Hazardous Waste Management by Small Quantity Generators—Chlorinated Solvents in the Dry Cleaning Industry

Kathleen Wolf, Christopher W. Myers
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Kathleen Wolf, Christopher W. Myers

June 1987

RAND
PREFACE

This report provides an assessment of chlorinated solvent use and waste generation in the dry cleaning industry. It summarizes the waste management practices in dry cleaning and extends them to other small quantity generators.

The research should be of primary interest to policymakers and industry representatives concerned with management of chlorinated solvent wastes. It should also be of interest to policymakers focusing on ways to bring small quantity generators under the rubric of hazardous waste regulations.


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SUMMARY

Thousands of businesses in the United States today generate small quantities of hazardous waste; such generators are known as small quantity generators (SQGs). In the 1984 Hazardous and Solid Waste Amendments (HSWA), Congress specified that SQGs be brought into the scope of the federal hazardous waste management system. In September 1986, they became subject to the Resource Conservation and Recovery Act (RCRA).

The dry cleaning industry is dominated by SQGs who together generate a significant amount of hazardous waste. In particular, two chlorinated solvents are employed in the dry cleaning of clothing and other items. These solvents are under regulatory scrutiny for a variety of reasons not related to hazardous waste. In terms of waste, such solvents have recently been restricted from land disposal, and in the last few years dry cleaners have adopted new management techniques to minimize the amount of waste they generate, by relying extensively on external recycling firms. We chose the dry cleaning industry for detailed analysis because of this unique waste management structure and because the results could shed light on management opportunities for other SQGs.

Policymakers concerned with the effect of hazardous waste regulations on small quantity generators and with the land disposal restrictions must understand how the private sector is likely to respond to the increasingly stringent regulatory regime. To assess and anticipate the effects of various policies, it is necessary to consider the solvents' "life cycle." Over its life cycle, the solvent is produced, used, emitted, perhaps reused, and finally disposed of. This characterization helps to focus on appropriate and technically feasible waste generation and management opportunities.

The amount of solvent used by the dry cleaning industry is debated. In the analysis presented here, we develop a materials balance that provides a reasonable estimate of solvent use. In terms of solvent waste, our results suggest that other research may have underestimated the level of waste generated in the industry. They also suggest that private sector recycling firms have already brought most retail and industrial dry cleaners into compliance with hazardous waste regulations. Virtually no recycling is practiced at present in the coin-operated dry cleaning sector in spite of the fact that a significant fraction of dry cleaning waste is generated there.
We present information illustrating that other SQGs in a range of diverse industries generate a substantial amount of solvent waste. Although some of this waste is currently managed through reclamation, the available data indicate that the potential for reclamation is much higher.
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I. INTRODUCTION

Thousands of small businesses in the United States today use hazardous substances in the course of providing their product or service. For hazardous waste management purposes, such businesses—those that generate between 100 and 1,000 kilograms of waste each month—have been termed small quantity generators (SQGs). It is estimated that there are 175,000 SQGs nationwide. These firms represent 98 percent of the generators but together account for only 760,000 metric tons (mt) or 0.3 percent of the total waste produced annually (Abt Associates, 1985). Because systematic enforcement of so many generators is impractical, they are the most likely generators to practice improper disposal. It is worthwhile therefore to study SQG waste practices to identify ways to bring them into the formal waste management system and induce them to stay.

SQGs include both industrial and commercial firms like print shops, pesticide formulators, auto repair and body shops, and dry cleaners. They range in size from “mom and pop” stores to large companies with several employees. Many are cash businesses and, as a result, industry data on their characteristics are often unavailable, incorrect, or inadequate. In spite of these data limitations, industry profiles can yield unexpected and useful information for formulating policy. The dry cleaning industry—composed largely of SQGs—is of particular interest because it is at the same time diverse and fairly well-defined. For these reasons, we chose that industry as the generic representative of the hazardous chemical use and waste generation patterns of SQGs.

This report, one of two companion documents, focuses on alternatives to land disposal for a class of chemical called chlorinated solvents. These solvents are interesting because they pose a range of environmental and health problems, they are used widely in a variety of diverse industries, and they were among the first substances to be banned from land disposal in November 1986 under the Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act (RCRA). Two of the chlorinated solvents—perchloroethylene (PERC) and 1,1,2-trichloro-1,2,2-trifluoroethane (CFC-113)—are used in the dry cleaning industry and it is these we address here.

This work has three main aims. The first is to develop a profile of the dry cleaning industry by describing and estimating the level of solvent use, emissions, and waste generated. The second is to suggest...
ways to use land disposal alternatives for managing waste generated in the dry cleaning industry. The third aim is to explore the similarities and differences among dry cleaners and other SQGs with an eye toward extending the results to other industries.

With these aims in mind, in Sec. II we briefly describe the life cycle of solvent use in three dry cleaning sectors. We track the chlorinated solvents from production, through use, and finally through emissions and disposal. There is debate about the amount of perchloroethylene devoted to dry cleaning. Our analysis involves an allocation that we believe to be reasonable. We also present an estimate of the amount of waste generated by the dry cleaning industry that is significantly greater than the widely accepted estimate of the Environmental Protection Agency (EPA).

In Sec. III, we describe the health and environmental effects of the solvents and we discuss the regulations that affect the dry cleaning industry. In this light, we present historical case studies of the two chlorinated solvents used in dry cleaning. These cases illustrate the importance of considering the complete regulatory environment of a chemical. This focus sets the stage for examining the context in which regulations affecting hazardous waste can be evaluated.

In Sec. IV, we focus on the impending land disposal ban and the SQG regulations that have recently brought dry cleaners under the rubric of RCRA. We identify and discuss alternatives to land disposal that are being and will be adopted in the future. We pinpoint similarities and differences between the dry cleaning industry and other SQGs and suggest methods that other industries might find useful for moving away from land disposal.

Sec. V draws some conclusions from the analysis and provides some direction for future work.
II. INDUSTRY DESCRIPTION

This section presents an overview of the dry cleaning industry. Most SQGs are not well characterized and a detailed assessment of waste practices in one industry consisting of SQGs can be useful for generalizing to other such industries. In developing the profile of the dry cleaning industry presented here we relied on published data whenever possible. Because such data are frequently unavailable, however, we have also used information from industry representatives with expertise in specific areas of dry cleaning. The method is an eclectic one—mandated by data limitations—that draws heavily on verifying information from very different sources using more than one approach.

In what follows, we first present relevant summary statistics on the three sectors that constitute the dry cleaning industry. We then describe the dry cleaning process and focus on the solvents used in the industry. Finally, we present a materials balance for tracking the chlorinated solvents used in the industry from production through disposal.

INDUSTRY CHARACTERIZATION

Table 2.1 presents statistics on the dry cleaning industry for 1977 and 1982. The Bureau of Census provides complete summary data on various industries at five-year intervals; the most recent data are for 1982.

As shown in Table 2.1, the dry cleaning industry is composed of businesses in three Standard Industrial Classification (SIC) codes. These include: 7215, coin-operated establishments; 7216, commercial dry cleaning plants; and 7218, industrial laundries. The values show that the number of coin-operated laundries and commercial dry cleaning plants declined between 1977 and 1982. In contrast, the number of industrial laundries increased. Receipts in the three sectors increased 38 percent for coin-operated laundries, 52 percent for dry cleaning plants, and 75 percent for industrial laundries over the period.

Coin-operated dry cleaning establishments are generally part of a so-called laundromat. They are frequently independently operated or a franchise and they offer low-cost, self-service dry cleaning. Not all coin-operated facilities contain dry cleaning equipment but those that do typically have two or three dry cleaning machines. Commercial dry cleaning facilities include the independent "mom and pop" dry cleaners
Table 2.1
INDUSTRY STATISTICS, 1977 AND 1982

<table>
<thead>
<tr>
<th>SIC Code</th>
<th>Description</th>
<th>1977</th>
<th>1982</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Establishments</td>
<td>Receipts ($1,000)</td>
<td>No. of Establishments</td>
</tr>
<tr>
<td>7215</td>
<td>Coin-operated laundries</td>
<td>12,446</td>
<td>844,916</td>
</tr>
<tr>
<td></td>
<td>and dry cleaning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7216</td>
<td>Dry cleaning plants,</td>
<td>21,968</td>
<td>1,895,772</td>
</tr>
<tr>
<td></td>
<td>except rug cleaning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7218</td>
<td>Industrial launderers</td>
<td>1,054</td>
<td>1,147,277</td>
</tr>
</tbody>
</table>


as well as franchised establishments and specialty shops. Each commercial firm cleans an average of 67,000 pounds of clothing annually. Industrial dry cleaners are typically large plants that offer rental services for uniforms or other goods to institutional, business, or industrial customers. Each industrial cleaner processes between 600,000 and 1.5 million pounds of clothing annually (U.S. EPA, 1978).

PROCESS DESCRIPTION

The dry cleaning process, displayed in Fig. 2.1, is similar to the common laundering process but employs organic solvents rather than detergent and water. In the first step, clothing is placed in the washer and solvent is added. In the second step, the clothing is agitated and then a spin cycle extracts the solvent. In the third step the solvent is filtered and then distilled to remove contaminants. The filtered solids contain solvent, which is removed and returned to the system. The filters and the still bottoms from the distillation process contain waste solvent.

There are two types of machines—dry-to-dry and transfer. In a dry-to-dry machine, the fourth step in the process, where the clothing is tumbled dry, is performed in the same machine as the cleaning. In a transfer machine, the clothing is transferred to a dryer. During the drying cycle, the solvent is either recovered in a condenser for reuse or vented to the atmosphere. In the final step—called aeration or deodorization—ambient air is passed through the clothing to evaporate remaining solvent.
DRY CLEANING SOLVENTS

Two classes of solvents are used in the dry cleaning industry. The first class—petroleum solvents—are mixtures of paraffins and aromatic hydrocarbons and are similar to kerosene. The second class—halogenated solvents—includes PERC, a chlorinated solvent, and CFC-113, a chlorofluorocarbon. Table 2.2 shows the fraction of plants in the three dry cleaning sectors using each solvent as estimated by an official of the International Fabricare Institute (IFI), an industry trade organization.

The disadvantage of petroleum solvents is their flammability. Petroleum solvents are cheaper than PERC, about $1.20 per gallon versus around $4 per gallon. The equipment for use with petroleum solvents is designed to be explosion-proof. Because of their explosivity and flammability, petroleum solvents are used in transfer equipment rather than in dry-to-dry machines. These solvents are used in the
industrial and commercial sectors mainly in the southeastern United States where fire regulations permit it.

PERC—the most widely used solvent—is nonflammable, relatively inexpensive, and has aggressive solvent properties. PERC is used in both transfer and dry-to-dry machines. CFC-113, like PERC, is nonflammable. It is a much less aggressive solvent, however, and is used largely to clean delicate items. Because of its much higher cost—about $16 per gallon—CFC-113 is used exclusively in dry-to-dry machines in which the consumption of solvent is minimized.

The National Fire Protection Codes prevent the use of petroleum solvents in coin-operated dry cleaners (GCA, 1983). Virtually all the coin-operated dry cleaning units today use PERC although some used CFC-113 in the past. Both petroleum solvents and PERC are used in commercial and industrial establishments. Although CFC-113 is used to a small extent in the commercial dry cleaning sector, most new commercial dry cleaners are choosing PERC. Because of health and environmental pressure on PERC (see Sec. III), industrial laundries are converting to water. In summary, one industry source estimates that PERC is used to clean about 70 percent of the clothing that is dry cleaned; the balance is nearly all petroleum solvent.

Consumption rates of the three solvents in dry cleaning differ because they depend on the characteristics of the solvent and of the equipment in which they are used. One industry source indicates that PERC consumption in commercial and industrial establishments is 10 to 12 pounds per hundred pounds of clothing cleaned; consumption in coin-operated units is 20 to 22 pounds per hundred pounds of clothing.

Table 2.2

<table>
<thead>
<tr>
<th>Dry Cleaning Sector</th>
<th>PERC</th>
<th>Petroleum</th>
<th>CFC-113</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coin-operated*</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Commercial</td>
<td>75</td>
<td>22.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Industrial*</td>
<td>50</td>
<td>50</td>
<td>0</td>
</tr>
</tbody>
</table>

SOURCE: Industry estimates.

*Only about 14 percent of the coin-operated facilities offer dry cleaning.

*A large percentage—perhaps 75 percent—of industrial plants are laundries that employ only water.
cleaned. Consumption of petroleum solvents in commercial and industrial facilities is 8 to 12 pounds per hundred pounds of clothing cleaned for users with cartridge filters and recovery; 20 pounds for users with cartridge filters alone; and 28 pounds for users with older "powder" machines. CFC-113 consumption in the commercial sector ranges from 7 to 8 pounds per hundred pounds of clothing cleaned; in new machines, it can be as low as 3 to 5 pounds.

In the dry cleaning process, most of the solvent is emitted to the atmosphere and some is retained as solid waste. According to an industry source, an average dry cleaner generates about 120 kilograms of waste PERC each month; such firms are SQGs.

Dry cleaners' waste is of two types. First, PERC and CFC-113 users produce a still residue that results from distilling the waste solvent on site, usually in a pot still, to remove contaminants. The second type of waste PERC users generate is either a standard cartridge filter or an adsorptive cartridge filter that contains a solvent residue. CFC-113 users generally employ standard cartridge filters. Some PERC users still use the older "powder" machines. They generate diatomaceous earth and no still residue. All wastes containing PERC and CFC-113 are considered hazardous under federal regulations (see Sec. III).

Petroleum solvent users generate only a still residue. In some cases—if the solvent has a flash point of 140°F or above—the waste is not legally hazardous. Wastes from petroleum solvents with a lower flash point, like Stoddard solvent, are classified as "ignitable" and therefore hazardous.

**SOLVENT MATERIALS BALANCE**

The amount of chlorinated solvent used in dry cleaning is not known with certainty. This uncertainty in use in turn creates uncertainty about the level of emissions and waste. As we see below, dry cleaning solvents are coming under increasing regulatory scrutiny and decisions that will affect the future of the industry require a more accurate profile. Accordingly, in what follows, we estimate the production of PERC and CFC-113 and their use, emissions, and waste levels in dry cleaning.

---

1 Small quantity generators produce between 100 and 1,000 kilograms of waste each month.

2 For users of petroleum solvents, well-drained filter cartridges and diatomaceous earth from "powder" machines are solids and do not meet the criteria of a hazardous waste.
Production

Figure 2.2 displays the relationship between PERC and CFC-113. As indicated, PERC is used in the production of CFC-113 and both chemicals are used in the dry cleaning industry. Production levels of PERC therefore are dependent on the demand for CFC-113.

In Table 2.3, we present annual production levels, exports, imports, and domestic demand for PERC and CFC-113 for several recent years in thousands of mt. Note that data on exports and imports for CFC-113 are not publicly available and the values for production of that solvent are RAND estimates. Appendix A describes the assumptions used in the derivation of the CFC-113 values.

The figures of Table 2.3 indicate that domestic PERC demand peaked in about 1980, declined through 1983, and increased again in 1984. As we shall see below, this reflected a decline in the demand for PERC in the dry cleaning industry and an increase in demand for PERC in CFC-113 production. In contrast to the PERC values, CFC-113 production increased steadily over the period. In this case, the growth is due largely to increased demand in the electronics industry, where CFC-113 is used in a variety of cleaning applications.

Use in Dry Cleaning

The level of PERC that is used in the dry cleaning industry is the subject of continuing debate. The chemical producers in a “top-down” approach estimate that use is equal to the amount of PERC they sell to

![Diagram showing the interrelationship between PERC and CFC-113](image)

Fig. 2.2—Interrelationship between PERC and CFC-113
Table 2.3

PRODUCTION AND DEMAND FOR PERC AND CFC-113, 1975 TO 1985
(In thousands of mt)

<table>
<thead>
<tr>
<th>Year</th>
<th>PERC</th>
<th>CFC-113</th>
<th>Exports</th>
<th>Imports</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>308</td>
<td>29</td>
<td>24</td>
<td>17</td>
<td>301</td>
</tr>
<tr>
<td>1976</td>
<td>303</td>
<td>31</td>
<td>22</td>
<td>28</td>
<td>309</td>
</tr>
<tr>
<td>1977</td>
<td>279</td>
<td>37</td>
<td>22</td>
<td>27</td>
<td>284</td>
</tr>
<tr>
<td>1978</td>
<td>329</td>
<td>39</td>
<td>29</td>
<td>17</td>
<td>317</td>
</tr>
<tr>
<td>1979</td>
<td>350</td>
<td>47</td>
<td>44</td>
<td>9</td>
<td>315</td>
</tr>
<tr>
<td>1980</td>
<td>347</td>
<td>50</td>
<td>34</td>
<td>14</td>
<td>327</td>
</tr>
<tr>
<td>1981</td>
<td>313</td>
<td>53</td>
<td>35</td>
<td>16</td>
<td>294</td>
</tr>
<tr>
<td>1982</td>
<td>265</td>
<td>56</td>
<td>20</td>
<td>17</td>
<td>262</td>
</tr>
<tr>
<td>1983</td>
<td>248</td>
<td>60</td>
<td>25</td>
<td>25</td>
<td>248</td>
</tr>
<tr>
<td>1984</td>
<td>260</td>
<td>68</td>
<td>13</td>
<td>60</td>
<td>307</td>
</tr>
<tr>
<td>1985</td>
<td>224</td>
<td>73</td>
<td>10</td>
<td>64</td>
<td>278</td>
</tr>
</tbody>
</table>


*See Appendix A for the derivation of CFC-113 production.

Demand for PERC is equal to production minus exports plus imports.

No data on CFC-113 exports and imports are available and our estimates of production probably also correspond roughly to demand.

distributors who market to dry cleaners. This estimate is probably too high because most distributors who sell to dry cleaners also sell to customers in other industries.

The "bottom-up" approach for estimating the amount of PERC that goes into dry cleaning involves using census data. These data—shown in Table 2.1—give the receipts and number of establishments in the commercial, coin-operated, and industrial sectors. This information together with the costs of dry cleaning and solvent consumption rates lead to an estimate of PERC use. This procedure is likely to underestimate PERC use because only establishments with payrolls are included in census data, and because underreporting of receipts is common in cash businesses like dry cleaning.

Our procedure is to choose an estimate between the values obtained from the top-down approach on the one hand and the bottom-up approach on the other hand. Table 2.4 shows these virgin use estimates for PERC as well as those for CFC-113 for two recent years. The year 1982 was chosen because the Bureau of Census summary data are given for that year. We include estimates for 1984 because
Table 2.4
ESTIMATES OF VIRGIN SOLVENT USE IN DRY CLEANING
(In thousands of mt)

<table>
<thead>
<tr>
<th>Year</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Coin-Operated</th>
<th>Total</th>
<th>CFC-113 Commercial</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>75</td>
<td>10</td>
<td>25</td>
<td>110</td>
<td>1.6</td>
</tr>
<tr>
<td>1984</td>
<td>83</td>
<td>7</td>
<td>40</td>
<td>130</td>
<td>2.0</td>
</tr>
</tbody>
</table>

SOURCE: See Appendix B for detailed calculations.

Preliminary values from the Bureau of Census are available. Appendix B describes the allocation procedure in detail.

Table 2.4 illustrates that the majority of chlorinated solvent used in the dry cleaning industry is PERC. CFC-113 is used only to a small extent, generally for cleaning specialty items in the commercial sector. It also shows that a healthy fraction of the PERC is used in the commercial sector, that PERC use in the commercial sector and coin-operated dry cleaning increased over the period, and that PERC use in the industrial sector declined during the period.3

Waste Generation

The solvent used in the dry cleaning process is either emitted to the atmosphere or retained as solid waste. As discussed above, PERC dry cleaners using new machines in the commercial sector generate two types of wastes—a still residue, and either standard cartridge or adsorptive cartridge filters. Dry cleaners using older machines do not use stills and generate only a cooked power residue. Industrial and coin-operated establishments likely generate waste in the same proportion of use as commercial establishments.

Commercial dry cleaners employing CFC-113 all use new machines, which are very conservative of solvent. As with PERC, they generate both a still residue and a filter but the total amount of waste is less than that of a PERC user.

In Table 2.5, we show our estimates of the amount of PERC and CFC-113 waste generated in the three dry cleaning sectors. The data are based on the use estimates in Table 2.4 and rely heavily on information supplied to RAND by reclaimers who service the industry. The

3Reclaimed PERC is also used in the dry cleaning industry in place of virgin PERC. One source claims that as much as 8,000 mt of reclaimed PERC may be reused in dry cleaning; another source suggests a much smaller amount.
Table 2.5

ESTIMATES OF SOLVENT WASTE IN DRY CLEANING, 1984
(In thousands of mt)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Coin-Operated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERC</td>
<td>9.8</td>
<td>0.8</td>
<td>4.7</td>
<td>15.3</td>
</tr>
<tr>
<td>CFC-113</td>
<td>0.2</td>
<td>—</td>
<td>—</td>
<td>0.2</td>
</tr>
</tbody>
</table>

estimates were derived according to the assumptions described in Appendix C. Note that the total amount of waste given in Table 2.5 represents about 12 percent of the PERC and 10 percent of CFC-113 used in the dry cleaning industry.

Water Releases

In principle, the difference between the solvent used in dry cleaning and the amount of waste solvent generated should equal solvent emissions. In fact, however, dry cleaners release a small amount of solvent in their separator water.4 One source estimates that each year the average dry cleaner (presumably commercial) generates 500 gallons of separator water containing 6 fluid ounces of PERC. If each commercial dry cleaner releases 6 ounces, then total commercial releases amount to about 3 to 4 mt per year. Even if we include industrial and coin-operated establishments, the amount of solvent released in this manner is still negligible.

Emissions

Table 2.6 shows our estimates of dry cleaning emissions. The data were determined by subtracting the amount of waste generated from the amount of solvent used in each sector. Note that the values represent about 88 percent of the PERC and 90 percent of the CFC-113 used in dry cleaning in Table 2.4. This agrees fairly well with one study that indicates that PERC emissions from dry cleaning in 1978 amounted to 85 percent of use (U.S. EPA, 1980).

4Many dry cleaners who distill add water which forms an azeotrope or constant boiling blend with PERC at about 194°F. This blend comes off at a lower temperature than PERC alone, which has a boiling point of 212°F. A small amount of PERC remains in the water after separation.
Table 2.6
ESTIMATES OF SOLVENT EMISSIONS IN DRY CLEANING, 1984
(In thousands of mt)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Commercial</th>
<th>Industrial</th>
<th>Coin-Operated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERC</td>
<td>73.3</td>
<td>6.2</td>
<td>35.3</td>
<td>114.8</td>
</tr>
<tr>
<td>CFC-113</td>
<td>1.8</td>
<td>—</td>
<td>—</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Summary of Solvent Life Cycle

The results of the materials balance for 1984 are summarized in Table 2.7. In the case of PERC, dry cleaning accounts for roughly 40 percent of total demand, and emissions and waste represent 87 and 13 percent of total use in dry cleaning, respectively. For CFC-113, dry cleaning use represents a much smaller fraction of total demand—only about 3 percent—and the emissions and waste breakdown is roughly the same as that for PERC.

COMPARISON WITH OTHER VALUES

In what follows, we compare our estimates of chlorinated solvent use and waste generation in dry cleaning with others.

Table 2.7
SUMMARY OF SOLVENT MATERIALS BALANCE, 1984
(In thousands of mt)

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Use in Dry Cleaning</th>
<th>Emissions</th>
<th>Waste</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demand Amount % of Demand</td>
<td>Amount % of Use</td>
<td>Amount % of Use</td>
</tr>
<tr>
<td>PERC</td>
<td>307 130 42</td>
<td>115 88</td>
<td>15 12</td>
</tr>
<tr>
<td>CFC-113</td>
<td>68   2   3</td>
<td>1.8 90</td>
<td>0.2 10</td>
</tr>
</tbody>
</table>
Solvent Use

The procedure we used to determine the level of use of PERC in dry cleaning is described in detail in Appendix B. Here, we briefly compare our value with other estimates. The 1982 Chemical Marketing Reporter profile on PERC states that 59 percent or 166,000 mt of the chemical was used in dry cleaning and textile processing. The International Fabricare Institute estimates that 122,500 mt of PERC was sold into the dry cleaning industry in 1982. These two top-down estimates are higher than a bottom-up estimate of 82,000 mt derived from the 1982 Bureau of Census data.

Our estimate for 1982—110,000 mt in Table 2.4—lies between the high and low estimates. The Chemical Marketing Reporter value is much too high, even taking into account significant use in textile processing. As discussed in Appendix B, the value in the chemical profile for PERC intermediate use was underestimated in that year. The estimate derived from the Bureau of Census data is probably much too low because of underreporting of receipts, because many dry cleaners do not have payrolls, and because parttime employees are not included. Our estimate agrees more closely with that of the International Fabricare Institute.

Waste Generation

There are two other estimates of dry cleaning industry waste generation. The first—an EPA value for SQG dry cleaning filtration residues—is apparently based on the second—an Abt Associates (1985) figure for dry cleaning filtration residues.

EPA reports the waste generated by small quantity generators in 1981 (U.S. EPA, 1985). The data indicate that small quantity generator dry cleaning filtration residues amount to 1.6 million gallons annually. About 72 percent or 1.15 million gallons was designated as halogenated waste—presumably meaning PERC and CFC-113. We do not know what EPA assumed about the composition of the waste. For simplicity, if we assume it is all halogenated solvent, then 15.6 million pounds or 7,000 mt of waste was generated. This value is much lower than the 1984 estimate of 15,500 mt developed here for all dry cleaners' waste PERC and CFC-113 combined.

5The densities of PERC and CFC-113 are 13.55 and 13.16 pounds per gallon, respectively. Because so little of the waste is CFC-113, we introduce little error by using the density of PERC for the conversion. If we assume that part of EPA's waste is other organic material, we would use a lower density and would obtain a lower weight of solvent. Furthermore, the part of the residue that is not halogenated solvent would have to be subtracted for comparison with our values.
The EPA estimate for dry cleaning SQG waste is lower than our estimate by a factor of two. An explanation for a small part of the discrepancy is that our estimate is for 1984 and the EPA estimate is for 1981. PERC demand in 1981, however, was only slightly lower than that for 1984 (see Table 2.3). Another explanation for the discrepancy may involve the definition of small quantity generators as monthly generators of between 100 and 1,000 kilograms of waste. We have included all dry cleaners' waste, and a significant fraction of them may generate less than this amount.

In this light, the Abt Associates study (which EPA cites for its figure) estimates dry cleaning filtration residues at 13,660 mt per year. Some 8,500 mt is generated by SQGs and the remainder comes from firms who generate less than 100 kilograms per month (Abt Associates, 1985). The Abt study did not survey coin-operated facilities but may have included an estimate of their waste in the total figures. We did not apportion the waste among the different waste level generators—very small quantity generators (VSSQGs) (less than 100 kilograms per month), small quantity generators, and large quantity generators (greater than 1,000 kilograms per month).

A more general question arises about the level of waste we calculate here. One EPA official and both of the firms that reclaim waste in the dry cleaning industry believe that dry cleaners with whom they have contracts do not give them all the waste they generate and that some of the waste is probably disposed of illegally.\(^6\) One estimate is that waste in the retail and industrial sectors may actually be about 25 percent higher, giving a total estimate of PERC waste of 18,000 rather than 15,300 mt. There is an even larger discrepancy between this value and those of EPA and Abt Associates.

Our analysis suggests that chlorinated solvent waste from dry cleaning in the retail, industrial, and coin-operated sectors amounts to at least 15,400 mt. We have not distinguished between SQGs and VSSQGs. Although SQGs are now subject to federal hazardous waste regulations, VSSQGs are not.\(^7\) It is useful to policymakers to have good figures on the amount of waste in the dry cleaning industry subject to regulation. In future work, we plan to use the 1984 Bureau of Census data to correlate receipts of the different sizes of firms with waste generation.\(^8\) This will allow us to estimate how much of the total dry cleaning waste is generated by SQGs and how much by VSSQGs.

---

\(^6\) One reclaimers has recently sold his dry cleaning business to the other. Thus, there is now only one dry cleaning waste reclaimer in the United States.

\(^7\) SQGs are regulated in some states. See Table 4.1.

\(^8\) The assumption is that receipts are proportional to pounds of clothing cleaned, which is proportional to solvent use, which is proportional to waste generation.
III. THE HISTORICAL REGULATORY REGIME

A number of regulations apply to the PERC and CFC-113 used in the dry cleaning industry. Although some of these regulations do not address hazardous waste, they have in the past and they will in the future govern trends in the industry that will affect the level of waste generated. In what follows, we first present the health and environmental effects of the chlorinated solvents used in dry cleaning. We then discuss the various regulations that influence solvent use. Finally, we present a historical case study of an industry under increasing regulatory scrutiny.

HEALTH AND ENVIRONMENTAL EFFECTS

Table 3.1 presents a summary of some important characteristics of the chlorinated solvents used in dry cleaning.

The first column of the table gives the threshold limit value or TLV for the two chemicals. It is defined as the maximum allowable time-weighted average concentration to which a human may be exposed over an eight-hour working day, 40-hour work week. The higher the TLV, the higher the allowable level of exposure. CFC-113 has a TLV of 1,000 ppm, the highest level assigned to any chemical; PERC, on the other hand, has a very low TLV.

<table>
<thead>
<tr>
<th>Solvent</th>
<th>TLV (ppm)</th>
<th>Carcinogenicity in Animals</th>
<th>Potential Ozone Layer Depletion</th>
<th>Hazardous Air Pollutant</th>
</tr>
</thead>
<tbody>
<tr>
<td>PERC</td>
<td>100*</td>
<td>Positive</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CFC-113</td>
<td>1,000</td>
<td>Negative</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>


*The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended that the TLV be lowered to 50 ppm.
The second column of Table 3.1 indicates whether the chemical has been found to cause cancer in animals. CFC-113 has been tested on rats and did not induce tumors (Signon, 1985). PERC was traditionally classified as a possible human carcinogen (class C). A recent inhalation study showed an increased incidence of liver tumors in mice and elevated levels of cell leukemia and kidney tumors in rats. Since earlier mice studies were also positive, the positive findings for rats, in particular, may lead to PERC’s formal recategorization as a probable human carcinogen (class B) by the National Toxicology Program (Fed. Reg., December 26, 1985). Indeed, on the basis of the recent test results, the EPA has already so classified it (Call and Massouda, 1986).

The third column of Table 3.1 indicates whether the chemical decomposes in the lower atmosphere and forms precursors that lead to photochemical smog (ozone) formation. All chemicals are considered to contribute to ozone formation in the troposphere (lower atmosphere) unless specifically exempted. CFC-113 as a member of the chlorofluorocarbon family is exempted; PERC is not.

The fourth column indicates whether the chemical potentially causes ozone depletion in the upper atmosphere or stratosphere. Because CFC-113 contains no hydrogen, it is not subject to attack by the hydroxyl radical in the lower atmosphere. It therefore survives intact until it reaches the stratosphere where ultraviolet light leads to decomposition. The liberated chlorine can react catalytically with ozone. CFC-113’s long atmospheric lifetime—about 86 years—and its high chlorine content make it a relatively strong potential depletor (Quinn et al., 1986). PERC does not contribute to potential ozone depletion because it does react with the hydroxyl radical in the troposphere.

The fifth column specifies whether the chemical is classified as a hazardous air pollutant under Section 112 of the Clean Air Act. Although EPA published an intent to list PERC under Section 112 of the Clean Air Act, the agency is still evaluating whether such action is necessary.

The petroleum solvents that are also used in the dry cleaning industry are combustible in contrast to the chlorinated solvents. Most of these solvents have TLVs below 500 ppm (GCA, 1983) and many contribute to photochemical smog formation in the lower atmosphere.

REGULATORY STATUTES

A number of different statutes and regulations apply to the solvents used in dry cleaning. In what follows, we discuss several of these.
Air Regulations

Volatile Organic Compounds. In 1977, EPA announced its “recommended policy on the control of volatile organic compounds (VOCs).” Periodically thereafter, the agency issued lists of organic compounds that are negligibly photoactive and thus exempt from regulation to attain the national ambient air quality standards under State Implementation Plans (SIPs).

Exempted VOCs include methane, ethane, methylene chloride, methyl chloroform, and eight chlorofluorocarbons. In 1983, EPA issued a notice to propose that PERC be exempted as well (Fed. Reg., October 24, 1983). The proposal was never made, however, and PERC therefore is still considered photochemically reactive.

A number of states have regulations designed to reduce emissions of photochemically reactive substances. They commonly require an 85 percent reduction in emissions of such substances. In the case of PERC, reductions are required for dry cleaners, for solvent metal cleaners, and for fugitive emissions from other sources. Some states have adopted these standards only for nonattainment areas—areas that have not achieved the ambient air quality standards for ozone—whereas others have adopted them statewide.

Hazardous Air Pollutants. Under Section 112 of the Clean Air Act, EPA is required to set National Emission Standards for Hazardous Air Pollutants (NESHAP). Hazardous air pollutants are defined as air pollutants that “contribute to mortality or serious irreversible, or incapacitating reversible, illness” (Fed. Reg., December 23, 1985). The list presently includes the carcinogens asbestos, beryllium, mercury, and vinyl chloride and as indicated in Table 3.1, EPA is considering the addition of PERC.

In December 1985, EPA issued a notice of intent to list PERC under Section 112 apparently because of the recent positive animal carcinogenicity test (Fed. Reg., December 26, 1985). The agency intended to solicit information on the use, emissions, and health effects of the chlorinated solvent. Although a final decision on the listing has not yet been reached, it is expected within the next two years.

Ozone Layer Depletion. The EPA is also examining the feasibility of regulating chlorofluorocarbon emissions. A decision on regulation is expected in May 1987 and it could affect the use of CFC-113.
Waste Regulations

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Both PERC and CFC-113 are listed as hazardous substances under 101(14) of CERCLA or the "Superfund." As we see below, the effect of this listing on the dry cleaning industry may influence future waste management practices.

Resource Conservation and Recovery Act. PERC and CFC-113 are subject to the manifest waste tracking system set up under RCRA. In 1984, Congress passed comprehensive amendments to RCRA specifying a ban on land disposal of virtually all untreated hazardous substances within the following six years. The first set of substances banned from land disposal on November 8, 1986, included dioxins and solvents. In March 1986, EPA announced final standards for generators of between 100 and 1,000 kilograms of hazardous waste per month. Such generators—deemed SQGs—would henceforth be subject to RCRA (Fed. Reg., March 24, 1986). We focus more heavily on the RCRA regulations in Sec. IV.

Other Regulations

Clean Water Act. PERC is one of the substances designated under the Clean Water Act. This means that EPA is required to set water quality standards.

Integrated Assessment of Chlorinated Solvents. Several offices of EPA and other governmental agencies have launched a joint integrated assessment of the chlorinated solvents including PERC. One of the markets being addressed is the dry cleaning industry. The assessment may eventually lead to regulatory controls on one or more of the solvents in particular uses (Call and Massouda, 1986).

HISTORICAL SOLVENT MARKETS

The information on the health and environmental effects of PERC and CFC-113 developed over the last decade and the increasingly encompassing regulatory regime have influenced the solvent markets. Although we are interested here in dry cleaning which has certain characteristics that differ from other markets, we must also view the historical record of each solvent in the context of all their markets. This holistic view can shed light on the expected future response of the dry cleaning industry to inclusion under the rubric of RCRA. In what follows, we present case histories of PERC and CFC-113 with special emphasis on industry response to increasing regulation.
Perchloroethylene

In Table 3.2, we present the historical record of PERC production capacity. This, combined with the production and demand levels of the solvent given in Table 2.3 allow some insights into the changes that occurred in the PERC market over time.

The values of Table 2.3 show that PERC production and demand peaked in 1980, declined through 1983, showed a moderate increase in 1984, and declined again in 1985. The capacity figures of Table 3.2 show a similar trend—an increase in the early years and a decline in capacity after about 1979.

In our analysis here, we wish to focus on the dry cleaning industry. Accordingly, we must allocate PERC demand to the various applications. In Table 3.3, we present the percentage and amount of PERC production devoted to five end uses—dry cleaning and textile processing, industrial metal cleaning, chemical intermediate, exports, and other. The demand values are those for domestic demand plus exports

<table>
<thead>
<tr>
<th>Table 3.2</th>
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<tbody>
<tr>
<td>PERC PRODUCTION CAPACITY</td>
</tr>
<tr>
<td>(In thousands of mt)</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<td>Detrex (Astabula, Ohio)</td>
<td>11</td>
<td>—</td>
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<td>—</td>
<td>—</td>
<td>—</td>
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<td>75</td>
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<td>75</td>
<td>75</td>
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<tr>
<td>Dow (Freeport, Texas)</td>
<td>54</td>
<td>54</td>
<td>54</td>
<td>68</td>
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<td>9</td>
<td>18</td>
<td>23</td>
<td>23</td>
<td>23</td>
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<tr>
<td>Dow (Plaquemine, Louisiana)</td>
<td>68</td>
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<td>68</td>
<td>54</td>
<td>41</td>
<td>41</td>
<td>41</td>
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<td>27</td>
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<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>Ethyl (Baton Rouge, Louisiana)</td>
<td>23</td>
<td>23</td>
<td>45</td>
<td>23</td>
<td>23</td>
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<td>Hooker (Tacoma, Washington)</td>
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<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>Hooker (Taff, Louisiana)</td>
<td>16</td>
<td>23</td>
<td>27</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
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<tr>
<td>PPG (Lake Charles, Louisiana)</td>
<td>32</td>
<td>91</td>
<td>109</td>
<td>91</td>
<td>109</td>
<td>109</td>
<td>91</td>
</tr>
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<td>Stauffer (Louisville, Kentucky)</td>
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<td>—</td>
</tr>
<tr>
<td>Vulcan (Geismar, Louisiana)</td>
<td>50</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
</tr>
<tr>
<td>Vulcan (Wichita, Kansas)</td>
<td>18</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>DuPont (Corpus Christi, Texas)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>73</td>
<td>73</td>
<td>73</td>
<td>—</td>
</tr>
</tbody>
</table>

Total* | 390 | 466 | 478b | 525 | 503 | 480 | 394 |

SOURCES: OP&DR (November 30, 1970); CMR (August 13, 1973); CMR (August 9, 1976); CMR (June 18, 1979); CMR (March 22, 1982); CMR (March 14, 1983); CMR (February 3, 1986).

*Capacities can vary by as much as 60 percent depending on the relative demand for the coproducts (trichloroethylene and carbon tetrachloride).

bTotal value of 500,000 mt in CMR (August 9, 1976) is incorrect.
in Table 2.3 for the historical period including 1976, 1979, 1982, and 1986.

The values of Table 3.3 show that PERC use in dry cleaning and textile processing declined by 27 percent over the period. Use of the solvent as a chemical intermediate, largely in the production of CFC-113, increased by 88 percent. Indeed, this increase agrees well with the increase in CFC-113 production in Table 2.3 of 87 percent for the same period. Use of PERC in metal cleaning declined by 37 percent over the period. Total PERC demand plus exports for the period declined by 13 percent.

What caused the decline in recent years in the amount of PERC used in dry cleaning? The trend started in 1976 when the industry reported, “Domestic dry cleaning is on the decline” (CMR, August 9, 1976). The reason became obvious in 1979 when the industry explained, “The increasing popularity of wool blends, silks and other clothing fabrics that must be dry cleaned has shored up demand that had been undercut by wash-and-wear wardrobes.” The same source indicated that, “More efficient dry-cleaning machines reduce demand.

Table 3.3
PERC END USE ALLOCATION

<table>
<thead>
<tr>
<th>Use</th>
<th>1976</th>
<th>1979</th>
<th>1982</th>
<th>1986*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount (mt)</td>
<td>%</td>
<td>Amount (mt)</td>
<td>%</td>
</tr>
<tr>
<td>Dry cleaning and textile processing</td>
<td>209,000</td>
<td>63</td>
<td>215,000</td>
<td>60</td>
</tr>
<tr>
<td>Chemical intermediate</td>
<td>43,000</td>
<td>13</td>
<td>46,000</td>
<td>15</td>
</tr>
<tr>
<td>Industrial metal cleaning</td>
<td>46,000</td>
<td>14</td>
<td>54,000</td>
<td>15</td>
</tr>
<tr>
<td>Exports</td>
<td>10</td>
<td>12</td>
<td>44,000</td>
<td>12</td>
</tr>
<tr>
<td>Other</td>
<td>11,000*</td>
<td></td>
<td>(e)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>331,000</td>
<td>100</td>
<td>359,000</td>
<td>100</td>
</tr>
</tbody>
</table>

*For 1986, we use 1985 demand and export data.

Called dry cleaning solvent.

In CMR (March 14, 1983), the allocation is as follows: dry cleaning and textile processing, 59 percent; industrial metal cleaning, 21 percent; exports, 11 percent; chemical intermediate, 6 percent; and other, 3 percent. As discussed in Appendix B, intermediate use (primarily to produce CFC-113 and CFC-114) in 1982 is much higher—about 20 percent of demand. Metal cleaning use is also probably higher (see Wolf and Camm, 1987). We have adjusted all values to reflect these changes. Exports have been set at the actual level.

Exports in 1976 were 22,000 mt leaving 11,000 mt for “other.”

Exports in 1979 accounted for the total of exports and other.
Capacity exceeds consumption significantly" (CMR, June 18, 1979). Indeed, a comparison for 1979 of the production of PERC in Table 2.3 of 350,000 mt and the capacity in Table 3.2 of 525,000 mt shows this to be the case.

In 1979, amendments to the Clean Air Act required states with areas not in compliance with specified ozone levels to submit plans for meeting the standards for VOCs. PERC was one of the chemicals specifically restricted.

In 1978 and 1979, the Occupational Safety and Health Administration (OSHA) developed a new carcinogen classification scheme. Around the same time the Consumer Product Safety Commission (CPSC) developed its own carcinogen policy. The first chemical to be classified by CPSC was PERC. In this light, in 1979, the industry reported that, "CPSC has clouded PERC's future by branding it a carcinogen. Growth is tied otherwise to population trends. Petroleum cleaning solvents will not replace PERC because of their flammability. Government actions, if they came, would most alter PERC's future" (CMR, June 18, 1979). Sometime later, CPSC withdrew its proposal to classify PERC as a carcinogen. The action, however, may have had an effect on the market.

By 1982, PERC production had declined significantly (see Table 2.3). One industry source claims that there are two reasons for the long-term decline. First, synthetic fibers replaced natural fibers in the 1970s to some extent in this country. Dry cleaning, for these garments, was no longer necessary. Second, dry cleaning equipment has become more efficient and solvent losses have been reduced considerably largely in response to the more stringent VOC regulations. Thus, demand for virgin PERC has correspondingly declined.

The Chemical Marketing Reporter seems to verify the second reason. In 1982 it claimed that, "More efficient dry-cleaning machinery, stewardship programs, and recycling steadily reduced demand for the material [PERC]" (CMR, March 22, 1982). In 1986, this theme was reiterated. "Greater recycling and less solvent emissions from dry cleaning equipment and metal cleaning machinery have gradually reduced PERC demand in these sectors. Demand for PERC in the dry cleaning and metal cleaning industry will continue to decline slowly, but gains in the F-113 [CFC-113] businesses will largely offset this loss barring further restrictions on PERC's use" (CMR, February 3, 1986). This latter comment implies that growth in CFC-113 demand increased PERC use as an intermediate.

In general terms, metal cleaning and dry cleaning equipment has become more conservative of solvents in recent years. In dry cleaning specifically, one reliable industry official attributes the more
conservative trends partly to solvent costs but also to increased health and environmental concerns. He cited the smog regulations under Section 111 of the Clean Air Act as having led to reduced PERC consumption. He maintained that the EPA proposal to list PERC as a hazardous air pollutant under Section 112 of the Clean Air Act and the recent positive animal carcinogenicity tests contributed to the decline in use. He claimed that dry cleaners are not only nervous about employee lawsuits from exposure to a potential carcinogen but also concerned that there could be lawsuits from people living in the neighborhood if they later developed cancer.

CFC-113

The CFCs were first produced commercially just after World War II. Within the next two decades, it was recognized that the CFCs had a variety of properties that made them useful as refrigerants, in foam blowing, as propellants in aerosols, and as solvents. By 1970, six chemical firms—Allied, DuPont, Kaiser, Pennwalt, Racon, and Union Carbide—had entered the market. Table 3.4 shows the capacity held by each firm at the time and displays the changes in capacity that occurred until the present. Three of the producers in Table 3.4—Allied, DuPont, and Union Carbide—produced CFC-113 and CFC-114; all six firms produced CFC-11, CFC-12, and CFC-22.

Between 1970 and 1975, CFC capacity steadily increased from 431,000 mt to 599,000 mt. Indeed, the CFCs had found use in numerous products, and the aerosol market where CFC-11, CFC-12, and CFC-114 were employed was doing especially well. The other two CFCs—CFC-22 and CFC-113—were not used as propellants.

In 1974, a theory was proposed suggesting that the fully halogenated CFCs were stable enough to survive until they reached the stratosphere. Once there, impinging ultraviolet light caused the molecules to decompose, liberating their chlorine. This chlorine, it was hypothesized, was then available to catalytically react with ozone which shields the earth from ultraviolet radiation (Molina and Rowland, 1974; Stolarski and Cicerone, 1974). In 1975 the industry reported that, "Scientists in several countries theorize that ambient fluorocarbons destroy stratospheric ozone that shields the earth from much radiation. If this theory is found to be correct, fluorocarbon aerosol propellants stand a good chance of being banned. Substitute propellants are already seen to be a threat to fluorocarbon domination of the aerosol business" (CMR, September 1, 1975).

By 1978, according to the figures of Table 3.4, capacity had declined to 492,000 mt, apparently in anticipation of the aerosol ban. Late that
### Table 3.4
**HISTORICAL CFC CAPACITY**

(In thousands of mt)

<table>
<thead>
<tr>
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<td>Elizabeth, New Jersey;</td>
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<tr>
<td><strong>Kaiser</strong></td>
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<td>Thorofare, New Jersey;)</td>
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<td>(Institute, West Virginia)</td>
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<tr>
<td><strong>Total</strong></td>
<td>431</td>
<td>520</td>
<td>599</td>
<td>492</td>
<td>544</td>
<td>574</td>
<td>616</td>
</tr>
</tbody>
</table>

**SOURCES:** OP&DR (March 9, 1970); CMR (August 21, 1972); CMR (September 1, 1975); CMR (August 7, 1978); CMR (March 7, 1983); Farhad and Elkin (1985); CMR (March 10, 1986).

*In 1975, this appears as Pennsville, New Jersey; in 1978 and 1983 as Deepwater, New Jersey.

*Closed between 1975 and 1978.

*Built between 1972 and 1975.

*Later known as Essex.

*Total in the CMR, 442,000 mt, is not correct.

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year, the first phase of the ban—a prohibition on CFC production for aerosol applications—went into effect. By then, one producer, Union Carbide, had left the market, and DuPont and Pennwalt had closed plants. There remained only two producers of CFC-113—Allied and DuPont.
In 1977, an interagency task force including the Food and Drug Administration (FDA), the Consumer Product Safety Commission, and the EPA began investigating the impacts of regulating nonaerosol CFC emissions. A 1979 National Academy of Sciences panel predicted that significant ozone depletion, approximately 16 percent, would occur if emissions of potential ozone depleting substances continued (NAS, 1979). The CMR stated in 1978 that “nonessential uses of fluorocarbon propellants will be banned this year. Producers do not expect an across the board ban on refrigerant and other uses of fluorocarbons, but some regulations on emissions are probably forthcoming. How this will affect volume is not known” (CMR, August 7, 1978).

In contrast to CFC-11 and CFC-12, CFC-113 experienced rapid growth over the period 1975 through 1985 largely because of its extensive use in the electronics industry. According to the values of Table 2.3, production increased by two and one-half times, an average annual growth of nearly 10 percent. In 1986, the industry reported, “solvents consumption, mainly F-113, is also posting strong growth in making semiconductors, and is getting another boost as a replacement for chlorinated solvents, under regulatory pressure” (CMR, March 10, 1986).

In spite of the continuing possibility that nonaerosol emissions of CFCs might eventually be regulated, according to the values of Table 3.4, producers increased capacity by 25 percent over the period from 1978 to 1986. From 1978 to 1984, combined CFC production increased much more, by nearly 50 percent, as the excess capacity after the aerosol ban was more fully utilized. In fact, most CFC markets are growing rapidly and CFC-11 and CFC-12 have once again reached pre-aerosol ban levels of production.

In 1984, an environmental organization brought suit against EPA claiming the agency had not acted to regulate nonaerosol CFC applications or explained why it had not acted. Later, a settlement was reached that required EPA to study the issue and decide on nonaerosol regulations by 1987. CFC-11 and CFC-12 are still the most widely used CFCs. If regulation did occur, they would be the most likely candidates for regulation. Future regulatory action that includes CFC-113, however, cannot be ruled out.
IV. THE IMPACTS OF HAZARDOUS WASTE REGULATION

This section focuses on the regulations that govern hazardous waste generation by SQGs in the dry cleaning industry. In what follows, we first describe the importance of SQGs and their regulatory history. We also discuss the regulations on solvents that have recently been implemented. We then present the technically feasible waste management techniques available in the dry cleaning industry and describe the response of the industry to the increasingly stringent hazardous waste regulations. Finally, we relate these actions in a more general sense to SQGs as a whole.

WHY SQGS ARE IMPORTANT

SQGs represent an important problem in the nation’s efforts to improve hazardous waste management practices for four reasons. In the first place, they pose difficulties for the administration and enforcement of hazardous waste regulatory programs because there are so many of them. Estimates vary considerably, but one recent study for EPA suggests that there are some 175,000 firms generating between 100 and 1,000 kilograms per month operating in the United States. In contrast, about 14,000 firms generate more than 1,000 kilograms per month (Abt Associates, 1985). In addition, a estimated 455,000 firms generate less than 100 kilograms of hazardous waste per month. These VSQGs, although largely exempted from federal regulation, may be regulated under state programs. Thus, the sheer number of SQGs that are covered by federal and state law creates a large community to be monitored and regulated.

A second reason for concern over SQGs is the wide belief that they are much more likely to manage their hazardous waste improperly. It is the way their waste is managed that causes concern, rather than the amount of waste. SQGs generate an estimated 760,000 mt of hazardous waste per year, whereas VSQGs generate an additional 180,000 mt annually. These totals represent less than 1 percent of the estimated total volume of hazardous waste generated by industry each year (Abt Associates, 1985). Despite these relatively small volumes of waste, it is the small quantity generators that are believed to be less likely to comply with state and federal hazardous waste regulations and more likely
to dispose of their waste in an improper or unsafe manner. This characterization clearly is not meant to apply to all businesses generating small amounts of hazardous waste. But it is widely reported to be much more common than among larger waste generators.\(^1\)

A third factor that distinguishes SQGs from larger generators is that many are small businesses. Such businesses generally do not have access to information on the technologies for managing waste. Even if they knew of technologies, they lack trained staff to implement the management, they are too small to use the management techniques efficiently, and they lack the capital to install and operate new equipment.

Finally, SQGs are important because as a group they are largely new to hazardous waste regulation. This may contribute to the perception that SQGs are responsible for most illegal or improper hazardous waste management practices. That is, an important reason for their assumed lower degree of compliance is that they had been excluded from previous regulatory programs that focused on larger generators. Accordingly, they may be unaware that they generate hazardous waste at all and they may not recognize their responsibilities for hazardous waste management under RCRA.\(^2\) Many SQGs are only now entering the federal hazardous waste management system under the 1984 Hazardous and Solid Waste Amendments to RCRA. Before this, most were exempt from federal and state requirements and could dispose of their wastes in municipal sanitary landfills, managing them much as households do, without special consideration. Of course, SQGs were subject to different regulatory requirements in different states; some have been subject to the same regulations as larger generators for some time. The important point is that SQGs are an important problem for state and federal hazardous waste program administration and enforcement in part because of the new federal requirements that they manage their hazardous wastes under RCRA requirements. This entails educating small generating firms about the regulations, monitoring their behavior, and enforcing the new standards when needed.


\(^{2}\)There are trade associations that keep dry cleaners aware of regulations through newsletters.
HOW SQG WASTE IS REGULATED

The way small quantity generators of hazardous wastes are regulated has changed significantly over the past few years at both the federal and state levels. SQGs have been subject to increasingly stringent requirements. Although standards still vary across different states, they must be at least as stringent as the federal regulations. EPA’s initial standards for hazardous waste generators under the 1976 RCRA were adopted in 1980. Believing it would be administratively infeasible to regulate all generators at once, EPA established minimum requirements for generators of less than 1,000 kilograms per month, focusing the federal program on the larger generators instead. This meant that, barring more stringent state requirements, SQGs were able to dispose of their “hazardous” wastes in non-RCRA permitted facilities, such as sanitary landfills commonly used for household garbage. In essence, SQG wastes were not classified as hazardous and were largely exempt from federal regulation.\(^3\) Generators of less than 1,000 kilograms in a calendar month were required to (1) determine whether their wastes were hazardous, according to specified definitions; (2) use a “short form” waste manifest for off-site shipments; (3) use only state or federally approved treatment or disposal facilities (which need not meet RCRA standards), or a legitimate recycler; and (4) not accumulate more than 1,000 kilograms of hazardous wastes on site at any time. Generators of less than 100 kilograms of nonacutely hazardous wastes per month were not regulated at all by EPA.

In the 1984 RCRA amendments, however, Congress directed EPA to adopt more extensive requirements for small quantity generators. EPA was required to bring these generators into the scope of the federal hazardous waste management system in a manner that would protect human health and the environment and at the same time avoid unreasonably burdening the large numbers of small businesses that would be affected by the new requirements. In seeking to balance these concerns, EPA studied the relative risk posed by the small quantities of wastes generated by SQGs. They concluded that although the amount was smaller, the hazard posed by land-based waste management is much the same, irrespective of the amount generated in a given month, and that the standards should not be relaxed for these generators:

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3 An important exception was provided for "acutely hazardous" wastes, which were and continue to be regulated in quantities greater than 1 kilogram per month.
The potential for release of hazardous waste to the environment becomes significant where 100-1000 kilograms per month generators engage in waste management in surface impoundments, waste piles, landfills, or land treatment facilities. Thus, in order to fulfill its mandate to protect human health and the environment, EPA has rejected any suggestions to reduce the ... facility standards [for SQGs] (Fed. Reg., March 24, 1986).

Thus, to the extent possible, all technical standards for storage, transportation, and treatment established for larger generators are to be required of SQGs as well. Relief is granted only from certain administrative requirements. EPA’s final rule on SQG standards in effect subjects generators of between 100 and 1,000 kilograms per month to the federal hazardous waste regulatory program (Fed. Reg., March 24, 1986). The new requirements became effective on September 22, 1986, for SQGs managing their wastes off site, and on March 24, 1987, for those managing their wastes on site. Wastes that previously were not considered “hazardous” because they were not generated by large industrial or commercial concerns will now be regulated as hazardous. This means that off-site facilities managing wastes for generators of 100 to 1,000 kilograms per month will now also come under RCRA permitting requirements. SQGs will be allowed longer storage periods (up to 270 days) compared with generators of more than 1,000 kilograms per month (limited to 90 days) before being required to obtain a storage permit. They will also be exempted from many of RCRA’s requirements if they deal with an approved reclaimer or recycler who also sells reclaimed material back to the generator.

In sum, SQGs will be required to:

- Determine whether their wastes are hazardous,
- Obtain an EPA identification number,
- Use only authorized transporters,
- Use the complete (multiple copy, round-trip) uniform hazardous waste manifest form,
- Send their wastes only to RCRA-approved recycling, storage, treatment, or disposal facilities, and
- Certify that they have a waste minimization program in place.

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4Accumulation of hazardous wastes up to 6,000 kilograms is permitted for up to 180 days for SQGs. If the wastes are to be managed (that is, treated or disposed of) at a facility more than 200 miles away, wastes may be accumulated for up to 270 days. Thirty-day emergency extensions may be granted by the EPA Regional Administrator.

5Some SQGs are entitled to variances if they do not have facilities, contractors, or reclaimers in their area who handle waste.
The requirement for biennial reporting of waste quantities to state authorities has not been extended to SQGs. They have also been relieved of the requirement to file exception reports when they do not receive a signed copy of the manifest back from the designated facility within the allowed 45 days.\(^6\)

**State Exemptions**

Table 4.1 presents a summary of the levels of waste that are subject to state regulatory oversight. Generators of less than 1,000 kilograms per month of hazardous waste are exempted from regulation by the states specified under the first category in Table 4.1. Under the second category of Table 4.1, generators in the states listed are exempted if they generate less than 100 kilograms of hazardous waste each month with certain requirements. States listed under the third category of the table exempt generators of less than 100 kilograms per month. Under the fourth category, Kansas and Massachusetts exempt generators of less than 50 and 20 kilograms per month, respectively. The states listed under the fifth category of Table 4.1 regulate all generators of hazardous waste.

The federal regulations on SQGs that became effective in September 1986 will bring all states in the first category under the regulatory system for generators of between 100 and 1,000 kilograms per month. All other generators of less than 100 kilograms per month—VSQGs—are exempted from federal regulation except in those states in the last two categories.

**Exception for Recycling**

The new federal standards contain an important exemption for on-site recycling of hazardous wastes. This provision is intended to create a strong incentive for all generators to reclaim and recycle their wastes as they are generated. In effect, the process of reclaiming wastes is not subject to federal regulation. Only the accumulation, transportation, long-term storage, and management of residues or sludges resulting from the reclamation process are subject to federal regulation. Any waste reclaimed on site (if it is not accumulated for greater than specified periods before recycling) is not counted in determining a generator's status as an SQG. For example, waste reclaimed using an on-site still without intervening storage and reused on site is not

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\(^6\)In its final rule, EPA reported receiving very few exception reports, since the requirement was adopted for large generators, leading them to believe that the tracking function of the multiple-copy manifest system is working as a self-policing mechanism. Although EPA is not requiring that SQGs file exception reports, the agency specifically encourages SQGs to perform the necessary follow-up to ensure that their waste shipments reach the designated facility.
Table 4.1

STATES EXEMPTING SQGs, BY MONTHLY PRODUCTION OF (NONACUTELY) HAZARDOUS WASTE

<table>
<thead>
<tr>
<th>Less Than 1,000 Kilograms</th>
<th>Less Than 100 Kilograms, with Additional Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>Georgia</td>
</tr>
<tr>
<td>Alaska</td>
<td>Hawaii</td>
</tr>
<tr>
<td>Arizona</td>
<td>Idaho</td>
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<tr>
<td>Arkansas</td>
<td>Indiana</td>
</tr>
<tr>
<td>Colorado</td>
<td>Iowa</td>
</tr>
<tr>
<td>Delaware</td>
<td>Kentucky</td>
</tr>
<tr>
<td>Florida</td>
<td>Mississippi</td>
</tr>
</tbody>
</table>

| Connecticut | Manifest required only for > 1,000 kilograms per month generators. |
| Washington  | Variable depending on type of waste; generally > 400 pounds per month. |
| Oregon      | Variable depending on type of waste.                |
| New Hampshire| All generators can use only permitted TSDFs.          |
| Maine       | All generators must manifest and can use only permitted TSDFs. |

<table>
<thead>
<tr>
<th>Less Than 100 Kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illinois</td>
</tr>
<tr>
<td>Maryland</td>
</tr>
<tr>
<td>Michigan</td>
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<td></td>
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</table>

1–100 Kilograms

<table>
<thead>
<tr>
<th>Kansas (&lt; 50 kilograms per month)</th>
<th>Massachusetts (&lt; 20 kilograms per month)</th>
</tr>
</thead>
</table>

No Exemptions

<table>
<thead>
<tr>
<th>California</th>
<th>Minnesota</th>
<th>Rhode Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>Louisiana</td>
<td>Ohio</td>
<td>West Virginia</td>
</tr>
</tbody>
</table>


NOTE: Data are given as of mid-1986. Table summarizes only major provisions and somewhat oversimplifies actual requirements and thresholds.

*Treatment, storage, and disposal facilities.

regulated under RCRA and is not required to be counted in determining a generator’s status (Fed. Reg., March 24, 1986). However, the residues from on-site reclamation like still bottoms are subject to RCRA if they exceed 100 kilograms per month. As noted in Table 4.1 above, even amounts less than 100 kilograms per month may be subject to state regulations which can be stricter than RCRA.
In addition to the general exemption for on-site recycling, SQGs are not subject to these new standards if they deal with an approved reclaimer from whom the SQG also purchases reclaimed material. That is, the exchange between an SQG and a reclaimer involving wastes and material reclaimed from similar wastes is largely exempted from the new RCRA requirements.

HOW SOLVENT WASTES ARE REGULATED

The 1984 Hazardous and Solid Waste Amendments (HSWA) to RCRA required EPA to phase out the land disposal of untreated wastes by 1992 at the latest. The first group of wastes—dioxins and solvents—was restricted from land disposal on November 8, 1986.

In May 1985, bulk or containerized liquid waste of any kind was prohibited from landfills. In January 1986, EPA proposed the rule that would restrict the land disposal of untreated dioxins and solvents. In terms of solvents, the proposal established the ban for all but three types of excluded waste for which treatment technology was not available (Fed. Reg., January 14, 1986). On November 7, 1986, EPA published the final rule (Fed. Reg., November 7, 1986).

The regulation prohibits land disposal of wastes containing more than 1 percent or 10,000 ppm by weight of solvents of certain types. These include a number of spent halogenated and nonhalogenated solvents; all spent solvent mixtures/blends used in degreasing containing, before use, a total of 10 percent or more of the specified solvents by volume; and still bottoms from the recovery of these spent solvents and spent solvent mixtures. Alternatively, a generator can treat the waste and dispose of the residues. The treatment standards for PERC and CFC-113 are 0.079 and 1.05 ppm, respectively.

Although the proposed rule did not, the final rule exempted SQGs generating halogenated solvent waste from the regulation until November 1988 (Fed. Reg., November 7, 1986). On the same date, the proposed regulations will exclude certain halogenated solvents from land disposal altogether unless they are treated and meet the standards given above (Fed. Reg., January 14, 1986).

APPLICATION TO DRY CLEANERS

Dry cleaners account for about 4 percent of SQGs and VSQGs. They generate approximately 2 percent of the wastes. SQG and solvent regulations will specifically affect dry cleaners who use PERC and CFC-113. PERC and CFC-113 still residues, cartridges, and filter
muck are hazardous and subject to the 1988 land disposal ban. The International Fabricare Institute, which has a membership of about 21,000 commercial dry cleaners, and the Institute of Industrial Launderers (IIIL), which represents industrial dry cleaners, petitioned EPA to delist cartridge filters from regulation. Such a petition is not likely to be granted but if it were, dry cleaners could continue to dispose of their filters legally in municipal landfills (Hazardous Waste Report, 1986).

Before the SQG regulations were implemented, many dry cleaners—those who generated less than 1,000 kilograms of waste each month—were not subject to hazardous waste regulations. These dry cleaners simply disposed of their wastes in municipal landfills. Those who generated more than 1,000 kilograms per month probably disposed of their waste in permitted hazardous waste facilities or illegally disposed of it in municipal landfills.

One option for all dry cleaners subject to RCRA after the SQG regulations took effect in September 1986 was to dispose of their waste directly in a permitted landfill. An official of the International Fabricare Institute estimates that the cost to an average dry cleaner for land disposal amounts to about $5,000 annually. One drawback to this option is that after November 1988, the dry cleaning filtration residues and still bottoms cannot be disposed of in landfills without a significant reduction of chlorinated organics in the waste.

A second option open to dry cleaners in the future is incineration of wastes. An International Fabricare Institute representative estimates that incineration costs to the dry cleaner can range from $8,000 to $13,000 annually depending on the costs of transportation. Indeed, one group of about 300 dry cleaners in Massachusetts is exercising this option presently at an annual cost to each dry cleaner of $8,800.

A third option that has in fact been chosen already by most dry cleaners is to use the services of a reclaimer. Such firms pick up dry cleaners' waste on a regular schedule and fill out the manifest. They take the cartridge filters and still bottoms to central processing facili-

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7 Any liquid hazardous waste like petroleum still residue with a flash point of less than 140°F is an ignitable hazardous waste. Nonliquid petroleum filter residues and cartridges are not hazardous waste. According to an industry source, this applies to 85 percent of the petroleum solvents used in dry cleaning. Although petroleum solvents are considered hazardous and therefore subject to the May regulation on SQGs, they are not affected by the land disposal ban in November 1986.
ties where they reclaim the PERC. One reclaimer reports that about 85 percent of the reclaimed PERC is sold back into the dry cleaning industry; the balance is sold into other industrial markets.

As discussed above under the SQG regulations, by using the services of a reclaimer, the dry cleaner can sidestep the disposal problem. The reclaimer must then deal with the sludges generated in the purification processes. Such sludges were traditionally disposed of in landfills. Indeed, it is worth noting here that the land disposal ban will provide a general disincentive to all users to reclaim their waste on site. The still bottom generated in the process is extremely expensive to dispose of. Although reclaimers are willing to take dry cleaning still bottoms they are generally unwilling to accept still bottoms from other processes. Incinerators—both destructive and nondestructive like cement kilns—will not accept the waste directly from generators. The only option is to pay a waste hauler a large fee for solidification and subsequent destructive incineration. This can be extremely costly.

One reclaimer has stated that the impending November land disposal regulations will not affect his business. The sludges that result from the operation contain perhaps 50 ppm which will still meet the proposed November standards of 1 percent or 10,000 ppm. This level of PERC will not meet the 1988 proposed regulation, however, and the reclaimer is exploring future options for incineration.

Before the land disposal restriction, a second reclaimer sent some of his waste to landfills and some to a cement kiln that will accept waste with less than 3 percent chlorinated organics. The November 1986 regulations will force him to rely exclusively on cement kiln destruction.

Reclaimers have provided a mechanism for bringing a significant fraction of dry cleaning establishments into the RCRA system. In fact, most of the retail and industrial facilities presently use reclaimers’ services. The one dry cleaning sector that reclaimers do not service currently is coin-operated establishments. Although it may not be feasible to reclaim the waste generated in coin-operated facilities, the idea bears further investigation.

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9 The amount of CFC-113 waste is so small that it is probably not reclaimed.
9 To obtain the SQG exemption, the SQG must send the waste to landfill. A reclaimer cannot legally send SQG residuals to landfill.
10 Reclaimers indicate that they believed the waste generated in that sector was much less than reported here.
APPLICATION TO OTHER SQGS

The regulations on SQGs and the impending regulations on solvents will affect a significant number of businesses in the country. There are about 3,000 SQGs and VSQGs who generate roughly 2,000 mt of solvent still bottoms annually; significantly more—about 111,000—generate approximately 105,000 mt of spent solvents annually. According to one study, together these establishments account for perhaps 30 percent of combined SQGs and VSQGs and they represent some 18 percent of the waste (Abt Associates, 1985).

There is a diverse range of SQGs and VSQGs who employ solvents—both chlorinated and nonchlorinated—in the course of their business. In Table 4.2, we list the industries identified by EPA where SQGs generate solvent wastes and specify the type of waste generated. Note that some businesses generate only spent solvents and some generate both spent solvents and still bottoms.

In Table 4.3, we present estimates of the level of waste generation of solvent and still bottom waste for the industries shown in Table 4.2. We include an estimate of the present level of reclamation. The data are summarized from Abt Associates (1985).

The figures of Table 4.3 show that the largest generators of solvent waste by far are vehicle maintenance and metal manufacturing. The

<table>
<thead>
<tr>
<th>Industry</th>
<th>Type of Waste*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical manufacturers</td>
<td>Spent solvents and still bottoms (C and N)</td>
</tr>
<tr>
<td>Chemical and chemical product formulators</td>
<td>Spent solvents and still bottoms (C and N)</td>
</tr>
<tr>
<td>Cleaning agents and cosmetics manufacturing</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Construction</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Educational and vocational shops</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Equipment repair</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Furniture/wood manufacturing and refinishing</td>
<td>Spent solvents and still bottoms (C and N)</td>
</tr>
<tr>
<td>Metal manufacturing</td>
<td>Spent solvents and still bottoms (C and N)</td>
</tr>
<tr>
<td>Motor freight terminals/railroad transportation</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Paper industry</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Printing and allied industries</td>
<td>Spent solvents (C and N)</td>
</tr>
<tr>
<td>Printing ink formulators</td>
<td>Spent solvents and still bottoms (N)</td>
</tr>
<tr>
<td>Textile manufacturing</td>
<td>Spent solvents and still bottoms (C and N)</td>
</tr>
<tr>
<td>Vehicle maintenance</td>
<td>Spent solvents (C and N)</td>
</tr>
</tbody>
</table>

SOURCE: EPA SQG brochures.
*C refers to chlorinated; N refers to nonhalogenated.
two together represent 80 percent of the spent solvent waste generators and account for 81 percent of the waste generated. Metal manufacturing alone accounts for nearly all the solvent still bottom waste that is produced. Off-site reclamation of spent solvent waste in vehicle maintenance is significant; some 81 percent of generators today reclaim externally. In contrast, off-site reclamation in metal manufacturing is much lower; only 53 percent of generators reclaim externally. This presents a reasonably large market for reclaimers.

Table 4.3

<table>
<thead>
<tr>
<th>Industry</th>
<th>Spent Solvents</th>
<th>Still Bottoms</th>
<th>% Recycling</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Establishments</td>
<td>Amount (mt/yr)</td>
<td>No. of Establishments</td>
</tr>
<tr>
<td>Analytical and clinical</td>
<td>4,584</td>
<td>3,416</td>
<td>--</td>
</tr>
<tr>
<td>laboratories*</td>
<td></td>
<td></td>
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<tr>
<td>Chemical manufacturers</td>
<td>430</td>
<td>1,144</td>
<td>38</td>
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<tr>
<td>Cleaning agent and cosmetics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>manufacturing^</td>
<td>223</td>
<td>430</td>
<td>7</td>
</tr>
<tr>
<td>Construction</td>
<td>2,548</td>
<td>1,528</td>
<td>--</td>
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<tr>
<td>Educational and vocational</td>
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<td></td>
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<tr>
<td>shops</td>
<td>1,164</td>
<td>269</td>
<td>--</td>
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<tr>
<td>Equipment repair</td>
<td>1,346</td>
<td>737</td>
<td>--</td>
</tr>
<tr>
<td>Formulators*</td>
<td>559</td>
<td>1,227</td>
<td>--</td>
</tr>
<tr>
<td>Furniture manufacturing</td>
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<tr>
<td>and refinishing^</td>
<td>948</td>
<td>1,017</td>
<td>43</td>
</tr>
<tr>
<td>Metal manufacturing</td>
<td>30,025</td>
<td>39,855</td>
<td>2,631</td>
</tr>
<tr>
<td>Motor freight terminals^</td>
<td>122</td>
<td>18</td>
<td>--</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>1,965</td>
<td>3,562</td>
<td>88</td>
</tr>
<tr>
<td>Paper industry</td>
<td>136</td>
<td>367</td>
<td>3</td>
</tr>
<tr>
<td>Photography^</td>
<td>796</td>
<td>458</td>
<td>--</td>
</tr>
<tr>
<td>Printing industry^</td>
<td>6,104</td>
<td>4,481</td>
<td>--</td>
</tr>
<tr>
<td>Textile manufacturing</td>
<td>246</td>
<td>506</td>
<td>30</td>
</tr>
<tr>
<td>Vehicle maintenance</td>
<td>58,542</td>
<td>45,472</td>
<td>--</td>
</tr>
<tr>
<td>Wholesale and retail sales^</td>
<td>835</td>
<td>698</td>
<td>--</td>
</tr>
<tr>
<td>Total^</td>
<td>110,573</td>
<td>105,185</td>
<td>2,840</td>
</tr>
</tbody>
</table>


NOTE: NA is not applicable.

*This category is not included in Table 4.2.

^Abt Associates indicates that still bottoms are generated whereas EPA in Table 4.2 does not.

^Includes chemicals and chemical product formulators and printing ink formulators from Table 4.2. Abt Associates data contain information on still bottoms.

^Called furniture/wood manufacturing and refinishing in Table 4.2.

^Called motor freight terminals/railroad transportation in Table 4.2.

^A subset of educational and vocational shops in Table 4.2.

^Called printing and allied industries in Table 4.2.

^Total values of Abt Associates (1985) differ slightly from figures in Table 4.2.
Other industries that generate a reasonable amount of solvent waste include analytical and clinical laboratories, construction, the printing industry, and other manufacturing. In all of these industries, off-site reclamation is not now practiced widely. These represent a market for reclaimers that is largely untapped.\textsuperscript{11}

Two factors indicate that waste generation actually may be higher than Tables 4.2 and 4.3 show. First, one reclaimer believes that all published reports significantly underestimate the number of SQGs in this country. If this is the case, then the waste generated by these firms and the potential for reclamation and reuse is greater than estimated here. Second, the data of Tables 4.2 and 4.3 exclude VSQGs. As indicated in Table 4.1, eight states regulate VSQG wastes. This also suggests that the waste subject to regulation is higher and that the potential for reclamation is greater. Bringing SQGs and regulated VSQGs into the scope of RCRA is all the more important in this light.

\textsuperscript{11}There may be waste reduction options other than reclamation that SQGs might exercise.
V. CONCLUSIONS AND DIRECTIONS FOR FUTURE WORK

We have analyzed the dry cleaning industry in the context of the recent regulations on small quantity generators and the regulations that will restrict land disposal of chlorinated solvent waste. Most dry cleaners are classified as small quantity generators, who produce between 100 and 1,000 kilograms of waste each month. Traditionally, such small generators have generally been exempted from federal regulations on hazardous waste.

The findings suggest that the amount of chlorinated solvent waste generated by the dry cleaning industry may be higher than previously thought. We estimate that such waste amounted to 15,500 mt in 1984. According to reclaimers familiar with the industry, this estimate may be conservative; the level of waste may actually be as high as 18,000 mt.

A range of waste management options are available to the dry cleaning industry. The one chosen by most dry cleaners is reclamation of solvent by an external firm. Since 1983, two such firms have contracted with most retail and industrial dry cleaners in the country to recycle the waste. As of late 1986 one reclaimer remains. Reclaimers have not successfully contracted with coin-operated establishments. Our estimates show that the amount of waste available for reclamation in that sector is 4,700 mt or 30 percent of the total chlorinated solvent waste generated in dry cleaning.

The Abt Associates report shows that a number of other SQG industries generate a significant amount of solvent waste—both chlorinated and nonchlorinated. Vehicle maintenance generates the largest amount of solvent waste, but most of it is already reclaimed off site. Metal manufacturing also generates a substantial amount of waste and only 53 percent is reclaimed off site. There is significant potential for increased reclamation in these two industries alone. Other SQG sectors that generate a large amount of solvent waste include analytical and clinical laboratories, construction, and printing. In each of these sectors the potential for off-site reclamation is much higher.

Many reclaimers believe that the number of SQGs and regulated VSQGs is much larger than that presently reported. They also believe that the amount of waste generated is much higher than commonly accepted and that much of it is disposed of improperly. Future work should focus on methods of better estimating the number of SQGs and the level of waste by type that they generate.
In focusing on the dry cleaning industry in particular, better estimates of the number of dry cleaners in the three dry cleaning sectors could shed more light on waste generation. In future work, the Bureau of Census data on receipts might be used to apportion waste levels to dry cleaners. This would give a distribution of waste generation in dry cleaning and an estimate of how many generators fall into the SQG and VSQG categories. Given information on state regulation of VSQGs, we could develop a better estimate of the number of generators and the amount of waste generated that is subject to regulation.

Extension of the analysis reported here might focus on developing an improved understanding of the incentive structure for recycling solvents or on- vs off-site waste management by SQGs, and the prospects of developing greater recycling treatment, incineration, and residuals repository capacity to handle these wastes. Such concerns pose difficult regulatory problems for state and federal policymakers as they seek to tailor exemptions and other approaches to the special needs of SQGs.
Appendix A

CFC-113 PRODUCTION/DEMAND ESTIMATES

In Table A.1, we reproduce the production/demand estimates for CFC-113 shown in Table 2.3 of the main text. There are only two domestic CFC-113 producers, and, as a result, production data are not reported to the International Trade Commission. Because we have no consistent data on CFC-113 exports and imports, we assume, undoubtedly, with some error, that production levels reflect demand.

The first five values in Table A.1 for 1975 through 1979 were taken from Palmer et al. (1980); the information was derived from industry-supplied data. The remainder of the values were determined from the chemical profiles on “fluorocarbons” and PERC in the Chemical Marketing Reporter.

The estimate for 1978 was derived from a CFC profile in CMR for that year (CMR, August 7, 1978) indicating that solvent use of CFCs amounted to 11 percent of total CFC use. Virtually all CFC solvent

<table>
<thead>
<tr>
<th>Year</th>
<th>Production/Demand (1,000s mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>29</td>
</tr>
<tr>
<td>1976</td>
<td>31</td>
</tr>
<tr>
<td>1977</td>
<td>37</td>
</tr>
<tr>
<td>1978</td>
<td>39</td>
</tr>
<tr>
<td>1979</td>
<td>47</td>
</tr>
<tr>
<td>1980</td>
<td>50</td>
</tr>
<tr>
<td>1981</td>
<td>53</td>
</tr>
<tr>
<td>1982</td>
<td>56</td>
</tr>
<tr>
<td>1983</td>
<td>60</td>
</tr>
<tr>
<td>1984</td>
<td>68</td>
</tr>
<tr>
<td>1985</td>
<td>73</td>
</tr>
</tbody>
</table>
use is CFC-113 and nearly all CFC-113 is used as a solvent.\textsuperscript{1} Accordingly, we assume that the International Trade Commission production data on CFC-11, CFC-12, and CFC-22 together with an industry estimate of CFC-114 production account for 89 percent of total CFC production, as indicated in the chemical profile.\textsuperscript{2} If, as also specified in the profile, CFC-113 production accounted for 11 percent of total CFC production, then 1978 CFC-113 production totaled about 39,000 mt.

For the 1979 value, we use a chemical profile on PERC (CMR, June 18, 1979). That profile suggests that 13 percent of PERC was used as a chemical intermediate, largely for the production of CFC-113 and CFC-114.\textsuperscript{3} This implies that 45,500 mt of PERC was used to produce CFC-113 and CFC-114. Assuming a CFC-114 production level of about 2,300 mt,\textsuperscript{4} this leaves 43,200 mt of PERC for CFC-113 production. Since one pound of CFC-113 requires 0.92 pounds of PERC (Wolf, 1980), CFC-113 production in 1979 amounted to 47,000 mt.\textsuperscript{5}

The 1983 CFC-113 production level was estimated in a similar manner using a "fluorocarbon" profile that indicated that 15 percent of CFC production was devoted to solvent uses (CMR, March 7, 1983). In that year, CFC-11, CFC-12, and CFC-22 production amounted to 97,000, 131,000, and 107,000 mt (U.S. ITC, 1983). Assuming that these values together with a CFC-114 production estimate of about 3,500 mt account for 85 percent of total CFC production, the CFC-113 production in 1983 totaled about 60,000 mt.

For the years between 1979 and 1983, we assume that CFC-113 production grew at an average rate of 6.3 percent annually.

The values in Table A.1 for 1984 and 1985 are based on estimates supplied by industry representatives.

\textsuperscript{1}A few million pounds of CFC-11 are used in solvent applications each year. Some CFC-113 is used in refrigerant, foam, and intermediate applications. In more recent years CFC-113 use as an intermediate in fluoropolymer production has grown, but for earlier years the assumption that all CFC-113 is used as a solvent will not introduce much error.

\textsuperscript{2}In that year CFC-11, CFC-12, and CFC-22 production was reported to be 78,000, 130,000, and 96,000 mt (U.S. ITC, 1978). CFC-114 production is estimated at 9,500 mt—a high value because aerosol use was not banned until late 1978 and early 1979.

\textsuperscript{3}Since it is unlikely that imported PERC was used as an intermediate, we assume the percentage applies to domestic production.

\textsuperscript{4}After the aerosol ban, CFC-114 was used almost exclusively for production of CFC-115, one component of the refrigerant CFC-502.

\textsuperscript{5}To produce one pound of CFC-114 requires 1.01 pounds of PERC (see Wolf, 1980).
Appendix B

SOLVENT USE IN DRY CLEANING

In this appendix, we describe procedures for allocating PERC and CFC-113 dry cleaning use. As we shall see below, different allocation methods lead to very different estimates of solvent use in dry cleaning.

Three SIC codes largely account for the dry cleaning industry. They include coin-operated laundries and dry cleaning (SIC 7215), dry cleaning plants, except rug cleaning (SIC 7216), and industrial launderers (SIC 7218). In Table B.1, we show statistics for each of these SIC codes for 1977 and 1982 from Table 2.1 of the main text as well as preliminary data for 1983 and 1984.

The values of Table B.1 illustrate that the number of coin-operated (SIC 7215) and commercial dry cleaning establishments (SIC 7216) decreased between 1977 and 1982. In contrast, the number of industrial laundries (SIC 7218) increased. As expected, receipts in all three sectors increased. Receipts for coin-operated facilities and industrial laundries remained approximately constant between 1982 and 1984. Receipts in commercial establishments increased significantly over the period.

In the discussion that follows, we use two techniques for estimating PERC use in dry cleaning. The first—a bottom-up approach—relies on the figures of Table B.1. The second—a top-down approach—employs industry use estimates.

BOTTOM-UP PERC ALLOCATION—1982

The data of Table B.1 can be used with industry supplied data to estimate the amount of PERC used in dry cleaning; we focus on 1982 in detail. In that year, receipts in the 10,943 coin-operated dry cleaning establishments amounted to $1.168 billion. A trade organization representative estimates the cost of cleaning a 6 pound load of clothing at $4 to $5.75. Assuming PERC is used in 14.1 percent of the coin-operated facilities, between 172 and 247 million pounds of clothing was cleaned. At a consumption rate of 20 pounds of PERC per 100 pounds of clothing cleaned, this suggests between 34 and 49 million pounds of PERC was required. Assuming the average, 41.5 million pounds or 19,000 mt of PERC was used in coin-operated dry cleaning in 1982.
Table B.1  
DRY CLEANING INDUSTRY STATISTICS, 1977 THROUGH 1984

<table>
<thead>
<tr>
<th>SIC Code</th>
<th>Description</th>
<th>Receipts ($1,000)</th>
<th>No. of Establishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>7215</td>
<td>Coin-operated laundries and dry cleaning*</td>
<td>844,916</td>
<td>12,446</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,167,955</td>
<td>10,943</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,528,000</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,688,000</td>
<td>NA</td>
</tr>
<tr>
<td>7216</td>
<td>Dry cleaning plants, except rug cleaning*</td>
<td>1,895,772</td>
<td>21,868</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,872,823</td>
<td>20,202</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,326,000</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3,796,000</td>
<td>NA</td>
</tr>
<tr>
<td>7218</td>
<td>Industrial launderers</td>
<td>1,147,277</td>
<td>1,054</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,006,547</td>
<td>1,288</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,895,295</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2,111,000</td>
<td>NA</td>
</tr>
</tbody>
</table>


NOTE: NA is not available.
*Limited to establishments with payrolls.
*Preliminary estimates.

Receipts in commercial plants in that year totaled $2.873 billion. At that time, industry sources suggest that a man's suit weighing 2.25 pounds cost $4.75 to clean. We assume 75 percent of the retail establishments used PERC and adopt a PERC consumption rate of 12 pounds per hundred pounds of clothing cleaned. This indicates that 122 million pounds or 55,000 mt of PERC was used in commercial dry cleaning in 1982.

Industry sources claim that about one-fourth of the industrial laundries used PERC at an average consumption of 4,000 gallons per year in 1982. In that year there were 1,288 plants, 322 of which employed PERC. At a plant consumption of 4,000 gallons, 1982 PERC use in industrial plants amounted to 17.5 million pounds or about 8,000 mt.¹

In summary, the estimated 1982 use of PERC in the three sectors combined was about 82,000 mt.

TOP-DOWN PERC ALLOCATION—1982

IFI estimates that 270 million pounds or 122,500 mt of PERC was sold to the dry cleaning industry in 1982.

In 1982, the Chemical Marketing Reporter in a PERC chemical profile indicated that 59 percent of the PERC went toward dry cleaning and textile processing applications (CMR, March 22, 1982). Applying

¹The density of PERC is 13.55 pounds per gallon.
this percentage to the demand values plus exports given in Table 2.2 of the main text suggests that 1982 use of PERC in dry cleaning amounted to about 166,000 mt. This is far higher than the IFI estimate given above.

One reclaimer who services much of the dry cleaning industry estimates that 15 to 16 million gallons or 92,000 to 98,000 mt of PERC goes into the dry cleaning industry at present and was used for that purpose in the last several years. This estimate excludes coin-operated facilities. If we include the estimate for coin-operated establishments above—19,000 mt—the reclaimer’s estimate is about 114,000 mt.

**RAND PERC ALLOCATION—1982**

The bottom-up allocation leads to a dry cleaning use of 82,000 mt. The top-down approach leads to three different estimates—122,500 mt by IFI, 166,000 mt using the Chemical Marketing Reporter values, and another lower estimate by a reclaimer of about 114,000 mt.

Several factors lead to the discrepancy between the top-down numbers on the one hand and the bottom-up numbers on the other hand. The bottom-up values are probably too low for two reasons. First, the receipts reported by the Census of Business excludes mom-and-pop plants without a payroll. Second, because dry cleaning is a cash business, there may be significant underreporting of receipts to the Internal Revenue Service. Including receipts from mom-and-pop and underreporting facilities could increase the estimate of PERC used in dry cleaning substantially.

The top-down estimate from the Chemical Marketing Reporter data is probably somewhat high for three reasons. First, the estimate in the CMR includes PERC use in textile processing. Second, the producers of PERC sell their chemical to distributors who stabilize it appropriately and sell it to users largely in the metal cleaning or dry cleaning industries. Producers may list the PERC as going to dry cleaning even when the distributor sells only a fraction to that market.

Third, the Chemical Marketing Reporter in 1982 significantly underestimates the amount of PERC used as a chemical intermediate. Most of this use is in the production of CFC-113 and CFC-114. In that year CFC-113 production amounted to an estimated 56,000 mt. At least 52,000 mt of PERC or about 20 percent of total PERC was required to produce the CFC-113. The Chemical Marketing Reporter reports incorrectly that only 6 percent of the PERC was used as an intermediate.

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2The CMR includes an allocation of exports.

3About 0.92 mt of PERC is required to produce 1 mt of CFC-113 (Wolf, 1980).
intermediate. If instead, 20 percent is the correct number, then the percentage of PERC allocated to dry cleaning may actually be smaller.\footnote{The 21 percent of PERC allocated to metal cleaning in 1982 may also be too high. In the PERC chemical profile for 1975 and 1986 the values for metal cleaning were 15 and 10 percent, respectively (CMR, June 15, 1979; CMR, March 22, 1982; CMR, February 3, 1986).}

In the light of all of this information, we believe that the top-down Chemical Marketing Reporter estimate—at 166,000 mt—is too high and the bottom-up estimate based on the Bureau of Census receipts—at about 82,000 mt—is too low. The reclaimer's estimate of about 114,000 mt and the IFI's estimate of 122,500 mt lie between the other two estimates. This reclamation firm services 15,000 of the 20,000 commercial and industrial plants and is likely to have a good knowledge of the market. Accordingly, we adopt an estimate of the PERC used in dry cleaning in 1982 of about 110,000 mt. If we partition this use according to the ratios of use in the three sectors calculated in the bottom-up analysis, this suggests that the commercial, industrial and coin-operated sectors used 75,000, 10,000, and 25,000 mt, respectively.

**RAND PERC ALLOCATION—1984**

Using the procedure described above, we can estimate PERC use in dry cleaning for a more recent year—1984. In the bottom-up approach we adopt a value of $3.796 billion for the receipts in commercial plants, a cleaning cost of about $4.95 in 1984 for a man's suit weighing 2.25 pounds, and a PERC consumption rate of 11 pounds per hundred pounds of clothing cleaned in the 75 percent of the plants that use PERC. Note that the dry cleaning cost increased slightly over the period between 1982 and 1984, and that PERC consumption declined from 12 pounds per hundred pounds of clothing cleaned in 1982 to 11 pounds in 1984. This decline is largely attributable to regulations on PERC emissions as discussed in Sec. III of the main text. These assumptions together lead to commercial PERC consumption of about 65,000 mt.

For coin-operated units the 1984 receipts totaled $1.688 billion. We again use a cost of $4 to $5.75 for a 6 pound load and assume that 14.1 percent of coin-operated facilities contain PERC machines. An industry source indicates that PERC consumption in these machines has increased from 20 pounds per hundred pounds of clothing cleaned to perhaps 22 pounds, largely because the machines are less efficient as they age. These assumptions lead to a PERC consumption of 25,000 to 36,000 mt or an average of about 30,000 mt.
Industry sources claim that 1984 consumption by industrial laundries is about two-thirds the 1982 value—or about 5,000 mt. The reason for the decline is conversion away from PERC to water because of the more stringent PERC regulations (see Sec. III).

The sum of the PERC in the three sectors for 1984 amounts to 100,000 mt. This is about 20 percent higher than the 1982 bottom-up estimate of 82,000 mt. Applying this increase to our 1982 estimate of 110,000 mt leads to about 130,000 mt. Apportioning this to each sector as before, 1984 PERC use in the commercial, industrial, and coin-operated sectors amounted to 83,000, 7,000, and 40,000 mt, respectively.

**CFC-113 USE IN DRY CLEANING**

As for PERC, there are two methods for estimating CFC-113 use—the top-down and the bottom-up methods. Below, we describe each in turn.

Except for certain minor uses, in dry cleaning CFC-113 is used exclusively in the commercial sector. An industry source estimates that about 4 million pounds or 2,000 mt of CFC-113 is used in dry cleaning.

This number agrees well with a bottom-up approach using the receipts in the commercial sector of $3.796 billion in 1984. We assume a cost of $4.95 for a man’s suit weighing 2.25 pounds, and that CFC-113 is used in 2.5 percent of the plants at a consumption rate of 7.5 pounds per hundred pounds of clothing cleaned. This implies a CFC-113 use of 3.2 million pounds or 1,500 mt. Assuming again as we did for PERC that the bottom-up approach underestimates demand by about 32 percent leads to a CFC-113 use in dry cleaning of about 2,000 mt.

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6Some CFC-113 is also used in a few industrial plants to dry clean uniforms worn in nuclear plants.
Appendix C

CALCULATION OF WASTE GENERATION

In this appendix, we estimate the amount of PERC and CFC-113 waste generated in the dry cleaning industry. Users of newer machines generate waste PERC in the form of standard cartridge filters or adsorptive cartridge filters as well as a still residue from distillation of spent solvent. Older PERC machines—estimated by one industry source to represent about 10 percent of the commercial sector—are called “powder” machines. They generate waste in the form of a cooked powder residue. Such users do not distill and therefore do not produce a still residue. Virtually all the CFC-113 is used in dry-to-dry machines. Users generate two types of waste—standard cartridge filter and still residues. Below, we discuss each solvent in turn.

PERC WASTE

According to one industry source, the “average” industrial or commercial dry cleaner’s annual waste can be characterized as follows. The dry cleaner generates 2.1 drums or 105 gallons of still residue; about 50 percent or 52.5 gallons of this waste is PERC. The average dry cleaner also generates 42 standard cartridge filters, each of which contains about one-fourth gallon of PERC for a total PERC content of 10.5 gallons. Dry cleaners also produce an average of 7.8 adsorptive cartridge filters containing one gallon of PERC each for a total volume of PERC of 7.8 gallons.

The total amount of PERC generated by the average dry cleaner amounts to about 71 gallons of PERC annually. About 20,000 commercial establishments use PERC. This suggests that the total waste generated is 1.42 million gallons or about 8,730 mt of PERC.

These estimates apparently do not include waste from users of “powder” machines, which account for 11 percent of the commercial market. The PERC waste generated by these users is approximately equal to that generated by users of newer machines. In an analysis of waste in retail dry cleaning plants, for instance, the IFI Fabricare News reports that the waste generated per 1,000 pounds of clothing cleaned is 28 pounds of still residue (the entire weight) and 26 pounds of standard cartridge filter (half the weight is PERC). Thus the dry cleaner
generates 41 pounds of PERC waste (IFI Fabricare News, November 1982). The publication also reports that cooked powder residue equivalent to 42 pounds of PERC is generated by users of older “powder” machines. The wastes of users with older and newer machines are therefore approximately equal. If we assume that powder machines account for 10 percent of the waste generated in commercial establishments, then the total waste produced in the commercial sector is 9,800 mt.

According to the values of Table 2.3 in the text, the commercial sector accounts for 92 percent of the PERC use in the industrial and commercial sectors combined. Assuming that this value represents the fraction of waste generated as well, the commercial and industrial sectors together generate 10,600 mt.

Coin-operated businesses are also excluded from the total. According to Table 2.3 in the main text, coin-operated establishments account for 31 percent of the total PERC used in dry cleaning. If we assume waste generation to be in the same proportion, then coin-operated establishments generate 4,700 mt of waste. Thus the total amount of dry cleaning waste generated by dry cleaners is 15,300 mt.

This value can be compared with a value derived from a top-down approach. About one million standard cartridge filters are sold to the commercial and industrial dry cleaning sectors annually. At an average PERC content of one-fourth gallon, the waste PERC generated in standard cartridge filters is 250,000 gallons. There are about 250,000 adsorptive cartridge filters sold each year. At an average PERC content of one gallon each, this suggests that the waste PERC generated amounts to 250,000 gallons. About 52,000 drums of still residue each containing 25 gallons of PERC are produced for a total of 1.3 million gallons of PERC. The total amount of PERC generated is about 1.8 million gallons or 11,000 mt, which agrees well with the total calculated above for the commercial and industrial sectors.

**CFC-113 WASTE**

An industry source estimates that CFC-113 waste is less than PERC waste. A PERC user generates a 28 pound still residue and a 26 pound standard cartridge filter containing about 13 pounds of PERC per thousand pounds of clothing cleaned. CFC-113 waste includes the standard cartridge filter but a much smaller still residue—only 11.5 pounds of CFC-113. A CFC-113 user’s waste therefore is only 60 percent of a PERC user’s waste.
In the commercial dry cleaning sector, there were about 25,000 dry cleaners in 1984. Some 75 percent of them were PERC users and 25 percent were CFC-113 users. This implies there were 18,750 PERC and 625 CFC-113 users. Since PERC waste in the commercial sector amounted to 9,800 mt, each user generated about 500 mt. If we assume a CFC-113 dry cleaner generates only 60 percent of this amount, then total CFC-113 waste generation reached about 200 mt in 1984.
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