WASTE MANAGEMENT ADVISORY NOTE

Solid and Hazardous Waste Management Branch
Environmental Health Section
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This publication is one of a series concerned with waste management. Its purpose is to provide North Carolinians both in the public and private sector with information on changes in rules regulating solid and hazardous waste and information on techniques that can be successfully applied to improve the way we manage waste.

ALTERNATIVES FOR HANDLING WASTE SOLVENTS IN NORTH CAROLINA

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This issue of Waste Management Advisory Note provides information on Alternatives for Handling Waste Solvents in North Carolina. It covers Recommendations, RCRA Regulations, Waste Handling Options, and Practices in Other States.

This issue is divided as follows:

I. INTRODUCTION

The total 1982 volume of hazardous waste generated in North Carolina was 109 million pounds excluding electroplating and process wastewater.* The four categories of waste solvents listed in Table 1 total 38,496,880 pounds which represents 35% of the 109 million pounds. Solvent wastes contribute a significant portion to the total hazardous waste generated in North Carolina.

The regulations under the Resource Conservation and Recovery Act (RCRA) governing waste solvents have been the subject of many revisions and interpretations over the past three years. In Section III North Carolina's present interpretation of "legitimately and beneficially used, reused, recycled, or reclaimed" is discussed. That section provides answers to the questions such as: What are the regulations on waste solvents used as fuel? If you recycle solvents in-house, are they classified as a waste?

Section IV on Waste Solvent Handling Options presents what we learned from:

(1) solvent users on what they do with their solvent wastes and what steps they have taken to eliminate or minimize those wastes;

(2) recycle equipment suppliers on types of stills available, their capacity, cost, and their special features;

(3) commercial recyclers of their capability and their recommendations to their customers on action that would minimize recycling cost;

(4) companies purchasing waste solvents for use as fuel in their kilns; we obtained their limitations on BTU, chlorine and metal content;

(5) companies operating commercial incinerators; we obtained information on cost versus BTU content and on their incineration capabilities; and

(6) operators of solidification and landfill facilities; we obtained performance data, regulations and charges.

The information obtained from this survey of waste treaters and disposers is included in Appendices B through G.

When a solvent is "used" it can leave the plant in the product, in the air or water, or as a "waste" solvent. North Carolina industries use solvents for:

(1) degreasing or otherwise cleaning surfaces and fabrics;
(2) manufacturing and use of surface coatings such as paints or inks;
(3) chemical or pharmaceutical production;
(4) refrigerants.

*North Carolina Hazardous Waste 1982 Annual Report

TABLE 1. NORTH CAROLINA 1982 WASTE QUANTITIES OF SELECTED SOLVENTS

Industry and EPA hazardous waste No./ Hazard Codes	Hazardous waste	Quantity (pounds)
Generic		
F001/(T)*	The following spent halogenated solvents used in degreasing: tetrachloroethylene, trichloroethylene, methylene chloride, 1, 1, 1-trichloroethane, carbon tetrachloride, and chlorinated fluorocarbons; and sludges from the recovery of these solvents in degreasing operations.	5,373,396
F002/(T)*	The following spent halogenated solvents; tetrachloroethylene, methylene chloride, trichloroethylene, 1, 1, 1-trichloroethane, Chlorobenzene, 1, 1, 1-trichloro-1,2,2-trifluoroethane, ortho-dichlorobenzene, and trichlorofluoromethane; and the still bottoms from the recovery of these solvents.	17,961,713
F003/(I)**	The following spent non-halogenated solvents:xylene, acetone, ethyl acetate, ethyl benzene, ethyl ether, methyl isobutyl ketone, n-butyl alcohol, cyclyhexanone, and methanol; and still bottoms from the recovery of these solvents.	8,918,273
F005/(I,T)***	The following spent non-halogenated solvents: Toluene, methyl ethyl ketone, carbon disulfide, isobutanol, and pyridine; and the still bottoms from the recovery of these solvents.	6,243,498
	TOTAL	38,496,880

*Toxic Waste
**Ignitable Waste

The principal solvents used by North Carolina industries are tabulated in Appendix A with their important properties. When these solvents have been used and termed "waste solvents" each waste solvent's status under RCRA hinges on whether it is an EPA listed waste or an EPA characteristic waste. Each solvent in the table has been categorized as listed (L), characteristic (C) or non-hazardous (NH).

Many halogenated organic compounds can cause adverse health effects* in human beings. Acute (short-term) exposure by inhalation to concentrated vapors of volatile, halogenated organics can produce a narcotic effect much like intoxication. Skin contact with halogenated organics may produce irritations and dermatitis.

Of most concern is the potential for chronic (long-term) health effects from repeated exposures to low levels of certain halogenated organics by inhalation or by ingestion. Several halogenated organics have been shown to produce carcinogenic, or mutagenic effects in laboratory tests.

Recent studies link the presence of very low levels of halogenated organics in drinking water to cancer. Although these studies are widely disputed, it is clear that certain halogenated organics that have been found as contaminants in drinking water (e.g., chloroform, carbon tetrachloride, and trichloroethylene) are suspected human carcinogens.

Potential pathways of human exposure to halogented organics from land disposal are air emissions and groundwater pollution. Halogenated organics are also extremely persistent.

Several non-halogenated volatile organics can cause adverse health effects by inhalation. Acute (short-term) exposure to concentrated vapors of compounds such as ketones, aldehydes, alcohols, and hydrocarbon solvents can produce a narcotic effect much like intoxication. Irritations of the eyes and respiratory tract may also occur.

Of most concern is the potential for chronic (long-term) health effects from repeated exposure to low levels of certain non-halogenated organics by inhalation. Compounds such as benzene and formaldehyde have been shown to produce carcinogenic and mutagenic effects in laboratory tests.

Furthermore, non-halogenated volatile organics have been implicated as smog-producing chemicals (though automobiles are by far the biggest contributors). They react with nitrogen oxides and sunlight to produce ozone and trace compounds such as peroxy acyl nitrate (PAN). Photochemical smog causes eye and respiratory irritations, especially for people with a history of respiratory illness.

*The material on health effects is taken from the California study "Alternatives to the Land Disposal of Hazardous Wastes."

II. SUMMARY OF FINDINGS AND RECOMMENDATIONS

Waste solvents and still bottoms from solvent recycling represent an important segment of North Carolina's hazardous waste production. They are important in terms of tonnage, their potential deleterious effects on landfill liners, and their potential value as recycled goods or as fuel.

Visits and telephone contacts to a sampling of North Carolina industry producing waste solvents have provided examples of companies:

(1) that have changed their process to reduce waste solvent production;
(2) with in-plant recycling equipment;
(3) sending their waste solvents to outside recyclers;
(4) sending their waste solvent to be used for fuel or to be incinerated; and
(5) having their waste solvents solidified for burial in non-hazardous and hazardous waste landfills.

To handle North Carolina's hazardous waste solvent production, we have developed a North Carolina list of:

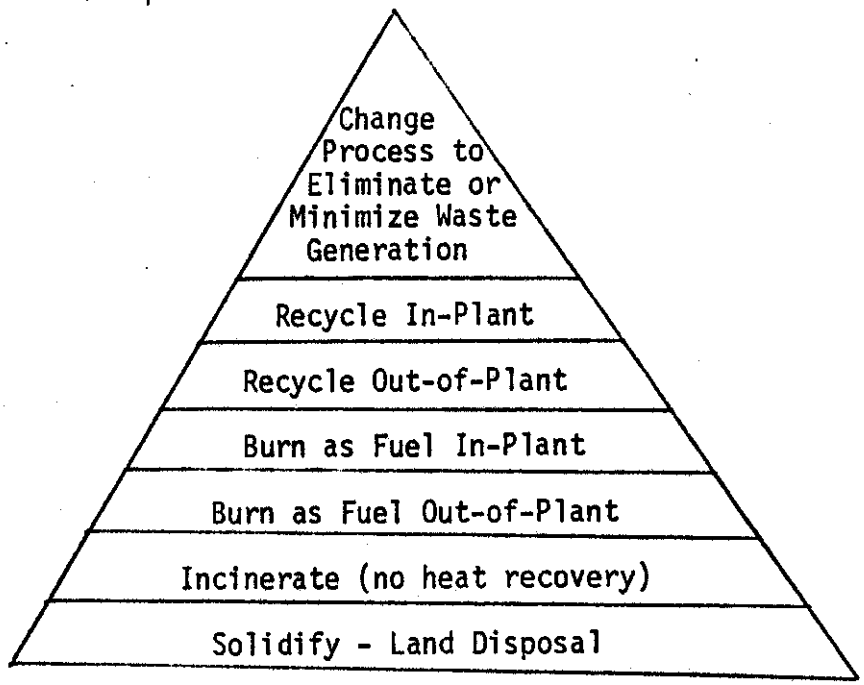
(1) manufacturers of stills for in-house recycling;
(2) solvent suppliers who will take back waste solvents for reprocessing or disposal;
(3) commercial solvent recyclers;
(4) firms able to utilize waste solvents as fuel;
(5) firms able to incinerate waste solvents; and
(6) firms able to solidify waste solvents for burial.

We observe a trend in California and Oregon as well as North Carolina towards the discouragement of land disposal of hazardous waste. The discouragement results from:

(1) the closing of many landfills due to operational problems and local pressure;
(2) the near impossibility of getting site approval for a new landfill;
(3) test results that indicate than many solvents damage the retention properties of clays used as a landfill liner; and
(4) an increasing public pressure for recycle or reuse rather than burial of wastes.

Far-sighted companies are also reluctant to landfill any wastes (given any other alternative) because of a concern for open-ended and unpredictable liability for wastes that might at some future time have to be exhumed from a "troubled" landfill. Present regulations impose "cradle-to-grave" responsibility on the generator, and this includes responsibility for the waste in the grave or landfill. High costs of new solvents and of fuels coupled with

increasing costs of land disposal and legal barriers to land disposal of some solvents* are motivating solvent users to move towards the apex of the pyramid sketched below. Effective October 1, 1983, a Federal tax of $2.13 per dry weight ton will be imposed on burial wastes.



The ideal situation is one in which no wastes are generated or at least no hazardous waste; in this Advisory Note we discuss, for example, changes in printing that eliminate solvent wastes. A second choice is to recycle the solvents in-plant (avoiding transportation accidents) and to use the still bottoms as fuel. If the still bottoms cannot be used in-plant, it is environmentally more desirable that these bottoms be used out-of-plant as fuel rather than be incinerated without heat recovery. However, thermal destruction of still bottoms is preferable to landfilling and in the case of thermal destruction, it is desirable that any ash be classified as a non-hazardous waste.

Moving down the pyramid we encounter out-of-plant recycle of waste solvents, use of the waste solvents as fuel, incineration of waste solvents without heat recovery, and finally solidification and land disposal of waste solvents. Solidification can be of two quite different types. The Stablex Co.** mixes hazardous wastes with cement and fly ash to make a synthetic rock which passes the EPA EP Toxicity Test.*** The "rock" is considered a non-hazardous

*In California these legal barriers were created because solvents have the following undesirable properties: acute or chronic toxicity, mobility, persistence in land disposal environment, and ability to bioaccumulate.

**See Landfill listing in Appendix F.

***Under this procedure, constituents are extracted from the waste in a manner designed to simulate the leaching action that occurs in landfills. This extract is then analyzed to determine whether it possesses any of the toxic contaminants identified in the National Interim Primary Drinking Water Standards (NIPDWS). IF the extract contains any of the contaminants in concentrations 10 times greater than that specified in the NIPDWS, the waste is considered to be hazardous.

waste and can be used for construction or placed in a sanitary landfill. Solid Tek* has a similar process. Solidification is also done at some hazardous waste landfills where the solvent or slurry is mixed with dried Fuller's earth or with fly ash to produce a nominally dry (no free liquid) solid that is acceptable for burial. The possibility of future liability from waste solvent disposal appears to be greatest for burial of the waste in a hazardous waste landfill. Table 2 summarizes limitations, liability, and economics of the waste solvent disposal options discussed in this Advisory Note.

Recommendations

To minimize exposure to future liability, it is recommended that solvent users try to eliminate transportation of their hazardous solvent wastes out-of-plant. Where it is necessary to send the wastes out-of-plant, it is recommended that, if at all possible, no waste or waste residue be sent to a hazardous waste landfill. Given a choice of recyclers select one whose still bottoms are used as fuel rather than a recycler who sends still bottoms for land disposal. If wastes cannot be burned as fuel and cannot be incinerated, try to convert them to a Stablex or Solid Tek type non-hazardous solid.

To simplify waste solvent handling, the following procedures should be followed:

(1) Keep solvents segregated! In the reclamation process it is much easier to separate a solvent from its impurities than to separate two solvents.

(2) Keep waste solvents as free from water and garbage as possible. Label the container as SOLVENT FOR RECYCLE, keep the container closed and, if possible, sheltered from rain. See label included (page 16).

(3) Try to use solvents in a "countercurrent" manner to minimize the need for high purity material.

(4) Keep a chemical identification label on each waste container. Record the exact composition and the method by which the waste solvent was generated.

(5) Don't label "in-process" solvents as wastes. These materials come under RCRA when called a waste!

(6) Avoid the Part B Permitting process by not storing "waste" solvents over ninety days.

(7) Move carefully in selecting outside recyclers or waste handlers by checking reputation, insurance, financial stability, and backlog of untreated materials. Work out a clear, contractural relationship.

*See Appendix F

TABLE 2

LIMITATIONS, LIABILITY AND ECONOMICS OF
WASTE SOLVENT DISPOSAL OPTIONS

Option	Limitations	Liability	Economics
Change process to eliminate or minimize waste generation	Process and management must be amenable to change	Eliminated or reduced	Depends on particular situation
Recycle in-plant	Capital for equipment, operating and maintenance headaches and costs	Eliminate transportation, reduce disposal problem to sludge	Depends on volume and value of solvent
Recycle out-of plant	Limitations on water, halogens, mixtures	Transportation, failure of recycler, backfire on sludge	"Service charge" ranges from 60-80¢/gal with no fractionation or dehydration
Burn as fuel	Need minimum fuel value 8,000-9,000 BTU/pound, limitations on metals, ash, halogens, sulfur, nitrogen	Transportation and failure of purchaser (minimal)	Cost range $0-1.00/gal.
Incinerate	N.C. commercial incineration firms limited on halogens - not so for Rollins or SCA	Transportation, ash and failure of purchaser (minimal)	Low halogen waste high in BTU (greater than 10,000 BTU/lb) cost 35¢/gal; low BTU waste cost 65¢/gal.
Solidify and dispose	Can't bury solvents that can be incinerated. Can't bury liquids.	Transportation plus later possible site problems	About $1/gal

(8) Check your recycler to verify that he promptly recycles your solvent and to find out how he disposes of any residues.

(9) If solvents are to be burned for fuel or incinerated, keep the BTU value high and the chlorine and metal contents low.

(10) Train your personnel to assist you in your hazardous waste program, especially 1 through 5 above.

III. NORTH CAROLINA REGULATIONS GOVERNING WASTE SOLVENTS*

A. A Quick Review: Waste Solvents as Hazardous Wastes

A waste solvent may be determined hazardous by two methods:

1. It exhibits one or more of the following characteristics:

   a. Ignitability
   b. Corrosivity
   c. Reactivity
   d. EP toxicity

   or

2. It is listed as a hazardous waste.

A waste solvent is "listed" because it has already demonstrated to possess one or more of the characteristics indicated above or it has proven to be chronically toxic to human beings. In either case no further testing is required. Listed waste solvents have generic code number F001 through F005 (not including F004, creosols) as shown in Table 1. A waste solvent which exhibits the characteristic of ignitability but is not listed as a hazardous waste in Table 3 has the EPA Hazardous Waste Number D001.

Waste handling options are numerous with regard to waste solvents. Each option carries with it a different degree of regulatory application. Section B outlines each option and identifies the pertinent regulations. Handling options include recycling, reuse, recovery of usable energy, incineration, and disposal.

B. Regulations Governing the Recycle, Reuse, and Recovery of Usable Energy of Waste Solvents

Section 261.6 of the North Carolina Hazardous Waste Management Rules is entitled "Special Requirements for Hazardous Waste Which is Used, Reused, Recycled or Reclaimed." The intention of Section 261.6 is to encourage generators to re-

*As stated in North Carolina Hazardous Waste Management Rules available from the Solid and Hazardous Waste Management Branch.

cycle and to utilize alternative waste handling procedures by allowing exemption from all or part of RCRA regulations. Non-listed and listed waste solvents are regulated differently under Section 261.6, and these differences are outlined below. However, both listed and non-listed wastes must meet the following standards* to be considered a fuel:

-The material must inherently sustain combustion at standard temperature and pressure with no auxillary fuels or other sources of BTU amendments; and

-The material must effectively substitute for the conventional fuel source in the particular combustion device without adversely affecting the normal operation of the device; and

-Utilization of the material as a fuel does not result in a violation of state or local regulations including, but not limited to, air emission permits or approvals; and

-Utilization of the material as fuel will not cause a significant adverse effect on public health and the environment from the release of large volumes of low concentrations of toxic materials over time.

Note: Each individual hazardous waste stream must meet all the above standards/conditions as it is generated and/or prior to blending.

1. Non-listed waste solvents

A generator having a waste solvent which is 1) hazardous due to the characteristic of ignitability and 2) not listed in Table 3 is exempt from RCRA regulation when:

a. The waste solvent is being beneficially used or reused or legitimately recycled. EPA does not define the terms "beneficial" and "legitimate." The North Carolina Solid and Hazardous Waste Management Branch, SHWMB, defines the two key terms as follows:

   Beneficial - the promotion of public health and well-being, offers equivalent success relative to other alternatives and available devices for managing hazardous wastes, yields a savings of natural resources and is economically profitable.

   Legitimate - conformance to recognized and accepted engineering principles and procedures for control of combustion in specific devices, including emission controls.

b. The waste solvent is being accumulated, stored, or physically, chemically, or biologically treated prior to beneficial use or reuse or legitimate recycling or reclamation.

*From the N.C. Solid and Hazardous Waste Management Branch.

However, one should note that difficulties may arise for a generator of a non-listed hazardous waste who is trying to recycle the waste out-of-plant. Transporters and recycling facilities may be hesitant about accepting any waste from a generator without an EPA identification number and a completed manifest. Therefore, many generators who want to recycle non-listed waste out-of-plant choose to comply with the RCRA regulations as set forth for listed wastes.

2. Listed waste solvent

If a generator's waste solvent is listed in Table 1 and the waste solvent remains on-site and is not stored over 90 days prior to being used, reused, recycled or reclaimed, then the generator is subject to the following:

a. Notification to the Solid and Hazardous Waste Management Branch of its hazardous waste activities.

b. Compliance with generator regulations, Part 262 of N.C. Hazardous Waste Management Rules.

If storage over 90 days is occurring then the generator is subject to the following:

c. Issuance of a storage permit as well as compliance with N.C. Hazardous Waste Management Rules' Standards for Owners/Operators of Hazardous Waste Management Facilities (HWMF's), Part 264, Subparts A through L, and/or Interim Status Standards for HWMF's, Part 265, Subparts A through L. Storage facilities established prior to November 19, 1980, must comply with Part 265 and eventually with Part 264; storage facilities established after November 19, 1980, must comply with Part 264.

If a generator's waste solvent is listed in Table 1 and the waste solvent is being transported off-site prior to being used, reused, recycled, or reclaimed, then the generator is subject to a. and b. above. If the generator is transporting his waste solvents in his own vehicles then the generator is a transporter and subject to the following:

d. Compliance with transporter regulations as outlined in N.C. Hazardous Waste Management Rules and the referenced Department of Transportation regulations in addition to a. and b. above.

If the generator is storing his waste solvent over 90 days prior to being transported for reuse or reclamation, then the generator is subject to d. above.

Exempted operations would include apparati which are directly connected to the manufacturing process, such as vapor degreasing equipment which continuously recycles degreasing solvents.

C. Regulation Governing Treatment, Storage or Disposal Other Than Recycle and Reuse of Listed and Non-Listed Waste Solvents

A waste solvent which is considered hazardous, whether listed or non-listed but is not going for use, reuse, recycle, or reclamation, must be regulated as a hazardous waste. The generator is required to comply with pertinent regulations as outlined in the N.C. Hazardous Waste Management Rules.* At a minimum the generator standards must be met. Transporter standards apply when the generator transports his or someone else's waste solvent. Facility standards apply if the waste solvent is being stored on-site over 90 days, treated on-site, or disposed on-site. Some disposal and treatment options are discussed below.

1. Secure landfill. Although disposal of waste solvents in landfills was once a common practice, there are indications that solvents may have deleterious effects upon the clay liners. North Carolina does not presently have a secure landfill, and it is interesting to look at South Carolina's and Alabama's regulations since most hazardous wastes to be securely landfilled go to these two states. South Carolina prohibits land disposal of ignitable liquid wastes (flash point less than 140°F) which can be incinerated by incineration units in the State of South Carolina. Nor can any liquids be buried without first being solidified. Alabama also places restrictions on the burial of liquids from secure landfills.

2. Incineration with no BTU recovery. The incineration unit must be "permitted" to handle non-halogenated and/or halogenated waste solvent. The ash becomes the responsibility of the incinerator operator and is considered a hazardous waste.

IV. WASTE SOLVENT HANDLING OPTIONS: A HIERARCHICAL APPROACH INCLUDING TECHNOLOGIES AND CASE STUDIES

From the discussion on North Carolina Hazardous Management Rules in Section III of this report, it becomes apparent that a variety of waste solvent handling procedures exist, each with applicable regulations (or non-regulations as the case may be). How does a generator of waste solvent evaluate the pros and cons of each handling procedure? Included in such an evaluation at a minimum should be future liability, regulatory status, costs, and environmental impact.

*As stated in North Carolina Hazardous Waste Management Rules, available from SHWMB.

Liability is an important consideration due to the RCRA "cradle-to-grave" philosophy, which never relieves the generator of responsibility for his hazardous wastes. A manufacturer who does not generate any waste solvents at his plant cannot be liable. The non-existence of hazardous waste generation provides the greatest protection from future legal conflicts and accusations. A few companies are moving ahead with this attitude and eventually hope to remove themselves from the RCRA picture. Printers who are utilizing water inks versus solvent inks are good examples.

Decreasing the volume of waste solvent generated also makes good sense since any damaging environmental effects of wastes are usually related to volume. In-house recycling decreases one's liability by reducing the transportation of hazardous wastes on the highways where accidents may occur. Heat recovery and incineration decrease liability tremendously when compared to the potential problems with clay liners in secure landfills.

The regulatory status of waste solvent is directly linked to the manner chosen for handling the waste. 10 NCAC 10F .0029 (a) (Section 261.6) of the N.C. Hazardous Waste Management Rules is especially designed to exempt certain wastes from RCRA when they are being recycled or reused. (See discussion in Section III of this report.)

When examining costs, you need to look at the costs of:

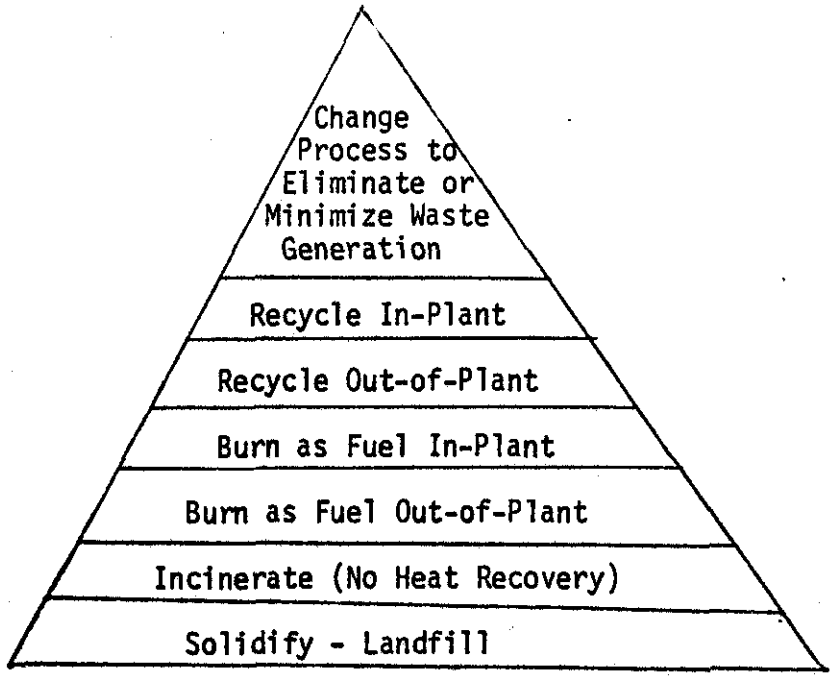
1) virgin solvents;
2) transportation or virgin and waste solvents to and from your plant;
3) reclamation, in-plant and out-of-plant;
4) heat recovery and/or incineration; and
5) disposal/solidification of waste solvents and still bottoms.

It should be noted that while cash costs may appear lower for a waste handling procedure such as land disposal versus recycling, the lower cost option may result in a greater future liability. Minimizing future liability is a most important factor.

The environmental impact of waste solvent handling procedures has the following facets to examine:

1) the health and well-being of plant personnel;
2) the health and well-being of the community today and in the future;
3) the protection of the environment (animal and plant life, air quality, groundwater quality and surface water quality); and
4) the conservation of natural resources.

Based upon an examination of liability, costs, regulations, and environmental impact, a hierarchy of handling procedure options has been formed as illustrated in the figure below.



A change in process to eliminate or minimize waste generation can reduce liability, regulation and environmental impact. In-plant recycle (versus out-of-plant recycle) can reduce liability and conserves natural resources when comparing recycling to other treatments such as incineration. Out-of-plant recycle and burning waste solvents as fuel conserve natural resources; recycling is closer to the apex due to the potential for greater material reuse. Burning waste solvents as fuel, however, solves the liability problem since the waste is destroyed. Incineration also destroys a waste solvent but no heat recovery makes it a less environmentally attractive choice. Finally, solidification and landfilling are last due to the potential environmental impact as well as the loss of natural resources.

The following section examines briefly the technology behind each of these options and presents case studies to illustrate the options. Due to the nature of the "Change Process to Eliminate or Minimize Waste Generation," only a general discussion precedes the case studies of the first option.

A. Change Process to Eliminate or Minimize Waste Generation

A change in a manufacturing process to eliminate or minimize waste production is specific to that process. Very little can be said here except some guidelines can be offered:

1. Conduct an audit of your waste solvent production, identifying quanitities being produced at any given site in the plant or step in the process.

2. Determine the process step at which the solvent becomes compositionally dirty or contaminated with another waste stream such as water.

3. Examine your alternatives such as equipment replacement (equipment replacement may increase process efficiency and yield), better housekeeping practices, and segregation of waste streams as well as their costs.

4. Examine present costs for waste solvent treatment and/or disposal. Be sure to consider the cost of: 1) virgin solvent, 2) transportation, 3) treatment method, and, most importantly, 4) liability.

Good housekeeping practices include the proper labelling of waste solvents especially those going for reclamation or heat recovery. Employees need to be aware of the value of the waste solvent. The use of labels, such as the one below, is suggested. Expenses due to human error can be kept at a minimum.

Figure 1

The following three books contain many references to changes in processes that eliminated the generation of wastes.

1. Campbell, Monica E. and William M. Glenn, Profit from Pollution Prevention, Pollution Probe Foundation, Toronto, 1982. Available from Pollution Probe, 12 Madison Ave., Toronto, Ontario, Canada MSR 2S1.

2. Huisingh, Donald and Vicki Bailey, eds., Making Pollution Prevention Pay, Pergamon Press, New York, 1982.

3. Royston, Michael G., Pollution Prevention Pays, Pergamon Press, Oxford, 1979.

Rexham in Greensboro is the recipient of a Governor's Award of Excellence for Waste Management. They achieved reduction in their hazardous waste solvent streams through two methods:

1) Use of water-based inks and
2) Reclamation of spent alcohol/acetate solvent.

Rexham uses a flexography process and prints on film, foil and paper. After trials, it was determined that when printing on paper, water inks could be used instead of traditional alcohol/acetate-borne inks. Air emissions as well as hazardous waste production were reduced. Though some operator retraining had to occur, Rexham eventually got excellent quality in their products. It was also found that the clean-up process was about the same as for alcohol/acetate inks.

It is important to note that there are some problems to be worked out with water inks when printing on films. Currently, a company has to sacrifice run speed as well as gloss and quality. Since a customer is very specific about his needs, gloss can be a necessary quality in the final product and make water inks impractical when printing on film.

Admittedly water ink is not a universal panacea, and many technical problems need to be worked out when using water inks on film or foil. However, Rexham believes that these problems will be solved by the ink companies within three to five years. At that time Rexham plans to go to a total water ink system, thus greatly reducing the use of solvents in their plant.

An ink supplier in North Carolina who wished to remain anonymous produces water inks for industry. The supplier has purposely avoided solvent use in his plant, and pigments containing chromium (chrome yellow) and molybdenum (moly orange) are never incorporated into his inks. All materials, resins and additives are screened to be non-hazardous. As a result the plant generates no hazardous waste. Wastewater is sent to a public wastewater treatment facility.

According to the ink supplier, water inks have been commonly used in the corrugated cardboard business for the last 20 years. Recently successes have been gained in several flexographic printing areas including:

1) The narrow web or roll label industry where paper or film is 6 to 16 inches wide and production is between 100 to 500 feet per minute. On non-porous film a clear resin primer is sometimes used to overcome the non-electrical bonding surfaces. (Non-electrical: no attractive forces exist.)

2) The wide web industry where paper is 24 to 60 inches wide and production is about 300 feet per minute. Products include Kentucky Fried Chicken and Kool-Aid boxes.

Research is being performed at various industries on printing on aluminum foil, other nonporous substrates, and paper. Water inks dry either by surface evaporation or absorption. Nonporous substrates create a problem because the water evaporates slowly and a film on the outside layer of ink can form preventing the remaining water from evaporating, resulting in smudges and smears in a rapid printing operation. Proper formulation of water inks and equipment modification can often eliminate many of the problems making water inks a viable alternative.

The water ink supplier states that a greater consistency in printing quality control is possible with water inks over solvent inks due to the slower evaporation rate of water. Solvents evaporate so quickly that pigment concentrations at the ink station can change, producing variations in product color because of variations in viscosities.

Desoto in Greensboro is a manufacturer of trade sales paints. Before RCRA, waste mineral spirits from the clean-up process were recycled by Seaboard Chemical. Rising costs for disposal, reclamation and virgin materials prompted the initiation of an in-plant program to use waste solvent. Wash solvent from each paint batch is collected in drums and put aside. When a paint is to be mixed, "waste" solvent from that paint's previous batch clean-up is used in the manufacturing process. Desoto produced 25,000 gallons of waste mineral spirits in 1981; in 1982 they only produced 400 gallons. The same waste volume reduction technique is being applied to their wastewater production from latex paints, the wastewater being stored in two 4500-gallon tanks.

B. Recycle In-Plant and Out-of-Plant: 1. The Technology

Reclamation of solvents usually involves the process of distillation. Distillation of a liquid mixture achieves separation of components by virtue of the differences in component boiling points. By applying heat to the mixture the lighter, low-boiling, more volatile component(s) vaporize, leaving the heavier, high-boiling component(s) in the still pot or reservoir. The vaporized component(s) are condensed and collected.

Evaporation. A simple distillation technique is evaporation. Traditionally in evaporation, water is driven off as steam which is lost to the atmosphere. For solvent reclamation the necessary equipment for an evaporation process in-

cludes a heat source (steam, a heating coil or furnace, or a heating element) and a pot such as a stainless steel vessel. To this set-up, add a cover on the pot so as not to lose the vapor and a condenser to condense the vapor for the simplest distillation unit. A distillation unit or still of this type is known as a pot still and is shown in Figure 2A.

Fractionation. Unless the feed components have large differences in boiling points, a single vaporization and condensation step will not be very effective in separating the components. To provide the desired separation, a number of successive vaporization and condensation steps are often used.

The liquid feed is heated to drive off the more volatile components which are contacted countercurrently by reflux (condensed vapor) in a tall, cylindrical column containing trays or packing. A typical distillation-fractionation requires a still pot to heat the liquid mixture and a condenser to condense the vapor as is shown in Figure 2B.

Steam Stripping. Steam stripping is a special application of distillation where heat is applied directly to a mixture by injecting steam into the pot. Volatile components and steam are driven off and condensed leaving oily sludges at the bottom. This technique is used by some commercial recyclers for removal of residual chlorinated solvents from an oily, sludgy still bottom, rich in BTU's. Reducing the chloride level in the sludge to 2% allows a recycler to send the still bottom to a heat recoverer or incinerator.

Still Bottoms. After volatile fractions have been vaporized and useful heavier fractions removed, the residue in the still pot can represent a disposal problem. Still bottom may contain heavy organics, tars, and sludges, some of which may be toxic. Presently, North Carolina still bottoms are being 1) solidified and buried, 2) burned as fuel, or 3) incinerated with no heat recovery.

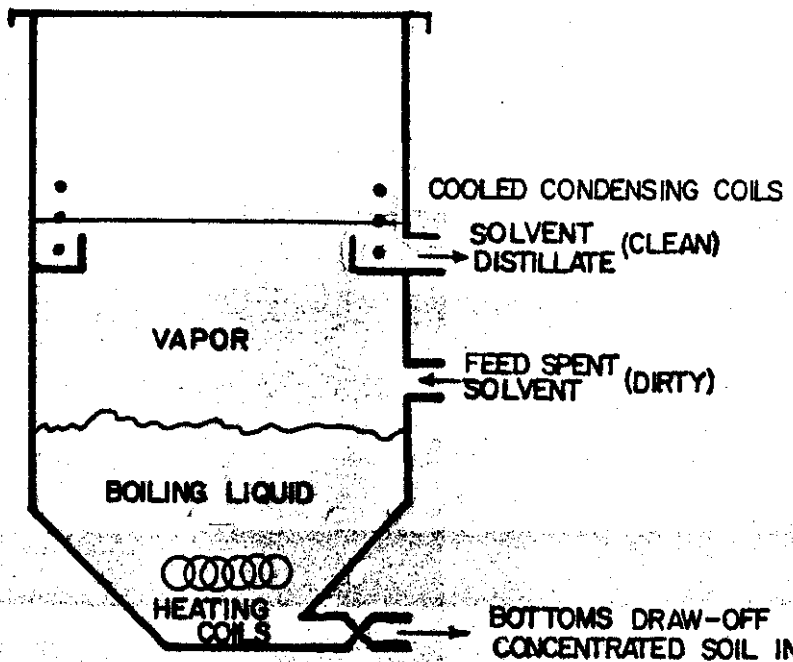
In-House Recycling. To design a solvent recovery system which ideally fits your needs, LUWA Corporation, a manufacturer of evaporators, identifies several factors which must be taken into account.

1) Quantity of feed material. An accurate knowledge of the quantity of waste solvent produced by your manufacturing process is needed to determine the recovery system capacity. This information can also be helpful when deciding whether to purchase a continuous flow or batch recovery system. In either case, downtime for maintenance must be considered.

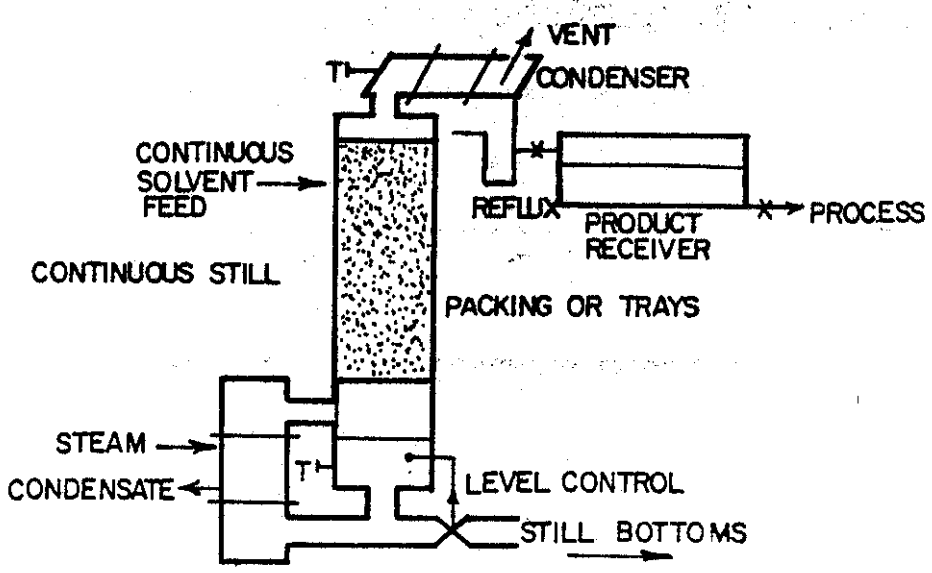
2) Feed composition. The recovery unit must be equipped to handle the materials in your waste stream.

3) Physical properties. Recovery will be affected by boiling points and viscosities of the waste solvents.

4) Preferred materials of construction (based on corrosive properties of the waste solvent).



A. POT, SINGLE PLATE, BATCH OR CONTINUOUS STILL



B. FRACTIONAL DISTILLATION – CONTINUOUS STILL

FIGURE 2

5) Plant layout. Select the site which makes the most sense.

6) Available utilities. Consider the available steam sources, cooling water temperature and electrical characteristics.

7) Required recovery. Determine what composition and purity of the recovered solvent is necessary to make it useful for your needs.

B. Recycle In-Plant and Out-of-Plant: 2. Case Studies

Equipment for In-House Recycling

Zerpa Industries in California currently manufactures Recyclene, a pot still type solvent recovery system which is distributed in North Carolina by Activation, Inc.* of Charlotte and Baron-Blakeslee*. The most interesting feature of Recyclene is the chemical and heat resistant bag which keeps the boiler clean and captures the still bottoms. Recyclene units are available in capacities ranging from 20 gal/day to 100 gal/hr. Some units are available with an automatic loading feature. All units have an automatic shut-off feature, which comes into operation when the residue bag is full.

Costs range from $5000 to $16,000 including installation. Leases and rentals are available with the option to purchase the equipment. The smallest unit rents for $120/mo.

LUWA Corporation* manufactures an evaporator in which the heat transfer occurs through the column wall instead of through the bottom of a pot. The column is enclosed within a heating jacket. Product enters at the top of the column and moves downward by gravity. Rotor blades distribute the liquid evenly over the inside surface of the evaporator enhancing a constant heat transfer and minimizing local overheating and fouling (residue build-up). Vapors are captured at the top of the column and are condensed; residues exit at the bottom of the unit. LUWA evaporators are available in sizes ranging up from 10 gallons per hour. Environmental Recycling, a commercial solvent recycler in Durham, and Safety-Kleen Solvent Recycle Center in Lexington, South Carolina, both operate LUWA thin-film evaporator.

Baron-Blakeslee* is a supplier of solvents and recovery equipment. For their customers they will pick up waste solvents and transport them to their S. Kearny, New Jersey, facility for reclamation, but they also sell a variety of both standard and custom-engineered stills ranging in distillate output from 10 gallons to 500 gallons per hour. Price ranges are from $4000 to $20,000 depending on design and optional equipment. Carbon adsorption systems which recover solvents from airstreams or exhausts are also available from Baron-Blakeslee.

*See listing in Appendix C.

In-Plant Solvent Recycler

To handle their waste solvents (alcohol/acetate mixture), Rexham of Greensboro purchased a still from Cardinal Manufacturing at a cost between $15,000 and $16,000. "At the time the system was placed into operation the company was generating 300 drums per year [of wastes]. After complete implementation of the project, waste generation was reduced to 10 drums per month or 120 drums annually, a 60% waste reduction . . . [The payback of the] initial $16,000 investment has been . . . less than a year and subsequent savings [amount to] $2000 per month."* The reclaimed alcohol/acetate mixture is reblended with virgin materials to provide the required composition for new ink batches as well as for cleanup purposes.

Currently, an EPA-qualified transporter and reclaimer is handling Rexham's still bottoms by removing and recycling any remaining solvent at a cost of approximately $70 per drum.

Commercial Solvent Recyclers

For the waste solvent generator who chooses to utilize out-of-plant recovery services, importance is placed on the choice of a recycler due to generator "cradle-to-grave" liability. A large, conservative corporation in North Carolina uses the following criteria to evaluate the practices of each potential recycler:

1. solvents which are recovered
2. lab testing facilities and procedures
3. quality control
4. available trucks and the transportation of waste solvents
5. state regulatory agency's comment about the facility in question
6. fate of still bottoms
7. fate of drums
8. insurance on operations in question
9. the geology and groundwater of the immediate and surrounding areas to the facility
10. emergency preparedness for fires and spills
11. permits held by the recovery operation
12. proximity and type of neighbor
13. ground wells, industrial and private, in the vicinity of the plant.

Investigating any waste treater or disposer you are considering makes good sense since the ultimate liability always remains with the generator of the waste.

Alternate Energy Resources** (AER) operates a live-steam distillation solvent recovery system in Augusta, Georgia. Steam is injected into the waste solvent, vaporizing the solvents and leaving behind the oils and solids. The distillation unit was purchased from DCI Corporation in Indianapolis, Indiana. AER recovers ester, fluorocarbons, ketones, aliphatic hydrocarbons, aromatic hydrocarbons, and chlorinated hydrocarbons. Usually the reclaimed solvents are re-

*From the nomination for Governor's Award of Excellence for Outstanding Achievement in Waste Management, 1982.
**See listing in Appendix D.

turned to the generator of the waste solvent, but AER will find outlets for certain reclaimed solvents when the original owner cannot recycle them. AER is equipped to pick up drums; bulk waste solvents must be delivered by the customer. Though no minimum quantity of waste solvent was designated, AER commonly reclaims no less than 4 drums.

Still bottoms are sent to Chemical Waste Management* in Emelle, Alabama, since the live steam distillation process leaves too much water in the residue to make it a good fuel. AER is considering incineration of the still bottoms at Caldwell Systems** as an alternative.

AER is under interim status with the State of Georgia. Their Part B permit application has been filed, and they expect to become fully permitted.

An additional service provided by AER is waste oil reclamation. Waste oil is heated to drive off liquid contaminants and then filtered to remove solid contaminants. Reclaimed oil is sold for its BTU value to industries such as asphalt producers.

Environmental Recycling* in Durham operates a LUWA thin-film evaporator for the reclamation of chlorinated and fluorinated solvents, ketones, alcohols and lacquer thinners. Lab tests on-site or at a commercial laboratory are performed on a potential customer's waste solvent to determine composition and physical characteristics. If the generator wants the reclaimed solvent returned, Environmental Recycling returns a solvent sample from a bench distillation unit to the generator who OK's the quality of the reclaimed solvent. Accepted waste solvents which are reclaimed and not returned to the original owner are resold by Environmental Recycling. Waste solvents which cannot be reclaimed are sent to Oldover to be burned or to South Carolina to be buried.

Waste solvents to be shipped to Environmental Recycling should be transported in properly labeled 55-gallon drums or by tank truck and should be manifested.*** As little as one drum is accepted for reclamation.

Still bottoms are sent to Oldover** to be utilized as fuel unless the bottoms are contaminated with chlorine. Presently, a steam stripping unit is being designed which will remove chlorine from otherwise BTU-rich bottoms. Bottoms which cannot be burned are sent to South Carolina to be buried.

Reclamation fees are charged according to percent solvent, solid, and water content as well as cost for still bottom disposal.

One problem which presents itself continuously is the improper labelling of drums. Improperly identified solvents cause delays and can create recovery and maintenance problems for the thin-film evaporator.

*See listing in Appendix D.
**See listing in Appendix E.
***A small generator does not have to manifest his hazardous waste.

The Prillaman Company* in Martinsville, Virginia is a manufacturer of furniture finishes and coatings. In 1946 the company began to commercially recycle waste solvents using thin-film distillation. At present the major solvents which Prillaman recycles are lacquer thinner removing liquid waste, furniture plant wastes, perchloroethylene, 1,1,1-trichloroethane, methylene chloride, and tipsolve (a fiberglass industry solvent). After recovery, Prillaman tests the product on a gas chromatograph to determine composition and purity. Prillaman will reclaim solvents from non-furniture finish customers. Initially, a detailed analysis of the waste solvent is required. Determination of pH, percent of solids and composition are made at Prillaman's to see if the waste stream is compatible with Prillaman's process. If the waste solvent is accepted for recovery, subsequent detailed testing is not necessary as long as the waste stream remains within a certain compositional range.

Prillaman utilizes Oldover or Mitchell Systems for the combustion of still bottoms. Prior to the incineration of still bottoms from halogenated solvent recovery, a secondary process, steam stripping, is utilized to keep the chlorine level under 2%.

Prillaman will pick up waste solvents from customers. D.O.T. 55-gallon drums are used for waste solvent storage and are provided by Prillaman. Drums are painted pink to ensure identification as well as to point out the value of the drum contents to those people working with the drums.

Seaboard Chemical* in Jamestown is a commercial recycler of solvents and operates a 90-foot fractionation-distillation column with 26 trays. A pot still is also operated. New customers must send a representative sample which is tested on-site for composition, pH, specific gravity and percent solvent. Solvents accepted for recovery may be delivered in tank trucks or drums. Transportation services are available.

Reclamation can be performed on a toll basis or Seaboard will sell the product to other businesses or distributors. As little as one drum is accepted for recovery but Seaboard needs a minimum of twenty drums of like waste to operate the distillation column.

Seaboard's fee structure is as follows:

1) $.60 - $.80 per gallon for returned non-halogenated distillate, no fractionation or dehydration.
2) 75% - 80% of virgin price for halogenated distillate.
3) $.45 - $.50 per pound for recovered virgin spec fluorocarbons.
4) $1.50 - $3.00 per mile for 74 drums or 5,000 gallons or less of hazardous waste or recovered product transportation.

*See listing in Appendix D.

Still bottoms are liquid or semi-liquid and are sent to Oldover to be burned as fuel. Methanol, which is economically unfeasible to recover, is at times mixed with still bottoms to liquify them and to provide BTU value. Oldover charges $.30/gallon to burn the still bottoms.

Generator Using Out-of-Plant Recycler

Almay Cosmetics in Apex, North Carolina received the Governor's Award of Excellence for Outstanding Achievement in Waste Management. Almay makes hypoallergenic cosmetics and must be very careful with quality control. Therefore, only virgin acetone can be used in the cleaning of their nail enamel dispensing equipment. After cleaning the nozzle heads, the waste is 80-90 percent acetone. By sending their waste acetone to Seaboard Chemical, Almay figures that $72,000 is saved annually due to reprocessing rather than transporting the waste to a landfill. The reclaimed solvent is sold by Seaboard Chemical to customers with less stringent purity requirements. Almay formerly used another recycler but found that their waste solvents were getting contaminated with water. Since the water could not be coming from their plant, they gathered that the recycler was allowing the drums to sit outside for a period of time prior to reclamation and rain water was entering the drums.

To clean the nozzle heads, Almay uses ultrasonic degreasers which use very little acetone. The employees keep the waste acetone separate and avoid any contamination with dirt and water. Isopropyl alcohol is used to clean and sanitize the equipment. It is estimated that 200 gal/month of waste isopropyl alcohol is generated. The waste isopropyl alcohol is picked up by Oldover to be used as a fuel in Oldover's light-weight aggregate plant.

American Colors in Charlotte produces coatings for fiberglass. Gelcoats have a polyester resin base and are used to protect and decorate fiberglass products such as boats and shower stalls. Acetone is the clean-up solvent and, when spent, is sent to Seaboard Chemical in Jamestown for reclamation. American Colors buys back the clean acetone, usually getting a 70% recovery of the original acetone. The waste acetone is sent out at the rate of 35-60 drums per month. The waste acetone analysis is as follows:

.3% Styrene
.5% MEK
1.0% H_2O
97.0% Acetone

Cost of recycling acetone is as follows:

$1.00/gal for reclamation services
$15.00/drum reconditioning fee
or
$.26/lb recycled acetone
versus
$.31-.33/lb virgin acetone

American Colors offered the following suggestions:

1. Decrease clean-up activity by production scheduling.
2. Make changes in personnel training to enhance proper hazardous waste management.
3. Keep a close eye on operations.

Lilly in High Point manufactures coatings for the furniture industry including lacquers, paints and stains. Coatings consist of three basic constituents:

1) pigment, either organic or inorganic,
2) resin which acts as a binder, and
3) a vehicle, such as a solvent, which usually evaporates.

Solvents utilized include ketones, esters, aliphatic and aromatic hydrocarbons. Waste solvents are generated by Lilly in the equipment cleaning process and in the rejection of off-spec products. In addition, customers return dirty products to Lilly for recycling. Waste solvents are stored in three 5000 gallon aboveground tanks and are segregated by high and low boiling points. Wastes with low boiling points are recycled at Seaboard Chemical. Seaboard picks up the waste solvents from Lilly and Lilly picks up reclaimed solvents from Seaboard. Wastes with a high boiling point, and also higher BTU value, are sent to Oldover for incineration since no useable product can be reclaimed. Lilly charges a handling fee to its customers for these services.

Suppliers That Handle Customer's Waste Solvents

Ashland Chemical Company* operates an industrial chemicals and solvents division which has almost seventy distribution centers around the United States, three of which are in North Carolina (Charlotte, Greensboro, and Raleigh). Solvents account for 75% of their business.

In addition to supplying virgin solvents, Ashland picks up waste solvents and delivers them to Seaboard Chemical in Jamestown. Seaboard tests the waste solvent and make the decision as to whether it can be reclaimed or must be otherwise disposed. Reclamation takes place at Seaboard, whereas disposal is at Chemical Waste Management in Emelle, Alabama.

Reclaimed solvents are redistributed by Ashland to customers whose industrial process does not require virgin materials. A typical acceptor of reclaimed goods is the coatings industry.

Usually waste solvents are picked up in drums. Ashland provides aid to customers when manifesting and containerizing their waste solvents.

*See listing in Appendix B.

Van, Waters, and Rogers* sells virgin solvent and picks up waste solvent. A customer's waste sample is sent to a lab and reclamation or disposal is decided, depending on lab results. Reclaimed solvents are resold at reduced rate to those industries with lower purity requirements.

Detrex Chemical* in Charlotte supplies chlorinated and fluorinated solvents to industry primarily for degreasing purposes. They also sell equipment for vapor degreasing, vapor recovery and solvent distillation.

Spent trichloroethylene and 1,1,1-trichloroethane are recovered at the Detrex site in pot stills. As an example, virgin trichloroethylene costs 27¢/lb or $3.24/gallon. Detrex will buy back the waste trichloroethylene (80-90% solvent content) and credit the customer with 15¢/lb for solvent content. The recovered solvents are sold to customers, demand for recovered solvents being greater than the availability. Very little discount is given on reclaimed solvents since reclaimed solvents have the same specs as virgin solvents. Recovered trichloroethylene may cost 26¢/lb. Transportation is included in all prices. Waste solvents should be stored in 55-gallon drums. Detrex will handle the disposal of waste solvents if they prove non-recoverable. Restabilizers and inhibitors are available to customers who have in-house recycling units.

C. Heat Recovery and Incineration: 1. The Technology**

Heat recovery and incineration are used to reduce the volume or toxicity of organic wastes by exposing them to high temperatures, and in heat recovery, the wastes' energy value is recovered. When organic chemical wastes are subjected to temperatures from 800°F to 3000°F, they break down into simpler and less toxic forms. The wastes are heated with oxygen present, and combustion occurs. The main products from complete combustion include water, carbon dioxide, ash and certain acids and oxides depending upon the waste in question.

Common heat recovery and incineration techniques (See Table 4) applied to North Carolina waste solvents are

- o Single-Chamber Liquid Systems
- o Rotary Kilns
- o Cement Kilns
- o Coincineration

*See listing in Appendix B.
**Excerpted from the California Study, "Alternatives to the Land Disposal of Hazardous Wastes."

TABLE 4. INCINERATION TECHNOLOGIES

TYPE	PROCESS PRINCIPLE	APPLICATION	COMBUSTION TEMPERATURE	RESIDENCE TIME
Cement Kilns	Waste is co-fired in a kiln with constituents of cement during the manufacture of cement.	Liquid organic wastes	2600°-3000°F	Up to 10 seconds for gases; up to hours for liquids
Coincineration	Hazardous wastes are mixed with refuse/sludge to improve combustion characteristics. Not a unique technology.	Wastes which have low energy values.	Depends on type of incineration	Depends on type of boiler
Rotary Kilns	Waste is burned in a rotation, refactory lined cylinder.	Any combustible solid, liquid, or gas	1500°-3000°F	Seconds for gases to hours for liquids and solids.
Single Chamber/ Liquid Injection	Wastes are atomized with high pressure air or steam and burned in suspension.	Liquids and slurries which can be pumped.	1300°-3000°F	.1 to 1 second

Single-Chamber Liquid Injection Systems

A liquid injection incineration system consists of one or two refractory-lined combustion chambers and a series of atomizing nozzles. It is capable of burning virtually any combustible waste which can be pumped. Wastes to be burned are usually blended in mixing tanks prior to atomization to improve either their pumpability or combustability, and then are atomized and burned in suspension. The incinerator capacity will vary depending upon the energy value of the waste. Typical combustion chamber residence time and temperature ranges are 0.5 to 2 seconds and 1300°F to 3000°F, respectively.

Liquid injection incinerators have been used to destroy a variety of wastes including phenols, PCB's, still and reactor bottoms, solvents, polymer wastes, herbicides, and pesticides. They are not recommended for burning heavy metals, high-moisture content wastes, or materials with high, inorganic content.

Rotary Kilns. A rotary kiln incinerator is a large cylinder (the larger ones are 16' x 40') lined with firebricks and mounted with its axis at a slight slope from horizontal. Solid, liquid, and gaseous wastes are injected into the kiln at the higher end and are passed through the combustion zone as the kiln rotates. The rotation creates turbulence and improves combustion. Ash is removed continuously from the lower end of the kiln, and gaseous combustion products pass through an afterburner chamber. Residence times for wastes range from seconds for gases to hours for solids, and combustion temperatures range up to 3000°F. Combustion gases from the kiln pass through scrubbing devices prior to exiting the stack. Rotary kilns vary in size from units which can combust a ton of waste per hour to units which can combust eight tons of waste per hour. Some rotary kilns are equipped with boilers to reclaim heat energy.

Rotary kilns have been used to combust a wide variety of hazardous waste including PCB's in waste capacitors, obsolete munitions, obsolete chemical warfare agents, polyvinyl chloride wastes, waste paint and solvents, and bottoms from solvent reclamation operations. Rotary kilns are not recommended for heavy metal sludges, inorganic salts, and other wastes with high, inorganic content.

Cement Kilns. An integral part of the process for manufacturing cement is exposing limestone and several additives to temperatures above 2600°F in a large rotary kiln fueled with a fossil fuel. The end product of this process is a solid material called "clinker." Ground-up clinker is the major constituent of cement. Since the combustion conditions in cement production are much more severe than those present in many waste incinerators, cement kilns may be applicable for incinerating chlorinated wastes since the hydrochloric acid produced serves to neutralize the clinker production process which is normally alkaline.

In test burns carried out in Canada, Sweden and the United States, it has been determined that hard-to-burn wastes such as PCB's can be successfully combusted in cement kilns. Less hazardous chemicals such as waste solvents and still bottoms from solvent reclamation operations are already being purchased by cement companies and burned on a continuous basis in cement kilns.

The advantages of using cement kilns are that, in addition to the wastes being destroyed, the energy value of the waste is reclaimed, the capacity of the cement industry to consume chemical wastes is quite large, and cement plants are already located near many waste-generating sources. The disadvantages are that burning chlorinated wastes in cement kilns appears to increase the production of particulates, requiring more extensive air pollution control devices. Utilizing wastes as fuel in plants not used to handling wastes will require an upgrading of the facilities.

Coincineration

The term "coincineration" describes the use of combustible wastes as supplemental fuels in boilers designed for and operated primarily on a fossil fuel. As a result of coincineration, the energy value of the waste is used to produce steam, and the original form of the waste is destroyed through combustion. Rather than requiring a unique technology, this incineration process can be carried out in any boiler where feed combustion parameters make it possible.

C. Heat Recovery and Incineration: 2. Case Studies

Commercial Heat Recovery

ABCO Industries* in Roebuck, South Carolina, has been a manufacturer of textile specialty chemicals since 1964. In 1977 ABCO built a liquid injection incinerator system with waste heat recovery boilers and started the Thermal Oxidation Division. Presently, ABCO services the East Coast area of the United States. Sales are generated from direct sales efforts, recommendations from satisfied customers and pleased regulatory agencies in South Carolina.

Accepted wastes include organic liquids, aqueous and non-aqueous mixtures, emulsions and suspensions, organic residues and sludges that are pumpable or capable of being made pumpable. The wastes must be transported in bulk using ABCO's compartmentalized tank trucks, the customer's tank truck, a common carrier or railcar.

Samples of each waste are thoroughly tested in ABCO's laboratory which is equipped with a Parr Bomb Calorimeter, an Instrumental Laboratories atomic absorption spectrophotometer, a microprocessor ionanalyzer, a gas/liquid chromatographer and an infrared spectrophotometer. Immiscible layers in a waste will be tested separately.

An accepted waste proceeds to the 600,000 gallon capacity tank farm where blending and mixing occur before wastes are pumped to the incinerator. Halogenated wastes are neutralized with lime to prevent corrosion of the system. The blended wastes have a minimum of 8000 to 9000 BTU's per pound.

The liquid injection incinerator operates at 2200°F with a residence time of 5 to 6 seconds. A baghouse filter and acid fume scrubber clean and neutralize the gases. Waste heat boilers generate steam for the chemical plant at ABCO.

*See listing in Appendix E.

Initially, the incinerator is heated by burning natural gas; once hot, no natural gas is needed. The incineration system has the capacity to thermally oxidize 180,000 pounds per 24 hour period.

Ash from the incineration process becomes the responsibility of ABCO, which removes all liability from the generator. ABCO delivers the ash to a secure landfill for hazardous wastes.

There is a minimum fee of $400 for ABCO's incineration services. This minimum does not include transport of a customer's waste to ABCO.

An additional service available on a toll basis only is ABCO's solvent recovery service. Customers can specify their requirements as to the purity and composition of a reclaimed solvent. The decision to reclaim or incinerate a waste solvent is always made by the customer instead of ABCO.

The Solite Corporation in Richmond, Virginia and Aquadale, North Carolina produces a light-weight aggregate from shale rock which is expanded in a high-temperature (2700°F) rotary kiln. Waste solvents from industrial sources are utilized as supplemental fuel, the main fuel source being powdered coal.

Arrangements for waste solvent testing and pick-up are made through Oldover Corporation, a subsidiary of Solite. Oldover transports waste solvent in bulk, arriving at a customer's with a tank equipped with drum-pumping or tank-pumping capabilities. A customer may transport his waste, if desired.

The following criteria give an idea of the type of waste accepted as a Solite fuel:

1. 90,000 BTU/gallon or greater
2. Less than 2% chlorine content
3. Maximum of 15% suspended solids
4. Only trace amounts of heavy metals.

For a waste with less than 90,000 BTU/gallon or over 2% chlorine blending is a possibility. A customer with a waste solvent which has a BTU value/gallon of 90,000 or greater pays little or no disposal costs.

Typically, "truckloads of solvent arrive at the tank farm, and after preliminary lab testing, the load is pumped into one of two receiving tanks. After final lab approval, the batch is pumped into a 20,000 gallon blended fuel tank. From here it is fed directly into the coal-fired furnace and all the combustion gases pass directly through the rotary kiln. The exhaust gases are scrubbed."*

Since Solite is recovering the heat value of waste solvents, their operation is exempt from RCRA. However, a RCRA manifest is required even if a waste is not considered hazardous. Solite urges that all customers be knowledgeable as to the generation source of a waste solvent stream as well as know the exact composition of a waste solvent since EPA requires a waste profile analysis sheet.

*From Paul Cowgill's (Industrial Extension Service, NCSU) personal visit to Solite's Aquadale, N.C. plant.

Stauffer Chemical Company* in Mt. Pleasant, Tennessee, operates a 300 foot rotary kiln phosphorus furnace at temperatures between 2400°F to 2900°F with a 6.2 second residence time. Stauffer accepts organic waste materials for heat recovery purposes. Their fee structure ranges from 0¢ per gallon to 55¢ per gallon depending upon water, chloride, BTU and metal contents. They will accept no waste solvent with less than 5000 BTU per pound. Waste solvents with high chloride or high metal content are blended off but will usually incur a larger disposal fee.

Systech Corporation* of Xenia, Ohio, acquires liquid combustibles including some waste solvents to be used as fuel in the cement kilns at General Portland Cement plants in Ohio, California and Kansas.

Commercial Incinerators

Caldwell Systems* in Lenoir and Mitchell Systems in Spruce Pine operate two chamber liquid injection incinerators and incinerate hazardous waste without heat recovery. They will accept either a customer's trucking service or provide the pick-up for the hazardous waste. A potential customer is required to supply a representative sample of the waste prior to its acceptance as an incinerable waste. The waste can be either in solid or liquid form.

The following stipulations are made on waste to be incinerated: PCB concentration less than 50 ppm, organic chloride concentration less than 1/2%, heavy metal concentration less than 200-300 ppm and no cyanide contamination. According to a Caldwell representative, the percent solvent in the wastes they receive is usually low and solvent recovery is not a viable option.

Caldwell's incineration fee structure is based upon BTU content of the solvent waste. A waste high in BTU's (10,000 BTU/pound or greater) burns readily and requires little auxillary fuel. Material of this kind to be incinerated costs 35¢/gal for bulk liquids or $29/drum. On the other hand, a waste low in BTU value (less than 10,000 BTU/pound) requires considerable auxillary fuel to ensure its destruction. (Auxillary fuel is usually #6 fuel oil which sells for approximately $1.01/gal at present.) Wastes of this type cost 65¢/gal in bulk or $45/drum to be incinerated.

Caldwell's advice to customers is to keep water contamination levels at a minimum so that higher BTU values in the waste are maintained; considerable energy is required to vaporize water.

In addition to incineration services Caldwell also provides tank cleaning services, spill clean-up and PCB clean-up.

In Chicago SCA** operates a rotary kiln/liquid injection incinerator which destroys both incinerable liquid and solid wastes, including halogenated hydrocarbons and still bottoms. Operating temperature is in excess of 2000°F and

*See listing in Appendix E.
**See listing in Appendix F.

the two second residence time exceeds the regulatory requirements. The incinerator has a total capacity of 120 million BTU's/hr and up to 50,000 gallons of waste can be fed in and incinerated every day.

Generators Who Use Heat Recoverers

Almay in Apex manufacturers hypoallergenic cosmetics and uses 200 gal/month of isopropyl alcohol to clean and sanitize the equipment. The waste alcohol is picked up by Oldover Corporation (Solite) to be used as a fuel in a light-weight aggregate plant. For other information on Almay see Out-of-Plant Solvent Recyclers.

Lilly of High Point separates their wastes according to high and low boiling points. Wastes with low boiling points are reclaimed by a commercial solvent recycler; wastes with high boiling points and also higher BTU values are sent to Oldover for incineration since no useable product can be reclaimed. For more information on Lilly see their case study under Out-of-Plant Solvent Recyclers.

Generators Who Use Incinerators

Intercraft in Statesville makes one and a half million frames per year from metal and wood. They generate a spray booth waste from applying paint or lacquer to the frames, which is a common waste produced by the furniture and metaling finishing industry. At present, Intercraft is sending the waste to Caldwell Systems for incineration. Waste is stored in 55 gallon drums and Intercraft generates approximately 2200-2500 pounds per month, depending on production.

D. Stabilization/Solidification: 1. The Technology*

Chemical stabilization/solidification describes several techniques which stabilize liquid wastes into a solid with high structural integrity. Stabilized or solidified wastes are much less likely to leach out of a land disposal site than are untreated wastes--even though the physical and chemical characteristics of the constituents of the waste may not be changed by the process. Stabilization usually involves the addition of materials that ensure that the hazardous constituents are maintained in their least soluble form.

The stabilization/solidification process currently used for North Carolina still bottoms going to Chemical Waste Management in Emelle, Alabama is a pozzolanic process. The wastes are mixed with cement kiln dust which is a fine grained silicious (pozzolanic) material and water to produce a concrete-like solid. SCA at Pinewood, South Carolina, solidifies still bottoms with Fuller's earth which is mined at the site. The other common materials used are fly ash and ground blast furnace slag.

*Excerpted in part from the California study "Alternatives to the Land Disposal of Hazardous Wastes.

Chemical stabilization/solidification appears to be an excellent process for inorganic residues and ashes from other treatment and incineration processes, and is expected to become an integral part of waste treatment facilities in the future.

D. Stabilization/Solidification: 2. Case Study

Commercial Stabilizers/Solidifiers

Stablex Corporation* recently purchased the Industrial Chemical Company in Rock Hill, South Carolina. Stablex is primarily known for its solidification of hazardous wastes technique, rendering the waste non-hazardous. Using a proprietary technology, "Sealosafe," the "solidification process is based primarily on Portland cement and fly ash. The end product has the consistency of synthetic rock. It is as impermeable as impervious clay, and ten times more impermeable than concrete. Metals are chemically fixed within an aluminasilicate matrix . . . Typically the solidified product is used for land reclamation . . ."** The Rock Hill site will be ready to accept wastes for solidification the second quarter of 1984.

Stablex also operates two pot stills and an incinerator. Solvent recovery is performed on a toll basis, but Stablex does not reclaim chlorinated solvents at present. The incinerator is designed to burn chlorinated and non-chlorinated still bottoms.

Transportation is provided by Stablex. Waste solvents may be stored in bulk or in drums. Laboratory testing includes infrared spectroscopy, atomic absorption, gas chromatography, and bomb calorimetry.

E. Secure Landfill: 1. The Technology***

A secure landfill is designed to receive chemical and other industrial wastes. Secure landfills differ from conventional sanitary landfills in the degree to which the site is engineered to diminish the migration of pollutants.

A simple design for a secure landfill is a pit lined with clay or a synthetic membrane. The pit liner is underlaid with a leachate collection system that pumps to a leachate treatment system. The perimeter of the landfill contains monitoring wells which collect groundwater for analysis of contaminants. At closure, a layer of clay is deposited over the waste to minimize water movement into the pit.

However, some of the synthetic polymers used to line landfills are vulnerable to disintegration by specific solvents and corrosive agents. Clay,

*See listing in Appendix F.
**From Chemical Engineering, August 13, 1979, p. 141.
***Excerpted from the California study "Alternatives to the Land Disposal of Hazardous Wastes.

also used in lining landfills, is mistakenly identified as highly impermeable. Its permeability is drastically increased when penetrated by certain organics, acids, and bases.

Solvents can only be placed in secure landfills in solidified form. Ignitable liquid solvents are not acceptable by some landfills, even if solidified, unless alternative waste handling treatments, such as incineration, have been rejected due to metal or chlorine content.

A secure landfill cannot substitute for other waste treatment technologies such as waste volume reduction, recovery, treatment or destruction. The many environmental problems and unknowns associated with landfilling make it a disposal option that should be minimized in the face of alternative technologies.

E. Secure Landfills: 2. Case Study

SCA Chemical Services, Inc.* is a wholly owned subsidiary of SCA Services, Inc. in Boston, Massachusetts. Since SCA Services was found in 1969, it has become a $300 million per year company operating solid and chemical waste disposal facilities in 32 states. SCA Chemical Services provides chemical detoxification, resource recovery, incineration and secure landfill. On-site clean-up and transportation services are also offered. Each facility is equipped with sophisticated instrumentation necessary to analyze waste streams.

In Pinewood, South Carolina, SCA operates a secure landfill. The base of the landfill is Fuller's earth, which is covered by five feet of variegated clay, a synthetic liner and sand clay to protect the liner. Wastes are segregated according to compatibility. A leachate management system consisting of drainage pipes and pumps is permanently installed. Groundwater wells are monitored.

It is important to note that South Carolina prohibits the burial of a liquid with a flash point of 140°F or less unless a recognized incinerator has rejected the waste and put those reasons in writing. A common reason for a waste's rejection by incinerators is a high lead content. A sludge with a flash point of 140°F or less is acceptable.

*See listing in Appendix F.

V. Practices in Other States

North Carolina has managed its hazardous waste by essentially following the EPA RCRA Federal regulations. As EPA changes the Federal regulations, North Carolina follows. North Carolina has recently adopted more stringent rules pertaining to: the burial of liquid hazardous waste;* commercially feasible landfill alternatives; the annual report requirement; locating waste disposal sites in relation to water supplies and population center.** California is an example of a state whose hazardous waste regulations lead national regulations. California practices are probably very indicative of the future regulation of waste solvents.

Another reason to examine the practices of other states is that North Carolina sends great quantities of hazardous waste out-of-state to be treated or disposed of. South Carolina alone accepted over 47 million pounds of North Carolina hazardous waste in 1982, much of it going to SCA's Pinewood, South Carolina, secure landfill. Virginia accepts waste solvents from North Carolina which are used as fuel at Solite Corporation's light-weight aggregate facilities headquartered in Richmond.

Following is a brief discussion covering highlights of important waste solvent regulatory practices in California, Oregon, South Carolina, Virginia and Washington.

California

In environmental control California has often led the nation. In the regulation of air pollution and hazardous wastes California developed standards, testing methods and regulations which were subsequently adopted nationwide.

So it is with great interest that we examine the direction in which California is moving since this may well be a future direction for North Carolina. Two California actions of interest are (1) a ban on certain materials to landfills and (2) penalizing burial of recyclable materials.

California has a new law that will permit banning certain materials from landfills as technology and facilities become available to handle these materials on a statewide basis. The first ban, which went into effect June 1, 1983, is on liquids containing cyanides and is based on the determination of the availability of cyanide treatment capacity. As treatment capacity becomes available, additional materials banned from California landfills will include toxic metal wastes, acid wastes, PCB wastes, halogenated organic wastes and waste liquids. By July 1, 1985, it is expected that some waste sludges and solids will also be banned from burial. Banning all of these materials will require large scale treatment facilities and a need for incinerators which are difficult to site in California.

*10 NCAC 10F .0032 (r) (1)
**10 NCAC 10F .0038

California is attempting also to reduce the amount of recyclable materials which are landfilled. Their approach is to review manifests of materials which went to a landfill and to require a written justification from the generator for landfilled wastes which possibly could have been recycled. The State provides suggestions as to recycling facilities. By these letters they are motivating companies to cease landfilling and start recycling. If the companies fail to respond to the letter, they are liable to a higher State tax on the buried recyclable materials. The present tax totals $17 per ton, and it can be doubled to motivate recycling.

In his response the waste generator must describe the waste, give the amount of similar waste discarded in the preceding year, estimate the quantity for the next year, and summarize the efforts made to find a use for the waste. The uses to be examined include fuel, reclaimed solvent, waste modification and use, and sellable waste or exchange.

Recyclable wastes in California are defined to include

Commercial chemical products
Solvents: halogenated, oxygenated, hydrocarbon
Petroleum products - motor oil, cutting oil
Pickling liquor
Unspent acids and alkalis
Unrinsed empty containers - including pesticide

The State has had to review a large number of manifests to operate this program but believes that they have enabled 140 businesses to recycle 23,000 tons of wastes in 1982 that would otherwide have been landfilled.

Oregon

The State of Oregon has only one land disposal site at Arlington, Oregon operated by Chem Security Systems. Even though this site is located in an arid region where evaporation exceeds rainfall, the State is not permitting the burial of wastes (particularly solvents) that could be recycled. The control of the site is managed by requiring that the State approve all requests for burial before the site can accept these wastes. As this landfill is filled up, the closed zone is turned over to the State for long term management.

Oregon has four commercial recyclers. These are inspected every three months. They are only accepting materials when they are ready to recycle them to obviate a back-up of stored materials. They are only allowed to accumulate up to 150 barrels of non-recycled material or 6000 gallons of still bottoms. Oregon has not had any bad experiences with these recyclers. One facility is recycling on-site.

Oregon's program offers some ideas for North Carolina in regulating solvent recyclers and another indication of the move towards recycling over land disposal.

South Carolina

South Carolina regulations for recyclers and recoverers differ from EPA regulations as follows:

1) Recycle as part of a closed loop system (part of process) is given a variance. This would include vapor degreasers.

2) Recycle of by-product material is exempt only if an application has been filed with and approved by the Bureau of Solid and Hazardous Waste. The decision is based upon the proposed reuse and management of by-products and whether the environment is endangered.

3) Recovery of the heat value of a waste solvent is not automatically exempt.

To send a waste for disposal in South Carolina, an application is filed with the Bureau of Solid and Hazardous Waste where it is reviewed and recommendations made. All ignitable liquids (including some solvents) must be incinerated unless an incineration facility, such as ABCO in Roebuck, South Carolina, rejects the waste and specifies the reasons in writing. Common reasons for rejection are high chlorine or lead levels. According to SCA Chemical Services, which operates a secure landfill in Pinewood, South Carolina, ignitable solids, including sludgy still bottoms, can be solidified with Fuller's earth and buried.

Virginia

The State of Virginia closely follows EPA regulations and adopts all changes. EPA recently published some guidelines (40 FR April 4, 1983) concerning blending which Virginia interprets as follows. If wastes are blended to increase the BTU value which is a common practice by companies such as Solite, then these companies will be considered treaters and must receive a permit under Part A. (Solite Corporation in anticipation of this requirement has completed a Part A application.)

Washington

The Department of Ecology in the state of Washington differentiates waste into two categories: dangerous wastes (DW) and extremely hazardous wastes (EHW). Extremely hazardous wastes include ignitables, carcinogens and liquids; some examples of EHW's are discarded chemical products such as toluene and trichloroethylene. EHW's may not be buried within the state of Washington (Washington has no hazardous waste landfill). However, there is no restriction on recycling or treating an EHW. On the other hand, if toluene and trichloroethylene are generated as wastes from a process, it is up to the individual to determine whether the waste is a dangerous waste or extremely hazardous waste.

The recycling and recovery of wastes are regulated as set forth by the EPA rules. As in North Carolina, requirements exist for storage and transport depending upon the reasons the waste was considered hazardous. Whether

California is attempting also to reduce the amount of recyclable materials which are landfilled. Their approach is to review manifests of materials which went to a landfill and to require a written justification from the generator for landfilled wastes which possibly could have been recycled. The State provides suggestions as to recycling facilities. By these letters they are motivating companies to cease landfilling and start recycling. If the companies fail to respond to the letter, they are liable to a higher State tax on the buried recyclable materials. The present tax totals $17 per ton, and it can be doubled to motivate recycling.

In his response the waste generator must describe the waste, give the amount of similar waste discarded in the preceding year, estimate the quantity for the next year, and summarize the efforts made to find a use for the waste. The uses to be examined include fuel, reclaimed solvent, waste modification and use, and sellable waste or exchange.

Recyclable wastes in California are defined to include

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Solvents: halogenated, oxygenated, hydrocarbon
Petroleum products - motor oil, cutting oil
Pickling liquor
Unspent acids and alkalis
Unrinsed empty containers - including pesticide

The State has had to review a large number of manifests to operate this program but believes that they have enabled 140 businesses to recycle 23,000 tons of wastes in 1982 that would otherwide have been landfilled.

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The State of Oregon has only one land disposal site at Arlington, Oregon operated by Chem Security Systems. Even though this site is located in an arid region where evaporation exceeds rainfall, the State is not permitting the burial of wastes (particularly solvents) that could be recycled. The control of the site is managed by requiring that the State approve all requests for burial before the site can accept these wastes. As this landfill is filled up, the closed zone is turned over to the State for long term management.

Oregon has four commercial recyclers. These are inspected every three months. They are only accepting materials when they are ready to recycle them to obviate a back-up of stored materials. They are only allowed to accumulate up to 150 barrels of non-recycled material or 6000 gallons of still bottoms. Oregon has not had any bad experiences with these recyclers. One facility is recycling on-site.

Oregon's program offers some ideas for North Carolina in regulating solvent recyclers and another indication of the move towards recycling over land disposal.

a waste is determined to be a dangerous waste or an extremely hazardous waste, a person is not prohibited from reclaiming, recycling, recovering, treating, detoxifying, etc. the waste as long as he acts in accordance with the regulations.

Approval for the use of a waste stream as a fuel is determined by the Department of Ecology on a case by case basis. Waste stream composition and physical characteristics are the critical issues. Incineration of hazardous wastes is also regulated similarly to the laws in North Carolina.

Acknowledgements

We wish to acknowledge the support received from the Solid and Hazardous Waste Branch that made this report possible. We particularly wish to acknowledge the guidance and help received from Emil Breckling and the assistance in reviewing Section III received from O.W. Strickland, Bill Meyer, William Paige and Jerry Rhodes. Teresa Berry handled the typing and retyping, and Martha Brinson did the editing. All errors, omissions and the like are our fault. Please direct corrections and suggestions to Jerome Kohl, Senior Extension Specialist, P.O. Box 5636, NCSU, Raleigh, NC 27650 (919) 737-2303.

APPENDIX A. SELECTED SOLVENTS AND THEIR PROPERTIES[a]

Glycols

PRODUCT	LB./GAL. 20°C	SP. GR. 20°/20°C	BOILING RANGE °C	BOILING RANGE °F	FL. PT. °F COC[b]
Propylene Glycol (NH)	8.64	1.038	186-190	367-374	225
Ethylene Glycol (NH)	9.28	1.115	193-202	379-396	240
Diethylene Glycol (NH)	9.31	1.119	242-250	468-482	290

PRODUCT	LB./GAL. 20°C	SP. GR. 20°/20°C	BOILING RANGE °C	BOILING RANGE °F	FL. PT. °F TCC[c]	EVAP. RATE[d]
Alcohols						
Methanol (L)	6.60	0.792	64 - 65	147-149	54	5.2
Ethanol, Prop. Anhy. (C)	6.75	0.809	74 - 80	165-176	51	6.8
Ethanol, Spec. Ind. Anhydrous (C)	6.59	0.790	75 - 81	167-178	50	6.8
Isopropanol, Anhydrous (C)	6.55	0.786	82 - 83	180-182	53	7.7
Isobutanol (L)	6.68	0.803	107 -109	225-228	86	16.3
n-Butanol (L)	6.75	0.811	116 -118	241-245	96	20.0
Ketones						
Acetone (L)	6.59	0.792	55.5- 56.5	131-133	-4	1.9
Methyl Ethyl Ketone (L)	6.71	0.806	78 - 80	172-176	24	2.7
Methyl Isobutyl Ketone(L)	6.67	0.802	114 -117	237-243	61	5.6
Methyl Isoamyl Ketone(C)	6.78	0.812	141 -148	286-298	96	17.0
Diacetone Alcohol, A.F.(C)	7.82	0.937	145 -172	293-342	120	60.0
Methyl Amyl Ketone (C)	6.81	0.818	147 -154	297-309	102	22.0
Ester Solvents						
Ethyl Acetate 99% (L)	7.51	0.900	75.5- 78	168-172	26	2.7
Isopropyl Acetate 99%(C)	7.27	0.871	86 - 90	187-194	47	3.0
n-Propyl Acetate (C)	7.40	0.887	99 -103	210-217	55	4.8
Isobutyl Acetate (C)	7.24	0.870	112 -119	234-246	63	5.8
n-Butyl Acetate 99% (C)	7.34	0.879	118 -128	244-262	81	8.2
Isobutyl Isobutyrate(C)	7.13	0.855	144 -151	291-304	101	15.0
Glycol Ether EE Acetate (C)	8.10	0.973	150 -160	302-320	130	32.0
Glycol Ether EB Acetate (NH)	7.83	0.938	186 -194	367-381	160	137.0
Glycol Ethers						
Glycol Ether EM (C)	8.04	0.966	123 -125	253-257	97	
Glycol Ether EE (C)	7.74	0.930	134 -136	273-277	110	
Glycol Ether EB (C)	7.51	0.903	169 -173	336-343	140	

Aliphatic Solvents

PRODUCT	LB./GAL. 20°C	SP. GR. 20°/20°C	BOILING RANGE °C	BOILING RANGE °F	FL. PT. °F TCC	KB[e]	ANILINE PT. °F	% ARO.[f]	EVAP. RATE[d]
Hexane (C)	5.61	0.675	65- 70	150-158	<0	28	151	0.1	1.9
Heptane (C)	5.76	0.704	94- 98	202-209	25	32	146	0.1	2.9
Mineral Spirits(C)	6.55	0.787	157-196	315-385	105	31	155	< 1	70.0

Aromatic Solvents

PRODUCT	LB./GAL. 20°C	SP. GR. 20°/20°C	BOILING RANGE °C	BOILING RANGE °F	FL. PT. °F TCC	KB	MAP	EVAP. RATE[d]
Toluene (L)	7.26	0.870	110-111	230-233	45	105	50	4.5
Xylene (L)	7.23	0.866	138-142	280-288	80	98	52	9.5

Amines

PRODUCT	LB./GAL. 20°C	SP. GR. 20°/20°C	BOILING RANGE °C	BOILING RANGE °F	FL. PT. °F TOC	FREEZING POINT °C
Monoethanolamine (NH)	8.48	1.016	166-174	331-345	200	10
Triethanolamine (NH)	9.37	1.126	App. 360	App. 680	375	21

Chlorinated Solvents

PRODUCT	LB./GAL. 25°/25°C	SP. GR. 25°/25°C	BOILING RANGE °C	BOILING RANGE °F	EVAP. RATE[d]
Methylene Chloride (L)	11.0	1.320	39.4- 40.4	103-105	1.8
1, 1, 1-Trichloroethane (L)	10.8	1.300	72 - 88	162-191	2.6
Trichlorethylene (L)	12.1	1.449	86 - 88	187-190	3.9
Perchloroethylene (NH)	13.5	1.618	120 -122	248-252	6.0

(C) - Characteristic
(L) - Listed
(NH) - Non-Hazardous

[a]Selected solvents from a chart provided by Industrial Chemicals & Solvents Division, Ashland Chemical Company, Box 2219, Columbus, OH 43216.
[b]Cleveland Open-Cup Test (flashpoint).
[c]TAG Closed Cup Test (flashpoint).
[d]Ethyl Ether = 1.
[e]Kauri-Butanol Value (relative solvent power).
[f]Aromaticity

Fluorinated Solvents

PRODUCT	LB./GAL. 25°C	SP. GR. 25°C	BOILING POINT °C	°F
Freon TF (Trifluoro-trichloroethane)	1.565	13.0	117.6	243.7
Freon TMS (Azeotrope of TF with methanol and nitromethane)	1.5	12.5	103.5	218.3
Freon TES (Azeotrope of TF with ethanol and nitromethane)	1.5	12.5	111.9	233.4

APPENDIX B

SOLVENT SUPPLIERS

The following list was compiled through personal interviews, telephone conversations, and sales literature. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

ASHLAND CHEMICAL CO.
2802 Patterson St., Greensboro, NC 27407
(919) 299-1101
Contact: Mike Trull
Industrial Chemical Sales
Recycling Service: Transports waste solvents to outside recycler for customers
Other Branches:
3930 Glenwood Dr.
Charlotte, NC 28208
(704) 392-2121

1415 S. Bloodworth St.
Raleigh, NC 27601
(919) 828-0615

BARON-BLAKESLEE
Charlotte, NC
See listing under Equipment Suppliers.

DETREX CHEMICAL INDUSTRIES, INC.
P.O. Box 5278, Charlotte, NC 28225-5278
(704) 372-9280
Contact: Mark Teal
Industrial Chemical Sales
Equipment: Vapor degreasers, distillation, industrial filtration
Recycling Services: Trichloroethylene, perchloroethylene, 1,1,1-trichloroethane and methylene chloride
Other Services: Environmental services, laboratory services, equipment services, training programs

MCKESSON CHEMICAL COMPANY
P.O. Box 18805, Greensboro, NC 27419
(919) 292-0624
Contact: Sarah Austin
Industrial Chemical Sales
Equipment: Recyclene units
Recycling Services: See McKesson Envirosystems under Recyclers
Other Branches:
Charlotte, NC
(704) 399-4255

SAFETY-KLEEN CORP.
Elgin, Illinois
See listing under Recyclers.

TICAR CHEMICAL CO., INC.
P.O. Box 4205, Asheville, NC 28812
(704) 667-0161
Contact: Steve Woolard
Industrial Chemical Sales
Recycling Services: Transports customer's waste solvents to outside recycler

VAN, WATERS & ROGERS
3001 Holts Chapel Road, Greensboro, NC 27401
(800) 632-1095
Contact: Roger Williams
Industrial Chemical Sales
Recycling Services: Transports waste solvent to outside recycler for customers
Other Branches: Service Road
Charlotte, NC
(800) 632-1095

APPENDIX C

EQUIPMENT SUPPLIERS

The following list was compiled through personal interviews, telephone conversations, and sales literature. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

ACTIVATION, INC.
8041-F Arrowridge Blvd., Charlotte, NC 28210
(704) 527-6880
Contact: Mack Ferguson, President
Equipment: RECYCLENE units with disposal bags for still bottom residues

BARON-BLAKESLEE
1225 Apando Ave., Charlotte, NC 28206
(704) 333-9682
Contact: John Sparrow
Equipment: Recovery units for chlorinated and fluorinated solvents by Baron-Blakeslee; also RECYCLENE units and carbon adsorption systems for recovering solvents from exhausts.
Recycling Services: See Recyclers listing
Industrial Chemical Sales

DETREX CHEMICAL INDUSTRIES, INC.
Charlotte, N.C.
See listing under Solvent Suppliers.

LUWA CORP.
4404 Chesapeake Dr., Charlotte, NC 28216
(704) 394-8341
Contact: Steve Yandle
Equipment: Thin film evaporators and auxiliary equipment

SAFETY-KLEEN CORP.
Raleigh, N.C.
See listing under Recyclers.

APPENDIX D

SOLVENT RECYCLERS

The following list was compiled through personal interviews, telephone conversations, sales literature and/or the National Association of Solvent Recyclers' (NASR) Greenbook, a membership directory. The format for each listing is similar to that found in the Greenbook. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

ABCO INDUSTRIES, INC.
Roebuck, S.C.
See listing under Incinerators

ALLWORTH, INC.
500 Medco Rd., Birmingham, AL 35217
(205) 841-1707
Contact: Leslie S. Allen, President
Products: Chlorinateds, fluorinateds, alcohols, esters, ketones, aliphatics, aromatics
Recycling Services: Thin film vacuum distillation, drying
Lab Facilities: GC, flash point, distillation, KF
Transport: Bulk, drum, and railcars
Other Services: Hazardous waste transportation to any TSD facility.

ALTERNATE ENERGY RESOURCES, INC.
2736 Walden Dr., Augusta, GA 30904
(404) 738-1571
Contact: Lamar Garrard, Assistant Manager
Products: Acetone, chlorinated solvents, freon, paint thinners, etc.
Recycling Services: Distillation
Lab Facilities: Pilot still, GC, KF, etc.
Transport: Bulk and drum
Other Services: Waste oil removal and spill cleanup

AQUAIR
P.O. Box 7048, Charlotte, NC 28217
(704) 588-0332
Contact: Jim Pugh
Products: Chlorinated and non-chlorinated solvents
Recycling Services: distillation
Lab Facilities: GC, AA, IR
Transport: Common carrier

ARIVEC CHEMICALS, INC.
7962 Huey Rd., Box 54, Douglasville, GA 30133
(404) 942-4332
Contact: James Parivechio, Jr., Vice President
Products: Aromatics, aliphatics, alcohols, ketones, glycols, esters, fluorocarbons, and chlorinated hydrocarbons
Recycling Services: Thin film, forced feed evaporation, and fractional distillation
Lab Facilities: All methods required for SW846 (EPA methods)
Transport: Bulk and drum

BARON-BLAKESLEE, INC.
1225 Apando Ave., Charlotte, NC 28206
(704) 333-9682
Contact: John Sparrow
Products: Chlorinated and fluorinated solvents
Recycling Services: Strictly distillation, thin film, pot still, columns on a toll basis for chemical customers only
Transport: Bulk
Other Services: Direct buy back, in-house recycling equipment sales

CHEMICAL SOLVENTS, INC.
3751 Jennings Rd., Cleveland, OH 44109
(216) 741-9310
Contact: Ron Forster, Recycling Manager
Products: chlorinated, fluorinated, flammables
Recycling Services: Thin-film evaporator, drying of solvents
Lab Facilities: GC, Karl Fischer moisture analysis, tag closed cup flash point tester
Transport: Bulk and drum
Other Services: Solvent blending

CHEMICAL WASTE MANAGEMENT, INC.
c/o SOLVENT RESOURCE RECOVERY
4301 Infirmary Rd., West Carrollton, OH 45449
(513) 859-6101
Contact: Joseph P. Henehan, Sales Representative
Products: Solvent blends, ink washes, aliphatic/aromatic hydrocarbons, ketones, ester, chlorinated hydrocarbons, freons
Recycling Services: Fractionation column, thin film evaporator, vacuum batch still
Lab Facilities: Gas chromatograph, Karl Fischer, tag closed cup tester, distillation column, etc.
Transport: Bulk and drum
Other Services: Solvent disposal pick-up service, cement kiln fuel service

CUSTOM ORGANICS INC.
1445 W. 42nd St., Chicago, IL 60609
(312) 247-2828
Contact: David A. Durakovich, Sales Manager
Products: DMAC, DMF, NMP, THF, freon, esters, misc., chlorocarbons and fluorocarbons
Recycling Services: Reaction, distillation (simple, fractional, azeotropic, extractive), and liquid-liquid extraction
Lab Facilities: Process development and analytical identification, utilizing all glass distillation equipment, wet chemical and instrumental analysis
Transport: Utilization of national carriers, both common and waste
Other Services: Process equipment design for internal utilization
Also see listing under Landfills.

DETREX CHEMICAL INDUSTRIES, INC.
Charlotte, N.C.
See listing under Chemical Suppl's

ENVIRONMENTAL RECYCLING
1901 E. Peabody St., Durham, NC 2770
(919) 596-7886
Contact: Dick Bray
Products: Chlorinated and fluorinated solvents, alcohols, ketones, lacquer thinner
Recycling Services: Wiped film evaporator
Lab Facilities: Gas chromatograph, test bench distillation
Transport: Pick-up locally, common carrier or chemical distributor

M & J SOLVENTS CO., INC.
P.O. Box 19703, Station N, Atlanta, GA 30325
(404) 355-8240
Contact: Donald E. McQueen, President
Products: Aromatics, aliphatics, ketones, esters, alcohols, glycols, paint and blends, chlorinated solvents
Recycling Services: Thin film distillation, solvent fractionation
Lab Facilities: Complete analysis services with chemist

M & J SOLVENTS CO., INC., continued
Transport: Bulk and drum
Other Services: Used solvent disposal, transportation, consulting services for waste handling

MARISOL INCORPORATED
125 Factory Lane, Middlesex, NJ 08846
(201) 469-5100
Contact: Eugene R. Streiter, Sales Executive; Robert I. Polgar, Sales Manager
Products: Thinners, aromatics, aliphatics, glycols, ketones, alcohols, chlorinated and fluorinated solvents
Recycling Services: Manufacturers of recycled solvents
Lab Facilities: Complete laboratory featuring GLC equipment, titration, Baum calorimeters, centrifuge, wet lab, K.F.
Transport: Bulk and drum
Other Services: Legal disposal of unrecyclables

MCKESSON ENVIROSYSTEMS CO.
127 West Berry St., Fort Wayne, IN 46802
(219) 424-1940
Contact: Sarah Austin
Territory Manager
McKesson Chemical Co.
P.O. Box 18805
Greensboro, NC 27419
(919) 292-0624
Products: Fluorocarbons, chlorinated solvents, ketones, alcohols, esters
Recycling Services:
State Hwy. No. 146
New Castle, KY 40050
(502) 845-2453
Steam stripping, atmospheric and vacuum distillation, batch and continuous fractionation and solvent extraction

MCKESSON ENVIROSYSTEMS CO., cont.
Lab Facilities: Chromatography
Transport: Tank fleet, bulk or drums
Branch Offices: Charlotte, N.C.
(704) 399-4255

THE PRILLAMAN COMPANY
P.O. Box 4024, Martinsville, VA 24115
(703) 638-8829
Contact: Sherman S. Dutton, Safety Director
Products: Compound, lacquer thinner, liquid waste -- 1-1-1 trichloroethane, methylene chloride, perchloroethylene
Recycling Services: Evaporation, distillation, dehydration

Lab Facilities: Four chemists
Transport: Bulk and drum
Branch Offices: American Alchemy Co.
P.O. Box 34189
Richmond, VA 23234
(804) 748-8139
Wade Ogg

RAMSEY CHEMICAL, INC.
P.O. Box 5006, Valdosta, GA 31601
(912) 247-7797
Contact: Fred Ramsey, Owner
Products: MEK, acetone, methylene chloride, 1-1-1 trichloroethylene, toluene, acetates, xylene, ferrin
Recycling Services: Thin film evaporation and drying
Lab Facilities
Transport: Bulk and drum
Other Services: Transport disposal materials to dump sites

SAFETY-KLEEN CORP.
655 Big Timber Rd., Elgin, IL 60120
(312) 697-8460
Contact: David Dattilo, Vice President Sales
Products: Metal parts cleaning service, industrial solvents, restaurant services, automotive paint refinishing services
Recycling Services: Six plants in United States to recover spent hydrocarbon and chlorinated solvent similar plant in Australia, solvent recovery plants in U.K. and Germany by contract.

SAFETY-KLEEN CORP., continued
Lab Facilities: Development and control lab at Corporate Headquarters. Also control laboratory at each recycle plant
Transport: Bulk and drum
Branch Offices: Over 200 branches worldwide

SCA CHEMICAL SERVICES, INC.
See information under Landfills.

SEABOARD CHEMICAL CORPORATION
5899 Riverdale Dr., Jamestown, NC 27282
(919) 886-4804
Contact: Robert Cottam III, Sales Manager
Products: Alcohols, ketones, aliphatics, aromatics, esters, glycol ethers, chlorinated solvents, fluorinated solvents, phenol, glycols
Recycling Services: Wiped film, fractionation, flash distillation, fuel program, blending, pilot projects
Lab Facilities: G/C, pilot plant, full solvent evaluation, analytical capabilities, flash point, BTU, chlorides
Transport: Bulk and drum
Other Services: Waste water treatment, vacuum service, fuel program, incineration off-site, waste consolidation service

SOUTHEASTERN CHEMICAL
170 S. Lafayette Blvd., Sumter, SC 29150
(803) 775-2121
Contact: Homer Tyson, Sales Manager
Products: Alcohols, ketones, hydrocarbons, chlorinated solvents
Recycling Services: Solvent distillation and water dehydration
Lab Facilities
Transport: Bulk and drum

SPECTRON, INC.
111 Providence Rd., Elkton, MD 219[illegible]
(301) 398-1736
Contact: R.V. Butt, Inc., Marketing Manager
Products: Chlorinated solvents (MCL, 1-1-1 TCE, perchlor, TCE, EDC), freon 113, lacquer solvents (ketones, alcohols, toluene, xylene), pharmaceutical solvents (incl. DMA)
Recycling Services: Turba-film distillation, flash distillation, plate column fractionation, double drum dryer, bottoms reduction, liquid-liquid extraction
Lab Facilities: Gas phase, chromatography, I-R spectrophotometry, Karl Fischer, calorimetry, flash point, around-the-clock quality control on processes, products, crudes, wastes
Transport: Bulk and drum
Other Services: Sales of surplus solvents in all categories, engineering design and consultation in waste management and solvent recovery
Branch Offices:
Illington Road (914) 762-5[illegible]9
Ossining, NY 10562 Richard V. Butt

STABLEX
Rock Hill, S.C.
See listing under Landfills.

VAN, WATERS & ROGERS, division of Univa
2660 Campus Dr., San Mateo, CA 94403
(415) 573-8000
Contact: Ronald B. Johnson, Vice President
Products: 1-1-1 trichloroethylene, perchloroethylene, methylene chloride, trichloroethylene, fluorocarbons
Recycling Services: Distillation, decanting, water washing
Lab Facilities: Full quality control including GLC
Transport: Bulk and drum
Branch Offices: Greensboro, N.C.
1-800-632-1095
Charlotte, N.C.
1-800-632-1095

APPENDIX E

HEAT RECOVERERS AND INCINERATORS

The following list was compiled through personal interviews, telephone conversations, and sales literature. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

ABCO INDUSTRIES, INC.
P.O. Box 335, Roebuck, SC 29376
(803) 576-6821
Contact: Charles Milford
Wastes Accepted: Organic liquids, aqueous and non-aqueous mixtures, emulsions and suspensions, organic residues and sludges that are pumpable or capable of being made pumpable
Incineration Services: Liquid injection, scrubbers, bag house filter, waste heat recovery
Recycling Services: 6000 gallon still for recycling solvents on a toll basis
Lab Facilities: Atomic absorption spectrophotometer, microprocessor ionalyzer, gas liquid chromatography, infrared spectrophotometer, bomb calorimeter
Transport: Bulk only; ABCO compartmentalized tank trucks available; common carrier or customer's truck; railcars

CALDWELL SYSTEMS, INC.
MITCHELL SYSTEMS, INC.
P.O. Box 1018, Lenoir, NC 28645
(704) 728-3251
Contact: Charles Foushee
Wastes Accepted: Solids and liquids with low chlorine and metals content, no cyanides

CALDWELL SYSTEMS, INC., continued
Incineration Services: Two-chamber liquid injection incinerator
Lab Facilities: Parr Laboratory in Charlotte
Transport: Pick-up services or customer's truck
Other Services: PCB clean-up and storage; spill clean-up; tank cleaning

CHEMICAL WASTE MANAGEMENT, INC.
Marietta, Ga.
See listing under Landfills.

ROLLINS ENVIRONMENTAL SERVICES, INC.
One Rollins Plaza, Wilmington, DE 19899-2349
(302) 429-2768
Contact: Richard Sernyak, Director of Marketing
Wastes Accepted: All hazardous waste and materials, solids, liquids and gases
Incineration Services: Three rotary kiln incinerators, with complete emission control equipment
Secure Landfill: No liquids, leachate systems, solidification and stabilization
Lab Facilities: Complete
Other Services: Deep well injection; PC disposal; clean-up services; chemica physical and biological treatment; laboratory waste management

SCA CHEMICAL SERVICES, INC.
Charlotte, N.C.
See listing under Landfills.

SOLITE/OLDOVER CORPORATION
P.O. Box 27211, Richmond, VA 23261
(804) 355-7851
Contact: Don Burris
Wastes Accepted: Solvents with 90,000 BTU/gal, less than 2% chlorides
Heat Recovery Services: High-temperature (2700°F) rotary kiln used to make light-weight aggregate
Lab Facilities
Transport: Bulk
Branch Office:
Carolina Solite
Aquadale, NC
(704) 474-3918

STABLEX
Rock Hill, S.C.
See listing under Landfills.

STAUFFER CHEMICAL COMPANY
P.O. Box 86, Mt. Pleasant, TN 38474
(615) 379-5813
Contact: Tony Livengood
Wastes Accepted: Wastes with 5000 BTU/lb or greater, includes solvents, still bottoms, chemical process waste and contaminated oil
Heat Recovery Services: 300 ft. rotary kiln for elemental phosphorus production
Lab Facilities
Transport: Provided by customer

SYSTECH
245 North Valley Rd., Xenia, OH 45385
(513) 372-8077
Contact: Joe Durczynski
Wastes Accepted: Liquids with a minimum of 80,000 BTU/gal, heavy metals limit
Heat Recovery Services: Provides fuel for General Portland Cement plants
Lab Facilities
Transport: Bulk

APPENDIX F

LANDFILLS

The following list was compiled through telephone conversations and sales literature. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

CHEMICAL WASTE MANAGEMENT, INC.
P.O. Box 3065
Marietta, GA 30061
(800) 241-7829
Contact: Charles Morrell, Technical representative
Wastes Accepted: All solid and liquid hazardous waste with a few exceptions
Secure Landfill: Disposal of bulk and drummed waste; some wastes solidified with cement kiln dust
Lab Facilities: Fully equipped
Transport: Bulk or drums, truck fleet
Other Services: U.S.E.P.A. permit to dispose of PCB materials; specialized laboratory disposal service; ocean incineration
Secure Landfill Address:
Hwy. 17 North Mile Marker 163
Emelle, AL 35459
(205) 652-9531

Deep Well Injection Address:
Chemical Waste Management, Inc.
(Ohio Liquid Disposal)
3956 S. W. 412
Vickery, Ohio 43464
(419) 547-7791

ROLLINS ENVIRONMENTAL SERVICES, INC.
Wilmington, Delaware
See listing under Heat Recoverers and Incinerators.

SCA CHEMICAL SERVICES, INC.
Rt. 1 Box 255, Pinewood, SC 29125
(803) 452-5003

Contact: Sales Manager
Landfill Services: Operates secure landfill, solidification of waste with Fuller's earth
Recycled Products: All solvents
Recycling Services: Thin film evaporation
Wastes Accepted For Incineration: All incinerable liquids and solids
Incineration Technology: Rotary kiln/liquid injection, quenchers, scrubbers
Lab Facilities: Fully equipped for waste analysis
Transport: Pick-up service

SOLID TEK
5371 Cook Rd., Morrow, GA 30260
(404) 361-6181
Contact: Judy McElroy
Wastes Accepted: Liquid or solid hazardous and non-hazardous waste
Services: Chemical fixation and solidification, mobile treatment unit and other technical services

STABLEX
P. O. Box 2664 CRS, Rock Hill, SC 29731
(803) 324-5310
Contact: Randy Cook
Waste Accepted: Non-chlorinated and chlorinated organic solids, sludges and liquids.
Solidification and Stabilization: Sealo-safe technology available in mid-1984; solidified waste is considered non-hazardous and can go to sanitary landfill.
Recycling Services: Two pot stills for solvent recovery.
Incineration Technology: Two-chamber multiple hearth E.A.M. incinerator.
Lab Facilities: Fully equipped.
Transport: Bulk or drum, truck fleet.

US ECOLOGY
P.O. Box 7246, Louisville, KY 40207
(502) 426-7160
Contact: Vicki Lenz, Manager, Chemical Sales
Wastes Accepted: RCRA Solid waste
Secure Landfill: Nevada, Texas - sites for hazardous chemical wastes
Lab Facilities
Transport
Other Services: Incineration and recycling.

APPENDIX G

HAZARDOUS WASTE SERVICES

The following firms offer a variety of services to generators of hazardous wastes. The list was compiled through personal interviews, telephone conversations, and sales literature. The preparers of this list take no responsibility for the list's completeness or for the quality of services offered by these firms.

ECOFLO
823 North Elm St., Suite 203-A
Greensboro, NC 27401
(919) 378-0166
Contact: Michael Kelly
Services: On-Site handling, transportation, treatment or disposal, lab pack service, PCB destruction, spill response, waste characterization, compliance audits and consulting, lagoon replacement

ENVIRO-CHEM WASTE MANAGEMENT SERVICES
P.O. Box 10784, Raleigh, NC 27605
(919) 469-8490
Contact: Jerry Deakle
Services: Waste analysis, transportation, technical services, on-site treatment, consolidation, resource recovery, neutralization, high temperature incineration, secure landfill, abandoned site clean-up, spill response, industrial cleaning, explosive material disposal, consulting and audits

NATIONAL ASSOCIATION OF SOLVENT RECYCLERS
P.O. Box 1288, Dayton, OH 45402
(513) 223-0419
Contact: Andy Goutman
Services: A trade organization which promotes solvent reclamation activities. Benefits for its members include meetings, industry surveys, travel discounts, insurance, the "Green Book" which profiles the association's members, a monthly newsletter and numerous bulletins on regulatory topics relevant to the recycling industry.

TRI/TRIANGLE RESOURCE INDUSTRIES
(Purchased by SCA)
Rt. 1, Watlington Industries Rd.,
Reidsville, NC 27320
Contact: Michael Burns or Gary Seavey
Services: Regulatory briefing seminars, compliance documentation, lab analysis, disposal method selections, site selection, transportation, follow-up audits, emergency spill clean-up, safety supplies and packaging materials