25	$ 11,900	
Progressive Recovery, Inc.	SC-25	15	$ 7290	$ 12,865
	SC-50	35	$ 11,300	$ 16,895

Table 61

Life Cycle Costs and SIR and DPP Calculations for Paint Booth Operations

Option Name	Inv. Costs. $	O&M Costs $ ($/yr)	Total $	SIR	DPP years
Wet Booth	-	25,036 (2504)	25,036	-	-
Dry Booth	3124	14,970 (1497)	16,532	7.44	2.45

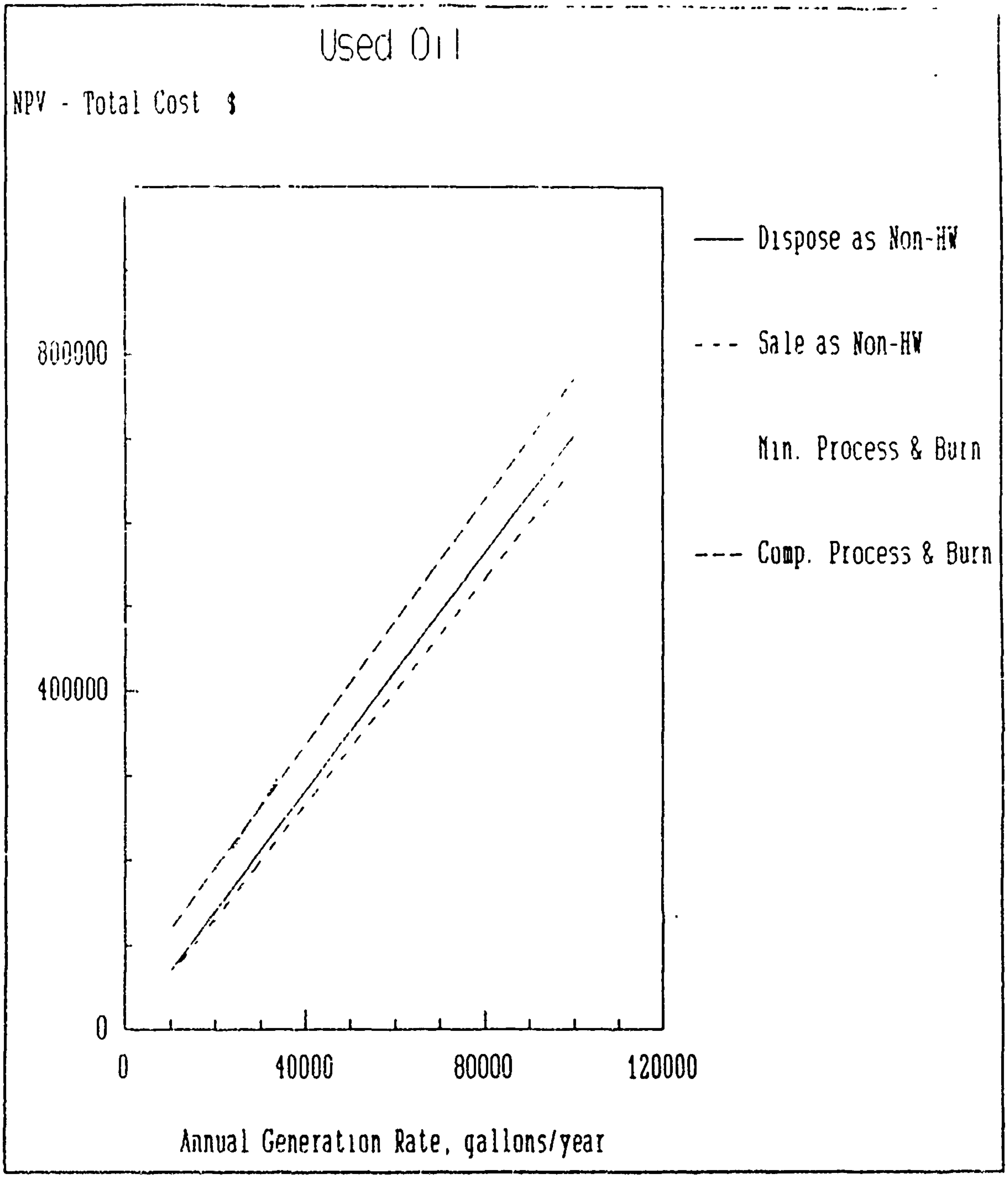

Figure 5. **Comparison of the net present values of options for minimizing used oil wastes.** Disposal as nonhazardous waste defines the status quo.

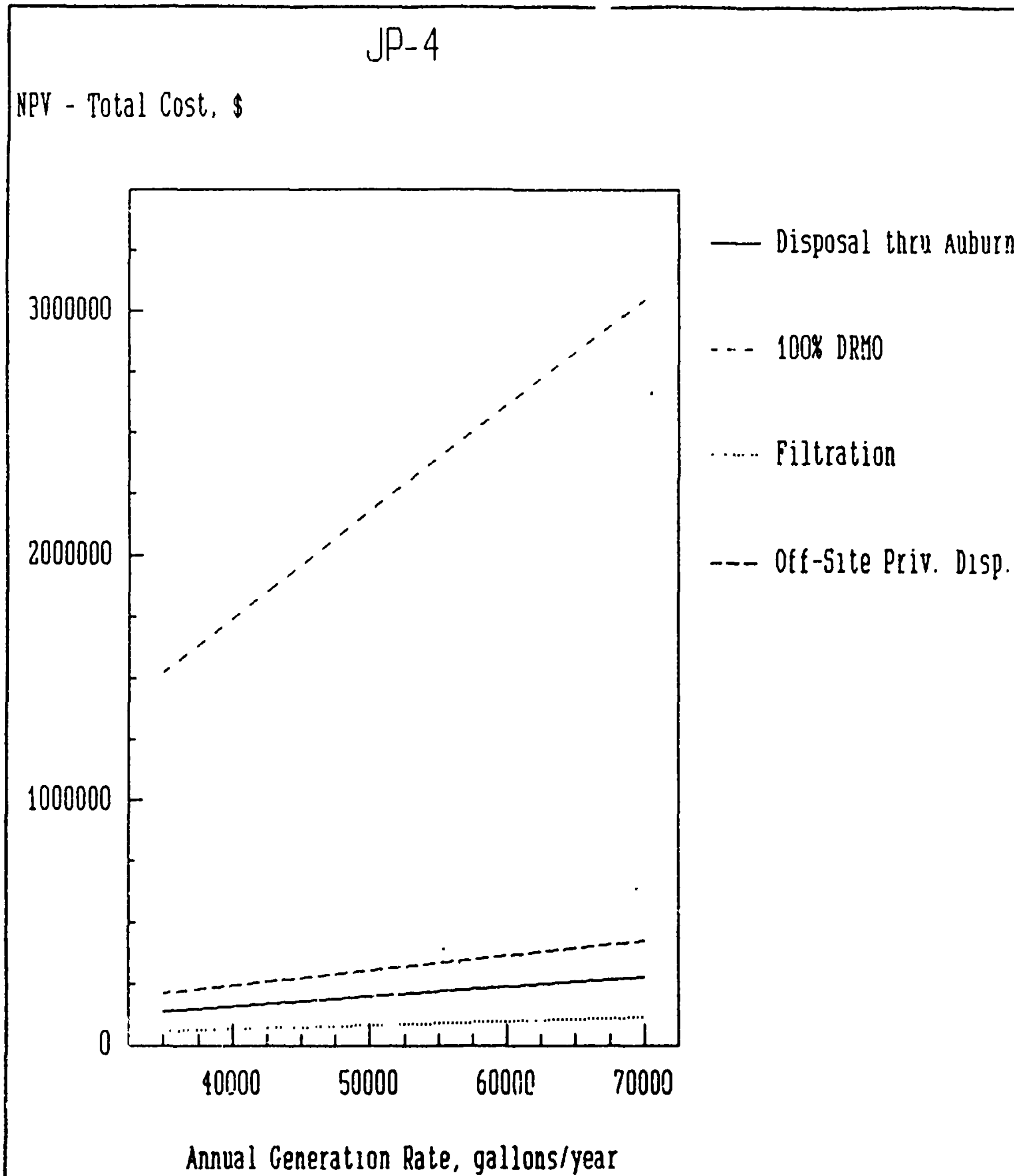

Figure 6. Comparison of the net present values of options for minimizing contaminated JP-4. Disposal through Auburn University defines the status quo.

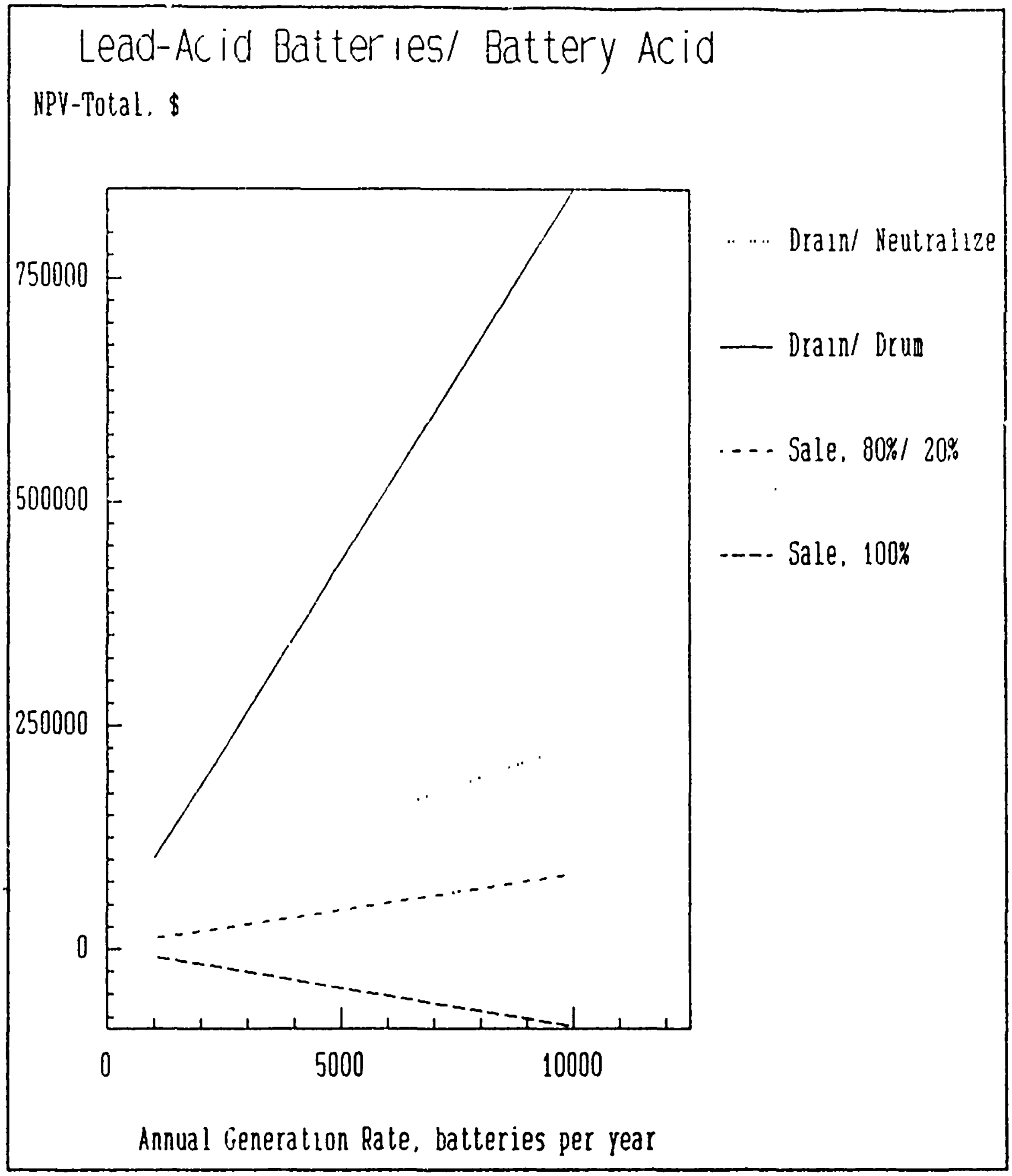

Figure 7. **Comparison of the net present values of options for minimizing lead-acid batteries and battery acid waste. Draining acid for disposal defines the status quo.**

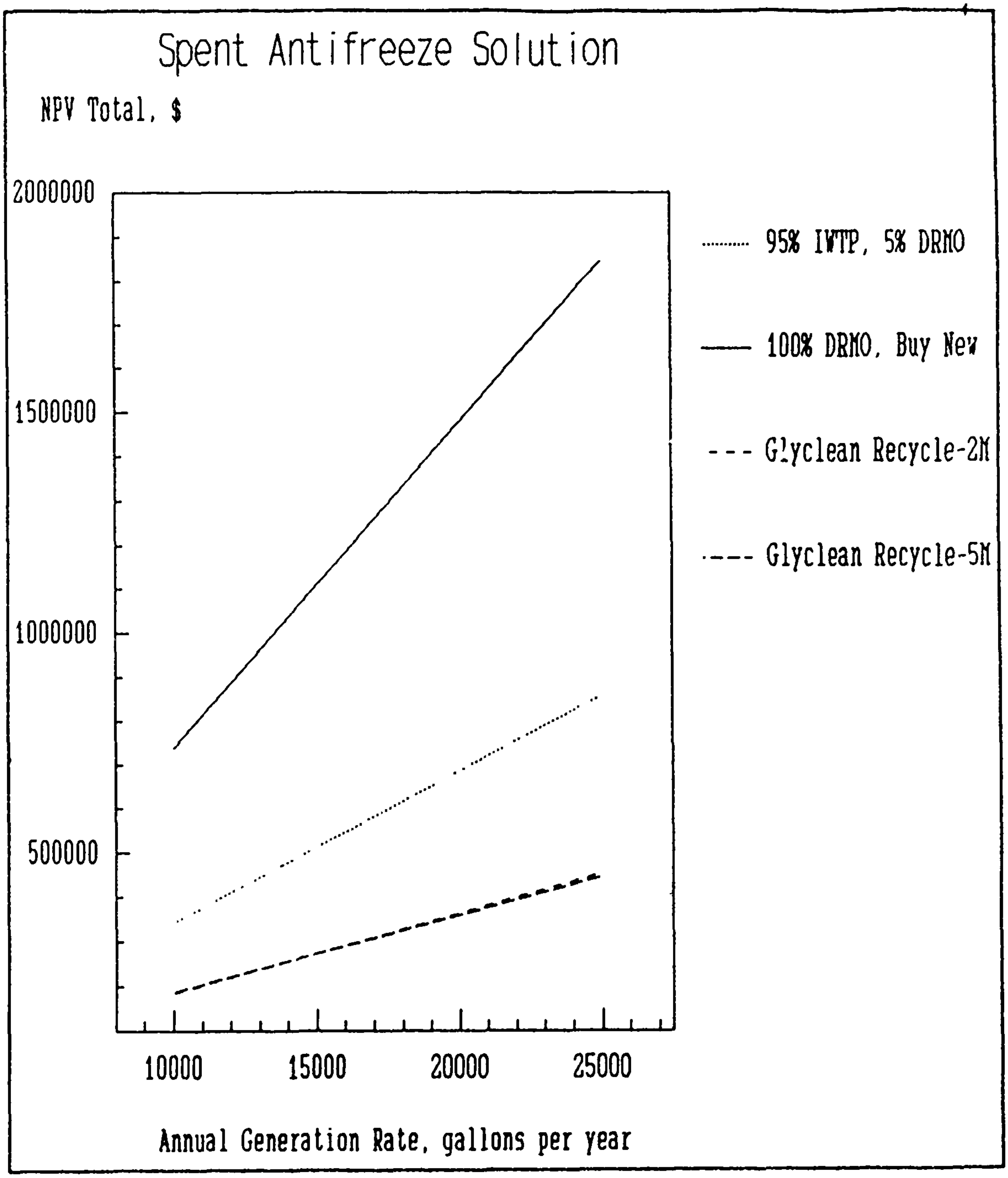

Figure 8. Comparison of the net present values of options for minimizing waste antifreeze solution. Disposal through DRMO defines the status quo.

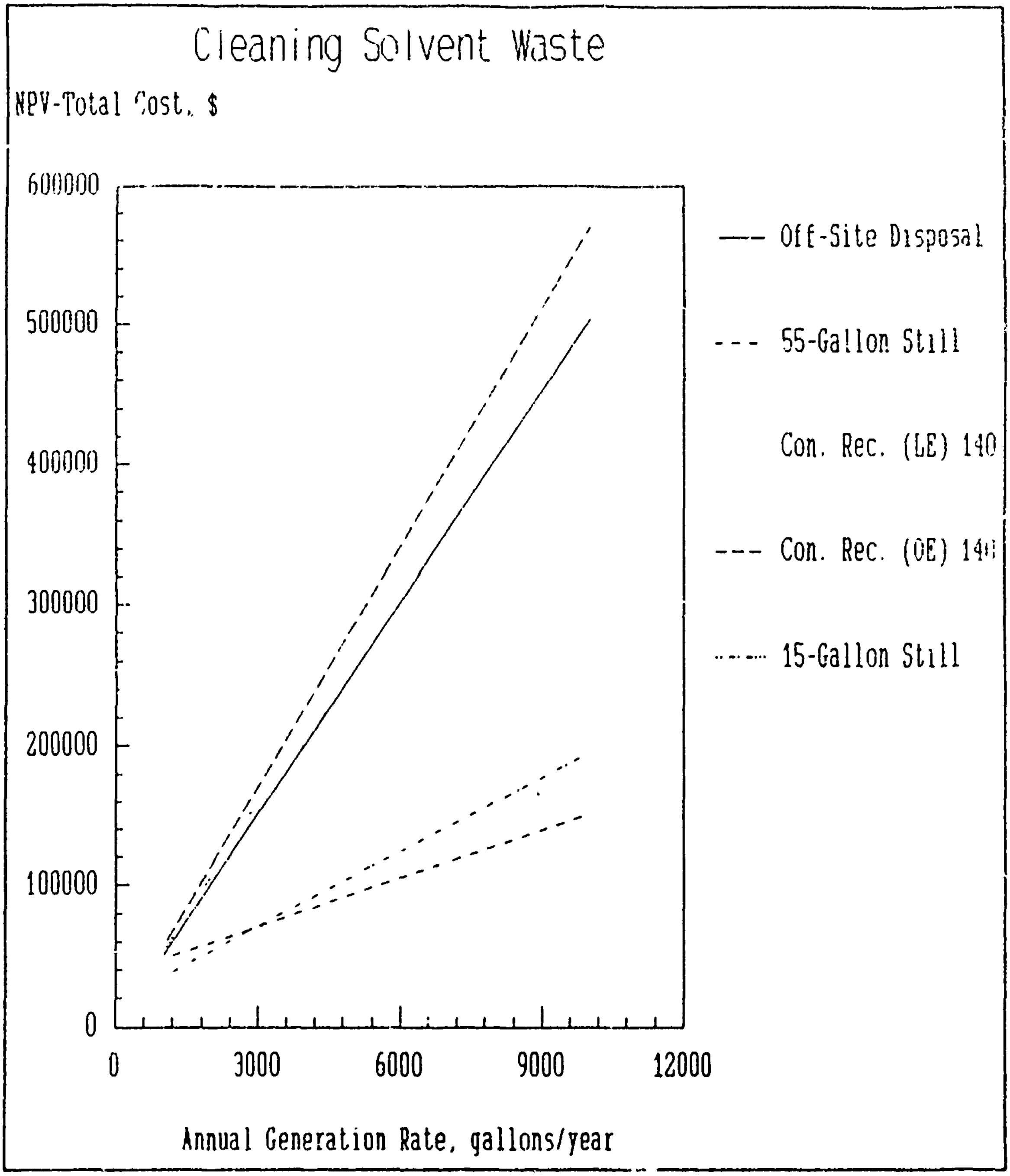

Figure 9. Comparison of the net present values of options for minimizing cleaning solvent waste. Offsite disposal defines the status quo.

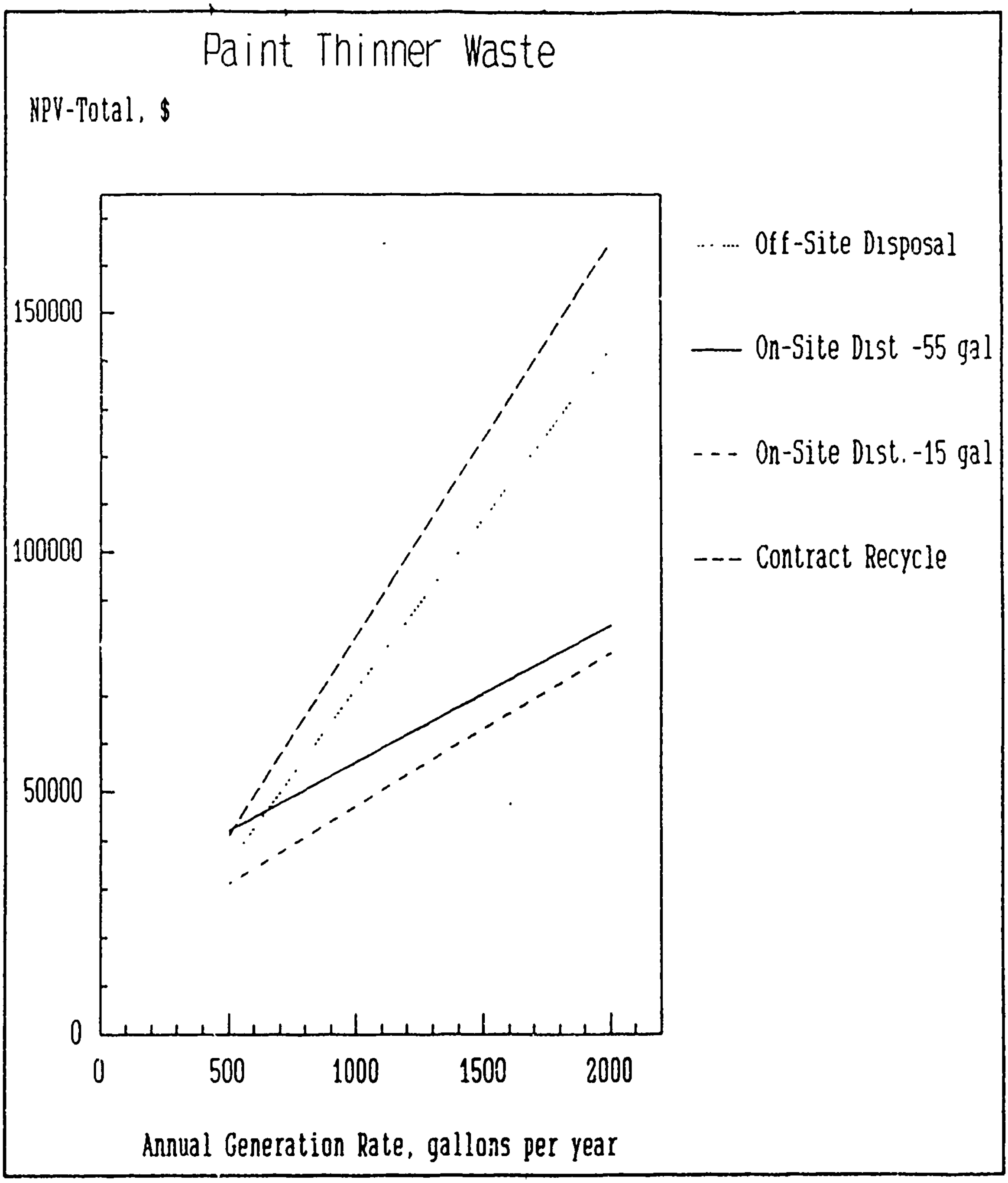

Figure 10. Comparison of the net present values of options for minimizing of paint thinner wastes. Offsite disposal defines the status quo.

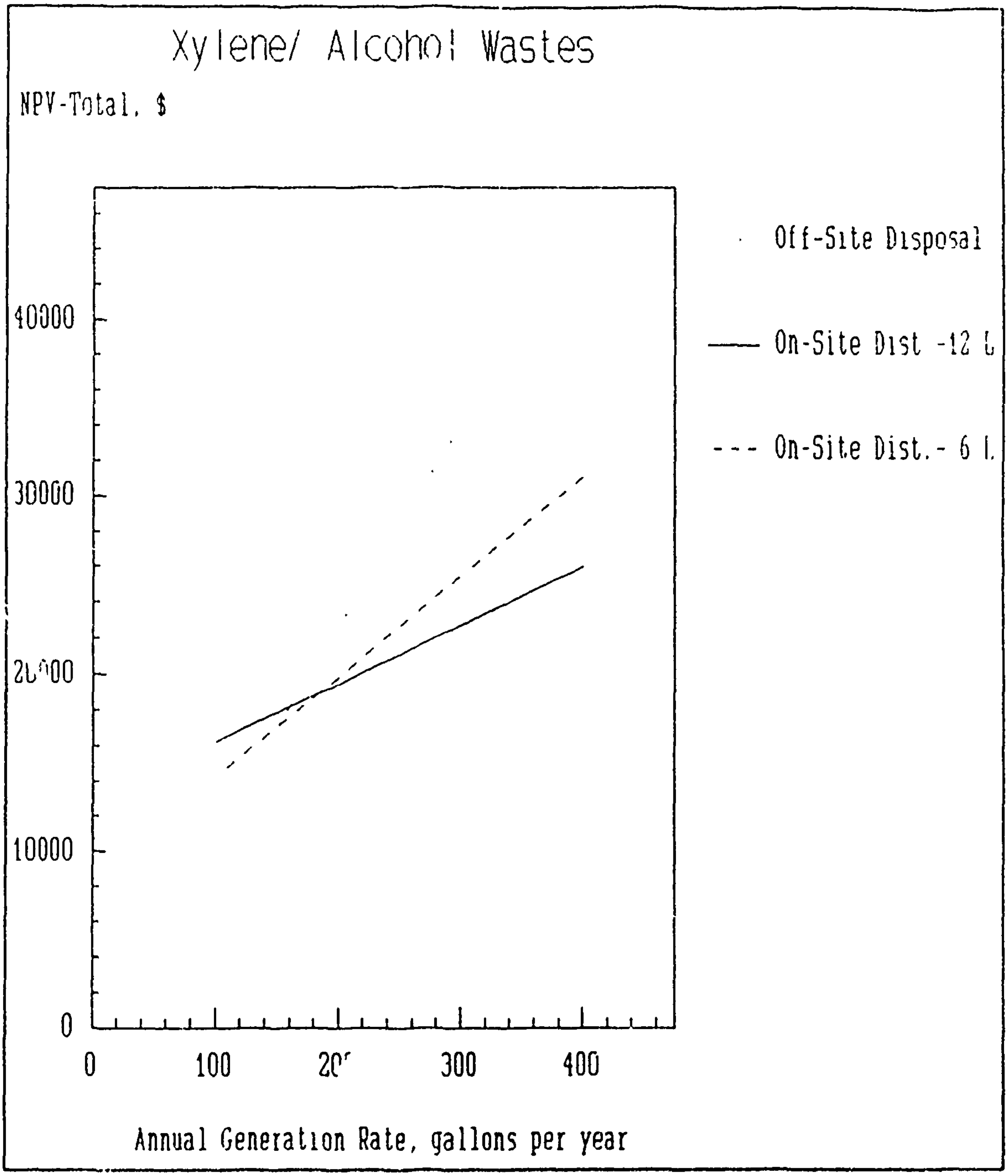

Figure 11. **Comparison of the net present values of options for minimizing xylene/alcohol wastes. Offsite disposal defines the status quo.**

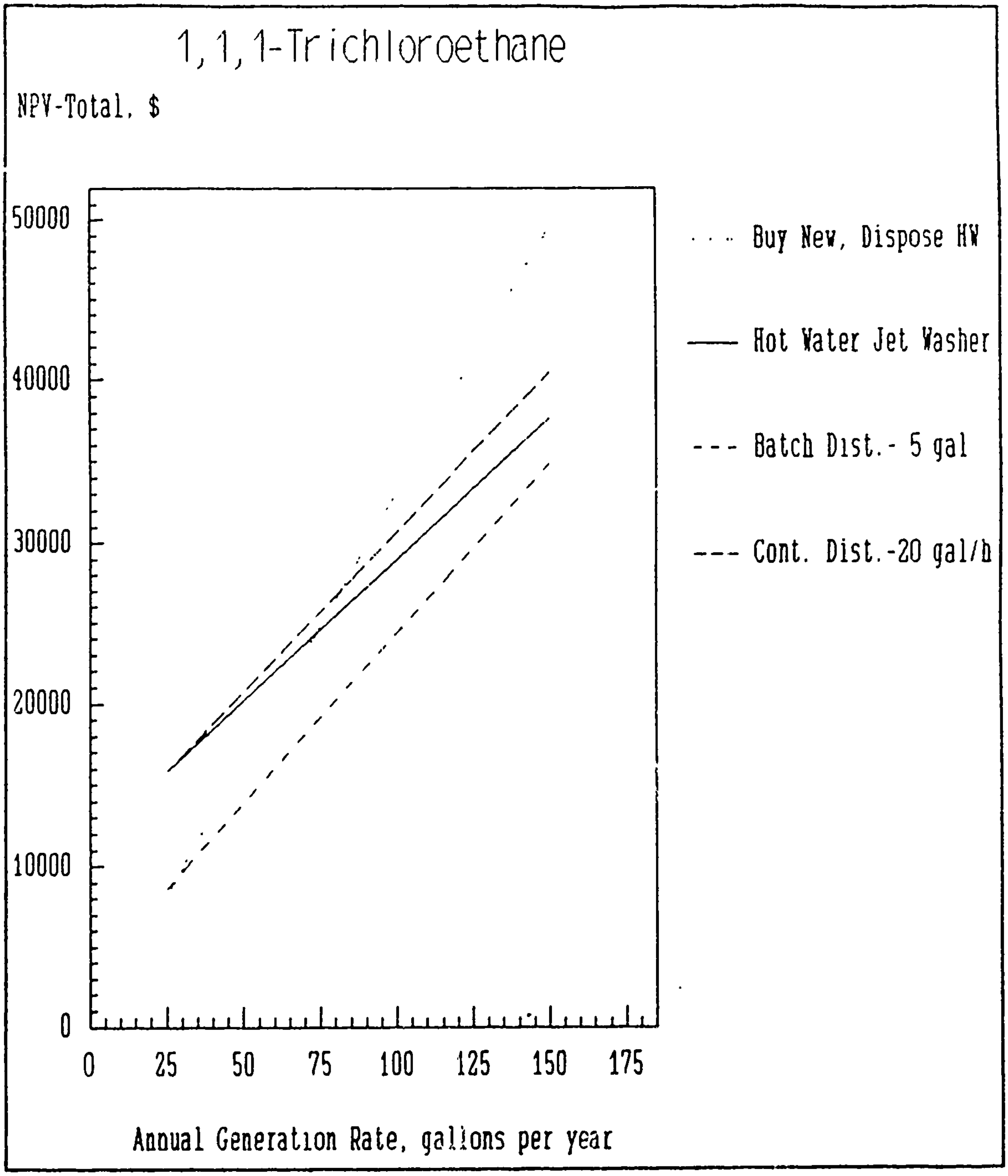

Figure 12. Comparison of the net present values of options for minimizing 1,1,1-trichloroethane waste. Disposal as hazardous waste defines the status quo.

13 SUMMARY AND RECOMMENDATIONS

Summary

All Army installations that are generators or small quantity generators (according to RCRA definitions) are required to implement programs to reduce hazardous waste generation. Waste minimization is a method of preventing pollution with the primary focus on reducing waste generation. A number of benefits are accrued by implementing a waste minimization program. The benefits can be classified into the following four categories: economic, regulatory compliance, reduced liability, and positive public image/community relations.

Minimization of a particular waste can best be achieved by an appropriate combination of source reduction, recycling onsite/offsite, and treatment techniques. Source reduction is on the top of USEPA's heirarchy of waste management priorities. It is followed by recycling, waste separation and concentration, waste exchange, energy/material recovery, waste incineration/treatment, and, finally, ultimate disposal. A number of waste minimization techniques have been discussed in this report pertaining to wastes generated from: motor pools/vehicle maintenance facilities; aviation maintenance facilities, industrial maintenance, small arms shops; paint shops; printing, photography, arts/crafts shops; hospitals, clinics, and laboratories; and other miscellaneous sources on an Army installation.

Fort Campbell is a troop combat training installation that primarily supports the mission assignment of the U.S. Army 101st Airborne Divison (Air Assault). It is regulated by the USEPA as a generator of hazardous waste and owner and operator of a temporary hazardous waste treatment, storage, or disposal facility (i.e., DRMO). Fort Campbell must report annually to the USEPA the quantity and types of hazardous waste managed for treatment or disposal; it is currently seeking approval for a Part B permit for the construction of a conforming storage area for hazardous waste. Hazardous waste management is additionally regulated by statutes promulgated by the State of Tennessee and Commonwealth of Kentucky.

The existing Hazardous Waste Management Plan was developed and implemented in 1987 and has undergone modifications in response to ever changing Federal, State, and DOD environmental policy. The Plan is currently being revised by EENR. There is no formal HM or HW tracking program at Fort Campbell, although attempts have been made in the past to inventory the type and quantity of hazardous waste generated that required disposal through DRMO. Past inventories were incomplete and not regularly updated.

Recent improvements in HM and HW management procedures are evident but are not consistently practiced throughout the installation. Direct Support level vehicle maintenance shops of the ESG and DISCOM require the greatest corrective action because hazardous and potentially hazardous materials are used in substantial quantities at these locations and the resultant waste streams are poorly managed. Antiquated maintenance facilities hinder proper management procedures at several MPVMs and have resulted in site contamination in some instances. The greatest obstacle to successful and substantial minimization of hazardous wastes will be to get troop unit personnel to recognize the necessity and importance of HAZMIN and environmental preservation. EENR is currently sponsoring informal training sessions that are available to all personnel that use HM or generate HW. Standard operating procedures outlining proper HW containerization, storage, and transport procedures have been disseminated to generating units. Onsite petroleum waste screening procedures have been implemented. The result of these and other HAZMIN and RCRA compliance efforts being made by EENR has been improved attitudes and actions of many generators. Additional environmental protection and regulatory specialists have been appointed recently to both EENR and DRMO to further improve the interaction and exchange of regulatory and HAZMIN information among generating units and installation hazardous waste managers. The importance of source reduction through proper segregation, secure storage, and product substitution as a practical means for achieving HAZMIN has been strongly emphasized in response to the proposed decentralization of funding within DOD for hazardous waste disposal.

Recent procedural changes that can or will minimize hazardous waste generation or reduce the liability associated with worker safety and environmental degradation are discussed in Section 7.3 of the HAZMIN Plan (Appendix A) and are only briefly outlined below. (Findings specific to individual generators are discussed in Chapter 4.)

Battery acid generated from nonserviceable lead-acid batteries is no longer neutralized with sodium bicarbonate and discharged to the sanitary sewer system. Previous neutralization involved no testing for heavy metal contaminants before discharge and was performed in small, poorly lit, poorly ventilated auxiliary buildings. Nonserviceable batteries are now turned into DRMO wet (with their acid) for transfer to DOE via a licensed hauler. Battery acid is drained only from leaking or badly damaged batteries. It is put into DOT approved containers and disposed on contract as hazardous waste. Wet batteries destined for recycling are still considered nonhazardous.

Use of TCE as a cleaning solvent in the vapor degreaser at the DOL Weapons Shop has been terminated; 1,1,1-trichloroethane is now used. Although the quantity of hazardous waste generated from this facility remains about the same, use and cleaning maintenance of the equipment now exposes personnel to less hazardous working conditions.

The frequency of solvent dip tank cleaning and the quantity of spent cold cleaning solvent and solvent tank bottoms will be reduced at DOL vehicle repair shops located in the maintenance area once a hot water jet washer that uses steam and biodegradable detergents is installed. Approval was granted to purchase this equipment. It will provide excellent degreasing results with less labor than is currently required for maintenance and operation of the dip tanks and will provide a safer working environment.

Lithium/sulfur dioxide battery cells used in a wide range of communications and electronics equipment employed by troops in the field and during training manuevers are now procured with manual discharge devices. Formerly, the type of cell issued to troops did not contain this feature and the batteries had to be disposed of as hazardous waste through DRMO because of reactivity characteristics. Lithium batteries in stock are being depleted from supply channels through normal use and prescribed disposal procedures, but they are no longer purchased. Issue of the manually dischargeable type of batteries will eliminate lithium battery wastes entirely.

Standardized containerization and disposal procedures for unserviceable stocks of decontaminating solution - 2 (DS-2) and super tropical bleach (STB) have been issued by the Office of the Chief of Staff. The procedures for each of these hazardous materials (or wastes) are enforced by Unit Nuclear, Biological, and Chemical (NBC) NCOs and subject to further review by officials from EENR and DRMO. Unserviceable DS-2, which at one time had been stockpiled at the NBC training range, treated and disposed of in the sanitary landfill, and in some instances burned, is now handled exclusively as a hazardous waste through DRMO. The generation of unserviceable STB is less prevalent and has been found useful for waste water treatment procedures at the post IWTP.

A large percentage of the medical infectious waste generated from medical, dental, and veterinary facilities is burned in a newly installed incinerator located at Blanchfield Army Community Hospital. The incinerator can reduce large volumes of medical infectious waste to small quantities of ash, saving money and transportation time. Less space will be required to accommodate the waste stream. The incidence of accidental exposure at the landfill from poor placement and burying procedures will be eliminated. Operation of the incinerator is closely monitored as are the quantitative trends and segregative procedures of generating activities.

Ranked in decreasing rate of generation by waste category (Table 31), contaminated fuels are generated at the greatest rate on Fort Campbell (511,488 lb/yr, 23 percent of total), followed by used motor oil (452,761 lb/yr, 20 percent of total), nonserviceable lead-acid battery casings (285,080 lb/yr, 13 percent of total), spent antifreeze solution (164,135 lb/yr, 7 percent of total), spent acids and bases (83,564 lb/yr, 4 percent of total), spent photographic solutions (82,712 lb/yr, 4 percent of total), spent nonhalogenated degreasing solvent (63,428 lb/yr, 3 percent of total), and contaminated paint thinner (11,023 lb/yr, 0.5 percent of total).

Recommendations

A formal HW management plan must be developed and adopted by Fort Campbell to comply with AR 420-47. A waste analysis plan to characterize and define all (air, water, liquid, and solid) wastes from all the generators should be implemented, to include frequency of analysis, etc., to ensure compliance with Federal and State laws.

A formal training program must also be established, to train personnel from each of the individual units. It should include proper HW management (including packaging, labeling, storing, transport, etc.) and minimization

EENR office personnel must conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes. A comprehensive survey of waste generation and management will help develop inventories (e.g., the tables in Chapter 4) of quantities of hazardous materials used and wastes generated. These inventories must be updated periodically to reflect changes and disbanding of certain activities.

A HM/HW manifest system should be implemented. Tracking HM from the supply warehouse to generators and HW from the generators to final storage before disposal, will provide a mass balance and improve minimization opportunities.

All generators must develop an inventory system and maintain proper records of materials procured and wastes generated from each activity. These records must be inspected regularly by the supervisors and EENR personnel.

Implementation of the HAZMIN plan (Appendix A) must begin immediately; the plan should be updated annually.

Plan Implementation

Careful planning and a systematic approach are required to implement a successful waste minimization program. Three key elements (policy, commitment, and responsibility) are necessary for a strong program foundation.

The Commander must prepare a formal, written policy on waste minimization and pollution control, including its philosophy, objectives, and proper practices. Such a policy must be publicized in the installation newsletters and distributed to all military and civilian employees. An example of a policy statement is provided in Appendix A.

The installation command heirarchy and the commanders of tenant activities must adopt and support the policy statement. They should also willingly commit resources necessary to launch and support the waste minimization program.

A leader (such as the Chief, EENR) should be appointed to oversee, direct, and assume all responsibility for the program. Supervisors and other employees of waste generating activities must be committed to the program for it to be effective. To encourage such a commitment, the Commanders and supervisors must implement motivational techniques. They must set goals for achieving waste/emissions reduction and provide incentives and awards for implementation of waste minimization ideas.

All waste generators must immediately implement HAZMIN options that require little or no capital investment (e.g., procedural or administrative changes) as discussed in Chapters 5 through 11. These options are generally characterized as "better operating practices," a subcategory of source reduction that does not require detailed technical and economic evaluation. Better operating practices are methods that achieve source reduction by:[164] (1) segregation (e.g., eliminate mixing of hazardous and nonhazardous wastes to improve their recyclability); (2) improved material handling and inventory practices (e.g., avoid accumulation of expired shelf-life materials avoid spills, etc.); (3) preventive maintenance (e.g., prevent leaks and spills); (4) production scheduling (e.g., minimize quantities of unused raw materials and batch-generated wastes); and (5) minor operational changes. Implementation of "better operating practices" usually requires only minimal employee training and changes to standing operating procedures/practices (SOPs).

The feasible options, discussed in Chapter 12, for minimization of used oil. waste JP-4, acid from nonserviceable vehicle batteries, antifreeze solution, cold cleaning solvent waste, spent paint thinner, xylene and ethyl alcohol waste, spent 1,1,1-trichloroethane and its sludge, aqueous paint sludge, and drycleaning fluid filter sludge must be funded and implemented. Improved segregation practices and construction of a centralized conforming storage facility at DRMO for hazardous wastes will greatly facilitate proper management procedures.

Used oil, if managed properly, in most instances will not be a hazardous waste. Testing may be required, under RCRA, to prove that the oil is nonhazardous. If found nonhazardous, it can be sold to recyclers with an estimated annual savings of $2332.

The current disposal procedure with Auburn University for waste JP-4 should be continued while striving to eliminate the quantity of heavily contaminated JP-4 that must be disposed through DRMO as hazardous waste. The present annual O&M cost of this management practice is $20,178. Should the policy of Auburn University change to include a disposal cost, the possibility of purchasing a JP-4 filtration system should be considered. Recycling and reusing JP-4 could provide an annual savings of $12,214 over the current procedure and result in a SIR and DPP of 7.98 and 1.92 years, respectively.

Recycling nonserviceable lead-acid vehicle batteries wet (with acid) through a local battery manufacturer will eliminate a large percentage of battery acid now requiring disposal through DRMO as a hazardous waste. This procedure will cause little disruption to the established battery exchange program. No investment is required to implement this alternative and, compared to the present practice, could provide an annual savings in O&M costs of $9367.

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[164] National Association of Manufacturers, *Waste Minimization: Manufacturers' Strategies for Success* (ENSR Consulting and Engineering, 1989).

A large quantity of antifreeze solution is generated at Fort Campbell. Spent antifreeze can be recycled as discussed in Chapter 5. An investment of $78,419 is required to purchase two Glyclean Reconditioning Systems. With an annual savings of $34,697 (when compared to the present procedure), a payback period of 3.02 years is expected.

Onsite recycling of cold cleaning solvents with a 55-gal batch still must be implemented. An investment of $45,451 and an annual O&M cost of $14,692 is required. Recycling will result in an annual savings of $30,045 and payback will be realized in 2.31 years.

For paint thinner waste, it is recommended that a 55-gal batch still be purchased at . total investment cost of $32,011 The annual operating cost is $6908 and payback can be expected in 5.68 years.

Xylene and ethyl alcohol wastes generated at the hospital must also be recycled through onsite distillation. Purchase of a 12-Liter spinning band distillation unit at a total investment of $15,561 will provide an annual savings of $3193 compared to current practice of offsite disposal. The payback period will be approximately 5.34 years if the equipment is used only for xylene and ethyl alcohol. It could also be used to distill other organic compounds commonly used in the hospital.

The generation of spent 1,1,1-trichloroethane degreasing residues contaminated with the solvent may be completly eliminated by purchasing and using a hot water jet washer that uses biodegradable detergents. An investment of $12,039 would be required. The annual O&M costs would be $2233. An annual savings of $1011 could be realized while providing a payback in approximately 10 years.

Conversion of the one remaining wet paint booth to use dry filters will require an investment of $1638. With an annual savings of $1054, this conversion will provide a payback in 2.45 years.

The laundry and drycleaning plant, which is operated by DOL, generates drycleaning fluid filter sludge contaminated with residual quantities of PD680-I, lint, and dirt. This waste may not be hazardous and, with adequate testing, may be disposed of as solid waste in the sanitary landfill at little cost.

Generation of all other wastes can be reduced by at least 20 percent by managerial changes, training, and implementation of "better operating practices."

The Fort Campbell Hazardous Waste Management Board, chaired by the Assistant Division Commander (Support), must adopt the HAZMIN plan and establish policies and procedures required for its implementation. The expected implementation date is 31 September 1990.

After implementation of HAZMIN techniques at the generating activities, progress must be monitored and results recorded. The quantities of wastes generated before and after implementation of the techniques must be monitored and the achievements in waste minimization (e.g., percent minimized) documented. Waste minimization of 35 percent and "hazardous" waste minimization of 61 percent (see Appendix A, and Table A3) are to be expected upon proper implementation.

A waste minimization program never ends. Preventing waste generation and thereby reducing air, land, and water pollution must be a continuous quest. The goal of such a program must be to reduce wastes to the maximum extent possible. All waste generating processes must be continuously assessed and reassessed to account for changes in economic status (e.g., increase in disposal costs), changes in design of production processes, maintenance procedures, and/or technical/technological breakthroughs.

METRIC CONVERSION TABLE

1 Btu	=	0.293 W
1 gal	=	3.785 L
1 in.	=	25.4 mm
1 lb	=	0.37 kg
1 mi	=	1.6 km
1 psi	=	6.89 kPa
1 ton	=	0.9 MT
°C	=	5(°F - 32)/9

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APPENDIX A:

FORT CAMPBELL HAZMIN PLAN

1. BACKGROUND

The Hazardous and Solid Wastes Amendments (HSWA)[1] to the Resource Conservation and Recovery Act (RCRA),[2] passed in 1984, require the generators of hazardous wastes to certify that they have a waste minimization program. Every waste shipment manifest is accompanied by the following declaration, in compliance with Section 3002 (b) of HSWA:

> The generator of the hazardous waste has a program in place to reduce the volume and toxicity of such waste to the degree determined by the generator to be economically practicable;.....

Therefore, all facilities that meet the RCRA definition of Generator (> 1000 kg/month) and Small Quantity Generator (100 to 1000 kg/month) of HW have to implement waste minimization programs.

HSWA [Section 3002(a)] also requires the generators of hazardous wastes to submit a biennial report, including documentation of efforts to reduce the volume and toxicity of wastes generated. Facilities that treat, store, or dispose of hazardous wastes are required [HSWA, Section 3005(h)] to submit annual reports accompanied with similar declarations on wastes' minimization.

In the broadest sense, HAZMIN may be defined as the process of reducing the net outflow of hazardous waste effluents from a given source (or generating process). Minimization would include any source reductions in the generation of hazardous wastes as well as any recycling activities that would result in either a reduction in the total volume or quantity of hazardous wastes, or a reduction in the toxicity of hazardous wastes produced, or both as long as it is consistent with the national goal of minimizing present and future threats to the environment.[3] HAZMIN, therefore, can be achieved by:

> Source Reduction - which refers to reduction or elimination of waste generation at the source, usually within a process. It also implies any action taken to reduce the amount of waste leaving a process; and/or
>
> Recycling Onsite/Offsite - which is the use or reuse of a waste as an effective substitute for a commercial product, or as an ingredient or feedstock in a process. Recycling also implies the reclamation of useful constituent fractions from within a waste or removal of contaminants allowing it to be reused; and/or
>
> Treatment - elimination of hazardous characteristics of a waste making it nonhazardous to human health and environment.

For any particular waste, the minimization options must be evaluated in the hierarchy of source reduction first, followed by recycling (including, recovery and reuse), and, finally, treatment. There

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[1] Public Law 98-616, *Hazardous and Solid Waste Amendments*, 1984.
[2] Public Law 94-480, *Resource Conservation and Recovery Act*, 1976.
[3] *Minimization of Hazardous Waste. Executive Summary and Fact Sheet*, EPA/530/SW-86/033A (EPA, Office of Solid Waste, Washington, D.C., 1986).

may always remain some small amount of residue (e.g., ash) which will require "ultimate" disposal (e.g., landfill burial). Although attempts have been made to clearly define the three HAZMIN categories, there may be overlap for certain specific techniques. Maximum waste reduction is usually achieved by using the best combination of suitable techniques from all three categories.

Recognizing the liabilities of improper disposal and the advantages of waste minimization, the Joint Logistics Commanders set a DOD wide goal of 50 percent reduction in hazardous waste generation by 1992, based on the baseline generation in 1985. The Department of Army has adopted this DOD goal and established a policy[4] applicable to all Active Army, Reserve, and National Guard installations.

2. PURPOSE

The purpose of the Fort Campbell Installation Hazardous Waste Minimization (HAZMIN) plan is to provide a specific plan of action to reduce the quantities and toxicities of hazardous wastes (HW) generated within the installation boundaries.

3. SCOPE

The scope of the plan extends to all the HW regulated under the RCRA, the HSWA, and hazardous waste management regulations specific to the states of Kentucky and Tennessee.

4. GOALS

4.1 Department of Army (DA) HAZMIN Goals

Process, Operation, or Condition	Percent HW Reduction Desired by 1992
Cleaning/degreasing	40
Transportation vehicle maintenance	30
Fueling operations	30
Battery shop operations	50
Painting	50
Sand blasting	60
Metal working	15
Graphic Arts	40

[4]Office of the Assistant Chief of Engineers, "Hazardous Waste Minimization (HAZMIN) Policy," Department of the Army, 1989.

Electrical maintenance	60
Waste treatment sludges	60

4.2 Fort Campbell HAZMIN Goals

Same as DA goals.

4.3 HAZMIN Reduction Estimation

Percent HW reduction for any calendar year (CY) =

$$\frac{(\text{Baseline Year HW Generation} - \text{CY HW Generation}) * 100}{\text{Baseline Year HW Generation}}$$

5. PROGRAM MANAGEMENT

5.1 Fort Campbell will manage the HAZMIN program according to the revised AR 200-1[5] and AR 420-47. The installation's Hazardous Waste Management Board (HWMB) shall review and adopt this plan, and establish other policies, and procedures for its implementation. The HWMB is chaired by the Assistant Division Commander (Support) and must consist of the following members:

Assistant Division Commander (Support) (ADC/S)
Garrison Commander (GS)
Director, Directorate of Engineering and Housing (DEH)
Chief, Energy, Environment and Natural Resources Division (EENR)
Director, Directorate of Logistics (DOL)
Director, Directorate of Personnel and Community Activities (DPCA)
Director, Directorate of Reserve Component Support (DRCS)
Director, Directorate of Plans, Training, and Mobilization (DPTM)
Director, Directorate of Information Management (DOIM)
Assistant Chief of Staff (ACofS, G1/AG)
Assistant Chief of Staff (ACofS, G2)
Assistant Chief of Staff (ACofS, G3)
Assistant Chief of Staff (ACofS, G4)
Assistant Chief of Staff (ACofS, G5)
Deputy Chief of Staff (DC/S)
Inspector General (IG)
Chief, Defense Reutilization and Marketing Office (DRMO)
Installation Safety and Occupational Health Manager
Public Affairs Officer (PAO)
Staff Judge Advocate (SJA)
Director, Directorate of Resource Management (DRM)
Director, Directorate of Health Services (DHS)

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5 *Environmental Protection and Enhancement*, "Draft" Revised Army Regulation 200-1, 1990.

Director, Directorate of Dental Services (DDS)
Commander, 1st Brigade
Commander, 2nd Brigade
Commander, 3rd Brigade
Commander, Aviation Brigade
Commander, Division Artillery (DIVARTY)
Commander, 160th Special Operations Aviation Group (Airborne)
Commander, 5th Special Forces Group (Airborne)
Commander, 2nd Battalion, 44th Air Defense Artillery
Commander, Division Support Command (DISCOM)
Commander, Eagle Support Group
Commander, 326th Engineering Battalion
Commander, 501st Signal Battalion
Commander, 311th Military Intelligence Battalion
Commander, Campbell Army Air Field (CAAF)

5.2 The activities at Fort Campbell that are generators of hazardous wastes; and references to the appropriate chapters (in the assessment technical report) are:

	Chapter Number
Motor Pools/Vehicle Maintenance Facilities	4, 5
Aviation Maintenance Facilities	4, 5
Industrial Maintenance, Small Arms Shops, etc.	4, 6
Paint Shops	4, 7
Photography, and Printing Operations	4, 8
Hospitals, Clinics, and Laboratories	4, 9
Other Generators	4, 10

6. TRAINING

6.1 Personnel Training

A training program will be developed by the Chief, EENR, for personnel involved in handling of hazardous materials and management of hazardous wastes to ensure compliance with 40 CFR 264.16.

6.2 Training Content, Schedules, and Techniques

Personnel from HW generating activities must be given supervised on-the-job training as well as formal courses. The formal course must be designed similar to the program offered by the U.S. Army Environmental Hygiene Agency, or the U.S. Army Logistics Management Center. The offering of periodic refresher courses should be considered by EENR to keep personnel responsible for hazardous waste management at the generating units abreast of changing Army Environmental policy and improvements in installation operating procedures.

The objective of a formal (or refresher) course must be to provide each student with the following abilities:[6]

1. To recognize, identify, and classify hazardous materials.

2. To take actions necessary to prevent hazardous chemical incidents, protect personnel health, and prevent damage to the environment.

3. To properly package, label, store, handle, and transport hazardous materials and hazardous waste

4. To take immediate action in response to hazardous materials spills or other emergencies.

5. To implement appropriate HAZMIN techniques.

6. To properly manage the resources under his/her control to prevent violation of applicable laws, regulations, and policies.

6.3 Implementation of Training Program. The Chief of the Training Division (under DPTM) will direct a training program designed by the Chief, EENR. All new and/or reassigned personnel will not work in positions dealing with hazardous materials/wastes unless they have completed the appropriate program within 6 months of the date of employment or reassignment. All supervisors will, annually, review the training status of their personnel.

6.4 Records

a. The Personnel Directorate (of Fort Campbell and tenant activities) will maintain records pertaining to job experience and the training completion requirements. The records must include description of the type/nature of initial and continuing training each person receives.

b. Fort Campbell will maintain records of all current personnel until deactivation of a particular unit/organization or the entire post. Training records of past employees must be kept for at least 3 years after the date of last employment.

7. HAZMIN ACTIONS

7.1 General Actions

a. Command Initiatives: For the HAZMIN program to be successful, the Assistant Division Commander (Support), the Garrison Commander and the chain of command for all the generators, tenants, and troops should make a commitment to all the goals (Section 4) and establish specific goals at the generator (or activity) level.

The Garrison Commander will develop an environmental policy statement emphasizing pollution minimization and assign direct responsibility to all personnel as protectors of the environment in

[6] *Defense Hazardous Materials Handling Course (DHMHC)* (U.S. Army Logistics Management Center [ALMC], Fort Lee, Virginia).

their day-to-day work ethic. All personnel will be notified (through the Courier Newspaper and interoffice memorandums) regarding the command commitment and goals.

Personnel incentives (such as awards, commendation, etc.) must be provided to encourage new HAZMIN ideas and for implementation of successful HAZMIN projects.

b. The installation must solicit cooperation with the host communities (Montgomery and Stewart Counties in Tennessee, Christian and Trigg Counties in Kentucky) for success of HAZMIN projects.

c. Participation is required among appropriate personnel from: Directorate of Logistics (DOL) responsible for supply/procurement, transportation; Directorate of Engineering and Housing (DEH) - responsible for interim and long-term storage, compliance with federal/state environmental laws, and pollution control guidance; and Defense Reutilization and Marketing Office (DRMO) - responsible for proper disposal; in implementation, programming, and budgeting HAZMIN programs.

d. A hazardous material (HM) and hazardous waste (HW) tracking (manifest) program must be implemented. Tracking HM from the supply warehouse to generators and HW from the generators to final storage before disposal, will provide a mass balance and improve minimization opportunities.

e. HAZMIN programs will be incorporated into the agenda of the Environmental (and Hazardous Waste) Management Board Meetings. Proper coverage must be provided in the newspaper (Courier) to ensure wide acceptance among personnel.

f. Chief, EENR, and the Installation Safety and Occupational Health Manager will combine their resources to develop a training program for personnel in hazardous materials/waste handling and emergency response (according to Section 6) which is required by law.

g. Chief, EENR, will develop a waste analysis program to characterize and define all (air, water, liquid, and solid) waste streams from all the generators to ensure compliance with Federal and State laws.

h. Chief, DRMO, and the Chief, EENR, will examine the utilization of waste exchange programs as a proper recycle methodology for some of the hazardous wastes.

i. The EENR Hazardous Waste Program Manager will conduct monthly inspections, minimization audits, and periodic training classes in recognition/handling/storage of hazardous materials and wastes and hazardous waste minimization.

7.2 Generator Actions

a. All generators must program for disposal of hazardous wastes following the decentralization of funding beginning in Fiscal 1990.

b. All generators will appoint environmental (hazardous waste) managers who would be responsible for minimizing generation (of air emissions, water pollution and solid wastes), proper interim storage, and turn-in of hazardous wastes.

c. The environmental (or hazardous waste) manager should interface with the EENR Hazardous Waste Program Manager in all matters pertaining to waste management and minimization. Individuals appointed to this duty will devote more time than is customary for a typical "extra duty."

d. All environmental managers will maintain proper records (logbooks) of hazardous materials procured and hazardous wastes generated from each activity and report on a monthly basis to the EENR.

e. All generators must, with the help of EENR, completely characterize (in terms of composition, periodicity of generation, why and how generated, etc.) all the waste streams, document and provide relevant data when requested by the EENR.

f. All generators will include HAZMIN requirements ("Better Operating Practices" as outlined in Chapters 5 through 11 of the main report) and specified by the EENR in their standing operating procedures (SOPs).

7.3 Current HAZMIN Projects

a. *Nonserviceable Lead-Acid Batteries/Battery Acid - Source Reduction - Proper Management*

On Fort Campbell, nonserviceable lead-acid batteries generated from military MPVM are transported to direct exchange points operated by personnel of either the 801st MNT BN of DISCOM or the 584th MNT CO of the 561st S&S BN (ESG). The batteries are exchanged on a "one-for-one" basis for new batteries through the Tech Supply Office (TSO). Previously, the acid was drained from the batteries and neutralized with sodium bicarbonate before being discharged into the sanitary sewer system. Testing of the neutralized effluent for likely heavy metal contaminants (i.e., lead) was not performed. Sealed batteries were deliberately cracked or punctured to release their acid and inverted over a sump. The preparation of new batteries for issue (filling with fresh acid and charging of the electrolyte) was accomplished in the same shop. Similar battery exchange/neutralization shops were operative for civilian maintenance activities (CTS) at CAAF and for the fleet of ground vehicles assigned to DOL and DEH. Once drained, the empty battery casings were stacked and strapped to wooden pallets for transfer to the DOE lead recycling facility. Typically the rate of drained casing generation exceeded the abilities of the contracted hauler and DOE to accept possession and to remove the casings from open storage on post. As of September 1989, the practice of neutralizing battery acid was terminated and replaced by the procedure of draining and drumming for disposal as a corrosive hazardous waste. Empty battery casings were still palletized and transferred to DOE, but under more stringent stacking and strapping regulations designed to reduce pallet weight and to limit the quantity of nonrecyclable items sent to DOE (i.e., aluminum cased aircraft batteries, carbon/alkaline batteries) With the recent completion of a heated storage building at DRMO, nonserviceable lead-acid vehicle batteries are no longer drained on Fort Campbell except in instances where the battery casing is damaged and leaking. The batteries are still transferred to DOE via a licensed hauler, but with their acid intact. Acid drained from damaged batteries is disposed on contract as a corrosive hazardous waste. The increase in heated storage capacity at DRMO has lessened the quantity of nonserviceable batteries stockpiled at the exchange points, improved the operational efficiency of battery shop personnel, eliminated a tremendous source of liability for Fort Campbell, and reduced hazardous waste generation and disposal costs. Additional improvements in the current battery management program could still be achieved by reducing the quantity of damaged batteries generated by the troop units and pursuing a contract with a local battery recycler who would buy nonserviceable batteries with their acid (see section 7.4.c for further details).

b. *Cleaning Solvent Waste/Tank Bottoms and Oil/Water Separator Sludge-Source Reduction-Process Change*

DOL MNT DIV-Auto End Item Repair Shop, Auto Component Rebuild Shop, and Tactical and Heavy Equipment Repair Shop utilize several cold cleaning solvent (PD-680 I,II) dip tanks and a high pressure water wand for degreasing vehicle parts being rebuilt or replaced. With the increasing impetus on hazardous waste minimization and spiraling waste management costs, personnel of DOL decided to investigate a change in process. Hot jet washers, with biodegradable detergent sprays, were found to provide excellent cleaning/degreasing results with minimal maintenance costs and could lower the frequency of dip tank and water wand usage. The high pressure water wand was originally installed for different cleaning and degreasing applications and is difficult to access and use during the winter months. It was also apparent that the cleaning frequency required to remove oily sludge from the oil/water separator connected to the water wand and spent solvent and degreaser tank bottoms from the dip tanks would be reduced. The costs for purchase and operation of one hot water jet washer and the projected annual savings provided from its use were presented by DOL and reportedly approved for procurement. Installation of the equipment should take place during FY90.

c. *Trichloroethylene - Source Reduction - Product Substitution*

The Weapons Repair Shop of DOL MNT DIV formerly used Trichloroethylene (TCE) for degreasing howitzer and small arms components prior to bluing through the parkerizing process. In August 1989, use of TCE was discontinued by substitution with the less toxic 1,1,1-trichloroethane. Although hazardous wastes are still generated (spent solvent and tank bottoms) in the same quantity as before, the wastes exhibit a lesser degree of toxicity which supports DOL's and Fort Campbell's commitment to HAZMIN.

d. *All Hazardous Wastes - Source Reduction - Proper Management*

Improvements have been achieved in the management of hazardous wastes at Fort Campbell compared to the early 1980's when a number of compliance problems were discovered. Now all vehicle and aircraft maintenance facilities are provided with HW containerization and turn-in procedures outlined in accordance to RCRA. The SOPs stipulate requirements for waste containerization, segregation, labeling, temporary storage onsite, and transport to DRMO. Adherence to the outlined procedures has been reinforced through frequent compliance inspections by EENR and improved coordination between waste generating units and post hazardous waste managers. Informal training sessions are sponsored by EENR and all organizational and support level personnel routinely involved in the handling of hazardous materials or hazardous waste are encouraged to attend. Additional efforts to reduce hazardous waste through source reduction have recently included the screening of petroleum wastes at their site of generation for chlorinated contaminants (Clor-D-Tect Test), approval for construction of a hazardous waste conforming storage area at DRMO, the reutilization of off-military specification materials by nonmilitary organizations on post with less stringent material requirements (i.e., DPCA Auto Crafts Shop), and general improvements in waste segregation and storage throughout the installation. The existing "Hazardous Waste Management Plan" for Fort Campbell was originally developed in 1987. The plan is currently being revised by EENR and when completed will provide all generators of hazardous waste with uniform guidance for the proper management of hazardous waste.

e. *DS-2 and STB - Source Reduction - Proper Management/Reutilization*

Decontaminating solution-2 (DS-2) and super tropical bleach (STB) powder are hazardous materials issued to troop units for potential use during deployment missions where a threat for chemical warfare exists. DS-2 and STB are seldom used in garrison or during training maneuvers. As such, a tendency has existed in the past for troop units to over accumulate these agents in their respective storage connexes beyond the chemicals' dated shelf lives. Post-dated storage of these materials, especially in warm, humid environments, often results in premature deterioration of their packaging and accidental spillage. Mixing with other materials in confined areas creates a potential fire hazard. The recovery of spill residues exposes troop unit personnel to concentrated levels of the agents and results in the additional generation of hazardous waste.

Unserviceable stocks of DS-2 and STB were once stored at a centralized warehouse maintained by Division Chemical. For several years, unserviceable and leaking stocks of these agents were improperly stored at this location pending arrangements for final disposition through DRMO or onsite treatment. The centralized method of storage provided little control for monitoring the quantity or rate of generation from individual troop units and resulted in inconsistent and unsafe containerization and labeling procedures. Unserviceable or leaking containers of DS-2 or STB are no longer stored at the NBC training range. Generators now follow explicit procedures, disseminated from the Office of the Chief of Staff in the form of a MOI (dated July 1989), as how to properly prepare unserviceable stocks of these chemicals for transport and disposal. DS-2 is handled and disposed of exclusively as hazardous waste through DRMO and STB may be reutilized at the waste water treatment plant. The MOI has established Unit NBC NCOs as primarily responsible for assuring compliance with prescribed overpacking and documentation procedures which are subject to further review by EENR. The change to a standardized procedure for disposing unserviceable stocks of decontaminating agents will reduce the incidence of improper storage or illegal dumping, help prevent the over accumulation of these agents in Unit storage areas which will lessen the probability of leaking and contamination of nonhazardous materials, and provide a more accurate means for tracking the procurement and disposal trends of individual units.

f. *Paint Stripping Wastes - Source Reduction - Plastic Media Blasting*

The practice of chemically stripping large metallic surfaces on the runway apron [illegible]craft painting facilities located at CAAF has been completely eliminated through the purchas[illegible]d use of plastic media blasting (PMB) equipment. PMB is a relatively new waste minimization technology that allows for the recovery of the blasting media through vacuum devices for reuse. The process eliminates the use of voluminous quantities of hazardous halogenated strippers and provides less hazardous working conditions for operative personnel. The only waste generated for disposal through PMB operations is the quantity of removed paint which may be disposed of as solid waste in the local landfill.

g. *Spent Lithium-Sulfur Dioxide Battery Cartridges-Source Reduction-Product Substitution*

Lithium-sulfur dioxide batteries are used in a variety of communications and electronics equipment employed by troops in the field and during training missions. Charged lithium batteries are considered reactive hazardous wastes and require special disposal procedures. Spent power packs (comprised of several individual lithium cells) are generated in appreciable quantity and require disposal which is expensive. Efforts to procure and distribute a type of lithium cartridge that allows for manual discharge have been successful and will eliminate this hazardous waste stream from Fort Campbell in time as supply stocks of the nondischargeable batteries are depleted. Manual discharge will permit disposal of spent lithium cells as ordinary solid waste in the post landfill.

h. *Infectious Wastes - Source Reduction - Segregation/Treatment*

Infectious wastes generated from BACH include blood and other bodily fluids, articles of clothing heavily contaminated with bodily fluids, medical cultures, disposable equipment used in laboratories and surgical rooms, and other items associated with the treatment of patients with infectious diseases. These wastes are currently accumulated in specifically colored containers or bags, collected by specially trained hospital personnel, and then transported to the hospital autoclaves or incinerator for sterilization or destruction. Sterilized wastes from the autoclaves and ash from the incinerator are disposed as solid waste in the local landfill. The majority of medical infectious waste generated are incinerated. Incineration substantially reduces the volume of waste requiring landfilling and eliminates the potential danger of exposing landfill operators to infected wastes. Efforts are consistently made by hospital personnel to minimize the quantity of infectious waste requiring such treatment through methods of source reduction. To date, these efforts have included improved segregation of infectious waste from noninfectious waste in hospital laboratories and patient rooms through the proper placement of specific types of wastes in their appropriate disposal containers. The monthly quantity of medical infectious waste generated from BACH and affiliated medical and dental clinics is closely monitored and well documented.

j. *POL Solids - Source Reduction - Proper Management*

Solids contaminated with petroleum or other lubricants are generated primarily from MPVM, AMF, or IMSS operations where solvents, oils, and greases are routinely used in the maintenance or repair of vehicles. POL solids generated in appreciable quantity include spent fluid filters, contaminated dry sorbent used to recover spills, heavily soiled rags, sediment cleaned from maintenance bay grease traps, and soil contaminated by leaking POL containers in material or waste storage areas. Fort Campbell has initiated training programs for POL specialists in an effort to educate personnel assigned to these facilities in proper handling and storage procedures for POL materials or wastes and has stressed source reduction as the best means for waste minimization. Specially designed waste storage areas have been constructed at several locations which provide roofed shelter from the elements and bermed perimeters to prevent the proliferation of accidental spills and drips. At a few vehicle maintenance facilities, filters changed from vehicles during regular servicing are inverted on special drain racks to dry before disposal as solid waste. The extravagant use of dry sorbent to clean up spills has been restricted at some maintenance shops and eliminated at others. The quantity of oily sediment requiring periodic removal from vehicle wash racks has been reduced at some MPVM by limiting the use of such racks to the removal of light accumulations of dirt. Vehicles returning from field maneuvers with heavy accumulations of clay and mud must use the centralized wash facility before entering the cantonment area.

7.4 Future HAZMIN Projects.

a. *Used Oil - Source Reduction - Segregation and Sale*

Used oil is currently accumulated by all the generators and turned in to DRMO for disposal as a hazardous waste or turned over to Auburn University as a nonhazardous waste. Approximately 60,370 gallons per year of waste oil are generated. In the past, the oil was contaminated with halogenated solvents (primarily, TCE), nonhalogenated solvents, hydraulic fluids, brake fluid, transmission fluid, and diesel fuel. The segregation practices have improved and the construction of bermed perimeters and secure facilities at some locations have facilitated proper waste management. If proven nonhazardous through testing, the oil must be sold to recyclers/re-refiners.

The continued segregation of different waste streams by individual generators must be emphasized at all temporary waste accumulation points on Fort Campbell. Chloride detection kits (e.g., Clor-D-Tect 1000 and Clor-D-Tect Q4000) can be used to detect approximate levels of chlorinated contamination in used oil at accumulation points prior to its transfer and consolidation into larger underground storage tanks managed by DRMO. Although results provided by the detection kits are not always conclusive, they are nevertheless cheap, easy to perform, and useful as a deterrent to troop units in preventing the indiscriminate commingling of waste streams. Contaminated oil should not be mixed with oil collected from other sources. For the oil collected at the USTs, a complete laboratory analysis is required to determine flash point, total halogens, sulfur, and heavy metals concentrations (As, Cd, Cr, Pb) content. Continuation of the current management program for used oil is recommended with increased emphasis on source reduction through segregation and secure storage.

Estimated Price: Investment - $0; Annual O & M - $65,306

Estimated Annual Savings: $2332

Estimated Payback Period: 0 years

Estimated Waste Reduction (Source Reduction): 30 percent

Estimated Hazardous Waste Reduction: 100 percent

If the halogen content in the waste oil is less than 1000 ppm and the heavy metals are within specifications, then the oil could be blended and burned in an industrial boiler. Although, Fort Campbell has an industrial boiler, blending and burning was deemed a less practical alternative than sale of used oil for economic and logistic reasons. These reasons are based on the assumption that either minimal or comprehensive processing of the used oil is required before burning. If this processing is discovered to be unnecessary, the burning of oil for heat recovery should be explored as an alternative. An air pollution permit has to be obtained for such an activity.

b. *Waste Aviation Fuel (JP-4) - Source Reduction - Auburn University*

Waste JP-4 is generated from the daily testing of helicopter fuel tanks, lines, and pumps, the testing of bulk storage tanks, and the repair of fuel drums or tanker trucks. As an Airborne Division status installation with nearly three hundred assigned aircraft, contaminated JP-4 is generated at an appreciable rate (approximately 53,000 gal/yr). Currently contaminated JP-4 is centrally stored by DRMO until arrangements can be made with Auburn University for its removal. Auburn University refines the fuel, which is contaminated primarily with low concentrations of water, and sells it as a low cost industrial boiler fuel to commercial industries with large heating or power generating requirements. The present management procedure allows for the fuel to be transported from Fort Campbell without reporting it as a hazardous waste. In the long run, the procedure could be unreliable and at the rate at which contaminated JP-4 is generated a consistently dependable, legal, and economically sound method of disposal or recycling and reuse must be explored. Past attempts to burn the fuel in regulated fire fighter training pits was unsuccessful due to the enormous rate of JP-4 generation and the infrequency of fire fighting training exercises. Additional complications arose from the need to obtain proper permits for the activity which could be considered treatment and disposal of a hazardous waste in addition to problems of containment of the JP-4 in the fire pit. In light of these considerations, several alternatives to the present disposal procedure for contaminated JP-4 were examined for their feasibility of implementation. Recycling the fuel with the use of coalescing and filtration equipment and reusing it in the aircraft is the most promising of these alternatives and warrants further investigation. Although filtration equipment has been used successfully by commercial airlines and large oil companies with no significant problems, little information exists pertaining to the use of the equipment and the recycled product in military applications. For this reason, continuing with the present management procedure with Auburn University is advised while striving to reduce the percentage of this waste stream that must be disposed through DRMO as a hazardous waste. Estimated costs of the current management procedure are presented below. Results of the economic analysis pertaining to use of filtration equipment and reuse of recycled JP-4 are presented in Chapter 12.

Estimated Price: Investment - 0; Annual O&M- $20,178

Estimated Annual Savings: -

Estimated Payback Period: -

Estimated Waste Reduction (Source Reduction): 30 percent

Estimated Hazardous Waste Reduction: 100 percent

c. *Nonserviceable Lead-Acid Batteries/Battery Acid - Source Reduction - Recycle Wet*

Although the current lead-acid battery management program is feasible compared to draining and neutralization procedures of the past, both economically and in effort to minimize hazardous waste generation, negotiating a contract with a commercial battery manufacturer (i.e., Electro-Lite Battery Manufacturing Company, Chattanooga, TN) for recycling batteries with their acid could provide a greater financial return to Fort Campbell than transfer to DOE. If properly implemented, such a contract could provide Fort Campbell reimbursement (up to $0.03/lb) for wet or dry batteries with minor disruption to the resent procurement/exchange procedure. The costs associated with procurement and implementation of a wet recycling management option with the Electro-Lite Battery Company were explored and are presented in this economic analysis. Assuming there will always be a variable percentage of nonserviceable lead-acid batteries that will require draining because they are physically damaged and leaking, two different scenarios specific to the generation rate were compared to the current management procedure. Results of this analysis presented below are representative of wet recycling of 80 percent of the nonserviceable batteries with the remaining 20 percent requiring draining and drumming of their acid for disposal through DRMO. Empty casings derived from draining are recycled dry. Should vehicle operating and battery handling procedures of Troop Units improve such that no cracked batteries are generated, the incentives offered by this management option will improve.

Estimated Price: Investment - $0; Annual O&M- $7458

Estimated Annual Savings: $9367

Estimated Payback Period: -

Estimated Waste Reduction (Wet Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

d. *Spent Antifreeze Solution - Recycle and Reuse - Glyclean Reconditioning*

Spent antifreeze solution is generated at an approximate rate of 18,148 gallons per year primarily from MPVM. Presently, the majority of this waste stream is diluted with water and discharged to the sanitary sewer system. A small percentage of spent antifreeze is turned over to DRMO for disposal or reutilization. Antifreeze solution managed by DRMO in most instances is either heavily contaminated with oils, fuel, or solvent or is unused material contaminated with excessive water or rust from poor storage practices. Although the practice of discharging spent antifreeze solution through the sewer system in both Kentucky and Tennessee is legal in regulated quantities, commercial scale reconditioning equipment is available that may provide a recycled material suitable for reuse in military and nonmilitary vehicles. With the price of new antifreeze having more than doubled in the past two years ($4.00 to $8.45/gal), purchase and use of such equipment on Fort Campbell is recommended. The technology (Glyclean Reconditioning System - unit price: $2400) exists for recycling a 50 percent spent antifreeze solution at a rate up to 100 gal/h. The recycled product may be added directly to a vehicle's cooling system without subsequent additions of water or virgin antifreeze depending on the original characteristics of the spent solution and the desired thermal protection range for a given vehicle. Although results of an economic analysis pertinent to spent antifreeze solution management indicated a favorable return on investment and suitable payback period for the purchase of five Glyclean Reconditioning Systems, the purchase and implementation of only two systems is suggested. Results of the economic analysis for two Glyclean Systems are provided below.

Estimated Price: Investment - $78,419; Annual O&M - $27,467

Estimated Annual Savings: $34,697

Estimated Payback Period: 3.02 years

Estimated Waste Reduction (Recycling Alone): 90 percent

Estimated Waste Reduction (Source Reduction and Recycling): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

e. *Cleaning Solvent - Recycle Onsite/Offsite - Contract Recycling*

A used solvent recycling program must be designed to collect and recycle used cleaning solvent (PD680-II) used in motor pools, vehicle/aviation maintenance facilities, and other parts cleaning activities. Source reduction (e.g., better operating practices, testing, etc.) must be implemented by all generators to reduce the quantities used. Use of a substitute (e.g., Citrikleen) must also be explored.

From the economics of solvent use (at a total rate of 7870 gal/yr) it is determined that onsite distillation (using a 55-gal batch still) is the most economical option compared to the current practice of offsite disposal. The purchase of a 55-gal still is recommended. It could be installed and operated at the DOL vehicle maintenance shop.

Estimated Price: Investment - $45,451; Annual O & M - $14,692

Estimated Annual Savings: $30,045

Estimated Payback Period: 2.31 years

Estimated Waste Reduction (Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated Hazardous Waste Reduction: 90 percent

f. *Spent Paint Thinner/Thinner Residue - Recycle and Reuse - Onsite Distillation*

Paint shops on Fort Campbell generate approximately 1470 gal/yr of spent paint thinner. The majority of this waste stream is attributable to the large scale military vehicle and aircraft coating operations of DOL and the commercial contractor (Dynalextron Corporation) assigned to H Company 159th AVN REGT of DISCOM. Thinner related wastes generated at these facilities are currently disposed through DRMO as ignitable hazardous waste. Distillation equipment suitable for use with the type of thinners required for military vehicle and aircraft coatings is available in a variety of batch sizes that will accommodate the rate of generation. Distillation equipment considered in this economic analysis were 15- and 55-gallon batch units and are available from several different vendors. The costs associated with the use of this equipment were compared to those of the present management practice and to those of offsite recycling through a commercial vendor such as Safety Kleen. At the present rate of spent thinner generation, use of the 55-gal batch unit would provide a favorable return on investment over the projected life of the equipment and an attractive payback period. Purchase of a 55-gal distillation unit for implementation and use within the paint shops of DOL is recommended. To optimize the usefulness of the still and to achieve a maximum reduction in spent paint thinner wastes, coordination between DOL and other generators of spent paint thinner regarding access to the still and return of the recycled material for use must be accomplished. Residue produced from the operation of the still will require periodic removal to maintain efficient operation of the equipment. Adequate sampling and testing of these residues to determine proper disposal procedures will be required. Should the distillation residues be void of heavy metal contaminants (i.e., lead or chromium) it is conceivable that drying and disposal in the sanitary landfill may be permitted. Necessary operating permits from either Kentucky or Tennessee, if required, should be reviewed by the environmental office before the installation and operation of the still. Results of the economic analysis for the purchase and use of a 55-gal still for the recycling of spent paint thinner on Fort Campbell is provided below.

Estimated Price: Investment - $32,011; Annual O&M - $6908

Estimated Annual Savings: $6206

Estimated Payback Period: 5.68 years

Estimated Waste Reduction (Recycling Alone): 80 percent

Estimated Waste Reduction (Source Reduction and Recycling): 90 percent

Estimated Hazardous Waste Reduction: 90 percent

g. *Contaminated Xylene and Ethyl Alcohol Wastes at BACH - Recycling and Reuse - Onsite Distillation*

Approximately 150 gal/yr of contaminated xylene and 230 gal/yr of contaminated ethyl alcohol are generated from laboratory procedures conducted within the Pathology Department of BACH. Both are managed for disposal through DRMO as hazardous wastes because of their ignitable characteristics. Contaminated xylene is generated primarily within the Histology Laboratory where it is used as a fixative for tissue specimens and as a cleaning agent for the removal of microscope slide mounting agents (paraffin). Ethyl alcohol is used for similar histology processing applications. For both waste streams, the primary contaminants are paraffin, staining solutions, methanol, and small quantities of detached tissue. Product purity standards for both materials are very high and must remain consistent from one fresh lot to another. Batch distillation equipment suitable for use with laboratory grade solvents is available, cost effective, and provides high rates of throughput and purity of separation. The equipment is marketed in both 6- and 12-liter batch capacities and may be used for a variety of solvents with the addition of a fractioning column. Both size classes were considered in this analysis for practical application within the Pathology Department. Results specific to the purchase and use of the 6-liter still to recycle only xylene and those for the purchase and use of the 12-liter still to recycle both xylene and ethyl alcohol are discussed in Chapter 12. To accommodate both waste streams, the purchase of a 12-liter distillation unit is recommended. Results of the economic analysis for this management option are presented below.

Estimated Price: Investment - $15,561; Annual O&M - $1908

Estimated Annual Savings: $3193

Estimated Payback Period: 5.34 years

Estimated Waste Reduction (Recycling Alone): 90 percent

Estimated Waste Reduction (Source Reduction and Recycling): 95 percent

Estimated Hazardous Waste Reduction: 95 percent

h. *Spent 1,1,1-Trichloroethane/Degreaser Tank Bottoms - Source Reduction - Process Change*

1,1,1-trichloroethane is used at the DOL Weapons Repair Shop for vapor degreasing of howitzer and small arms components prior to bluing. Use of this listed hazardous material in this capacity results in the generation of hazardous spent solvent and degreaser tank bottoms which are drummed and disposed through DRMO. Shop personnel are exposed to the toxic solvent. In this section, the results of an economic analysis that examines the feasibility of substituting a hot water jet washer for the vapor degreaser at this shop are presented. The proposed change in process would completely eliminate the generation of halogenated solvent wastes and tank bottoms from this shop, provide personnel involved in degreasing procedures a safer working environment, and reduce the potential for contaminating other waste streams generated in same shop. Although the economic incentives provided by this change in process are marginal, replacement of the vapor degreaser and 1,1,1-trichloroethane use with hot water and biodegradable detergents should be considered.

Estimated Price: Investment - $12,039; Annual O&M - $2233

Estimated Annual Savings: $1011

Estimated Payback Period: 10 years

Estimated Waste Reduction (Process Change): 75 percent

Estimated Hazardous Waste Reduction: 100 percent

i. *Aqueous Paint Sludge - Source Reduction - Process Change*

A small water curtain located at DOL Weapons Shop is the only painting facility on Fort Campbell that still uses a wet filtration system to remove overspray from booth emissions. Fort Campbell maintains an operating permit (expires in 1991) with the State of Tennessee for this shop. Although the booth is small and used infrequently, a reduction in the volume of wastes generated from its maintenance and cleaning could be realized if its filtration system was retrofitted to use dry filter elements. Presently, overspray entrained by the water curtain is concentrated into an aqueous sludge in the equipment's sump by the addition of coagulants and surfactants. The paint sludge, which is mostly water, is time consuming to remove and drum and requires costly disposal as a hazardous waste. Retrofitting the existing equipment to use dry filter elements, either pleated paper or fiberglass mesh, would eliminate the generation of hazardous waste and provide considerable savings in maintenance labor costs. Spent exhaust filters could be dried and disposed as nonhazardous waste in the sanitary landfill. Results of an economic analysis for the conversion of one small paint booth to use dry filter elements are presented below.

Estimated Price: Investment - $1638; Annual O&M - $2327

Estimated Annual Savings: $1054

Estimated Payback Period: 2.45 years

Estimated Waste Reduction (Process Change): 100 percent

Estimated Hazardous Waste Reduction: 100 percent

j. *Spent Drycleaning Filters - Treatment - Disposal as Solid Waste*

Drycleaning fluid filter sludge is generated at the post laundry and drycleaning facility operated by DOL. Large reusable filter elements are used to trap and remove solids entrained in the drycleaning fluid (PD680-I) during the cleaning process. Once the fluid is passed through a series of filters, it returns to a centralized sump for recirculation and reuse. The filters require cleaning maintenance approximately every 18,000 lbs of clothes drycleaned. The sludge generated during cleaning is drummed and disposed through DRMO as hazardous waste under the presumption that it contains ignitable drycleaning fluid residues. The sludge should be tested to verify the need to continue disposal as hazardous waste. Should test results indicate a flashpoint below RCRA ignitability criterium, the possibility of placing the sludge outdoors in large vented drums to evaporate lingering solvent residues and render it nonhazardous should be explored. Although no economic analysis could be formulated for this management option, inquiry concerning alternatives to the present management practice by the facility manager is advised to possibly reduce the quantity of hazardous waste presently being generated and to lower operation and maintenance costs associated with the drycleaning service.

k. *Other Wastes - Source Reduction*

Implement better operating practices and other appropriate minimization techniques according to references in Section 5.2.

Estimated Waste Reduction: 20 percent

Estimated Hazardous Waste Reduction: 20 percent

7.5 Overall Estimate of Expected Waste Reduction

Expected Waste Reduction: 35 percent

Expected Hazardous Waste Reduction: 61 percent

8. REFERENCES

8.1 Fort Campbell installation waste generation data is given in Tables A1 and A2.

8.2 The calculations for the "overall" estimated waste reduction (in section 7.5) is presented in Table A3.

8.3 This plan is in Appendix A of the *Hazardous Waste Minimization Assessment: Fort Campbell, KY.*

9. IMPLEMENTATION

Estimated Implementation Date: September 31, 1991.

10. RESPONSIBILITIES

10.1 The duties and responsibilities of persons directly responsible for implementation of this plan and success of the HAZMIN program are described in this section. The following personnel will form the Fort Campbell HAZMIN committee, which will oversee the implementation of this plan and keep it revised and updated.

Job Title	Name	HAZMIN Activity
Chief, Energy, Environment, and Natural Resources Division	Mr. Smith	Overview of the entire program; chair the committee; and others as noted in section 10.3.
Hazardous Waste Program Manager, EENR	Mr. Jasper	Establish a hazardous materials/ waste training program; establish waste inventory and inspection program; establish a HW/HM tracking program; co-ordinate with Safety Officer, Fire Chief, DRMO and all the environmental coordinators.
Installation Safety and Occupational Health Manager		Establish a chemical inventory program; flag and control purchase of hazardous materials; coordinate with the environmental engineer regarding maintaining and updating inventory.
Chief, Defense Reutilization and Marketing Office	Mr. Solomon	Establish proper waste turn-in procedures; waste contract management; explore offsite reclamation and waste exchange options.
Chief, DEH Operations and Maintenance Division	Mr. May	Inventory control of materials and wastes; vehicle/equipment maintenance, painting and laboratory wastes minimization; pesticides management; PCB transformer inventory management.
Chief, DEH Fire Prevention and Protection Division	Mr. Burgess	Coordinate with safety office; inventory flammable/toxic materials; SARA Title III compliance.
Chief, DOL Transportation Division	Mr. Ferguson	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DOL Maintenance Division	Mr. Waters	Inventory control of materials and wastes; painting, machining, and weapons cleaning wastes minimization.

Chief, DOL Supply and Services Division	Ms. Anderson	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical use inventory and demand history by each generator.
Chief, DEH Supply and Storage Division	Mr. Over	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical use inventory and demand history by each generator.
Chief, DHS Logistics	LTC Velker	Flag and control procurement of hazardous materials; coordinate with Safety and EENR; establish chemical use inventory and demand history by each laboratory and generator.
Chief, DPCA Education Office	Mr. Allen	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, DPTM Training and Support Center	Mr. Goodwin	Inventory control of materials and wastes; photographic and printing wastes minimization.
Chief, DPTM Photolab		Inventory control of materials and wastes; photographic wastes minimization.
Chief, DPTM Aviation Division		Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Chief, Preventive Medicine Colonel Florence A. Blanchfield Army Community Hospital (BACH)	Dr. Burke	Establish inventory of hazardous materials/wastes; establish waste generators monitoring program; coordinate minimization and proper disposal practices (infectious, hazardous, and radioactive wastes) with environmental office.
XO, 1st Brigade	MAJ Hutchison	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 2nd Brigade	LTC Bridges	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 3rd Brigade	LTC Berdy	Inventory control of materials and wastes; vehicle maintenance wastes minimization.

XO, Aviation Brigade	LTC Parmelee	Inventory control of materials and wastes; aviation and vehicle maintenance wastes minimizati on.
XO, Division Artillery	LTC Murray	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
XO, 160th Special Operations Aviation Group	LTC Binkley	Inventory control of materials and wastes; aviation and vehicle maintenance wastes minimization.
XO, 5th Special Forces Group	MAJ Macaltao	Inventory control of materials and wastes; vehicle maintenance waste minimization.
CO, 2nd Battalion, 44th Air Defense Artillery	LTC Kwist	Inventory control of materials and wastes; vehicle maintenance waste minimization.
XO, Division Support Command	MAJ Booze	Inventory control of materials and wastes; vehicle maintenance, and industrial maintenance wastes minimization.
XO, Eagle Support Group	LTC Gillies	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 326th Engineering Battalion	LTC Kershaw	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 501st Signal Battalion	LTC McRae	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, 311th MI Battalion	LTC Conway	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
CO, HHC 101st ABN DIV	CPT Schumack	Inventory control of materials and wastes; vehicle maintenance wastes minimization.
Environmental (or Hazardous Waste) Managers	As appointed	As discussed in Section 10.4.

10.2 Responsibilities of all HAZMIN Committee Members (except Chief, EENR).

a. Identify and prioritize goals necessary to achieve the goals outlined in this plan.

b. Provide information on HAZMIN techniques to the generators of hazardous waste.

c. Organize a team to conduct annual HAZMIN assessments (or audits) to determine sources, types, and quantities of hazardous materials used and hazardous wastes generated.

d. Report on the status of the HAZMIN program to the Chief, EENR regularly.

e. Assist the Chief, EENR, in preparing an Annual HAZMIN status report.

10.3 Responsibilities of the Chief, Energy, Environment and Natural Resources Division

a. Oversee and provide resources (including technological assistance) in the conduct of the annual HAZMIN assessments. Report the state of HAZMIN program to the commander.

b. Revise and update this plan annually.

c. Prepare a HAZMIN status report when requested by HQ FORSCOM or HQ DA.

d. Program funds necessary to accomplish HAZMIN goals.

e. Chair the HAZMIN Committee.

f. Conceive, develop, and implement HAZMIN techniques consistent with this plan.

10.4 Responsibilities of Environmental (or Hazardous Waste) Managers

a. Establish goals for minimizing all forms of environmental pollution (air, water, solid, and hazardous waste).

b. Obtain training (organized by EENR) on all the applicable environmental laws and train all subordinate personnel.

c. Implement better operating practices through: inventory control (maintaining logbooks for materials procured and pollution generated); segregation of wastes; spill and leak prevention; and scheduling frequent preventive maintenance of equipment.

d. Examine and implement the use of substitute nonhazardous or less hazardous materials in place of hazardous materials.

e. Examine and implement process changes such as: process modifications; equipment modifications; and changes in operation settings, to reduce the quantities of waste generated.

f. Examine and implement technologies for recycling, reuse, or treatment of wastes. Information about technologies and equipment suppliers can be obtained from environmental personnel at EENR.

Table A1

Summary of Fort Campbell Hazardous Waste Generation

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories*	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Motor Pools and Vehicle Maintenance Facilities	1	50604	50604	PD-680, Neptha, Varsol
	2	192	192	Carburetor Cleaner, Methylene Chloride
	3	403666	259704	Motor Oil
			8000	Motor Oil, Halogenated
			10616	Brake Fluid
			112033	Transmission Fluid
			13313	Hydraulic Fluid
	4	156717	156717	Ethylene Glycol
	5	75	75	Methanol
	6	80430	80430	Sulfuric Acid
	7	90	90	Paint Thinner, NOS
	10	187230	187230	Lead-Acid Batteries
	11	306011	37296	MOGAS
			74090	DF-2
			194625	JP-4
	13	138248	4086	Caustic Engine Detergent
			24454	Floor Wash Detergent
			9434	Contaminated Grease
			1100	Contaminated Soil/Sand
			6419	Contaminated Water
			39815	Spent Sorbent
			5035	Solvent Tank Bottoms
			34225	Oily Rags
			5171	Hazardous Faulty Parts
			859	Hazardous Empty Containers
			7650	Mixed Wastes
Industrial Maintenance and Small Arms Shops	1	7090	6863	PD-680, Naptha, Varsol
			204	Methyl Ethyl Ketone
			23	Toluene
	2	1800	80	1, 1, 1-trichloroethane
			200	Trichloroethylene
			150	Methylene Chloride
			1000	Paint Stripper, NOS
			370	Halogenated Cleaning Solvent, NOS
	3	38054	34486	Motor Oil
			275	Cutting/ Penetrating Oil, Fluid
			75	Brake Fluid
			2175	Transmission Fluid

*Insert fn from Ft. Meade, TA1.

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Industrial Maintenance and Small Arms Shops continued			1043	Hydraulic Fluid
	4	6615	6615	Ethylene Glycol
	6	996	900	Sulfuric Acid
			72	Potassium Hydroxide
			24	Corrosive, NOS
	7	15	15	Paint Thinner, NOS
	8	54	3	Paints
			40	Adhesives
			11	Sealants
	10	4340	4340	Lead-Acid Batteries
	11	7088	525	MOGAS
			563	DF-2
			6000	JP-4
	13	7784	252	Caustic Engine Detergent
			459	Floor Wash Detergent
			668	Contaminated Grease
			200	Contaminated Soil/Sand
			1900	Spent Sorbent
			125	Solvent Tank Bottoms
			445	Oily Rags
			90	Hazardous Faulty Parts
			155	Spent Fluid, Fuel Filters
			1480	Hazardous Empty Containers
			2010	Mixed Wastes
Aircraft Maintenance Facilities	1	2554	1697	PD-680, Naptha, Varsol
			857	Methyl Ethyl Ketone
	3	10852	8882	Aircraft Engine Oil
			1970	Hydraulic Fluid
	4	803	803	Deicer Solution
	6	327	327	Potassium Hydroxide
	7	8	8	Paint Thinner, NOS
	10	185	185	NICAD Batteries
	11	198389	198389	JP-4
	13	27752	2383	Caustic Engine Detergent
			1233	Floor Wash Detergent
			450	Turbine Engine Gas Path Cleaner
			113	Contaminated Grease

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Aircraft Maintenance Facilities continued			100	Contaminated Soil/Sand
			8835	Contaminated Water
			13700	Spent Sorbent
			150	Solvent Tank Bottoms
			650	Oily Rags
			118	Hazardous Empty Containers
Paint Shops	2	1254	1254	Paint Stripper
	7	10798	223	Paint Thinner, NOS
			8325	Aircraft Thinner
			1125	Laquer Thinner
			1125	Xylene
	8	8974	1712	Paint, Primer
			2884	CARC Sludge (>60%)
			560	Blasting Media
			1018	Paint Filters
			2800	Contaminated Clothing
	13	5470	10	Caustic Detergent
			442	Floorwash Detergent
			25	Contaminated Soil/Sand
			2200	Spent Sorbent
			2788	Hazardous Empty Containers
			5	Mixed Wastes
Print, Photography, and Arts/Crafts Shops	1	15	15	Degreasing Solvent, NOS
	2	783	12	Surface Cleaner (1,1,1-trichloroethane)
			624	Blanket Wash Solution
			1	Blanket Fix Solution
			56	Offset Plate Cleaner
			56	Deglazing Compounds
			34	Fountain Solution
	5	17	17	Denatured Alcohol
	8	60	50	Paint
			10	Preserving Gum
	9	82712	32359	Photographic Developer
			49343	Photographic Fixer
			442	Photographic Bleach
			53	Dry Toner

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Wastes Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Print, Photography, and Arts/Crafts Shops continued			200	Offset Fixer
			315	Offset Developer
Hospitals, Clinics, and Laboratories	1	1441	301	Acetone
			15	Toluene
			1125	Xylene
	2	641	640	Formaldehyde
			1	Formalin
	5	3623	4	Alpha Napthol
			1725	Ethyl Alcohol
			355	Isopropyl Alcohol
			1501	Methanol
			38	Phenol
	6	1777	426	Acetic Acid
			10	Boric Acid
			43	Formic Acid
			9	Nitric Acid
			85	Hydrochloric Acid
			9	Oxalic Acid
			43	Picric Acid
			26	Sulfuric Acid
			4	Tannic Acid
			4	Tungstic Acid
			30	Hydrogen Peroxide
			5	Sodium Hydroxide
			11	Ammonium Hydroxide
			1072	Sodium Hypochlorite
	13	138198	5707	Pathological Waste, Body Fluids
			500	Pathological Waste, Body Parts
			126011	Infectious Dressings, Gauze
			1520	Infectious Metallic Sharps
			15	Infectious Plastic Containers
			1276	Crystal Violet
			1701	Wright Stain
			1468	Miscellaneous Chemicals
Troop Units	10	93325	11702	Lithium Batteries

Table A1 (Cont'd)

Hazardous Wastes Generating Operations, Processes, or Conditions	Hazardous Waste Categories	lb/yr	lb/yr/unit	Hazardous Waste Stream Unit
Troop Units continued			3134	Mercury Batteries
			8196	Magnesium Batteries
			162	Carbon/Alkaline Batteries
			4854	NICAD Batteries
			65277	Lead-Acid Batteries
	12	5041	4496	DS-2
			495	STB
			25	Chemical Detection Kits
			25	Skin Decontamination Kits
	13	1679	1157	Protective Mask Filters
			10	Heat Tabs
			483	Insecticides
			9	Herbicides
			20	Rodenticides
Grounds and Utilities Maintenance Operations	13	5	5	Hazardous Empty Containers
Miscellaneous Waste Generating Activities				
	1	1724	12	Degreasing Solvent, NOS
			1712	Surface Cleaner, NOS
	3	189	8	Motor Oil
			15	Lube/Cutting Oil
			113	Pine Oil
			38	High Voltage Insulation Oil
			15	Break Free
	5	15	15	Isopropyl Alcohol
	6	34	34	Corrosive Coil Cleaner
	7	112	106	Paint Thinner, NOS
			4	Mineral Spirits
			2	Acetone
	8	25	25	Paint
	13	216263	250	Caustic Detergent
			26	Bleach
			51	Glass Cleaner
			212500	Contaminated Water
			3325	Solvent Tank Bottoms
			1	Moth Balls
			110	Hazardous Empty Containers

Table A2

Total Waste Generation Rates Sorted By Waste Category

Generator	Total	1	2	3	4	5	6	7	8	9	10	11	12	13
MPVM	1323263	50604	192	403666	156717	75	80430	90			187230	306011		138248
IMSS	73836	7090	1800	38054	6615		996	15	54		4340	7088		7784
AMF	240850	2554		10852	803		327	8			185	198389		27732
PS	26496		1254					10798	8974					5470
PPAS	83587	15	783			17			60	82712				
HCL	145680	1441	641			3623	1777							138198
Troop NBC / COMMO	100045										93325		5041	1679
GMO	5													5
MISC	218362	1724		189		15	34	112	25					216263
TOTAL	2212124	63428	4670	452761	164135	3730	83564	11023	9113	82712	285080	511488	5041	535379

Waste Categories

1. Spent Cleaning Solvents (Non-Halogenated)
2. Spent Cleaning Solvents (Halogenated)
3. Used Oils, Lubricating Fluids
4. Spent Antifreezes
5. Used Alcohols
6. Spent Acids or Bases
7. Spent Paint Thinners
8. Waste Paint Related Materials
9. Spent Photo or Print Chemicals
10. Waste Batteries
11. Contaminated Fuels
12. Waste Decontamination Chemicals, Materials
13. Miscellaneous Chemicals or Materials

Table A3

Calculation of the Overall Waste and Hazardous Waste Reduction Factors

Hazardous Waste	lb/yr (gal/yr)	Est. "HW" Reduction	Nonhaz. Waste	lb/yr (gal/yr)	Est. Waste Reduction
Contaminated Oil	61,600 (8,000)	1.00	Used Oil	403,234 (52,368)	0.30
Contaminated JP-4	21,000 (3,000)	1.00	JP-4	351,414 (50,202)	0.30
Antifreeze Solution	9,000 (1,000)	1.00	Antifreeze	154,332 (17,148)	0.90
Battery Acid*	77,055 (7,706)	1.00	-	77,055 (7,706)	1.00
Cleaning Solvent (PD-680)	60,599 (7,870)	0.90	-	60,599 (7,870)	0.90
Paint Thinner	11,025 (1,470)	0.90	-	11,025 (1,470)	0.90
Xylene and Ethanol (BACH)	2,850 (380)	0.95	-	2,850 (380)	0.95
TCA and Degreasing Sludge**	1,000 (100)	1.00	-	1,000 (100)	0.75
Aqueous Paint Sludge***	4,992 (624)	1.00	-	4,992 (624)	1.00
Other Hazardous Wastes****	160,403	0.20	Other Wastes*****	1,032,415	0.20
Weighted Average		0.61			0.34

*Not included in the estimated "HW" reduction calculation. Anticipated from recent procedural change to drumming and disposal.
**Not included in the estimated "HW" reduction calculation. Waste volume estimated from degreaser tank capacity and usage rate.
***Not included in estimated "HW" reduction calculation. Waste volume estimated from water curtain sump capacity and usage rate.
****Does not include PCB contaminated items, boiler blowdown, empty lead-acid battery casings, pathological, or medical infectious waste.
*****Does not include PCB contaminated items or boiler blowdown.

APPENDIX B:

HAZMIN PROTOCOL AND SURVEY FORMS

HAZMIN Protocol

Goals

1. Define current status of waste generation and management practices.
2. Identify and evaluate new waste minimization alternatives.
3. Identify support for existing alternatives/activities.
4. Identify areas/activities requiring further research and development.

Approach

I. Review information available at the installation.

II. Talk to several groups of individuals.

III. Develop a list of waste streams and rank them.

IV. Develop information on each waste stream.

V. Identify minimization options for each waste stream.

VI. Evaluate and rate options (preliminary or first screen) for each waste stream.

VII. Conduct detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

HAZMIN Protocol

I. Review information available at the installation.

The information reviewed by the survey team includes:

1. Installation policies/programs on waste minimization, if any.
2. Hazardous waste manifests, annual (and biennial) reports, and other RCRA information since 1985.
3. State and local regulations that are more stringent than federal regulations.
4. Environmental audit/review reports.
5. Emission inventories.
6. Permit and/or permit applications, and any regulatory violations.
7. Contracts with waste management firms.
8. Waste assays and/or tests.
9. Materials purchase orders, purchase records.
10. Maps, organizational charts, list of activities associated with different buildings.
11. Production/maintenance schedules.
12. Operator data logs, batch sheets.
13. Operation manuals, process descriptions, standard operating procedures (SOPs).
14. Process flow diagrams (PFDs) and facilities layout.
15. Heat and material balances for production processes and pollution control systems.
16. Safety procedures for handling hazardous materials.

Products:

1. List of information sources.
2. Waste stream list.
3. Survey agenda or checklist detailing what is to be accomplished.
4. List of questions that need to be resolved.
5. List of information that needs to be gathered.

II. <u>Talk to several groups of individuals.</u>

Identify appropriate individuals to interview among:

1. Environmental personnel
   - who compile USEPA/State reports
   - who compile DRMO reports

2. Waste generators
   - supervisors
   - shop foremen and production employees

3. Hazardous waste managers
   - operators of on-site treatment, storage, and disposal (TSD) facilities
   - transporters of waste from generation points to TSD facilities

4. Individuals responsible for purchasing/acquisition of hazardous materials (for possible substitution alternatives, costs of purchase, etc.)

5. Individuals with broad HAZMIN responsibilities
   - finance and accounting
   - construction/renovation of facilities
   - higher levels of management
   - legal advisors

III. Develop a list of waste streams and rank them.

Develop a waste generation inventory based on reports, permits, and observation. Inventory must be representative of "normal" operations.

Ranking criteria:

1. Composition
2. Quantity (volume or mass generated per year and unit of production)
3. Degree of hazard (toxicity, flammability, corrosivity, etc.)
4. Method and cost of disposal
5. Potential for minimization and recycling
6. Compliance status (in or out)
7. Potential liability (past spills or accidents; proximity to water)
8. Degree of acceptability of changes at the installation
9. Installation personnel preference for options.

Products:

1. Waste description with rationale for selection
2. Description of facilities, processes, and waste streams.

IV. Develop information on each waste stream.

The following information must be developed on each waste stream based on observation and available reports:

1. Waste characterization
   - chemical/physical analysis
   - reason for hazardous nature

2. Waste source

3. Baseline generation

4. Present method of TSD and associated costs

5. Past/present minimization efforts and associated costs.

Some points to be reviewed in the above determination are:

- actual point of generation
- details about subsequent handling/mixing
- "hazardous" versus nonhazardous
- physical and chemical characteristics
- quantities by waste treatability category
- potential variations in the rate of production, maintenance, etc.
- potential for contamination or upset
- true costs for management, onsite and offsite including tax, fringe, and overhead for labor; cost of space; vehicle insurance, maintenance, fuel, etc.

V. Identify minimization options for each waste stream.

Follow USEPA guidelines on waste minimization. The categories arranged in a heirarchical order are:

1. Source reduction
   a. product/material substitution
   b. source control
      i. input material changes (e.g., dilution, purification)
      ii. technology changes (e.g., process changes, layout changes, etc.)
      iii. procedural/institutional changes

2. Recycle/reuse
   a. onsite
   b. offsite

3. Waste separation and concentration

4. Waste exchange

5. Energy/material recovery

6. Waste incineration/treatment

7. Treatment

8. Ultimate disposal.

VI. Evaluate and rate options (preliminary or first screen) for each waste stream.

Some considerations for a preliminary evaluation and rating of minimization options for each waste stream are:

1. Waste reduction effectiveness (i.e., reduction of waste quantity and/or toxicity)
2. Extent of current use in the facility
3. Industrial precedent
4. Technical soundness
5. Cost (preliminary capital and operating cost evaluation)
6. Effect on product quality
7. Effect on operations
8. Implementation period
9. Resources availability and requirement.

VII. Detailed technical and economic feasibility analysis of select minimization options for high priority waste streams.

The following aspects must be considered in the final detailed analysis:

1. Technical soundness and commercial availability

2. Evaluation of detailed life cycle costs of all the options for each waste stream

3. Detailed comparison of costs of the current practices with alternative options to obtain savings to investment ratios and discounted payback periods

4. Implementation period.

HAZMIN Survey Forms

Installation____________________ Date__________ POC____________________
Phone__________

WASTE STREAM/MATERIALS USAGE: Motor Pools & Vehicle Maintenance Facilities

Generator (Unit Name)________________ Building________ DODAAC________ UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
Carburetor cleaner		Carburetor cleaner	
Waste oil		Engine oil	
Antifreeze solution		Antifreeze	
Lead-acid batteries		Lead-acid batteries	
Battery acid		Battery acid	
Aqueous detergent or caustic wastes (engine/radiator washing)		Caustic/detergent	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (mogas/diesel)		Fuel: diesel mogas	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Other fluids (transmission, brake, etc.)		Other fluids (transmission, brake, etc.)	
Mixed wastes			
Hazardous faulty parts (e.g., brake pads)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation______________________ Date__________ POC________________________
Phone________

WASTE STREAM/MATERIALS USAGE: Aviation Maintenance Facilities

Generator (Unit Name)________________ Building________ DODAAC______ UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Spent cleaning solvent		Cleaning solvent	
MEK degreaser & cleaner		Methyl ethyl ketone	
Calibrating fluid (specify)		Calibrating fluid (specify)	
Paint stripper (specify)		Paint stripper (specify)	
Paint thinner (specify)		Paint thinner (specify)	
Filters (paint booth)		Filters (paint booth)	
Used paint cans			
Waste engine oil		Engine oil	
Deicer solution		Deicer	
Nickel-cadmium batteries		Nickel-cadmium batteries	
NICAD battery electrolyte		Battery electrolyte (pottasium hydroxide)	
Aqueous detergent or caustic wastes (engine washing)		Caustic/detergent (engine washing)	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Contaminated fuel (Avgas)		Fuel (Avgas)	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Industrial Maintenance, Small Arms Shops, etc.

Generator (Unit Name)__________________Building_______DODAAC______UIC______

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Degreasing solvent (trichloroethylene)		Trichloroethylene	
Degreasing solvent (1,1,1-trichloroethane)		1,1,1-trichloroethane	
Degreasing solvent (others)		Degreasing solvent (others, specify)	
Paint thinners (specify)		Paint thinners (specify)	
Surface cleaners (specify)		Surface cleaners (specify)	
Paint wastes			
Waste oil		Lubricating oil	
Hydraulic/cutting fluids		Hydraulic & cutting fluids	
Corrosive chemicals (caustic soda)		Caustic soda	
Corrosive chemicals (phosphoric acid)		Phosphoric acid	
Corrosive chemicals (chromic acid)		Chromic acid	
Corrosive chemicals (phosphate solution)		Phosphate	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Tank bottoms (specify)			
Paint/sand blasting wastes			
Steam cleaning compound (alkali wastes)		Alkali	
Radioactive wastes		Radioactive sources	
Batteries (lead-acid, NICAD)		Batteries: Lead-acid Nickel-cadmium	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Paint Shops

Generator (Unit Name)________________Building_______DODAAC______UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Old/used paint cans			
Old/used paint			
Paint thinners (specify)		Paint thinners (specify)	
Paint strippers (specify)		Paint strippers (specify)	
Caustic wastes		Caustic soda	
Detergent solution from floor wash		Detergent floor wash	
Oily dirt with heavy metals			
Spent sorbent (Dry-Sweep)		Sorbent	
Dirty rags		Rags	
Solvent tank-bottom sludges			
Contaminated water			
Filters from paint booths		Filters (paint booths)	
Sludges from water-wall booths			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Hospitals, Clinics, and Laboratories

Generator (Unit Name)________________Building_______DODAAC________UIC___

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Pathological wastes (specify)			
Medical infectious wastes (specify)			
Pharmaceutical wastes (specify)			
Chemical wastes (specify)		Laboratory chemicals (xylene) Laboratory chemicals (mercury) Laboratory chemicals (others, specify)	
Radioactive wastes (specify)			
Photographic wastes (specify)		Photographic chemicals (specify)	
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Photography, Printing, Arts/Crafts Shops, etc.

Generator (Unit Name)________________Building_______DODAAC_______UIC_____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Solvents (specify)		Solvents (specify)	
Inks (specify)		Inks (specify)	
Photographic chemical wastes (specify)		Photographic chemicals (specify)	
Printing chemical wastes (specify)		Printing chemicals (specify)	
Bath dumps			
Paint wastes			
Paint/sand blasting wastes			
Other dry wastes			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________ Date_ _________ POC____________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Heating and Cooling Plants

Generator (Unit Name)________________ Building_______ DODAAC_______ UIC___

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
		Waste oil	
Contaminated fuel oil		Fuel oil	
		Natural gas	
Combustible chemicals (cyclohexylamine)		Combustible chemicals (cyclohexylamine)	
Combustible chemicals (other, specify)		Combustible chemicals (others, specify)	
Corrosive chemicals (caustic soda/potash)		Corrosive chemicals (caustic soda/potash)	
Corrosive chemicals (other, specify)		Corrosive chemicals (other, specify)	
Boiler blowdown			
Toxic emissions			
Ash			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Laundry and Drycleaning Facilities

Generator (Unit Name)________________Building_______DODAAC_______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Corrosive chemicals (caustic soda)		Corrosive chemicals (caustic soda)	
Corrosive chemicals (others, specify)		Corrosive chemicals (others, specify)	
Drycleaning compound (perchloroethylene)		Perchloroethylene	
Drycleaning compound (others, specify)		Drycleaning compound (others, specify)	
Equipment filters		Filters	
Contaminated water			
Other dry wastes (specify)			
Miscellaneous (specify)		Miscellaneous (specify)	

Installation____________________Date__________POC______________________
Phone_________

WASTE STREAM/MATERIALS USAGE: Miscellaneous Generators

Generator (Unit Name)________________Building_______DODAAC______UIC____

Waste Stream	Generation Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)	Material Input	Usage Rate (indicate units: gal/yr lb/yr, pints/mo, etc.)
Wet chemical wastes (specify)		Wet Chemicals (specify)	
Dry chemical wastes (specify)		Dry Chemicals (specify)	
Off-shelf life chemicals			
Used chemicals (pesticides, etc.)			
Batteries (specify)		Batteries (specify)	
Battery electrolyte (specify)		Battery electrolyte (specify)	
Contaminated soil			
Demilitarized ammunition			
Decontaminating agents (STB, DS2, etc.)			
Hazardous empty containers (drums etc.)			
Contaminated equipment (PCB transformers etc.)			
Contaminated water		Water	
Sludge from water treatment		Water treated	
Leachate into groundwater			
Infectious wastes			
Ordinance			
Fire-fighting foam		Fire fighting foam	
Miscellaneous (specify)		Miscellaneous (specily)	

LIST OF ABBREVIATIONS AND ACRONYMS

AAFES	Army Air Force Exchange Service
AEHA	U.S. Army Environmental Hygiene Agency
AFFF	Aqueous Fire Fighting Foam
AFPMB	Armed Forces Pest Management Board
AHS	Academy of Health Sciences
AMC	U.S. Army Materiel Command
AMF	Aviation Maintenance Facility
AOAP	Army Oil Analysis Program
APCD	Air Pollution Control Division
AQCR	Air Quality Control Region
AR	Army Regulation
ARCOM	U.S. Army Reserve Command
BACH	Colonel Florence A. Blanchfield Army Community Hospital
BOD	Biochemical Oxygen Demand
BMO	Battalion Maintenance Officer
CARC	Chemical Agent Resistant Coating
CEWI	Combat Electronic Warfare Intelligence
CFR	Code of Federal Regulations
CIC	U.S. Army Criminal Investigation Command
CO	Commanding Officer
CW	Chemical Wastes
DA	Department of the Army
DEH	Directorate of Engineering and Housing
DENTAC	U.S. Army Dental Activity
DERA	Defense Environmental Restoration Act
DESR	Defense Environmental Status Report

DISCOM	Division Support Command
DIVARTY	Division Artillary
DLA	Defense Logistics Agency
DOD	Department of Defense
DOL	Directorate of Logistics
DOT	Department of Transportation
DPCA	Directorate of Personnel and Community Affairs
DPP	Discounted Payback Period
DPTM	Directorate of Plans, Training, and Mobilization
DRMO	Defense Reutilization and Marketing Office
DRMS	Defense Reutilization and Marketing Service
DSU	Direct Support Unit
EA	Environmental Assessment
EENR	Energy, Environment, and Natural Resources Division
EOD	Explosive Ordnance Disposal
EOR	Environmental Operations Review
EP	Extractive Procedure
ESG	Eagle Support Group
ETIS	Environmental Technical Information Service
FLOCS	Fast Lubricating Oil Change System
FORSCOM	U.S. Army Forces Command
FR	Federal Register
FY	Fiscal Year
GSA	General Services Administration
GW	General Waste
HAZMIN	Hazardous Waste Minimization

HCL	Hospitals, Clinics, and Laboratories
HMTC	Hazardous Materials Technical Center
HSC	Health Services Command
HSWA	Hazardous and Solid Waste Amendments
HW	Hazardous Waste
HWMB	Hazardous Waste Management Board
IL	Infectious Linen
IMSS	Industrial Maintenance, Small Arms Shops
INSCOM	U.S. Army Intelligence and Security Command
ISC	U.S. Army Information Systems Command
ISCP	Installation Spill Contingency Plan
IW	Infectious Waste
IWTP	Industrial Wastewater Treatment Plant
JAG	Judge Advocate General
JLC	Joint Logistics Commanders
JP-4	Jet Propellant No. 4
LE	Leased Equipment
LPI	Leak Potential Index
LW	Laboratory Waste
MACOM	Major Command
MEDDAC	Medical Department Activity
MEK	Methyl Ethyl Ketone
MI	Military Intelligence
MOGAS	Motor Gasoline
MPVM	Motor Pool and Vehicle Maintenance Facilities
MSB	Main Support Battalion
MSDS	Material Safety Data Sheet

MWSA	Medical Waste Sanctions Act
NAAQS	National Ambient Air Quality Standard
NBC	Nuclear, Biological, and Chemical
NCO	Noncommissioned Officer
NIPDWR	National Interim Primary Drinking Water Regulations
NIPER	National Institute for Petroleum and Energy Research
NPDES	National Pollutant Discharge Elimination System
NPV	Net Present Value
NSDWR	National Secondary Drinking Water Regulations
NSN	National Stock Number
OB/OD	Open Burning/Open Detonation
OE	Owned Equipment
OEM	Original Equipment Manifest
OSHA	Occupational Safety and Health Administration
PC	Perchloroethylene
PCB	Polychlorinated Biphenyl
PCP	Pentachlorophenol
PL	Public Law
PMB	Plastic Media Blasting
POL	Petroleum, Oils, and Lubricants
PPAS	Photography, Printing, and Arts/Crafts Shops
PS	Paint Shops
RCRA	Resource Conservation and Recovery Act
RO	Reverse Osmosis
RW	Radioactive Waste
SAH	Sabre Army Heliport
SIP	State Implementation Plan

SIR	Savings to Investment Ratio
SOAG	Special Operations Aviation Group
SOP	Standing Operating Procedure
SPCCP	Spill Prevention Control and Countermeasures Plan
SQG	Small Quantity Generator
TCE	Trichloroethylene
TMP	Transportation Motor Pool
TSC	Training Support Center
TSDF	Treatment, Storage, or Disposal Facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
USACERL	U.S. Army Construction Engineering Research Laboratory
USAEHA	U.S. Army Environmental Hygiene Agency
USAETL	U.S. Army Engineering Technical Laboratory
USAISC	U.S. Army Information Systems Command
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USE	Used Solvent Elimination
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
XO	Executive Officer

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